Cystic Fibrosis our focus

Standards of Care and Good Clinical Practice for the Physiotherapy Management of Cystic Fibrosis

Third edition – April 2017

Fighting for a Life Unlimited

Members of the Physiotherapy Working Group

Editorial Board

Tracey Daniels, Advanced Clinical Specialist Physiotherapist for Cystic Fibrosis – York Teaching Hospital NHS Foundation Trust

Lisa Morrison, Clinical Specialist Physiotherapist – Queen Elizabeth University Hospital, Glasgow

Nuala Harnett, Principal Physiotherapist – Great North Children's Hospital, Newcastle upon Tyne

Sophie Lewis, Clinical Care Adviser at the Cystic Fibrosis Trust

Contributors

Melony Archer, Wolverhampton Hospitals NHS Trust

Suzanne Barclay, Queen Elizabeth University Hospital, Glasgow

Catherine Brown, Heartlands Hospital, Birmingham

Fiona Cathcart, Royal Brompton & Harefield NHS Foundation Trust, London

Tracey Daniels, York Teaching Hospital Foundation NHS Trust, York

Hannah Day, Sheffield Children's NHS Foundation Trust

Emma Dixon, Royal Brompton & Harefield NHS Foundation Trust, London

Elaine Dhouieb, Royal Hospital for Sick Children, Edinburgh

Nicola Duncan, Western General Hospital, Edinburgh

Elaine Edwards, Sheffield Children's NHS Foundation Trust

Katie Ferguson, King's College Hospital NHS Foundation Trust, London

Penny Galey, Norfolk & Norwich University NHS Foundation Trust

Alison Gates, Oxford University Hospitals NHS Foundation Trust

Stephanie Graham, Great North Children's Hospital, Newcastle upon Tyne

Miriam Green, Royal Devon & Exeter NHS Foundation Trust

Nuala Harnett, Great North Children's Hospital, Newcastle upon Tyne

Nathan Hilton, Liverpool Heart and Chest Hospital NHS Foundation Trust

Marlene Hutchings, Northern General Hospital, Sheffield

Susan Johnson, University Hospital of South Manchester NHS Foundation Trust

Ashley Johnstone, Royal Alexandra Hospital, Paisley

Victoria Keenan, Addenbrookes Hospital, Cambridge

Hannah Langman, University Hospital of South Manchester NHS Foundation Trust

Roseanna Lowless, Royal Devon & Exeter NHS Foundation Trust

Margaret MacLeod, Aberdeen Royal Infirmary

Richard Macphee, NHS Lanarkshire

Katherine Miles, Barts Health NHS Trust, London

Adrian Morris, Liverpool Heart and Chest Hospital NHS Foundation Trust

Lisa Morrison, Queen Elizabeth University Hospital, Glasgow

Monica Musgrave, Addenbrookes Hospital, Cambridge

Louella O'Herlihy, Poole Hospital NHS Foundation Trust

Helen Parrott, Royal Brompton & Harefield NHS Foundation Trust, London

Sarah Rand, Great Ormond Street Hospital, London

Charles Reilly, King's College Hospital NHS Foundation Trust, London

Myra Robson, Lewisham continence service, London

Pamela Scarborough, lifeandbreath.co.uk

James Shelley, Royal Devon & Exeter NHS Foundation Trust

Sheona Stubbs, Royal Gwent Hospital, Newport

Jodee Tame, University Hospital of Wales, Cardiff

Julia Taylor, University Hospital of South Manchester NHS Foundation Trust

Jayne Trott, Royal Devon & Exeter Hospital

Louise Warnock, Oxford University Hospitals NHS Foundation Trust

Charlotte Wells, Royal Brompton & Harefield NHS Foundation Trust, London

Megan Willis, Papworth Hospital NHS Foundation Trust, Cambridge

Many thanks to all the physiotherapists and other members of the multidisciplinary teams who contributed to the formulation of these guidelines. We appreciate all the comments received throughout the development of this document and acknowledge the wealth of expertise nationally. Special thanks to the Cystic Fibrosis Trust for their ongoing support.

Standards of Care and Good Clinical Practice for the Physiotherapy Management of Cystic Fibrosis

1. Foreword

1.1 Document development
1.2 How to use this document
1.3 Review of the document
1.4 Grading scheme for recommendations in the document

2. Physiotherapy National Standards of Care for People with Cystic Fibrosis (2017)

2.1 How to use the Standards
2.2 Introduction

3. Outcome measures

3.1 Airway clearance
3.2 Exercise testing
3.3 Induced sputum
3.4 Other outcome measures

4. Adherence

4.1 Airway clearance
4.2 Exercise/activity
4.3 Inhaled medication
4.4 Measuring adherence
4.5 Strategies to impact on adherence

5. Airway clearance techniques

5.1 Active Cycle of Breathing Techniques
5.2 Autogenic Drainage
5.3 Positive Expiratory Pressure
5.4 Oscillatory Devices
- Flutter®
- Acapella®
- Cornet®
- Aerobika®
- Quake®

5.5 Extra-thoracic oscillations (High frequency chest wall oscillation)
5.6 Intra-pulmonary Percussive Ventilation
5.7 Postural Drainage
5.8 Intermittent Positive Pressure Breathing

6. Sinus disease

6.1 Introduction
6.2 Sinonasal washout
6.3 Sinus nebuliser therapy

7. Exercise

7.1 Exercise prescription
7.2 Evidence for physical training

8. Inhalation therapy

8.1 Bronchodilator trials
8.2 Drug response assessment
8.3 Inhaler devices
8.4 Nebuliser devices
8.5 Timing of medications
8.6 Cleaning and maintenance of equipment

9. Oxygen therapy

9.1 Emergency oxygen
9.2 Long-term oxygen therapy
9.3 Nocturnal oxygen therapy
9.4 Oxygen and non-invasive ventilation
9.5 Ambulatory oxygen
9.6 Oxygen for air travel
9.7 Oxygen equipment

10. Non-invasive ventilation

10.1 Introduction
10.2 Non-invasive ventilation for airway clearance
10.3 Non-invasive ventilation for exercise
10.4 Non-invasive ventilation for respiratory failure
10.5 Non-invasive ventilation for nocturnal hypoventilation
10.6 Non-invasive ventilation provision

11. Musculoskeletal problems and postural management

11.1 Posture and thoracic kyphosis
11.2 BMD and fracture
11.3 Pain
11.4 Other problems
11.5 Screening and prevention of MSK dysfunction
11.6 Treatment

12. Management of specific issues

12.1 Urinary incontinence
12.2 Pregnancy
12.3 Liver disease
12.4 Haemoptysis
12.5 Pneumothorax
12.6 Critical care
12.7 Pre-transplant management
12.8 Physiotherapy intervention following bilateral lung transplantation
12.9 Palliative and end of life care

13. Independent and supplementary prescribing

13.1 Regulation of non-medical prescribing practice

14. Complementary therapies

14.1 Acupuncture
14.2 Halotherapy (salt caves/salt lamps)
14.3 Pilates
14.4 Relaxation techniques (including massage, aromatherapy and reflexology)
14.5 Singing
14.6 Tai chi
14.7 Yoga
14.8 Other complementary therapies

15. References

16. Glossary of abbreviations

17. Appendices

Appendix I Self Evaluation Tool
Appendix II Physiotherapy Guidance Paper: Physiotherapy Management of Screened Infants with CF (2008)
Appendix IIa Parent Assessment Tool
Appendix IIb Physical activity in infants
Appendix IIc Airway clearance techniques
Appendix III Exercise tests available
Appendix IV SNOT 22
Appendix V The Borg perceived exertion scale
Appendix VI Medications
- VIa Standard operating procedure – Drug response assessment
- VIb Drug response assessment testing proforma
- VIc Drug response assessment competency document
- VId Nebulised and inhaled medication for people with CF
- VIe Inhalers, medications and devices

Appendix VII Manchester MSK Screening Tool

1. Foreword

1.1 Document development

This document is the updated "Standards of Care and Good Clinical Practice for the Physiotherapy Management of Cystic Fibrosis" (2011). It incorporates relevant information from the ACPCF/Cystic Fibrosis Trust endorsed 'Standards of Care' (2011) and the Physiotherapy Guidance paper 'Physiotherapy management of screened infants with CF' (2008) (Appendix II) to complete a comprehensive support document for physiotherapists working in cystic fibrosis (CF). It covers infants, children and adults with CF.

All contributors are professionals working in the specialist field of cystic fibrosis. The ACPCF acknowledges the invaluable input of other health professionals and have consulted in areas where other professionals are pivotal e.g. respiratory exercise physiology. This document has been developed independently of any funding bodies.

1.2 How to use this document

The Standards of Care and Good Clinical Practice for the Physiotherapy Management of Cystic Fibrosis aims to be a useful tool and comprehensive reference document for all physiotherapists and clinicians involved in the delivery of care to people diagnosed with cystic fibrosis. It can also be used as a reference document for people with CF and their families/carers. The endorsement process of the document by the Cystic Fibrosis Trust has included review by relevant experts as well as peer review.

The recommendations are intended to encourage physiotherapists to develop local guidelines tailored to their specific needs and circumstances. Good clinical practice points highlight areas of expert practice which are relevant to clinicians, but which do not currently have substantive evidence.

1.3 Review of the document

This document will be reviewed in 2020 by the ACPCF and updated according to any new evidence available and/or changes in practice.

1.4 Grading scheme for recommendations in the document

In this document, with the exception of Appendix II 'Physiotherapy Management of Screened Infants with CF', the evidence used to support the recommendations has been graded using the Grading of Recommendations Assessment, Development and Evaluation[1] (GRADE) system. The 'Scottish Intercollegiate Guidelines Network'[2] is used in the aforementioned Appendix II, as this document was produced in 2009.

GRADE gives the clinician a useful tool in making clear, pragmatic interpretations of strong versus weak recommendations. As few areas of physiotherapy management in CF have sufficient and robust evidence, it is of paramount importance to inform the clinician about:

- the quality of the evidence (QoE) (high, moderate, low or very low)
- which outcomes are critical
- the overall strength of the recommendation (strong or weak) to better inform their clinical reasoning and decision process.

Although recommendations overall may be graded as 'strong' (i.e. the degree of confidence that the desirable effects outweigh the undesirable) the quality of the evidence may be moderate or low, due to the methodological issues within the studies available. Where there is no evidence to either support or refute practice, no recommendation is made.

2. Physiotherapy National Standards of Care for people with Cystic Fibrosis (2017)

The standards have been incorporated into the Self Evaluation Tool (Appendix I) which provides the opportunity for each centre or clinic to audit their service and allows the ACPCF to assist CF physiotherapists to undertake regular national benchmarking.

2.1 How to use the Standards

The standards have been developed in association with the following documents (note these may be updated or superseded since publication of this document) which should be consulted as required:

- NHS England National Service Specification – adult https://www.england.nhs.uk/commissioning/wp-content/uploads/sites/12/2015/01/a01-spec-cystic-fibrosis-adlt.pdf
- NHS England National Service Specification – child https://www.england.nhs.uk/commissioning/wp-content/uploads/sites/12/2015/01/a01-spec-cystic-fibrosis-child.pdf
- Clinical Commissioning Policy: Inhaled Therapy for Adults and Children with Cystic Fibrosis https://www.england.nhs.uk/commissioning/wp-content/uploads/sites/12/2015/01/a01-policy-inhld-thrpy-cf.pdf
- Standards of Care and Good Clinical Practice for the Physiotherapy Management of Cystic Fibrosis Second Edition (2017)
- Clinical Guidance for the Physiotherapy Management of Screened Infants with Cystic Fibrosis (ACPCF Physiotherapy Guidance Paper 2008)
- Guidelines for the Physiotherapy Management of the Adult, Medical, Spontaneously Breathing Patient. Section 3, Cystic Fibrosis (Joint BTS/ACPRC guideline 2009)
- Quality Assurance Standards for Physiotherapy Service Delivery (CSP 2012)
- Code of Members Professional Values and Behaviour (CSP 2011)
- *Pseudomonas aeruginosa* Infection in People with Cystic Fibrosis. Suggestions for Prevention and Infection Control. Second Edition. November 2004
- Methicillin-resistant *Staphylococcus aureus* (MRSA). April 2008
- The *Burkholderia cepacia* complex. Suggestions for Prevention and Infection Control Second Edition. September 2004
- Laboratory Standards for Processing Microbiology Samples from People with Cystic Fibrosis. September 2010
- *Mycobacterium abscessus*. Suggestions for Infection Prevention and Control. Interim Guidance. October 2013
- National Consensus Standards for the Nursing Management of Cystic Fibrosis (Cystic Fibrosis Trust, 2001)
- Nutritional Management of Cystic Fibrosis. Cystic Fibrosis Trust. 2016
- Pharmacy Standards of Care. Cystic Fibrosis Trust. 2011

European Cystic Fibrosis Society Guidelines:

- European Cystic Fibrosis bone mineralisation standards (Journal of Cystic Fibrosis, 2011)
- European Cystic Fibrosis Society Standards of Care: Framework for the Cystic Fibrosis Centre (2014)
- European Cystic Fibrosis Society Standards of Care: Best Practice guidelines (2014)
- European Cystic Fibrosis Society Standards of Care: Quality Management in cystic fibrosis (2014)
- Guidelines for the diagnosis and management of distal intestinal obstruction syndrome in cystic fibrosis patients (Journal of Cystic Fibrosis, 2011)
- Best practice guidance for the diagnosis and management of cystic fibrosis-associated liver disease (Journal of Cystic Fibrosis, 2011)
- End of Life Care for Patients with Cystic Fibrosis (Journal of Cystic Fibrosis, 2011)
- Guiding principles on how to manage relevant psychological aspects within a CF team: Interdisciplinary approaches (Journal of Cystic Fibrosis, 2011)
- New clinical diagnostic procedures for cystic fibrosis in Europe (Journal of Cystic Fibrosis, 2011)
- Chronic *Pseudomonas aeruginosa* infection definition: EuroCareCF Working Group report (Journal of Cystic Fibrosis, 2011)
- Pulmonary exacerbation: Towards a definition for use in clinical trials. Report from the EuroCareCF Working Group on outcome parameters in clinical trials (Journal of Cystic Fibrosis Volume 10 2011)
- Travelling with cystic fibrosis: Recommendations for patients and care Team members (Journal of Cystic Fibrosis, 2010)
- Guidelines for the management of pregnancy in women with cystic fibrosis (Journal of Cystic Fibrosis, 2008)

NICE guidance:

- Cystic fibrosis: long-term azithromycin (NICE 2014)
- Colistimethate sodium and tobramycin dry powders for inhalation for treating pseudomonas lung infection in cystic fibrosis (NICE 2013)
- Mannitol dry powder for inhalation for treating cystic fibrosis (NICE 2012)

2.2 Introduction

The majority of people with CF in the UK receive all or some of their care from a Specialist CF Centre. In some circumstances, particularly in the care of children, network care arrangements between a Specialist CF Centre and the network clinic have been developed.

A safe and effective specialist CF service will require a team with appropriate levels of experience, knowledge and skill.

The standards are set out under the following headings:

1. **Staffing**
2. **Service provision**
3. **Facilities**
4. **Equipment**
5. **Clinical standards**
6. **Infection control**
7. **Professional development and training**

Standard 1: Staffing

People with cystic fibrosis will be cared for by physiotherapists with an appropriate level of expertise in the physiotherapy management of cystic fibrosis.

CF Specialist Centres

A CF Specialist Centre must be led by a Principal CF Physiotherapist Practitioner (Band 8).

Definition of a Principal CF Physiotherapist Practitioner

- Working in a Regional Centre with a minimum of 50 people with CF (NHS Commissioning)
- Minimum of 5 years' working as an Advanced CF Practitioner (Band 7)
- CF-specific continuing professional development including annual attendance at National and International Conference
- Undertakes CF specific clinical audit, quality improvement and research
- Provides CF specialist clinical education at graduate and post graduate level

The Principal CF Physiotherapist Practitioner post must be underpinned by Advanced CF Physiotherapist Practitioner post(s) (Band 7 or above).

Definition of Advanced CF Physiotherapy Practitioner

- Working in a centre/clinic with a minimum of 50 people with CF (adults or paediatrics) **or** working in a network clinic with responsibility of delivering CF specialist care under the supervision of a regional centre
- Minimum of 3 years' experience assessing and treating CF specialist caseload
- CF specific continuing professional development including annual attendance at National and International Conference
- Teaches and supervises the specialist physiotherapists

The number of Advanced CF Physiotherapist Practitioner Posts will depend on the size of the centre and the role and responsibilities of the posts.

The complexity of the caseload requires robust cross cover arrangements between the Principal CF Physiotherapist Practitioner and the Advanced CF Physiotherapist Practitioner posts.

In addition to these posts multidisciplinary teams in large and/or complex Specialist CF Centres benefit from the strategic leadership and expertise provided by a Consultant Nurse or a Consultant Allied Health Professional Post.

Recruitment to these pivotal physiotherapy posts will be undertaken in collaboration with the Clinical Director of the CF Centre.

Staffing will include an appropriate skill mix to meet the recommended staffing levels.

The Recommended Qualified Physiotherapy Staffing Levels: (Working Group, 2015)

The table shows recommended Whole Time Equivalent (WTE) of qualified Physiotherapists for a 5-day service. It will be noted that these staffing levels refer to both specialist centres and network clinics. The UK Cystic Fibrosis Registry Annual Data Report (2014) demonstrates a trend where adult centres with greater numbers of people with CF (>250) have lower median FEV_1% predicted values. Staffing levels for adult centres will be maintained at the ratio of 2 WTE physiotherapists per 75 people to reflect the requirements of this more severely affected complex group.

	75 patients	150 patients	250 patients	>250 patients
Adult Centres (WTE)	2	4	6	Increase of 2 WTE/75 patients
Paediatric Centres (WTE)	2	3	4	Increase of 1 WTE/100 patients

The mechanism for weekend, on-call and 7-day provision will not impinge on these weekday staffing levels. Guidance within the Chartered Society of Physiotherapy (CSP) seven data extended hours' service pack will be observed (CSP 2014a).

Continuity of care is known to improve health outcomes and patient satisfaction for people with long-term conditions. Continuity of care is best achieved by the use of static Specialist CF Physiotherapists (Band 6) to both underpin the lead posts already described and to achieve the recommended staffing levels. Broad rotational physiotherapy posts (Band 6 and Band 5) should be used cautiously. They cannot contribute to continuity of care and have a large training requirement. They should represent no more than 10% of the CF physiotherapy workforce.

It is recommended that a safe and effective specialist CF service will require a team with the levels of experience, knowledge and skill detailed below. This should be used as a framework for local application.

Definition of a Specialist Physiotherapist

Physiotherapists developing clinical expertise in the physiotherapy management of CF, in either a static or wider rotational post, or community staff who treat individuals with CF as part of a mixed caseload.

- Working in either a specialist centre or a CF network clinic.
- At least 2 years post-qualification.
- Will have access to specialist advice from the Principal CF Physiotherapist Practitioner or Advanced CF Physiotherapy Practitioner.
- Maintains own competencies and skills through continuing professional development relevant to CF practice.

Definition of a Physiotherapist

- Qualified physiotherapists in a wider rotational post. Requires daily supervision and specialist advice from the Principal CF Physiotherapist Practitioner, Advanced CF Physiotherapy Practitioner or Specialist Physiotherapist. Will not work in isolation.

Definition of Technical Instructors (non-graduate physiotherapists) and Physiotherapy Assistants

This staffing group must work within their scope of practice, (CSP scope of practice for physiotherapy assistants (2014).

- There must be an ongoing competency based training, development and assessment programme in place.
- Must have access at all times to support and advice from the Principal CF Physiotherapist Practitioner, Advanced CF Physiotherapy Practitioner or Specialist Physiotherapist.

Network Clinics

Care at each clinic visit and on the ward where people with CF are admitted must be either delivered or directly managed and supervised by an Advanced Physiotherapist Practitioner (Band 7).

The Advanced Physiotherapist Practitioner must have strong links and regular two-way communication with the Principal CF Physiotherapist Practitioner at the Specialist CF Centre.

Continuity of care is known to improve health outcomes and patient satisfaction for people with long-term conditions. Continuity of care is best achieved by the use of static Specialist CF Physiotherapists (Band 6) to both underpin the lead posts already described and to achieve the recommended staffing levels. Broad rotational physiotherapy posts (Band 6 and Band 5) will be used cautiously. They cannot contribute to continuity of care and have a large training requirement. They will represent no more than 10% of the CF physiotherapy work force.

Previous peer review reports demonstrate that posts shared with other services are often challenged to spend a disproportionate amount of time providing care to their non-CF caseload. Strategies to mitigate these pressures will be in place.

All physiotherapists who are permanently part of teams providing care for people with CF must:

- Have access to training and continuing professional development opportunities in CF.
- Follow the Standards of Care and Good Clinical Practice for the Physiotherapy Management of Cystic Fibrosis (ACPCF 2017).

Standard 2: Service Provision

Individuals with CF will have an appropriate physiotherapy service from sufficiently skilled individuals at different stages of their care in different settings.

New diagnosis

- All newly diagnosed people with CF (through either newborn screening or later diagnosis) will see a Principal CF Physiotherapist Practitioner.
- Care may be provided jointly by the Principal CF Physiotherapist Practitioner and the Advanced CF Physiotherapist Practitioner, but there will be a clear management plan from the Principal CF Physiotherapist Practitioner and regular communication.
- For infants "Recommendation of Practice" stated in the Clinical Guidance for the Physiotherapy management of Screened Infants with Cystic Fibrosis (ACPCF Physiotherapy Guidance Paper 2008) will be followed.
- For late diagnosis, following assessment, a physiotherapy management plan will be advised appropriate to clinical manifestation.
- Frequency of input will be tailored to the individual but frequent assessment and advice will be required in the months following diagnosis. Access to physiotherapy will be weekly in the months following diagnosis.

Clinic

All individuals with CF will:

- Have access to physiotherapy care that is supervised and directed by the Principal CF Physiotherapist Practitioner in partnership with an Advanced CF Physiotherapist Practitioner.
- See the Principal CF Physiotherapist Practitioner at least twice a year (one of these may be the annual review visit) and more frequently if required.
- Be seen by a Specialist Physiotherapist at each clinic visit. Clinic physiotherapy provision will be supervised by an Advanced CF Physiotherapy Practitioner. Long-term treatment plans will be directed by the Principal CF Physiotherapist Practitioner.
- Have the opportunity to visit or have contact with a Specialist CF Physiotherapist between clinic visits if required.
- Be reviewed as an outpatient during a course of intravenous antibiotics if community physiotherapy is not available.

Annual review

The physiotherapy annual review will be carried out by the Principal CF Physiotherapist Practitioner. If this is not possible it will be carried out by the Advanced CF Physiotherapist Practitioner and reviewed by the Principal CF Physiotherapist Practitioner within a clinical supervision session.

- There will be sufficient time at annual review to address airway clearance, exercise (including exercise testing), inhalation therapies (and associated devices), musculoskeletal/posture and continence issues and gastro-oesophageal and sinus disease.
- There will be treatment/referral pathways in place for management of musculoskeletal, continence or sinus issues.
- An individualised, goal-orientated physiotherapy plan will be developed in conjunction with the person/carer and communicated to the physiotherapy and multidisciplinary team.
- There will be processes in place for submission of accurate physiotherapy related National registry and quality dashboard data, subject to patient consent and national requirements.

Inpatients

There will be adequate staffing and appropriate skill mix to ensure that:

- Inpatient care packages are overseen by the Principal CF Physiotherapist Practitioner and delivered by a team led by an Advanced CF Physiotherapist Practitioner. Advice from the Principal CF physiotherapist Practitioner will be sought and will be freely available.
- All individuals with CF admitted to hospital for in-patient care will have access to physiotherapy assessment and treatment. There will be an initial assessment and regular review of patient progress by an Advanced CF Physiotherapist Practitioner.
- People with CF who are admitted to hospital will be entitled to optimisation of physiotherapy and will receive a minimum of twice daily treatment, more regularly if required (unless an alternative regimen is agreed by the person/carer and the Advanced CF Physiotherapist Practitioner).
- Individuals with CF and/or their carers will not be expected to provide their own inpatient physiotherapy because of shortfalls in physiotherapy staffing levels.
- Individuals with CF admitted for inpatient care will have opportunities to exercise on a daily basis.
- Physiotherapy to support airway clearance will be available at weekends in line with weekday treatment plans. It will be delivered by physiotherapists trained and competent in CF physiotherapy provision.
- An emergency on-call physiotherapy service will be available to inpatients with CF overnight if required.

Community/home care service

Home care physiotherapy (where appropriate) will be provided by an Advanced CF Physiotherapist Practitioner at times of particular need. For example:

- At diagnosis
- To provide school visits on starting primary or secondary school if required.
- When additional support is required to implement changes to a treatment plan e.g. airway clearance modifications, new inhaled therapy regimens, exercise programmes.
- To support adherence with complex treatment regimens.
- In the event of palliative care at home.
- To resolve complex oxygen/non-invasive ventilation issues.
- When home IV treatment is prescribed, community physiotherapy at home or school will be available to support an optimisation in physiotherapy treatment. This will be once a week as a minimum.

Transition

- All people with CF transitioning from paediatric to adult CF care will have appropriate input from the relevant adult, paediatric and network physiotherapy services throughout the transition process.
- Processes will be in place to allow ongoing communication between the relevant physiotherapy services during transition in order to optimise support of the individual and their families.
- The Principal or Advanced CF Physiotherapy Practitioner will carry out the initial physiotherapy consultation on transition to adult services. An individualised physiotherapy plan will be developed and communicated with the person/carer and the receiving physiotherapist and multidisciplinary team.

Surgery

- All people with CF undergoing surgical procedures (e.g. port insertion) should have access to specialist physiotherapy to optimise respiratory status pre-operatively and provide appropriate support in the post-operative period.

Pregnancy

- There should be regular specialist physiotherapy support throughout and post-pregnancy for modification and optimisation of airway clearance, exercise programmes, inhaled therapies and screening for musculoskeletal and continence issues, with appropriate referral pathways in place.

Transplantation

- There will be appropriate specialist physiotherapy support in the work up for transplantation with optimisation of airway clearance, inhalation therapies, exercise, oxygenation and ventilation needs. Where appropriate, complementary therapies may be considered for symptom relief.
- There will be communication between the physiotherapy team at the individual's CF Centre and the transplant centre with a clear physiotherapy management plan.
- There will be appropriate specialist physiotherapy input following transplantation for support with exercise programmes and inhalation therapies. Additional input should be provided as required e.g. for optimisation of airway clearance, sinus management, etc.

End of life care

- There will be appropriate specialist physiotherapy input throughout the stages of end of life care to support individuals with symptom relief through optimisation of airway clearance, oxygenation and ventilation as required. Complimentary therapies may be considered for pain relief, breathlessness and anxiety management.

Airway clearance techniques

- All individuals undergoing changes to airway clearance techniques will receive the necessary education and support, with age appropriate verbal and written instruction.
- Processes will be in place for regular assessment and monitoring of treatment response, including any adverse effects.
- A structured adherence programme will be available to support individuals with changes to treatment programmes.

Exercise

- All individuals undergoing changes to exercise programmes will receive the necessary education and support, with age-appropriate verbal and written instruction.
- Processes will be in place for regular assessment and monitoring of treatment response, including any adverse effects.
- A structured adherence programme will be available to support individuals with changes to treatment programmes.

Inhalation therapies

- All people with CF will have a regular, structured review of inhaled therapies (including mucoactive agents), with any alterations to drug regimens or delivery devices being discussed with the Principal or Advanced CF Physiotherapy Practitioner.
- All people with CF will have access to inhaled therapies in accordance with the NHS England policy or the policy of their devolved nation.
- New inhaled therapies will be initiated by the specialist CF centre or by the network clinic in discussion with the specialist CF Centre.
- Appropriate delivery devices will be provided, with replacement of consumables at the recommended intervals.

- For any new inhaled therapy, a formal drug response assessment will be undertaken. A supervised test dose will be carried out in the hospital environment with objective assessment for post-dose broncho-constriction, according to local protocol and standard operating procedures (Appendices VIa-e.).
- Physiotherapy staff undertaking drug response assessments will have undergone appropriate competency-based training.
- All individuals undergoing changes to inhaled therapies will receive the necessary education and support, with age appropriate verbal and written instruction.
- Processes will be in place for regular assessment of lung function and subjective reporting to ensure on-going tolerance and identification of any adverse effects.
- Delivery methods will take into consideration optimisation of drug delivery and adherence to treatments.
- A structured adherence programme will be available to support individuals with changes to treatment programmes.

Non-invasive ventilation (NIV)

- Physiotherapy staff initiating or altering NIV either for ventilatory failure or supporting airway clearance techniques/exercise will have undergone appropriate competency based training.
- All individuals with CF will receive the necessary education and support, with age appropriate verbal and written instruction.
- Processes will be in place for regular assessment and monitoring treatment response, including any adverse effects.

Standard 3: Facilities

People with CF will have access to age-appropriate facilities for their physiotherapy care as inpatients and outpatients

3.1 Facilities will recognise the need for privacy and dignity when carrying out airway clearance and exercise.

3.2 Adequate facilities for exercise will be available to people with CF as inpatients e.g. gym with adequate range of exercise equipment and sufficient space/ facilities for aerobic exercise and exercise testing to be carried out.

3.3 Facilities for physiotherapy treatment must enable adherence with national and local infection control policies.

Standard 4: Equipment

All people with CF will be provided with appropriate respiratory and exercise equipment and will be trained in its use and maintenance, as appropriate.

4.1 There must be written protocols regarding the use of the equipment used by and issued to people with CF.

4.2. People with CF will be provided with the respiratory equipment they require for use at home e.g. to nebulise medication, for airway clearance, for oxygen delivery and humidification.

4.3 People with CF/carers will be trained in the use of equipment supplied for home use.

4.4 Written instructions regarding the use and maintenance of equipment provided for home use (including cleaning/disinfection/sterilisation as applicable) will be issued to all people/carers.

4.5 All equipment used by people in hospital or at home will be serviced and maintained (including cleaning/ disinfection/sterilisation as applicable) according to the manufacturer's instructions and/or national and local policies.

4.6 There must be a clear and adequate budget available, as outlined in the national service specification, for the provision of respiratory equipment, including advanced, fast and efficient nebuliser devices e.g. vibrating mesh technology VMT nebulisers. There will be clear responsibility as to who holds this budget.

Standard 5: Clinical standards

Physiotherapy clinical care will be based on the best evidence available; ACPCF, Cystic Fibrosis Trust and NICE guidelines, protocols and consensus documents will be followed.

- Copies of all documents listed at the start of this document will be available in all hospital areas where people with CF receive care.
- All physiotherapy staff caring for people with CF will be expected to read these documents during their induction period and areas for training and development identified.
- There must be evidence that the physiotherapy service provided for individuals with CF is regularly evaluated through clinical audit and quality assurance programmes].

Standard 6: Infection control

All physiotherapists working with people with CF will consider issues of hygiene and the prevention of cross-infection.

- All staff will have knowledge of and work to: Local Infection Control Policies, Cystic Fibrosis Trust guidelines relating to prevention and infection control with *Burkholderia cepacia* complex, *Pseudomonas aeruginosa*, *Mycobacterium abscessus* and *MRSA* in people with CF. Local Infection Control Policies will make specific reference to physiotherapy management in different settings.

- All people with CF will have their own home respiratory equipment e.g. airway clearance devices, nebuliser devices and consumables, oxygen equipment and NIV.
- Some respiratory equipment e.g. Intermittent Positive Pressure Breathing (IPPB), High Frequency Chest Wall Oscillation (HFCWO) and NIV devices may be used by more than one person in the hospital setting. Local standard operating procedures relating to minimisation of cross-infection between people with CF will be in place for these devices.
- Physiotherapists will have access to records of individual microbiological status and be able to identify people at high risk of cross-infection
- There will be rigid adherence to infection control policies when carrying out airway clearance, exercise, nebulisation and spirometry.
- All staff, including weekend staff, will take all reasonable precautions to reduce the risk of cross-infection in accordance with local policy: rigorous hand-washing, decontamination of pulse oximeters, stethoscopes and exercise equipment between people with CF, wearing of aprons and gloves for airway clearance, careful handling of respiratory secretions (sputum pots to be covered and disposed of at least daily and soiled tissues disposed of immediately).

Standard 7: Professional development and training

Physiotherapists caring for people with CF have a professional responsibility to keep up to date with current CF research and continually to up-date their skills and knowledge to provide the best possible clinical care.

All physiotherapists with permanent posts providing care to people with cystic fibrosis must:

- Ensure they maintain their continuing professional development in general respiratory care and ensure they have adequate clinical skills to follow the Standards of Care and Good Clinical Practice for the Physiotherapy Management of Children and Adults with CF (2017).
- Will be members of the ACPCF and will attend local ACPCF meetings.
- In addition to supporting local or regional CF study events, they will attend at least one national CF meeting annually. This will be the annual national ACPCF study event or a national CF study day/ conference.
- There will be opportunity to attend international CF conferences.
- The Principal CF Physiotherapist will annually attendance a National and an International Conference. They will demonstrate knowledge of current CF research and be involved in CF research locally as appropriate.
- Have an annual appraisal and be able to provide evidence of meeting professional development plans.

Bibliography

ACPCF Physiotherapy National Standards of Care for people with Cystic Fibrosis 2009 (updated 2010). Available at: http://www.csp.org.uk/documents/acpcf-physiotherapy-national-standards-care-people-cystic-fibrosis-2009-latest-version?networkid=225967

Quality Assurance Standards. Available at: http://www.csp.org.uk/professional-union/professionalism/csp-expectations-members/quality-assurance-standards

The UK CF annual registry data report (2014). Available at: https://www.cysticfibrosis.org.uk/the-work-we-do/uk-cf-registry/reporting-and-resources

Cystic Fibrosis Trust (2016) UK Cystic Fibrosis Registry. Available at: https://www.cysticfibrosis.org.uk/the-work-we-do/uk-cf-registry

NHS employers (2013). National Profiles for Physiotherapy. Available at: http://www.nhsemployers.org/~/media/Employers/Documents/Pay%20and%20reward/Physiotherapy.pdf

The chartered Society of Physiotherapy (2014a). Seven Day and Extended Hours Services Resource Pack. Available at: http://www.csp.org.uk/publications/seven-day-extended-hours-services-resource-pack

The chartered society of physiotherapy (2014b) Scope of Practice for Support Workers http://www.csp.org.uk/professional-union/professionalism/scope-of-practice/support-workers

Code of Members Professional Conduct. Available at: http://www.csp.org.uk/search/all/%E2%80%A2%09Code%20of%20Members%20%20Professional%20Values%20and%20Behaviour%20%20%28CSP%202011%29

The following documents pertaining to prevention and control of infection are available at: https://www.cysticfibrosis.org.uk/the-work-we-do/clinical-care/consensus-documents

- *Pseudomonas aeruginosa* Infection in People with Cystic Fibrosis. Suggestions for Prevention and Infection Control. Second Edition. November 2004
- Methicillin-resistant *Staphylococcus aureus* (MRSA). April 2008
- The *Burkholderia cepacia* complex. Suggestions for Prevention and Infection Control Second Edition. September 2004
- Laboratory Standards for Processing Microbiology Samples from People with Cystic Fibrosis. September 2010
- US Cystic Fibrosis Foundation and European Cystic Fibrosis Society consensus recommendations for the management of non-tuberculous mycobacteria in individuals with cystic fibrosis." Floto RA, et al. *Thorax* 2016

3. Outcome measures

Outcome measures are used for a variety of reasons including to assess the impact of the disease on daily function, assist in clinical decision making, assess the efficacy/effectiveness of treatment interventions within clinical practice and research, to assess the cost/benefit of a service and potentially to commission funding for a service. An outcome measure should be assessed for important clinimetric properties such as validity, reliability and responsiveness to treatment. The use of outcome measures relevant to physiotherapy is restricted by their complexity and feasibility. Feasibility is multifaceted and refers to financial, practical and ethical considerations as well as patient and assessor acceptability and ease of use in the clinical setting[3] (e.g. high resolution CT scan, radioisotope aerosol labelling carry risk to the patient; Lung Clearance Index is not yet used clinically but primarily in the research setting).

For the purpose of this document we have concentrated on outcome measures that could potentially be used to evaluate physiotherapy interventions.

3.1 Airway clearance

As long-term routine airway clearance techniques are seen as a substantial burden for patients and families, physiotherapists have a duty to recommend regimes that are tailored to the individual patient's needs, lifestyle and symptoms.[4]

There is great difficulty in selecting sensitive, responsive and clinically valid outcome measures when evaluating airway clearance techniques in cystic fibrosis. Many patients, especially in the paediatric population, have normal or near normal imaging, clinical scores and exercise tolerance and do not produce sputum. In a complex disease such as CF, other changes in treatment (not limited to airway clearance techniques) may affect outcomes. There are several papers illustrating the methodological and ethical issues in assessing airway clearance techniques.[5-7]

In clinical trials outcome measures of convenience, which are easy to measure and have been shown to be valid and reliable, are often used. Commonly used outcome measures in existing airway clearance trials include spirometry and sputum volume and weight.

With reference to spirometry it can be difficult to demonstrate a change in FEV_1 as it may not be sensitive enough to measure short-term change and is found to be increasingly within normal limits especially in the paediatric population. Rate of decline in FEV_1 has been proposed as a useful alternative. However, on an individual basis, spirometry maybe useful in monitoring a response to treatment or longer-term intervention (e.g. after a course of intravenous antibiotics) and provide clinicians with useful information. FEF_{25-75} is also used; however, there are issues with variability of this outcome measure.

More complex physiological assessments (e.g. lung clearance index, high resolution CT for early bronchiectasis and ventilatory in-homogeneity) have been suggested as surrogate biomarkers.[8] However these often require specialist laboratory equipment and are not yet widely available or are unsuitable for regular use.[9,10]

The literature supports the increased use of Lung Clearance Index as a surrogate biomarker in the evaluation of clinical deterioration. It appears to detect early airways disease in children and is more sensitive and easier to perform in this age group. There is a narrow range of normal thus making it suitable for long-term follow up. Lung Clearance Index measurements are found to deteriorate quicker than spirometry and have been found to be particularly sensitive to small airways dysfunction. It is a sensitive measure of structural abnormalities. Currently more limited to lab based projects however as more opportunities for its use in clinical practice arise it is possible that it may feature more prominently as a physiotherapy outcome measure.[11]

The use of sputum volume/weight as an outcome measure is controversial. Should we measure 24 hour or treatment duration; wet weight or dry weight; how much is swallowed; how to assess non-sputum producers? Sputum volume/weight can often be over or under estimated. However, when evaluating treatment options in the individual it is often very helpful. If used, careful attention should be given to methodology (e.g. use of graduated sputum containers for measuring sputum volume and a calibrated scales for sputum weight) to ensure accuracy of results.

Several studies have used number of exacerbations over a 12-month period as an outcome measure, which in a well-constructed large robust multicentre trial[12] proved to be a valuable measure when comparing physiotherapeutic interventions.

Patient reported outcomes (e.g. CFQ-R quality of life questionnaire) and patient preference may be the most meaningful to patients and the most useful in those with fewer symptoms. Many Cochrane reviews recognise a variety of outcome measures, however also suggest further work is required to identify the most appropriate outcome measures for use in airway clearance interventions.[13-20] This work needs to focus on their clinimetric properties and use across the disease trajectory (mild through to severe disease).

Good practice points

- Factors influencing the choice of outcome measure for airway clearance include:
  - Clinimetric properties.
  - Ease of use in day to day practice.
  - Clinical relevance to the individual.

Recommendations

- Respiratory physiotherapists should use the best clinically applicable outcome measures to assess the efficacy of airway clearance techniques on an individual basis (*QoE – high*). The outcome measures used may include:
- Healthcare utilisation e.g. number and frequency of exacerbations, time to next exacerbation.
  - Patient reported outcomes e.g. CFQ-R, satisfaction, adherence, preference.
  - Spirometry.
  - Sputum volume, weight, colour, ease of expectoration.
  - Exercise tolerance.
  - Physiological assessments e.g. lung clearance index.

3.2 Exercise testing

Exercise testing offers an integrated, objective assessment of cardiovascular, respiratory, muscular and metabolic function of the patient.[21] This cannot be achieved by more static methods of monitoring of lung function, radiological investigations or measures of nutritional status that are routinely used in clinical practice. A recent (2015) expert consensus statement on exercise testing in CF is now available which summarises the information available on specific exercise test protocols and outcome parameters used in patients with CF.[21] This document should be used as a key accompaniment to the below information.

Standardised exercise testing is recommended in several countries, but there is no current agreement on a single best exercise test to answer all possible questions in individuals with CF who differ widely in age and disease severity.[21]

Exercise testing can be used to identify limitations and symptoms relating to exercise and physical activity, can aid in disease prognosis and the evaluation of therapeutic interventions and is used to guide exercise prescription and assess the efficacy of training programmes. Additionally, information regarding requirement for oxygen supplementation during exercise can be provided. The monitoring of exercise capacity can provide an objective assessment of level of disability, which is used in the surveillance of the patient when transplantation is a consideration.[21-24,27]

Routine and regular (at least annual) exercise testing should commence at 10 years of age however younger children (>5 years) could start to be tested on an annual basis to facilitate familiarisation with the exercise testing protocols and to encourage exercise participation.

Protocol

Aerobic exercise testing

The protocol selected for exercise testing will depend on the purpose of the test and the characteristics of the patient (including age, severity of disease and co-morbidities).

The recommended gold-standard exercise test for assessing aerobic capacity is full cardio-pulmonary exercise testing (CPET) with gas analysis, performed on either a cycle ergometer or treadmill using an incremental 'ramp' protocol to exhaustion for people aged 10 years and older. The recommended protocol is the Godfrey Cycle Ergometer Protocol with monitoring of oxygen saturation and ventilatory gas exchange.[21] The availability of CPET in many centres is limited[26], with less than 10% of UK CF Centres having access to facilities.[26] The 2015 European statement on exercise testing recommends the use of the gold standard CPET[21] where possible and efforts should be made to implement this to enable the most accurate and effective assessment of exercise capacity and for exercise prescription.

If full CPET testing is unavailable it is recommended that the same ramp cycle and treadmill protocols be performed using predictive metabolic equations to estimate oxygen consumption in lieu of direct gas analysis.[21] This should be undertaken with caution as predictive equations can only provide an estimate of 'true' exercise capacity.

Other options for aerobic fitness testing include field tests such as incremental shuttle tests, sub-maximal treadmill, walking tests and step tests. These are logistically easier to perform as they are usually portable and require less formalised equipment consequently being reasonable surrogates for formal CPET.[25] Although these cannot replace a full CPET and not all will elicit a peak response, they can be useful in assessing exercise tolerance and guiding exercise prescription. It should be noted that field tests give only limited information about exercise capacity, reasons for exercise limitations, and potential exercise-associated adverse reactions in patients with CF.[21]

Alternative components of exercise testing

Alternative components of fitness can be measured and may prove useful both in the prescription of exercise programmes and in the management of muscular and postural issues. These include assessment of muscular strength and endurance, flexibility and core strength/stability.[20] Other forms of exercise testing, such as those to assess short-term muscle performance for example the Wingate Test and isokinetic testing, have been used for scientific purposes but rarely in a clinical setting.[21]

Outcome measures for exercise testing

Dependent on the exercise test chosen and the equipment available, there are a number of outcome measures that can be used for exercise testing. Some are specific to the test such as work rate and VO_2peak or VO_2max for CPET, distance covered, steps completed but many are common to all tests. Objective measurement of heart rate and oxygen saturation as a minimum will be measured before, during and after an exercise test and the use of subjective measures of perceived exertion, breathlessness or fatigue will also be used to assess symptoms during exercise testing (e.g. Borg, Modified Borg, etc). Readers should refer to the previously mentioned statement on exercise testing for further details.[21]

Physical activity assessment

Assessment of CF patients' physical activity, including sedentary behaviours, is also recommended and there exist a number of objective and subjective tools to aid in this.[25]

Motion sensors, activity questionnaires and diaries are useful to gauge an individuals' general physical activity. The purpose of data collection will guide the choice of tool used.

Sophisticated activity monitoring can eliminate the subjective evaluation of activity, however it is more technical and costly to offer in most clinical settings. SenseWear, ActiGraph, and DigiWalker have the most data supporting their use and provide clinically important data on clinimetric properties (reliability, validity and responsiveness). There is some evidence indicating a positive correlation between physical activity and measures of lung function, exercise capacity, respiratory symptoms and bone mineral density.[25] Questionnaires provide an appreciation of the person's perception of their physical activity but not data reflecting symptoms whilst active. It may however be useful as a screening tool to guide further discussion about exercise patterns, goal setting and subsequent exercise prescription. It should be noted that questionnaires depend on patient recall and are often very subjective so should be used with caution.

In the future, new technologies such as the LifeShirt® may be useful to allow cardiopulmonary assessments to be made in the field. However, the role of these devices in clinical practice is yet to be established.[25]

A recent (2015) expert position statement on physical activity monitoring in CF[25] summarises the information available with respect to motion sensors, questionnaires and exercise diaries and is a valuable accompaniment to this document.

Summary

Exercise testing is a standard of care and is essential to provide an accurate dynamic assessment of physical fitness. Exercise testing allows for individualised exercise prescription and guidance on prognosis (in association with other clinical measures) and disease severity in CF patients 10 years and older. Where possible the recommended gold standard CPET should be undertaken for all individuals with CF but in the absence of this an appropriate alternative standardised test will be undertaken ensuring the results are interpreted with due caution.

The prescription of individualised exercise programmes is essential in the management of individuals with CF in order to help preserve and maintain the functional capacity and overall health of the patient. The only method of providing accurate and effective training programmes is by exercise testing.

Good practice points

- Exercise testing should be undertaken annually to evaluate the physical fitness of individuals with CF.
- Exercise testing is an integral part of the management of people with CF.
- People with CF will be assessed for clinical stability prior to annual assessment of exercise testing (i.e. during a period where there is no evidence of pulmonary exacerbation) to ensure accurate and useful results.
- Age appropriate subjective measures of perceived exertion, breathlessness or fatigue should be used to assess symptoms during exercise tests and to guide intensity of exercise training.

Recommendations

- In the UK exercise testing is recommended as part of the routine assessment of people with CF at least annually but should be undertaken during other periods of time e.g. pre and post admission (*QoE – high*).
- Exercise testing is recommended to assess for responses to changes in overall management (e.g. examining efficacy of intervention, pre/post admission or modifying exercise prescription) (*QoE – high*).
- Exercise testing is essential to monitor response to exercise training, to assess fitness, and to allow safe and effective exercise prescription (*QoE – high*).
- Exercise testing is recommended in people with CF aged 10 years and older but can be started at a younger age to aid familiarisation in later years *(QoE – moderate*).

- The gold standard cardiopulmonary exercise test (CPET Godfrey cycle ergometer protocol) should be used where possible and in the absence of gas analysis an incremental ramp protocol should be implemented to provide the most accurate assessment of exercise capacity *(QoE – moderate*).
- Emergency procedures will be accessible during all exercise testing *(QoE – moderate*).
- Contraindications to testing will be assessed before each testing session (*QoE – high*).
- Exercise test specific standardised objective measurements should be recorded as appropriate and as a minimum heart rate and oxygen saturation will be performed before, during and after testing (*QoE – moderate*).

Research recommendations

- Other measures of fitness (e.g. strength, flexibility) and physical activity may be appropriate but should be assessed on an individual basis and follow recommended guidelines.

3.3 Induced sputum

Sputum collection is essential to detect changes in sputum and guide the management of respiratory disease. It may be one of the most valuable methods for monitoring disease activity as lung function and imaging may be insensitive especially in the case of younger children.[27]

Spontaneously expectorated samples have been shown to be representative of lower airway secretions.[28] There are many people with CF, particularly children, who are unable to spontaneously produce a valid sample.

Bronchial-alveolar lavage (BAL) has been seen as the "gold standard" for obtaining sputum to identify microbial and inflammatory changes in the airways. This technique is expensive requires sedation, risky, invasive and is potentially limited to certain areas of the lungs.[27-31]

Some studies show that induced sputum provides as valid a sample as BAL but is much cheaper, easier to do, non-invasive and reproducible.[29,32] Other studies have shown induced sputum to be superior to samples obtained by BAL.[31-35] Some studies have also shown that induced sputum has produced a more representative sample of the bronchial tree than spontaneously expectorated sputum.[35-37] The majority of the research has been in children therefore expectorated samples may not be as good quality and more representative of upper airways.

Induced sputum has been demonstrated to be safe to use with young children[27,29,30,38] and is not thought to promote inflammatory changes in the airways.[30] Induced sputum has been demonstrated to have a higher microbial content than cough swabs, although this was not statistically significant.[25] Another study questions the accuracy of upper airway cultures predicting lower airway infections as obtained with the use of cough swabs.[34]

To date there has not been a universally agreed procedure for sputum induction.[35] Contraindications to this technique are considered to be similar to those in the TB sputum induction guidelines.[39]

Technique considerations

There is no universally agreed methodology for carrying out induced sputum. The various components of induced sputum will be discussed individually.

Oral hygiene

It is considered good practice to rinse out the mouth with water +/- brush teeth to get rid of any potential contaminants.[28,36,39,40]

Short acting bronchodilator prior to induced sputum

A number of studies used a short acting bronchodilator prior to commencing induced sputum.[27-29, 33, 35, 37, 38, 41] Guidelines for sputum induction in TB support this.[39] However bronchodilators can have a paradoxical affect and increase airway instability.[30] Consequently studies have been done without giving short acting bronchodilator without a significant fall in FEV_1.[30,42]

Nebuliser

It has been suggested that the nebuliser, aerosol generated and rate of aerosol generation may affect how successful the outcome of the procedure,[43,44] however when directly compared this was not substantiated. It is considered good practice to use the most efficient device available. The majority of studies used ultrasonic nebulisers. Guidelines for induced sputum in TB support this.[39,40] Other studies used Mesh or Jet nebulisers without adversely affecting the samples obtained.

Saline concentration

There are no valid direct comparisons of the concentration of hypertonic saline used for induced sputum. Due to the nature of hypertonic saline higher concentrations may be more effective but may have a higher risk of bronchospasm.[30,45] This was reversible with use of a short acting bronchodilator. Some studies have suggested that higher concentrations may be more effective however it is unclear whether it was the duration of nebulised saline that resulted in successful sample. Studies looking at the effect of mucociliary clearance in relation to concentration of hypertonic saline in CF found that higher concentrations (7% and 12%) significantly improved mucociliary clearance.[45] If a patient is at risk of bronchospasm, it is recommended to start at a lower concentration and gradually increase it until a sample has been obtained.[39]

Monitoring

The majority of studies have performed spirometry to monitor for changes in FEV_1 during induced sputum.[37,38,46] Observing the patient for adverse effects as well as continual SpO_2 monitoring and auscultation are adequate, with use of short acting bronchodilator to reverse any clinical signs of bronchospasm[27,29,41] Induced sputum should be stopped if $SpO_2 < 90\%$[28,47] or if the patient is showing signs of bronchospasm.

Airway clearance

There were no published studies looking at the effect of airway clearance in induced sputum. One study suggested that samples are only obtained from the central airways[36] as the sputum is generally only cleared by a cough; however other studies have found evidence of sputum from the peripheral airways and alveolar space,[31,33,35,48] which may suggest that samples from the periphery may be easier to yield if airway clearance is employed.

Suction

At times patients are unable to expectorate despite receiving induced sputum. In order to gain an effective sample the option of performing oro-pharyngeal suction following sputum induction can be used. Assessments should be taken to ensure that the benefit of this procedure will not be outweighed by any distress caused to those affected. Oropharyngeal Cough Swabs in combination with induced sputum have also been effective in obtaining valuable samples.[41]

Infection control

There have not been any studies that specifically looked into infection control with CF during induced sputum. There is no mention of infection control precautions detailed in the studies reviewed. There is continued debate as to whether use of nebulisers and chest physiotherapy are aerosol-generating procedures.[49] It was found that nebulisers did produce aerosol but with variable particle size. A study looking at *Pseudomonas aeruginosa* in cough aerosol reported that it remained viable in the air in 78% of patients after 45 minutes.[50]

Currently we are unaware as to the transmissibility of bacteria such as *Mycobacterium abscessus*,[51] how long their aerosol remains viable and how far they travel. It is suggested that the room be left empty for as long as possible following a procedure, in concordance with local infection control policies and dependent on air exchanges per hour.

Good practice points

- Brush teeth with a new toothbrush and water and rinse mouth with water prior to carrying out induced sputum to help avoid contamination of the sample.
- Consider using short acting bronchodilator prior to sputum induction.
- Use an ultrasonic nebuliser if available taking into consideration infection control policies.
- Use a low output device e.g. jet nebuliser if high output devices are not tolerated or not available. There is no current evidence evaluating vibrating mesh nebulisers in induced sputum.
- Use a higher concentration if able for induced sputum to optimise mucociliary clearance i.e. 7%.
- Consider starting with a lower concentration of hypertonic saline i.e. 3% if the patient is at known risk of bronchospasm.
- Process samples produced later in the procedure if possible.
- Oropharyngeal suction with soft catheter and sputum trap can be performed if the patient is unable to expectorate. The potential distress caused by this should be considered.
- Oropharyngeal cough swab can also be considered if expectorated sputum is not possible however the value of such a sample is questionable and can give false negative results.

Recommendations

- Induced sputum should be considered when clinically indicated as a means of sampling the microbiome (a community of micro-organisms (such as bacteria, fungi, and viruses) that inhabit a particular environment) of the CF lung particularly in patients who do not expectorates sputum *(QoE – moderate*).
- Monitoring should be continuous *(QoE – moderate*).
- Stop induced sputum if there is subjective or objective wheeze, if SpO_2 falls below 90% or a fall in $FEV_1 > 20\%$ (if using Spirometry) (*QoE – low*).
- Induced sputum will be performed in a clinical area with resuscitation equipment available *(QoE – moderate*).
- Perform induced sputum in a room with the door closed where the air from the room is exhausted to the external environment unless a well-maintained HEPA filtration unit is in place *(QoE – moderate*).
- Avoid anyone entering the room for 1-2 hours after induced sputum procedure, depending on the frequency of air exchanges *(QoE – moderate*).
- Consult local infection control and prevention guidelines (*QoE – low*).

3.4 Other outcome measures

There are various methods for the subjective measurement of symptoms, which can be used in conjunction with an exercise test, or in daily practice.

Borg rating of perceived exertion scale and modified Borg dyspnoea scale has been shown to be a valid and reliable score in measuring shortness of breath and perceived exhaustion in adults[52,53] and older children.[54,55] The visual analogue scale has also been shown to be a useful measure of shortness of breath and leg discomfort.[54] Studies on validity and reliability have shown mixed results.

In children, it is extremely difficult to obtain a reliable score of subjective symptoms using measures designed for adults.[55] Some objective measures of breathlessness in children have been studied and shown to have good correlation with objective outcomes of exercise, including the 15 count breathlessness score,[59,61] breath hold time,[56] single breath counting score and sustained phonation time.[57] Some of these measures need further research to provide evidence of their validity, reliability and responsiveness in CF.

Good practice points

- Subjective measures of perceived exertion, breathlessness or fatigue should be used within an exercise test.
- Subjective measures should also be used to identify difficulties associated with activities of daily living.

4.0 Adherence

Adherence is defined as "The extent to which the patient's behaviour matches agreed recommendations from the prescriber".[62] It has been recognised that this term is preferable to compliance, defined as "The extent to which the patient's behaviour matches the prescriber's recommendations".[62] Concordance is a wider concept that does not only refer to the taking of treatment but focuses on the interaction between clinician and person. It is based on the idea that consultations are a negotiation between equals and recognises the rights of people to decide whether or not to take prescribed medicines.[63] Adherence is considered the preferred term for medication-taking or treatment behaviours.[62,64]

People with cystic fibrosis may require large amounts of medication to control symptoms and slow disease progression.[65] Studies suggest that the median number of daily medications prescribed for those with CF is seven.[66] Administering these treatments takes a mean time of 108 minutes a day[66] posing significant challenges in terms of scheduling treatment around education, work and families.[67] People with cystic fibrosis also need to undertake many non-medication based treatments on a daily basis including airway clearance, activity and structured exercise, dietary supplements and monitoring dietary intake. In view of this treatment burden, poor adherence has been identified as the greatest cause of treatment failure[68] and monitoring adherence to prescribed therapy identified as a priority.[69]

Many influences and barriers to adherence are reported in the literature, including lack of knowledge,[70] communication,[71] self-efficacy,[72] perceived illness severity,[73] coping styles,[74] depression,[75] family factors,[76] support,[77] parental supervision,[78] characteristics of the treatment regimen,[76] problems with fitting treatment into lifestyle, a perception that treatment doesn't help and the physical consequences of the treatment.[79]

Adherence is recognised as variable depending on the treatment;[71] for example, good adherence to pancreatic enzymes does not predict good adherence to nebulised RhDNase (Dornase Alfa). It may also vary for a single treatment in an individual at different times.[80] Adherence levels in people with CF have been found to decline with increasing age[81] which may reflect the transition from family administration of treatment to independence. This would suggest that ongoing comprehensive assessment of adherence patterns is needed and an individual multi-intervention approach is needed when aiming to impact on adherence.

4.1 Adherence to airway clearance

Most studies assessing adherence to airway clearance used questionnaires or other reported methods such as telephone diary to assess adherence to airway clearance. They also tended to assess adherence to airway clearance overall rather than provide individual data for each different technique. Adherence rates to airway clearance range from 33.3 ± 43.15% to 91.2%.[82] A pilot study using electronic data capture suggested adherence rates to oscillating PEP of 45% as compared to self-reported adherence of 100%.[83]

4.2 Adherence to exercise and activity

Despite exercise and activity being widely advocated as a beneficial treatment within cystic fibrosis care, there are little data looking at adherence levels. Adherence levels to exercise have been assessed as higher than adherence to airway clearance.[84] Overall, people with cystic fibrosis report a preference for exercise as compared to other treatments.[85,86,87] Exercise is regarded as socially acceptable,[88] and an area over which people feel they have control,[90] however preference to a treatment doesn't necessarily link to adherence.

4.3 Adherence to inhaled medication

Monitoring adherence levels to inhaled medication has become easier and more accurate with the advent of adaptive aerosol delivery technology, which provides detailed monitoring including date, time, completeness of dose and time taken to nebulise. The evidence, using objective measures such as electronic data capture, suggests that adherence to nebulised medications can be low and/or variable.[91,92,93] Monitoring allows greatly improved accuracy in identifying adherence levels and is acceptable in the CF population.[91,93] When measured objectively using electronic data capture, long-term adherence rates to nebulised treatments are 36% in adults[93] and 67% in children.[91]

4.4 Measuring adherence

There are many different methods of measuring adherence, each with varying objectivity and validity. The most common methods of assessment are self-reported methods. When compared to more objective measures, these strategies have been shown to over-estimate adherence.[93] The reasons for this are multifactorial and may include inaccurate recall and a reluctance to admit behaviour that is not in keeping with the agreed treatment plan. Daily diary methods have been shown to be more accurate[71] but are time- and resource-consuming and so not appropriate for long-term clinical use.

Prescription filling is more objective, although studies have shown this method also over-estimates adherence as there is no guarantee all dispensed medication is taken.[68] Other direct measurement techniques such as blood levels are also used but have limitations in accuracy and in practicality for long-term use[94] as well as being unsuitable for the measurement of many physiotherapy treatments such as airway clearance.

Electronic data capture is the most objective adherence measure, and its use in adherence trials is increasing. Pill bottles, nebulisers, inhalers and some methods of airway clearance can be electronically monitored to log the exact date and time of use. This data can be fed back to individuals to aim to improve future adherence. Early devices had high rates of malfunction, but as technology advances, they are now more reliable.[68] For some areas of this technology such as pill bottles, there is still no guarantee the medication is taken, which prevents this method from being the gold standard.[68]

4.5 Strategies to impact on adherence

A Cochrane systematic review identified evidence for psychological interventions to impact on adherence.[69] Positive effects were seen predominantly with behavioural and educational interventions but with an impact on dietary intake and nutritional status rather than on other aspects of treatment and are therefore less applicable to physiotherapy related treatments.[69]

Self-management strategies such as educational approaches have also been assessed by a Cochrane review.[96] The trials included used self-report outcomes to assess adherence and found conflicting and unclear results. One study which assessed a wide ranging programme aimed at self-management of cystic fibrosis demonstrated no differences in adherence to physiotherapy related treatments such as airway clearance, exercise and inhalation therapy[97] whereas an airway clearance and inhalation therapy specific programme demonstrated improved adherence outcomes but with wide confidence intervals.[98]

There have been some other small-scale pilot studies looking at strategies to impact on adherence. These have included 'token economy',[99] which found variable improvements in adherence to exercise which may have been related to the type of reward. Motivational interviewing is also an area of interest to researchers but little evidence of significant impact on adherence has yet been demonstrated.

There are ongoing studies that will enhance future understanding of strategies to impact on adherence. A significant study is ACtiF: Development and evaluation of an intervention to support adherence to treatment in adults with Cystic Fibrosis. This project involves the development of a behaviour change intervention which includes the development of a web portal, CFHealthhub, to capture adherence data from patients' nebulisers and display this to clinicians and people with CF. CFHealthhub will facilitate a range of evidence-based interventions including problem solving and setting implementation plans to increase treatment adherence.

Good practice points

- Physiotherapists should spend time during consultations aiming to understand the person's adherence patterns.
- Where adherence levels are measured, this should, where possible, be to different treatments and over time.
- Treatments should be rationalised or combined where possible and appropriate in order for the person with cystic fibrosis to have the simplest and quickest treatment regimen possible.
- People with cystic fibrosis and their families should be supported to monitor and enhance adherence to treatment.

Recommendations

- Consideration should be given to using devices which record adherence in order to tailor provision of treatments and adherence interventions to the individual *(QoE – moderate*).
- When adherence to inhaled therapy is poor, clinicians should aim to use the quickest and simplest device possible for each medication (*QoE – low*).

- Self-management and educational strategies should be considered when addressing adherence patterns *(QoE – moderate)*.

Research recommendations

- There is a need for studies assessing long-term adherence to airway clearance and exercise/activity using objective data capture methods.
- There is a need to assess the variation in adherence to different airway clearance techniques.
- There is a need for high quality studies to assess the impact of strategies aiming to enhance adherence to airway clearance, exercise/activity and inhaled therapies.

5. Airway clearance

Airway clearance is a mainstay of treatment for people with CF[100] and is considered essential for all, ideally starting from diagnosis.[101] These guidelines discuss the evidence for the different treatment options individually. However, since there is no strong evidence to show that any treatment technique is superior to another, it is important that patient/carer preference should be highly regarded when deciding which treatment option to choose.[6] Adherence to airway clearance tends to be lower when the person with CF has a negative association with their treatment and this is associated with lower outcomes.[103]

Whilst treatment options are discussed and generally researched individually, combining different treatments can make airway clearance more effective. For example McIlwaine (2014) advises that effective airway clearance has two components; a method to ventilate behind obstructed lung units, and secondly an expiratory airflow of greater than 30-60l/min with a peak expiratory flow/peak inspiratory flow of ratio of 1:4.[104]

5.1 Active Cycle of Breathing Techniques (ACBT)

ACBT consists of three components: breathing control, thoracic expansion exercises, and the forced expiration technique (FET). In breathing control the breathing pattern is addressed, the individual performs tidal breathing (gentle relaxed breathing) using the lower chest with a slower flow but at his or her own rate.[105] Participants are encouraged to relax their shoulders and upper chest to encourage diaphragmatic breathing. Breathing control is the resting periods between active parts of ACBT, to relax the airways, control the urge to cough, and reduce fatigue. Thoracic expansion exercises consist of deep breathing with inspiration but expiration remains passive. A three-second hold at the top of the breath, aiming to keep the airway/glottis open before passively breathing out is encouraged. Increasing the lung volume above tidal volume breathing reduces collateral ventilatory resistance, allowing air to flow behind secretions aiding their mobilisation, while at the same time forces exerted between adjacent alveoli aid lung re-expansion.[101] The FET combines huffing and breathing control. It can be done at various lung volumes with an active expiration, an open glottis and rounded mouth shape. The length of the huff or FET can be adapted to optimise clearance.

It can be adapted to individual need, but with each component of the cycle clearly defined. It is a relatively simple technique which is not dependent on a device or dependent on a care giver assisting, minimising treatment burden.[101] It has been suggested that it can be taught to people with CF from as young as 4 years of age,[102] depending on the individual.

ACBT has been shown to be effective and efficient in the mobilisation and clearance of secretions[15,106] and improvement in lung function.[108] It does not increase hypoxaemia[109] or airflow obstruction.[106,110] The evidence thus far has not shown ACBT is further improved by the addition of adjuncts such as positive expiratory pressure (PEP)[111] or Flutter®[110,112] or high frequency chest wall oscillation.[113] However in order to best suit the needs of patients, families and care-givers, airway clearance techniques need to be individually and continuously adapted.[100,101]

ACBT has been used in many short-term comparative crossover studies and when other techniques (e.g. oscillating PEP) include the forced expiration technique it has shown equivalence in amount of sputum cleared.[112] Over a study period of one year, ACBT is as equivalent in airway clearance effectiveness as autogenic drainage, PEP, or oscillating PEP.[113]

Good practice points

- The length of each phase is flexible and should be adapted to individual patient need.
- ACBT is a useful technique in all stages of disease.
- ACBT promotes independence.
- There are no contra-indications for use of ACBT and it is recommended to be considered as a mainstay airway clearance technique.
- Combining ACBT with other adjuncts, taking into consideration patient disease severity, preferences, lifestyle, treatment burden and individual tailoring and effectiveness of treatment combinations can be advantageous.

Recommendations

- ACBT should be considered when recommending an airway clearance technique for all people with CF (as long as they are able to follow instruction) (*QoE – low*).

5.2 Autogenic drainage (AD)

Autogenic drainage is based on a series of principles aimed at normalizing the breathing pattern.[102] It is a 3-phased breathing regime to unstick, collect and evacuate sputum using accelerated expiratory flow rates[102,116-118] at varying lung volumes to facilitate mucus clearance.[116-118] The technique aims to maximise expiratory flow velocity to produce shearing forces and mobilise secretions within the different generations of the bronchi.[115] Inspiratory flow rates are encouraged to be slow, quiet and gentle while expiratory flow should be high; it should avoid airway closure as in an FET or cough. They must balance their maximum expiratory airflow against collapse of dynamically unstable airways.[102] Breathing out is often done through the mouth as a sigh, but not exclusively; it can be done through the nose. It is thought that with tidal breaths at a low lung volume going into expiratory reserve volume, with the addition of a three-second pause at the end of each inspiration, secretions can be mobilized from peripheral airways, moving the lung volumes up to low/mid volumes to collect mucus in the middle airways and finally progressing to higher lung volumes to clear (evacuate) mucus from central airways. Once sputum is expectorated this sequence is repeated until as much secretions as possible are cleared.[102] AD can be performed in any position, although thought should always be given to optimise and/or support a participant's posture in whichever position they prefer.

There may be an age consideration to the involvement of this technique as it has been noted that children under 12 years of age may not have the focus and concentration required.[102]

Most of the studies of AD compare its efficacy with other airway clearance techniques.[114,119-125] A one-year study with five treatment arms (ACBT, AD, PEP, Flutter®, and Cornet) found no difference in efficacy for all techniques.[114] Those who used the AD technique modified the style of breathing and applied it to other physiotherapy techniques used.[120] Modified AD was reported to increase sputum weight when compared to PEP.[125]

Other studies of AD with Flutter®,[124,125] postural drainage with percussion,[121,123] and high-PEP[121] have shown that AD was less effective at clearing sputum than the other techniques studied. However, others found AD comparable with PD with percussion at clearing sputum.[115]

A study comparing AD with ACBT found that equal volume of sputum was cleared with both techniques, but AD cleared sputum faster.[119] When changes in sputum rheology were compared between the Flutter® and AD, AD was found to be less effective at reducing sputum viscoelasticity.[125]

Two short-term studies suggested that patients performing AD led to fewer episodes of oxygen desaturation.[121] Studies looking at the effect of AD on lung function have shown a greater short-term increase in forced vital capacity (FVC) compared to high-PEP,[121] equal increase in FVC to Flutter[125] and no difference in values when compared to PD and percussion.[120,124]

It has been suggested that AD may be a preferable technique for people with CF who exhibit airway hyper-reactivity.[121] AD can also be used in children (assisted AD)[126-128] where gentle manual pressure is applied on inspiration to guide the breathing level. No pressure is applied on expiration. Assisted AD is often combined with therapeutic exercise such as bouncing on an exercise ball.[127]

Good practice points

- Teaching of AD requires a trained physiotherapist who understands how to adapt the technique to the individual patient.
- The avoidance of airway closure as described in AD may be beneficial particularly in patients with significant hyper-reactive or unstable airways.
- In some circumstances it may be appropriate to combine AD with inhalation (for muco-actives) and/or other airway clearance devices e.g. IPV.
- Individual patient preference must be considered when formulating an airway clearance program.
- Autogenic drainage promotes independence as they are not dependent on a device or care-giver.

Recommendations

- Autogenic drainage should be considered when choosing an airway clearance technique (*QoE – low*).
- There is evidence to suggest that autogenic drainage is as effective as other airway clearance techniques (*QoE – low*) with no negative effects.
- Consider AD particularly in those with airway hyper-reactivity (*QoE – very low*).
- Consider autogenic drainage when choosing an airway clearance technique for a patient with CF who has shown decreases in oxygen saturations with other airway clearance techniques (*QoE – very low*).
- Regularly assess knowledge level and understanding of airway clearance technique and correcting airway clearance technique skills is important to improve and maintain FEV_1 (*QoE – very low*).
- Continual assessing of airway clearance effectiveness is advised to tailor each patients airway clearance regimen and in combining or choosing airway clearance techniques appropriately (*QoE – very low*).

Research recommendations

- More long-term RCT studies comparing AD to other airway clearance therapies is needed to provide data for patient-important outcomes including quality of life.

5.3 Positive expiratory pressure (PEP)

The use of resistance when breathing out creates a positive expiratory pressure (PEP) which can be used to enhance the mobilisation of bronchopulmonary secretions. PEP breathing induces a temporary increase in functional residual capacity (FRC), increasing interdependence between alveoli, facilitating collateral ventilatory flow and therefore recruiting previously obstructed airways. Periods of PEP breathing are combined with the forced expiration technique (FET) and cough to facilitate airway clearance.[129]

Low pressure positive expiratory pressure

Clinically, low pressure PEP is the most commonly used form for this treatment choice. PEP may be applied via a mouthpiece or mask. Treatment is usually undertaken in the sitting position[129] but may also be performed in positions to focus on a particular area to increase ventilation (e.g. supine or side lying).[105] Breathing through the device should be at tidal volume with only slightly active expiration (not prolonged or forced).[130] In order to select the appropriate level of expiratory resistance a manometer should be inserted between the expiratory valve and the resistor to measure mid-expiratory pressure. The appropriate resistance is one which achieves a stable mid-expiratory pressure of 10-20cm H2O.[130, 14]

Several studies have compared low pressure PEP with other methods of airway clearance both in the short-term[131-134] and long-term (>1 year).[12,114,135,136] A systematic review of PEP in CF reported that in short-term or long-term studies no significant difference had been demonstrated between PEP and other airway clearance modalities with reference to forced expiratory volume in one second (FEV_1). Longer-term studies comparing PEP with other airway clearance techniques show equivocal or conflicting results in terms of FEV[1].[13,137] A significant increase in respiratory exacerbations requiring antibiotics was demonstrated in those who used high frequency chest wall oscillation (HFCWO) – The Vest compared to PEP over a one-year period.[12]

High pressure positive expiratory pressure

High pressure PEP involves forced expiratory manoeuvres against resistance, creating a high expiratory pressure. The same mask for low pressure PEP is used with a different manometer equipped to measure higher pressures (typically 40 – 100 cmH_20).[105]

The technique is performed in sitting where the patient is advised to perform approximately 8 – 10 breaths at moderate tidal volume after which the patient inhales to total lung capacity before performing a forced expiratory manoeuvre against the resistance to residual volume. This normally results in the patient coughing from low lung volumes and expectorating secretions. This is repeated until the cough is dry and no more secretions are produced.[105, 138]

The appropriate resistance is calculated by connecting the outlet of the PEP mask to a spirometer, this should be routinely assessed at clinics or more frequently on initiation of the technique. The patient is instructed to perform forced expiratory manoeuvres through different sized resistors where the resistor is chosen based on the maximal expiratory flow through all lung units which is demonstrated by interpretation of the flow – volume curve.[105]

A short-term study found high pressure PEP yielded greater sputum when compared to autogenic drainage (AD). Improved lung function parameters were also found but did not exceed those achieved after AD and were associated with significantly lower sputum yield in those with airway hyperactivity leading the authors to conclude high pressure PEP may induce bronchospasm and should either be preceded by the use of a bronchodilator or consideration of another available airway clearance technique such as AD.[121] A long-term study[139] concluded high pressure PEP resulted in improved lung function, greater sputum yield, decreased airway stability and hyperinflation when compared to conventional physiotherapy while ensuring patient technique was optimal and ensuring the chosen resistance was appropriate for the patient and therefore requires access to lung function laboratories to perform.

Pryor & Prasad[138] advise this technique takes a considerable amount of effort and therefore would not be suitable for a patient who tires easily.

Baby positive expiratory pressure

The use of PEP has also been investigated in infants and is reported to be as effective as postural drainage and percussion.[140] This technique uses a soft face mask which is placed on the baby's face and gives a small amount of back pressure to the airways (PEP) when the baby breathes out, helping to open up the airways, and clear any mucus. There is no specific guidance to resistor selection when using baby PEP therefore the assumption is that appropriate resistance is one which achieves an approximate mid-expiratory pressure of 10 – 20cm H_2O when a manometer is situated within the circuit.[130, 14]

Bubble positive expiratory pressure

A bubble PEP circuit can be made up from a plastic bottle, tubing and water. The bottle is filled to 10 – 20cm in depth. The tubing is placed into the water and as the individual breathes out against the resistance of the water positive expiratory pressure is set up. Breathing out against the resistance of the water should be interspersed with the FET and cough to encourage the clearance of secretions. The inner diameter of the tube should be 8mm to ensure the PEP threshold is the same as the water column pressure.[141]

There appears to be limited research on bubble PEP available.

Participant preference to PEP has been reported in several studies,[132,134,135,140] although the quality of many of these studies is reported as low.[137]

Good practice points

- No single treatment technique is suitable for all patients and the physiotherapist delivering airway clearance must be well-educated in all aspects of airway clearance and associated therapy techniques.
- PEP has not been proven to be more or less effective overall than other airway clearance techniques.
- Consider patient preference and their health beliefs when selecting an appropriate airway clearance technique for a patient with CF.
- Consider the age-appropriateness of specific airway clearance devices when recommending them for use as an airway clearance technique.
- The level of the expiratory resistor used should be regularly re-assessed and may need to be changed with alterations in clinical status.
- Patients must be instructed in appropriate cleaning regimens of PEP devices as per manufacturer guidelines.
- If used, treatment with high pressure PEP must be assessed regularly, by a physiotherapist skilled in the technique, due to the high pressures used (40 – 100cm H_2O).

Recommendations

- PEP should be considered when recommending an airway clearance technique for all patients with CF (*QoE – low*).
- There is insufficient evidence to support or refute the use of high pressure PEP in CF (*QoE – low*).

5.4 Oscillatory devices in cystic fibrosis

Devices that offer oscillatory resistance alter expiratory airflow. These devices are either intra- or extra-thoracic. Intra-thoracic oscillatory devices are placed in the mouth and provide resistance during exhalation, which results in the airways vibrating thus loosening secretions.

Oscillations or interruptions during expiratory airflow are considered to mechanically reduce the viscoelasticity of sputum and enhance mucociliary clearance.[143] Oscillations, both internally and externally, have also been considered to improve airway patency by preventing spontaneous compression through the introduction of alternating positive pressure where the consequent vibration loosens secretions allowing ease of expectoration.[110,144]

Intra-thoracic oscillations are generated orally and internally they create variable resistances within the airways during expiration, generating controlled oscillating positive pressure that mobilises respiratory secretions.[15]

When the oscillation frequency approximates the resonance frequency of the pulmonary system, endobronchial pressure oscillations are amplified and result in vibrations of the airways.[15] These vibrations loosen mucus from the airway walls. The intermittent increases in endobronchial pressure reduce the collapsibility of the airways during exhalation, increasing the likelihood of clearing mucus from the tracheobronchial tract.[15] The airflow accelerations increase the velocity of the air being exhaled, facilitating the movement of mucus up the airways.[144] Exhalation through these devices generates both oscillations of positive pressure in the airways and repeated accelerations of expiratory airflow that have been shown to result in improved sputum clearance.[145]

The devices frequently employed for this purpose are:

a. Flutter®
A small plastic device containing a large ball bearing, which repeatedly interrupts the outward flow of air.[144,146]

b. Acapella®
A flow-operated oscillatory PEP device, which uses a counterweighted plug and magnet to generate the oscillatory resistance.[147]

c. Cornet®
A horn-shaped tube, which houses a rubber inner tube. The degree of rotation of this inner tube reflects the resistance generated. As the individual exhales through the horn the inner tube unfurls generating a rhythmic bending and unbending of the inner tube within the horn throughout the expiration phase.[147]

d. Aerobika (Trudell Medical International, London, Ontario, Canada)®
A flow-operated oscillatory PEP device, which uses a one-way valve to generate the oscillatory resistance.[15] The Aerobika may also be used simultaneously with nebulised aerosol drug delivery.

e. Quake®
This device oscillates a column of air in both inspiratory and expiratory phases of respiration. It does not rely on an oscillating valve like the Flutter and Acapella, as it uses a manually turned cylinder that fits within another cylinder. Airflow occurs only when slots within the two cylinders line up. Therefore, the airflow is interrupted at regular intervals as the user turns the crank. The rate at which the device is cranked will determine the frequency of the flow interruption. Since the resulting vibration is not determined by the patients' rate of flow, the Quake theoretically may be more helpful for patients with severe obstructive lung disease who are unable to generate high peak expiratory flow rates.[15]

A systematic review of oscillatory devices in cystic fibrosis[15] reported no clear evidence that oscillatory devices were more or less effective than other forms of airway clearance and no evidence that one device was superior to another. In one long-term study, a statistically significant difference in FVC was demonstrated in those who used the flutter over breathing techniques.[148] Morrison and Agnew (2014) also found some small but significant changes in sputum volume and weight, but these results were not wholly in favour of oscillating devices.

Good practice points

- No single treatment technique is suitable for all patients and the therapist delivering airway clearance must be well-educated in all aspects of airway clearance and associated therapy techniques.
- Oscillating PEP has not been proven to be more or less effective overall than other airway clearance techniques. There is no evidence that one device is superior to another.
- Consider patient preference and their health beliefs when selecting an appropriate airway clearance technique for a patient with CF.
- Consider the age-appropriateness of specific airway clearance devices when recommending them for use as an airway clearance technique.
- Patients must be instructed in appropriate cleaning regimens of oscillatory PEP devices as per manufacturer guidelines.

Recommendations

- Consider oscillatory devices when recommending an appropriate airway clearance technique for a patient with CF (*QoE – low*).

Research recommendations

- Further research is required to assess patient preference for positive expiratory pressure as compared with other airway clearance techniques.
- Further research is required to assess the effects and safety of high pressure PEP in comparison to other available airway clearance techniques.

5.5 Extra-thoracic oscillations – High frequency chest wall oscillation (HFCWO/Vest)

Extra-thoracic oscillations are generated by forces external to the respiratory system, for example high frequency chest wall oscillation (HFCWO). HFCWO consists of an air-pulse generator connected to an inflatable jacket that fits over the chest.[149] Air pulses are transmitted to the vest, creating oscillations to the chest wall of 5-25Hz. Physiologically HFCWO enhances mucociliary transport by creating a cough-like expiratory flow bias that shears mucous from the airway walls and also the vibrations alter the rheological properties of mucous.[12]

Evidence is variable when considering sputum clearance (wet or dry sputum weight). No consistent statistical difference between HFCWO and other airway clearance techniques have been demonstrated.[113,150-158] When respiratory function is the primary outcome, there is no evidence to suggest that HFCWO is superior to other airway clearance techniques.[113,143,150,151,159-163] One study demonstrated significant desaturation using HFCWO compared to PEP in patients with moderate to severe disease and recommended SaO_2 monitoring if used in this patient group.[143] There is now strong evidence illustrating an increase in pulmonary exacerbations and shorter time to next exacerbation when HFCWO is compared to PEP over a sustained period of time.[12] Nebulisation during HFCWO does not affect peripheral drug deposition.[163]

Convenience, efficacy and comfort were the comparisons evaluated for patient satisfaction and again results were variable. In some studies, patients preferred the flexibility of alternative devices but others preferred HFCWO.[12,14,113,150 ,151,153-155,164]

As a consequence of improved adherence to therapy, individual patient preference must be considered when formulating an airway clearance programme.

The HFCWO compressor can be decontaminated after use as per local infection control guidelines. The Vest component is single patient use and must not be used for any other person.

Good practice points

- HFCWO could be considered when adherence with other airway clearance techniques is problematic.
- HFCWO should be considered when patients are unable to carry out other airway clearance techniques for reasons such as autism, learning difficulties.
- HFCWO could be considered for use in conjunction with other airway clearance techniques e.g. ACBT, PEP.
- SaO_2 monitoring should be used for patients with moderate to severe disease using HFCWO.
- When considering frequency of exacerbation and time to next pulmonary exacerbation an alternative treatment other than HFCWO should be considered.

Cost of these devices may be prohibitive, especially in view of the lack of evidence of superiority over other airway clearance techniques.

Recommendations

- HFCWO should not be used in isolation as a primary airway clearance technique, unless extenuating circumstances dictate *(QoE – moderate)*.

5.6 Intrapulmonary percussive ventilation (IPV)

Intrapulmonary percussive ventilation is a mechanical airway clearance device that combines internal thoracic percussion and inspiratory pressure through rapid mini bursts of air superimposed on a spontaneous breathing pattern. Expiration against the percussive element of the device leads to the maintenance of positive pressure within the airways.[164] Like other mechanical devices, IPV can be delivered either via mouthpiece or facemask.

The proposed methods of action include:

- Maintenance of small airway patency, ventilation and prevention of airway closure and atelectasis;
- Enhanced movement of secretions;
- Improved distribution of nebulised medications.

A number of studies have investigated the use of IPV in cystic fibrosis,[154,165-167] however, the evidence is limited and is directed to patients with only mild or moderate disease severity.

A comparative study of IPV and conventional chest physiotherapy (frequently considered in the literature to be manual techniques including postural drainage and percussion and/or vibrations) reported no differences between the techniques in terms of pulmonary function and expectorated sputum.[166,168] A single intervention study[165] compared IPV with conventional physiotherapy and the Flutter® in a randomised cross-over design concluding that IPV and the Flutter® were equivalent to chest physiotherapy in terms of sputum cleared or change in pulmonary function measures from baseline. Both studies included stable children and adults, however the sample sizes were small and only the short-term effects of the interventions were studied. Similar findings have been found in stable CF patients in the outpatient setting.[169]

A short-term randomised cross-over study compared the efficiency of IPV with CPT and high frequency chest wall compression (HFCWC).[154] All three treatment regimens had similar short-term efficacy in terms of sputum clearance with no positive or negative preference for comfort or convenience. Only one longer-term study[169] compared IPV to 'conventional physiotherapy' over a six month period and found no significant difference in hospitalisations or use of oral and intravenous antibiotic use. All patients who used IPV for the duration of the study reported they would continue with the device if given the opportunity.

It is advised that every 48 hours the circuitry is dissembled and thoroughly cleaned and disinfected. There are disposable single patient circuits available and the non-disposable parts must be ethylene oxide sterilised, pasteurised, or autoclaved between patients.

Good practice points

- IPV is a costly airway clearance device that requires ongoing purchase of consumables such as tubing, filters and interfaces and servicing of the device is recommended at regular intervals. As a result, these devices are not considered a convenient long-term airway clearance strategy and this should be taken into account when considering this device.
- IPV could be considered when other airway clearance techniques have proved unsuccessful or fatiguing in patients with advanced or complex airways disease, the presence of thick, tenacious secretions or for areas of unresolved consolidation despite conventional management strategies.
- Consider combining or alternating IPV with other airway clearance techniques to maximise effectiveness e.g. ACBT or AD.
- When using IPV, consider also using the device for the inhalation of mucoactive drugs to maximise effect or improve tolerance e.g. hypertonic saline
- IPV settings should be tailored to the patient depending on clinical presentation and tolerance. Consider starting on low pressures for comfort and build up as tolerated until chest wall movement can be felt at the base of the thorax. Start with a high oscillating frequency (high cycles per minute) to break down mucus and shear secretions from the airway walls then change to a low frequency (low cycles per minute) as the treatment progresses to promote migration of secretions centrally and enhance alveolar ventilation.

Recommendations

- Consider intrapulmonary percussive ventilation when recommending an airway clearance technique for adults with mild to moderate cystic fibrosis *(QoE – very low)*.

5.7 Postural drainage (PD)

Postural drainage (PD) incorporates 12 specific positions to utilise gravity on mucociliary action in draining individual lobes/segments of the lungs.[170]

In people with CF, mucociliary action is impeded. McIlwaine et al. (2007) found airway secretions moved slowly in the opposite direction towards the periphery of the lung and putting them in a head down tilt 'normalised' secretion movement 3-5mm per min aiding secretion removal from the periphery. However, in practice with these speeds it would require someone to be in this position for 60-100 minutes. In clinical practice PD was often combined with percussion. The hypothesis of the use of PD more recently can be changed when looking at modified PD positions without a head down tilt in that more secretions have been found to clear from the dependant lung rather from that of the upper most.[102]

The detrimental effects of PD & percussion often referred to as conventional chest physiotherapy (CCPT) include hypoxic episodes, aggravation of gastro-oesophageal reflux particularly in infants,[171-173] an increased burden placed on family as requires a second person and a significant amount of time, and bronchospasm. Changes in cardiac rhythm and raised intracranial pressures are other recognized precautions. Adherence even in hospitalised patients to CCPT is poor.[174] As a consequence of this, most therapists, if using manual techniques, are likely to employ modified PD positions to facilitate an improvement in regional ventilation and the possible improvement in V/Q matching.

There is some evidence to support CCPT combined with FET compared to FET alone or no physiotherapy, as it can reduce the annual rate of decline in respiratory function.[175,176]

Despite the detrimental effects of PD noted, it may still be used, particularly in the presence of a lung abscess or localised pathology. Modified PD positions may also be used without the head down tilt. Cecins et al. ([177]) showed that side-lying (modified PD) was as effective as side lying with head down tilt (PD) in a cohort of CF and non-CF bronchiectasis patients. This study also demonstrated an increase in dyspnoea with head down positioning.

As PD is passive and relies purely on gravity and alterations in regional ventilation to mobilise secretions it should not be used as an airway clearance technique alone. In clinical practice, modified PD is used in conjunction with techniques such as ACBT, AD and PEP.

Good practice points

- Head down tilt should not be used in infants or those with identified GORD. It should be used with caution in others.
- PD or modified PD should always be combined with an airway clearance technique.
- If gravity assisted positioning is not beneficial, consider a comfortable position to perform airway clearance techniques in, such as sitting or high side lying.
- Postural drainage can be useful for patients who either because of their age or disease progression are not able to be as independent or as active a participant in their usual airway clearance regimen.

5.8 Intermittent positive pressure breathing (IPPB)

Intermittent positive pressure breathing (IPPB) is an established technique in physiotherapy airway clearance clinical practice.[178] Its clinical use was first described in the late 1940s; since then other systems have been developed, which can also deliver inspiratory positive airway pressure. Clinicians and patients are faced with increased treatment options but with no evidence from randomised controlled trails in CF to demonstrate superiority of one system over another.

IPPB is used in spontaneously breathing patients and involves patient triggered delivery of positive airway pressure during inspiration usually with a mouthpiece. Airway pressure then returns to atmospheric pressure during expiration. Flow rate can be adjusted to patient comfort, which may vary throughout active and rest phases of an airway clearance session.

IPPB requires either compressed oxygen or air as a driving gas making it a treatment unsuitable for home use. Careful consideration needs to be given to the most appropriate driving gas selection particularly in patients with established chronic hypercapnic respiratory failure (CHRF) given that the lowest oxygen concentration possible is approximately 45%.[179] Non-invasive ventilatory support may be a better option for these patients allowing longer duration of pressure support (if clinically indicated) and more precise titration of any additional oxygen requirement.

The dry compressed driving gas must be humidified via a nebuliser in the circuit. Clinical Practice Guidelines acknowledge that there is no evidence demonstrating superiority of IPPB to delivered bronchodilators over metered dose inhalers (MDI) or jet nebuliser systems. However when all other validated systems have failed careful evaluation of IPPB delivery in individual patients may be considered.[180]

IPPB has been reported to increase tidal volume and therefore minute ventilation, and reduce work of breathing. Expert patient assessment and instruction is required to ensure that the positive pressure is delivered to a relaxed patient who is not fighting the ventilator; allowing IPPB to be exploited to successfully augment the patient's usual airway clearance technique. Circuits are intended for single patient use and must be disposed of after patient has discontinued this treatment. All non-disposable parts of the equipment must be appropriately decontaminated in line with local infections control.[180]

Good practice points

- There are no published clinical trials investigating IPPB use in cystic fibrosis and so the clinical decision making of the physiotherapist must be informed by the pathophysiology, the clinical status, and an in depth knowledge of the advantages and disadvantage of the available equipment and operator competence.[178]
- Cleaning and appropriate decontamination must be done in conjunction with national and local infection control policies.
- Continue drug delivery through the pharmaceutically recommended systems and use 0.9% NaCl to provide humidity to the IPPB driving gas.
- An oscillating PEP device or positive end expiratory pressure (PEEP) valve may be added on to the expiratory port in the circuit, which may enhance mucociliary clearance.

6.0 Sinus disease

6.1 Introduction

Sinonasal complications including chronic rhinosinusitis and nasal polyps can significantly impact on the quality of life and overall health of a patient with CF.[181] There is a substantial variation in the prevalence and reporting of symptoms, with chronic rhinosinusitis affecting up to 67% of patients.[182] It has been found that patients with high-risk genotypes have more severe sinonasal findings than those with lower risk genotypes.[183]

6.2 Sinonasal washout

In current clinical practice there is little consensus as to the investigation and treatment of sinonasal disease. Many studies have used the validated SNOT-20 or SNOT-22(Appendix IV) tool to identify patients with sinus symptoms, grade the severity of their symptoms initially and as an outcome measure in response to treatment. Reported symptoms are variable but can often include facial pain or pressure, loss of sense of smell or taste, nasal congestion and post-nasal discharge.[184] Additionally there has been a strong correlation between the bacterial colonisation in the upper and lower airways.[185] It is well-established that bacterial colonisation in the lower airways is associated with poor clinical outcomes and high morbidity. This highlights the need for continued research into sinonasal disease and prompt treatment once symptoms have been identified.

6.3 Sinus nebuliser therapy

There are several physiotherapy treatment options for sinonasal disease, which include nasal irrigation, topical corticosteroids and antibiotic and/or mucolytic nebulisation. Sinonasal inhalation of vibrating aerosols (antibiotics or mucolytics) is a more recent innovation. Unlike conventional aerosols, vibrating aerosols applied with the PARI Sinus nebuliser deposit drugs directly into the paranasal sinuses, reducing pathogen colonisation, and are found to be well-tolerated.[181]

Good practice points

- Patients should be screened for symptoms of sinonasal disease, at least annually or more frequently if symptoms persist.
- Physiotherapists should be aware of existing treatment regimens and alternative opportunities to enable patient choice and optimise adherence to treatment.
- Physiotherapists should remain aware of sinonasal nebuliser developments in order to offer the most appropriate delivery system.
- Assessment of the response to treatment should be completed using an appropriate outcome measure.

Recommendations

- The SNOT-22 outcome measure is quick to administer, is inexpensive and is validated for use with adults *(QoE – moderate)*.
- Consider sinonasal inhalation of Dornase Alpha to help improve sinonasal symptoms[181] (*QoE – high*).
- Consider sinonasal inhalation of antibiotics such as Tobramycin to reduce pathogen colonisation of the sinuses, reduce number of exacerbations and for symptom control (*QoE – low*).
- Nasal saline irrigation in various concentrations should be considered to improve symptoms and quality of life (*QoE – low*).
- Topical corticosteroids should be considered for symptom relief and reduction of polyp size (*QoE – low*).
- Consider the use of Montelukast for symptom relief (*QoE – low*).

7. Exercise

The importance of exercise in maintaining a healthy lifestyle is well-recognised in both health and disease. There is a growing body of evidence showing that people with CF are not only affected by decreased cardiorespiratory fitness (i.e. aerobic) but also decreased muscle power, strength and endurance (i.e. anaerobic).[186] Furthermore, poor posture and flexibility are common features in patients with CF.[187]

The current guidelines for physical activity for healthy children and adults are applicable in CF and can be used as a basis for exercise advice in CF until respiratory disease progresses. Regular assessment of fitness, monitoring, advice and education on type and frequency of activity should be initiated from diagnosis in order to ensure fitness levels are maintained. As disease becomes more severe patients may need to have individually tailored exercise programmes that are frequently re-evaluated.

7.1 Exercise prescription

Physical activity is considered to have an important role in maintaining the health of people with CF. There is some evidence that regular cardiorespiratory (aerobic) exercise can slow the rate of lung function decline, increase peak aerobic capacity (VO_2peak) and improve health–related quality of life.[188-193] In adults with CF, peak aerobic capacity has long been considered as a strong predictor of both mortality and the risk of hospitalisation.[194] In addition, there is emerging evidence that people with CF have abnormalities in their systemic large arterial circulation, which may increase their cardiovascular risk, particularly in an aging population.[195-197]

The consensus amongst experts in the field is that people with CF should strive to achieve equitable physical activity levels to those without the disease. It is for this reason that current physical activity guidelines for healthy children and adults are applicable to those with CF. Physical activity advice should consider the health status of the patient and be tailored to that individual, particularly as the disease progresses.

7.2 Evidence for physical training

In 2015 a systematic review concluded that there was some evidence to suggest that physical training has a positive effect on exercise capacity, pulmonary function and health-related quality of life based upon thirteen randomised controlled trials.[188] Evidence has also emerged to support the hypothesis that physical training results in improvements in muscle strength.[198-200] There is some observational evidence that suggests that an increase in self-reported habitual physical activity is associated with a reduced rate of decline in pulmonary function. There is a significant need for high-quality randomised controlled trials to comprehensively assess and clearly define the benefits of physical training in adults with CF.

The guidelines below aim to offer a practical guide to exercise prescription in those with CF:

Cardiorespiratory (aerobic) fitness

- Adults with CF should be advised to participate in at least 150 minutes (2½ hours) of moderate intensity physical activity or at least 75 minutes (1¼ hours) of vigorous intensity physical activity each week *(QoE – moderate)*.
- Those who are inactive and/or are limited in their physical capacity to exercise should be encouraged to accumulate 10-minute bouts of physical activity throughout the day (*QoE – low*).
- Patients should be educated on the difference between moderate and vigorous intensity physical activity and on the use of subjective measures of exertion, for example the validated subjective measure of breathlessness and/or exertion such as the Borg scale (*QoE – low*).
- Moderate intensity physical activity equates to (or can be defined as):

1. The individual working (exercising) at 40 to 59% of a patient's peak aerobic capacity (VO_2peak) as measured during cardio-pulmonary exercise test (CPET) *(QoE – moderate)*.

2. Or, the individual working (exercising) at self-reported perceived exertion rating between 11-13, as measure on the Borg perceived exertion scale. The Borg perceived exertion scale is a validate 15 item scale (ranges 6-20) for exercise prescription (*QoE – low*). Appendix V.

3. Or, the individual working (exercising) at a rating of perceived breathlessness between 3-4 as measured using the modified Borg breathlessness scale (range 0-10) (*QoE – low*). Appendix V.

- Vigorous intensity physical activity equates to (or can be defined as):

1. The patient (or individual) working at 60 to 85% of a patients peak aerobic capacity (VO_2peak) as measured during cardio-pulmonary exercise test (CPET) *(QoE – moderate)*.

2. Or the individual working (exercising) at self – reported perceived exertion rating between 14-16, as measure on the Borg perceived exertion scale. (*QoE – low*) Appendix V.

3. Or the individual working (exercising) The individual working at a rating of perceived breathlessness between 5-6 as measured using the modified Borg breathlessness scale (range 0- 10) (*QoE – low*). Appendix V.

4. High intensity interval training may be considered in patients who have achieved the recommended amount of physical activity for more than six months *(QoE – moderate)*.

5. All patients who have expressed a desire to become more physically active should be offered support and advice (*QoE – low*).

6. Adults with CF may benefit from incorporating activities to maintain and/or improve posture and flexibility on most days of the week (*QoE – low*).

Resistance exercise

Peripheral muscle weakness is common in those with CF and is particularly apparent in the lower limbs.[198,199] Muscle weakness can have a significant impact on exercise tolerance and the capacity to undertake activities of daily living.[200,201] Lower limb strength and function has been demonstrated to be of significant prognostic importance in people with CF.[202-204]

Disuse atrophy is the predominant mechanism underpinning lower limb muscle weakness in those with CF.[200,201] Sedentary behaviour should therefore be discouraged, particularly during periods of clinical stability.

Given the prognostic importance of lower limb strength and function, resistance training should be considered an essential complement to an individual's exercise routine. The guidelines below aim to offer practical guide to resistance training in people with CF:

Good practice points

- Patients should be made aware of the health benefits of a physically active lifestyle and the physiological principles that underpin exercise training.
- A prescribed exercise programme should be offered for all patients who may benefit and/or request one.
- Prescribed exercise programmes must consider: motivations and goal; current level of physical activity and ability; circumstance, preferences and barriers to being physically active; health status.
- Patients should be advised to minimise the time spent inactive for extended periods of time, particularly during periods of clinical stability.
- A structured exercise programme will be offered to patients who have musculoskeletal disorders that are likely to benefit from exercise training.

Recommendations

- Adults with CF should undertake resistance exercise as a complement to and not a replacement for cardiorespiratory (aerobic) exercise *(QoE – moderate*).
- Adults should be advised to undertake resistance exercise on two or more non–consecutive days of the week (*QoE – low*).
- Weight training should be regarded as the preferred mode of resistance exercise to optimise the health benefits and monitor progression. Alternative modes of resistance training may be considered such as using body weight, resistance bands, free weights, medicine balls or weight machines (*QoE – low*).
- Resistance training should incorporate both upper and lower limb exercises that target the major muscle groups *(QoE – moderate*).
- A load should be selected that equates to 60-70% of the patient's one repetition maximum (1RM) to improve muscular strength. To improve muscular endurance a load should be selected that equates to less than 70% of the patients one repetition maximum (1RM) *(QoE – moderate*).
- In the absence of the patient's one repetition maximum (1RM), a resistance (weight) should be selected that brings about local muscular fatigue after the desired number of repetitions for each exercise (*QoE – low*).

Risks associated with specific exercise

There is limited evidence on the incidence of injuries during strength training in children and adolescents, however the CSMF/AAP guidelines[205] state that specific types of strength training (e.g. power lifting, body building and maximal lifts) should be avoided until physical and skeletal maturity.[205] Prolonged exercise may increase the risk of dehydration and hyponatraemia, particularly in warm or hot conditions, which can reduce exercise capacity and lead to increased mucous viscosity and theoretical increased risk of exacerbation.[206] In patients with CFRD prolonged exercise may increase the risk of hypoglycaemia. Exercise at high-altitude (e.g. skiing) may increase the risk of desaturation and right heart failure.[207,208] Diving may increase the risk of pneumothorax especially in patients with more severe disease.[207] Contact sports (e.g. combat sports) should be avoided in patients with advanced lung disease, liver disease, and those at risk of breaks/fractures e.g. those with low bone density.[209]

As disease progresses patients may be at increased risk of exercise induced oxygen desaturation and may require assessment for supplementary oxygen.[207] The use of positive pressure during or prior to exercise may also be considered. However, it must be noted that no clinical trials examining the efficacy/safety of NIV/ positive pressure as an adjunct to exercise performance in patients with CF have been conducted.

Recommendations

- Patients should be made aware of any increased medical risks associated with specific exercise or sporting activities (*QoE – low*).
- Specific types of strength training (e.g. power lifting, body-building and maximal lifts) should be avoided until physical and skeletal maturity (*QoE – low*).
- Specific guidance should be given on fluid-replacement and dietary/insulin requirements when appropriate (*QoE – low*).
- Patients who exhibit desaturation will be assessed for supplementary oxygen during exercise (*QoE – low*).

8. Inhalation therapy

Delivering medication via the inhaled route (inhaler or nebuliser) gives potential advantages; medication is delivered straight to the lungs (target area) and so a lower dose can be given with less of the systemic side effects of oral or intravenous treatment,[210] some medication is only available in inhaled form (e.g. some mucolytics/hyperosmolar agents), and some people may perceive inhaled therapy as being more acceptable than other ways of delivering medication.

A wide range of medications may be delivered by the inhaled route and various devices are available.[211] Frequently the practicalities of inhaled therapy such as choice of medication, trials of medication, device selection, provision, education and monitoring is undertaken by physiotherapists.[212] This is logical given the timing needs of some medications which are often around airway clearance and given that many inhalation devices (inhalers and nebulisers) require breathing pattern training. With the advent of independent and supplementary prescribing for physiotherapists, prescriptions for inhaled medication are often completed by the physiotherapist.

8.1 Bronchodilator trials

When using bronchodilators such as Salbutamol, Terbutaline Sulphate and Ipratropium Bromide, it is recommended that spirometry is used to assess the initial response to the medication[65] with regular re-assessment to ensure this response is maintained.[213] Timing of post-dose spirometry is variable depending on the medication given. An increase of 15% in FEV_1 or FEF_{25-75}, 15-minutes following inhalation of a Beta 2 agonist and 30-minutes post-anti cholinergic agent, being suggested as significant.[214]

8.2 Drug response assessment

Inhaled antibiotics, RhDNase and osmotics such as Bronchitol and hypertonic saline may cause bronchoconstriction.[215,216] The summary of product characteristics (SPC) of the current commonly used inhaled antibiotics and Bronchitol all specify the need for a bronchoconstriction trial.[217-224] The need is not stated for RhDNase[225] although there are case reports of bronchoconstriction. As hypertonic saline is classified as a medical device and not a medication, there is no SPC for it but there is evidence for the potential for bronchoconstriction.[226] A decrease of ≥10-15% FEV_1 or FEF_{25-75} following inhalation defines significant bronchoconstriction.[37,212,214] Should this occur, a further test dose with pre-medication of a bronchodilator is advisable.[37,212,214,227-229] Appendix VIa/b describes and provides a template and competencies for the bronchoconstriction trial/test dose procedure.

There is the potential for bronchial hyper-reactivity to inhaled medication once long-term treatment is established. Processes will be in place to ensure ongoing monitoring for subjective and/or objective bronchoconstriction to inhaled medications.

8.3 Inhaler devices

There has been a great increase in the number and type of inhaler devices for bronchodilators, inhaled steroids and combinations of these medications available in recent years (Appendix VIc). Different devices have different delivery characteristics and may require different inhalation techniques and inspiratory flow rates in order to effectively use the inhaler.[230] It is therefore important to understand the link between the availability of particular medications through particular devices and that an assessment is made of the person's ability to use a particular device before prescribing a particular medication (for example prescribing Terbutaline Sulphate rather than Salbutamol because you'd like the person to have a Turbohaler). The NHS business authority therefore state that medication delivered via an inhaler must be prescribed by brand rather than generically. It is also helpful to consider the number of different medications and devices that the person with CF requires and consider medication choices in order to limit the number of different types of devices where possible.

There have been great developments in dry powder inhalers for antibiotic and osmotic delivery with the approval by NICE of dry powder Colistimethate sodium, Tobramycin and Bronchitol.[231,232] It has been recognised that test dosing and education, particularly around technique, are key when commencing these medications in order to assess suitability and limit side effects such as cough.

8.4 Nebuliser devices

There are increasing numbers of nebuliser devices available. The most common types available are conventional nebulisation systems, ultrasonic nebulisers, adaptive aerosol delivery devices (AAD) and/or vibrating mesh technology systems (VMT).

There is little evidence to recommend one type of nebuliser device over another in terms of randomised trials demonstrating improved clinical efficacy or patient preference. There is however an indication that new nebuliser technologies such as AAD and VMT have advantages over conventional systems. These include speed of nebuliser administration with AAD[233] and VMT devices being quieter. They may also provide better deposition[234] and more consistent dosing.[235] Further high quality trials are needed to confirm these suggestions.[236]

There is an increasing issue of new medications having deposition data and being marketed only for use with a specific nebuliser system (e.g. Cayston with the Pari eflow and altera handset). It is important to note that different nebuliser systems have different delivery characteristics and therefore the delivered dose may vary depending on the device used.[236] Where there is a choice to deliver an inhaled medication through a device which isn't named on the summary of product characteristics, consideration must be given as to whether there is sufficient data to ensure a safe and effective dose is delivered. There should be an awareness that delivering medications through an alternative device is an off label use.

It is helpful to consider the number of different medications and devices that the person with CF requires and consider medication choices in order to limit the number of different types of devices where possible. There are some possibilities around mixing medications in order to reduce burden but consideration must be given around the legalities and appropriateness of doing so. Appendix VIe provides a summary of medication compatibility.

8.5 Timing of medications

It is generally suggested that nebulised antibiotics should be taken after physiotherapy and after bronchodilators in order to ensure best deposition and protection from bronchoconstriction.[37] Questions remain around the optimal timing of RhDNase. Studies have suggested that inhalation either pre- or post-airway clearance is equally effective.[238,239] Others suggest that inhalation 30-minutes pre-airway clearance may improve small airway patency more than inhalation post-airway clearance.[240] Hypertonic saline and Bronchitol should be taken immediately prior to or during airway clearance as it is thought to have an immediate mode of action. This may be dictated by individual patient preference.

8.6 Cleaning and maintenance of equipment

Advice about cleaning of inhalers can be found within the medication summary of product characteristics or patient information leaflet. Advice about cleaning of nebuliser devices can be found in the manufacturer's information such as handbooks. Appropriate cleaning and maintenance of nebuliser equipment is essential to avoid bacterial contamination of the equipment, to decrease the risk of acquiring pathogens and to ensure efficiency of the delivery of inhaled medication.[211,241,242]

Good practice points

- Appropriate education for the use of inhalation devices and treatment strategy will be given to the person with CF/appropriate family and ongoing support provided.
- Physiotherapists should remain aware of inhaler and nebuliser developments in order to offer the most appropriate device.
- Physiotherapists must ensure that the medication and device issued to the person are compatible and will deliver a comparable dose to the medication and device combination stated within the summary of product characteristics.
- Cleaning and maintenance education must be an integral aspect of the provision of nebuliser equipment.
- A mouthpiece should be the preferred route of delivery for standard nebulisers.
- There will be a process to ensure that parts and the device are replaced appropriately and in accordance with the manufacturer's guidance.
- Processes will be in place to ensure ongoing monitoring for subjective and/or objective bronchial hyper-reactivity to inhaled medications once long-term treatment is established.

Recommendations

- Inhaled medication (inhalers and nebulisers) must be prescribed by brand and not generically *(QoE – moderate)*.
- Regular reassessment of the response to bronchodilators should be carried out where appropriate *(QoE – moderate)*.
- A test dose will be performed in order to assess suitability and/or effectiveness of the medication for the individual *(QoE – moderate)*.
- Where bronchoconstriction is present on a test dose, a further test dose with pre-medication of a bronchodilator is advisable *(QoE – moderate)*.
- An assessment of the ability of the person to use an inhaler or nebuliser device will be made before commencing treatment (*QoE – low*).

- Consideration should be given to using intelligent nebuliser technologies such as AAD and VMT (*QoE – low*).
- Relaxed tidal volume breathing through the mouth and not the nose is recommended for people using nebulised antibiotics through a conventional nebuliser system (*QoE – very low*).
- Expiratory filters should be used to avoid environmental contamination with exposure of others to the medication and also to avoid damage to property (*QoE – very low*).

9. Oxygen

Oxygen therapy is commonly-prescribed for the treatment of hypoxaemia in people with CF. Chronic and recurrent airway infection and inflammation, leading to progressive lung damage results in chronic hypoxaemia and can lead to cor pulmonale.[243] Episodic hypoxaemia can occur during sleep, exercise, air travel, at altitude, and during infective exacerbations of CF.[244] Individuals with respiratory disease are most at risk of compromised gas exchange during sleep and exercise, and the development of nocturnal hypoxaemia and hypercapnia are poor prognostic signs in CF.[245] It has also been postulated that chronic hypoxaemia may up-regulate airway inflammation, contribute to persistence of PA infection, and inhibit CFTR function.[244] However, there is no universally accepted method of measuring hypoxaemia in CF, leading to a lack of uniformity among published studies.[243] There are currently no CF specific guidelines to inform best practice with regard to supplementary oxygen therapy in CF.

Oxygen therapy can be associated with some adverse effects, such as suppression of respiratory drive and decreased mobility due to tethering to a device.[243] There are also psychological implications, including issues with self-image and increased burden of care.[244] Adherence to oxygen therapy may be poor if no benefit is felt and often improves when oxygen therapy provides symptomatic relief.[245]

The practical use of oxygen in CF is complex.[246,247] Supplemental oxygen has a role in emergency care, respiratory exacerbation, chronic long-term use, sleep and exercise. It is also used with NIV, during air travel and at altitude. Oxygen requirement may differ during each of these situations and should therefore be assessed independently to ensure adequate oxygen prescription. Physiotherapists may be involved in the assessment, set-up and monitoring of oxygen therapy in CF.

Oxygen therapy in CF is complex and further investigation into the role of oxygen in CF is required with regard to the benefits of long-term oxygen therapy, administered continuously or during sleep or exercise, to inform when and how best to use oxygen therapy in the management of CF.[243,248]

9.1 Emergency oxygen

People with CF may become critically ill, requiring emergency oxygen therapy or may require supplemental oxygen during a hospital admission for an acute exacerbation. In CF adults, the time spent with oxygen saturations lower than 90% is greater during an infective exacerbation than in the stable state.[244] Those with advanced CF may suffer from exacerbations similar to advanced COPD exacerbations with associated hypoxaemia and hypercapnia.[249] There is currently no CF specific guidance on the use of emergency oxygen so much of the information available is extrapolated from COPD guidelines.

All people with CF requiring emergency oxygen should be admitted to a regional centre.[249] If, due to geographical reasons, this is not possible, cases should be discussed and managed according to a protocol agreed by the regional centre.[249]

It is recommended that emergency oxygen therapy is prescribed to achieve a normal or near-normal target saturation range of 94-98% for most acutely ill patients.[240] People with CF with advanced disease may demonstrate hypoxaemia and hypercapnia, those at risk of hypercapnic respiratory failure should be prescribed emergency oxygen with a target saturation range of 88-92%.[249] As disease progression is variable, individuals with CF may need to be managed differently according to previous and current blood gas measurements.[249] There is a requirement to maintain adequate oxygenation and to avoid excessive hypercapnia and acidosis, and NIV may be useful in individual cases.[249-251]

Arterial blood gases are required when hypoxaemia is unexpected, oxygen saturations are deteriorating despite optimal management, there is increased breathlessness in previously stable hypoxaemia, or there are risk factors for hypercapnic respiratory failure.[249] For most people who require blood gas sampling, either arterial blood gases or arterialised earlobe blood gases may be used to obtain an accurate measure of pH and PCO_2. However, the arterial oxygen tension (PaO_2) is less accurate in earlobe blood gas samples (it underestimates the oxygen tension by 0.5–1 kPa), so oximetry should be monitored carefully if earlobe blood gas specimens are used.[249]

People with CF who have had previous episodes of hypercapnic respiratory failure should be given an oxygen alert card with recommendations for target saturation range and oxygen prescription based on previous blood gas measurements.[249]

Many people with CF may demonstrate high respiratory rates when critically ill or during an infective exacerbation. Those with a respiratory rate greater than 30 breaths per minute may benefit from oxygen supplied via venturi mask with the flow rate increased by 50% above the recommended level, to ensure gas flow rate exceeds inspiratory flow rate.[249]

There is little evidence to support the use of humidification but it may be beneficial in those who require high flow oxygen for more than 24hrs, those who experience upper airway discomfort and dryness, and those who have thick secretions that are difficult to expectorate. This can also be achieved with the use of nebulised normal saline.[249] A nasal high flow oxygen delivery system can deliver high flow rates with accurate FiO_2 and humidification; these are generally well tolerated.

9.2 Long-term oxygen therapy

The progression of CF respiratory disease often results in chronic hypoxaemia and a myriad of complications associated with this. Long-term oxygen therapy (LTOT) is often prescribed to treat hypoxaemia and prevent these complications. Published studies regarding oxygen in CF primarily concern the effects of nocturnal and ambulatory oxygen on CF parameters.[243,250,252-256] There are no studies available that analyse the effects of LTOT in CF and recommendations for use are generally extrapolated from COPD guidelines.

In CF adults, LTOT should be ordered for those with a resting $PaO_2 \leq 7.3$kPa. LTOT should also be ordered for those with CF with a resting $PaO_2 \leq 8$kPa in the presence of peripheral oedema, polycythaemia, or evidence of pulmonary hypertension.[257] There is little evidence to guide when LTOT is indicated in CF children and it is generally thought that LTOT should be considered for hypoxaemic CF children to improve school attendance and for those who obtain symptomatic relief.[244,245] LTOT can also relieve dyspnoea when NIV is not tolerated in children with CF.[245]

Many people with CF develop hypoxaemia during sleep and exercise prior to the onset of daytime resting hypoxaemia.[245] Awake and exercise oxygen saturation levels do not accurately predict nocturnal oxygen saturation levels.[250] If long-term oxygen therapy (LTOT) is required, arterial blood gases are recommended to assess daytime resting PaO_2.[257] along with nocturnal and ambulatory oximetry to allow accurate oxygen prescription for daytime, sleep and exercise.[245,247] It is recommended that non-hypercapnic patients initiated on LTOT should increase their flow rate by 1 litre/minute during sleep, but this recommendation is not specific to CF.[257]

In advanced disease, people with CF who are experiencing intractable breathlessness and are non-hypoxaemic ($SpO_2 \geq 92\%$) should receive a trial of opiates. Palliative oxygen therapy may be considered if breathlessness is unresponsive to all other treatments.[257]

Supplemental oxygen may cause hypercapnia, and close monitoring of $PaCO_2$ after commencing LTOT is essential in those at risk of developing hypercapnic respiratory failure.[243] A retrospective study cited a baseline $PaCO_2 > 6.5$kPa at LTOT assessment strongly correlated with the development of progressive hypercapnia requiring NIV within 12 months of commencing LTOT.[250]

Formal LTOT assessment should be done after a period of stability, ideally eight weeks. If LTOT is ordered during an acute exacerbation, it should be limited to those with $SpO_2 < 92\%$ who are breathless and unable to manage off oxygen.[257] Suitability for LTOT is assessed by performing two arterial blood gases, usually three weeks apart.[257] When oxygen titration is complete, arterial blood gases should be reassessed to determine whether adequate oxygenation has been reached without precipitating hypercapnia.[257] Capillary blood gases and $TcCO_2$ can be used in place of arterial gases for monitoring.

LTOT should be used for a minimum of 15hrs/day and up to 24hrs/day may be of additional benefit.[257] The needs of the individual will be considered when selecting the delivery device and interface. Regular follow up by a healthcare professional experienced in oxygen therapy is required, either in hospital or at home.

Good practice points

- Oxygen alert cards should be provided to those who have had previous episodes of hypercapnic respiratory failure, with recommendations for target SpO_2 range and oxygen prescription to ensure appropriate pre-hospital care.
- Oxygen supplied via venturi at a flow rate of 50% greater than the recommended flow rate may be beneficial in those with respiratory rates of greater than 30.

Recommendations

- Emergency oxygen should be prescribed in the critically ill patient to achieve a target SpO_2 94-98% unless at risk of hypercapnic respiratory failure, in which case the target SpO_2 should be 88-92% (*QoE – high*).
- LTOT should be ordered in CF adults with resting $PaO_2 \leq 7.3$kPa *(QoE – moderate*).
- LTOT should be ordered in CF adults with resting $PaO_2 \leq 8$kPa in the presence of peripheral oedema, polycythaemia, or pulmonary hypertension *(QoE – moderate*).
- LTOT should be used for a minimum of 15hrs/day but 24hrs/day may give additional benefits *(QoE – moderate*).

9.3 Nocturnal oxygen therapy

Development of nocturnal hypoxaemia and hypercapnia are known to be poor prognostic indicators in CF.[257] However, there are no disease specific guidelines to suggest the optimum time for initiation of nocturnal or supplementary oxygen in the person with CF.[250]

Sleep-related hypoxaemia is defined by the measurement of nocturnal $SpO_2 < 93.8\%$.[265-267] Time spent below 93.8 % can be between 5-30% of total sleep time before nocturnal hypoxaemia is considered of consequence.[244,258,263] It is recognised that nocturnal

desaturation is more prevalent in patients with worsening disease and in particular in those with FEV_1 <65% predicted even if they exhibit normal daytime oxygen saturations.[248,252,257,262,264]

Nocturnal desaturation has been associated with greater difficulty in performing treatment, increased exertional dyspnoea and impairment in neurocognitive performance, development of pulmonary hypertension and the ability to perform normal physical function.[244,258]

Although not yet studied in subjects with CF, chronic and intermittent hypoxaemia has been linked to low-grade systemic inflammation in other disorders and could worsen the already present airway inflammation and tissue destruction characteristic of CF lung disease.[263]

Before daytime resting hypoxaemia develops, many patients develop nocturnal or sleep time oxygen desaturation due to a combination of worsening V/Q mismatch in a supine posture, physiologic changes in the mechanics of respiration and derecruitment of ventilatory muscles especially during the rapid eye movement (REM) portion of sleep.[257,262,266] In the absence of daytime or exercise related hypoxaemia it has been demonstrated that there was evidence of sleep related desaturation which may be clinically significant.[250,252,266] However where exertional desaturation occurs it is prudent to assess for nocturnal desaturation.[243]

Monitoring evening PaO_2 and morning $PaCO_2$ were better predictors of nocturnal desaturation rather than measurements of lung function. Additionally evening PaO_2 in those with moderate to severe disease (PaO_2 42mmHg-84mmHg) contributed significantly to the prediction of a rise in transcutaneous carbon dioxide monitoring ($TcCO_2$) from non-REM to REM sleep.[252]

There is little evidence identifying significant benefit from provision of supplemental nocturnal oxygen in isolation within advanced lung disease. There were no significant improvements in sleep arousal, sleep quality, total sleep time or indeed survival statistics.[248,250,253,257] Additionally no change was identified in mood or social maintenance.[243] It did however improve non-REM, REM sleep, nocturnal oxygenation and improved participation in activities of daily living such as school and work attendance.[243,251,252,257,267] However, there was also evidence to suggest an increase in $TcCO_2$ particularly in those with severe lung disease e.g. FEV_1 29% predicted.[243,257] It is therefore recommended that the monitoring of transcutaneous CO_2 monitoring or capillary CO_2 (in the absence of more invasive arterial blood gas analysis) should be carried out to guide the clinician in the need for non-invasive ventilatory support to prevent CO_2 retention and consequent morbidity.[245,248,257]

9.4 Oxygen and non-invasive ventilation

In the presence of significant hypercapnia, non-invasive ventilation (NIV) may need to be considered in conjunction with oxygen supplementation.[245]

There are a number of reports of the use of NIV in patients with respiratory failure due to severe or end-stage CF lung disease. This topic will be covered in more detail in section 10: non-invasive ventilation.

There are a number of studies looking at the benefits of NIV with or without supplementary oxygen during sleep and the subsequent changes in oxygenation.[248,252] In these studies, the use of nasal continuous positive airway pressure (CPAP) or Bi-level pressure supported ventilation demonstrated an improvement in oxygen saturations during both non-REM and REM sleep. This was postulated to be as a consequence of prevention of airway closure, maintenance of end-expiratory lung volumes, and reduction in the work of breathing with a possible reduction on oxygen cost of breathing.[248,252]

NIV was found to be effective in minimising the degree of hypoventilation occurring during sleep, as evidenced by arterial blood gas samples showing an improvement in pH and a trend toward a lower $PaCO_2$ after a night of NIV compared with supplementary oxygen alone. The improvements in nocturnal oxygenation and reductions in CO_2 with NIV were achieved without modification of sleep quality or efficiency.[251,252]

Further investigations into the role of oxygen in people with CF, with regards to potentially improving daytime function and producing survival benefits are warranted in order to determine when and how oxygen therapy should best be used.[248] Despite the widespread use of nocturnal oxygen and the growing interest in NIV in people with CF and nocturnal desaturation, many questions remain regarding the effectiveness of these therapies in positively modifying daytime function, as a bridge to transplantation in end-stage disease and long-term survival.[248]

Good practice points

- Polysomnography is useful for measuring sleep architecture.
- Simple overnight oximetry is widely available and provides clinically useful data.

Recommendations

- With those patients who have FEV_1 < 65% predicted or a daytime SpO_2 of <93% overnight oximetry monitoring is advised to ensure nocturnal desaturation is not missed *(QoE – moderate)*.
- Monitoring of $TcCO_2$ is advantageous in guiding the application of supplementary oxygen and the initiation of Non-invasive ventilation *(QoE – moderate)*.
- Spirometric parameters and measurements of awake resting oxygenation are of limited utility in predicting nocturnal desaturation. Nocturnal oximetry should be considered in patients with moderate to severe lung disease even with preserved awake resting SpO_2 (*QoE – low*).
- Nocturnal oxygen should be prescribed with caution and further analysis of $TcCO_2$ should be undertaken to ensure no adverse effects occur, e.g. nocturnal hypercapnia *(QoE – moderate)*.

9.5 Ambulatory oxygen

Ambulatory oxygen therapy (AOT) describes the use of supplemental oxygen during exercise or activity and can also be used to enable effective airway clearance in CF.[257] There are some studies considering the use of AOT in exercise but rarely during activities of daily living. People with advanced CF lung disease are likely to have reduced exercise tolerance.[268] AOT minimises desaturation during exercise and can aid episodes of desaturation during airway clearance and/or activities of daily living[255] and has been shown to offer improvements in both intensity and endurance during exercise and thus will maximise the benefit of exercise programmes.[243,253,257] Despite the improvement in oxygenation and exercise duration with oxygen supplementation, peak work capacity and oxygen uptake did not improve in exercise studies.[254-256,270] The use of supplemental oxygen however, has been shown to result in raised CO_2 levels,[243,256] and it is unclear what advice to give patients for whom AOT is impractical or declined.[259]

Desaturation on exertion may be identified during annual exercise test and this is likely to develop before the need for LTOT.[255,257] Assessment will be considered if patients are experiencing breathlessness that is impacting on activity or exercise levels. It is appropriate then to consider the degree of desaturation and options for AOT with the patient, taking into account their views of AOT. A formal AOT assessment can then be carried out. Assessment for AOT is based on measurement of oxygen saturation (SpO_2) using a finger probe or the earlobe to determine if there is desaturation on exercise, defined as a drop in SpO_2 of ≥4% to<90%[244,269,270] and also to assess patients response to AOT. Assessment will also consider the most appropriate device and setting to correct exercise desaturation. Where the respiratory rate is high, assessment using Venturi oxygen at a flow rate sufficient to exceed the patient's peak tidal (and exertional) inspiratory flow can offer advantages over oxygen therapy delivered by nasal cannulae. People with high respiratory rates should receive AOT at a flow rate via a Venturi mask, which exceeds their peak tidal and exertional inspiratory flow and be supplied with home oxygen equipment, which is able to deliver the required high flow rates. It is worth considering that equipment delivering higher flow rates is likely to be heavier, supplying reduced hours of use and that portability and duration of use declines considerably above 6Lpm.[247,257] Assessment will consider daily activity and treatment programmes, which may include exertion related to employment and sport.[247] If the patient already has an LTOT prescription, it is likely that they will require a different flow rate for activity and exercise.[247]

AOT requirements should be reviewed regularly, especially if commenced during an exacerbation or when unwell with an initial review at 4–6 weeks to consider if this therapy is still indicated. Home visits may be useful to identify problems with equipment or set-up and to further assess activities undertaken during daily activity. Further reviews should be carried out every 6 months when stable, or sooner if there are clinical changes. Supplemental oxygen should improve participation in and maximise the benefits of exercise.[254,256]

Good practice points

- Patients should be routinely monitored for exertional desaturation, annually as a minimum and more frequently as necessitated.
- A venturi device may be considered where the respiratory rate is high.
- Consideration will be given to the type of equipment suitable for the patient and the types of activities they will undertake.

Recommendations

- AOT should be assessed by monitoring desaturation on exertion either using a formal exercise test or during specific activities (*QoE – low*).
- Desaturation requiring consideration for AOT/LTOT is defined as a drop in SpO_2 of ≥4% to<90% (*QoE – low*).

9.6 Oxygen for air travel

Air travel is common for people with CF but the guidance for air travel is vague as there is no threshold at resting sea level oxygen levels or FEV_1 that will reliably predict hypoxaemia or complications during air travel, thus there is no specific evidence for CF. All people with CF should be assessed by examination prior to flying.[260]

CF teams should consider the person's previous flight experience, flight duration, destination and, if relevant, the time since the last exacerbation when giving advice.[260]

Contraindications to commercial air travel include ongoing pneumothorax with persistent air leak, major haemoptysis, and oxygen requirement at sea level with a flow rate exceeding 4 l/min. Desaturation during flight or altitude is considered unlikely if FEV_1 is greater than 40% and resting saturations are greater than 92-94%.[246]

The hypoxic challenge test is a method of assessing whether people with CF need in-flight oxygen. It involves a 15% normobaric oxygen challenge, which simulates the partial pressure of oxygen at altitude. In adults, if hypoxic challenge test results demonstrate PaO_2<6.6kPa or SpO_2<85% in flight oxygen at 2 litres is recommended. In children, if SpO_2 <90% during hypoxic challenge test in-flight oxygen is recommended.[260] Whilst the hypoxic challenge test can be a more accurate predictor of risk patients who are likely to desaturate during air travel, it is not available at all hospitals and does not replicate a 2-week holiday where the patient may return in poorer health than when they left. Further research is needed to determine its place in assessing patients before air travel.[260]

In children who are old enough for spirometry and whose FEV_1 is <50% predicted, hypoxic challenge test is recommended, and if SpO_2 falls below 90%, in-flight oxygen is advised. Infants and children who are oxygen-dependent at sea level will need their oxygen flow rate doubled at cruising altitude and should not need hypoxic challenge test, however if they have had long-term oxygen within the last 6 months then hypoxic challenge test should be considered.[260] Infants under 1 year with a history of neonatal chronic respiratory problems should have hypoxic challenge test performed.

Advance planning is required and people with CF are advised to seek advice before booking, to book extra services required with the airline such as in-flight oxygen and airport assistance. If oxygen is required at ground level it will not be provided by the airlines within the airport. Patients should be advised to consider booking an aisle seat near the toilets to minimise further in-flight activity and consequent energy and oxygen expenditure.[260]

Airlines will generally require a medical form to be completed by the oxygen prescriber in order to supply in flight oxygen but may also allow the patient to take on-board portable cylinders or concentrators. All arrangements and costs associated with in flight oxygen will vary between airlines. Patients with medical needs who fly often can obtain a Frequent Traveller Medical Card, which represents temporary medical authorisation for passengers travelling on many airlines which records important medical information and replaces forms otherwise needed for each flight. Once registered, assistance is available whenever the patient flies. The Frequent Traveller Medical Card is issued by many airlines, with its validity period dependent on the medical condition.[271,272]

Patients most at risk can be advised to avoid sleep and alcohol, to stay well hydrated and to have a small carbohydrate meal, all of which will prevent further desaturation.

Good practice points

- Patients should be advised to plan ahead and seek advice before booking and patients should contact their considered airline for advice as well as their CF team.
- Patients at higher risk should be offered advice regarding sleep, alcohol, hydration and diet.
- An hypoxic challenge test may be helpful, but if this is unavailable then desaturation during flight or altitude is considered unlikely if FEV_1 is greater than 40% and resting saturations are greater than 92-94%.

9.7 Oxygen equipment

There are few published studies considering this topic and technological advances mean that the results are outdated quickly. Equipment used in the provision of oxygen can be divided into 3 categories as follows:

- Source (concentrators, cylinders and liquid)
- Delivery (cannulae, masks, conservers and tracheal devices)
- Supplementary (conservers, humidifiers and carrying bags/trolleys)

All sources of oxygen can be portable or static and decisions on the most appropriate type of device will be based on lifestyle, level of activity, flow rate required and patient preference. Equipment will be delivered directly to the patient by the oxygen contractor supplying the local area. Different contractors may source different types of equipment for their contract. This can result in slight variances in the specific equipment available in different parts of the UK, but all will have availability of a range of flow rates and a variety of portable equipment. Some of the more portable equipment is likely to offer pulsed oxygen in order to minimise the size and weight of the device and higher flows of continuous oxygen are likely to be provided by liquid oxygen. Home concentrators are now available in some areas, which enable the person to fill small portable cylinders that can then be used outdoors. Oxygen concentrators are available in more than one size and flow rates and will vary depending on supplier and across the UK.

Controlled, fixed flow oxygen can be provided by a venturi mask but where a variable flow is acceptable, nasal cannulae are more discreet and have less impact on communication and eating or drinking. Psychological factors should also be considered such as the impact on self-image and burden of care.[246] Other devices such as the oxyarm have been developed but have not been found to be preferred by patients. Oxygen conserving devices can be integral or separately attached to the oxygen source, delivering pulsed oxygen on inspiration. Whilst some studies have agreed that these devices can reduce oxygen usage by around 50%, it has also been shown that demand flow oxygen is not as beneficial as continuous flow oxygen during exercise or activity.

In addition, some people, especially those who mouth breath may have difficulty triggering the devices and therefore an ambulatory assessment should be carried out before it is recommended.[261] There is no evidence for the use of conservers overnight.

Backpacks and trolleys can be provided by the oxygen provider and are likely to improve compliance with ambulatory oxygen therapy, although people may prefer to source their own bag or carrier.[246]

Humidification devices are available for static sources of oxygen supply by bubbling oxygen through the sterile water. Despite the view that humidification will be helpful in the presence of excessive thick secretions, there is no evidence to support this other than when oxygen is supplied via a tracheostomy.

Good practice points

- The oxygen equipment provided to the patient will be considered in order to meet the individual requirements of their prescription and to suit their lifestyle and preferences.
- Conserving devices should be considered in order to reduce the oxygen usage and extend cylinder life. The patient will require and assessment for this.
- Equipment to carry oxygen equipment should be provided and is likely to improve compliance.
- Humidification may not be helpful.

10. Non-invasive ventilation

10.1 Introduction

Non-invasive ventilation (NIV) refers to the mechanical augmentation of minute ventilation. It is a flexible form of ventilation, which can be used continuously, at night or intermittently for specific treatments in the day as indicated by clinical status. NIV use in CF was first described in the management of severe life threatening respiratory failure. Reports described its ability to achieve adequate oxygenation without exacerbation of hypercapnia, for improvement in the symptoms related to hypercapnia, and for those able to be discharged, a decrease in inpatient hospital days. As a consequence NIV has become an accepted tool as a bridge to transplantation in CF clinical practice.[273,274]

Depending on local expertise physiotherapists may be involved in the assessment, set-up of equipment and monitoring of NIV. If appropriate expertise is available, it can be provided on the CF ward and also in the community.[275]

10.2 NIV for airway clearance

The use of NIV to augment airway clearance techniques is now becoming an established treatment option within the UK and is increasingly not limited to patients using NIV for nocturnal ventilation. A Cochrane Collaboration review suggests NIV may be a useful adjunct to other airway clearance techniques in people with CF who have difficulty expectorating sputum.[276] The person with CF will most commonly perform their usual airway clearance technique whilst simultaneously using NIV. A mouthpiece allows easier expectoration, but patients may prefer to use a facial or nasal mask. Careful manipulation of the NIV settings responding to patient feedback is key, and it is likely settings will differ from those used for nocturnal ventilation.

Use of NIV as an airway clearance adjunct has been investigated in two adult trials using patients with an acute exacerbation[277,278] and one paediatric trial including stable patients.[279] These studies all investigated short-term effects following one or two treatment sessions. One adult study has also investigated daily NIV usage over one inpatient admission for an acute exacerbation.[280] All studies demonstrated a reduction in fatigue following treatment with the addition of NIV compared to control. Positive effects were also demonstrated for respiratory rate, respiratory muscle strength, FEV_1, FEF_{25-75} and oxygenation.[277,279,280] No study demonstrated superiority of treatment with NIV in terms of sputum volume produced.

One long-term study of 14 adults with CF investigated the effect of the addition of NIV to home airway clearance techniques in those not already using NIV for nocturnal ventilation. All participants in this study had previously found positive benefit from the addition of intermittent positive pressure breathing as an inpatient. Significant improvements were reported for ease of clearance and breathlessness comparing visual analogue data before and after the addition of NIV. There were also non-significant trends to reduced hospital admission and increased home intravenous antibiotic use comparing data from one year pre/post addition of NIV to an established air way clearance regime.[281]

The importance of personal preference for all airway clearance interventions is well established. Both short and long-term studies have indicated patients had a preference towards treatment with NIV.[277,279,281]

All these studies had some methodological flaws and were limited by low patient numbers. It is therefore difficult to draw robust conclusions about the efficacy of NIV in this context. There is also limited evidence to guide practitioners as to which people might benefit most from this intervention and no study has compared the effects of NIV supported airway clearance with oxygen-supported clearance in those who desaturate. Further robust research into the use of NIV as an adjunct to airway clearance will help to fully identify short and long-term benefits and possibly guide patient selection.

10.3 NIV for exercise

Clinically NIV has been reported to be used during exercise to decrease dyspnoea, improve oxygenation and ultimately improve exercise tolerance in those patients with advanced respiratory disease.[282,284] One randomized control study involving 13 paediatric CF participants (aged 7-16), compares the effect of no NIV and use of NIV on 6-minute walking distance on a treadmill.[283] The results show some improvement in distance completed, improved pulmonary function results (FEV_1 and FVC) and less reduction in post-test peripheral oxygen saturation when NIV was used.

There is a need however for further research into the benefits of NIV for people with CF with reduced exercise tolerance.

10.4 NIV for respiratory failure

Worsening hypercapnic respiratory failure, as a marker of pulmonary deterioration, has been strongly linked with reduced survival.[248,250,258] The prevention of the physiological, psychological and metabolic effects of sustained hypercapnia and acidosis[251] by the early application of bi-level ventilatory support may be beneficial.

NIV has become established as part of clinical practice as a tool for bridge to transplantation in adult patients with severe life threatening respiratory failure.[273,274] Reports are now emerging describing its use beyond a bridge to transplantation in those with established chronic hypercapnic respiratory failure.

A retrospective report of 20 years NIV clinical practice in 47 people with CF demonstrated that half of those treated with long-term NIV were not on the transplant list. The data suggested that in this severe CF population NIV initiation and long-term use may have contributed to a slowing or reversal of lung function decline.[282] A matched case control study in 12 adult CF participants with chronic hypercapnic respiratory failure demonstrated a survival benefit and a decrease in the number of exacerbations for those established on NIV compared to those who continued with long-term oxygen therapy (LTOT).[284]

Whilst certain inferences on the effects of long-term NIV in chronic hypercapnic respiratory failure are impossible without control group comparisons, the continued emergence of such observational data means that randomised placebo controlled trials of long-term NIV in this group would have substantial ethical challenges. There are no studies exploring the use of short-term NIV during acute hypercapnic respiratory exacerbations.

10.5 NIV for nocturnal hypoventilation

Three adult randomised controlled trials in a total of 27 participants assess the use of NIV for nocturnal hypoventilation.[251,270,285] These show in single night studies that both NIV and oxygen therapy can correct nocturnal desaturation. Compared to oxygen therapy NIV attenuates increases in hypercapnia during sleep.[251,270] When used over 6 weeks, NIV improved chest symptoms, exertional dyspnoea and peak exercise capacity compared with placebo.[285] There are variable reports on personal tolerance and preference for oxygen therapy or NIV. Further research is required to understand the individual's experience of NIV use.

10.6 NIV provision

A recent review of NIV in CF highlights important considerations around NIV use.[286]

- Skilled introduction, careful physiological monitoring and education of patient and nursing staff.
- On-going careful re-evaluation as the clinical condition changes, during initial admission and all subsequent admissions.
- Skilled personnel who are familiar with the different properties of the ventilators and interfaces available to them.
- The provision of 2 ventilators and battery support to those using NIV for more than 16 hours out of 24.
- The use of humidification.
- The availability of different ventilator and interface options.

People with CF should have access to comprehensive ventilatory support provided by skilled personnel, who may be a physiotherapist, with access to various ventilator and interface systems keeping abreast of technology as developments occur. There is no published evidence addressing infection control issues specifically in relation to NIV.[275] Nonetheless, equipment used in delivering NIV may be exposed to potentially infectious material during routine use through contact with the patient's skin, mucous membranes and respiratory secretions.[275] Where possible single use equipment is encouraged and appropriate decontamination of all other component parts taken between patients.

Good practice points

- As NIV is often used in advanced disease, appropriate radiological investigations and medical review will have been undertaken prior to commencement of therapy to ensure the presence of an undrained pneumothorax or other contraindications are excluded.
- Appropriate monitoring and review will be carried out during the use of NIV to ensure optimal therapy is applied.
- A selection of ventilators, interfaces; mouthpieces, nasal pillows, nasal masks, full face masks and total face masks should be available and used appropriately according to individual assessment.
- Hospital policies to reduce the likelihood of cross-infection must be developed in conjunction with local infection control teams.
- NIV may be used to facilitate airway clearance and for ventilatory support in both adults and children.
- If nocturnal ventilation is indicated, prior use of NIV for airway clearance may help reduce patient anxiety and ease the process of initiation due to patient familiarity with the device.
- NIV may be considered for use during exercise where dyspnoea or oxygenation limits activity despite optimal regimen and oxygen therapy. Use of NIV during exercise should be monitored carefully as little is known about the outcomes of this intervention.

Recommendations

- NIV should be considered for all people with CF demonstrating nocturnal hypoventilation with a rise in PCO_2 despite optimal treatment *(QoE – moderate*).
- NIV should be considered for those in ventilatory failure in terms of improved oxygenation, improved clinical stability or control of symptoms related to hypercapnia *(QoE – moderate*).
- NIV should be considered if fatigue is limiting airway clearance (*QoE – low*).
- NIV should be considered as an adjunct where desaturation is present during airway clearance (*QoE – very low*).
- NIV should be considered where there is difficulty clearing secretions with other techniques (*QoE – very low*).
- NIV-supported exercise could be considered in those with chronic hypercapnic respiratory failure established on long-term NIV to help increase exercise tolerance (QoE – very low).

11. Musculoskeletal and postural issues

With an aging CF population and ever-increasing life expectancy, MSK problems specific to the disease process occur in addition to those of the general aged matched population.[287] The combination of abnormal respiratory mechanics, reduced bone mineral density (BMD) and reduced muscle mass in CF lead to a high incidence of MSK pain, fractures and postural changes.[104,187,287-291] These secondary complications contribute to the overall morbidity and mortality of the CF population.[187,289,293]

11.1 Posture and thoracic kyphosis

The muscles of the trunk have a dual role for respiration and posture.[104,294,295] To illustrate this relationship in CF it is useful to refer to the 'Soda-Pop Can Model of Postural Control and Respiration' proposed by Massery.[187] If breathing is compromised, the postural response and capability of the trunk muscles will be reduced in order to focus on the needs of respiration.[187,296] This altered neuromuscular control may compromise spinal stability leaving the spine vulnerable to injury and lead to postural adaption[187,195] and MSK problems.[187,195,292,296,297]

Increased thoracic kyphosis is a common postural change in CF and occurs as a result of altered respiratory mechanics (altered neuromuscular control, increased work of breathing, hyperinflation and an excessive, prolonged cough) and low BMD.[104,187,293,298] In addition, sitting in slouched postures, an inability to lie in thoracic extension and pain, may further contribute to the problem [(293)]. Studies have shown that prolonged coughing and accessory muscle use will lead to shortening of the trunks anterior myofascial structures resulting in a muscle imbalance with the posterior structures.[187,298,299] Postural changes and tightening of the pectoralis muscles have been noted in children from the age of seven[298,300] and MSK problems begin to present during the pre-pubescent years and are present by puberty.[187]

The association between worsening severity of CF lung disease and increasing thoracic kyphosis has been found in many studies but is not universally agreed.[293,298,301-303] A recent study concluded that thoracic kyphosis is now considered to be uncommon in children with a mean FEV_1 of 93% but its development is in part related to deteriorating lung function.[304]

Lack of clarity in the literature about thoracic kyphosis measurement taken in habitual or corrected postures and the method of assessment used, make studies difficult to compare.[305] The current gold standard method for measuring thoracic kyphosis is a standing lateral radiograph, which provides a Cobb angle. This method does have limitations of high cost, exposure of the patient to radiation and often fails to represent the full contour of the thoracic spine.[305] Thoracic kyphosis can also be measured with the Flexicurve.[287] This device is a useful tool in clinical practice as it is inexpensive, easy to use and in the general population has high levels of reliability and validity.[287,305] In the general population, gravity-dependent inclinometers are also reliable instruments for thoracic kyphosis measurement.[305]

An improvement in posture is considered important in the CF population to prevent pain and deterioration and to address the poor body image and reduced self-confidence that people report when they acknowledge that their posture is poor.[287,293]

11.2 BMD and fracture

The reasons for low BMD in CF are multifactorial[288,306,307,308-310] and problems start during childhood and puberty, when people with CF achieve approximately half of the bone density of their healthy counterparts.[311] Bone loss is most often observed in the peripubertal age range of 8-10 years and by young adulthood the prevalence of osteoporosis is 23.5% and osteopenia is 38%. Puberty is especially important for the development of bone density and is a time where there is both peak bone growth velocity and bone density accrual.[313] Therefore, during childhood and the pubertal growth spurt, regular weight-bearing exercises are particularly important and continue to be recommended throughout the patient's lifespan.[314]

Fracture rates are higher in the CF population[312,315] and there is evidence of under reporting.[288,299] Vertebral fractures are most common at the thoracic level[312] and when present may contribute to the development of an increased thoracic kyphosis. Patients with painful rib or vertebral fractures should receive adequate analgesia and physiotherapy advice as a priority, to enable chest expansion and airway clearance. Also, intravenous antibiotics and additional mucolytic therapies may be required.[313]

11.3 Pain

Pain in CF is associated with reduced quality of life and has a negative impact on the ability to participate in disease related daily care.[289] An evaluation of 'patient reported quality of life' found physical functioning and pain were the strongest predictors of survival in CF.[289] A study looking at pain in CF found a high incidence of undertreated pain in people with CF throughout their lives, with 59% of children and 89% of adults reporting at least one episode of pain in the previous month.[311] Studies show that the incidence of MSK pain ranges from 12% to 61% and back pain from 15% to 70%.[289] One adult centre recently reported that 36% of people with CF had MSK pain and that spinal pain was associated with a significant postural component.[290]

Back pain in the general population has been shown to compromise the recruitment of the spinal stabiliser muscles,[316] which in the CF population will further reduce the capability of these muscles to provide adequate postural support and will in turn impact on airway clearance, ability to exercise and lung function.

Persistent (chronic) pain, including chronic back pain has been reported in the CF population.[303] A review of chronic pain is beyond the scope of these guidelines but multidisciplinary team involvement or a referral to a specialist pain team should be considered best practice, to manage the multidimensional aspects of chronic pain.[317]

11.4 Other problems

Arthritis has been recognised as a complication of CF and it is evident that it will become more common as patients live longer.[308] Episodes of joint pain (arthralgia) are well-recognised in CF, usually starting after 10 years of age, and occurring in about 5-10% of patients. Episodic arthritis (EA) or CF-related arthropathy, and hypertrophic pulmonary osteoarthopathy (HPOA) are reported but clinical manifestations are not consistently described in the literature. Systemic diseases have been reported in association with CF including rheumatoid arthritis and sarcoidosis, but whether the associations are co-incidental or not remains unclear.[288] When inflammatory joint disease is suspected, a referral to the medical team should be made and a low threshold for referral to a rheumatology specialist should be considered.[317]

Scoliosis is not common in young children with CF, but the incidence is significantly higher in adolescents than in the general population and is associated with a negative effect on lung function.[300, 318, 319]

11.5 Screening and prevention of MSK dysfunction

Postural changes have been noted in children from the age of seven[298,320] and MSK problems are present by puberty.[187] It has been suggested that children as young as pre-school should receive regular screening for spinal or other postural abnormalities, to minimise or potentially prevent secondary MSK impairments.[187]

MSK screening tools have been developed that aim to pro-actively identify problems and facilitate early intervention.[288,321,322] A thoracic spine movement screen, questions about pain and posture and a validated pain questionnaire, allow clinicians to select the appropriate care pathway for optimal patient management.[321,322]

Posture assessment cannot be considered in isolation from movement and muscle activation[316] and should be individualised.

11.6 Treatment

The previous clinical guidelines (2008) noted an increasing body of evidence demonstrating the role of physiotherapy MSK techniques for the prevention and management of non-inflammatory pain and postural changes, in both adults and children with CF.[187,193,299,323,324] A recent RCT provided 6 weekly sessions (up to 45 minutes) of MSK treatment (joint mobilisations, techniques to address muscle dysfunction/ tightness, postural awareness and education based on the Alexander technique), and demonstrated an improvement in thoracic kyphosis.[287]

A study of 34 children and adolescents, demonstrated an improvement in posture following a three month programme of aerobic physical exercise and stretching exercises. This study could not state which part of the intervention was the most effective.[298] Payne et al[323] found that in children the incidence of postural problems was directly related to the amount of regular exercise taken: 90% of children with postural issues reported doing little or no exercise. Both studies suggest that exercise should be incorporated into lifestyle from an early age.

Changes in posture and thoracic kyphosis are achievable in patients with CF. However, a stretching programme of the muscles most commonly affected in CF may not be sufficient to address the multifactorial nature of altered posture.[293] In the general population there is also no consensus on the most effective methods to achieve a change in posture but cognitive learning, manual techniques and exercise are recommended.[316]

Good practice points

- All patients should have an annual MSK screen from age seven (earlier if necessary):
  - to proactively identify postural problems;
  - to ask about pain (including MSK pain).

The Manchester Adult MSK screening tool (Appendix VII) provides a validated outcome measure for pain assessment and includes a matrix to signpost appropriate care pathways for those people with CF who have problems with pain or posture.[319,320]

- Children and adults should be offered advice on how to develop postural awareness and encouraged to create habits that will maintain optimal posture and muscle balance.
- Exercise should be encouraged to help improve posture and prevent the progression of postural problems.
- Regular weight-bearing activities should be encouraged to optimise bone mineral density.
- Individual ergonomic advice should be given to all patients and should encompass advice for home, school, the workplace and other daily activities.
- Patients should be made aware that they can seek advice about posture, pain and MSK issues. When MSK problems or acute injuries occur, prompt assessment and treatment to enable a timely return to daily activities, sport and exercise should be given.
- If necessary, early referral to a physiotherapy MSK specialist is recommended to provide optimal and individually tailored management.
- When required, referrals should be made to a rheumatology or pain specialist to provide optimal patient management.

Recommendations

- MSK intervention and postural advice should be considered in all patients (*QoE – low*).
- All patients should have at least an annual MSK screen from age seven years (*QoE – low*).

12. Management of specific issues

12.1 Urinary incontinence in CF

Urinary incontinence (UI) is well recognised as being more prevalent in women and girls with CF than the healthy population.[325-334] Onset of UI has been reported in girls as young as 11 years.[330] Symptoms of UI in males with CF do occur, but to a lesser degree than in females.[335] A recent study reports increased incidence of UI in males with CF aged 18-50 when compared with age-matched controls.[335] This was associated with higher levels of anxiety and depression.[336]

Tolerance of symptoms may result in under-reporting of UI[325,326] although the impact of UI on quality of life is reported to increase both with age and severity of symptoms.[332]

Vigilant and sensitive surveillance for UI is recommended.[325-327]

The risk factors associated with UI in people with CF are multi-factorial and may include poor nutritional status in younger people,[331] imbalance of the muscles of respiration, posture and continence and increased intra-abdominal pressure associated with persistent cough and constipation.[336]

Cough is the most commonly reported cause of UI and symptoms are associated with forced expiratory manoeuvres. Individuals with CF and UI may be reluctant to perform airway clearance treatment and lung function procedures effectively due to the increased risk of urinary incontinence. The occurrence of UI seems to increase at times when cough is worse such as during a chest exacerbation. The amount of leakage reported varies

greatly and can be a few drops to emptying the full bladder.[327] The occurrence and severity of UI increases as disease progresses.[326,327]

Analysis of scores from a musculoskeletal screening tool that uses validated questionnaires to assess pain and UI demonstrated an association between the presence of low back pain and symptoms of UI in females with CF.[338]

Three studies have addressed the assessment and treatment of the pelvic floor muscles.[339-341] An improvement in pelvic muscle endurance was reported following a three-month programme of pelvic floor exercises in a small self-selected group of CF female adults.[339] A three-month intervention of pelvic floor muscle training, electrical stimulation, biofeedback and bladder training resulted in reports of significantly fewer episodes of leakage and an improvement in electromyography and ultrasound imaging measures.[340] Tension-free vaginal taping has also been reported as a safe and effective solution for stress incontinence in a very small sample of women with CF.[341]

An abstract report describes improvement in symptoms of both back pain and UI reported by adult females who were taught pelvic floor muscle exercises.[338]

Good practice points

- A sensitive and open approach with early recognition of symptoms will be adopted for both males and females with CF.
- People with CF should be taught controlled and effective coughing during airway clearance.
- The 'knack' (a quick, voluntary contraction of pelvic muscles to help prevent urine leakage during a rise in intra-abdominal pressure) may be a useful technique to use before coughing or performing forced expiratory manoeuvres.
- The Manchester Adult MSK screening tool provides a validated outcome measure to assess symptoms of UI and includes a matrix to signpost appropriate care pathways for those people with CF in whom leakage is identified.[321,320]

Recommendations

- Physiotherapists should include enquiry about presence of UI symptoms as a routine part of assessment from the age of 11 (*QoE – high*).
- Both preventative and active strategies for the management of UI should be adopted (*QoE – low*).
- Referral to a specialist physiotherapist should be considered in those with symptoms of UI (*QoE – very low*).

12.2 Pregnancy

CF teams are now more frequently required to support women with CF through one, if not multiple pregnancies, as part of routine CF Centre care. Pregnancy is well-tolerated in women with CF with a good health status at baseline (FEV_1>60% predicted) and this is associated with a lower risk of developing complications during pregnancy, delivery and post-partum.[342,343,346,348-350] Many women however do experience difficulties in maintaining stability of their health during this time and pre-pregnancy risk factors for this include diabetes, inadequate nutrition and poor or declining lung function.[347] Due to the potential complications, wherever possible pregnancies should be carefully planned, with genetic counselling, optimisation of health pre-conception and close monitoring during and after pregnancy in order to detect any decline in health status.[343] Treatment for decline in lung function or nutrition should be proactive during and after pregnancy to ensure the best outcome for both mother and baby.[343] Relatively little data exists regarding the outcome for mothers and almost none on the outcome of infants beyond the neonatal period.[346]

One study examined the long-term effects on mothers up to 11 years after pregnancy and showed pregnancy and motherhood do not appear to accelerate disease progression but lead to more illness-related visits, pulmonary exacerbations, and a decrease in some domains of quality of life.[349] However, a retrospective review of pregnancies over 10 years at one UK CF Centre showed moderate falls in lung function immediately after delivery, which persisted at 12 months postpartum.[351]

There are no prospective studies evaluating physiotherapy interventions during pregnancy. However, pregnancy has a significant impact on respiratory status and physiotherapy requirements are likely to change throughout the antenatal period.[342,344,345] It has been suggested that patients with an FEV_1<60% are more likely to need frequent changes in their airway clearance techniques and may require the addition of positive pressure during hospital admission to enhance airway clearance technique effectiveness and reduce work of breathing.[345] As the pregnancy progresses a reduction in functional residual capacity causes early airway closure into closing volumes and may lead to a risk of hypoxia and impaired secretion clearance due to atelectasis.[343] Proactive monitoring and escalation of treatment strategies with a low threshold for positive pressure (such as NIV and intermittent positive pressure breathing) may help to minimise these risks.

Additional nebulised medications are commonly utilised during pregnancy when the use of systemic preparations is limited by concerns about possible teratogenicity. Proactive use of mucoactive agents such as RhDNase, hypertonic saline and inhaled dry powder mannitol will help to optimise airway clearance when it is limited by physiological changes. The CF specialist physiotherapist is well-placed to support the pregnant woman with CF in planning the support and care they will need post-delivery. Completing airway clearance and nebulised medication is essential to stabilise and improve pulmonary function once the baby has arrived however; it can be the most challenging time as the CF mother will be torn between doing treatment and tending to her

child. Pregnant women should be advised to modify their exercise programmes to avoid contact sports and reduce overheating and dehydration that can occur. Walking, swimming and prenatal yoga are recommended forms of exercise that can be utilised to maintain fitness levels during pregnancy.

Good practice points

- Airway clearance techniques and inhalation therapy will be reviewed regularly throughout pregnancy and modified as necessary.
- Several different techniques used alone or in combination may be introduced to maximise ventilation and utilise lung volumes that could be compromised by the growing baby.
- The abdominal muscles are progressively stretched during a pregnancy and can become separated down the midline (diastasis–rectus abdominus). If mechanical pain or muscular herniation occurs, a stabilising binder can be useful.[343]
- Positioning for airway clearance will require modifications potentially from an early stage in the pregnancy when nausea can impact on chest clearance and sitting, standing and head-up positions should be considered.
- Gastro-oesophageal reflux should be identified and treated if present.
- Proactive use of mucoactive agents such as RhDNase, hypertonic saline and inhaled dry powder mannitol will help to optimise airway clearance when it is limited by physiological changes.
- The importance of pelvic floor exercises should be stressed, and the 'knack' taught, to be used preceding any forced expiratory manoeuvres.
- If on the rare occasion the patient becomes more unwell towards or during the delivery period, NIV can be used to support ventilation.
- Advice should be provided for managing treatments post-partum including; structuring family assistance, combining treatments (e.g. hypertonic saline and PEP), using nap times for airway clearance and planning who can clean equipment.
- Physiological and mechanical changes encountered during pregnancy affect the breathing pattern and some women may benefit from help to differentiate between the dyspnoea that occurs during respiratory exacerbations that require treatment and normal "physiological" breathlessness of pregnancy, the management of which should be taught early.[343]
- Nasal obstruction may occur during pregnancy due to the increased amount of blood flowing through the body causing mouth breathing and/or snoring. Effective sinus management should be is taught using saline spray or nasal lavage.[343]
- Pregnancy in people with CF post-transplant usually require little physiotherapy input but the physiotherapist will have a role in monitoring for signs of possible infection or rejection episodes, and maintaining posture, mobility, pelvic floor and physical strength. The patient still has their own upper airways and nasal obstruction or sinus infections may occur.[343]

Recommendations

- Airway clearance techniques will continue throughout pregnancy and be regularly reviewed and modified as pregnancy progresses with consideration to the degree of breathlessness and discomfort (*QoE – very low*).
- Pregnant women should be familiar with using a fast and intelligent nebuliser system. This is good preparation for the post partum period where time can be limited when caring for the newborn child (*QoE – very low*).
- All patients should be given postural awareness advice, strengthening and stability exercises for the lumbosacral and pelvic floor regions. Onward referrals to musculoskeletal and women's health services for further input should be completed as appropriate (*QoE – very low*).
- Proactive assessment for ambulatory oxygen desaturation is recommended and supplementary oxygen can be utilised to avoid drops (maintain SpO_2 >90%) in foetal oxygen delivery (*QoE – very low*).

12.3 Liver disease in cystic fibrosis

Cystic fibrosis-associated liver disease affects up to 33% of people with CF and is the most common non-pulmonary cause of mortality.[352] Almost all cases present in the first two decades of life with a peak incidence in adolescence.[354] There is a marked variation in presence and severity of disease and it is only a significant clinical problem in a minority. Cystic fibrosis-associated liver disease affects males:females in a ratio of 2:1. There is a four-fold risk of developing cystic fibrosis-associated liver disease in cases of meconium ileus.[355] No specific genotype/phenotype connection has been identified as being associated with cystic fibrosis-associated liver disease.[356]

Most cases of cystic fibrosis-associated liver disease are detected on routine screening. Cirrhosis with secondary portal hypertension is rare, and only a small proportion present with variceal bleeding, ascites or persistent jaundices.[317] Liver transplantation may be considered in end-stage liver disease. A recent review following liver transplantation in adults with CF gave survival figures of 80%, 74% and 67% at 1, 3 and 5 years respectively. Paediatric patients had a slight survival advantage over adults (P=.08).[353]

There is no data examining the efficacy of physiotherapy interventions in patients with cystic fibrosis-associated liver disease; however, it is recognised that massive splenomegaly can cause significant abdominal discomfort, gastric compression leading to impaired nutritional intake and impaired diaphragmatic function causing dyspnoea.[317] Physiotherapy would therefore be focussed on symptom management and safety when considering airway clearance and exercise opportunities.

Good practice points

- Abdominal distension due to hepatosplenomegaly or ascites may restrict diaphragm excursion and cause basal atelectasis. In these circumstances, supine positioning should be avoided; airway clearance techniques may be more comfortable and effective in an upright position.
- Contact sports should be avoided in those with hepatosplenomegaly.
- Physiotherapists should work closely with dietitians to optimise nutritional status to allow the patient to remain as active as possible and to exercise effectively.
- In the presence of abnormal clotting, manual techniques should be avoided.
- Deficiency in regulatory mechanisms result in derangement in the extracellular fluid volume, and may lead to ascites, oedema or pleural effusion.[357] Careful attention to positioning for airway clearance and during exercise is important.
- In the presence of active variceal bleeding, physiotherapy may need to be discontinued or carried out with extreme caution.
- Intensification of airway clearance (including treatment during anaesthesia) may be required if repeated anaesthetics are required for monitoring and management of oesophageal varices.
- Anaemia should be considered as a cause of breathlessness when carrying out respiratory assessment and anaemia may affect ability to exercise.
- In those with hepato-pulmonary syndrome, monitoring of oxygen saturations SpO_2 during exercise and any physiotherapy interventions is important.

12.4 Haemoptysis in cystic fibrosis

Haemoptysis is the expectoration of blood from the airways and occurs in approximately 60% of patients with CF, with the median age of the first episode occurring between 18 and 30 years of age.[358,359] Major haemoptysis occurs in approximately 1-4.1% of all patients with CF and is more frequent as their disease progresses.[358-360] It is rarely seen in children younger than 10 years.[358,359]

The bleeding site usually arises from a bronchial artery, but many reports have also suggested aberrant origin of the haemorrhage from non-bronchial collateral vessels or from anastomosis between bronchial and non-bronchial circulation.[361] The pathogenesis of haemoptysis has been attributed to the persistent inflammation of the airways and vascular growth, which results in hypertrophied bronchial arteries.[360,362] Chronic and acute inflammation weakens the vessel walls and often leads to episodic or persistent bleeding into the bronchial lumen.

Rigid bronchoscopy can be performed as a diagnostic measure in identification of the bleeding vessel, however, there are some limitations to this and unless the vessel is bleeding at the time of bronchoscopy it is often difficult to localise. CT bronchial arteriogram is used to identify which vessels would benefit from bronchial arterial embolisation (BAE) and CT was shown to have a high sensitivity when compared to bronchoscopy for diagnosing bronchial arterial abnormalities.[363]

The estimation of volume of blood expectorated is challenging and often can be under or overestimated.[364] Much of the literature considers the definitions of haemoptysis as follows:

- Mild haemoptysis >5mls <50mls in 24hr
- Moderate haemoptysis >50mls <250ml in 24hr
- Massive haemoptysis >250ml in 24hr

Mild haemoptysis or blood streaking within expectorated sputum is commonplace and often associated with pulmonary exacerbation. Generally, this is self-limiting and responds to a course of antibiotic therapy. Other medical treatment options suggested are vitamin K, blood replacement and the use of tranexamic acid.[359,365,366] In the event of a massive haemoptysis, BAE is an accepted and effective method of controlling the bleeding.[361]

There are no published studies regarding the physiotherapeutic management of haemoptysis. North American guidelines[366] based on a Delphi consensus provide some guidance. Whilst there was no representation from physiotherapy on the expert panel, these guidelines include recommendations regarding physiotherapeutic strategies for managing haemoptysis. There is no evidence to indicate that alteration in treatment strategies is necessary when mild haemoptysis has occurred, and there is good consensus to suggest that stopping airway clearance is inappropriate.[366]

It has been suggested that enhanced airway clearance to aid the removal of purulent secretions contributing to the pulmonary exacerbation may be beneficial.[365] In the management of moderate haemoptysis, modification of physiotherapy is prudent. In theory, positive pressure treatments may aggravate friable vessels and consideration should be given to discontinuing these in favour of more controlled breathing techniques such as ACBT or AD. Percussive devices and oscillatory devices should also be used with caution.

There are fears that airway clearance therapies may dislodge a clot and exacerbate bleeding but this is unlikely, and if bleeding is related to the underlying infection and inflammation, clearance of airway secretions is an important component of care.[365]

There should be consideration for temporarily ceasing all airway clearance in the event of massive haemoptysis,[366] with continual assessment and review being maintained. There is also strong consensus regarding the recommendation to withhold NIV in the event of massive haemoptysis in many circumstances.[366] The use of hypertonic saline and RhDNase has been suggested to present a risk, although this remains unproven. Hypertonic saline might be considered more of a risk due to potential to irritate the airways and provoke cough, and there is strong recommendation to consider stopping this in the event of massive haemoptysis.[366] These guidelines also suggest that the benefit of continuing other inhaled therapies outweighs the risks, and therefore should only be withheld if they seem to exaggerate or provoke bleeding.[366] Flume[365] found a decreased incidence of haemoptysis in patients who were using RhDNase.

There is a lack of published studies regarding exercise following haemoptysis. The recently published 'Exercise and habitual physical activity guidelines', [367] based on the results of a worldwide informal survey, recommend ceasing exercise following moderate or massive haemoptysis, resuming a gradual exercise programme following 24-48 hours of no new bleed.

Good practice points

Moderate haemoptysis

- Avoid the use of positive pressure techniques (internal, external or oscillatory) for 24-48 hours post bleed.
- Consider airway clearance techniques such as ACBT or AD.
- Careful positioning (high side lying bleeding side down).
- Minimise vigorous or excessive coughing.
- There is no evidence to support the cessation of inhaled therapies, which could potentiate coughing, but this should be assessed on an individual basis.

Massive haemoptysis

- Optimise oxygen and humidification.
- Following embolisation and in liaison with interventional radiologist resume normal airway clearance and exercise management.

Recommendations

- For mild haemoptysis there should be no immediate change to airway clearance, exercise, NIV or inhalation therapies (*QoE – low*).
- For moderate haemoptysis vigorous exercise should be ceased for 24-48 hrs (*QoE – low*).
- For massive haemoptysis airway clearance, vigorous exercise and NIV should be temporarily ceased (*QoE – low*).
- Consider stopping hypertonic saline (*QoE – low*).
- Continue other inhaled therapies unless they appear to aggravate or provoke bleeding ; then they should be temporarily ceased and re-assessed once bleeding settles (*QoE – low*).

12.5 Pneumothorax in cystic fibrosis

Spontaneous pneumothorax is defined as the presence of air in the pleural cavity, and is frequently considered a poor prognostic indicator, with the average survival rate of 24-30 months following the initial episode.[365,366,368-370] A recent small paediatric study suggested this survival rate to be slightly better at 48 months.[371]

The annual incidence of spontaneous pneumothoraces in patients with CF is approximately 0.64% (1 in 167 patients),[365,366,372,373] with the average age of incidence being 23 years of age.[194] Flume[365] found that 75% of patients experiencing a pneumothorax had an FEV_1 of <40% predicted. Specific pathogens and nebulised therapies have been linked to an increased risk of pneumothoraces, however it is more likely that their presence reflects the severity of the airways disease and airflow limitation.[374,375]

The primary goal for the medical management of pneumothoraces is to re-expand the lung and to prevent recurrence, as recurrence rates in CF patients are high (20-75% of patients) and therefore more aggressive management is justified in this population.[366,376-379] Medical management includes chest drain insertion, high-flow oxygen therapy and chemical or surgical pleurodesis. Surgical pleurodesis or pleural abrasion using video-assisted thoracoscopic surgery (VATS) appears to be the most effective management option.[365,366,368] Pleural procedures, including pleurodesis, do not have a significant adverse effect on the outcome of later lung transplantation.[370]

In addition, it is suggested that supplemental oxygen at high flow rates generates a partial pressure gradient between the pleural cavity and end capillary blood by decreasing the partial pressure contribution of nitrogen, theoretically increasing the reabsorption of gas from the pleural cavity. Increased rates of reabsorption whilst on oxygen were demonstrated, in a small prospective study of 10 patients, which extended into the paediatric age range.[371]

There are no published studies on the physiotherapeutic management of pneumothorax in the CF population. There are however two recently published guidelines that provide some recommendations regarding physiotherapy interventions. These have been based on results of a worldwide informal survey regarding exercise management[367] and expert opinion by a Delphi consensus regarding airway clearance techniques, NIV, inhaled therapies and general activities;[366] however, the latter did not have physiotherapy representatives on the expert panel.

Flume et al[366] highlight that it is generally considered appropriate to continue airway clearance. Reducing airway obstruction by clearing mucus may aid resolution and/or prevent any worsening of the pneumothorax. Withholding positive pressure techniques is strongly recommended due to risk of progression of the pneumothorax. Whilst it did not reach good consensus, there is suggestion that when a chest drain is in situ this may not be necessary in all circumstances. There is also strong recommendation to withhold NIV in most circumstances, with appropriate high level care settings utilised where ventilatory support remains a necessity. Whilst there is no evidence or strong recommendation on the use of inhaled therapies with pneumothorax it is considered inappropriate to stop treatments in most circumstances.

The guidelines do not address exercise whilst a pneumothorax remains evident but do provide recommendations for the acute recovery period. Flume et al[366] highlight good consensus on the recommendation to avoid activities for two weeks post-resolution that may increase intrathoracic pressure, such as lifting weights and spirometry, with some consensus on the avoidance of rigorous activities. Swisher et al[367] also recommend avoidance of lifting weights of more than 5lb or activities that produce the Valsalva manoeuvre for two weeks post-resolution. These guidelines also recommend airways clearance prior to exercise to minimise coughing which has been associated with pneumothorax.

Good practice points

- Patients should be advised and taught how to avoid paroxysms of coughing.
- Ensure appropriate and adequate hydration to ensure mucus is readily expectorated.
- Ensure appropriate analgesia and enable the maintenance of thoracic expansion.
- Encourage gradual cardio-vascular exercise.
- Gradual re-introduction of therapy techniques using positive pressure when patient resumes manoeuvres such as respiratory function testing. This has been suggested at 2 weeks as a minimum, but there is no literature to support this.
- Scuba diving should be avoided permanently and there should be caution around high altitude activities following a pneumothorax.

Recommendations

- Airway clearance should be continued, with avoidance of techniques that increase positive pressure in favour of more controlled techniques (e.g. ACBT, AD) (*QoE – low*).
- NIV should be withheld or in circumstances where ventilatory requirements are such that it cannot be withheld, close monitoring in high-level care settings should take place (*QoE – low*).
- Upper limb weight lifting should be avoided for 2 weeks post-resolution and airway clearance is advisable prior to exercise to minimise the risk of coughing during exertion (*QoE – low*).
- Inhaled therapies should be continued, in particular mucolytics to optimise airway clearance (*QoE – low*).

12.6 Critical care

Admission to the critical care or intensive care unit is associated with a poor prognosis in CF. Factors associated with a poor outcome include prior colonisation with *Burkholderia cepacia* complex, rapid decline in FEV_1 and severe exacerbation.[380] Positive outcomes are associated with potentially reversible conditions such as the acute management of haemoptysis or pneumothorax[381] and post-operative management. Endotracheal intubation (mechanical ventilation) is associated with a poor prognosis.[382,383] However, the outcome of treatment with non-invasive ventilation is good[383,384] and many centres may manage non-invasive ventilation in high dependency or ward areas. Extracorporeal membrane oxygenation is used on critical care as a salvage strategy in patients with CF with respiratory failure and is being increasingly used as a bridge to lung transplantation.[385,386] The use of extracorporeal membrane oxygenation has emerged as a promising intervention that can avoid invasive ventilation and allows patients to eat, ambulate and undertake airway clearance while awaiting lung transplantation.[387-389]

There are no published studies of physiotherapy management of the intubated and ventilated patient with CF. However the NICE guideline, 'Rehabilitation after critical illness in adults', should be adhered to as appropriate[390].

Good practice points

- To ensure optimal management there needs to be excellent communication and liaison between both the critical care and CF physiotherapy teams and the wider multidisciplinary teams.
- The use of timetables to protect airway clearance and rehabilitation time for patients may be beneficial.

Recommendations

- Ensure regular airway clearance is continued, and optimise humidification (*QoE – low*).
- Ensure good positioning for optimal ventilation and drainage of secretions (*QoE – low*).
- During the patient's critical care stay and as early as clinically possible, perform a short clinical assessment to determine the patient's risk of developing physical and non-physical morbidity (NICE guidelines [CG83]) *(QoE – moderate*).
- For patients at risk of physical and non-physical morbidity, perform a comprehensive clinical assessment to identify their current rehabilitation needs. This should include assessments by healthcare professionals experienced in critical care and rehabilitation (NICE guidelines [CG83]) *(QoE – moderate*).
- For patients at risk, agree short-term and medium-term rehabilitation goals, based on the comprehensive clinical assessment. The patient's family and/or carer should also be involved (NICE guidelines [CG83]) *(QoE – moderate*).
- The comprehensive clinical assessment and the rehabilitation goals should be collated and documented in the patient's clinical records (NICE guidelines [CG83]) *(QoE – moderate*).
- For patients at risk, start rehabilitation as early as clinically possible, based on the comprehensive clinical assessment and the rehabilitation goals. Rehabilitation should include:
  - Measures to prevent avoidable physical and non-physical morbidity, including a review of previous and current medication *(QoE – moderate*).
  - An individualised, structured rehabilitation programme with frequent follow-up reviews. The details of the structured rehabilitation programme and the reviews should be collated and documented in the patient's clinical records (NICE guidelines [CG83]) *(QoE – moderate*).
- For patients on extracorporeal membrane oxygenation ambulation and rehabilitation should be completed as able by physiotherapists trained in managing patients on ECMO (*QoE – low*).

Research recommendations

- The heterogeneity and the low number of patients with CF admitted to critical care may explain the reason why there have been no published studies of physiotherapy and/or rehabilitation interventions in this patient cohort. To overcome these methodological challenges, a case series approach (single or multi centre) would be useful to explore the effectiveness of airway clearance and rehabilitation interventions in patients with CF admitted to critical care.

12.7 Pre-transplant rehabilitation (prehab)

The physiotherapy intervention before lung transplant can be a complex balance of airway clearance, inhalation therapy and rehabilitation. The goal of physiotherapy prior to lung transplant is to maintain people with CF in as clinically optimal condition for surgery as is possible, while optimising quality of life.[391]

There are currently no published studies on prehab in people with CF. One study examined pulmonary rehabilitation in people awaiting lung transplant and showed regular exercise is feasible in this low lung function population, however there was only one person with CF included.[392] Pulmonary rehabilitation classes are not possible in CF due to infection control. However, individually tailored exercise programmes to maintain/improve functional capacity, including strength training and flexibility exercises, should be provided to all patients awaiting lung transplant. Interval training and strength training are often better tolerated than continuous aerobic exercise that is limited by breathlessness.

Although the evidence is limited, supplemental oxygen therapy and non-invasive ventilation may facilitate exercise training and allow a better exercise response in patients with severely affected respiratory function.[273,391,392] The use of short- and long-term goal setting with patients is encouraged by clinical experts but there is currently no evidence in CF.

Good practice points

- All people with CF on the lung transplant waiting list should be educated about the benefits of prehab.
- People with CF should have individually tailored exercise programmes that include interval training, strength training and flexibility and these should be reviewed regularly by a physiotherapist or exercise practitioner (as pre-exercise prescription guideline).
- Ambulatory oxygen therapy may be used during exercise following a formal assessment by a physiotherapist demonstrating improvement in exercise performance and or symptoms.[260]
- Non-invasive ventilation can be used to support exercise but settings should be adjusted from baseline settings.
- Short- and long-term goals will be completed with people with CF to facilitate and motivate prehab.

Research recommendations

- Define the rehabilitation needs of people with CF awaiting transplant.
- Define the efficacy of exercise interventions in people with CF awaiting transplant, with regards to the type (endurance, strengthen or combined) intensity, duration and mode of delivery (hospital, community, virtual).
- Evaluate the acceptability and effectiveness of non-invasive ventilation as an adjunct to exercise in people with CF.

12.8 Physiotherapy intervention following bilateral lung transplant

The physiotherapy input following lung transplantation can be extremely varied and diverse and includes the management of the individual in the intensive care unit, on the ward and as an outpatient. Physiotherapy intervention includes treatments to improve functional capacity, muscle strength, joint range of movement and postural alignment.[391] Other musculoskeletal issues may also need to be addressed, along with appropriate short-term and long-term goal setting. Physiotherapy input may also involve respiratory weaning (weaning from a tracheostomy, non-invasive ventilation and oxygen support), liaison with gyms and pulmonary rehabilitation centres, organisation of nebuliser units and preparation for employment or for a major life goal.[391]

The majority of studies investigate the effects of exercise/activity of daily living post-lung transplant and have a mixed patient population, including patients with chronic obstructive pulmonary disease, emphysema, interstitial lung disease, pulmonary hypertension, alpha-1 antitrypsin deficiency.[393-399] These studies included participants with both single and bilateral lung transplant.

A systematic review investigating the effects of exercise training in adults after lung transplantation[396] found 7 studies that fulfilled the inclusion criteria, 2 of which were randomised controlled trials, 4 prospective cohort studies and 1 controlled trial with healthy subjects.[396,398] The majority of the studies investigated aerobic exercise training with 2 studies including resistance exercise and 2 studies investigating the effect of resistance exercise on lumber bone mineral density. Exercise training showed positive effects on maximal and functional exercise capacity, skeletal muscle function and bone mineral density. Aerobic exercise training methods that produced positive effects included treadmill, cycle, arm ergometry and stairs. The review shows evidence that structured exercise training post-transplant could improve maximal and functional outcomes but due to the variety of protocols and outcomes used it is impossible to provide specific exercise training recommendations following lung transplant.[396]

A study investigating exercise performance in people with CF before and after bilateral lung transplant showed exercise capacity improved post-transplant but remained below the aged matched healthy controls.[397] An increase was shown between peak exercise arterial-venous oxygen difference pre- and post-transplantation but was not of statistical significance. The investigators conclude that an impaired oxygen extraction was suggested to be the predominant mechanism limiting exercise capacity after transplantation and that this abnormality could not be solely explained by deconditioning or anaemia.

Good practice points

- Non-invasive ventilation may be needed post-extubation particularly in those who have used it as a bridge to transplant.
- Liaison with the pain management team may be necessary to ensure effective airway clearance and participation in an exercise regimen.
- Due to vagal nerve denervation and impaired cough reflex post-transplant, appropriate airway clearance techniques should be used.
- The use of any positive/negative pressure adjuncts will be discussed with the surgeons before use due to the effect on the bronchial anastomosis.
- An individually tailored exercise programme including cardiovascular and resistance work to improve functional capacity should be introduced in line with the patient's goals. Resistance exercise is important to help combat the effects of the long-term steroids required with the immunosuppression regimen.
- High dose steroid therapy following a rejection episode can increase the risk of tendonitis, tendon rupture and osteoporotic changes. Care must be taken when advising on exercise programmes.
- Liaison with the dietitian to ensure that the exercise programme prescribed does not exceed calorific intake.

Recommendations

- All people with CF should receive a structured exercise programme following discharge from hospital after lung transplant (*QoE – very low*).

Research recommendations

- Define the acute and long-term rehabilitation needs of people with CF post-transplant.
- Evaluate the presence of long-term secondary effects of transplant on peripheral muscle function/dysfunction in people with CF.
- Define the efficacy of exercise interventions in people with CF post-transplant, with regards to the type (endurance, strengthen or combined) intensity, duration and mode of deliver (hospital, community, virtual).
- Explore perceived benefits and barriers to exercise in people with CF post-transplant.

12.9 Palliative and end of life care

People with CF experience a slow deterioration of lung function coupled with numerous disease complications and increased symptom burden, which may continue for many years. This long, chronic 'terminal phase' of their disease trajectory is associated with intensive daily therapy regimen, making it difficult to predict prognosis.[400-403]

The timing of death is difficult to predict in CF with individuals often experiencing multiple 'near misses'.[403,404] Active and palliative treatment usually run in parallel, as both therapeutic models help to improve and relieve symptoms in end-stage disease.[403-405] The majority of people with CF die in hospital and this is likely due to the intensity of treatments and the complexity in predicting the terminal stage. Advanced care planning is particularly important as predicting time of death is so difficult, it should start early and be part of usual care.[403]

Although the majority of people with CF die from respiratory failure, technological advances e.g. non-invasive ventilation and extracorporeal membrane oxygenation have provided alternative treatment choices for the very sick person. Lung transplantation is a potential option for people with advanced disease, although it must be acknowledged that not all individuals are eligible or choose this option. In addition, organ availability remains an issue with 40% of patients dying on the waiting list.[403,405,407-409] Patients awaiting lung transplant can further complicate end of life care as the patients' families and multidisciplinary team have to balance the hope of possible transplantation alongside the reality of possible death.[403,401]

The World Health Organisation (WHO) defines palliative care[410] for both adults and children as follows:

"Palliative care is an approach that improves the quality of life of patients and their families facing problems associated with a life-threatening illness. This is provided through the prevention and relief of suffering by means of early identification, accurate assessment and treatment of pain and other problems, physical, psychosocial and spiritual."

Palliative care:

- Provides relief from pain and other distressing symptoms
- Affirms life and regards dying as a normal process
- Intends neither to hasten nor to postpone death
- Integrates the psychological and spiritual aspects of patient care
- Offers a support system to help patients live as actively as possible until death
- Offers a support system to help the family cope during the patient's illness and in their own bereavement

Physiotherapists have a key role in end-stage disease management where much of the patient care is orientated to the alleviation of symptoms. As end-stage disease progresses, physiotherapy may need to be adapted to consider many different factors and while it is important to appreciate the benefit it may give, it is also important to appreciate the possible burden it imposes.[411]

Physiotherapists focus on maximising functional ability and comfort in order to enhance quality of life and this does not change during end-stage disease management and end of life care.[411,412] Many of the symptoms experienced at end of life (e.g. breathlessness, anxiety, fear, secretions and pain) can be alleviated by a variety of physiotherapy techniques in conjunction with multidisciplinary and medication strategies. Early integrated palliative care input is essential in the management of these complex symptoms, and to allow patients to establish relationships and build trust with the palliative care team.[403]

Few studies have directly addressed the input of physiotherapy during end of life care. In a retrospective analysis[411] common treatments included airway clearance with active cycle of breathing techniques, intermittent positive pressure breathing, non-invasive ventilation, exercise, anxiety management and relaxation techniques, with a reduction in the use of adjuncts such as positive expiratory pressure and oscillating positive expiratory pressure. It is important to note that many individuals continued with airway clearance techniques to within 24 hours of death.

Good practice points

- Good communication between the CF team, the person with CF and their family is paramount during all aspects of the terminal stages. The CF team must take into account the person with CF and their family's level of understanding, concern, and fear of the unknown when discussing any treatment changes and be prepared to answer questions.
- Early discussions around preferred place of death should be completed by the multidisciplinary team, and if appropriate physiotherapist that leads on these conversations.
- If an individual's preferred place of death is home or hospice, physiotherapy input needs to be provided and/or supported in this setting, and if necessary training should be provided by the physiotherapy team to hospice staff, community palliative care team or the individual's family around non-invasive ventilation and physiotherapy treatment.
- Frequent short treatment sessions may be required to maximise symptomatic relief but minimise burden.

- Consider positive pressure such as non-invasive ventilation to reduce work of breathing and provide symptomatic relief during airway clearance treatments, exercise or to support breathlessness management pre- and post-activities of daily living such as washing or dressing.
- People with CF using non-invasive ventilation may choose to remove their non-invasive ventilation in the terminal stages. Physiotherapists should be prepared to discuss with individuals and families what may happen when they remove their non-invasive ventilation and liaise with the wider multidisciplinary team to optimise symptom control medications if this is the patient's wish.
- Individuals who are 24-hour non-invasive ventilator dependent will have two machines to alternate (day and night) and should have more than one face interface to alternate to reduce the risk of pressure areas.
- The use of nasal masks or mouthpiece interfaces for short periods may enable individuals to speak to relatives and drink/eat more easily.
- To optimise individual independence, if they are non-invasive ventilation-dependant, consider setting up their non-invasive ventilator on a trolley to enable them to mobilise more easily.
- Physiotherapists need to consider how to support their colleagues and manage their own emotions when managing people with CF at end of life. The opportunity to reflect as a team or individually should be available for all staff and teams should promote positive coping strategies.[413]

Recommendations

- Consider referral or seek advice from palliative care services with regards to patients with high symptom burden such as pain, breathlessness which limited the efficacy of physiotherapy treatments (*QoE – low*).
- Physiotherapy treatment should focus on optimising quality of life and symptom control in advanced disease (*QoE – low*).
- Physiotherapy airway clearance interventions need to be tailored to the individual needs of the patient (*QoE – low*).
- Consider intermittent positive pressure breathing and non-invasive ventilation as physiotherapy adjunction to reduced treatment burden (*QoE – low*).
- Patient should be offered physiotherapy input/support in the last stages of life (*QoE – low*).

Research recommendations

- Explore physiotherapists experiences and challenges of providing physiotherapy interventions towards the end of life in people with CF.
- Explore what the role of the physiotherapy in supporting people with CF who choose to die at home.

13. Non-medical prescribing

Non–medical prescribing (NMP) refers to the prescribing practiced by specially trained nurses, optometrists, pharmacists, physiotherapists, podiatrists and radiographers, working within their clinical competence and specialism as either independent and/or supplementary prescribers.[414]

In August 2013, legislation was introduced to permit physiotherapists to practice as independent prescribers.[415] An independent prescriber has full autonomy over their prescribing decisions and may advise on medicines use within their personal scope of practice. Prior to this change, a supplementary prescribing qualification allowed physiotherapists to prescribe and modify medicines for patients for whom they have a clinical management plan (CMP) in place. The CMP is an agreement between the patient, the supplementary prescriber and an independent prescriber and will define what may be prescribed and the parameters within which changes to prescriptions can be made.

The purpose of physiotherapist prescribing (PP) is to enhance the delivery of tailored physiotherapy interventions aimed at addressing the health and well-being needs of individuals, and to enable complete care pathways to be effectively delivered by a physiotherapist.[415] Physiotherapists who develop extended expertise tend to do so in one area of clinical practice and therefore the activities of a prescribing physiotherapist will also be focused within their chosen specialism. As a result, NMP is becoming increasingly common in areas of chronic disease management with CF care being no exception.

A survey of UK CF non-medical physiotherapist prescribers in 2015 revealed an unsurprising trend towards the prescription of inhalation therapies. The most prescribed medicines included mucolytics, inhaled antibiotics and bronchodilators. The survey detailed an extended role, which respondents reported as 'very safe' and in many cases has resulted in service remodelling. The prescription of medicines to promote airway clearance, rationalising medicines and offering non-pharmacological options to patients were the most frequently prescribed activities by PPs.

13.1 Regulation of non-medical prescribing practice

The Health and Care Professional Council (HCPC) 'Standards for Prescribing'[416] outline the prescribing requirements for physiotherapists who are either independent and/or supplementary prescribers. The HCPC are required to set the standards of education, training, conduct and performance and approve

education programmes that prepare healthcare professionals to prescribe. The CSP have published 'Practice Guidance for physiotherapist supplementary and independent prescribers' and the National Prescribing Centre have a 'Single Competency Framework' that provides an outline of prescribing competencies that if maintained will ensure safe and effective prescribing.

Good practice points

- Non-medical prescribing practice must be endorsed by the CF Centre MDT and improve the patient experience without compromising safety or access to quality care.
- Physiotherapists in CF considering undertaking a prescribing qualification should have a minimum of 3 years' of experience specialising in CF care.
- Prescribers must remain up to date with CF medication guidance relevant to their prescribing practice and could include local guidelines, Cystic Fibrosis Trust guidance, Commissioning guidance and NICE appraisals.
- Prescribers will plan their annual continued professional development to include CF specific training on medicines relevant to their personal scope of practice e.g. CF conferences, ACPCF prescribing events, local medicines reviews and journal clubs etc.

Recommendations

- You must only prescribe once you have successfully completed an HCPC approved prescribing programme, and had your entry on the register of the Health Professions Council annotated to show your prescribing status as a supplementary and/or independent prescriber (*QoE – high*).
- You must only prescribe within your own defined scope of practice and clinical specialty (*QoE – high*).
- Prescribers must meet, and continue to meet, the requirements of HCPC, CSP and their NHS Trust in order to ensure they are prescribing safely and with endorsement from the CF MDT and NHS Trust (*QoE – high*).
- Physiotherapists working as non-medical prescribers must be able to demonstrate how they meet the single competency framework for all prescribers published by the National Prescribing Centre (2012) (*QoE – high*).
- You must ensure that you have adequate personal liability insurance to cover your prescribing practice (covered with CSP membership or an alternative) and that your practice has been endorsed by your NHS Trust (which may require an addition to your job description) (*QoE – high*).

14. Complementary therapies

Complementary therapy and alternative medicine are terms often used to describe treatments outside the usual medical remit. Complementary therapies (CTs) are being increasingly used in the field of CF for a multitude of reasons including improving pain, posture, fitness and relaxation. The evidence base pertaining to the use of complementary therapies in CF is limited and therefore for the purpose of these guidelines, a questionnaire was sent to all adult and paediatric CF Centres in the UK and 39 responses were received. Of those 39 centres, 24 stated CTs are integrated into their management of people with CF and are applied by the physiotherapist, an external 'complementary therapist', or another member of the multidisciplinary team. Some of the most common therapies described under this umbrella include acupuncture, aromatherapy, art therapy, massage, music therapy, pilates, reflexology, relaxation techniques, singing, tai chi and yoga. Salt caves/salt lamps (halotherapy) are reportedly not currently utilised by CF teams, however it is reported to be of interest to patients.

Although there may be evidence for some CTs in the non-CF population, research relating to many of these treatments in people with CF are limited and there is insufficient evidence to support or refute the use of complementary therapies in this condition. Many physiotherapists have an interest in CTs and some techniques form core training at an undergraduate level with further courses available and targeted at experienced physiotherapists.

It is beyond the scope of these guidelines to produce a full systematic review of all CTs, however some guidance is offered below.

14.1 Acupuncture

Although there is insufficient high-grade evidence to support a recommendation for the use of acupuncture in respiratory disorders, acupuncture has been an integral part of Traditional Chinese Medicine (TCM) for thousands of years.[417] This may therefore reflect that reported clinical trials available in acupuncture are poorly designed and underpowered, due mainly in part to the difficulty in designing a study with an appropriate control. There is, however, a growing use of acupuncture in respiratory conditions and anecdotal evidence that patients are requesting acupuncture as a treatment modality.[418-420] TCM provides a holistic approach when formulating an individual therapeutic strategy.

With consideration to the totality of the disease-process pattern in CF acupuncture points are selected to regulate and strengthen diseased "organs" as well as suggestions made to change diet and lifestyle.[418]

In 2010 Carrolan et al.[417] mapped the treatment of adults with CF by physiotherapists using acupuncture. Four adult CF Centres were providing acupuncture treatment by physiotherapists, most commonly treating back pain, breathlessness, headaches, joint pain, anxiety, sinus pain and pleuritic chest pain. Other studies have found similar improvements including quality of life, exercise capacity and decreased anxiety and dyspnoea scores.[419-422]

It was further reported that "acupuncture is not widely available in UK adult CF Centres mainly due to lack of trained professionals available to provide a service". This would therefore require additional funding to train more physiotherapists in the use of Western-style acupuncture. Some Centres do provide individual funding for acupuncturists that are not within the NHS, but this is not feasible as a general recommendation as funding varies between centres. Interestingly Carrolan's[417] study demonstrates that of the surveyed physiotherapist respondents, 71% felt that acupuncture treatment should be carried out by a physiotherapist with acupuncture training, rather than a fully qualified acupuncturist.

Good practice points

Consider a professionally trained acupuncturist as an alternative if no physiotherapist qualified in acupuncture is available – visit the British Acupuncture Council website www.acupuncture.org.uk for guidance.

- There is no age limit for when acupuncture or acupressure can be performed, however, children may have a more acute response to acupuncture and it is therefore advisable to trial acupressure first.
- Much of the research available on acupuncture is methodologically weak including small sample sizes, lack of proper controls and poor statistical analysis.[420] These are all flaws that can also be attributed to much of the research within CF care. Although results should be considered with caution, patients' reporting of subjective improvements should be noted and used to determine continuing treatment.
- People with CF should be treated individually according to the principles and symptom patterns of Traditional Chinese Medicine rather than by wholesale use of traditional prescriptions.
- In the absence of physiotherapists trained in practising Western-style acupuncture, patients may be referred to a fully qualified Traditional Chinese Medicine/Five Element acupuncturist (details available from BAcC) in order to benefit fully from this holistic treatment approach.
- Alternative therapies such as acupuncture must not replace standard CF treatment.
- The person with CF should be encouraged to discuss use of alternative therapies with the CF team before commencing.

Further research of acupuncture in the field of CF is required to determine benefit.

14.2 Halotherapy (salt Caves/salt lamps)

For centuries, especially in Eastern Europe, people have visited natural salt caves for the healing properties of the air. Halotherapy (HT) can be delivered in artificially constructed 'salt caves' that simulate the conditions of a natural cave by dispersing dry aerosol microparticles of salt. Other modes of HT delivery are via salt inhalers, or 'salt pipes'.

Suggested mechanisms for the observed positive therapeutic effect of HT include: improved mucociliary clearance; control and elimination of bacterial infections; stimulation of the immune system; and regulation of inflammatory mediators.

Evidence to support HT use is limited. One study explored the efficacy of salt cave HT in a study of 139 chronic respiratory patients, among whom only 5 had CF.[423] Improvements in flow-volume loop parameters and decreased bronchial resistance measured by plethysmography were reported after 10-20 daily sessions occurring for one hour. Two smaller studies have also shown benefit; 6 CF subjects had 5 salt cave HT sessions (45 minutes on five consecutive days) and showed improvement in lung function and sputum production [(424)], and 13 CF patients showed no significant change in lung function, but improvements in Borg dyspnoea index scores, SNOT-20 score and subjective health perception levels with no recorded adverse events.[425] It is well-recognised that hypertonic saline (even in the lowest concentration) can provoke bronchospasm in susceptible individuals; none of the participants in the study reported such symptoms.[425]

There is minimal evidence available evaluating the efficacy of use of salt spray inhalers or salt pipes in CF patients. Rabbini et al.[426] explored the use of salt spray inhalers in 20 non-CF bronchiectatic patients (inhalation through the inhaler for 25 minutes per day for 2 months). After a 2-month treatment course no significant improvements were identified in lung function tests, 6-minute walk test results or quality of life questionnaires. However, there were no significant adverse effects.

There is no evidence available to suggest salt lamps might have a physiological beneficial impact on the respiratory health of patients with CF. There have however been no reports of adverse side effects as a result of its use in any studies. The benefits to emotional health and wellbeing provided by salt lamps have been extensively documented, if not scientifically supported.[424,426]

Good practice points

- Where people demonstrate an interest in salt therapy, physiotherapists should offer inhaled hypertonic saline as a safe and known alternative.
- There is no information regarding the management and control of infection and therefore physiotherapists should advise patients accordingly.

Research recommendation

- The evidence supporting the use of HT is weak due to poor quality of study design, methodology and data collection. Exploratory studies have demonstrated that HT may have some benefit in CF patients. However, longer-term studies using larger sample sizes and randomised controlled study design are necessary to be able to add strength to support recommendation of use.

14.3 Pilates

Pilates is a series of carefully controlled movements that aim to strengthen the body in an even way, with particular emphasis on strengthening the core muscles and using controlled breathing in time with the exercises. Pilates exercises can be performed in a 1:1 or group environment and are done on a mat or using special equipment. The suggested benefits of Pilates include improved body awareness, postural alignment, tone, strength and flexibility. The principle of Pilates (building core strength) has been used in conventional physiotherapy for decades, and many physiotherapists currently use Pilates-based exercises in their own clinical practice alongside other techniques for the treatment of low back pain and neurological conditions. Upon review of the literature, there are no research trials which evaluate the benefits of purely a Pilates session for people with CF; however, 9 out of the 39 centres who responded to the CT questionnaire reported that they use Pilates in their clinical practice and find it beneficial for posture, fitness, musculoskeletal pain relief, airway clearance, breathing control and relaxation.

Good practice points

- Pilates may be considered in the management of people with CF and may be suitable throughout disease severity; however, it is important that a patient finds a qualified teacher who is able to adapt the class to the individual's needs.

Research recommendations

- Research is required to evaluate the effectiveness of Pilates in the treatment of people with CF.

14.4 Relaxation techniques (including massage, aromatherapy and reflexology)

A recent Cochrane review[428] considered the impact of psychological interventions which were largely concerned with adherence to treatment, emotional and social adaptation and health-related quality of life. Whilst there were no concrete recommendations, there is some evidence that behavioural interventions targeting specific illness-related symptoms and behaviours can work. There is clearly some multidisciplinary cross over in this area, with many of the multidisciplinary team being appropriately-trained in aspects of relaxation, cognitive behavioral therapy and massage.

Massage has been used as a therapy for thousands of years for its benefits such as improving circulation, decreasing some forms of oedema, and reducing musculoskeletal pain and tension.[429] Short-term benefits of massage and musculoskeletal physiotherapy on pain reduction in adults with CF have also been documented[432] but longer-term, large-scale studies are needed. Common symptoms of chronic illness such as anxiety and depression may be alleviated by massage.[429] A small RCT study in children with CF noted subjective improvements in both anxiety levels and mood of parents and children using parent-administered massage therapy.[430] An inpatient survey of adults with CF reported keen use of CT such as massage and patients expressed the importance of these modalities:[431] this is in abstract form only. Benefits of massage therapy are documented, but contraindications must be noted and massage should not be performed over pitting oedema, areas of impaired tissue integrity and fractures. Caution should be applied in patients with prolonged bleeding times.[429] Use of aromatherapy massage (the therapeutic use of plant-derived, aromatic essential oils combined with massage to promote physical and psychological wellbeing) in CF has limited documentation and is currently only cited in pilot studies in abstract form; subjectively, all 6 adult patients with CF reported improvement in anxiety and possible ease in airway clearance.[433]

Research for the use of reflexology (a system of massaging specific areas of the foot or sometimes the hand in order to promote healing or relieve stress in other parts of the body) in cystic fibrosis was found lacking so no recommendations are available.

Research for the use of art therapy (a form of psychotherapy involving the encouragement of free self-expression through painting, drawing or modelling used as a remedial or diagnostic activity – definition may vary) in CF was found lacking so no recommendations are available.

Good practice points

- Consideration of massage therapy for the relief of musculoskeletal pain.
- Consideration of massage therapy to decrease anxiety in parents and patients with CF.
- Contraindications to massage therapy must be noted.
- CF teams should consider who takes a lead on introducing relaxation techniques and who can carry them out within the team so that there is a coherent and consistent approach.

Research recommendations

- Lack of trials and high-powered evidence for massage/aromatherapy massage and its use in the management of patients with CF indicate further areas for good quality studies are required. There is insufficient evidence to recommend any specific frequency, type, or duration of massage therapy over another.

14.5 Singing

Many families feel singing is a good form of treatment for children with CF. A Cochrane review in 2014 reported there is insufficient evidence to recommend singing as an effective adjunct treatment in individuals with CF, but that participation should be encouraged but not replace current modalities.[435] More recently in Scotland, the Breath Cycle project evaluated the benefits of classical singing techniques and breathing control on respiratory health in adults with CF. This was a pilot study completed by only 14 patients, which made statistically significant improvements hard to draw, however, improvements are suggested in tidal breathing during exercise, FEV_1 and lung clearance index.[436]

14.6 Tai chi

Tai chi is a Chinese form of meditative movement, which combines slow, choreographed movements with deep breathing and mindfulness. Research suggests tai chi can improve physical and emotional wellbeing for various chronic conditions including arthritis, low bone density, heart disease, hypertension and sleep problems; and benefits include increased muscle strength, improved flexibility, pain and balance, and mild aerobic benefits (depending on the speed and size of the movements). However, only one study has been conducted in the CF population to date.[437] This study was a small sample feasibility study (n=7) which showed no adverse effects and suggested that tai chi may reduce CF treatment impact, improve respiratory symptoms, self-efficacy and sleep.

Research recommendations

- Higher-powered, well-designed RCT with alternate outcomes such as QOL and symptom scoring are required in CF for the future[437] and are being undertaken.

14.7 Yoga

Yoga is an ancient mind-body practice which has its origins in the Indus Valley. The physical practice of yoga (known as Hatha yoga) is just one element of what constitutes yoga but it is what is commonly recognised as yoga in the West and what is discussed here. Yoga combines breathing exercises (pranayama), physical postures (asanas) and relaxation/mindfulness techniques.

Although there is a growing body of evidence for yoga in the non-CF population, there is currently no published research evaluating its effectiveness in CF. Two pilot studies presented in abstract form have shown that yoga is safe and tolerated in adolescents and young people with CF,[438] and can lead to improvements in posture, chest wall excursion, lower extremity muscle performance and self-perceptions of body weight.[439] Five out of the 39 centres who responded to our questionnaire integrate yoga into their clinical practice; benefits reported include improved low back pain, thoracic kyphosis, stress incontinence, ease of airway clearance, body image, body awareness, breath awareness, cardiovascular fitness, anxiety, sleep and disease mastery.

There is a wide range of different types of yoga practices including Anusara, Ashtanga, Bikram, Iyenga, Jivamukti, Kundalini, Restorative, Vinyasa, Yin, etc. Practices may vary in sequencing, asana, use of props, the duration of how long poses are held for, the temperature of the room and philosophical focus.

Good practice points

- When prescribing yoga for strengthening, flexibility and/or cardiovascular fitness, consideration should be given to the frequency, intensity, type and duration of yoga practice. For example, a yoga practice may be more beneficial if the class focuses on alignment and the poses are help for longer (e.g. Iyenga).
- Hot yoga may carry a risk of infection and dehydration due to the humidity and temperature in the room.
- Patients should be cautious/avoid head down postures (inversions) due to the risk of gastro-oesphageal reflux. The patient should inform the teacher so that their practice can be modified accordingly.

- Patients with low bone mineral density should avoid flexed weight-bearing postures such as halasana (plough).
- Ideally, one-to-one yoga sessions are preferred so that the yoga practice can be tailored to the individual.

Research recommendations

- High powered randomised research trial to assess holistic benefits on health and well-being.

14.8 Other complementary therapies

There are many other areas that fall under the complementary therapies umbrella, and those included in this guideline are not exhaustive. It is worth noting that from our survey of CF Centres CT, on the whole, are liked by patients, however funding and staffing are among the limiting factors around provision. There appear to be no standardised outcome measures. Adequately-powered, well-designed RCT are needed with precise methodology recorded for the future.

Whilst CT are considered to be a useful adjunct to standard therapies for the management of holistic CF care, it should be acknowledged that standard therapies must not be discontinued or modified without close consultation with the CF team. It is also advisable that physiotherapists consider any potential risks to the patient should they choose to embark on complementary therapies, for example the possibility of infection control within salt caves and the risks associated with osteoporosis and yoga as highlighted above. It is also worth commenting that alternative therapists although specialists in their chosen fields may not have the rigorous regulations and clinical governance that state registered physiotherapists work within, and may have little experience of working with the complexities of CF.

15.0 References

1. Kavanagh BP. The GRADE System for Rating Clinical Guidelines 2009. PLoS Med 6(9): e1000094. doi:10.1371/journal.pmed.1000094.

2. Petrie GJ et al. on and behalf of the Scottish Intercollegiate Guidelines Network. Clinical guidelines criteria for appraisal for national use. Edinburgh, Royal College of Physicians, 1995.

3. Greenhalgh J et al. Reviewing and selecting outcome measures for use in routine practice. J Eval Clin Pract. 1998 Nov; 4(4):339-50.

4. Cystic Fibrosis Trust. Strategic Review 'Project Life' 2000. Cystic Fibrosis Trust, Bromley, Kent, UK.

5. Prasad SA et al. Finding the evidence to support airway clearance in CF. Disability and Rehabilitation 1998; 20 (6/7): 235-246.

6. Main E. What is the best airway clearance technique in CF. Paediatric respiratory reviews 2013;14(1); 10-12.

7. Main E. Airway clearance research in CF: the perfect storm of strong preference and effortful participation in long-term, non blinded studies. Thorax 2013; 68(8). 701-702.

8. Cunningham S. What you don't know can't hurt you; early asymptomatic lung disease in CF. Thorax 2012; 67:849–850.

9. Main E at al . Evaluation of lung clearance index as an outcome measure for airway clearance intervention studies. J Cyst Fibrosis 2004 ; abstract 334.

10. Prasad SA et al. Clinical Guidance for the Physiotherapy Management of Screened Infants with Cystic Fibrosis. ACPCF Physiotherapy Guidance Paper no. 4 2008.

11. Horsley A . Lung Clearance Index in the assessment of airways disease. Respiratory Medicine 2009, 103, 793-799.

12. McIlwaine MP et al. Long-term multicentre randomised controlled study of high frequency chest wall oscillation versus positive expiratory pressure mask in cystic fibrosis. Thorax 2013; 68(8):746-51.

13. Bradley JM et al. Evidence for physical therapies (airway clearance and physical training) in CF: An overview of five Cochrane systematic reviews. Respiratory Medicine 2006; 100:191-201.

14. McIlwaine M et al. Positive expiratory pressure physiotherapy for airway clearance in people with cystic fibrosis. Cochrane Database of Systematic Reviews 2015, Issue 6. Art. No.: CD003147. DOI: 10.1002/14651858.CD003147.pub4.

15. Morrison L et al. Oscillating devices for airway clearance in people with cystic fibrosis. Cochrane Database of Systematic Reviews 2014, Issue 7. Art. No.: CD006842. DOI: 10.1002/14651858.CD006842.pub3.

16. Main E et al. Conventional chest physiotherapy compared to other airway clearance techniques for cystic fibrosis. Cochrane Database of Systematic Reviews 2005, Issue 1. Art. No.: CD002011. DOI: 10.1002/14651858.CD002011.pub2.

17. Wilson LM et al. Airway clearance techniques for cystic fibrosis: an overview of Cochrane systematic reviews. Cochrane Database of Systematic Reviews 2014, Issue 8. Art. No.: CD011231. DOI:10.1002/14651858.CD011231.

18. Warnock L et al. Chest physiotherapy compared to no chest physiotherapy for cystic fibrosis. Cochrane Database of Systematic Reviews 2013, Issue 9. Art. No.: CD001401. DOI: 10.1002/14651858.CD001401.pub2.

19. Mckoy NA et al. Active cycle of breathing technique for cystic fibrosis. Cochrane Database of Systematic Reviews 2012, Issue 12. Art. No.: CD007862. DOI: 10.1002/14651858.CD007862.pub3.

20. McCormack P et al. A systematic Cochrane review of autogenic drainage for airways clearance in cystic fibrosis (Abstract) 2015 Pediatr Pulmonol S41, 474.

21. Hebestreit H et al. for the European Cystic Fibrosis Exercise Working Group. Respiration Vol. 90, No. 4, 2015.

22. Barker MA et al. Exercise testing and training in German CF Centres. Pediat Pulmonol 2004; 37:351-355.

23. Rogers D et al. Exercise testing in children with cystic fibrosis. J R Soc Med 2003; 96 (Suppl 43):23-29.

24. Stevens D et al. Exercise testing and training with the young cystic fibrosis patient. J Sports Sci Med 2007; 6:286-291.

25. Bradley J et al. Physical activity in cystic fibrosis: A position statement. J Cyst Fibrosis, 2015, currently in press, but open access.

26. Stevens D et al. A survey of exercise testing and training in UK cystic fibrosis clinics. J Cyst Fibrosis 2010; 9:302-306.

27. Mussaffi H et al. Induced sputum in the very young: a new key to infection and inflammation. Chest 2008; 133(1):176-182.

28. Sagel SD et al. Airway inflammation in children with cystic fibrosis and healthy children assessed by sputum induction. American Journal of Respiratory & Critical Care Medicine 2001; 15; 164:1425-1431.

29. Blau H et al. Induced sputum compared to bronchoalveolar lavage in young, non-expectorating cystic fibrosis children. J Cyst Fibrosis 2014; 13(1): 106-110.

30. Suri R et al. Safety and use of sputum induction in children with cystic fibrosis. Pediatr.Pulmonol 2003; 35(4):309-313.

31. Gershman NH et al. Fractional analysis of sequential induced sputum samples during sputum induction: evidence that different lung compartments are sampled at different time points. J Allergy Clin Immunol 1999; 104(2):322-8.

32. Nocker RE et al. Induced sputum and bronchoalveolar lavage as tools for evaluating the effects of inhaled corticosteroids in patients with asthma. J Lab Clin Med 2000; 136 (1); 39-49.

33. Aitken ML et al. Analysis of sequential aliquots of hypertonic saline solution-induced sputum from clinically stable patients with cystic fibrosis. Chest 2003; 03; 123(3):792-799.

34. Ahmed B et al. How to use: bacterial cultures in diagnosing lower respiratory tract infections in cystic fibrosis. Archives of Disease in Childhood Education & Practice 2014; 99(5):181-187.

35. Henig NR et al. Sputum Induction as a research tool for sampling the airways. Thorax 2001;56:306–311.

36. Alexis NE et al. Induced Sputum Derives from the Central Airways. Confirmation Using a Radiolabeled Aerosol Bolus Delivery Technique. Am J Respir Crit Care Med 2001; 164, 1964–1970.

37. Al-Saleh S, et al. Sputum Induction in Routine Clinical Care of Children with Cystic Fibrosis. J Pediatr 2010 157(6):1006-11.

38. Ordonez CL et al. Variability of markers of inflammation and infection in induced sputum in children with cystic fibrosis. J.Pediatr 2004; 145(5):689-692.

39. Zsoka W et al. 2013. Induced sputum analysis: step by step. ERS. DOI: 10.1183/20734735.042912.

40. NSW TB- Sputum Induction Guidelines. 2013. http://www.health.nsw.gov.au/infections/tuberculosis/Pages/tb-sputum-induction-guidelines.aspx

41. Ho et al. Clinical Value of Obtaining Sputum and Cough Swab Samples Following Inhaled Hypertonic Saline in Children with Cystic Fibrosis. Pediatr Pulmonol 2004; 38:82–87.

42. Rodwell LT et al. Airway responsiveness to hyperosmolar saline challenge in cystic fibrosis: a pilot study. Pedoatr Pulmonol. 1996 May; 21(5): 282-9.

43. Kelly MG et al. Comparison of sputum induction using high-output and low-output ultrasonic nebulizers in normal subjects and patients with COPD. Chest 2002; 09; 122(3):955-959.

44. Davidson WJ et al. Identification and validation of nebulized aerosol devices for sputum induction. Canadian Respiratory Journal 2014; 21(2):101-106.

45. Robinson M et al. Effect of increasing doses of hypertonic saline on mucociliary clearance in patients with cystic fibrosis. Thorax 1997: 52 (10); 900-903.

46. Araujo L et al. Induced sputum in children: success determinants, safety, and cell profiles. Journal of Investigational Allergology & Clinical Immunology 2011; 21(3):216-221.

47. De Boeck K et al. Sputum Induction in young cystic fibrosis patients. Eur Respir J 2000; 16 (1):914.

48. Reinhardt N et al. Cellular profiles of induced sputum in children with stable cystic fibrosis: comparison with BAL. Eur Respir J 2003; 22: 497–502.

49. Simonds AK et al. Evaluation of droplet dispersion during non-invasive ventilation, oxygen therapy, nebuliser treatment and chest physiotherapy in clinical practice: implications for management of pandemic influenza and other airborne infections. Health Technology Assessment 14 2010:46.131-172.

50. Knibbs LD et al. Viability of *Pseudomonas aeruginosa* in cough aerosols generated by persons with cystic fibrosis. Thorax 2014; 69(8):740-5.

51. Bryant JM et al. Whole -Genome sequencing to establish relapse or re- infection with Mycobacterium tuberculosis: a retrospective observational study. The Lancet Respiratory Medicine 2013; 1(10); 786-792.

52. Borg G et al. The reliability and validity of a physical work test. Acta Physiol Scan 1962; 55:353-61.

53. Easton RG et al. Reliability of ratings of perceived effort regulation of exercise intensity. British Journal of Sports Medicine 1988; 22(4);153-5.

54. Cullen D et al. Clinical utility of measures of breathlessness. Respiratory Care 2002; 47(9):986-93.

55. Prasad SA et al. Fifteen-Count Breathlessness Score: An Objective Measure for Children. Pediatr Pulmonol 2000; 30:56-62.

56. Barnai M et al. Relationship between breath-hold time and physical performance in patients with Cystic Fibrosis. European journal of Applied Physiology 2005; 95:172-8.

57. Orenstein DM et al. Measuring Ease of Breathing in Young Patients with Cystic Fibrosis. Pediatr Pulmonol 2002; 34:473-7.

58. Paranjape SM et al. Use of the modified shuttle walk test in children hospitalized for cystic fibrosis pulmonary exacerbations. Pediatr Pulmonol 2011; vol./is. 46/(354-355), 8755-6863.

59. Holden HJ et al. The development and validation of the incremental step test (IST) in children with cystic fibrosis (CF). J Cyst Fibrosis 2010; 9/(S69), 1569-1993.

60. Pike S E. Effect of intravenous antibiotics on exercise tolerance (3-min step test)) in cystic fibrosis. Pediatr Pulmonol 2001; 32,.1: 38-43, 8755-6863.

61. Balfour-Lynn, IM et al. Step in the right direction: assessing exercise tolerance in cystic fibrosis. Pediatr Pulmonol 1998; 25, 4: 278-284.

62. Horne R 2005. Concordance, adherence and compliance in medicine taking. Report for the National Co-ordinating Centre for NHS Service Delivery and Organisation R & D (NCCSDO).

63. Royal Pharmaceutical Society of Great Britain and Merck Sharpe and Dohme. Partnership in medicine taking: A consultative document. London: Royal Pharmaceutical Society of Great Britain and Merck Sharpe and Dohme 1996.

64. World Health Organization. *Adherence to Long-Term Therapies: Evidence for Action*. 2003.

65. Halfhide C et al. Inhaled bronchodilators for cystic fibrosis. Cochrane Database of Syst Rev 2005; 4: CD003428.

66. Sawicki GS et al. High treatment burden in adults with Cystic Fibrosis: challenges to disease self-management. J Cyst Fibrosis 2009; 8:91-96.

67. Dodd ME et al. Understanding non-compliance with treatment in adults with Cystic Fibrosis. J R Soc Med 2000; 93(suppl38):2-8.

68. Quittner AL et al. Evidence-based assessment of adherence to medical treatments in pediatric psychology. J Pediatr Psychol 2008; 33(9):916-936.

69. Goldbeck L et al. 2014. Psychological interventions for individuals with cystic fibrosis and their families. Cochrane Database of Systematic Reviews 2014, Issue 6. *Art. No.: CD003148. DOI: 10.1002/14651858. CD003148.pub3*.

70. Levers C E et al. Knowledge of physician prescriptions and adherence to treatment among children with cystic fibrosis and their mothers. Journal of Developmental and Behavioural Pediatrics 1999; 2, 335–343.

71. Modi AC et al. A multi-method assessment of treatment adherence for children with cystic fibrosis. J Cyst Fibrosis 2006; 5(3):177-185.

72. Czajkowski DR et al. Medical compliance and coping with cystic fibrosis. Journal of Child Psychology & Psychiatry 1987. 28(2):311-9.

73. Bucks RS et al. Adherence to treatment in adolescents with cystic fibrosis: the role of illness perceptions and treatment beliefs. Journal of Pediatric Psychology 2009; 34:893–902.

74. Abbott J et al. Ways of coping with cystic fibrosis: implications for treatment adherence. Disability and Rehabilitation 2001; 23 (8). pp. 315-324.

75. Smith BA et al. Depressive symptoms in children with cystic fibrosis and parents and its effects on adherence to airway clearance. Pediatr Pulmonol 2010.; 45(8): 756-63.

76. Abbott J et al. Treatment compliance in adults with cystic fibrosis. Thorax 1994; 49: (2):115-120.

77. Conway SP et al. Compliance with treatment in adult patients with cystic fibrosis. Thorax 1996; 51(1): 29-33.

78. Zindani GN et al. Adherence to treatment in children and adolescent patients with cystic fibrosis. Journal of Adolescence Health 2006; 38, 13-17.

79. Myers LB et al. Adherence to chest physiotherapy in adults with cystic fibrosis. Journal of Health Psychology 2006; 11, 915–926.

80. Shakkottai A et al. Adherence to Medications in Cystic Fibrosis Patients: A Five-Year Retrospective Analysis. American journal of respiratory and critical care medicine 2014; 189, A5530: D25.

81. Arias Llorente RP et al. Treatment compliance in children and adults with cystic fibrosis. J Cyst Fibrosis 2008.;7(5):359-67.

82. O'Donohoe R et al. Adherence of Subjects with Cystic Fibrosis to Their Home Program: A Systematic Review. Respiratory care 2014; 59 (11).

83. Hoo ZH et al. Feasibility study to objectively measure airway clearance technique in cystic fibrosis. J Cyst Fibrosis 2014; 13, S30.

84. Schneiderman-Walker J et al. A randomized controlled trial of a 3-year home exercise program in cystic fibrosis. Journal of Pediatrics 2000.; 136:304-310.

85. Abbott J et al. Treatment Compliance in Adults with Cystic-Fibrosis. Thorax 1994; 49:115-120.

86. Moorcroft AJ et al. Individualised unsupervised exercise training in adults with cystic fibrosis: a 1 year randomised controlled trial. Thorax 2004; 59:1074-1080.

87. Moorcroft AJ et al. Exercise limitations and training for patients with cystic fibrosis Journal: Disability and Rehabilitation – DISABIL REHABIL 1998; 20, 6-7: 47-253.

88. Orenstein D.M. et al. Update on the role of exercise in cystic fibrosis. *Curr Opin in Pulm Med*. 2005; 111:519–523.

89. Prasad S.A. et al. Factors that influence adherence to exercise and their effectiveness: Application to cystic fibrosis. Pediatr Pulmonol 2002; 34: 66–72.

90. Abbott J et al. Health perceptions and treatment adherence in adults with cystic fibrosis. Thorax 1996; 51(12):1233–1238.

91. McNamara P et al. Open adherence monitoring using routine data download from an adaptive aerosol delivery nebuliser in children with cystic fibrosis. J Cyst Fibrosis 2009; 8(4):258-63.

92. Latchford G et al. Adherence to nebulised antibiotics in cystic fibrosis. Patient education and counselling 2009; 75:141-144.

93. Daniels T et al. Accurate assessment of adherence: self-report and clinician report vs. electronic monitoring of nebulizer's. Chest 2011; 140(2):425-32.

94. Kettler L et al. Determinants of adherence in adults with cystic fibrosis. Thorax 2002; 57:459-464.

95. Jones S et al. Interventions for improving adherence to treatment in cystic fibrosis (Protocol). Cochrane Database of Systematic Reviews 2015, *Issue 4. Art. No.: CD011665. DOI: 10.1002/14651858.CD011665*.

96. Savage E et al. Self-management education for cystic fibrosis. Cochrane Database of Systematic Reviews 2014, Issue 9. Art. No.: CD007641. DOI: 10.1002/14651858.CD007641.pub3.

97. Cottrell CK et al. The development and evaluation of a self-management program for cystic fibrosis. Pediatric Asthma, Allergy & Immunology 1996; 10(3):109-18.

98. Downs JA et al. Benefits of an education programme on the self-management of aerosol and airway clearance treatments for children with cystic fibrosis. Chronic Respiratory Diseases 2006; 3(1):19-27.

99. Bernard RS et al. A token economy for exercise adherence in pediatric cystic fibrosis: a single-subject analysis. J Pediatr Psychol 2009.; 34(4):354-65.

100. Pisi G et al. Airway Clearance in cystic fibrosis patients. Acta Biomed 2009; 80:102-106.

101. Daniels. T. Physiotherapeutic management strategies for the treatment of cystic fibrosis in adults. J Multidiscip Healthc 2010; 19; 3:201-12.

102. McIlwaine M. Chest physical therapy, breathing techniques and exercise in children with CF. Paediatric Respiratory Reviews 2007; 8:8-16.

103. Flores. JS et al. Adherence to airway clearance therapies by adult cystic fibrosis patients. Respiratory Care 2013; 58:2; 279-285.

104. McIlwaine MP et al. Physiotherapy and cystic fibrosis: what is the evidence base? Curr Opin Pulm Med 2014; 20:613-617.

105. International Physiotherapy Group for Cystic Fibrosis. Physiotherapy in the treatment of Cystic Fibrosis. 2009 (https://www.ecfs.eu/ipg_cf/booklet International Physiotherapy Group – The Blue Booklet.

106. Pryor JA et al. Evaluation of the forced expiration technique as an adjunct to postural drainage in the treatment of cystic fibrosis. Br med J 1979; 2: 417-8.

107. Wilson GE et al. A comparison of traditional chest physiotherapy with the active cycle of breathing in patients with chronic suppurative lung disease. European Respir J 1995; 8: (Suppl 19): 171S.

108. Webber BA et al. Effects of postural drainage incorporating the forced expiration technique, on pulmonary function in cystic fibrosis. Br J of Dis Chest 1986; 80: 353-9.

109. Pryor JA et al. Effect of chest physiotherapy on oxygen saturation in patients with cystic fibrosis. Thorax 1990; 45: 77.

110. Pryor JA et al. The Flutter VRP1 as an adjunct to chest physiotherapy in cystic fibrosis. Respir Med 1994; 88:677-81.

111. Hofmeyr JL et al. Evaluation of positive expiratory pressure as an adjunct to chest physiotherapy in the treatment of cystic fibrosis. Thorax 1986; 41: 951-4.

112. Pike SE et al. Comparison of Flutter VRP1 and forced expirations with active cycle of breathing techniques in subjects with cystic fibrosis. Netherlands J of Med 1999 ; 54: S55-6.

113. Osman LP et al. Short-term comparative study of high frequency chest wall oscillation and European airway clearance techniques in patients with cystic fibrosis. Thorax 2010; 65:196-200.

114. Pryor JA et al. Beyond postural drainage and percussion: Airway clearance in people with cystic fibrosis. J Cyst Fibrosis 2010; 9:187-192.

115. McIlwaine M et al. Long-term comparative trial of two different physiotherapy techniques; postural drainage with percussion and autogenic drainage, in the treatment of cystic fibrosis. Pediatr Pulmonol 2010; 45(11):1064-9.

116. Dab I et al. The mechanism of autogenic drainage studied with flow volume curves. Monographs of Paediatrics; 1979 10: 50-53.

117. Schöni MH. Autogenic drainage: a modern approach to physiotherapy in cystic fibrosis. Journal of the Royal Society of Medicine 1989; 82 (Suppl.16): 32-37.

118. David A. Autogenic Drainage – the German approach. In: Pryor JA. (ed) Respiratory Care 1991. London, Churchill Livingstone; pp. 65-78.

119. Miller S et al. Chest physiotherapy in cystic fibrosis: a comparative study of autogenic drainage and the active cycle of breathing techniques with postural drainage. Thorax 1995; 50:165-169.

120. Davidson AG et al. Long-term comparative trial of conventional percussion and drainage physiotherapy versus autogenic drainage in CF. Pediatr Pulmonol 1992;14:298.

121. Pfleger A et al. Self-administered chest physiotherapy in cystic fibrosis: a comparative study of high-pressure PEP and autogenic drainage. Lung 1992; 170: 323-330.

122. McIlwaine PM et al. The effect of chest physiotherapy by postural drainage and autogenic drainage on oxygen saturation in cystic fibrosis. Pediatr Pulmonol 1991;11:291.

123. Giles DR et al. Short-term Effects of Postural Drainage with Clapping vs. Autogenic Drainage on Oxygen Saturation and Sputum Recovery in Patients With Cystic Fibrosis. Chest 1995;108;952-954.

124. App EM et al. Sputum rheology changes in cystic fibrosis lung disease following two different types of physiotherapy: Flutter vs. autogenic drainage. Chest 1998; 114:171–7.

125. Lindemann H et al. Autogenic Drainage: efficacy of a simplified method. Acta Univ Carol Med (Praha). 1990; 36(1-4):210-2.

126. Cystic Fibrosis Trust Factsheet – Physiotherapy Treatment: Airway Clearance Techniques Written by S. Ammani Prasad, MCSP, Tamara Orska, MCSP, Kate Ferguson, MCSP, Penny Agent, MCSP and Mary Dodd, FCSP on behalf of the Association of Chartered Physiotherapists in Cystic Fibrosis. June 2007. Found at: http://www.cftrust.org.uk/aboutcf/publications/factsheets/Airways-clearance-june07-for_web.pdf

127. Van Ginderdeuren F et al. Influence of assisted autogenic drainage (AAD) and AAD combined with bouncing on gastro-oesophageal reflux (GOR) in infants under the age of 5 months. J Cystic Fibrosis 2003; 2 (Suppl 1): A251.

128. Cystic Fibrosis Trust Factsheet – Physiotherapy Treatment for Babies and Toddlers with Cystic Fibrosis. Written by S. Ammani Prasad, MCSP, Research Physiotherapist, Cystic Fibrosis Unit, Great Ormond Street Hospital for Children, London and reviewed by members of the Association of Chartered Physiotherapists in Cystic Fibrosis. May 2007. Found at: http://www.cftrust.org.uk/aboutcf/publications/factsheets/FS_Physio_(Babies__toddlers)_-_web.pdf

129. West K et al. Acapella vs. PEP mask therapy: a randomised trial in children with cystic fibrosis during respiratory exacerbation. Physiotherapy Theory Practice. 2010; 26:143-9.

130. Prasad SA et al. 1995 Paediatric respiratory care; a guide for physiotherapists and health professionals. Springer Science + Business Media.

131. Darbee JC et al. Physiologic evidence for the Efficacy of Positive Expiratory Pressure as an Airway Clearance Technique in Patients with Cystic Fibrosis. Physical Therapy. 2004; 84; 524-537.

132. Braggion C et al. Short-term effects of three chest physiotherapy regimens in patients hospitalized for pulmonary exacerbations of cystic fibrosis: a cross-over study. Pediatr Pulmonol. 1995; 19; 16-22.

133. van Winden CM et al. Effects of flutter & PEP mask physiotherapy on symptoms and lung function in children with cystic fibrosis. Eur Respir Journal. 1998; 12; 143-147.

134. West K et al. Acapella versus PEP mask therapy; a randomised trial in children with cystic fibrosis during respiratory exacerbation. Physiotherapy Theory & Practice. 2010; 26 (3). P 143-149.

135. McIlwaine PM et al. Long-term comparative trial of positive expiratory pressure versus oscillating positive expiratory pressure (flutter) physiotherapy in the treatment of cystic fibrosis. Journal of Pediatrics. 2001; 138; 845-850.

136. McIlwaine PM et al. Long-term comparative trial of conventional postural drainage and percussion versus positive expiratory pressure physiotherapy in the treatment of cystic fibrosis. Journal of Pediatrics. 1997; 131; 570-574.

137. Elkins M et al. Positive expiratory pressure physiotherapy for airway clearance in people with cystic fibrosis. Cochrane Database of systematic reviews. 2006;Issue 1. Art No: CD003147 DOI: 10.1002/14651858.CD003147.PUB3.

138. Pryor J et al. 2002 3rd Edition Physiotherapy for Respiratory and Cardiac Problems: Adults and Paediatrics (Physiotherapy Essentials). Churchill Livingston.

139. Oberwaldner B et al. Forced expirations against a variable resistance: A new chest physiotherapy method in cystic fibrosis. Pediatr Pulmonol 1986; 2(6):358-67.

140. Constantini D et al. PEP mask vs. postural drainage in infants a long-term comparative trial, Paediatr Pulmonol. 2001; Suppl 22;308.

141. Mestriner RG et al. Optimum design parameters for a therapist-constructed positive-expiratory-pressure therapy bottle device. Respiratory Care 2009; 54: 504-8.

142. Newbold ME et al. The flutter device versus The PEP mask in the treatment of adults with Cystic Fibrosis. Physiotherapy Canada. 2005; 57. 199-207.

143. Oermann CM et al. Comparison of high-frequency chest wall oscillation and oscillating positive expiratory pressure in the home management of cystic fibrosis: a pilot study. Pediatr Pulmonol. 2001; 32 (5); 372-7.

144. Konstan MW et al. Efficacy of the flutter device for airway mucus clearance in patients with cystic fibrosis. Journal of Pediatrics 1994; 124 (5 (pt 1): 689-693.

145. Rogers D et al. Physiological principles of airway clearance techniques used in the physiotherapy management of cystic fibrosis. Current Paediatrics. 2005; 15 (3); 233-238.

146. Pryor J. Physiotherapy for airway clearance in adults. European Respiratory Journal. 1999; 14 (6); 1418-1424.

147. Volsko TA et al. Performance comparison of two oscillatory positive pressure devices: Acapella versus Flutter. Respiratory Care. 2003; 48 (2); 124- 130.

148. Orlik T et al. Long-term evaluation of effectiveness for selected chest physiotherapy methods used in the treatment of cystic fibrosis. 2001;24th European CF conference.

149. Warwick WJ et al. The long-term effect of high frequency chest compression therapy on pulmonary complications of CF. Pediatr Pulmonol 1991; 11: 265-71.

150. Scherer TA et al. Effect of high-frequency oral airway and chest wall oscillation and conventional chest physical therapy on expectoration in patients with stable cystic fibrosis. Chest. 1998; 113(4): 1019-1027.

151. Fainardi V et al. Short-term effects of high-frequency chest compression and positive expiratory pressure in patients with CF. J Clin Med Res 2011; 3 (6): 279-284.

152. Arens R et al. Comparison of high-frequency chest compression and conventional chest physiotherapy in hospitalised patients with CF. American Journal of Resp and Critical Care Medicine 1994; 150; 4: 1154-7.

153. Phillips GE et al. Comparison of the active cycle of breathing techniques and high frequency oscillation jacket in children with CF. Pediatr Pulmonol 2004; 37: 71-5.

154. Varekojis SM et al. A comparison of the therapeutic effectiveness of and preference for postural drainage and percussion, intrapulmonary percussive ventilation, and high-frequency chest wall compression in hospitalized cystic fibrosis patients. Respiratory Care. 2003; 48(1): 24-8.

155. Cappelletti LM et al. Short-term effects of three chest physiotherapy regimens on patients with cystic fibrosis hospitalized for a pulmonary exacerbation: a crossover randomized study. 1993; 18th European CF Conference Madrid W9,3.

156. Warwick WJ et al. Comparison of expectorated sputum after manual chest physical therapy and High frequency chest compression.2004; 470-475 Biomedical Instrumentation and Technology.

157. Castile R et al. Comparison of three sputum clearance methods in in-patients with cystic fibrosis [abstract]. Pediatr Pulmonol. 1998; Suppl 17: 329.

158. Darbee JC et al. Physiological evidence for high-frequency chest wall oscillation and positive expiratory breathing in hospitalised subjects with CF, Physical Therapy.2005 Dec; 85 (12): 1278-89.

159. Tecklin JS et al. High frequency chest wall oscillation vs. traditional postural drainage with percussion and vibration in cystic fibrosis – a large, long-term controlled study. Journal of the Israeli Physical Therapy Society. 2009; 11 (3): 26.

160. Davies GA et al. The use of high frequency chest wall oscillation during an acute infective pulmonary exacerbation of cystic fibrosis, Publisher: WILEY-BLACKWELL, 2012; Pages: 366-366, ISSN: 8755-6863.

161. Grzincich GL. Short-term effects of high frequency chest compression (HFCC) and positive expiratory pressure (PEP) in adults with cystic fibrosis. Proceedings of the European Respiratory Society Congress. 2008 Oct; Berlin 2008; 502S.

162. Stites SW et al. Effect of high-frequency chest wall oscillation on the central and peripheral distribution of aerosolized diethylene triamine penta-acetic acid as compared to standard chest physiotherapy in CF. Chest. 2006; 129 (3): 712-717.

163. Oermann CM et al. Validation of an instrument measuring patient satisfaction with chest physiotherapy techniques in CF. Chest. 2000; 118(1): 92-97.

164. Modi AC et al. Adherence to airway clearance therapies in patients with cystic fibrosis [abstract]. J Cyst Fibrosis. 2006; 5 Suppl: S97.

165. Newhouse PA et al. The intrapulmonary percussive ventilator and flutter device compared to standard chest physiotherapy in patients with cystic fibrosis. Clinical Pediatrics. 1998; 37, 7, 427-432.

166. Natale JE et al. Comparison of intrapulmonary percussive ventilation and chest physiotherapy. A pilot study in patients with cystic fibrosis. Chest. 1994; 105, 6, 1789-1793.

167. Homnick DN et al. Comparison of effects of an intrapulmonary percussive ventilator to standard aerosol and chest physiotherapy in treatment of cystic fibrosis. PediatrPulmonol. 1995; 20, 50-55.

168. McInturff SL et al. Intrapulmonary percussive ventilation (IPV) in the treatment of COPD. (abstract), Respiratory Care. 1985; 30, 10, 885.

169. Marks JH et al. Pulmonary function and sputum production in patients with cystic fibrosis: a pilot study comparing the PercussiveTech HD device and standard chest physiotherapy. Chest. 2004; 125, 4, 1507-1511.

170. Lorin MI et al. Evaluation of postural drainage by measurement of sputum volume and consistency. American Journal of Physical Medicine. 1971; 50: 215-9

171. Button BM et al. Postural drainage in cystic fibrosis: is there a link with gastro-oesophageal reflux? J Paediatr Child Health. 1998; 34:330-4.

172. Button BM et al. Chest physiotherapy in infants with cystic fibrosis: to tip or not? A five-year study. Pediatr Pulmonol. 2003; 35:208-13.

173. Button BM et al. Gastroesophageal reflux (symptomatic and silent): a potentially significant problem in patients with cystic fibrosis before and after lung transplantation. J Heart Lung Transplant. 2005; 24:1522-9.

174. Van der Schans CP et al. Physiotherapy and bronchial mucus transport. Eur Respir J 1999; 13: 1477-86.

175. Reisman JJ et al. Role of conventional physiotherapy in cystic fibrosis. J Pediatr 1988; 113: 632-36,

176. Thomas J et al. Chest Physiotherapy management of patients with cystic fibrosis. Am J Resp Crit CareMed 1995; 151; 846-50.

177. Cecins NM et al. The active cycle of breathing techniques – to tip or not to tip? Respiratory Medicine 1999; 93:660-5.

178. Physiotherapy skills: techniques and adjuncts. In: Webber BA, Pryor JA, ed. Physiotherapy for Respiratory and Cardiac Problems. London: Churchill Livingstone, 1993; 113–172.

179. Bott J et al. Intermittent Positive Pressure Breathing A Dying Art? Physiotherapy 1992; Volume 78, Issue 9, Pages 656–660.

180. Sorenson HM et al. AARC. AARC clinical practice guideline. Intermittent positive pressure breathing--2003 revision & update. Respir Care. 2003 May; 48(5):540-6. Pub Med PMID: 12778895.

181. Mainz JG et al. Sinonasal inhalation of dornase alfa administered by vibrating aerosol to cystic fibrosis patients: A double-blind placebo-controlled cross-over trial. J Cyst Fibrosis, 2014; 13(4), 461.

182. DiCicco M et al. Efficacy and tolerability of a new nasal spray formulation containing hyaluronate and tobramycin in cystic fibrosis patients with bacterial rhinosinusitis. J Cystic Fibrosis. 2014; 13(4), 455.

183. Ferril GR et al. Comparison of radiographic and clinical characteristics of low-risk and high-risk cystic fibrosis genotypes. Int Forum Allergy Rhinol. 2014; 4:915-920.

184. Kang SH et al. Chronic rhinosinusitis and nasal polyposis in cystic fibrosis: update on diagnosis and treatment. Jornal brasileiro de pneumologia : publicaça?o oficial da Sociedade Brasileira de Pneumologia e Tisilogia, Jan 2015; vol. 41, no. 1, p. 65-76.

185. Wilson P et al. Paranasal sinus pathogens in children with cystic fibrosis: Do they relate to lower respiratory tract pathogens and is eradication successful? J Cyst Fibrosis 13 (2014) 449-454.

186. Selvadurai HC,et al. Validation of shuttle tests in children with cystic fibrosis. Pediatr Pulmonol 2003; 35: 133-138.

187. Massery M. Musculoskeletal and neuromuscular interventions: a physical approach to cystic fibrosis. J Royal Society Med 2005; 98 (Suppl 45): 55-66.

188. Radtke T et al. Physical exercise training for cystic fibrosis (Review). Cochrane Database of Systematic Reviews. 2015; 28 (6), pp. 1–135.

189. Hebestreit H. et al. Long–term effects of a partially supervised conditioning programme in cystic fibrosis. European Respiratory Journal. 2010; 35 (3), pp. 578–583.

190. Kriemler S et al. Effect of supervised training on FEV1 in cystic fibrosis: a randomised controlled trial. J Cyst Fibrosis. 2013; 12 (6), pp. 714–720.

191. Santana–Sosa E et al. Benefits of combining inspiratory muscle with 'whole muscle' training in children with cystic fibrosis: a randomised controlled trial. British Journal of Sports Medicine. 2014; 48, pp. 1513–1517.

192. Santana–Sosa E et al. Intrahospital weight and aerobic training in children with cystic fibrosis: a randomized controlled trial. Medicine and Science in Sports and Exercise. 2012; 44 (1), pp. 2–11.

193. Nixon, PA et al. The prognostic value of exercise testing in patients with Cystic Fibrosis. The New England Journal of Medicine. 1992; 327 (25), pp.1785–1788.

194. Perez M et al. Aerobic fitness is associated with lower risk of hospitalization in children with cystic fibrosis. Pediatr Pulmonol. 2014; 49 (7), pp. 641–649.

195. Buehler T et al. Increased arterial stiffness in children with cystic fibrosis. European Respiratory Journal. 2012; 39 (6), pp. 1536–1537.

196. Hull JH et al. The effect of exercise on large artery haemodynamics in cystic fibrosis. J Cyst Fibrosis. 2011; 10 (2), pp. 121–127.

197. Perrin FMR et al. Ischaemic heart disease – a new issue in cystic fibrosis? Journal of the Royal Society of Medicine. 2010; 103 (1), pp. 44–48.

198. Moser, C, et al. Muscle size and cardiorespiratory response to exercise in cystic fibrosis. American Journal of Respiratory and Critical Care Medicine. 2000; 162 (5), pp. 1823–1827.

199. de Meer, K et al. Peripheral muscle weakness and exercise capacity in children with cystic fibrosis. American Journal of Respiratory and Critical Care Medicine. 1999; 159 (3), pp. 748–754.

200. Troosters Tet al. Skeletal muscle weakness, exercise tolerance and physical activity in adults with cystic fibrosis. European Respiratory Journal. 2009; 33 (1), pp. 99–106.

201. Arikan H et al. A comparison of respiratory and peripheral muscle strength, functional exercise capacity, activities of daily living and physical fitness in patients with cystic fibrosis and healthy subjects. Research in developmental disabilities. 2015; 45, pp. 147–156.

202. Martin C et al. Prognostic value of six minute walk test in cystic fibrosis adults. Respiratory medicine. 2013; 107 (12), pp. 1881–1887.

203. Reilly CC et al. Neural respiratory drive, pulmonary mechanics and breathlessness in patients with cystic fibrosis. Thorax. 2011; 66 (3), pp. 240–246.

204. Schneiderman JE et al. Longitudinal relationship between physical activity and lung health in patients with cystic fibrosis. European Respiratory Journal. 2014; 43 (3), pp. 817–823.

205. Council on Sports Medicine and Fitness/American Academy of Pediatrics. Strength training by children and adolescents: Policy statement. Pediatr 2008; 121: 835-840.

206. Orenstein DM et al. Heat acclimation in cystic fibrosis. J Appl Physiol 1984; 57: 408-412.

207. Webb AK et al. Exercise and sport in cystic fibrosis: benefits and risks. Br J Sports Med 1999; 33: 77-78.

208. Speechly-Dick ME et al. Exacerbation of cystic fibrosis after holidays at high altitude: a cautionary tale. Respir Med 1992; 86: 55–56.

209. Haworth CS et al. Osteoporosis in adults with cystic fibrosis. J R Soc Med 1998; 91 Suppl 34: 14-18.

210. Rao JL. The inhalation of drugs: advantages and problems. Respir Care. 2005 Mar; 50(3):367-82.

211. Heijermann H et al. Inhaled medication and inhalation devices for lung disease in patients with cystic fibrosis: A European consensus. J Cyst Fibrosis 2009; 8: 295-315.

212. Bott J et al. Physiotherapy management of the medical respiratory patient: the adult spontaneously breathing patient. Thorax. 2009; 64(supp1).

213. Holzer FJ et al. Variability of airways hyper-reactivity and allergy in cystic fibrosis. Arch Dis Child. 1981 Jun; 56(6): 455–459.

214. British Thoracic Society. BTS guidelines on current best practice for nebuliser treatment. Thorax 1997; 52(Suppl 2): S1e106.

215. Dodd ME et al. Effect of tonicity of nebulised colistin on chest tightness and pulmonary function in adults with cystic fibrosis. Thorax 1997; 52:656.

216. Cunningham S et al. Bronchoconstriction following nebulised colistin in cystic fibrosis. Arch Dis Child 2001; 84:432e3.

217. Bronchitol:http://www.medicines.org.uk/EMC/medicine/26446/SPC/Bronchitol+40+mg+inhalation+powder%2c+hard+capsules/

218. Promixin: http://www.medicines.org.uk/emc/medicine/13495

219. Colomycin: http://www.medicines.org.uk/emc/medicine/1590

220. Bramitob: http://www.medicines.org.uk/emc/medicine/21427

221. Cayston: http://www.medicines.org.uk/emc/medicine/22358

222. TOBI: http://www.medicines.org.uk/emc/medicine/19020

223. Colobreathe: http://www.medicines.org.uk/emc/medicine/27647

224. TIP: http://www.medicines.org.uk/emc/medicine/24989

225. DornaseAlfa: http://www.medicines.org.uk/EMC/medicine/1723/SPC/Pulmozyme+2500+U++2.5ml%2c+nebuliser+solution/

226. Elkins MR et al. A controlled trial of long-term inhaled hypertonic saline in patients with cystic fibrosis. N Engl J Med 2006;354:229-240.

227. Pasteur MCet al. Guidelines for non CF Bronchiectasis. Thorax 2010; 65 (Suppl 1).

228. Donaldson SH et al. Mucus clearance and lung function in cystic fibrosis with hypertonic saline. N Engl J Med 2006;354:241-250.

229. Elkins MR et al. National Hypertonic Saline in Cystic Fibrosis (NHSCF) Study Group. A controlled trial of long-term inhaled hypertonic saline in patients with cystic fibrosis. N Engl J Med 2006; 354:229–240.

230. Capstick T et al. Inhaler Technique and Training in People with Chronic Obstructive Pulmonary Disease and Asthma: Effects of Inspiratory Flow on Lung Deposition. Expert Rev Resp Med. 2012; 6(1):91-103.

231. NICE Colobreathe/TIP: https://www.nice.org.uk/guidance/ta276

232. NICE Bronchitol: https://www.nice.org.uk/guidance/ta266

233. Denyer J et al. Journal of Aerosol Medicine and Pulmonary Drug Delivery. April 2010; 23 (s1): S-29-S-36. doi:10.1089/jamp.2009.0768.

234. Mullinger B et al. Inhalation therapy can be improved in CF patients by controlling the breathing pattern during inspiration. J Cyst Fibrosis 2004; 3: S65.

235. Potter R et al. Precise dose delivery of Colistimethate sodium using prototype I-neb AAD system. J Cyst Fibrosis 2005; 4 (Suppl 1): S30.

236. Daniels T et al. Nebuliser devices for drug delivery in cystic fibrosis. Cochrane Database of Systematic Reviews 2009; Issue 1. Art. No.:CD007639. DOI: 10.1002/14651858.CD007639.

237. Fitzgerald DA et al. A crossover, randomized, controlled trial of dornase alfa before versus after physiotherapy in cystic fibrosis. Pediatrics. 2005; 116(4):549-54.

238. Wilson CJ et al. Is a longer time interval between recombinant human deoxyribonuclease (dornase alpha) and chest physiotherapy better? A multi-center, randomised crossover trial. Pediatr Pulmonol 2007;42(12): 1110-1116.

239. Van der Giessen LJ et al. RhDNase before airway clearance therapy improves airway patency in children with CF. Pediatr Pulmonol. 2007; 42:624–30.

240. Cystic Fibrosis Trust. Antibiotic treatment for cystic fibrosis: London: Cystic Fibrosis Trust, 2002.

241. Lannefors L et al. Nebuliser systems, contamination, microbial risks, cleaning and effect on function. Eur Respir Rev 2000; 10:571e5.

242. Webb AK et al. Nebulised antibiotics in cystic fibrosis and non-CF bronchiectasis in children and adults. In: Boe J, O'Driscoll R, Dennis J, eds. Practical handbook of nebuliser therapy. London: Martin Dunitz, 2004.

243. Elphick HE et al. Oxygen Therapy for Cystic Fibrosis, The Cochrane Collaboration, John Wiley and Sons Ltd. 2013; Issue 7.

244. Urquhart DS et al. Assessment of hypoxia in children with cystic fibrosis, Arch Dis Child. 2005 Nov;90(11):1138-43.

245. Balfour-Lynn IM et al. BTS guidelines for home oxygen in children, Thorax. 2009; 64 (Suppl 2):1–26.

246. Dinwiddie R et al. Oxygen Therapy for cystic fibrosis, J R Soc Med. 1999; Vol 92 Suppl 37, 19-22.

247. Dodd ME. A practical approach to oxygen therapy in cystic fibrosis, J R Soc Med. 1998; 91:(Suppl. 34): 30-9.

248. Milross MA et al. Sleep disordered breathing in cystic fibrosis. Sleep Medicine Reviews. 2004; Volume 8, Issue 4, 295–308.

249. O'Driscoll BR et al. Guideline for emergency oxygen use in adult patients, Thorax. 2008;Vol 63 Supple VI.

250. Dobbin CJ et al. Sequential use of oxygen and bi-level ventilation for respiratory failure in cystic fibrosis. J Cyst Fibrosis 2004; 3, 237-242.

251. Gozal D. Nocturnal ventilatory support in patients with cystic fibrosis: comparison with supplemental oxygen, Eur Resp Journal. 1997; 10:1999–2003.

252. Milross MA et al. Predicting Sleep-Disordered Breathing in Patients With Cystic Fibrosis. Chest. 2001; 120:1239–1245.

253. Zinman R et al. Nocturnal home oxygen in the treatment of hypoxaemic cystic fibrosis patients, Journal of Paediatrics. 1989; 114:368-77.

254. McKone EF et al. The role of supplemental oxygen during submaximal exercise in patients with cystic fibrosis, Eur Resp Journal. 2002; 20: 134–142.

255. Nixon PA et al. Oxygen supplementation during exercise in cystic fibrosis, American review of Resp Disease. 1990; 142: 807–811.

256. Marcus CLet al. Supplemental oxygen and exercise performance in patients with cystic fibrosis with severe pulmonary disease. Chest. 1992; 101:52–7.

257. Hardinge M. BTS guidelines for home oxygen use in adults, Thorax. 2015; Vol 70 Suppl 1.

258. Young AC et al. The impact of nocturnal oxygen desaturation on quality of life in cystic fibrosis, J Cyst Fibrosis. 2011; 10;100-106.

259. Coates AL. Oxygen therapy, exercise, and cystic fibrosis. Chest. 1992; 101(1):2-4.

260. Ahmedzai S et al. Managing passengers with stable respiratory disease planning air travel, Thorax 2011; Vol 66 Supplement 1.

261. Bliss PL et al. A bench Study Comparison of Demand Oxygen Delivery Systems and Continuous Flow Oxygen. Respiratory Care. 1999; 44 (8): 925–931.

262. Versteegh FGA et al. Relationship between airway obstruction, desaturation during exercise and nocturnal hypoxaemia in cystic fibrosis patients. Eur Respir J 1990, 3, 68-73.

263. Yankaskas JR et al. Cystic fibrosis adult care: consensus conference report Chest 2004; 125:1S-39S.

264. Frangolias DD et al. Predictability of Oxygen Desaturation during Sleep in Patients with Cystic Fibrosis; Clinical, Spirometric and Exercise Parameters. Chest 2001; 119:434–441.

265. Piper AJ. Sleep Disordered breathing in Children. Part of the series Respiratory Medicine. 2012; pp 365-383.

266. Coffey MJ et al. Comparison of oxygen desaturation during sleep and exercise in patients with cystic fibrosis. Chest. 1991; 100;659-62.

267. Spier S et al. The effect of oxygen on sleep, blood gases, and ventilation in cystic fibrosis, American Review of Resp Diseases. 1984; 129:712–18.

268. Shah AR et al. Effect of supplemental oxygen on supramaximal exercise in cystic performance and recovery fibrosis, J of Applied Physiology. 1997; 11;(83) 5;1641-7.

269. Heijerman HG et al. Oxygen-assisted exercise training in adult cystic fibrosis patients with pulmonary limitation to exercise, International J of Rehab Research. 1991 June; Volume 14, 2, pg 101-116.

270. Milross MA et al. Low-flow oxygen and bilevel ventilatory support: effects on ventilation during sleep in cystic fibrosis, American J of Respiratory and Critical Care Medicine. 2001; 163(1): 129–134.

271. UK Civil Aviation Authority (2012) Assessing fitness to fly, Civil Aviation Authority.

272. Verma A et al. Holidays and Cystic Fibrosis, J R Soc Med. 2000; 93 (Suppl 38):20-26.

273. Hill AT et al. Long-term nasal intermittent positive pressure ventilation in patients with cystic fibrosis and hypercapnic respiratory failure (1991-1996). Respir Med. 1998 Mar; 92(3):523-6. Pub Med PMID: 9692116.

274. Madden BP et al. Non-invasive ventilation in cystic fibrosis patients with acute or chronic respiratory failure. Eur Respir J. 2002 Feb; 19(2):310-3. Erratum in: Eur Respir J. 2002 Sep; 20(3):790. Pub Med PMID: 11866011.

275. British Thoracic Society Standards of Care Committee. Non-invasive ventilation in acute respiratory failure. Thorax. 2002 Mar; 57(3):192-211. Pub Med PMID: 11867822; Pub Med Central PMCID: PMC1746282.

276. Moran F et al. Non-invasive ventilation for cystic fibrosis. Cochrane Database Syst Rev. 2013 Apr 30; 4:CD002769. doi: 10.1002/14651858.CD002769.pub4. Review. Pub Med PMID: 23633308.

277. Holland, AE et al. Non-invasive ventilation assists chest physiotherapy in adults with acute exacerbations of cystic fibrosis. Thorax. Oct 2003; vol. 58, no. 10, p. 880-884, 0040-6376.

278. Placidi G et al. Chest physiotherapy with positive airway pressure: a pilot study of short-term effects on sputum clearance in patients with cystic fibrosis and severe airway obstruction. Respiratory Care. 01 October 2006; vol./is. 51/10(1145-1153), 00201324.

279. Fauroux B et al. Chest physiotherapy in cystic fibrosis: improved tolerance with nasal pressure support ventilation. Pediatrics. Mar 1999; vol. 103, no. 3, p. E32.

280. Dwyer TJ et al. Non-invasive ventilation used as an adjunct to airway clearance treatments improves lung function during an acute exacerbation of cystic fibrosis: a randomised trial.

Journal of Physiotherapy. 01 July 2015; vol./is. 61/3 (142-147), 18369553.

281. Stanford, G et al. Positive pressure – analysing the effect of the addition of non-invasive ventilation (NIV) to home airway clearance techniques (ACT) in adult cystic fibrosis (CF) patients. Physiotherapy Theory & Practice. 01 May 2015; vol./is. 31/4(270-274), 09593985.

282. Flight WG et al. Long-term non-invasive ventilation in cystic fibrosis -- experience over two decades. J Cyst Fibrosis. 2012 May; 11(3):187-92. doi: 10.1016/j.jcf.2011.11.006. Epub 2011 Dec 16. Pub Med PMID: 22177738.

283. Lima CA et al. Effects of non-invasive ventilation on treadmill 6-min walk distance and regional chest wall volumes in cystic fibrosis: randomized controlled trial. Respir Med. 2014 Oct; 108(10):1460-8. doi: 10.1016/j.rmed.2014.04.006. Epub 2014 Apr 23. Pub Med PMID: 25195137.

284. Avdeev S et al. Home non-invasive ventilation (HNIV) improves survival in hypercapnic patients with cystic fibrosis. Eur Respir Journal. 2012 Sep; vol./is. 40/, 0903-1936.

285. Young ACet al. Randomised placebo controlled trial of non-invasive ventilation for hypercapnia in cystic fibrosis. Thorax. 2008 Jan; 63(1):72-7. Epub 2007 Aug 3. Pub Med PMID: 17675317.

286. Bright-Thomas RJ et al. What is the role of non-invasive ventilation in cystic fibrosis? Curr Opin Pulm Med. 2014 Nov; 20(6):618-22. doi: 10.1097/MCP.0000000000000105. Review. Pub Med PMID: 25225790.

287. Sandsund CA et al. Musculoskeletal techniques for clinically stable adults with cystic fibrosis: a preliminary randomised controlled trial. Physiotherapy. 2011; 97:209–217.

288. Botton E et al. Musculoskeletal manifestations in cystic fibrosis. Joint Bone Spine. 2003;70:327–35.

289. Havermans T et al. Pain in CF: review of the literature. J Cyst Fibrosis. 2013 Sep;12(5):423-30.

290. Bridges C et al. Prevalence of musculoskeletal pain in the Welsh adult cystic fibrosis population J Cyst Fibrosis. 2015 ;14, Supp 1, S97.

291. Wells GD et al. Skeletal Muscle Metabolism in Cystic Fibrosis and Primary Ciliary Dyskinesia. Pediatric Research. 2011; 69, 40–45.

292. Rose J et al. Back pain and spinal deformity in cystic fibrosis. Am J Dis Child.1987; 141(12):1313-6.

293. Tattersall R et al. Posture and cystic fibrosis. J R Soc Med. 2003; 96 Suppl 43:18-22.

294. Hodges PW et al. Coexistence of stability and mobility in postural control: evidence from postural compensation for respiration. Exp Brain Res. 2002 Jun; 144(3):293-302.

295. Hodges PW et al. Postural activity of the diaphragm is reduced in humans when respiratory demand increases. J Physiol. 2001; 537(Pt 3):999–1008.

296. Smith MD et al. Disorders of breathing and continence have a stronger association with back pain than obesity and physical activity. Aust J Physiother. 2006; 52(1):11-6.

297. Lannefors L et al. Physiotherapy in infants and young children with cystic fibrosis: current practice and future developments. J R Soc Med. 2004; 97 Suppl 44: 8-25.

298. Schindel CS et al. Physical Exercise Recommendations Improve Postural Changes Found in Children and Adolescents with Cystic Fibrosis: A Randomized Controlled Trial. Journal of Pediatrics. 2015;166; 3,710–716.

299. Dodd ME et al. Physiotherapy management of cystic fibrosis. Chron Respir Dis. 2005; 2(3):139-49.

300. Fainardi V et al. Prevalence of scoliosis in cystic fibrosis: Pediatr Pulmonol. 2013; 48/6(553-555).

301. Okuro RT et al. Influence of thoracic spine postural disorders on cardiorespiratory parameters in children and adolescents with cystic fibrosis. J Pediatr (Rio J). 2012; 88:310–316.

302. García ST et al. Bone Health, Daily Physical Activity, and Exercise Tolerance in Patients with Cystic Fibrosis Chest. 2011; 140(2):475-481.

303. Reilly C et al. Thoracic kyphosis and complications in adult and paediatric CF patients – Multi centre data collaboration. J Cyst Fibrosis. 2012; 11/(S22), 1569-1993.

304. Barker N et al. Thoracic Kyphosis is Now Uncommon Amongst Children and Adolescents with Cystic Fibrosis. Pediatr. 2014; 2: 11.

305. Barrett E et al. Reliability and validity of non-radiographic methods of thoracic kyphosis measurement: A systematic review. Manual Therapy. 2013; Volume 19, Issue 1, 10 – 17.

306. King SJ et al. Reduced bone density in cystic fibrosis: ΔF508 mutation is an independent risk factor. Eur Respir Journal. 2005; 25, 54-61.

307. Haworth CS et al. Low bone mineral density in adults with Cystic Fibrosis. Thorax. 1999;54:961-967.

308. Gensburger D et al. Tibial cortical bone is impaired in adults with CF. J Cyst Fibrosis. 2015; 14/(S110), 1569-1993.

309. Putman M et al. Trends in bone mineral density in young adults with cystic fibrosis over a 15 year period. J Cyst Fibrosis. 2015; 14 (4): 526-532.

310. Marquette M et al. Bone health and disease in cystic fibrosis. Paediatric Respiratory Reviews 2016; online available at: http://dx.doi.org/10.1016/j.prrv.2016.06.003

311. Gore A et al. A roadmap to the brittle bones of cystic fibrosis. Journal of Osteoporosis. 2011; article ID607575.

312. Paccou J et al. The prevalence of osteoporosis, osteopenia, and fractures among adults with cystic fibrosis: a systemic literature review with meta-analysis. Calcif Tissue Int. 2010; 86:1–7.

313. Sermet-Gaudelus I et al. Update on cystic fibrosis-related bone disease: a special focus on children. Paediatr Respir Rev. 2009 Sep; 10(3):134-42.

314. Button BM et al. Physiotherapy for cystic fibrosis in Australia and New Zealand: A clinical practice guideline. Respirology. 2016; 21: 656–667. doi: 10.1111/resp.12764.

315. Kealaher E, et al. Duckers J. Bone mineral density and fractures at the All Wales Adult CF Centre. J Cyst Fibrosis. 2015; 14/(S110), 1569-1993.

316. P Hodges et al. Spinal Control: The Rehabilitation of Back Pain. 2013. State of the art and science.

317. The Leeds Method of Management. April, 2008. Cystic fibrosis and liver disease [online]. Leeds Regional Adult and Paediatric Cystic Fibrosis Units, St James's University Hospital, Leeds, UK. Available from http://www.cysticfibrosismedicine.com

318. Mamprin G et al. Spinal deformities in young patient with cystic fibrosis (CF): Proposal of a screening and follow up protocol. Pediatr Pulmonol. 2012; 47 (pp 372).

319. Hathorn C et al. Incidence of scoliosis in adolescent cystic fibrosis patients. Arch Dis Child 2014; 99:A43

320. Mandrusiak A et al. Muscle length and joint range of motion in children with cystic fibrosis compared to children developing typically. Physiotherapy Canada. 2010; 62/2(141-146).

321. Ashbrook JE et al. The development of a musculoskeletal screening tool for adults with cystic fibrosis. J Cyst Fibrosis. 34th European Cystic Fibrosis Conference Hamburg Germany. 2011; 10 (pp S65).

322. Ashbrook J et al. The development of a musculoskeletal screening tool for adults with cystic fibrosis: Stage 2. J Cyst Fibrosis. 2012; 11/(S109), 1569-1993.

323. Payne SJ et al. The incidence of postural problems identified via the postural screening assessment used in a paediatric annual review and the relationship with the levels of exercise taken. J Cyst Fibrosis. June 2011;10,S65-S.

324. Demry A et al. Chest strength and mobility training: a new approach to airways clearance. J Cyst Fibrosis. 2006; 29:371.

325. White D et al. The prevalence and severity of symptoms of incontinence in adult cystic fibrosis patients. Physiotherapy Theory & Practice. 2000; 16(1): 35-43.

326. Cornacchia M et al. Prevalence of urinary incontinence in women with cystic fibrosis. BJU international. 2001; 88(1): 44-48.

327. Orr A et al. Questionnaire survey of urinary incontinence in women with cystic fibrosis. British Medical Journal. 2001; 322(7301).

328. Nixon M et al. Urinary incontinence in female adolescents with cystic fibrosis. Pediatrics. 2002; 110(2).

329. Moran F et al. Incontinence in adult females with cystic fibrosis: a Northern Ireland survey. International journal of clinical practice. 2003; 57(3): 182-184.

330. Blackwell K et al. The prevalence of stress urinary incontinence in patients with cystic fibrosis: An under-recognized problem. Journal of pediatric urology. 2005; 1(1): 5-9.

331. Prasad SA et al. A comparison of the prevalence of urinary incontinence in girls with cystic fibrosis, asthma, and healthy controls. Pediatr Pulmonol. 2006; 41(11): 1065-1068.

332. Vella M et al. Prevalence of incontinence and incontinence-specific quality of life impairment in women with cystic fibrosis. Neurourology and urodynamics. 2009; 28(8): 986-989.

333. Korzeniewska-Eksterowicz A et al. Urinary incontinence in adolescent females with cystic fibrosis in Poland. Central European Journal of Medicine. 2014; 9(6): 778-783.

334. Nankivell G et al. Urinary Incontinence in Adolescent Females with Cystic Fibrosis. Paediatric respiratory reviews. 2010; 11(2): 95-99.

335. Gumery L et al. The prevalence of urinary incontinence in adult cystic fibrosis males [abstract] J Cyst Fibrosis. 2005; 4:S97.

336. Burge AT et al. Prevalence and impact of incontinence in adult men with cystic fibrosis. Respirology. 2011; 16.

337. Dodd ME et al. Urinary incontinence in cystic fibrosis. Journal of the Royal Society of Medicine. 2005; Supplement 98(45): 28-36.

338. Ashbrook JE et al. Is there a relationship between stress urinary incontinence and back pain in the Manchester Adult Cystic Fibrosis Centre female population? Journal of Cystic Fibrosis. 2010; 9. S74.

339. McVean RJ et al. Treatment of urinary incontinence in cystic fibrosis. J Cyst Fibrosis. 2003; 2(4): 171-176.

340. Button BM et al. Effect of three month physiotherapeutic intervention on incontinence in women with chronic cough relate to cystic fibrosis and COPD. Pediatr Pulmonol. 2005; Suppl 28 113 a:369.

341. Helm JM et al. A novel solution for severe urinary incontinence in women with cystic fibrosis. J Cyst Fibrosis. 2008; 7(6): 501-504.

342. Edenborough FP et al. Outcome of pregnancy in women with cystic fibrosis. Thorax. 1995; 50:170-174.

343. Edenborough FP et al. Guidelines for the management of pregnancy in women with cystic fibrosis. J Cyst Fibrosis. 2008; 7; S2-S32.

344. Thorpe-Beeston JG. Contraception and pregnancy in cystic fibrosis. J R Soc Med. 2009; 102 (Suppl 1): 3-10.

345. Parrott H et al. Airway clearance requirements during pregnancy. Pediatr Pulmonol. 2008; S31:523.

346. McArdle JR. Pregnancy in cystic fibrosis. Clinics in chest medicine. 2011; 32(1), 111-120.

347. Lau EM et al. Pregnancy outcomes in the current era of cystic fibrosis care: A 15-year experience. Australian and New Zealand Journal of Obstetrics and Gynaecology. 2011; 51(3), 220-224.

348. Burden C et al. Current pregnancy outcomes in women with cystic fibrosis. European Journal of Obstetrics & Gynaecology and Reproductive Biology. 2012; 164(2), 142-145.

349. Thorpe-Beeston JG et al. The outcome of pregnancies in women with cystic fibrosis—single centre experience 1998–2011. British Journal of Obstetrics and Gynaecology. 2013; 120:354-361.

350. Patel EM et al. Medical and obstetric complications among pregnant women with cystic fibrosis. American journal of obstetrics and gynaecology. 2015; 212(1), 98-e1.

351. Renton M et al. Pregnancy outcomes in cystic fibrosis: a 10-year experience from a UK centre. Obstetric Medicine: The Medicine of Pregnancy. 2015; 8, 99-101.

352. Parisi GF et al. Liver disease in cystic fibrosis: an update. Hepatitis monthly. 2013; 13; 8, p 1735-1743.

353. Desai CS et al. Survival of cystic fibrosis patients undergoing liver and liver-lung transplantations. Transplantation proceedings. 2013; vol.45, no.1, p.290-292.

354. Lamireau T et al. Epidemiology of liver disease in cystic fibrosis: a longitudinal study.J Hepatol. 2004 Dec; 41(6):920-5.

355. Colombo C et al. Analysis of risk factors for the development of liver disease in CF. J Pediatr. 1994; 124: 393-399.

356. Duthie A et al. Genotype analysis for delta F508, G551D and R553X mutations in children and young adults with cystic fibrosis with and without chronic liver disease. Hepatology. 1992; 15(4):660-4.

357. Kashani A et al. Fluid retention in cirrhosis: pathophysiology and management. QJM. Feb 2008; vol./is. 101/2(71-85), 1460-2725.

358. Roebuck D J et al. Mini-symposium: Imaging and Interventional Radiology. Haemoptysis and bronchial artery embolisation in children. Paediatric Respiratory Reviews. 2008; 9, 95–104.

359. Barben JU et al. Major haemoptysis in children with cystic fibrosis: a 20-year retrospective study. J Cyst Fibrosis. 2003; 2 105–111.

360. Flume PA et al. Massive Hemoptysis in Cystic Fibrosis. Chest. 2005; 128; 729-738.

361. Furnari ML et al. Case report: Bronchial to subclavian shunt in a CF patient. A potential pitfall for embolisation. J Cyst Fibrosis. 2003; 2, 217–219.

362. Efrati O et al. Hemoptysis in Israeli CF patients – Prevalence, treatment and clinical characteristics. J Cyst Fibrosis. 2008; 7, 301–306.

363. Marshall TJ et al. Review: The Role of Radiology in the Investigation and Management of Patients with Haemoptysis. Clinical Radiology. 1996; 51, 391-400.

364. Ibrahim WH. Massive haemoptysis: the definition should be revised. Eur Respir J. 2008; 32:1131-1132.

365. Flume PA. Pulmonary Complications of Cystic Fibrosis. Respiratory Care. 2009; 54(5) 618-627.

366. Flume PA et al. Concise Clinical Review. Cystic Fibrosis Pulmonary Guidelines. Pulmonary Complications: Hemoptysis and Pneumothorax. Am J of Respir and Critical Care Medicine. 2010; 182.

367. Swisher AK et al. Exercise and Habitual Physical Activity for People With Cystic Fibrosis: Expert Consensus, Evidence-Based Guide for Advising Patients. Cardiopulmonary Physical Therapy Journal. 2015; 26: 85-98.

368. Macduff A et al. BTS Draft Guidelines for the Management of Spontaneous pneumothoraces 2009; http://www.brit-thoracic.org.uk/clinical-information/pleural-disease/draft-guidelinespleural-disease.aspx

369. Cuenca AG et al. Pulmonary surgery in cystic fibrosis. Seminars in Pediatric Surgery. 2008; 17, 60-65.

370. Curtis HJ et al. Lung transplantation outcome in cystic fibrosis patients with previous pneumothorax. J Heart Lung Transplant. 2005;24:865-9

371. Robinson PD et al. Evidence-based management of paediatric primary spontaneous pneumothorax. Paediatric Respiratory Reviews. 2009; 10,110–117.

372. MacDuff A et al. Pneumothorax in cystic fibrosis: Prevalence and outcomes in Scotland. 2010; 9 : (4): 246-24.

373. Flume PA et al. Pneumothorax in cystic fibrosis. Chest. 2005;128:720-8.

374. Henry M et al. BTS guidelines for the management of spontaneous pneumothorax. Thorax. 2003;58(Suppl II):39-52.

375. Hafen GM et al. Pneumothorax in cystic fibrosis: a retrospective case series. Arch Dis Child. 2006; 91: 924-925.

376. Dicken BJ et al. Surgical management of pulmonary and gastrointestinal complications in children with cystic fibrosis. Current Opinion in Pediatrics. 2006; 18:321–329.

377. Schuster SR et al. Management of pneumothorax in adults with cystic fibrosis. J Pediatr Surg. 1983; 18:492-7.

378. Tschopp JM et al. Management of spontaneous pneumothorax: state of the art. European Respir Journal. 2006:28: 637-650.

379. Flume PA. Pneumothorax in cystic fibrosis. Chest. 2003; 123(1):217- 221.

380. Ellafi M et al. One-year outcome after severe pulmonary exacerbation in adults with cystic fibrosis. Am J Respir Crit Care Med. 2005; 171(2): 158-64.

381. Sood N et al. Outcomes of intensive care unit care in adults with cystic fibrosis. Am J Respir Crit Care Med. 2001; 163; 2: 335-8.

382. Texereau J et al. Determinants of mortality for adults with cystic fibrosis admitted in intensive care unit: a multicentre study. Respir Res. 2006; 7; 14.

383. Efrati O et al. Outcome of patients with cystic fibrosis admitted to the intensive care unit: is invasive mechanical ventilation a risk factor for death in patients waiting lung transplantation? Heart Lung. 2010; 39(2): 153-9.

384. Vedam H et al. Improved outcomes of patients with cystic fibrosis admitted to the intensive care unit. J Cyst Fibrosis. 2004; 3(1): 8-14.

385. Reid DW et al. ICU outcomes in cystic fibrosis following invasive ventilation. Respirology. 2013; 18(4), 585-586.

386. Shafii AE et al. Growing experience with extracorporeal membrane oxygenation as a bridge to lung transplantation. ASAIO Journal. 2012; 58(5), 526-529.8.

387. Rehder KJ et al. Active rehabilitation and physical therapy during extracorporeal membrane oxygenation while awaiting lung transplantation: A practical approach. Critical care medicine. 2011; 39(12), 2593-2598.

388. Rehder KJ et al. Active rehabilitation during ECMO as a bridge to lung transplantation. Respir Care. 2013 Aug;58(8):1291-8.

389. Jones ABD et al. Predictors of outcome inpatients with cystic fibrosis requiring endotracheal intubation. Respirology. 2013; doi: 10.1111/resp.12051.

390. NICE guidelines [CG83] 2009; Rehabilitation after critical illness in adults.

391. Hirche TO et al. Practical Guidelines: Lung Transplantation in Patients with Cystic Fibrosis. Pulmonary Medicine. 2014; Article ID 621342, 22 pages, 2014. doi:10.1155/2014/621342.

392. Meira L et al. Maintenance of exercise capacity in lung transplant candidates undergoing a pulmonary rehabilitation program. Eur Respir Journal. 2014; 44(Suppl 58), P631.

393. Maury G et al. Skeletal muscle force and functional exercise tolerance before and after lung transplantation: A cohort study. American Journal of Transplantation. 2008; 8:1275-1281.

394. Langer D et al. Physical activity in daily life 1 year after lung transplantation. Journal of Heart and Lung Transplantation. 2009; (28)6; 572-578.

395. Munro P et al. Pulmonary rehabilitation following lung transplantation. Transplantation Proceedings. 2009; 41:292-295.

396. Wickerson L et al. Exercise training after lung transplantation: A systematic review. Journal of Heart and Lung Transplantation. 2010; 29(5):497-503.

397. Oelberg D et al. Exercise performance in cystic fibrosis before and after bilateral lung transplantation. Journal of Heart and Lung Transplantation. 1998; 17(11):1104-1112.

398. Langer D et al. Exercise Training After Lung Transplantation Improves Participation in Daily Activity: A Randomized Controlled Trial. American Journal of Transplantation. 2012; 12: 1584–1592.

399. Vivodtzev I et al. Benefits of home-based endurance training in lung transplant recipients. Respir Physiol Neurobiol. 2011; 177(2):189-98.

400. Mitchell I et al. Cystic Fibrosis. End stage care in Canada. Chest. 2000; 118:80–4.

401. Philip J et al. End of life care in adult with cystic fibrosis. J Palliat Med. 2008;11:198–203.

402. Lowton K. A bed in the middle of nowhere: parents' meanings of place of death for adults with cystic fibrosis. Soc Sci Med. 2009 Oct; 69(7):1056-62.

403. Sands D et al. End of life care for patients with cystic fibrosis. J Cyst Fibrosis. 2011; 10 Suppl 2, S37-44.

404. Sawicki GS et al. Advance care planning in adults with cystic fibrosis. J Palliat Med. 2008; 11(8), 1135-1141.

405. Bourke SJ et al. An integrated model of provision of palliative care to patients with cystic fibrosis. Palliat Med. 2009; 23(6), 512-517.

406. Smyth AR et al. European Cystic Fibrosis Society Standards of Care: Best practice guidelines. J Cyst Fibrosis. 2014; 13 Suppl 1, S23-42.

407. Dario Vizza C et al. Outcome of Patients with Cystic Fibrosis Awaiting Lung Transplantation. American Journal of Respiratory Critical Care Medicine. 2000; 162, 917-925.

408. Dellon EP et al. Effects of lung transplantation on inpatient end of life care in cystic fibrosis. J Cyst Fibrosis. 2007; 6(6), 396-402.

409. Macdonald K. Living in limbo – patients with cystic fibrosis waiting for transplant. Br J Nurs. 2006; 15(10), 566-572.

410. WHO: http://www.who.int/cancer/palliative/definition/en/

411. Agent P et al. A retrospective analysis of physiotherapy input during a standard admission compared to a terminal admission in adults with CF. J Cyst Fibrosis. 2007; 6 (Suppl 1):S63.

412. Agent P et al. Physiotherapy adaptations in end of life care in adults with cystic fibrosis – a retrospective analysis. Pediatr Pulmonol. 2006; 41; S29: A399.

413. Clisby N et al. Psychological impact of working with patients with cystic fibrosis at end-of-life, pre-transplant stage. Palliat Support Care. 2013; 11(2), 111-121.

414. A Single Competency Framework, National Prescribing Centre, May 2012 (www.associationforprescribers.org.uk)

415. Practice Guidance for Physiotherapist Supplementary and Independent Prescribers in the safe use of medicines, 2nd edition, 2013, Chartered Society of Physiotherapy (www.CSP.org.uk).

416. Standards for Prescribing, 2013, Health and Care Professions Council (www.hcpc-UK.org).

417. Carrolan V et al. Mapping physiotherapist use of acupuncture treatment of adults with cystic fibrosis. J Cyst Fibrosis. June 2010; vol/is 9/(S76), 1569-1993.

418. Fleischman G. Possibilities of the treatment of cystic fibrosis with Acupuncture and Chinese Herbs: theory and case study. American Journal of Acupuncture. 1996; Vol 24, Issue 2/3, 135-142.

419. Kemper K et al. Massage therapy and acupuncture for children with chronic pulmonary disease. Clinical Pulmonary Medicine. 2004; Vol 11, Nr 4, 242-250.

420. Lin Y-C et al. Acupuncture pain management for patients with cystic fibrosis: a pilot study. American Journal of Chinese Medicine. 2005; 33 (1) 151-156.

421. Gibson D et al. Acupuncture for respiratory disorder: what's the point? Expert Rev. Resp. Med 2010; 4 (1) 29-37.

422. Coyle M et al. Acupuncture therapies for chronic obstructive pulmonary disease: a systematic review of randomised, controlled trials. Alternative therapies in health and medicine. 2014; 20 (6) 10-23.

423. Chervinskaya AV et al. Halotherapy for treatment of respiratory diseases. Journal of Aerosol Medicine. 1995; 8(3):221-232.

424. Graepler-Mainka U et al. Dry powder inhalation with NaCL for increasing secretolysis in cystic fibrosis patients – A pilot study. J Cyst Fibrosis. 2011; 10 (Suppl. 1): S53.

425. Al Achkar M et al. Halotherapy in patients with cystic fibrosis: A pilot study. International Journal of Respiratory and Pulmonary Medicine. 2015; 2:009.

426. Rabbani B et al. Efficacy of Halotherapy for Improvement of Pulmonary function Tests and Quality of Life of Non-Cystic Fibrosis Bronchiectatic Patients. Tanaffos. 2013; 12;(2):22-27.

427. Rashleigh R et al. A review of halotherapy for chronic obstructive pulmonary disease. International Journal of Chronic Obstructive Pulmonary Disease. 2014; 21;9:239-46.

428. Goldbeck L et al. Psychological interventions for individuals with cystic fibrosis and their families. Cochrane Database of Systematic Reviews 2014; Issue 6. Art. No.: CD003148. DOI: 10.1002/14651858. CD003148.pub3.

429. Kemper K et al. Massage Therapy and Acupuncture for Children with Chronic Pulmonary Disease. Clinical Pulmonary Medicine. July 2004; Vol 11(4), pp242-250.

430. Hernandez-reif M et al. Children with Cystic Fibrosis Benefit from Massage Therapy Journal of Pediatric Psychology. 1999; Vol 24. No 2, pp 175-181.

431. Hildage J et al. Abstract 304, ECFC 2009, J Cyst Fibrosis. 2009; 06-01, Volume 8, Pages S75- S75.

432. Lee A et al. Immediate effect of Musculo-skeletal physiotherapy techniques and massage on pain and ease of breathing in adults with CF. J Cyst Fibrosis. 2009; 01-01, Vol 8 Issue 1 p 79-81.

433. Haynes F. Benefits of aromatherapy massage for adult patients with CF. J Cyst Fibrosis. 2007; 06-01, 6: S69-S69.

434. Cincinnati Children's Hospital Medical Center. Best evidence statement (BESt). Cystic fibrosis – effects of massage therapy on quality of life. Cincinnati (OH): Cincinnati Children's Hospital Medical Center; 2009 May 8. 6 p. [11 references, Cincinnati Children's Hospital 2015.

435. Irons YJ et al. Singing as an adjunct therapy for children and adults with Cystic Fibrosis. The Cochrane Library. June 2014.

436. Drury R. 2015 http://www.breathcycle.com/uploads/2/5/2/7/25270799/dr_rachel_drury_-_research_paper.pdf. http://www.breathcycle.com/about.html

437. Lorenc Ava B et al. Meditative Movement for Respiratory Function: A Systematic Review. Respiratory Care. March 2014; Vol 59 No 3.

438. Ruddy J et al. Yoga as a Therapy for Adolescents and Young Adults with Cystic Fibrosis: A Pilot Study. American Journal of Respiratory Critical Care Medicine. 2014; Vol 189.

439. Russell S et al.Yoga improves posture and physical performance in adult persons with cystic fibrosis. Presented at NACFC, Atlanta, 2014.

16.0 Glossary of abbreviations

AAD	Adaptive Aerosol Delivery
ACBT	Active Cycle of Breathing Techniques
ACPCF	Association of Chartered Physiotherapists in Cystic Fibrosis
ACT	Airway Clearance Techniques
AD	Autogenic Drainage
BAE	Bronchial Artery Embolisation
BTS	British Thoracic Society
CF	Cystic Fibrosis
CFALD	Cystic Fibrosis-Associated Liver Disease
CFQ-R	Cystic Fibrosis Questionnaire – Respiratory
COPD	Chronic Obstructive Pulmonary Disease
CT	Computed Tomography
FEF_{25-75}	Forced Expiratory Flow (25-75)
FET	Forced Expiration Technique
FEV1	Forced Expiratory Volume in 1 second
FRC	Functional Residual Capacity
FVC	Forced Vital Capacity
GORD	Gastro Oesophageal Reflux Disease
GRADE	Grading of Recommendations Assessment, Development & Evaluation
HFCWC	High Frequency Chest Wall Compression
HFCWO	High Frequency Chest Wall Oscillation
HRCT	High Resolution CT Imaging
IPPB	Intermittent Positive Pressure Breathing
IPV	Intrapulmonary Percussive Ventilation
MRSA	Methycillin-Resistant *Staphylococcus aureus*
NIV	Non-Invasive Ventilation
PD	Postural Drainage
PEEP	Positive End Expiratory Pressure
PEP	Positive Expiratory Pressure
QoE	Quality of Evidence
SIGN	Scottish Intercollegiate Guidelines Network
UI	Urinary Incontinence
VAS	Visual Analogue Scale
VATS	Video-Assisted Thoracoscopic Surgery
VMT	Vibrating Mesh Technology
Microbiome	A community of microorganisms (such as bacteria, fungi, and viruses) that inhabit a particular environment and especially the collection of microorganisms living in or on the human body

Appendix I

Self Evaluation Tool

Standards of Care and Good Clinical Practice for the Physiotherapy Management of Cystic Fibrosis 2017

Standard 1:	**STAFFING**
Rationale:	**People with Cystic Fibrosis should be managed by physiotherapists with an appropriate level of expertise in the physiotherapy management of cystic fibrosis. There should be adequate staffing levels to maintain standards of care**

Essential Criteria	**Evaluation questions/ information request**	**Response**	**How do you plan to progress this for the future?**
1.1 Physiotherapy Lead The Lead Physiotherapist working in CF specialist centres should be a specialist CF Physiotherapist* Gp1 * definitions of Gp1,2 and 3 found on page 2 of the Standards Documentation	1.1.1 Please provide the number of patients treated by your centre annually		
	1.1.2 Please provide the ACPCF membership number of the Lead Physiotherapist		
	1.1.3 Please outline the role undertaken by your Lead Physiotherapist e.g. job plans, CPD, PDP, etc		
1.2 Network Clinics All designated CF Network clinics should have a named physiotherapist responsible for the care of people with CF (Group 2). They will have strong links and regular 2 way communication with the CF Specialist physiotherapist at the CF specialist centre	1.2.1 Does your service support Network clinics? If so, please provide details of main contact		
	1.2.2 Where applicable, please explain how such clinics are provided. e.g. how often/ capacity, staffing, treatments/ tests performed, etc		
	1.2.3 How is information shared across the various physiotherapy teams? Briefly describe how you communicate e.g. email, letter or phone Are you aware of the standardised inpatient and outpatient electronic forms available on iCSP? If so, have you used these?		

Essential Criteria	Evaluation questions/ information request	Response	How do you plan to progress this for the future?
1.3 Access to services All physiotherapists providing care for people with CF in settings other than the CF specialist centre should:- ▪ Have access to specialist physiotherapy advice from the CF specialist centre ▪ Have access to training/ CPD in CF ▪ Follow Clinical Guidelines of Physiotherapy Management in the CF patient, ACPCF (2011, updated in 2016) ▪ Follow local treatment guidelines as set out by the specialist CF centre	1.3.1 Describe the interaction between the specialist centre and all other areas where physiotherapy staff provide care e.g. joint study days/meetings, case conferences, etc		
	1.3.2 What CF training is available to physiotherapy staff working across primary, secondary and tertiary care? e.g. course flyers, programme content, competencies, In service training programmes, etc Would you like access to ACPCF clinical competencies? This would be a minimum competency framework for CF centres		
	1.3.3 Describe how local guidelines and protocols are made readily available to all staff caring for people with CF e.g. electronic or paper format. Is this easily accessible If internet information is available, please provide links		
1.4 Staffing Levels Staffing levels should be in line with those set out in the "Standards for the Clinical Care of Children and Adults with Cystic Fibrosis in the UK 2001". Please take into account the revision made by the Cystic Fibrosis Trust in 2008	1.4.1 Please outline your staffing levels describing Grade and WTE Do you require assistance with the development of a business case if you feel that you need to increase your staffing levels in line with the UK Standards?		
	1.4.3 Which patient cohort does your centre treat? Identify any dedicated resource for treating patients who do not meet your usual criteria	Adult ☐ Paeds ☐ Transitional ☐	

Standard 2:	STAFFING
Rationale:	People with CF should have an appropriate physiotherapy service from sufficiently skilled individuals at different stages of their care in different settings

Essential Criteria	Evaluation questions/ information request	Response	How do you plan to progress this for the future?
2.1 Diagnosis All people newly diagnosed with CF (either through newborn screening or later diagnosis) should see a specialist CF Physiotherapist soon after diagnosis. Frequency of input should be tailored to the individual but frequent assessment and advice will be required in the months following diagnosis. Access to physiotherapy should be weekly if required in the months following diagnosis.	2.1.1 How soon are patients seen by physiotherapy staff after diagnosis?		
	2.1.2 Do patients receive a standard management plan/ standard operating pathway? If so, would you be willing to share this?		
	2.1.3 How frequently are patients reviewed following diagnosis?		
2.2 Clinic All people with CF should: ▪ Have access to a physiotherapist at each clinic visit. This will be a network centre physiotherapist, specialist CF physiotherapist or a joint consultation with both ▪ See a specialist CF physiotherapist at least twice a year (one of these to be the annual review visit), and more frequently if required. ▪ Have the opportunity to visit a physiotherapist between clinic visits as required ▪ Be reviewed as an out-patient during a course of I.V's if community physiotherapy is not available	2.2.1 How do you ensure that patients see a specialist physiotherapist at least twice a year?		
	2.2.2 How do patients access additional sessions with physiotherapy staff out of normal working hours? Do you offer a Homecare service?		
	2.2.3 Are your patients reviewed during a course of outpatient IV's? If so please identify by whom and the frequency of review If not, why not, e.g. resource implications, not clinically indicated.		

Essential Criteria	Evaluation questions/ information request	Response	How do you plan to progress this for the future?
2.3 Annual Review The physiotherapy annual review should be carried out by the specialist CF physiotherapist	2.3.1 Describe the process of annual review for patients e.g. demonstration of ACT, exercise testing, postural assessment etc		
	2.3.2 Please provide the documentation used to ensure that there is appropriate standardisation of the annual assessments carried out for each patient		
2.4 In-patients All people with CF admitted to hospital for in-patient care should have access to daily physiotherapy assessment and treatment as required	2.4.1 Do you have a formal mechanism to record in-patient activity? If so, please describe.		
	2.4.2 Do you have a formal mechanism to record out-patient activity? If so, please provide evidence e.g. Data collection sheet or monthly collated statistics (ensure anonymised or sheet provided is blank)		
	2.4.3 What is the frequency of physiotherapy treatments offered? Please describe the system in place to ensure this occurs e.g. ACT sessions, Gym sessions, etc		
	2.4.4 Do patients and/or their carers ever need to undertake their own physiotherapy regimen whilst in hospital?		
	2.4.5 Who provides in-patient physiotherapy care? e.g. Grades of staff and number of staff available		
	2.4.6 What is the exercise opportunity available for inpatients? How does this vary with M Abscessus patients?		
	2.4.7 How is weekend care provided?		
	2.4.8 Do you offer a 5/7, a 5+2 or 7/7 service? For clarity a 5 over 7 is the current week day staffing over a 7-day period, this usually means there are weekdays which can be under staffed. A 5+2 is normal 5-day service with additional staff over the weekend specific only to CF (not as part of the on-call service). A 7/7 is a full properly funded service every day of the week and weekend		

Essential Criteria	Evaluation questions/ information request	Response	How do you plan to progress this for the future?
2.5 Community Community Physiotherapy should be provided for people with CF especially at times of particular need e.g.:- ▪ At diagnosis ▪ When changes in therapy delivery or technique is required ▪ During chest exacerbation ▪ In the event of palliative care at home. When home IV treatment is prescribed, community physiotherapy at home or school should be available to support intensification in physiotherapy treatment. This should be once a week as a minimum.	2.5.1 Please describe your local arrangements for the provision of community physiotherapy		
	2.5.2 What are your clinical criteria for home visits? Please provide evidence		

Standard 3:	FACILITIES
Rationale:	People with CF should have access to appropriate facilities for their physiotherapy care as in-patients and out-patients

Essential Criteria	Evaluation questions/ information request	Response	How do you plan to progress this for the future?
3.1 Facilities should recognise the need for privacy and dignity when carrying out airway clearance and exercise	3.1.1 What in-patient facilities are available for your patients? e.g. Single rooms, Exercise areas, Play rooms adolescents rooms, school rooms Laundry facilities, internet access Kitchen facilities Relatives room Facilities for parents and carers to sleep overnight if appropriate		
3.2 Adequate facilities for exercise should be available to people with CF as in-patients e.g. gym with adequate range of exercise equipment and sufficient space for aerobic exercise and exercise testing to be carried out	3.2.1 How do you ensure that staff are available to oversee physical activity and deliver exercise testing for in-patients?		
3.3 Facilities for physiotherapy treatment must enable local infection control policies to be adhered to	3.3.1 How do you ensure that local infection control policies are followed? Please provide Copies of local IC policies/protocols/etc If a room has been used for an exercise session, how long do you leave between patients?		

Standard 4:	EQUIPMENT
Rationale:	**All people with CF should be provided with appropriate respiratory and exercise equipment and will be trained in its use and maintenance.**

Essential Criteria	Evaluation questions/ information request	Response	How do you plan to progress this for the future?
4.1 Patients should be provided with the respiratory equipment they require for use at home e.g. to nebulise medication, for airway clearance, for oxygen delivery and humidification	4.1.1 Identify the respiratory equipment frequently used by your service, including nebuliser equipment and different therapy adjuncts (e.g. PEP and oscillatory PEP if applicable), I-nebs/E-Flow, Cough assist, NIV, HFCWO		
4.2 There are written protocols for equipment used by and issued to patients	4.2.1 Provide evidence of the protocols and any other relevant information. If available electronically, please provide link		
	4.2.2 Do you have a register which details what type of equipment is held by patients? If so, please provide an anonymous example of the documentation used		
4.3 Inpatient/Departmental Use: All equipment is maintained, serviced, cleaned and sterilised according to the manufacturer's instructions and local policies	4.3.1 How do you ensure that this occurs? e.g. Handout of nebuliser cleaning advice etc How do you decontaminate an NIV machine used by an M.Abscessus or B,Cepacia patient? When resident in hospital do you provide alternative nebuliser systems and if so how do you ensure appropriate decontamination after use?		
4.4 Patients and carers should be trained in the use of equipment supplied for home use	4.4.1 Describe the process used to educate and inform patients and carers about the use of equipment e.g. training schedules, receipt of equipment forms, etc		

Essential Criteria	Evaluation questions/ information request	Response	How do you plan to progress this for the future?
4.5 Home Use Written instructions about the use, cleaning and sterilising procedures are issued to all patients taking equipment home	4.5.1 Please provide evidence of the information that is given to patients and their carers e.g. Leaflets, Booklets, etc		
	4.5.2 What process is in place to ensure such documentation is regularly reviewed and updated? e.g. Annual review checks on equipment and upload of I neb data		
	4.5.3 How do you ensure that the information is appropriate for patients in that it addresses issues such as language barriers, physical impairment and literacy? e.g. Equality and diversity issues, Different languages/Braille etc, Advocacy/interpreter access Eflow manufacturers instructions are in multiple languages, Picture guides		
4.6 There must be clear and adequate budget available for the provision of physiotherapy and nebulisation equipment, and clear responsibility as to who holds this budget	4.6.1 How are physiotherapy equipment and nebulisers funded?		
	4.6.2 Is this funding adequate for the demands of your service? If not, please identify the gaps		
	4.6.3 Where there is a shortfall, how do you prioritise patient needs?		

Standard 5:	CLINICAL STANDARDS
Rationale:	Physiotherapy clinical care should be based on best evidence available: current ACPCF and Cystic Fibrosis Trust guidelines. Protocols and consensus documents will be followed

Essential Criteria	Evaluation questions/ information request	Response	How do you plan to progress this for the future?
5.1 Copies of all documents listed in the introduction to the clinical standards should be available at centres where people with CF receive care	5.1.1 How do you ensure that these documents are available? e.g. Induction packs (electronic copies and/or paper folders), internet links to documents		
	5.1.2 What different formats can this information be supplied in? egg Literature in braille, audio, DVD, language translations, etc		
5.2 All Physiotherapy staff caring for people with CF should be expected to read these documents during their induction period and areas for training and development identified	5.2.1 How is awareness of current guidelines and protocols incorporated into staff induction programmes?		
	5.2.2 Is acknowledgement of new guidelines and existing best practice recognised within formal systems? e.g. PDP/KSF/ rotational objectives, etc		
	5.3.3 How are any findings & recommendations acted upon and implemented? Please supply examples		

Standard 6:	INFECTION CONTROL
Rationale:	**All physiotherapists working with people with CF should consider issues of hygiene and cross infection.**

Essential Criteria	Evaluation questions/ information request	Response	How do you plan to progress this for the future?
6.1 All staff should have knowledge of and work to: Local Infection Control Policies, Cystic Fibrosis Trust guidelines on prevention & infection control with Burkholderia Cepacia complex, Pseudomonas Aeruginosa and MRSA in people with CF	6.1.1 Please describe how such adherence is implemented locally e.g. E learning on hand washing, Hand washing audit etc		
	6.1.2 Please provide evidence of the local, regional and national protocols that are available to staff		
6.2 All patients should have their **own** equipment such as: ▪ Compressors/nebulisers ▪ O_2 equipment ▪ Airway Clearance Devices	6.2.1 How do you ensure that such equipment is readily available? What do you do if patients do not bring their own nebuliser into hospital?		
	6.2.2 Currently, what % of your patients have this type of equipment for their individual use: ▪ Nebulisers (specify type) ▪ O_2 (specify type e.g. Liquid/ Homefill) ▪ ACT devices		
6.3 Physiotherapists should have access to records of individual microbiological status	6.3.1 Please describe what access you have locally e.g. Computer systems, Paper records, etc		
6.4 There should be rigid adherence to infection control policies when carrying out airway clearance, exercise, nebulisation and spirometry.	6.4.1 Please demonstrate the process used to ensure that infection control policies are enforced when performing such tasks e.g. Single patient rooms, or in gym, X-ray spirometry, pharmacy etc Does this differ if a patient has M.Abscessus or B.Cepacia?		

Essential Criteria	Evaluation questions/ information request	Response	How do you plan to progress this for the future?
6.5 Staff should take all reasonable precautions to reduce the risk of cross-infection Areas of concern should include rigorous hand-washing , Pulse Oximeters and exercise equipment wiped between patients, wearing of aprons and gloves for ACT in accordance with local policy, Stethoscopes wiped between patients, Respiratory secretions handled with care (cover sputum pots and dispose of at least daily soiled tissues dispose immediately)	6.5.1 What arrangements are in place to review any concerns raised through infection control issues? e.g. incident reporting, etc		
	6.5.2 What is the segregation policy for treating patients at high risk of infection whilst in-patients? e.g. Separate wards, Different clinic times, etc		
	6.5.3 What is the segregation policy for treating patients at high risk of infection whilst attending clinics, e.g. *MRSA, M.Abscessus, B.Cepacia*		

Standard 7:	PROFESSIONAL DEVELOPMENT AND TRAINING
Rationale:	Physiotherapists caring for people with CF have a professional responsibility to keep up to date with current CF research and continually to up-date their skills and knowledge to provide the best possible clinical care.

Essential Criteria	Evaluation questions/ information request	Response	How do you plan to progress this for the future?
7.1 Physiotherapists in Group 1, 2 and 3 should ensure they maintain their CPD in general respiratory care and ensure they have adequate clinical skills to follow the Clinical Guidelines of Physiotherapy Management in the CF Patient (ACPCF 2002 updated 2010)	7.1.1 Please provide evidence of CPD and Competency records for staff e.g. Generic CPD/IST programme for work within CF unit Would you be willing to share clinical competency frameworks?		
7.2 Physiotherapists in Group 1 and 2 should be members of the Association of Chartered Physiotherapists in Cystic Fibrosis (ACPCF) and will attend local ACPCF meetings	7.2.1 Do staff attend at least one local CF meeting annually? Please provide evidence of attendance and participation in local meetings e.g. Certificate of attendance, Minutes, etc		
7.3 Physiotherapists in Group 2 should attend annual local or regional CF study events (e.g. organised by Regional Specialist Centre)	7.3.1 Do staff attend at least one regional or national CF meeting annually? Please provide evidence of attendance and participation in regional or national study events e.g. Oral/Poster presentations at events, certificate of attendance, etc		
7.4 Physiotherapists in Group 1 should attend at least one CF meeting annually. This should be the annual national ACPCF study event or a national CF study day. They should have the opportunity to attend international CF conferences	7.4.1 Please provide evidence of attendance and participation at such meetings		
	7.4.2 Are there any limitations on staff attending such conferences? If so, what are these constraints? e.g. cost implications, study leave, etc		
7.5 Physiotherapists in Group 1 demonstrate knowledge of current CF research and should be involved in CF research locally as appropriate	7.5.1 Please provide evidence of any research undertaken in the last 2 years or give a brief outline of any work that is ongoing		

Thank you for your time completing this audit. The information you provide will be in confidence, however following the national report we hope to be able to provide a report individualised for your unit. For this reason we would ask you to provide the name of your CF Unit here: _____

Appendix II

Physiotherapy Management of Screened Infants with CF

Physiotherapy Guidance Paper:

The ACPCF have released a number of guidance papers. These papers have been written and approved by members of the ACPCF committee and ACPCF protocols working group.

Wherever possible, experts within a particular area have been consulted and contributed to a paper. Reference is made to the literature on the subject, but a rigorous protocol with thorough review of the literature may not have been undertaken. These papers should therefore be considered as an aid to clinical practice and not as a definitive protocol for a given topic.

Date of Issue: October 2008

Authors: Ammani Prasad, Elaine Dhouieb

Contact details: PRASAA@gosh.nhs.uk

Contributors: Penny Agent, Katie Ferguson, Mary Dodd, ACPCF Committee

ACPCF Physiotherapy Guidance Paper no. 4

Clinical guidance for the Physiotherapy Management of Screened Infants with Cystic Fibrosis

II.1 Clinical guidance for the Physiotherapy Management of Screened Infants with Cystic Fibrosis

Introduction

These guidelines have been compiled to complement the Delphi Consensus on Physiotherapy Management of Asymptomatic Infants with Cystic Fibrosis (CF).[1] Babies born with CF have essentially normal lungs but within variable timescales develop chronic respiratory disease, which will ultimately be fatal in the majority of patients. With the recent introduction of newborn screening throughout the UK babies are diagnosed with CF soon after birth, often before they have any symptoms or lung pathology. Additionally, babies with mild mutations who may not have become symptomatic until adult life are also being diagnosed in infancy. This means that there is now a cohort of infants who present to CF Centres at a very young age and often with no signs or symptoms of disease. Over the last two decades, the importance of early intervention has been recognised,[2,3] and most CF Centres have adopted a policy of close monitoring and aggressive treatment of early lung disease. A significant number of children with CF now have normal lung function well into early adulthood even though they are very likely to have underlying lung pathology.[4] Traditionally in the UK, chest physiotherapy has been instigated at diagnosis, consisting of twice daily postural drainage (PD) using a head down tip combined with chest wall percussion. Many babies and young children presenting to CF Centres now display no overt signs of respiratory disease and have good nutritional status with body mass index (BMI) within normal limits. Specialist physiotherapists in the UK caring for these babies have begun to question the role of traditional, routine airway clearance in these 'asymptomatic' babies. While health professionals agree unanimously that physiotherapy interventions are appropriate once respiratory symptoms are apparent,[5,6] the place of routine daily airway clearance prior to this is less clear. It is also recognised that while infants may be asymptomatic at diagnosis they may over a given time span, swing along a spectrum of being asymptomatic at times and symptomatic at others. How this should be dealt with in terms of routine airway clearance is also not established. A review of patients and families by the Cystic Fibrosis Trust reported that chest physiotherapy is considered a large burden of care. Families wish to know if routine treatment is necessary in those babies with few or no symptoms.[7] Physiotherapists have a duty to provide safe and effective care and daily treatment regimens need to be tailored to individual needs, lifestyle and symptoms, particularly as long-term routine ACT is seen as a substantial burden for patients and families.[7] With these apparently asymptomatic babies the dilemma now facing physiotherapists is whether it is necessary to recommend daily routine airway clearance, and if so then which airway clearance technique (ACT) is most appropriate.

There is currently no evidence addressing these questions and the issue of whether routine airway clearance is necessary has generated considerable international debate. Present circumstances preclude a rigorous clinical trial in the UK.[1]

Arguments for early commencement of physiotherapy in symptom free babies are three-fold. Firstly, there is good evidence that early lung disease precedes the development of overt symptoms in children with CF.[2,8-14] Secondly, anatomical and physiological differences, which result from immaturity of the respiratory system, in combination with CF, render the CF infant more vulnerable than the older child to respiratory complications and infection.

Finally, establishing daily routines early in a life-long illness is thought to facilitate acceptance of the need for treatment and adherence on the part of both the child and family. It may also enable parents to maintain their competency in airway clearance techniques.[15–17] Conversely, the presence of bacterial infection and raised inflammatory markers reported from BAL is not always associated with excessive sputum production or symptoms that respond to airway clearance. There is no physiological argument or scientific proof that physiotherapy is helpful in alleviating the inflammatory process within the airways. It is well known that adherence to routine therapy in chronic disease poses a significant problem and that when the benefit of a treatment is not immediately apparent, adherence is often poorest.[18-21]

Literature review

There is good evidence that babies may have respiratory involvement even when well on clinical examination and showing no overt symptoms. Sophisticated investigative techniques such as infant lung function, bronchoalveolar lavage (BAL) and high resolution computed tomography (HRCT) show that early changes are present from an early age.

Bronchoalveolar lavage

Kahn et al. (1995) reported airway inflammation to be present in infants as young as four weeks (increased IL-8 levels and neutrophils) from bronchoalveolar lavage fluid (BALF) of 16 infants diagnosed with CF through a state wide neonatal screening programme.[8] Levels were increased even in some infants who had negative cultures for common CF-related bacterial pathogens. Armstrong et al. (1995) reported that *Staphylococcus aureus* was present in BALF of almost 40% of CF infants (14/45), more than one third of whom were symptom free. Although respiratory pathogens were found to be an important cause of inflammation, not all infected subjects had inflammatory cells or symptoms. This study also suggested that infection was overestimated by throat cultures, suggesting that for many subjects bacterial pathogens remain confined to the upper airways. Rosenfeld et al. studied 40 CF infants over a two year period and reported an increase in CF pathogens with age.[2] Infants had elevated markers of inflammation whether CF pathogens were recovered or not, although the concentrations of these markers increased with the density of CF pathogens in BALF. These infants were also reported to have obstructive lung disease (expiratory flows and air trapping). Nixon et al. (2002) investigated the relationship between lower airway infection and inflammation, respiratory symptoms and lung function in infants and young children with cystic fibrosis diagnosed by newborn screening.[22] Thirty-six children (<3yrs) underwent BAL and lung function testing, Lower airway infection was associated with a significant reduction in lung function. Although a daily moist cough within the week before testing was reported on 20/54 testing occasions, infection was only detected in only seven samples. Children with a daily cough had lower lung function than those without respiratory symptoms at the time of BAL. The authors concluded that both respiratory symptoms and airway infection have independent additive effects on lung function (unrelated to airway inflammation). The presence of a moist daily cough in young children with mild CF lung disease is independently associated with a reduction in lung function. In a retrospective review of a non-newborn screened population, Hilliard et al. (2007) reported the presence of P. aeruginosa in 20% (5/25) and S. aureus in 16% (4/25). The median age of the study population was 12 months and lavage culture was reported to be positive in eight out of eighteen asymptomatic children.[23]

Lung function

Lung function abnormalities in infants with CF have been reported from as early as 1988.[24, 25] Measurements of airway function in non-screened newly diagnosed infants made soon after diagnosis and then repeated six months later were reported by Ranganathan et al. (2004).[11] After adjusting for age, length, sex and exposure to maternal smoking, the authors reported a significant reduction in FEV0.[5] both soon after diagnosis and on repeat testing six months later. This study implies that airway function is diminished in a non-screened population soon after diagnosis and the reduction persists during infancy.

Lung clearance index (LCI) is a measure of ventilation inhomogeneity, which is derived from a multiple-breath inert gas washout (MBW) technique. Lum et al. studied 39 non-screened infants using MBW to measure LCI alongside measures of other airway function.[26] Using both techniques, abnormalities were detected in 72% of infants (41% of abnormalities were detected by both techniques and a further 15% by each of the two tests performed). Kozlowska et al. (2008) reported findings of a longitudinal study of 48 children (non-screened, but managed at a specialist CF Centre) with CF and 33 healthy control.[13] Over these early years, the diagnosis of CF itself accounted for a significant reduction in $FEV_{0.75}$ and $FEF_{25–75}$. Wheeze on auscultation, recent cough, and *Pseudomonas aeruginosa* infection (even if apparently effectively treated) were all independently associated with further reductions in lung function. This study demonstrated that CF per se, in the absence of complications, is associated with decreased lung function and specialist treatment does not appear to ameliorate this, implying that new treatments are needed to improve lung health.

Computed tomography of the chest

There are many studies that show early inflammation and air trapping in infants with CF. Martinez et al. showed that infants with CF have thickened airway walls, narrowed airway lumens and air trapping compared with controls in High Resolution Computed Tomography.[14] These measurements correlated with airway function. However, it is unclear which if any of these changes ACT will influence.

Adherence

The argument for establishing a daily routine to optimise adherence is not established. Non-adherence to treatment regimens in chronic disease has been reported to be as high as 50%.[18-20] Time-consuming interventions which have no immediately palpable benefit and those interventions which cause disruption to lifestyle are associated with poorer rates of adherence.[19-21] It has also been suggested that insistence on routine daily treatment may even reduce adherence during the adolescent years when the need for treatment may become greater.[27]

Physiotherapy

One of the dilemmas for CF physiotherapists is when and what treatment to teach parents and carers of asymptomatic infants diagnosed by newborn screening. There is clear evidence to suggest early lung disease is present even in the absence of symptoms and it is widely accepted that early and aggressive treatment of lung disease is essential. However, the early pathophysiological changes are not always associated with signs or symptoms that respond to airway clearance. If these "asymptomatic" babies are carefully monitored and have no apparent chest pathology that responds to airway clearance, what is the place of daily routine airway clearance have in this cohort? Also, if inflammation plays a significant role in early lung disease, can ACT have any role in alleviating this process? Conversely if infection, with likely sputum production is part of the early pathological picture then early institution of airway clearance would appear sensible. There is nothing in the current literature that addresses these specific issues but some studies are relevant to this topic.

A systematic review comparing chest physiotherapy to no chest physiotherapy in CF has been undertaken by Van der Schans et al.[28] In a comprehensive search, 126 randomised controlled trials were identified but only six studies were eligible for inclusion in the review, due mainly to methodological issues, such as the lack of a "no treatment" control population. Even the included studies scored poorly in terms of methodological quality (using the Jadad scoring system[29]), mainly because two of the items scored are blinding and in physiotherapy studies it is impossible to blind both investigator and subject to the intervention. Due to high variability of outcome measures meta–analysis was not possible and the authors could not draw any conclusions with regard to the long-term effects of chest physiotherapy in CF. However the results of this review indicated that airway clearance techniques have short-term effects in the terms of increasing mucus transport.

Very few studies examine the effects of chest physiotherapy in children specifically. Desmond et al. (1983) evaluated the effects of chest physical therapy in eight children with CF.[30] Spirometric measures of lung function were compared from baseline to the end of a three-week period without chest physical therapy with measurements at baseline and the end of a period of chest physiotherapy on a twice-daily basis. The authors reported deterioration in lung function following the three-week period without treatment, which was reversed with resumption of treatment. The immediate effect of four modes of treatment on lung function in 19 infants was assessed by Maayan et al. (1985) during the first year of life.[31] The regimens were applied in a randomised fashion (inhaled salbutamol, inhaled N-acetyl cysteine, chest physiotherapy; or a combination of all three). No significant changes in lung volumes were reported in individual groups but there was a small improvement with the combined treatment group when compared with inhalation therapy or chest physiotherapy alone. Both of these studies are now over 20 years old and therefore relate to a very different population of infants, and none were carried out in asymptomatic infants.

More recently Constantini et al. (2003) compared the long-term efficacy of PEP mask versus postural drainage and percussion in infants with CF. There was no difference in deterioration on chest radiograph or days per year of antibiotics over a one year period.[32] The authors concluded that PEP was safe to use in early childhood and equally effective as postural drainage and percussion, although patients and parents preferred PEP. In Sweden significant changes were made to the physiotherapy management of patients with CF at the beginning of the 1980s from postural drainage & percussion or active cycle of breathing techniques (ACBT) to an individually tailored programme of physical activity, inhalation therapy and airway clearance.[33] Dennersten et al. reported the lung function of their patient population (7 years or older) over a three-year period, with a median FEV_1 of 93% in the 7-12 year old age group, concluding that their management regimen showed goodresults.[34]

The issue of gastro-oesophageal reflux (GOR) has received much attention over the past decade. Button et al. demonstrated that GOR increased in physiotherapy regimens which used postural drainage incorporating a head down tilt when compared with regimens which used a modified postural drainage (omitting any head down tilt).[35,36] Long-term follow up of these infants also reported fewer respiratory complications in the group receiving modified postural drainage.[37] Despite weaknesses in these studies (in particular with regard to subject numbers), the potentially detrimental effects of postural drainage raised have led many to recommend that the head-down tipped position should no longer be used in infants during airway clearance regimens.[38]

In a prospective randomised controlled study, Dhouieb et al. investigated the effect of a single airway clearance session (ACBT) compared with a control group on LCI, FEV_1 and FRC in 18 children with CF (12m; 6f), mean age 11.94 years (7-17yrs).[39] There were no statistically significant differences in any of the outcome measures between the groups. However, the treatment group showed an increase in LCI. This increase may be due to changes in ventilation and movement of secretions resulting from the airway clearance session. The rise is likely to be temporary but larger numbers are required to investigate the effect of ACTs on LCI.

Formulation of clinical guidance

The literature to date does not provide us with clear evidence as to who may benefit from routine ACTs and whether those who have no symptoms require routine daily airway clearance. Prasad and Main[27] stated:

However, in the era of evidence-based medicine, adopting new approaches without a substantial evidence base risks the loss of potentially beneficial elements of traditional treatments.

The best way to address this issue would be to undertake a prospective randomised control trial comparing twice-daily routine airway clearance with a regimen of close monitoring and airway clearance on a p.r.n basis. However, present circumstances preclude a rigorous clinical trial in the UK.[1] In view of this, the absence of any robust scientific evidence and the concerns of some physiotherapists, The Association for Chartered Physiotherapists in CF conducted a Delphi consensus exercise amongst specialist physiotherapists in the UK, in order to formulate guidelines for the management of infants with cystic fibrosis diagnosed by newborn screening. The Delphi technique is a consensus method that can be applied to situations where published information is non-existent or inadequate.[40] It is used to canvas opinion and to make structured decisions using a multiple postal survey technique to gather and refine expert opinion on any given issue. It has been widely used within the nursing and allied health professions. The results of this process showed that there was a very high consensus of opinion amongst senior physiotherapists in the UK on most aspects of the physiotherapy management of babies with CF. However; consensus could not be achieved on whether routine daily chest physiotherapy is necessary in 'asymptomatic' babies.

The issue of routine daily airway clearance remains contentious. While most physiotherapists agreed that a rigid twice-daily prescription of airway clearance is often no longer needed, some were reluctant to advise that airway clearance was not necessary on a daily basis. An agreed amendment to the original statement allows the individual practitioner to make this judgement on an individual patient basis with the sanction of a professional body. The wording of the guidelines reflects this agreed amendment to the single statement, which did not achieve consensus during the process. The results of this process have been used to form the basis of the following clinical practice guidance.

References

1. Prasad S A, Main E, Dodds M E. Finding Consensus on the Physiotherapy Management Of asymptomatic Infants with CF. *Pediatric Pulmonology* 2008; 43; 236-244.

2. Rosenfeld M, Gibson RL, McNamara S, Emerson J, Burns JL, Castile R, Hiatt P, McCoy K, Wilson CB, Inglis A, Smith A, Martin TR, Ramsey BW. Early pulmonary infection, inflammation and clinical outcomes in infants with cystic fibrosis. *Pediatr Pulmonol* 2001; 32:356–366.

3. Sims EJ, Clark A, McCormick J, Mehta G, Connett G, Mehta A, United Kingdom Database Steering Committee. Cystic fibrosis diagnosed after two months of age leads to worse outcomes and requires more therapy. Pediatrics 2007; 119:19-28.

4. Tiddens H A. detecting early structural lung damage in cystic fibrosis. *Pediatric Pulmonology* 2002; 34: 228-231.

5. Robinson P. Cystic fibrosis. Thorax 2001; 56:237–241.

6. Gibson RL, Burns JL, Ramsey BW. Pathophysiology and management of pulmonary infections in cystic fibrosis. Am J Respir Crit Care Med 2003; 168:918–951.

7. Cystic Fibrosis Trust. Strategic Review 'Project Life' 2000. Cystic Fibrosis Trust, Bromley, Kent, UK.

8. Khan TZ, Wagener JS, Bost T, Martinez J, Accurso FJ, Riches DWH. Early pulmonary inflammation in infants with cystic fibrosis. Am J Respir Crit Care Med 1995; 151:1075–1082.

9. Armstrong DS, Grimwood K, Carzino R, Carlin JB, Olinsky A, Phelan PD. Lower respiratory infection and inflammation in infants with newly diagnosed cystic fibrosis. BMJ 1995; 310: 1571–1572.

10. Ranganathan SC, Dezateux C, Bush A, Carr SB, Castle RA, Madge S, Price J, Stroobant J, Wade A, Wallis C, Stocks J, London Collaborative Cystic Fibrosis Group. Airway function in infants newly diagnosed with cystic fibrosis. Lancet 2001; 358: 1964–1965.

11. Ranganathan SC, Stocks J, Dezateux C, Bush A, Wade A, Carr S, Castle R, Dinwiddie R, Hoo AF, Lum S, Price J, Stroobant J, Wallis C. The evolution of airway function in early childhood following clinical diagnosis of cystic fibrosis. Am J Respir Crit Care Med 2004; 169:928–933.

12. Aurora P, Kozlowska W, Stocks J. Gas mixing efficiency from birth to adulthood measured by multiple-breath washout. Respir Physiol Neurobiol 2005; 148:125–139.

13. Kozlowska WJ, Bush A, Wade A, Aurora P, Carr SB, Castle RA, Hoo A, Lum S, Price J, Ranganathan S, Saunders C, Stanojevic S, Stroobant J, Wallis C, Stocks J, on behalf of the London Cystic Fibrosis Collaboration. Lung Function from Infancy to the Preschool Years following Clinical Diagnosis of Cystic Fibrosis. American Journal of Respiratory and Critical Care Medicine; 2008; 178: 42-49.

14. Martinez TM, Llapur CJ, Williams TH, Coates C, Gunderman R, Cohen MD, Howenstine MS, Saba O, Coxson HO, Tepper RS. High-resolution computed tomography imaging of airway disease in infants with cystic fibrosis. Am J Respir Crit Care Med 2005; 172:1133–1138.

15. Lannefors L, Button BM, McIlwaine M. Physiotherapy in infants and young children with cystic fibrosis: current practice and future developments. J R Soc Med 2004; 97:8–25.

16. (a) Lemons PM, Weavers DD. Beyond the birth of a defective child. Neonatal Netw 1987; 5:13–2015. (b) Myer PA. Parental adaptation to cystic fibrosis. J Pediatr Health Care1998; 2:20–28.

17. Jedlicka-Kohler I, Gotz M, Eicher I. Parents' recollection of the initial communication of the diagnosis of cystic fibrosis. Pediatrics 1996; 97:204–209.

18. Finney JW, Hook RJ, Friman PC, Rapoff MA, Christophersen ER. The overestimation of adherence to pediatric medical regimens. Child Health Care 1993; 22:297–304.

19. Czajkowski DR, Koocher GP. Medical compliance and coping with cystic fibrosis. J Child Psychol Psychiatry 1987; 28:311– 319.

20. Bryon M. Adherence to treatment in children. In: Myers L, Midence K, editors. Adherence to treatment in medical conditions. Oxford: Harwood; 1996. pp. 161–189.

21. Gudas LJ, Koocher GP, Wypij D. Perceptions of medical compliance in children and adolescents with cystic fibrosis. J Dev Behav Pediatr 1991; 12:236–242.

22. Nixon G M et al. Early airway infection, inflammation and lung function in CF. *Archives of Diseases of Childhood* 2002; 87:306-311.

23. Hilliard ADC 2007.

24. Beardsmore CS, Bar-Yishay E, Maayan C, Yahav Y, Katznelson D, Godfrey S. Lung function in infants with cystic fibrosis. Thorax 1988; 43:545-51.

25. Tepper RS, Montgomery GL, Ackerman V, Eigen H. Longitudinal evaluation of pulmonary function in infants and very young children with cystic fibrosis. Pediatr Pulmonol 1993; 16:96-100.

26. Lum S, Gustafsson P, Ljungberg H, Hulskamp G, Bush A, Carr S, Castle R, Hoo A, Price JF< Ranganathan S, Stroobant J, Wade A, Wallis C, Wyatt H, Stocks J, London Cystic Fibrosis Collaboration. Detection of cystic fibrosis lung disease: multiple-breath washout vs. raised volume tests. Thorax. 2007; 62: 341-7.

27. Prasad S A and Main E. Routine airway clearance in asymptomatic infants and babies with cystic fibrosis in the UK: obligatory or obsolete? *Physical Therapy Reviews*. 2006 Mar; 11(1): 11-20.

28. Van der Schans C et al. Chest physiotherapy compared to no chest physiotherapy for CF. *Cochrane Library* (Oxford) 2005; (4): 0011401.

29. Jadad A R et al. Assessing the quality of reports of randomised clinical trials: is blinding necessary? *Controlled Clinical Trials* 1996; 17:1-12.

30. Desmond KJ, Schwenk WF, Thomas E, Beaudry PH, Beaudry, Coates AL. Immediate and long-term effects of chest physiotherapy in patients with cystic fibrosis. Journal of Paediatrics 1983; 103:538-542.

31. Maayan C, Bar-Yishay E, Yaacobi T, Marcus Y, Katznelson D, Yahav Y, Godfrey S. Immediate effect of various treatments on lung function in infants with cystic fibrosis. Respiration 1989; 55:144-151.

32. Constantini D, Brivio A, Brusa D, Delfino R, Fredella C, Russo M, Sguera A, Moretti E. PEP-Mask versus postural drainage in CF infants. A long-term comparative trial. Pediatric Pulmonology 2001 (Suppl 22): A400.

33. Lannefors L, Dennersten U, Theander K, Jartensson J, Kornfalt R. Successful treatment of infants and small children. J Cystic Fibrosis 2003; 2:S65–S250.

34. Dennersten U, Lannefors L, Johansson H, Andersson M, Sellberg M, Lagerkvist A, Sahlberg M. Lung function and peak working capacity in the entire Swedish population ≥7 years old over a three years period. Pediatric Pulmonology 2003 (Suppl 25): A411.

35. Button BM, Heine RG, Catto Smith AG, Postural drainage and gastro-oesophageal reflux in infants with cystic fibrosis. Archives of Disease in Childhood 1997; 76: 148-150.

36. Heine RG, Button BM, Olinsky A, Phelan PD, Catto-Smith AG.Gastro-oesophageal reflux in infants under 6 months with cystic fibrosis. Arch Dis Child. 1998 Jan; 78(1):44-8.

37. Button BM, Heine RG, Catto-Smith AG, Olinsky A, Phelan PD, Ditchfield MR, Story I. Chest physiotherapy in infants with cystic fibrosis: to tip or not? A five-year study. Pediatr Pulmonol 2003; 35: 208-13.

38. Orenstein DM. Heads up! Clear those airways! Pediatr Pulmonol 2003; 35:160–161.

39. Dhouieb E. Evaluation of Lung Clearance Index as an Outcome Measure in Airway.

Clearance in Children with Cystic Fibrosis. MSc Dissertation 2007.

40. Jones J, Hunter D. Consensus methods for medical and health services research. BMJ 1995; 311:376–380.

Recommendations for practice

Grading scheme for recommendations

The criteria used for the grading of the recommendations below are based on published on behalf of the Scottish Intercollegiate Guidelines Network.[1]

Grade Type of recommendation

A Requires at least one randomised controlled trial as part of the body of literature of overall good quality and consistency addressing the specific recommendation.

B Requires availability of well conducted clinical studies but no randomised clinical trials on the topic of the recommendation.

C Requires evidence from expert committee reports or opinions and/or clinical experience of respected authorities. Indicates absence of directly applicable studies of good quality.

Petrie GJ, Barnwell E, Grimshaw J, on behalf of the Scottish Intercollegiate Guidelines Network. Clinical guidelines: criteria for appraisal for national use. Edinburgh: Royal College of Physicians, 1995.

Recommendations

- On confirmation of diagnosis, all families with newly diagnosed infants with cystic fibrosis should be referred for physiotherapy. Initial physiotherapy tuition should always be given by a Specialist CF Physiotherapist (Standards for the Clinical Care of Children and Adults with Cystic Fibrosis in the UK 2001) http://www.cftrust.org.uk/aboutcf/publications/consensusdoc) [C]
- The infant should be reviewed on a regular basis by a physiotherapist with experience in paediatric CF care. An easily accessible physiotherapy service for assessment, advice and support is essential. Direct contact numbers for the CF physiotherapist should be available to the parents/carers, multidisciplinary teams and to the primary care and network care teams as appropriate [C]
- All parents/carers should be taught to assess signs and symptoms, using a structure respiratory assessment tool as appropriate (Appendix 1) [C]
- The emphasis should be on a holistic approach to treatment, considering the fitness of the whole child.
- The beneficial effects of exercise are well-documented. Advice regarding positioning, movement and exercise programmes should begin from diagnosis (Appendix 2)
- Even if the baby is “asymptomatic”, all parents/carers should be taught to assess symptoms in addition to being taught an appropriate airway clearance technique [C]
- The physiotherapist is not required to routinely initiate airway clearance (Appendix 3) on diagnosis unless; following assessment, the infant or child has symptoms that respond to respiratory physiotherapy. The advice given to parents/carers as to the need for and frequency of treatment should be based on the specialist physiotherapist’s evaluation of individual circumstances [C]
- The use of a head down tilt with postural drainage should be carefully considered with regard to both its efficacy in infants with relatively few secretions and the potential for exacerbating gastro-oesophageal reflux. If required, the use of modified chest physiotherapy, omitting the head down tilt may be more appropriate [B]
- When airway clearance (Appendix 3) is required parents/carers should be advised as to the type and frequency of treatment needed, based on clinical status. Families/carers should be fully involved in this decision process. A more prescriptive physiotherapy regimen may be appropriate for some families who feel or seem unable to confidently assess their child’s chest [C]

Appendix IIa

Breathing Assessment tool for parents/carers in Cystic Fibrosis

The aim of airway clearance/chest physiotherapy is to clear secretions from the lungs and maintain normal lung function. Many babies when diagnosed with CF do not show any signs of a chest problem so it is important that you are familiar with the way your baby normally breathes. There are things you can see, feel and hear if your baby has secretions in the chest, or is unwell with a chest infection. Babies are unable to tell us when they are unwell, so it is important that you learn to recognise the signs. This is not difficult to do and you can very quickly learn to become familiar with recognising chest symptoms and knowing when to give treatment

The first step is to take the time to look at your baby with their vest/t-shirt off and familiarise yourself with the following:-

- The colour of your baby's skin and lips
- The movement of the chest as they breathe, looking at the shape of the chest and the ribs as they breathe in and out as well as how fast they breathe
- The way their nostrils and head move as they breathe
- Whether they breathe though their nose or mouth, and whether you can hear any sounds other than the air moving in and out, such as secretions rattling or wheezing
- The feel of the chest as they breathe
- The way your baby breathes when asleep and when awake
- Whether your baby coughs, and whether the cough is a "wet" or a "dry" cough

Your physiotherapist will teach you to recognise what is normal, so you will learn to recognise changes. These changes can be discussed with your CF team if you are concerned, they may indicate you should begin to do, or increase the amount of chest physiotherapy you are currently doing.

Use the assessment sheet overleaf to help you to assess any changes. It is important that you "practice" using this form when you are with your physiotherapist until you are confident and understand what you are looking for.

If you have any questions or concerns, you should contact your CF Centre on the number below:

Name Contact Number

CF Physiotherapist:
CF Specialist nurse:

Breathing Assessment Checklist for Parents

Stage 1

If the answer to either of the following questions is yes, it is important that you do carry out chest physiotherapy and contact your CF team but not urgently.

Action		Yes	No
Hear	Is he/she coughing? (notice whether the cough sounds “wet” as if mucus is present, or “dry”)		
Feel	Place hands around ribs – can you feel any secretions moving/ rattling in the chest as they breathe?		

Stage 2

Even if there is no obvious cough or rattle in the chest, it is still important to double check for some less obvious signs which might mean that there are some secretions in the chest or a chest infection. If the answer to one or more of the following questions is yes, it is still a good idea to give your baby some chest physiotherapy; you will also need to contact your CF team or GP if they are not available, to discuss if they need to be seen by a doctor.

Action		Yes	No
Observe	Is their breathing rate faster than normal?		
	Baby under one year 30-50 breaths per minute, baby one to two years 20-40 breaths per minute		
	Are there signs of a cold such as snuffles or blocked nose?		
	Is your baby more unsettled/crying more than normal or do they seem to be unwell?		
	Is skin paler than normal, or flushed?		
	Does their skin feel warmer than usual (do you think he/she has a fever)?		
Hear	Can you hear a wheeze (this is a high almost musical noise usually on breathing out, but may be heard on breathing in)		

NB If your baby does have a fever and this does not improve with normal fever medication, he/she should be seen by their general practitioner.

Stage 3

If the answer to any of the following questions is “yes” you should contact your CF team/GP to discuss whether your baby needs to be reviewed at the hospital. Your child is very likely to require additional medication, for example antibiotics, as well as needing extra chest physiotherapy

Action		Yes	No
Observe	Does their breathing look more laboured than usual? (look at them with their vest/t-shirt off)		
	Can you see their ribs more clearly on breathing in? (Is the skin between the ribs sucked inwards on breathing in?)		
	Does the front of their chest or the area below the ribs get “sucked inwards” on breathing in?		
	Are their nostrils flaring on breathing in?		
	Is the skin at the bottom of the neck sucked in on breathing in?		
	Are the lips paler than normal or blue? If blue, you need to seek urgent medical attention.		
Hear	Does your baby make any grunting noises as they breathe?		

Appendix IIb

Physical Activity in Infants with CF

The beneficial effects of exercise are well documented (Cystic Fibrosis Trust Physiotherapy guidelines), although no studies have formally investigated the value of early introduction of physical activity in babies with CF. The use of physical activity in babies with CF, in the form of positioning and movement have the following specific aims:

- Using positioning and movement to influence breathing pattern and utilise the effects of regional ventilation, redistributing ventilation in order to optimise ventilation to all areas of the lungs
- Using movement to maintain mobility of the trunk, chest and spine
- Using physical activity as part of “respiratory assessment”. Movement and “play” may make the presence of secretions apparent.

Appendix IIc

Airway Clearance Techniques

The term airway clearance represents a number of different treatment modalities, which aim to enhance clearance of bronchopulmonary secretions. These may include breathing techniques such as assisted autogenic drainage; devices which deliver positive expiratory pressure and postural drainage and manual techniques.[1]

Very few studies have evaluated airway clearance techniques in babies with CF.[2-4] Techniques commonly used in the infant population are briefly described below but more detail can be found in the further reading list below.

Postural Drainage

Gravity assisted positioning (postural drainage [PD]), using various positions to help drainage of secretions from particular areas of the lungs has traditionally been a major component of physiotherapy treatment of infants and young children with CF. The effects of gravity in enhancing airway clearance is likely to be a result not only of drainage but also of a change in distribution of ventilation.[5]

More recently, the use of a head down tip during postural drainage has been questioned due to concerns regarding gastro-oesophageal reflux.[2] Although the use of postural drainage remains very common in the treatment of infants and babies with CF, many centres no longer incorporate a head-down tip but instead use a flat or slight head up positioning regimen (modified postural drainage).

Percussion (chest clapping)

Chest percussion or clapping again has been a mainstay of physiotherapy regimens in the younger CF population. Often combined with modified postural drainage it aims to mobilise secretions and stimulate cough.

Percussion is generally well tolerated and is widely used in infants. It is generally felt that is should be performed over a layer of clothing, using “tented” fingers or a cupped hand. In very small babies the use of a soft plastic cup shaped device (such as a face mask) may be helpful to administrating the technique.

Positive Expiratory Pressure (PEP)

Positive expiratory pressure aims to facilitate airway clearance by increasing lung volume, opening up peripheral airways and enhancing collateral ventilation. The technique can be effectively applied in babies using an infant sized face mask and has been reported to be safe and as effective as postural drainage and percussion[4].

Assisted Autogenic Drainage (AAD)

The use of this technique in babies has developed from AD in the older population. During assisted AD the therapist’s hands/arms are used to gently guide inspiration to the desired lung volume. No pressure is applied during expiration. Expiratory flow may be enhanced by combining the technique with bouncing on a gym ball. It is suggested that a session of treatment using any period of breathing at low lung volume should end with stimulation of breathing at a higher lung volume in order to re-open airways and maximise ventilation.

Assisted Expiratory Manoeuvres

Compression of the thorax during expiration (similar to chest vibrations but without the oscillatory component) interspersed with bouts of physical activity (Appendix Ib) can also be used as a treatment technique to mobilise airway secretions[6].

References

1. Physiotherapy in the treatment of cystic fibrosis. International Physiotherapy Group for Cystic Fibrosis. http://www.cfww.org/ipg-cf/

2. Button BM. Postural drainage techniques and gastro-oesophageal reflux in infants with cystic fibrosis. Eur Respir J 1999; 14:1456–1457.

3. Button BM, Heine RG, Catto-Smith AG, Olinsky A, Phelan PD, Ditchfield MR, Story I.

Chest physiotherapy in infants with cystic fibrosis: to tip or not? A five-year study. Pediatr Pulmonol 2003; 35:208–213.

4. Constantini D, Brivio A, Brusa D, et al. PEP-mask versus postural drainage in CF infants: a long-term comparative trial. Pediatr Pulmonol 2001; A400.

5. Lannefors L, Wollmer P Mucus clearance with three chest physiotherapy regimes in cystic fibrosis: a comparison between postural drainage, PEP and physical exercise.
European Respiratory Journal 1992; 5: 748-753.

6. Lannefors L, Dennersten U, Theander K et al. Successful treatment of infants and children with cystic fibrosis. J Cystic Fibrosis 2003; 2 (Suppl 1): A250.

Appendix III

Exercise tests available

Exercise Test	May be useful to:
Incremental cycle/treadmill ergometry ▪ Wpeak ▪ VO_2peak (with gas exchange) ▪ HRpeak ▪ SpO_2nadir	▪ Identify deficiency in cardiorespiratory fitness ▪ Explore exertional signs symptoms e.g. breathlessness, desaturation or heart disease ▪ Evaluation for lung transplant ▪ Evaluation of interventions that aim to improve cardiorespiratory fitness ▪ Prescription of specific training programme
Submaximal endurance cycle/treadmill ergometry ▪ Endurance time ▪ HR ▪ SpO_2	▪ Identify deficiency in functional capacity ▪ Evaluation of interventions that aim to improve functional capacity
Shuttle tests ▪ Distance walked/run ▪ HRpeak ▪ SpO_2nadir	▪ Identify deficiency in cardiorespiratory fitness ▪ Evaluation for lung transplant ▪ Evaluation of interventions that aim to improve cardiorespiratory fitness ▪ Prescription of specific training programme
Walk Tests (e.g. 6 Minute Walk Test) ▪ Distance walked ▪ SOB/fatigue pre/post test ▪ SpO_2 pre/post test	▪ Identify deficiency in functional capacity ▪ Evaluation for lung transplant ▪ Evaluation of interventions that aim to improve functional capacity
3 Minute Step Test ▪ number of steps performed ▪ HR pre/post test ▪ SpO_2 pre/post test ▪ SOB/fatigue pre/post test	▪ Explore exertional signs symptoms e.g. desaturation
WAnT ▪ Peak power ▪ Mean power ▪ Fatigue index	▪ Identify deficiency in muscle power ▪ Evaluation of interventions that aim to improve muscle power ▪ Prescription of specific training programme
1RM	▪ Identify deficiency in muscle strength ▪ Evaluation of interventions that aim to improve strength ▪ Prescription of specific training programme
Dynamometry	▪ Identify deficiency in muscle strength ▪ Evaluation of interventions that aim to improve muscle strength ▪ Prescription of specific training programme

*Usual for patients to complete full test therefore this outcome measure is not useful

Appendix IV

Sino-nasal outcome test (SNOT-22)

Washington University grants permission to use and reproduce the *SNOT-22* as it appears in the PDF available here without modification or editing of any kind solely for end user use in investigating rhinosinusitis in clinical care or research (the "Purpose"). For the avoidance of doubt, the Purpose does not include the (i) sale, distribution or transfer of the *SNOT-22* or copies thereof for any consideration or commercial value; (ii) the creation of any derivative works, including translations; and/or (iii) use of the *SNOT-22* as a marketing tool for the sale of any drug. All copies of the *SNOT-22* shall include the following notice: "All rights reserved. Copyright 2006. Washington University in St. Louis, Missouri." Please contact Jay Piccirillo (314-362-8641) for use of the *SNOT-22* for any other intended purpose.

I.D.:_____ **SINO-NASAL OUTCOME TEST (SNOT-22)** DATE:_____

Below you will find a list of symptoms and social/emotional consequences of your rhinosinusitis. We would like to know more about these problems and would appreciate your answering the following questions to the best of your ability. There are no right or wrong answers, and only you can provide us with this information. Please rate your problems as they have been over the past two weeks. Thank you for your participation. Do not hesitate to ask for assistance if necessary.

1. Considering how severe the problem is when you experience it and how often it happens, please rate each item below on how "bad" it is by circling the number that corresponds with how you feel using this scale: ➔	No problem	Very Mild Problem	Mild or slight Problem	Moderate Problem	Severe Problem	Problem as bad as it can be		5 Most Important Items
1. Need to blow nose	0	1	2	3	4	5		○
2. Nasal Blockage	0	1	2	3	4	5		○
3. Sneezing	0	1	2	3	4	5		○
4. Runny nose	0	1	2	3	4	5		○
5. Cough	0	1	2	3	4	5		○
6. Post-nasal discharge	0	1	2	3	4	5		○
7. Thick nasal discharge	0	1	2	3	4	5		○
8. Ear fullness	0	1	2	3	4	5		○
9. Dizziness	0	1	2	3	4	5		○
10. Ear pain	0	1	2	3	4	5		○
11. Facial pain/pressure	0	1	2	3	4	5		○
12. Decreased Sense of Smell/Taste	0	1	2	3	4	5		○
13. Difficulty falling asleep	0	1	2	3	4	5		○
14. Wake up at night	0	1	2	3	4	5		○
15. Lack of a good night's sleep	0	1	2	3	4	5		○
16. Wake up tired	0	1	2	3	4	5		○
17. Fatigue	0	1	2	3	4	5		○
18. Reduced productivity	0	1	2	3	4	5		○
19. Reduced concentration	0	1	2	3	4	5		○
20. Frustrated/restless/irritable	0	1	2	3	4	5		○
21. Sad	0	1	2	3	4	5		○
22. Embarrassed	0	1	2	3	4	5		○

2. Please mark the most important items affecting your health (maximum of 5 items)_____ ➔

SNOT-22 Developed from modification of SNOT-20 by National Comparative Audit of Surgery for Nasal Polyposis and Rhinosinusitis Royal College of Surgeons of England.

Appendix V

The Borg perceived exertion scale

15 Point Scale

- 6 – 20% effort
- 7 – 30% effort – Very, very light (Rest)
- 8 – 40% effort
- 9 – 50% effort – Very light – gentle walking
- 10 – 55% effort
- 11 – 60% effort – Fairly light
- 12 – 65% effort
- 13 – 70% effort – Somewhat hard – steady pace
- 14 – 75% effort
- 15 – 80% effort – Hard
- 16 – 85% effort
- 17 – 90% effort – Very hard
- 18 – 95% effort
- 19 – 100% effort – Very, very hard
- 20 – Exhaustion

BORG, G. (1982) Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise*, 14 (5), p. 377-81.

BORG, G. et al. (1983) A category-ratio perceived exertion scale: relationship to blood and muscle lactates and heart rate. *Med. Sci. Sports Exerc*. 15 (6), p. 523-528.

Borg GAV. *Borg's Rating of Perceived Exertion and Pain Scales*. Champaign, IL: Human Kinetics, 1998.

Appendix VI

Medications

Appendix VIa

Standard operating procedure – Drug response assessment

Drug Response Assessments (DRA) – previously known as bronchoconstriction trial

SCOPE OF PROCEDURE

- This procedure applies all adult and paediatric patients who are prescribed a test dose of an inhaled antibiotic, anti-fungal or mucolytic drug.
- All adult and paedatric patients will undergo a DRA for the first dose of an inhaled medicine that they have not been prescribed before or if a significant time has lapsed since they have used the medicine or there are suspicions of intolerance whilst using the drug.
- This must be carried out within the hospital setting by a Chartered Physiotherapist.
- A DRA should only be completed if a DRA testing proforma is fully completed (Appendix 1).
- The prescriber is responsible for the correct prescription of the medication to be administered, including the diluent if appropriate and the pre and post bronchodilator.

COMPETENCIES FOR PROCEDURE

- Physiotherapists should have completed 'DRA competencies' (Appendix 2) prior to completing a DRA.
- Physiotherapists are independently responsible for ensuring they are competent to complete the DRA procedure and to seek senior support or further training if required.
- Regular DRA competency updates will be completed yearly within the department In Service Training rota and competency will be discussed as part of the physiotherapists annual/rotational appraisal.

OTHER GUIDANCE

- Outcome measures that can be used to assess suitability are FEV_1, heart rate and oxygen saturations, auscultation and patient reported symptoms.
- For those patients unable to complete reliable spirometry (including children under the age of 8), they should be formally observed for changes in respiratory symptoms, auscultation pre and post inhalation of the medicine and assessment of oxygen saturations completed.

FURTHER READING

- Staff should be aware of the Medicines Management Policy – Prescribing and Administration of Medicines, which may found on the intranet http://www2.rbht.nhs.uk/services/medicinesmanagement/policies.
- Trust CF guidelines on the management of children and adults with cystic fibrosis (appendices on inhalation medicines).

The Drug Response Assessment

DRA PAPERWORK

- The medicine to be administered must be prescribed by a prescriber on a 'Drug Response Assessment testing proforma' (available on the intranet) prior to starting the assessment (Appendix 1).
- This must state the patient's name, hospital number, date of birth, known allergies to medicines, drug required, dose and route of delivery.
- For outpatients as prescription for the inhaled medicine needs to be attached in order to carry out the procedure.
- If the trial form is not filled out correctly or completely, the trial cannot take place and the prescriber will be informed.

PRE-TEST BRONCHODILATOR

- If the patient is routinely prescribed a short acting bronchodilator then a pre-test dose (e.g. 200mcg salbutamol MDI) should also be prescribed to be taken 5-10 minutes before the baseline spirometry and test drug administration. Pre dosing with a short-acting bronchodilator can improve tolerance of inhaled medications, especially in patients with irritable airways or asthma.
- If the patient is not usually prescribed a bronchodilator at all, then the test drug can be given without a pre-test bronchodilator. However, if the patient fails the test as a result of bronchoconstriction (i.e. >15% FEV_1) they should be automatically re-booked for a repeat assessment with a pre-test bronchodilator prescribed.

POST-TEST BRONCHODILATOR

- The patient should always be prescribed a post-test bronchodilator to use in the incidence of symptomatic bronchoconstriction (>15% drop in FEV_1).

TRIAL PROCEDURE

Trial preparation

1. Ensure documentation is completed and filled in correctly.

2. Collection of prescribed medications from pharmacy/ward pharmacy.

a. Inpatients: Pharmacy should be made aware of the trial prior to completion and either the drug ordered for delivery onto the ward or collected from ward stock.

b. Outpatients: For medicine not in stock at the physiotherapy outpatients (anti-fungals/Cayston), the DRA form and script should be given into the outpatient pharmacy at least 2 hours prior to the patients' appointment time and collected by the physiotherapist. All others, including dry powder inhalers, can be taken from physiotherapy outpatients' stock.

3. Confirmation of correct administration/reconstitution of medication by a senior physiotherapist or pharmacist if required (details can be found in the appendix of the Trust guideline for management of the adult with cystic fibrosis).

4. Counter signature and check of dosing/expiry dates for all medications to be used, by a clinician who routinely administer medicines (e.g. senior physiotherapist, pharmacist, ward nurse).

5. Collection of the correct nebuliser/DPI equipment required for completion of the DRA.

6. Description of procedure of DRA to the patient including giving advice and education on nebuliser or dry powder inhaler technique.

7. Check that patient is ready to complete DRA, if patient has had any change to their clinical stability (feeling more unwell, haemoptysis, increase in steroid medication) or has had any recent contraindications to spirometry (e.g. chest pain, sinus surgery) then the trial should be withheld and suitability discussed with the prescriber.

8. The patients should be that if they feel nauseous, light headedness, tight in the chest or generally feel unwell when taking the nebuliser or DPI to report it to you immediately. If relevant re-educate the patient regarding technique in case this is due to breathing pattern during nebulisation or inhalation.

9. If the patient feels chest tightness, breathlessness or wheeze, lip or tingling in mouth or throat tightness, then the medication should be stopped immediately and the medical team informed for an immediate review, as this could be the sign of anaphylaxis.

Trial procedure

10. Completion of FEV_1/FVC measurement. Best of 3 FEV_1 measurements recorded including % predicted.

11. Apply pulse oximeter probe to patient's finger and monitor oxygen saturation and HR throughout procedure.

12. Give prescribed dose of medication via the appropriate nebuliser/chamber/dry powder device.

13. If saturation falls below normal levels (for the patient) for a consistent period, then the test should be stopped. On occasion such a drop can be due to patient breathing pattern, or patients may require additional oxygen to complete the nebulisation or inhalation. This should be reviewed with a senior clinician and a re-trial of the medication organised with relevant changes.

14. During the test and immediately post inhalation, ask the patient to describe any symptoms e.g. chest tightness.

15. Repeat FEV_1/FVC measurements.

16. Calculate amount of constriction (if any):

$$\frac{\text{Pre } FEV_1 - \text{Post } FEV_1}{\text{Pre } FEV_1} \times 100 = \% \text{ Constriction}$$

17. If post inhalation of the drug the FEV_1 **has not** reduced by more than 10% **this is a PASS.**

18. If post inhalation of the drug the FEV_1 has reduced by between 10-15% and the are **no** adverse symptoms associated (such as wheeze and irritable cough) then it is suitable for use and **a PASS.**

19. If post inhalation of the drug the FEV_1 has reduced by between 10-15% and the **ARE** adverse symptoms associated (such as wheeze and irritable cough) then this is a FAIL.

20. If post inhalation of the drug the FEV_1 **has** reduced by more than 15% post, then **this is a FAIL and the patient should be closely monitored for deterioration.**

a. Repeat FEV_1 should be taken after 10 minutes and FEV_1 change from **baseline** re-calculated.

b. If 10 minutes after inhalation of the drug the FEV_1 remains reduced more than 15%, the physiotherapist should administer the post test bronchodilator prescribed and monitor the patient closely throughout and repeat the FEV_1 again after a further 10 minutes.

21. Once the reduction in FEV_1 has recovered to 10% or less and the patient is not symptomatic then the monitoring can be stopped and the patient is safe to leave.

22. If the patients FEV_1 drop remains persistently above 10% from baseline, please seek medical review for the patient by the registrar on call and continue to monitor them closely.

23. Any other scenario outside of those discussed above should be discussed with a senior physiotherapist for further guidance.

DOCUMENTATION

- After the DRA is completed and the result confirmed, this should be recorded on the DRA form immediately and uploaded and published in the patients electronic record (EPR). All discussions should be documented clearly on the DRA Form, including the electronic copy. For inpatients, the original DRA can be filed in the clinical notes of the current medical record.
- For those patients with FEV_1 below 1 litre, the change in measurements in millilitres pre and post inhalation must be considered alongside the FEV_1 percentage change. This is because the clinical significance of the difference may not be adequately assessed by percentage change. Such patients should be discussed with a senior physiotherapist for confirmation of trial result.

TECHNIQUE & EQUIPMENT

- All patients should be taught how to reconstitute and/or prepare the medication by the physiotherapist completing the trial. However practice of this during inpatient stay may be relevant and can be carried out by physiotherapists, nursing staff and pharmacy staff as appropriate.
- Relevant equipment including cleaning instructions should be given to the patients after completion of the trial. The nebuliser equipment should be reviewed to ensure that the patient is using the optimal device. (Appendix 3).

Appendix VIb

Drug response assessment testing proforma

Adapted from the Royal Brompton Hospital Drug response assessment testing proforma

ACPCF Association of Chartered Physiotherapists in Cystic Fibrosis

DRUG RESPONSE ASSESSMENT TESTING PROFORMA

*****THE TEST WILL NOT BE UNDERTAKEN WITHOUT ALL SHADED AREAS COMPLETED*****

APPROPRIATE PRESCRIPTION ATTACHED? ☐

PATIENT NAME: **DOB:**	**Inpatient/Outpatient**
HOSPITAL NO: **PATIENT WEIGHT:**	
DATE OF REFERRAL: REASON FOR REFERRAL:	**ALLERGIES**
PRESCRIBER: PRINT: ..... SIGN:	
PRESCRIBER BLEEP/EXT no. #	
CONSULTANT:	

Terminal clean required post-test? *(i.e. MRSA/M. abscessus/B. cepacia)*: YES/NO

	Medicine	**DOSE**	**Admninistered?**	**Initials for check**
MEDICATION FOR TEST			**YES NO**	
Diluent (e.g. 0.9% saline for Colistin/Amikacin etc)				
PRE TEST BRONCHODILATOR ***(if part of parient usal. regime)***			**YES NO**	
POST TEST BRONCHODILATOR ***(please circle/indicate dose)***	**Salbutamol NEB** **INHALER**	**..... mg** **..... puffs**	**YES NO**	

TO BE COMPLETED BY PHYSIOTHERAPIST:

DATE OF TRIAL..... **SPIROMETRY APPROPRIATE?: YES NO**

DEVICE USED? .....

TRIAL NOT COMPLETED? Why .....

	FEV_1	**$Sp0_2$**	**Other (e.g. ausc/HR)**
PRE test	**L/min % pred.**		
POST test	**L/min % pred.**		
% change	***(see guidance attached)***		
Symptoms/ comments			
10 mins post ***(if needed)***	**L/min % pred.**		
% change			
Symptoms/ comments			

Inhalation technique discussed (i.e. DPI)

Explained potential adverse events ☐ Equipment explained/issued ☐

Safe for Use: Yes/No Therapist signature _____ Date _____

ACPCF
Association of Chartered Physiotherapists in Cystic Fibrosis

Action:	Instruction/guidance:
Preparation	Ensure prescription and trial form completed and medication checked **Collect equipment:** Nebuliser kit, compressor, spirometer, oxygen saturation monitor, stethoscope
Administer pre-test bronchodilator (if prescribed). Some centres may choose to administer the bronchodilator following the pre-trial assessment	
Pre-trial assessment: Spirometry Oxygen saturations Auscultation	Take 3 reproducible forced spirometry readings required (ATS guidelines within 5% of each other) If unable to perform reproducible lung function then auscultation can be used to detect wheeze pre and post dose
Administer inhaled drug	
Re-Assess: **5 mins post dose inhalation)** Lung Function Oxygen saturations Auscultation	Take up to 3 reproducible spirometery readings Calculate if bronchoconstriction – % drop in FEV_1 after dose given: FEV_1 actual value (post – pre)/pre x 100 Re-auscultate to compare to baseline
Analysis for possible bronchospasm (measured by $Sp0_2$ and spirometry)	**<10%** constriction? → PASS **10-15%** constriction and **asymptomatic**? → PASS **10-15%** constriction and **symptomatic**? → FAIL **>15%** constriction → FAIL
No: Test dose successful	
Yes: Test dose failed	*Ensure these findings are due to bronchospasm rather than loosened and retained sputum (encourage airway clearance, consider repeat spirometry and auscultation)*
Report back to referrer and proceed with course of inhaled medication	
Recover	If >15% constriction after 10mins post-drug, give post-test bronchodilator to reverse bronchospasm
Plan	Consider test dose to be repeated on a separate visit (discuss with referrer) Pre-treat with a bronchodilator or consider alternate medication)

Appendix V1c

Drug response assessment competency document

Drug Response Assessment Competency Document

Developed in conjunction with the Standard Operating Procedure for Drug Response Assessments

Created by the Physiotherapy Department, RBH

Staff Members Name:_____ Supervisors Name:_____

A drug response assessment (formally known as a bronchoconstrictor trial) is carried out by the physiotherapy team for inpatients and outpatients commencing upon a new nebulised or inhaled medication (with the exception of bronchodilators and 0.9% saline). It is essential that these assessments are carried out by a competent individual, who understands the reasoning and process of the assessment, alongside knowing what adverse events may occur and how to manage these. This document is a record of each individuals' training in completing these assessments, and (once signed) is an agreement between the individual and their senior line manager/supervisor of their competence to be able to compete these trials safely and effectively.

	Competency Achieved			
Component	**Method of Demonstrating Understanding**	**Supervisors Signature**	**Staff Members Signature**	**Date**
Background Knowledge ▪ Is aware of and has read related Trust policies e.g. RBH Trust Medicines Management Policy – Prescribing and Administration of Medicines' and national guidelines ▪ Is aware of and has read the local procedures e.g. Physiotherapy department SOP for DRA ▪ Is aware of why a DRA is required for an inhaled medication ▪ Is aware of the different types of medications and why they would be required	▪ Completion of background reading ▪ Discussion with senior ▪ Attendance at teaching sessions on medications			

	Competency Achieved			
Component	**Method of Demonstrating Understanding**	**Supervisors Signature**	**Staff Members Signature**	**Date**
Preparation of Equipment/Forms ▪ Is able to identify the correct paperwork required for an inpatient and outpatient DRA ▪ Understands each component of the DRA form, and when each section needs to be completed ▪ Is able to explain the process of how to clarify sections of the DRA if outside of usual SOP guidelines ▪ Is able to demonstrate the correct technique for performing spirometry including equipment required, precautions and contraindications to spirometry ▪ Is aware when spirometry would not be completed and demonstrates suitable assessment skills in this circumstance ▪ Is able to list and obtain the equipment required for completion of a DRA ▪ Is able to explain and demonstrate the correct procedure for identifying which nebuliser equipment is suitable for medications prior to a DRA	▪ Review of paperwork with a senior ▪ Discussion of SOP and DRA form components with a senior ▪ Teaching session on how to perform spirometry attended ▪ Demonstration of correct spirometry technique ▪ Discussion with senior regarding precautions or contraindications to spirometry ▪ Demonstration of alternative assessment skills ▪ Practical completion of gaining equipment prior to DRA commencing ▪ Discussion of unusual scenarios with senior and demonstration of understanding of actions to be taken ▪ Attendance at teaching sessions on nebuliser equipment			

Component	Competency Achieved			
	Method of Demonstrating Understanding	Supervisors Signature	Staff Members Signature	Date
Medications ▪ The physiotherapist can demonstrate the techniques required for correct mixing, dilution, & reconstitution of common nebulised medications, following the DRA prescription ▪ The Physiotherapist can describe and demonstrate the correct inhalation technique for inhaler devices ▪ The physiotherapist is aware of where to find guidance for the reconstitution and administration of medications if unclear from the DRA prescription, or an unfamiliar drug ▪ Is able to explain and demonstrate the use of correct countersigning procedures as described in the DRA SOP ▪ The physiotherapist can demonstrate understanding of when not to administer medications or complete the DRA and explain the correct procedure for further actions required	▪ Senior demonstration of medication preparation ▪ Attendance at teaching sessions for inhaled medication techniques ▪ Discussion with senior regarding the SOP and processes to clarify medications, countersigning and scenarios when DRAs would not be completed			
Performing The DRA ▪ Is able to demonstrate the abilty to explain to the patient reasons for the DRA, and the DRA process ▪ Is able to perform the DRA in a logical and safe sequence, following the correct SOP procedure ▪ The physiotherapist can describe adverse symptoms that may occur during the administration of medications and actions that could be taken ▪ The physiotherapist can describe how to monitor a patient for possible side effects and can describe what to do if symptoms arise. ▪ The physiotherapist can demonstrate an understanding of the results of the DRA and when the medication is safe/not safe to use. They can also demonstrate when it may be appropriate for further guidance with this.	▪ Explanation to senior of the correct DRA process ▪ Explanation to senior (in lay terms) of what a DRA entails and the process ▪ Explanation of how a DRA with a paediatric patient may differ ▪ Explanation to a senior of what adverse symptoms may occur, and actions to be taken in this instance ▪ Explanation of how a drug is deemed safe/ unsafe to a senior, using SOP as reference ▪ Observation of a senior completing a DRA ▪ Completion of a DRA with supervision ▪ Completion of a DRA with senior discussion before and afterwards			

	Competency Achieved			
Component	**Method of Demonstrating Understanding**	**Supervisors Signature**	**Staff Members Signature**	**Date**
Documentation/Communication ▪ The physiotherapist can describe and complete the correct documentation at the end of the trial and is aware of the process for communication to the senior physiotherapy team and medical team	▪ Attended ▪ Explanation of correct documentation to senior ▪ Observation of DRA documentation/follow up communication following DRA completed by a senior ▪ Completion of correct documentation/follow up communication following DRA observed by a senior ▪ Discussion of independent trial documentation with a senior			

I feel competent to complete DRAs for inhaled medications:

Signed: _____ Date: _____

I have assessed this staff member and believe them to be competent to complete DRAs for inhaled medications:

Signed: _____ Date: _____

Appendix VId

Nebulised/inhaled medications for people with Cystic Fibrosis

This is a quick reference guide to important points about nebulised medications and is intended to be used by clinicians who have received appropriate training and who are familiar with the summary of product characteristics (SPC) of each medication. Note that all people commencing a new nebulised/inhaled medication, or where the medication hasn't been for the last year, should have a supervised test dose as per documented test dose procedure.

Medication	Usual indication	Prescription	Delivery system	Reconstituting	Notes
Amikacin	Mycobacterium abscessus	**Paed:** 250-500 milligrammes twice daily **Adult:** 500 milligrammes twice daily IV preparation for nebulised use	Conventional compressor & Pari LC plus with filter	**Paed (250 mg):** 1 millilitre Amikacin for injection (250mg/ml) with 3 millilitres sodium chloride 0.9% **Paed (500mg) & adult:** 2 millilitres Amikacin for injection (250mg/ml) with 2 millilitres sodium chloride 0.9%	Glass ampoules, preferably issue syringes & filter needles
Amphotericin (Ambisome)	Aspergillus	**Adult:** 25 milligrammes twice daily	Conventional compressor & Pari LC plus with filter	Add 12ml sterile water to 50mg vial Amphotericin. 6 millilitres to be nebulised and other 6 millilitres to be kept in fridge for second daily dose (discarded if not used within 24 hours)	Lipsomal amphotericin (Ambisome) should be prescribed NOT the non-lipid amphotericin (Fungizone) Rubber bung on vial not removable therefore will need syringes (10ml) and needles (green)
Aztreonam (Cayston)	Pseudomonas Aeruginosa (fifth line) Burkholderia Cepacia (fourth line)	75mg three times daily See notes	EFlow using **altera handset** with filter (altera handset included in monthly Cayston pack)	1 vial aztreonam powder with 1 ampoule sodium chloride 0.17% (included in Cayston pack)	**Keep in fridge** Usual starting regimen is 28 days on/28 days off. Alternating with another inhaled antibiotic or continuous treatment may be indicated if deterioration in month off treatment

Medication	Usual indication	Prescription	Delivery system	Reconstituting	Notes
Colistimethate Sodium (Promixin)	Pseudomonas Aeruginosa (first line)	**Paediatric <2 years:** 0.5 megaunits twice daily **Paediatric >2 years & Adult:** 1 megaunit twice daily **Note these priming doses used with the INeb give a received dose equivalent to those listed below for Colomycin. This is due to increased efficiency of the INeb over the eflow**	INeb	**Paed <2years:** 1 megaunit Promixin reconstituted with 2 millilitres water for injection. 1 millilitre to be nebulised with 1 millilitre kept in fridge for second daily dose (discard after 24 hours) **Paed >2years & adult:** 1 megaunit Promixin reconstituted with 1 millilitre water for injection	Brand name Promixin must be used in order to obtain disks needed for INeb use. Syringes needed (1 or 2 ml syringes) In case of bronchoconstriction, already using nebulised salbutamol, Promixin may be reconstituted with salbutamol 2.5milligrammes (2 millilitre for paeds <2 years and 1 millilitres for paeds >2 years/adults). **Must be used immediately, do not store in fridge for later use**. If reconstituting with water/sodium chloride, acceptable to reconstitute 2 doses and store second dose in fridge **to be used within 24 hours** or discard
Colistimethate Sodium (Colomycin)	Pseudomonas Aeruginosa (second line) >6 years	1.66 megaunits twice daily	Turbospin powder inhaler (inhaler in pack)	No reconstitution One capsule to be inhaled twice daily. Note multiple inhalations may be needed to clear inhaler	Cough may be an issue usually related to technique Time between doses 12 hours but minimum 6 hours
Dornase Alpha (DNase/ Pulmozyme)	>6 years Consider off license use in <6 years if clinically indicated	2.5 milligrammes once daily	Ineb OR EFlow	No reconstitution Ineb: 1 fill of green chamber (discard remainder) EFlow: 2.5 milligrammes in 2.5 millilitres (1 vial)	**Keep in fridge** May use twice daily in patients with se¬vere disease or during exacerbations Do not take within 1 hour of nebulised antibiotic/antifungal

Medication	Usual indication	Prescription	Delivery system	Reconstituting	Notes
Hypertonic Sodium chloride 7% (nebusal) Note 6% & 3% (mucoclear) also available but not used within York trust	DNase not tolerated As add on therapy if clinical deterioration or difficulty clearing chest despite DNase	7% in 4 millilitres (1 vial) twice daily Can increase to four times daily if needed	INeb OR EFlow	No reconstitution INeb: 2 fills of lilac chamber (discard remainder) EFlow: 4 millilitres (1 vial)	Often used as required rather than regular twice a day
Mannitol (Bronchitol)	>18 years DNase not tolerated Clinical deterioration despite DNase	**Adult:** 400 milligrammes twice daily	Osmohaler in pack	No reconstitution Ten capsules to be inhaled twice daily. Note multiple inhalations may be needed to clear inhaler	Cough may be an issue usually related to technique
Meropenem	Mycobacterium abscessus Where sensitivities indicate or as add on to neb Amikacin if continuing to deteriorate	**Adult:** 250 milligrammes twice daily	Conventional compressor & Pari LC plus with filter	Reconstitute with 8ml water. Use 4ml and store 4ml in fridge for 2nd dose of the day	Rubber bung on vial not removable therefore will need syringes (10ml) and needles (green)
Tauroldine Solution 2%	Burkholderia Cepacia Post transplant	4ml of 2% solution bd	Conventional compressor & Pari LC plus with filter	Pre made, draw up as needed. Keep in fridge once used for first time. Discard as per pharmacy instructions.	Unlicensed Rubber bung on vial not removable therefore will need syringes (5ml) and needles (green)
Tobramycin (Tobi)	Pseudomonas Aeruginosa (third line) Burkholderia Cepacia (first line)	300 milligrammes twice daily See notes section	INeb Eflow	**INeb:** 2 fills of lilac chamber **Eflow:** 300 milligrammes in 5 millilitres (1 vial)	Keep in fridge (allow to come to room temperature before nebulising) Only licensed in children over 6 but is used >6 months Usual starting regimen is 28 days on/28 days off (unless eradication 3 months continuously, however alternating with another inhaled antibiotic or continuous treatment may be indicated if deterioration in month off treatment

Medication	Usual indication	Prescription	Delivery system	Reconstituting	Notes
Tobramycin (Bramitob)	Pseudomonas Aeruginosa (third line) Burkholderia Cepacia (second line)	300 milligrammes twice daily See notes section	Eflow	**Eflow:** 300 milligrammes in 4 millilitres (1 vial)	**Keep in fridge** (allow to come to room temperature before nebulising) Only licensed in children over 6 but is used >6 months Usual starting regimen is 28 days on/28 days off (unless eradication 3 months continuously, however alternating with another inhaled antibiotic or continuous treatment may be indicated if deterioration in month off treatment
Tobramycin (Tobramycin inhalation powder)	Pseudomonas Aeruginosa (fourth line) Burkholderia Cepacia (third line) > 6 years	112 milligrammes twice daily See notes section	Podhaler (inhaler in pack)	Four capsules to be inhaled twice daily. Note multiple inhalations may be needed to clear inhaler	Cough may be an issue usually related to technique
Vancomycin	MRSA	**Paediatric**: 5mg/kg bd **Adult:** 250mg bd **Always state 500mg vials to be issued from pharmacy not 1 gram vials** Usually a five day duration of treatment	Conventional compressor & Pari LC plus with filter	**Use 500mg vial:** Reconstitute 500 milligrammes with 8 millilitres water for injection. 4 millilitres to be nebulised and other 4 millilitres to be kept in fridge for second daily dose (discarded if not used within 24 hours)	Rubber bung on vial not removable therefore will need syringes (10ml) and needles (green) Important to bronchodilate pre dose

Appendix V1e

Inhalers, medications and devices

NEWER AND COMMON INHALED THERAPY LICENSED FORM ASTHMA OR COPD

DEVICE generic (Trade)	SABA short acting B2 agonist	SAMA Short acting muscarinic antagonist	LAMA Long acting muscarinic antagonist	LABA Long acting B2 agonist		ICS Inhaled gluco cortico steriod	
Metered Dose Inhaler (Teva, Napp, GSK, Chiesi, Mylan) 	salbutamol (Ventolin®, Airomir®)	ipratropium (Atrovent®)		formoterol (Atimos®) salmeterol (Serevent®)	fluticasone & salmeterol (Seretide® and Sirdupla®)* beclometasone & formoterol (Fostair®) fluticasone & formoterol (Flutiform®)*		beclometasone (Qvar®, Clenil®)* fluticasone (Flixotide®)* ciclesonide (Alvesco®)
Easi-Breathe (Teva) 	salbutamol (Salamol®)						beclometasone * (Qvar®)
Autohaler (Teva) 	salbutamol (Airomir®)						beclometasone * (Qvar®)
Respimat (Boehringer) 			tiotropium (Spiriva®)	tiotropium & olodaterol ** (Spiolto®)	olodaterol ** (Striverdi®)		
HandiHaler (Boehringer) 			tiotropium ** (Spiriva®)				
Easyhaler (Orion) 	Easyhaler ® salbutamol			Easyhaler ® formoterol			Easyhaler® beclometasone * Easyhaler® budesonide *
Turbohaler (AstraZeneca) 	terbutaline (Bricanyl®)			formoterol (Oxis®)	budesonide & formoterol (Symbicort®)		budesonide * (Pulmicort®)
Accuhaler (GSK) 	salbutamol (Ventolin®)			salmeterol (Serevent®)	fluticasone & salmeterol (Seretide®)		fluticasone * (Flixotide®)
Nexthaler (Chiesi) 					beclometasone & formoterol * (Fostair®)		
Breezhaler (Novartis) 			glycopyrronium ** (Seebri®)	glycopyrronium & indacaterol** (Ultibro®)	indacaterol ** (Onbrez®)		
Genuair (Almirall) 			aclidinium ** (Eklira®)	aclidinium & formoterol ** (Duaklir®)			
Ellipta (GSK) 			umeclidinium** (Incruse®)	umeclidinium & vilanterol ** (Anoro®)	fluticasone furoate & vilanterol (Relvar®)		
Spiromax (Teva) 					budesonide & formoterol (DuoResp®)		

Source: BNF, Dec 2015 & Electronic Medicines Compendium UK 2016. See Summary of Product Characteristics for full indications and prescribing information. * Licensed for asthma only **Licensed for COPD only. Updated January 2016. Sodium cromoglicate (Intal®) and nedocromil sodium (Tilade®) are also available in MDI.

Produced by Andrew Booth (andrew.booth1@nhs.net) for the Primary Care Training Centre. www.primarycaretraining.co.uk and the Association of Respiratory Nurse Specialists. www.arns.co.uk

ARNS
Association of Respiratory Nurse Specialists

PC tc
PRIMARY CARE TRAINING CENTRE

Primary Care

INHALED THERAPY LICENSED FOR ASTHMA OR COPD

DEVICE generic (Trade)		SABA short acting B2 agonist	SAMA Short acting muscarinic antagonist	LAMA Long acting muscarinic antagonist	LABA Long acting B2 agonist	ICS Inhaled gluco cortico steriod
Forspiro (Sandoz)					fluticasone & salmeterol ** (AirFluSal®)	
Pulvinal (Chiesi)		salbutamol (Pulvinal®)				beclometasone * (Pulvinal® beclometasone)
Clickhaler (RPH)		salbutamol (Asmasal®)				beclometasone * (Asmabec®)
Twisthaler (MSD)						mometasone * (Asmanex®)
Novolizer (Meda)		salbutamol (Salbulin®)				budesonide * (Budelin®)
Aerolizer (Novartis)					formoterol (Foradil®)	

Source: BNF, Dec 2015 & Electronic Medicines Compendium UK 2016. See Summary of Product Characteristics for full indications and prescribing information. * Licensed for asthma only **Licensed for COPD only. Updated January 2016. Sodium cromoglicate (Intal®) and nedocromil sodium (Tilade®) are also available in MDI.

Produced by Andrew Booth (andrew.booth1@nhs.net) for the Primary Care Training Centre. www.primarycaretraining.co.uk and the Association of Respiratory Nurse Specialists. www.arns.co.uk

Appendix VII

Manchester MSK Screening Tool

MANCHESTER ADULT CYSTIC FIBROSIS CENTRE

Manchester Musculoskeletal Screening Tool

1. Do you have any episodes of pain? Y/N (If yes complete MPQ)

2. Do you have any episodes of leaking urine, or an urgent or frequent need to pass water? Y/N (If yes, ICIQ)

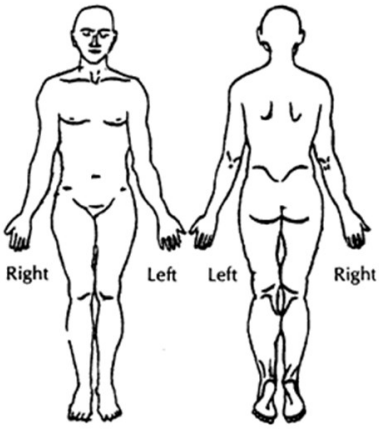
3. Do you have any concerns about your posture? Y/N

4. What is the cause of pain? Musculoskeletal Y/N

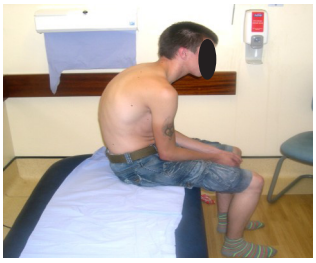
Other: (eg, PEG, surgery, gout, unknown)……...

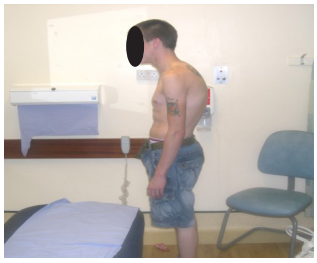
Date:
Name:
DOB:
Height:
Gender: M/F
Microbiological group:
FEV1 today:
Diabetes: Y/N
Experiencing exacerbation: Y/N
Hospital:

Mark site of pain on body chart



5. Is there a fixed thoracic kyphosis?



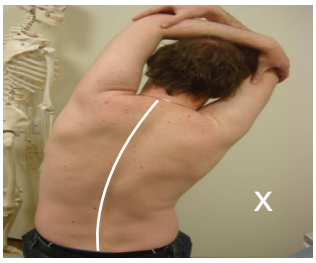


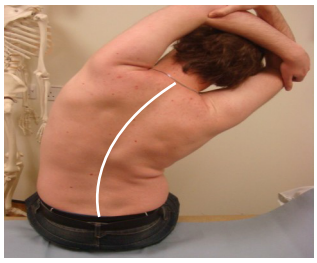
In sitting:

6. Is patient unable to lift both arms straight above head level with ears?

7. With arms across chest is patient unable to rotate upper body to 45°?

8. With arms above head is patient unable to lean to 45°?





Outcome:

A) If all answers **NO**, no intervention required, screen in 1-2 years.

If answer **YES** to any question select outcomes via screening pathway matrix:

B) Posture and exercise leaflet.

C) Pelvic floor leaflet.

D) Musculoskeletal physio assessment.

E) Refer to Women's health for specialist assessment.

F) Patient declined intervention, screen in 1-2 years.

Therapist name/signature:

Score (admin use only)		
Q	Y	N
1		
2		
3		
4		
5		
6		
7		
8		
MPQ	Max 50	
VAS	Max 100	
UCIQ	Max 21	
Outcome	A-f	

Manchester Musculoskeletal Screening Tool: MPQ
Short Form McGill Pain Questionnaire

A. PLEASE DESCRIBE YOUR PAIN DURING THE LAST 7 DAYS. (√ one box on each line.)

	None	Mild	Moderate	Severe
1. Throbbing	0 ☐	1 ☐	2 ☐	3 ☐
2. Shooting	0 ☐	1 ☐	2 ☐	3 ☐
3. Stabbing	0 ☐	1 ☐	2 ☐	3 ☐
4. Sharp	0 ☐	1 ☐	2 ☐	3 ☐
5. Cramping	0 ☐	1 ☐	2 ☐	3 ☐
6. Gnawing	0 ☐	1 ☐	2 ☐	3 ☐
7. Hot/burning	0 ☐	1 ☐	2 ☐	3 ☐
8. Aching	0 ☐	1 ☐	2 ☐	3 ☐
9. Like a weight	0 ☐	1 ☐	2 ☐	3 ☐
10. Tender	0 ☐	1 ☐	2 ☐	3 ☐
11. Splitting	0 ☐	1 ☐	2 ☐	3 ☐
12. Tiring/exhausting	0 ☐	1 ☐	2 ☐	3 ☐
13. Sickening	0 ☐	1 ☐	2 ☐	3 ☐
14. Fearful	0 ☐	1 ☐	2 ☐	3 ☐
15. Punishing/cruel	0 ☐	1 ☐	2 ☐	3 ☐

B. RATE YOUR PAIN DURING THE PAST 7 DAYS

The following line represents pain of increasing intensity from “no pain” to “worst possible pain”. Place a vertical line (|) across the line in the position that best describes your pain during the past 7 days.

No Pain — **Worst possible paid**

☐☐☐ **Score in mms (Investigators use only)**

C. PRESENT PAIN INTENSITY

0 ☐ No pain
1 ☐ Mild
2 ☐ Discomforting
3 ☐ Distressing
4 ☐ Horrible
5 ☐ Excruciating

S = sum of A1-11. A = sum of A12-15. E = C

Max:33 | Max:12 | Max:5

Total MPQ score = S+A+E

Max:50

Questionnaire Developed by: Ronald Melzack

MACFC
MANCHESTER ADULT CYSTIC FIBROSIS CENTRE

Manchester Musculoskeletal Screening Tool: ICIQ

Initial number

ICIQ-UI Short Form

CONFIDENTIAL

DAY MONTH YEAR

Many people leak urine some of the time. We are trying to find out how many people leak urine, and how much this bothers them. We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

1 Please write in your date of birth:

DAY MONTH YEAR

2 Are you *(tick one):*

Female ☐ Male ☐

3 How often do you leak urine? *(Tick one box)*

never ☐	0
about once a week or less often ☐	1
two or three times a week ☐	2
about once a day ☐	3
several times a day ☐	4
all the time ☐	5

4 We would like to know how much urine you think leaks.

How much urine do you usually leak (whether you wear protection or not)? *(Tick one box)*

none ☐	0
a small amount ☐	2
a moderate amount ☐	4
a large amount ☐	6

5 Overall, how much does leaking urine interfere with your everyday life?

Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 10
not at all — a great deal

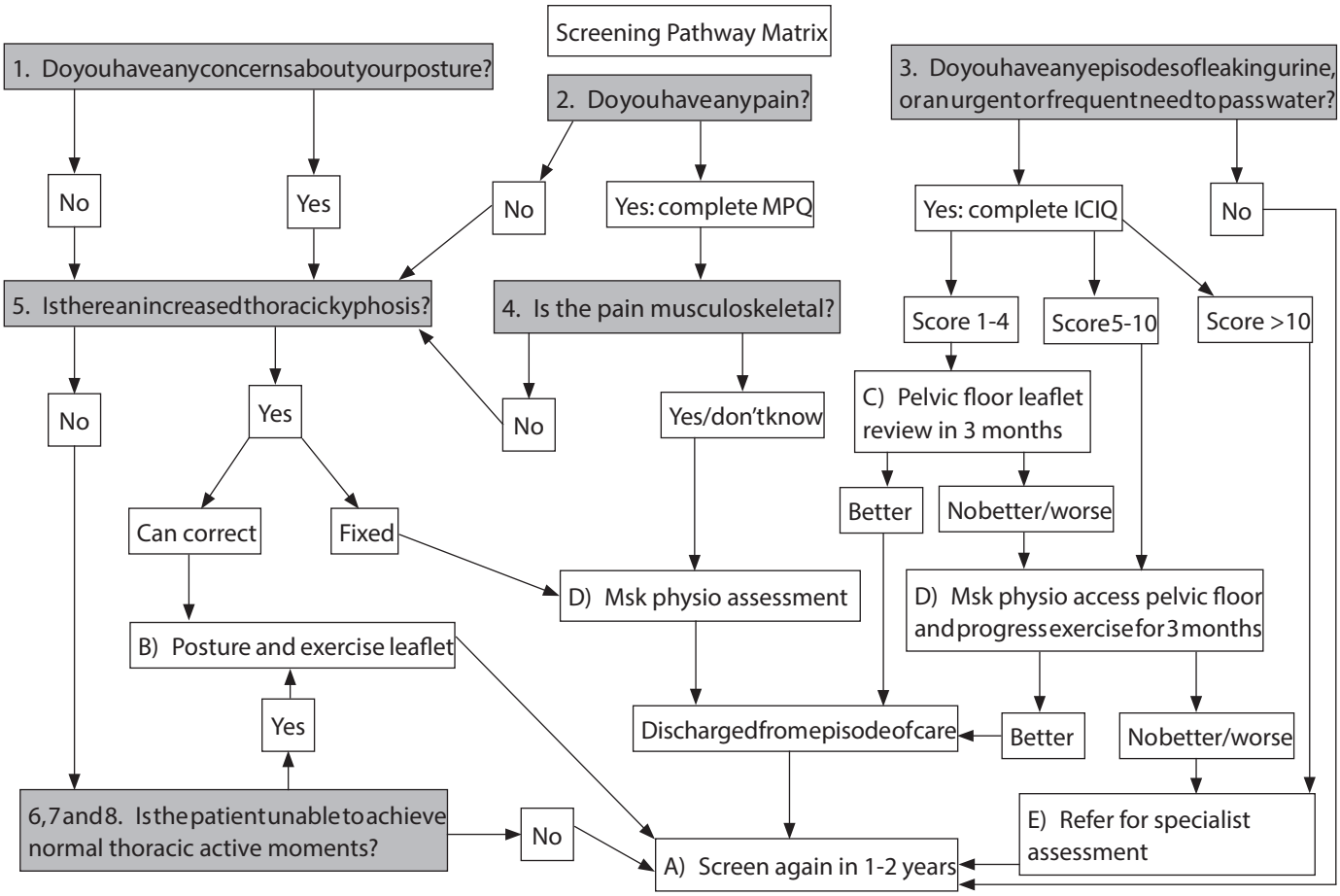
ICIQ score: sum scores 3+4+5 ☐☐

6 When does urine leak? *(Please tick all that apply to you)*

never – urine does not leak	☐
leaks before you can get to the toilet	☐
leaks when you cough or sneeze	☐
leaks when you are asleep	☐
leaks when you are physically active/exercising	☐
leaks when you have finished urinating and are dressed	☐
leaks for no obvious reason	☐
leaks all the time	☐

Thank you very much for answering these questions.

MACFC
MANCHESTER ADULT CYSTIC FIBROSIS CENTRE



Disclaimer

This material has been developed by the University Hospital of South Manchester NHS Foundation Trust (UHSM) and is to be used as a guide only in conjunction with local practices and guidelines.

Use of this material is not a substitute for the exercise of appropriate professional skill and judgement.

University Hospital of South Manchester NHS Foundation Trust shall not be liable to any person for any loss or damage which may arise from the use of this material.

MACFC
MANCHESTER ADULT CYSTIC FIBROSIS CENTRE

UHSM

Cystic Fibrosis Trust
2nd Floor
One Aldgate
London EC3N 1RE

020 3795 1555
enquiries@cysticfibrosis.org.uk
cysticfibrosis.org.uk

The Cystic Fibrosis Trust is the only UK-wide charity dedicated to fighting for a life unlimited by cystic fibrosis (CF) for everyone affected by the condition. Our mission is to create a world where everyone living with CF will be able to look forward to a long, healthy life.

At the Trust we are:

- Investing in cutting-edge research
- Driving up standards of clinical care
- Providing support and advice to people with CF and their families
- Campaigning hard for the issues that really matter

Fighting for a Life Unlimited