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# Contents

# Introduction

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Welcome to the Association of Chartered Physiotherapists in Respiratory Care (ACPRC) journal for 2014. This journal provides physiotherapists working within respiratory care with evidence upon which to base practice but also a chance to reflect on practice within changing healthcare systems. The articles within this edition include an audit and review of practice, an intervention study, a review and additionally personal perspectives on a Cochrane review and preparing for the future in the changing world of healthcare. Physiotherapists work in a range of specialities and these are reflected in articles on post-surgery care; management of people using extra corporeal membrane oxygenation; non-invasive ventilation and active cycle of breathing and adherence to treatment for people with bronchiectasis.

The ACPRC conference from 24th-25th April 2015 moves to a new venue in Cheltenham with the theme of 'Walking in the steps of the patient: Integrating theory and practice'. This is an exciting occasion for us to meet, share our experiences in both formal and informal settings and most importantly develop the best evidence based care for people with respiratory problems. Further details can be found on the new website: www.acprc.org.uk.

As a national specialist journal, the ACPRC welcomes articles from members and non-members of the association. For some, this is the first step into writing for a journal and we have created new writing guidelines, available on the website, that provide structure and direction for writing up a service evaluation; case study; literature review; experimental study and qualitative study. We also provide support from the research officer, the journal editors and reviewers to develop the articles. Please feel free to get in touch with Una or Emma if you have any articles that are just waiting to be written and published.

We hope you enjoy this edition of the ACPRC journal and we look forward to seeing you at the Conference in April.

Una Jones MSc BSc MCSP
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# A retrospective audit of respiratory physiotherapy used in the management of adult patients on extracorporeal membrane oxygenation (ECMO) in a single trust.

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Team Leader for ECMO

## *Summary*

***The expanding and successful use of extracorporeal membrane oxygenation (ECMO) has led to a need for further research, discussion and knowledge, to assist physiotherapists who treat patients on ECMO and those involved in their further care and rehabilitation. This study is a retrospective audit of respiratory physiotherapy techniques used in the management of adult patients on veno-venous (VV) ECMO for respiratory failure at a single trust. The use of manual hyperinflation (MHI), which varies between trusts, is a particularly interesting debate. The reasons for and against its use will be discussed.***

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**ECMO**
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**ARDS**
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## Introduction

Extracorporeal membrane oxygenation (ECMO) has been used successfully for severe respiratory failure in newborn infants for 40 years (Mugford et al 2008). Its use in adults developed more slowly due to early negative studies (Lim, 2006), but has increased greatly in the last 5 years due to significant outcomes in research (Peek et al 2010), improvements in equipment (Sidebotham et al 2012) and its success in providing support during the H1N1 virus outbreak (Noah et al 2011). The constantly improving outcomes are likely to continue the expansion of its use (Hung et al 2012), which is best served in specialist centres that use the technique regularly (Allen et al 2011). In 2011 five NHS Trusts became specialist centres in England, which now has the largest established respiratory ECMO capacity in the world.

ECMO is a process that allows for oxygenation of blood outside of the body, and is essentially a modification of the cardiopulmonary bypass circuit which is used routinely in cardiac surgery. An ECMO machine can take over the work of a patient's heart and/or lungs by oxygenating blood and pumping it back into the patient, allowing the lungs and/or heart to rest and recover from an acute, reversible cardiothoracic pathology. It is used as temporary support, usually awaiting recovery or transplantation of organs (Sidebotham et al 2012). ECMO comes in two forms: venoarterial (VA) and venovenous (VV) and in both forms blood is taken from the venous system and is oxygenated outside of the body. VV ECMO returns the blood to the venous system and thus only supports gas exchange (the lungs). VA ECMO provides circulatory (the heart) support in addition by pumping blood back into the arterial system. By functioning as an artificial lung VV (respiratory) ECMO allows ventilation settings to be reduced and thus decreases ventilator-induced lung injury (barotrauma, volutrauma and oxygen toxicity) caused by high positive pressure ventilation with high oxygen intake. High plateau pressures, which may be required to achieve effective mechanical ventilation without ECMO, can cause excessive stretch (overdistention) of the alveoli (Hung et al 2012). The mechanical sheer forces applied in the cyclic opening and closing of alveoli may cause volutrauma, a component of ventilator-induced lung injury. ECMO allows for ultra-protective lung ventilation. It is not a cure for the underlying disease but it does provide support and time for the lungs to rest and recover from the original diagnosis, such as acute respiratory distress syndrome (ARDS) or severe pneumonia.

The treatment of patients on ECMO is similar to that for any ventilated patients, although an understanding of ECMO is important as there are some special considerations (Fiddler and Williams 2000). These include being aware of ECMO flow and oxygen sweep rate and that auscultation, chest x-rays and tidal volumes (TV) are likely to show much reduced ventilation when initially placed on ECMO due to the sudden reduction in airway pressure support. A complete white-out on x-ray is common. As the lungs rest and recover gradual improvements are usually made in lung volume, and oxygenation through ECMO can be gradually reduced (Sidebotham et al 2012). Whilst ECMO allows the lungs to rest it does not provide any treatment for the underlying disease/diagnosis. Atelectasis, consolidation and sputum retention may be present with these reversible severe respiratory disorders and physiotherapy has been shown to have benefits in the treatment of patients that are ventilated on intensive care units (Denehy and Berney 2006). Physiotherapy management is therefore important in assisting in the recovery of the lungs.

There is a lack of research and discussion on the physiotherapy management of adult patients on ECMO. Fiddler and Williams (2000) suggested that physiotherapy techniques may be important, where appropriate, in treating the underlying disease. Gatehouse (2011) provided a single case study of a patient on ECMO with physiotherapy chest care involving suction, vibrations and positioning. MHI was not used but it was discussed that, with a knowledge of the pathophysiology of ARDS, it could be used.

Prior to this article ECMO had been used occasionally at the Trust following cardiothoracic transplantation. The Trust became a national adult ECMO centre and with more regular use of ECMO came a need for more knowledge.

### *Aims and Objectives*

This study is a retrospective audit of physiotherapy respiratory treatment provided to twenty adult patients that received respiratory (VV) ECMO at a single national ECMO centre. The treatment techniques used will be discussed and the clinical reasons for and against the use of MHI debated.

## Methods

The physiotherapy treatment provided to twenty patients that received VV ECMO was recorded. A physiotherapy treatment session was regarded as an assessment and an intervention, even if this was passive movements or suction only. Physiotherapy was provided routinely once or twice every day, depending on time constraints and each patient's daily need as assessed by the physiotherapist. If no treatment was provided, due to cardiovascular instability for example, this was not included in the audit. Physiotherapy documentation was kept together within medical notes and a copy of these was taken prior to each patient's discharge from the cardiothoracic critical care unit (CTCCU). The age, sex and initial diagnosis of each patient was taken. The numbers of days on ECMO, physiotherapy treatment sessions received and treatment techniques used were all counted. A physiotherapy team leader produced an initial assessment and treatment plan, and carried out the majority of treatment sessions. In their absence any grade of qualified physiotherapist could provide a daily assessment and treatment session.

Patients received pressure-controlled mandatory ventilation 'rest' settings of 0.30 fraction of inspired oxygen ($FiO_2$) and a positive end-expiratory pressure (PEEP) of 10. Bronchoscopy was performed as required by the medical team, although this was typically every two days, which is much more frequent than usual for ventilated patients on the CTCCU. It is usual practice for ventilated patients, including those on ECMO, to receive MHI and suction on a regular basis from nursing staff. Chest physiotherapy was encouraged by the medical team. The frequency of treatment and the treatment techniques used is the same for other ventilated patients on the unit, with sputum retention and volume loss requiring management. All twenty patients were kept fully sedated on ECMO and received daily passive movements to all limbs depending on cardiovascular stability and the position of an ECMO line in the femoral artery.

MHI breaths were delivered using a Mapleson C, two litre, anaesthetic circuit. Each physiotherapist used their clinical judgement to determine MHI application time, number of breaths delivered per set, suction requirement and length of inspiratory hold. TV were observed during the assessment but were not documented.

Patients were kept sedated whilst on ECMO to maintain flow through the machine, and thus maintain cardiovascular stability. If patients weren't fully sedated and coughing occurred, a loss of flow may occur as a result of the increase in intra-thoracic pressure which causes a constriction on the ECMO cannula and resultant flow.

## Results

Table 1 shows general patient information including diagnosis, the number of days on ECMO and the number of physiotherapy treatment sessions each received whilst on ECMO. The original diagnosis included respiratory failure following extensive burns, pancreatitis and a road-traffic accident, with pneumonia making up half of the cases. The mean age of the patients was 37 (range 16-64) and the mean number of days on ECMO was 14.65. Patients received an average of 21.45 physiotherapy treatments, or an average of 1.5 treatment sessions per day.

## Table 1 - Patient Information

| Age | Sex | Initial Diagnosis | Number of days on ECMO | Number of physiotherapy treatment sessions received |
|---|---|---|---|---|
| 58 | Male | Road-traffic accident; multiple fractures | 8 | 12 |
| 44 | Male | Pancreatitis | 23 | 51 |
| 18 | Female | Pneumonia | 6 | 11 |
| 32 | Female | Pneumonia | 7 | 15 |
| 30 | Male | Pneumonia | 12 | 24 |
| 22 | Female | Exacerbation of asthma | 15 | 25 |
| 48 | Female | Pneumonia | 7 | 5 |
| 27 | Female | Pneumonia | 10 | 15 |
| 30 | Male | Pancreatitis | 10 | 16 |
| 57 | Male | Drugs overdose | 22 | 32 |
| 44 | Male | Viral pneumonitis | 8 | 12 |
| 64 | Female | Pneumonia | 37 | 42 |
| 44 | Male | Pneumonia | 29 | 32 |
| 43 | Female | Removal of kidney stone | 6 | 7 |
| 33 | Female | Extensive burns to face and arms following house fire; fractured pelvis and skull following fall from first floor | 20 | 33 |
| 49 | Male | Pneumonia | 17 | 19 |
| 23 | Male | Respiratory failure | 7 | 10 |
| 17 | Female | Pneumonia | 22 | 33 |
| 41 | Male | Diabetic keto-acidosis | 17 | 25 |
| 16 | Male | Pneumonia | 7 | 10 |

Mean age = 37 (range = 16-64)
Mean number of days on ECMO = 14.65 (range = 6-37)
Mean number of physiotherapy treatment sessions received = 21.45 (range = 5-51)

Table 2 shows the type and frequency of physiotherapy treatment techniques that each patient received for respiratory care, with the totals for each technique shown in table 3.

## Table 2 - Frequency of Treatment Techniques Used with Each Individual Patient

| Number of physiotherapy treatment sessions received | MHI | Suction | Saline Instillation | Manual techniques (vibrations) |
|---|---|---|---|---|
| 12 | 12 | 12 | 1 | 0 |
| 51 | 43 | 43 | 14 | 3 |
| 11 | 7 | 7 | 0 | 0 |
| 15 | 11 | 11 | 4 | 0 |
| 24 | 16 | 17 | 4 | 0 |
| 25 | 13 | 19 | 17 | 10 |
| 5 | 0 | 2 | 0 | 0 |
| 15 | 4 | 13 | 10 | 10 |
| 16 | 1 | 5 | 4 | 4 |
| 32 | 20 | 28 | 19 | 11 |
| 12 | 3 | 8 | 3 | 1 |
| 42 | 14 | 37 | 19 | 3 |
| 32 | 4 | 15 | 5 | 3 |
| 7 | 4 | 7 | 4 | 0 |
| 33 | 12 | 26 | 6 | 0 |
| 19 | 10 | 17 | 8 | 2 |
| 10 | 7 | 10 | 5 | 1 |
| 33 | 20 | 26 | 2 | 0 |
| 25 | 20 | 24 | 11 | 1 |
| 10 | 9 | 10 | 7 | 0 |

## Table 3 - Total Frequency of Treatment Techniques Used

| Total number of physiotherapy treatment sessions received | Total number of times MHI was used | Total number of times suction was used | Total number of times saline instillation was used | Total number of times manual techniques (vibrations) was used |
|---|---|---|---|---|
| 431 | 230 | 337 | 143 | 49 |

Suction was used in 78% of all physiotherapy treatment sessions. It was not used when suction was not indicated, immediately after a bronchoscopy for example, or when passive movements only were used. A patient that had extensive burns required frequent passive movements and received these more than the usual once-a-day. Sputum was mostly described as small volume and blood coloured. This may be explained by reduced ventilation of the lungs leading to fewer mobilisations of secretions and anticoagulation therapy, given to maintain flow through the machine, possibly causing bleeding from any trauma caused by suction.

Saline instillation was used in a third (33%) of all sessions and manual techniques (vibrations) in only 11% of sessions. MHI was used in over a half (53%) of all physiotherapy treatment sessions. When saline was instilled a cumulative total of 7.96 millilitres was used on average per treatment session (range 2-10 millilitres). Three of the twenty patients received the majority of manual techniques (on 31 occasions from the total of 49) due to them having thicker secretions that were difficult to clear.

TV increased gradually during time on ECMO. Initially, when low, MHI would not be used and physiotherapy likely to be provided only once-a-day. As TV improved MHI would be used and treatment frequency increased to twice daily

## Discussion

The main aim of this study was to gather information/data on the treatment used with patients on ECMO. It is not a reflection of the treatment used nationwide, nor does it suggest the most beneficial or necessarily appropriate techniques.

Whilst saline instillation was used occasionally and manual techniques (vibrations) rarely, MHI was frequently used when respiratory physiotherapy was required. The use of MHI is known to be variable between trusts that have patients on ECMO. The aim of ECMO is to allow the lungs to 'rest and recover'. The 'complete' resting of the lungs and prevention of barotrauma is an argument against the use of MHI. The need to treat the underlying condition, improve TV and aid the recovery of the lungs is an argument for. Barotrauma is very difficult to measure and the positive effect of MHI in all ventilated patients has been extensively researched and discussed (Berney and Denehy 2002). The clinical reasoning that exists both for and against the use of MHI has led to its varying use between ECMO centres.

Saline instillation is likely to be more frequent than for patients who receive conventional ventilation without ECMO as all of the patients had VV ECMO for respiratory failure and were likely to have increased sputum/ consolidation. The rare use of manual techniques could be explained by the caution taken by physiotherapists in not increasing intra-thoracic pressure and trying to maintain flow though the ECMO machine. The study audited the first twenty patients following the unit becoming a national ECMO centre and, therefore, there may have been more caution due to unfamiliarity.

Tidal volumes were very useful in the assessment, and for monitoring improvement. The dramatic effects on TV after initially being placed on ECMO, due to the collapsing of the lungs from the sudden reduction in pressure support, make TV and ECMO very important. Thus recruitment of lung volume, and MHI, plays an important role in the management of patients on ECMO. All patients lose lung volume when initially placed on ECMO, and in most it is a significant amount, hence the high use of MHI and the emphasis in this study. Secretion volume, however, varied and this helps to explain the less frequent use of saline instillation and manual techniques. Recordings of TV pre- and post-treatment sessions would have been beneficial to this study to evaluate the effectiveness of the techniques used and to investigate their use in the different stages of recovery.

VV ECMO is used to provide respiratory support for acute respiratory distress syndrome (ARDS), recently classified as mild, moderate or severe (Ranieri 2012). Caution is generally taken by physiotherapists when using MHI with ARDS as the loss of PEEP and shearing stresses it causes can lead to de-recruitment (Hodgson et al 1999). Thus, it could be said that MHI is not appropriate, or certainly requires caution, when used with ECMO. ECMO does, however, require special considerations and the fact that 'rest' ventilator settings are used may mean that disconnection from the ventilator, and the resulting loss of PEEP, may not effect oxygenation and have less of an effect on lung volume than conventional ventilation without ECMO. Lung volume is likely to have been lost when placed on ECMO and thus, at that stage of recovery, recruitment is more important than maintaining airway pressure support. Removing the patient from PEEP may also have other effects such as increased expiratory flow from the lungs that may mobilise secretions. ARDS is a pathological syndrome in which secretions are often not considered an issue. The initial injury or infection may however be causing secretions. The ventilatory management of ARDS is controversial, complex and debatable, and indeed whether the lungs should be recruited during ARDS (Kacmarek 2006).

The use of ventilator hyperinflation (VHI) has been researched as an alternative to MHI with similar results (Berney and Denehy 2002; Dennis et al 2012; Savian et al 2006). Benefits of this include no disconnection, and thus no loss of PEEP, and greater control of airway pressure (Clarke et al 1999), allowing the lungs more 'rest'. VHI is not used by physiotherapists on the unit as it is felt that VHI is comparable to MHI and that physiotherapists feel more familiar with MHI.

Further studies into the effect of MHI on airways and whether barotrauma is caused, particularly during ECMO support, would be extremely beneficial. A manometer should always be used in the MHI circuit (Davies and Igo 2004; Hila and Ellis 2002) and is of particular importance when ECMO is involved as high pressures (and the potential barotrauma) are the initial indications for its use. Manometers are to be introduced on the unit for all ventilated patients, including those on ECMO. PEEP valves can also be used with MHI to maintain a PEEP throughout, although this may reduce the movement of secretions due to a reduction in peak expiratory flow (Savian et al 2005).

Respiratory physiotherapy, and recruitment of lung volume, is clearly an important issue for patients on ECMO and further research and discussion would be beneficial. A study comparing the differing use of treatment techniques at national ECMO centres could be made, although there will be other variables in the overall management of these patients. A physiotherapy special interest group is to be arranged that can meet and compare treatment techniques and to discuss issues further.

## Key points

- MHI was used frequently for patients on ECMO at a single trust; there is an argument for and against its use.
- Tidal volumes are an important objective measure for patients on ECMO.
- Physiotherapy special interest group on ECMO is to be set up.

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# Incentive Spirometry following scoliosis correction surgery for adolescent idiopathic scoliosis: A review of practice at a tertiary referral centre.


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**Vital Capacity**



### *Summary*

***The role of incentive Spirometry (IS) following corrective surgery for scoliosis is unclear. The purpose of this study is to review and audit current practice at a Tertiary Referral Centre. The findings of this review indicate that patients undergoing a single stage posterior spinal fusion rarely require IS. By contrast IS is frequently deemed necessary after the anterior release component of a two stage procedure which comprises of thoraco-abdominal approach to the anterior aspect of the spine followed by a posterior spinal fusion. Pre-operative vital capacity measurements appear to be of limited value when predicting requirement for IS or length of hospital stay in adolescent idiopathic scoliosis patients.***


## Introduction

Correction of scoliosis is a major surgical procedure and postoperative respiratory problems are common and include atelectasis, pneumothorax, haemothorax, pleural effusion, pulmonary oedema and pneumonia (Carreon et al 2007). This is exacerbated by the fact that patients with severe scoliosis have compromised lung function with reduced vital capacity (Koumbourlis 2006).

Incentive spirometry (IS) involves deep breathing through a device utilising visual feedback, thought to maximise compliance and motivation to deep breathing exercises (Bartlett et al 1973). IS is often used as a

prophylactic measure to prevent post-operative pulmonary complications but the value of IS is controversial and there is differing opinion into its efficacy in the literature (Carvalho et al 2011, Guimaraes et al 2012, Hassanzedh et al 2012). It has been suggested that it may be of more value in selected at risk groups (Agostini et al 2013). Measurement of vital capacity is commonly used to identify at risk patients. Padman and McNamara (1990) and Jenkins et al (1983) showed that patients undergoing scoliosis correction surgery with a predictive vital capacity of <30% demonstrated increased post-operative complications.

At our institution, during the time of this practice review, no patients were assigned to IS pre-operatively and IS was only instituted when respiratory problems arose. This review of current practice assessed which types of patients were deemed to require IS and the role of bedside spirometry conducted by the physiotherapist prior to surgery. The purpose of this review was to make recommendations for the optimal use of IS and bedside spirometry in patients undergoing scoliosis correction surgery for idiopathic adolescent scoliosis.

## Methods

Consecutive patients, who had been given a diagnosis of adolescent idiopathic scoliosis and underwent primary corrective surgery, were reviewed over a 6 month period for this service evaluation. Ethical approval was not deemed necessary as this was an observation of current practice. All patients had to have been assessed by a physiotherapist prior to surgery and the past medical history and lung function tests including % predicted vital capacity (VC) were recorded. A total of 60 patients were prospectively audited; 12 were over the age of 18 years (range 18-57 years), and 48 were 17 years or younger (range 12-17 years). Thirty seven had a posterior single stage fusion, 7 had an anterior single stage fusion and 16 had a two stage anterior and posterior procedure (Table1). The anterior procedures required a thoracotomy. Those patients receiving the two stage procedure initially had an anterior release and then generally had 7 days bed-rest before proceeding to the posterior fusion. The anterior release is performed by excising the intervertebral discs allowing increased flexibility prior to posterior instrumentation, which compromises the spine's stability and therefore bed rest is required to minimise the chances of neurological compromise between stages.

Each patient had their past medical history (PMH) recorded, by the ward physiotherapist, and were deemed to have a positive PMH if they had any co-morbid conditions which might impair post-surgical recovery; this included chronic or recurrent respiratory and cardiovascular disease, cognitive impairment and a history of smoking. Spirometry was performed at the bedside in a standardised standing position by the ward physiotherapist with a Care Fusion MicroPlus Spirometer (Micro Medical Ltd 2007) with the highest reading from 3 attempts recorded. The % of predicted VC was calculated according to the method of Nunn and Gregg (1989) using weight and arm-span to calculate body area as the measurements of height were unreliable due to the scoliosis.

Following surgery, routine observations (heart rate, temperature, systolic blood pressure, oxygen saturation and urine output) were measured 2 hourly for patients using patient controlled analgesia and 4 hourly for those without and from these observations the Modified Early Warning Score (MEWS) was calculated (Subb et al 2001), see Appendix 1. Routine observations were taken by the ward nursing staff and documented in the medical recording observation chart.

It is normal practice, at the institution, to provide patients with incentive spirometry (IS) as deemed necessary by any member of the multi-disciplinary team. Patients undergoing scoliosis surgery are routinely seen once daily by the ward physiotherapist, or more if clinically indicated. No patient was

assigned to post-operative incentive IS prior to surgery. Following a single stage fusion, or following the second component of the two stage procedure all patients were taught deep breathing exercises post operatively and early mobilisation out of bed and mobility retraining was encouraged. Deep breathing exercises were encouraged to be undertaken hourly by the patients, in addition to the once daily physiotherapy sessions. IS was only instituted by the ward physiotherapist if the MEWS was >5, auscultation revealed decreased air entry or there was lack of compliance with the deep breathing exercises. Lack of compliance was determined as not undertaking deep breathing exercises hourly, as reported by the patient, family or ward staff responsible for the patient. For patients who received IS after the anterior release phase of the two stage procedure, the incentive spirometer was kept at the bedside after the second phase and could be used by that patient. The Incentive Spirometer used for this project was the Coach 2® (Smiths Medical 2014), see Figure 1.

Figure 1 - The Coach 2 Incentive Spirometer

The length of stay in hospital, % predicted VC and MEWS scores were compared using the Mann Whitney U test for non-paired non-parametric data (Kirkwood 1988). Statistical comparison of the requirement for IS between different groups of patients was performed using the Chi-squared test with Yates correction for small numbers (Yates 1934).

## Results

### *Provision of Incentive Spirometry*

Thirteen patients (22%) were given IS (primary reasons: failure to comply with deep breathing exercises n=7; reduced breath sounds = 5; elevated MEWS to 5 n=1) and this requirement for respiratory support was strongly related to the type of surgical technique, see Table 1. Only 1 out of 37 patients receiving a single stage posterior fusion (3%) required IS, 2 out of 7 (29%) receiving a single stage anterior fusion and 10 out of 16 (63%) following the first phase of a two stage procedure. The single patient receiving a posterior fusion who required IS was because of failure to comply with deep breathing exercises. The difference in requirement for IS between patients receiving a single or a two stage procedure was highly significant ($p<0.0001$). There was a trend for anterior single stage fusion to have a higher requirement for IS than a single stage posterior fusion, but the number of anterior single stage corrections was small and this did not reach statistical significance ($p=0.94$). The difference between those receiving an anterior procedure which included both the anterior fusions and anterior release phases of a two stage procedure, and a posterior fusion was highly significant $p<0.0001$.

### *Positive Past Medical History*

Of the sixty patients undergoing scoliosis correction surgery, sixteen were reported to have a positive PMH (asthma n=6, Attention deficit hyperactivity disorder (aDHD) n=1, recent history of bronchitis n=1, unspecified connective tissue disorder n=1, Chiari type I malformation n=1, developmental delay n=1, dilated aortic root n=1, epilepsy n=1, short of breath on exertion n=1, vitamin D deficiency n=1, Wolff Parkinson White Syndrome n=1), see Table 2. The impact of a positive past medical history and % predicted VC was then assessed in those 16 patients receiving a two stage fusion procedure. Eight patients (50%) had a positive PMH and 6 of these (75%) required IS compared

to 50% in those without a positive PMH. This difference was not significant (p=0.27). The % predicted VC was lower in those patients with a positive PMH (median 73% vs 80.5%) but this was not significant (p=0.24). There was no relationship between % predicted VC and the requirement for IS (77.5% in those requiring IS and 80.5% in those not requiring IS, p=0.7).

## Table 1 - Indication for Incentive Spirometry

| | Single Stage Posterior n=37 | Single Stage Anterior n=7 | Two Stage Anterior and Posterior n=16 |
|---|---|---|---|
| Poor compliance with deep breathing exercises | 1 | 1 | 5 |
| Reduced breath sounds | 0 | 1 | 4 |
| MEWS > 5 | 0 | 0 | 1 |
| Total number (%) | 1 (3%) | 2 (29%) | 10 (63%)* |

* P < 0.0001 compared with single stage procedures

## Table 2 - Patient Demographics

| | Single Stage Posterior | Single Stage Anterior | Two Stage Anterior and Posterior |
|---|---|---|---|
| Number of patients | 37 | 7 | 16 |
| Median Age (years) | 15.5 (12-57) | 15 (9-19) | 13.5 (11-18) |
| Male / Female | 9 / 28 | 0 /7 | 4 / 12 |
| Median Weight (kg) | 56 (36-82) | 59 (28-75) | 52.5 (29-90) |
| Median Arm Span (cm) | 165 (142-192) | 157.5 (135-171) | 164 (154-173) |
| Median FVC (l) | 2.56 (1.42-3.85) | 2.81 (1.37-3.05) | 2.39 (1.38-4.38) |
| Median % Predicted FVC | 78 (32-120) | 90 (54-108) | 77.5 (49-121) |
| LOS | 8 (3-12) | 7 (6-14) | 14.5 (9-35) |
| Co-morbidity | 5<br>ADHD = 1<br>Connective Tissue Disorder = 1<br>Asthma = 1<br>Wolff Parkinson White Syndrome = 1<br>Chiari Type i Malformation = 1 | 3<br>Asthma = 2<br>Dilated Aortic Root = 1 | 8<br>SOBOE = 1<br>Asthma = 3<br>Bronchitis = 1<br>Vitamin D Deficiency = 1 |

## MEWS

As expected the MEWS was higher in those patients requiring IS as this measure had been used as an indication for IS (median score 5 compared to 3.5) although this difference was not significant (p=0.34). There was also a trend for a higher MEWS in those patients with a positive PMH (median score 5 compared to 4, p=0.093).

### Length of Stay in hospital

The median length of stay (LOS) in hospital for all patients was 8 days. It was much greater for patients receiving a two stage procedure (median 14.5 days) than patients receiving a posterior single stage fusion (median 8 days) and patients receiving an anterior single stage fusion (median 7 days) partly due to the interval between procedures.

The LOS was greater in those patients with a positive PMH (n = 16, median LOS 12.5 days) compared to patients without a positive PMH (n = 44, median LOS = 8 days), (p=0.004), but was not related to the % predicted VC, see Figures 2-4.

**Figure 2 Length of stay vs % Predicted Vital Capacity in patients undergoing posterior single stage fusion**

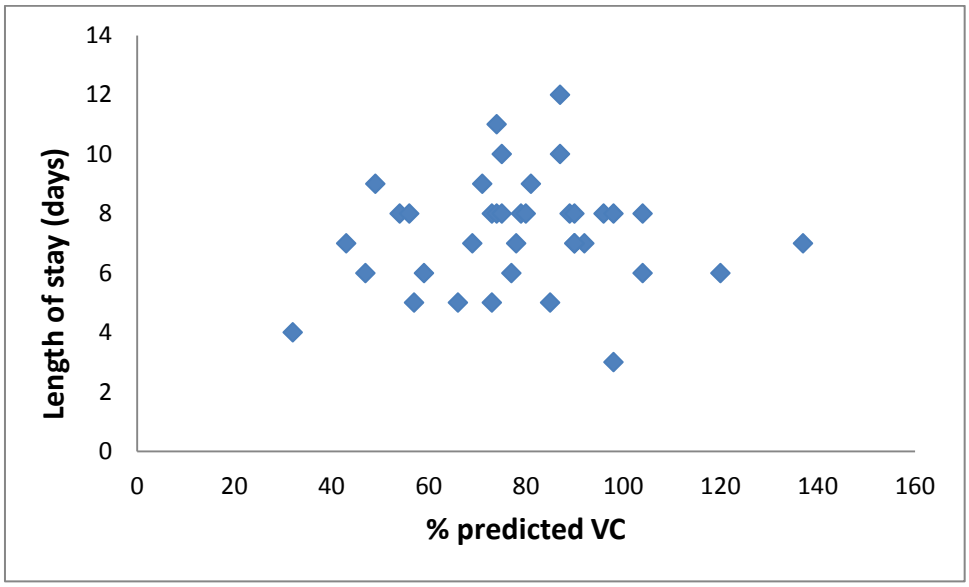


**Figure 3 Length of stay vs % Predicted Vital Capacity in patients undergoing anterior single stage fusion**

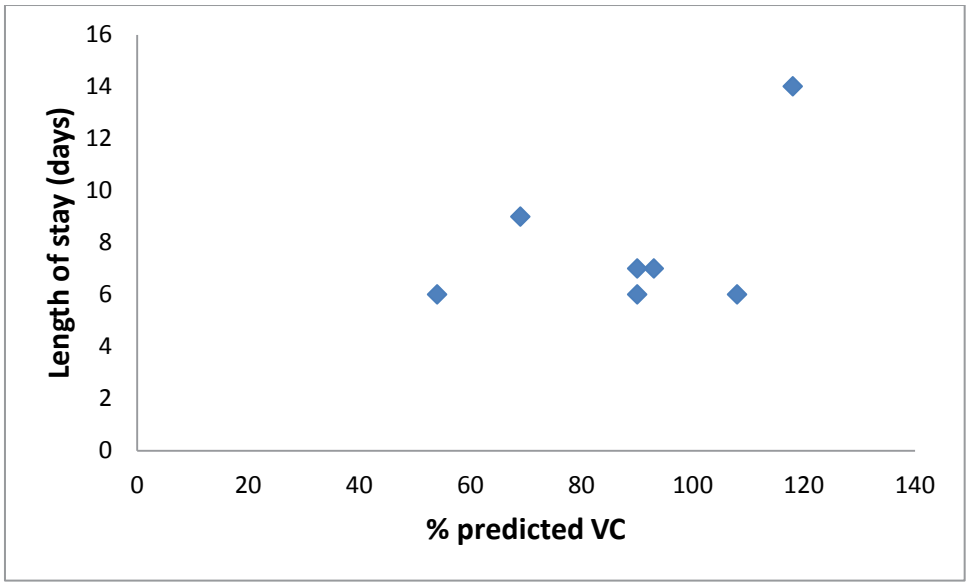
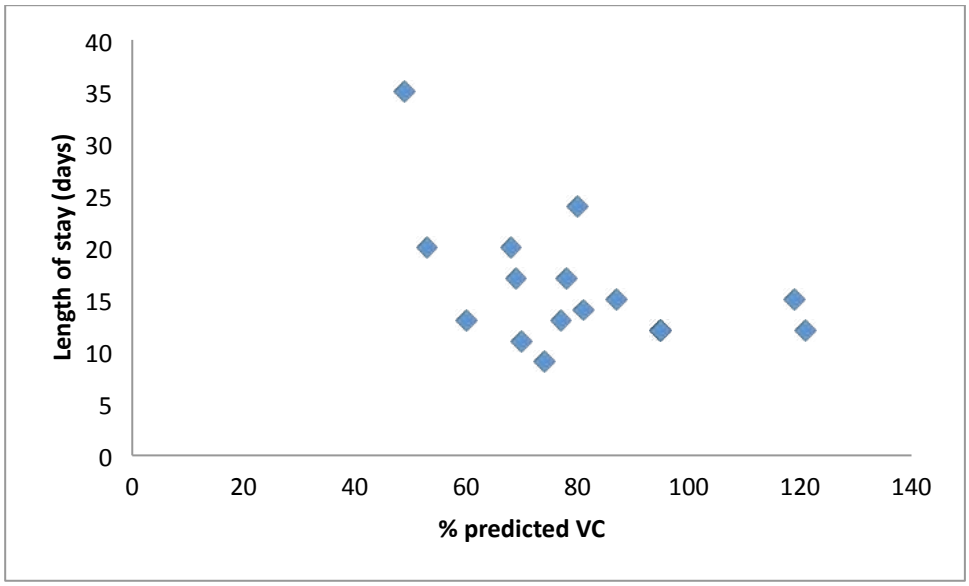



**Figure 4 Graph to show Length of stay vs % Predicted Vital Capacity in patients undergoing 2 stage anterior and posterior fusion**



## Discussion

This review of practice at the Royal National Orthopaedic Hospital shows that in patients receiving a two stage procedure there is a high rate of requirement for IS following the anterior release (63%). The patients with adolescent idiopathic scoliosis who required two stage correction comprising of an anterior and posterior spinal fusion generally had a more marked deformity than those who could be corrected with only a single procedure whether a single stage anterior or single stage posterior fusion and could explain their greater need for IS. This appeared to be particularly high in those patients with a relevant past medical history, but there are insufficient patients for the statistical significance of the importance of past medical history to be determined. It thus seems clinically justified to offer IS to all patients receiving a two stage procedure, although the efficacy of IS is unclear (Guimaraes et al 2012) and further research on this needs to be conducted. The provision of IS to patients undergoing a two stage procedure may be offered pre-operatively, to enhance understanding and compliance for the use of the device (Hassanzedh 2008).

By contrast IS is rarely required for patients undergoing a single stage posterior fusion and its use cannot therefore be recommended. It is possible that there is a higher requirement for IS after a posterior fusion which is the second component of a two stage procedure but this was not evaluated in this review. This analysis would be of interest in future studies.

The higher requirement for IS after the first phase of a two stage procedure compared to a single stage posterior fusion, could be due to the thoracotomy procedure or to the fact that the two stage patients are restricted to bed rest during the 7 day interval between procedures. Of the 7 patients provided with an IS due to poor compliance with routine deep breathing exercises, 5 patients (71%) had undergone a 2 stage scoliosis correction and were provided with IS whilst on bed-rest.

Those patients having a single stage anterior fusion are of interest because they also have a thoracotomy but are mobilised post–surgery following removal of chest drain and these patients also had less curvature of the spine compared with those who requires a two stage fusion. The combination of a milder scoliosis deformity and early mobilisation meant that these patients had less respiratory problems that required IS even though they had a thoracotomy. In fact the number of patients requiring IS in this group is too small to enable firm conclusions, and a larger study recruiting more of these single stage anterior spinal fusion patients may give clearer evidence of whether these patients do indeed have less respiratory problems compared with the combined 2 stage correction.

IS might have a role to play in the respiratory management of patients undergoing 2 stage correction, however, there is a lack of consensus for the respiratory management of patients in this group, and further research is required to ascertain their optimal management strategy.

An important finding in this study was that the pre-operative lung function tests carried out by the physiotherapist at the bedside had no predictive power to discriminate between those who would be deemed to require IS and those who would not, and had no relationship to the length of stay in hospital. This is not in accord with the views of McAllister et al (2013) who found that reduced $FEV_1$ strongly predicted increased length of stay and in-hospital mortality following cardiac surgery, and whether more informative lung function data would have been obtained had the patients been formally assessed in a lung function laboratory cannot be determined. Nonetheless, the bedside tests carried out in this series of idiopathic scoliosis patients with relatively good lung function appear to be of limited value.

## Conclusion

This practice review indicates that IS is rarely

required after a single stage posterior fusion but is frequently deemed necessary after the first anterior phase of a two stage procedure. Bed-side measurement of vital capacity did not predict which patients developed respiratory problems leading to the use of IS nor did they predict for length of stay in hospital or postoperative MEWS.

## Key points

- The perceived requirement for incentive spirometry following scoliosis correction surgery is dependent on the type of operation performed.
- Pre-operative vital capacity is not a predictor for requirement of incentive spirometry.
- Pre-operative vital capacity is not a predictor for length of stay in hospital.
- Pre-operative vital capacity is not a predictor for post-operative MEWS.

## Appendix 1 - MEWS (Subb et al 2001)

| Score | 3 | 2 | 1 | 0 | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|
| **Systolic BP** | <45% | <30% | 15% down | Normal | 15% up | >30% | >45% |
| **Heart Rate (BPM)** | - | <40 | 41-50 | 51-100 | 101-110 | 111-129 | >130 |
| **Respiratory Rate (RPM)** | - | <9 | - | 9-14 | 15-20 | 21-29 | >30 |
| **Temperature (°C)** | - | <35 | - | 35.0-38.4 | - | >38.5 | - |
| **AVPU** | - | - | - | A | V | P | U |

A score of 5 or more is statistically linked to increased likelihood of death or admission to an intensive care unit (Subb et al 2001)

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# Non-Invasive ventilation as an airway clearance adjunct in exacerbations of non-cystic fibrosis bronchiectasis: A pilot study


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## Keywords:

**Non-invasive ventilation**
**Airway Clearance**
**Bronchiectasis**



***Summary***

***Background: Airway clearance is part of non-cystic fibrosis (CF) bronchiectasis management.***

***Objectives: To assess the efficacy of airway clearance on respiratory muscle strength using active cycle of breathing techniques (ACBT) assisted non-invasive ventilation (NIV) versus ACBT alone. The secondary aims were to provide data on the appropriateness, feasibility and safety of this study design. Methods: Twenty patients with moderate to severe non-CF bronchiectasis, difficulty expectorating sputum, and an acute pulmonary exacerbation***

***were recruited and randomised to ACBT+NIV group (n=10) or ACBT group (n=10). The primary outcome measure (respiratory muscle strength), was assessed at the beginning and end of intravenous antibiotics. Results: Demographic data was similar at baseline. There was a significant improvement in inspiratory muscle strength in favour of ACBT+NIV versus ACBT alone: 16.7 (95% CI 4.5 to 29) cm$H_2O$, p = 0.01. There was no other between group differences, with the exception of a very small statistically significant but clinically insignificant difference in oxygen saturations. Patients reported that both airway clearance interventions were tolerable and acceptable with no adverse side effects reported. Conclusions: Airway clearance becomes more difficult as bronchiectasis disease progresses. This study provides preliminary data using ACBT with NIV compared to ACBT alone for airway clearance in patients with bronchiectasis and moderate to severe disease who have difficulty clearing sputum.***

## Introduction

Bronchiectasis, not caused by cystic fibrosis (CF), is a disease characterised by excessive sputum and recurrent chest infections due to impaired mucociliary transport. In the UK 30,000 to 60,000 people have bronchiectasis and present with an average of two pulmonary exacerbations per year (Hill et al 2011). Individualised physiotherapy airway clearance techniques are strongly recommended for patients who present with chronic cough and/or evidence of mucus plugging on computerised tomography scan (Chang et al 2010; BTS/ACPRC 2009; Pasteur et al 2010). The active cycle of breathing techniques, (ACBT) i.e. a cycle of breathing control, thoracic expansion exercises and the forced expiration technique, is considered an effective standard airway clearance technique for individuals with non-CF bronchiectasis (BTS/ACPRC 2009). It is important to explore the efficacy of airway clearance to ensure that only effective treatments are adopted into clinical practice (De Souza et al 2013; Main 2013).

During pulmonary exacerbations, an increase in the volume and purulence of sputum, worsening dyspnoea and cough occur, increasing energy expenditure thereby promoting respiratory muscle fatigue and further worsening dyspnoea (Holland et al 2003). As the disease progresses, patients may find Non Invasive Ventilation (NIV) a useful adjunct to incorporate into their standard physiotherapy airway clearance management (BTS/ACPRC 2009; Pasteur et al 2010). The physiological rationale is that NIV acts as an external respiratory muscle preserving performance. This maintenance or improvement in respiratory muscle strength may beneficially influence other physiological parameters associated with airway clearance resulting in an increase in alveolar ventilation, increased expiratory flow rates, prevention of airway closure during expiration, unloading of respiratory muscles, thereby reducing the work of breathing (Granton and Kesten 1998; Holland et al 2003; Fauroux 2010). There is no evidence to support the use of NIV for airway clearance in bronchiectasis however there is evidence of its role in Cystic Fibrosis (CF) (Granton and Kesten 1998; Holland et al 2003;

Fauroux et al 1999; Fauroux 2010; Moran et al 2012).

Agreement is required for the validated clinical endpoints that should be used in bronchiectasis management (Smith and Hill 2012). Respiratory muscle strength was chosen as the primary outcome measure based on extrapolation of evidence from the CF population and evidence of its clinometric properties in bronchiectasis (Holland et al 2003; Moran et al 2010; Moran et al 2012). We included a range of other outcome measures in order to fully explore the efficacy (spirometry; patient reported outcomes) and potential mechanisms of action (sputum weight and rheology; respiratory inductive plethesmography) underlying NIV for airway clearance.

The primary aim of this study was to assess the impact of airway clearance on respiratory muscle strength, using ACBT + NIV versus ACBT alone, in people with moderate to severe bronchiectasis who had difficulty expectorating sputum, during a pulmonary exacerbation requiring intravenous antibiotics. The secondary aims were to provide information on the appropriateness, feasibility and safety of this study design and outcome measures.

## Methods

This randomised controlled trial was based at a University Teaching Hospital and, after 48 hours of IV antibiotics in hospital, if patients were discharged home to complete the prescribed 10 to 14 day course of IV antibiotics, then they continued physiotherapy assisted airway clearance treatment in their own home. The study was approved by the University of Ulster Research Ethics Committee and the Office of Research Ethics Committee for Northern Ireland (ORECNI Project reference number: 02/75) and written informed consent was obtained from each participant. This study was registered with ClinicalTrials.gov: NCT00522314.

Patients were assessed for inclusion if they were: diagnosed with bronchiectasis by high resolution computerised tomography; had moderate to severe bronchiectasis {i.e. $FEV_1$ < 60% predicted}; admitted to the specialist respiratory ward with a pulmonary exacerbation requiring IV antibiotics and presented with 4 out of 12 criteria: change in sputum production; new or increased haemoptysis; increase in coughing; more SOB; feel ill; feel tired or lethargic; fever; recent weight loss; sinus pain or tenderness; change in sinus discharge; drop in $FEV_1$ greater than 10% of previous value; radiographic changes indicative of infection (Fuchs et al 1994). In addition, patients had to report difficulty expectorating sputum and have 2 out of 4 criteria: unable to adopt a postural drainage position to clear secretions; short of breath and tiring easily; unable to complete airway clearance treatment; unable to cough and clear secretions effectively.

Patients were excluded from taking part in the study if they were unwilling to participate; had any condition that would contraindicate the use of NIV: pneumothorax; large bullae or severe haemoptysis; were unable to perform lung function tests or had osteoporosis, which would prevent chest clapping or shaking. Patients were withdrawn within 24 hours of signing consent if they were subsequently diagnosed as having a medical reason unrelated to the study.

Patients were randomly assigned to ACBT+NIV group or ACBT group alone for the course of the IV antibiotics using a computerised random allocation system with treatment allocation concealed in closed opaque envelopes in a locked drawer. Independent researchers performed the outcome measures and were blinded to the intervention.

**Treatment methods:**

All patients were taught to competently perform airway clearance techniques (ACBT+NIV group or ACBT group) by chartered physiotherapists prior to enrolment in the study. Use of bronchodilators was standardised with respect to timing and dosage. If a

participant used supplemental oxygen when breathing spontaneously at rest, then this was administered via nasal cannula, during and after airway clearance treatment interventions, irrespective of group.

ACBT + NIV group

Patients performed up to a thirty-minute session of ACBT+NIV assisted by a physiotherapist, with individualised postural drainage twice daily for the duration of IV antibiotics. ACBT+NIV was administered using a bi-level pressure support device (NIPPY3: B &D Electromedical, England) and latex free 22mm mouthpiece (Intersurgical, England). Nose clips were worn during treatment and a disposable bacterial filter in the circuit prevented cross infection (Armstrong Medical, Ireland). Supplemental oxygen, if required, was entrained through a 'T' connection. The mouthpiece was removed during the forced expiration technique and for expectoration. Inspiratory pressure (IPAP) was set at 12cm$H_2O$ and expiratory pressure (EPAP) was set at 4cm$H_2O$ for breathing control periods. During the four thoracic expansion exercises with manual chest clapping and shaking, the IPAP was raised to 16-20cm$H_2O$.

ACBT group

Patients performed up to a thirty-minute session of ACBT assisted by a physiotherapist twice daily, in all but two patients who performed treatment once daily as per their normal routine, for the duration of IV antibiotics. Treatment included individualised postural drainage position(s). The components of ACBT were: Breathing Control (BC); four thoracic expansion exercises (TEE) or approximately one minute with manual chest clapping and shaking; Forced Expiration Technique (FET) i.e. one or two huffs performed from mid to low lung volume combined with BC and cough (Pryor et al 2008).

**Outcome measures:**

Outcome measures were recorded by one of two independent blinded assessors at various time points (Table 1).

## Table 1 - Timing of outcome measurements

| Outcome Measure | Start of IV antibiotics | Middle of IV antibiotics | End of IV antibiotics | Daily |
|---|---|---|---|---|
| Respiratory mouth pressures | ✓ | ✓ | ✓ | |
| Spirometry | ✓ | ✓ | ✓ | |
| Bloods (WCC and CRP) | ✓ | ✓ | ✓ | |
| Sputum dry weight (day 1 and final day treatment) | ✓ | | ✓ | |
| Sputum rheology (half hour after day 1 and final day treatment) | ✓ | | ✓ | |
| Arterial / Ear lobe blood gas | ✓ | | ✓ | |
| Lifeshirt (Respiratory Inductive Plethysmography) | ✓ | | ✓ | |
| Sputum wet weight (treatment; half hour post treatment; 24 hours) | | | | ✓ |
| Oximetry ($SpO_2$) (pre and post treatment) | | | | ✓ |
| Borg CR10 scale & 15 count breathlessness scores (before and after treatment) | | | | ✓ |
| Participant tiredness (before and after treatment) | | | | ✓ |
| Participant ease of treatment | | | | ✓ |
| Physiotherapist perception of Borg (before and after treatment) | | | | ✓ |
| Physiotherapist perception of benefit of treatment | | | | ✓ |
| Physiotherapist time spent performing intervention | | | | ✓ |

NB: Two participants on continuous oxygen had gases taken with oxygen in situ

Primary Outcome Measure

Respiratory muscle strength was recorded according to the American Thoracic Society (ATS) /European Respiratory Society (ERS) standards before the first and last airway clearance treatment with IV antibiotics (ATS/ ERS 2002).

Maximum inspiratory mouth pressure ($P_I$max) was measured from residual volume after maximal expiration, maximum expiratory mouth pressure ($P_E$max) was measured from total lung capacity after a maximal inspiration, using a handheld mouth pressure meter (Micro Medical Ltd UK). There was one minute of rest between each manoeuvre.

Secondary Outcome Measures

Spirometry ($FEV_1$ and FVC using Microlab 3500) was measured and conducted according to the ERS guidelines at the start of treatment on both day 1 and final day of IV antibiotics (Quanjer et al 1993). Pulse oximetry (Ohmeda 3775) recorded oxygen saturation and heart rate immediately before and after each treatment.

Patient reported outcomes were recorded by both the participant and the physiotherapist immediately before and after every airway clearance treatment: Borg CR10 scale of

rated perceived breathlessness (Borg 1998); 15 count breathlessness score (Williams et al 2006); Likert scale of perception of ease of treatment, tiredness and benefit of treatment. The physiotherapist counted and recorded the number of coughs per treatment.

Sputum was collected in pre-weighed containers daily during treatment, for half hour after treatment and for the remaining 24 hours and wet weight was calculated (Metter J Balance,Meter-Toledo, Switzerland). Sputum collected during the first and final day of IV antibiotic treatment underwent slow gentle drying in an oven at $65^0$C (Heraus Kendro Laboratory Products, Germany), and reweighed until weight loss had diminished and stabilised. Sputum collected in the half hour after treatment on day 1 and final day of IV antibiotics underwent rheological analysis i.e. viscoelasticity (Log G*) (King 2005).

The Vivometrics LifeShirt® System is Respiratory Inductive Plethysmography [LifeShirt, Vivometrics, Ventura, CA], which monitors breathing patterns by using respiratory bands which pass a continuous, low voltage electrical current through externally placed wires that surround the patient's rib cage and abdomen. This inductive plethysmography reduces the signal interference and distortion often associated with other technologies, resulting in a more accurate measurement of the patient's respiratory function. It established respiratory changes during airway clearance treatment: ventilation and breathing rate during breathing control and thoracic expansion breathing pattern, heart rate during the first and last airway clearance treatment with IV antibiotics (Clarenbach et al 2005) reflecting the physiological impact of the airway clearance interventions in this study. Breath by breath analysis, at the Vivometrics data centre and by the researcher, provided synchronous data streams for interpretation of the participants breathing pattern during two independently annotated cycles of Breathing Control and Thoracic Expansion at the start and end of treatment on both day 1 and final day of IV antibiotics.

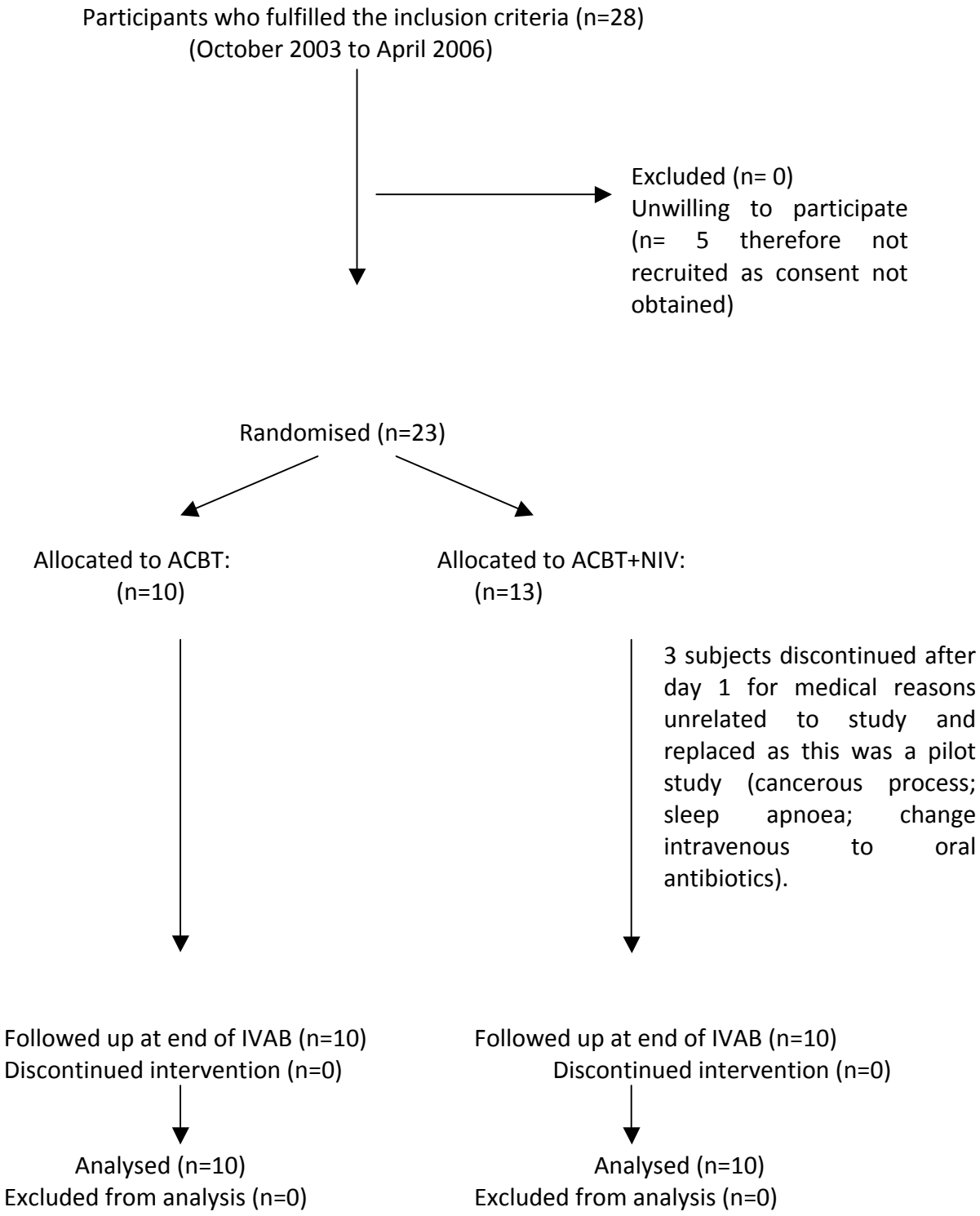
## Statistical Analysis:

As this was a pilot study only data for participants who completed the study was analysed in the Statistical Package for the Social Sciences (SPSS: version 14, Chicago, Illinois). No attempt was made to replace missing data. A formal sample size calculation was not performed (Norman et al 2012) however the selected sample size is similar to that from historical data from another randomised controlled airway clearance study that recruited 26 patients (Holland et al 2003). Exploratory data analysis showed that all continuous data were normally distributed so outcome measures were analysed using independent t test; Pearson's r was used for correlation of sputum wet/dry weight and rheology; Mann Whitney tests for outcome measures using Likert scales; a mixed effects analysis of variance (ANOVA) for respiratory inductive plethysmography measurements. Two sided significance tests were used throughout. A p value $< 0.05$ was considered to be statistically significant. ANOVA analysis that demonstrated statistical between group significance had a profile plot compiled to identify any interaction or pattern in the mean differences between the groups.

## Results

In this pilot study 28 patients fulfilled the inclusion criteria over a period of 31 months (October 2003 to April 2006), following admission to the specialist respiratory ward with an exacerbation, difficulty expectorating sputum and moderate to severe bronchiectasis. Five patients declined to participate for personal reasons, 3 patients withdrew due to non-study related medical conditions and were not included in the analysis, therefore 20 patients completed the study (Figure 1).

**Figure 1: CONSORT Participants flow chart**



Nine patients required oral antibiotics prior to IV antibiotics and 17 patients required bronchodilator medication. Seven people were prescribed oxygen via nasal cannula (20 hour/day) and this was used before, during and after airway clearance treatment; three in the ACBT+NIV group and four in the ACBT group. All patients spent a minimum of 48 hours in hospital when IV antibiotics were first administered and then continued treatment at home if the community nurse and physiotherapy support was available. Four people completed their IV antibiotic treatment at home receiving similar interventions from the medical teams regardless of environment: 2 patients in the ACBT+NIV group had three days of IV antibiotics and physiotherapy assisted intervention at home; two participants in the ACBT group had seven days of IV antibiotics and physiotherapy assisted intervention at home. Fifteen patients had a 10-14 day course of IV antibiotics while 2 patients (1 from each group) received 8 days and 3 patients (all in ACBT group) received an 18-21 day course.

There were no statistically significant differences between groups in demographic data or clinical characteristics (Table 2). Adherence to treatment was 100%.

## Table 2 - Demographic data of study participants at baseline prior to commencement of IV antibiotics (Mean (SD))

| | ACBT + NIV group (n=10) Mean (SD) | ACBT group (n=10) Mean (SD) | P Value |
|---|---|---|---|
| Gender: Male(M) / Female (F) | 5M / 5F | 6M / 4F | |
| Age (years) | 61.3 (13.6) | 61.6 (9.2) | 0.96 |
| $FEV_1$ (L) | 1.01 (0.33) | 0.98 (0.44) | 0.69 |
| $FEV_1$ (% predicted) | 39.4 (11.75) | 36.10 (10.41) | 0.52 |
| FVC (L) | 1.89 (0.54) | 2.30 (1.04) | 0.29 |
| FVC (% predicted) | 57.20 (14.92) | 67.50 (16.43) | 0.16 |
| Highest $P_I$max ($cmH_20$) | 56 (30) | 67 (29) (n=8) | 0.46 |
| Highest $P_E$max ($cmH_2O$) | 73 (31) | 90 (33) (n=8) | 0.28 |
| WCC mmol/L | 8.8 (2.6) | 10.4 (3.3) | 0.22 |
| CRP mg/L | 30 (49) | 52 (66) | 0.39 |
| pH | 7.42 (0.05) | 7.44 (0.06) | 0.47 |
| $PaO_2$ (kPa) | 9.02 (1.7) | 9.57 (2.5) | 0.57 |
| $PaCO_2$ (kPa) | 5.21 (0.7) | 4.96 (0.8) | 0.45 |
| $SpO_2$ (%) | 93 (4) | 89 (7) | 0.43 |
| Number of airway clearance sessions daily prior to and during study | Twice daily (am and pm) n=10 | Twice daily n=8; once daily (pm only) n=2 | |
| Normal time spent doing ACT prior to study commencing | 18(9) minutes | 15(4) minutes | 0.33 |

For the primary outcome there was a significant increase in mean difference of inspiratory muscle strength ($P_I$max) using ACBT+NIV for airway clearance compared to ACBT from day 1 to final day: 16.7 (95% CI 4.5 to 29) $cmH_2O$, p = 0.01 (Table 3, Figure 2a & 2b) though the confidence interval was large. Using this P max data the current study was powered at 72%, assuming a two-sided 5% level test.

## Table 3 - Mean differences for ACBT=NIV group vs ACBT group from day 1 to final day

| | NIV+ACBT (n=10) | ACBT (n=10) | Mean difference between groups |
|---|---|---|---|
| $P_I$max ($cmH_2O$) Day 1 | 56.10 | 66.63 (n=8) | -10.53 (-39.76 to 18.71) |
| $P_I$max ($cmH_2O$) Final Day | 72.20 | 66.00 (n=8) | 6.20 (-24.02 to 36.42) |
| $P_I$max ($cmH_2O$) Mean difference between days | -16.1 | 0.63 | 16.73 (4.5 to 28.95)* |
| | | | |
| $SpO_2$ % Day 1 immediately after treatment | 94.90 | 94.40 | 0.5 (-1.18 to 2.18) |
| $SpO_2$ % Final Day immediately after treatment | 94.30 | 95.20 | -0.9 (-3.26 to 1.46) |
| $SpO_2$ % mean difference between days | 0.60 | -0.80 | -1.40 (02.73 to -0.07)** |

P=0.01* P=0.04**

Two participants in the ACBT group were unable to have respiratory muscle strength measurements taken at both the start and end of IVAB as the Micro Medical machine was unavailable. They were included for analysis for all other OCM.

*Positive mean difference value indicates an increase in NIV+ACBT verses ACBT from day 1 to final day. Negative mean difference value indicates a decrease for NIV+ACBT verses ACBT from day 1 to final day.*

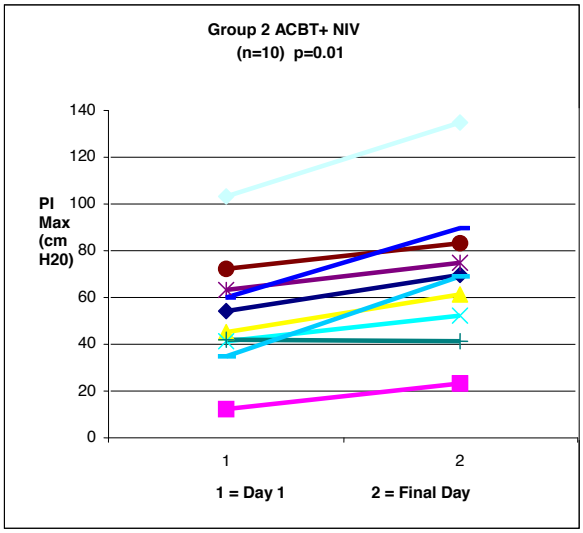



**Figure 2 a:** $P_I$max: ACBT+ NIV, Day 1 and Final Day

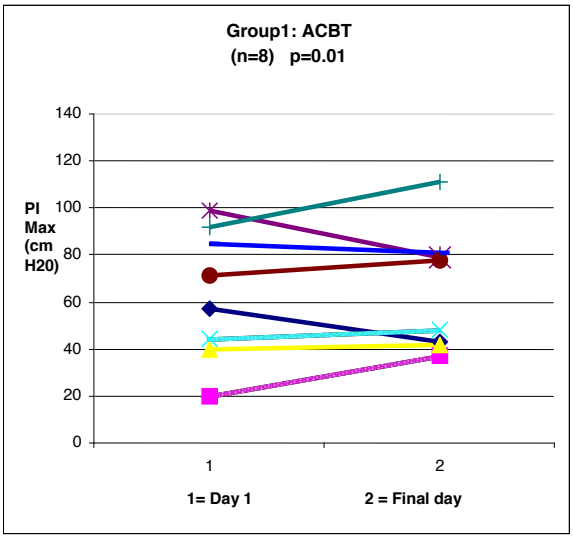



**Figure 2 b:** $P_I$max: ACBT, Day 1 and Final Day

All patients in both groups had $SpO_2$ >94% at baseline (although some patients required oxygen via nasal cannula to achieve this $SpO_2$). There was a statistically significant decrease in pulse oximetry $SpO_2$ immediately after treatment using ACBT+NIV for airway clearance compared to ACBT from day 1 to final day: -1.4 (95% CI -2.73 to -0.07) %, p = 0.04 (Table 3). The actual difference between groups was <1% and is not considered clinically important.

Respiratory inductive plethysmography provided data during the components of airway clearance treatment. Less effort was required initially to generate breathing in ACBT+NIV group however the increase in size of breath was not maintained throughout the course of IV antibiotics. The spontaneous breathing pattern using ACBT alone was more laboured in the early stages however the increase in the size of the breath generated during thoracic expansion increased over time throughout the course of IV antibiotics.

There were no between group treatment induced mean differences and no trend towards significance for any of the other secondary outcome measures i.e respiratory inductive plethysmography, duration of IV antibiotics, spirometry, expiratory respiratory muscle strength, sputum wet or dry weight or rheology, breathlessness (Table 4).

There were no significant differences in patient reported outcome measures (Table 5).

## Table 4 - Non significant between group mean differences for ACBT+NIV vs ASBT, day 1 to final day

| | Mean difference between groups (95% CI) | P value |
|---|---|---|
| Lifeshirt Vent (L) during Breathing Control | 1.22 (-3.10 to 5.56) | 0.63 |
| Lifeshirt Br/M (bpm) during Breathing Control | -0.29 (-4.68 to 4.10) | 0.87 |
| Lifeshirt HR (bpm) during Breathing Control | -1.40 (-16.05 to 13.23) | 0.72 |
| Lifeshirt Vent (L) during Thoracic Expansion | 2.93 (-2.69 to 8.55) | 0.29 |
| Lifeshirt Br/M (bpm) during Thoracic Expansion | 0.18 (-4.04 to 4.40) | 0.94 |
| Lifeshirt HR (bpm) during Thoracic Expansion | -0.40 (-13.94 to 13.14) | 0.92 |
| IVAB (days) | 0.4 (3.5 to -2.7) | 0.8 |
| $FEV_1\%_{predicted}$ | -1.3 (-8.5 to 5.9) | 0.7 |
| $FEF_{25-75\% predicted}$ | -1.7 (-5.7 to 2.4) | 0.4 |
| PEmax ($cmH_2O$) | 10 (-12 to 33) | 0.3 |
| Wet weight sputum (g) | -5.6 (-22.5 to 11.3) | 0.5 |
| Dry weight sputum (g) | -0.6 (-1.1 to 0.02) | 0.1 |
| 24 hour wet weight sputum (g) | -5.0 (-22.3 to 12.5) | 0.6 |
| Duration of treatment (mins) | -1.7 (-9.7 to 6.3) | 0.6 |
| Post treatment Borg (participant perspective) | -1.6 (-3.4 to 0.1) | 0.1 |
| Cough frequency | -0.2 (-6.1 to 5.7) | 0.9 |
| Post treatment Borg (physiotherapist perspective) | -0.4 (-2.6 to 1.8) | 0.7 |
| Viscoelasticity (G*) (n=8) | -0.05 (-0.02 to 0.12) | 0.5 |

## Table 5 - Between group differences for ACBT+NIV vs ACBT, at day 1 and at final day for Patient Reported Outcome Measures using the Likert Scale

| Non parametric outcome measures | Median difference | Interquartile Range (25-75%) | P value |
|---|---|---|---|
| Day 1 ease of treatment | 3 | 2-3 | 0.6 |
| Final day ease of treatment | 2 | 2-3 | 0.4 |
| Day 1 post treatment tiredness | 3 | 2-4.5 | 0.1 |
| Final day post treatment tiredness | 2.5 | 1-4 | 0.2 |
| Day 1 benefit of treatment (physiotherapist perception) | 4 | 4-5 | 0.6 |
| Final day benefit of treatment (physiotherapist perception) | 4.5 | 3-5 | 0.9 |

Nonparametric statistics i.e.
Ease of treatment: 1 = extremely easy; 5 = not at all easy / Tiredness: 1 = not at all tired; 5 = very, very tired
Benefit of treatment: 1 = not at all beneficial; 5 = very, very beneficial

The secondary aims of this study were to provide information on the appropriateness, feasibility and safety of the study design. The overall design of the intervention was safe and appropriate with no adverse events reported. Although a feasible study design, the choice of primary outcome measure and the number of sites required to conduct a powered study needs consideration.

## Discussion

This study demonstrated that airway clearance using ACBT+NIV compared to ACBT alone, during a course of IV antibiotic treatment for moderate to severe bronchiectasis, potentially results in some improvement in inspiratory muscle strength. However the sample size for this study is small and the study was not powered to establish a difference in other established clinical endpoints. Using a different primary outcome measure i.e. a direct physiological measure of the effectiveness of airway clearance, rather than a surrogate outcome measure with an inferred indirect association to airway clearance, may prove beneficial in determining the selective applicability of NIV as an adjunct to airway clearance techniques. There is no clear guidance on the minimum clinically important difference for inspiratory muscle strength but improvements were similar to the findings of single intervention studies in the CF population (Fauroux et al 1999; Holland et al 2003).

This study has provided important information about the design of the intervention and the evaluation which could inform a full-scale appraisal of the use of NIV within an airway clearance trial (MRC 2008). Although this was a realistic study design it proved difficult to recruit the required patient numbers in a realistic timeframe, highlighting the need for a full-scale evaluation to be multicentre.

It has been suggested that positive pressure could impact and propel excess sputum further into the tracheobronchial tree causing blockage of small airways and airway plugging (Elkins et al 2005). This undesirable effect was not observed in the current study and there were no adverse events reported by any patient in the hospital or home environment. Regardless of the airway clearance treatment undertaken neither regime caused a detrimental clinical effect on oxygenation.

This study provides information on outcome measures useful in understanding the mechanisms of action of airway clearance. It could be inferred that improved inspiratory muscle strength may indirectly influence measures of sputum volume and rheology (Rubin 2007). Reducing the viscoelasticity of sputum is important to enable greater interaction between mucus and the ciliary system thereby facilitating cough and mucociliary clearance mechanisms (King 1987; King 2005; Ntoumenopoulos 2007). Rheology measurement is feasible and may be a worthwhile outcome measure for future research trials if specialist equipment is readily available to undertake this analysis.

In managing a respiratory exacerbation clinical questioning includes establishing patient reported outcome measures and these were appropriate and easy to collect (Pasteur et al 2010; Main 2013). An increase in inspiratory muscle strength may indirectly influence measures of dyspnoea (Rubin 2007).

Respiratory inductive plethysmography is a valid, reliable and dynamic respiratory tool providing an accurate analyse of respiratory waveforms with additional visual information of the mechanics of breathing and airflow during components of airway clearance treatment (Grossman et al 2006). The data generated is extensive however as a research tool it may provide novel information that could be explored further to optimise NIV pressure settings to establish whether this influences dynamic respiratory flow.

Current clinical practice has embraced the use of positive pressure at higher levels (Phua et al 2010). Future studies need to consider the

impact of using higher levels of inspiratory support, especially in those patients with significant airflow limitation, along with the introduction of humidification into the circuit.

## Limitations of study

The daily frequency and duration of the intervention was informed by patients usual care (i.e. once versus twice daily and up to 30 minutes) however these could have been confounding variables and therefore future studies should standardise the frequency and duration of daily interventions between groups. Future studies should carefully consider the choice of primary outcome however there is no consensus on what the best clinical endpoint is for airway clearance trials. Patient preference and adherence are important considerations when choosing the optimal airway clearance technique (Flude et al 2012; McCullough et al 2013).

### Implications for clinical and research practice

This study has added knowledge to existing level D evidence based guidelines establishing that ACBT+NIV should not be used routinely for airway clearance (BTS 2002; Pasteur et al 2010). We have demonstrated limited benefit of NIV in improving inspiratory muscle strength during airway clearance in a specific sub group of individuals however this did not translate into other clinically important improvements. This pilot study provides information that will inform future research in this area. Future research should focus on those already using NIV to manage respiratory failure, those with lower inspiratory muscle strength, greater degrees of hyperinflation, more severe baseline gas abnormalities e.g. more hypercapnic or higher breathlessness scores at baseline than in this current study. Further studies should consider recruitment of these subgroup populations. Additional exploration of impact on quality of life, exercise tolerance, frequency of IV antibiotics and hospital readmission should be investigated in future long-term clinical studies to ensure cost effective therapeutic strategies are implemented.

## Conclusion

This study provides a rationale for further exploration of the role of NIV during airway clearance in sub groups of patients who have difficulty expectorating and are not responding to standard airway clearance techniques. Airway clearance with NIV was safe and well tolerated in this bronchiectasis patient group over a course of IV antibiotics. This pilot study provides information that would inform the design and conduct of a multicentre study to examine the efficacy of ACBT + NIV compared to other airway clearance techniques.

## Key points

- ACBT+NIV showed some improvement in respiratory muscle strength and maintains $SpO_2$ compared to ACBT alone, in patients with moderate to severe bronchiectasis disease, prescribed IV antibiotics during a pulmonary exacerbation.
- The unloading of the respiratory muscles did not translate into improvements in other direct physiological outcome measures. There is a need to establish the best clinical endpoint for airway clearance trials.
- Using NIV as an adjunct for airway clearance is safe and well tolerated.

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# Adherence to treatment in bronchiectasis: a challenge that physiotherapists can't ignore


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## Summary

***The purpose of this article is to highlight the importance for physiotherapists of patient adherence to treatment in bronchiectasis. This review provides evidence that adherence is important in bronchiectasis as it is low and affects health outcomes. We also show that there are a number of potentially modifiable factors that affect adherence that could be targeted through adherence interventions. The most effective methods of measuring adherence or interventions to enhance adherence are not known for bronchiectasis. Therefore, future research should focus on developing accurate and simple methods of adherence measurement for bronchiectasis that could be used in clinical practice, as well as, developing interventions to enhance adherence that are theoretically derived and able to be implemented as part of routine clinical practice.***


## Introduction

Patients with bronchiectasis are prescribed a complex treatment regimen that can include airway clearance techniques (ACTs) and inhaled, nebulised and oral medication. The British Thoracic Society (BTS) guidelines for non-cystic fibrosis (CF) bronchiectasis recommend that patients with bronchiectasis and a productive cough should be taught an ACT for routine use and those with a non-productive cough should be taught an ACT for use during an exacerbation (Pasteur et al 2010). Medications such as oral and inhaled antibiotics, hypertonic saline and β2 agonists are also recommended for use in this population (Pasteur et al 2010), despite there being no licensed medications for

this condition. Inhaled corticosteroids are not recommended for use (Pasteur et al 2010) but approximately 80% of patients are prescribed this treatment (Hill et al 2012). Evidence for the efficacy of these recommended treatment interventions is lacking and recommendations are mostly based on data from other conditions and low quality data in bronchiectasis. ACTs are considered a 'cornerstone of therapy' (De Soyza et al 2012) but evidence of long-term effectiveness of this treatment is not available. A recent review of studies on ACTs concluded that ACTs were safe in patients with bronchiectasis but that the low quality of the five included studies meant that definite conclusions about long-term effectiveness could not be drawn (Lee et al 2013). The superiority of one ACT over another is unclear, but there appears to be a patient preference for oscillating devices compared to active cycle of breathing technique (ACBT) (with and without postural drainage) (Eaton et al 2007; Patterson et al 2005) and this may be due to the potentially reduced burden of treatment associated with the use of these adjuncts.

Determining the most effective management strategies in bronchiectasis is a key research priority for this patient population (De Soyza et al 2012). The interest in development of new medical therapies for bronchiectasis is growing and studies exploring new treatments have been recently published (Altenburg et al 2013; Bilton et al 2013; Haworth et al 2014; Serisier et al 2013; Wilson et al 2013), indicating that new medical therapies could be on the horizon for this population. To ensure that potential benefits of new and existing treatments are gained, we need to have an understanding of adherence to treatment.

At present, there are no high quality data on adherence to treatment in bronchiectasis. However, we know that approximately 50% of patients are adherent to treatments for CF, asthma and chronic obstructive pulmonary disease (COPD) (Eakin et al 2011; Gamble et al 2009; Krigsman et al 2007). Adherence rates for ACTs can often be the lowest of any prescribed treatment in CF and this may be due to the high burden of this treatment (George et al 2010). It has been shown that the prescription of two of more nebulised therapies and ACT of greater than 30 minutes is associated with higher treatment burden in CF (Sawicki et al 2009). In bronchiectasis, a treatment regimen may involve pre-treatment with an inhaled or nebulised bronchodilator and/or nebulised hypertonic saline, and/or an ACT and/or nebulised therapies such as, inhaled antibiotics and/or inhalers. This regimen including preparation and cleaning of equipment is time-consuming, taking a minimum of 45 minutes which may have to be repeated twice daily and thus, may make adherence to these treatments difficult. Low adherence is known to be linked with poorer health outcomes for patients with CF (Quittner et al 2014), COPD (van Boven et al 2014) and asthma (Gamble et al 2009) and can be influenced by a number of factors including the burden of treatment (George et al 2010) and beliefs about the need for treatment (Bucks et al 2009). The purpose of this review article was to highlight the importance for physiotherapists of patient adherence to treatment in bronchiectasis. Specifically this review explored if adherence is important in bronchiectasis, how to measure adherence, what the predictors of adherence are, how adherence can be improved and what future research is needed. The clinical implications and current challenges facing clinicians when managing adherence are also addressed.

## Why is adherence important in bronchiectasis?

A search on Medline using the search terms 'bronchiectasis' and 'adherence' demonstrates that there are two published studies that measure adherence to inhaled antibiotics in bronchiectasis (Gulini et al 2012; McCullough et al 2014a). Gulini et al (2012) reported that 73% of the 22 included patients were adherent to inhaled antibiotics. However, the study was very small and only explored adherence to one treatment type. We recently

completed a large, high quality study in which we monitored patients' adherence to airway clearance, inhaled antibiotics and other respiratory medicines for bronchiectasis for one year (McCullough et al 2014a). We found that only 41% were adherent to ACT, 53% were adherent to inhaled antibiotics, 53% were adherent to other respiratory medicines (i.e. oral, nebulised and inhaled therapies) over the course of a year and that only 16% of patients were adherent to all prescribed treatments (McCullough et al 2014a). Adherence to ACTs was measured using self-report, which is known to over-estimate adherence (Quittner et al 2008; Horne & Weinman 2002) and therefore, even fewer patients are likely to be adherent than reported.

Low adherence is known to be linked to poorer health outcomes in other respiratory disease populations (Quittner et al 2014; van Boven et al 2014). Our recent data show that adherence to ACT is associated with better Physical Functioning as measured by the Quality of Life Questionnaire-Bronchiectasis (QOL-B) (McCullough et al 2013; Quittner et al 2014). Therefore, adherence to ACT may be important in maintaining patients' level of physical functioning. Furthermore, those who were adherent to inhaled antibiotics had nearly half as many pulmonary exacerbations annually compared to non-adherers (McCullough et al 2014a). There was no effect of adherence on pulmonary function (McCullough et al 2014a).

**Clinical implications**

Adherence monitoring is not part of routine care for patients with bronchiectasis. However, the low level of adherence demonstrated and the negative impacts of non-adherence on health outcomes in this patient population indicate that there is an urgent need for adherence to treatment to be a priority during clinical interactions with patients with bronchiectasis as it could be low adherence, rather than treatment failure, that could be leading to disease progression. By not considering adherence fully in our interactions with patients, we may prescribe increasingly escalating therapies which may lead to a greater burden of treatment, more non-adherence and worse outcomes for patients. Clinicians need to understand how to measure adherence, be aware of who is at risk of non-adherence and how to enhance adherence in this population.

## How do we measure adherence in bronchiectasis?

There is presently no 'gold standard' measure of treatment adherence (Hughes 2004) and no detail in the literature on what can be used to measure adherence in bronchiectasis. Patient self-report is commonly used to measure adherence in clinical practice usually via questions such as 'are there any problems with your treatment?' However, this type of questioning is not likely to elicit a true representation of patients' adherence to treatment. Our data shows that more patients self-reported adherence to inhaled antibiotics and other respiratory medicines compared to a more objective measure of adherence (McCullough et al 2014a). These data support findings in CF, in which, self-reported adherence elicited via questions such as the one above or via a validated self-report questionnaire are consistently shown to over-estimate adherence due to patients feeling 'social pressure' to please their healthcare professional (Daniels et al 2011; Quittner et al 2008; Horne & Weinman 2002).

The ideal measure to monitor adherence would be accurate, allow the calculation of adherence on a continuous scale and in real time without its presence altering adherence behaviour. Electronic monitoring of adherence to airway clearance, nebulisers or inhalers using chipped Acapella® devices, inhalers and nebulisers appears to be the ideal measure. New technologies are being developed and existing technology is evolving quickly to allow detailed monitoring of adherence. There are currently no chipped Acapella® devices on the market for use in research or clinical practice but this

is likely to be an area for future development. I-neb® nebuliser devices measure the amount of medication inhaled each time the device is used and can give long-term adherence data which can be downloaded directly by the clinician. These devices are currently used in CF for the inhalation of colistin and are able to accurately measure adherence to treatment for these patients in routine clinical practice (Daniels et al 2011). However, the lack of evidence for and current cost of this device preclude its use in most bronchiectasis services. Sophisticated inhaler devices are in development which monitor adherence to inhaler technique as well as the frequency of medication usage (Costello & Reilly 2013) but are not yet available in clinical practice.

Medication possession ratios (MPR) offer a potential solution for adherence monitoring for medication that balances objectivity with ease of use in clinical practice. MPRs are calculated using data that is already available through patients' general practitioners (GP) or pharmacists. The calculation is completed by totalling up the amount of medication that a patient was dispensed (either from their GP or pharmacy) over a period of time divided by the amount that should have been collected over that time period and multiplying it by 100 to give a percentage rate (Hess et al 2006). This approach does not prove ingestion or inhalation of medication (Osterberg & Blaschke 2005) but it does provide a maximum level of adherence that patients could achieve based on how much they had collected. These data are already being collected as part of routine care, meaning that this approach could be used to monitor adherence to medication in bronchiectasis. We have used this method to calculate adherence to inhaled antibiotics and other respiratory medicines in bronchiectasis (McCullough et al 2014a) and although completed as part of a research project, it would be a feasible and useful method for routine clinical practice.

**Clinical implications**

Self-reported adherence using traditional clinical questioning skills is likely to lead to an under-estimation of the non-adherence problem for these patients. This could have subsequent effects on treatment burden and adherence due to escalating treatments as described above. Thus, there is a need for clinicians to be able to question patients about their adherence in a way that allows patients to be honest about their adherence and it may be better for clinicians to ask patients about their views on treatment and barriers to adherence rather than specifically ask about the level of adherence. Given the effect of adherence on health outcomes we have reported, monitoring of clinical end-points such as frequency of pulmonary exacerbations along with MPR could be used by clinicians to identify issues with adherence and to instigate a discussion about adherence. Challenging patients about their adherence may have implications for clinical relationships between patients and healthcare professionals if undertaken in a way that is confrontational. Therefore, clinicians may require training on how to question about adherence and work with patients to overcome barriers to adherence.

## What are the predictors of non-adherence?

There is no published data on predictors of non-adherence in bronchiectasis. However, we recently determined that beliefs about treatment were the strongest predictors of adherence to treatment (McCullough et al 2013), with patients who did not believe their ACT was necessary less likely to be adherent. Patients who were concerned about the side-effects or long-term effects of medicines were less likely to be adherent to those treatments. These data were supported in a study in which we asked patients about what affected their decisions about adherence in bronchiectasis (McCullough et al 2014b). In both studies, beliefs about treatment were consistent

factors affecting adherence (McCullough et al 2013; McCullough et al 2014b); yet, these are not something that are routinely explored in clinical interactions. To be able to assess beliefs about treatment in bronchiectasis, we may need to consider the use of an assessment tool such as the Beliefs about Medicines Questionnaire (Horne et al 1999) prior to and following prescription of treatment, as a lack of perceived necessity or high concerns about a treatment may indicate a risk of non-adherence.

Age is also an independent predictor of adherence in bronchiectasis (McCullough et al 2013) and this finding was potentially explained in the qualitative findings, in which, patients recognised that younger age was associated with more family and work commitments and also, patients tended to have less problematic symptoms (McCullough et al 2014b). Younger patients could therefore be at risk of low adherence, in particular, for treatments that are time-consuming such as airway clearance. This finding may also indicate that different barriers to adherence exist for younger patients, meaning that any strategies to overcome adherence may need to be tailored specifically for these patients.

Treatment burden as measured by the number of prescribed medications predicted adherence to inhaled antibiotics, (McCullough et al 2013) and therefore, may be an indicator of risk of non-adherence to these treatments. Patients prescribed more medications may be more at risk of non-adherence which may provide a rationale for medication review for these patients prior to the prescription of new therapies or as part of a strategy to enhance adherence to existing treatments.

**Clinical implications**

Clinicians can use these predictors along with the measurement of adherence to highlight those patients who might be at risk of non-adherence and thus, who to specifically target to explore their adherence or who may require more frequent monitoring. For example, a young patient who is prescribed many treatments and doesn't believe their airway clearance is necessary is less likely to be adherent compared to an older patient with few treatments and a strong belief about the need for airway clearance. Therefore, clinicians could prioritise the patient who is less likely to adhere to prevent to long-term impact on this patient's health outcomes and escalation of prescribed therapies. This prioritisation of patients will also allow clinicians to target adherence within their existing workload and clinic format.

## How can we improve adherence in bronchiectasis?

There are no bronchiectasis-specific interventions with the primary aim of enhancing adherence. In other chronic respiratory diseases, a multitude of interventions have been tested including education-based interventions, self-management interventions, pharmaceutical care and telemedicine interventions (McCullough et al 2014c). There does not appear to be any consistent effect of any particular type of intervention on adherence and health outcomes in chronic respiratory disease which may reflect a lack of high quality studies, adherence frequently being measured as self-report and also a diverse range of poorly defined, non-theoretically-based interventions being tested (McCullough et al 2014c). However, there is some evidence that interventions that can be tailored to the individual, such as shared decision-making and cognitive behavioural therapy are effective in asthma (Gamble et al 2011; Wilson et al 2010). Clinicians are already using strategies such as feeding back to patients about their lung function to reinforce adherence behaviour, using patient peer support in pulmonary rehabilitation to reinforce positive adherence behaviours, giving patients self-management action plans, using cognitive behavioural therapy and shared decision-making strategies to enhance adherence. Current guidance

states that for behaviour change interventions to be effective, they should be theoretically-based and developed using input from all relevant stakeholders including patients and clinicians (Medical Research Council 2008). Therefore, this would be important to do for bronchiectasis rather than incorporating strategies which may or may not be effective. We have recently explored the barriers and motivators to adherence in bronchiectasis and some of the factors affecting adherence decision-making in bronchiectasis that we have described such as beliefs about treatment, lack of disease knowledge, low self-efficacy and having a good relationship with healthcare professionals are potentially modifiable factors affecting adherence that could be targeted through a bronchiectasis specific intervention (McCullough et al 2014b). These factors affecting adherence could be used to direct the choice of behaviour change techniques that may act directly on these barriers to adherence behaviour and thus, potentially enhance adherence (Michie et al 2011). However, prior to strategies to enhance adherence being recommended for use in clinical practice for bronchiectasis, these should undergo pilot/feasibility testing and be subject to evaluation in a rigorous randomised controlled trial. This will ensure that ineffective and burdensome intervention and strategies are not implemented into clinical practice.

### Clinical implications

Clinicians should identify patients' specific barriers to adherence and use these to choose strategies to enhance adherence to treatment. There is some evidence that individualised strategies which elicit patients' specific barriers to adherence and tailor strategies to this may be useful to enhance adherence (Gamble et al 2011; Wilson et al 2010) and could be used in clinical practice during routine interactions with patients. However, implementation of strategies to enhance adherence may have potential implications for clinician workload and training needs, as some strategies such as shared decision-making can be time-consuming and may require extra training.

## Conclusion

This review provides evidence that adherence is important in bronchiectasis as it is low and affects health outcomes but that there are a number of potentially modifiable factors that affect adherence that could be targeted through adherence interventions (McCullough et al 2013; McCullough et al 2014b; McCullough et al 2014c). However, the most effective methods of measuring adherence or interventions to enhance adherence are not known for bronchiectasis. Patients with bronchiectasis are already burdened with treatments; therefore, implementing ineffective adherence measurement strategies or interventions may further add to this management burden. Therefore, it will be important to implement strategies that are proven to be effective.

## What future research is needed?

Future research should focus on developing accurate and simple methods of adherence measurement for bronchiectasis that could be used in clinical practice, as well as, developing interventions to enhance adherence that are theoretically derived and able to be implemented as part of routine clinical practice. To be able to do this, clinicians need to lobby for research into adherence in bronchiectasis to be prioritised, as in CF (Bradley et al 2012), and for financial investments in this area of research.

## Key points

- Adherence is a huge problem in bronchiectasis which may lead to escalating therapies and greater management burden for patients and clinicians.
- Measurement of adherence is not routine in clinical practice but could be implemented by questioning patients about their beliefs about treatment. Additionally, for inhaled,

nebulised and oral medications existing data collected about dispensed medications could be used.

- Predictors of adherence could be used by clinicians to target those who might be at risk of non-adherence.
- Factors affecting adherence could be used by clinicians to choose strategies to enhance adherence to treatment but the most effective strategies are not currently known.
- Clinicians need to lobby for research into adherence to be prioritised and for financial investment in this research area.

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# Forward Thinking: preparing ourselves and our services for the changing world of healthcare


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## Introduction

The journal editors asked Catherine Thompson, the outgoing Chair of the ACPRC to share her thoughts on the changing NHS and the impact this has on physiotherapists working in respiratory care. Catherine has worked as a clinician, an academic and a national quality improvement lead for respiratory services and is now Head of Patient Experience for Acute Services at NHS England and we would like to share her expertise and experience with physiotherapists across the UK. Since 2010 there have been significant changes in NHS structure and policy in England. Although healthcare is organised differently in Scotland, Northern Ireland and Wales, some of these changes and their implications for physiotherapists will be echoed across the UK.

## Seven Day Services

Bruce Keogh, Medical Director for NHS England announced in July 2014 that seven day services across the NHS was his number one priority; that services should be delivering the same standard of patient care at weekends and bank holidays as during the 'normal' Monday – Friday working week. This will have an impact on service delivery for respiratory physiotherapists whether they work in the community or in an acute hospital setting and means that all patients requiring respiratory physiotherapy care at the weekend should receive it from respiratory specialist physiotherapy staff as they would during the week. In some Trusts this is already happening but for others significant change will be required to meet this level of service delivery.

There are many advantages from seven day services: patients are seen sooner, the most appropriate treatment plan can be initiated more quickly and there is great potential to positively impact on outcomes as seen in places such as Guys and St Thomas's where the introduction of a seven day physiotherapy service in critical care reduced patient length of stay.

Patients will no longer need to have a two day break in their rehabilitation, preventing the deterioration which can sometimes be experienced during Monday's therapy session. Services may not be able to offer seven days of rehabilitation to all patients, and indeed this may not be appropriate or necessary, but avoiding two consecutive days without therapy

is likely to be beneficial. We do not know the impact this will have on outcomes due to a lack of evidence but the collection of audit data pre- and post- service change could easily provide the evidence.

It is our own professional responsibility to collect and report audit and service delivery data from our own practice, and it will become increasingly important in helping us to champion our role as an essential part of service delivery. At ACPRC we would welcome contributions to this journal that covered such aspects of service development and audit.

Despite its clear advantages to the patient, the move to seven day services is not without its challenges. One consequence of seven day services is that there will be no more weekend respiratory working for non-respiratory staff. Many physiotherapy departments still rely on this 'exposure' to keep the non-specialist staff adequately skilled to be able to participate in the on-call rota. The impact this will have on staff's ability to maintain competence for on-call provision at night and how the department addresses this will need careful consideration. The services will have to be developed and evolved to compensate for this, and it will be important to plan ahead to inform the decision making process as it is happening.

## Urgent and Emergency Care Review

Over the next three to five years there will be a programme of whole system change to provide highly responsive, effective and personalised urgent care outside of hospital, so that the vast majority of urgent and emergency care is delivered by primary and community care services.

Hospital-based emergency facilities will be designated as one of two kinds: Emergency Centres and Major Emergency Centres. Emergency Centres will assess and initiate treatment for all patients and safely transfer them when necessary. Major Emergency Centres will be larger units, capable of assessing and starting treatment for all patients as well as providing a range of highly specialist services. There will be around 40 to 70 Major Emergency Centres across England and the overall number of Emergency Centres and Major Emergency Centres will be about equal to the number of current A&E departments.

The Urgent and Emergency Care Review proposals mean that, for a wider range of conditions, patients may be admitted to the hospital that is more appropriate to care for them, rather than the one that is nearest – similar to the model for Stroke care that has been introduced in London.

For physiotherapists, this means there is potential for change in the acuity of the case load which is managed and therefore the skills required in the physiotherapy teams. It could also mean that services currently delivered in an acute hospital will move into the community and therapy staff will need to reflect this in their working patterns, as happens in so many community services already.

## Specialised Commissioning

At the time of writing, the final framework for specialised commissioning is still to be determined and so the impact on respiratory medicine remains uncertain. For some diseases, low incidence means that services cannot be effectively commissioned at a local level, and clinicians need to be seeing an adequate volume of patients to maintain their clinical skills and ensure best patient outcomes. As the proposals for Specialised Services Commissioning are agreed and implemented we will see changes to case mix and case load at a local level i.e. an increase or decrease in particular patient groups.

In future we may need to have a 'virtual network' of peer support between respiratory physiotherapists in specialist centres. This could easily be achieved through iCSP or through the ACPRC champions and the ACPRC's new

website.

It will also be important to ensure effective follow up services for patients leaving specialist centres, such as the availability of pulmonary rehabilitation, which will need to be delivered close to the patient's home rather than by the specialist provider. This already happens, for example following cardio-thoracic surgery however the number of patients and range of conditions that need to be considered will be greater.

## Commissioning for Outcomes

The way services are commissioned has changed significantly over the past few years, with the emphasis now on outcomes. Outcome is about the difference made by the intervention or service, not the numbers treated and might require a change in mind-set. Physiotherapists will need to be able to be able to report outcome measures rather than process measures e.g. the proportion of patients meeting the minimum clinically significant difference for improvement in PR rather than just the number of patients who completed the programme .

Many of our clinical outcome measures do not translate well into commissioning outcome measures, and we will need to think about how we will sell ourselves to the best effect and make sure our benefit and 'value add' is noticed. Over the past couple of years CSP has been working with ACPRC and several other professional networks on exactly this.

## Patient Experience and Patient Safety

The Francis report into the failings at Mid Staffordshire NHS Trust has highlighted poor standards of care which we may have seen to a greater or lesser extent in our own places of work. As physiotherapists we need to consider our own role in improving these aspects of care. The patient experience and patient safety are everyone's joint responsibility and it isn't just about nursing care or nursing staff. It is as much our responsibility as anyone else to attend to call bells, address cleanliness, and challenge others (and ourselves) on hand hygiene, infection control or 'healthcare deviance' (where something happens outside of best practice protocol, even if the intention is well meaning).

In 2012, Jane Cummings launched 'Compassion in Practice' and the 6Cs (care, compassion, competence, communication, courage and commitment) to try and raise the standards of care in all professions, not just nursing. I know this has been integrated into the admission processes for physiotherapists at many Universities, but to be effective, needs to be embedded across all professions. We need to focus on improvement – what can we learn from others and implement into our own practice, how we can share our learning to help spread best practice etc.

# Beyond the Cochrane abstract: what is the role for physiotherapists in adults with pneumonia?


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### Keywords:

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**Adults**


## Introduction

It has been recognised for many years by physiotherapists that there is a paucity of good quality primary research in respiratory care (Bott et al 2009). As an academic, I direct students to ACPRC/BTS and NICE guidelines and systematic reviews e.g. Cochrane reviews to support respiratory interventions. Undergraduate physiotherapy students are taught to critically appraise original research papers but there is less emphasis on appraisal of national guidelines and systematic reviews. When a review is flawed I have to justify to my students why it should be read with care. The recently published Cochrane review on chest physiotherapy in pneumonia (Yang et al 2013) has an abstract and a plain language summary which are worryingly misleading and this commentary will attempt to redress the balance and hopefully generate a debate within the profession as a whole.

## Commentary on Cochrane Review: Chest physiotherapy for pneumonia in adults

Yang et al's (2013) abstract and summary assert that "chest physiotherapy" has no role in the management of pneumonia. This has to be challenged as firstly all types of pneumonia do not present in the same way, secondly it is my view that the review's outcome measures are inappropriate and thirdly that "chest physiotherapy" is not a one size fits all intervention. At this point I must point out that the full text has a more balanced conclusion but why the authors did not write a balanced abstract and summary is a cause for speculation; researcher bias or medico-economic pressures could be reasons.

Yang et al's review (2013) aimed to assess the effect of "chest physiotherapy" on the pathological process of pneumonia in adults. Their search strategy included all forms of pneumonia; hospital and community acquired; viral, bacterial, ventilator acquired pneumonia and aspiration pneumonia. This ignores the fact there are significant differences in the pathology between the various manifestations of pneumonia and their management (Bourke & Burns 2011). These diverse presentations can have some similar clinical features including raised temperature, raised leukocyte levels and changes on chest X-ray. The review makes the assumption that resolution of the pneumonia

is dependent on using techniques to facilitate sputum production and/or increase lung volume. However not all patients with pneumonia present with detrimental sputum production or have a significant enough lung volume loss to cause hypoxaemia. The consolidation process reduces the alveolar-capillary surface area available for gas exchange, but as the collateral ventilation channels will also be affected (Beasley et al 2008), there is little justification for using techniques for increasing lung volume before the resolution stage. Therefore the review's results have to be interpreted with care due to a lack of homogeneity of participant pneumonia disease processes making comparisons challenging.

Yang et al's review (2013) primary outcome measures of mortality and cure rate (undefined) are flawed as both are dependent on many variables that physiotherapy intervention will not affect including the source and type of the pathogen, the effectiveness of antibiotic therapy, the patient age and their co-morbidities (Bourke & Burns 2011). The outcome measures that would be more appropriate include reduction in the perception of breathlessness, increased exercise capacity, increased feeling of wellbeing or more restful sleep.

The term "chest physiotherapy" has continued to be used by those outside the profession to describe a number of techniques historically used in combination to promote airway clearance. The Cochrane review's methodology generated six papers published between 1978 and 2000. Four papers (Graham & Bradley 1975, Britton et al 1985, Tydeman 1989. Borkqvist et al 1997) compare a variety of sputum clearance techniques, two of which also included techniques for increasing lung volume (Britton et al, 1985., Borkqvist et al 1997). A further two papers (Noll et al 1999, Noll et al 2000) compared osteopathy techniques with placebo, techniques that I am not aware are used in the UK in acute respiratory management. The review team do acknowledge that the term "chest physiotherapy" is not a representation of current practice, but the abstract misses this significant point. Far more concerning is the plain language summary which states that chest physiotherapy should not be recommended as a routine additional treatment for pneumonia in adults: taken literally this will put some groups of patients at risk.

So what do I consider is physiotherapist's role in the management of pneumonia in 2014? There is insufficient trial data in the original papers to establish if all the participants would have a CURB-65 severity score of 2 or more (Lim et al 2003). We prepare students to manage increasingly complex patients including those in respiratory failure, who our clinical placement providers report are commonly referred to physiotherapy teams, yet these patients were excluded from some of the trials. In the UK less severe patient episodes are managed by general practitioners (Bourke & Burns 2011). It has been recommended that some patient groups are routinely referred to physiotherapists: those with pneumonia as an exacerbation of chronic respiratory disease (COPD), as a complication of neuromuscular disease (NMD) or if significant detrimental secretions are present (Guessous et al 2003). The methods of treatment will be focused on reversal of respiratory failure, early mobilisation and function rather than sputum clearance (Bott et al 2009)

Pneumonia accounts for 20% of the cost of emergency ambulatory case sensitive admissions to NHS hospitals (Tian et al 2012). Physiotherapy is an expensive resource and health service managers are increasingly looking at the body of evidence to decide on where the priorities should be directed. I hope this commentary will make individual physiotherapy teams aware of the potential risk to vulnerable patients and their service from Yang et al's (2013) abstract and summary.

## Key points

- Cochrane review of chest physiotherapy for pneumonia (2013) should be interpreted with caution.
- Patients with detrimental secretions, those with COPD, NMD and patients presenting with hypoxaemia with or without hypercapnia can benefit from rigorous assessment and problem based physiotherapy management.
- Patients with uncomplicated pneumonia without important co-morbidities will not benefit from airway clearance or lung volume recruitment techniques.

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# Clearly an advantage in helping to move mucus

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Forest

## Book Review – Amy Bendall

## Managing Breathlessness in Clinical Practice 2014

*Authors:*

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*Published by Springer-Verlag, London*

*ISBN 978-1-4471-4754-1*

*Price £27.99 e-book; £35.99 soft cover*

This detailed book presents evidence-based and clinically useful information for the healthcare professional to use in the management of breathlessness across any specialty. It is written by a range of professionals who work with the Cambridge Breathlessness Intervention Service (CBIS) and as such it would be useful to all professionals working with the breathless person, e.g. physiotherapists, occupational therapists, specialist nurses and physicians.

It is a concise 265-page book comprising five distinct topic areas, which are divided into 12 chapters. The authors have set out to design each chapter so that it refers to another, but also that it can be read on its own and this is achieved with clear demarcations between chapters and a logical flow of ideas through the book. The five distinct topic areas are: (1) an introduction to breathlessness; (2) non-pharmacological interventions: breathing; (3) non-pharmacological interventions: thinking; (4) non-pharmacological interventions: functioning; and (5) an integrated strategy. References are used where appropriate and there is a list of recommended further reading at the end of each chapter, with key points from the chapter summarised in a distinct grey box. The book also summarises the relevant practice guidelines (e.g. BTS/ACPRC) in each chapter. A grey box is also used to separate the more pertinent aspects and messages that the authors wish to convey throughout the text.

The person centered approach and the need for holistic management for breathlessness is at the very centre of the book. Within the foreword, the distinction between 'patient' and 'person' is made as the authors identify that in managing the person with breathlessness it is imperative that their lived, personal experience in terms of lifestyle and the impact that this has on their family and friends is addressed. Throughout the chapters quotations from people with breathlessness, obtained from both CBIS service-users and qualitative literature excerpts are used to illustrate key aspects of breathlessness.

The first of the topic areas incorporates chapters 1 and 2, where chapter 1 uses clinical case scenarios and quotations from service-users to depict the features of breathlessness; alongside description of the recommended key components of a breathless intervention service. Chapter 2 provides a succinct yet comprehensive overview of literature based genesis models of breathlessness. Key considerations to take into account during assessment of the person with breathlessness are then summarised with inclusion of practical tips.

The second topic entitled 'Non-pharmacological approach: breathing' is covered in chapters 3, 4 and 5. These chapters provide a summary of the evidence base and practical application of fan and oxygen therapy; positions to ease breathlessness and breathing techniques for breathlessness. Noteworthy are the visual aids that the authors recommend when encouraging completion of breathing control techniques. Furthermore the clinical rationale for positions to ease breathlessness is clearly defined in context of an overview of the anatomical and physiological understanding of the respiratory system in health and breathlessness.

The 'Non-pharmacological approach: thinking' is covered in chapters 6 and 7 which include anxiety management and energy conservation. Physical symptoms commonly described by a person with breathlessness are considered and are explained by the authors using lay terminology to empower the clinician in the

facilitation of the person's understanding of why these symptoms occur. The chapter on energy conservation covers key aspects to consider when designing with an with an individual, a management plan that includes activity planning, pacing and sleeping.

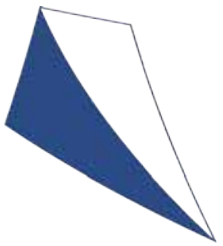
Chapters 8 and 9 cover the areas of exercise and activity promotion and supporting carers under the umbrella topic of 'Non-pharmacological approach: functioning'. This considers aspects involved in exercise, activity, motivation and goal setting; the importance of supporting the carers is also central to this topic and practical factors e.g. respite and support groups are discussed.

'An Integrated Strategy' in chapters 10 and 11 provides an overview of pharmacological management and considerations for care towards the end of life. The information on considerations for care towards the end of life outlines the 'Twelve Principles for a Good Death' and offers clinically useful information on ways of communicating with patients, carers, family members and colleagues regarding this important aspect of care.

The final chapter culminates in the authors recommending an approach to helping the breathless person and their family by synthesising the practices discussed in the book. The 'Breathing-Thinking-Functioning' approach to act as an aid memoire is recommended to ensure that all aspects of a multifaceted assessment and suitable interventions are considered. The authors are quick to point out that the complexities of chronic breathlessness cannot be contained within a set of algorithms and delivered in a fixed order; instead they succeed in translating the current evidence base with current practice and provide practical advice for the healthcare professional to use to ensure an individual, holistic management approach.

This is an excellent book and its strengths are that it is practically orientated, and the information is effectively interspersed with clinical case scenarios to demonstrate the translation of knowledge into a clinical application. It is excellent value and a resource that an individual healthcare professional can affordably own. It is also lightweight so that it could be easily carried between the wards, clinic or home. The book would be particularly relevant to developing the knowledge and skills of students and junior members of staff (or indeed any professional new to the management of breathlessness); particularly the visual aids and clinical recommendations throughout the book will be most helpful. The clinical case scenarios could be used to provide discussion points to facilitate learning both within in-service training and university settings. There are also plenty of aspects within the book that may offer a more experienced healthcare professional working with the breathless person an opportunity to pause and reflect on their own professional practice.

# Promoting best practice in respiratory physiotherapy for the benefit of patients



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