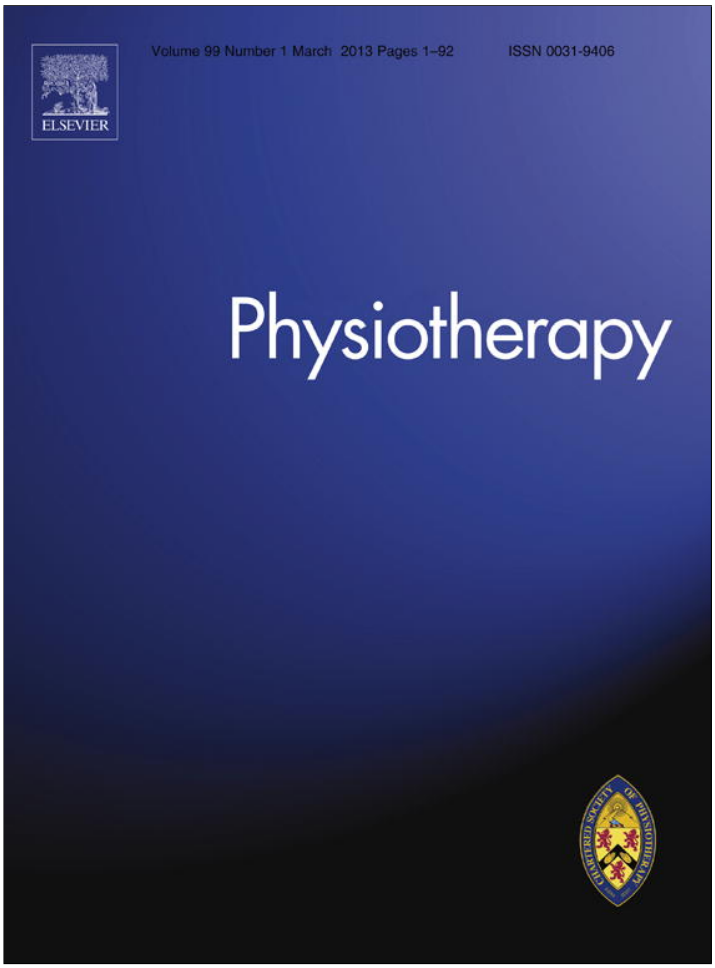

ELSEVIER

Physiotherapy 99 (2013) 56–62

Physiotherapy

# A survey of physiotherapeutic provision for patients undergoing thoracic surgery in the UK

P. Agostini [a,b,*], J. Reeve [c], S. Dromard [d], S. Singh [b], R.S. Steyn [a], B. Naidu [a,e]

[a] *Department of Thoracic Surgery, Heart of England NHS Foundation Trust, Birmingham Heartlands Hospital, Birmingham, UK*
[b] *School of Health and Life Sciences, Coventry University, Coventry, UK*
[c] *School of Physiotherapy, Faculty of Health and Environmental Studies, Auckland University of Technology, Auckland, New Zealand*
[d] *Department of Cardiothoracic Surgery, St George's Healthcare NHS Trust, St George's Hospital, London, UK*
[e] *University of Warwick, Coventry, UK*

**Abstract**

**Objectives** Evaluation of physiotherapeutic provision for patients undergoing open thoracotomy and lung surgery in the UK. Timing of physiotherapy, modalities used and factors influencing practice were also investigated.
**Design** Survey.
**Setting** Tertiary centres performing thoracic surgery.
**Participants** Forty UK centres were identified, and senior physiotherapists were invited to participate.
**Methods** A postal survey was distributed to identified centres in August 2008, with further follow-up of non-responders. This was adapted from a similar study conducted in Australia and New Zealand.
**Results** Thirty-one responses were received (78%). Pre-operative physiotherapy was provided by 87% of respondents: 10% provided physiotherapy for all patients and 77% only provided physiotherapy for high-risk patients. Pre-operative pulmonary rehabilitation was reported in 13% of centres. Postoperative physiotherapeutic assessment was undertaken routinely by 97% of respondents: 81% provided physiotherapy to all patients, and 16% only provided physiotherapy when a specific problem was identified. The treatments given were relatively standardised. The provision of physiotherapy following hospital discharge was generally very sparse.
**Conclusion** This study provides a guide for physiotherapists working with patients undergoing thoracic surgery to use to compare their current practices. Postoperative physiotherapy is provided extensively to UK patients undergoing open thoracotomy. However, pre-operative provision is more variable and is mainly provided for high-risk patients. Despite the subsequent publication of pre- and postoperative pulmonary rehabilitation studies, UK physiotherapy practice remained similar to that reported in Australia and New Zealand. Further research in this field is necessary to investigate the role of pre-operative physiotherapy, the role of pre- and postoperative pulmonary rehabilitation, and the effectiveness of routine postoperative physiotherapy.


*Keywords:* Physiotherapy; Thoracic surgery; Thoracotomy

## Introduction

Pre- and postoperative physiotherapy is provided for patients undergoing major thoracic surgery to reduce postoperative complications, despite there being little empirical research in this area. Physiotherapy is widely considered to be important in limiting the development of postoperative pulmonary complications, which are associated with significant clinical and economic impact [1–3], and to prevent and treat shoulder dysfunction following thoracotomy, which has been reported extensively [4]. The aim of this study was to investigate the provision of physiotherapy for patients undergoing open thoracotomy for lung surgery in the UK; to ascertain what interventions are applied; when and by

* Correspondence: Department of Thoracic Surgery, Heart of England NHS Foundation Trust, Birmingham Heartlands Hospital, Bordesley Green East, Bordesley Green, Birmingham B9 5SS, UK. Tel.: +44 0121 424 2000; fax: +44 0121 424 1064.
*E-mail address:* paulaagostini@aol.com (P. Agostini).

0031-9406/$ – see front matter © 2012 Chartered Society of Physiotherapy. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.physio.2011.11.001

whom; and to establish which factors, given the limited evidence to date, influence the provision of physiotherapy. This is becoming of increasing relevance as new UK guidelines for lung cancer resection surgery include broader selection criteria than previously [5]; this may result in more patients developing complications following surgery. This study also enables comparison of physiotherapeutic practice in the UK with overseas practice [6], and thus helps to determine the applicability of the evidence from more recent investigations following thoracic surgery within the UK context.

## Methods

Hospitals in the UK providing thoracic surgery services were identified from the database of the Society of Cardiothoracic Surgery of Great Britain and Ireland, and an internet search of all UK hospitals with cardiothoracic surgical facilities, and this was confirmed by telephone contact with units undertaking thoracic surgery. The study was approved by the clinical governance team at the Heart of England NHS Foundation Trust, and further ethical approval was deemed unnecessary as the study was considered to be observational. A postal survey was distributed in August 2008 to the relevant senior physiotherapist in each thoracic surgical unit, with a covering letter explaining the aims of the study. Confidentiality, but not initial anonymity, was assured as a coding system was needed for follow-up of non-responders. Anonymity of respondents was maintained during data entry, data analysis and write-up phases. The questionnaire was adapted, with permission, from a similar study in Australia and New Zealand [6]. Questions referred to the management of patients undergoing open thoracotomy for lung surgery unless stated. Questions were closed with the exception of respondents citing research that had influenced their practice, and where respondents were asked to rank (on a five-point Likert scale, 1 = no influence at all, 5 = very influential) how much personal experience, literature recommendations, anaesthetic or surgical colleagues' preferences, resource considerations, tradition and staffing numbers/caseload had influenced their pre- and postoperative provision of physiotherapy. Data were analysed using primarily descriptive statistical analysis with Statistical Package for the Social Sciences Version 17 (IBM Corporation, NY, USA).

## Results

Forty-one questionnaires were distributed. However, one respondent indicated that they no longer provided thoracic surgery services, so the actual valid number of questionnaires distributed was 40. The response rate was 78% ($n = 31$). Data are reported as the number of respondents for each individual question, which varied throughout the survey. Demographic data are displayed in Table 1.

Table 1
Demographic data.

| | *n* (%) |
|---|---|
| *Number of patients undergoing open thoracotomy per week in each centre* | |
| 1 to 5 | 16 (52) |
| 6 to 10 | 8 (26) |
| >10 | 6 (19) |
| Not stated | 1 (3) |
| *Type of surgery* | |
| Pulmonary resection | 31 (100) |
| Pleural surgery | 31 (100) |
| Video-assisted thoracoscopic surgery | 31 (100) |
| Oesophageal | 11 (35) |
| Chest wall surgery | 26 (84) |
| Lung volume reduction surgery | 24 (77) |
| Other | 5 (16) |
| *Mean postoperative length of stay (days)* | |
| 1 to 3 | 2 (7) |
| 4 to 7 | 28 (90) |
| 8 to 10 | 0 |
| >10 | 1 (3) |

### *Pre-operative physiotherapeutic management*

Twenty-seven respondents (27/31, 87%) indicated that pre-operative physiotherapy was provided for patients undergoing open thoracotomy at their centres. Three respondents (3/31, 10%) reported that all patients were given pre-operative physiotherapy, and 24 respondents reported that some patients were given pre-operative physiotherapy (24/31, 77%). Reasons for non-provision of pre-operative physiotherapy were lack of time, insufficient evidence or lack of referral. At centres where some, but not all, patients were given pre-operative physiotherapy, this was due to insufficient staff (7/31, 23%) or because these patients were perceived as high risk (17/31, 55%). Patients in this category were seen because they had reduced lung function or exercise tolerance, chronic obstructive pulmonary disease, bronchiectasis or poor mobility. Patients were assessed either before admission (6/31, 19%), after admission (13/31, 42%) or both (8/31, 13%), and the majority of respondents (24/31, 77%) reported that patients were assessed on a face-to-face basis. Pre-operative physiotherapeutic interventions included deep breathing exercises (19/27, 70%), huffing and coughing (24/27, 89%), active cycle of breathing techniques (17/27, 63%), incentive spirometry (10/27, 37%) and administration of written information (19/27, 70%). Pre-operative pulmonary rehabilitation was reported by 14 respondents (14/31, 45%). Of the centres offering pre-operative pulmonary rehabilitation, 11 respondents reported that this was provided routinely (11/31, 35%), primarily for patients undergoing lung volume reduction surgery (10/11, 91%). Only one respondent (1/31, 3%) reported pre-operative pulmonary rehabilitation provision for all patients undergoing open thoracotomy and lung resection, and three respondents (3/31, 10%) reported occasional provision for high-risk patients.

*Postoperative physiotherapeutic management*

Postoperative physiotherapeutic assessment on postoperative day 1 was provided routinely for patients undergoing open thoracotomy in 30 centres (30/31, 97%). Twenty-five respondents (25/31, 81%) reported that prophylactic physiotherapeutic treatments were subsequently provided to all patients, and five respondents (5/31, 16%) reported that treatment was administered as necessary following assessment. Two centres (2/31, 6%) reported that physiotherapy was initiated on the day of surgery. On postoperative day 1, more than half of the respondents (17/31, 55%) reported that patients were treated once, and 11 respondents (11/31, 35%) reported that patients were treated twice or more. After postoperative day 1, patients were generally reported as receiving treatment once daily.

Table 2 shows the number of respondents who reported regular use of certain postoperative interventions at their centres. Interventions that were not normally used or that were considered contraindicated are also shown. The frequency of mobilisation/exercise interventions and advice/discharge information are shown in Fig. 1, together with the number of staff instigating these practices. As relatively vigorous exercise is considered to be safe in this population [7], the use of bicycles and steps was also investigated. The majority of respondents reported sitting patients out of bed (28/31, 90%), and commencing assisted mobilisation (20/31, 65%) and bedside marching (4/31, 13%) on postoperative day 1. Twenty respondents (20/31, 65%) reported that they used incentive spirometry in the treatment of patients following open thoracotomy: 11 (11/31, 35%) normally used this modality and nine (9/31, 29%) used it occasionally.

*Postoperative physiotherapeutic management following video-assisted thoracoscopic surgery*

Twelve respondents (12/31, 39%) reported that they assessed and treated all patients following video-assisted thoracoscopic surgery (VATS), and 18 (18/31, 58%) respondents reported that they only treated and assessed patients at high risk of developing postoperative complications following VATS, or patients demonstrating respiratory deterioration. One respondent (1/31, 3%) reported that patients were only assessed following VATS on referral.

*Postdischarge physiotherapeutic management*

Physiotherapeutic follow-up in outpatient clinics, postoperative pulmonary rehabilitation and post-thoracotomy pain management were not widely reported following hospital discharge. These services were only offered to some patients in 26% (8/31), 19% (6/31) and 3% (1/31) of centres, respectively.

*Factors influencing physiotherapeutic management*

The responses on the Likert scale indicated that personal experience was the most influential factor in pre-operative provision of physiotherapy (mode 4), whereas personal experience and literature recommendations were most influential for postoperative provision of physiotherapy (mode 4).

*Influence of research awareness on physiotherapy service provision*

Respondents were asked which literature, if any, had influenced their physiotherapeutic management of patients following thoracic surgery. Six respondents (6/31, 19%) named specific papers or articles regarding patients undergoing thoracic surgery [6–9], two respondents (2/3, 6%) named specific papers or articles regarding patients undergoing cardiac surgery [10,11], and a further four respondents (4/31, 13%) alluded to some of the thoracic surgery studies in open comments but were unable to name specific papers.

## Discussion

The responses to this survey provide an insightful snapshot of physiotherapeutic practice for patients undergoing thoracic surgery in the UK, helping clinicians to compare their practice with that of others in the UK and overseas, and with the evidence to date.

Table 2
Interventions normally used by physiotherapists for non-complicated patients undergoing open thoracotomy.

| Postoperative intervention | Number of respondents (%) | | | |
|---|---|---|---|---|
| | Normally used | Not normally used | Contraindicated | Not specified |
| Deep breathing exercises | 28 (90) | 1 (3) | 0 | 2 (6) |
| Active cycle of breathing techniques | 22 (71) | 7 (23) | 0 | 2 (6) |
| Forced expiratory technique | 26 (84) | 4 (13) | 0 | 1 (3) |
| Sniff | 7 (23) | 20 (65) | 0 | 4 (13) |
| Cough | 30 (97) | 1 (3) | 0 | 0 |
| Incentive spirometry | 11 (35) | 19 (61) | 0 | 1 (3) |
| Intermittent positive pressure breathing | 3 (10) | 23 (74) | 3 (10) | 2 (6) |
| Bi-level positive airway pressure | 1 (3) | 26 (84) | 2 (6) | 2 (6) |
| Continuous positive airway pressure | 2 (6) | 24 (77) | 2 (6) | 3 (10) |
| Positive expiratory pressure | 2 (6) | 27 (87) | 0 | 2 (6) |

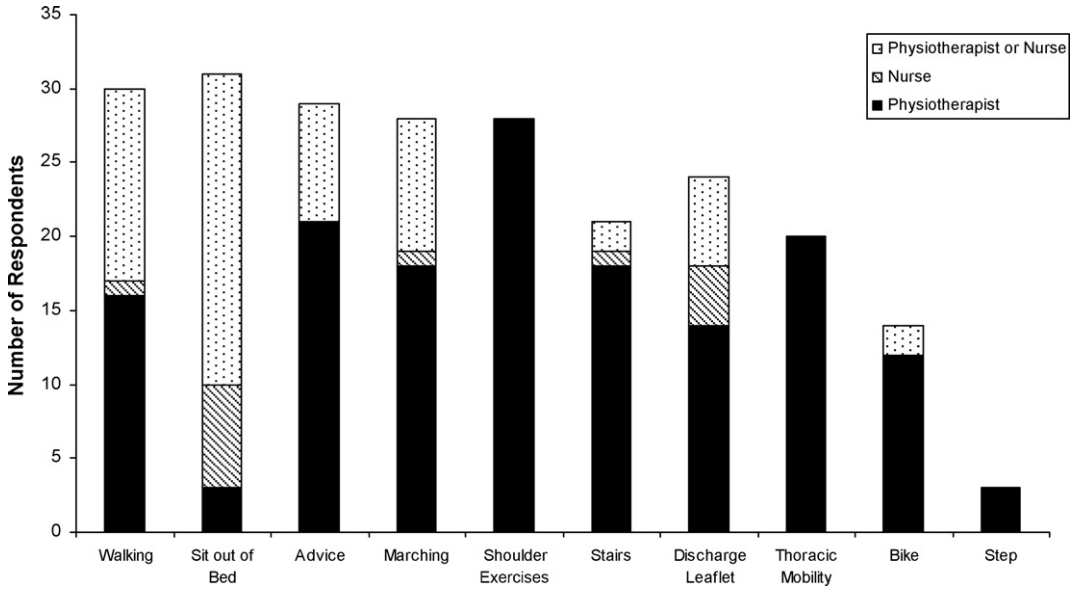


Fig. 1. Mobilisation/exercise interventions, and advice and discharge information.

*Pre-operative physiotherapeutic management*

Provision of pre-operative physiotherapy for patients undergoing open thoracotomy was relatively widespread for those perceived to be at high risk. However, despite many centres providing pre-operative physiotherapy, research in this area is sparse and methodologically limited [7,8,12]. In addition, most respondents reported a lack of provision of pre-operative pulmonary rehabilitation and, where provided, it was typically offered to patients undergoing lung volume reduction surgery for whom there is evidence of benefit [13]. Recently, studies investigating pre-operative pulmonary rehabilitation in patients undergoing open lung resection have also been undertaken and demonstrate improvements in pre-operative exercise capacity and predicted postoperative lung function [14–17]. However, these studies were small and non-randomised, and the impact upon postoperative complications is not yet clear. Most of these studies [14–16] were published shortly before the current survey was undertaken but do not, as yet, appear to have influenced UK practice. The present study corroborates that of Reeve *et al.* [6], whereby a similar proportion of respondents reported routine face-to-face contact with either all patients or selective high-risk patients, and only limited centres offered pre-operative pulmonary rehabilitation. Similar to Reeve *et al.* [6], the present study found that personal experience was the most influential factor in guiding pre-operative practice, and this is not surprising given the limited evidence. Interestingly, in other types of major surgery, studies have found that a pre-operative tailored physiotherapeutic intervention significantly reduces the incidence of postoperative pulmonary complications [18,19]. Future studies should focus on the efficacy of differing pre-operative physiotherapeutic interventions to improve postoperative outcomes.

*Postoperative physiotherapeutic management*

This study found that provision of postoperative physiotherapy following open thoracotomy for lung surgery was widespread across the UK. The actual interventions provided varied, but the majority of respondents offered prophylactic treatment including deep breathing exercises, early mobilisation (provided by both physiotherapy and nursing staff) and shoulder exercises. In the survey by Reeve *et al.* [6], the majority of respondents also reported providing routine physiotherapeutic assessment, but fewer respondents offered prophylactic treatment. Other interventions, including shoulder exercises, were comparable. This survey demonstrated wide variability in the postoperative use of adjuncts such as incentive spirometry and positive expiratory pressure devices, also similar to the study by Reeve *et al.* [6].

Incentive spirometry has been shown to contribute to faster postoperative recovery of lung function in patients undergoing pneumonectomy and lobectomy [8]. However, there is no documented benefit in terms of reduction in postoperative pulmonary complications in thoracic surgery [9,20] or other surgical populations [21]. Despite this, the present study found relatively wide use of incentive spirometry. Similarly, evidence for positive expiratory pressure therapy is also lacking, with two older, comparative studies of questionable methodology revealing little benefit in this population [22,23]. The use of exercise equipment, compared with more traditional forms of exercise such as walking, marching and stair climbing, was also variable and limited amongst respondents. A small amount of evidence supports the widespread practice of including early postoperative mobilisation within care pathways following thoracic surgery; these studies showed a reduction in adverse outcomes and hospital costs [24,25]. Since the survey, further higher-quality research has

been published, including the only randomised controlled trial in this field [26,27]. One of these studies found that targeted postoperative respiratory physiotherapy, in addition to early mobilisation, good pain relief and a standardised clinical pathway, did not reduce postoperative pulmonary complications in patients undergoing open lung resection [26]. However, given the small number of patients in this study, further studies are warranted to clarify the necessity for such interventions, especially in higher-risk patients. The inclusion of a physiotherapy-led postoperative shoulder exercise programme in this regimen was also evaluated, and significant benefits were demonstrated [27]. A further study found that, following lung resection, a programme implementing respiratory physiotherapy, early mobility, and strength and mobility training did not reduce postoperative pulmonary complications, or improve quality of life or exercise tolerance despite a significant prevention in decline of quadriceps strength [28]. Most recently, a large non-randomised, quasi-experimental study to estimate the causal treatment effects of postoperative physiotherapy, including deep breathing, cough, early mobilisation, and exercise using a static bicycle and treadmill, found an overall reduction in pulmonary morbidity [29]. The evidence presented in the latter study has provoked recent discussion that specialised, expert physiotherapy should continue to be included within the postoperative protocols of thoracic surgery centres, but that the exact way in which this is administered should be the subject of further investigations [30]. The provision of postoperative physiotherapy following thoracic surgery in the UK corresponds to current European recommendations for the routine provision of physiotherapy [31], and the belief of thoracic surgeons that the provision of physiotherapy following thoracic surgery is beneficial [32]. Given the small amount of high-quality evidence to date, physiotherapists have limited evidence upon which to base their treatment interventions, and further studies are warranted. With the general lack of high-quality evidence at the time of administration of this survey, and only a small proportion of respondents able to name any relevant papers/articles, it is not surprising that personal experience was cited as an influential factor in guiding postoperative practice at this time.

VATS is increasingly used for surgical access for lung resection and, although its use remains limited to date, it has been shown to result in a shorter length of stay, less pain, reduced costs and lower complication profiles following lung resection [33]. The present study found that provision of physiotherapy following VATS was relatively widespread, with many UK respondents reporting assessment and treatment, particularly for high-risk patients. Reeve *et al.* [6] found that almost all centres in Australia and New Zealand routinely assess patients postoperatively following VATS; however, to date, no research has been conducted to support this practice. The present survey did not distinguish between different surgical procedures being undertaken via VATS, and it is possible that respondents reported their interventions for all surgical procedures rather than lung resection via VATS alone. Nonetheless, with the increasing use of lung resection via VATS and no physiotherapeutic studies to date investigating the impact of interventions in this specific population, future studies are warranted.

### *Postdischarge physiotherapeutic management*

Similar to the findings of Reeve *et al.* [6], the reported provision of physiotherapeutic interventions following discharge from hospital in the UK is infrequent. This is surprising given the small but increasing amount of evidence in this area. Since the survey of Reeve *et al.* [6], three small non-randomised studies have evaluated the safety and efficacy of postoperative pulmonary rehabilitation in patients with lung cancer, and found improvements in exercise capacity compared with baseline [34–36]. This finding is of potential importance for improving quality of life [37]. Further, larger randomised studies investigating the effectiveness of pulmonary rehabilitation in improving clinical outcomes following thoracic surgery are required.

### *Limitations*

The limitations of this survey are similar to those noted by Reeve *et al.* [6]. By sending questionnaires to a single physiotherapist at each surgical unit, responses may have been influenced by personal rather than institutional attitudes and beliefs. Additionally, it is acknowledged that it is not known whether or not the senior physiotherapist responded to the survey as requested, and varying amounts of respondent experience may have affected the results. It is acknowledged that provision of care may vary in clinical practice depending upon the requirements of each individual patient's clinical condition, and thus the accuracy of routine care questions is unknown. Finally, it is acknowledged that since administration of this survey, further studies have investigated the impact of physiotherapy on patient outcomes [12,27–29,37]. Some of these studies support the trends observed in current practice, but some may have impacted upon physiotherapeutic practice since this survey was undertaken.

## Conclusion

This study provides a guide for physiotherapists working with patients undergoing thoracic surgery to use to compare their current practices. In the UK, postoperative physiotherapy is currently provided extensively to patients undergoing open thoracotomy for lung surgery, with interventions such as deep breathing, early mobilisation and shoulder exercises being widely provided. The provision of pre-operative physiotherapy is more variable and is mainly provided for patients perceived to be at high risk. Despite the subsequent publication of the previously mentioned pre- and postoperative pulmonary rehabilitation studies, UK physiotherapy practice remained similar to that reported in Australia and

New Zealand [6]. Further research in this field is necessary, and should encompass the role of pre-operative physiotherapy in preventing postoperative complications, pre- and postoperative pulmonary rehabilitation, physiotherapy in patients undergoing lung resection via VATS, and the effectiveness of routine postoperative physiotherapeutic management.

## Acknowledgements

The authors wish to acknowledge and thank Laura Battle and Hayley Cieslik of the Heart of England NHS Foundation Trust for administrative and clinical support, respectively, during this project. Also, the authors would like to acknowledge Linda Denehy, Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne, Melbourne, Australia, and Kathy Stiller, Royal Adelaide Hospital, Adelaide, South Australia, for their role in the development of the original survey questionnaire.

*Ethical approval:* The study was approved by the clinical governance team at the Heart of England NHS Foundation Trust (Audit reference number: 1153). Further ethical approval was not deemed necessary as the study was observational.

*Funding*: No funding was gained for this study.

*Conflict of interest:* None declared.

## References

[1] Stephan F, Boucheseiche S, Hollande J, Flahault A, Cheffi A, Bazelly B, *et al.* Pulmonary complications following lung resection: a comprehensive analysis of incidence and possible risk factors. Chest 2000;118:1263–70.

[2] Bernard A, Deschamps C, Allen MS, Miller DL, Trastek VF, Jenkins GD, *et al.* Pneumonectomy for malignant disease: factors affecting early morbidity and mortality. J Thorac Cardiovasc Surg 2001;121:1076–82.

[3] Algar FJ, Alvarez A, Salvatierra A, Baamonde C, Aranda JL, Lopez-Pujol FJ. Predicting pulmonary complications after pneumonectomy for lung cancer. Eur J Cardiothorac Surg 2003;23:201–8.

[4] Li WW, Lee TW, Yim AP. Shoulder function after thoracic surgery. Thorac Surg Clin 2004;14:331–43.

[5] British Thoracic Society; Society for Cardiothoracic Surgery in Great Britain and Ireland. Guidelines on the radical management of patients with lung cancer. Thorax 2010;65(Suppl. 3):iii1–27.

[6] Reeve J, Denehy L, Stiller K. The physiotherapy management of patients undergoing thoracic surgery: a survey of current practice in Australia and New Zealand. Physiother Res Int 2007;12:59–71.

[7] Varela G, Ballesteros E, Jimenez MF, Novoa N, Aranda JL. Cost-effectiveness analysis of prophylactic respiratory physiotherapy in pulmonary lobectomy. Eur J Cardiothorac Surg 2006;29:216–20.

[8] Weiner P, Man A, Weiner M, Rabner M, Waizman J, Magadle R, *et al.* The effect of incentive spirometry and inspiratory muscle training on pulmonary function after lung resection. J Thorac Cardiovasc Surg 1997;113:552–7.

[9] Gosselink R, Schrever K, Cops P, Witvrouwen H, De Leyn P, Troosters T, *et al.* Incentive spirometry does not enhance recovery after thoracic surgery. Crit Care Med 2000;28:679–83.

[10] Pasquina P, Tramer MR, Walder B. Prophylactic respiratory physiotherapy after cardiac surgery: systematic review. BMJ 2003;327:1379–81.

[11] Stiller K, Montarello J, Wallace M, Daff M, Grant R. Are breathing and coughing exercises necessary after coronary artery surgery? Physiotherapy Theory Pract 1994;10:143–52.

[12] Reid JC, Jamieson A, Bond J, Versi BM, Nagar A, Ng BHK, *et al.* A pilot study of the incidence of post-thoracotomy pulmonary complications and the effectiveness of pre-thoracotomy physiotherapy patient education. Physiother Can 2010;62:66–74.

[13] Ries AL, Make BJ, Lee SM, Krasna MJ, Bartels M, Crouch R, *et al.* The effects of pulmonary rehabilitation in the national emphysema treatment trial. Chest 2005;128:3799–809.

[14] Cesario A, Ferri L, Galetta D, Cardaci V, Biscione G, Pasqua F, *et al.* Pre-operative pulmonary rehabilitation and surgery for lung cancer. Lung Cancer 2007;57:118–9.

[15] Jones LW, Peddle CJ, Eves ND, Haykowsky MJ, Courneya KS, Mackey JR, *et al.* Effects of presurgical exercise training on cardiorespiratory fitness among patients undergoing thoracic surgery for malignant lung lesions. Cancer 2007;110:590–8.

[16] Bobbio A, Chetta A, Ampollini L, Primomo GL, Internullo E, Carbognani P, *et al.* Preoperative pulmonary rehabilitation in patients undergoing lung resection for non-small cell lung cancer. Eur J Cardiothorac Surg 2008;33:95–8.

[17] Sekine Y, Chiyo M, Iwata T, Yasufuku K, Furukawa S, Amada Y, *et al.* Perioperative rehabilitation and physiotherapy for lung cancer patients with chronic obstructive pulmonary disease. Jpn J Thorac Cardiovasc Surg 2005;53:237–43.

[18] Hulzebos EH, Helders PJ, Favie NJ, De Bie RA, Brutel de la Riviere A, Van Meeteren NL. Preoperative intensive inspiratory muscle training to prevent postoperative pulmonary complications in high-risk patients undergoing CABG surgery: a randomized clinical trial. JAMA 2006;296:1851–7.

[19] Dronkers J, Veldman A, Hoberg E, van der Waal C, van Meeteren N. Prevention of pulmonary complications after upper abdominal surgery by preoperative intensive inspiratory muscle training: a randomized controlled pilot study. Clin Rehabil 2008;22:134–42.

[20] Vilaplana J, Sabate A, Gasolibe V, Villalonga R. Inefficiency of incentive spirometry as coadjuvant of conventional chest physiotherapy for the prevention of respiratory complications after chest and oesophagus surgery. Rev Esp Anestesiol Reanim 1991;37:321–5.

[21] Overend TJ, Anderson CM, Lucy SD, Bhatia C, Jonsson BI, Timmermans C. The effect of incentive spirometry on postoperative pulmonary complications: a systematic review. Chest 2001;120:971–8.

[22] Chatham K, Marshall C, Campbell IA, Prescott RJ. The flutter VRP1 device for posthoracotomy patients. Physiotherapy 1993;79:95–8.

[23] Ingwersen UM, Larsen KR, Bertelsen MT, Kiil-Nielsen K, Laub M, Sandermann J, *et al.* Three different mask physiotherapy regimens for prevention of post-operative pulmonary complications after heart and pulmonary surgery. Intensive Care Med 1993;19:294–8.

[24] Zehr KJ, Dawson PB, Yang SC, Heitmiller RF. Standardized clinical care pathways for major thoracic cases reduce hospital costs. Ann Thorac Surg 1998;66:914–9.

[25] Das-Neves-Pereira J, Bagan P, Coimbra-Israel A, Grimaillof-Junior A, Cesar-Lopez G, Milanez-de-Campos J, *et al.* Fast-track rehabilitation for lung cancer lobectomy: a five year experience. Eur J Cardiothorac Surg 2009;36:383–92.

[26] Reeve JC, Nicol K, Stiller K, McPherson KM, Birch P, Gordon I, *et al.* Does physiotherapy reduce the incidence of postoperative pulmonary complications following pulmonary resection via open thoracotomy? A preliminary randomised single-blind clinical trial. Eur J Cardiothorac Surg 2010;37:1158–66.

[27] Reeve J, Stiller K, Nicol K, Mc Pherson KM, Birch P, Gordon IR, *et al.* A post operative shoulder exercise program improves function

and decreases pain following open thoracotomy; a randomised trial. J Physiother 2010;56:245–52.
[28] Arbane G, Tropman D, Jackson D, Garrod G. Evaluation of an early exercise intervention after thoracotomy for non-small cell lung cancer (NSCLC), effects on quality of life, muscle strength and exercise tolerance: randomised controlled trial. Lung Cancer 2011;7:229–34.
[29] Novoa N, Ballesteros E, Jimenez MF, Aranda JL, Varela G. Chest physiotherapy revisited: evaluation of its influence on the pulmonary morbidity after pulmonary resection. Eur J Cardiothorac Surg 2011;40:130–5.
[30] Ferguson MK. Back to the future: chest physiotherapy comes full circle. Eur J Cardiothorac Surg 2011;40:134–5.
[31] EACTS/ESTS Working Group on Structures in Thoracic Surgery. Structure of general thoracic surgery in Europe. Eur J Cardiothorac Surg 2001;20:663–8.
[32] Varela G. Editorial comment. Eur J Cardiothorac Surg 2010;37:1166–7.
[33] McKenna Jr RJ, Mahtabifard A, Pickens A, Kusuanco D, Fuller CB. Fast-tracking after video-assisted thoracoscopic surgery lobectomy, segmentectomy, and pneumonectomy. Ann Thorac Surg 2007;84:1663–7.
[34] Spruit MA, Janssen PP, Willemsen SC, Hochstenbag MM, Wouters EF. Exercise capacity before and after an 8-week multidisciplinary inpatient rehabilitation program in lung cancer patients: a pilot study. Lung Cancer 2006;52:257–60.
[35] Cesario A, Ferri L, Galetta D, Pasqua F, Bonassi S, Clini E, *et al.* Post-operative respiratory rehabilitation after lung resection for non-small cell lung cancer. Lung Cancer 2007;57:175–80.
[36] Jones L, Eves N, Peterson B, Garst J, Crawford J, West M, *et al.* Safety and feasibility of aerobic training on cardiopulmonary function and quality of life in postsurgical non-small cell lung cancer patients. Cancer 2008;113:3430–9.
[37] Granger CL, McDonald CF, Berney S, Chao C, Denehy L. Exercise intervention to improve exercise capacity and health related quality of life for patients with non-small cell lung cancer: a systematic review. Lung Cancer 2011;72:139–53.