

Video-assisted thoracoscopic lobectomy: which patients require postoperative physiotherapy?

Agostini, P.; Lugg, S.T.; Adams, K.; Smith, T.; Kalkat, M.; Rajesh, P.B.; Steyn, R.S.; Naidu, B.; Rushton, A.; Bishay, E.

DOI:

[10.1016/j.physio.2019.01.001](https://doi.org/10.1016/j.physio.2019.01.001)

License:

Creative Commons: Attribution-NonCommercial-NoDerivs (CC BY-NC-ND)

Document Version

Peer reviewed version

Citation for published version (Harvard):

Agostini, P, Lugg, ST, Adams, K, Smith, T, Kalkat, M, Rajesh, PB, Steyn, RS, Naidu, B, Rushton, A & Bishay, E 2019, 'Video-assisted thoracoscopic lobectomy: which patients require postoperative physiotherapy?', *Physiotherapy*, vol. 50. <https://doi.org/10.1016/j.physio.2019.01.001>

[Link to publication on Research at Birmingham portal](#)

Publisher Rights Statement:

Checked for eligibility 06/02/2019

This is an author-produced, peer-reviewed version of an article forthcoming in *Physiotherapy*.
<https://www.physiotherapyjournal.com/>

General rights

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

- Users may freely distribute the URL that is used to identify this publication.
- Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.
- User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?)
- Users may not further distribute the material nor use it for the purposes of commercial gain.

Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

Take down policy

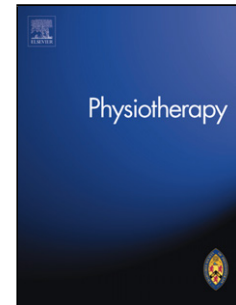
While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact UBIRA@lists.bham.ac.uk providing details and we will remove access to the work immediately and investigate.

Accepted Manuscript

Title: Video-assisted thoracoscopic lobectomy; which patients require postoperative physiotherapy?

Authors: P. Agostini, S.T. Lugg, K. Adams, T. Smith, M. Kalkat, P.B. Rajesh, R.S. Steyn, B. Naidu, A. Rushton, E. Bishay



PII: S0031-9406(19)30006-9
DOI: <https://doi.org/10.1016/j.physio.2019.01.001>
Reference: PHYST 1079

To appear in: *Physiotherapy*

Please cite this article as: Agostini P, Lugg ST, Adams K, Smith T, Kalkat M, Rajesh PB, Steyn RS, Naidu B, Rushton A, Bishay E. Video-assisted thoracoscopic lobectomy; which patients require postoperative physiotherapy?. *Physiotherapy* (2019), <https://doi.org/10.1016/j.physio.2019.01.001>

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Video-assisted thoracoscopic lobectomy; which patients require postoperative physiotherapy?

P Agostini,^{1,2,3} ST Lugg,⁴ K Adams,¹ T Smith,² M Kalkat,¹ PB Rajesh,¹ RS Steyn,¹ B Naidu,^{1,4} A Rushton,² E Bishay¹

¹ Department of Thoracic Surgery, Heart of England NHS Foundation Trust, Bordesley Green East, Birmingham, B9 5SS. UK

² School of Sport, Exercise and Rehabilitation Sciences, University of Birmingham, Birmingham, B15 2TT. UK

³ Faculty of Education, Health and Wellbeing, University of Wolverhampton, Walsall Campus, Gorway Rd, Walsall, WS1 3EZ

⁴Institute of Inflammation and Ageing, University of Birmingham, Birmingham, B15 2TT. UK

Corresponding author: Dr Paula Agostini: p.agostini@wlv.ac.uk

Tel: + 44 (0) 1902 321000

Sebastian Lugg: sebastian.lugg@nhs.net

Kerry Adams: kerry.adams@heartofengland.nhs.uk

Tom Smith: tom_smith@yahoo.co.uk

Maninder Kalkat: maninder.kalkat@heartofengland.nhs.uk

Pala Rajesh: p_rajesh51@yahoo.com

Richard Steyn: richard.steyn@heartofengland.nhs.uk

Babu Naidu: babu.naidu@heartofengland.nhs.uk

Alison Rushton: A.B.Rushton@bham.ac.uk

Ehab Bishay ehab.bishay@heartofengland.nhs.uk

Abstract

Objectives: Following major thoracic surgery physiotherapy is recommended to improve reduced lung volume, aid secretion clearance, and improve mobility, however, in many centres physiotherapy provision is variable following minimally invasive Video-Assisted Thoracoscopic Surgery (VATS). The objective of this study was to observe frequency of problems potentially amenable to physiotherapy following VATS lobectomy, and to identify associated baseline factors of patients in whom physiotherapy may be beneficial.

Methods: A prospective observational study was performed including all consecutive cancer patients undergoing VATS lobectomy in a regional centre over 4 years (2012-2016). Standard postoperative care included early mobilisation by nursing staff from postoperative day 1 (POD1). Physiotherapy assessment of all patients on POD1 determined presence of issues potentially amenable to physiotherapy intervention, and treatment was commenced. Outcome measures included postoperative pulmonary complication (PPC) development, hospital and high dependency unit (HDU) length of stay (LOS).

Results: Of 285 patients, 209 (73%) received physiotherapy to assist/improve reduced mobility, of these 23 (8%) also received sputum clearance therapies and 65 (23%) specific therapy for lung volume loss. The remaining 76 (27%) patients had significantly lower hospital/ HDU LOS ($p < 0.001$) reflecting uncomplicated recovery. Chronic obstructive

pulmonary disease (COPD), body mass index (BMI), preoperative mobility and age were independently associated with issues potentially amenable to physiotherapy ($p=0.013$).

Conclusion: Following VATS lobectomy a large proportion of patients demonstrated issues potentially amenable to physiotherapy. We recommend that patients receive routine physiotherapy assessment following this type of surgery to ensure that all issues are identified early. Screening of COPD, BMI, preoperative mobility and age will allow early identification of patients who may benefit most from postoperative physiotherapy and preoperative optimisation, however, these factors cannot predict the need for physiotherapy.

Introduction

Video-assisted thoracoscopic surgery (VATS) is being increasingly performed for early stage non-small cell lung cancer (NSCLC) instead of open thoracotomy because of its minimally invasive nature [1]. VATS lobectomy has been found to reduce hospital length of stay (LOS) [2, 3] and postoperative pain [4]. However, postoperative pulmonary complications (PPC), including pneumonia and clinically significant atelectasis after VATS lobectomy affect 7% of patients. The development of PPC is associated with increased physiotherapy requirements [5], and smoking has been found to be the major risk factor [6].

Postoperative physiotherapy aims to improve reduced lung volume, aid clearance of secretions, and improve mobility, thus minimising the development of PPC. Postoperative physiotherapy is therefore recommended in Europe following major thoracic surgery [7]. and in practice some patients receive no routine intervention. Those undergoing VATS

lobectomy are similar in their baseline characteristics to their historical counterparts undergoing thoracotomy [5] including the extent of co-morbidities, smoking status and exercise tolerance, and may include octogenarians. It is entirely possible that many of these patients will therefore have pulmonary and mobility issues potentially amenable to physiotherapy similar to those undergoing thoracotomy.

The aim of this study was to identify baseline factors associated with problems potentially amenable to physiotherapy intervention following VATS lobectomy, thus identifying if and in whom physiotherapy may be beneficial.

Materials and Methods

This prospective observational study was conducted at a single-centre large regional thoracic surgical unit serving six million people. Consecutive cancer patients who underwent video-assisted thoracoscopic surgery (VATS) lobectomy between January 2012 and January 2016 were included. Decisions regarding patient operability and resectability were informed by the British Thoracic Society guidelines for lung cancer resection [8].

VATS was defined as the use of a utility incision, without rib-spreading, two further port incisions and use of a thoracoscope to visualise the anatomical hilar dissection (as defined by Swanson et al) [9]. Decisions regarding surgical approach by VATS rather than thoracotomy were as previously described [5], including cases of N1 involvement, previous neoadjuvant chemo/radio therapy, visibility of the tumour at bronchoscopy requiring hand sewn bronchial stump closure, and bi-lobectomy where tumours crossed fissures. Cases

where patients were undergoing re-do procedures, such as completion lobectomy were excluded.

Patients were admitted to hospital on the day of surgery. All operations were performed with single lung ventilation under general anaesthesia, and patients were subsequently scheduled for extubation in the operating room. Postoperatively, patients were managed in a dedicated thoracic high-dependency unit (HDU) (level 2) and/or the thoracic surgery ward unless complications required their admission to the intensive therapy unit (ITU). Postoperative pain control was achieved by continuous thoracic epidural analgesia, paravertebral infusion or systemic opioids (parenteral administration or intravenous patient-controlled administration). The choice of analgesic technique was made by the anaesthetist after discussion with the patient. Standard postoperative care also included nursing staff sitting patients out of bed on postoperative day 1 (POD1) and from that point starting early mobilisation with patients as able, with safety assistance as necessary for surgical attachments.

On POD1 all patients were assessed by a physiotherapist specialist to working in the area of thoracic surgery to determine the presence of atelectasis, sputum retention, or reduced mobility/ exercise tolerance which are all issues amenable to physiotherapy intervention (for which physiotherapy is indicated). Physiotherapy treatment/exercise was then commenced as necessary in the relevant patients to clear secretions, improve lung volume or for specific mobility issues; to both increase reduced physical activity level beyond that achieved with standard care, and to regain former levels of function where applicable. If physiotherapy was not deemed necessary patients continued with standard postoperative care. When pulmonary complications developed physiotherapy input was escalated as

appropriate. All patients received physiotherapy until resolution of pulmonary issues, and/or usual mobility independence and exercise tolerance were restored.

Data collected included demographics and preoperative record of smoking status, body mass index (BMI), percentage predicted FEV₁, American Society of Anesthetists (ASA) score, subjective preoperative activity level, which is the self-reported pre-operative walking distance measured in meters. Other comorbidities including chronic obstructive pulmonary disease (COPD) defined by clinical diagnosis of the referring clinician were reported. Postoperative data included type of analgesia used and underlying pathology (including lung cancer staging). Total length of stay (LOS) was defined as the LOS in hospital after the date of surgery. The HDU LOS was also recorded, as well as ITU admission and in-hospital mortality.

PPC frequency was observed and identified using the Melbourne Group Scale (MGS), which is a standardised scoring system validated by our group to define the presence of a PPC, such as pneumonia or clinically significant atelectasis, likely to adversely affect the patient's clinical course [5, 10]. PPC is defined in those patients presenting with four or more of the following eight dichotomous factors: chest X-ray (CXR) findings of atelectasis or consolidation; raised white cell count (WCC) ($>11.2 \times 10^9/L$); temperature $>38^\circ C$; signs of infection on sputum microbiology; purulent sputum differing from preoperative status; oxygen saturations $<90\%$ on room air; physician diagnosis of pneumonia; and prolonged HDU stay or readmission to HDU or ITU for respiratory complications. From POD1 the MGS variables were collected daily by the specialist physiotherapists.

This study was conducted with the approval of the National Research Ethics Service (NRES) Committee West Midlands. This study was registered with the Birmingham Heartlands Hospital audit department (audit code 1672).

Statistical analysis

Normally distributed continuous variables are expressed as mean (SD), skewed continuous variables as median (interquartile range), and categorical variables as actual number (percentage). Normality of distributions was assessed using the Kolmogorov-Smirnov test. Differences in baseline demographics, risk factors and outcomes were tested for using Chi-square, Fisher's exact, independent samples t-tests and Mann-Whitney U tests; p-values <0.05 were considered significant. Forward stepwise logistic regression was performed to estimate odds ratios and their 95% CIs of variables associated with POD1 issues potentially amenable to physiotherapy. Goodness-of-fit was assessed by the Hosmer and Lemeshow chi-square test. The sensitivity and specificity of the model were calculated from the percentage accuracy in classification after application of the model. Analysis was performed using IBM Statistics SPSS Version 22.

Results

Over 4 years 287 cancer patients underwent lobectomy using a VATS approach; 2 patients were subsequently excluded as they underwent re-do procedures/completion lobectomy. Of all patients (n=285); 137 were male (48%), with a median (IQR) age of 69 years (13) and mean (SD) FEV₁ of 87% (19). In terms of our previously identified risk factors, 73 (26%) patients were ≥75 years old, 144 (51%) patients had ASA score ≥3, 63 (22%) patients had BMI ≥30, 84 (30%) patients had a history of COPD and 60 (21%) patients were current

smokers. There were 43 (15%) patients that had a self-reported restricted preoperative mobility of <400m. Analgesia was administered by epidural in 27 (9%) patients, paravertebral infusion in 233 (82%) patients, patient controlled analgesia in 22 (8%) patients and morphine infusion in 3 (1%) patients. Of the 285 patients, 258 (91%) patients were diagnosed with primary lung cancer, and 27 (9%) metastatic disease. Of patients with primary lung cancer, the staging was IA in 116 (45%) patients, IB in 84 (32%) patients, IIA in 40 (16%) patients, IIB in 6 (2%) patients and IIIA in 12 (5%) patients.

Early mobility and Physiotherapy

Following assessment, physiotherapy for mobility or pulmonary issues was not required in 76 (27%) patients who only required standard nursing care to facilitate successful early mobilisation; these patients either only required 1 member of nursing staff to mobilise or were independent. Patients that did not require physiotherapy had both shorter hospital and HDU LOS compared to those that did require physiotherapy, reflecting a fast, uncomplicated recovery (Table 2). The remaining 209 (73%) patients had reduced postoperative mobility and/or had oxygen desaturation on exercise due to pulmonary issues deemed amenable to physiotherapy. Specific pulmonary physiotherapy interventions for established sputum retention or lung volume loss (with associated clinical signs/deterioration) were given to relatively few of the 209 patients, 65 (23%) received lung expansion intervention (incentive spirometry) for specific and symptomatic atelectasis, with 23 (8%) of this group also found to have sputum retention. Patients with sputum retention received chest physiotherapy specific to sputum clearance for example manual and breathing techniques, in some cases suction via minitracheostomy needed to be performed (within the ward environment rather than intensive care based suction). 21 (7%) patients

developed PPC and were amongst those requiring pulmonary treatments, also all those admitted to ITU (6, 2 %) were amongst those requiring physiotherapy.

A median of 4 physiotherapy sessions were given to those who received physiotherapy, with a median (IQR) of 90 (65) minutes in total spent with each patient. The median (IQR) number of physiotherapists involved in each patient's treatment was 6 (4) as some patients required assistance of 2 for mobility as dictated by surgical attachments and/or portable oxygen and patient stability/safety.

Factors associated with issues amenable to physiotherapy

Univariate analysis compared baseline factors of those who were and those who were not assessed as having postoperative issues potentially amenable to physiotherapy (Table 3). Forward stepwise logistic regression was performed to identify any significant baseline variables independently associated. The model correctly classified 73% of patients with issues amenable to physiotherapy. Nagelkerke R^2 values demonstrated that the variables explained between 10% and 14% of the outcome, with goodness-of-fit χ^2 remaining non-significant through the steps. A significant contribution to the model was made by age, COPD, BMI and restricted pre-op mobility (Table 4). The odds ratios are all positive, indicating the variables selected are associated with issues amenable to physiotherapy intervention. The 95% CIs do not cross 1 indicating that as the predictor variable increases in value so do the odds of requiring physiotherapy for sputum retention, atelectasis, or reduced exercise tolerance/ postoperative mobility.

If factors including age (≥ 75 years), COPD, BMI (≥ 30) and restricted pre-op mobility ($< 400\text{m}$), PPC and ITU admission were used to identify patients may have issues potentially amenable

to physiotherapy in this cohort, 215 patients of the 285 would have been identified. Of the 215 identified, 177 actually demonstrated issues potentially amenable to physiotherapy, according to their POD1 assessment, and 38 did not; sensitivity of the criteria used was therefore good at 82%. The remaining 70 patients, who would not have been identified as potentially needing physiotherapy with these criteria actually included 38 patients with relevant mobility and pulmonary issues, giving a low specificity of 46%.

Discussion

VATS is used because of its minimally invasive approach over open thoracotomy and its association with a quicker return to normal activity, even in frail/high-risk patients [11]. Despite this, our study has demonstrated that in VATS lobectomy patients mobility/exercise tolerance issues potentially amenable to physiotherapy were present in 3 out of 4 patients, with 1 in 3 of those also receiving specific pulmonary therapy for sputum retention or atelectasis. Issues potentially amenable to physiotherapy were identified in all patients requiring ITU admission (either before, during or after ITU stay) and in those who went on to develop a PPC. Issues potentially amenable to physiotherapy may be frequent in this particular type of VATS patient (VATS lobectomy) because the demographic, as demonstrated by this cohort, includes relatively frequent characteristics of COPD, current smoking, co-morbidities and elderly patients. The demographic for other more minor procedures undertaken by VATS may be quite different, and less 'high risk'.

In routine practice there is widespread postoperative physiotherapy provision after open thoracotomy for lung surgery throughout the UK [12], Australia and New Zealand [13],

however early postoperative mobility after open thoracotomy is associated with minimal morbidity and mortality with high satisfaction of patients [4, 14]. A previous cross-sectional study with historical controls demonstrated the benefit of postoperative physiotherapy regimen by reducing the incidence of atelectasis (1.7% vs 7.7%) and LOS (5.7 vs 8.3 days) in a mixed group of patients receiving either open thoracotomy or video-assisted small axillary thoracotomy lobectomy (n=639) [15]; though this study was performed before the increasing use of VATS approach for lobectomy over the last decade. A more recent randomised controlled trial in patients undergoing lobectomy, found a significant difference in physical activity in those who received postoperative physiotherapy [16], however only 1 in 5 patients underwent VATS rather than thoracotomy. Despite relatively little empirical research, recommendations by the European Association of Cardiothoracic Surgery (EACTS) and the European Society of Thoracic Surgery (ESTS) have long supported routine physiotherapy provision following thoracic surgery [7] and it has recently been recommended in the guidelines for Enhanced Recovery After Lung Surgery (ERAS) [17].. There are, however no studies which have investigated the frequency of pulmonary and mobility issues amenable to postoperative physiotherapy in a cohort exclusive to VATS approach.

Despite patients undergoing minimally invasive surgery, the majority of VATS lobectomy patients in this study presented with postoperative mobility/ pulmonary issues amenable to physiotherapy. Because of the routine nature of physiotherapy assessment on POD1 not only were these issues identified swiftly but physiotherapy to ameliorate the issues was commenced immediately. With the frequency of such issues high, it may be prudent to routinely provide a physiotherapy assessment to all VATS lobectomy patients on POD1,

ensuring early identification and intervention for postoperative mobility/ pulmonary issues, thus enhancing physical activity achieved in early mobility care pathways. The predictive factors, with the addition of ITU admission and presence of PPC, could be used to guide physiotherapy practice, however, this method alone may miss some patients who have issues amenable to physiotherapy (owing to low specificity), adding more weight to the recommendation for routine assessment.

The incidence of PPC in VATS patients (7%) in our study group is supported in other studies which when looking at the specific development of pneumonia and atelectasis found incidences of 3 to 7.5% [18 - 20] and 3 to 13.6% [21, 22] respectively. VATS patients who developed a PPC had a significantly worse short term outcome demonstrated by increases in ITU admission, and significantly increased hospital LOS. Furthermore, VATS patients who developed PPC were identified as having more sputum retention and loss of lung volume potentially amenable to physiotherapy, and were given specific respiratory physiotherapy with the aim of ameliorating related symptoms. Physiotherapy has shown benefit in thoracotomy patients to reduce PPC; a large, quasi-experimental study (n=784), which excluded VATS cases, demonstrated reduction in PPC using a similar physiotherapy protocol (15.5% before vs 4.7% after; $p < 0.001$)[23]. Postoperative respiratory physiotherapy after thoracotomy and lung resection in addition to early mobilisation, pain relief, and a standardised clinical pathway failed to demonstrate benefit in another study, although the relevance of this study's findings are limited by the low frequency of PPC and small numbers (3.8% (n=3) [24]. Another study looking at NSCLC patients after open thoracotomy and lung resection (n=53) found that the provision of postoperative exercise including strength and mobility training program in addition to respiratory physiotherapy and mobilisation had no

effect on the PPC frequency (7.4% in intervention vs 11.5% in control) [25]. A limitation of the study however numbers was that the numbers were small and PPC definition only included the most severe pulmonary complications, including the need for ventilation.

The 1 in 4 patients who did not require physiotherapy were independent, had no pulmonary complications, and had an uncomplicated recovery period, as evidenced by a significantly shorter hospital length of stay when compared to those with identified postoperative mobility and pulmonary complication. We have demonstrated for the first time that preoperative factors associated with postoperative issues potentially amenable to physiotherapy following VATS lobectomy were increasing age, COPD diagnosis, limitation in preoperative mobility <400m and BMI ≥ 30 . Patients ≥ 75 years have previously been shown to be at risk of developing PPC following thoracotomy and lung resection [26], though more recent study showed age not be a risk factor in a mixed VATS/thoracotomy group of patients [27]. Thus, inclusion of age as a risk factor may be dependent on the methodology, and though significant in this study, the confidence limits are small with an odds ratio of 1, suggesting the risk is small. Patients with COPD diagnosis, however, are twice more likely to develop issues potentially requiring physiotherapy following VATS lobectomy. In patients undergoing lung resection via open thoracotomy, COPD diagnosis has previously been shown to be a risk for PPC development (more so than percentage predicted FEV₁) [28], the reason for this is most likely an increase in atelectasis and sputum retention associated with loss of elasticity and increased preoperative secretion volume. Restricted preoperative mobility (<400m) has also been shown to be associated with issues potentially amenable to physiotherapy as well as being an important indicator for postoperative outcome. A previous study shows that restricted preoperative activity (<400m) in thoracotomy and lung

resection patients was associated with significantly reduced postoperative physical activity (as measured with accelerometers over PODs 2 and 3), longer LOS (6 vs 5 days; $p = 0.013$) and higher frequency of PPC (20% vs 4%; $p=0.034$) [29]. Finally we found BMI ≥ 30 was also independently associated with issues potentially amenable to physiotherapy regardless of possible limited preoperative mobility often seen in obese patients; this may be because these patients are at higher risk of PPC due to restrictive pulmonary patterns and postoperative mobility issues [26].

Some of the predictive factors identified are arguably modifiable, such as those patients with COPD and reduced preoperative activity. Optimisation before surgery may be of importance in these patients, objectives to improve pulmonary function and address/highlight mobility issues, with the aim of reducing postoperative LOS and incidence of PPC. Pre-operative exercise known as 'prehab' (in the style of pulmonary rehabilitation classes) is a strategy for such optimisation; improvements in the quantity of daily activity following pulmonary rehabilitation have been described [30], and there is evidence suggesting benefit of prehab, especially to high risk groups [31], in terms of improved exercise capacity prior to surgery [32-34]. Best evidence reports on prehab prior to major thoracic surgery for lung resection found improvements in exercise capacity and preservation of pulmonary function, however, whether this might translate to reduction in PPC, studies conflicted [35]. The most recent ERAS guidelines for thoracic surgery state that patients with poor physical capacity have the most to gain from prehab [17].

Conclusions

Despite patients undergoing minimally invasive surgery, a large proportion of VATS lobectomy patients in this study presented with some limitation to postoperative mobility, some also with pulmonary issues amenable to physiotherapy interventions. Age, COPD, limitation to preoperative mobility and BMI were found to be associated with the development of these issues. Preoperative optimisation, such as pulmonary rehabilitation to improve preoperative respiratory function and activity/mobility warrants further investigation upon outcomes in this group of patients. The predictive factors could be used to guide physiotherapy practice towards higher risk patients, however, they may not correctly identify every patient with issues amenable to physiotherapy. We therefore recommend that following VATS lobectomy all patients receive routine postoperative physiotherapy assessment to correctly identify issues early.

Ethics approval: The study received ethics approval by the National Research Ethics Service (NRES) Committee West Midlands, Edgbaston. REC ethics approval reference: 10/H1208/41

Funding: none

Declarations of interest: none

Ethics approval: The study received ethics approval by the National Research Ethics Service (NRES) Committee West Midlands, Edgbaston. REC ethics approval reference: 10/H1208/41

References

1. Howington JA, Blum MG, Chang AC, Balekian AA, Murthy SC *Treatment of stage I and II non-small cell lung cancer: Diagnosis and management of lung cancer, 3rd ed: American College of Chest Physicians evidence-based clinical practice guidelines*. Chest, 2013. **143**(5 Suppl):e278S-313S.
2. Paul S, Altorki NK, Sheng S, Lee PC, Harpole DH, Onaitis MW, et al. *Thoracoscopic lobectomy is associated with lower morbidity than open lobectomy: a propensity-matched analysis from the STS database*. J Thorac Cardiovasc Surg, 2010. **139**(2):366-78.
3. Villamizar NR, Darrabie MD, Burfeind WR, Petersen RP, Onaitis MW, Toloza E, et al. *Thoracoscopic lobectomy is associated with lower morbidity compared with thoracotomy*. J Thorac Cardiovasc Surg, 2009. **138**(2):419-25.
4. Bagan P, Coimbra-Israel AP, Grimaillof-Junior A, Cesar-Lopez G, Milanez-de-Campos JR, Das-Neves-Pereira JC, et al. *Fast-track rehabilitation for lung cancer lobectomy: a five-year experience*. Eur J Cardiothorac Surg, 2009. **36**(2):383-91; discussion 391-2.
5. Agostini P, Lugg ST, Adams K, Vartsaba N, Kalkat MS, Rajesh PB, et al. *Postoperative pulmonary complications and rehabilitation requirements following lobectomy: a propensity score matched study of patients undergoing video-assisted thoracoscopic surgery versus thoracotomy*. *Interactive Cardiovascular and Thoracic Surgery* 2017 1-7.
6. Agostini PJ, Lugg ST, Adams K, Smith T, Kalkat MS, Rajesh PB, et al. *Risk factors and short-term outcomes of postoperative pulmonary complications after VATS lobectomy*. *Journal of Cardiothoracic Surgery*. Manuscript in press.
7. Klepetko W, Aberg TH, Lerut AE, Grodzki T, Velly JF, Walker WS, et al. *Structure of general thoracic surgery in Europe*. Eur J Cardiothorac Surg, 2001. **20**(4):663-8.
8. Lim E, Baldwin D, Beckles M, Duffy J, Entwisle J, Faivre-Finn C, et al. *Guidelines on the radical management of patients with lung cancer*. Thorax, 2010. **65 Suppl 3**:iii1-27.
9. Swanson SJ, Herndon JE 2nd, D'Amico TA, Demmy TL, McKenna RJ Jr, Green MR, et al. *Video-assisted thoracic surgery lobectomy: report of CALGB 39802--a prospective, multi-institution feasibility study*. J Clin Oncol, 2007. **25**(31):4993-7.
10. Agostini P, Naidu B, Cieslik H, Rathinam S, Bishay E, Kalkat MS, et al. *Comparison of recognition tools for postoperative pulmonary complications following thoracotomy*. Physiotherapy, 2011. **97**(4):278-83.
11. Demmy TL, Curtis JJ. *Minimally invasive lobectomy directed toward frail and high-risk patients: a case-control study*. Ann Thorac Surg, 1999. **68**(1):194-200.
12. Agostini P, Reeve J, Dromard S, Singh S, Steyn RS, Naidu B. *A survey of physiotherapeutic provision for patients undergoing thoracic surgery in the U.K*. Physiotherapy, 2013. **99**(1):56-62.
13. 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**(2):59-71.
14. Cerfolio RJ, Pickens A, Bass C, Katholi C. *Fast-tracking pulmonary resections*. J Thorac Cardiovasc Surg, 2001. **122**(2):318-24.
15. Varela G, Ballesteros E, Jiménez MF, Novoa N, Aranda JL, et al. *Cost-effectiveness analysis of prophylactic respiratory physiotherapy in pulmonary lobectomy*. Eur J Cardiothorac Surg, 2006. **29**(2):16-20.
16. Jonsson M, Hurtig-Wennlöf A, Ahlsson A, Vidlund M, Cao, Y, Westerdahl E. *In-hospital physiotherapy improves physical activity level after lung cancer surgery: a randomized controlled trial*. Physiotherapy, 2018. Manuscript in press. doi:10.1016/j.physio.2018.11.001
17. Batchelor TJP, Rasburn NJ, Abdelnour-Berchtold E, Brunelli A, Cerfolio RJ, Gonzalez M, et al. *Guidelines for enhanced recovery after lung surgery: recommendations of the Enhanced*

- Recovery After Surgery (ERAS®) Society and the European Society of Thoracic Surgeons (ESTS). *Eur J Cardiothorac Surg*. 2018. doi: 10.1093/ejcts/ezy301.
18. Yang CJ, Meyerhoff RR, Mayne NR, Singhapricha T, Toomey CB, Speicher PJ, et al. *Long-term survival following open versus thoracoscopic lobectomy after preoperative chemotherapy for non-small cell lung cancer*. *Eur J Cardiothorac Surg*, 2016. **49**(6):1615-23.
 19. Laursen LØ, Petersen RH, Hansen HJ, Jensen TK, Ravn J, Konge L. *Video-assisted thoracoscopic surgery lobectomy for lung cancer is associated with a lower 30-day morbidity compared with lobectomy by thoracotomy*. *Eur J Cardiothorac Surg*, 2016. **49**(3):870-5.
 20. Cao C, Manganas C, Ang SC, Peeceeyen S, Yan TD. *Video-assisted thoracic surgery versus open thoracotomy for non-small cell lung cancer: a meta-analysis of propensity score-matched patients*. *Interact Cardiovasc Thorac Surg*, 2013. **16**(3):244-9.
 21. Paul S, Sedrakyan A, Chiu YL, Nasar A, Port JL, Lee PC, et al. *Outcomes after lobectomy using thoracoscopy vs thoracotomy: a comparative effectiveness analysis utilizing the Nationwide Inpatient Sample database*. *Eur J Cardiothorac Surg*, 2013. **43**(4):813-7.
 22. Wang, Z, Zhang J, Cheng Z, Li X, Wang Z, Liu C, et al. *Factors affecting major morbidity after video-assisted thoracic surgery for lung cancer*. *J Surg Res*, 2014. **192**(2):628-34.
 23. Novoa N, Ballesteros E, Jiménez 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**(1):130-4.
 24. Reeve JC, Nicol K, Stiller K, McPherson KM, Birch P, Gordon IR, 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**(5):1158-66.
 25. Arbane G, Tropman D, Jackson D, Garrod R. *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. **71**(2):229-34.
 26. Agostini P, Cieslik H, Rathinam S, Bishay E, Kalkat MS, Rajesh PB, et al. *Postoperative pulmonary complications following thoracic surgery: are there any modifiable risk factors?* *Thorax*, 2010. **65**(9):815-8.
 27. Lugg ST, Agostini PJ, Tikka T, Kerr A, Adams K, Bishay E, et al. *Long-term impact of developing a postoperative pulmonary complication after lung surgery*. *Thorax*, 2016. **71**(2):171-6.
 28. Agostini P, Naidu B, Cieslik H, Steyn R, Rajesh PB, Bishay E, et al. *Effectiveness of incentive spirometry in patients following thoracotomy and lung resection including those at high risk for developing pulmonary complications*. *Thorax*, 2013. **68**(6):580-5.
 29. Agostini PJ, Naidu B, Rajesh P, Steyn R, Bishay E, Kalkat M, et al. *Potentially modifiable factors contribute to limitation in physical activity following thoracotomy and lung resection: a prospective observational study*. *J Cardiothorac Surg*, 2014. **9**:128.
 30. Sewell L, Singh SJ, Williams JEA, Collier R, Morgan MDL. *Can individualised rehabilitation improve functional independence in elderly patients with COPD?* *Chest*, 2005. **128**(3), 1194-200.
 31. 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**(2):139-53.
 32. 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*. *European Journal of Cardiothoracic Surgery*, 2008. **33**:95-98.
 33. Jones LAW, 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*. 2007. *Cancer* **110**(3):590-598.
 34. 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**(1):118-119.

35. Nagarajan K, Bennett A, Agostini P, Naidu B. *Is preoperative physiotherapy/pulmonary rehabilitation beneficial in lung resection patients?* Interact Cardiovasc Thorac Surg, 2011. **13**(3):300-2.

ACCEPTED MANUSCRIPT

Table 1. Details of postoperative early mobilisation

Early mobility	All included patients (n=285)
POD1 Unable to sit out	10 (4%)
POD1 sat out but unable to mobilise	32 (11%)
Independent mobility/with nursing assistance	70 (25%)
POD1 Distance walked <10m with physiotherapist(s)	5 (2%)
POD1 Distance walked ≥10m with physiotherapist(s)	168 (59%)

POD1, postoperative day 1

Table 2. Length of stay, ITU admission and PPC frequency for treated and none treated patients.

	Not treated (n=76)	Treated (n=209)	p value
Hospital LOS (days) median (IQR)	3 (2)	4 (3)	<0.001
HDU LOS (days) median (IQR)	1 (1)	2 (1)	0.004
ITU admission	0	6 (3%)	0.347
PPC Frequency	0	21 (10%)	0.002

LOS, length of stay; HDU, high dependency unit

Table 3. Baseline characteristics for patients with and without issues potentially amenable to physiotherapy

	No issues (n=76)	Issues identified (n=209)	p value
Mean (SD) age (years)	64 (11)	69 (8)	
Median (IQR) age (years)	67 (16)	70 (11)	0.006
Age ≥75 years (%)	15 (20%)	60 (29%)	0.165
ASA score ≥3 (%)	25(33%)	119 (57%)	0.001
BMI ≥30 (%)	12 (16%)	51 (24%)	0.16
Median BMI (IQR)	25.5 (5.8)	26.4 (6.3)	0.05
COPD Diagnosis (%)	11 (14%)	73 (34%)	0.009
Current smokers (%)	17(22%)	43 (21%)	0.87
Pre-op mobility (<400m)	12 (16%)	72 (34%)	0.004

ASA, American Society of Anaesthesiologists; BMI, body mass index; COPD, chronic obstructive pulmonary disease

Table 4. Predictive factors for issues amenable to physiotherapy

	Odds Ratio	95% CI	p value
Age	1.0	1.0 – 1.1	<0.001
COPD	2.3	1.1 – 4.7	0.02
BMI (≥ 30)	2.2	1.0 – 4.6	0.04
Pre-op mobility (<400m)	2.0	1.0 – 4.1	0.05

BMI, body mass index; COPD, chronic obstructive pulmonary disease