A Pilot Study of the Incidence of Post-thoracotomy Pulmonary Complications and the Effectiveness of Pre-thoracotomy Physiotherapy Patient Education

Julie C. Reid, Anne Jamieson, Jennifer Bond, Bashir M. Versi, Arpit Nagar, Bernard H.K. Ng, Julie D. Moreland

ABSTRACT

Purpose: To estimate the incidence and examine the pattern of post-thoracotomy pulmonary complications (PPC) that are amenable to physiotherapy treatment and to estimate the effect size of a pre-thoracotomy physiotherapy education session compared to no preoperative physiotherapy for reducing PPC.

Methods: Forty-two patients undergoing thoracotomy participated in this two-group retrospective-prospective cohort study. The preop group ($n = 22$) received physiotherapy education prior to surgery and the no preop group ($n = 20$) did not receive preoperative physiotherapy education. Chest radiographs were examined for PPC for 5 days postoperatively. Incidences of PPC were determined. The effect size was based on a grand count of PPC.

Results: The 5-day incidence of atelectasis, collapse, consolidation, and other complications was 85.0%, 39.0%, 31.7%, and 38.1%, respectively. Patterns of PPC showed large increases at days 2 and 3. The effect size for pre-thoracotomy physiotherapy education was zero.

Conclusions: In our sample, incidence of PPC was high and did not substantially differ based on whether or not preoperative education was provided.

Key Words: education, postoperative pulmonary complications, preoperative physiotherapy, thoracotomy

Reid JC, Jamieson A, Bond J, Versi BM, Nagar A, Ng BHK, Moreland JD. 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.

RÉSUMÉ

Objectif : Évaluer l'incidence et analyser le modèle des complications postopératoires pulmonaires (CPP) à la suite d'une thoracotomie dans les cas soumis à des traitements de physiothérapie; évaluer la valeur de l'effet d'une séance de physiothérapie éducative préopératoire comparativement à aucun traitement de physiothérapie visant à réduire les CPP avant l'intervention.

Méthodes : Quarante-deux patients subissant une thoracotomie ont formé la cohorte de cette étude rétrospective-prospective à deux groupes. Le groupe préopératoire ($n = 22$) a reçu des traitements de physiothérapie éducative avant l'intervention, alors que le groupe non préopératoire ($n = 20$) n'en a reçu aucun. Des radiographies thoraciques ont été examinées afin de détecter toute CPP dans les cinq jours suivant l'intervention. Les incidences de CPP ont été établies. La valeur de l'effet était basée sur un dénombrement total des CPP.

Résultats : Après cinq jours, les incidences d'atélectasie, de collapsus cardiovasculaire, de consolidation et d'autres complications étaient de 85,0 %, de 39,0 %, de 31,7 % et de 38,1 %, respectivement. Les modèles de CPP ont été marqués par des augmentations appréciables aux jours deux et trois. La valeur de l'effet de la physiothérapie en préthoracotomie était donc de zéro.

Conclusions : Dans notre échantillon, les incidences de CPP ont été élevées et ne différaient pas substantiellement en fonction du fait qu'une éducation préopératoire était offerte ou non.

Mots clés : complications postopératoires pulmonaires, éducation, physiothérapie préopératoire, thoracotomie

There are no conflicts of interest with any of the authors of this study.

The research described in this article was carried out in the physiotherapy department of St. Joseph's Healthcare Hamilton, Hamilton, Ontario.

Julie C. Reid, MSc (PT): Physiotherapist, Intensive Care Unit, Hamilton General Hospital, Hamilton, Ontario.

Anne Jamieson, MSc (PT): Physiotherapist, Grand River Physiotherapy, Fergus, Ontario.

Jennifer Bond, MSc (PT): Physiotherapist, Royal Jubilee Hospital, Victoria, British Columbia.

Bashir M. Versi, MSc (PT): Physiotherapist, St. Joseph's Healthcare Hamilton, Hamilton, Ontario.

Arpit Nagar, MD: Fellow, Radiology Department, St. Joseph's Healthcare Hamilton, Hamilton, Ontario.

Bernard H.K. Ng, MD: Fellow, Radiology Department, St. Joseph's Healthcare Hamilton, Hamilton, Ontario.

Julie D. Moreland, BHSc (PT), MSc: Research Therapist, Physiotherapy Department, St. Joseph's Healthcare Hamilton, Hamilton, Ontario; Associate Clinical Professor, McMaster University, Hamilton, Ontario.

Address correspondence to *Julie Reid*, Hamilton Health Sciences – Hamilton General Site, Rehabilitation Services, 237 Barton Street East, Hamilton, ON L8L 2X2 Canada; Tel.: 905-467-0498; E-mail: reidju@hhsc.ca.

DOI:10.3138/physio.62.1.66

INTRODUCTION

Thoracotomy is the most frequently used open procedure in thoracic surgery and is performed primarily for lung resections and lobectomies secondary to cancer.^{1,2} This is an extremely invasive procedure with the inherent risk of multiple postoperative complications.^{1,3}

Pulmonary complications are a common sequela of surgery in general,⁴ but can be particularly frequent and unrelenting following thoracotomy.^{1,2,5–7} Common postoperative pulmonary complications (PPC) include atelectasis, pulmonary collapse, consolidation, pleural effusions, persistent air leaks, and pneumonia.¹ Other frequently observed post-surgical complications are post-thoracotomy pain syndrome and ipsilateral reductions in upper-extremity range of motion (ROM) and strength.^{1,6–8} These problems, while not of a respiratory nature, can indirectly influence pulmonary status via their impact on the ability to move, breathe, and cough, leading to ineffective management and clearing of secretions.^{1,6,7} The incidence of PPC following thoracotomy has been reported to be anywhere between 2% and 75% in the literature.^{7–10}

Acute-care physiotherapists perform a variety of functions in the care of patients undergoing surgery, from the preoperative period up until postoperative discharge.⁷ Vital to this patient population is the prevention and resolution of PPC, wherein lies a distinct role for physiotherapists.⁷ Through such interventions as education, deep breathing and coughing manoeuvres, chest physiotherapy, and early mobilization, it may be possible to prevent PPC or lessen their impact on recovery.^{7,11} Although physiotherapy interventions cannot prevent or treat PPC such as pneumothorax and pulmonary edema, postoperative secretion mobilization and clearance techniques have been shown to be effective in improving atelectasis, pulmonary collapse, and consolidation.^{12–14}

There is increasing interest in investigating the effectiveness of preoperative physiotherapy.^{3,7,14,15} Active interventions such as preoperative walking, cycle ergometry, respiratory muscle strengthening (via inspiratory muscle trainer), and incentive spirometry have been found to reduce the incidence of PPC in populations undergoing lung resection via thoracotomy, as well as in patients undergoing cardiac surgery.^{3,14,15} This preoperative intervention is costly, however, and in some centres preoperative physiotherapy is limited to an assessment and education session. During these sessions, instructions may be given for deep breathing and splinted coughing exercises, prophylaxis exercises for deep vein thrombosis, and shoulder ROM exercises. The premise is that preoperative education will enable patients to effectively start their exercise programme as soon as possible following surgery and will provide an opportunity to address any preoperative concerns or anxiety. In the absence of preoperative teaching, patients' ability to learn the programme postoperatively may be compro-

mised by pain and medications. The effectiveness of preoperative physiotherapy education has not been studied in patients undergoing thoracotomy.

To prepare for a larger study of the effectiveness of pre-thoracotomy physiotherapy education, the objectives of the current study were (1) to estimate the incidence and pattern of post-thoracotomy pulmonary complications—specifically, atelectasis, consolidation, and pulmonary collapse; (2) to obtain an estimate of the effect size of the impact of preoperative physiotherapy education for the reduction of these complications by comparing a group of patients who received preoperative physiotherapy education (retrospective group) to a group that did not receive preoperative physiotherapy education (prospective group); and (3) to examine hospital length of stay according to whether or not preoperative education was given.

METHODS

This was a two-group retrospective–prospective cohort study. To achieve the objectives, and given the feasibility of recruitment and the available time period, the target sample size was limited to 20 patients per group. Inclusion criteria were as follows: thoracotomy for the purposes of lobectomy (partial or total), pneumonectomy, or esophagectomy; age >18 years; and the ability to speak and understand English. From December 2007 through June 2008 a sample of 42 patients was recruited from St. Joseph's Healthcare Hamilton in Hamilton, Ontario. The *preop group* (retrospective phase) consisted of patients who had received preoperative physiotherapy education, and data were gathered via a retrospective chart review. The *no preop group* (prospective phase) did not receive preoperative physiotherapy education, and data were gathered prospectively on these individuals. Ethics approval was obtained from St. Joseph's Healthcare Hamilton Research Ethics Board. Patients in the no preop group provided informed consent.

Preop Group—Received Preoperative Physiotherapy Education

All 22 patients who had undergone thoracotomy at St. Joseph's Healthcare Hamilton between December 2007 and February 2008 were identified from medical records. This group received standard preoperative physiotherapy education prior to their surgery in a preoperative assessment unit. A physiotherapist performed a preoperative assessment for each patient. Data were obtained on past medical history, social history, smoking history, and preoperative level of function, as well as a descriptive assessment of lung function including breathing pattern, chest expansion, and cough. Education was given regarding deep breathing and splinted coughing exercises, deep vein thrombosis prophylaxis exercises (ankle pumps), and shoulder ROM exercises. Patients were instructed to perform the deep breathing exercises three to five times

per hour, followed by a splinted cough using a pillow on the side of the incision. To ensure proper technique, patients were asked to demonstrate these exercises at the preoperative clinic. Postoperative shoulder-flexion exercises were prescribed at a frequency of two to three times per day with 10 repetitions, while ankle pumps were to be performed as frequently as possible. At the end of the session, patients were given the opportunity to ask questions. The specific content of the education session was recorded for each patient on a checklist. A pamphlet including a summary of the information was given to each patient.

No Preop Group—Did Not Receive Preoperative Physiotherapy Education

Patients scheduled to undergo thoracotomy between March and June 2008 were consecutively recruited for this study. These patients received the same pamphlet as the preop group, but no formal physiotherapy education was provided. The patients received standard postoperative care, including the educational intervention from a physiotherapist on postoperative day 1.

Data Collection

The following data were collected via chart review for each group: age, gender, diagnosis, surgical approach, presence of chronic obstructive pulmonary disease (COPD), other respiratory conditions, smoking history, pre-morbid conditions, and preoperative ambulatory status. Postoperative data were gathered on number of postoperative chest tubes, length of stay (LOS), surgeon performing the thoracotomy, intraoperative time, postoperative analgesia (epidural vs. patient-controlled analgesia; number of days), number of postoperative physiotherapy treatments, and presence of fever ($\geq 38^{\circ}\text{C}$) and abnormal leukocyte counts (≤ 4 or $\geq 11 \times 10^9/\text{L}$) in the first 5 postoperative days.

Radiology Data Collection

Two radiologists from St. Joseph's Healthcare Hamilton, blinded to physiotherapy management, collected PPC data for each group. Chest radiographs were interpreted up to 5 days postoperatively for each patient. The presence of atelectasis, collapse, consolidation, and other related findings was reported using a standard data-collection sheet. The radiologists used definitions from *Felson's Principles of Chest Roentgenology*,¹⁶ in which *atelectasis* is defined as subsegmental areas of collapse; *collapse* is defined as anything more significant than subsegmental (segmental, lobar, or whole lung);¹⁶ and *consolidation* is defined as the filling of alveoli by fluid or tissue. On radiograph, these areas are uniformly white, as they are not aerated; air bronchograms may be visible.¹⁶ Agreement between the two radiologists was required, and in cases of disagreement, a consensus was reached via discussion.

Postoperative Physiotherapy

Each group received standard postoperative physiotherapy treatment, including early mobilization and secretion mobilization and clearance techniques (including percussions, vibrations, deep breathing, and coughing) as required. The goals of postoperative physiotherapy were to prevent PPC, optimize recovery, and/or prevent worsening of existing PPC.¹⁷ Specifically, treatments were directed at enhancing ventilation and facilitating optimal oxygenation and secretion clearance.¹⁷

Data Analysis

Statistical analyses were done using the Statistical Package for the Social Sciences (SPSS), version 11.5 (SPSS Inc., Chicago, IL), and PEPI version 4.04X (Sagebrush Press, Salt Lake City, UT).

1. Baseline demographic and clinical variables were summarized by means, standard deviations, and frequencies as appropriate. Between-group differences were analysed using independent *t*-tests and chi-square tests. The criterion for statistical significance was set at $p < 0.05$.
2. Incidences of complications were calculated for each day and over 5 days for all 42 patients; 95% confidence intervals (95% CIs) were determined.

Study outcomes were summarized in three ways:

1. For each patient, a grand count of days of atelectasis, collapse, and consolidation was calculated, yielding one outcome variable per patient. These data were used to determine the effect size, which was calculated as (mean preop group – mean no preop group) / SD no preop group.
2. For each patient, a count of days of atelectasis, collapse, and consolidation was separately computed, yielding three outcomes per patient. Visual inspection of the graphs was used to identify patterns over the 5 postoperative days.
3. Hospital length of stay (LOS) was calculated for each group.

RESULTS

The two groups did not differ significantly with respect to age, gender, smoking history (pack years), presence of COPD or other respiratory conditions, diagnosis, or level of preoperative function, nor was there a substantial difference between groups from a clinical perspective (see Table 1). Comorbidities were ubiquitous between the two groups, with the exception of one patient. The more common comorbidities noted were hypertension, osteoarthritis, previous cardiac surgery, diabetes, depression, hypercholesterolemia, dyslipidemia, and gastroesophageal reflux disease. With respect

Table 1 Descriptive Data

		Preop Group (n = 22)	No Preop Group (n = 20)	Statistical Testing
Age (years) (mean $\pm$ SD)		66.2 $\pm$ 10.9	62.6 $\pm$ 13.1	$t_{40} = 0.99, p = 0.33$
Sex (%)	Male	36.4	50.0	$\chi^2_1 = 0.79, p = 0.53$
	Female	63.6	50.0	
Diagnosis (%)	Cancer	95.5	90	$\chi^2_1 = 0.47, p = 0.60$
	Other	4.5%	10	
Approach (%)	Postero-lateral	80	85	$\chi^2_2 = 0.23, p = 0.89$
	Muscle sparing	15	10	
	Other	0	5	
Chest tubes (%)	1	32	45	$\chi^2_2 = 2.16, p = 0.34$
	2	68	50	
	3	0	5	
COPD (%)		50	58	$\chi^2_1 = 0.26, p = 0.76$
Other lung conditions (%)		9	10	$\chi^2_1 = 1.22, p = 0.41$
Function	Walks independently	91	100	$\chi^2_1 = 0.17, p = 0.49$
	Uses gait aid	9	0	
Length of stay (days) (mean $\pm$ SD)		8.5 $\pm$ 13.6	7.6 $\pm$ 5.8	$T_{40} = 0.29, p = 0.77$
Smoking (pack years) (mean $\pm$ SD)		50.8 $\pm$ 28.2	53.5 $\pm$ 25.3	$T_{30} = 0.29, p = 0.77$
Surgeon (%)	A	22.7	55.0	$\chi^2_4 = 9.20, p = 0.06$
	B	9.1	10.0	
	C	36.4	25.0	
	D	27.3	0.0	
	E	10.0	4.5	
Length of surgery (minutes) (mean $\pm$ SD)		165.00 $\pm$ 27.28	157.25 $\pm$ 33.07	$T_{40} = 0.83, p = 0.41$
Days of epidural use (mean $\pm$ SD)		3.50 $\pm$ 1.26	3.40 $\pm$ 1.63	$T_{40} = 0.22, p = 0.83$
Days of PCA use (mean $\pm$ SD)		median = 0.00	median = 0.0	$U = 207.00, p = 0.46$
Physiotherapy visits (mean $\pm$ SD)		4.23 $\pm$ 1.07	4.05 $\pm$ 1.10	$T_{40} = 0.53, p = 0.60$
Presence of fever ($\geq 38^\circ\text{C}$)		36.4%	52.6%	$\chi^2_1 = 1.10, p = 0.35$
Abnormal leukocyte counts (≤ 4.0 or $\geq 11.0 \times 10^9/\text{L}$)		45.5%	80.0%	$\chi^2_1 = 5.30, p = 0.03$

PCA = patient-controlled analgesia; COPD = chronic obstructive pulmonary disease

to surgical approach, the postero-lateral technique was the most frequently used (83% of cases). The remaining patients underwent the muscle-sparing approach, with the exception of two patients who underwent antero-posterior and sternotomy procedures. In addition, there were no statistically significant differences ($p > 0.05$) between groups in intraoperative time, days or type of postoperative analgesia, number of physiotherapy treatments, or presence of fever in the postoperative period. Patients in the no preop group had significantly higher rates of abnormal leukocyte counts than their preop counterparts (see Table 1). With respect to the surgeon performing the procedure, there was no statistically significant difference between groups, although surgeon A performed a larger percentage of thoracotomies in the no preop group. On further examination, the data show that surgeon A tended to operate on a larger percentage of patients with COPD (63.6% vs. 12.5% for other surgeons) and had more patients with two postoperative chest tubes (81.8% vs. 11.1% for other

surgeons), which may have affected postoperative pain and mobility. Despite surgeon A's operating on higher-risk patients, however, no clinically important differences in PPC existed between surgeon A and the other surgeons in the no preop group (grand total 6.2 PPC vs. 6.7 PPC for other surgeons).

Incidence of Pulmonary Complications

Over 5 postoperative days, the incidence of at least one reported atelectasis was 38/42 cases, or 90.5% (95% CI: 77.4%–97.3%), while that of lung collapse was 17/42 cases, or 40.5% (95% CI: 25.6%–56.7%), and that of consolidation was 18/42 cases, or 42.9% (95% CI: 27.7%–59.0%). Overall, other complications had an incidence of 24/42, or 57.1% (95% CI: 41.0%–72.3%), over 5 postoperative days. Other complications included pleural effusions, pneumothoraces, pulmonary edema, and subcutaneous emphysema. Figure 1 represents the incidence of postoperative PPC (atelectasis, consolidation, collapse, and other) per day for each group.

Figure 1 Incidence of any post-thoracotomy complication for each group on each postoperative day (includes atelectasis, consolidation, collapse, and “other”; 95% CI reported)

Figure 2 Incidence of post-thoracotomy atelectasis for each group on each postoperative day (95% CI reported)

Postoperative Pulmonary Complications by Groups

Frequencies of atelectasis, collapse, and consolidation by group are reported in Figures 2–4. There was a tendency for atelectasis to increase in frequency after postoperative day 1 for both groups (see Figure 3). The most dramatic increase was observed between postoperative day 1 and day 2, but frequencies were also appreciably higher on days 3–5 than on day 1.

For the grand count of PPC per patient, the preop group had a mean of 6.4 (SD = 3.7), and the no preop group also experienced a mean of 6.4 (SD = 4.2) complications over 5 postoperative days. Thus, the effect size for preoperative physiotherapy education was zero.

The median number of days of atelectasis was 4.0 for the preop group and 4.0 for the no preop group. The median number of days of collapse was 0.5 and 0.0

days, respectively, and consolidation medians were 0.0 and 0.5 days, respectively.

Length of Stay

The mean LOS was 8.5 (SD = 13.6) days for the preop group and 7.6 (SD = 5.8) days for the no preop group, for a mean difference of 0.9 (95% CI: –5.6–7.4) days between groups.

DISCUSSION

The incidence of pulmonary complications following thoracotomy is neither well nor consistently reported in the literature. In the present study, incidences were determined from radiographic data that were collected by two in-house radiologists. Evaluation of chest x-rays

Figure 3 Incidence of post-thoracotomy lung collapse for each group on each postoperative day (95% CI reported)

Figure 4 Incidence of post-thoracotomy consolidation for each group on each postoperative day (95% CI reported)

is interpretive in nature, with varying definitions and no universal classification system.¹⁶ While this ambiguity may lead to limited reliability in the data, the current study used two radiologists who concurred on findings, making this a strength of the design.

The incidences for collapse and consolidation (39.0%, 31.7%) in this study are consistent with previously reported incidence rates, which range from 2% to 75% in the post-thoracotomy population.^{7–10} These large differences in reported incidences can be attributed to a number of differences in study characteristics, including the nature of the population, the degree of lung resection, antibiotic prophylaxis, defining criteria for PPC, and postoperative management (including pain control).¹⁸

Atelectasis was the most frequent complication detectable via radiography. While subsegmental atelectasis may not be the most important complication, it is con-

sidered an early identifier of an increased risk of subsequent, clinically significant collapse.¹⁹ As a result, this is an important finding in the scheme of understanding the patterns of complications and potential courses of treatment. Interestingly, atelectasis increased considerably after postoperative day 1 in both groups and included nearly 100% of patients in the preop group on day 2. Similar trends for increasing PPC in the first 48–72 postoperative hours have been reported elsewhere in the literature.²⁰ It is postulated that this increase may be due to a combination of the surgery itself, involving invasive manipulation of the lung; the effects of general anaesthesia; and postoperative pain leading to immobility and the inability to complete deep breathing and coughing exercises.^{1,2,6,21}

The incidence of other complications over 5 days, including pleural effusion, pneumothorax, subcutaneous

emphysema, and pulmonary edema, was 38.1%. At first glance these PPC values may appear alarming; however, PPC are not an unexpected phenomenon following this type of invasive procedure. Furthermore, considering the nature of the population and the associated pre-existing comorbidities, it is not surprising that high frequency rates were observed.

Historically in the literature, PPC have sometimes been defined by a set of criteria including radiographic changes; presence of fever, leukocytosis, or leukopenia; and presence of purulent secretions.^{3,8,22} In this study, the no preop group was found to have significantly higher rates of abnormal leukocyte counts; however, given the lack of difference in radiographic findings and fever, this difference may be related to other complications, such as wound infection.

Postoperative pain is widely known to significantly impede physiotherapy treatments, leading to increased risk of pulmonary complications.^{1,2,6,8,21} In this population, epidural infusion was the choice of analgesia for all patients in both groups. No statistically significant between-group difference was detected in the number of days of postoperative analgesia used; however, there was no standardized method of assessing or documenting pain as a problem from the patient's perspective. Increased pain may limit positional changes, mobilization, chest expansion, and effective coughing, leading to secretion retention, possible infection, and progressive atelectasis.^{2,21}

Hospital LOS was not substantially different between the groups. Systemic factors including holidays (the preop group was recruited between December and February) and bed availability may have differed between the two groups. Though not statistically significant, the 1-day difference between groups may represent an important clinical difference, given that the cost of 1 day's hospitalization in Ontario is approximately \$1,300.²²

In this pilot study, the addition of preoperative physiotherapy education alone did not significantly decrease the incidence or alter the pattern of PPC following thoracotomy. In other populations, preoperative physiotherapy education has been found to be effective. Olsen et al. reported significant reductions in PPC with the use of a preoperative physiotherapy education programme for patients undergoing abdominal surgery.²³ Similarly, Roukema et al. investigated the use of deep breathing and coughing education by physiotherapists with patients undergoing upper abdominal surgery;²⁴ they reported that the education group had significantly fewer PPC than the control group. Although our study did not detect any differences for a similar preoperative education programme, thoracotomy is an inherently different procedure with different risks. More active rehabilitation programmes, in addition to education, may be necessary in order to reduce PPC for this population.^{3,15}

Previous research has demonstrated a significant rela-

tionship between patient risk factors and the risk of PPC.^{3,25} Preoperative variables including obesity, COPD, smoking history (especially if >20 pack years), poor exercise tolerance, and severity of underlying lung disease have all been closely linked to poor postoperative recovery.³ In the present study, nearly half of all patients had COPD and significant smoking histories exceeding 50 pack years. Smoking alone has been shown to increase the risk of PPC two- to six-fold following lung resection.⁸ Similarly, pre-existing cardiovascular disease is known to increase all cause morbidity 12-fold and mortality rate five-fold.⁸ Advanced age is another established risk factor, particularly for those 70 years and older, because of age-related changes in lung function.⁸⁻¹⁰ Although data related to preoperative factors and comorbidities were collected and analysed for frequency, their impact on the development of PPC was not established in the present study. Specifically, relationships between risk factors and the potential role of preoperative physiotherapy education in decreasing risks were not investigated. This is a particularly important area for future research, as high-risk populations may derive greater benefit than their healthier counterparts from preoperative physiotherapy intervention.

Limitations

Although PPC may be important outcomes to assess, other outcomes—such as patient anxiety, patient satisfaction, mobility status, and total minutes of physiotherapy—should also be measured in future studies. In the present study, because multiple physiotherapists were responsible for performing the pre- and postoperative treatments, inconsistencies in administration of these interventions cannot be ruled out. It should also be noted that the physiotherapist was the last health professional of the team to be seen during the preoperative assessment clinic, and therefore patients' tolerance and their ability to learn and retain information may have been compromised by the time they received their preoperative education. Furthermore, provision of the educational pamphlet to patients in the no preop group may have been a contaminating factor; however, the purpose of the study was to evaluate the effect of one-to-one education by a physiotherapist in the preoperative clinic.

There may be other reasons why no significant benefit of preoperative education was revealed. Because patients in the no preop group were recruited on a volunteer basis, there may have been an element of volunteer bias, such that participants may have been more likely to have fewer complications or a quicker recovery. As well, there may have been changes in the methods of management of these patients over the two time periods; however, the physiotherapists involved in the study verbally reported none. The retrospective-prospective design used for this pilot study has inherent potential for biases: without

randomization, it is not possible to ensure that confounders are distributed equally between groups. A definitive evaluation would require a randomized controlled design.

CONCLUSIONS

In this investigation, the incidence of atelectasis was high, although the occurrences of collapse and consolidation were similar to previously reported incidence studies. Overall, the pattern of frequencies of PPC showed increases at postoperative days 2 and 3. The estimated effect size for preoperative physiotherapy education versus no preoperative physiotherapy education was zero.

Although no definitive conclusions can be drawn because of study limitations, our findings suggest that preoperative physiotherapy education may not be effective. Given the increases in PPC observed on postoperative days 2 and 3, it may be advantageous to increase treatment time or frequency on day 1, perhaps with reallocation of resources from the preoperative period. Additional patient and clinician benefits may be realized through preoperative education by a physiotherapist, but these outcomes have not yet been investigated.

Further research is warranted in this area and should include adequately powered randomized controlled studies and measurement of more comprehensive outcomes such as patient anxiety, patient satisfaction, mobility status, and minutes of physiotherapy. Evaluating the effectiveness of a preoperative intervention in reducing PPC in high-risk patients is another important aspect to consider. Our findings suggest that the effectiveness of preoperative physiotherapy education should be compared to an intervention in which enhanced physiotherapy is given on postoperative day 1 without the preoperative visit.

KEY MESSAGES

What Is Already Known on This Subject

Some researchers have studied the incidence of pulmonary complications following thoracotomy; however, none have charted their pattern of occurrence over a 5-day period. The effectiveness of preoperative physiotherapy education for thoracotomy patients has not previously been studied.

What This Study Adds

While this pilot study may not draw definitive conclusions as to the effectiveness of preoperative physiotherapy education, it does delineate a clear pattern of PPC development in the thoracotomy population. These preliminary data suggest that PPC development occurs irrespective of preoperative physiotherapy education

and that the pattern of postoperative pulmonary complications shows an increase at days 2 and 3 post surgery. These findings suggest that until a more definitive study is done, physiotherapy time might be better invested in increased physiotherapy treatment at postoperative day 1.

REFERENCES

1. Maddaus MA, Luketich JD. Chest wall, lung, mediastinum, and pleura. In: Brunicki FC, Andersen DK, Billiar TR, Dunn DL, Hunter JG, Matthews JB, et al., editors. *Schwartz's principles of surgery*. 8th ed. New York: McGraw-Hill; 2005. p. 545–611.
2. Nomori H, Horio H, Suemasu K. Comparison of short-term versus long-term epidural analgesia after limited thoracotomy with special reference to pain score, pulmonary function, and respiratory muscle strength. *Surg Today*. 2001;31:191–5.
3. 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.
4. Doherty GM. Postoperative complications. In: Doherty GM. *Current surgical diagnosis and treatment*. 12th ed. Norwalk, CT: Appleton & Lange; 2006. p. 21–35.
5. Wall MJ, Huh J, Mattox KL. Indications for and techniques of thoracotomy. In: Feliciano DV, Mattox KL, Moore EE, editors. *Trauma*. 6th ed. New York: McGraw-Hill; 2008. p. 513–25.
6. Athanassiadi K, Kakaris S, Theakos N, Skottis I. Muscle-sparing versus posterolateral thoracotomy: a prospective study. *Eur J Cardiothorac Surg*. 2007;31:496–500.
7. 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.
8. Belda J, Cavalcanti M, Iglesias M, Gimferrer JM, Torres A. Respiratory infections after lung cancer resection. *Clin Pulm Med*. 2006;13:8–16.
9. Cerfolio RJ, Bryant AS. Survival and outcomes of pulmonary resection for non-small cell lung cancer in the elderly: a nested case-control study. *Ann Thorac Surg*. 2006;82:424–9.
10. Cattaneo SM, Park BJ, Wilton AS, Seshan VE, Bains MS, Danny RJ, et al. Use of video-assisted thoracic surgery for lobectomy in the elderly results in fewer complications. *Ann Thorac Surg*. 2008;85:235–6.
11. Brasher PA, McClelland KH, Denehy L, Story I. Does removal of deep breathing exercises from a physiotherapy program including preoperative education and early mobilisation after cardiac surgery alter patient outcomes? *Aust J Physiother*. 2003;49:165–73.
12. Gosselink R, Bott J, Johnson M, Dean E, Nava S, Norrenberg M, et al. Physiotherapy for adult patients with critical illness: recommendations of the European Respiratory Society and European Society of Intensive Care Medicine Task Force on physiotherapy for critically ill patients. *Intensive Care Med*. 2008;34:1188–99.
13. Nomor H, Kobayashi R, Fuyuno G, Morinaga S, Yshima H. Preoperative respiratory muscle training. *Chest*. 1994;105:1782–8.
14. 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.
15. Hulzebos E, Helders P, Favie N, DeBie R, Brutel de la Riviere A, Van Meeteren N. Preoperative intensive inspiratory muscle training to prevent postoperative pulmonary complications in high-risk patients undergoing CABG surgery: a randomized clinical trial. *J Am Med Assoc*. 2006;296:1851–7.
16. Goodman LR. *Felson's principles of chest roentgenology: a programmed text*. 3rd ed. Philadelphia: Saunders Elsevier; 2007.
17. Dean E. Optimizing outcomes: relating interventions to an individual's needs. In: Frownfelter D, Dean E. *Cardiovascular and pul-*

- monary physical therapy: evidence and practice. 4th ed. St. Louis: Mosby Elsevier; 2006. p. 247–61.
18. Schussler O, Alifano M, Dermine H, Strano S, Casetta A, Sepulveda S, et al. Postoperative pneumonia after major lung resection. *Am J Respir Crit Care Med.* 2006;173:1161–9.
 19. Dean E. Individuals with acute medical conditions. In: Frownfelter D, Dean E. *Cardiovascular and pulmonary physical therapy: evidence and practice.* 4th ed. St. Louis: Mosby Elsevier; 2006. p. 507–27.
 20. Peeters-Asdourian C, Gupta S. Choices in pain management following thoracotomy. *Chest.* 1999;115:122S–4S.
 21. Brooks-Brunn J. Postoperative atelectasis and pneumonia. *Heart Lung.* 1995;24:94–115.
 22. Association of Ontario Health Centers. Backgrounder for community members and policy makers advocating an end to the OHIP 3-month wait period for recent landed immigrants in Ontario [Internet]. Toronto: The Association; 2007 [cited 2008 Jul]. Available from: <http://www.aohc.org/app/wa/doc?docId=274>.
 23. Olsen M, Hahn I, Nordgren S, Lonroth H, Lundholm K. Randomized controlled trial of prophylactic chest physiotherapy in major abdominal surgery. *Brit J Surg.* 1997;84:1535–8.
 24. Roukema JA, Carol EJ, Prins JG. The prevention of pulmonary complications after upper abdominal surgery in patients with noncompromised pulmonary status. *Arch Surg.* 1988;123:30–4.
 25. Nici L. Preoperative and postoperative pulmonary rehabilitation in lung cancer patients. *Thorac Surg Clin.* 2008;18:39–43.