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Cost-effectiveness analysis of prophylactic respiratory physiotherapy in pulmonary lobectomy☆

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Abstract

Objective: To evaluate the cost-effectiveness balance of implementing an intensive program of chest physiotherapy in pulmonary lobectomy. **Methods:** *Design*: cross-sectional study with historical controls. Cases are 119 patients operated on during a 15-month period of time, after implementation of an intensive chest-physiotherapy program. Controls are 520 patients operated on by the same team before the program started. In these patients, only incentive spirometry was indicated besides routine nursing care. In both series, operative selection criteria and anaesthetic management were similar. Population homogeneity was assessed by comparing age, body mass index (BMI) and estimated postoperative FEV1 (ppoFEV1) of the patients in both series. Selected outcomes were as follows: 30-day mortality, prevalence of respiratory morbidity (atelectasis and pneumonia) and hospital stay. Hospital stay was estimated by Cox regression using age, ppoFEV1, BMI, diagnosis and postoperative morbidity as covariates. Costs were calculated adding chest therapists' salaries and acquisition value of specific training and monitoring devices and its consumable items. Savings from avoided hospitalisation days was discounted. **Results:** Prevalence of atelectasis and median hospital stay decreased in physiotherapy group. Cost of the program was 48,447.81€ (407.12€ per treated patient). An estimated total of 151.75 hospital days was saved in the physiotherapy group. Since daily hospitalisation cost is 590.00€ in our centre, 89,532.50€ savings was estimated from avoided hospitalisation days. **Conclusions:** We have found a significant decrease in the rate of postoperative atelectasis without additional costs. In fact, the program has produced considerable monetary savings.

Keywords: Pulmonary lobectomy; Chest physiotherapy; Postoperative morbidity

1. Introduction

For many years, chest physiotherapy has been considered fundamental in the pre- and postoperative care of thoracic surgical patients. However, evidence is lacking on the benefits of any method of prophylactic respiratory physiotherapy after cardiac surgery [1], and it has been published that, in valve surgery cases, routine prescription of physical therapy does not improve patient outcomes but significantly increases the costs [2]. We have not found, in recent medical literature, studies demonstrating the effectiveness of routine respiratory physiotherapy in lung resection cases.

This study has been designed to evaluate the influence of implementing a routine program of intensive chest physiotherapy on postoperative respiratory morbidity and hospital costs in a series of pulmonary lobectomy patients.

2. Methods

2.1. Settings

A tertiary, academic, general hospital.

2.2. Design

Cross-sectional study with historical controls.

2.3. Studied population

A series of 639 consecutive patients were operated on from January 1994 to January 2004. All cases underwent a scheduled lobectomy. Starting from November 2002, an intensive postoperative respiratory physiotherapy program was instituted and 119 cases were operated on from that time.

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2.4. Perioperative management

Case selection criteria remained substantially unchanged during the study period. Patients were requested to quit smoking 3 weeks before surgery. Surgical approach was muscle-sparing or video-assisted small axilary thoracotomy in all cases. Pulmonary fissures were completed, when needed, using stapling machines and no sealant was routinely indicated. Extubation was performed in the operating room and, after a few hours in the recovery room, patients were transferred to the cardio-thoracic ward. Postoperative analgesia consisted of epidural bupivacaine and fentanyl for 3 days and paracetamol and non-steroid anti-inflammatory drugs thereafter. Before the introduction of the chest physiotherapy programme, ward nurses were in charge to encourage patients for early deambulation and deep breathing manoeuvres using an incentive spirometer with known low imposed work of breathing. In order to start the chest physiotherapy program, a dedicated respiratory technician was appointed and specific facilities were implemented in the same ward. Chest physiotherapy started the day before surgery and continued up to discharge. Basically, patients were instructed to use a treadmill and ergometric bicycle under supervision, to have effective cough and to perform deep inspiratory manoeuvres. Besides, arm and shoulder exercises and physical therapy were indicated to prevent upper extremities motility impairment.

2.5. Variables and outcomes

The independent variables included in the analysis were as follows: age of the patient, body mass index (BMI), predicted postoperative FEV1% value (ppoFEV1%) and diagnosis (inflammatory or malignant disease). These variables were used to assess the homogeneity of both series of cases.

Studied outcomes were the occurrence of postoperative pulmonary complications (nosocomial pneumonia or atelectasis), 30-day postoperative death and length of hospital stay (LOS). Nosocomial pneumonia was defined according to published clinical criteria [3]. Lobar or pulmonary collapse was confirmed by chest X-ray in all cases. LOS was measured from the day of admission up to hospital discharge.

All studied variables and outcomes were recorded prospectively on a customised computerised database.

2.6. Data analysis

2.6.1. Homogeneity of the series and outcome analysis

Series homogeneity was assessed by ANOVA (age, ppoFEV1 and BMI) or chi-square tests (diagnosis). Differences in outcome prevalence between groups were studied by chi-square and odds ratio calculation on 2×2 tables.

2.6.2. Comparison of LOS in both series and theoretical estimation of LOS for the studied population

Recorded LOS values in both series were compared using non-parametric Mann–Whitney test. According to previously published method [4], probability of discharge for each patient was calculated by Cox regression analysis including the following variables in the model: age, diagnosis, BMI, ppoFEV1, postoperative cardio-respiratory morbidity, scheduled pneumonectomy and being included in the physiotherapy group. The estimated LOS value was plotted against individual true LOS and the difference between the estimated and the recorded LOS was found for each patient.

2.6.3. Cost calculation

Economical analysis was used to evaluate daily hospital costs, including direct medical and non-medical charges except operating room ones, considered homogeneous for all cases and excluded from the study. Chest physiotherapy series included newly appointed staff wages and charges for physiotherapy facilities and consumables. Data were retrieved from the Hospital Accountability Department.

3. Results

Patients in both series were comparable in age, ppoFEV1% and BMI. Data are shown in Table 1. Concerning outcomes (Table 2), mortality rate was lower in physiotherapy group, but differences were not statistically significant (0.8% in physiotherapy vs 3.5% in control group; O.R. 0.23; 95% CI: 0.03–1.79). Nosocomial pneumonia and atelectasis rates were also higher in control group, but only the difference in atelectasis rates was significant (pneumonia rates: 5% in physiotherapy and 9.2% in control; O.R. 0.52; 95% CI: 0.22–1.25; atelectasis rates: 2% in physiotherapy and 7.7% in control; O.R. 0.20; 95% CI: 0.05–0.86).

Median LOS was 5.73 days (range, 3–22 days) in physiotherapy group and 8.33 days (range, 3–40 days) in control group ($p < 0.001$, Fig. 1).

Results of logistic regression analysis are shown in Table 3. In Fig. 2, estimated LOS for each case is plotted against recorded LOS. A total of 151.75 hospital days was saved in physiotherapy group. Since mean daily hospital cost for lobectomy during the study period was 590.00€, a total of 89,523.50€ savings was estimated from shorter hospital stay.

The final balance of expenditures and savings of implementing the physiotherapy program is presented in

Table 1
Comparison of continuous variables in both series

	Physiotherapy, mean (SD)	Control, mean (SD)	*p*
Age (years)	63.98 (11.81)	63.36 (10.92)	0.17
ppoFEV1%	68.08 (15.72)	69.14 (16.97)	0.47
BMI	25.82 (3.88)	25.75 (4.16)	0.99

Table 2
Comparison of categorical outcomes

	Mortality, *n* (%)	Pneumonia, *n* (%)	Atelectasis, *n* (%)
Cases, *n* = 119	1 (0.8)	6 (5)	2 (1.7)
Controls, *n* = 520	18 (3.5)	48 (9.2)	40 (7.7)
Odds ratio (95% CI)	0.23 (0.03–1.79)	0.52 (0.22–1.25)	0.20 (0.05–0.86)

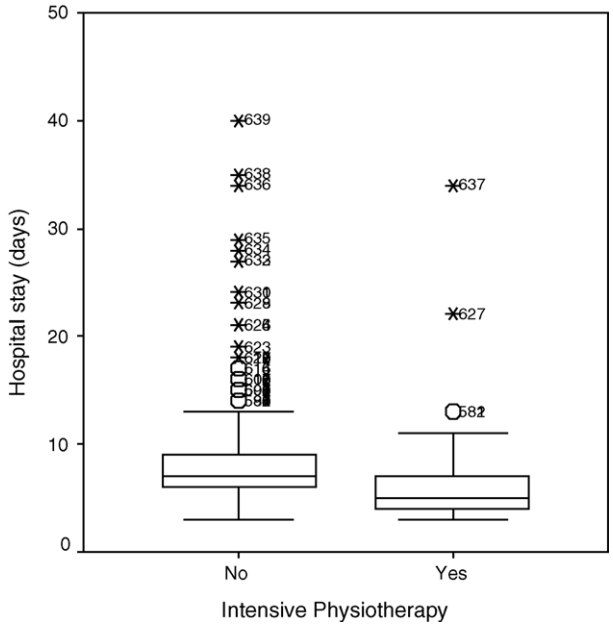

Fig. 1. Differences in length of hospital stay between both series of cases ($p < 0.001$ on Mann–Whitney test).

Table 4. A total cost of 48,447.81€ was directly attributable to the physiotherapy program. Discounting savings from avoided hospitalisation days, we estimated that 41,084.69€ was saved since the program started.

4. Discussion

Economic assessment of the use of medical interventions has become fundamental due to the increasing costs of healthcare all over the world [5]. Currently, it is required to demonstrate that new medical technologies or interventions produce significant health benefits at a reasonable cost.

In lung resection surgery, it is considered that chest physiotherapy is a very important tool in postoperative care [6,7] due to the prevalence of postoperative pulmonary problems [8–10] and previous comorbidities [11,12]. Nevertheless, its effectiveness has never been demonstrated, and recently a systematic review of the literature has been published concluding that routine chest physiotherapy after cardiac surgery has no demonstrated benefits, and it is likely to produce only adverse effects and increased costs [1]. Besides, some authors have published that chest physiotherapy is frequently overindicated [13] and selective use of respiratory physiotherapy managed by technicians [14] is recommended on the basis of similar outcomes and lower costs.

In this scenario, we decided to implement a program of routine intensive postoperative chest physiotherapy managed by a therapist and to compare the outcomes with historical controls.

Ours is neither a blind nor a randomised study, so we have to acknowledge the limitations derived from design. Other

Table 3
Variables influencing hospital stay on logistic regression

Variable	p	O.R. (95% CI)
Age	0.035	0.991 (0.983–0.999)
BMI	0.001	1.038 (1.015–1.061)
ppoFEV1%	0.001	1.009 (1.004–1.014)
Malignant disease	0.001	1.842 (1.286–2.639)
Physiotherapy	<0.001	2.201 (1.758–2.755)
Major morbidity	<0.001	2.419 (1.865–3.136)

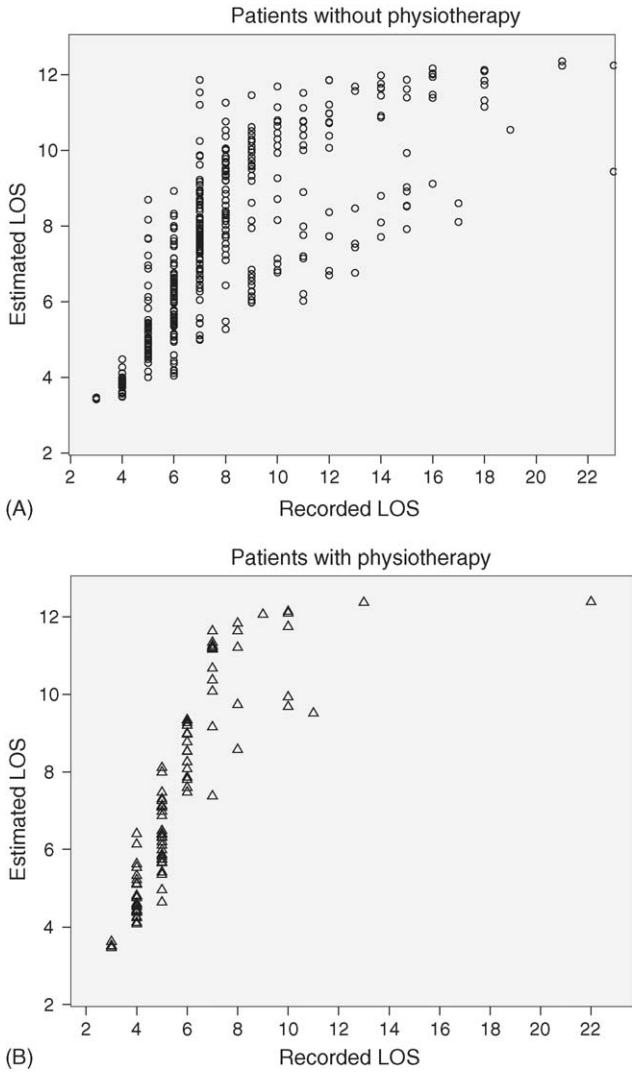

Fig. 2. Estimated vs recorded length of stay (LOS). Marks to the right of the figure means that LOS was superior to estimated. (A) Patients without physiotherapy. (B) Patients with physiotherapy.

Table 4
Monetary evaluation of implementing the intensive physiotherapy program

	Estimation in €
Costs	
New staff wages	−30,447.81
New equipment	−18,000.00
Total	−48,447.81
Savings	
151.75 avoided hospital days	+89,532.50
Balance	+41,084.69

limitation is that we have reported only hospital costs ignoring the cost derived from patient care after discharge [15]. Unfortunately, we do not have enough clinical information to report such data.

On the other hand, we have compared homogeneous groups in terms of patient characteristics and postoperative analgesia. Surgical approach has been considered homogeneous. In the second series, more cases underwent video-assisted procedures, but there is evidence that both kinds of approaches (muscle-sparing and video-assisted mini-axilary thoracotomy) have comparable effects [16]. Besides, all relevant clinical strategies have been included. Patients in control group underwent standard nursing care — including early deambulation — plus incentive spirometry taking care to use a device with a known low imposed work of breathing [17].

It is discussed in medical literature whether or not incentive spirometry has some effect on postoperative pulmonary complications. To some authors, evidence does not support its use in pulmonary [18], cardiac or upper abdominal surgery [19], while others find that incentive spirometry has equivalent clinical efficacy as that of physiotherapy in the management of patients undergoing upper abdominal surgery [20]. Disregarding this controversy, our strategy diminished the rate of postoperative atelectasis.

The relevance of selected outcomes needs some discussion. We have found decreased LOS and atelectasis rates in physiotherapy group but the decrease in overall mortality and pneumonia did not reach statistical significance. Postoperative mortality cannot be expected only as a consequence of respiratory postoperative problems [21], so it could have been advanced that mortality would remain unchanged in the experimental group. On the other hand, hospital-acquired pneumonia also depends on multiple factors [22]. Decreased LOS has been demonstrated but several bias could have influenced the outcome. As recognised before, this cannot be a blind study and it has not been randomised. The fact that all perioperative practices remained unchanged in the experimental group decreases the relevance of design deficiencies.

Finally, our study lacks a sensitivity analysis [23], increasing the uncertainty of the conclusions. In such analysis, the estimates for key variables are altered in order to assess their impact on results. This kind of analysis increases the accuracy of reported monetary values, but our aim is not to produce accurate mathematical data but to support the use of routine chest physiotherapy in thoracic wards, as recommended by the EACTS/ESTS Working Group on Structures in Thoracic Surgery [24].

To conclude, we have found that the implementation of an intensive chest physiotherapy program for lobectomy patients decreased the rate of postoperative atelectasis without increasing the cost of the procedure. In fact, considerable savings was calculated.

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Appendix A. Conference discussion

***Dr E. Rendina** (Rome, Italy)*: I would like to ask you a couple of questions. The problem with historical controls is that sometimes the standard of care is not homogeneous. The question is twofold. Do you think that costs remained stable throughout the time of your investigation, even for old cases, and has your postoperative pain therapy also remained the same since the beginning of the historical series?

Dr Varela: I'll answer your second question first. Pain therapy remained the same all along the study period, including historical controls. All the patients had an epidural catheter, morphine and nonsteroidal anti-inflammatory drugs postoperatively. So substantially, we didn't change the analgesia in both series. But you are right, historical controls do not permit an Evidence A study. To my knowledge, this is the only study confirming the effectiveness of physiotherapy in pulmonary lobectomy. So we can use this paper to support the guidelines of our society recommending a specific physiotherapy unit in every thoracic surgery unit. So the degree of evidence is may be C, but I think it is good to start with.