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Intermittent positive-pressure breathing after lung surgery

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Abstract

Intermittent positive-pressure breathing is thought to avoid atelectasis and improve pulmonary function after major lung resections. Since no clear scientific data was available to confirm this, our objective was to determine whether atelectasis can be avoided and if postoperative lung function is improved. Prospective analysis was carried out in 135 patients operated on between 2007 and 2009; 55 received intermittent positive-pressure breathing. Pre- and postoperative lung function tests were similar in both groups. Pulmonary complications were observed in 19% of patients without intermittent positive-pressure breathing and 27% of those who received this treatment. We were unable to find evidence that additional improvement in postoperative pulmonary function is achieved when adding intermittent positive-pressure breathing to the standard physical therapy.

Keywords

pneumonectomy, postoperative complications, respiratory insufficiency, treatment outcome

Introduction

A poor coughing reflex postoperatively, wound pain with limited movement of the chest, and the stress of surgery have an adverse effect on pulmonary function. These factors may cause atelectasis, bacterial pneumonia, and acute exacerbation of obstructive lung disease or acute respiratory lung disease. The extent to which physiotherapy improves the management of patients after chest surgery is unclear. Two recent reviews could not reach conclusions because the available data had many flaws.[1,2] As early as 1934, a pioneer rehabilitation program was started at the Brompton Hospital in London, for patients after non-tuberculosis chest surgery. It included pressure expiration, diaphragmatic breathing, postural correction, and shoulder girdle motion for 2 to 3 weeks. The benefit of these methods was confirmed during World War II by American physicians on duty in England, and later adopted in the United States. Anderson and colleagues[3] were intrigued by the effect of intermittent positive-pressure breathing (IPPB) devices, which deliver an inspiratory pressure of up to 40 mmHg, to prevent hypoventilation on the operated side induced by postoperative pain. After studying a small group of patients, they concluded that IPPB may be helpful in accelerating recovery after thoracic surgery. Recently, postoperative stay has decreased considerably; thus we must pay more attention to pain management and rapid rehabilitation after complex thoracic surgery. Postoperative pulmonary complications increase hospital morbidity, prolong hospital stay and increase healthcare costs.[4] This study aimed to determine whether IPPB prevents atelectasis of the operated lung, decreases the incidence of pulmonary complications, and improves postoperative lung function.

Patients and methods

Between June 2007 and March 2009, we prospectively randomized 135 patients who underwent anatomic resection with curative intent for bronchial carcinoma. Informed consent was obtained, and randomization into 2 groups was performed preoperatively according to year of birth: 55 patients had a standard

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rehabilitation program with IPPB and 80 had a standard rehabilitation program without IPPB. There were 63 women and 72 men with a median age of 62 years (range, 40–90 years) and a median body mass index of 26 kg/m^2. Lobectomy was necessary in 106 (79%) patients, bilobectomy in 8, pneumonectomy in 9, and segmental resection in 12. The 2 groups had similar demographic and surgical data (Table 1).

All patients underwent standard pulmonary preparation and evaluation in terms of spirometric and plethysmographic tests, carbon monoxide diffusing capacity, arterial blood gas measurement, and a 6-min walk test (MWT). The surgical approach was a muscle-sparing thoracotomy in all cases, standard anatomic resection was performed with hilar and mediastinal lymph node dissection. Two chest tubes were placed anterolaterally and posterobasally. Extubation was achieved in all patients in the operating room. After the first postoperative night in the intermediate care unit, patients were transferred to the thoracic ward. Rehabilitation was started on the morning after surgery and included pressure expiration, diaphragmatic breathing, postural correction, stretching, and shoulder girdle motion. Early mobilization was favored whenever possible at the bedside on the 1st day. Patients receiving additional IPPB were encouraged to undergo it at least 3 times per day, with a positive pressure of 15–20 mmHg. Positive pressure was administered via a mouthpiece with a preset Aerolife 2 ventilator (Medicap Homecare GmbH, Ulrichstein, Germany). To favor early mobilization, strict pain management was carried out. Our objective was to have a pain score of 4/10 or less at all times. The rehabilitation program was continued until the patients were discharged. Postoperative lung function tests and the 6-MWT were repeated on day 7.

Table 1. Demographic and surgical data of patients with and without intermittent positive-pressure breathing (IPPB)

Variable	Without IPPB	With IPPB
No. of patients	80	55
Height (cm)	170	171
Weight (kg)	76	74
Body mass index (kg/m^2)	26	25
Smoker	44 (55%)	29 (53%)
Ex-smoker (>3 months)	28	21
Nonsmoker	8	5
Operation		
Lobectomy	63 (79%)	43 (78%)
Bilobectomy	3	4
Pneumonectomy	5	3
Segmental resection	7	5

Data recorded included smoking status, body mass index, extent of operation, pre- and postoperative lung function, 6-MWT results, and postoperative pulmonary complications (secretion retention, pneumonia, air-leakage >7 days, pleural infection, chest tube drainage). The results are given as median values. Data were entered into an Excel spreadsheet (Microsoft, Bellevue, WA, USA). Analysis of the data was performed using Medcalc statistical software (MedCalc Software, Mariakerke, Belgium) to determine the difference between groups in terms of lung function and pulmonary complications.

Results

No mortality was recorded. There were no statistically significant differences in the median pre- and postoperative values of forced expiratory volume in 1 sec or the 6-MWT between groups (Table 2). Postoperative O_2 therapy, duration of chest tube drainage, and hospital stay were similar in both groups (Table 2). Comparisons of data as independent samples in a box-plot graph are given in Figures 1 and 2. In terms of overall postoperative complications, the 2 groups showed no difference (76% vs. 82%); whereas the group receiving additional IPPB seem to have a higher pulmonary complication rate (27% vs. 19%; Table 3), but there was no statistical significance between the 2 groups.

Discussion

Postoperative respiratory therapy is given to obtain better functional recovery after lung surgery.[5–7] In an animal study, atelectasis was shown to promote bacterial growth due to reduced alveolar macrophage function and reduced functional surfactant, explaining the risk of pneumonia.[8] Early mobilization after lung surgery is mandatory to prevent atelectasis. Some reports describe postoperative mobilization 4 h after lobectomy as safe and feasible.[9] In our series, patients started postoperative physiotherapy on the morning after surgery. We remove all unnecessary items such as intravenous infusion lines and catheters on the first postoperative day. If there is an air leak, patients receive a mobile suction pump; otherwise, only a Heimlich valve is used to facilitate early mobilization.

Although respiratory physiotherapy is labour-intensive and costly, postoperative pulmonary complications increase hospital morbidity and hospital stay, which contribute to additional healthcare costs that are definitely higher.[10] Varela and colleagues[4] retrospectively analyzed 639 patients operated on between 1994 and 2004, 119 patients who underwent lobectomy were included in an intensive physiotherapy program.

Table 2. Outcome of patients with and without intermittent positive-pressure breathing

Variable	Without IPPB	With IPPB
FEV_1 preoperatively [range]	71% [34%–119%]	75% [39%–106%]
FEV_1 postoperatively [range]	45% [24%–79%]	52% [27%–77%]
Change in FEV_1 (%) [median]	−61% to 49% [−23%]	−68% to 5% [−27%]
Change in 6-MWT (m) [median]	−242 to 90 [−65]	−270 to 93 [−69]
O_2 therapy	6 (7%)	4 (9%)
Chest tube drainage (days) [range]	5.8 [1–39]	6 [1–30]
Hospital stay (days) [range]	11 [5–41]	11 [6–37]

FEV_1 = forced expiratory volume in 1 sec, IPPB = intermittent positive-pressure breathing, 6-MWT = 6-min walk test.

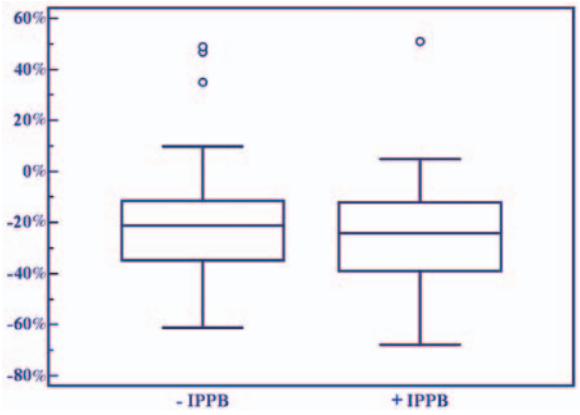

Figure 1. Box plot of forced expiratory volume in 1 sec with and without intermittent positive-pressure breathing (IPPB).

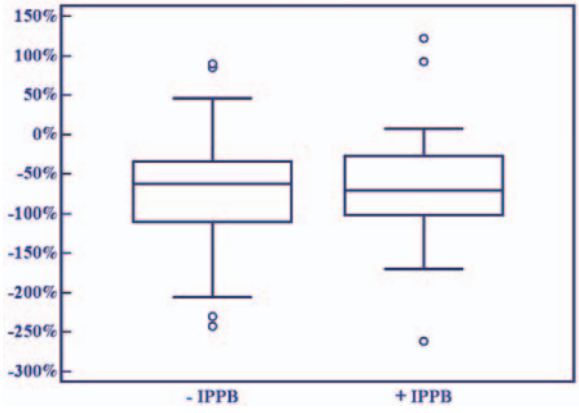

Figure 2. Box plot of 6-MWT (in meters) with and without intermittent positive-pressure breathing (IPPB).

Patients were requested to stop smoking 3 months prior to surgery. Physiotherapy was started the day before surgery, and continued until discharge. This study found a definite reduction in postoperative atelectasis without an overall significant decrease in pneumonia and mortality. The cost of the physiotherapy program was compensated by the savings achieved by reduced overall costs due to decreased postoperative pulmonary morbidity. More information is available regarding prevention of pulmonary complications after cardiac and abdominal surgery, using intensive respiratory physiotherapy.[1,2,11] In 2 reviews that included only randomized studies (35 abdominal surgery and 18 cardiac surgery patients), end-points were prevention of atelectasis, pneumonia, postoperative complications, as well as vital capacity and O_2 consumption.[1,2] Only one trial had a positive outcome in terms of reduction of postoperative pneumonia.

A review of additional noninvasive ventilation (NIV) associated with chest physiotherapy after lung surgery showed that in 5 trials with the best evidence on the topic, NIV was favorable in improving outcome after lung resection surgery.[12] Perrin and colleagues[13] applied NIV in 39 patients 7 days before and 3 days after lobectomy. The 14 patients receiving NIV had a higher PaO_2 and lower $PaCO_2$ and pH. It was concluded that pre- and postoperative NIV significantly reduces pulmonary dysfunction after lung resection.

Table 3. Postoperative pulmonary complications

Variable	Without IPPB	With IPPB
No complication	66/80 (82%)	42/55 (76%)
Pulmonary complications	15/80 (19%)	15/55 (27%)
Secretion retention	4	7
Pneumonia	4	3
Air leakage >7 days	5	4
Pleural infection	1	0
Chest tube	1	1

IPPB = intermittent positive-pressure breathing.

To our knowledge, this is the first prospective randomized study comparing the additional use of IPPB with standard chest physiotherapy in patients undergoing anatomic lung resection. We certainly believe that early standard postoperative mobilization and pulmonary rehabilitation is important for the recovery of lung function. In the data collected up to now, we were unable to find evidence that additional improvement of postoperative pulmonary function is achieved when adding IPPB to standard physical therapy. The rate of pulmonary complications, such as pneumonia, was slightly higher in the patients receiving IPPB. To confirm the observed trend, it is necessary to consider a larger group of patients.

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Conflict of interest statement

None declared.

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