Evaluation of respiratory muscle strength by randomized controlled trial comparing thoracoscopy, transaxillary thoracotomy, and posterolateral thoracotomy for lung biopsy

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Abstract

Objective: The aim of this study was to demonstrate that the postoperative recovery of respiratory muscle strength is better in patients who undergo video-thoracoscopy than in patients who undergo transaxillary thoracotomy or posterolateral thoracotomy. Design: Randomized controlled trial with three parallel groups. Study population: Eligible patients had undergone wedge resection for interstitial lung disease or in pulmonary nodule. Twenty-four patients were randomly assigned to one of the three thoracic procedures: eight in the video-thoracoscopy (VT) group, eight in the transaxillary thoracotomy (TT) group, and eight in the posterolateral thoracotomy (PLT) group. Measurements: The postoperative respiratory muscle strength was assessed by maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) measured by mouth pressure. Measurements were made the day before the operation and 2, 4, and 30 days after the operation. Changes in postoperative MIP and MEP were expressed as a percentage of preoperative values. Results: The three groups were comparable with respect to age, gender, comorbidity, preoperative spirometry, preoperative MIP, MEP and peak flow, and volume of lung tissue. At 2, 4, and 30 days after the operation, mean MIP were, respectively, 111 ± 22%, 119 ± 22%, and 124 ± 22% in the VT group, 76 ± 22%, 109 ± 22%, and 127 ± 22% in the TT group, and 51 ± 22%, 50 ± 22%, and 77 ± 22% in the PLT group (p < 0.0001). At 2, 4, and 30 days after the operation, mean MEP were, respectively, 94 ± 15%, 103 ± 15%, and 105 ± 15% in the VT group, 61 ± 15%, 98 ± 15%, and 126 ± 15% in the TT group, and 62 ± 15%, 75 ± 15%, and 87 ± 15% in the PLT group (p < 0.05). Conclusions: Video-thoracoscopy allows better recovery of respiratory muscle function after surgery than posterolateral thoracotomy. However, at 4 and 30 days after surgery, video-thoracoscopy and transaxillary thoracotomy gave similar results of impairment of respiratory muscle strength.

Keywords: Respiratory muscle strength; Mouth pressure; Video-thoracoscopy; Thoracotomy

1. Introduction

Recently, the use of thoracoscopy lung biopsies for the diagnosis of diffuse interstitial lung disease or nodules has increased. Thoracoscopy is less invasive than posterolateral thoracotomy and it has advantages over limited or muscle-sparing thoracotomy. Many comparisons have shown that thoracoscopy decreased postoperative pain and improved pulmonary function compared to thoracotomy [1–3]. Also, transaxillary thoracotomy approach would be considered less invasive compared to posterolateral thoracotomy [4].

One study [4] showed that the recovery of respiratory muscle strength is affected by thoracotomy. However, this study was limited by its retrospective and nonrandomized study design. The reduction in respiratory muscle function after operation is not affected by postoperative pain alone because pain relief by epidural anesthesia did not reduce diaphragm dysfunction [5]. Other causes are also responsible for postoperative respiratory muscle dysfunction. Before now, no prospective randomized, controlled trial comparing three procedures has evaluated respiratory muscle strength.

Respiratory muscle function can be evaluated by maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) measured by mouth pressure, which is a noninvasive method [6]. The test was evaluated in patients with COPD where values of MIP significantly correlate with dyspnea and PaCO2 [7,8]. Maximum inspiratory pressure measures inspiratory muscle strength, mainly the diaphragm, and maximum expiratory pressure measures expiratory muscle strength in intercostal and abdominal muscle.

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better in patients who undergo video-thoracoscopy than in those who undergo transaxillary thoracotomy or posterolateral thoracotomy.

2. Material and methods

2.1. Eligibility criteria

Eligible patients had undergone wedge resection for lung biopsy in interstitial lung disease or in pulmonary nodules and were aged between 18 and 75 years. Exclusion criteria were major pulmonary resection (lobectomy or pneumonectomy) and previous thoracic surgery. All patients provided informed written consent. The research ethics committee approved the study.

2.2. Randomization

Eligible patients were randomly assigned to the procedures of thoracotomy: video-thoracoscopy, transaxillary thoracotomy or posterolateral thoracotomy. Fixed blocks of six were used. Sealed, numbered envelopes containing procedure of thoracotomy assigned were prepared and given to the research assistant. In the operating theatre, the surgeon was handed the envelope to assign the procedure of thoracotomy.

2.3. Thoracic procedures

Video-thoracoscopy was performed under general double-lumen anesthesia with patients in the lateral decubitus position. A 10-mm video-thoracoscope was used and the ports were positioned at the discretion of the surgeon. The diagnostic lung biopsy was done with an endoscopic stapling device.

Transaxillary thoracotomy of 10 cm in length was done from the axilla to the nipple line. The split serratus anterior muscle was performed. Occasionally, few lateral fibers of the latissimus dorsi required division. The fourth or fifth intercostal space was incised to enter the pleural cavity. After a demonstration of the required technique, each subject performed serial maximal maneuvers, repeated until at least three readings with a variation of less than 10% had been recorded. The highest value achieved was used in the analysis. Preoperative MIP and MEP were measured the day before operation. Postoperative MIP and MEP were measured 2, 4, and 30 days after operation.

In patient with chest tubes, in situ measurements were possible at 2 and 4 days after operation. The percentage of change in postoperative MEP and MEP from preoperative values was evaluated as MEP (% of preoperative level) and MEP (% of preoperative level), calculated by (postoperative MEP/preoperative MIP) × 100 and (postoperative MEP/preoperative MEP) × 100, respectively.

The secondary end points included forced expiratory volume in 1 s (FEV) and peak flow were measured the day before operation and 2, 4, and 30 days after operation. The percentage of change in postoperative FEV and peak flow from preoperative values was evaluated as FEV (%) of preoperative level and peak flow (% of preoperative level). Postoperative pain was assessed using a 10-cm line visual analog scale (VAS) at 2, 4, and 30 days after surgery.

2.5. Statistical analysis

The planned sample size of 26 patients provided 90% statistical power to detect a difference of 30% for MIP between video-thoracoscopy and posterolateral thoracotomy at 4 days with a 5% false-positive rate (one-sided).

Continuous variables were compared using the one-way analysis of variance. Categorical variables were compared using the \( \chi^2 \)-test. Repeated measurements such as MIP, MEP, FEV, peak flow, and sequential visual analog scale scores were analyzed using two-way, between-within ANOVA [10].

3. Results

3.1. Characteristics of the patients

Between February 2001 and January 2002, 24 patients were randomly assigned to one of the three thoracic procedures: eight in the video-thoracoscopy (VT) group, eight in the transaxillary thoracotomy (TT) group, and eight in the posterolateral thoracotomy (PLT) group. In the postoperative period, all patients had a complete follow-up. The groups were well matched, with no significant differences in age, gender, preoperative spirometry, MIP, MEP, peak flow or blood gas (Table 1). Preoperative Karnofsky index values were 100 in the three groups. A definitive pathologic diagnosis was made in all patients (Table 2). The
Differences in values between the three groups were significant (p < 0.0001). Values following posterolateral thoracotomy were significantly lower than those in the TT and PLT groups (p < 0.05). Postoperative complications or blood loss were similar in all three groups. In the postoperative period, there were no pulmonary complications or deaths. In the posterolateral group there was one wound infection. For the three procedures, the average duration of chest tube drainage was 2.25 ± 0.18 days for the VT group, 2.37 ± 0.18 for the TT group, and 2.37 ± 0.18 days for the PLT group (p = 0.8). For the three procedures, the length of hospital stay was similar: VT 5 ± 0.8 days, TT 5 ± 0.9 days, and PLT 4.8 ± 0.6 days (p = 0.8).

### 3.2. Primary end point

Postoperative changes in MIP in the three groups are shown in Fig. 1. Mean MIP in patients undergoing video-thoracoscopy was 5.3 ± 1.3 cm, TT 5.1 ± 0.4 cm, and PLT 5.5 ± 1.9 cm (p = 0.5) and small axis: VT 1.3 ± 0.4 cm, TT 1.4 ± 0.4 cm, and PLT 1.7 ± 0.7 cm (p = 0.3). Intraoperative complications or blood loss were similar in all three groups. In the postoperative period, there were no pulmonary complications or deaths. In the posterolateral group there was one wound infection. For the three procedures, the average duration of chest tube drainage was 2.25 ± 0.18 days for the VT group, 2.37 ± 0.18 for the TT group, and 2.37 ± 0.18 days for the PLT group (p = 0.8). For the three procedures, the length of hospital stay was similar: VT 5 ± 0.8 days, TT 5 ± 0.9 days, and PLT 4.8 ± 0.6 days (p = 0.8).

### 3.3. Secondary end point

Postoperative MIP in VT and TT groups was significantly higher than that in the PLT group 4 and 30 days after operation (Fig. 1). Postoperative changes in MEP in the three groups are shown in Fig. 2. Mean MEP in patients undergoing video-thoracoscopy was 95 ± 15%, 103 ± 15%, and 105 ± 15%, respectively. Values following transaxillary thoracotomy were 61 ± 15%, 98 ± 15%, and 126 ± 15%. Values following posterolateral thoracotomy were 62 ± 15%, 75 ± 15%, and 87 ± 15%. Postoperative changes in MEP in the three groups were significant (p < 0.05). At 2 days after operation, MEP in the VT group was significantly higher than that in the TT and PL groups (Fig. 2). At 4 and 30 days after operation, MEP in the VT and TT groups were significantly higher than that in the PLT group (Fig. 2).
4. Comment

In the present study, the advantage of video-thoracoscopy over transaxillary thoracotomy or posterolateral thoracotomy was an increase in diaphragm function during the 2 days after surgery. However, we found no differences in the respiratory muscle strength between the video-thoracoscopy group and the transaxillary thoracotomy group on the 4th and 30th day after surgery. The influence of the thoracotomy procedure in the postoperative recovery of respiratory muscle strength was demonstrated by the nonrandomized study of Nomori et al. [4]. They reported the same postoperative changes in MIP as our series. However, Nomori et al. [4] measured respiratory muscle strength from 1 week after the operation whereas in our study the measurement of postoperative MIP and MEP was carried out 2 days after operation. A randomized controlled trial comparing VATS and limited thoracotomy to perform a lobectomy reported similar impairments of respiratory muscle strength for both techniques [3]. This study [3] showed that the recovery of diaphragm function in VATS patients was similar to those that had undergone limited thoracotomy. In another randomized, controlled trial comparing thoracoscopy and limited thoracotomy for lung biopsy in interstitial lung disease, there was no statistical difference in outcome with regard to pain or FEV for the two procedures [11]. Conversely, muscle-sparing procedures appear to decrease postoperative pain compared to standard posterolateral thoracotomy [12]. In our study, postoperative values of FEV and peak flow were higher among patients in VT and TT groups than in patients in PLT group but however, this difference was not significant. The sample size was too small to detect differences between groups concerning FEV and peak flow.

Most studies demonstrated the influence of the type of incision on postoperative pain [2,13]. The influence of the thoracotomy procedure on diaphragm function is controversial [4]. Studies [5,14] reported that pain relief by epidural anesthesia did not reduce diaphragm dysfunction after upper abdominal surgery or cardiac surgery. Indeed, postoperative pain is not the only factor affecting diaphragm function. These same conclusions were reported by Nomori et al. [4]. In lung volume reduction surgery, factors that may contribute to the improvement in diaphragm function, are unknown [15]. It is possible that chest wall muscle function could influence diaphragm function [13,16]. And the type of incision affects chest wall muscle function, which in turn may affect diaphragm function and reduce chest compliance. Postoperative respiratory muscle strength may be dependent on the type of thoracotomy procedure used. In the present study, differences between posterolateral thoracotomy and transaxillary thoracotomy with regard to postoperative respiratory muscle strength could be explained by the lesser degree of damage to muscles of chest wall in the latter. In our study, the posterolateral thoracotomy is not conventional posterolateral thoracotomy. This procedure can be regarded as muscle-sparing thoracotomy because latissimus dorsi and serratus anterior muscles were preserved. Despite preserving muscle, the recovery of respiratory muscle function is better in the transaxillary thoracotomy group than the posterolateral thoracotomy group.

For either procedure, better pain-relief from epidural anesthesia may improve the ability to cough by a greater expiratory muscle strength [5]. In our study, the variability of MEP values is greater than for MIP. Like for MIP, we found no differences in the MEP values for video-thoracoscopy and transaxillary thoracotomy group on the 4th and 30th day after surgery, whereas values for MEP was significantly lower after posterolateral thoracotomy. Several investigators have demonstrated the advantage of video-thoracoscopy or limited thoracotomy over standard posterolateral thoracotomy in decreasing pain and reducing injury to the respiratory muscles of the chest wall [2,4,11].

Both MIP and MEP measurements show the advantage of noninvasive techniques, however, these methods are poorly reproducible with an average coefficient of variation of 25% [17]. Inspiratory and expiratory mouth pressures are volitility-dependent, which explains the variability in values measurement. A specific respiratory warm-up may attenuate the ‘learning effect’ during repeated PImax measurements, which is one the main contributors to test variability [18]. There is one limitation in our study: as the patient knew the type of incision which had been performed, it might have influenced the quality of the measurement of PImax, which depends on the motivation of the patient [18].

In conclusion, video-thoracoscopy enables a better recovery of respiratory muscle function after surgery than does posterolateral thoracotomy. However, although respiratory muscle function was significantly lower in the TT group than in the VT group on the 2nd day after operation, on the 4th and 30th day it was similar for the two groups.

References


