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# Bilateral Shoulder Dysfunction Related to the Lung Resection Area After Thoracotomy

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**Abstract:** This study aimed to investigate the mobility, pain, and disability of the shoulders after different pulmonary surgical procedures.

It is a cross-sectional prospective study. A total of 38 patients who underwent lung surgery via thoracotomy (mean age = 57 ± 10 years) were evaluated in the preoperative period, and first and second postoperative days were assessed for range of motion of shoulder; pain intensity; and application of the Shoulder Pain and Disability Index questionnaire. This study compared the 3 days of evaluation, and the subgroups according to the resection area (biopsy/nodulectomy, lung segmentectomy and lobectomy).

There was a decrease of flexion (153° ± 16°–98° ± 23°), abduction (151° ± 20°–126° ± 38°), and increased Shoulder Pain and Disability Index (2.4–44.3) in the shoulder ipsilateral to surgery from the preoperative to the first postoperative day ($P < 0.05$). There was a greater loss of ipsilateral flexion and abduction in the lobectomy subgroup ($P < 0.05$), and decreased abduction of the contralateral shoulder in the lung segmentectomy and lobectomy subgroups ($P < 0.05$).

After pulmonary surgery, there is bilateral impairment in shoulder range of motion, with greater limitation on ipsilateral shoulder, and larger resections.

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**Abbreviations**: ICC = intraclass coefficient correlation, ICU = intensive care unit, MCI = minimal clinically important change, PO1 = first postoperative day, PO2 = second postoperative day, ROM = range of motion, SA = shoulder abduction, SF = shoulder flexion, SPADI = Shoulder Pain and Disability Index, SPADI-Br = Brazilian version of the SPADI questionnaire, VAS = visual analogue scale.

## INTRODUCTION

Open thoracotomy is a surgical procedure to perform different techniques, which allows for the proper exposure of the chest tissues. Postoperative pulmonary complications are the main cause of morbidity after thoracotomy, resulting in patient discomfort and increased length of hospital stay and costs.[1–4]

The clinical care following this procedure, including physical therapy, must be effective for proper treatment and good recovery of the patient, which can contribute to reduce or minimize postoperative pulmonary complications.[5–7] Physical therapy may be initiated in the preoperative period and maintained throughout the postoperative period, with prophylactic or curative purpose.[8]

The surgical procedure and resultant postoperative pain can cause a decrease in the patient's mobility, including restriction of chest and shoulder movements, with consequent overall decrease in activity, loss of muscle strength, and decreased health-related quality of life.[9–12] Thus, it is important to include functional assessment of the shoulder in the evaluation of patients undergoing thoracotomy, because early mobilization of the shoulder can contribute to improve or to prevent higher impairment in lung function in the postoperative period.[11,13–14]

Although the clinical routine care with the shoulder in the postoperative period after thoracotomy, only the study by Reeve et al[15] evaluated the results of a specific exercise program for the affected shoulder, that is, on the same side of the surgery, initiated in the immediate postoperative period. These exercises resulted in reduced pain and improved shoulder function in these patients.

Considering that shoulder mobility may be related to postoperative recovery of lung function, and a loss of function of this joint can impair daily living activities and patient independence,[15–17] it is important to identify which groups are susceptive to greater dysfunction. The hypothesis of this study was that the shoulder mobility could be impaired and that this restriction could be proportional to the extension of surgical procedure, in the sense that the greater surgical area will be related with greater shoulder impairment. The aim of this study was to investigate whether bilateral shoulder mobility in patients who undergo pulmonary resection via open conventional thoracotomy is related to the different areas of surgical resections.

## METHODS

### Design

This was a descriptive and analytical cross-sectional prospective study, conducted at the Clinical Hospital of the School of Medicine of Ribeirão Preto, in the Cardiovascular and Thoracic Surgery Unit, from 2012 to 2014. The study was approved by the Research Ethics Committee of the Clinical Hospital of the School of Medicine of Ribeirão Preto under Protocol No. 13657/2012.

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## Setting and Participants

The study population was composed of patients who underwent pulmonary surgical procedures at the Clinical Hospital of the School of Medicine of Ribeirão Preto, from 2012 to 2014. Inclusion criteria were 18 years of age or older, both sexes, and all types of surgical procedures as long as they were performed by conventional open thoracotomy.

The study participants had surgical incisions ranging from 10 to 12 cm, regardless of the surgical procedure and pulmonary resection. The patients were grouped according to the extent of surgery, by biopsy/nodulectomy, lung segmentectomy and lobectomy.

All patients received postoperative analgesia by epidural catheter, according to routine procedures of the sector and the needs of each patient.

Exclusion criteria were: patients with serious illnesses that made it impossible to apply the tests in the preoperative period; clinical conditions or previous constraints that could affect the range of motion (ROM) of the shoulder; patients who dropped out; intensive care unit stay or mechanical ventilation for more than 24 hours; prior tracheotomy; new surgical approach; and those who did not agree to participate.

## Data Measurement and Variables

The patients admitted for lung surgery were approached by the researchers in the preoperative period, informed about the study objectives, and invited to participate. Those who agreed to participate signed an informed consent form.

The patients were evaluated by the same examiner, who was blind to the purpose of the thoracotomy, the day before surgery (preoperative), and reevaluated on the first (PO1) and second (PO2) day of the postoperative period.

The intensity of the pain was assessed by visual analogue scale (VAS), and then the results were evaluated with the corresponding number, ranging from 0 to 10 (in which 0 = no pain and 10 = severe pain). The assessment of pain intensity was performed twice on each day (preoperative, PO1, and PO2), before and after the test for shoulder ROM.

The subjective perception of quality of life related to disability and shoulder pain was assessed by the Brazilian version of the SPADI questionnaire (SPADI-Br),[18] which was applied by the examiner through an interview. The interview was conducted on the sixth day after surgery, and patients were instructed to respond according to their perceptions on the PO1 and PO2 days of the postoperative period.

The total score of the SPADI-Br was obtained by adding the points in the field of pain and disability, and then the value is divided by the maximum score of the questionnaire, disregarding any not applicable answers, then multiplied by 100. The total score of the SPADI-Br can vary from 0 to 100, where higher scores indicate greater impairment of the shoulder.[19]

Finally, the active range of pain-free motion in the shoulders, ipsilateral and contralateral, to lung surgery was obtained using a universal goniometer (Carci®, São Paulo, Brazil). Flexion movements (lifting motion in the sagittal plane) and shoulder abduction (elevation in the frontal plane) were assessed.[20] The intraexaminer reliability for flexion measurements (intraclass coefficient correlation = 0.95) and shoulder abduction (intraclass coefficient correlation = 0.97) were previously established for limbs with and without pain, and the absolute error for the measurements was 2°.[21,22]

## Statistical Analysis

The sample size was calculated in a pilot study using the variable ROM, in which the statistical power was adjusted to 0.9 and with an error $\alpha$ of 0.05, requiring a minimal of 14 patients.

The Kolmogorov–Smirnov test was used to confirm normality of data distribution in the measurements of the total score of the SPADI-Br, active ROM for flexion and abduction, and intensity of pain. These variables are presented as means and standard deviations. To compare the 3 surgical subgroups, an analysis of repeated measurements of variance was used, followed by Tukey posttest when indicated. To compare the variables evaluated in the preoperative and postoperative periods, *t* test was used. The hypothesis tests were interpreted using a significance level of 5% ($P < 0.05$).

The correlations between the total score of the SPADI-Br, ROM of elevations of the shoulder and pain intensity were analyzed using the Spearman correlation test. The frequency of study participants who showed a change in scores on the SPADI-Br that was equal to or greater than the minimal clinically important change was also analyzed (equal to or greater than 10 points).[23]

# RESULTS

Thirty eight patients have completed the study (Fig. 1). Thirteen patients underwent biopsy/nodulectomy, 14 underwent pulmonary segmentectomy, and 11 underwent lobectomy. Patients in the study were between 18 and 78 years of age, with a mean of 57 ± 10 years. Seventeen patients were men and 19 were women.

The results obtained from all patients for shoulder elevation amplitudes, total score of the SPADI-Br and intensity of pain are described in Table 1. In the postoperative period,

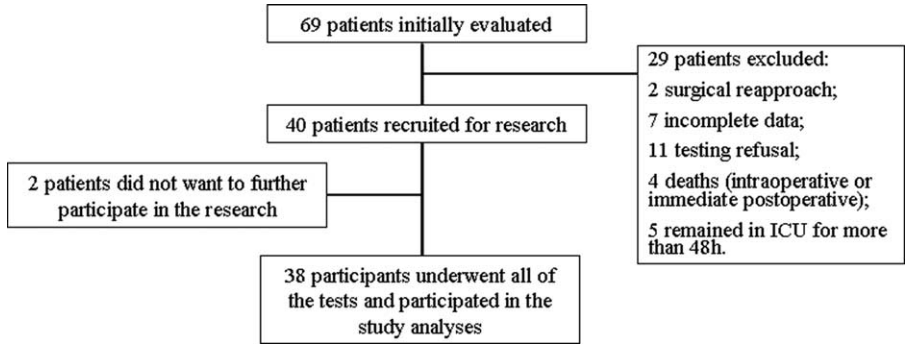


**FIGURE 1.** Flowchart of patients.

**TABLE 1.** Mean and Standard Deviation of the Values of Amplitude of Shoulder Elevation, Total Score of the Brazilian version of the Shoulder Pain and Disability Index questionnaire and Intensity of Pain in the Pre- and Postoperative Period of all Patients, Independent of the Surgical Procedure (n = 38)

| | Preoperative | PO1 | PO2 | Δ (Pre- and PO1) | Δ (Pre- and PO2) |
|---|---|---|---|---|---|
| SF ipsilateral | 153 ± 16 | 98 ± 23 | 110 ± 29 | 55 ± 7 | 43 ± 6 |
| SF contralateral | 157 ± 10 | 153 ± 14 | 153 ± 13 | 4 ± 4 | 4 ± 3 |
| SA ipsilateral | 151 ± 20 | 126 ± 38 | 108 ± 32 | 25 ± 18 | 43 ± 12 |
| SA contralateral | 156 ± 13 | 128 ± 30 | 152 ± 18 | 28 ± 17 | 4 ± 5 |
| SPADI-Br | 2.4 ± 10.4 | – | 44.3 ± 18.2 | – | 41.9 ± 7.8 |
| VAS before the ROM | 0.08 ± 0.5 | 6 ± 3 | 5 ± 3 | ≈6 ± 2.5 | ≈5 ± 2.5 |
| VAS after the ROM | 0.08 ± 0.5 | 7 ± 3 | 6 ± 3 | ≈7 ± 2.5 | ≈6 ± 2.5 |

PO1 = first postoperative day, PO2 = second postoperative day, ROM = range of motion, SA = shoulder abduction, SF = shoulder flexion, SPADI-Br = Brazilian version of the SPADI questionnaire, VAS = visual analogue scale.

there was a decrease of 49° for flexion ($P < 0.05$) and 34° for abduction ($P < 0.05$) of the shoulder ipsilateral to the thoracotomy. In the contralateral shoulder, the difference of 4° for flexion and to 16° for abduction was not statistically significant, suggesting that, in the group with all patients, decreased ROM occurred only on the ipsilateral side of the surgery.

In the preoperative period and considering the average age of the study participants (57 years), the patients had no functional limitation of the shoulder before surgery.[24] The total score of the mean SPADI-Br for the sample in the preoperative period was 2.4, with restriction on the PO1 and PO2 (44.3 ± 18.2), with a deficit in mobility of the shoulder joint in the immediate postoperative period. Confirming the limitation, all patients showed variation greater than 10 points, defined by Roy et al[23] as the minimal clinically important difference.

The VAS assessed in the preoperative period showed that patients did not have shoulder pain. Even using analgesia by epidural catheter, which is the recommended method for these patients, the mean scores on the PO1 and PO2, however, were 6 and 5, respectively.

The ROM of ipsilateral shoulder flexion showed a statistically significant decrease for the 3 subgroups on the PO1 ($P < 0.05$), whereas abduction had a significant reduction for the pulmonary segmentectomy and lobectomy groups ($P < 0.05$). The decreased range of flexion and abduction of the ipsilateral shoulder was significantly higher for the lobectomy group compared with the pulmonary segmentectomy and biopsy/lumpectomy groups ($P < 0.05$) (Figure 2).

Regarding the contralateral shoulder, there was a decreased amplitude of abduction in the pulmonary segmentectomy and lobectomy groups from the preoperative to postoperative periods ($P < 0.05$), and although the loss of flexion was not statistically significant compared with the preoperative period ($P > 0.05$), the ROM values of the lobectomy group were lower than the pulmonary segmentectomy and biopsy/nodulectomy groups on the PO1 (Figure 3).

In summary, there was no statistical difference between the lung surgery subgroups analyzed in this study ($P > 0.05$) for the SPADI-Br and pain analyses. The data showed a weak correlation between the SPADI-Br and pain in the postoperative period assessed by VAS ($r = 0.3157$ and $P = 0.026$), and in the analyses between SPADI-Br and ROM of the ipsilateral and contralateral shoulder, there were no significant correlation ($P > 0.05$).

Data analysis indicated a difference between pre- and postoperative data in both flexion and abduction. There, however, was no significant difference in the comparisons between the PO1 and PO2 in relation to the surgical procedures investigated.

## DISCUSSION

This study investigated ROM, pain, and function in the shoulders after conventional open thoracotomy in patients undergoing biopsy and nodulectomy, pulmonary segmentectomy and lobectomy. Our results showed bilateral limitation of

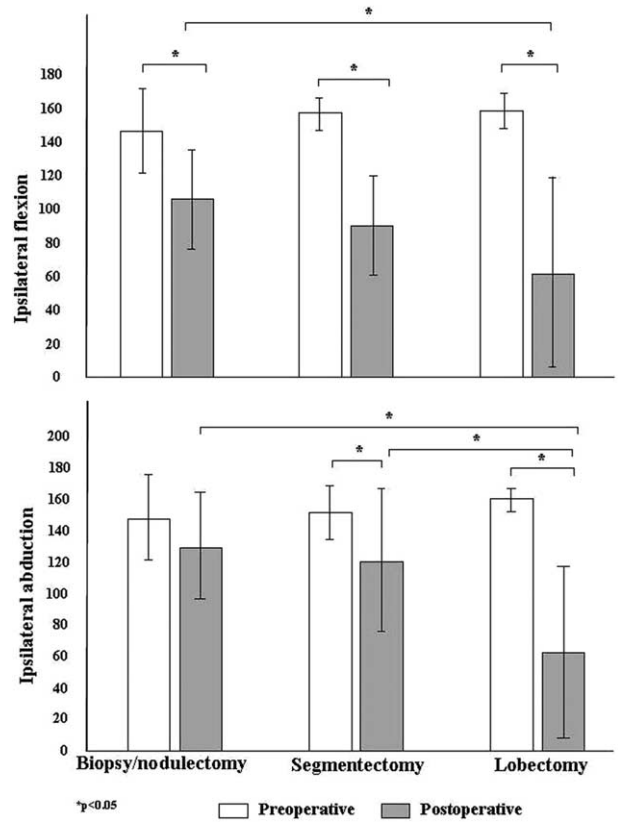


**FIGURE 2.** Analysis of ipsilateral flexion and abduction pre- and first postoperative and between the types of surgical procedures.

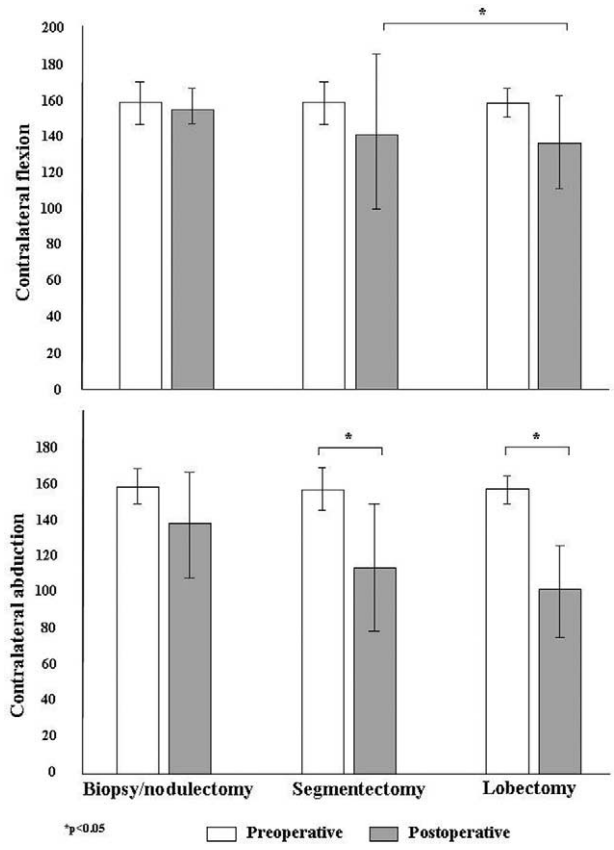


**FIGURE 3.** Analysis of pre- and first postoperative contralateral flexion and abduction between the types of surgical procedures.

the range of shoulder elevation movements, with greater impairment of the ipsilateral shoulder.

The limitation of shoulder function, which can interfere in the activities of patients in the immediate postoperative period and harm or increase recovery time, has been demonstrated by other authors.[14–15] This, however, is the first study showing a relationship between the extent of the surgery and the loss that occurs in the ipsilateral shoulder after conventional open thoracotomy.

It is possible that the reduced range of ipsilateral motion is related to the patient's position during the surgical procedure. For the best exposure of the surgical field during thoracotomy, the patient is positioned in lateral recumbence with the hemithorax to be operated on facing upward, keeping the ipsilateral upper limb in a position of intermediate arm elevation between the sagittal and frontal planes, supported on a surface with elbow flexion. Larger procedures such as lobectomy require longer surgical time, requiring patients to remain in this position for longer.

The data obtained in studies by Bonde et al[25] Gosselink et al[26] Stephan et al,[1] and Reeve et al[15] corroborate the data from this study in relation to loss of motion in the ipsilateral shoulder. The study by Reeve et al[15] compared a group that received motor exercises for the upper limbs and a control group, and detected a difference of 15° in the range of ipsilateral shoulder motion between the groups.

Our results showed a decrease of 49° for flexion and 34° for abduction of the ipsilateral shoulder, and 4° for flexion and to 16° for abduction of the contralateral shoulder. When the whole group was analyzed, the decreased ROM occurred only on the ipsilateral side to the surgery. In the subgroups according to the resection area, we also, however, obtained a significant decrease in ROM in the shoulder contralateral to surgery, and in both, the largest losses were related to major lung resections.

Thus, this is the first study to demonstrate impairment of the shoulder contralateral to surgery, especially in procedures with larger resection, which can also be explained by the positioning, because the contralateral shoulder undergoes compression from part of the patient's weight throughout the surgical procedure. In addition to the weight bearing on the glenohumeral joint, some compression load passes through the small, flat joint surfaces of the sternoclavicular, and acromioclavicular joints that contribute to completing the arm lifting ranges, particularly when the glenohumeral joint exceeds 90°.[27] Although the glenohumeral joint is eventually subjected to axial compression load when the upper limb works in a closed kinetic chain (eg, pushing a heavy object forward or upward), the sternoclavicular and acromioclavicular joints should suffer more with axial efforts because of their smaller area compared with that of the contact between the glenoid cavity of the humeral head.

The pain reported by patients using a VAS was on average $0.08 \pm 0.5$ in the preoperative period and $6 \pm 3$ in the postoperative period, measured after the research tests, despite the use of epidural analgesia by catheter in all patients. These results are in agreement with data found by Gerner,[9] who reported that over 75% of patients undergoing thoracotomy reported severe and constant pain in the shoulder on the same side as the surgery, suggesting that the positioning and type of surgery contributed to the shoulder pain reported by the patient. Reeve et al[15] demonstrated that there was an increase in pain after surgery, and deterioration of ROM of the shoulder until hospital discharge, with improvement of movement in assessments performed in 1 and 3 months after pulmonary resection.

Although there is no significant difference in external surgical incisions among the groups, being a mean of 10 cm independent of the surgical procedure, it is known that individuals who undergo larger resections can have greater extension of the anterior and posterior intercostal opening, and increased opening of the intercostal retractor and/or muscle resection, to expand the work area required by the surgeon. This may contribute to high rates of pain reported in the immediate postoperative period for major resections, as well as to greater impairment of shoulder movement related to procedures with larger resection areas. In contrast, Nosotti et al[14] observed that the performance of conventional thoracotomy or muscle-sparing technique showed no difference in limitation and postoperative pain of the shoulder.

Reeve et al[15] used the Shoulder Pain and Disability Index tool for assessment of shoulder function and ability, concluding that there was improvement in shoulder function during the postoperative period with the group that underwent physical therapy exercises for the shoulder, with reestablishment of function within 3 months after surgery. Our results also showed limitation of the shoulder as evaluated by the Shoulder Pain and Disability Index; however, there was only a weak correlation with referred pain.

Regarding the extent of the surgical procedure, Alar et al[28] demonstrated that patients with larger resections had lower scores on quality of life. We do not know which factors contribute to this worsening perception of quality of life, but it is possible that the greater loss of ROM of the shoulders

related to the procedures with larger resection area, as our results, are among these factors.

Based on the data of this study, the development of an intensive program of analgesia and bilateral exercises for the upper limbs to achieve reduction of shoulder dysfunction and pain in the immediate postoperative period, especially in patients undergoing procedures with larger resections, is recommended.

## STUDY LIMITATIONS

This is not a blinded study. During examination, the researcher knew if it was being performed in the ipsilateral shoulder or not, introducing a possible source of bias. Another limitation is related to short follow-up and the absence of thoracic cage mobility evaluation because of the complexity of doing so.

## CONCLUSIONS

In the postoperative period after pulmonary surgery, there is bilateral impairment in shoulder ROM, with greater limitation on the ipsilateral shoulder, and greater losses related to procedures with greater resection.

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