Robotic-Assisted Lobectomy Favors Early Lung Recovery versus Limited Thoracotomy

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Abstract

Background Postoperative pulmonary recovery after lobectomy has showed early benefits for the video-assisted thoracoscopic surgery and sparing open techniques over nonsparing techniques. Robotic-assisted procedures offer benefits in term of clinical outcomes, but their advantages on pulmonary recovery and quality of life have not yet been distinctly prospectively studied.

Methods Eighty-six patients undergoing lobectomy over a period of 29 months were prospectively studied for their pulmonary function recovery and pain score level during the in-hospital stay and at 1, 2, and 6 months. Quality of life was evaluated at 2 and 6 months. Forty-five patients were operated by posterolateral limited thoracotomy and 41 patients by robotic approach. The postoperative analgesia protocol differed for the two groups, being lighter for the robotic group.

Results The pulmonary tests were not significantly different during the in-hospital stay. At 1 month, the forced expiratory volume in 1 second, forced vital capacity, vital capacity, and maximal expiratory pressure were significantly better for the robotic group ($p = 0.05$, 0.04, 0.05, and 0.02, respectively). There was no significant difference left at 2 and 6 months. Pain intensity was equivalent during the in-hospital stay but was significantly lower for the robotic group at 1 month ($p = 0.02$). At 2 and 6 months, pain and quality of life were comparable.

Conclusion Robotic technique can offer similar pulmonary and pain recovery during the in-hospital stay with a lighter analgesia protocol. It clearly favors the early term recovery compared with the open limited technique. The objective and subjective functional recovery becomes equivalent at 2 and 6 months.

Keywords
- lung cancer
- pulmonary function
- quality of life
- robotic approach
- postoperative pain

Introduction

Postoperative pulmonary recovery after lobectomy for non-small-cell lung carcinoma has been described, depending on the surgical approach, being video-assisted thoracoscopic surgery (VATS) or thoracotomy. VATS techniques implying limited muscular division, or limited thoracotomies that consider muscle sparing, are both considered rather equivalent, but superior to open nonsparing thoracotomy.[1–8]

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Robotic lobectomy shows favorable results over postoperative pulmonary complications[9,10] and over postoperative pain compared with a muscle-sparing thoracotomy approach and VATS,[11,12] that could suggest a better early pulmonary recovery, but this has not yet been proven in the literature.

The goal of this study is to compare the early and midterm postoperative pulmonary testing and quality of life after lobectomy for lung cancer, performed by robotic and limited thoracotomy.

Patients and Methods

Study Cohort

After Ethical Committee Approval (Ethics Committee University Hospital recordB403201525121), we collected data from 86 consecutive patients who underwent single lobectomy in our institution over a period of 29 months (October 2015–March 2018). Patients were operated by posterolateral limited thoracotomy (45 patients, group T) of robotic approach (41 patients, group R). Selection of the technique was based on the location, size of the tumor, and risk factors of the patient. Central or large (more than 4 cm) lesions were considered for open procedure. Patients presenting risk factors for bronchopleural fistula[13,14] were also directed to open procedure with use of an intercostal flap (eight patients in T group).

Surgical and Anesthetic Technique

All patients underwent single lobectomy, associated with a mediastinal lymph node dissection. The thoracotomy technique implied a limited posterolateral incision with serratus anterior muscle sparing. Analgesia was provided in all patient of the T group by means of a patient-controlled pump, connected to an epidural catheter inserted before induction of general anesthesia.

The robotic technique, which has been described in an earlier paper,[15] was complete four arms, with a single intercostal space port access and a 0-degree camera. All patients in the R group received an intravenous patient-controlled analgesia device, combined with either a serratus plane block before surgery (21 patients), an endoscopic intercostal nerve block by the surgeon at the start of the procedure (three patients), or a wound infiltration at the end of the surgery (17 patients).

Postoperative Management

Postoperative management was in the intensive care unit for the first 24 hours and then in the thoracic surgery unit. Drainage tubes were removed when there was no air leak for 24 hours and when output fell below 250 mL.

Pulmonary Function Tests

The pulmonary function testing determined the forced expiratory volume in 1 second (FEV1), vital capacity (VC), forced vital capacity (FVC), maximum inspiratory pressure, and maximum expiratory pressure (MEP). These tests were performed preoperatively and repeated at 2 and 6 months, using a Morgan TLC spirometer (Morgan Medical, Rainham, UK; MDas v.4.01 software).

Same acquisition protocol was performed preoperatively, every day of the postoperative in-hospital stay and at 1 month, using a Micromedicalmicroloop spirometer Mk8 with spirometry software (MicroMedical Limited, Rochester, UK) for the volumes testing and a MEC Pocket-Spiro MPM100 (MEC Medical Electronic Construction, Brussels, Belgium) for the pressure testing. All measurements are expressed in percentages with respect to a reference value. As both protocols were used preoperatively, we can assume a strong correlation between them.

Evaluation of Postoperative Pain and Quality of Life

Postoperative pain intensity was assessed daily during the in-hospital stay as well as 1 month after surgery, using a 0 to 10 numerical rating scale. Pain scores were recorded by an independent person before the measurement of pulmonary function.

Two and 6 months after surgery, patients were contacted by mail. Persistent pain was assessed with the French version of the brief pain inventory questionnaire. This validated instrument has been used before in studies evaluating pain after thoracic surgery.[15,16] Besides pain intensity and location, it also collects information on pain medication and the degree to which pain interferes with different daily activities. The probability for neuropathic pain was assessed with the first seven items of the DN4 questionnaire.[17]

Two and 6 months after surgery, we also evaluated health-related quality of life with the Medical Outcomes Study 36-item Short Form (SF-36). This instrument has been recommended for evaluation of health-related quality of life after thoracic surgery[18] and we already used it in previous studies.[15,19] The SF-36 assesses eight different health concepts: physical functioning, role limitation caused by physical problems, bodily pain, general health perception, energy and vitality, social functioning, role limitation caused by emotional problems, and mental health. Each dimension is scored on a Likert scale and subsequently grouped into two summary scores: a physical component scale (PCS) and an emotional component scale (MCS, mental component scale). Both score ranges from 0 to 100, with a higher score indicating better quality of life (QoL).[20]

Statistical Analysis

Data are presented as mean (standard deviation), median (interquartile range), or proportions. Normality of the date was assessed with the Shapiro-Wilk test. We compared baseline data, pulmonary function, and pain scores of patients who underwent robotic surgery with those of patients who underwent open surgery using Chi-square test, unpaired Student *t*-test, or Wilcoxon test. We considered a *p*-value of 0.05 to be statistically significant. We performed all statistical analysis with JMP Pro 14.0 (SAS Institute Inc.).

Results

Demographics and Surgical Characteristics

Forty-five patients were operated by posterolateral muscle-sparing thoracotomy (group T) and 41 patients with a robotic approach (Group R). ►**Table 1** describes the general

Table 1 Demographic and surgical characteristics of the patients, according to the operative technique

	Thoracotomy group ($n = 45$)	Robotic group ($n = 41$)	*p*-Value
Sex (male/female)	22/23 (49/51)	27/14 (65/35)	0.11
Age (y)	63 (11)	64 (8)	0.73
BMI	25 (4)	27 (4)	0.10
Tobacco habit (pack-years)	21 (0–32)	30 (20–45)	0.06
Primary/ secondary lesion	38/7 (84/16)	40/1 (97/3)	0.02
Lesion size (mm)	30 (19–42)	18 (12–36)	0.01
%FEV1 (% predicted)	93 (20)	87 (17)	0.22
%VC (% predicted)	100 (16)	95 (18)	0.23
%FVC (% predicted)	98 (18)	95 (19)	0.43
%DL_{CO} (% predicted)	83 (19)	83 (13)	0.89
PEmax (cm H_2O)	81 (28)	88 (36)	0.30
Operating room occupation time (min)	274 (249–297)	289 (260–323)	0.12

Abbreviations: BMI, body mass index; DL_{CO}, carbon monoxide diffusing capacity; FEV, forced expiratory volume in one second; FVC, forced vital capacity; VC, vital capacity.
Note: Data are presented as numbers (%), mean (SD), or median (IQR); Data are presented as numbers (%).

Table 2 Distribution of the operated lobe, according to operating technique

	Thoracotomy group ($n = 45$)	Robotic group ($n = 41$)	*p*-Value
Right upper lobe	13 (29)	12 (29)	0.74
Right middle lobe	2 (4)	2 (5)	
Right lower lobe	9 (20)	6 (15)	
Left upper lobe	13 (29)	9 (22)	
Left lower lobe	8 (18)	12 (29)	

demographics, which were equivalent in the two groups except for type (primary NSLC or secondary) and size of the tumor. Mean lesion size was a selection criterion for the operative technique and was significantly greater in the group T (30 vs.18 mm, $p = 0.01$). The distribution of the operated lobes was equivalent (►**Table 2**). Mean operating room occupation time was equivalent for both procedures.

Pre- and Postoperative Pulmonary Function

Preoperative pulmonary function testing was available in all patients and did not differ between groups T and R. Similarly, acute postoperative pulmonary function was not significantly different between the two groups. One month after surgery, however, patients in the robotic group had significantly higher FVC (70% predicted ± 15 vs. 81% predicted ± 19, $p = 0.04$) and MEP (73 cm $H_2O \pm 22$ vs. 97 cm $H_2O \pm 40$, $p = 0.02$). Forced expiratory volume (69% predicted ± 13 vs. 76% predicted ± 15) and VC (73% predicted ± 16 vs. 81% predicted ± 15) were also higher in the robotic group, but the difference fell just short of statistical significance ($p = 0.05$). At 2 and 6-month follow-up, there was no significant difference in the pulmonary testing (►**Figs. 1–4**).

Postoperative Pain and Quality of Life

Acute pain intensity during the first postoperative week was similar in both groups. At 1 month, significantly less patients in group R reported the presence of pain (82 vs. 42%, $p = 0{,}005$) and their pain intensity was lower (1 [IQR 1–2] vs. 0 [IQR 0–1], $p = 0.04$). There was a significant correlation between pain intensity at 1 month and VC ($p = 0.04$), FVC ($p = 0.02$), and maximal expiratory pressure ($p = 0.002$; ►**Table 3**).

Two months after surgery, 46 (53%) patients returned completed questionnaires. Of those, 13 (28%) reported no pain, 26 (57%) mild, five (11%) moderate, and two (4%) severe pain in the area of surgery. Significantly less patients in group R reported moderate or severe pain ($p = 0.03$). Pain did not interfere significantly with daily activities, with a median interference score of 1 (IQR 0.5–3). According to the DN4 questionnaire, five patients (15%) reported neuropathic pain characteristics. A quarter of painful patients did not take any pain medication. Acetaminophen was the most commonly taken analgesic (70%), followed by weak opioids (27%), pregabalin (6%), and nonsteroidal anti-inflammatory drugs (NSAIDs) (3%). Mean SF-36 PCS score was 59.8 ± 17.6 while mean MCS score was 65.9 ± 22.5, without difference between group T and R.

Six months after surgery, 33 (38%) patients returned completed questionnaires. Of those, 11 (33%) reported no pain, 17 (52%) mild, and five (15%) moderate pain in the area of surgery, without difference between patients in groups T and R ($p = 0.45$). Pain interfered only mildly with daily activities, with a median interference score of 1 (IQR 0–2). According to the DN4 questionnaire, four patients (18%) reported neuropathic pain characteristics. Almost half (45%) of the patients with pain did not take any pain medication. Acetaminophen was the most commonly taken analgesic (27%), followed by weak opioids (13%), NSAIDs (13%), and pregabalin (5%). Mean SF-36 PCS score was 63.7 ± 22.2 while mean MCS score was 62.6 ± 24.4, without difference between group T and R.

Discussion

Our two groups showed equivalent pulmonary function tests before surgery. The surgical approach was based between-other on the size of the tumor (lesion less than 40 mm for the group R), which explains a statistically greater mean tumor size for the T group. One must here keep in mind that we studied a same procedure, a single lobectomy. Considering the tumor size range for the two groups (ca. 20–48 mm for the group T and 13–38 mm for the group R), no difference in technical management should be evoked.

Pulmonary function recovery after lobectomy in lung cancer has been described for thoracotomy approach[21] and for VATS.[22-] Data clearly show the advantages of the VATS technique on pulmonary recovery in the short-term compared with open

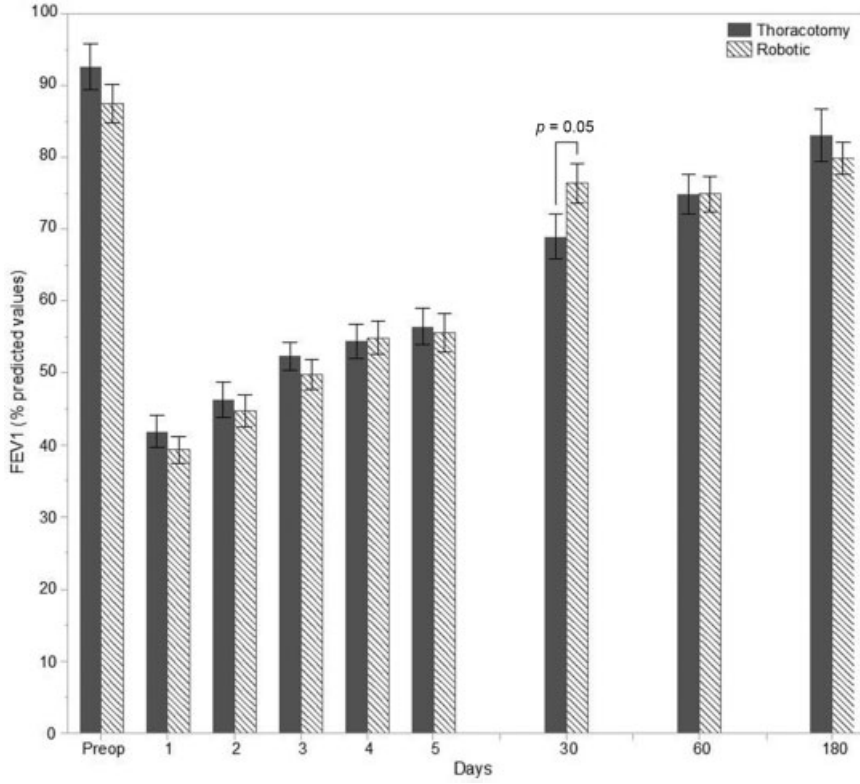

Fig. 1 Pre- and postoperative forced expiratory volume, according to the operating technique.

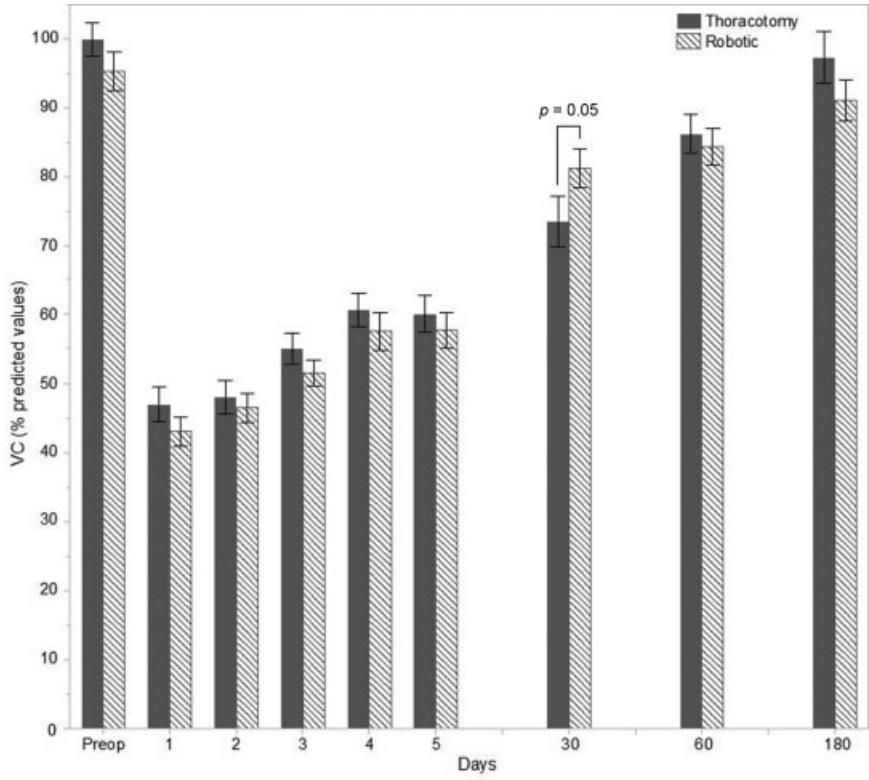

Fig. 2 Pre- and postoperative vital capacity, according to the operating technique.

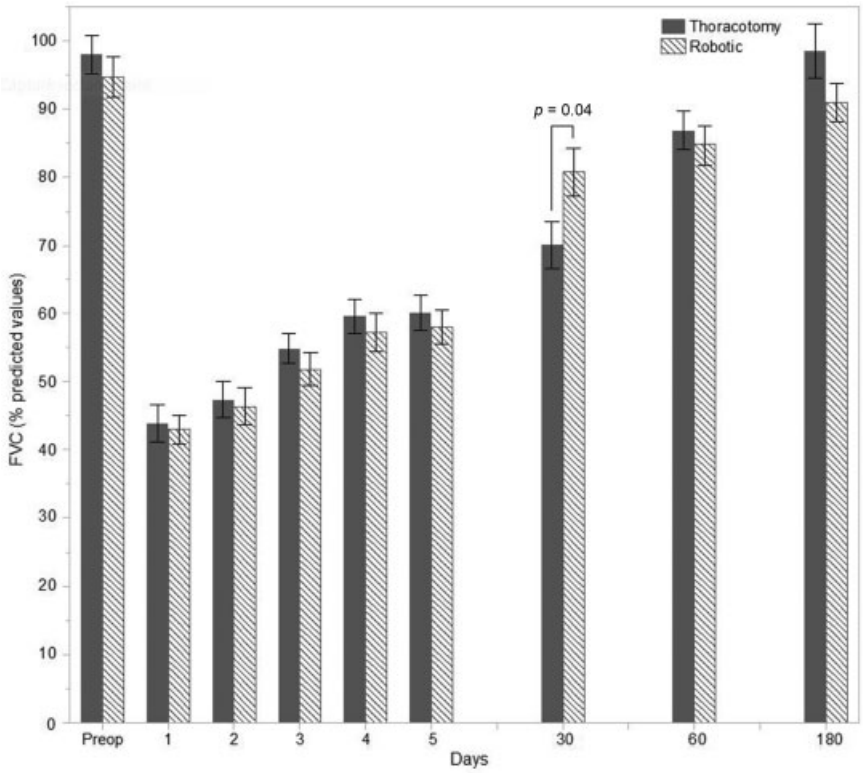

Fig. 3 Pre- and postoperative forced vital capacity, according to the operating technique.

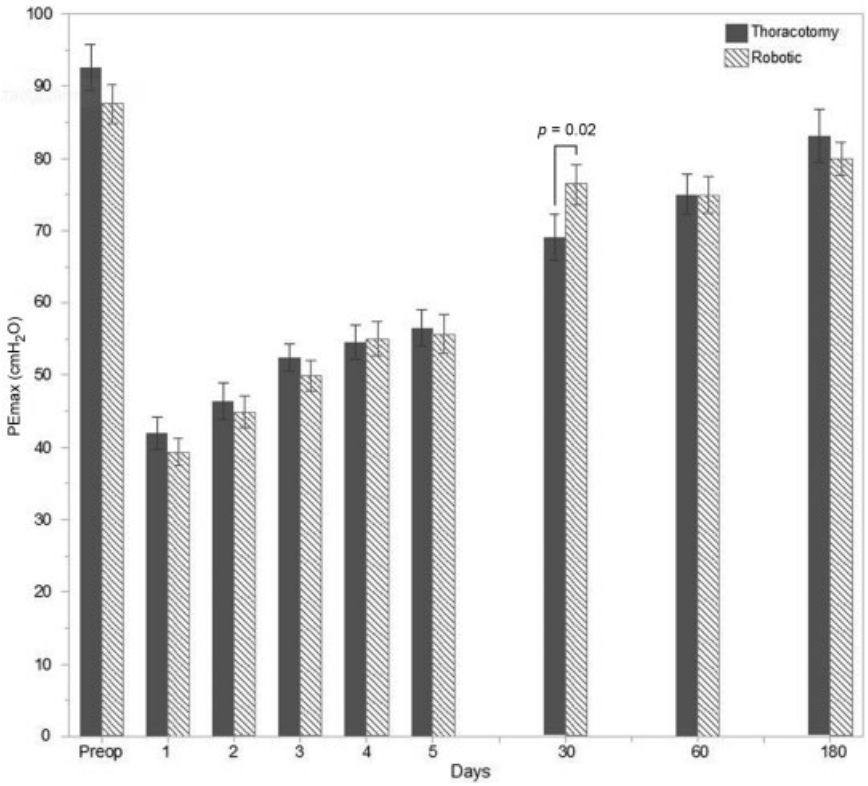

Fig. 4 Pre- and postoperative maximal expiratory pressure, according to the operating technique

nonsparing techniques.[1,4,5,8,23] Mid-term functional recovery after lobectomy has been compared between VATS and sparing open approach,[4,24] and showed no advantages of the VATS technique. There is actually in the literature no comparative data on pulmonary function after robotic and sparing open lobectomy. In the present study, we showed a significant difference at 1 month for the FVC and MEP, with higher FEV1 and VC in favor for the robotic group. There was no difference

Table 3 Numerical pain scores during the study period, according to operative technique

	Number	Thoracotomy group	Robotic group	*p*-Value
Preoperative	86	0 (0–0)	0 (0–0)	0.63
Day one	75	5 (3–6)	4 (3–6)	0.61
Day two	73	4 (3–5)	4 (2-5)	0.66
Day three	76	3 (2–5)	32 (1–4)	0.09
Day four	74	3 (2–4)	32 (1–4)	0.25
Day five	59	3 (2–4)	2 (1–4)	0.27
One month	50	1 (1,2)	0 (0–1)	0.04[a]
Two months	46	1 (0–2)	0.25 (0–1)	0.19
Six months	33	1 (0–3)	0.5 (0.2–25)	0.33

[a]Data are presented as median (IQR).

left at mid and long term, in accordance to few studies that showed no difference left, considering open or VATS approaches.[1,4] Acute pain following thoracic surgery is often intense, requiring multimodal and often invasive analgesic techniques.[25] In addition to NSAIDs and acetaminophen, all thoracotomy patients benefited from continuous epidural analgesia, whereas patients in the robotic group received an intraoperative single-shot nerve block and an intravenous patient-controlled analgesia pump. Despite this different—and less invasive—analgesic regimen, pain scores were similar in both groups during the first postoperative days. These results seem to support previous reports that suggested that the analgesic requirements are reduced after robotic surgery when compared with open approaches.[26] Moreover, significantly more patients in the robotic group were pain-free 1 month after surgery. These findings are consistent with an earlier study by Cerfolio, who reported lower pain intensity 3 weeks after robotic surgery, compared with a rib- and nerve-sparing thoracotomy procedure.[11] In our sample, pain intensity was correlated with pulmonary function; this could be one of the factors explaining the quicker functional recovery we observed in the robotic group.

Persistent postoperative pain is a frequent complication of thoracic surgery, affecting around 50% of the patients.[27] In our study, 71 and 67% reported persistent pain at 2 and 6 months, respectively. Pain intensity was mostly mild, with only 15% reporting moderate pain or higher at both time-points. Moreover, the pain only modestly interfered with their daily activities, and most patients only took simple analgesics. This is in line with the results of a recent study describing pain after VATS—another minimally invasive approach—where 11% of patients reported moderate or higher pain scores 3 months after their procedure.[28] In our sample, the incidence of persistent pain was not different between the robotic and thoracotomy group, in line with a recent prospective observational study that found a similar incidence of chronic pain after thoracotomy or VATS.[29] Contrary to a meta-analysis which concluded that 66% of persistent pain after thoracic surgery was neuropathic,[30] only 15% (at 2 months) and 18% (at 6 months) of our patients with pain reported a DN4 score indicating likely neuropathic pain.

The evidence on QoL after open or minimally invasive thoracic surgery is mixed, with studies reporting better, equivalent, or worse QoL after VATS.[31–33] Cerfolio et al were the first to study QoL in thoracic robotic surgery patients.[34] They reported improved QoL 3 weeks after robotic surgery compared with open surgery, but this difference was no longer significant by the fourth postoperative month. Similarly, in this study, both MCS and PCS scores were similar between the thoracotomy and robotic group at 2 and 6 months. In terms of QoL, our results are similar to those of an earlier study by our team[15] and compare favorably with previous studies that also used the SF-36 to evaluate QoL after thoracic procedures.[19,31] A possible explanation for the lack of difference between the groups could be the use of the SF-36, a generic QoL instrument. Procedure-specific questionnaires could be more sensitive to change and thus unmask subtle differences. The PIDATS (pain-related impairment of daily activities after thoracic surgery) questionnaire has been specifically developed for the evaluation of QoL after thoracic surgery,[33] but as it has not yet been translated and cross-culturally validated in French and we were therefore unable to use it for this study.

Conflict of Interest

None declared.

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