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Postoperative outcomes of robotic-assisted lobectomy in obese patients with non-small-cell lung cancer

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Key question

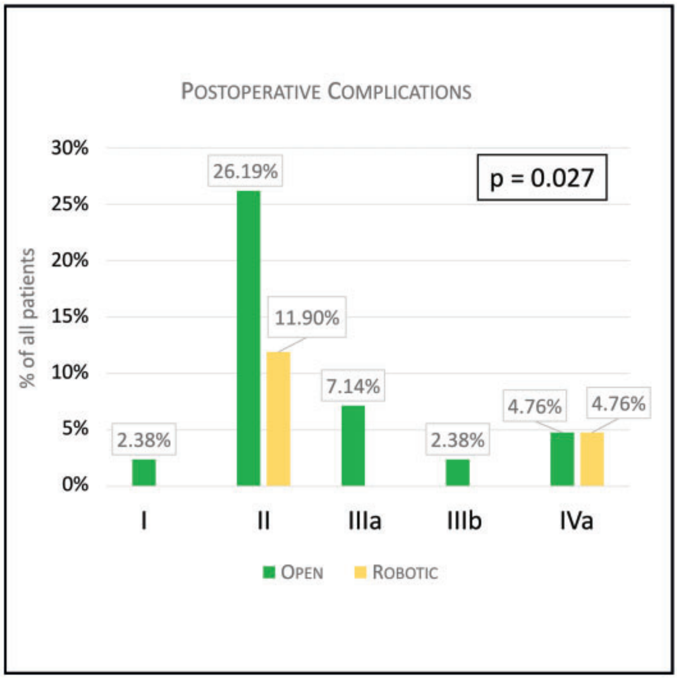
Is robotic-assisted lobectomy safe compared to open surgery for obese patients with non-small-cell lung cancer?

Key finding(s)

Postoperative complications were significantly more frequent after open lobectomy than after robotic-assisted lobectomy (42.9% vs 16.7%; p=0.027).

Take-home message

Robotic-assisted lobectomy is feasible and safe for obese patients with non-small-cell lung cancer and has clear advantages compared to open surgery.



Abstract

OBJECTIVES: The aim of this study was to assess the postoperative outcomes of robotic-assisted lobectomy in obese patients to determine the impact of the robotic approach on a high-risk population who were candidates for major pulmonary resection for non-small-cell lung cancer (NSCLC).

METHODS: Between January 2007 and August 2018, we retrospectively reviewed the medical records of 224 obese patients (body mass index ≥ 30) who underwent pulmonary lobectomy at our institution via robotic-assisted thoracic surgery (RATS, $n = 51$) or lateral muscle-sparing thoracotomy ($n = 173$).

RESULTS: Forty-two patients were individually matched with those who had the same pathological tumour stage and similar comorbidities and presurgical treatment. The median operative time was significantly longer in the RATS group compared to that in the thoracotomy group (200 vs 158 min; $P = 0.003$), whereas the length of stay was significantly better for the RATS group (5 vs 6 days; $P = 0.047$).

Postoperative complications were significantly more frequent after open lobectomy than in the RATS group (42.9% vs 16.7%; $P = 0.027$). After a median follow-up of 4.4 years, the 5-year overall survival rate was 67.6% [95% confidence interval (CI) 45.7–82.2] for the RATS group, and 66.1% (95% CI 46.8–79.9) for the open surgery group (log-rank $P = 0.54$). The 5-year cumulative incidence of cancer-related deaths was 24.8% (95% CI 9.7–43.5) for the RATS group and 23.6% (95% CI 10.8–39.2) for the open surgery group (Gray's test, $P = 0.69$).

CONCLUSIONS: RATS is feasible and safe for obese patients with NSCLC with advantages compared to open surgery in terms of early postoperative outcomes. In addition, the long-term survival rate was comparable to that of the open approach.

Keywords: Robotic surgery • Non-small-cell lung cancer • Minimally invasive surgery • Obesity • Body mass index

ABBREVIATIONS

AF	Atrial fibrillation
BMI	Body mass index
CT	Computed tomography
ICU	Intensive care unit
NSCLC	Non-small-cell lung cancer
RATS	Robotic-assisted thoracic surgery
VATS	Video-assisted thoracic surgery

INTRODUCTION

In 2016, more than 1.9 billion adults over 18 years of age were overweight and over 650 million adults were obese [body mass index (BMI) > 30 kg/m^2] [1]. Worldwide obesity has nearly tripled since 1975, becoming a significant health problem, especially considering that obesity is often related to the risk of developing chronic diseases such as cardiovascular disease, musculoskeletal disorders, type 2 diabetes, coronary heart disease, kidney failure and various types of cancers [1]. Although in the past some studies demonstrated an inverted relationship between weight and lung cancer [2, 3], recent studies have found a higher incidence of high BMI in patients with lung cancer [4, 5].

Nowadays, a significant number of patients with non-small-cell lung cancer (NSCLC) are overweight or obese [6], probably due to the recent outburst of obesity in industrialized countries where the smoking habit and lung cancer have also progressively increased. Thus, it is not uncommon for thoracic surgeons to recommend obese patients for major pulmonary resection for NSCLC, despite their well-known poor outcomes and postoperative complications [4, 6–10] as well as the technical difficulties encountered during surgery due to the limited visibility caused by increased internal fat, limited movements of instruments and deeper body cavity.

Minimally invasive approaches such as video-assisted thoracic surgery (VATS) and, more recently, robotic-assisted thoracic surgery (RATS) have been introduced as alternative modalities to the standard open approach via thoracotomy to improve outcomes and reduce postoperative complications [10–17] while guaranteeing the same oncological results [18–20]. These new approaches could play an important role in treating high-risk obese patients, in whom the impact of a thoracotomy on the chest physiology could increase respiratory postoperative complications and overall early outcomes. In addition, they could offer the surgeon better visualization and an easier surgical approach compared to open surgery.

The aim of this study was to assess the postoperative outcomes of robotic lobectomy compared to open thoracotomy in obese patients to determine the impact of RATS on the high-risk population of candidates for major pulmonary resection for NSCLC.

MATERIALS AND METHODS

We retrospectively reviewed the medical records of all consecutive patients who underwent pulmonary lobectomy for NSCLC at our institution between January 2007 and August 2018. The ethics committee approved data collection and analysis and waived the need for written consent.

Two hundred and twenty-four obese patients with BMI ≥30 undergoing pulmonary lobectomy by either a robotic-assisted or an open thoracotomy approach were considered for the study. BMI was defined as a person's weight in kilograms divided by the square of his/her height in metres (kg/m^2). According to the definition of the World Health Organization, a patient is defined as 'obese' when his/her BMI is ≥30 kg/m^2 [1]. Our exclusion criteria were BMI <30, pulmonary resection other than lobectomy (wedge resection, bilobectomy, pneumonectomy, extended pulmonary resection) and Pancoast tumour. Patients with benign lesions and lung metastases who did not undergo radical lymphadenectomy were excluded. The choice of the surgical approach (RATS vs open) was based on the experience of the surgeon and was shared by the multidisciplinary team, including the entire group of surgeons involved in RATS.

Preoperative evaluation

Preoperative staging included chest computed tomography (CT) and positron-emission tomography with fluorodeoxyglucose. A standard functional evaluation included an electrocardiogram, cardiological examination, pulmonary function test and anaesthesia evaluation. Staging and functional examinations were always performed within 5 weeks before the operation.

All patients who were clinically suspected of lymph node involvement (positive results on positron-emission tomography scan or with lymph nodes larger than 1.5 cm on CT scans) underwent endobronchial ultrasound-guided transbronchial needle aspiration or mediastinoscopy to stage the mediastinal lymph nodes. Patients with stage IIIA-N2 NSCLC underwent induction platinum-based chemotherapy for at least 3 cycles.

Surgery

All patients underwent pulmonary lobectomy and radical lymphadenectomy. Systematic lymph node dissection according to the classification of the American Thoracic Society was performed in all patients; all lymphatic tissue was removed from stations 2R, 4R, 7R and 10R for right-sided tumours and from

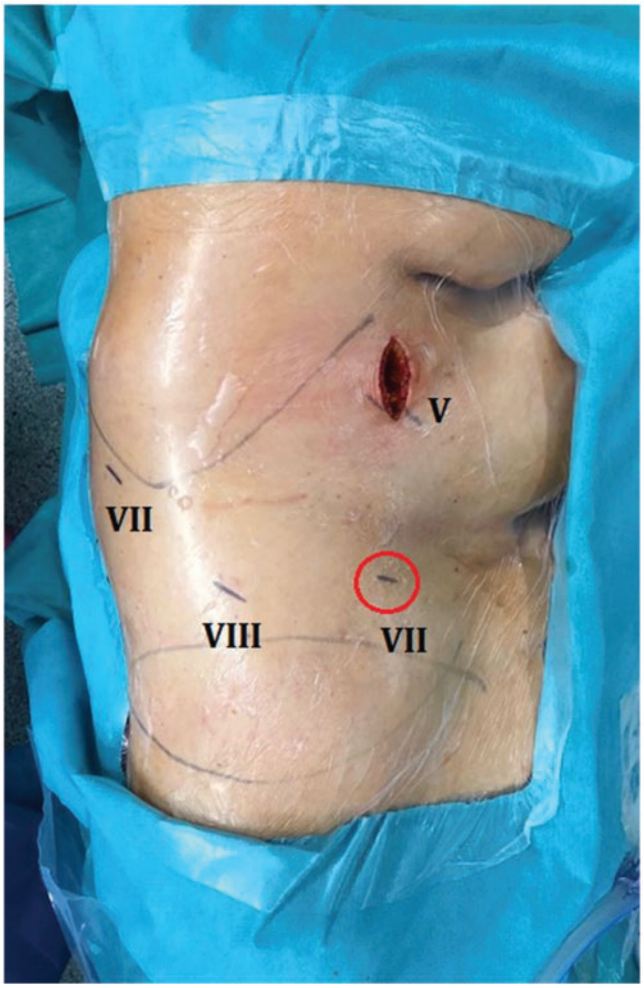


Figure 1: Four-arm robotic approach with utility incision: patient positioning and port placement. The red circle indicates the camera port.

stations 5L, 6L, 7L and 10L for left-sided tumours. Lesions without a preoperative diagnosis were first excised by standard or VATS (using utility incision) wedge resection followed by intraoperative examination of frozen sections.

Since we started our robotic experience, we have always used the same 4-arm non-completely portal robotic approach (Fig. 1) described previously [19]. Briefly, the patient was put under general anaesthesia and, after insertion of a double-lumen endotracheal tube, placed in the lateral decubitus position. A 3-cm utility incision was performed at the 4th or 5th intercostal space, anteriorly; through this incision an 8-mm 30° tridimensional robotic camera was placed into the chest and, under direct vision, 3 additional camera ports were placed: The camera port in the 7th or 8th intercostal space was on the midaxillary line; 1 port was placed at the 7th or 8th intercostal space in the posterior axillary line; and another port was added at the auscultatory triangle. The portal placement did not change with the type or side of resection or with the type of robotic system (S, SI or XI). The operative specimens including the pulmonary lobe were usually extracted from the 3-cm utility incision without any ribs spread.

However, with the introduction of the new da Vinci XI robotic system in 2015, we made the following technical changes: (i) The surgical cart was docked from the left side of the patient either for right or left thoracic procedures thanks to the technical innovation of the new robotic system that displaced the robotic arms correctly despite its side position, without any changes in the operating theatre. (ii) The new system allowed surgeons to work with a minimum distance of 4 cm between the ports, without the need for a specific distance between the ports. (iii) The camera could be moved between 2 different ports, allowing for a better view. (iv) We used an EndoWrist stapler (30 vascular and 30 or 45 parenchyma), which could be placed through a 12-mm port, as previously reported [21]. The open surgery approach was performed via a lateral muscle-sparing thoracotomy in the 4th or 5th intercostal space.

Postoperative management and follow-up period

Patients were admitted to the intensive care unit (ICU) following the operation only if required by the anaesthesiologist; the decision was based on surgical risk according to the guidelines of the American College of Chest Physicians. All patients with severe cardiac comorbidities were usually monitored postoperatively for at least 24 h or longer, based on the decision of the cardiologist. Postoperative pain control during the hospital stay was managed with the administration of patient-controlled morphine supplemented with intravenous analgesia. Oral analgesics were subsequently used after the patient was discharged.

Postoperative complications were defined according to the classification of Seely *et al.* [22]. Patients received a physical examination, chest radiograph and blood tests 1 month after the operation followed by a physical examination plus a chest and upper abdominal CT scan every 6 months for 3 years and then every year for up to 5 years. Physical examinations and follow-up of the patients were always performed by a thoracic surgeon.

Statistical analyses

To account for differences in patients characteristics and in tumour stages in the 2 groups, we performed a matched case-control study: patients who had robotic surgery were individually matched with patients treated with open surgery who had the same pathological tumour stage (IA, IB, IIA, IIB, IIIA, IIIB according to the AJCC Cancer Staging Manual, 8th edition) [23], similar comorbidities (cardiovascular, pulmonary, diabetes or previous malignancy) and similar presurgical treatment. The McNemar test of symmetry and the non-parametric sign rank test were used to assess differences in the distribution of categorical and continuous characteristics between the 2 paired groups. The log-rank test and Gray's test, respectively, were used to assess differences in overall survival and the cumulative incidence of cancer-related deaths between the 2 groups. All analyses were 2-tailed; P-values <0.05 were considered significant. All analyses were performed with the SAS software (version 9.4, SAS Institute, Cary, NC, USA).

RESULTS

The perioperative and postoperative characteristics of the 224 enrolled patients are detailed in Supplementary Material, Table S1. Fifty-one of 220 (23.2%) patients underwent RATS lobectomy, whereas 169 (76.8%) underwent open surgery via a lateral muscle-sparing thoracotomy. The median BMI was 32.6 (30.0–43.1) for patients who had open surgery and 32.0

THORACIC

Table 1: Patient characteristics in the robotic-assisted thoracic surgery and thoracotomy groups after matching

	All procedures (*n* = 84)	Open lobectomies (*n* = 42)	Robotic lobectomies (*n* = 42)	*P*-value[a]
Age (years), median (range)	66 (36–81)	66 (36–78)	66 (45–81)	0.99
Male gender, *n* (%)	55 (65.5)	27 (64.3)	28 (66.7)	1.00
BMI (kg/m^2), median (range)	31.9 (30.1–43.6)	31.4 (30.1–43.1)	32.3 (30.1–43.6)	0.64
Obesity class, *n* (%)				
1 (BMI 30 to <35)	74 (88.1)	38 (90.5)	36 (85.7)	
2–3 (BMI ≥ 35)	10 (11.9)	4 (9.5)	6 (14.3)	0.69
Clinical stage, *n* (%)				
I	67 (79.8)	30 (71.4)	37 (88.1)	
II	11 (13.1)	7 (16.7)	4 (9.5)	
III	6 (7.1)	5 (11.9)	1 (2.4)	0.062
Comorbidities, *n* (%)				
Previous malignancy	18 (21.4)	9 (21.4)	9 (21.4)	Matching
Diabetes	8 (9.5)	4 (9.5)	4 (9.5)	Matching
Cardiac comorbidity	52 (61.9)	26 (61.9)	26 (61.9)	Matching
Pulmonary comorbidity	4 (4.8)	2 (4.8)	2 (4.8)	Matching
FEV1 (% predicted), median (range)	87.9 (46–141)	90.1 (56–133)	86.0 (46–141)	0.13
Laterality, *n* (%)				
Left	37 (44.0)	16 (38.1)	21 (50.0)	
Right	47 (56.0)	26 (61.9)	21 (50.0)	0.38
Site, *n* (%)				
Upper lobe	48 (57.1)	24 (57.1)	24 (57.1)	
Medial lobe	2 (2.4)	1 (2.4)	1 (2.4)	
Lower lobe	34 (40.5)	17 (40.5)	17 (40.5)	1.00
Histological diagnosis, *n* (%)				
Squamous	16 (19.1)	7 (16.7)	9 (21.4)	
Adenocarcinoma	66 (78.6)	34 (81.0)	32 (71.2)	
Adenosquamous	2 (2.4)	1 (2.4)	1 (2.4)	0.95
Diameter (mm), median (range)	22.0 (9–80)	23.0 (9–80)	22.0 (10–75)	0.40
<20, *n* (%)	29 (34.5)	12 (28.6)	17 (40.5)	
20–29, *n* (%)	27 (32.1)	14 (33.3)	13 (31.0)	
30–39, *n* (%)	12 (14.3)	7 (16.7)	5 (11.9)	
≥40, *n* (%)	16 (19.1)	9 (21.4)	7 (16.7)	0.14
Pathological stage (8th edition), *n* (%) [23]				
IA	36 (42.9)	18 (42.9)	18 (42.9)	Matching
IB	18 (21.4)	9 (21.4)	9 (21.4)	
IIA	0 (0.0)	0 (0.0)	0 (0.0)	
IIB	16 (19.1)	8 (19.1)	8 (19.1)	
IIIA	12 (14.3)	6 (14.3)	6 (14.3)	
IIIB	2 (2.4)	1 (2.4)	1 (2.4)	
Presurgical treatment, *n* (%)	6 (7.1)	3 (7.1)	3 (7.1)	Matching
Postsurgical treatment, *n* (%)	13 (15.5)	5 (11.9)	8 (19.1)	0.51
CT/RT/CT + RT	8/4/1	3/1/1	5/3/0	

[a]McNemar test of symmetry or signed rank test.

BMI: body mass index; CT: chemotherapy; FEV1%: forced expiratory volume in 1 s (% of predicted); RT: radiotherapy.

(30.1–43.6) for those who had RATS. A BMI ≥35 (class 2–3 obesity) was found in 6 (11%) patients in the RATS group and in 33 (19%) patients who had the open approach. The type of robot used was 'S' in 4 cases, 'SI' in 27 cases and 'XI' in 20 cases. Most of the patients undergoing RATS (46/51; 90.2%) were clinical stage I NSCLC, with a tumour diameter smaller than 3 cm (34/51; 76.7%). Only 3 (5.9%) patients out of 51 had preoperative treatments such as chemotherapy or radiotherapy. Four robotic (7.8%) cases were converted to open surgery: 1 for adherence, 1 for bleeding due to pulmonary artery rupture while performing fissure dissection and 2 for tumour stage requiring extended resection such as bronchial/vascular sleeve resection. These patients were not excluded from the analysis and were considered in the RATS group.

Thus, 42 patients undergoing RATS lobectomies were individually matched to 42 patients who underwent open thoracotomy lobectomy during the same period at our institution (Table 1).

After matching for tumour stage, comorbidities and presurgical treatment, no difference was observed between the 2 groups for age, sex, BMI, clinical stage, pulmonary function, tumour site, histological diagnosis, diameter of the tumour and postoperative treatments.

Postoperative complications

The postoperative complications according to the Seely classification and outcomes for both groups are reported in Table 2. Overall postoperative complications were more frequent after open lobectomy than after RATS (42.9% vs 16.7%; $P = 0.027$). In the RATS group, only 7 (16.7%) patients had postoperative complications: 2 (4.7%) patients had atrial fibrillation (AF), 2 (4.7%) patients had pneumonia treated only with antibiotics, 2 (4.7%) patients had acute respiratory distress syndrome requiring a stay

Table 2: Postoperative complications and outcomes of the matched groups

	Open lobectomy (*n* = 42)	Robotic lobectomy (*n* = 42)	*P*-value
Overall postoperative complications, *n* (%)	18 (42.9)	7 (16.7)	0.027
Seely I	1 (2.4)	0 (0.0)	
Seely II	11 (26.2)	5 (11.9)	
Seely IIIa	3 (7.1)	0 (0.0)	
Seely IIIb	1 (2.4)	0 (0.0)	
Seely IVa	2 (4.8)	2 (4.8)	
Cardiac complications, *n* (%)	9 (21.4)	2 (4.8)	0.065
AF	9 (21.4)	2 (4.8)	
Pulmonary complications, *n* (%)	6 (14.3)	4 (9.5)	0.73
ARDS	1 (2.4)	2 (4.8)	
Pneumonia	2 (4.8)	2 (4.8)	
Bronchial toilette	3 (7.1)	0 (0.0)	
Surgical complications, *n* (%)	3 (7.1)	1 (2.4)	0.63
Anaemia	2 (4.8)	0 (0.0)	
Air leak	0 (0.0)	1 (2.4)	
Air leak requiring rethoracotomy, *n* (%)	1 (2.4)	0 (0.0)	
Other, *n* (%)	3 (7.1)	0 (0.0)	0.24
Renal insufficiency	2 (4.8)	0 (0.0)	
Diabetes	1 (2.4)	0 (0.0)	
Need for ICU, *n* (%)	1[a] (2.4)	3[b] (7.1)	0.63
Operating time (min), median (range)	158 (95–310)	200 (105–388)	0.003
Length of hospitalization (days), median (range)	6 (4–21)	5 (3–33)	0.047
<6, *n* (%)	13 (31.0)	24 (57.1)	
6–9, *n* (%)	25 (59.5)	16 (38.1)	
≥10, *n* (%)	4 (9.5)	2 (4.8)	0.080
Deaths, *n*			Log-rank *P*-value
Overall deaths	11	10	0.54
Deaths of cancer	8	7	0.60
Deaths of other cause	3	3	0.74

[a]One patient was admitted to the ICU for postoperative ARDS requiring invasive ventilation.

[b]Two patients were admitted to the ICU for postoperative ARDS requiring non-invasive ventilation, whereas 1 patient required the ICU only for postoperative monitoring due to severe cardiac comorbidity.

AF: atrial fibrillation; ARDS: acute respiratory distress syndrome; ICU: intensive care unit.

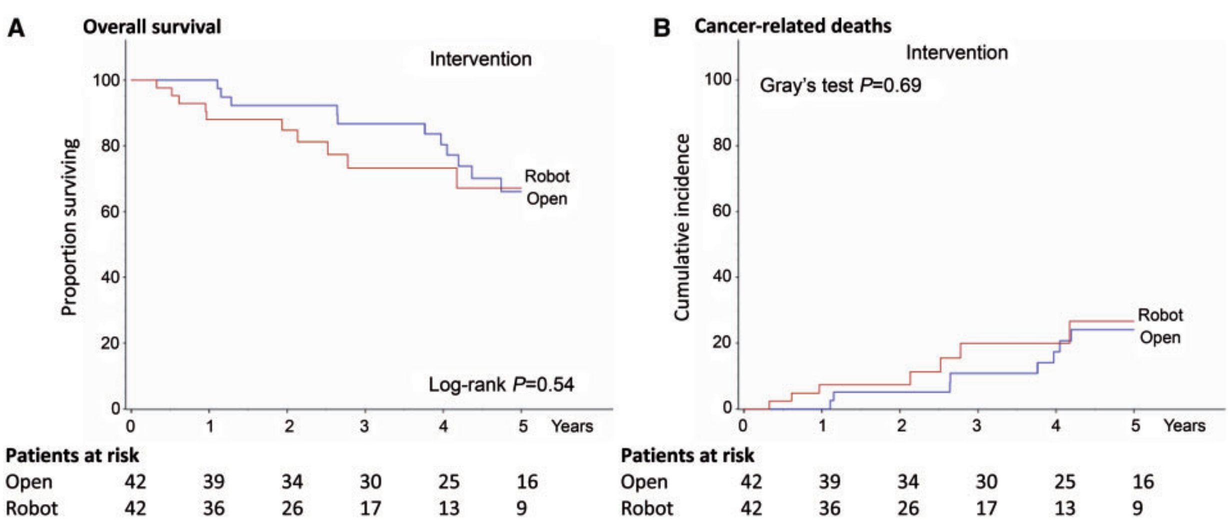


Figure 2: (**A**) Overall survival and (**B**) cancer-related deaths.

in the ICU for non-invasive ventilation and 1 patient had prolonged air leak (>5 postoperative days).

In the open surgery group, 18 patients (42.9%) experienced 21 postoperative complications including AF in 9 (21.4%) patients, glucose imbalance in 1 (2.3%), sputum retention and bronchial toilette in 3 (7.1%), anaemia requiring transfusions in 2 (4.7%), pneumonia treated only with antibiotics in 2 (4.7%), acute kidney failure in 2 (4.7%), rethoracotomy for prolonged air leak in 1 (2.3%) patient and 1 (2.3%) case of acute respiratory distress syndrome requiring a stay in the ICU and invasive ventilation.

The median operative time was significantly longer in the RATS group compared with the thoracotomy group (200 vs 158 min; *P* = 0.003), whereas the length of stay was significantly shorter for the RATS group (5 vs 6 days; *P* = 0.047).

No operative or in-hospital deaths occurred in either group of patients.

Oncological outcomes

There were 11 recurrences in the RATS group and 12 in the open surgery group. In the RATS group, 2 patients had local recurrences (1 hilar and 1 mediastinal N2 relapse), 1 patient had a new ipsilateral pulmonary nodule and 8 patients developed distant metastases. In the thoracotomy group, 4 patients had local recurrences (2 hilar and 2 mediastinal N2 relapses), 3 patients had a new contralateral pulmonary nodule and 5 patients had distant metastases.

After a median follow-up of 4.4 years, the 5-year overall survival rate (Fig. 2) was 67.6% (95% CI 45.7–82.2) for the RATS group and 66.1% (95% CI 46.8–79.9) for the open surgery group (log-rank $P = 0.54$). The 5-year cumulative incidence of cancer-related deaths (Fig. 2) was 24.8% (95% CI 9.7–43.5) for the RATS group and 23.6% (95% CI 10.8–39.2) for the open surgery group (Gray's test $P = 0.69$).

Three patients in the RATS group died of other causes (1 of leukaemia, 1 of pulmonary embolism and 1 of cardiac arrest) as did 3 patients in the open surgery group (2 of pancreatic cancer and 1 of colorectal cancer).

DISCUSSION

Although several studies have already demonstrated an inverse relationship between obesity and lung cancer [2, 3], in the last decades the incidence of lung cancer in obese patients has dramatically increased, forcing thoracic surgeons to routinely deal with this category in their clinical practices.

Obesity is mostly an independent risk factor for cardiovascular disease and respiratory dysfunctions that changes the surgical risk and affects perioperative decision-making. In particular, the excess weight of the obese patient alters lung physiology; it increases the intra-abdominal pressure and decreases the compliance of the chest wall. This restrictive lung disease pattern leads to a reduction in lung volume and an increase in the breathing effort especially during the perioperative period. In addition, postoperative pain and narcotic drugs could add to the already existing lung dysfunction, leading to hypoxaemia and respiratory failure [24].

After major pulmonary resection, obese patients are usually considered to be at high risk for adverse postoperative events, in particular respiratory complications or complications from prolonged operative time, due to their physical body habitus and the numerous related comorbidities [6, 7, 25, 26].

In the era of minimally invasive surgery, it is clear that the minor surgical impact and the related quicker recovery time could lead to a better postoperative outcome especially in high-risk patients. Numerous studies already report benefits of both VATS and RATS compared with open surgery in terms of less postoperative pain, shorter hospitalizations, fewer overall complications and reduced postoperative deaths [15–17]. However, few data are available about the advantages of minimally invasive surgery in obese patients, in particular RATS. In 2017, Montané *et al.* [27] studied 287 patients who underwent robotic lobectomy (7 patients 'underweight', 94 'normal weight', 106 'overweight' and 80 'obese'), showing that obese patients might benefit from minimally invasive surgery due to a quicker recovery time compared to open lobectomy, while still providing an adequate oncological resection. However, the authors confirmed the necessity of increasing physical and respiratory therapy in addition to administering an anticoagulant drug to reduce the risk of postoperative respiratory complications, including embolism [28]. In our study, the length of stay was significantly lower for the RATS group compared with the thoracotomy group (5 vs 6 days; $P = 0.027$).

The incidence of overall postoperative complications was lower in the RATS group than in the open surgery group ($P = 0.03$). In particular, cardiac and pulmonary complications such as AF and bronchial toilet were less frequent in patients undergoing robotic lobectomy, probably due to the minor impact of the robotic approach on the chest physiology. Prolonged air leak is usually more frequent after robotic surgery due to the absence of tactile feedback, which could lead to important parenchymal damage if the surgeon is not yet confident with the robotic approach. However, only 1 patient (2.4%) in the RATS group had prolonged air leak, which is particularly low considering that the prolonged air leak rates reported in the literature usually ranged from 4% to 23% for RATS lobectomies and from 0% to 27% for open lobectomies [28]. Even the operative time could be longer in obese patients: the progressive increase of operative duration mirrors the increase in BMI, which is related to an excess of body fat and to the greater depth of the operative field, both of which cause major difficulties for the surgeon to identify and isolate the anatomical structures. Analysing the Society of Thoracic Surgeons General Thoracic Surgery database, St Julien *et al.* [26] demonstrated a mean increase of 7.2 min in the operative time for every 10-unit increase in BMI but with no consequences for the postoperative outcomes. Liou and Berry [29] recently published a review of thoracic surgery considerations in obese patients, concluding that even if surgery on obese patients could be challenging from a technical point of view, minimally invasive procedures should be considered whenever feasible because they are technically and physically less difficult for the surgeon owing to a better view compared with the open approach. Also in our experience, despite the significantly longer operative time for the RATS group compared to the open surgery group (200 vs 158 min; $P = 0.03$), probably due to the learning curve of the different surgeons associated with the robotic approach, the better view and the easier manoeuvrability of the robotic instrument make the RATS definitely less challenging for the surgeon in obese patients. Even if, in our matched group, there was no evidence of postoperative dysphonia, upon analysing the entire cohort of patients we found that none of the 51 patients of the robotic group had postoperative dysphonia due to a lesion of the recurrent laryngeal nerve, compared with 6 (3.6%) out of 169 patients in the open group, probably due to the better vision with the robotic system (data not shown).

We did not find any significant difference in long-term survival between the 2 approaches both for overall and cancer-related deaths, which emphasizes that robotic surgery has acceptable long-term results compared with open surgery.

Limitations

The major limitations of this study are the small number of patients evaluated and the retrospective nature of the study, which probably limit and influence all of the variables included in the analysis. Another limitation could be the single-centre experience with robotic surgery, due to patient selection (mono-centre study). On the other hand, it could be considered a strength of the study, accounting for a minor variability due to a different approach and the surgical experiences typical of multicentre studies with both the RATS and the open approach. Finally, 4 surgeons performed RATS at different times during their learning curves, which could negatively influence some findings such as the operative time (definitely longer in the RATS group) and postoperative complications. Nevertheless, most of the RATS cases were performed in the last 5 years when our activity became more frequent and intense due to the major expertise of the surgeons involved.

CONCLUSION

In conclusion, RATS is feasible and safe for obese patients with NSCLC with clear advantages compared to open surgery in terms of early postoperative outcomes; in addition, long-term survival was comparable to that with open surgery. In the future, thanks to more extensive experience with the technique, the robotic approach could also be extended to more advanced cases, but a longer follow-up period to evaluate the oncological results is still needed.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *ICVTS* online.

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Author contributions

Monica Casiraghi: Conceptualization; Project administration; Writing—Original draft; Writing—Review & Editing. **Giulia Sedda:** Data curation; Software; Supervision; Writing—Original draft; Writing—Review & Editing. **Cristina Diotti:** Data curation; Writing—Review & Editing. **Alessio Vincenzo Mariolo:** Data curation; Writing—Review & Editing. **Domenico Galetta:** Methodology; Writing—Review & Editing. **Adele Tessitore:** Formal analysis; Writing—Review & Editing. **Patrick Maisonneuve:** Formal analysis; Methodology; Software; Writing—Original draft; Writing—Review & Editing. **Lorenzo Spaggiari:** Conceptualization; Supervision; Writing—Review & Editing.

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