Video-assisted thoracic surgery major pulmonary resections.
Present experience

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Abstract

Objective: The purpose of this report is to review our experience of video-assisted thoracic surgery (VATS) major pulmonary resections. Methods: From January 1993 to December 1999 we proposed VATS, for major pulmonary resections, with these indications: benign lesions and solitary metastases not removable by wedge resection and stage I non-small cell lung cancer (NSCLC). The maximum size of the lesion had to be less than 4 cm. Results: There were 125 patients, 87 men and 38 women with a mean age of 62. We successfully performed VATS procedure in 112 cases (one hamartoma, one tuberculoma, 12 typical carcinoids, 11 metastases and 87 lung cancers), while in another 13 (10.4%) a conversion to open surgery was required. There were 108 lobectomies, three bilobectomies and one pneumonectomy. Out of the first three cases of NSCLC, in all patients mediastinal node sampling or lymphadenectomy was performed. We recorded 13 (11.6%) postoperative complications, one of which required re-operation (bleeding). In the 99 patients without complications, the mean postoperative stay was 5.8 days. In a mean follow-up period of 36 months with patients having lung cancer we achieved a 3-year survival rate of 85% and 90% when only the patients in Stage I were considered. Conclusions: We believe that VATS, in performing pulmonary lobectomy, is a safe and effective approach and it seems to give the same long-term results as open surgery. Now the main problems concern the indications that should be strictly respected and the conversion to thoracotomy which should be undertaken without hesitation when the anatomic or pathologic conditions are not favourable. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Video-assisted thoracic surgery; Pulmonary lobectomy; VATS lobectomy

1. Introduction

Video-assisted thoracic surgery (VATS) was first performed at the beginning of the 1990s and almost immediately, though in various ways, the first major lung resections were carried out, particularly lobectomies [1–3]. Subsequently, since video-assisted techniques were found to be effective not only for lobectomies but also for pneumonectomies [4,5], an attempt was made to provide a clear definition of the indications and limits of such techniques. However, in spite of numerous reports in the literature attesting to the reliability of VATS in carefully selected cases [6–13], most thoracic surgeons are still reluctant to use it and, as a result, it is adopted only in certain centres.

The purpose of this report is to present our findings on 125 cases of VATS major pulmonary resections in order to contribute towards a clearer definition of the related problems, with particular reference to the indications, perioperative results and long-term outcomes.

2. Materials and methods

At the Thoracic Surgery Unit of the Department of Surgery at the S. Maria delle Croci Hospital in Ravenna (Italy) between 1 January 1993 and 31 December 1999 we selected 125 patients for VATS major pulmonary resection, consisting of 87 men and 38 women in the age range from 21 to 81 years (mean age: 62 years).

All the patients were examined with chest X-ray, computed tomography (CT) scan and bronchoscopy with transbronchial biopsy; in cases in which no histological diagnosis was available, a transcutaneous biopsy was performed. In 20 of these cases no diagnosis was obtained and for these patients the indication for surgery was therefore of an indeterminate nodule. In these cases, a videothoracoscopic
Pulmonary wedge resection was initially carried out and when the frozen section revealed the presence of a lesion for which a lobectomy was required, this was performed during the same surgical session. In just two of these cases, in which the indeterminate nodule was located at the hilum of the middle lobe, the lobectomy was directly performed.

The indications for VATS lobectomy are shown in Table 1. In addition to the 100 cases of stage I non-small cell lung cancer (NSCLC), there were 11 patients with solitary metastasis that could not be excised with a wedge resection due to the proximity of the lesion to the hilum. An indication for VATS for typical carcinoids, discussed in detail in an earlier report [14], was ascertained in seven cases for peripheral nodules and in five cases for central lesions, of which one was located at the bifurcation of the intermediate bronchus and the others at the branch of a lobar or segmental bronchus. The indication for VATS was based on a careful examination of the CT scan: the lesion must be no greater than 4 cm in diameter, it must not infiltrate the thoracic wall, the mediastinum or the diaphragm and no hilar or mediastinal lymph nodes should be greater than 1 cm in diameter. However, in five patients with pulmonary carcinoma, in which the CT scan had revealed larger peritracheal nodes, a mediastinoscopy was carried out that identified the adenopathies as benign. Moreover, only in the cases of carcinoma, the lesion should not be visible in the lobar or segmental bronchi during bronchoscopic examination. With regard to further preoperative tests and preparation for the operation, there were no variations from the standard criteria for traditional surgical pulmonary resection.

Consent was obtained for a VATS procedure and the possible need for conversion to open thoracotomy was explained to the patients involved.

The surgical technique (Fig. 1) applied is now standard and is similar to that proposed by Roviaro et al. [1,4] and briefly described in a previous report [15]. We use three ports and an anterior mini thoracotomy no greater than 5 cm in length without spreading the ribs; all the bronchovascular structures are separately isolated and divided.

After the operation the patients underwent clinical and chest X-ray every 6 months for the first 2 years and thereafter once a year; CT scans were carried out 1, 3 and 5 years after the operation.

Probability of survival after VATS lobectomy was estimated by the Kaplan–Meier method. The influence of variables on survival (univariate analysis) was analyzed using the log-rank test; values of $P < 0.05$ were considered significant.

### Table 1

<table>
<thead>
<tr>
<th>Indications for major pulmonary resections in 125 patients</th>
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<tbody>
<tr>
<td>Stage I NSCLC</td>
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<tr>
<td>Solitary metastasis not removable by wedge resection</td>
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<tr>
<td>Typical carcinoid</td>
</tr>
<tr>
<td>Solitary indeterminate nodule (middle lobe)</td>
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### Table 2

<table>
<thead>
<tr>
<th>Type of major pulmonary resections successfully performed by VATS (89.6% of those planned)</th>
<th>Left</th>
<th>Right</th>
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<tbody>
<tr>
<td>Upper lobectomy</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>Middle lobectomy</td>
<td>–</td>
<td>7</td>
</tr>
<tr>
<td>Lower lobectomy</td>
<td>31</td>
<td>34</td>
</tr>
<tr>
<td>Bilobectomy</td>
<td>–</td>
<td>3</td>
</tr>
<tr>
<td>Pneumonectomy</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

3. Results

In 112 cases (89.6%) the operation was completed by VATS, whereas in 13 cases (10.4%) thoracotomy was required. The types of resection carried out are shown in Table 2. We want to emphasize that we did not plan any pneumonectomy, but in one case we performed one because while operating we found a neoplasia of the lower lobe infiltrating the upper lobe that also presented bullous disease.

The reasons for conversion to thoracotomy were of a technical nature in six cases and an oncological nature in seven others. The technical cases include two bleeding in which transfusions and an immediate thoracotomy were
necessary; these cases occurred during the first 2 years of operations and were associated with a lack of experience with the technique. In six other patients a haemorrhage occurred that was brought under control endoscopically, but in two of these cases transfusions were necessary. The other cases of conversion for technical reasons include two cases of fusion of fissures, one case of widespread pleural adhesions and one case of blockage of the endostapler in the inferior pulmonary vein necessitating a thoracotomy to divide the vein inside the pericardium and the removal of the lobe with the instrument still attached. The conversion to thoracotomy for oncological reasons was carried out in six patients due to the presence of sizeable hilar lymph nodes, which not only led us to believe that the disease was not stage I, but also prevented a satisfactory dissection of the vessels. Conversion to thoracotomy was also carried out in one patient due to infiltration of the pulmonary hilum that required a pneumonectomy.

In the patients with NSCLC, mediastinal lymph node dissection was carried out in 22 cases and sampling was performed in 62 cases, whereas in three cases, which were the first VATS lobectomies to be performed, the lymph nodes were not considered. In patients with typical carcinoids, only lymph node sampling was performed, whereas in those with solitary metastases and in those with benign pathology, the mediastinal lymph nodes were not removed.

The amount of time required for the procedure diminished with the increase in experience; whereas the first operations took five hours, the later operations took no more than 2.5 h, even in complicated cases.

Postoperative stay was uneventful in 99 (88.4%) of the 112 patients undergoing operations that were completed by VATS and in all 13 cases in which thoracotomy was necessary. The mean length of postoperative stay was 6.2 days (range: 4–21 days) but in the 98 patients undergoing lobectomy or bilobectomy with no complications, it was 5.8 days (range: 4–8 days). Postoperative complications arose in 13 cases (11.6%) with one of these requiring a subsequent operation. This patient, treated for a carcinoid, had a haemothorax requiring transfusion 12 h after the procedure; during the re-operation, also carried out by VATS, the source of the haemorrhage was not identified. In spite of this complication he was discharged 7 days after the operation. Seven patients presented air leaks: five of these were prolonged and associated with subatelectasis of the residual lobe, whereas two were revealed by a large mediastinal and subcutaneous emphysema. In a period of 11–21 days after surgery all these air leaks were completely resolved. Moreover, two remaining patients presented atrial fibrillation treated with amiodarone and one presented urinary retention that was treated with a fixed urinary catheter.

The definitive pathological finding of the pulmonary lesions and the postoperative staging of the primary carcinomas are shown in Table 3. With regard to the anatomopathological examination, it should be mentioned that in seven cases during the extraction of the specimen from the thoracic cavity a laceration of the tumour and the surrounding parenchyma occurred; as a result it was difficult to measure the exact size of the tumour and to identify the ‘T’ for the TNM staging with any precision. Consequently, among the group of 72 cases of stage I NSCLC, we undoubtedly had 41 T1 and 24 T2. Moreover, in the same group of patients we found 37 squamous carcinomas and 35 adenocarcinomas.

The long-term results, with a mean period of follow-up of 36 months (range: 6–82 months), are restricted to the cases of VATS lobectomy for primary lung cancer. As shown in Fig. 2, the 86 patients considered have an overall 3-year survival rate (OS) of 85%±9% that increases to 90%±8% (Fig. 3) if we only examine the 72 cases with stage I. In addition, the univariate analysis of this last group of patients does not show any significant difference ($P > 0.05$) when comparing those older than 70 to those younger (Fig. 4) and adenocarcinomas with squamous carcinomas (Fig. 5).

![Fig. 2. Overall survival (OS) rate in 86 lung cancer patients treated with VATS lobectomy.](image-url)
4. Discussion and conclusions

In a comparison between the first pioneering lobectomies carried out by VATS [1–3] and present-day procedures, no major innovations have been reported in terms of technique, though the feasibility and replicability of such operations has improved considerably [6–13]. The techniques in use still vary considerably among the various centres [16]; in the cases in the present series the operation was carried out in exactly the same way as a thoracotomy while taking full advantage of the benefits of endoscopic surgery, whereas in other cases the broncho-vascular structures of the hilum are not separately divided [6] or the mini thoracotomy is always widened [3,17].

The rate of conversion to thoracotomy reported in the literature (Table 4) ranges from 0 [6] to 26.8% [18]. This is mainly due to oncological factors, as there are many cases in which preoperative staging is underestimated with the result that the operation cannot be continued endoscopically. The second cause is bleeding which, especially in the early cases, results in the need to convert to thoracotomy, at times very rapidly; in this connection, however, it must be stressed that there do not appear to be any cases of mortality due to bleeding of this kind in the literature. Except in the case of serious mistakes during dissection or malfunctioning of an endostapler [19], haemorrhages are always easily brought under control by the application of pressure or the closure of the vessel with endoscopic pincers; subsequently, a decision must be taken about whether to proceed by means of thoracotomy. Another frequent cause of the conversion to thoracotomy is that of adhesion preventing proper dissection of the broncho-vascular structures of the hilum.

The incidence of postoperative complications appears to be lower than for thoracotomy, varying from 10.0 [10] to 27.3% [14]. In control studies [12,17,20–22], VATS presents a considerably lower rate of morbidity than thoracotomy and this is related to the reduced level of invasiveness required for endoscopic access. The most frequent cause of postoperative morbidity emerging from many

### Table 4

<table>
<thead>
<tr>
<th>Conversion to thoracotomy (%)</th>
<th>Postoperative complications (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giudicelli et al. [17]</td>
<td>10.2</td>
</tr>
<tr>
<td>Yim et al. [16]</td>
<td>26.8</td>
</tr>
<tr>
<td>Lewis et al. [6]</td>
<td>0</td>
</tr>
<tr>
<td>Walker [9]</td>
<td>11.8</td>
</tr>
<tr>
<td>Roviaro et al. [10]</td>
<td>16.5</td>
</tr>
<tr>
<td>McKenna et al. [11]</td>
<td>6.0</td>
</tr>
<tr>
<td>Present series</td>
<td>10.4</td>
</tr>
</tbody>
</table>

Fig. 3. Overall survival (OS) rate of 72 patients with stage I NSCLC treated with VATS lobectomy.

Fig. 4. Survival curves of patients with stage I NSCLC treated with VATS lobectomy. Adenocarcinomas A (n = 35) vs. squamous carcinomas S (n = 37). There are no significant differences between the two groups: \( P > 0.05 \)

Fig. 5. Survival curves of patients with stage I NSCLC treated with VATS lobectomy. Median follow up 36 months.
reports [6–10,13,15] is prolonged air leak and this is related to the difficulty of managing adhesions and incomplete fissures by VATS. The postoperative haemorrhage requiring a second operation that occurred in one case, the cause of which was not identified in the second operation, is a rare complication also reported by Guidicelli et al. [17]. There are also other complications, such as bronchial fistula and pleural empyema reported sporadically [9–11], but they do not seem to bear a direct relationship to the technique utilized.

The results of follow-up studies of patients undergoing VATS lobectomy for cancer do not seem to vary greatly from those obtained for open surgery: Lewis et al. [6], in a report of 100 cases with a mean follow-up of 26.5 months, found six cases of recurring neoplasia, whereas McKenna et al. [11], with a mean follow-up of 28.9 months, report a survival rate 4 years after operation of 70% for stage I NSCLC. Kirby et al. [20], who compared the results for a group of VATS lobectomies with those for a group of thoracotomies did not report any significant differences in survival rates 13 months after the operation; in a prospective study, Sugi et al. [13] reported in 100 cases of stage I A NSCLC a 5-year survival rate of 90% for VATS and 85% for thoracotomy. Our long-term results show a 3-year survival rate of 90% for stage I pulmonary carcinoma and therefore they are similar to the previous studies. We believe that all these good results of VATS lobectomy will have to be confirmed by large series, but at present they seem not to significantly differ from those achieved by open surgery.

The main criticism regarding the use of VATS in major pulmonary resection concerns the indications for this type of treatment, with particular reference to compliance with the principles of oncological surgery in neoplastic patients. In order to make a careful selection it is important to assess the position and size of the tumour, in order to operate only on stage I patients, preferably with squamous type [23] and in a peripheral part of the lung. This assessment is carried out on the basis of CT scan and bronchoscopy: the tumour must be no greater than 4 cm in diameter, must be within the parenchyma and must not be visible during bronchoscopy. Unlike other authors [6,11], we believe that lesions of a larger size should not be treated by VATS due to the objective difficulty of the endoscopic movements and the high probability that such tumours are at an advanced stage. On the basis of these considerations it may be stated that though pneumonectomies can be carried out by VATS, they are only indicated in isolated cases. Moreover, CT scan should not show enlarged hilar or mediastinal lymph nodes, which would give rise to problems in identifying arterial and bronchial branches during endoscopic surgery or would spread from the cancer. The presence of enlarged lymph nodes only in the mediastinum is not a contraindication, but it should first be investigated by mediastinoscopy. In agreement with other authors [7,11,13,23,24], we are of the opinion that with VATS it is possible to carry out a complete pulmonary resection with an adequate surgical staging of the tumour. In order to assess the mediastinal lymph nodes, we prefer to perform sampling, as we do in conventional surgery, even if complete lymphadenectomy can be done by VATS [7,23,24].

In conclusion, we believe that VATS could be the preferred method to perform lobectomy in the treatment of selected cases of pulmonary lesions including stage I NSCLC. It seems to produce the same results over time as open surgery, but it has the advantages of being minimally invasive. However, VATS lobectomy must be used only with precise indications, since it is a relatively complex procedure; there is a need to select patients carefully for this technique and to convert to thoracotomy in cases in which the anatomical and pathological conditions are not suitable.

References


