Feasibility and Results of Awake Thoracoscopic Resection of Solitary Pulmonary Nodules

Eugenio Pompeo, Davide Mineo, Paola Rogliani, Alessandro F. Sabato and Tommaso C. Mineo

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://ats.ctsnetjournals.org/cgi/content/full/78/5/1761

Feasibility and Results of Awake Thoracoscopic Resection of Solitary Pulmonary Nodules

Eugenio Pompeo, MD, Davide Mineo, MD, Paola Rogliani, MD, Alessandro F. Sabato, MD, and Tommaso C. Mineo, MD

Division of Thoracic Surgery and Multidisciplinary Pulmonary Program, Policlinico Tor Vergata University, Rome, Italy

Background. General anesthesia with single-lung ventilation is considered mandatory for thoracoscopic pulmonary resection. We assessed in a randomized study the feasibility and results of awake thoracoscopic resection of solitary pulmonary nodules.

Methods. Between March 2001 and February 2003, 60 patients were randomized into two 30-patients arms: a general anesthesia arm entailing double-lumen intubation and thoracic epidural anesthesia (control group); and an awake arm entailing sole thoracic epidural anesthesia at T4-T5 (awake group). Anesthesia time; operative time; global operating room time; patient satisfaction with the anesthesia and technical feasibility scored into 4 grades (from 1 = poor to 4 = excellent); visual analog pain score (VAS), nursing care (number of patient calls per day), 24 hours changes in arterial oxygenation (ΔPaO_2), and hospital stay were assessed.

Results. There was no mortality. There was no difference in technical feasibility between the groups although 2 patients in the awake group required conversion to thoracotomy due to severe adhesions. Other 2 patients in each group required conversion due to unexpected lung cancer requiring lobectomy. Comparisons of awake versus control group results showed that in the awake group, anesthesia satisfaction score was greater (4 vs 3, $p = 0.04$), whereas ΔPaO_2 (-3 mm Hg vs −6.5 mm Hg, $p = 0.002$); nursing care (2.5 calls per day vs 4 calls per day, $p = 0.0001$), and hospital stay (2 days vs 3 days, $p = 0.02$) were significantly reduced.

Conclusions. In our study, awake thoracoscopic resection of solitary pulmonary nodules proved safely feasible. It resulted in better patient satisfaction, less nursing care and shorter in-hospital stay than procedures performed under general anesthesia.

(Ann Thorac Surg 2004;78:1761–8)
© 2004 by The Society of Thoracic Surgeons

A solitary pulmonary nodule is an approximately round lesion that is less than 3 cm in diameter and is completely surrounded by pulmonary parenchyma, without other abnormalities. It is noted on 0.09% to 0.20% of all chest radiographs [1, 2]. Infectious granulomas and hamartomas account for the most common benign diagnosis but 40% up to 50% of indeterminate pulmonary nodules prove to be malignant [3].

Surgical lung biopsy by video-assisted thoracic surgery (VATS) has demonstrated proven accuracy and has become an increasingly accepted approach for management of solitary pulmonary nodules [3–6]. General anesthesia with one-lung ventilation, is deemed mandatory for pulmonary VATS resection although several adverse effects can derive from this type of anesthesia including the development of atelectasis in both the dependent and nondependent lung, and the so called ventilator-induced lung injury [7].

We hypothesized that to avoid general anesthesia-related risks, awake VATS resection of peripheral solitary pulmonary nodules could be performed under sole thoracic epidural anesthesia (TEA). We reasoned that avoidance of general anesthesia and double-lumen intubation could result in shorter in-operating room time, and faster recovery eventually leading to a shorter hospital stay.

For this reason, having assessed feasibility in a short pilot study, we undertaken a randomized trial comparing results of awake VATS resection of solitary pulmonary nodules versus those of a control group operated under general anesthesia with one-lung ventilation.

Material and Methods

The study was started in March 2001 and was closed in February 2003. Written informed consent was obtained from all patients who took part and the study was approved by the institutional review board of the Tor Vergata University. Sixty patients with undetermined solitary pulmonary nodule, who met the entry criteria, were randomized by computer into two groups: 30 patients underwent VATS resection of the pulmonary nodule under conventional general anesthesia with one-lung ventilation. Thirty patients underwent awake VATS resection under sole thoracic epidural anesthesia (TEA). All patients underwent preoperative fiberoptic bronchoscopy, high resolution computed tomography and pulmonary function testing. To be eligible patients should have a solitary pulmonary nodule localized in the peripheral

GENERAL THORACIC

Abbreviations and Acronyms

ASA = American Society of Anesthesiology
COPD = chronic obstructive pulmonary disease
FEV_1 = forced expiratory volume in 1 second
FVC = forced vital capacity
PaO_2 = arterial oxygen tension
TEA = thoracic epidural anesthesia
VATS = video-assisted thoracic surgery
VAS = visual analog pain scale

one-third of the lung and measuring less than 3 cm at the high resolution computed tomography. In addition, to avoid the risk of suboptimal management of malignant lesions, only patients with radiologically benign nodules, discovered within 1 month from enrollment, no signs of enlarged lymphnodes, unremarkable fiberoptic bronchoscopy findings, and no history of malignancy were considered eligible. Other inclusion criteria were the absence of radiologic signs of pleural scarring in the hemithorax targeted for lung resection, no clinical signs of active infectious disease, less than 80 years old, ASA score equal to or less than 3, and the absence of severe emphysema requiring lung volume reduction surgery.

Contraindications for TEA included unfavorable anatomy, previous surgery of the cervical or upper thoracic spine, compromised coagulation (thromboplastin time < 80%, prothrombin time > 40 seconds, or platelets < 100/nl) or bleeding disorder.

Evaluated variables included anesthesia time calculated as the time required for performing each type of anesthesia; operative time calculated as the time comprised between skin incision and completion of skin closure; global operating room time that was the overall time spent by the patient into the operating room and included anesthesia time, operative time and the time required for weaning and achievement of stable clinical condition deemed necessary to allow the patient to be transferred from the recovery room to the ward. Finally, the patient was asked to express his satisfaction with the anesthesia type while the surgeon himself judged the technical feasibility of each procedure. For each of these factors 4 possible scores were possible (4 = excellent, 3 = good, 2 = satisfactory, 1 = unsatisfactory). Nursing care was estimated and scored by recording the number of patient calls for nursing care and was deemed a measure reflecting the overall patient discomfort and the degree of limitation in his autonomy during simple daily life activities. Postoperative pain was assessed by a standard visual analog pain scale (VAS).

Both nursing care need and VAS assessment were performed 24 hours after the procedure or just before discharge if hospital stay lasted 1 day only. In addition, preoperative to postoperative (day one) changes in arterial oxygenation (ΔPaO_2), postoperative complications, and hospital stay were also recorded in all patients.

Criteria for discharge were standardized and discharge was performed in uneventful courses, 1 hour after re-

moval of the chest tube. The chest tube was removed after that a chest roentgenogram demonstrated complete re-expansion of the lung and 24 hours after that any air leak stopped and drainage fluid did not exceed 150 mL.

Surgical Technique

All the procedures were performed with the patient placed in full lateral decubitus position and through a three-flexible-thoracoscopic-trocars access. Localization of the nodule was performed by digital and instrumental palpation without additional adjuvant methods. To facilitate identification of smallest nodules, a custom made ring forcep was used.

Excision of the nodule was performed by staple wedge resection (Fig 1). Dependent pleural drainage was obtained with a single 28F chest tube placed to –20 cm H_2O suction at the conclusion of each procedure. All patients in the general anesthesia group were extubated in the operating room.

Anesthesia

The objective of TEA was to achieve somatosensory and motor block at the T1 to T8 level. The maximum permissible block level was C6, which was monitored by the development of Horner's syndrome. One of the major objectives was to achieve motor block of the intercostal muscles while preserving diaphragmatic respiration. The thoracic epidural catheter was inserted at the T4 level after that patients were premedicated orally with 7.5 mg midazolam. In the operating room, patients received a continuous infusion of ropivacaine 0.5% and sufentanil 1.66 μg/mL into the epidural space. Sensory level was tested every 5 minutes with warm-cold discrimination. Thus sensory block was achieved between the neck and the abdomen, including the arms.

During the procedure patients breathed O_2 through a ventimask as required to keep oxygen saturation above 90%. Whenever somatosensory block was judged unsatisfactory by the patient, additive anesthesia was provided by local injection of a 50% mixture of ropivacaine (7.5%) and bupivacaine (2%). During wound closure, the TEA anesthetic regimen was changed to ropivacaine 0.16% and sufentanil 1 μg/mL at 2 to 5 mL/hour to provide postoperative analgesia. All patients received lactated Ringer's solution at 12 mL · Kg^{-1} · h^{-1}. The epidural catheter was removed 24 hours after surgery. Patients undergoing general anesthesia with single-lung ventilation had a thoracic epidural catheter inserted between T5 and T8 with a continuous infusion of ropivacaine started during surgery and continued for the first postoperative 24 hours to assure postoperative analgesia. General anesthesia was induced with intravenous propofol (1.5 to 2 mg/Kg), fentanyl (0.1 mg), and vecuronium (0.1 mg/Kg), and maintained using a continuous infusion of propofol (4 to 8 mg · Kg), fentanyl and vecuronium. A left-sided double-lumen tube was placed under fiberoptic control. In both groups usual monitoring was used. Whenever conversion to thoracotomy was required in patients undergoing awake VATS, this was performed after switching to general anesthesia and single-lung ventilation. In
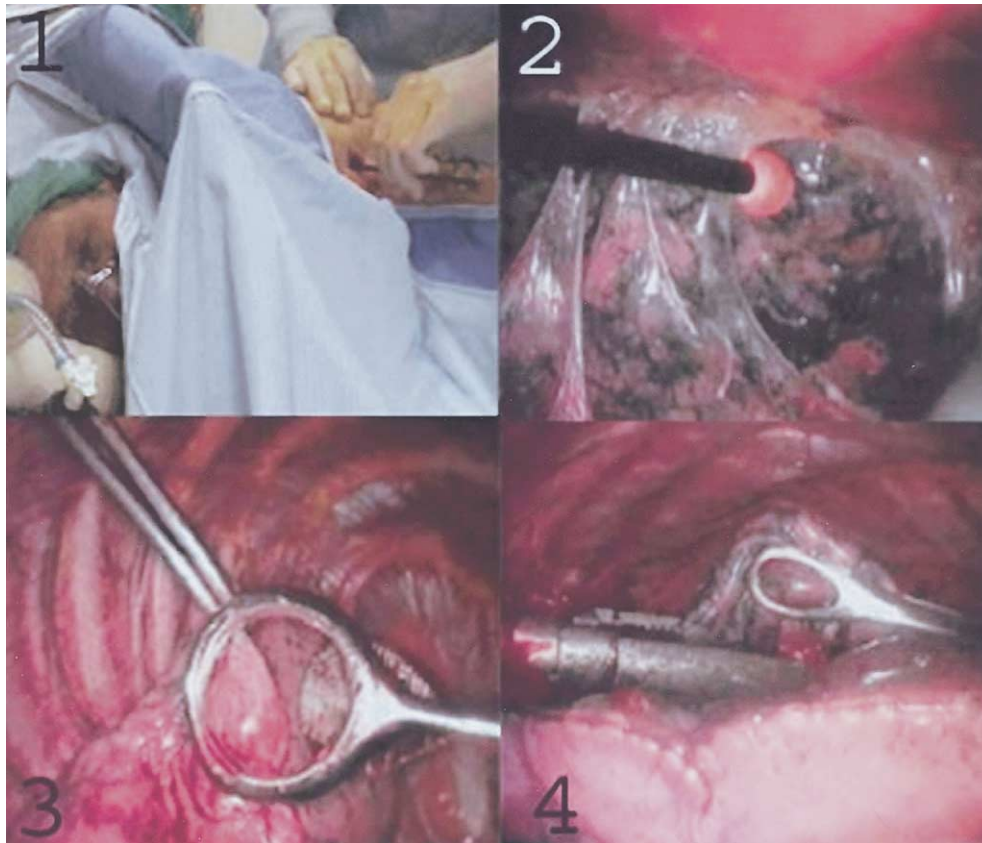
Fig 1. Surgical details of awake VATS resection of pulmonary nodules. Patient positioning and thoracoscopic access (1); lysis of filmy adhesions is not compromised during awake VATS (2); custom-shaped ring forceps with a filled-in ring to facilitate palpation of small nodules (3); and staple resection of a nodule with the ventilating lung (4). (VATS = video-assisted thoracic-surgery.)

these cases, intubation with single-lumen tube and bronchial blocker was performed under bronchoscopic guidance without changing the patient position.

Postoperatively, in the awake group, liquids infusion was stopped immediately and drinking, meal intake and ambulation were started on the same day of surgery. In the general anesthesia group, liquids infusion (1500 mL/24 hours) continued up to the morning after surgery when drinking, meal intake and ambulation were resumed. Urinary catheterization was not performed unless urinary retention did occur.

Study Design and Statistical Methods

The primary outcome measure chosen was hospital stay while secondary outcome measures were global operating room time, anesthesia satisfaction score, technical feasibility score, ΔPaO_2, and nursing care requirement.

Given that in an historical cohort undergoing VATS resection of pulmonary nodules at our institution, 15% of the patients were discharged within the first 48 hours, trial size was originally determined by the number of patients necessary to yield, by a nonparametric two-sided test, with an α error of 0.05, an increment of at least 10% of discharges within the first 48 postoperative hours. Group descriptive statistics are presented as median with interquartile range. Due to the small cohort, the nonparametric Mann-Whitney test was used to compare unpaired data while relationship between variables was assessed by the Spearman correlation test. Proportions were compared by the two tailed Fisher's exact test and C.I. 95% was calculated by the Ciba-Geigy Scientific Tables [8].

Results

During the study period, 12 of 72 eligible patients refused to accept the randomization and were excluded from the analysis. Of these, 8 patients asked to undergo the awake procedure while 4 preferred general anesthesia. Table 1 shows that the two study groups were well matched in terms of base line characteristics and measures. Overall, the nodules were localized in the right upper, middle or right lower lobe in 22, 7, and 10 instances, respectively; in the left upper or lower lobe in 11 and 10 instances, respectively.

Perioperative and postoperative results in the study groups are illustrated in Table 2. There was no significant difference in median operative time between the groups while anesthesia time and global in-operating room time were significantly longer in the control group. Technical feasibility demonstrated that the procedure was easily accomplished in both groups (Fig 2A) although 2 patients

Table 1. Baseline Characteristics and Measures in the Study Groups

Variable	Awake Group	Quartile Range	Control Group	Quartile Range	Intergroup p Value
Age (y)	60	45–68	63.5	55–68	0.4
Male:Female (n)	20:10	—	21:9	—	NS
Tobacco use (n)					
Current	22	—	24	—	0.76
Former	3	—	2	—	0.67
Never	5	—	4	—	0.73
ASA score	1	1–2	1	1–2	1.0
Home oxygen use (n)	3	—	2	—	0.67
Corticosteroid use (n)	3	—	2	—	0.67
Comorbidities					
COPD (n)	9	—	10	—	1.0
Cardiopathy (n)	8	—	6	—	0.76
Arteriopathy (n)	2	—	1	—	1.0
Diabetes (n)	3	—	3	—	0.61
Pulmonary function					
FEV1 (% predicted)	87.5	82–100	90.5	74–102	0.8
FVC (% predicted)	92	78–101	91	79–101	0.73
PaO_2 (mm Hg)	89	80–98	85.5	80–93	0.3

ASA = American Society of Anesthesiology;   COPD = chronic obstructive pulmonary disease; FEV_1 = forced expiratory volume in 1 second;   FVC = forced vital capacity; PaO_2 = arterial oxygen tension.

in the awake group required conversion to thoracotomy and general anesthesia due to severe fibrous adhesions.

Anesthesia satisfaction score was better in the awake group than in the control group with 22 patients versus 13 patients, respectively, having a score of 4 ($p = 0.03$; Fig 2B).

Pathologic examination of benign nodules is detailed in Table 3. Despite radiologic evidence of benignity was required for eligibility, an unexpected malignant lesion was found in 9 patients (15%). Of these, 4 patients in the

awake group had nonsmall-cell lung cancer, 3 adenocarcinomas, and 1 large-cell carcinoma. In the general anesthesia group, 3 patients had nonsmall-cell lung carcinoma of the adenocarcinoma type and 2 had pulmonary metastases from seminoma and renal-cell carcinoma, respectively. Among patients with carcinoma, 2 patients in each group underwent lobectomy through thoracotomy after conversion to general anesthesia and single-lung ventilation, while other 3 patients with severe chronic obstructive pulmonary disease who would have

Table 2. Results in the Study Groups

| Variable	Awake Group	Quartile Range	Control Group	Quartile Range	Intergroup p Value
Nodule characteristics					
Size (cm)	1.75	1.1–2.3	1.75	1.5–2.1	0.95
Lung (Right:Left)	21–9	—	18–12	—	0.59
Benign:Malignant	26–4	—	25–5	—	0.73
Thoracotomy needed (n)	4	—	2	—	0.67
Anesthesia time (min)	17.5	10–22	36	33–40	<0.00001
Operating time (min)	24	22–32	24	21–28	0.87
Global in-operating room time (min)	65	56–72	100	95–110	<0.00001
Patient anesthesia satisfaction score	4	4–4	3	3–4	0.04
Technical feasibility score	4	3–4	4	3.5–4	0.57
ΔPaO_2 (mm Hg)*	−3	0.5–5	−6.5	3.5–9	0.002
Pain (VAS score)*	2.5	2–3	3	2–3.5	0.19
Nursing Care (No of calls/day)*	2.5	2–3	4	3–5	0.0001
Mortality (n)	0	—	0	—	1.0
Morbidity (n)	1	—	3	—	0.61
Hospital stay	2	2–3	3	3–4	0.02

* Assessed 24 hours after surgery.
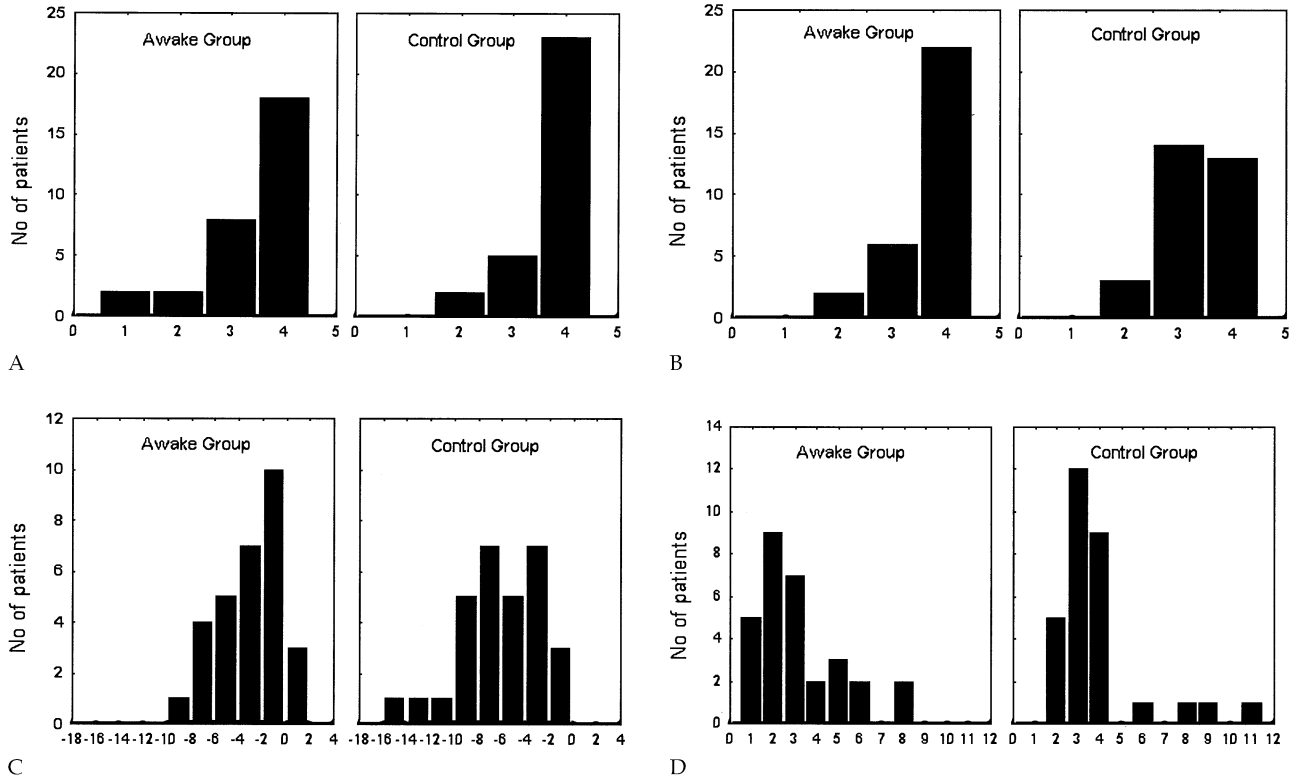
Fig 2. *Categorized istograms of (A) technical feasibility score, (B) anesthesia satisfaction score, (C) changes in arterial oxygenation (mm Hg), and (D) hospital stay in the study groups.*

not tolerated a lobectomy underwent sole wedge resection.

On postoperative day 1, the absolute decrease in PaO_2 was greater in the control group than in the awake group with 23 versus 12 patients, respectively, having a ΔPaO_2 greater than or equal to 3 mm Hg ($p = 0.008$; Fig 2C).

There was no mortality in either group while the only meaningful complication regarded prolonged air leaks, which occurred in 1 patient of the awake group and in 3 of the control group. In the awake group, no patient complained of fever or nausea postoperatively while 2 patients had urinary retention, which required temporary urinary catheterization. Nursing care was significantly less frequently required in the awake group than in the control group with 15 patients versus 23 patients,

respectively, with more than 3 nurse calls per day ($p = 0.001$). Overall, nursing care showed a direct relationship with VAS ($R = 0.39$, $p = 0.001$).

Median hospital stay was significantly shorter in the awake group than in the control group (Fig 2D) with 14 patients or 46.7% (95% confidence interval [95% CI] = 28.3 to 65.7) versus 5 patients or 16.6% (95% CI = 5.9 to 35.8) with an hospital stay of 2 days or less ($p = 0.025$; Fig 2D). The difference in median hospital stay remained significant even after exclusion of the 4 patients with prolonged air leaks ($p = 0.04$).

Comment

Selected controlled ventilation came with the introduction of the double-lumen endobronchial tube introduced by Zavod in 1940 [9] and refined by Carlens in 1949 [10]. It proved to be a revolutionary advance in thoracic surgery and is now the standard type of anesthesia for both open and VATS pulmonary resections. However, despite some indisputable and well-known advantages, several adverse effects can derive from this type of anesthesia including an increased risk of pneumonia, impaired cardiac performance, and neuromuscular problems relating to sedation and muscle relaxants. Moreover, during general anesthesia, mechanical ventilation can cause damage known as ventilator-induced lung injury. This type of injury include airway pressure-induced injury, lung inflation-induced injury, injury due

Table 3. *Benign Diagnoses*

Diagnosis	Awake Group	Control Group	Total
Inflammatory granuloma	9	12	21
Hamartoma	7	6	13
Scar nodule	5	4	9
Tuberculoma	2	2	4
Abscess	1	0	1
Carcinoid	1	0	1
Sarcoidosis	0	1	1
Pulmonary thromboembolysm	1	0	1

to cyclic opening and closing of small airways/lung units, and release of a variety of proinflammatory mediators [7]. Yet, atelectasis in the dependent lung is a regular finding during one-lung ventilation with muscle paralysis [11]. Moreover, prolonged collapse of the nondependent lung during one-lung ventilation can delay its complete re-expansion after weaning leading to the development of further atelectasic areas in the nondependent lung.

Theoretically, these adverse effects could be avoided by using TEA in an awake patient. Successful awake major surgery under TEA including aortic aneurysm repair [12], and coronary artery bypass grafting [13] has been recently reported. Furthermore, TEA has been anecdotally employed for thoracoscopic management of secondary pneumothorax [14].

The major finding of this study is that awake VATS resection of solitary pulmonary nodules was easily and safely performed under TEA since the procedure could be completed in 26 of 28 patients in the awake arm with no mortality and negligible morbidity. These results contradict the accepted assumption that the main prerequisite for allowing successful thoracoscopic lung surgery is general anesthesia with one-lung ventilation. No particular training has been necessary to accomplish awake pulmonary resection and the only two failures were due to the presence of extensive and dense pleural adhesions that thus represented the only contraindication for the procedure. In addition, awake pulmonary resection was easily accepted and well tolerated by the patients as confirmed by the high anesthesia satisfaction score in this group, which was significantly greater than in the control group.

Avoidance of general anesthesia reflected in a faster recovery with immediate return to many daily life activities including drinking, eating and walking. As a result, the hospital stay was significantly shorter than in the control group.

One of our major concern related to the risk that operating on a ventilating lung would have rendered surgical maneuvers more difficult due to the lung movements and the lack of a sufficient "operating space". Instead, we have early noticed that the open pneumothorax created after trocars' insertion, produced a satisfactory lung collapse which did not hamper surgical maneuvers.

A further noteworthy finding is that despite radiologic features of benignity was a selection criteria, in 15% of our operated patients pathologic examination disclosed a malignant lesion. This result emphasizes that particularly in patients at increased risk for lung cancer, strict radiologic surveillance and early removal of solitary pulmonary nodules should be pursued.

Preoperative and intraoperative nodule localization techniques include computed tomography dye injection [15, 16], intraoperative endoscopic ultrasonography [17] and preoperative computed tomography guided hookwire localization [18]. In our series, nodules as small as 4 mm in size were identified without the need of additional methods.

In a recent study from Ueda and colleagues [19],

significant preoperative factors related to recovery after VATS pulmonary resections included age, breathlessness, performance status, radiologic emphysema and partial pressure of arterial oxygen less than 80 mm Hg.

In our study including only wedge resections, the overall postoperative impairment of oxygenation was less pronounced than in the Ueda series. Nonetheless, we have observed not only that arterial oxygenation worsened during the first postoperative day but also that this impairment was greater in the general anesthesia group than in the awake group. We hypothesize that avoiding general anesthesia resulted in a faster recovery as indicated also by the significantly shorter hospital stay we observed in the awake group. One criticism might be addressed to the finding that despite the use of TEA, mean hospital stay still averaged 2 days, which reduces the cost-effectiveness of this method in comparison with nonsurgical alternative diagnostic methods. However, in our series, the patient discharge was strictly related to the criteria applied for chest tube removal, which so far remain an open matter for discussion. Russo and coworkers [20] reported that removal of the chest tube within 90 minutes after thoracoscopic wedge resection or biopsy resulted in a complication rate that compared that of a control group undergoing traditional chest tube management. Ueda and colleagues [19] reported that even though the average pleural drainage during the last day before removal of the chest tube was 168 ml, no patient developed collection of pleural effusion. This led the authors to conclude that the amount of pleural drainage does not represent a limiting factor for early removal of the chest tube if there is no hemorrhage or air leak. In accordance with this assumption, Chang and coworkers [21] recently reported on an outpatient thoracoscopic lung biopsy experience in which 59 out of 62 operated patients were discharged within 23 hours after the operation. Since in the Chang series all patients were operated through general anesthesia and single-lung ventilation, we are tempted to predict that using awake VATS resection with more liberal criteria for chest tube removal will implement early discharge in future outpatient series.

Despite the satisfactory results achieved in this study are encouraging, we acknowledge that some criticisms can be raised against awake VATS.

First, the open pneumothorax created to perform an awake lung resection can determine a mediastinal movement with compression of the dependent lung eventually resulting in a functional compromise. On the other hand, in an awake patient, the maintained diaphragmatic motion decreases the detrimental effect of the abdominal pressure, which leads the paralyzed diaphragm to compress the dependent lung during general anesthesia.

A further concern relates to the patient participation in operating room conversations when unexpected lung cancer is encountered. We believe that in these delicate instances special care must be devoted by the operating team in reassuring the patient while explaining the reasons that require conversion to general anesthesia and thoracotomy.

In conclusion, this randomized study suggests that VATS resection of solitary pulmonary nodules was easily and safely performed under TEA in awake patients. Yet, this approach proved superior to conventional VATS resection under general anesthesia with one-lung ventilation in terms of global in-operating room time, postoperative recovery, need of nurse care and overall hospital stay. If confirmed by future studies, these results could lead to advocate an earlier VATS resection of peripheral solitary pulmonary nodules to reduce the risk of delaying a diagnosis of unexpected pulmonary malignancy.

References

1. Holin SN, Dwork RE, Glaser S, Rickli AE, Stocklen JB. Solitary pulmonary nodules found in a community-wide chest roentgenographic survey. Am Tuberc Pulm Dis 1959; 79:427–39.
2. Swensen SJ, Silverstein MD, Edell ES, et al. Solitary pulmonary nodules: clinical prediction model versus physicians. Mayo Clin Proc 1999;74:319–29.
3. Hazelrigg SR, Magee MJ, Cetindag IB. Video-assisted thoracic surgery for diagnosis of the solitary lung nodule. Chest Surg Clin North Am 1998;8:763–74.
4. Mitruka S, Landreneau RJ, Fetterman LS, et al. Diagnosing the indeterminate pulmonary nodule: percutaneous biopsy versus thoracoscopy. Surgery 1995;118:676–84.
5. Allen MS, Deschamps C, Lee RE, Trastek VF, Daly RC, Pairolero PC. Video-assisted thoracoscopic stapled wedge excision for indeterminate pulmonary nodules. J Thorac Cardiovasc Surg 1993;106:1048–52.
6. Murasugi M, Onuki T, Ikeda T, Kanzaki M, Nitta S. The role of video-assisted thoracoscopic surgery in the diagnosis of the small peripheral pulmonary nodule. Surg Endosc 2001; 15:734–6.
7. Whitehead T, Slutsky AS. The pulmonary physician in critical care. 7: Ventilator induced lung injury. Thorax 2002; 57:635–42.
8. Lentner C. *Tavole Scientifiche Geigy*. Ciba Geigy Ediz VIII ediz. 1984:89–102.
9. Zavod WA. Bronchospirography 1. Description of the catheter and the technique of intubation. J Thorac Surg 1940;10: 27–31.
10. Björk VO, Carlens E. The prevention of spread during pulmonary resection by use of a double-lumen catheter. J Thorac Surg 1950;20:151–7.
11. Tokics L, Hedenstierna G, Svensson L, et al. V/Q distribution and correlation to atelectasis in anesthetize paralyzed humans. J Appl Physiol 1996;81:1822–33.
12. McGregor WE, Koler AJ, Labat GC, Perni V, Hirko MK, Rubin JR. Awake aortic aneurysm repair in patients with severe pulmonary disease. Am J Surg 1999;178:121–4.
13. Aybek T, Kessler P, Dogan S, et al. Awake coronary artery bypass grafting: utopia or reality? Ann Thorac Surg 2003;75: 1165–70.
14. Mukaida T, Andou A, Aoe M, Shimizu N. Thoracoscopic operation for secondary pneumothorax under local and epidural anesthesia in high-risk patients. Ann Thorac Surg 1998;65:924–6.
15. Asamura H, Kondo H, Naruke T, Tsuchiya R, Kaneko M, Suemasu K. Computed tomography-guided coil injection and thoracoscopic pulmonary resection under roentgenographic fluoroscopy. Ann Thorac Surg 1994;58:1542–44.
16. Wicky S, Mayor B, Cuttat JF, Schnyder P. CT-guided localization of pulmonary nodules with metilene blue injections for thoracoscopic resections. Chest 1994;106:1326–8.
17. Shennib H, Bret P. Intraoperative transthoracic localization of occult lung lesion. Ann Thorac Surg 1993;55:67–9.
18. Partik BL, Müller MR, Breitenseher M, et al. Using a dedicated lung-marker system for localization of pulmonary nodules before thoracotomic surgery. AJR 2003;180:805–9.
19. Ueda K, Kaneda Y, Sakano H, Tanaka T, Li T, Hamano K. Obstacles for shortening hospitalization after video-assisted pulmonary resection for lung cancer. Ann Thorac Surg 2003;76:1816–20.
20. Russo L, Wiechmann RJ, Magovern JA, et al. Early chest tube removal after video-assisted thoracoscopic wedge resection of the lung. Ann Thorac Surg 1998;66:1751–4.
21. Chang AC, Yee J, Orringer MB, Iannettoni MD. Diagnostic thoracoscopic lung biopsy: an outpatient experience. Ann Thorac Surg 2002;74:1942–7.

DISCUSSION

DR KENNETH M. STEINGLASS (New York, NY): That was an intriguing series. I have a question. Four of your patients in the local anesthesia group required conversion. They were in the lateral thoracotomy position. Could you just give us some practical information on what happened in your operating room with your anesthesiologists placing double-lumen tubes in the lateral position, or did you turn the patients back into a supine position? Give us an idea of how that worked.

DR POMPEO: Thank you for the question. For patients in the awake group who needed the conversion to thoracotomy, we used a Univent without changing the position of the patient. The intubation was performed under fiberoptic control with a Univent tube without changing the position of the patient.

DR PAUL VAN SCHIL (Antwerp, Belgium): Regarding your preoperative work-up, did you include results of PET scanning to decide which nodules should be treated and which not? Would you consider resecting nodules that do not show up on PET scan?

DR POMPEO: Well, actually we do not use the PET scan in Rome. We have no PET scan at our hospital. We don't use it for studying pulmonary nodules before surgery. I know it is a promising diagnostic tool and will surely improve the possibility of avoiding resection for many patients. For the moment, we didn't use it.

DR DANIEL L. MILLER (Atlanta, GA): Again, I agree that it's very intriguing, but it looks to me like 90% of your patients had benign nodules, so why were you even doing the procedure to begin with? And, secondly, your hospital stay of 48 hours as your

norm, most people here, if we do a wedge excision thoracoscopically, they are usually out the next day, or the majority of them, you know, 100% by the second day. So by cutting it down 1 day, you know, I don't know if you're really making a big difference. And the big thing, too, is why do it at all?

DR POMPEO: Thank you for the question. They are important points. There are many patients with benign lesions since we have excluded those with clearly malignant lesions for ethical problems. It was ethical problems at the beginning of the study to avoid suboptimal management of clearly malignant lesions. The patient could choose to undergo surgery thoracoscopically or follow a wait-and-see policy. This is the reason why there are so many benign lesions in this series.

Regarding the hospital stay, you said that the hospital stay is actually long. We have read an interesting study from the University of Michigan Medical Center where 60% of the patients were discharged within 8 hours after the biopsy by VATS. This is interesting and the possibility of discharging your patient depends on the policy you apply to remove your chest tube, of course. In this study we were quite conservative, but I am confident that in future studies, if we will decide to remove our chest tubes earlier, maybe a possibility to perform such procedures under TEA will even improve the rate of patients who will be discharged earlier.

DR MILLER: Also, I'm not familiar with your country's ethics in regards to studies. Is there an institutional review board that evaluated this study before it was done? How was that handled within your institution?

DR POMPEO: Yes, there is an ethical committee that is reviewing our studies and then is deciding if we can do that.

DR RICHARD H. FEINS (Rochester, NY): Certainly Dan has historical precedence for doing thoracoscopy under local anesthesia.

DR MILLER: It's taking it from the pleuroscopy to wedge excision. It's very intriguing, but as we have all learned over the years, I think there are new technologies, that we have to, you know, jump on board for those things.

DR RAJA FLORES (New York, NY): I can try to convince myself that this approach is justified in sick patients where one is trying to avoid general anesthesia. This would include patients who had poor PFTs, COPD, etc. Therefore, one is faced with a pneumothorax in an awake patient with compromised lung function. I'm curious about your physiologic effects. Did you have problems oxygenation and ventilation in patients like that or did you just perform this procedure on patients who were healthy? What's the effect of intraoperative pneumothorax on awake, spontaneously breathing patient with poor PFTs and COPD?

DR POMPEO: The point is very important. I can answer you maybe in one way. I can say that we are performing lung-volume reduction surgery in awake patients under TEA and I hope we will publish our results in the near future.

DR STEVEN R. DEMEESTER (Los Angeles, CA): Did you have much trouble with patients coughing or moving around during the procedure?

DR POMPEO: Sometimes, yes. You actually can have coughing when there is a deeper or larger lesion. Maybe when cartilaginous bronchioles are touched, sometimes you can have coughing, but it is a temporary finding that can resolve rapidly.

Feasibility and Results of Awake Thoracoscopic Resection of Solitary Pulmonary Nodules

Eugenio Pompeo, Davide Mineo, Paola Rogliani, Alessandro F. Sabato and Tommaso C. Mineo

Updated Information & Services	including high-resolution figures, can be found at: http://ats.ctsnetjournals.org/cgi/content/full/78/5/1761
References	This article cites 20 articles, 12 of which you can access for free at: http://ats.ctsnetjournals.org/cgi/content/full/78/5/1761#BIBL
Citations	This article has been cited by 15 HighWire-hosted articles: http://ats.ctsnetjournals.org/cgi/content/full/78/5/1761#otherarticles
Permissions & Licensing	Requests about reproducing this article in parts (figures, tables) or in its entirety should be submitted to: http://www.us.elsevierhealth.com/Licensing/permissions.jsp or email: healthpermissions@elsevier.com.
Reprints	For information about ordering reprints, please email: reprints@elsevier.com

THE ANNALS OF THORACIC SURGERY