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Video-assisted thoracic surgery versus pleural drainage in the management of the first episode of primary spontaneous pneumothorax

Duilio Divisi, Ph.D., M.D.*, **Gabriella Di Leonardo, M.D.**, **Roberto Crisci, M.D., Ph.D.**

Department of Thoracic Surgery, University of L'Aquila, "G. Mazzini" Hospital, Piazza Italia 1, Teramo, Italy

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Abstract

BACKGROUND: The aim of the study was to analyze the cost-effectiveness outcomes of video-assisted thoracic surgery (VATS) in the treatment of primary spontaneous pneumothorax (PSP), comparing the minimally invasive procedure with pleural drainage (PD).

METHODS: Between July 2006 and October 2012, we treated 122 patients with a first episode of PSP by VATS (61 patients) or pleural drainage (61 patients). We established the relationship between costs and quality-adjusted life (QAL) for both techniques.

RESULTS: The total cost per patient of minimally invasive procedure was more advantageous than that of chest tube (€2,422.96 vs €4,855.12). The QAL expectancy of VATS was longer than that of PD (57.00 vs 40.80 at 60 months). The QAL year of VATS (.32 at 1st year and .25 at 5th year) was better than that of PD. Incremental cost-effectiveness ratio of VATS versus PD was between €7,600.00 (1st year) and €10,045.00 (5th year), remaining well below the threshold of acceptability.

CONCLUSION: VATS as the first-line treatment for PSP allowed low morbidity, short hospitalization, and excellent quality of life.

The management of primary spontaneous pneumothorax (PSP) is still debated. Pleural drainage, video-assisted thoracic surgery (VATS), and axillary minithoracotomy represent the therapeutic options that should be evaluated in terms of cost effectiveness, considering the cuts to the health budget. VATS was judged the gold standard approach in recurrent spontaneous pneumothorax. Crisci et al[1] showed, in a retrospective study of 60 patients, that VATS compared with traditional thoracotomy allowed a cost savings of 23%. However, VATS appeared to be justified even at the first spontaneous pneumothorax compared with pleural drainage (PD),[2] ensuring a reduction in hospitalization (6 vs 12 days), recurrences (1 vs 8 patients, equivalent to 2.8% vs 22.8%), and costs (33%). The purpose of the study was to clarify the role of VATS in PSP, assessing the indications based on quality-adjusted life (QAL) and costs to avoid relapses.

Patients and Methods

From July 2006 to October 2012, we observed 122 patients with a first episode of PSP. Symptoms responsible for arrival at the emergency room were sudden chest pain

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* Corresponding author. Tel.: +39-0861-42-94-82; fax: +39-0861-42-94-78.

E-mail address: duilio.divisi@aslteramo.it

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associated with difficulty in breathing. No patient displayed acute respiratory insufficiency requiring aspiration or PD. Chest X-ray and thin-section computerized tomography of the thorax allowed diagnosis, characterized by no evidence of lung disease. Large pneumothorax (distance between the lung margin and the chest wall superior to 2 cm) was found in 96% of the patients. There were 79 men (65%) and 43 women (35%), with an average age of 23 ± 2 years ranging from 16 to 30 years. After ethics committee approval, we proposed in primary intention the minimally invasive approach or PD to resolve pneumothorax. Sixty-one patients were treated with VATS and 61 with PD in the ratio of 1 to 1, within 35 ± 3 minutes of arrival at the hospital. A written informed consent from each patient was obtained before each procedure. The VATS and thoracostomy tube male/female ratio was 4: 1 and 3: 1, respectively.

Surgical procedures

Thoracostomy tube (Redax S.r.l., Mirandola, Italy) sized 28 French was placed under local anesthesia (2% Mepivacaine) in the 5th or 4th intercostal spaces on the mid-axillary line and connected to continuous suction of 25 cm H_2O.

VATS was performed under general anesthesia and selected bronchial intubation. Three port thoracoscopic accesses were made in the 6th, 5th, and 4th or 3rd intercostal spaces for insertion of a video camera (through an 8-mm thoracoport on the mid-axillary line), stapler (through an 11.5-mm thoracoport on the anterior axillary line), and Endo Dissect (through a 5-mm thoracoport on the posterior axillary line). Visceral blebs and bullae were resected using the Endo GIA 30 (Autosuture; United States Surgical Corporation, North Haven, CT) or Echelon 60 Flexible (Ethicon Endo-Surgery; Johnson & Johnson Medical SpA, Pomezia, Rome, Italy). If no lesion was highlighted, an apical wedge resection of the upper lobe was carried out. The electro-pleurodesis on the 3rd, 4th, and 5th ribs was performed in all patients. Two silicone chest tubes sized 28 French were inserted through the incision on the 5th and 6th intercostal spaces and connected to continuous suction of −20 cm H_2O. The incision on the 4th or 3rd intercostal space was closed by 2 separate stitches with nonabsorbable polyfilament 3-0.

Costs

We analyzed operating room charges (operating room time, anesthesia fees, filaments of suture, double-lumen tube, chest tube, hardware). The surgical factors evaluated were divided into operative (time of intervention), postoperative (prolonged air leaks (PAL) beyond 6 days, duration of PD, length of hospitalization) and long-term morbidity with a follow-up at 60 ± 3 months (recurrences and subsequent management). The cost of employment of the operating room was €167.00 per hour (equivalent to €2.8 per minute) inclusive of surgeon's and anesthesiologist's fees, while that of a single day of hospitalization was €350.00. Costs of camera, monitor, thoracoscope, and light source were not taken into account because totally paid for by VATS carried out until to 2005. Costs of relapses and PAL were spread out over all patients according to the "Intention to treat" analysis.[3] It is a statistical analysis based on the initial intent of the procedure preserving the effects of comparability randomization and measuring its effectiveness on patients.

Quality-adjusted life

Effectiveness evaluation for each technique was carried out based on the adjustment of quality of life expectancy (QALE) and quality of life year (QALY). QALE and QALY allow to assess the value of interventions in health and medicine. The QAL was established through the EuroQol questionnaire[4–6] administered to all patients at the 1st, 2nd, 3rd, 4th, and 5th years after treatment. The utilities (EQ-5D with US scoring) of health status taken into consideration were the following: (1) ability to move (*m*); (2) care for themselves (*s*); (3) usual activity (*a*); (4) pain/discomfort (*p*); (e) anxiety/depression (*d*). Three levels of severity were evaluated through specific scores for single dimension: (1) none; (2) moderate; and (3) severe. The synthetic value of quality of life at the time of the interview (time trade-off method) was obtained by the following algorithm: $1 - c - m - s - a - p - d - \mathrm{n}3$. The index ranged from 1 (perfect health) to 0 (death of the patient). Changes in patient health were calculated by subtracting the maximum value, that is 1, from the values of points *m*, *s*, *a*, *p*, and *d* corresponding to the dimensions of health status derived from the questionnaire. The coefficients *c* (.081) and n3 (.269) were subtracted if any dysfunction was noticed and if any dimension had level 3, respectively. The QALE was obtained multiplying the value of utilities (established by the time trade-off method) at the time of first interview by the follow-up (up to 5 years). The EQ-5D values, adjusted to the overall mean baseline health status per year, provided the QALY for VATS and PD. This makes it possible to determine the incremental cost per life year gained, weighted per QALY (incremental cost-effectiveness ratio). We calculated the costs of both procedures at baseline and assessed the follow-up for 5 years. The expected costs and health status for 5 years were analyzed with 2-way sensitivity analyses, using an inflation rate of .8% as discounting rate per year. Based on the guidelines of the Italian Association of Health Economics, we decided to adopt a threshold of acceptability inferior to €15,000.00 per year of life saved. Any value above this value was deemed unacceptable.

Statistical analysis

Analysis was performed using SPSS 10.0. Data were entered in a database using SPSS Data Entry II (SPSS, Inc,

Table 1 Clinical differences in the variables evaluated

Parameters	VATS	Chest tube	*P* value
Mean age (years)	19.6 ± .5	22.3 ± .8	.00001
Left side	34 patients	25 patients	NS (.083)
Right side	27 patients	36 patients	NS (.107)
Operative time (minutes)	32 ± 1	5.0 ± 1	.00001
Operating room time (minutes)	80.0 ± 2	0	.00001
Prolonged air leaks	0	5 patients (8.1%)	NS (.025)
Duration of pleural drainage (days)	2 ± 1	10 ± 2	.00001
Length of hospitalization	$3 \pm 1^{(2-7)}$	$12 \pm 3^{(3-21)}$	.00001
Recurrences	2 patients (3.2%)	12 patients (19.6%)	.004

NS = no significance; VATS = video-assisted thoracic surgery.

Chicago, IL) and were expressed as mean ± standard deviation (range 95%). We evaluated using analysis of variance test the average age, side involved, time of intervention, total time of employment of operating room, duration of drainage, length of hospitalization, and the number of relapses for each method. The Student *t* test for independent data was used for comparison between VATS and PD, while the significance value (*P*) was evaluated by the log-rank test. All *P* values less than .05 were considered to indicate significance and confidence interval at 95%.

Results

No complications were noted during the surgical approaches and the introduction of pleural tube. Blebs/bullae were found in 95% of patients undergoing surgery. All patients completed the survey at the 1st, 2nd, 3rd, 4th, and 5th year after VATS or PD. Nonreusable instruments used in VATS with an average use of 1 device showed a total cost of €913.00 per patient resulting from €120.00 for endograsp, €140.00 endodissect, €400.00 stapler, €232.00 recharge, and €21.00 thoracoports. The duration of PD and length of hospital stay was reduced in VATS with respect to the chest tube insertion (Table 1), with a statistical significance ($P = .00001$). VATS was less expensive than PD (Table 2). Patients treated by PD showed 5 (8.1%) PAL (15 to 20 cc/minute) and 12 (19.6%) recurrences after 22 ± 1 month of procedure, needing VATS. Costs of complications were €11,595.00 and €27,828.00 and calculated as follows: €2,319.00 (total cost of VATS without complication) × 5 (number of PAL) × 12 (number of relapses). VATS patients displayed 2 recurrences (3.2%) after 10 ± 2 months of intervention, treated with axillary minithoracotomy. Cost of relapses was €6,341.60 and calculated as follows: €3,170.80 (total cost of open surgery) × 2 (number of complications) (Table 3). On the basis of these assessments, the minimally invasive procedure was economically more advantageous than that of chest tube. In fact, the cost of VATS and PD without complications for 61 patients was €141,459.00 versus €256,739.24. Adding the costs of complications, we had a total cost of €147,800.60 versus €296,162.24 equivalent to €2,422.96 versus €4,855.12 per patient. The effectiveness analysis of treatments showed that the QALE of VATS was longer than the QALE of chest tube for every year up to 5 years of follow-up (Fig. 1). The incremental costs of VATS versus PD varied between €7,600.00 (1st year) and €10,045.00 (5th year) per patient (Table 4). These data were within the limit of acceptability and showed that the VATS was more effective compared with PD, although the difference in QALY between the 2 procedures was reduced over time.

Comments

PSP is a frequent pathology, ranging between 63% and 80% of spontaneous pneumothorax.[7–9] The study aims to answer 2 questions in the treatment of PSP: do the costs justify VATS and what is the ideal timing for VATS? In

Table 2 Cost analysis per patient of VATS versus pleural drainage without complications

Parameters	VATS	Chest tube
Double-lumen tube	€69.00	–
Anesthesia fees (drug and antalgic)	€42.00	€.62
Polyfilaments	€4.00	€1.00
Hardware	€913.00	–
Pleural drainages	€17.00 (2)	€7.22 (1)
Operating room time$^{(€167.00 \text{ per hour})}$ including surgeon and anesthesiologist fees	€224.00	–
Length of hospitalization$^{(€350.00 \text{ per day})}$	€1,050.00	€4,200.00
Total	€2,319.00	€4,208.84

VATS = video-assisted thoracic surgery.

Table 3 Cost analysis per patient of axillary minithoracotomy

Parameters	Axillary minithoracotomy
Double-lumen tube	€69.00
Anesthesia fees (drug and antalgic)	€84.00
Polyfilaments	€48.00
Hardware	€500.00
Pleural drainages (2)	€17.00
Operating room time(€167.00 per hour) (126 ± 4 minutes)	€352.80
Length of hospitalization(€350.00 per day) (6 ± 2 days)	€2,100.00
Recurrence	–
Total	€3,170.80

fact, in literature there is a concordance on the thoracoscopic technique (lung wedge resection using endoscopic stapler associated to chemical or mechanical pleurodesis), with a recurrence rate of .4% to 8.6%.[10–12] The problem is to determine when VATS is necessary, given the continued reduction in the budget of the National Health System (NHS) in Italy. Our retrospective analysis showed that the use of VATS as the first-line treatment allowed a savings of 50% compared with PD. These economic data are supported by the clinical findings of the thoracoscopic approach, as evidenced by the evaluation of the QAL in terms of actuality (QALY) and expectation (QALE). The QALY of patients treated using VATS has grown more than that of patients who underwent PD who displayed severe anxiety and depression (minimum chest pain induced patients to go to the hospital emergency room for a chest X-ray). The incremental cost-effectiveness ratio, expressed in units of cost per QALY gained,[13] confirmed a return to proportionate health and an appropriate use of NHS money with the minimally invasive procedure. Chen et al,[14] studying 164 patients treated with simple aspiration for the first episode of PSP, revealed the need for VATS in 30 patients and of PD in 22 patients owing to the failure of the first technique. Although VATS was more expensive than PD ($1,273 vs $865), the reduction in recurrence (P = .038) and hospitalization (P = .034) suggests the use of videothoracoscopy as the initial approach for PSP. This study showed that simple aspiration in the initial management of spontaneous pneumothorax is questionable because of the fact that 52 of the 164 patients required a second treatment. These results were in agreement with the guidelines of the American College of Chest Physicians[15] and in contrast with those of the British Thoracic Society in 2003.[16] Morimoto et al[17] showed that VATS was necessary at 24 months, after unsuccessful treatment with PD, in 45% of patients for twice strategy (PD for the first and second episodes of PSP followed by VATS for the third episode) and 59% of patients for once strategy (PD for the first episode of PSP followed by VATS for the second episode). In contrast, 92% of patients undergoing VATS as a first treatment displayed no recurrence in the same timeframe. VATS was more expensive than PD

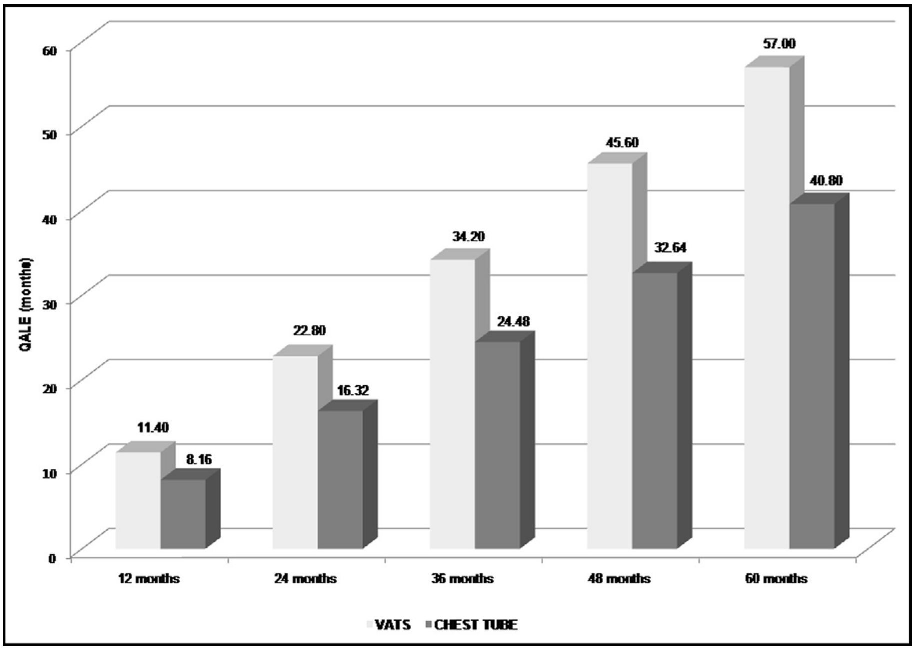

Figure 1 Although the QALE grew each year in both procedures, the expectancy of minimally invasive approach was more satisfactory than that obtained with chest tube.

Table 4 Two-way sensitivity analyses for QALY of follow-up state after VATS and pleural drainage

Parameters	1 year	2 years	3 years	4 years	5 years
VATS cost (€)	2,422.96	2,442.50	2,462.04	2,481.90	2,501.91
VATS QALY	.85	.88	.91	.95	.99
ICER VATS* (€)	2,850.00	2,775.00	2,705.00	2,612.00	2,527.00
PD cost (€)	4,855.12	4,894.27	4,933.43	4,973.21	5,013.33
PD QALY	.53	.57	.61	.68	.74
ICER PD* (€)	9,160.00	8,586.00	8,087.00	7,313.00	6,774.00
Difference costs (€)	2,432.16	2,451.77	2,471.39	2,491.31	2,511.42
Difference QALY	.32	.31	.3	.27	.25
ICER VATS vs PD* (€)	7,600.00	7,908.00	8,237.00	9,227.00	10,045.00

ICER = incremental cost-effectiveness ratio; PD = pleural drainage; QALY = quality-adjusted life years; VATS = video-assisted thoracoscopic surgery.
*Euro/QALY

(US$6,556 vs US$2,532 twice strategy and US$2,988 once strategy), but the incremental costs of VATS per QALY gained (US$28,919 compared with PD twice strategy and US$30,564 compared with PD once strategy) justified video-thoracoscopy as first strategy of PSP. Unlike our experience, the Chen et al[14] and Morimoto et al[17] studies revealed the higher cost of VATS to the other method applied. Obviously, as healthcare costs differ from country to country, comparisons may not be correct. In our study, the duration of hospitalization for PD was quite long because of the need to achieve a good mechanical pleurodesis and to assure the clinical safety of the patient, considering the lack of adequate health facilities in our territorial district. The ambulatory treatment of pneumothorax with the Heimlich valve, which Brims et al[18] highlighted success in 344 of the 413 PSP patients, is recommended only in cases where complications or failures can be treated immediately. In fact, Choi et al[19] performed VATS in 26 of the 27 patients (47 in total) previously treated unsuccessfully with Heimlich valve. Moreover, the possible economic benefits of this approach in health care have yet to be proven. The difference in costs could also be because of the fact that we have not calculated the costs of complications considering them individually but rather by assessing the economic impact on all patients, resulting in a targeted statistical analysis of the relationship between the cost and the effect of VATS in extending life and increased quality of life. Our outcomes are in disagreement with the British Thoracic Society guidelines[20] that consider decisive the simple aspiration or PD in a high percentage of cases and do not foresee VATS as first approach. Sahn and Heffner[21] displayed that the recurrence rate by nonsurgical treatment was between 16% and 52% of patients, in a period of 6 months and 2 years. Chou et al[22] in 51 patients and Margolis et al[23] in 156 patients applied VATS as first-line treatment of PSP, showing no postoperative air leaks or relapses after an average follow-up of 38 and 62 months, respectively. In our experience, the overall long-term morbidity by VATS was 3% (2/61 patients), associated with better clinical postoperative outcomes than PD. Kaneda et al,[24] after a wide review of literature, determined a management of pneumothorax based on the objectives of treatment. In keeping with our findings, we believe that the minimally invasive approach by VATS can be proposed not only in step 3 (prevention of relapse) and step 2 (stoppage of air leaks) but also in step 1 (rapid recovery of respiratory function or prevention of respiratory dysfunction).

Conclusions

VATS as first-line treatment for PSP offered patients greater clinical satisfaction and psychosocial advantages, quickly restoring them to normal living habits. Moreover, the lower costs of VATS over PD was not only associated to a return to proportionate health, but also to an appropriate use of NHS money. PD may be warranted in the prevention or resolution of a tension pneumothorax, given the high incidence of air leaks or recurrences.

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