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Clinical Research

Factors Affecting the Number of Stapler Cartridges in Complete Video-Assisted Thoracoscopic Surgery Lobectomy for Non-small Cell Lung Cancer

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Background: Video-assisted thoracoscopic surgery (VATS) lobectomy has become the major surgical option for the treatment of non-small cell lung cancer (NSCLC). Endoscopic instruments such as stapler cartridges are essential for VATS procedures. In this study, we investigated the factors that affect the number of stapler cartridges used in VATS lobectomy.
Methods: A retrospective analysis was conducted of patients who underwent complete VATS lobectomy for NSCLC from January 2013 to December 2015.
Results: In total, 596 patients underwent complete VATS lobectomy. The average number of stapler cartridges used for VATS lobectomy was 5.3±1.9. The number of stapler cartridges used for VATS lobectomy was higher in men (5.5±1.9 vs. 5.0±18, p=0.006), those aged older than 70 years (5.5±2.1 vs. 5.1±1.7, p=0.038), those who underwent upper or middle lobectomy procedures (5.7±1.9 vs. 4.1±1.2, p<0.001), those with a higher fissure sum average (p<0.001), and those in whom surgery was performed by a surgeon with a preference for staplers (5.6±2.0 vs. 4.9±1.6, p<0.001).
Conclusion: The number of stapler cartridges required to perform VATS lobectomy in NSCLC patients appears to be influenced by sex, age, the location of the tumor, the degree of fissure development, and the surgeon's preference.

Keywords: Non-small-cell lung carcinoma, Video-assisted thoracic surgery, Fissure sum average, Stapler cartridges

Introduction

Lung cancer is currently the leading cause of cancer-related death in both sexes [1]. Video-assisted thoracoscopic surgery (VATS) has been used with increasing frequency in daily practice to diagnose and treat lung diseases, especially non-small cell lung cancer (NSCLC) [2,3]. VATS lobectomy is considered to be one of the major treatment options for patients with NSCLC. Since the introduction of VATS in the 1990s, a paradigm shift has occurred in lung cancer surgery.

The drawbacks of VATS include higher equipment costs, a longer operative duration, and a steeper learning curve for surgeons and operating room personnel [4]. Its primary advantages compared with conventional open thoracotomy, aside from its reduced overall costs, are faster recovery, reduced pain, less morbidity, a shorter hospital stay, and a shorter chest tube duration [5].

In VATS lobectomy, the cost of surgery increases as more stapler cartridges are used. To the best of our knowledge, the number of stapler cartridges required for VATS lobectomy and the factors affecting that number have not been fully investigated. Therefore, the purpose of this study was to investigate the factors that affect the number of stapler cartridges used for VATS lobectomy in patients with NSCLC.

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Methods

This study was approved by the Severance Hospital Institutional Review Board (IRB approval no., 4-2019-0678). Written informed consent was obtained from the patient before the operation.

Patients

This study retrospectively analyzed patients who underwent complete VATS lobectomy for NSCLC between January 2013 and December 2015. Consistent protocols were used for preoperative evaluations, surgery, and postoperative treatment, and the data were retrospectively collected from a single thoracic surgery unit with 6 consultant thoracic surgeons, all experienced in VATS resection. Patients' medical records were reviewed carefully, and variables including sex, age, the number of stapler cartridges used, and fissure development were evaluated.

During this period, 1,177 VATS procedures were performed at our institution. The exclusion criteria were as follows: the use of another surgical method (open thoracotomy and robotic thoracotomy), preoperative treatment (preoperative neoadjuvant), another operation (pneumonectomy, bilobectomy, sleeve lobectomy, or other lobe wedge resection), a combined operation, and no available information on fissure development. In total, 596 patients who underwent complete lobectomy for NSCLC were included in the final analysis.

Operative technique and instruments

The vast majority of VATS procedures used 3 or 4 incisions, most often 3. The camera port (10 mm) was usually placed on the lower chest. A utility incision (4 to 6 cm) was usually made along the anterior axillary line. The third and/or fourth incision, usually 5 or 10 mm in length, was made through the auscultatory triangle on the low chest. A soft tissue retractor was often used at the utility incision. All patients underwent lobectomy with extensive mediastinal lymph node dissection. VATS was used preferentially in nearly all patients. All operations were performed by 1 of the 6 surgeons of the thoracic surgery unit.

Three types of endoscopic stapler bodies and cartridges were used. The stapler bodies were Covidien Endo GIA Ultra Universal staplers (Medtronic, Minneapolis, MN, USA), Echelon Flex powered vascular staplers (Ethicon, Somerville, NJ, USA), or Echelon Flex powered articulating staplers (Ethicon), and the cartridges were Endo GIA Roticulators (Medtronic), Endo Linear Cutter Cartridges (Ethicon), and Echelon Endoscopic Cartridges (Ethicon), respectively. Surgeons were divided into 2 groups according to their stated preference of pulmonary fissure division methods. One group tended to use staplers for fissure division, while the other group tended not to use staplers.

Fissure development score and fissure sum average

Pulmonary fissure status was quantified by the fissure development score (FDS; range, 0–3). Since 2007, FDSs have been recorded prospectively for all patients with resected lung cancer at Severance Hospital. Pulmonary fissures were grouped into 4 categories based on their anatomical location: E, area over the pulmonary artery; A, upper major fissure; B, lower major fissure; and C, minor fissure. Patients' pulmonary fissure status was quantified by the FDS. Patients were divided into the following 4 groups, based on the FDS and the degree of fissure completeness: grade 0, complete fissure; grade 1, fusion between 0% and 30%; grade 2, fusion between 30% and 70%; and grade 3, fusion more than 70%. At least 3 fissures were dissected and divided before lobectomy; therefore, the fissure sum average (FSA), calculated as the sum of 3 FDSs divided by 3 (range, 0–3) was used to assess patients' status [6].

Statistics

We retrospectively analyzed the perioperative data of patients who underwent VATS lobectomy. Continuous variables were analyzed using the independent-samples t-test and presented as means with standard deviations, while categorical variables were analyzed using the chi-square test or the Fisher exact test and presented as frequencies and percentages. All statistical analyses were performed using IBM SPSS ver. 25.0 (IBM Corp., Armonk, NY, USA), and p-values <0.05 were considered to indicate statistical significance.

Results

In total, 1,177 patients underwent surgery for NSCLC from January 2013 to December 2015, of whom 581 were excluded. Therefore, 596 patients who underwent complete VATS lobectomy were included in the final analysis. There were 324 men (54.4%), and 375 patients (62.9%) were under the age of 70 years (Table 1). Most of the procedures were performed on the right lung; the right upper lobe (RUL)

Table 1. Demographic and clinical characteristics of the 596 patients

Characteristic	No. (%)
Sex	
Male	324 (54.4)
Female	272 (45.6)
Age (yr)	
<70	375 (62.9)
≥70	221 (37.1)
Smoking history	
No	419 (70.3)
Yes	177 (29.7)
Tuberculosis	
No	559 (93.8)
Yes	37 (6.2)
Side	
Right	366 (61.4)
Left	230 (38.6)
Lobe	
Right upper lobe	172 (28.9)
Right middle lobe	69 (11.6)
Right lower lobe	125 (21.0)
Left lower lobe	115 (19.3)
Left lower lobe	115 (19.3)
Pleural adhesion	
No	408 (68.5)
Yes	188 (31.5)
Completeness of the fissure	
Complete	108 (18.1)
Incomplete	488 (81.9)
FSA	
0 (complete fissure)	108 (18.1)
0<FSA≤1 (incomplete fissure 1)	309 (51.8)
1<FSA≤2 (incomplete fissure 2)	163 (27.3)
2<FSA≤3 (incomplete fissure 3)	16 (2.7)
Preoperative cancer confirmation	
Unknown	274 (46.0)
Tissue-confirmed	322 (54.0)
Diagnostic wedge resection	
Yes	192 (32.2)
No	404 (67.8)

FSA, fissure sum average

Table 2. The number of stapler cartridges used in the 596 patients

Variable	Cartridge	p-value
Total stapler cartridges	6.3±2.4	
With diagnostic wedge resection (total stapler)		<0.001
Yes	8.1±2.1	
No	5.4±1.8	
Only lobectomy		0.006
Male	5.5±1.9	
Female	5.0±1.8	
Only lobectomy		0.038
Age <70 yr	5.1±1.7	
Age ≥70 yr	5.5±2.1	
Only lobectomy	5.3±1.9	
Right upper lobe	5.7±1.9	
Right middle lobe	5.3±2.0	
Right lower lobe	4.4±1.5	
Left lower lobe	5.9±1.9	
Left lower lobe	4.8±1.7	
Only lobectomy		<0.001
Upper and middle lobe	5.7±1.9	
Lower lobe	4.6±1.6	
Only lobectomy		<0.001
Surgeons 1, 2, 4, and 6	4.9±1.6	
Surgeons 3 and 5 (with a preference for staplers)	5.6±2.0	
Only lobectomy		<0.001
Complete fissure	4.1±1.2	
Incomplete fissure	5.5±1.9	
FSA[a]		<0.001
0 (complete fissure)	4.1±1.2	
0<FSA≤1 (incomplete fissure 1)	5.0±1.7	
1<FSA≤2 (incomplete fissure 2)	6.4±1.9	
2<FSA≤3 (incomplete fissure 3)	7.2±1.8	

Values are presented as mean±standard deviation.
FSA, fissure sum average.
[a]Sum of 3 fissure development scores divided by 3.

was the most common location, followed in order by the right lower lobe, left upper lobe (LUL), left lower lobe, and right middle lobe (RML). There were 488 (81.9%) incomplete fissures, greatly exceeding the number of complete fissures. The most common FSA was 1, followed by 2 and 0. The total average number of stapler cartridges used was 6.3±2.4 (range, 2–17). The number of stapler cartridges used for VATS lobectomy, excluding the stapler cartridges used for diagnostic wedge resection, was 5.3±1.9 (range, 2–14). The number of stapler cartridges used to perform VATS lobectomy was higher in men (5.5±1.9 versus 5.0±18, p=0.006), those aged older than 70 years (5.5±2.1 versus 5.1±1.7, p=0.038), those who underwent upper or middle lobectomy (5.7±1.9 versus 4.1±1.2, p<0.001), those with a higher FSA (p<0.001), and in those who underwent surgery performed by a surgeon who preferred to divide pulmonary fissures with a stapler (5.6±2.0 versus 4.9±1.6, p<0.001) (Table 2).

Discussion

The main findings of the present study are that RUL or RML lobectomy, a higher FSA, and the surgeon's preference to divide pulmonary fissures with a stapler were associated with a higher number of stapler cartridges used for VATS lobectomy.

The number of stapler cartridges required to perform

VATS lobectomy in patients with NSCLC is influenced by sex, age, and tumor location. The difference by sex seems to have only statistical significance, as it is not highly relevant for clinical purposes. Regarding the difference by age, a higher number of stapler cartridges seemed to be used in older patients for lobectomy, because pulmonary division is often more difficult in older patients due to adhesions caused by calcified nodes and inflammatory disease. Casali and Walker demonstrated that upper lobectomy was more expensive than other types of lobectomy, and that the cost difference was mainly caused by the use of more stapler cartridges [7]. The upper lobe seems to require more stapler cartridges due to anatomical features that require more artery division. In this study, more stapler cartridges were used in RUL, RML, and LUL lobectomies.

In 1997, pulmonary fissures were classified by Craig and Walker [8] based on the degree of fissure development and exposure of the pulmonary artery. Lee et al. [6] proposed a modified fissure assessment model and FDS system. Incomplete fissure development has been found to be significantly associated with a prolonged hospital stay and the duration of chest tube drainage [9,10]. A higher degree of fissure incompleteness requires the use of more stapler cartridges.

With the advancement of instruments, such as staplers and scopes, VATS lobectomy has become the treatment of choice for lung cancer surgery. VATS lobectomy techniques can be classified as fissure-based (or fissure-first) and fissure-less (or fissure-last). In this study, 3- or 4-port VATS was performed, using the fissure-based technique [11]. The reason for using the 3- or 4-port method with the fissure-based technique is that it offers greater exposure, optimal vision, and extensive vascular dissection and bronchial clearance [12]. The surgeons in this study who showed a tendency to divide pulmonary fissures with a stapler used more stapler cartridges.

In the Korean health insurance system, up to 6 stapler cartridges are covered under insurance for VATS lobectomy. As discussed above, the tumor location, pulmonary fissure development, and surgeon's preference ultimately affected the costs of VATS lobectomy procedures. Further research on postoperative morbidity before and after the change in the insurance policy (June, 2014) may influence subsequent changes in insurance policies in Korea.

The limitations of this study include its retrospective and single-center design, as well as a small number of patients. Fissure development is an important consideration when performing VATS lobectomy. Preoperative predictive methods for pulmonary fissure development may include imaging techniques, especially high-resolution computed tomography (CT) and multidetector CT, with 3-dimensional reconstructions; however, further research is still needed. Additional research is also needed regarding differences in postoperative morbidity according to the method of fissure division.

In conclusion, the number of stapler cartridges required to perform VATS lobectomy in patients with NSCLC appears to be influenced by sex, age, the location of the tumor, the degree of fissure development, and the surgeon's preference.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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