European Review for Medical and Pharmacological Sciences 2020; 24: 9844-9851

Choice between video-assisted thoracic surgery and thoracotomy: importance of required operative time and blood transfusion

Z.-P. LANG[1], M.-W. BAO[2]

[1]Department of Laboratory Medicine, Shanghai Pulmonary Hospital Affiliated to Tongji University, Shanghai, China
[2]Department of Thoracic Surgery, Shanghai Pulmonary Hospital Affiliated to Tongji University, Shanghai, China

Abstract. – OBJECTIVE: The current evidence in support of Video-assisted thoracic surgery (VATS) over conventional open thoracotomy is based upon outcomes related to perioperative complications. The aim of the current study was to compare the mean operative time and amount of blood transfusion required for VATS and thoracotomy.

PATIENTS AND METHODS: A retrospective data analysis was carried out of all patients undergoing pulmonary surgery in the year 2017 for either for benign or malignant conditions at our institute. The primary outcomes were mean operative times and amounts of blood transfusion required during the procedure. Adjusted regression models were used to draw an association between the type of surgical modality (VATS or thoracotomy) and the outcomes considered.

RESULTS: There were 278 subjects that underwent VATS and 237 that had thoracotomy. The mean operating time for the VATS group (2.58 ± 0.98 hours) was significantly less than that of the thoracotomy group (2.99 ± 1.18 hours). Similarly, the amounts of combined blood and plasma transfused were significantly less with VATS (5.81±6.3 units) as compared to the thoracotomy group (9.9 ± 15.1 units). VATS also required significantly fewer blood units as compared to thoracotomy (3.79 ± 3.1 *vs.* 7.15 ± 12.3). Our analysis indicated that, with VATS, the requirement of blood and plasma transfusion was reduced by nearly 4 units (b=-4.09; 95% CI: -6.04, -2.14) and the mean operative time was reduced by around 40 minutes (b=-0.41; 95% CI: -0.60, -0.22).

CONCLUSIONS: Both VATS and thoracotomy are acceptable surgical techniques for the management of lung pathology. However, VATS technique is associated with lower need for blood transfusion and reduced operating time. The decision of the surgical technique should be guided by the availability of resources and the skills of the surgeon.

Key Words:
Video-assisted thoracic surgery, Thoracotomy, Blood transfusion, Operative time.

Introduction

Video-assisted thoracoscopic surgery (VATS) is a recently developed minimally invasive surgical technique, commonly used in the diagnosis and management of pathologies in the thoracic cavity[1]. In this procedure, a camera (called as thoracoscope) and instruments used in the surgery are inserted into the chest through small incisions in the chest wall. The main function of the thoracoscope is to provide the images of the thoracic cavity on a video monitor, thereby, assisting and guiding the surgeon in undertaking the procedure[1,2]. Thoracotomy, on the other hand, is a comparatively more invasive wherein an incision is made in the intercostal space to have access to the lungs and other vital organs in the thorax[2]. The procedure is conducted for the diagnosis or management purpose.

Recently, there has been an upsurge in the use of VATS approach for a wide variety of intrathoracic pathologic processes[3,4]. However, there has been little objective documentation of the relative benefits of this approach compared with open thoracotomy techniques. The current evidence in support of VATS over conventional open thoracotomy is mainly based on observational non-randomized studies, national database analyses, and institutional reports[5,6]. Most of the studies[7-9] have reported results in favor of VATS regarding perioperative complications, time to

Corresponding Author: Minwei Bao, MD; e-mail: 13818089090@139.com

reach chest tube removal stage, time required for hospital stay, pain and subsequently quality of life. A recent systematic review[10] showed that VATS lobectomy, compared to the thoracotomy, was associated with a shorter duration of chest intubation, shorter stay at the hospital and an overall improved survival in patients with lung carcinoma. Evidence11 is also emerging in support of the hypothesis that decreased immunosuppression during the perioperative period in VATS may contribute to the improved outcomes. Many studies[5,6] that compare VATS and standard thoracotomy often lack data on the intra/peri-operative complications, especially the need for blood transfusion following bleeding. Apart from the lack of adequate evidence, other factors could affect the decision on the choice of surgical technique. Minimally invasive surgery, such as VATS, is a technically challenging procedure and surgeons may be reluctant to adopt the minimally invasive approach because of the initial learning curve that is involved in acquiring the skills required for this approach[12,13]. Surgical centers new to this modality would therefore record longer operating time with this minimally invasive technique. Therefore, the current study was designed to compare intra-operative outcomes of VATS and thoracotomy at a large tertiary-care hospital routinely performing this procedure. We primarily compared the operative time and amount of blood transfusion required during VATS and open thoracotomy.

Patients and Methods

The study was conducted at Shanghai Pulmonary Hospital, China which is currently the hospital that performs the highest number of thoracoscopic lung surgery worldwide. There were 56 doctors in the entire thoracic surgery department, including 9 chief physicians and 15 deputy chief physicians. In addition, there were 24 attending physicians and 8 resident physicians. For the purpose of this retrospective study, we retrieved medical records of all patients undergoing pulmonary surgery via VATS or open thoracotomy from 1st January 2017 to 31st December 2017 at our institute. Patients undergoing surgery for both benign and malignant conditions were included. Data were extracted from operative records which are routinely collected for all patients in the hospital. Range and logical checks were in place in the data management system. The following data were extracted: demographic details, co-morbidities, blood panel, diagnosis, operative time, blood transfusion and post-operative hemostatic use. The Ethical Committee of Shanghai Pulmonary Hospital approved this retrospective study (approval number: K18-175). Informed written consent was obtained from all patients for the surgical procedures.

Surgical Procedures Adopted

All the study subjects underwent surgery under general anaesthesia (GA) with intubation using a double lumen endotracheal tube in order to support lung ventilation. For those undergoing VATS, they were placed in the full lateral decubitus position and a thoracoscope was introduced through the 6th or 7th intercostal space on the mid-axillary line using a trocar. A 3-4 cm long utility incision was made through the 4th or 5th intercostal space on the anterior axillary line. In patients undergoing open thoracotomy, the operative procedure included posterolateral thoracotomy accompanied by division of the latissimus dorsi and serratus anterior muscles

Statistical Analysis

Mean and standard deviation (SD) were calculated for continuous variables and proportions for categorical variables. Chi-square test was used to compare proportions and independent *t*-test to compare mean across the two groups. The primary outcomes for the analyses were mean operative time and mean amount of blood transfusion required. For outcomes that were continuous, i.e., operative time and units of blood transfused, adjusted linear regression models were used to draw an association with type of surgical modality (VATS or thoracotomy). The results were presented as beta-coefficients along with 95% Confidence Intervals (CI). Similarly, for outcomes that were categorical in nature, i.e., post-operative anaemia and post-operative hemostatic use, adjusted logistic regression models were run. The results were presented as odds ratio (OR) with 95% CI. Adjustments were done for age, weight, presence of diabetes mellitus, presence of hypertension, type of pathology of the lesion, pre-operative hemoglobin, operative time, prothrombin time, activated partial thromboplastin time and international normalized ratio. For all analyses, a p-value of <0.05 was considered statistically significant. Anaemia was defined as haemoglobin levels <130 g/L for men and <120 g/L for women, as per World Health Organization guidelines[14]. We also created

scatter plots with regression line (with 95% CIs) to present the relationship of amount of blood and plasma transfused with total surgical time and pre-operative haemoglobin levels in each of the two surgical groups.

Results

Data for 515 study participants were available for analysis. Table I presents the comparison of characteristics of the study participants that underwent VATS and thoracotomy. There were 278 subjects that underwent VATS and 237 that had thoracotomy. The mean age, weight and height of the subjects in the two groups were statistically similar. The group that underwent thoracotomy had significantly higher proportion of males (81.8%) compared to the VATS group (61.5%). The distribution of various blood group types, presence of diabetes, and hypertension among the study subjects across the two groups were statistically similar. The proportion of subjects with malignant lesions requiring surgical intervention were also similar in both cohorts. There were no differences in the mean pre-operative and post-operative haemoglobin levels, prothrombin time, activated partial thromboplastin time and international normalized ratio (INR) across the two groups.

The operative time with VATS (2.58 ± 0.98 hours) was significantly shorter compared to thoracotomy (2.99 ±1.18 hours) (Table I). The combined amount of blood and plasma transfused were significantly lower in the VATS group (5.81 ±6.3 units) as compared to the thoracotomy group (9.9 ±15.1 units). Similarly, VATS patients required significantly lower amount of blood cell transfusion compared to open thoracotomy (3.79 ±3.1 units vs. 7.15 ±12.3 units). The proportion of subjects requiring post-operative haemostatic was similar in the two groups.

The regression analysis revealed that the requirement of blood and plasma transfusion in VATS patients was reduced by nearly 4 units as compared to those undergoing thoracotomy [*b*=-4.09; 95% CI: -6.04, -2.14] (Table II). Also, the mean operative time was around 40 minutes shorter in patients who underwent VATS [*b*=-0.41; 95% CI: -0.60, -0.22]. The risk of post-operative anaemia [OR 0.80; 95% CI: 0.53, 1.21] and risk of haemostatic use [OR 0.92; 95% CI: 0.65, 1.30] were similar in the two groups (Table II).

Figures 1 and 2 present the pictorial relationship of amount of blood and plasma transfused with total surgical time, as well as pre-operative hemoglobin levels in the two study groups. In the VATS group, there was no change in the units of blood and plasma transfused with increase in pre-operative hemoglobin or with increase in total surgical

Table I. Correlation analysis between RBM10 expression and clinicopathological parameters of HCC patients.

Clinicopathologic features	No. of cases	RBM10 expression		*p*-value
		Low (n=25)	High (n=25)	
Age (years)				0.767
≤60	21	11	10	
>60	25	12	13	
Gender				0.369
Male	19	8	11	
Female	27	15	12	
Tumor size				0.036*
≤5 cm	19	6	13	
>5 cm	27	17	10	
TNM stage				0.035*
I-II	22	7	15	
III-IV	22	14	8	
Vascular invasion				0.116
Negative	15	5	10	
Positive	31	18	13	
Histological classification				
Low grade	19	10	9	0.765
Medium and High grade	27	13	14	

HBV: hepatitis B virus.

Table II. Regression analyses to determine the association between type of surgical technique and outcomes considered.

	Units of blood and plasma transfused Adjusted ß coff (95% CI)	Operation time (in hours) Adjusted ß coff (95% CI)	Risk of post-operative anaemia Adjusted OR (95% CI)	Risk of post-operative hemostatic use Adjusted OR (95% CI)
Study group				
Thoracotomy	Reference	Reference	Reference	Reference
VATS	-4.09 (-6.04, -2.14)*	-0.41 (-0.60, -0.22)*	0.80 (0.53, 1.21)	0.92 (0.65, 1.30)

p-value of <0.05 is considered statistically significant. *Adjusted for age, weight, presence of diabetes, presence of hypertension, type of pathology of the lesion, pre-operative hemoglobin, operative time, prothrombin time, activated partial thromboplastin time and international normalized ratio. OR, Odds ratio; CI, confidence interval.

time. Similarly, in the thoracotomy group, there was no change in the units of blood and plasma transfused with increase in pre-operative hemoglobin. However, in this group, with increase in the total surgical time, the amount needed to be transfused increased significantly.

Discussion

In recent years, VATS has gained popularity in the management of pulmonary, mediastinal, and pleural pathologies. This minimally invasive procedure offers several key benefits like avoidance of a thoracotomy incision, reduced post-operative morbidity, and early return to function[2,4]. However, does the utility of the procedure for intra-operative outcomes has received limited attention in literature. The current analysis was, therefore, undertaken to compare VATS technique with conventional thoracotomy with regards to the operative time and amount of blood transfusion required.

We found that in patients who underwent VATS, the mean operative time was shorter by around 40 minutes, compared to those who were treated by thoracotomy. Similar results have been reported by other studies as well. Liu et al[15] in a recently published study in 2020 have also compared VATS with open thoracotomy. They reported a significantly reduced operating with VATS (147.96 ± 58.91 min) as compared to open procedures (165.34 ± 58.91 min). Reichert et al16 in their 12-year experience with VATS in chronic stage III pleural empyema patients have also reported significantly reduced operating time with VATS.

Further, the amount of blood and plasma transfusions required were also significantly lower in patients undergoing VATS. Our analysis also indicated that the amount of post-operative blood and plasma transfusion increased with the increase in total surgical time in the standard thoracotomy group but not in the VATS group. Our findings provide evidence in support to previously published studies that indicate that VATS is beneficial compared to standard thoracotomy[17,18]. Studies[17,18] have reported low intra-operative blood loss with reduced requirement for transfusion, decreased post-operative pain, and fewer overall complications with the VATS technique.

Minimally invasive surgery, such as VATS is a technically challenging procedure and hospitals may be reluctant to adopt the minimally-invasive approach because of the initial learning curve that is involved in training surgeons. Some scholars[19] have indicated that the requirement of high-level of technical skills along with the small field of surgery may increase the risk of injury to the pulmonary vessels leading to greater blood loss with this technique as compared to the standard thoracotomy. Some surgeons even consider blood loss following injury to the pulmonary vasculature as one of the most critical complication of VATS[20]. However, in our analysis, we have shown that if the skills of the surgeon are optimal, the requirement of blood transfusion is in fact reduced with the VATS technique. Additionally, we have also shown that in VATS, the amount of blood transfusion required is not dependent upon the operation time, unlike in thoracotomy where there is a proportional increase in the required blood transfusion with increase in operation time. Thus, in our case series and in concurrence with data from previously published studies[15-21], we believe that VATS is an important technological development which can significantly reduce intra-operative outcomes as compared to open thoracotomy.

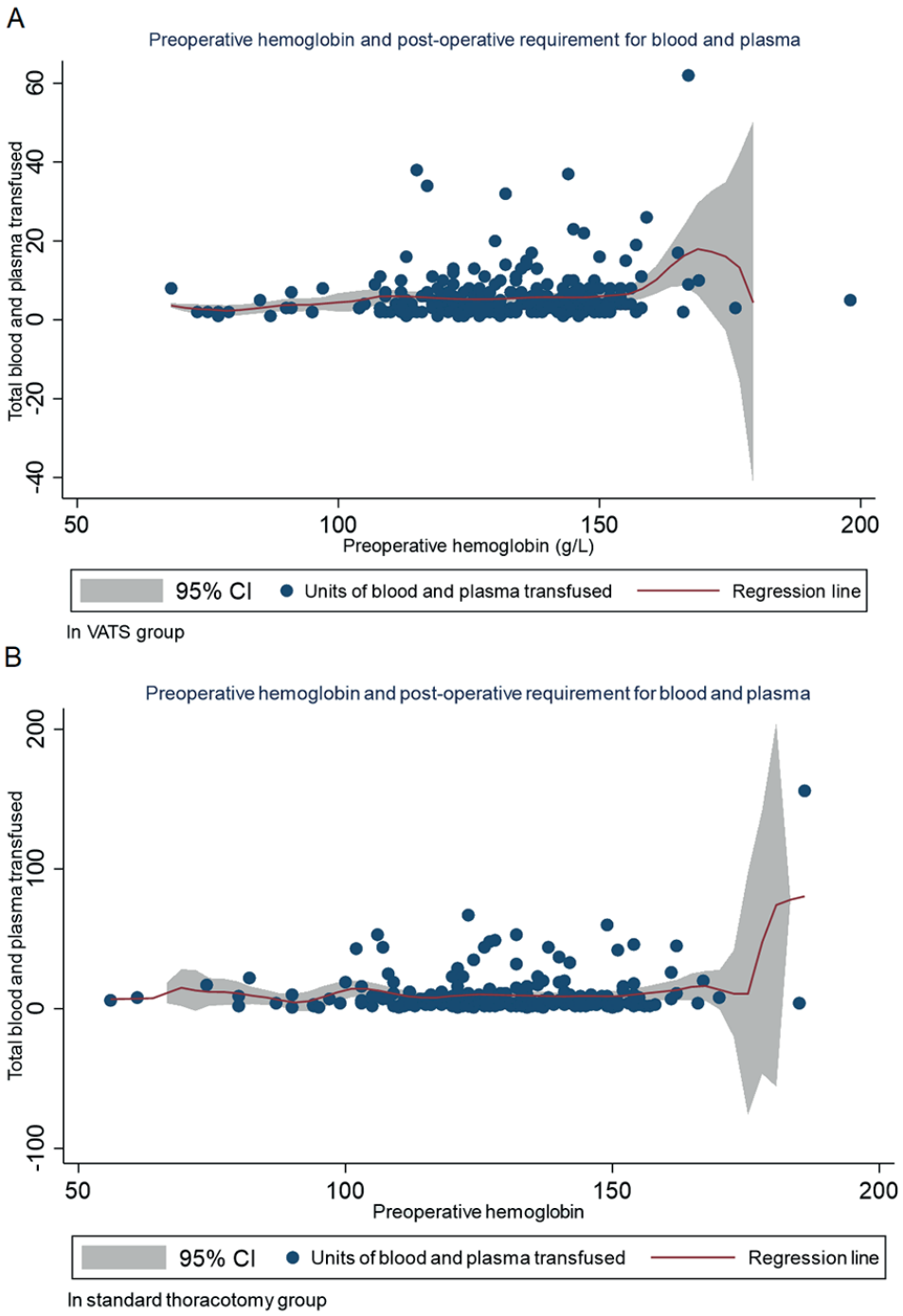

Figure 1. Scatter plot with regression line to show the relationship between pre-operative haemoglobin and requirement for blood and plasms transfusion among VATS and thoracotomy groups **(A)** in the VATS group; **(B)** in the standard thoracotomy group.

Our study has some strengths. The evidence generated from this analysis is credible as the study population and its baseline characteristics were similar for both the study groups. There were no significant differences in the any patient comorbidities and other confounders. This analysis has some limitations that are worth mentioning. First, this is a retrospective data analysis and therefore it is difficult to establish causality. There could be unknown variables not recorded in our study which could have altered the associations observed in the analysis. Therefore, a high-qual-

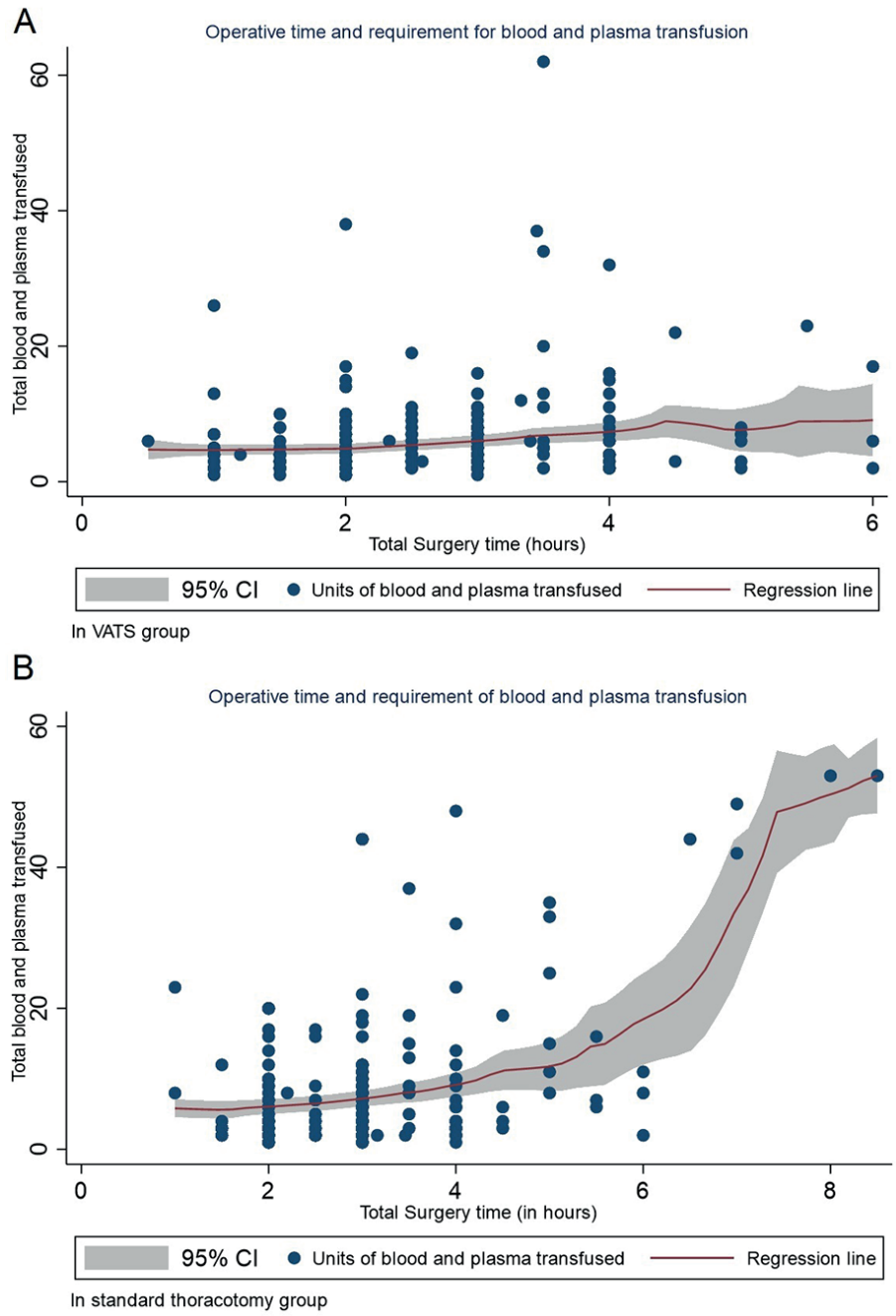

Figure 2. Scatter plot with regression line to show the relationship between operative time and requirement for blood and plasms transfusion among VATS and thoracotomy groups **(A)** in the VATS group; **(B)** in the standard thoracotomy group.

ity randomized controlled trial would better establish the benefits and disadvantages of VATS and thoracotomy. Secondly, the intra-operative outcomes of any surgical procedure also depend upon the skills of the surgeon which may vary in different settings thereby influencing outcomes. However, it is unlikely that the basic conclusions would change.

Conclusions

In summary, both VATS and thoracotomy are acceptable in terms of surgical modalities for treatment of lung pathology. However, VATS technique is associated with lower need for blood transfusion and reduced operative time. The decision to opt for either of the two

surgical technique should be guided by the skill of the surgeon and the extent of the disease. In case where the extent of the spread of disease demands a thoracotomy, this has to be preferred surgical procedure.

Conflict of Interest

The Authors declare that they have no conflict of interests.

References

1) Daniels LJ, Balderson SS, Onaitis MW, D'Amico TA. Thoracoscopic lobectomy: a safe and effective strategy for patients with stage I lung cancer. Ann Thorac Surg 2002; 74: 860-864.
2) Flores RM, Park BJ, Dycoco J, Aronova A, Hirth Y, Rizk NP, Bains M, Downey RJ, Rusch VW. Lobectomy by video-assisted thoracic surgery (VATS) versus thoracotomy for lung cancer. J Thorac Cardiovasc Surg 2009; 138: 11-18.
3) Boffa DJ, Allen MS, Grab JD, Gaissert HA, Harpole DH, Wright CD. Data from the society of thoracic surgeons general thoracic surgery database: the surgical management of primary lung tumors. J Thorac Cardiovasc Surg 2008; 135: 247-254.
4) Swanson SJ, Herndon JE 2nd, D'Amico TA, Demmy TL, McKenna RJ Jr, Green MR, Sugarbaker DJ. Video-assisted thoracic surgery lobectomy: report of CALGB 39802--a prospective, multi-institution feasibility study. J Clin Oncol 2007; 25: 4993-4997.
5) Grogan EL, Jones DR. VATS lobectomy is better than open thoracotomy: what is the evidence for short-term outcomes? Thorac Surg Clin 2008; 18: 249-258.
6) Papiashvilli M, Sasson L, Azzam S, Hayat H, Schreiber L, Ezri T, Priel IE. Video-assisted thoracic surgery lobectomy versus lobectomy by thoracotomy for lung cancer: pilot study. Innovations (Phila) 2013; 8: 6-11.
7) Database of Abstracts of Reviews of Effects (DARE): Quality-assessed Reviews [Internet]. Is video-assisted thoracic surgery lobectomy better than thoracotomy for early-stage non-small-cell lung cancer? A systematic review and meta-analysis. Eur J Cardiothorac Surg 2013; 44: 407-414.
8) Handy JR Jr, Skokan M, Rauch E, Zinck S, Sanborn RE, Kotova S, Wang M. Does video-assisted thoracoscopic lobectomy for lung cancer provide improved functional outcomes compared with open lobectomy? Eur J Cardiothorac Surg 2010; 37: 451- 455.
9) Aoki T, Tsuchida M, Hashimoto T, Saito M, Koike T, Hayashi J. Quality of life after lung cancer surgery: video-assisted thoracic surgery versus thoracotomy. Heart Lung Circ 2007; 16: 285-289.
10) Whitson BA, Groth SS, Duval SJ, Swanson SJ, Maddaus MA. Surgery for early-stage non-small cell lung cancer: a systematic review of the video-assisted thoracoscopic surgery versus thoracotomy approaches to lobectomy. Ann Thorac Surg 2008; 86: 2008-2016.
11) Whitson BA, D'Cunha J, Maddaus MA. Minimally invasive cancer surgery improves patient survival rates through less perioperative immunosuppression. Med Hypotheses 2007; 68: 1328-1332.
12) Fernandez FG, Kosinski AS, Burfeind W, Park B, DeCamp MM, Seder C, Marshall B, Magee MJ, Wright CD, Kozower BD. The society of thoracic surgeons lung cancer resection risk model: higher quality data and superior outcomes. Ann Thorac Surg 2016; 102: 370-377.
13) S Sihoe ADL, Gonzalez-Rivas D, Yang TY, Zhu Y, Jiang G. High-volume intensive training course: a new paradigm for video-assisted thoracoscopic surgery education. Interact Cardiovasc Thorac Surg 2018; 27: 365-371.
14) Peña-Rosas JP WHO. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. Geneva, World Health Organization, 2011 (WHO/NMH/NHD/MNM/11.1).
15) Liu C, Guo C, Gan F, Mei J, Pu Q, Liu Z, Zhu Y, Liao H, Ma L, Lin F, Liu L. Results of video-assisted thoracic surgery versus thoracotomy in surgical resection of pN2 non-small cell lung cancer in a Chinese high-volume Center. Surg Endosc 2020 May 11. doi: 10.1007/s00464-020-07624-2. Online ahead of print.
16) Reichert M, Pösentrup B, Hecker A, Schneck E, Pons-Kühnemann J, Augustin F, Padberg W, Öfner D, Bodner J. Thoracotomy versus video-assisted thoracoscopic surgery (VATS) in stage III empyema-an analysis of 217 consecutive patients. Surg Endosc 2018; 32: 2664-2675.
17) Cattaneo SM, Park BJ, Wilton AS, Seshan VE, Bains MS, Downey RJ, Flores RM, Rizk N, Rusch VW. Use of video-assisted thoracic surgery for lobectomy in the elderly results in fewer complications. Ann Thorac Surg 2008; 85: 231-235.
18) Kaseda S, Aoki T, Hangai N, Shimizu K. Better pulmonary function and prognosis with video-assisted thoracic surgery than with thoracotomy. Ann Thorac Surg 2000; 70: 1644-1646.
19) Whitson BA, Andrade RS, Boettcher A, Bardales R, Kratzke RA, Dahlberg PS, Maddaus MA. Video-assisted thoracoscopic surgery is more favorable than thoracotomy for resection of clinical stage I non-small cell lung cancer. Ann Thorac Surg 2007; 83: 1965-1970.
20) Flores RM, Ihekweazu U, Dycoco J, Rizk NP, Rusch VW, Bains MS, Downey RJ, Finley D, Adusumilli P, Sarkaria I, Huang J, Park B. Video-assisted thoracoscopic surgery (VATS) lobectomy: catastrophic intraoperative complications. J Thorac Cardiovasc Surg 2011; 142: 1412-1417.
21) Kawachi R, Tsukada H, Nakazato Y, Takei H, Koshishi Y, Goya T. Morbidity in video-assisted thoracoscopic lobectomy for clinical stage I non-small cell lung cancer: is VATS lobectomy really safe? Thorac Cardiovasc Surg 2009; 57: 156-159.