

## ORIGINAL ARTICLE

# Comparative study of three-dimensional versus two-dimensional video-assisted thoracoscopic two-port lobectomy

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## Keywords

2D; 3D; lobectomy; lung cancer; two-port; video-assisted thoracoscopic surgery.

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## Abstract

**Background:** The advantages and disadvantages of three-dimensional (3D) and two-dimensional (2D) two-port video-assisted thoracoscopic surgery (VATS) lobectomy and systematic dissection of mediastinal lymph nodes for lung cancer were investigated.

**Methods:** Between December 2013 and July 2015 at Beijing Hospital, 191 patients underwent lobectomy and systematic dissection of mediastinal lymph nodes for lung cancer. After applying the study criteria, a total of 165 patients were included and allocated to 3D ( $n = 76$ ) and 2D ( $n = 89$ ) groups. Variables of the study design, including duration of surgery, volume of intraoperative bleeding, numbers and groups of lymph nodes dissected, drainage volume after surgery, duration of drainage tube insertion, hospitalization time after surgery, hospitalization costs, and complications, were recorded and analyzed. Intergroup differences for all data were compared and statistically analyzed.

**Results:** No statistical difference was found between the two groups with respect to duration of surgery, volume of intraoperative bleeding, drainage volume after surgery, duration of drainage tube insertion, hospitalization time after surgery, hospitalization costs, and complications ( $P > 0.05$ ). Additionally, there was no significant difference in the numbers and groups of all lymph nodes or N<sub>2</sub> lymph nodes resected ( $P > 0.05$ ).

**Conclusion:** Lobectomy with systematic lymph node dissection can be undertaken with two ports using a 3D thoracoscope, and presents similar results to the use of a traditional 2D thoracoscope, at no greater hospitalization cost but with better operational perception and sensitivity during surgery. Two-port lobectomy with systematic lymph node dissection using a 3D thoracoscope is a safe and effective surgical process for lung cancer treatment.

## Introduction

Video-assisted thoracoscopic surgery (VATS) has widely been utilized by thoracic surgeons because of the reduced trauma, quicker recovery, and recognized therapeutic effects associated.<sup>1</sup> Nevertheless, traditional VATS has innate disadvantages because of the two-dimensional (2D) visual constraint; for example, it lacks stereo perception, demands difficult hand-eye coordination, and has a steep learning curve. To overcome these disadvantages, three-dimensional (3D) endoscopic systems and surgical robotic systems have been developed. Surgical robotic

systems are very expensive to deploy, and extensive high-tech medical equipment is required during each robotic operation, which Chinese patients can seldom afford. Thus, 3D endoscopic systems may become widely used in China. The purpose of this study was to evaluate the advantages and disadvantages of both 3D and 2D two-port VATS lobectomy and systematic dissection of mediastinal nodes for lung cancer, including assessment of the safety of the operation, postoperative complications, duration of the operation, oncologic efficacy (the numbers of lymph nodes resected), and hospitalization cost.

## Methods

### Patients

Initially, 191 patients who underwent lobectomy and systematic dissection of mediastinal lymph nodes for lung cancer at Beijing Hospital from December 2013 to July 2015 were recruited. The inclusion criteria were as follows: (i) diagnosis of lung cancer and VATS lobectomy and systematic dissection of the mediastinal nodes performed as treatment; and (ii) clinical neoplasm staging of I–IIIa. The exclusion criteria were: (i) clinical neoplasm staging of IIIb–IV; (ii) history of preoperative chemotherapy or radiotherapy; and (iii) poor candidature for surgery. Finally, 165 patients were included in the study. Patients were allocated to 2D ( $n = 89$ ) and 3D ( $n = 76$ ) groups. A non-random allocation method was used, as there were only two available 3D endoscopic systems, shared between the abdominal, urological, gynecological, and thoracic surgeons in the hospital. The demographic characteristics and preoperative examination data of both groups are summarized in Table 1.

### Methods

All patients were placed in a lateral and jackknife position and were intubated with double-lumen endotracheal tubes after administration of general anesthesia; therefore, single-lung ventilation was applied.

All surgeries were performed by the same surgeon who had performed at least 1800 VATS lobectomies, via two ports and without rib spreading. The three attending doctors, proficient in VATS lobectomy, have operated in the same team with the surgeon for more than five years. Karl Storz 2D (Karl Storz GmbH & Co. KG, Tuttlingen, Germany) and Einstein Vision 3D (Aesculap, B. Braun, Germany) endoscopic systems were used. Surgeons wore polarized 3D lenses to view the screen during the 3D VATS procedure. The incisions were positioned based on the location of the tumor on preoperative chest radiography. The observing port, about 1.5 cm, was usually located at the eighth intercostal space crossed to the mid-axillary

line. The 2.5–4 cm operating port incision, was usually made at the fourth intercostal space for upper lobectomy, fifth intercostal space for lower lobectomy, fourth intercostal space for middle lobectomy with transverse fissure hypoplasia, and at the fifth intercostal space for middle lobectomy with oblique fissure hypoplasia. The operating port was on the anterior axillary line. No auxiliary manipulative incisions were required.

The arteries, veins, and bronchi were treated anatomically. Lymph nodes from at least four stations were dissected, including at least three stations in the mediastinal lymph nodes.

### Clinical data and statistical analysis

Clinical information of all patients, including duration of operation, volume of intraoperative bleeding, numbers and groups of lymph nodes dissected, postoperative drainage volume, duration of drainage tube insertion, hospitalization time after surgery, hospitalization costs, and complications, was collected.

Statistical analysis was performed using SPSS version 19.0 for Windows (SPSS Inc., Chicago, IL, USA). Data, including age, duration of surgery, volume of intraoperative bleeding, drainage volume and duration following surgery, numbers and groups of lymph nodes resected, hospitalization time after surgery, and hospitalization costs, were recorded and expressed as mean values and standard deviations (mean  $\pm$  SD) and were compared using the *t*-test between the two groups. Data including gender, complications, pathological pattern, and pathological staging were evaluated and expressed as counts and analyzed using the Chi-square test. For all statistical analyses,  $P < 0.05$  was considered significant.

## Results

No deaths occurred during the perioperative period. No significant differences existed between the 3D and 2D VATS groups regarding duration of surgery ( $P = 0.096$ ); volume of intraoperative bleeding ( $P = 0.859$ ); postoperative drainage volume ( $P = 0.705$ ) and duration ( $P = 0.369$ ); numbers

**Table 1** Demographic characteristics and preoperative examination data

Group	Age(years)	Gender			Rumor diameter (cm)	Tumor location				
		M	F	FEV1(L)		LUL	LLL	RUL	RML	RLL
3D ( $n = 76$ )	64.76 $\pm$ 9.86	39	37	1.97 $\pm$ 0.39	2.44 $\pm$ 1.47	19	14	21	7	15
2D ( $n = 89$ )	64.02 $\pm$ 10.53	46	43	2.01 $\pm$ 0.46	2.67 $\pm$ 1.43	24	16	27	8	14
T value ( $\chi^2$ value)	0.464	0.002		-0.660	-1.007	1.735				
P value	0.644	0.962		0.510	0.316	0.784				

2D, two-dimensional; 3D, three-dimensional; FEV1, forced expiratory volume in one second; LLL, left lower lobe; LUL, left upper lobe; RLL, right lower lobe; RML, right middle lobe; RUL, right upper lobe.

**Table 2** Clinical variables

Group	Surgical duration (min)	Blood loss (mL)	Conversion to thoracotomy	Drainage duration (day)	Drainage amount (mL)	Hospital stay (days)	Complications	Hospitalcost (thousands¥)
3D ( <i>n</i> = 76)	112.5 ± 45.9	125.3 ± 132.4	1	4.7 ± 1.5	913.6 ± 482.5	8.4 ± 1.9	11	58.9 ± 4.9
2D ( <i>n</i> = 89)	125.7 ± 54.2	121.4 ± 148.0	1	4.9 ± 1.6	860.8 ± 477.3	8.1 ± 2.3	14	59.9 ± 5.5
T value ( $\chi^2$ value)	-1.674	0.178	0.013	-0.902	0.705	1.010	0.050	-1.266
P value	0.096	0.859	1.000	0.369	0.482	0.314	0.822	0.207

2D, two-dimensional; 3D, three-dimensional.

**Table 3** Lymph nodes and pathology

Group	Lymph nodes	Lymph node station	N2 lymph nodes	N2 lymph node station	Pathology			Pathologic staging				
					Adeno.	Squa.	Other	IA	IB	IIA	IIB	IIIA
3D ( <i>n</i> = 76)	23.3 ± 7.4	5.3 ± 0.9	15.2 ± 5.8	4.0 ± 0.8	49	22	5	28	20	7	2	19
2D ( <i>n</i> = 89)	21.9 ± 7.3	5.5 ± 0.9	15.8 ± 6.5	4.2 ± 0.9	59	23	7	30	26	7	4	22
T value ( $\chi^2$ value)	1.243	-1.895	-0.616	-1.572	0.259			0.718				
P value	0.216	0.060	0.539	0.118	0.879			0.949				

2D, two-dimensional; 3D, three-dimensional; adeno, adenosquamous; squa, squamous.

( $P = 0.216$ ) and groups ( $P = 0.060$ ) of total lymph nodes resected; numbers ( $P = 0.539$ ) and groups ( $P = 0.118$ ) of N<sub>2</sub> lymph nodes resected; conversion to open surgery ( $P = 1.000$ ); complications ( $P = 0.822$ ); hospitalization time after surgery ( $P = 0.314$ ); and hospitalization costs ( $P = 0.207$ ). The results are shown in Tables 2 and 3. Complications included pulmonary infection, cardiac complication, bleeding, atelectasis, prolonged air leak, deep vein thrombosis, and cerebral infarction.

## Discussion

Video-assisted thoracoscopic surgery, compared with open thoracotomy, reduces: trauma, because of the shorter incisions required; injury to respiratory muscles; loss of respiratory function; pain; and the incidence of postoperative pulmonary infection and other complications.<sup>2-5</sup> Because of these advantages, VATS has developed rapidly and has been widely adopted throughout the world. The traditional 2D endoscopic systems lack depth perception, which disables accurate judgment of the distance between the surgical instruments and the tissue and causes difficulty in hand-eye coordination. In the absence of depth perception and spatial orientation, it is difficult for surgeons to perform surgery, and they need a longer period of time to adapt to the use of 2D systems. Therefore, to counter these disadvantages, 3D endoscopic systems and surgical robotic systems have been applied in thoracic surgery. However, the cost of surgical robotic systems is very high, and robotic operations require highly expensive, high-tech, dedicated medical equipment. Because Chinese medical insurance does not cover these costs, Chinese patients can seldom afford robot-assisted treatment. Hence, surgical

robotic systems are unavailable to the overwhelming majority of Chinese patients.

The first 3D endoscopic system was designed by the Karlsruhe Nuclear Research Center. At that time, 3D images were caught by shutter glasses and the screen resolution was low, which soon made the surgeons' eyes tired; hence, the 3D system could not be widely used. Nowadays, polarimetric glasses that are more comfortable and lighter than the traditional equipment are used. At the same time, the technology of 3D systems and their displays has been developed to achieve a much higher resolution. Therefore, 3D systems have been adopted by increasing numbers of surgeons. However, little comparison has been made between 3D and 2D VATS in two-port lobectomy and the systematic dissection of mediastinal nodes in patients with non-small cell lung cancer. Our study, therefore, compared the two surgical methods in order to establish whether 3D is superior to 2D VATS systems.

There were no significant intergroup differences with respect to duration of surgery, volume of intraoperative bleeding, drainage volume after surgery, duration of drainage tube insertion, hospitalization time after surgery, hospitalization costs, and complications (all  $P > 0.05$ ). Moreover, there were no significant differences between the numbers and groups of all of the lymph nodes or N<sub>2</sub> lymph nodes resected ( $P > 0.05$ ). The same surgeon, who was experienced in 2D VATS lobectomy, but relatively less experienced in the use of 3D systems, performed all operations. Because of his extensive experience, the surgeon could compensate for the limitations of the 2D system by using 2D cues, such as light and shade, the relative size and position of tissues and organs, texture gradient, spatial perspective, and motion parallax.<sup>6</sup> Some studies have

proven that very experienced surgeons can compensate for the lack of stereo perception inherent in 2D systems.<sup>7,8</sup> Nevertheless, several studies have shown that 3D endoscopic systems are superior to 2D systems, especially when involving complex operations, and for less experienced surgeons.<sup>6,9–13</sup> Our surgeon reported that the 3D system provides a better sense of depth, which can facilitate precise tasks, such as suturing.

Our results indicated the following advantages of 3D over 2D endoscopic systems. The Einstein Vision 3D endoscopic systems that we used can achieve an optical magnification of 10–15 times, while the Karl Storz 2D systems can only deliver an optical magnification of about four times. Therefore, surgery using a 3D system is more precise and, thus, safer.<sup>14</sup> The 3D vision allows surgeons to be present virtually “in” the scene, rather than just seeing a photo of it, thereby creating a much stronger sense of depth and position that can reduce the incidence of injury to important organs or tissues.<sup>14,15</sup> Surgeons can perform complex tasks, such as suturing or ligation, more quickly and precisely.<sup>12</sup> Complex operations, such as bronchial or vessel sleeve resection, are performed more easily and surgical duration is shorter.<sup>6</sup> Surgeons, particularly beginners, need not adapt the conversion from stereoscopic vision to 2D vision, so they can learn to perform VATS more easily and more rapidly. The costs of 2D and 3D VATS are similar, thus, no additional medical consumables are required, which is therefore an advantage regarding Chinese national insurance claims.

On the other hand, the disadvantages of 3D endoscopic systems are as follows. The 30° lens of traditional 2D systems can be rotated, so a 360° view is possible; however, the 30° lens of 3D systems cannot be rotated separately, unless it is rotated with the hand shank, which could lead to the frames in the display being rotated as a result. It is very challenging for a surgeon to adapt to a rotated view. The different images seen by each eye will be reintegrated in the brain. If the images move too fast, the surgeon may become dizzy and nauseous, which may cause vomiting. Therefore, the camera assistant must work in close coordination with the surgeon, and have a steady grip on the camera to ensure movement-free imaging. However, the hand shanks of 3D systems are very heavy and this creates hard work for the camera assistant. 3D VATS systems require more surgical space than 2D systems. In addition, all 3D systems are made up of dual-channel cameras, which require greater object distances than 2D systems, otherwise the imaging will not be clear enough. The image magnification of 3D systems is larger than that of 2D systems, so only a much smaller operative field of vision can be obtained for the same object distance. It is difficult to undertake surgical manipulations for which a wider field of vision is required. The requirement for a clean and clear

camera lens is greater in 3D than in 2D systems, because dirty/smudged lenses lead to unclear image processing in the brain, again causing nausea and dizziness. Finally, some surgeons cannot adjust to working with 3D systems. The different images that are separately caught by each eye through the polarizing filter glasses are reintegrated and become new 3D images in the brain. The eyes and the brain are all intensely active during surgery, which makes some surgeons nauseous.

In conclusion, the chosen variables in our study showed no significant intergroup differences. Although 3D systems can provide more amplification, clearer vision, and a better sense of depth than 2D systems, thereby facilitating surgical precision, 3D VATS has only recently been applied to two-port lobectomy. Following previous literature reports of the advantages of 3D VATS, we recommend the continued use of 3D systems to further establish their advantages and disadvantages in the lobectomy and systematic dissection of mediastinal lymph nodes.

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## Disclosure

No authors report any conflict of interest.

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