

ORIGINAL ARTICLE

Analysis of lymph node impact on conversion of complete thoracoscopic lobectomy to open thoracotomy

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Keywords

Complete video-assisted thoracoscopy; conversion thoracotomy; lobectomy; lymph nodes.

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Abstract

Background: The aim of the study was to analyze the influence of lymph nodes in conversion thoracotomy and its measurements.

Method: Between September 2006 to April 2013, 1006 patients (545 men, 461 women, median age 60 years, range: 13 to 86 years) received a complete thoracoscopic lobectomy. The main procedure was complete video-assisted anatomical lobectomy with mediastinal lymphadenectomy.

Results: All procedures were carried out smoothly without serious complication. Eighty-three cases were converted to thoracotomy (8.2%), including 70 cases of initiative conversion and 13 of passive conversion, in which 59 cases had interference by doornail lymph nodes. The average operative time was significantly longer (272.7 ± 67.2 vs. 186.9 ± 58.1 minutes, $P = 0.001$); the average blood loss was significantly increased (564.2 ± 507.7 ml vs. 158.0 ± 121.0 ml, $P = 0.001$); and the drainage time and postoperative hospital stay were significantly longer (8.9 ± 5.0 vs. 6.6 ± 3.5 days, $P = 0.001$; 12.5 ± 7.7 vs. 9.2 ± 5.8 days, $P = 0.001$, respectively) in the conversion thoracotomy compared with the complete endoscopic surgery group.

Conclusion: Interference of the lymph nodes was the main reason for conversion to thoracotomy on video-assisted thoracoscopic lobectomy, which prolonged operative time, increased the blood loss during surgery, and delayed postoperative recovery. Selecting the proper indication of conversion thoracotomy may reduce the negative effects.

Introduction

Conversion to open thoracotomy occurs when thoracoscopic manipulation becomes difficult as a result of particular situations during complete thoracoscopic lobectomy after the surgeon starts to dissect blood vessels.^{1–3} Based on special intra-operative situations, conversion to open thoracotomy can be divided into active and passive conversion. Active conversion to open thoracotomy implies that the surgeon gives up thoracoscopic manipulation voluntarily and performs open surgery under direct vision as a result of the difficulty of thoracoscopic manipulation when encountering problems, such as adhesions of lymph nodes and difficulty of exposing huge tumors, which may result in massive bleeding, tumor rupture, and undue extension of operative time. Passive conversion to open thoracotomy implies that the surgeon has to discontinue thoracoscopic manipulation and perform open surgery under direct vision because of urgent or serious

intra-operative complications, including blood vessel breakage and bronchial membrane rupture, which are difficult to treat thoracoscopically. Lymph nodes are an important etiology affecting the conversion of complete thoracoscopic lobectomy to open thoracotomy.^{4–6} Five hundred consecutive patients with non-small cell lung cancer underwent complete thoracoscopic lobectomy at the Department of Thoracic Surgery of Peking University People's Hospital, and the conversion to open thoracotomy was performed in 47 cases (9.4%). Lymph node interference means that a lymph node cannot be separated easily, and was the reason for conversion to open surgery in 31 cases (65.9% of 47 cases).^{7–9} The effect of lymph node interference on surgery has not been thoroughly addressed to date.^{10–12} We studied the data of patients who underwent complete thoracoscopic lobectomy in our hospital, and analyzed the effect of lymph nodes on the conversion to open thoracotomy and corresponding factors. Some lymph nodes are quite hard, closely adherent to the

peripheral blood vessels and bronchia, and cannot be separated, like a doornail tightly fixed in the door; therefore, we call them “doornail lymph nodes.”

Materials and methods

To facilitate our research, we termed the proliferative and sclerous lymph nodes closely adhering to the blood vessels and bronchia as “doornail lymph nodes.” Specifically, computed tomography (CT) scans showed enlarged lymph nodes around the hilar vessels or bronchia, which were accompanied with or without calcifications, and the boundary between the blood vessel and the bronchia was not clear. During surgery, the lymph nodes were hard and closely adherent to the peripheral blood vessels and bronchia. The peripheral blood vessel sheath could not be incised. Even if the sheath could be incised, the blood vessel could not be dissected. Part of or one side of the blood vessel (mainly the pulmonary artery) wall was completely fused to the bronchia, and could not be separated with scissors or a scalpel, hence the term “doornail lymph node.”

Between September 2006 and April 2013, 1125 patients underwent anatomic pulmonary resections in our hospital. Among them, 119 patients underwent open thoracotomies and 1006 patients underwent thorascopies; 545 were men and 461 women. The median age was 60 years (range: 13–86 years). Surgical procedures included: segmentectomies in 13 patients, simple lobectomies in 846, composite lobectomies in 131 (combined lobectomy, lobectomy + segmentectomy, and lobectomy + pulmonary wedge resection), total pulmonary resections in eight, and sleeve resections in eight patients. The detailed surgical procedures were the same as described in previous reports.⁷

Results

The surgery was performed successfully in all cases. The peri-operative mortality rate was 0.6% (6 cases), and no serious complications occurred. The mean operative time was 198.8 ± 66.0 minutes (range: 60–280 minutes), the mean blood loss was 206.7 ml ± 169.4 ml (range: 20–3100 ml), the mean duration of drainage was 6.7 ± 3.7 days (range: 1–30 days), and the mean postoperative length of stay was 9.7 ± 6.0 days (range: 2–47 days). Postoperative pathologic examinations showed that 821 patients had malignant disease. One hundred and eighty-five patients had benign disease (Table 1).

Intra-operative conversion to open surgery occurred in 83 cases (8.2%). Among the conversions, passive conversion occurred in 13 patients (13/83 [15.7%]). The cause of conversions included inappropriate instrument handling in one patient and pulmonary arterial bleeding in 12 patients. Electrical injury of the blood vessel was caused by careless handling of the instrument in one patient and bleeding caused by

Table 1 Results of pathologic examinations in patients who underwent thoracoscopic lobectomy

	Number
Malignant diseases	821
Adenocarcinoma	561
Squamous cell carcinoma	120
Adenosquamous carcinoma	13
Carcinosarcoma	3
Large cell lung cancer	7
Alveolar cell carcinoma	37
Small cell lung cancer	18
Metastatic carcinoma	30
Carcinoid	14
Atypical adenomatous hyperplasia	9
Lymphoma	5
Synovial sarcoma	2
Pleuropulmonary blastoma	1
Melanoma	1
Benign diseases	185
Bronchiectasis	66
Tuberculosis	31
Inflammation	25
Pulmonary fungal disease	13
Pulmonary sequestration	10
Chronic inflammation	9
Hamartoma	8
Congenital lung cyst	7
Lung abscess	7
Pulmonary hypoplasia	6
Bullae	2
Actinomycosis	1
Sum	1006

an unstable titanium clip, and blood vessel rupture occurred when placing the stapler in two patients. In the remaining nine patients (9/13 [69.2%]), the pulmonary artery was injured when dissecting the peripheral lymph nodes and massive bleeding occurred. Active conversion occurred in 70 patients (70/83 [84.3%]). Detailed causes of conversion included incomplete interlobar fissures in three patients, extensive pleural adhesion in three patients, huge tumors or tumor invasion to the peripheral vital organs in 14 patients, and lymph node adhesions causing difficulty dissecting the blood vessel or bronchia in 50 patients (50/70 [71.4%]). A peri-operative death occurred in one patient after conversion to open thoracotomy (1/83 [1.2%]). The results of pathologic examinations in the group of conversion to open thoracotomy are indicated in Table 2.

When comparing the peri-operative indicators of the conversion to open thoracotomy and complete thoracoscopic surgery groups, the operative time was significantly extended, the blood loss significantly increased, and the post-operative duration of drainage and length of stay significantly extended in the conversion to open thoracotomy group (Table 3).

Table 2 Results of pathologic examinations in the conversion to open thoracotomy group

	Passive conversion			Active conversion			
	Doornail lymph node	Vascular injury	Inappropriate instrument handling	Doornail lymph node	Huge tumors	Extensive pleural adhesion	Incomplete interlobar fissures
Adenocarcinoma	7	3		19			
Squamous cell carcinoma	1			12	8		1
Adenosquamous carcinoma				4	1		
Carcinosarcoma					2		
Large cell lung cancer				2	2		
Alveolar cell carcinoma				3			
Small cell lung cancer				5			
Metastatic carcinoma				1	1		1
Pulmonary fungal disease				2			
Inflammatory pseudotumor				1			
Bronchiectasis			1	1		1	1
Tuberculosis	1						
Inflammation						1	
Lung abscess						1	
Sum	9	3	1	50	14	3	3

When comparing the passive conversion to open thoracotomy and the active conversion to thoracotomy groups, the blood loss was significantly increased in the passive conversion to thoracotomy group, but the operative time, post-operative duration of drainage, and length of stay were similar in both groups (Table 4).

Discussion

Lymph nodes are often located around important blood vessels and bronchia. Enlarged lymph nodes usually obscure local anatomic structures, and increase the difficulty in

endoscopic management of the blood vessels and bronchia. Forcible adhesiolysis may cause tears in the artery and result in uncontrollable bleeding. Data from the current study showed that lymph node interference, which made the thoracoscopic dissection of blood vessels impossible, accounted for 71.4% of the active and 69.2% of the passive conversions to open thoracotomy. Thus, lymph node interference is one of the most important factors affecting the conversion of complete thoracoscopic surgery to open thoracotomy.^{13–17}

Common causes for the appearance of the doornail lymph node in the current study include: (i) old tuberculosis — China has a high incidence of tuberculosis, and tuberculosis-

Table 3 Comparison of the results of peri-operative indicators of the conversion to open thoracotomy and complete thoracoscopic surgery groups

	Conversion to open thoracotomy	Complete thoracoscopic surgery	<i>P</i>
Operative time (minutes)	272.7 ± 67.2	186.9 ± 58.1	0.001
Intra-operative blood loss (ml)	564.2 ± 507.7	158.0 ± 121.0	0.001
Post-operative duration of drainage	8.9 ± 5.0	6.6 ± 3.5	0.001
Length of stay	12.5 ± 7.7	9.2 ± 5.8	0.001

Table 4 Comparison of the results of peri-operative indicators of the passive conversion to open thoracotomy and active conversion to thoracotomy groups

	Passive conversion to open thoracotomy	Active conversion to thoracotomy	<i>P</i>
Operative time (minutes)	302.7 ± 92.8	268.5 ± 62.3	0.118
Intra-operative blood loss (ml)	1040.9 ± 553.1	492.7 ± 328.5	0.002
Post-operative duration of drainage	7.8 ± 1.8	9.0 ± 5.3	0.432
Length of stay	14.7 ± 8.9	12.2 ± 7.6	0.324

induced lymph node enlargement is common. Because patients with inactive tuberculosis are more common than those with active tuberculosis, most patients cannot describe a history of tuberculosis, and granulomatous inflammation of the lymph node is only noted during pathologic examination. Among 59 patients who underwent conversion to open thoracotomy as a result of the doornail lymph node, calcified lymph nodes were identified in 33 patients (56.0%) without a history of tuberculosis on pre-operative CT. (ii) Tumor metastasis — hilar and mediastinal lymph node metastasis may occur during the early stage of adenocarcinoma.^{18–22} The boundaries of the lymph nodes are often unclear. The lymph nodes are fused and closely adherent to the peripheral blood vessels and bronchia, which even invade the vascular sheath and make surgery difficult. Table 1 shows that the doornail lymph node is easily found in patients with adenocarcinomas. The boundary between the hilar and mediastinal lymph nodes is usually distinct and the fusion between lymph nodes is not severe, thus surgical difficulty is not increased. Among 59 patients who underwent conversion to open thoracotomy because of the doornail lymph node, tumor metastasis was identified in 12 patients (20.3%). (iii) Chronic bronchitis or chronic obstructive pulmonary disease — because of reasons such as smoking, environmental pollution, and lack of industrial protection, patients with chronic bronchitis, chronic obstructive pulmonary disease, and emphysema in China are significantly greater in number than those in Western countries, and enlargement, adhesions, and calcifications of the hilar and mediastinal lymph nodes resulting from long-term inflammation are relatively common.^{23,24} Among 59 patients who underwent conversion to open thoracotomy because of the doornail lymph node, chronic inflammation was identified in 10 patients (16.9%). (iv) Undefined reasons — repeated inflammation caused by bronchiectasis, pulmonary fungal infections, and rare mycobacterial infections can cause enlargement of the hilar lymph nodes. Among 59 patients who underwent conversion to open thoracotomy because of doornail lymph nodes, no obvious cause could be defined in four patients (6.7%).

Lymph node interference has a significant impact on complete thoracoscopic lobectomy; the pre-operative CT scan is an important examination. Because of the doornail lymph node, seven out of nine patients (77.8%) who underwent passive conversion to open surgery and 26 of the 50 patients (52%) who underwent active conversion to open surgery had calcified lymph nodes. Attention should be paid to patients with periportal lymph node calcifications on pre-operative CT scans.

The results of the current study showed that the conversion to open thoracotomy, whether active or passive, may extend the operative time, increase bleeding, and extend the duration of post-operative drainage and length of hospital stay. However, passive conversion to open surgery may further

increase the amount of blood loss. Therefore, it is critical to develop techniques for accurately treating the lymph nodes to protect patients from the severe pain induced by open thoracotomy. Timely pre-judgment should be carried out to avoid massive bleeding caused by vascular injury, which results in the conversion to open surgery.

During our practice, we found that lymph nodes are mainly distributed around the branches of the pulmonary artery and veins are often not affected. No bleeding or conversion to open thoracotomy occurred because of adhesions between the lymph nodes and the vein in the current study. The lymph nodes may adhere to the vascular sheath closely, but in most cases do not involve the vascular sheath. Therefore, the most effective method of avoiding lymph node adhesions to the pulmonary artery or pulmonary vein is to incise the vascular sheath and dissect the blood vessel within the sheath, whether the artery or the vein. If the lymph nodes have already invaded the vascular sheath and sufficient vascular dissection is not possible, even after incising the vascular sheath, sharp dissection can be performed with conventional thoracotomy instruments thoracoscopically. If necessary, the ipsilateral pulmonary trunk can be clipped with an occlusion clamp and the blood vessel repaired after sharp dissection or ligated from the distal end. If tumor metastasis is excluded by frozen biopsy, the hard core of the lymph nodes closely adherent to the bronchia can be removed and the majority of residual lymph tissue can be sharply dissected. Finally, only the outer membrane of the lymph node with adhesions is retained on the wall of the bronchia. Because the outer membrane of the lymph node is soft, it will not affect the stapling and cutting of the endoscopic linear stapler. At this time, the linear stapler can be directly placed in to cut off the bronchia and the remnant lymph node together.

If the boundary of the mediastinal lymph nodes is not clear and the lymph nodes tightly adhere to the blood vessels, which cannot be dissected even after incising the vascular sheath, conversion to open thoracotomy should be prepared in advance. If the bleeding is minimal, the bleeding point can be compressed using a peanut or a small gauze ball for five minutes, and the surgery can proceed after the bleeding is controlled. If the bleeding is still significant, the main trunk of the ipsilateral pulmonary artery can be blocked to dissect the blood vessel. If the bleeding is massive, compressing the bleeding point with gauze will reduce the rate of bleeding and conversion to open thoracotomy should be performed to control the bleeding under direct vision.

Conclusion

Passive conversion to open thoracotomy as a result of lymph node interference-induced vascular injury may significantly increase blood loss and extend the operative time compared to active conversion to open thoracotomy based on the

prejudged difficulty in manipulation. Therefore, we suggest that an experienced surgeon operate according to the method recommended herein: flexibly grasp the indication and timing of conversion to open surgery, and make a timely decision.

Disclosure

No authors report any conflict of interest.

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