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Intraoperative conversion from video-assisted thoracoscopic lobectomy to thoracotomy for non-small-cell lung cancer: Does it have an impact on long-term survival?

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Summary

A best evidence topic in thoracic surgery was written according to a structured protocol. The question addressed was whether intraoperative conversions to thoracotomy have an impact on long-term survival for patients with non-small-cell lung cancer who underwent video-assisted thoracoscopic lobectomy initially. A total of 461 papers were found using the reported search, of which 6 retrospective cohort studies represented the best evidence to answer the clinical question. The authors, date of publication, journal, country of the authors, patient group, study type, relevant outcomes and results of these papers were tabulated. Five cohort studies clarified that conversion did not compromise long-term survival, whereas 1 cohort study reported worse long-term outcomes after conversion to thoracotomy. However, the limited samples, different characteristics between groups and selection bias due to inherent design made it difficult to make a conclusion. Based on the current evidence, we concluded that intraoperative conversion from video-assisted thoracoscopic surgery (VATS) to thoracotomy for non-small-cell lung cancer might not impact long-term survival compared to a successful VATS lobectomy. In-hospital mortality might not be prejudiced, whereas longer hospitalizations were observed. However, whether conversion would adversely affect postoperative complication rates remained unclear because of the conflicting results. Moreover, 3 studies reported no statistical differences in short- and long-term survival between emergency and non-emergency conversions. Therefore, we suggest that thoracic surgeons should not hesitate to convert VATS into thoracotomy in the case of blood vessel injury or difficult hilum.

Keywords: Intraoperative conversion • VATS • Thoracotomy • Long-term survival

A best evidence topic was constructed according to a structured protocol. It was fully described in the ICVTS [1].

In [patients underwent video-assisted thoracoscopic lobectomy for non-small cell lung cancer (NSCLC)], does [intraoperative conversion to thoracotomy] have any impact on [long-term survival including overall survival and recurrence-free survival]?

A 65-year-old male diagnosed with NSCLC was admitted to our hospital for surgical treatment and underwent VATS lobectomy for the tumour. However, you found thoracoscopic dissection difficult because of hilar lymphadenopathy and consequent hilar adhesion. The subsequent surgical strategy was discussed by the heart team. One of your colleagues suggested converting to thoracotomy immediately, but none of you had any idea whether conversion to thoracotomy would impact long-term survival of the patient. You resolved to check the matter further.

We searched the Medline database using the PubMed interface from 1993 to May 2022 with the following search terms: (((((((thoracoscopic lung resection) OR (video-assisted thoracoscopic surgery)) OR (thoracoscopy)) OR (VATS)) AND ((lung cancer) OR (lung tumour))) AND ((conversion) OR (converted))) AND ((thoracotomy) OR (open surgery))) AND (((prognosis) OR (outcome)) OR (survival)).

A total of 461 papers were found preliminarily. Papers were excluded for (i) being a conference paper, (ii) focusing on survival after robotic-assisted thoracoscopic surgery, (iii) including only the short-term outcomes, (iv) comparing conversion to an open procedure rather than to a successful VATS and (v) not specifically focusing on conversion during lobectomy. After screening, 6 papers were identified as the best evidence to answer the question. These are presented in Table 1.

In 2011, Park *et al.* analysed the clinical outcomes of 738 patients who underwent VATS lobectomy, 34 (4.61%) of whom were converted to thoracotomy [2]. Although the hospital stay was longer ($P < 0.0001$) for converted patients, there was no

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significant difference in postoperative complication rate ($P = 0.457$, Fisher's exact test; $P = 0.307$, logistic regression analysis). Simultaneously, intraoperative unplanned conversion was not related to the impaired survival ($P = 0.626$) or recurrence ($P = 0.767$) with regard to long-term survival; it was also comparable ($P = 0.789$ and 0.760, respectively) after adjusting for age and sex. The median follow-up period was 30.0 months. The conversion rate fluctuated with the technical experience of the surgeon. It indicated that thoracoscopic lobectomy could be performed safely in the case of unplanned conversion, and the long-term survival might not be compromised.

Puri *et al.* investigated the causes and impacts of intraoperative conversion to thoracotomy between 2004 and 2012 [3]. A total of 517 successful VATS lobectomy patients, along with 87 (7%) converted cases, were enrolled in the study. Worse short-term outcomes after conversion, such as more frequent complications ($P < 0.001$) and longer hospital stays, were detected in the conversion group; the surgical mortality was similar. However, intraoperative conversion was not associated with a greater hazard of long-term death (hazard ratio = 0.550; 95% confidential interval, 0.290–1.042; $P = 0.067$) for pathological stage I NSCLC. The potential advantages for VATS might result from better tolerance and less disrupted immune surveillance. The conversion rate dropped over a 3-year interval as experience developed. Only male gender was reported to confer an elevated risk of unplanned conversion. Moreover, further subgroup analysis found emergency conversion did not affect postoperative mortality and morbidity detrimentally. Overall, the authors concluded that VATS should still be strongly favoured.

Augustin *et al.* performed an analysis of their institutional database in 2016, including 217 patients who had successful VATS lobectomies and 15 (6.5%) patients who underwent conversion to thoracotomy [4]. They reported that conversion would not give rise to higher postoperative complication rates ($P = 0.767$) or increasing in-hospital deaths ($P = 1.00$). Nor was overall survival negatively affected by the conversion procedure ($P = 0.638$). However, hospital stays were significantly extended ($P = 0.028$), and more disease recurrences were seen following conversion (60% vs 30.5%, $P = 0.024$). Multivariate analysis demonstrated that induction therapy and tumour size were associated with conversion, which potentially explained the higher recurrence rate. Given the limited number of converted cases and the heterogeneous tumour stages, one should interpret the survival results with caution.

In 2019, Sezen *et al.* carried out a single-centre analysis of 147 patients with NSCLC who underwent VATS lobectomy [5]; 18 (12.2%) were converted to a thoracotomy. Although the length of the hospital stay was longer in converted patients, no statistical difference was noted in short-term outcomes (postoperative complication rate, 22.2% vs 20.9%, $P = 0.900$) and long-term survival (5-year survival rate, 80% vs 71.4%, $P = 0.548$) compared to patients whose VATS was completed. Advanced age was identified as the main risk factor for conversion, which could be attributed to age-related loss of vascular elasticity. The results also supported the safety and feasibility of conversion from VATS to thoracotomy.

Gabryel *et al.* investigated the clinical outcomes of 1002 patients eligible for a NSCLC thoracoscopic lobectomy; of these, 897 patients underwent completed VATS and 105 were converted to a thoracotomy [6]. The results indicated that conversion might prejudice short-term outcomes. The conversion group had longer hospitalizations ($P < 0.001$) and more complications ($P = 0.018$), for example, supraventricular arrhythmia. Of note, contrary to results from previous studies, conversion was associated with worse long-term outcomes for patients with stages I–IV NSCLC compared to those who were in the completed VATS group (5-year survival rate, 65% vs 81%, $P = 0.045$). Subsequent subgroup analysis presented similarly worse results for stage I NSCLC (70% vs 87%, $P = 0.014$) but not for stage II NSCLC ($P = 0.294$) or stage III NSCLC ($P = 0.944$). Pleural adhesions and mediastinal lymph node metastases were identified as independent risk factors for conversion, early identification of which was crucial for oncological treatment. They also identified different frequencies of conversion among surgeons, regardless of their experience. In addition, further subgroup analysis regarding the short-term outcomes of the emergency conversion group found no statistically significant differences in hospital stay ($P = 0.174$), postoperative complications ($P = 0.933$) and in-hospital deaths ($P = 0.652$) compared to the non-emergency conversion group. Similarly, long-term survival of the emergency conversion group was not prejudiced (5-year survival rate, 65% vs 63%, $P = 0.794$). As claimed by the authors, the poor clinical outcomes of conversion were difficult to interpret, and they supposed that it might be explained by the possible immune system disturbances and undesirable effects of postoperative complications.

Fourdrain *et al.* enrolled 533 patients in the study cohort, including 439 in the full VATS group and 94 (17.6%) in the conversion group [7]. All consecutive patients were treated by anatomical lobar pulmonary resection (486 by lobectomy and 8 by bilobectomy, 92.7%) or anatomical sublobar pulmonary resection (39 segmentectomy) for NSCLC. It is well established that the completed VATS lobectomy offered improved short-term benefits of fewer complications, shorter hospitalizations and a trend towards fewer short-term deaths for both stage I NSCLC and the entire group of patients with NSCLC. Although, in terms of long-term outcomes, it was comparable in overall survival ($P = 0.47$) and disease-free survival (full VATS vs conversion, $P = 0.32$), it was also comparable among the patients with locally advanced NSCLC in disease-free survival ($P = 0.071$) for stage II ($n = 133$) and stage III NSCLC ($n = 118$). Despite the favoured long-term overall survival in the full VATS group with advanced NSCLC, it was likely to be interpreted carefully by limited sample size and different ratio of patients with stage II/III. Moreover, the subgroup analysis also revealed comparable outcomes between the emergency and non-emergency conversion groups in early postoperative outcomes, overall survival ($P = 0.122$) and disease-free survival ($P = 0.151$).

The preceding 6 papers comparing VATS to VATS conversion in long-term survival of selected patients with NSCLC were retrospective studies. One concern about the findings was that the limited sample size of the conversion group, the short follow-up time and the heterogeneity in baseline characteristics (e.g. gender, tumour stage) between the 2 groups might reduce the power of the comparison. The retrospective design of studies confined to a single centre and the different management styles among surgeons inevitably have led to selection bias and therefore impact the interpretation of outcomes.

We corroborated the overall impression that intraoperative conversion from VATS to thoracotomy might not impact long-term survival for NSCLC compared to those with successful VATS, no matter whether it was an emergency or not. Although intraoperative conversion might not result in a short-term survival disadvantage of in-hospital deaths, it did lead to longer hospitalizations. In addition, short- and long-term outcomes of emergency conversion might not be compromised. However, whether conversion adversely affects postoperative complications remained unclear because of the conflicting results. More multicentre, prospective well-designed studies with a large sample are needed to give further insight. In conclusion, the available

Table 1 Best evidence papers

Author, date, journal, and country Study type (Level of evidence)	Patient group	Outcomes	Key results (full VATS group vs conversion group)	Comments
Park et al. (2011), World J Surg, Korea [2] Cohort study (level 3)	738 Patients diagnosed with NSCLC undergoing VATS lobectomy Full VATS: n = 704 Conversion: n = 34 Conversion rate: 4.61% Except 135 benign lung disease, 603 lung cancer cases reserved with 26 conversion cases	Median follow-up period Mean hospital stay Postoperative complications Overall survival Disease recurrence	30.0 Months 7.08 vs 10.12 Days, $P < 0.0001$ $P = 0.457$ (Fisher's exact test) $P = 0.307$ (logistic regression analysis, after adjusting for age and sex) $P = 0.626$ $P = 0.789$ (after adjusting for age and sex) $P = 0.767$ $P = 0.760$ (after adjusting for age and sex)	Conversion rate fluctuated with the technical experience of the surgeons
Puri et al. (2015), J Thorac Cardiovasc Surg, USA [3] Cohort study (level 3)	604 Patients diagnosed with lung cancer undergoing VATS lobectomy Full VATS: n = 517 Conversion: n = 87 Conversion rate: 7% 558 Patients with stage I NSCLC Emergency conversion: n = 20 Non-emergency conversion: n = 67	Postoperative complications Mean hospital stay Surgical deaths Overall survival Postoperative complications Operative mortality Mean hospital stay	23% vs 46%, $P < 0.001$ 4.6 vs 7.6 Days, $P < 0.0001$[b] 0% vs 1%, $P = 0.1$[b] HR 1.818; 95% CI, 0.960-3.448; $P = 0.067$ 43% vs 55%[a], $P = 0.446$ 2% vs 0%[a], $P = 1.00$ 7.2 vs 8.8 Days[a], $P = 0.409$	Conversion rates decreased with increasing experience Risk factor for conversion: male gender Comparable in patient and tumour characteristics within the emergency and non-emergency conversions
Augustin et al. (2016), Surg Endosc, Austria [4] Cohort study (level 3)	232 Patients intended for NSCLC undergoing VATS lobectomy (including 12 benign cases) Full VATS: n = 217 Conversion: n = 15 Conversion rate: 6.5%	Postoperative complication Mean hospital stay In-hospital deaths Overall survival Disease recurrence	29.5% vs 33.3%, $P = 0.767$ 9 vs 11 Days, $P = 0.028$ 2 vs 0 Cases, $P = 1.0000$ $P = 0.638$ 30.5% vs 60%, $P = 0.024$	Independent predictors of conversion: induction therapy and tumour size Conversion rate impacted by the learning curve of surgeons
Sezen et al. (2019), Gen Thorac Cardiovasc Surg, Turkey [5] Cohort study (level 3)	147 Patients with NSCLC undergoing VATS lobectomy Full VATS: n = 129 Conversion cases: n = 18 Conversion rate: 12.2%	Mean follow-up period Median hospital stay Postoperative complications Mean survival time 5-Year survival rate	33 Months 4 vs 5 Days, $P < 0.001$ 20.9% vs 22.2%, $P = 0.900$ Full VATS: 65.2 months; 95% CI, 59.6-70.8 months Conversion: 54.9 months; 95% CI, 45.9-63.8 months 71.4% vs 80%, $P = 0.548$	Risk factor of conversion: age $\geq$ 70 years Potential bias caused by surgeon's individual approach
Gabryel et al. (2021), Interact Cardiovasc Thorac Surg, Poland Cohort study [6] (level 3)	1002 Patients with lung cancer undergoing VATS lobectomy Full VATS: n = 897 Conversion: n = 105 Conversion rate: 10.5% 1002 Patients in stage I–IV NSCLC Conversion: n = 105 640 Patients in stage I NSCLC Conversion: n = 56 240 Patients in stage II NSCLC Conversion: n = 26 103 Patients in stage III NSCLC Conversion: n = 21 Non-emergency conversion: n = 74 Emergency conversion: n = 31	Median hospital stay Postoperative complication In-hospital mortality 5-Year survival rate 5-Year survival rate 5-Year survival rate 5-Year survival rate Median hospital stay Postoperative complications In-hospital deaths 5-Year survival rate	6 vs 8 Days, $P < 0.001$ 27.1% vs 38.1%, $P = 0.018$ 1.2% vs 1%, $P = 0.818$ 81% vs 65%, $P = 0.045$ 87% vs 70%, $P = 0.014$ $P = 0.294$ $P = 0.944$ 8 vs 7 days[a], $P = 0.174$ 37.8% vs 38.7%[a], $P = 0.933$ 14% vs 0%[a], $P = 0.652$ 65% vs 63%[a], $P = 0.794$	Risk factors of conversion: pleural adhesions, mediastinal lymph node metastases Different frequency of conversion among surgeons Large sample size

Continued

Table 1 Continued

Author, date, journal, and country Study type (Level of evidence)	Patient group	Outcomes	Key results (full VATS group vs conversion group)	Comments
Fourdrain et al. (2021), Interact Cardiovasc Thorac Surg, France [7] Cohort study (level 3)	533 Patients with NSCLC undergoing thoracoscopic anatomical pulmonary resection Full VATS: n = 439 Conversion cases: n = 94 Conversion rate: 17.6%	Median hospital stay	6.3 vs 9.4 days, $P = 0.003$	486 Lobectomies 39 Segmentectomies 8 Bilobectomies
		Postoperative pneumonia	13.2% vs 22.3%, $P = 0.02$	
		Postoperative arrhythmia	5.7% vs 14.9%, $P = 0.002$	
		30-Day deaths	1.1% vs 2.2%, $P = 0.36$	
		90-Day deaths	2.1% vs 4.3%, $P = 0.26$	
	431 Patients in stage I NSCLC Full VATS: n = 364 Conversion: n = 67	Median follow-up period	37 months	Trend towards better disease-free survival for full VATS group with stage I NSCLC
		Median hospital stay	6.3 vs 10.1 Days, $P = 0.004$	
		Postoperative pneumonia	12.7% vs 23.9%, $P = 0.02$	
		Postoperative arrhythmia	5.5% vs 16.4%, $P = 0.004$	
		30-Day deaths	1.4% vs 3%, $P = 0.30$	
		90-Day deaths	2.2% vs 6%, $P = 0.10$	
		5-Year survival rate	76% [3.6%][c] vs 72.3% [7%], $P = 0.47$[b]	
		5-Year disease-free survival	$P = 0.32$	
	59 Patients in stage II NSCLC Full VATS: n = 45 Conversion: n = 14 43 Patients in stage III NSCLC Full VATS group: n = 30 Conversion group: n = 13	Median follow-up period	29 Months	Small numbers of patients in advanced NSCLC groups
		5-Year survival rate	77.2% [6.7%][c] vs 40.4% [18.3%], $P = 0.016$[b]	
		3-Year disease-free survival	63.2% [6.2%][c] vs 35.3% [11.5%], $P = 0.071$[b]	
	Non-emergency conversion: n = 73 Emergency conversion: n = 21	Median hospital stay	9.7 vs 8.2 days[a], $P = 0.36$	Small sizes of the emergency and non-emergency groups No other significant differences in the patient characteristics except body mass index
		Postoperative pneumonia	21.9% vs 23.8%[a], $P = 0.51$	
		Postoperative arrhythmia	12.4% vs 23.8%[a], $P = 0.29$	
		30-Day deaths	2.7% vs 0%[a], $P = 1.00$	
		90-Day deaths	5.5% vs 0%[a], $P = 0.57$	
		Overall survival	$P = 0.122$[a]	
		Disease-free survival	$P = 0.151$[a]	

[a]Non-emergency conversion group versus emergency group.
[b]The *P*-value was calculated by comparing the full VATS group, the conversion group and the thoracotomy group.
[c]The results were expressed as percentage ± standard error.
CI: confidence interval; HR: hazard ratio; NSCLC: non-small-cell lung cancer; VATS: video-assisted thoracoscopic surgery.

evidence shows the safety and feasibility of conversion during VATS lobectomy and suggests that thoracic surgeons should not hesitate to convert VATS into a thoracotomy in the case of blood vessel injury or a difficult hilum.

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