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BEST EVIDENCE TOPIC

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Is video-assisted thoracoscopic surgery comparable with thoracotomy in perioperative and long-term survival outcomes for non-small-cell lung cancer after neoadjuvant treatment?

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Abstract

A best evidence topic in thoracic surgery was written according to a structured protocol. The question addressed was 'Is video-assisted thoracoscopic surgery comparable with thoracotomy in perioperative and long-term survival outcomes for patients with non-small cell lung cancer following neoadjuvant therapy intended for anatomical lung resection?'. Altogether 655 papers were found using the reported search, of which 12 studies represented the best evidence to answer the clinical question. The author, journal, date and country of publication, patient group studied, study type and relevant outcomes and results of these papers are tabulated. Almost all of the enrolled cohort studies reported that video-assisted thoracoscopic surgery (VATS) was comparable with thoracotomy in negative surgical margin rate, postoperative mortality, complication rate, overall survival and disease-free survival. Moreover, 7 studies found patients in the VATS group had a significantly shorter hospital stay. Furthermore, in these well-matched cohort studies (6 studies), it still held true that VATS was comparable with thoracotomy in long-term prognosis with enhanced recovery. However, the issue regarding surgical radicality and intraoperative conversion to thoracotomy still should be noted carefully among these patients receiving VATS surgery because all the current available evidence was retrospective based on relatively small sample sizes. Nevertheless, thoracic surgeons should not consider VATS inferior to thoracotomy for patients after neoadjuvant treatment. VATS surgery could be an alternative for selected patients with locally advanced but relatively small, peripheral, fewer positive N2 lymph nodes and non-squamous NSCLC intended for anatomic lung resection.

Keywords: Review • Neoadjuvant treatment • Video-assisted thoracoscopic surgery • Thoracotomy • Non-small-cell lung cancer

INTRODUCTION

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

THREE-PART QUESTION

In [patients with non-small-cell lung cancer (NSCLC) after neoadjuvant treatment intended for anatomical lung resection], regardless of the induction treatment regimens, is [video-assisted thoracoscopic surgery (VATS)] comparable with [thoracotomy] in [perioperative and long-term survival outcomes]?

CLINICAL SCENARIO

A 64-year-old male patient diagnosed with locally advanced but NSCLC was admitted to your hospital for multidisciplinary treatment. Neoadjuvant therapy was initially recommended for the patient and after neoadjuvant treatment, he was evaluated with excellent tumour response and suitable for surgical resection, and your team was discussing the surgical strategy. One of your colleagues suggested that we could perform VATS to reduce surgical trauma and postoperative complications, while you were uncertain whether VATS can achieve comparable long-term survival as thoracotomy. You resolved to check the literature for evidence.

SEARCH STRATEGY

We searched the Medline database using the PubMed interface from 1973 to July 2022 with the following search term: [(lung cancer) OR (lung carcinoma)] AND [(neoadjuvant) OR (preoperative) OR (induction)] AND [(thoracoscopic) OR (video-assisted) OR (minimally invasive) OR (VATS) OR (MIS)] AND [(thoracotomy) OR (open)].

† The first two authors contributed equally to this work.

SEARCH OUTCOME

A total of 655 papers were found using the reported search. In total, 12 papers were identified that provided the best evidence to answer the question (Table 1).

RESULTS

In 2016, Yang *et al.* [2] performed a retrospective single-centre analysis of 60 NSCLC patients who underwent lobectomy via thoracotomy or VATS following induction chemotherapy or chemoradiotherapy between 1996 and 2012. Propensity score matching (PSM) was employed to narrow selection bias, by which the patients' baseline characteristics in the 2 groups were well-matched successfully. There were 7 conversions (10%) in the original VATS cohort due to difficulty either from fibrosis and adhesions ($n = 5$) or bleeding ($n = 2$). The thoracotomy group and the VATS group were comparable in postoperative complication rate, 30-day mortality, 3-year overall survival (OS) [VATS, 54%; 95% confidence interval (CI), 34–71%; thoracotomy, 49%; 95% CI, 28–67%; $P = 0.56$] and 3-year recurrence-free survival (RFS) (VATS, 34%; 95% CI, 18–52%; thoracotomy, 24%; 95% CI, 9–42%; $P = 0.24$), but the VATS group presented significantly shorter hospitalization ($P = 0.007$). After multivariable adjustment of the entire cohort, there remained no significant difference in OS [hazard ratio (HR) = 0.88; 95% CI, 0.39–1.97; $P = 0.76$] or RFS (HR = 0.91; 95% CI, 0.46–1.83; $P = 0.80$) between the 2 groups. Thus, induction therapy should not be considered a contraindication to the application of VATS for patients with resectable NSCLC.

Kamel *et al.* [3] retrospectively investigated 114 NSCLC patients who underwent lobectomy after various induction therapy. Despite of PSM method applied, differences still remained as the thoracotomy group presented larger clinical tumour sizes ($P = 0.038$). A conversion from VATS to thoracotomy occurred in 5 cases due to severe adhesions. They found the 2 groups comparable in the R1 resection rate, hospital mortality and postoperative complications. After 75 months of the median follow-up, the median time to recurrence was 18 months for the entire cohorts, and there was no difference in 5-year disease-free survival (DFS) (VATS, 73.2%; thoracotomy, 47.8%; $P = 0.097$) or 5-year RFS (VATS, 76.6%; thoracotomy, 56.1%; $P = 0.206$). Notably, the VATS group reported shorter hospital stay ($P < 0.001$). The multivariable analysis indicated that not the surgical approach but the clinical N1/2 status (HR = 4.86; 95% CI, 2.00–11.82, $P < 0.001$) was independently related to poor DFS. The VATS approach appeared to improve the perioperative outcomes without compromising long-term survival.

Matsuoka *et al.* [4] retrospectively reviewed 110 NSCLC patients who received preoperative chemotherapy with or without radiotherapy prior to anatomical pulmonary resection. Dissection of regional lymph nodes was completed in all patients. Four patients in the VATS group underwent conversion to thoracotomy for angioplasty ($n = 2$) or combined resection of chest wall ($n = 2$). There were no significant difference in high-grade postoperative complications, in-hospital death, 5-year OS (VATS, 53.5%; thoracotomy, 39.8%; $P = 0.2726$) and 5-year RFS (VATS, 36.3%; thoracotomy, 45.5%; $P = 0.2654$). However, the thoracotomy group presented more lung squamous cell carcinoma (LSCC) and more complicated procedures ($P < 0.0001$). The unbalanced baseline characteristics and surgical complexity between groups might impact the interpretations of their findings.

Fang *et al.* [5] included 83 patients with LSCC in a retrospective study who underwent pulmonary resection preceded by neoadjuvant chemotherapy. Two patients converted to thoracotomy due to severe adhesion were eliminated from further analysis. The 2 groups had comparable outcomes in the surgical margin, complication rate, 3-year OS (VATS, 79.6%; thoracotomy, 80.5%; $P = 0.925$) and 3-year DFS (VATS, 88.6%; thoracotomy, 64.3%; $P = 0.335$). The VATS group trended towards an earlier discharge from the hospital ($P = 0.066$), and their findings supported the VATS approach practicable for stage IIIA–B LSCC patients.

In 2018, Jeon *et al.* [6] retrospectively analysed 35 patients with stage IIIA N2 NSCLC who underwent anatomic resection and mediastinal lymph node dissection (MLND) by 1 single surgeon after completing preoperative concurrent chemoradiation therapy (CCRT) between November 2009 and December 2013. Five patients were converted to thoracotomy due to anthracofibrotic nodes ($n = 4$) or tight adhesions ($n = 1$). No significant difference was noted in the R0 resection rate, postoperative complications, length of hospitalization, 5-year OS (VATS, 76.0%; thoracotomy, 57.8%; $P = 0.39$) and 5-year DFS (VATS, 40.3%; thoracotomy, 38.9%; $P = 0.8$). They concluded that VATS following neoadjuvant therapy could be feasible for stage IIIA N2 NSCLC patients without compromising oncologic efficacy.

Yang *et al.* [7] conducted a retrospective study among 876 patients in the National Cancer Database (NCDB) diagnosed with clinical T2-2 N0M0 or T1-4N1-2M0 NSCLC between 2010 and 2014. All the patients received neoadjuvant chemotherapy or chemoradiotherapy followed by lobectomy, and their baseline characteristics were well matched via PSM. Conversion to thoracotomy was performed in 96 cases. There was no significant difference in the positive resection margins and 5-year OS (VATS, 48.1%; 95% CI, 41.9–54.1%; thoracotomy, 49.6%; 95% CI, 43.4–55.4%; $P = 0.80$) between the 2 groups. The VATS group had shorter in-hospital stay ($P < 0.01$) and a trend of fewer postoperative death ($P = 0.06$). Moreover, the 5-year OS was comparable in both the sub-analyses of patients who received only preoperative chemotherapy (VATS, 48.9%; 95% CI, 40.3–56.9%; thoracotomy, 48.4%; 95% CI, 39.7–56.5%; $P = 0.72$) and of patients who received preoperative chemoradiotherapy (VATS, 47.5%; 95% CI, 38.1–56.2%; thoracotomy, 43.2%; 95% CI, 32.6–53.0%; $P = 0.76$). The multivariable analysis indicated that the chemoradiotherapy is an independent predictor of conversion to thoracotomy ($P = 0.05$). However, the absence of other critical outcomes limited the conclusions.

Tian *et al.* [8] enrolled 56 NSCLC patients who received neoadjuvant therapy followed by radical pulmonary resection (including lobectomy, bilobectomy, sleeve lobectomy and pneumonectomy) and MLND in a retrospective study. There were 28 well-matched pairs of patients in each group after employing PSM, while the original overall cohort indicated that the patients in the thoracotomy group were more likely to have male gender, LSCC, higher clinical T descriptor and/or pneumonectomy. Six patients in the original VATS group underwent conversion due to either tight adhesions ($n = 3$) or anatomic factors ($n = 3$). The 2 groups were comparable in the completion of resection, postoperative mortality, 5-year OS (VATS, 45.5%; thoracotomy, 21.5%; $P = 0.379$) and 5-year RFS (VATS, 42.7%; thoracotomy, 28.8%; $P = 0.613$), and a significantly shorter postoperative stay ($P < 0.001$) was observed in the VATS group. According to the multivariable analyses, VATS was not an

Table 1: Best evidence papers

Author, date, journal and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
Yang *et al.* (2016), Eur J Cardiothorac Surg, USA [2] Cohort study (level III)	60 NSCLC patients[a] Neoadjuvant chemotherapy or chemoradiotherapy preceding lobectomy within a year 1996–2012 With PSM VATS, *n* = 30 (including 10% conversions) Thoracotomy, *n* = 30	Postoperative complications 30-Day mortality LOS (days), median (IQR) 3-Year OS 3-Year RFS	VATS, 40%; thoracotomy, 57%; *P* = 0.20 VATS, 3%; thoracotomy, 7%; *P* = 0.55 VATS, 4 (3–5); thoracotomy, 5 (4–8); *P* < 0.007 VATS, 54%; 95% CI, 34–71%; thoracotomy, 49%; 95% CI, 28–67%; *P* = 0.56 VATS, 34%; 95% CI, 18–52%; thoracotomy, 24%; 95% CI, 9–42%; *P* = 0.24	Well-matched by age, gender, coronary artery disease, COPD, pathological T and N status, distant metastases, tumour location, radiation and operative date Limited sample size in both groups Time bias caused by long study period span
Kamel *et al.* (2017), J Laparoendosc Adv Surg Tech A, USA [3] Cohort study (level III)	114 NSCLC patients[a] Conventional chemotherapy for cN2 or other clinical trials (erlotinib alone, pazopanib alone or chemotherapy combined with a cyclooxygenase-2 inhibitor) for cN0-1 before lobectomy January 2002 to December 2014 With PSM VATS, *n* = 40 (including 5 conversions) Thoracotomy, *n* = 74	Non-R0 resection 30-Day mortality Postoperative complications LOS (days) 5-Year DFS 5-Year RFS	VATS, 5.0%; thoracotomy, 4.1%; *P* = 0.814 None VATS, 15%; thoracotomy, 31%; *P* = 0.06 VATS, 4 (3–5); thoracotomy, 6 (5–8); *P* < 0.001 VATS, 73.2%; thoracotomy, 47.8%; *P* = 0.097 VATS, 76.6%; thoracotomy, 56.1%; *P* = 0.206	Matched by age, gender and clinical stage Larger clinical tumour size in the thoracotomy group (*P* = 0.038) Inconsistency in the neoadjuvant treatment Limited sample size in the VATS group
Matsuoka *et al.* (2018), Asian Cardiovasc Thorac Ann, Japan [4] Cohort study (level III)	110 NSCLC patients[a] Neoadjuvant chemotherapy or chemoradiotherapy before anatomical resection January 2009 to December 2014 Excluded patients with previous treatment or small-cell lung cancer Without PSM VATS, *n* = 79 (including 4 conversions) Thoracotomy, *n* = 31	Postoperative complications with CTCAE grade ≥2 30-Day mortality LOS 5-Year OS 5-Year RFS	VATS, 36.7%; thoracotomy, 32.2%; *P* > 0.05 VATS, *n* = 1; thoracotomy, *n* = 1 *P* < 0.05 (favour VATS) VATS, 53.5%; thoracotomy, 39.8%; *P* = 0.2726 VATS, 36.3%; thoracotomy, 45.5%; *P* = 0.2654	Significantly more LSCC and combined resection in the thoracotomy group (*P* < 0.05 and *P* < 0.0001, respectively) Lacked comparison and statistical test of baseline characteristics Limited sample size in the thoracotomy group Only further examined patients with complete resection (103 of 110)
Fang *et al.* (2018), J Cardiothorac Surg, China [5] Cohort study (level III)	83 LSCC patients without distant metastasis Neoadjuvant chemotherapy before lung resection within 6 months October 2013 to October 2017 Excluded conversion cases and patients with previous cancer or lung resection and other concurrent malignant diseases Without PSM VATS, *n* = 14	R0 resection rate Postoperative complications LOS (days) 3-Year OS 3-Year DFS	*P* = 0.760 VATS, 21.4%; thoracotomy, 29.9%; *P* = 0.729 VATS, 6 (4–16); thoracotomy, 7 (4–21); *P* = 0.066 VATS, 79.6%; thoracotomy, 80.5%; *P* = 0.925 VATS, 88.6%; thoracotomy; 64.3%; *P* = 0.335	Confined to LSCC patients Limited sample size in the VATS group Limited follow-up duration (median 15 months) Incomplete follow-up (73 of 81 patients)

Continued

Table 1: Continued

Author, date, journal and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
	Thoracotomy, $n = 67$			
Jeon *et al.* (2018), Korean J Thorac Cardiovasc Surg, South Korea [6] Cohort study (level III)	35 patients with stage IIIA N2 NSCLC Neoadjuvant CCRT before anatomic resection and MLND by a single surgeon November 2009 to December 2013 Without PSM VATS, $n = 17$ Thoracotomy, $n = 18$ (including 5 conversions)	Non-R0 resection Postoperative complications 30-Day mortality LOS (days) 5-Year OS 5-Year DFS	None $P > 0.05$ VATS, 0%; thoracotomy, 5.6% VATS, 8.4 (5–49); thoracotomy, 11 (4–829); $P = 0.465$ VATS, 76.0%; thoracotomy, 57.8%; $P = 0.39$ VATS, 40.3%; thoracotomy, 38.9%; $P = 0.8$	More patients in the VATS group had higher BMI ($P < 0.05$) Limited sample sizes in both groups
Yang *et al.* (2019), Ann Thorac Surg, USA [7] Cohort study (level III)	876 patients with clinical T2–T4 N0 M0 and T1-4N1-2M0 NSCLC Neoadjuvant chemotherapy or chemoradiotherapy before lobectomy 2010–2014 Excluded patients with nonmalignant pathology and previous unrelated malignancy With PSM VATS, $n = 438$ (including 96 conversions) Thoracotomy, $n = 438$	Non-R0 resection 30-Day mortality LOS (days) 5-Year OS	$P = 0.58$ $P = 0.06$ VATS, 5 (4–7); thoracotomy, 6 (4–8); $P < 0.01$ VATS, 48.1%; 95% CI, 41.9–54.1%; thoracotomy, 49.6%; 95% CI, 43.4–55.4%; $P = 0.80$	Well-matched by age, gender, race, Charlson/Deyo comorbidity score, median census-tract education and income levels, clinical T- and N-status, tumour size, tumour location, type of induction therapy, time from preoperative chemotherapy to surgery, insurance type, histology, grade, distance from facility, facility type and year of diagnosis Lacked pulmonary function, postoperative complications and recurrences or disease-free survival
Tian *et al.* (2019), Thorac Cancer, China [8] Cohort study (level III)	56 patients with clinical or biopsy-proven N2 or T3-4N0-1 NSCLC Platinum-based doublet neoadjuvant chemotherapy with or without radiotherapy before radical resection and MLND 2000–2016 Excluded patients with multiple primary tumours With PSM VATS, $n = 28$ (including 3 conversions) Thoracotomy, $n = 28$	R0 resection 30-Day mortality No postoperative complications LOS (days) 5-Year OS 5-Year RFS	VATS, 96.4%; thoracotomy, 89.3%; $P = 0.611$ VATS, $n = 0$; thoracotomy, $n = 1$ VATS, 76.7%; thoracotomy, 70.0%; $P = 0.559$ VATS, 6 (5–7); thoracotomy, 8 (7–12); $P < 0.001$ VATS, 45.5%; thoracotomy, 21.5%; $P = 0.379$ VATS, 42.7%; thoracotomy, 28.8%; $P = 0.613$	Well-matched by age, gender, tumour histology, comorbidities, neoadjuvant therapy modality, surgical procedure and pathological T and N stages Limited sample sizes in both groups
Suh *et al.* (2019), Thorac Cancer, South Korea [9] Cohort study (level III)	85 NSCLC patients[a] Neoadjuvant cisplatin-based CRT before lung resection January 2008 to December 2017 Excluded non-anatomical and sublobar resection Without PSM VATS, $n = 26$ Thoracotomy, $n = 59$ (including 6 conversions)	R0 resection Operative mortality LOS (days), mean ± SD Postoperative complications 3-Year OS 3-Year DFS	VATS, 100%; thoracotomy, 98.3%; $P = 0.504$ VATS, 11.5%; thoracotomy, 5.1%; $P = 0.284$ VATS, 8.62 ± 4.72; thoracotomy, 14.46 ± 16.94; $P = 0.017$ VATS, 26.9%; thoracotomy, 28.8%; $P = 0.858$ VATS, 67.9%; thoracotomy, 69.3%; $P = 0.879$	Limited sample size in the VATS group Short follow-up period (median 12.6months) More invasion to other structures and combined procedures in the thoracotomy group ($P = 0.043$ and 0.0.031, respectively)

Continued

Table 1: Continued

Author, date, journal and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
			VATS, 61.9%; thoracotomy, 76.6%; $P = 0.516$	
Dell'Amore *et al.* (2021), Surg Endosc, Italy [10] Cohort study (level III)	155 NSCLC patients[a] Neoadjuvant chemotherapy before lobectomy January 2010 to December 2018 Excluded patients with multiple primary tumours or radiological evidence of progression after induction With PSM VATS, $n = 62$ Thoracotomy, $n = 93$ (including 8 conversions)	Non-R0 resection Postoperative complications LOS (days) 5-Year OS 5-Year DFS	None VATS, 12%; thoracotomy, 20%; $P = 0.219$ VATS, 6.63 ± 2.47; thoracotomy, 9.61 ± 4.40; $P < 0.01$ VATS, 43%; thoracotomy, 54%; $P = 0.57$ VATS, 37%; thoracotomy, 25%; $P = 0.9$	Well-matched by age, gender, BMI, diabetes, ischemic heart disease, preoperative FEV1 and DLCO, smoking history, ASA score, histology, tumour location, TNM and N status More adjuvant radiotherapy received in the thoracotomy group ($P = 0.002$)
Jeon *et al.* (2022), Semin Thorac Cardiovasc Surg, South Korea [11] Cohort study (level III)	143 cN2 NSCLC patients with peripheral tumours smaller than 5 cm after induction, non-bulky N2 (axial diameter <2.5 cm) and fewer than 4 positive N2 stations Neoadjuvant CCRT before anatomic resection June 2012 to July 2017 With PSM VATS, $n = 31$ (including 17.1% conversions) Thoracotomy, $n = 112$	R0 resection 30-Day mortality Postoperative complications LOS (days) 5-Year OS 5-Year RFS	VATS, 100%; thoracotomy, 96.4%; $P = 0.651$ None VATS, 9.7%; thoracotomy, 30.4%; $P = 0.036$ VATS, 7 (6–9); thoracotomy, 7 (6–9); $P = 0.49$ VATS, 77.1%; thoracotomy, 59.9%; $P = 0.276$ VATS, 66.3%; thoracotomy, 54.6%; $P = 0.354$	Well-matched by gender, age, pulmonary function test (FEV1, DLCO), method of N stage, histology and clinical T stage Limited sample size in the VATS group More adjuvant chemotherapy conducted in the VATS group ($P = 0.012$)
Dai *et al.* (2022), Transl Lung Cancer Res, China [12] Cohort study (level III)	23 patients with clinical stage II–IIIB(N2) NSCLC, ageing 18–75, EGFR and ALK wild type and ECOG score 0–1 Neoadjuvant platinum-based chemotherapy combined with PD-1 inhibitors before sleeve resection Excluded patients with other concurrent malignancies and pulmonary arterioplasty and/or bronchoplasty May 2019 to 2021 April Without PSM VATS, $n = 8$ (including 1 conversion) Thoracotomy, $n = 15$	Non-R0 resection 30-Day mortality Postoperative complications LOS (days)	None VATS, $n = 0$; thoracotomy, $n = 1$ VATS, $n = 0$; thoracotomy, $n = 3$; $P = 0.526$ VATS, 5.5 ± 2.8; thoracotomy, 9.2 ± 11.2; $P = 0.416$	Confined to sleeve resection Limited sample sizes in both groups Lacked long-term survival outcomes
Zhang *et al.* (2022), Front Oncol, China [13] Cohort study (level III)	88 patients with clinical stage IIB or T3-4N2M0 (single N2) NSCLC and ECOG score 0–1 Neoadjuvant PD-1 inhibitors plus chemotherapy before surgery January 2019 to August 2021 With PSM VATS, $n = 44$ Thoracotomy, $n = 44$ (including 53.8% conversion)	R0 resection 90-Day mortality Postoperative complications LOS (days) 1-Year RFS	VATS, $n = 42$; thoracotomy, $n = 41$; $P = 0.645$ None Overall: VATS, $n = 10$; thoracotomy, $n = 18$; $P > 0.05$ Prolonged air leak: VATS, $n = 5$; thoracotomy, $n = 1$; $e = 0.013$ VATS, 6.8 ± 4.2; thoracotomy. 6.9 ± 3.0; $P = 0.907$ VATS, 92.2%; thoracotomy, 84.2%; $P = 0.204$	Well-matched by tumour length before therapy, tumour location, clinical T and N stage, clinical TNM stage and radiographic tumour response Limited follow-up time (median 13.2 months) and sample sizes Relatively high conversion rate

[a]No other detailed eligible criteria were mentioned in the study, such as histologic type and clinical or pathological staging.

ALK: anaplastic lymphoma kinase; ASA: American society of Anesthesiologists; BMI: body mass index; CCRT: concurrent chemoradiation therapy; CI: confidence interval; COPD: chronic obstructive pulmonary disease; CRT: chemoradiotherapy; CTCAE: common terminology criteria for adverse events; DFS: disease-free survival; DLCO: diffusing capacity for carbon monoxide; ECOG: Eastern Cooperative Oncology Group; EGFR: epidermal growth factor receptor; FEV1: forced expiratory volume in 1 s; IQR: interquartile range; LOS: length of hospital stay; LSCC: lung squamous cell carcinoma; MLND: mediastinal lymph node dissection; NSCLC: non-small cell lung cancer; OS: overall survival; PD-1: programmed cell death ligand 1; PSM: propensity score matching; RFS: recurrence-free survival; SD: standard difference; TNM: tumour node metastasis; VATS: video-assisted thoracoscopic surgery.

independent predictor of OS (HR = 0.841; 95% CI, 0.338–2.093; $P = 0.709$) or RFS (HR = 0.955; 95% CI, 0.415–2.198; $P = 0.913$), but pathologic N2 stage was a poor prognostic factor of OS (HR = 3.449; 95% CI, 1.147–10.37; $P = 0.027$). Therefore, they considered VATS following neoadjuvant therapy as a qualified strategy for treating locally advanced NSCLC.

Suh *et al.* [9] retrospectively investigated the clinical outcomes and follow-up of anatomical lung resection (lobectomy, bilobectomy or pneumonectomy) and MLND after neoadjuvant chemoradiotherapy among 85 patients. Six patients were converted to thoracotomy due to bleeding ($n = 1$), oncologic causes ($n = 1$) and severe adhesions ($n = 4$). The R0 resection rate, operative mortality, complications rate and 3-year OS (VATS, 67.9%; thoracotomy, 69.3%; $P = 0.879$) and DFS (VATS, 61.9%; thoracotomy, 76.6%; $P = 0.516$) between the 2 groups were comparable, while patients in the VATS group had a shorter hospital stay ($P = 0.017$). However, significantly more complex procedures were conducted in the thoracotomy group ($P = 0.031$), especially chest wall resection ($P = 0.016$). They concluded that VATS could be alternative for patients with advanced-stage NSCLC but with little adjacent structural invasion.

Dell'Amore *et al.* [10] conducted a multicentre retrospective study of 155 NSCLC patients who received neoadjuvant chemotherapy followed by lobectomy. There were 8 conversions, the reasons of which were bleeding ($n = 3$), metastatic lymph nodes ($n = 4$) and severe adhesions ($n = 1$). R0 resection and complete dissection of the hilar and mediastinal lymph node stations were completed among all the well-matched patients after PSM approach. There was no significant difference in in-hospital mortality, postoperative surgical complications rate, 5-year OS (VATS, 43%; thoracotomy, 54%; $P = 0.57$) and 5-year DFS (VATS, 25%; thoracotomy, 37%; $P = 0.9$) between the 2 groups. VATS approach was associated with shorter hospitalization ($P < 0.01$), while the number of dissected lymph nodes favoured the thoracotomy group ($P = 0.022$). In conclusion, VATS was feasible for patients with locally advanced NSCLC posterior to induction chemotherapy without impaired oncological efficacy.

Jeon *et al.* [11] retrospectively analysed surgical and survival outcomes among 143 patients with clinical stage IIIA N2 NSCLC between June 2012 and July 2017. All the patients underwent neoadjuvant CCRT prior to anatomic lung resection plus MLND. No significant differences in patients' baseline characteristics were detected after applying the PSM method. Six of 35 patients (17.1%) in the original VATS cohort were converted to thoracotomy due to either anthracofibrotic nodes ($n = 2$) or severe adhesions ($n = 4$). They found no significant difference in complete resection rate, 30-day mortality, length of hospitalization, 5-year OS (VATS, 77.1%; thoracotomy, 59.9%; $P = 0.276$) and 5-year RFS (VATS, 66.3%; thoracotomy, 54.6%; $P = 0.354$) between the 2 groups. However, the VATS group had significantly fewer major postoperative complications ($P = 0.036$). The multivariable analyses in matched patients indicated that ex-smoker (HR = 131.25, 95% CI 4.13–4166.8; $P = 0.003$), number of dissected lymph nodes (HR = 1.05; 95% CI, 1.01–1.10; $P = 0.015$) and completeness of adjuvant therapy (HR = 0.25; 95% CI, 0.11–0.55; $P = 0.001$) were significant factors of OS and multiple positive stations (HR = 7.46; 95% CI, 1.34–41.40; $P = 0.022$) were poor prognostic factors of RFS. Overall, VATS could reach comparable perioperative and long-term survival outcomes versus thoracotomy in cN2 NSCLC patients after neoadjuvant CCRT.

Dai *et al.* [12] retrospectively reviewed 23 patients with clinical stage II–IIIB(N2) NSCLC who underwent sleeve resection following neoadjuvant chemoimmunotherapy between May 2019 and April 2021. One patient was converted to thoracotomy because of extensive pleural adhesion. No patients exhibited serious treatment-related adverse events or positive surgical margin. There was no significant difference in perioperative mortality, postoperative complications and hospital stay between the VATS group and the thoracotomy group. However, the limited sample sizes and lack of long-term outcomes weakened the reliability of the authors' recommendations.

Zhang *et al.* [13] performed a retrospective, single-centre, real-world observational study by enrolling 131 patients with clinical stage IIB or T3-4N2M0 (single N2) NSCLC who received neoadjuvant chemoimmunotherapy prior to curative-intent resection. There were 42 patients who underwent conversion to thoracotomy in the original cohort, the reasons of which included primary tumour invasion (45.2%), dense adhesion and fibrosis after neoadjuvant treatment (26.2%), fibrocalcified nodes (14.3%) and pleural adhesion (6.9%). After well balanced via the PSM method, the 2 groups were comparable in R0 resection rate, postoperative complications, hospital stay and 1-year RFS (VATS, 92.2%; thoracotomy, 84.2%; $P = 0.204$). Notably, more patients had prolonged air leak in the VATS group ($P = 0.013$). However, the short follow-up time and relatively high conversion rate limited their conclusions.

CLINICAL BOTTOM LINE

VATS, compared with thoracotomy, could yield similar surgical efficacy and survival outcomes and improved postoperative rehabilitation for those NSCLC patients received neoadjuvant therapy. However, the issue regarding surgical radicality and intraoperative conversion to thoracotomy still should be noted carefully among these patients receiving VATS surgery because all the current available evidence was retrospective based on relatively small sample sizes. The specific selection criteria of potential candidates suitable for VATS after neoadjuvant treatment have not come to an agreement for the lack of prospective evidence. Nevertheless, in conclusion, thoracic surgeons should not consider VATS inferior to thoracotomy, and VATS surgery could be an alternative for selected patients with locally advanced but relatively small, peripheral, fewer positive N2 lymph nodes and non-squamous NSCLC intended for anatomic lung resection.

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Reviewer information

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