MINI REVIEW

Did conversion to thoracotomy during thoracoscopic lobectomy increase post-operative complications and prejudice survival? Results of best evidence topic analysis

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Abstract
The potential complications related to unplanned conversion to thoracotomy remains a major concern in thoracoscopic lobectomy and may limit the wide adoption of this strategy. We reviewed the literature from 1990 until February 2022, analyzing all papers comparing successful thoracoscopic lobectomy versus converted thoracoscopic lobectomy and/or upfront thoracotomy lobectomy to establish whether unplanned conversion negatively affected outcomes. Thirteen studies provided the most applicable evidence to evaluate this issue. Conversion to thoracotomy was reported to occur in up to 23% of cases (range, 5%–16%). Vascular injury, calcified lymph nodes, and dense adhesions were the most common reasons for conversion. Converted thoracoscopic lobectomy compared to successful thoracoscopic lobectomy was associated with longer operative time and hospital stay in all studies, with higher postoperative complication rates in seven studies, and with higher perioperative mortality rates in four studies. No significant differences were found between converted thoracoscopic lobectomy and upfront thoracotomy lobectomy. Five studies evaluated long-term survival, and in all papers conversion did not prejudice survival. Surgeons should not fear unplanned conversion during thoracoscopic lobectomy, but to avoid unexpected conversion that may negatively impact surgical outcome, a careful selection of patients is recommended—especially for frail patients.

KEYWORDS
converted thoracoscopic, upfront surgery, video-assisted thoracoscopic surgery

CLINICAL SCENARIO

A 57-year-old man was transferred to our unit for management of lung adenocarcinoma of the left upper lobe. The patient’s medical history was unremarkable, and all standard cardio-pulmonary tests did not contraindicate surgical resection. The tumor was small (15 mm in size) and peripheral and no sign of pleural adhesions and/or of calcified lymph nodes (LNs) were seen on chest computed tomography (CT) scan. No other pathologic lesions were found on whole body fluorodeoxyglucose (FDG)-positron emission tomography (PET)/CT scans (cT1bN0M0). Based on the current guidelines for the treatment of lung cancer,1–3 the patient was scheduled for video-assisted thoracoscopic surgery lobectomy (VATSL).

A standard triportal VATS with anterior access was performed. During the mechanical resection of upper pulmonary vein, the stapler injured the main pulmonary artery resulting in unexpected intraoperative bleeding. Pressure was readily applied with a sponge at the site of bleeding site for an average of 5 minutes, but hemostasis was not achieved. Therefore, an emergent thoracotomy was performed by extending the anterior utility incision for 10–15 cm in length. The main pulmonary artery was proximally

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closed with a vascular clamp and the defect repaired by angiorraphy using 4–0 polypropylene suture. The blood loss was 550 mL. During arterial clamping, anticoagulation therapy was administered. The planned upper lobectomy with extended lymph node resection was carried out in a standard manner. Chest drainage was left in pleural cavity through the camera incision. Patient was extubated in operating room and then taken to the intensive care unit (ICU).

At this time, were you frightened that the unplanned conversion could lead to adverse outcomes and check the literature for an answer.

WHY IS THIS QUESTION IMPORTANT?

Lobectomy remains the standard of care for resectable lung cancer and the most authoritative guidelines1–3 recommended to perform lobectomy by VATS approach especially for early stage lung cancer. VATS demonstrates real advantages over thoracotomy, including decreased postoperative pain, shorter length of hospital stay (LHOS), less postoperative complications, similar oncological results, and no additional health care costs.4–6 The most recent analysis of the Society of Thoracic Surgeon (STS) show that 77.7% of lobectomies in 2018 were performed by minimally invasive procedures,7 whereas in Europe the rate of VATS performed in the period 2014–2020 was 49.6%.8,9 VATS remains a complex procedure that requires a demanding learning curve.10 Unplanned intraoperative conversion to thoracotomy may affect surgical outcomes, resulting in potential medical problems for the physicians. These concerns may explain the different worldwide adoption of VATS.

Although there have been enough evidence suggesting that patients who have received a successful VATS may benefit from the procedure, it might be at the price of those who have to be converted and suffered from a worse outcome compared to an upfront open thoracotomy. The major purpose of this study was to show that patients undergoing VATS conversion would have non-inferior outcomes compared to those who have upfront open lobectomy.

SEARCH STRATEGY

The study design was structured according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol. A literature review was performed using MEDLINE, PubMed, Scopus, Google Scholar, and Cochrane databases from 1990 until the end of February 2022 to find all studies comparing successful VATS versus converted VATS lung resection and/or upfront thoracotomy lung resection. The following MeSH search headings were used: [vats lung resection.mp. OR VATS LUNG RESECTION] AND [thoracotomy.mp. OR THORACOTOMY/] AND [converted vats lung resection.mp. OR CONVERTED VATS LUNG RESECTION/]. Additional papers, abstracts, chapters of books, letters, and editorials were retrieved from bibliographies by manual research. The Science Citation Index was used to cross reference for further studies that met the criteria of the study.

SELECTION PROCESS

Papers were included in this review if they fit the following criteria: (i) papers published in the English language; (ii) study population including patients undergoing planned VATS anatomic lung resections that were then converted to thoracotomy; and (iii) results comparing postoperative morbidity and mortality between successful VATS, converted VATS and upfront thoracotomy anatomic lung resections. We excluded (i) studies published in non-English languages; (ii) reviews, meta-analyses, abstracts, case reports, and case series; (iii) papers from the same groups (in these cases, only the most recent publication was reported to avoid duplication); and (iv) papers reporting the incidence, the causes, and/or the risk factors for the VATS conversion, but not evaluating the effects of conversion on outcomes and/or survival.

First, the titles of papers were inspected to decide whether they were appropriate to the research purpose. Second, the abstracts of the selected papers were evaluated, and those that were not appropriate were excluded. Third, the remaining articles were entirely inspected to decide their inclusion. Disagreements were judged by the three senior reviewers (M.S., R.P. and V.W.F.) after referring to the original articles.

END-POINTS

For each selected paper, the following data were extracted: authors, year of publication, and country; level of evidence based on the criteria of Centre for Evidence Based Medicine11; type of resection; incidence, cause, and risk factors for conversion; postoperative outcomes, recurrence, and survival. The end-points of the study were to evaluate: (i) the incidence, reasons, and the risk factors for conversion; (ii) the postoperative morbidity and mortality; and (iii) recurrence and survival associated with converted VATS as comparison to successful VATS and/or upfront thoracotomy anatomic lung resection.

No specific approval was needed for this study by Local Ethical Committees because it did not involve human subjects.

RESULTS

The flow chart of the study is summarized in Figure 1. The initial search using the MeSH heading yielded 323 results and an additional 21 papers were found by manual search from the references of the selected articles; 226 papers were then excluded as duplicate. Among the 118 papers screened,
81 were excluded based on the titles and abstracts. Of the remaining 37 studies, 24 studies were further excluded. Therefore, 13 papers were included in the analysis and summarized in Table 1.

Servais et al.\textsuperscript{12} retrospectively compared the data of successful VATSL ($n = 17.339$) and converted VATSL ($n = 2.148$) for lung cancer. The data was extracted from national database of Society Thoracic Surgery General thoracic Surgery Database (STS GTSD). The overall conversion rate was 11%. Emergent conversion occurred in 9.6% of cases and it was associated with increased mortality compared to non-emergent conversion (5.5% vs. 1.8%; $p < 0.001$). Age ($p < 0.0001$), body mass index (BMI) ($p < 0.0001$), male sex ($p < 0.0001$), hypertension ($p = 0.0008$), preoperative chemotherapy ($p = 0.0002$), low FEV1 ($p = 0.0004$), clinical stage ($p < 0.001$), left sided resection ($p = 0.0002$), positive margin resection ($p < 0.0001$), lobe location ($p = 0.01$), and center’s experience ($p < 0.0009$) were independent risk factors for conversion. Successful versus converted VATS was associated with a shorter operative time (162 minutes vs. 212 minutes; $p < 0.001$), and LOHS (4 days vs. 5 days; $p < 0.001$). Postoperative mortality ($p < 0.001$), postoperative morbidity ($p < 0.001$), and blood transfusion rates ($p < 0.001$) were higher in converted compared to successful VATS group. The retrospective nature of the study, different centers’ experience, the lack of upfront group for comparison, and of survival analysis were all limitations of this study.

Fourdrain et al.\textsuperscript{13} retrospectively compared the data of patients undergoing anatomic resections (segmentectomy, lobectomy, and bilobectomy) for lung cancer by successful VATS ($n = 439$), by converted VATS ($n = 94$) and by upfront thoracotomy ($n = 313$). The conversion rate was 17.6% ($n = 94$) and in 21 cases (22%) it was because of bleeding (emergent conversion).

Operation time ($p < 0.001$), chest tube duration ($p < 0.001$), and LOHS ($p = 0.003$) were shorter in successful VATS than in converted VATS and upfront thoracotomy. Successful VATS was associated with fewer overall complications than converted VATS and upfront thoracotomy (13% vs. 22% vs. 28%, $p = 0.02$, respectively), whereas no significant difference was found between converted VATS and upfront thoracotomy ($p = 0.27$). The conversion did not affect survival. No statistical differences were found in
| Authors, years, country, level of evidence | Study Groups | Conversions : incidence and reason | Outcomes | Results | Limitations | Conclusions |
|------------------------------------------|--------------|-----------------------------------|----------|---------|-------------|-------------|
| Servais et al. [12], 2022 United States  | Successful VATS: 17,399 Converted VATS: 2,148 Study Period: 2015-2018 | Conversion rates: 11% -Vascular: 14.3% -Anatomy: 68.5% -LN: 5.2% -Technical: 12% -Emergent: 9.6% | Comparison groups | Successful VATS vs. Converted VATS: 162 vs. 212; p < 0.001 | Retrospective nature Multiple Centers No upfront thoracotomy group for comparison No analysis of survival and recurrence | Converted VATS was associated with higher mortality and morbidity rates than successful VATS. |
| Fourdrain et al. [13], 2022 France  | Successful VATS: 439 Converted VATS: 94 Upfront thoracotomy: 313 Study Period: 2011-2018 | Conversion rates: 17.6% Bleeding: 21 (22%) Oncologic: 6 (6%) Failure of SLV: 13 (13%) Adhesions: 22 (23%) Technical difficulties: 32 (34%) | Operation time (min.) | LOHS (days) 4 vs. 5; p < 0.001 | p < 0.001 | Converted VATS and upfront thoracotomy were associated with higher complication rates than successful VATS. |

Comparison Emergent vs. No-emergent conversions Mortality 5.5% vs. 1.8%; p < 0.001

(i) Successful VATS vs. Converted VATS; (ii) Converted VATS vs. Upfront thoracotomy

(i) 159 vs. 183; p < 0.001 (ii) 183 vs. 159; p = 0.004

(i) 3.8 vs.5.9; p < 0.001 (ii) 5.9 vs. 6.1; p = 0.76

Different type of anatomical resections

Similar survival was found between three study groups.

(Continues)
| Study Groups                  | Conversions: incidence and reason | Outcomes               | Results                                                                 | Limitations                  | Conclusions                                                                 |
|------------------------------|-----------------------------------|------------------------|--------------------------------------------------------------------------|------------------------------|-----------------------------------------------------------------------------|
| Successful VATS: 20,360      |                                   | LOHS (days)            | (i) 6.3 vs. 9.4; \(p = 0.003\); (ii) 9.4 vs. 11; \(p = 0.16\)           |                              |                                                                             |
| Converted VATS: 205          |                                   | Postoperative complications | (i) 58 (13%) vs. 21 (22%); \(p = 0.02\); (ii) 21 (22%) vs. 88 (28%); \(p = 0.27\) |                              |                                                                             |
|                              |                                   | 30-day mortality       | (i) 5 (1%) vs. 2 (2%); \(p = 0.36\); (ii) 2 (2%) vs. 7 (2%); \(p = 1.0\) |                              |                                                                             |
| Retrospective study          |                                   | 90-day mortality       | (i) 9 (2%) vs. 4 (4%); \(p = 0.26\); (ii) 4 (4%) vs. 11 (3%); \(p = 0.76\) |                              |                                                                             |
| China                        |                                   | Comparison             | Full VATS vs. Converted VATS vs. upfront thoracotomy                      |                              |                                                                             |
| Retrospective study          |                                   | 5-YSRT before matching | Stage I 76% vs. 72% vs. 69%; \(p = 0.47\)                                |                              |                                                                             |
| Level 3a                     |                                   | DFSRT before matching  | Stage II-III 77% vs. 40% vs. 53.4%; \(p = 0.016\)                        |                              |                                                                             |
| Study period: 2016-2018      |                                   | Stage I 71 vs. 60% vs. 53%; \(p = 0.013\)                              |                              |                                                                             |
|                              |                                   | Stage II-III 63% vs. 35% vs. 41%; \(p = 0.071\)                          |                              |                                                                             |
| Risk factor for conversion   |                                   | Comparison             | Successful VATS + Converted VATS vs. upfront thoracotomy                  |                              |                                                                             |
|                              |                                   | YSRT after matching     | 88%, 77% and 65% vs. 92%, 80% and 67% at 1, 3 and 5 years \(p = 0.22\) |                              |                                                                             |
|                              |                                   | DFSRT after matching    | 84%, 64% and 52% vs. 82%, 67% and 53% at 1, 3 and 5 years \(p = 0.49\) |                              |                                                                             |
| Authors, years, country, level of evidence | Study Groups | Conversions : incidence and reason | Outcomes | Results | Limitations | Conclusions |
|-------------------------------------------|--------------|-----------------------------------|----------|---------|-------------|-------------|
| Sezen et al. [15] 2019 Turkey Retrospective study Level 3b | Successful VATS: 129 | Conversion rates: 12% | Reoperation: $p = 0.01$ | Low surgical experience: $p < 0.001$ | | |
| | Converted VATS: 18 | -Bleeding: 6 (33%) | Operative time (min) | 103 vs. 162; $p < 0.001$ | | |
| | Study period: 2012-2016 | -Dense adhesions: 7 (38%) | Blood loss (mL) | 95 vs. 427; $p = 0.001$ | | |
| | | -Fused fissure: 1 (5.5%) | Transfusion Intraoperative | 0.5% vs. 30%; $p < 0.001$ | | |
| | | -Calcified LN: 4 (22%) | Postoperative | 1% vs. 7%; $p = 0.001$ | | |
| | | | Chest drainage (days) | 4 vs. 5; $p < 0.001$ | | |
| | | | ICU stay (days) | 2 vs. 3; $p = 0.03$ | | |
| | | | LHOS (days) | 5 vs. 6; $p < 0.001$ | | |
| | | | Complications - Overall | 26% vs. 39%; $p = 0.006$ | | |
| | | | -Pulmonary | 26% vs. 37%; $p = 0.014$ | | |
| | | | Readmission to ICU | 1% vs. 4%; $p = 0.03$ | | |
| | | | Comparison | Emergent (n=37) vs. non emergent (205) | | |
| | | | Operative time (min.) | 180 vs. 159; $p = 0.03$ | | |
| | | | Blood loss (mL) | 1% vs. 78%; $p < 0.001$ | | |
| | | | Comparison | Successful VATS vs. Converted VATS | | |
| | | | Operative time (min.) | 180 vs. 235; $p = 0.003$ | | |
| | | | Blood loss (mL) | 263 vs. 562; $p < 0.001$ | | |
| | | | LHOS (days) | 4 vs. 5; $p < 0.001$ | | |
| | | | Complication rates | | | |
| | | | -Overall | 20% vs. 22%; $p = 0.90$ | | |
| | | | -Arrhythmia | 3% vs. 16%; $p = 0.01$ | | |
| | | | -Wound infection | 1% vs. 16%; $p = 0.01$ | | |
| | | | 5-YSRT | 71% vs. 80%; $p = 0.54$ | | |
| | | | Risk factor for conversion | Age; $p = 0.015$ | | |

Retrospective series Small sample size Multiple surgeons No difference between emergent and no-emergent conversion No upfront thoracotomy group for comparison

No significant difference regarding overall postoperative complications and survival between two study groups.
| Authors, years, country, level of evidence | Study Groups | Conversions: incidence and reason | Outcomes | Results | Limitations | Conclusions |
|------------------------------------------|-------------|---------------------------------|----------|---------|-------------|-------------|
| Matsuoka et al. [16]; 2019 Japan Retrospective study Level 3b | Successful VATS 1,527 Converted VATS: 39 Upfront thoracotomy: 89 Study period: 2009-2014 | Conversion rate: 2.5% Tumor extension: 15 (38%) Silicot L.N: 12 (30%) Adhesions: 3 (7%) Poor vision: 3 (7%) Vascular injury: 3 (7%) Bronchial injury: 2 (5%) Staple misfires: 1 (2%) | Comparison Groups | Successful VATS vs. Converted VATS | | VATS converted and upfront surgery were associated with higher complication rates than successful VATS. |
| | | | Intraoperative Bleeding (mL) | 82 vs. 365; \( p < 0.0001 \) | | |
| | | | Operation time (min) | 121 vs. 187; \( p < 0.0001 \) | | |
| | | | LHOS (days) | 6 vs. 8; \( p = 0.003 \) | | |
| | | | Complications | | | |
| | | | Grade 2 | 32% vs. 77%; \( p = 0.005 \) | | |
| | | | Grade 5 | 0.4% vs. 5%; \( p = 0.0001 \) | | |
| | | | Comparison Group | Upfront-thoracotomy vs. Converted-VATS | | |
| | | | Intraoperative Bleeding (mL) | 489 vs. 365; \( p = 0.62 \) | | |
| | | | Operation time (min) | 218 vs. 187; \( p = 0.02 \) | | |
| | | | LHOS (days) | 10 vs. 8; \( p = 0.002 \) | | |
| | | | Complications | | | |
| | | | Grade 2 | 59% vs. 77%; \( p = 0.48 \) | | |
| | | | Grade 5 | 4% vs. 5%; \( p = 0.98 \) | | |
| | | | Risk factors for conversion | Male; \( p = 0.16 \) Smoking; \( p = 0.82 \) Induction therapy \( p = 0.50 \) Tumor size; \( p = 0.15 \) Clinical stage; \( p = 0.03 \) | | |
| | | | Mortality | Converted VATS 5% Successful VATS 0.5% Upfront thoracotomy 4% | | |
| Vallance et al. [17]; 2017 United Kingdom Retrospective study Level 3b | Successful VATS 609 Converted VATS: 75 Study period: 2010-2015 | Conversion rate: 10.9% Vascular: 26; 34% Anatomical: 23;30% Technical: 14; 18% LN: 12; 16% | LOHS (mean) | 6.4 vs. 9.3 \( p < 0.001^* \) | Restrospective study No analysis of recurrence and survival No comparison between emergent vs. non-emergent conversion | Converted VATS was associated with more RESPIRATORY failure and 30-day mortality as well as longer LOS. |
| | | | 30-day mortality | 6 (1%) vs. 7 (9%); \( p = 0.003 \) | | |
| | | | Postoperative complications | 224 (36%) vs. 36 (52%); \( p = 0.14 \) | | |
| | | | Return to theatre | 43 (7%) vs. 6 (8%); \( p = 0.78 \) | | |

(Continues)
TABLE 1 (Continued)

| Authors, years, country, level of evidence | Study Groups | Conversions: incidence and reason | Outcomes | Results | Limitations | Conclusions |
|------------------------------------------|--------------|-----------------------------------|----------|---------|-------------|-------------|
| Augustin et al. [18]; 2016 Austria Retrospective study Level 3b | Successful VATS lobectomy: 217 Converted VATS lobectomy: 15 Study period: 2009-2012 | Conversion rate: 6.5% -Vascular injury: 6 (3%) -Oncologic: 5 (2%) -Technical: 4 (1.7%) | Reoperating for bleeding | 6 (1%) vs. 2 (2%) \( p = 0.21 \) | No upfront thoracotomy group for comparison | Converted VATS was associated with significant longer LOHS |
| | | | Readmission within 30 days | 41 (6%) vs. 5 (7%) \( p = 0.33 \) | | | |
| | | | Respiratory failure | 23 (3%) vs. 10 (14%) \( p < 0.001 \) | | | |
| | | | Empyema | 13 (2%) vs. 5 (7%) \( p = 0.023 \) | | | |
| | | | Pneumonia | 57 (9%) vs. 12 (17%) \( p = 0.09 \) | | | |
| | | | Arrhythmia | 34 (5%) vs. 8 (11%) \( p = 0.10 \) | | | |
| | | | Pulmonary embolus | 8 (1%) vs. 2 (2%); \( p = 0.36 \) | | | |
| | | | Myocardial infarction | 3 (0.5%) vs. 0; \( p = 0.54 \) | | | |
| | | | Cerebrovascular accident | 1 (0.2%) vs. 0; \( p = 0.73 \) | | | |
| | | | PAL | 123 (20%) vs. 15 (22%); \( p = 0.96 \) | | | |
| | | | Comparison Successful VATS vs. Converted VATS | | | Multiple surgeons |
| | | | Chest tube (days) (median) | 5 vs. 5; \( p = 0.31 \) | No evaluation of emergent conversion |
| | | | Postoperative complications | 64 (29%) vs. 5 (33%); \( p = 0.76 \) | No upfront thoracotomy group for comparison |
| | | | In-hospital mortality | 2 vs. 0; \( p = 1.0 \) | No evaluation of survival |
| | | | LOHS (days, median) | 9 vs. 11; \( p = 0.028 \) | | |
| | | | Overall survival | \( p = 0.63 \) | | |
| | | | Recurrence rates | 60% vs. 30%; \( p = 0.024 \) | | |
| Byun et al. [19] 2015 Korea Retrospective study Level 3b | Successful VATS: 1,041 Converted VATS: 69 Study period: 2005-2013 | Conversion rate: 6.2% -LN: 28 (40.6%) -Bleeding: 20 (29%) -Oncologic: 11 (15.9%) -Adhesions: 5 (7%) -Fused fissures: 3 (4%) -Failure of single-lung ventilation: 2 (2.9%) | Risk factors for conversion | Successful VATS vs. Converted VATS | Retrospective study | Converted VATS was not associated with increased postoperative morbidity and mortality |
| | | | Comparison | | | |
| | | | Operation time (min) | 150.9 vs. 222; \( p < 0.001 \) | | |
| | | | Estimated blood loss (mL) | 227.5 vs. 692.8; \( p < 0.001 \) | | |
| | | | Chest tube duration (days) | 6.3 vs. 7.1; \( p = 0.14 \) | | | (Continues)
| Authors, years, country, level of evidence | Study Groups | Conversions : incidence and reason | Outcomes | Results | Limitations | Conclusions |
|---|---|---|---|---|---|---|
| Puri et al. [20] 2015 United States Retrospective study Level 3b | Successful VATS: 517 Converted VATS: 87 Upfront thoracotomy: 623 Study period: 2004-2012 | Conversion rate 87 (7%) - Vascular injury: 22 (25%) - Anatomic reason: 56 (64%) - LN: 8 (9%) - Technical difficulties or equipment failure: 1 (1%) | ICU stay (days) | 1.4 vs. 3.3; \( p = 0.047 \) | | Retrospective nature Multiple surgeons Upfront thoracotomy and converted VATS group had higher clinical T stage Upfront thoracotomy group presented higher advanced pathologic stage No survival analysis | VATS converted and upfront surgery were associated with higher complication rates than successful VATS. Survival was similar between study groups |
| | | | In-hospital stay (days) | 8.4 vs. 9.4; \( p = 0.39 \) | | | |
| | | | Complications | Overall 14 vs. 8; \( p = 0.19 \) | | | |
| | | | - Respiratory 2 vs. 5; \( p = 0.012 \) | | | | |
| | | | - Non respiratory 12 vs. 3; \( p = 0.76 \) | | | | |
| | | | In hospital death 2 vs. 2; \( p = 0.26 \) | | | | |
| | | | Conversion rate 87 (7%) - Vascular injury: 22 (25%) - Anatomic reason: 56 (64%) - LN: 8 (9%) - Technical difficulties or equipment failure: 1 (1%) | | | | |
| Samson et al. [21] 2013 United States Retrospective study Level 3b | Successful VATS: 148 Converted VATS: 45 Upfront thoracotomy: 91 Study period: 2003-2009 | Conversion rates: 23% - LN calcification: 16 (36%) - Adhesions: 15 (33%) - Body habitus: 2 (4%) - Other: 2 (4%) | Complication rates | 23% vs. 46%; \( p < 0.001 \); 46% vs. 42%; \( p = 0.56 \); | | | |
| | | | - LHOS (days) 4.6 vs. 7.6; \( p < 0.0001 \); 7.6 vs. 7.5; \( p > 0.05 \) | | | | |
| | | | Transfusion rates | 1.3% vs. 16.7%; \( p < 0.001 \) 16.7% vs. 10.3%; \( p > 0.05 \) | | | | |
| | | | Surgical mortality | 0% vs. 1%; 1% vs. 0.8%; \( p = 0.10 \) | | | | |
| | | | Risk factors for conversions | Age; \( p = 0.0001 \) Sex (male); \( p = 0.02 \) Smoking; \( p = 0.019 \) Low DLCO; \( p = 0.021 \) | | | | |
| | | | Risk factor for long mortality | Age; \( p < 0.0001 \) Sex (male); \( p = 0.02 \) Smoking; \( p = 0.019 \) Low DLCO; \( p = 0.021 \) | | | | |
| | | | Comparison | Successful VATS vs. Converted VATS | | | | |
| | | | Operative time (min) | 211 vs. 252; \( p < 0.01 \) | | | | |
| | | | Blood loss (ml) | 150 vs. 325; \( p < 0.01 \) | | | | |
| | | | Chest tube | 3 vs. 4; \( p < 0.01 \) | | | | |
| | | | LHOS (days) | 4 vs. 6; \( p < 0.01 \) | | | | |

(Continues)
| Authors, years, country, level of evidence | Study Groups | Conversions : incidence and reason | Outcomes | Results | Limitations | Conclusions |
|------------------------------------------|--------------|-----------------------------------|----------|---------|-------------|-------------|
| Park et al. [22] 2011 Korea Retrospective study Level 3b | Successful VATS: 704 Converted VATS: 34 Study period: 2003-2008 | Conversion rate: 4.6% -Silicotic LN: 14 (41%) -Vascular or bronchial injury: 11 (32%) -Fused fissure: 4 (11.7%) -LN metastasis: 2 (5.8%) -Vascular anomalies: 3 (8.8%) | Complication rates -Arrhythmia 9% vs. 12%; $p = 0.04$ 30-day mortality 1% vs. 9%; $p = 0.01$ Risk factor for conversion LN calcification; $p = 0.04$ Comparison Converted VATS vs. upfront thoracotomy Operative time (min) 252 vs. 215; $p = 0.02$ Blood loss (ml) 325 vs. 200; $p = 0.02$ Chest tube 4 vs. 3; $p = 0.02$ LHOS (days) 6 vs. 5; $p = 0.07$ Complication rates -Arrhythmia 22% vs. 20%; $p = 0.054$ 30-day mortality 9% vs. 2%; $p = 0.10$ | Small sample size Short follow-up No difference between emergent and non-emergent conversion No upfront thoracotomy group for comparison | Unexpected conversion to thoracotomy during VATS does not appear to compromise prognosis |
| Sawada et al. [23] 2009 Japan Retrospective study Level 3b | Successful VATS: 468 Converted VATS: 24 Study period: 2003-2007 | Conversion rate 5% Adenopathies: 7 -Bleeding: 7 -Fused Fissure: 4 -LN involvement: 1 -Others: 5 | Operative time (minutes) 190 vs. 258; $p < 0.0001$ LHOS (days) 7 vs. 10; $p < 0.0001$ Operative death 1 | Retrospective No recurrence and survival analysis No comparison between emergent vs. non emergent conversion | VATS is a safe procedure also in case of conversions. |

Calcified LN was the main predictive factor of conversion.
TABLE 1 (Continued)

| Authors, years, country, level of evidence | Study Groups | Conversions: incidence and reason | Outcomes | Results | Limitations | Conclusions |
|-------------------------------------------|--------------|----------------------------------|----------|---------|-------------|-------------|
| Jones et al. [24] 2008                    | Converted VATS: 26 | Conversion rate: 10.5% -Vascular injury: 11 (37%) -Extent of disease: 9 (30%) -Adhesions: 7 (23%) -Formation: 2 (7%) -Contralateral pneumothorax: 1 (3%) | LHOS (days) | 10 vs. 12 | No upfront thoracotomy group for comparison | Converted VATS did not affect surgical outcomes and overall survival compared to upfront thoracotomy |
| United Kingdom Retrospective study Level 3b | Upfront thoracotomy: 52 | | Complications | 6% vs. 17% | Small sample size | No difference between successful and no-emergent conversion |
| Study period: 1992-2006                   |               |                                  | Converted VATS vs. Upfront Thoracotony |         |             |             |
|                                          |               |                                  | Complications |         |             |             |
|                                          |               |                                  | -Overall     | 13 vs. 25; *p* = 0.093 |             |             |
|                                          |               |                                  | -Minor       | 12 vs. 22 |             |             |
|                                          |               |                                  | -Major       | 1 vs. 3  |             |             |
|                                          |               |                                  | LHOS (days)  | 8.3 vs. 9.3; *p* = 0.3 |             |             |
|                                          |               |                                  | 5-YSRT       | 65% vs. 43%; *p* = 0.1 |             |             |

Abbreviations: CT = computed tomography; DFSR = disease free survival rate; ICU = intensive care unit; LN = lymph node; min = minutes; LOHS = length of hospital stay; PAL = persistent airleaks; VATS = Video-assisted Thoracoscopic Surgery; SLV = Single lung ventilation; YSRT = year survival rate. [Correction added on 20 July 2022, after first online publication: in table 1, alignment in columns four and five (Outcomes and Results) have been fixed.]
compared to successful VATS was associated with higher rate of arrhythmia (3% vs. 16%; respectively, \( p = 0.01 \)) and wound infection (1% vs. 16%; respectively, \( p = 0.01 \)). No intraoperative and postoperative mortal complications occurred in both groups. The 5 years survival rate in successful and in converted VATS was 74% and 80%, respectively (\( p = 0.54 \)). Yet, no difference was found between emergent and non-emergent conversion, and there is not the upfront thoracotomy group for comparison.

Matsuoka et al.\(^\text{16}\) retrospectively compared the data of patients undergoing anatomic resections (segmentectomy, lobectomy, and pneumonectomy) for lung cancer by successful VATS \(( n = 1,527)\), by converted VATS \(( n = 39)\), and by upfront thoracotomy \(( n = 89)\). The conversion rate was 17.6% \(( n = 94)\) and in 3 of 39 cases \(( 7\%)\) it was because of bleeding \(\text{(emergent conversion)}\). The risk factor for conversion was advanced lung cancer stage \(( p = 0.03)\). Successful compared to converted VATS was associated with shorter operative time \((121 \text{ minutes vs. 187 minutes}; \ p < 0.0001)\), and LOHS \((6 \text{ days vs. 8 days}; \ p < 0.0003)\) and with lower intraoperative bleeding \((82 \text{ mL vs. 365 mL}; \ p < 0.0001)\), lower grade 2 \((32\% \text{ vs. 77\%})\), and lower grade 5 \((0.4\% \text{ vs. 5\%}; \ p = 0.0001)\) complication rates. No significant differences were found between converted VATS and upfront thoracotomy. The mortality rate was lower in successful VATS group \((0.5\%)\) than in converted VATS \((5\%)\) and in upfront thoracotomy group \((4\%)\). There were two perioperative deaths in the conversion group because of respiratory complications. The main limitations of this study were the retrospective nature, multiple surgeons who performed operations, the lack of survival analysis between study groups, the lack of comparison between emergent and non-emergent conversion, and the inclusion of different types of resection from lobectomy \(\text{(i.e. sublobar resections and pneumonectomy)}\).

Vallance et al.\(^\text{17}\) retrospective compared the data of successful VATS \(( n = 609)\) versus converted VATS \(( n = 75)\) for lung cancer. The conversion rate was 10.9% and vascular injury was the main reason \((34.7\%)\). Converted versus successful VATS was associated with longer LOHS \((9 \text{ days vs. 6 days}; \ p < 0.001)\) and higher rate of respiratory failure \((14.1\% \text{ vs. 3.8\%}; \ p < 0.001)\) and higher rate of 30-day mortality \((9.3\% \text{ vs. 1\%}; \ p = 0.003)\). No recurrence or survival was evaluated. Furthermore, no comparison was found between emergent and non-emergent conversion, and there was not the upfront thoracotomy group for comparison.

Augustin et al.\(^\text{18}\) retrospectively compared the clinical data of 217 successful VATS vs. 15 converted VATS for lung cancer. The conversion rates were 6.5%, because of bleeding \((3\%)\), oncologic \((5\%)\), and technical \((1.7\%)\) reasons. Induction treatment \(( p = 0.013)\) and tumor size \(\geq 30 \text{ mm} \) \(( p = 0.04)\) were independent risk factors for conversion. Converted versus successful VATS was associated with longer LHOS \((11 \text{ days vs. 9 days}; \ p = 0.028)\), whereas no significant differences were found regarding overall postoperative complication rate \((33.3\% \text{ vs. 29.5\%})\), median chest drain duration \((5 \text{ days vs. 5 days})\) and in-hospital mortality \((0 \text{ vs. 1\%})\). More disease recurrences were found in converted vs. successful VATS group \((60\% \text{ vs. 30.5\%}; \ p = 0.024)\), but it did not affect the overall survival that was similar \(( p = 0.6)\). Different surgeons with different skills, the lack of comparison between emergent and non-emergent conversions, and between converted VATS and upfront thoracotomy were the main limitations of this article.

Byun et al.\(^\text{19}\) retrospectively compared the data of 1,041 successful VATS and of 69 converted VATS for lung cancer. Each converted patient was individually matched to three randomly selected non-converted patients based on date of operation, type of operation, and pathologic stage. The conversion rate was 6.2% because of calcified LN \(( n = 28; 40.6\%)\), vascular injury \(( n = 20; 29\%)\), tumor invasion or extension \(( n = 11; 15.9\%)\), pleural adhesions \((5\%\); fused fissure \((n = 3; 4\%);\) and failure of single-lung ventilation \((n = 2; 2.9\%);\). Converted vs. successful VATS was associated with prolonged operation time \((222 \text{ minutes vs. 150.9 minutes}; \ p < 0.001)\); higher blood loss \((692.8 \text{ mL vs. 227.5 mL}; \ p < 0.001)\), and prolonged ICU stay \((3.3 \text{ days vs. 1.4 days}; \ p = 0.047)\). The differences in overall postoperative complications and in-hospital deaths were not significant; however, respiratory complications were significantly more common in the converted VATS \(( p = 0.012)\). There were two deaths in the converted VATS group because of respiratory complications. Age \(( p = 0.031)\), FEV1 \(( p = 0.005)\), and calcified LN \(( p = 0.02)\) were independent predictive factors for conversion. Converted VATS was not associated with increased overall surgical morbidity and mortality. The retrospective nature and small sample size were the main limitations of the study. The differences between emergent versus non-emergent conversion, and between converted versus upfront thoracotomy, and survival and recurrence rates were not evaluated.

Puri et al.\(^\text{20}\) retrospectively compared the data of successful VATS \(( n = 517)\), converted VATS \(( n = 87)\), and upfront thoracotomy lobectomy \(( n = 623)\) performed for lung cancer. The overall conversion rate was 7%. It dropped from 21 of 74 \((28\%)\), to 29 of 194 \((15\%)\), to 37 of 336 \((11\%)\) \(( p < 0.001)\) over 3-year intervals. Emergent conversion because of vascular injury occurred in 22 of 87 cases \((25\%)\), and it was associated with higher intraoperative blood transfusion compared to non-emergent conversion \((47.4\% \text{ vs. 4.3\%}; \ p < 0.001)\), whereas perioperative morbidity was similar. Male sex \(( p = 0.043)\) was the only significant prognostic factor for conversion. Successful VATS was associated with a lower blood transfusion rate \((1.3\%; \ p < 0.001)\) and shorter LOHS \((4.6 \text{ days}; \ p < 0.0001)\) compared to converted VATS \((16.7\% \text{ and 7.6 days}; \ p < 0.0001)\) and to upfront thoracotomy lobectomy \((10.3 \text{ days and 7.5 days}; \ p < 0.001)\) respectively, whereas no significant differences were found between converted VATSL and upfront thoracotomy lobectomy. Postoperative complications were more frequent in converted VATS group \((46\%)\) than in successful VATS group \((23\%; \ p < 0.001)\), but similar to upfront thoracotomy group \((42\%; \ p = 0.56)\). No significant difference regarding
surgical mortality rate ($p = 0.10$) was found regarding between successful VATS ($0\%$), converted VATS ($1\%$), and upfront thoracotomy ($0.8\%$). Patients undergoing upfront thoracotomy were younger and had a higher incidence of prior lung cancers. Upfront thoracotomy and converted VATS group patients had higher clinical T stage than patients in the VATS group, whereas the upfront thoracotomy group presented higher advanced pathologic stage than other groups.

Samson et al.\textsuperscript{21} retrospectively compared the data of 148 undergoing successful VATSL versus 45 undergoing converted VATSL for lung cancer. Conversion rate was $23\%$ and the main cause of conversion was the presence of LN calcification ($33\%$). Converted VATSL had significantly higher 30-day mortality ($1\%$ vs. $9\%; p = 0.01$), more atrial arrhythmias ($9\%$ vs. $12\%; p = 0.04$), increased blood loss ($3\%$ vs. $4\%; p < 0.01$), longer operative time ($150$ minutes vs. $325$ minutes; $p < 0.01$), and increased LOHS ($4$ days vs. $6$ days; $p < 0.01$) compared with successful VATSL. On comparison of converted VATSL to upfront open thoracotomy lobectomy, mortality and morbidity rates were similar. Recurrence and survival analysis were not performed. Yet, emergent versus non-emergent conversions were not compared.

Park et al.\textsuperscript{22} retrospectively compared the data of patients undergoing lobectomy for management of lung cancer ($n = 603$) and benign disease ($n = 135$) by successful VATS ($n = 704$) versus converted VATS ($n = 34$). The conversion rate was $4.6\%$ and the main causes of conversion were the presence of silicotic LN ($41\%$) and bronchovascular injury ($32\%$). Converted compared with successful VATSL was associated with longer operating time ($258.8$ minutes vs. $190.9$ minutes; $p < 0.0001$), LHOS ($10.12$ days vs. $7.08$ days, $p < 0.0001$), whereas complication rates were similar also if corrected for sex ($p = 0.4579$) and age ($p = 0.307$). Survival ($p = 0.62$) and recurrence ($p = 0.76$) rates in patients with lung cancer were not significantly different between the two groups. The main limits of this article were the retrospective nature, the small sample size, the lack of comparison between emergent versus non-emergent conversion and between converted VATSL versus upfront thoracotomy lobectomy.

Sawada et al.\textsuperscript{23} retrospectively compared the data of successful VATSL ($n = 468$) versus converted VATSL ($n = 24$) for lung cancer. The conversion rate was $5\%$ and bleeding and adenopathies were the main reasons. Converted VATSL compared to successful VATS was associated with longer operative time ($260$ minutes vs $164$ minutes), higher amount of bleeding ($420$ mL vs. $144$ mL), higher overall complications ($17\%$ vs. $6\%$), and prolonged LOHS ($12$ days vs. $10$ days). However, there were no life-threatening perioperative complications or perioperative mortality in both groups. The small sample size, the lack of comparison between emergent versus non emergent conversions, no recurrence and survival analysis, the lack of upfront thoracotomy lobectomy were all limitations of this study.

Jones et al.\textsuperscript{24} retrospectively compared the clinical data of 26 patients undergoing converted VATSL versus 52 patients underwent upfront thoracotomy lobectomy. The converted group was matched 2:1 with upfront thoracotomy group based on age, sex, cancer stage, year, and type of operation. There were no statistically significant differences in postoperative complications between the two groups ($p = 0.093$). There were no in-hospital deaths in the converted VATS, but one patient in the control group died of respiratory complication. The survival curve of the converted VATSL seemed to be more favorable than that of the upfront thoracotomy lobectomy, but survival analysis for cancer-related death or no-associated death showed no statistically significant difference ($p = 0.16$). The small sample size and the lack of difference between emergent versus non emergent conversion were the main limits of this article.

**DISCUSSION**

Unplanned conversion to thoracotomy remains a major concern in VATSL and it may discourage thoracic surgeons, especially in the early phase of the learning curve, from adopting this approach.\textsuperscript{25} Despite the advantages of VATSL over thoracotomy lobectomy are well defined in literature; there are few and contrasting data regarding the consequences of unplanned converted VATSL on patients’ outcome. Therefore, we planned a review study to evaluate whether unplanned converted VATS could increase the postoperative complications and negatively affect survival compared to successful VATSL and/or upfront thoracotomy lobectomy.

**Conversions**

In this analysis, conversion to a thoracotomy was reported to occur in up to $23\%$ of cases. Vascular injury, calcified LN, and dense adhesions were the most common reasons for conversion and all studies found a decrease of conversion rate with the increase of the surgeon’s experience. Eight studies evaluated risk factors for conversion by multivariable analysis\textsuperscript{12,14–16,18,19}; the results varied significantly between studies, identifying age, tumor size, BMI, male sex, induction therapy, respiratory disease, history of smoking, side of resection, and surgeon’s experience as independent prognostic factors for conversion.

**Postoperative outcomes**

In seven studies,\textsuperscript{12–14,16,17,20,21} converted VATS compared to successful VATS was associated with higher rate of postoperative complications, whereas six studies showed no significant differences.\textsuperscript{15,18,19,22–24} Four of 13 studies found a higher rate of peri- and postoperative deaths after conversion.
because of cardio-respiratory complications. Longer operating time, lung manipulation with air-leaks, increased blood loss, and long-time ICU stay related to conversion and pre-operative patients’ comorbidities were likely explanations. Because the advantages of VATS compared to thoracotomy are well defined in literature, the comparison group for converted VATS should also include patients undergoing upfront thoracotomy. However, this issue was evaluated in only four studies, presenting comparable results between converted VATS and upfront thoracotomy. An additional critical point was to distinguish the reasons for conversions because they could have a different impact on surgical outcome. Emergent conversions because of vascular injuries were life-threatening conditions conversely to non-emergent conversions performed for technical reasons (i.e., pleural adhesions, limited space, stapler malfunction, difficult to perform single lung ventilation, and calcified nodes). Despite all, only four of 13 studies compared emergent versus non-emergent conversions. In three studies, no differences were found, but one study found that emergent conversion was associated with an increased mortality.

**Survival**

Five of 13 studies evaluated the long-term survival and found no significant difference between successful VATS and converted VATS. One study found a higher recurrence rate in converted compared to successful VATS group. Emergency conversion could lead to unintended disruption of cancer cells with dissemination of malignancy and higher risk of recurrence. By contrast, converted VATS group and/or upfront thoracotomy group included higher rate of patients with advanced cancer, likely more difficult to successfully resect by VATS. Therefore, it remained difficult to show whether these results were because of the negative impact of conversion, or the intergroup differences.

**Recommendations from the analysis**

VATSL remains a safe and feasible procedure. It should be strongly considered for the majority of patients undergoing lobectomy and the fear of unplanned conversion should not limit it being widely adopted. Because converted VATS could be associated with increased rates of post-operative complications, as found in seven studies, and of peri- and postoperative death as observed in four studies, the appropriate selection of patients remain mandatory to avoid unexpected conversion, especially in frail patients who would be considered high risk for thoracotomy. The preoperative identification of risk factors as calcified lymph node, advanced stage lung cancer, bronchovascular abnormalities, induction chemo-radiotherapy, and dense adhesions may help surgeons in selecting appropriate patients for VATSL. Furthermore, in case of unexpected complications, surgeons should be ready to convert to thoracotomy because patient safety must remain the primary objective of surgery. Delayed conversion and/or an unsuccessful attempt to manage complications by VATS increase the risk of intraoperative events that may be fatal.

**LIMITATIONS**

This article presented several limitations that should be taken in account before drawing definitive conclusions. All studies were retrospective. Obviously, the intraoperative conversion cannot be predicted and therefore, it makes it impossible to plan prospective randomized studies. Therefore, the different characteristics of the study groups (i.e., tumor stage, and pre-operative morbidity) could affect the results. Despite all, only one of 13 studies used propensity score matching analysis to balance the intergroup differences. Yet, the type of resection and the outcomes were not standardized between the studies as well as surgeon’s experience. Three of 13 studies included not only lobectomy, but also sublobar (i.e., wedge resection and segmentectomy) and/or more extended resections (i.e., bilobectomy and pneumonectomy). Only four of 13 studies compared emergent versus non-emergent conversion, 5 out of 13 studies evaluated long term survival, and 4 of 13 studies included upfront thoracotomy lobectomy for comparison. Yet, patients undergoing upfront thoracotomy presented higher rates of locally advanced cancer (usually considered difficult to resect by VATS) compared to patients undergoing converted VATS, making challenging any comparisons.

**CONCLUSIONS**

VATSL is the treatment of choice for early lung cancer. The fear of conversion should not limit the wide adoption of VATSL, but a careful selection of patients remains mandatory to avoid unexpected conversion that may negatively impact on surgical outcome especially for frail patients. Finally, the conversion should never be considered as a treatment failure. The decision to convert must be made promptly especially in case of life-threatening intraoperative complications.

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**REFERENCES**

1. https://www.nccn.org/patients/guidelines/content/PDF/lung-early-stage-patient.pdf
2. https://www.nice.org.uk/guidance/NG122
3. http://ascopubs.org/doi/suppl/10.1200/JCO.2017.74.6065/suppl_file/ms_2017.74.6065.pdf
4. Lim E, Batchelor TJP, Dunning J, et al. Video-assisted thoracoscopic or open lobectomy in early-stage lung cancer. NEJM Evid. 2022;1(3). Evidence.nejm.org/doi/abs/10.1056/EVIDoa2100016
5. Bendixen M, Jørgensen OD, Kronborg C, Andersen C, Licht PB. Post-operative pain and quality of life after lobectomy via video-assisted thoracoscopic surgery or anterolateral thoracotomy for early stage
lungs.

21. Samson P, Guitton J, Reed MF, Hanseman DJ, Starnes SL. Predictors of conversion to thoracotomy for video-assisted thoracoscopic lobectomy: a retrospective analysis and the influence of computed tomography-based calcification assessment. J Thorac Cardiovasc Surg. 2013;145(6):1512–8.

22. Park JS, Kim HK, Choi YS, Kim J, Shim YM, Kim K. Unplanned conversion to thoracotomy during video-assisted thoracic surgery is not compromise the surgical outcome. World J Surg. 2011;35(3):990–5.

23. Sawada S, Komori E, Yamashita M. Evaluation of video-assisted thoracoscopic surgery lobectomy requiring emergency conversion to thoracotomy. Eur J Cardiothorac Surg. 2009;36(3):487–90.

24. Jones RO, Casali G, Walker WS. Does failed video-assisted lobectomy for lung cancer prejudice immediate and long-term outcomes? Ann Thorac Surg. 2008;86(1):235–9.

25. Fiorelli A, Cascone R, Carlucci A, Natale G, Noro A, Bove M, et al. Conversion to thoracotomy during video-assisted thoracoscopic surgery lobectomy requiring emergency conversion to thoracotomy. Eur J Cardiothorac Surg. 2009;36(3):487–90.

26. Decaluwe H, Petersen RH, Hansen H, Piwkowski C, Augustin F, Brunelli A, et al. ESTS minimally invasive thoracic surgery interest group (MITIG). Major intraoperative complications during video-assisted thoracoscopic anatomical lung resections: an intention-to-treat analysis. Eur J Cardiothorac Surg. 2015;48(4):588–98.

27. Fiorelli A, Sagan D, Mackiewicz L, Cagini L, Scarneccia E, Chiodini P, et al. Incidence, risk factors, and analysis of survival of unexpected N2 disease in stage I nonsmall cell lung cancer. Thorac Cardiovasc Surg. 2015;63(7):558–67.

How to cite this article: Fiorelli A, Forte S, Santini M, Petersen RH, Fang W. Did conversion to thoracotomy during thoracoscopic lobectomy increase post-operative complications and prejudice survival? Results of best evidence topic analysis. Thorac Cancer. 2022;13(15):2085–99. https://doi.org/10.1111/1759-7714.14525