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META-ANALYSIS

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Perioperative Outcomes of Complex Versus Simple Segmentectomy Via Uniportal Video-Assisted Thoracoscopic Surgery for Lung Lesions: A Systematic Review and Meta-Analysis

Mohamed Elshiekh[1]; Laith Altawil[2]; Mohamed Yaseen Alfeetouri[3]; Felipe Passos[4]; Osama Barakat[5]; Samuel Heuts[6,7]; Setu Gupta[8]; Massimo Baudo[9]; Arian Arjomandi Rad[10]; Peyman Sardari Nia[6,7]; Muhammed Elhadi[11,12,*]

[1]Faculty of Medicine, University of Gezira, Wad Madani, Al-Jezira State, 5118 40466, Sudan
[2]Department of Cardiothoracic Surgery, Royal Brompton and Harefield Hospitals, Guy's and St Thomas' NHS Foundation Trust, London, UB9 6JH, United Kingdom
[3]Faculty of Medicine, University of Benghazi, Benghazi, Libya
[4]Department of Thoracic Surgery, MaterDei Hospital, Salvador, Bahia, 40.220-005, Brazil
[5]Faculty of Medicine, University of Aleppo, Aleppo, Syrian Arab Republic
[6]Department of Cardiothoracic Surgery, Maastricht University Medical Center, Maastricht, Limburg, 6229 HX, The Netherlands
[7]Department of Cardiothoracic Surgery, Cardiovascular Research Institute Maastricht (CARIM), Maastricht University, Maastricht, Limburg, 6229 ER, The Netherlands
[8]Brunel Medical School, Brunel University London, London, England, UB8 3PH, United Kingdom
[9]Department of Cardiac Surgery Research, Lankenau Institute for Medical Research, Main Line Health, Wynnewood, Pennsylvania, 19096, United States
[10]Department of Cardiothoracic Surgery, Oxford University Hospitals NHS Foundation Trust, Oxford, Oxfordshire, OX3 9DU, United Kingdom
[11]College of Medicine, Korea University, Seongbuk-gu, Seoul, 02841, South Korea
[12]Faculty of Medicine, University of Tripoli, Tripoli, 13275, Libya

*Corresponding author. College of Medicine, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul, 02841, South Korea (muhammed-elhadi@korea.ac.kr)

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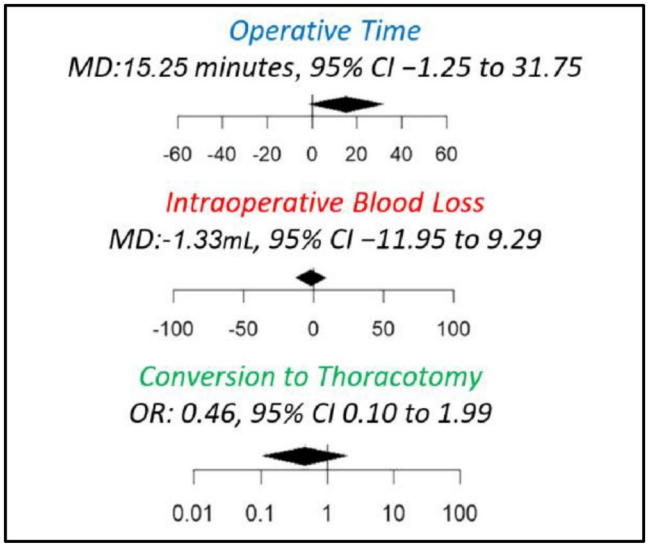
Author Contributions: Mohamed Elshiekh and Laith Altawil contributed equally and share first authorship.

Graphical abstract

Perioperative Outcomes of Complex versus Simple Segmentectomy via Uniportal Video-Assisted Thoracoscopic Surgery for lung lesions: A Systematic Review and Meta-Analysis

Summary

Study Summary
5 retrospective studies
1,051 patients (707 complex; 344 simple)
Population
Patients undergoing uniportal VATS segmentectomy for pulmonary lesions.
Comparison
Complex segmentectomy vs simple segmentectomy.
Main finding
No statistically significant differences were observed in perioperative outcomes.



Legend: Complex and simple uniportal VATS segmentectomy show similar perioperative outcomes, suggesting comparable safety in experienced centers.

Abstract

Objectives: Uniportal video-assisted thoracoscopic surgery (U-VATS) has been increasingly adopted for anatomical segmentectomy because of its minimally invasive nature and favourable recovery profile. However, whether perioperative outcomes differ between complex and simple segmentectomy when performed via U-VATS remains uncertain. This study compared perioperative outcomes between complex and simple U-VATS segmentectomy.

Methods: A systematic review and meta-analysis were conducted according to PRISMA 2020 and AMSTAR 2 guidelines, and the study was registered in PROSPERO (CRD420251151464). Six databases were searched for studies comparing complex and simple U-VATS segmentectomy for pulmonary lesions. Primary outcomes were operative time, intraoperative blood loss, and conversion to thoracotomy. Secondary outcomes included chest tube duration, hospital stay, and postoperative complications. Random-effects models were used for pooled analyses.

Results: Five retrospective studies, including 1051 patients (707 complex; 344 simple), were analysed. No statistically significant differences were detected in operative time (MD = 15.25 min, 95% CI: −1.25 to 31.75; $P = .07$; $I^2 = 88\%$), intraoperative blood loss (MD = −1.33 mL, 95% CI: −11.95 to 9.29; $P = .81$; $I^2 = 58\%$), or conversion to thoracotomy (OR = 0.46, 95% CI: 0.10-1.99; $P = .30$; $I^2 = 0\%$). Secondary outcomes also showed no significant differences, including chest tube duration (MD = −0.15 days, 95% CI: −0.41 to 0.11; $P = .25$; $I^2 = 26\%$), hospital stay (MD = −0.16 days, 95% CI: −0.73 to 0.40; $P = .57$; $I^2 = 66\%$).

Conclusions: No statistically significant differences were detected in key perioperative outcomes between complex and simple U-VATS segmentectomy; however, given substantial clinical heterogeneity and limited retrospective evidence, findings should be interpreted cautiously and are most applicable to selected patients treated in experienced, high-volume centres.

Keywords: complex segmentectomy; simple segmentectomy; uniportal video-assisted thoracoscopic surgery; meta-analysis; systematic review.

INTRODUCTION

Lung cancer remains one of the leading causes of cancer-related mortality worldwide.[1] Detection of early-stage disease has increased with advances in high-resolution CT and the broader adoption of screening programmes.[2–5] For patients with resectable non-small cell lung cancer (NSCLC), surgical resection remains the cornerstone of curative treatment. Although lobectomy has historically been regarded as the standard anatomical resection for early-stage NSCLC, anatomical segmentectomy has gained renewed attention as a lung-sparing option for carefully selected small peripheral tumours, supported by recent phase III randomized trials comparing segmentectomy/sublobar resection with lobectomy in peripheral stage IA NSCLC.[6,7]

Importantly, the extent of resection is primarily determined by oncologic adequacy (R0 margins and appropriate nodal assessment) and long-term outcomes (recurrence and survival), with perioperative outcomes providing complementary information regarding feasibility and short-term recovery.[8] In this setting, understanding whether technical complexity (simple versus complex segmentectomy) influences perioperative outcomes is relevant for operative planning and patient counselling.

With ongoing progress in minimally invasive techniques, video-assisted thoracoscopic surgery (VATS) has largely replaced thoracotomy for anatomical lung resection. VATS has been associated with improved early postoperative recovery—such as reduced postoperative pain and shorter hospital stay—compared with open surgery, while randomized evidence suggests overall complication rates may be similar in some settings.[9–11] More recently, uniportal VATS (U-VATS) has emerged as a refined single-incision approach with perioperative and oncological outcomes similar to those of multiportal VATS in appropriately selected patients, while potentially enhancing patient satisfaction through reduced invasiveness.[12]

Segmentectomy is commonly categorized by the number and configuration of intersegmental planes and is divided into simple and complex procedures.[13,14] A simple segmentectomy involves resection of a single segment with 1 intersegmental plane, whereas a complex segmentectomy requires dissection along 2 or more intersegmental planes.[15] Complex segmentectomy is technically demanding due to the need for accurate bronchovascular identification and management of multiple intersegmental planes. It has been associated with longer operative times and greater procedural complexity in some series.[16]

A recent meta-analysis by Bertolaccini et al[17] compared simple and complex segmentectomy using multiportal VATS and reported broadly similar postoperative outcomes, with longer operative times in complex procedures. However, evidence remains limited regarding the same comparison in the uniportal setting. Therefore, this systematic review and meta-analysis aimed to evaluate perioperative outcomes of complex versus simple segmentectomy performed via the U-VATS approach.

METHODS

This systematic review and meta-analysis were conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 statement[18] and the AMSTAR-2 checklist.[19] The PRISMA checklist and the AMSTAR2 evaluation are presented in **Tables S1 and S2**. The study protocol was registered in PROSPERO under the registration number CRD420251151464.

Search strategy

On August 20, 2025, a systematic search was conducted across 6 electronic databases: PubMed, Scopus, Embase, Cochrane Library, Web of Science, and the Virtual Health Library. In addition, manual searches were performed to identify relevant studies from other sources. The search strategy included keywords and Medical Subject Headings (MeSH) related to video-assisted thoracoscopic surgery, and Boolean operators (AND/OR) were applied to combine terms effectively. The complete search strategy is provided in **Table S3**.

Study selection

The study selection process was conducted in 2 stages: (1) title and abstract screening, followed by (2) full-text review. Both stages were carried out independently by 2 reviewers using the Covidence platform (covidence.org, Melbourne, Australia). Discrepancies were resolved through discussion or, if necessary, by consultation with a third reviewer.

Studies were eligible if they directly compared complex versus simple segmentectomy in patients undergoing uniportal video-assisted thoracoscopic surgery (U-VATS). The definitions of “simple” and “complex” segmentectomy varied slightly across the included studies, potentially introducing classification bias. To ensure consistency, we adopted an operational framework in which “simple segmentectomy” was defined as resection of a single anatomic segment with 1 intersegmental plane, and “complex segmentectomy” as an anatomical segmentectomy requiring division of 2 or more intersegmental planes. When study-specific definitions differed, classification followed the authors’ original descriptions and surgical illustrations. Across studies, definitions were generally consistent, though some also considered technical difficulty or bronchovascular complexity, which may contribute to minor heterogeneity. Specific definitions by each study are provided in **Table S4**.

Eligibility was assessed using the PICO framework: the population comprised patients undergoing U-VATS segmentectomy for pulmonary lesions; the intervention was complex segmentectomy; the comparator was simple segmentectomy; and the outcomes of interest included primary outcomes of operative time, intraoperative blood loss, and conversion to open thoracotomy (as this was consistently reported across included studies). Conversion

from uniportal to multiportal VATS/additional port placement was inconsistently reported. It could not be synthesized as a separate outcome, representing procedural efficiency and intraoperative safety. Secondary outcomes included chest tube drainage duration, postoperative hospital stay, and complication rates such as air leakage, pneumonia, and arrhythmia (mainly atrial fibrillation).

Exclusion criteria included studies involving multi-portal VATS (M-VATS), thoracotomy, or robotic approaches, as well as case reports, reviews, editorials, conference abstracts, and studies that did not report the specified outcomes. We also excluded overlapping publications by comparing author lists, study settings, and recruitment periods; duplicate studies; animal experiments; and *in vitro* research. No restrictions were applied regarding patient sex, country, language, or year of publication.

Data extraction

Data from eligible studies were extracted into a standardized Excel spreadsheet by 2 reviewers in a blinded manner. Continuous and dichotomous variables were collected and reported as mean ± SD. Where necessary, continuous data were converted to means and SDs to ensure consistency. A third reviewer resolved any discrepancies between the 2 reviewers to minimize bias. The extracted data included: study characteristics (author, name, publication year, study design, country, sample size, single versus multicentre), patients' demographics (including age and sex), lung lesions, preoperative localization, and Indocyanine green (ICG) for intersegmental delineation.

Quality assessment

The methodological quality and risk of bias of each included study were independently evaluated in a blinded manner by 2 reviewers using the Newcastle-Ottawa Scale (NOS) for cohort studies,[20] and a third reviewer resolved any disagreements. The NOS appraises the representativeness of the exposed cohort, the selection of the external control, the ascertainment of exposure, confirmation that the outcomes were not present at baseline, adjustment for main and additional factors, assessment of outcomes, and the adequacy and duration of follow-up. Each item that meets the criterion is awarded a "star," with a maximum possible score of 9. Studies scoring 7-9 stars were classified as high quality, those scoring 4-6 stars as moderate quality, and those scoring 0-3 stars as low quality.

Data analysis

Statistical analyses were performed in R (version 4.5.1) for all outcomes. A random-effects model was applied to account for potential heterogeneity among studies. For continuous variables, pooled analyses were conducted using mean differences (MD) and 95% confidence intervals (CIs), while for binary variables, odds ratios (ORs) with 95% CI were calculated. Statistical significance was defined as a *P*-value $<.05$. Heterogeneity was assessed using the *Q*-test ($P<.10$ indicating statistical significance) and the I^2 statistic, with values of 25%, 50%, and 75% representing low, moderate, and high heterogeneity, respectively. A leave-one-out analysis was performed to evaluate the robustness of the pooled results. Subgroup analyses were performed for studies reporting ICG use; however, given the small number of studies, these analyses should be considered exploratory. Assessment of publication bias was not feasible, as fewer than 10 studies were included in the analysis, rendering the funnel plots and statistical results inconsistent.

Certainty of evidence

We used the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) framework to evaluate the overall certainty of evidence,[21] which is categorized as very low, low, moderate, or high. The following predefined domains—risk of bias, inconsistency, indirectness, imprecision, and publication bias—serve as the basis for downgrading decisions.

RESULTS

Literature search results

A total of 286 studies were retrieved from the systematic search. After deduplication, 112 studies underwent title and abstract screening; the remaining 24 full-text articles were assessed for eligibility; one study identified from other resources was added manually. Ultimately, 5 studies met the inclusion criteria and were included in the final analysis.[22–26] The Prisma flow diagram is shown in **Figure 1**.

Study and patient characteristics

Five retrospective studies were included in this meta-analysis, encompassing 1051 patients. Among these, 707 patients underwent complex segmentectomy, and 344 patients underwent simple segmentectomy via the U-VATS approach. The studies were conducted in Japan, China, and the Republic of Korea between 2019 and 2025. The mean age ranged from 56.6 to 71.7 years, with a higher proportion of female patients across studies (416 males versus 635 females). Four of them were single-centre studies,[22,24–26] one was multicentre.[23]

Across included studies, clinical characteristics and operative context varied, including differences in underlying pathology (NSCLC-only cohorts versus mixed cohorts also including metastatic and benign/inflammatory lesions), tumour phenotype (including GGO-dominant lesions in some cohorts), and use of surgical adjuncts and planning strategies (ICG for intersegmental delineation and 3D reconstruction/planning/localization techniques).[22–26] The study characteristics are shown in **Table 1**.

Quality assessment

The 5 included studies were independently assessed using the NOS to assess the risk of bias. Their total scores ranged from 8 to 9, indicating low risk of bias across the studies (**Table S5**).

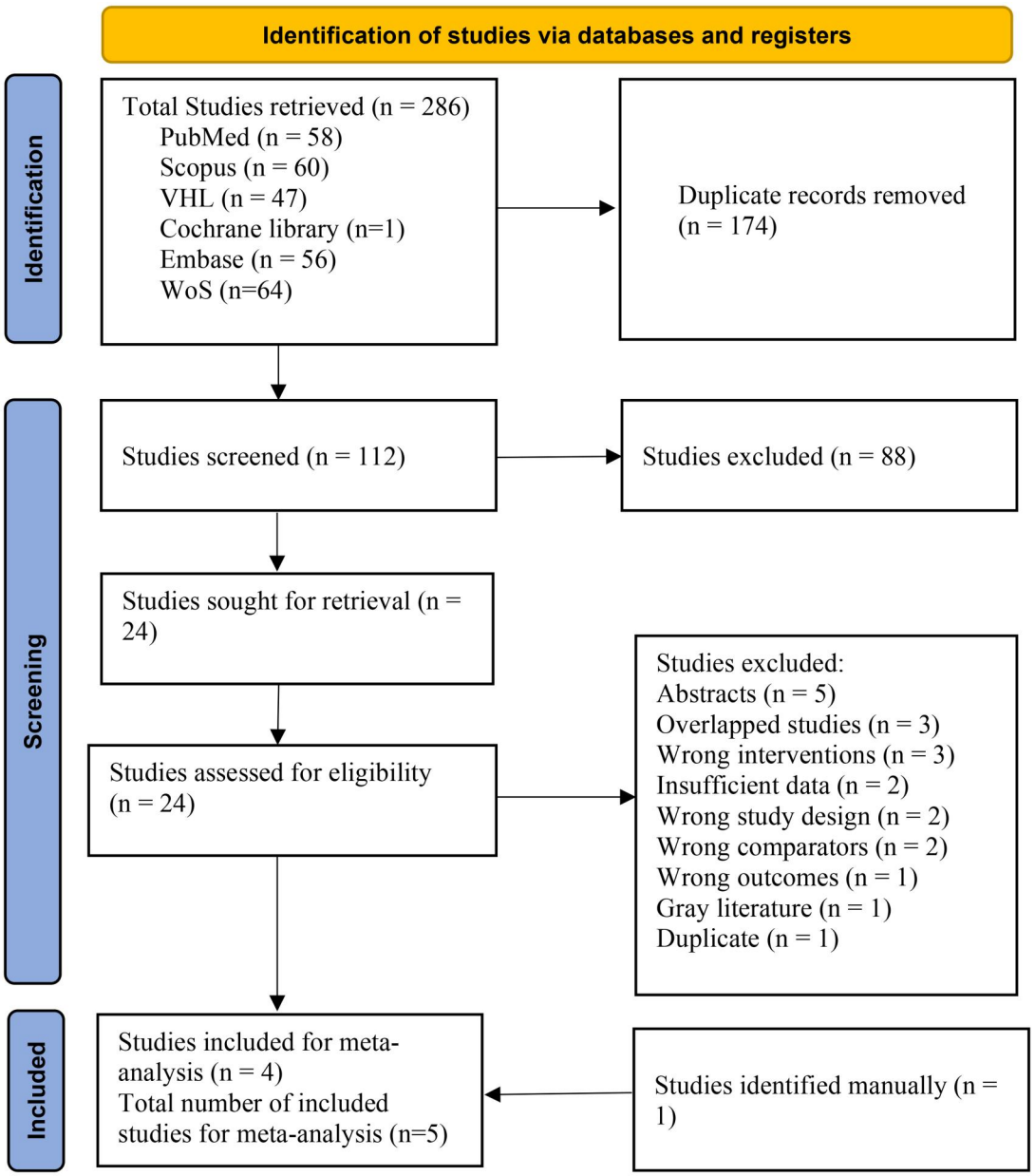


Figure 1. PRISMA 2020 flow diagram illustrating the study identification, screening, eligibility assessment, and inclusion process for studies comparing uniportal complex versus simple segmentectomy in patients with lung cancer.

Primary outcomes

Operative time

Five studies, comprising 1051 patients (707 complex segmentectomy, 344 simple segmentectomy), reported operation time; the pooled analysis showed no significant difference between the two groups (MD = 15.25 min, 95% CI: [−1.252, 31.752]; $P = .07$). Significantly high heterogeneity was observed between the included studies ($Tau^2 = 277.01$, $I^2 = 88\%$, $P < .0001$) (**Figure 2A**).

Intraoperative blood loss (mL)

Five studies, including 1051 patients (707 complex segmentectomy, 344 simple segmentectomy), reported blood loss (mL). The pooled analysis showed no significant difference between complex and simple segmentectomy in reducing blood loss (MD = −1.33 mL, 95% CI: [−11.95, 9.29]; $P = .806$). Heterogeneity was moderate ($Tau^2 = 74.838$, $I^2 = 58\%$, $P = .0484$) (**Figure 2B**).

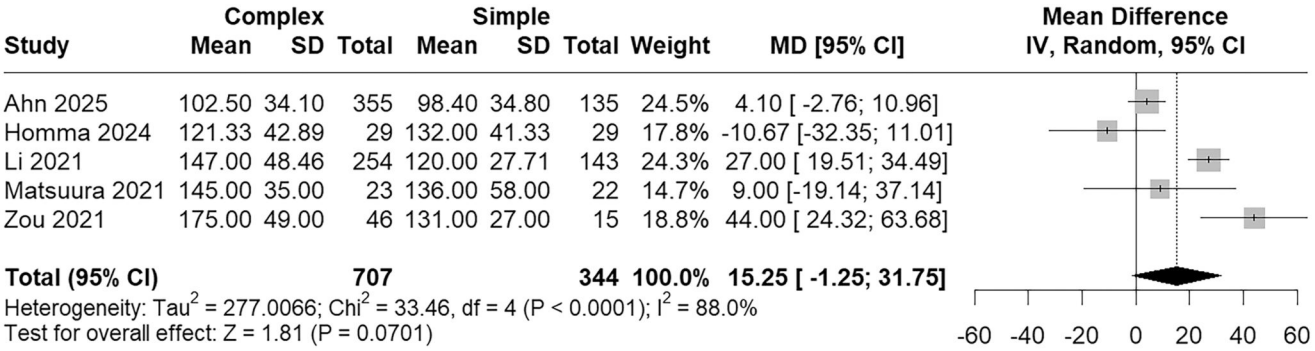
Conversion to open thoracotomy

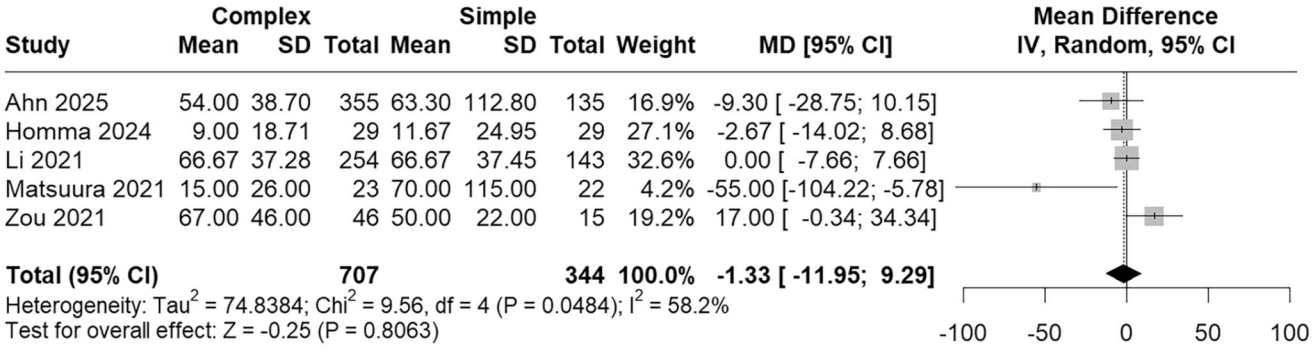
Four studies, reporting 993 patients (678 complex segmentectomy, 315 simple segmentectomy) reported conversion to open thoracotomy and were pooled for meta-analysis. There is no statistically significant difference between the two groups (OR = 0.46, 95% CI: [0.1, 1.99]; $P = .301$), with negligible heterogeneity observed ($Tau^2 = 0$, $I^2 = 0\%$, $P = .622$) (**Figure 2C**).

Table 1. Study and Patient Characteristics

Study name	Study design	Single/ multicentre	Country	Sample size	Age		Gender (male/female)		Smoking, *N* (%)		Lung lesion	Pre-operative localization	ICG use for intersegmental delineation
					Complex	Simple	Complex	Simple	Complex	Simple			
Ahn 2025	RS	Single centre	Republic of Korea	490	56.9 ± 11.2	56.6 ± 13	116/239	46/89	104 (29.3)	45 (33.3)	Peripheral NSCLC and metastases	Intraoperative CT, or intraoperative palpation with marking pen	Yes
Homma 2024	RS	Multi centre	Japan	58	71.67 ± 9.36	70.33 ± 13.26	16/13	19/10	15 (51.7)	14 (48.3)	Lung cancer, metastatic lung cancer or suspected lung cancer with GGO	Contrast enhanced CT with 3D reconstruction images	Yes
Li 2021	RS	Single centre	China	397	57.67 ± 9.69	56.67 ± 11.23	108/146	64/79	NR	NR	Subsolid nodules or benign lesions	HRCT	No
Matsuura 2021	RS	Single centre	Japan	45	70.5 ± 10.8	70.2 ± 9.8	13/10	11/11	NR	NR	Primary lung, metastatic lung cancer and inflammatory lesions	3D-CT angiography and bronchography	Yes
Zou 2021	RS	Single centre	China	61	57.3 ± 9.9	57.7 ± 10.5	17/29	6/9	6 (13)	2 (13.3)	NSCLC with GGO	HRCT	No

Abbreviations: GGO, ground glass opacity; HRCT, high-resolution CT; ICG, indocyanine green; NR, not reported; NSCLC, non-small cell lung cancer; RS, retrospective.





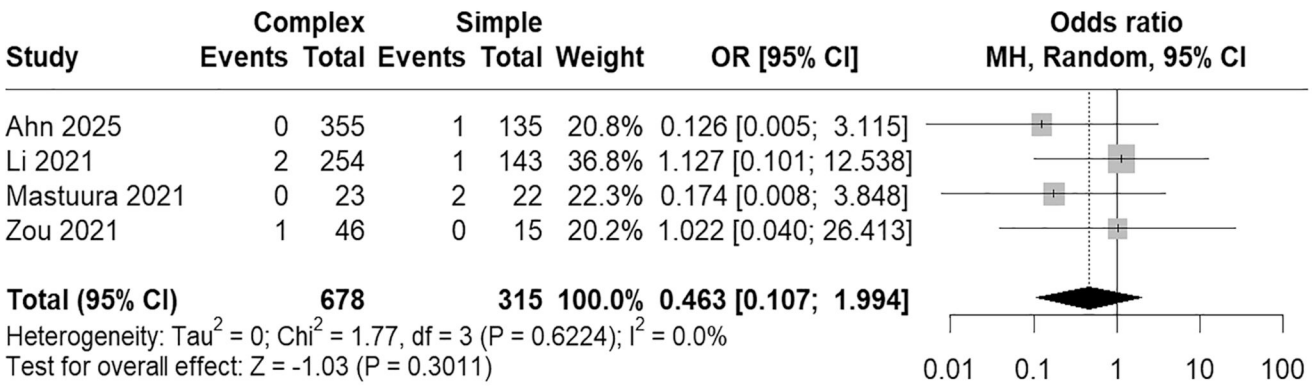


Figure 2. (A) Forest plot comparing operative time between complex and simple uniportal video-assisted thoracoscopic segmentectomy. (B) Forest plot comparing intraoperative blood loss between complex and simple uniportal video-assisted thoracoscopic segmentectomy. (C) Forest plot comparing conversion to open thoracotomy between complex and simple uniportal video-assisted thoracoscopic segmentectomy.

Secondary outcomes

Chest tube drainage duration (days)

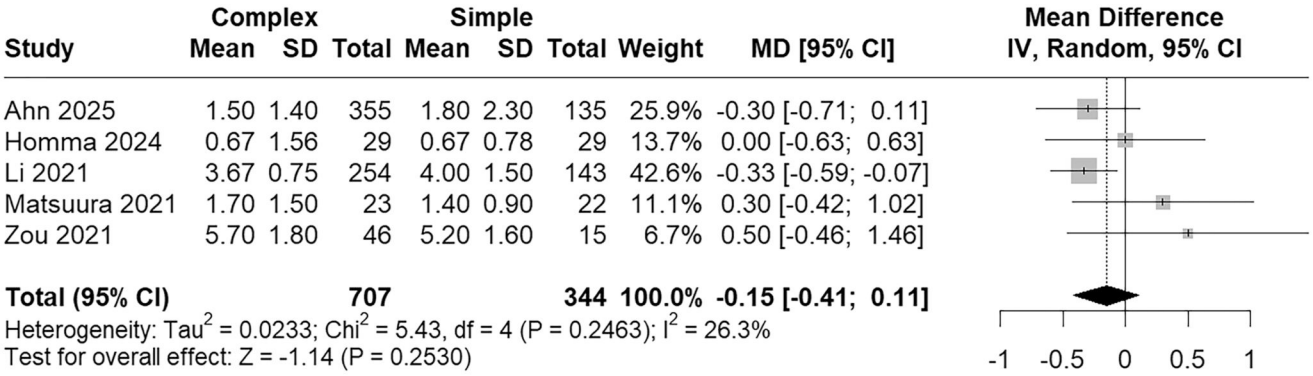
Five studies, comprising 1051 patients (707 complex segmentectomy, 344 simple segmentectomy), reported chest tube drainage duration (days). The meta-analysis did not find a statistically significant difference between the two groups (MD = −0.15, 95% CI: [−0.41, 0.11]; $P = .253$). Low heterogeneity was observed among the studies ($Tau^2 = 0.023$, $I^2 = 26\%$, $P = .2463$) (**Figure 3A**).

Postoperative hospital stay duration (days)

Five studies, comprising 1051 patients (707 complex segmentectomy, 344 simple segmentectomy), reported postoperative hospital stay duration (days). The pooled meta-analysis demonstrates no statistically significant difference (MD = −0.16 days, 95% CI: [−0.730, 0.40]; $P = .5713$). Moderate heterogeneity was observed among the studies ($Tau^2 = 0.257$, $I^2 = 66\%$, $P = .0188$) (**Figure 3B**).

Air leakage

Five studies, comprising 1051 patients (707 complex segmentectomy, 344 simple segmentectomy), reported air leakage. The pooled analysis showed no statistically significant difference between the two groups (OR = 1.465, 95% CI: [0.653, 3.286]; $P = .35$), with negligible heterogeneity ($Tau^2 = 0$, $I^2 = 0\%$, $P = .9828$) (**Figure 4A**).



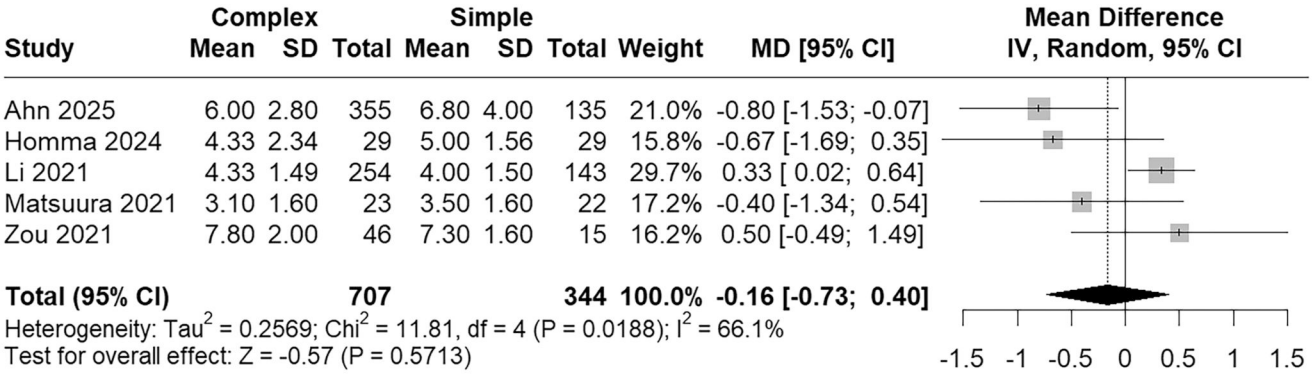


Figure 3. (A) Forest plot comparing chest tube drainage duration between complex and simple uniportal video-assisted thoracoscopic segmentectomy. (B) Forest plot comparing postoperative hospital stay duration between complex and simple uniportal video-assisted thoracoscopic segmentectomy.

Pneumonia

Three studies, comprising 609 patients (430 complex segmentectomy, 179 simple segmentectomy) reported pneumonia and were included in meta-analysis. The meta-analysis shows no significant difference between the two groups (OR = 0.55, 95% CI: [0.107, 2.83]; $P = .4749$) and demonstrated negligible heterogeneity ($Tau^2 = 0$, $I^2 = 0\%$, $P = 0.71$) (**Figure 4B**).

Arrhythmia

Three studies, with a total of 164 patients (98 complex segmentectomy, 66 simple segmentectomy), reported arrhythmia. There was no statistically significant difference between the two groups (OR 0.48, 95% CI: [0.104, 2.253]; $P = .3555$), also demonstrating negligible heterogeneity ($Tau^2 = 0$, $I^2 = 0\%$, $P = .9397$) (**Figure 4C**).

Sensitivity analysis

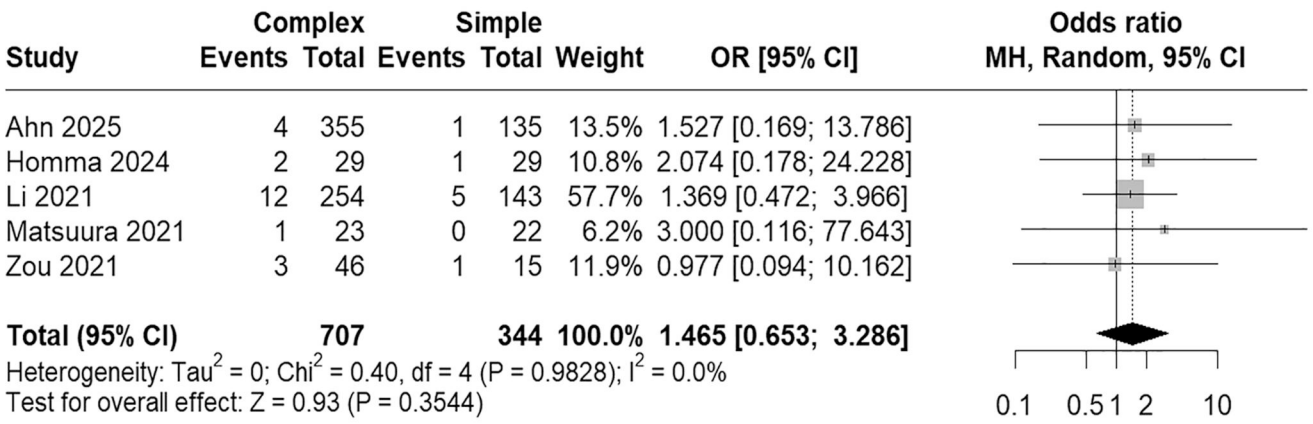
A leave-one-out sensitivity analysis was performed for all outcomes (**Figures S1-S8**). After excluding the study by Homma et al, operation time became statistically significant, with the complex segmentectomy group demonstrating a longer surgical duration (MD = 20.820 min; 95% CI: [3.072, 38.567]; $P = .0215$) (**Figure S1**). Similarly, exclusion of the studies by Matsuura et al and Zou et al from the analysis of chest tube drainage duration yielded significant mean differences (MD = −0.236 days; 95% CI: [−0.465, −0.007]; $P = .044$) and (MD = −0.230 days; 95% CI: [−0.447, −0.012]; $P = .038$), respectively (**Figure S4**). Sensitivity analyses of the remaining outcomes showed no meaningful impact on the overall results.

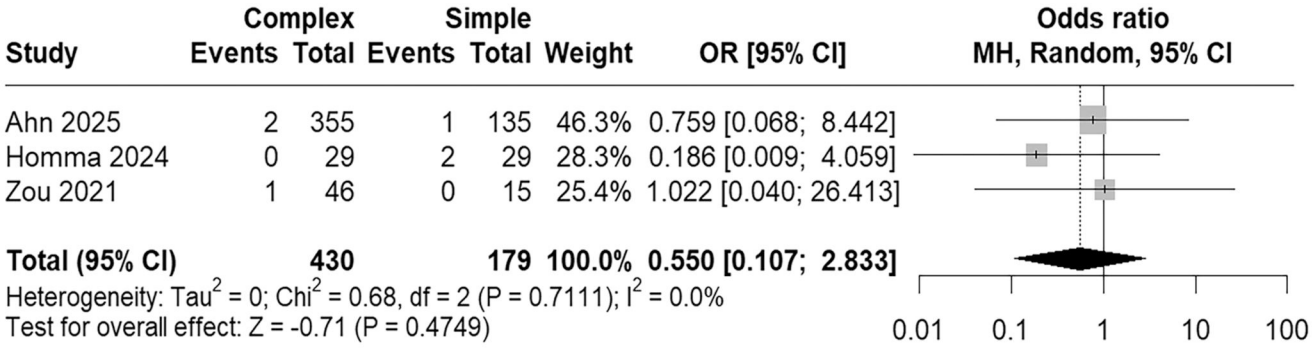
Subgroup analysis

Subgroup analyses were performed for studies reporting ICG use; these analyses are exploratory due to the small number of included studies. For operation time, the subgroup analysis demonstrated that MD remained non-significant between the 2 groups and heterogeneity became negligible (MD = 3.076 min; CI: [−3.294, 9.445]; $P = .34$) ($I^2 = 0\%$) (**Figure S9**). Similarly, for chest tube drainage duration, the MD remained non-significant, and heterogeneity decreased to a low level (MD = −0.104 days, CI: [−0.434, 0.227]; $P = .539$, $I^2 = 8\%$) (**Figure S12**). However, a difference in postoperative hospital stay duration was observed, with negligible heterogeneity; this finding should be interpreted cautiously given multiple comparisons and potential confounding (MD = −0.653, CI: [−1.156, −0.15]; $P = .011$, $I^2 = 0\%$) (**Figure S13**). Subgroup analysis for the remaining outcomes showed no meaningful results.

Publication bias

Because fewer than 10 studies were included, funnel plots and formal tests for asymmetry (eg, Egger's or





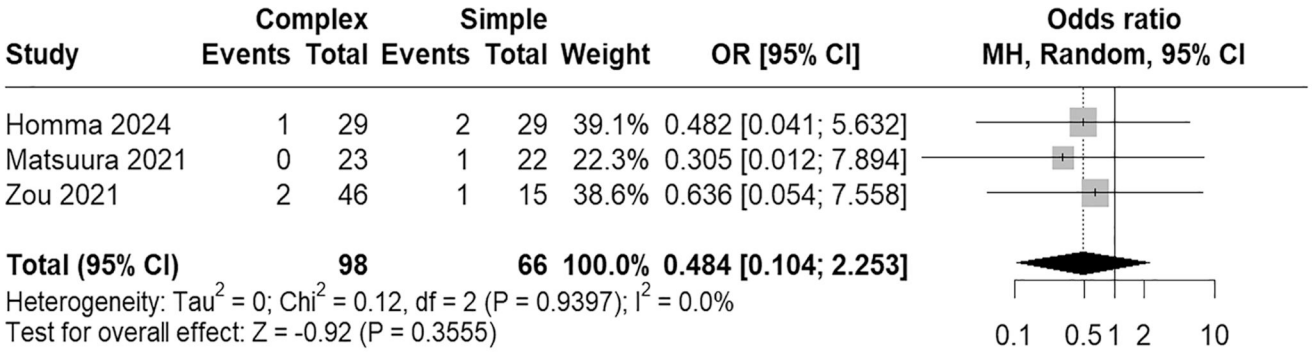


Figure 4. (A) Forest plot comparing postoperative air leakage incidence between complex and simple uniportal video-assisted thoracoscopic segmentectomy. (B) Forest plot comparing postoperative pneumonia incidence between complex and simple uniportal video-assisted thoracoscopic segmentectomy. (C) Forest plot comparing postoperative arrhythmia incidence between complex and simple uniportal video-assisted thoracoscopic segmentectomy.

Begg's tests) are generally considered unreliable and underpowered.[27] Therefore, publication bias could not be assessed formally in this meta-analysis.

GRADE summary

GRADE assessment revealed moderate-certainty evidence across air leakage, arrhythmia, and chest tube, downgraded due to imprecision. Conversion to open thoracotomy and pneumonia were rated as low-certainty due to imprecision and the limited number of studies. Operation time, intraoperative blood loss, and hospital stay were assessed as low for inconsistency, imprecision, and substantial heterogeneity—detailed justifications in **Table S6**.

DISCUSSION

In this systematic review and meta-analysis of 5 retrospective studies including 1051 patients, we evaluated perioperative outcomes of complex versus simple segmentectomy performed via the U-VATS approach. Across pooled analyses, no statistically significant differences

were detected between the groups for the primary outcomes (operative time, intraoperative blood loss, and conversion to thoracotomy) or secondary outcomes, including chest tube duration, length of stay, and postoperative complications (air leak, pneumonia, and arrhythmia). Although operative time tended to be longer for complex resections, estimates were imprecise and statistical heterogeneity was substantial for operative time and moderate for hospital stay, likely reflecting variation in case mix (including anatomic distribution of resections), surgeon experience/learning curve, and institutional protocols.

In exploratory subgroup analyses restricted to studies reporting ICG use, statistical heterogeneity was reduced for selected outcomes. However, given the small number of included studies, these subgroup findings are hypothesis-generating. They may reflect differences in technique, case selection, and centre experience rather than an effect attributable to ICG itself. Overall, the available evidence does not demonstrate clear perioperative disadvantages for complex versus simple U-VATS segmentectomy in appropriately selected patients treated in experienced centres, while acknowledging uncertainty related to heterogeneity and the limited observational evidence base.

Our findings align with prior evidence from multiportal VATS. The meta-analysis by Bertolaccini et al[17] reported broadly similar postoperative outcomes between simple and complex segmentectomy, with longer operative times in complex procedures. Our analysis extends this work by focusing on the uniportal approach and by including additional perioperative endpoints such as chest tube duration and intraoperative blood loss. While complex segmentectomy remains technically demanding—requiring precise bronchovascular identification and management of multiple intersegmental planes through a single access incision—the overall pattern across studies suggests that, in experienced hands, this complexity does not necessarily translate into clearly worse short-term outcomes at the group level.[28]

Importantly, under the definitions used in this review, classification as “simple” versus “complex” segmentectomy is largely determined by tumour location and segmental anatomy, as well as the technical requirements to achieve an oncologically adequate resection. In practice, the key operative decision is therefore less about choosing “simple versus complex” and more about selecting the appropriate resection strategy (segmentectomy versus lobectomy) and utilizing adjuncts that support safe plane identification and margin adequacy when segmentectomy is appropriate.

Regarding operative adjuncts, the included studies reported variable use of preoperative planning and intraoperative delineation strategies. Preoperative 3D planning was described in some cohorts (e.g. contrast-enhanced CT with 3D reconstruction in Homma et al, and routine 3D-CT angiography/bronchography in Matsuura et al). In contrast, other studies relied on high-resolution CT and/or alternative localization approaches. Beyond the included cohorts, preoperative 3D CT reconstruction has been shown to assist operative planning by confirming tumour location within the intended segment and helping anticipate surgical margins.[29,30] ICG for intersegmental delineation was reported in 3 included studies, while 2 studies did not report ICG use. Given this variability and the limited number of studies, these adjunct-related findings should be interpreted cautiously and do not support definitive conclusions regarding their independent impact on outcomes.

Oncologic surrogate reporting was inconsistent across studies. Margin distance was reported in Ahn et al and Zou et al, with similar margins between the complex and simple groups in those cohorts; however, R0 status and margin outcomes were not uniformly reported across all included studies, so we summarized these data narratively rather than pooling them.

Several limitations warrant emphasis. All included studies were retrospective and predominantly conducted in single-centre Asian cohorts, limiting generalizability. Clinical heterogeneity was substantial, including variation in underlying pathology (NSCLC-only cohorts versus mixed cohorts including metastatic and benign/inflammatory lesions), tumour phenotype (including GGO-dominant lesions), and use of adjuncts and planning/localization strategies (ICG and 3D planning). In addition, despite our operational framework, definitions of “simple” and “complex” segmentectomy were not fully uniform across studies, introducing potential classification bias and indirectness. Consequently, pooled estimates should be interpreted as average effects across heterogeneous clinical scenarios, and applicability is greatest for selected patients treated in experienced, high-volume centres.

Statistical heterogeneity was moderate to high for some outcomes (notably operative time and hospital stay). While sensitivity and subgroup analyses provide useful context, they cannot fully resolve underlying clinical differences. Finally, the small number of eligible studies and modest event counts for several secondary outcomes limit precision and preclude robust assessment of publication bias; therefore, the absence of statistical significance should not be interpreted as evidence of equivalence. Larger prospective, multicentre studies with standardized definitions and consistent reporting of perioperative and oncologic metrics are needed to confirm these findings.

CONCLUSION

In this systematic review and meta-analysis of 5 retrospective studies, no statistically significant differences were detected in key perioperative outcomes between complex and simple U-VATS segmentectomy. However, the available evidence is limited by substantial clinical heterogeneity, non-uniform definitions of “complex” segmentectomy, and imprecision for several outcomes; therefore, pooled estimates likely represent average effects across heterogeneous scenarios and should not be interpreted as evidence of equivalence. These

findings are most applicable to carefully selected patients undergoing U-VATS segmentectomy in experienced, high-volume centres. Larger prospective multicentre studies with standardized definitions and consistent reporting of perioperative and oncologic metrics are required.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *ICVTS* online.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest related to this article.

DATA AVAILABILITY

All data analysed in this study are derived from previously published articles and are included within this article and its supplementary materials. No new datasets were generated during the current study.

ETHICAL APPROVAL

Ethical approval was not required for this study as it involved analysis of previously published data.

USE OF ARTIFICIAL INTELLIGENCE TOOLS

Artificial intelligence tools (OpenAI ChatGPT, July 2025 version) were used to assist in scientific writing enhancement and language editing. All authors reviewed and approved the final content.

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Meta-analysis