Cureus
Part of SPRINGER NATURE

Open Access Review Article

Uniportal Robotic-Assisted Versus Uniportal Video-Assisted Thoracoscopic Surgery for Anatomic Pulmonary Resection: A Systematic Review and Meta-Analysis

Review began 10/16/2026
Review ended 11/15/2026
Published 11/20/2026

© **Copyright** 2026
Alahmadi et al. This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

DOI: 10.7759/cureus.120023

Hawazen O. Alahmadi [1], Latifah A. Alfaraj [2], Yaser Saleh Alkraidis [3], Imran Nizar Musawa [4], Manal Alsurahi [5], Saleh A. Almaktoum [6], Ahmed Jaffar Almarzooq [7], Rana A. Alharbi [2], Aqeel Mohammed Al-Sharif [5], Sharif Abuelgasim [8], Ali I. Atwi [9], Rafal Aseel [9], Marwan Amin Ibrahim Abu Fara [10]

1. College of Medicine, Taibah University, Madinah, SAU 2. College of Medicine, Princess Nourah Bint Abdulrahman University, Riyadh, SAU 3. Department of General Surgery, Saudi German Hospital, Riyadh, SAU 4. Faculty of Medicine, University of Tabuk, Tabuk, SAU 5. College of Medicine, Taif University, Taif, SAU 6. Department of General Surgery, Eastern Health Cluster, Dammam, SAU 7. College of Medicine, King Faisal University, Hofuf, SAU 8. Department of Medicine and Surgery, University of Medical Sciences and Technology, Khartoum, SDN 9. Department of Internal Medicine, King Abdulaziz University Faculty of Medicine, Jeddah, SAU 10. Department of General Surgery, Dr. Soliman Fakeeh Hospital, Jeddah, SAU

Corresponding author: Sharif Abuelgasim, saqqai@hotmail.com

Abstract

Uniportal robotic-assisted thoracic surgery (uRATS) combines single-incision access with robotic technology, but its advantages over uniportal video-assisted thoracoscopic surgery (uVATS) for anatomic pulmonary resection remain unclear. We systematically evaluated comparative perioperative, recovery, and lymph node outcomes. Following PRISMA guidelines, PubMed/MEDLINE, Scopus, Embase, Web of Science, and the Cochrane Library were searched from inception through October 2026. Studies directly comparing uRATS with uVATS in adults undergoing anatomic pulmonary resection were eligible. Risk of bias was assessed using Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I). Outcomes suitable for quantitative synthesis were pooled as mean differences (MDs) or risk ratios (RRs) with 95% confidence intervals using random-effects models. Four retrospective comparative studies encompassing 502 patients (235 uRATS, 267 uVATS) were included. uRATS was associated with shorter chest tube duration (MD: -0.76 days; 95% CI: -1.33 to -0.19; p = 0.009), higher lymph node yield (MD: 3.41 nodes; 95% CI: 2.15 to 4.68; p < 0.001), and lower rates of overall (RR: 0.43; 95% CI: 0.23 to 0.78; p = 0.006) and minor (RR: 0.29; 95% CI: 0.12 to 0.67; p = 0.004) postoperative complications. After excluding one study, confidence intervals crossed the null for chest tube duration and overall and minor complications. Higher lymph node yield persisted after separately excluding either study rated at serious risk of bias. Hospital stay was summarized narratively. Operative-time estimates differed substantially between studies. No statistically significant differences were detected in intraoperative blood loss, lymph node station count, early postoperative pain, or major complications. Conversion events were too few for a reliable comparison. uRATS may offer short-term advantages in selected recovery, lymph node, and complication outcomes, but sparse severe events limit safety conclusions. Evidence is limited by four retrospective studies, moderate risk of bias in two studies and serious risk in two, and substantial heterogeneity in chest tube duration (I^2 = 88.5%) and operative time (I^2 = 98%). Prospective multicenter trials with standardized outcomes and long-term oncologic follow-up are warranted.

Categories: General Surgery, Oncology
Keywords: lung cancer, meta-analysis, minimally invasive thoracic surgery, uniportal robotic-assisted thoracic surgery, uniportal video-assisted thoracoscopic surgery

Introduction And Background

Lung cancer remains the leading cause of cancer-related mortality worldwide, with an estimated 2.5 million new cases and 1.8 million deaths reported in 2022, and surgical resection remains the main treatment for patients with resectable disease [1-4].

Over recent decades, thoracic surgery has shifted from open thoracotomy toward minimally invasive approaches. Video-assisted thoracoscopic surgery (VATS) has been associated with less postoperative pain and better quality of life than thoracotomy in early-stage lung cancer [5-8]. The development of uniportal video-assisted thoracoscopic surgery (uVATS), first described for anatomical lung resection in 2011, further reduced surgical trauma by utilizing a single intercostal incision, potentially improving postoperative recovery while maintaining oncologic adequacy [9].

In contrast, robotic-assisted thoracic surgery (RATS) offers three-dimensional visualization, improved instrument articulation, and tremor filtration [10,11]. Evidence from comparative studies suggests that RATS

provides outcomes comparable to VATS, with some reports indicating improved lymph node dissection and shorter hospital stay [12,13]. However, conventional RATS typically requires multiple ports [14,15].

The integration of uniportal access with robotic technology has led to the development of uniportal robotic-assisted thoracic surgery (uRATS). This approach combines the single-incision concept of uVATS with the technical advantages of robotic systems. Early comparative studies have reported perioperative outcomes and lymph node assessment following uRATS for anatomic pulmonary resection [16-19]. However, direct comparisons between uRATS and uVATS remain limited, and the available studies are primarily retrospective, with relatively small sample sizes and heterogeneous outcome reporting.

Given the increasing use of both techniques, the clinical question is no longer whether minimally invasive surgery is beneficial, but rather whether the addition of robotic technology to the uniportal approach provides measurable advantages over uVATS. A comprehensive evaluation of perioperative outcomes, postoperative recovery, complications, and lymph node assessment is required to clarify the relative benefits of these approaches.

The aim of this systematic review and meta-analysis was to compare uRATS and uVATS for anatomical pulmonary resection, focusing on perioperative outcomes, postoperative recovery, and lymph node dissection parameters.

Review

Methods

Protocol and Reporting Standards

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and followed the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions [20,21].

Data Sources and Search Strategy

A comprehensive literature search was performed in PubMed/MEDLINE, Scopus, Embase, Web of Science, and the Cochrane Library from database inception to October 2026. The search strategy combined terms related to uniportal surgery, RATS, and VATS. The following search terms were used: (uniportal OR "single port" OR single-port OR "single incision" OR single-incision OR "single access" OR single-access) AND (robotic OR robot-assisted OR "robot assisted" OR robotic-assisted OR "robotic assisted" OR RATS OR uRATS OR URATS OR "uniportal robotic" OR "single-port robotic") AND (VATS OR uVATS OR UVATS OR "video-assisted thoracoscopic surgery" OR "video assisted thoracoscopic surgery" OR thoracoscopic OR thoracoscopy) AND (lung OR pulmonary OR thoracic OR lobectomy OR segmentectomy OR pneumonectomy OR bilobectomy OR "sleeve resection" OR "anatomic resection" OR "anatomical resection" OR "lung resection" OR "pulmonary resection" OR NSCLC OR "non-small cell lung cancer").

Eligibility Criteria and Study Selection

Studies were considered eligible if they included adult patients undergoing anatomic pulmonary resection and directly compared uRATS with uVATS. Eligible studies were required to report at least one relevant perioperative or oncologic outcome and could use either a randomized or non-randomized comparative design. Studies were excluded if they involved non-anatomic resections without separately reported results, compared multiport robotic approaches, or were case series without a comparator group. Reviews, editorials, and conference abstracts without full-text availability were also excluded. Potential cohort overlap was assessed across all included reports by comparing author lists, participating institutions, recruitment periods, eligibility criteria, sample sizes, patient characteristics, and surgical procedures. Reports sharing institutions and overlapping recruitment periods were examined further for similarities in cohort descriptions and participant characteristics. When overlap was identified or could not be excluded, the publication providing the most complete relevant dataset was retained to avoid counting the same participants more than once within a pooled analysis.

Two reviewers (H.O.A. and L.A.A.) independently screened all titles and abstracts and subsequently assessed potentially eligible full-text articles against the predefined eligibility criteria. Both stages were performed in duplicate using Rayyan to manage the screening process. Disagreements were resolved through discussion, with a third reviewer (Y.S.A.) adjudicating unresolved disagreements. All study inclusion and exclusion decisions were made by the reviewers; no automated eligibility decisions were used. Inter-reviewer agreement was not quantified using Cohen’s kappa.

Data Extraction

Data were extracted using a standardized form. Extracted variables included study characteristics (author,

year, study design, sample size), patient characteristics, surgical approach, and reported outcomes. Continuous outcomes included operative time, intraoperative blood loss, lymph node yield, lymph node stations, chest tube duration, postoperative hospital stay, and early postoperative pain. When outcomes were reported as medians with interquartile ranges, they were converted to means and standard deviations prior to analysis. For categorical pain data, the mean and standard deviation were calculated from reported distributions. Dichotomous outcomes included conversion to thoracotomy, overall postoperative complications, minor complications, and major complications.

Two reviewers (M.M.A. and S.A.A.) independently extracted data from each included study using the standardized extraction form. Completed forms were compared, and discrepancies were resolved through discussion and re-examination of the original reports. Unresolved discrepancies were adjudicated by a third reviewer (I.N.M.). Data extraction was conducted manually without automated extraction tools.

Risk of Bias Assessment

Risk of bias in the included studies was assessed using the Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I) tool. The domains evaluated were bias due to confounding, participant selection, classification of interventions, deviations from intended interventions, missing data, outcome measurement, and selective reporting. Each study was classified as having low, moderate, serious, or critical risk of bias. Confounding judgments considered whether matching or adjustment adequately controlled important prognostic factors and whether relevant imbalances remained between groups. Overall judgments reflected the most severe domain-level judgment for the outcome assessed [22,23].

Two reviewers (Y.S.A. and I.N.M.) independently assessed each included study. Disagreements were resolved through discussion, with a third reviewer (H.O.A.) adjudicating unresolved differences. Risk-of-bias assessment was conducted manually without automated assessment tools.

Outcomes

Continuous outcomes were pooled when reported in at least two studies. Dichotomous outcomes were pooled only when clearly reported in at least three studies. Minor complications were defined as grades I-II and major complications as grade ⩾III. For studies using the Ottawa Thoracic Morbidity and Mortality classification, grades 1-2 were considered minor and grades 3a-4b were considered major [24]. Pain outcomes were analyzed separately by timepoint. Early postoperative pain was defined as measurements within 24 hours after surgery.

Statistical Analysis

Statistical analyses were performed using R software (R Foundation for Statistical Computing, Vienna, Austria) with meta packages. Continuous outcomes were pooled as mean differences (MDs) and binary outcomes as risk ratios (RRs) using inverse-variance random-effects models. Between-study variance (τ^2) was estimated using restricted maximum likelihood (REML). Pooled effects were reported with 95% confidence intervals calculated using the conventional normal-approximation (Wald-type) method. Binary outcomes were pooled on the log-RR scale and back-transformed for presentation. The intervention group was defined as uRATS and the comparator group as uVATS. For studies with zero events in one arm, a continuity correction was applied to calculate finite log RRs and their standard errors for inverse-variance random-effects pooling. Studies with zero events in both arms were displayed in forest plots but excluded from pooled RR estimates. Heterogeneity was assessed using the I^2 statistic and Cochran's Q test. I^2 values below 25% were considered very low, 25-50% low, 50-75% moderate, and above 75% high heterogeneity. Leave-one-out sensitivity analyses were performed for outcomes reported in at least three studies to assess study influence and heterogeneity [25,26]. Additional sensitivity analyses for hospital stay, chest tube duration, and lymph node yield excluded the noncontemporaneous cohort judged to have serious risk of bias due to confounding, using the same random-effects model specifications as the primary analyses. A two-sided p-value <0.05 was considered statistically significant. Funnel plot analysis was not performed due to the small number of included studies [20]. Outcomes were summarized narratively when uncertainty in the reported summary statistics precluded reliable quantitative synthesis.

Results

Study Selection

A total of 833 records were identified through database searching: PubMed/MEDLINE (n = 172), Scopus (n = 213), Embase (n = 200), Web of Science (n = 239), and the Cochrane Library (n = 9). After removal of 196 duplicate records, 637 records remained for title and abstract screening. Title and abstract screening excluded 552 records: wrong population (n = 118), multiport robotic approach (n = 63), other ineligible intervention or comparator (n = 79), no comparator group (n = 83), review or editorial publication (n = 99), and non-anatomic resection (n = 110). Following full-text assessment, 81 reports were excluded because of an ineligible intervention or route (n = 27), an ineligible population (n = 21), an ineligible study design (n =

17), or duplication (n = 16). Finally, four studies were included in the qualitative synthesis and meta-analysis (Figure *1*).

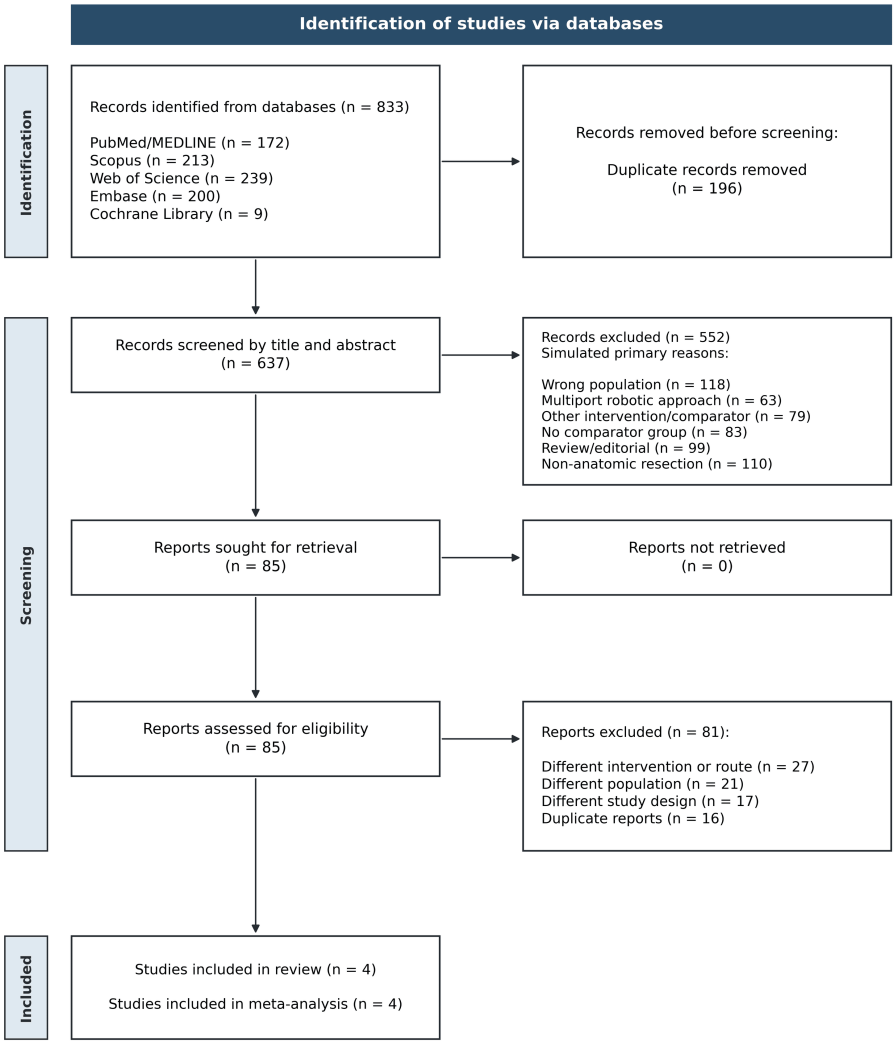


FIGURE 1: PRISMA flow diagram of study selection.

Quality Assessment

Overall risk of bias was moderate in Hsieh et al. [17] and Wang et al. [18] and serious in Paradela et al. [16] and İşcan et al. [19]. Confounding was rated as serious in Paradela et al. [16] because the initial uVATS and uRATS series were separated by approximately a decade, neither calendar period nor resection type was included in matching, and important differences in surgical procedures remained between groups. In İşcan et al. [19], serious confounding concerns arose from baseline pulmonary-function differences without matching or multivariable adjustment. Confounding was rated as moderate in Hsieh et al. [17] and Wang et al. [18]. Across all four studies [16-19], participant selection, deviations from intended interventions, outcome measurement, and selection of the reported result were rated as moderate risk, while intervention classification and missing data were rated as low risk (Figure *2*).

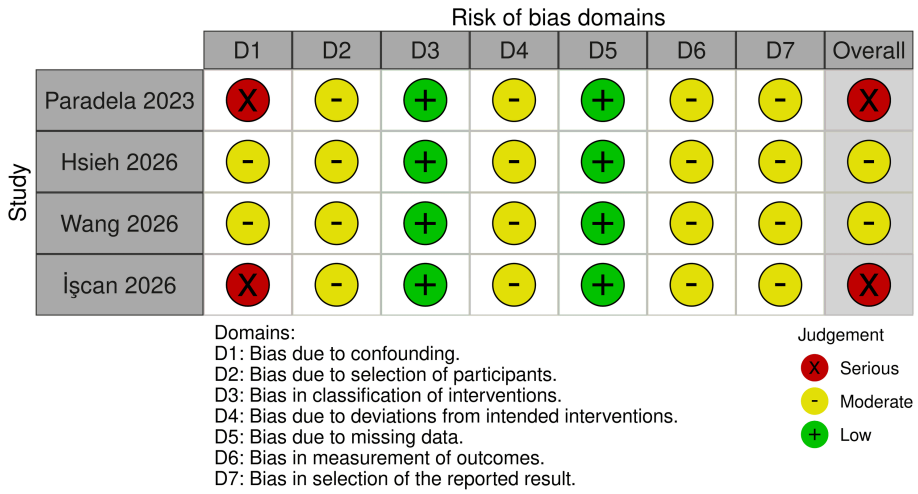


FIGURE 2: Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I) assessment.

References: [16-19]

Characteristics of the Included Studies

Four studies met the eligibility criteria and were included in the main analysis: Paradela et al. [16], Hsieh et al. [17], Wang et al. [18], and İşcan et al. [19]. All were retrospective comparative studies of uRATS versus uVATS for anatomic pulmonary resection. Three studies used propensity score matching [16-18], whereas İşcan et al. [19] was an unmatched cohort. The final analysis included 502 patients, with 235 patients in the uRATS group and 267 patients in the uVATS group. Most procedures were lobectomies or segmentectomies, although Paradela et al. [16] also included bilobectomy, pneumonectomy, and airway/sleeve resections. Wang et al. [18] and İşcan et al. [19] included only non-small cell lung cancer (NSCLC) patients, while Hsieh et al. [17] included malignant or suspicious pulmonary lesions, and Paradela et al. [16] included anatomic resections for lung cancer and other selected pathologies. Important between-group differences remained despite matching. In Paradela et al. [16], segmentectomies occurred in 20/68 uRATS versus 4/68 uVATS patients, pneumonectomies in 1/68 versus 7/68, and lung cancer diagnoses in 51/68 versus 64/68. In Hsieh et al. [17], ASA class III was more frequent in the matched uRATS group (85/98 versus 71/98). İşcan et al. [19] reported higher pulmonary function values in the unmatched uRATS group. The included studies mainly reported short-term perioperative outcomes, including operative time, complications, chest tube duration, hospital stay, pain scores, and lymph node assessment (Tables *1*-*2*).

Study	Country/setting	Study design	Study period	Sample size used in analysis	Population	uRATS approach	uVATS comparator	Anatomic procedures included	Matching/adjustment	Main reported outcomes	Follow-up/outcome window
Paradela et al., 2023 [16]	Europe: Spain/Romania/Portugal	Retrospective, noncontemporaneous comparative study with propensity score matching; both initial surgical series were performed by the same surgeon.	August 2010-October 2022 overall; initial uVATS series beginning in 2010, with uRATS introduced in September 2021	68 uRATS/68 uVATS matched pairs; some perioperative outcomes reported as 67/67	Patients undergoing anatomic lung resection; included lung cancer and other selected pathologies	Pure uRATS using a single intercostal incision with robotic camera, robotic instruments, and robotic staplers	uVATS through a single incision	Segmentectomy, lobectomy, bilobectomy, pneumonectomy, airway/sleeve resection	PSM using sex, age, smoking status, FEV_1, cardiovascular risk factors, pleural adhesions, and tumor size; calendar period and resection type were not included.	Operative time, conversion, complications, lymph node yield, lymph node stations, chest drain duration, hospital stay, mortality	30-day perioperative outcomes
Hsieh et al., 2026 [17]	Taiwan	Retrospective comparative study with propensity score matching	July 2023-July 2025	98 uRATS/98 uVATS matched pairs	Patients undergoing anatomic pulmonary resection for lung cancer or suspicious pulmonary lesions	Multi-arm da Vinci Xi uRATS through a single incision	uVATS through a single incision	Segmentectomy and lobectomy	1:1 PSM using age, sex, BMI, COPD, and resection type (segmentectomy versus lobectomy); ASA classification was not included.	Operative time, chest drainage duration, hospital stay, pain scores, lymph node counts, complications, mortality, cost-effectiveness	Early postoperative/30-day outcomes
Wang et al., 2026 [18]	China	Retrospective comparative study with propensity score matching	April 2023-April 2025	57 uRATS/57 uVATS matched pairs	NSCLC patients undergoing anatomic pulmonary resection	Multi-arm uRATS through a single incision; endoscopic stapler used for bronchial and vascular division	uVATS through a single incision	Lobectomy and segmentectomy	1:1 PSM using sex, age, BMI, smoking history, comorbidities, surgical site, surgical type, and pathological TNM stage	Operative time, blood loss, lymph node yield, lymph node stations, pain scores, complications, hospital stay, cost	Short-term perioperative outcomes; chronic pain/cough assessed at ≥2 months
İşcan et al., 2026 [19]	Türkiye	Retrospective single-center comparative cohort	January 2024-December 2025	12 uRATS/44 uVATS	Consecutive NSCLC patients undergoing uniportal anatomic lung resection	da Vinci Xi uRATS through a single 4-cm incision	uVATS through a single incision	Lobectomy, segmentectomy, pneumonectomy	No propensity matching or multivariable adjustment	Operative time, blood loss, pain, air-leak duration, chest tube duration, hospital stay, complications, lymph node yield, R0 resection, textbook outcome	30-day postoperative outcomes; follow-up also reported for recurrence and mortality

TABLE 1: Characteristics of the included studies.

ASA, American Society of Anesthesiologists; FEV_1, forced expiratory volume in one second; NSCLC, non-small cell lung cancer; PSM, propensity score matching; TNM, tumor, node, metastasis; uRATS, uniportal robotic-assisted thoracic surgery; uVATS, uniportal video-assisted thoracoscopic surgery

Study	Group	N	Age	Male sex	BMI	Smoking status	Pulmonary function	Comorbidities/performance status	Tumor/disease baseline	Resection type
Paradela et al., 2023 [16]	uRATS	68	65.7 ± 1.1 years	44/68	NR	47/68 smokers	FEV_1%: 85.3 ± 1.7	CVRF: 38/68; pleural adhesions: 22/68	Tumor size: 3.0 ± 0.2 cm; lung cancer: 51/68	Segmentectomy 20; lobectomy 40; bilobectomy 5; pneumonectomy 1; airway resection 2
	uVATS	68	64.8 ± 1.2 years	43/68	NR	48/68 smokers	FEV_1%: 84.4 ± 2.4	CVRF: 40/68; pleural adhesions: 23/68	Tumor size: 3.1 ± 0.2 cm; lung cancer: 64/68	Segmentectomy 4; lobectomy 54; bilobectomy 3; pneumonectomy 7; airway resection 0
Hsieh et al., 2026 [17]	uRATS	98	60.00 (53.25-67.00) years	35/98	23.12 (21.37-26.08) kg/m²	Ex/inactive/active: 13/78/7	FEV_1: 2.26 (1.88-2.68) L; FEV_1%: 93.50 (85.00-104.75)	ECOG 0/1: 86/12; ASA <3/3: 13/85; COPD: 4/98	CT tumor size: 1.20 (0.87-2.10) cm; malignant diagnosis: 85/98	Segmentectomy 83; lobectomy 15
	uVATS	98	60.00 (50.50-66.75) years	35/98	24.98 (22.00-26.00) kg/m²	Ex/inactive/active: 7/80/11	FEV_1: 2.23 (1.83-2.64) L; FEV_1%: 95.50 (85.00-106.00)	ECOG 0/1: 80/18; ASA <3/3: 27/71; COPD: 4/98	CT tumor size: 1.16 (0.80-1.80) cm; malignant diagnosis: 87/98	Segmentectomy 85; lobectomy 13
Wang et al., 2026 [18]	uRATS	57	66.00 (59.00-70.00) years	14/57	24.20 (21.60-26.50) kg/m²	8/57 smokers	NR	Comorbidities: none 34; hypertension 19; diabetes 4	NSCLC cohort; invasive adenocarcinoma 46/57; SCC 1/57	Lobectomy 43; segmentectomy 14
	uVATS	57	61.00 (57.00-70.00) years	18/57	23.80 (21.80-25.90) kg/m²	10/57 smokers	NR	Comorbidities: none 36; hypertension 16; diabetes 5	NSCLC cohort; invasive adenocarcinoma 43/57; SCC 2/57	Lobectomy 44; segmentectomy 13
İşcan et al., 2026 [19]	uRATS	12	67 (61-74) years	8/12	27.6 (22.8-29.4) kg/m²	Ever-smoker: 10/12; pack-years: 45 (25-62)	FEV_1: 2.46 (2.15-2.89) L; FEV_1 (% predicted): 102 (91-106)	CCI: 5 (3-6); ASA ≥III: 7/12; ECOG ≥1: 7/12; COPD: 5/12	CT tumor size: 27 (14-38) mm; PET-CT tumor size: 24 (13-38) mm; SUVmax: 7.0 (5.7-10.2)	Lobectomy 8; segmentectomy 3; pneumonectomy 1
	uVATS	44	68 (62-72) years	34/44	27.0 (25.0-30.0) kg/m²	Ever-smoker: 37/44; pack-years: 45 (19-62)	FEV_1: 2.29 (1.84-2.69) L; FEV_1 (% predicted): 85 (75-102)	CCI: 4 (3-5); ASA ≥III: 27/44; ECOG ≥1: 30/44; COPD: 16/44	CT tumor size: 24 (16-35) mm; PET-CT tumor size: 24 (16-33) mm; SUVmax: 8.6 (3.1-12.6)	Lobectomy 34; segmentectomy 9; pneumonectomy 1

TABLE 2: Baseline characteristics of the included studies.

FEV_1/forced vital capacity (FVC) values from İşcan et al. [19] were omitted because the source publication reported values exceeding 100% without clarifying whether these represented percentage-predicted measurements.

ASA, American Society of Anesthesiologists; BMI, body mass index; CCI, Charlson Comorbidity Index; COPD, chronic obstructive pulmonary disease; CVRF, cardiovascular risk factors; ECOG, Eastern Cooperative Oncology Group; FEV_1, forced expiratory volume in 1 second; NR, not reported; NSCLC, non-small cell lung cancer; SCC, squamous cell carcinoma; uRATS, uniportal robotic-assisted thoracic surgery; uVATS, uniportal video-assisted thoracoscopic surgery

Operative Time

Operative time was reported in four studies [16-19]. The study-level MDs, calculated as uRATS minus uVATS, were -16.20 minutes in Paradela et al. [16] (95% CI -18.99 to -13.41), 60.17 minutes in Hsieh et al. [17] (95% CI 43.83 to 76.51), 12.67 minutes in Wang et al. [18] (95% CI -2.69 to 28.03), and 75.00 minutes in İşcan et al. [19] (95% CI 52.38 to 97.62). Operative time was therefore shorter with uRATS in Paradela et al. [16], while the other estimates favored uVATS; the confidence interval for Wang et al. [18] included zero. Heterogeneity was extreme (I^2 = 98.0%). The pooled MD was 32.05 minutes (95% CI -9.45 to 73.55; p = 0.13) (Figure *3*). Heterogeneity remained high after exclusion of individual studies, with the lowest I^2 observed after excluding Paradela et al. (92.6%) (Figure *4*) [16].

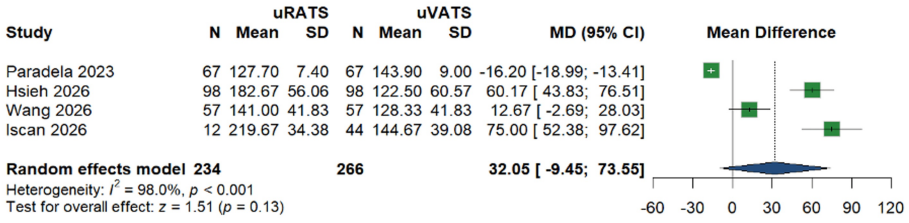


FIGURE 3: Forest plot of operative time.

References: [16-19]

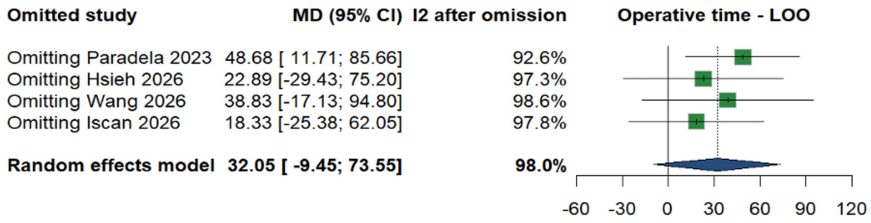


FIGURE 4: Leave-one-out analysis for operative time.

References: [16-19]

Intraoperative Blood Loss

Two studies reported intraoperative blood loss. The pooled MD was -12.89 mL (95% CI: -44.19 to 18.41; p = 0.42), indicating no statistically significant difference between groups (Figure *5*). Heterogeneity was high (I^2 = 77.4%).

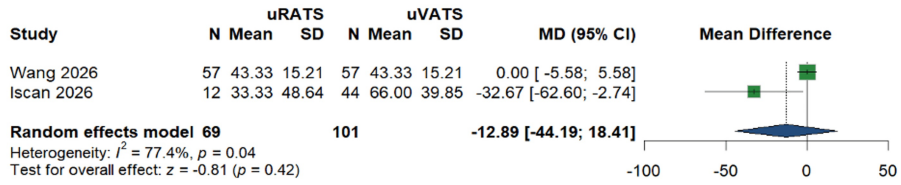


FIGURE 5: Forest plot of intraoperative blood loss.

References: [18,19]

Lymph Nodes Dissected or Retrieved

Three studies reported lymph node yield. The pooled analysis demonstrated a significantly higher number of lymph nodes in the uRATS group, with a MD of 3.41 lymph nodes (95% CI: 2.15 to 4.68; p < 0.001). Heterogeneity was low (I^2 = 47.6%) (Figure *6*). Hsieh et al. [17] reported N1 and N2 counts separately, with no statistically significant differences between groups, but did not provide sufficient summary data to derive total lymph node yield and its variance without additional assumptions.

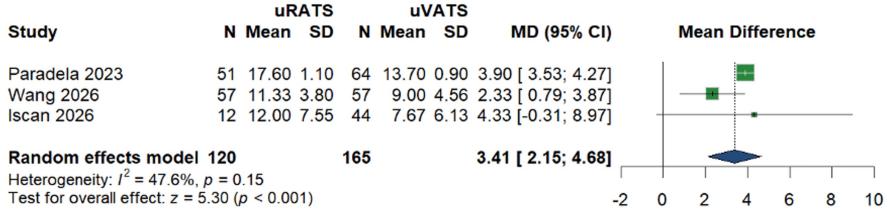


FIGURE 6: Forest plot of lymph nodes dissected or retrieved.

References: [16,18,19]

Lymph Node Stations Dissected, Retrieved, or Sampled

Four studies reported lymph node stations. The pooled MD was 0.07 stations (95% CI: -0.18 to 0.32; p = 0.59), showing no statistically significant difference between uRATS and uVATS. Heterogeneity was moderate (I^2 = 53.9%). In the leave-one-out analysis, heterogeneity decreased to 0% after excluding Wang et al. (Figures *7a*-*7b*) [18].

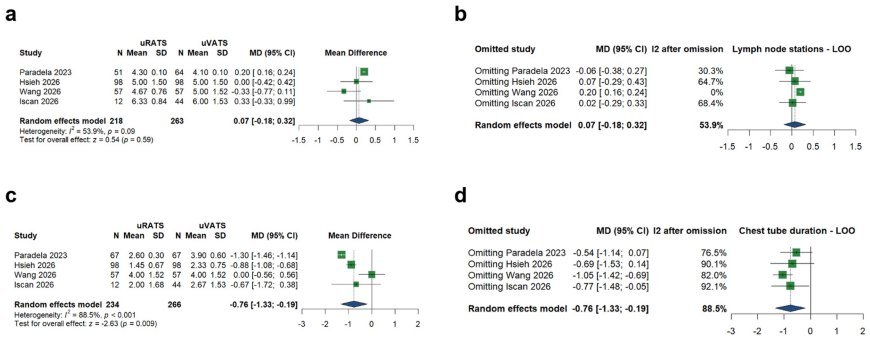


FIGURE 7: Perioperative continuous outcomes and influence analyses. (a) Forest plot of lymph node stations dissected, retrieved, or sampled. (b) Leave-one-out analysis for lymph node stations. (c) Forest plot of chest tube or drainage duration. (d) Leave-one-out analysis for chest tube or drainage duration.

References: [16-19]

Chest Tube or Drainage Duration

Four studies reported chest tube or drainage duration. The pooled MD was -0.76 days (95% CI -1.33 to -0.19; p = 0.009), with high heterogeneity (I^2 = 88.5%). The 95% prediction interval ranged from -2.66 to 1.13 days, encompassing both shorter and longer drainage duration with uRATS in a similar setting. This interval remains uncertain because only four studies contributed. Heterogeneity persisted in leave-one-out analyses (I^2 76.5%-92.1%). After excluding Paradela et al. [16], the estimated reduction was attenuated and no longer statistically significant (MD -0.54 days; 95% CI -1.14 to 0.07; I^2 = 76.5%) (Figures *7c*-*7d*; Table *3*).

Postoperative Hospital Stay

Postoperative hospital stay was reported in four studies [16-19]. Paradela et al. [16] reported mean stays of 4.4 days with uRATS and 5.1 days with uVATS, with 67 patients per group. Hsieh et al. [17] reported median stays of 2.70 days (IQR 2.00-2.96) and 3.00 days (IQR 3.00-4.00), respectively, in 98 matched pairs. Wang et al. [18] reported medians of 4.00 days (IQR 3.00-6.00) and 5.00 days (IQR 4.00-7.00) in 57 matched pairs. İşcan et al. [19] reported medians of two days (IQR 2-3) among 12 uRATS patients and three days (IQR 3-5) among 44 uVATS patients. Hospital stay was summarized narratively because uncertainty in the reported dispersion measures and the need to convert medians and quartiles limited confidence in the pooled estimate (Figure *8a*).

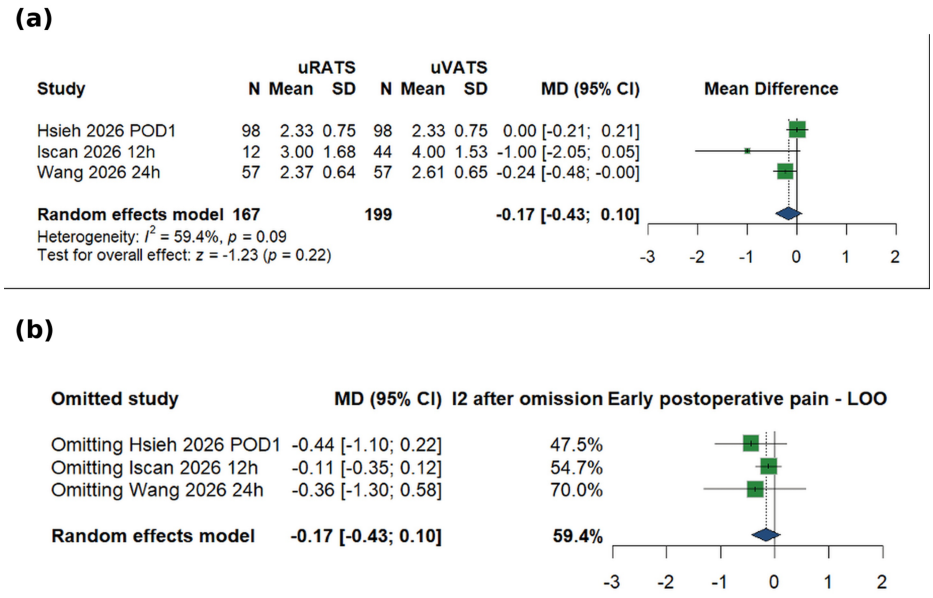


FIGURE 8: Early postoperative pain: (a) forest plot of mean differences with 95% confidence intervals and (b) leave-one-out sensitivity analysis.

References: [17-19]

Early Postoperative Pain Within 24 Hours

Three studies [17-19] reported early postoperative pain within 24 hours. The pooled MD was -0.17 VAS points (95% CI: -0.43 to 0.10; p = 0.22), showing no statistically significant difference between groups. Heterogeneity was moderate (I^2 = 59.4%). In the leave-one-out analysis, I^2 ranged from approximately 47.5% to 70.0%, indicating persistent heterogeneity across studies (Figures *8b*-*8c*).

Conversion to Thoracotomy

Four studies reported conversion to thoracotomy [16-19]. Paradela et al. [16] reported 0/67 conversions with uRATS versus 1/67 with uVATS. Hsieh et al. [17] reported no conversions in either group (0/98 versus 0/98). Wang et al. [18] reported 3/57 conversions with uRATS versus 0/57 with uVATS. İşcan et al. [19] reported no conversions in either group (0/12 versus 0/44). Given the sparse events, findings were summarized narratively without a pooled comparative estimate.

Overall Postoperative Complications

Four studies reported overall postoperative complications. The pooled analysis showed a significantly lower risk of complications in the uRATS group (RR: 0.43; 95% CI: 0.23 to 0.78; p = 0.006). Heterogeneity was very low (I^2 = 5.5%) (Figure *9a*).

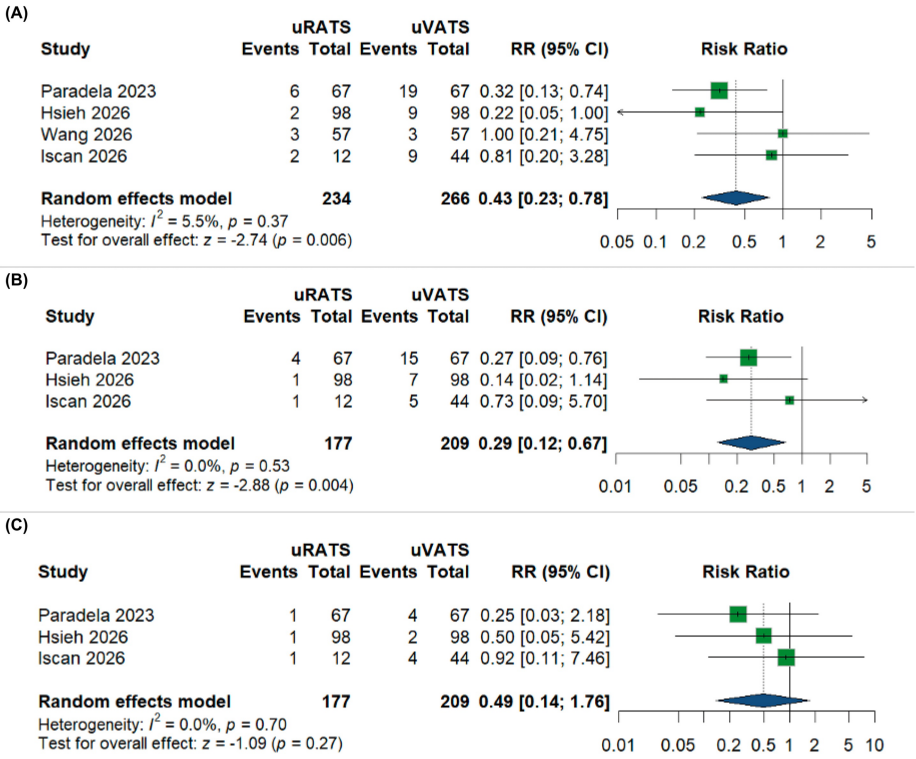


FIGURE 9: Postoperative complications: (a) overall complications; (b) minor complications; (c) major complications

CI, confidence interval; RR, risk ratio

References: [16-19]

Minor Complications

Three studies reported minor complications. Paradela et al. [16] used Ottawa Thoracic Morbidity and Mortality grades 1-2, İşcan et al. [19] used Clavien-Dindo grades I-II, and Hsieh et al. [17] reported grades I-II without explicitly identifying the classification system. The pooled RR was 0.29 (95% CI 0.12-0.67; p = 0.004; I^2 = 0%) (Figure *9b*). In the sensitivity analysis excluding Paradela et al. [16], the RR was 0.33 (95% CI 0.07-1.62; I^2 = 17.2%) (Table *3*).

Major Complications

Three studies reported major complications. The pooled RR was 0.49 (95% CI: 0.14 to 1.76; p = 0.27), showing no statistically significant difference between groups. No heterogeneity was observed (I^2 = 0%) (Figure *9c*).

Sensitivity Analyses

Sensitivity analyses separately excluding Paradela et al. [16] and İşcan et al. [19] are presented in Table *3*. After excluding Paradela et al. [16], the estimates were MD -0.54 days (95% CI -1.14 to 0.07) for chest tube duration, RR 0.57 (95% CI 0.23-1.40) for overall complications, and RR 0.33 (95% CI 0.07-1.62) for minor complications. After excluding İşcan et al. [19], the corresponding estimates were MD -0.77 days (95% CI -1.48 to -0.05), RR 0.36 (95% CI 0.19-0.71), and RR 0.23 (95% CI 0.09-0.60). For major complications, the RR was 0.70 (95% CI 0.15-3.40) after excluding Paradela et al. [16] and 0.34 (95% CI 0.07-1.70) after excluding İşcan et al. [19]. Excluding İşcan et al. [19] from the blood-loss analysis left Wang et al. [18] alone; its individual estimate is reported without pooling.

Outcome	Primary analysis estimate (95% CI)	I²	Excluding Paradela et al. [16] estimate (95% CI)	I²	Excluding İşcan et al. [19] estimate (95% CI)	I²
Operative time (min)	MD 32.05 (-9.45 to 73.55)	98.0%	MD 48.68 (11.71 to 85.66)	92.6%	MD 18.33 (-25.38 to 62.05)	97.8%
Blood loss (mL)	MD -12.89 (-44.19 to 18.41)	77.4%	N/A	N/A	MD 0.00 (-5.58 to 5.58)*	-
Lymph node yield (nodes)	MD 3.41 (2.15 to 4.68)	47.6%	MD 2.53 (1.07 to 3.99)	0%	MD 3.30 (1.81 to 4.80)	73.4%
Lymph node station count	MD 0.07 (-0.18 to 0.32)	53.9%	MD -0.06 (-0.38 to 0.27)	30.3%	MD 0.02 (-0.29 to 0.33)	68.4%
Chest tube duration (days)	MD -0.76 (-1.33 to -0.19)	88.5%	MD -0.54 (-1.14 to 0.07)	76.5%	MD -0.77 (-1.48 to -0.05)	92.1%
Early postoperative pain	MD -0.17 (-0.43 to 0.10)	59.4%	N/A	N/A	MD -0.11 (-0.35 to 0.12)	54.7%
Major complications	RR 0.49 (0.14 to 1.76)	0%	RR 0.70 (0.15 to 3.40)	0%	RR 0.34 (0.07 to 1.70)	0%
Overall complications	RR 0.43 (0.23 to 0.78)	5.5%	RR 0.57 (0.23 to 1.40)	11.3%	RR 0.36 (0.19 to 0.71)	6.4%
Minor complications	RR 0.29 (0.12 to 0.67)	0%	RR 0.33 (0.07 to 1.62)	17.2%	RR 0.23 (0.09 to 0.60)	0%

TABLE 3: Sensitivity analyses.

MDs are uRATS minus uVATS; RRs compare uRATS with uVATS. Exclusions were performed separately. *After excluding İşcan et al. [19], blood loss is represented by Wang et al. [18] alone; this is an individual-study estimate, not a pooled result, and I² is not estimable (-). Primary analyses included four studies for operative time, lymph node station count, chest tube duration, and overall complications; three for lymph node yield, early pain, major complications, and minor complications; and two for blood loss. Hospital stay and conversion were summarized narratively. Minor-complication categories differed: Paradela et al. [16] used Ottawa grading, İşcan et al. [19] used Clavien-Dindo, and Hsieh et al. [17] did not explicitly identify their system.

CI, confidence interval; I², statistic measuring heterogeneity; MD, mean difference; N/A, not applicable because the study did not contribute to that outcome; RR, risk ratio

Discussion

In this systematic review and meta-analysis, four comparative observational studies including 502 patients were analyzed to evaluate uRATS versus uVATS for anatomic pulmonary resection. The pooled results showed that uRATS was associated with several short-term advantages, including shorter chest tube or drainage duration, higher lymph node yield, and lower rates of overall and minor postoperative complications. Reported hospital stays were numerically shorter with uRATS, but these findings were summarized narratively and remain susceptible to confounding. The pooled analysis showed a higher lymph node count with uRATS but no significant difference in nodal station count. Residual differences in case mix, operative era, and nodal assessment practices limit attribution of this association to the surgical platform. Operative-time estimates differed substantially between studies. No statistically significant differences were detected in intraoperative blood loss, early postoperative pain within 24 hours, or major complications. Conversion events were sparse and were summarized narratively. Taken together, these findings suggest that uRATS may offer measurable benefits in selected recovery and lymph node outcomes, while its effect on operative efficiency, pain control, and major safety outcomes remains less certain.

Our findings are broadly consistent with the available comparative uRATS literature. Paradela et al. [16] reported higher lymph node yield, fewer postoperative complications, and shorter chest drain duration with uRATS, while Hsieh et al. [17] found shorter drainage duration and hospital stay but longer operative time. Wang et al. [18] also reported better lymph node dissection and shorter hospital stay with uRATS, whereas İşcan et al. [19] found improved lymph node yield and recovery-related outcomes in a smaller cohort. A meta-analysis by Kaaki et al., including 16 studies and 579 uRATS patients, reported low conversion and mortality rates [27]. That review provides broader context for our findings, although it pooled absolute outcomes after uRATS rather than direct comparisons with uVATS. Our analysis therefore addresses the additional question of whether outcomes differ between these two approaches. These findings also fit with the broader RATS literature, where robotic surgery has been associated with more detailed lymph node

assessment in some studies, but without consistent superiority across all perioperative outcomes [8,12,14].

The studies gave conflicting estimates of operative time. Differences in docking, surgeon experience, case complexity, and operative era may explain some of this variation [10,16-19]. Paradela et al. [16] also compared surgical series performed approximately a decade apart. The pooled estimate consequently has limited value for predicting operative time in an individual setting, and its nonsignificant p-value does not establish comparable operative times between the approaches.

Reported hospital stays were numerically shorter with uRATS across the four studies [16-19]. Chest tube duration was shorter on average, but heterogeneity was high (I^2 = 88.5%), and the 95% prediction interval crossed zero (-2.66 to 1.13 days). Differences in tissue handling or dissection precision are possible explanations, but these mechanisms were not established by the included studies. Confounding provides an equally plausible explanation: Paradela et al. [16] compared surgical series approximately a decade apart, allowing changes in perioperative care to influence recovery, while the unmatched uRATS group in İşcan et al. [19] had better baseline pulmonary function. Differences in drain removal criteria and discharge practice may also contribute. The chest tube duration confidence interval included zero after excluding Paradela et al. (Table *3*) [16]. These findings cannot distinguish a platform-specific recovery benefit from differences in patient selection and perioperative care.

The clinical importance of these recovery differences remains uncertain. The pooled reduction in chest tube duration was less than one day, while Hsieh et al. [17] reported median differences of approximately 0.30 days in hospital stay and 0.55 days in drainage duration. Such differences should be considered alongside resource use. Hsieh et al. [17] reported higher self-paid expenses, and Wang et al. [18] reported higher total hospitalization costs with uRATS. Operative time was also longer in Hsieh et al. [17], whereas the numerically longer operative time in Wang et al. [18] did not reach statistical significance. These findings leave uncertainty about whether the possible recovery benefits justify the additional expenditure.

Early postoperative pain within 24 hours did not differ significantly between uRATS and uVATS. This may be expected because both approaches are uniportal and involve a single intercostal access site. Previous randomized evidence has shown that minimally invasive VATS reduces pain compared with thoracotomy [5], but the present comparison is narrower because both groups underwent single-incision minimally invasive surgery. Differences in analgesic protocols, pain assessment timing, and reporting format may also have influenced the pooled estimate.

Conversion to thoracotomy and major complications were uncommon, limiting assessment of differences between the approaches. Conversion findings were summarized narratively. The pooled major-complication estimate was imprecise (RR 0.49; 95% CI 0.14-1.76) and remained compatible with an increased risk with uRATS. Lower pooled rates of overall and minor complications were observed with uRATS. However, the findings for both overall and minor complications were sensitive to exclusion of Paradela et al. [16].

Limitations

This review has several limitations. First, all included studies were observational, and important confounding remained despite matching. Paradela et al. [16] compared the same surgeon's initial uVATS series beginning in 2010 with uRATS introduced in September 2021, creating a temporal separation of approximately a decade. Changes in surgical experience, perioperative care, drainage and discharge protocols, and nodal assessment practices may therefore have influenced the outcomes. Calendar period and resection type were not included in matching, and important procedural imbalances remained. Although nodal analyses were restricted to patients with lung cancer, an independent platform effect cannot be distinguished from these influences [16]. Hsieh et al. [17] also showed residual ASA-class imbalance after matching. After excluding Paradela et al. [16], the association with higher lymph node yield persisted, whereas the confidence intervals crossed the null for chest tube duration and minor complications (Table *3*). These analyses included only three remaining studies for chest tube duration and two each for lymph node yield and minor complications.

Second, the evidence base was small and concentrated in centers with pioneering experience in uRATS. González-Rivas co-authored both Paradela et al. [16] and Hsieh et al. [17], and outcomes from these experienced teams may not generalize to units with less expertise. Publication bias and small-study effects could not be reliably assessed with only four studies. No review protocol was registered, limiting transparency regarding prespecified methods, and no formal certainty-of-evidence assessment was performed.

Third, several continuous outcomes required estimation of means and SDs from reported medians and quartiles, introducing additional uncertainty. For hospital stay, this uncertainty, together with inconsistencies in the source reporting of dispersion measures, led us to withdraw the pooled analysis and summarize the findings narratively. Fourth, definitions varied for lymph node measures, pain scores, and complication grading. Hsieh et al. [17], the largest included study, did not contribute to the total lymph node yield analysis because an extractable total-node summary was unavailable; its separately reported N1 and

N2 medians and quartiles could not be combined into a valid total-node estimate. Its exclusion further limits the representativeness of that pooled result. Its exclusion further limits the representativeness of that pooled result. Finally, long-term oncologic outcomes were unavailable for quantitative synthesis, restricting conclusions to short-term perioperative and recovery outcomes.

Future Directions

Future studies should use prospective multicenter designs, standardized definitions, and longer follow-up. Outcomes such as disease-free survival, overall survival, recurrence, quality of life, cost-effectiveness, and procedure-specific subgroup effects should be reported. Separate analyses for lobectomy and segmentectomy would also be useful, as the technical demands and potential advantages of robotics may differ between these procedures.

Conclusions

Based on four retrospective comparative studies from experienced uniportal centers, uRATS may offer modest short-term recovery advantages over uVATS, although their clinical magnitude and consistency remain uncertain. Potential benefits must be weighed against higher costs and longer operative times reported in some studies. Residual confounding and sparse severe events prevent firm conclusions about comparative safety or overall superiority. Prospective multicenter studies incorporating standardized recovery outcomes, economic evaluation, and long-term oncologic follow-up are needed.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Sharif Abuelgasim, Hawazen O. Alahmadi, Latifah A. Alfaraj, Yaser Saleh Alkraidis, Imran Nizar Musawa, Manal Alsurahi, Ali I. Atwi, Rafal Aseel, Marwan Amin Ibrahim Abu Fara

Critical review of the manuscript for important intellectual content: Sharif Abuelgasim, Hawazen O. Alahmadi, Latifah A. Alfaraj, Ali I. Atwi, Rafal Aseel, Marwan Amin Ibrahim Abu Fara

Acquisition, analysis, or interpretation of data: Hawazen O. Alahmadi, Latifah A. Alfaraj, Yaser Saleh Alkraidis, Imran Nizar Musawa, Manal Alsurahi, Saleh A. Almaktoum, Ahmed Jaffar Almarzooq, Rana A. Alharbi, Aqeel Mohammed Al-Sharif

Drafting of the manuscript: Hawazen O. Alahmadi, Latifah A. Alfaraj, Yaser Saleh Alkraidis, Imran Nizar Musawa, Manal Alsurahi, Saleh A. Almaktoum, Ahmed Jaffar Almarzooq, Rana A. Alharbi, Aqeel Mohammed Al-Sharif

Supervision: Hawazen O. Alahmadi, Marwan Amin Ibrahim Abu Fara

Disclosures

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, Jemal A: Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2024, 74:229-63. 10.3322/caac.21834
2. Sumiya R, Matsunaga T, Suzuki K: Lung cancer in young individuals; risk factors and epidemiology . J Thorac Dis. 2025, 17:1746-54. 10.21037/jtd-2024-1950
3. Montagne F, Guisier F, Venissac N, Baste JM: The role of surgery in lung cancer treatment: present indications and future perspectives—state of the art. Cancers (Basel). 2021, 13: 10.3390/cancers13153711
4. Li C, Lei S, Ding L, et al.: Global burden and trends of lung cancer incidence and mortality . Chin Med J (Engl). 2023, 136:1583-90. 10.1097/CM9.0000000000002529
5. Bendixen M, Jorgensen OD, Kronborg C, et al.: Postoperative pain and quality of life after lobectomy via video-assisted thoracoscopic surgery or anterolateral thoracotomy for early stage lung cancer: a randomised controlled trial. Lancet Oncol. 2016, 17:836-44. 10.1016/S1470-2045(16)00173-X
6. Wang JQ, Ma ZJ: Impact of video-assisted thoracic surgery versus open thoracotomy on postoperative wound infections in lung cancer patients: a systematic review and meta-analysis. BMC Pulm Med. 2025,

25:159. 10.1186/s12890-025-03589-x
7. Erdogu V, Akin H, Sonmezoglu Y, et al.: Comparison of the video-assisted thoracoscopic lobectomy versus open thoracotomy for primary non-small cell lung cancer: single cohort study with 269 cases. Sisli Etfal Hastan Tip Bul. 2020, 54:291-6. 10.14744/SEMB.2020.60963
8. Toker A, Özyurtkan MO, Demirhan Ö, Ayalp K, Kaba E, Uyumaz E: Lymph node dissection in surgery for lung cancer: comparison of open vs. video-assisted vs. robotic-assisted approaches. Ann Thorac Cardiovasc Surg. 2016, 22:284-90. 10.5761/atcs.oa.16-00087
9. Gonzalez D, Paradela M, Garcia J, Dela Torre M: Single-port video-assisted thoracoscopic lobectomy. Interact Cardiovasc Thorac Surg. 2011, 12:514-5. 10.1510/icvts.2010.256222
10. Gonzalez-Rivas D, Bosinceanu M, Motas N, Manolache V: Uniportal robotic-assisted thoracic surgery for lung resections. Eur J Cardiothorac Surg. 2022, 62: 10.1093/ejcts/ezac410
11. Kuzmych K, Lococo F, Nachira D, et al.: The evolution of robotic-assisted thoracic surgery: current platforms, emerging technologies, and future perspectives - a narrative review. J Robot Surg. 2026, 20:10.1007/s11701-026-03722-w
12. Habibi Nameghi F, Oghogho A, Baltag D, et al.: Outcomes of RATS in comparison to VATS and open lung resections for malignancy in propensity matched high-risk patients. J Robot Surg. 2025, 19:225. 10.1007/s11701-025-02344-y
13. Bottet B, Gillibert A, Seguin-Givelet A, et al.: Comparative short-term outcomes of robotic-assisted vs video-assisted thoracic surgery in lung cancer: a multicenter retrospective study from EPITHOR with a quality audit. J Robot Surg. 2025, 19:68. 10.1007/s11701-024-02174-4
14. Xu Y, Han Q, Wang C, Xu J, Li X, Zhang Q: Robotic-assisted thoracic surgery for resectable lung cancer: efficacy, safety and surgical approaches — an umbrella review of meta-analyses. BMC Surg. 2026, 26:123. 10.1186/s12893-026-03501-2
15. Kaneda H, Utsumi T, Murakawa T: Surgical technical aspects of uniportal hybrid RATS and biportal pure RATS using a subcostal port. J Vis Surg. 2026, 12:16. 10.21037/jovs-2025-1-63
16. Paradela M, Garcia-Perez A, Fernandez-Prado R, et al.: Uniportal robotic versus thoracoscopic assisted surgery: a propensity score-matched analysis of the initial 100 cases. Ann Cardiothorac Surg. 2023, 12:23-33. 10.21037/acs-2022-urats-169
17. Hsieh MJ, Wu CY, Wu YF, Chen KA, Gonzalez-Rivas D, Wu CF: Early clinical and economic outcomes of uniportal robotic- and video-assisted thoracoscopic surgery for lung anatomic resection: a retrospective study. J Robot Surg. 2026, 20:256. 10.1007/s11701-026-03218-7
18. Wang J, Xu MM, Chen ZJ, et al.: Short-term outcomes of multi-arm uniportal robotic thoracic surgery versus uniportal video-assisted thoracoscopic surgery for non-small cell lung cancer. J Robot Surg. 2026, 20:10.1007/s11701-026-03257-0
19. İşcan M, Yavuz Ö, Ertan R, Yeginsu A: Uniportal robotic-assisted versus video-assisted thoracoscopic surgery for anatomical lung resection in non-small cell lung cancer: a comparative single-center cohort study. J Clin Med. 2026, 15: 10.3390/jcm15114078
20. Higgins JPT, Thomas J, Chandler J, et al.: Cochrane Handbook for Systematic Reviews of Interventions . John Wiley & Sons, Hoboken, NJ; 2019. https://www.cochrane.org/authors/handbooks-and-manuals/handbook.
21. Page MJ, McKenzie JE, Bossuyt PM, et al.: The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021, 372:n71. 10.1136/bmj.n71
22. Sterne JA, Hernán MA, Reeves BC, et al.: ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ. 2016, 355:i4919. 10.1136/bmj.i4919
23. McGuinness LA, Higgins JP: Risk-of-bias VISualization (robvis): an R package and Shiny web app for visualizing risk-of-bias assessments. Res Synth Methods. 2021, 12:55-61. 10.1002/jrsm.1411
24. Seely AJ, Ivanovic J, Threader J, et al.: Systematic classification of morbidity and mortality after thoracic surgery. Ann Thorac Surg. 2010, 90:936-42. 10.1016/j.athoracsur.2010.05.014
25. The R Project for Statistical Computing . (2025). Accessed: March 29, 2026: https://www.R-project.org/.
26. Balduzzi S, Rücker G, Schwarzer G: How to perform a meta-analysis with R: a practical tutorial . Evid Based Ment Health. 2019, 22:153-60. 10.1136/ebmental-2019-300117
27. Kaaki S, Barnawi AB, Robaidi HA, et al.: Perioperative outcomes and safety of uniportal robotic-assisted thoracic surgery (U-RATS) for anatomic lung resection: a systematic review and meta-analysis. J Robot Surg. 2026, 20:10.1007/s11701-026-03349-x