Meta-Analysis of Observational Studies in Epidemiology

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Compare the prognosis of Da Vinci robot-assisted thoracic surgery (RATS) with video-assisted thoracic surgery (VATS) for non-small cell lung cancer

A Meta-analysis

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Abstract

To determine if there are advantages to transitioning to Da Vinci robotics by a surgeon compared to the video-assisted thoracic surgical lobectomy.

A systematic electronic search of online electronic databases: PubMed, Embase, and Cochrane library updated on December 2017. Publications on comparison Da Vinci-robot-assisted thoracic surgery (RATS) and video-assisted thoracic surgery (VATS) for non-small cell lung cancer were collected. Meta-analysis RevMan 5.3 software (The Cochrane collaboration, Oxford, UK) was used to analyze the combined pooled HRs using fixed or random-effects models according to the heterogeneity.

Fourteen retrospective cohort studies were included. No statistical difference was found between the 2 groups with respect to conversion to open, dissected lymph nodes number, hospitalization time after surgery, duration of surgery, drainage volume after surgery, prolonged air leak, and morbidity ($P > .05$).

Da Vinci-RATS lobectomy is a feasible and safe technique and can achieve an equivalent surgical efficacy when compared with VATS. There does not seem to be a significant advantage for an established VATS lobectomy surgeon to transition to robotics based on clinical outcomes.

Abbreviations: NSCLC = non-small cell lung cancer, RATS = robot-assisted thoracic surgery, VATS = video-assisted thoracic surgery.

Keywords: Da Vinci robot-assisted thoracic surgery, lung lobectomy, minimally invasive surgery, video-assisted thoracic surgery

1. Introduction

Conventional laparoscopic surgery is considered to be the conventional therapy for patients with non-small cell lung cancer (NSCLC). It allows more rapid postoperative recovery and has superior cosmetic outcomes, while it still has several technical drawbacks such as high morbidity and long postoperative stays.[1]

The last 2 decades have witnessed minimally invasive techniques, that is, video-assisted thoracic surgery (VATS) the rise in popularity and has been widely applied for lung cancer. Since VATS lobectomy was first performed in the early 1990s.[2,3]

Previous studies have demonstrated clear benefits of VATS superior to the traditional lobectomy by thoracotomy approach for early-stage NSCLC, including shorter length of hospital stay, improved recovery, fewer perioperative complications,[4–6] and improved long-term survival for selected patients.[7,8] However, the development of this technique be limited by some shortcomings such as steep learning curve, difficult hand–eye coordination, or lack of instrument flexibility.[9]

Robot-assisted thoracic surgery (RATS) is a relatively new platform for minimally invasive lung lobectomy. It has been proposed as an alternative to VATS. RATS lobectomy appears to present some advantages over VATS approach,[10–12] including three-dimensional optics, small-wristed instrument motions, which can facilitate complex movements in a closed space, and influences both intraoperative complication and postoperative outcomes.[13–15] On the other hand, in spite of the aforementioned advantages of RLS there are several controversial aspects of this approach, such as higher hospital costs and longer procedure times may restrict the RATS.[16]

A relatively new minimally invasive technique introduced to thoracic surgery is using the robotic Da Vinci surgical system. Several studies[15,17] have showed Introduced for robotic-assisted thoracoscopy the Da Vinci Surgical System the feasibility and safety of this novel technique for lobectomy.

Despite a growing body of literature regarding robotic lobectomy, there is a paucity of information on whether or

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not there are advantages to transitioning to robotics by surgeons who are already proficient in performing VATS lobectomy.[18]

For these reasons, combined to a very effective marketing campaign, the widespread enthusiasm for this technology led to a quick rise of both surgeon's utilization and patients' demand. To clarify the value of robotic thymectomy, a systematic literature review and meta-analysis was performed of all relevant comparative studies to compare surgical outcomes of VATS and RATS in terms of surgical and short-term outcomes.

2. Methods and materials

2.1. Search strategy

PubMed and Embase databases were searched to identify studies assessing the comparison between Da Vinci-RATS and VATS among lung cancer patients. Two investigators independently searched up to December 2017. The process was established to find all articles with the keywords: "video-assisted thoracic surgery" and "robotics OR robot OR robotic surgery OR computer-assisted surgery OR da Vinci," and relevant Medical Subject Heading (MeSH) terms were utilized. The reference lists of all articles that dealt with the topic of interest were also hand-searched to check for additional relevant publications.

2.2. Eligibility criteria

Studies were included in the meta-analysis should meet the following criteria: the studies are designed as trials comparing Da Vinci-RATS to VATS; comparisons of outcomes of patients with NSCLC patients; and the outcomes of interest were perioperative morbidity or mortality for both Da Vinci-RATS and VATS, and HRs with corresponding 95% CIs were provided. Studies without data on the outcomes were excluded.

2.3. Quality assessment

Two investigators separately rated the quality of the retrieved studies. Study quality was assessed using Newcastle–Ottawa quality assessment scale.

2.4. Data extraction

From each of the eligible studies, the main categories based on the following: first author family name, publication year, study design, study period, surgical technique for Da Vinci-RATS or VATS lobectomy, number of patients, geographic location, intraoperative parameters (operative time and conversion), and postoperative parameters (dissected lymph nodes number, hospital length of stay, duration of drainage [days], prolonged air leak, and composite morbidity). Data were extracted by 2 authors independently. Disagreement was resolved by consensus.

2.5. Statistical analysis

Meta-analysis was performed by pooling the results of reported incidence of intraoperative parameters and postoperative parameters. Results will be expressed as mean differences for continuous outcomes (standardized vs. weighted to be determined by available data); and the appropriate ratio/difference for dichotomous outcomes as determined by available data.

A sensitivity analysis was also performed to examine the impact on the overall results, depending on the heterogeneity across the included studies. The heterogeneity across studies was examined the I^2 statistic.[19] $I^2>50\%$ suggested high degree of heterogeneity, and $<50\%$ suggested low degree of heterogeneity, respectively.[20] When there was low heterogeneity among studies, the fixed-effects model was used. Otherwise, the random effects model was used. $P<.05$ was identified as statistically significant difference. The statistical analyses were performed using Review Manager version 5.3 software (RevMan; The Cochrane collaboration, Oxford, UK). Findings of our meta-analysis were shown in forest plots. The Begg test and the Egger test were conducted to evaluate publication bias.

2.6. Ethical Approval

The ethical approval was not necessary because our study was a meta-analysis that belongs to secondary researches.

3. Results

3.1. Overview of literature search and study characteristics

Through the literature search in PubMed and Embase databases, we found a total of 452 individual records. Based on the criteria described in the methods, 19 publications were evaluated in more detail, but some did not provide enough detail of outcomes of 2 approaches. Therefore, a final total of 14[21–33] retrospective cohort studies were included in this meta-analysis. The search process is described in Figure 1.

All included studies in this study were based on moderate to high-quality evidence. Table 1 describes the primary characteristics of the eligible studies in more detail.

3.2. Clinical and methodological heterogeneity

Pooled analysis of conversion to open after RATS vs. VATS for lung cancer:

The pooling analysis revealed that there was not statistically significant difference in conversion to open between RATS and VATS lobectomy (RR = 1.03, 95% CI 0.54–1.99; $P=.92$) (Fig. 2).

Pooled analysis of operative time after RATS vs. VATS for lung cancer:

A random-effects model was used to pool the operative time data, since the heterogeneity across the 3 studies was significant high. The pooled data showed that robotic resection was not associated with prolong the operative time (SMD = 0.18, 95% CI = −1.46–1.82, $P=.083$) than VATS treatment (Fig. 3).

Pooled analysis of hospital length of stay after RATS vs. VATS for lung cancer:

Hospital length of stay was available for 3 studies. Results showed that there was no benefit after RATS vs. VATS for lung cancer (MD = 0.29, 95% CI = −0.55–1.13, $P=.49$) (Fig. 4).

Pooled analysis of dissected lymph nodes number after RATS vs. VATS for lung cancer:

In the analysis of dissected lymph nodes number in patients with comparing RATS with VATS, 5 studies were included, and

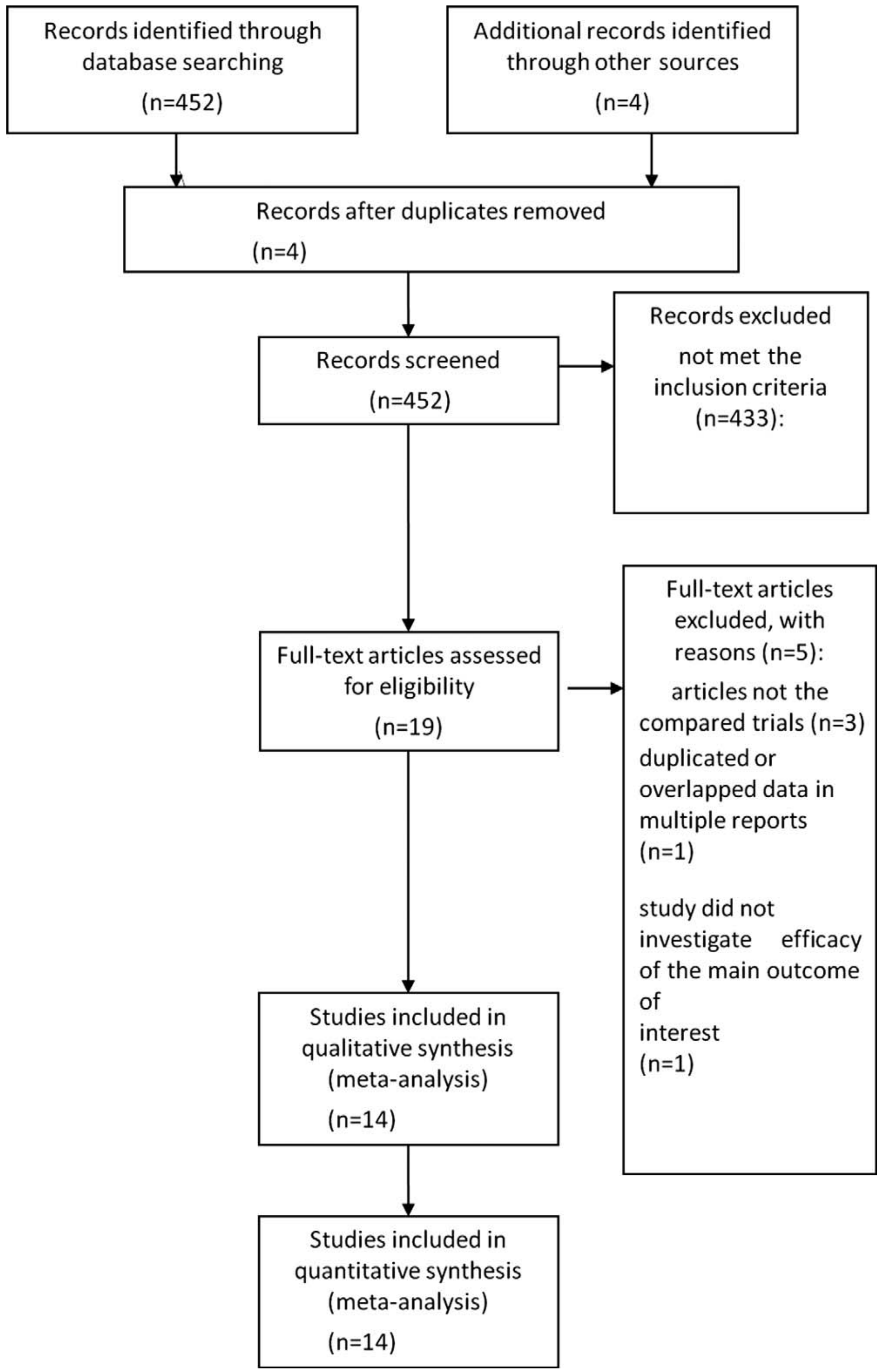


Figure 1. PRISMA flow chart of selection process to identify studies eligible for pooling.

the data are shown in Figure 5. While the data does not reach a statistically significant level (MD=0.87, 95% CI=−1.14–2.88, P=.39).

Pooled analysis of the mean duration of drainage after RATS vs. VATS for lung cancer:

The mean duration of drainage of the RATS compare with VATS in 3 studies (Fig. 6). Results showed that there was no statistically significant in terms of it (MD=0.29, 95% CI=−0.15–0.73, P=.20).

Pooled analysis of the incidence of prolonged air leak after RATS vs. VATS for lung cancer:

Pooling the data from 3 studies showed that RATS did not prolong air leak (RR=1.44, 95% CI=0.80–2.57; P=.22) compared with the VATS group (Fig. 7).

Table 1

The primary characteristics of the eligible studies in more detail.

			Study period		No. of patients		Median age		Surgical techniques	
References	Year	Country	RATS	VATS	RATS	VATS	RATS	VATS	RATS	VATS
[28]	2016	USA	2011–2014	2007.12–2014.5	53	80	66	67.5	NA	NA
[29]	2015	Turkey	2007.5–2014.7	2007.5–2014.7	34	65	61	57	NA	NA
[30]	2016	China	2014.9–2015.7	2014.9–2015.7	69	69	58.6	59.9	4-incision technique	
[27]	2016	USA	2009–2013	2009–2013	1220	12378	65	66	NA	NA
[22]	2014	USA	2010–2012	2009–2010	116	4612	64.6	66.2	4-arm CPRL	NA
[25]	2015	USA	2012–2014	2009–2014	53	158	71	72	4-arm CPRL	2-port VATS
[18]	2014	USA	2011–2012	2011–2012	35	34	71	77	4-arm CPRL	
[24]*,†	2014	USA	2009–2011	2009–2011	295	295	66.43	66.54	NA	NA
					325	325	61.74	61.5	NA	NA
[23]	2014	China	2012.6–2012.11	2012.6–2012.11	30	34	67.6	68.1	RAL	NA
[26]	2017	USA	2002.1–2012.12	2002.1–2012.12	172	141	68	67.5	3-arm or 4-arm	NA
[21]	2011	Korea	2006.1–2007.2	2006.1–2007.2	40	40	64.2	59.6	4-arm RAL	4-port VATS
[33]	2011	Germany	NA	NA	26	114	65	63	NA	NA
[31]	2014	USA	NA	NA	57	58	68	65	NA	NA
Mahieu	2016	France	2012–2013	2009–2010	28	28	65	61	3-arm CPRL	3-ports VATS

CPRL-4 = completely portal robotic lobectomy as done with the 4-arm technique, NA = not available, RAL = robot-assisted lobectomy, RATS = robot-assisted thoracic surgery, VATS = video-assisted thoracic surgery.

* Type of VATS procedure is lobectomy.

† Type of VATS procedure is wedge resection.

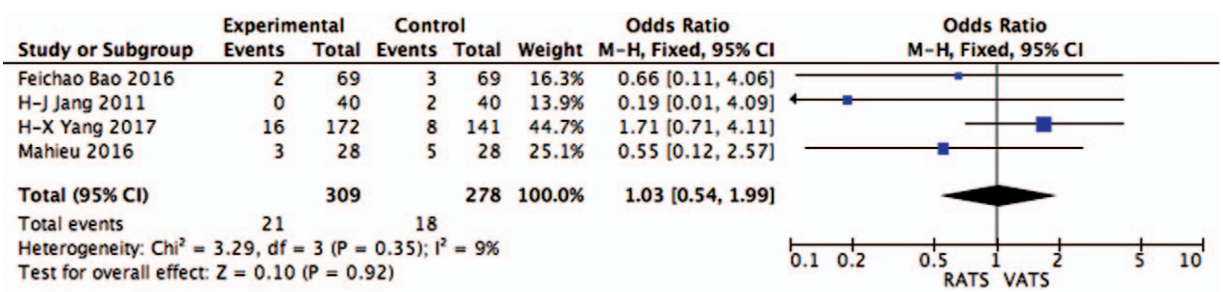


Figure 2. Pooled analysis of conversion to open after RATS vs. VATS for lung cancer. RATS = robot-assisted thoracic surgery, VATS = video-assisted thoracic surgery.

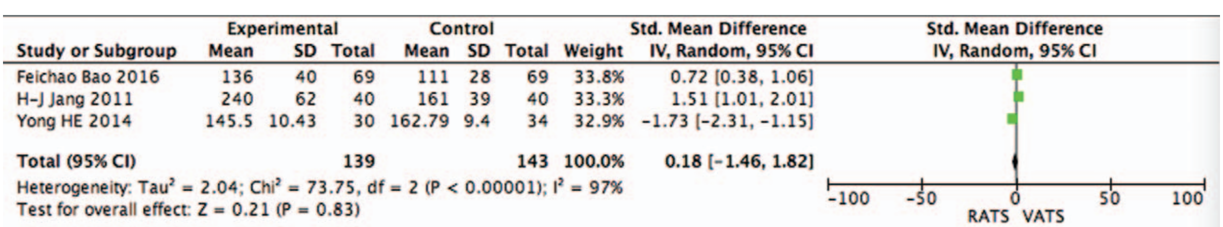


Figure 3. Pooled analysis of operative time after RATS vs. VATS for lung cancer. RATS = robot-assisted thoracic surgery, VATS = video-assisted thoracic surgery.

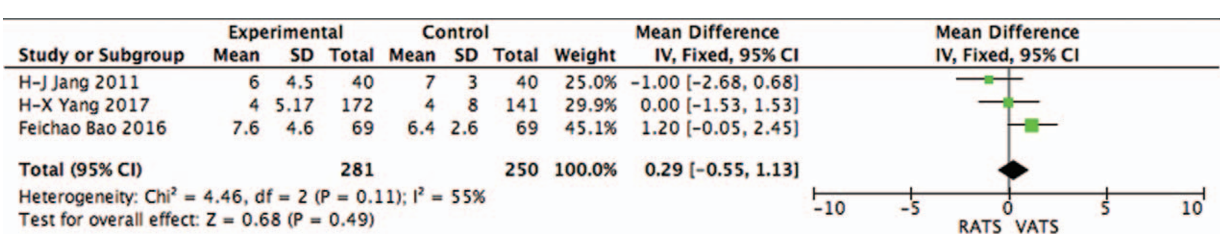
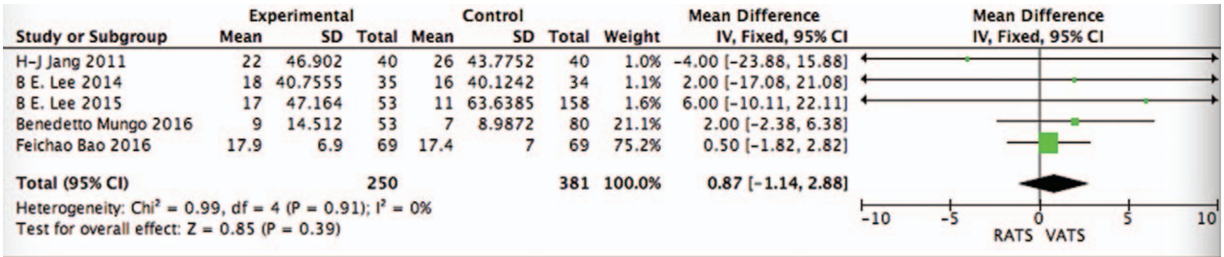
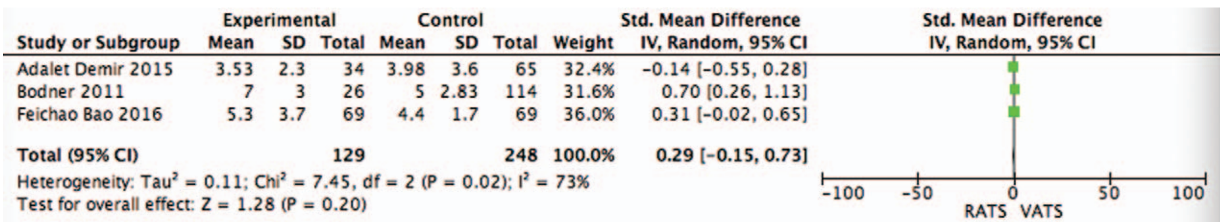


Figure 4. Pooled analysis of hospital length of stay after RATS vs. VATS for lung cancer. RATS = robot-assisted thoracic surgery, VATS = video-assisted thoracic surgery.



Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
H-J Jang 2011	22	46.902	40	26	43.7752	40	1.0%	-4.00 [-23.88, 15.88]
B E. Lee 2014	18	40.7555	35	16	40.1242	34	1.1%	2.00 [-17.08, 21.08]
B E. Lee 2015	17	47.164	53	11	63.6385	158	1.6%	6.00 [-10.11, 22.11]
Benedetto Mungo 2016	9	14.512	53	7	8.9872	80	21.1%	2.00 [-2.38, 6.38]
Feichao Bao 2016	17.9	6.9	69	17.4	7	69	75.2%	0.50 [-1.82, 2.82]
Total (95% CI)			250			381	100.0%	0.87 [-1.14, 2.88]

Figure 5. Pooled analysis of dissected lymph nodes station after RATS vs. VATS for lung cancer. RATS = robot-assisted thoracic surgery, VATS = video-assisted thoracic surgery.



Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Adalet Demir 2015	3.53	2.3	34	3.98	3.6	65	32.4%	-0.14 [-0.55, 0.28]
Bodner 2011	7	3	26	5	2.83	114	31.6%	0.70 [0.26, 1.13]
Feichao Bao 2016	5.3	3.7	69	4.4	1.7	69	36.0%	0.31 [-0.02, 0.65]
Total (95% CI)			129			248	100.0%	0.29 [-0.15, 0.73]

Figure 6. Pooled analysis of the mean duration of drainage after RATS vs. VATS for lung cancer. RATS = robot-assisted thoracic surgery, VATS = video-assisted thoracic surgery.

Pooled analysis of postoperative morbidity rate comparing robotic-assisted vs. laparoscopic surgery:

The pooled data showed that robotic-assisted surgery did not decrease the postoperative morbidity rate (OR = 1.26; 95% CI = 0.90–1.78; P = .18) with laparoscopic surgery (Fig. 8).

4. Discussion

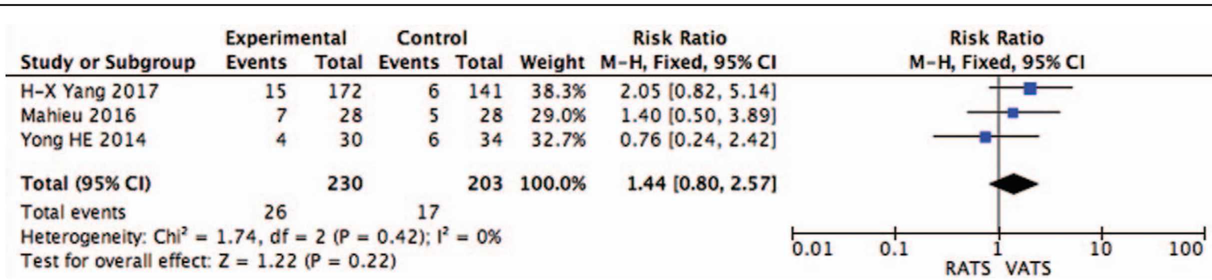
The use of robotics represents an alternative invasive approach, compared with VATS and thoracotomy.[34] The "da Vinci system" has been increasing used for thoracic surgical procedures.[35–38] Telerobotics improved dexterity by an active filtration of surgeon tremors, with ergonomic advantages, such as three-dimensional high-definition visualization, high-resolution magnification of the surgical field, and better maneuverability of instruments.[39] However, the drawback of the "da Vinci system" is health costs and profits, lack of haptic feedback, and debate regarding the management of intraoperative bleeding.

Our analysis revealed that RATS lobectomy did not reduce the mobility rate when compared with VATS lobectomy, and this was consistent with the pooled result of the meta-analysis.[40] Moreover, no statistically significant differences were observed in the incidence of intraoperative parameters and postoperative parameters when comparing RATS to VATS lobectomy.

While, clinical heterogeneity introduced by integrating various surgical procedures may affect the result, presumably reflecting the intrinsic properties of each surgical procedure such as retroperitoneal involvement of prostatectomy.[41]

These outcomes suggest that RATS lobectomy is a safe and feasible surgical approach for patients with lung cancer and can achieve an equivalent short-term surgical efficacy compared with VATS lobectomy.

The transition from VATS minimally invasive techniques to robotic surgery happened limit imposed by heterogeneities, which diminished the significance of the statistical results of weighing advantages and disadvantages. The difference of indications across studies could have resulted in the inclusion of patients from each study variable. For example, in addition to the apparent discrepancy between the patient's conditions and clinical indications.



Study or Subgroup	Experimental Events	Total	Control Events	Total	Weight	Risk Ratio M-H, Fixed, 95% CI
H-X Yang 2017	15	172	6	141	38.3%	2.05 [0.82, 5.14]
Mahieu 2016	7	28	5	28	29.0%	1.40 [0.50, 3.89]
Yong HE 2014	4	30	6	34	32.7%	0.76 [0.24, 2.42]
Total (95% CI)		230		203	100.0%	1.44 [0.80, 2.57]
Total events	26		17			

Figure 7. Pooled analysis of the incidence of prolonged air leak after RATS vs. VATS for lung cancer. RATS = robot-assisted thoracic surgery, VATS = video-assisted thoracic surgery.

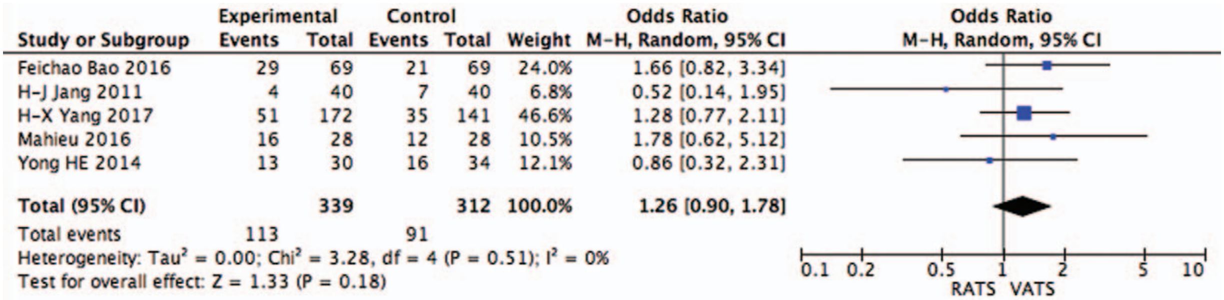


Figure 8. Pooled analysis of postoperative morbidity rate comparing robotic-assisted vs. laparoscopic surgery.

With respect to the operative results, most included studies reported a longer operative time for RATS compared to VATS lobectomy.[21,42,43] This can be explained by several potential factors. Taking into account its easier maneuverability, the robotic surgical system prolong the operative time by setting up the robotic system. But the short-term morbidity and mortality for patients did not increase in robotic surgery, which means that robotic surgery did not have negative impact on postoperative results.

However, due to the retrospective nature of this study, there were no enough reliable data about the operative cost. The lack of these data is a limitation of the study.

Although the present study demonstrates analysis of comparisons of VATS vs. RATS reported similar results there may be more reasons under debate. First, these benefits derive from the better depth visualization of RATS and increase in visual strain for surgeons. This influences both intraoperative complication[44] and conversion rates.[45] Second, robotic technology will continue to develop, and with the clearly delineated benefits of robotic surgery, like the wristed movements of the robotic instruments combined with the enhanced field of vision and the benefit of VATS were potentially combined.

This study still has several limitations, the most important of which is its retrospective nature, data included in the present meta-analysis were extrapolated from retrospective cohort studies, and bias might also exist due to the retrospective nature of the study. Furthermore, because of limited data on the cost, we did not compare costs, but the cost of robotic technology, especially in a time of increasing healthcare expenditures, may be a real issue. Nevertheless, we believe that with advances in the robotic technique, the device-related costs will decrease. Finally, it is worth mentioning that personal surgeons' preference played an important role in treatment.

5. Conclusion

In conclusion, our data suggest that Da Vinci-RATS lobectomy is a feasible and safe technique and can achieve an equivalent surgical efficacy when compared with VATS. Every procedure in medicine has its own indications, and the role of robotic surgery remains unclear. Hence, future studies should emphasize the rigorous eligibility criteria, clear definition of outcomes. Needless to say, approaching segmentectomy with minimally invasive techniques adds a further layer of complexity. We strongly believe that the advantages in dexterity and depth of visualization delivered by the robot facilitate execution of more complex procedures, therefore allowing for anatomical resection in patients who benefit from lung preservation.

Author contributions

Conceptualization: Feng Guo, Shanqing Li.
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Software: Shanqing Li.
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Writing – review & editing: Dongjie Ma, Shanqing Li.

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