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COMPARING ROBOTIC-ASSISTED THORACOSCOPIC SURGERY (RATS) VS VIDEO-ASSISTED THORACOSCOPIC SURGERY (VATS) APPROACHES FOR NON-SMALL CELL LUNG CANCER (NSCLC): A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Video-assisted thoracoscopic surgery (VATS) has demonstrated its efficacy and improved clinical outcomes as an option for early-stage non-small cell lung cancer. The development of robotic-assisted thoracoscopic surgery (RATS) has become the newest alternative to VATS. This study aims to compare VATS and RATS in terms of clinical outcomes. This Systematic Review research used the PRISMA method. RATS is proven to be an alternative with superior results compared to VATS on the Mortality in 30 days parameter (OR 0.59, 95% CI = 0.40, 0.86, I2 : 0%; p<0.006) and transfusion rate (OR = 0.50; 95% CI: 0.27 - 0.92, I2: 6%; p = 0.34). There was no significant difference between the RATS vs VATS procedure in terms of duration of surgery (OR = 0.50; 95%CI: 0.27 - 0.92), and intraoperative complications (OR 1.98, 95%CI: 0.12 - 32.44) and postoperative complications (OR 1.05, 95%CI: 0.93 - 1.19). The parameters of length of stay and chest drain duration in most of the studies show that VATS requires longer treatment time and thoracic drainage time than RATS. RATS can be an alternative to minimally invasive surgery in early-stage lung cancer with a lower risk of death and transfusion requirements than VATS, but there is no difference in the duration of surgery, as well as intraoperative and postoperative complications.

Keywords: *NSCLC, Lung Cancer, Mortality Rate, Transfusion Rate, Complication*

INTRODUCTION

Surgical intervention has emerged as the foremost therapeutic modality for managing early-stage Non-Small Cell Lung Cancer (NSCLC)1–3. Initially, surgical resection predominantly involved open lobectomy; however, the progressive evolution of medical technology has ushered in an era of minimal invasiveness, exemplified by Video Assisted Thoracoscopic Surgery (VATS), demonstrating superior safety and clinical outcomes in contrast to conventional open lobectomy procedures (Aiolfi et al., 2021; Nwogu et al., 2015; Wu et al., 2021). It has been documented that patients undergoing VATS procedures tend to experience less postoperative pain, shorter hospitalization durations, fewer complications, swifter physical recovery, and more favorable postoperative lung function outcomes in contrast to patients undergoing thoracotomy procedures.1,6 A study conducted by Cajipe et al. reported post-VATS procedure complications at 30% in 46 patients, as opposed to 58% in 45 patients for open procedures, with a statistically significant p-value of 0.009. Multivariate analysis further corroborated the reduction in postoperative complication risk associated with VATS (OR: 0.359; p=0.04) (Cajipe et al., 2012).

VATS is widely used for its advantages. However, it is important to recognize that it also comes with inherent limitations. These limitations include two-dimensional visual perception, demanding requirements for hand-eye coordination, exacerbated amplification of manual tremors, a steep learning curve, constrained adaptability, and limited instrument maneuvering capabilities (Ma et al., 2021; Zhang et al., 2022). The realm of medical technology has seen rapid advancements in the management of pulmonary malignancies, heralding the advent of robotic lobectomy as a novel alternative to VATS procedures. Robotic lobectomy, regarded as a viable and secure surgical approach for early-stage lung cancers, proffers additional benefits like three-dimensional high-definition visualization of the surgical area. enhances the surgeon's comfort, while also improving the precision of maneuvers through features like tremor filtration and enhanced instrument dexterity (Veronesi et al., 2016), and several studies show there are better results in the form of shorter hospitalization, diminished complication rates, reduced blood loss, and hastened recuperation (Balduyck et al., 2011; Boffa et al., 2008; Ma et al., 2021; Veronesi et al., 2016; Wu et al., 2021).

This study analyzes the outcomes of VATS and Robotic Surgery, encompassing 30-day postoperative mortality rates, operative duration, transfusion requirements, length of hospital stay, conversion rates to open lobectomy, and intra- and postoperative complications, with varying findings

Table 1. Study Characteristic

Author	Study Design	Study Arm	Period	Patient Number	Length Of Followup
(Adams et al., 1990)	Retrospective multicentre/national database	Robotic and VATS	2009-2012	4.732	30days
(M. Kent et al., 2014)	Retrospective review of a national database	Robotic and VATS	2008-2010	12.857	Hospital discharge
(Louie et al., 2016)	Retrospective review of a national database	Robotic and VATS	2009-2013	13.598	30days
(Paul et al., 2014)	Retrospective review of a national database	Robotic and VATS	2008-2011	40.093	Hospital discharge
(Swanson et al., 2014)	Multicentre retrospective matched cohort analysis	Robotic and VATS	2009-2011	590	30days
(Terra et al., 2022)	randomiszed control trial	Robotic and VATS	2015-2017	76	90days
(Sun et al., 2023)	case series prospective	Robotic and VATS	2019-2022	336	30days
(Kneuertz et al., 2019)	prospective maintained STS general thoracic surgery database	Robotic and VATS	2012-2017	457	30days

VATS: Video Assisted Thoracoscopic Surgery.

METHOD

Data Sources

This Systematic Review research uses the PRISMA method (Figure 1). A literature search relevant to this research was conducted on the Pubmed and Cochrane databases on July 22, 2023. A further search was performed using specific keywords: (((lung cancer[MeSH Terms])) OR (lobectomy)) AND ((robotic surgery) OR (robotic)) AND ((surgery, video-assisted thorax[MESH Terms]) OR (video-assisted surgery, thoracoscopy[MESH Terms])) AND (((complications, intraoperative[MESH Terms]) OR (postoperative complications[MESH Terms])) OR (survival rate[MESH Terms]) OR ((time of surgery) OR (duration of surgery)) OR (hospital stay)).

Data retrieved from the literature in the form of study design, period, total size, and outcomes collected in the form of intraoperative parameters (operation duration, transfusion rate), length of stay, intraoperative and postoperative complications, mortality in hospital or 30 days postoperatively, chest drain duration, conversion to open thoracotomy, and hospital costs.

Out of a total of 122 search results, 8 studies were found that were relevant to the research criteria. The inclusion criteria used in this study were procedures that compared Robotic Assisted Lobectomy/Surgery and Video Assisted Thoracoscopic Surgery procedures, research taken within the last 10 years with study designs in the form of Randomized Control Trials, and Prospective and Retrospective Studies. Exclusion criteria were research data with patients who underwent an open thoracotomy procedure, design study meta-analysis, and systematic review (table 1).

In the analysis for meta-analysis, continuous data were described in terms of mean and median, while discrete data were described in terms of proportions. Forest plots were constructed to compare Robotic Surgery with VATS (RevMan version 5.3, Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). Each comparison in the forest plots was stratified based on the overall effect, and a heterogeneity test was conducted for at least 2 studies included in the analysis. Mean differences and Odds Ratios (ORs) with 95% Confidence Intervals (CIs) were calculated for continuous and discrete data using the inverse variance method. For the heterogeneity test, data were considered heterogeneous if the chi-squared test (x2) yielded a p-value of less than 0.05 and the I2 statistic was greater than 50%. In all cases, a p-value of less than 0.05 was deemed statistically significant.

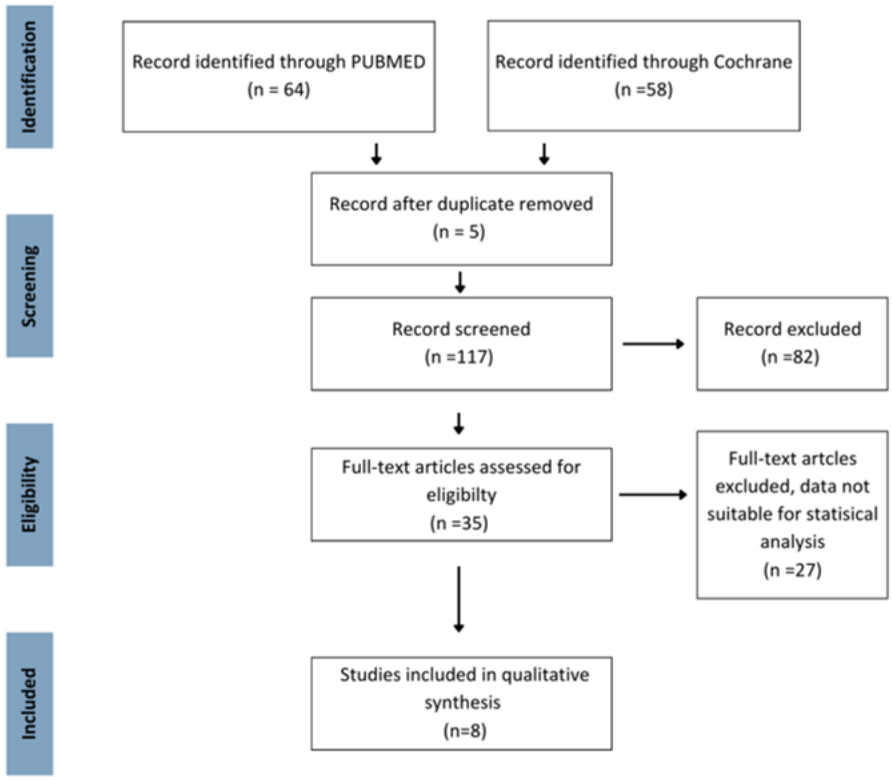

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses; Flow diagram of papers screened and included.

RESULTS AND DISCUSSION

Results

Patient Characteristic

Among the eight studies meeting our research criteria, five were retrospective cohort studies, two were prospective cohort studies, and one was a randomized control trial. These studies were published between 2013 and 2023 and are included in our analysis (see Table 1). In total, 5,069 patients underwent Robotic Lobectomy, while 67,670 patients underwent VATS procedures. The number of patients undergoing Robotic Lobectomy ranged from 37 to 2,498, and for VATS procedures, it varied from 69 to 37,595 (Paul et al., 2014; Terra et al., 2022). Study durations varied from 3 to 6 years. Patient follow-up durations also differed among the studies; Two studies followed patients until discharge from the hospital (M. Kent et al., 2014; Paul et al., 2014), whereas one study monitored patients for up to 90 days post-surgery(Terra et al., 2022).

Mortality In-Hospital or 30 Days Postoperation

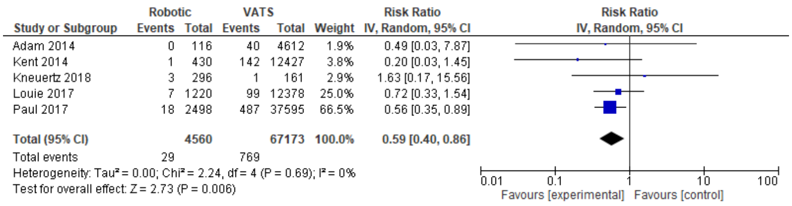

Figure 2. Mortality In-Hospital or 30 Days postoperation (Risk Ratio)

Duration of Surgery

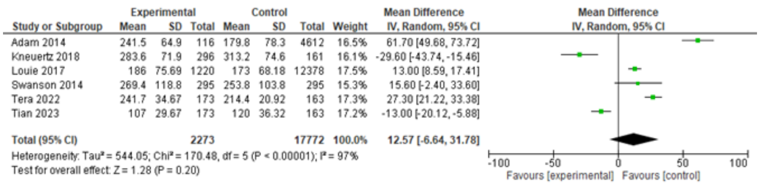

Figure 3. Duration of Surgery (Mean Differences)

Transfusion Rate

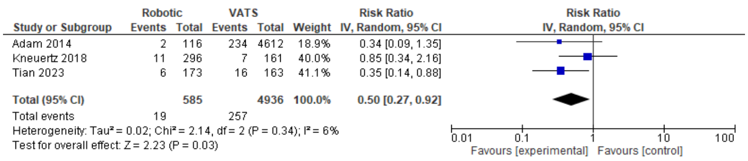

Figure 4. Transfusion Rate (Risk Ratio)

Intraoperative Complication

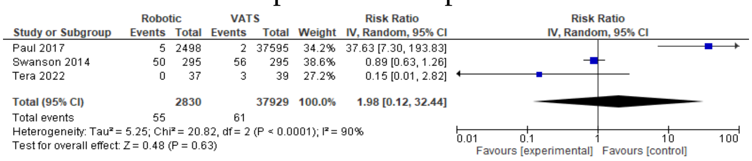

Figure 5. Intraoperative Complication (Risk Ratio)

Postoperative Complication

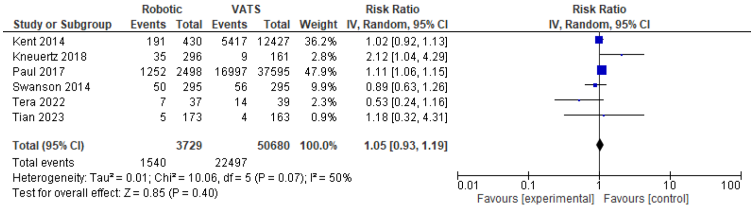

Figure 6. Postoperative Complication (Risk Ratio)

Mortality In-Hospital or 30 Days postoperation

Based on 5 out of the 8 studies that assessed the parameter of In-Hospital or 30-day postoperative mortality, four studies indicated a lower risk of in-hospital or 30-day postoperative mortality associated with RATS procedures (Adams et al., 1990; Paul et al., 2014). However, the study from Kneuertz et al. reported contrasting results. The results of the meta-analysis (see Fig 2) reveal a significant difference in this parameter between RATS and VATS procedures (OR 0.59, 95% CI [0.40 - 0.86]), with homogeneous data (I2: 0%; p < 0.006).

Duration of Surgery

Among the 8 studies we identified, 6 studies reported data on the duration of surgery for Robotic Lobectomy and VATS. Four studies indicated that Robotic Lobectomy required a longer duration compared to VATS (Adams et al., 1990; Louie et al., 2016; Swanson et al., 2014; Terra et al., 2022), while 2 other studies showed that VATS procedures took longer than Robotic Lobectomy (Kneuertz et al., 2019; Sun et al., 2023). Based on the results of the meta-analysis (see Fig 3), no significant difference was found in the parameter of surgical duration between robotic and VATS procedures (OR 12.57, 95% CI [-6.64, +31.78]), with heterogeneous data (I2: 97%; p < 0.0001).

Transfusion Rate

Three studies showed the need for transfusions in Robotic procedures is lower than in VATS (Adams et al., 1990; Kneuertz et al., 2019; Sun et al., 2023). The meta-analysis results (see Fig 4) confirm a significant difference in transfusion requirements between Robotic and VATS procedures (OR = 0.50; 95% CI: 0.27 - 0.92), with low heterogeneity (I2: 6%; p = 0.34).

Length of Stay

Eight studies reported data regarding the length of hospital stay (based on the average number of days) for Robotic Lobectomy and VATS procedures. Out of these eight studies, four studies indicated that VATS procedures required a longer hospital stay compared to Robotic Lobectomy (Adams et al., 1990; M. Kent et al., 2014; Sun et al., 2023; Terra et al., 2022). Notably, only the study by Kent et al. demonstrated a statistically significant difference in the length of hospital stay between Robotic and VATS procedures (4 vs. 5 days; p < 0.001)13. Three other studies found no significant difference in the length of hospital stay between Robotic and VATS procedures (Kneuertz et al., 2019; Louie et al., 2016; Paul et al., 2014). Meanwhile, a study by Swanson et al. suggested that Robotic procedures required a longer hospital stay than VATS, but this difference was not statistically significant (6.1 vs. 5.8 days; p = 0.61)16.

Intraoperative and Postoperative Complications

Based on eight studies, three studies discussed intraoperative complications, a study from Paul showed a significant difference in intraoperative complications in RATS procedures, which are higher compared to VATS, with consecutive results (5% vs 2%)15, while 2 other studies show the opposite results, but no statistically significant difference is observed (Swanson et al., 2014; Terra et al., 2022). Meta-analysis showed there are no statistically significant differences regarding the rates of intraoperative complications between Robotic-Assisted Thoracic Surgery (RATS) and Video-Assisted Thoracoscopic Surgery (VATS) procedures (OR 1.22, 95% CI: 0.46 - 3.22). with heterogeneity (I2: 93%, $p < 0.0001$).

Parameters for postoperative complications can be observed in 6 studies. 4 studies indicate higher complications in robotic procedures compared to VATS (M. Kent et al., 2014; Kneuertz et al., 2019; Paul et al., 2014; Swanson et al., 2014). However, overall, there is no significant difference between RATS and VATS procedures in terms of intraoperative complications (OR 1.98, 95% CI: 0.12 - 32.44) and postoperative complications (OR 1.05, 95% CI: 0.93 - 1.19).

Chest Drain Duration

Four studies reported data regarding the duration of chest drainage post Robotic Lobectomy and VATS procedures. Among these four studies, one study presented the average duration (in days) for Robotic vs. VATS (3.2 ± 4 vs. 3.7 ± 8.8; $p = 0.18$) (Adams et al., 1990). The remaining three studies provided data in terms of the median duration of chest drainage post-procedure (M. Kent et al., 2014; Sun et al., 2023; Terra et al., 2022). One of these studies indicated a longer duration for VATS compared to Robotic (M. Kent et al., 2014), while the other two studies reported the same median values for Robotic and VATS procedures (Sun et al., 2023; Terra et al., 2022).

Discussion

Surgical intervention remains the primary therapeutic choice for early-stage Non-Small Cell Lung Cancer (NSCLC). Robotic Assisted Thoracoscopic Surgery (RATS) has emerged as a recent alternative to Video Assisted Thoracoscopic Surgery (VATS). This study aims to compare VATS and RATS in terms of clinical outcomes. RATS has demonstrated its superiority over VATS in terms of postoperative mortality and transfusion requirements. However, there are no significant differences between the two procedures regarding surgical duration, and intraoperative and postoperative complications.

The results of the meta-analysis regarding the variable of in-hospital or 30-day postoperative mortality indicate that RATS carries a lower risk of mortality compared to VATS (OR 0.59, 95% CI = 0.40, 0.86, I2: 0%; $p < 0.006$). This finding aligns with the study by Kent, which significantly demonstrated that RATS had a lower risk of mortality compared to VATS (0.2% vs. 1.1%, $p = 0.062$) (M. Kent et al., 2014). However, it is important to exercise caution in interpreting these results, other studies show that RATS has a lower risk of mortality compared to VATS, but the differences are not statistically significant (Adams et al., 1990; Louie et al., 2016; Paul et al., 2014). One study from Kneuertz, et al. indicates the opposite result (1% vs. 0.6%, $p = 0.73$) (Kneuertz et al., 2019). The results of this meta-analysis are consistent with a previous meta-analysis conducted by Emmert in 2014, which included 3,375 RVATS resections and 58,683 VATS procedures and showed a mortality reduction benefit with an HR of 0.52 in favor of robotic surgery (Emmert et al., 2017). The results of this study are not consistent with the study conducted by Yong Cui, there was no significant difference in mortality within 30-90 days after surgery among Stage I NSCLC patients undergoing RATS-L and VATS-L procedures, despite a higher rate of conversion to open thoracotomy in the VATS-L group compared to the RATS-L group (15.2% vs. 7.8%; P < 0.01) (Cui et al., 2020)

The results of the meta-analysis in parameter transfusion requirements reveal a significant difference in transfusion needs between Robotic and VATS procedures (OR = 0.50; 95% CI: 0.27 - 0.92) with low heterogeneity (I2: 6%; p = 0.34). This finding aligns with the study by Tian et al., which demonstrated a statistically significant reduction in postoperative transfusion requirements with RATS compared to VATS (3.5% vs. 9.8%, p = 0.02) (Sun et al., 2023). This can be explained by the fact that the operator had completed the learning curve and the majority of patients in the research population were in the early stage of the disease. The findings of this study are also supported by a study conducted by Sun et al. in 2023, which demonstrated a lower transfusion rate in robotic procedures compared to VATS in the management of lung neoplasms (3.5% vs. 9.8%, p = 0.02). This parameter can serve as a benchmark for the safety and feasibility of minimally invasive surgery(Sun et al., 2023). Other studies by Adam et al and Kneuertz et al, RATS reduced transfusion requirements compared to VATS, but the differences were not statistically significant (0.9% vs. 3.8%, p = 0.13; 3.7% vs. 4.3%) (Adams et al., 1990; Kneuertz et al., 2019). This could be attributed to factors such as the operator's experience and the patient population's disease stage. Our findings align with a study by Lampridis et al. in 2023, which showed that the transfusion requirement rate in lung cancer patients undergoing resection with the robotic procedure was lower than that in VATS, although not significantly different {95% CI, −3.1 (−7.3, 1.2) P 0.161}. However, there was a significant difference in the estimated blood loss parameter, with RATS being lower by 87.5 mL compared to VATS (95% CI, 48.1 to 126.8 mL; p < 0.001)(Lampridis et al., 2023).

Table 2. Comparison Robotic vs. VATS

Author		Gender		Age	BMI	Clinical T Stage					
		Male	Female			No cancer	cT1	cT2	cT3	cT4	Unknown
(Adams et al., 1990)	Robotic	58 (48.3)	62(51.7)	64.6 (+- 10.5)	27.1 (+- 5.5)	N/A	75 (68.2)	35 (31.8)	N/A	N/A	N/A
	VATS	2.053(44.5)	2.559(55.5)	66.2 (+- 11.3)	27.3 (+- 5.9)	N/A	2808 (73.9)	988 (26)	N/A	N/A	N/A
	p-value	p 0.41		P 0.13	p 0.6			P = 0.24			
(M. Kent et al., 2014)	Robotic	N/A	239 (56)	67.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	VATS	N/A	6.934(56)	66.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	p-value	N/A	P 0.891	0.11	N/A			N/A			
(Louie et al., 2016)	Robotic	527 (43.2)	693 (56.8)	69 (61,75)	N/A	N/A	874 (71.6)	346 (28.4)	N/A	N/A	N/A
	VATS	5330 (43.1)	7.046 (56.9)	68 (61,75)	N/A	N/A	9094 (73.6)	1078 (26.5)	N/A	N/A	N/A
	p-value	P 0.93	N/A	P 0.0253	N/A		P 0.0087			P <.0001	
(Paul et al., 2014)	Robotic	1.207(48.4)	1.290(51.7)	68(60-74)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	VATS	16.219 (43.2)	21.348(56.8)	67(59-74)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	p-value	P .02	N/A	P.46	N/A	N/A		P.14		P.34	
(Swanson et al., 2014)	Robotic	141	154	66.43	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	VATS	132	163	66.54	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	p-value	P.4574	N/A	P.9112	N/A	N/A	N/A	N/A		P .4242	
(Terra et al., 2022)	Robotic	20 (54.0)	17 (46.0)	68.4 (65.2-71.5)	27.5 (26.2-28.8)	N/A	N/A	N/A	N/A	N/A	N/A
	VATS	22 (56.4)	17 (44.6)	65.7(61.8-69.5)	26.5 (24.9-28.1)	N/A	N/A	N/A	N/A	N/A	N/A
	p-value		P 1	P 0.31	P 0.24	0.78	P0.35		P0.42		N/A
(Sun et al., 2023)	Robotic	83	90	58 (50-65)	23 (21.5-25.4)	N/A	148 (85.5)	12 (6.9)	11 (6.4)	2 (1.2)	N/A
	VATS	81	82	59 (52-66)	23.3 (20.8-25.2)	N/A	134 (82.2)	16 (9.8)	10 (6.1)	3 (1.8)	N/A
	p-value	0.75	N/A	0.19	0.63			0.76			N/A
	Robotic	135 (45.6)	161 (54.4)	65.2(11.2)	27.9 (6.7)	44 (14.86)	155 (52.36)	46 (15.54)	29(9.8)	15(5.07)	7(2.36)

(Kneuertz et al., 2019)	VATS	75 (46.6)	86(53.4)	62.0(10.4)	27.8 (6.1)	17 (10.63)	89 (55.63)	38(23.75)	7(4.38)	8(5.00)	1(0.63)
	p-value	p .35		p .006	p .93			P <.001			

Table 3. Comparison Robotic vs. VATS

Author		Clinical N Stage					Smoking History (%)		Hypertension	Diabetes mellitus	Coronary artery disease	ASA		
		No cancer	cN0	cN1	cN2	cN3	Yes	No				2	3	4
(Adams et al., 1990)	Robotic	N/A	N/A	N/A	N/A	N/A	102	18	N/A	N/A	N/A	12 (10)	98 (81.7)	10 (8.3)
	VATS	N/A	N/A	N/A	N/A	N/A	3683	929	N/A	N/A	N/A	1023 (22.2)	3280 (71.1)	309 (6.7)
	p-value			N/A			P = 0.3		N/A	N/A	N/A		P = 0.04	
(M. Kent et al., 2014)	Robotic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	231(54)	77(18)	80(19)	N/A	N/A	N/A
	VATS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.320(51)	2.017(16)	2.173(17)	N/A	N/A	N/A
	p-value								N/A					
(Louie et al., 2016)	Robotic	N/A	1163 (95.3)	57 (4.7)	N/A	N/A	985 (80.7)		822 (67.4)	233 (19.1)	304 (24.9)	197 (16.1)	932 (76.4)	84(6.9)
	VATS	N/A	1163 (94,6)	674 (5,5)	N/A	N/A	10.354 (83.6)		7.422 (60)	2111 (17.1)	2.525 (20.4)	2331 (18.8)	9.105 (73.6)	885 (7.1%)
	p-value				P 0.0087				P <.0001	P 0.1475	P 0.0009		P = 0.12	
(Paul et al., 2014)	Robotic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.394(55.8)	477(19.1)	563(22.5)	N/A	N/A	N/A
	VATS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19.727(52.5)	6.543(17.4)	6.839(18.19)	N/A	N/A	N/A
	p-value				N/A				P.14	P.34	p.02			
(Swanson et al., 2014)	Robotic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	68	N/A	N/A	N/A	N/A
	VATS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	60	N/A	N/A	N/A	N/A
	p-value						N/A	N/A	N/A	P .4242	N/A	N/A	N/A	N/A
(Terra et al., 2022)	Robotic	N/A	N/A	N/A	N/A	N/A	N/A	12	24	7	5	N/A	N/A	N/A
	VATS	N/A	N/A	N/A	N/A	N/A	N/A	11	21	11	3	N/A	N/A	N/A
	p-value				N/A			0.78	P0.35	P0.42	P0.47	N/A	N/A	N/A
(Sun et al., 2023)	Robotic	N/A	154 (89)	10 (5.8)	9 (5.2)	0	57 (32.9)	59 (36.2)	N/A	N/A	N/A	N/A	N/A	N/A
	VATS	N/A	141 (86.5)	12 (7.4)	8 (4.9)	2 (1.2)	116 (67.1)	104 (63.8)	N/A	N/A	N/A	N/A	N/A	N/A
	p-value	N/A	0.58						N/A	N/A	N/A	N/A	N/A	N/A
(Kneuertz et al., 2019)	Robotic	44(14.8)	227(76.69)	11(3.72)	14(4.73)	N/A	N/A	58(19.6)	190 (64.2)	28(9.5)	123(41.6)	11(3.7)	238(80.4)	47(15.9)
	VATS	17(10.63)	121 (75.63)	10(6.25)	12(7.5)	N/A	N/A	36(22.5)	88(54.7)	25(15.5)	38(23.6)	12(7.5)	136(84.5)	13(8.1)
	p-value			P .010		N/A	N/A		P.13	P .15	P <.001		P .02	

The results of the meta-analysis regarding the parameter of surgical duration show no significant difference between robotic and VATS procedures (OR 12.57, 95% CI (-6.64, +31.78)), with high heterogeneity (I2: 97%; $p < 0.0001$). These findings are consistent with the study by Swanson, which observed that although robotic procedures took longer, there was no statistically significant difference compared to VATS (4.49 vs. 4.23 hours; p = 0.0959)(Swanson et al., 2014), one study also indicate similar findings (Terra et al., 2022). In contrast, a study from Sun, et al and Kneuertz, et al, both studies VATS procedures statistically significant took longer compared to robotic surgery (107 min [90-130] vs. 120 min [100-149], $p < 0.001$; 313.2 min [±74.6] vs. 283.6 min [±71.9, $p < 0.001$)18,19. Interestingly, Adam, et al and Louie, et al reported that RATS procedures took longer than VATS, with statistically significant differences in both cases, consecutively (241.5 ± 64.9 min vs. 179.8 ± 78.3 min, $p < 0.0001$; 186 minutes vs. 173 min, $p < 0.001$)12,14. The significant differences in operative time in the early cases due to the learning curve in Robotic Assisted surgery(Adams et al., 1990), Yang et al explained that performing robotic portal lobectomy with four arms (RPL-4) using The Da Vinci Si System, analyzed with RA-CUSUM (Risk-Adjusted Regression curves of cumulative sum analysis), requires 56 cases to truly master the procedure {1–10 cases (learning phase), 11–51 cases (plateau phase), and >51 cases (mastery phase)(Yang et al., 2021).

In this parameter of intra – postoperative complications, there were no significant differences in intraoperative complications (OR 1.98, 95% CI: 0.12 - 32.44) and postoperative complications (OR 1.05, 95% CI: 0.93 - 1.19). These results are noteworthy as they differ from a study by Swanson et al, which showed a higher incidence of major intraoperative complications and minor intraoperative complications in VATS procedures compared to RATS

(Major Intraoperative Complication 16.9% vs. 13.5%; Minor Intraoperative Complication 34.2% vs. 33.9%). The parameter of postoperative complications was also higher in VATS compared to RATS (Major Postoperative Complication 18.9% vs. 16%, Minor Postoperative Complication 38.3% vs. 36.95%) (Swanson et al., 2014). These findings are in line with the study from (Terra et al., 2022). Another study by Hanbo Pan et al. in 2023, which assessed the Clavien-Dindo postoperative complication score in non-small cell lung cancer (NSCLC) patients, also demonstrated no differences between the groups undergoing RATS and VATS ($p > 0.05$)24, Study from Kent et al, demonstrates a similar result with no significant difference in complication rates between patients undergoing robotic and VATS procedures for pulmonary neoplasms who undergo minimally invasive lobectomies Commonly occurring complications include pneumonia, prolonged air leak, and cases requiring bronchoscopy (Haque & El Bayani, 2023; M. S. Kent et al., 2023).

Various studies have yielded differing results in length of stay parameter, with four studies indicating that VATS procedures require longer hospital stays than robotic procedures. This is supported by Kent et al.'s study, which showed a statistically significant difference in hospital stay duration between Robotic and VATS procedures (4 vs. 5 days; $p < 0.001$)25. However, one study by Swanson et al. drew a different conclusion, suggesting that Robotic procedures required a longer hospital stay than VATS, although this difference was not statistically significant (6.1 vs. 5.8 days; $p = 0.61$)16. A study from Sun, et al showed different results that the postoperative length of stay for pulmonary neoplasm cases undergoing minimally invasive surgery between the RATS and VATS procedures did not differ significantly (5 days vs VATS 5 days, $p = 0.9$).

The study from Sun et al. in 2023 also demonstrated no difference in chest drainage duration for lung neoplasm patients undergoing RATS and VATS procedures {4 (3-5) vs. 4 (3-5) p 0.82. However, the study by Ma et al. in 2021 showed a significant difference with a shorter postoperative chest drain duration for RATS compared to VATS in patients with non-small cell lung cancer (NSCLC) (WMD = −0.61, 95% CI −0.78 to −0.44, $P < 0.001$, $I2 = 37\%$) The reason RATS performs better in this parameter is due to several advantages, such as lower irritation to the pleura and surrounding tissues, more thorough hemostasis, which makes the procedure more complex but reduces the risk of pleural effusion.

CONCLUSION

Robotic-assisted thoracic surgery (RATS) and video-assisted thoracic surgery (VATS) are two minimally invasive approaches commonly employed in the treatment of early-stage lung cancer. This discussion centers on a comprehensive analysis of their comparative effectiveness, with a particular focus on the mortality rate within 30 days post-surgery and the transfusion rate. The research indicates that RATS presents itself as a superior alternative in certain critical aspects.

One of the primary endpoints assessed in this study was the mortality rate within 30 days after surgery, a parameter of utmost importance in assessing the safety and effectiveness of surgical procedures. The results revealed a notable advantage for RATS, with an odds ratio (OR) of 0.59 (95% CI = 0.40, 0.86, I2 : 0%; $p<0.006$) when compared to VATS. This implies that patients undergoing RATS had a significantly lower risk of mortality within the first month following the procedure, highlighting its enhanced safety profile in this regard.

Transfusion requirements represent another crucial aspect of surgical outcomes, as excessive transfusions can lead to complications and adverse effects. The analysis demonstrated a substantial advantage for RATS, with an OR of 0.50 (95% CI: 0.27 - 0.92, I2: 6%; p = 0.34) in comparison to VATS. These findings suggest that RATS patients were less likely to require blood transfusions, reducing the associated risks and costs.

This comprehensive analysis supports the notion that RATS can be considered a viable alternative to VATS in the context of early-stage lung cancer surgery. RATS demonstrates a clear superiority in terms of reducing the risk of mortality within 30 days post-surgery and the need for blood transfusions. Importantly, it achieves these benefits without a significant difference in the duration of surgery or the incidence of intraoperative and postoperative complications. Additionally, RATS appears to offer advantages in terms of length of stay and chest drain duration, potentially contributing to improved patient outcomes and cost-effectiveness in the management of early-stage lung cancer. These findings provide valuable insights for clinicians and patients when considering the most appropriate surgical approach in this clinical setting.

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