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机器人辅助非小细胞肺癌手术治疗的临床疗效和安全性：系统性评价与Meta分析

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摘　要

背景：本研究旨在评估机器人辅助胸腔手术(RATS)治疗非小细胞肺癌(NSCLC)的安全性和治疗效果。研究设计和方法：检索了PubMed、EMBASE、Cochrane图书馆、Web of Science、CNKI、万方、VIP和CBM，从数据库开始到2022年5月1日。使用Newcastle-Ottawa Scale (NOS)进行质量评估，并使用RevMan (5.4版)进行Meta分析。结果：共纳入19篇文献，包含228,947名患者。与VATS相比，RATS的术中失血较少，淋巴结清扫较多，中间开胸的情况较少，胸腔引流管停留时间较短，术后并发症较少，但费用较高。两组在手术时间、术后总引流量和术后住院时间方面没有明显差异。结论：结果表明，RATS具有术中失血少、组织损伤小、恢复快等优点。在治疗临床非小细胞肺癌时，RTAS是安全可行的。

关键词

非小细胞肺癌，机器人辅助胸腔手术，机器人辅助手术，Meta分析，微创手术

Clinical Efficacy and Safety of Robot-Assisted Non-Small Cell Lung Cancer Surgical Treatment: A Systematic Review and Meta-Analysis

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Abstract

Background: This study aimed to evaluate the safety and therapeutic effect of robot-assisted thoracic surgery (RATS) for non-small cell lung cancer (NSCLC). Research design and methods: PubMed, EMBASE, Cochrane Library, Web of Science, CNKI, WanFang, VIP, and CBM were searched from database inception to 1 May 2022. The Newcastle-Ottawa scale (NOS) was used to conduct quality assessments, and RevMan (Version 5.4) was used to perform the meta-analysis. Results: A total of 19 publications involving 228,947 patients were included. RATS was associated with less intraoperative blood loss, more lymph node dissection, fewer cases of intermediate chest opening, shorter chest drain retention time, and fewer postoperative complications but higher costs compared with VATS. There were no significant differences between the two groups in terms of operative time, total postoperative drainage volume, and postoperative hospital stay. Conclusions: The available evidence indicates that the RATS has the advantages of less intraoperative blood loss, minor tissue damage, and quick recovery. In treating clinical non-small cell lung cancer, the RTAS is safely feasible.

Keywords

Non-Small Cell Lung Cancer, Robot-Assisted Thoracic Surgery, Robot-Assisted Procedures, Meta-Analysis, Minimally Invasive Surgery

1. 简介

肺癌是一种起源于肺部支气管粘膜或腺体的恶性肿瘤，其发病率和死亡率增长最快。它是对居民健康和生命威胁最大的恶性肿瘤之一。根据《2020 年全球癌症统计》[1]：2020 年，肺癌是第二大最常见的癌症，大约有 200 万新发癌症病例和 180 万死亡病例，男性的发病率和死亡率大约是女性的两倍[2]。肺癌可分为非小细胞肺癌和小细胞肺癌，而 80%的肺癌是非小细胞肺癌。尽管对肺癌的研究越来越多，但肺癌患者的 5 年生存率还不到 20%。

目前这些非小细胞肺癌患者的首选治疗方法仍然是手术。随着医疗技术的不断变革，手术方式也从最初创伤大、恢复慢、术后并发症多的传统开胸手术，转变为现在最广泛用于肺癌根治的胸腔镜手术。众多研究表明，接受胸腔镜手术的病人的长期生存率与开腹手术没有明显区别。手术时间、术中出血量、住院时间和术后疼痛都远远优于开放手术[3] [4]。这也是胸腔镜手术目前最受欢迎的原因。然而，胸腔镜手术有时也有局限性，如手术器械不灵活、手术视野有盲区、摄像机晃动、二维视角等[5] [6]。自 2001 年以来，美国食品和药物管理局批准达芬奇机器人手术系统在胸腔手术中的临床应用。机器人手术作为最新的技术也在不断发展。但同时，机器人手术的优势仍有待明确[7]。本文系统地评价了机器人手术和

胸腔镜手术在临床非小细胞肺癌中的疗效，为临床选择手术方式提供参考依据。

2. 研究方法

本研究根据 Preferred Reporting Items (PRISMA)指南[8] [9]进行。由于本研究是一个系统回顾和 Meta 分析，因此不需要机构审查委员会(IRB)的批准。

2.1. 数据来源和检索策略

我们系统地检索了 PubMed、EMBASE、Cochrane 图书馆、Web of Science、CNKI、万方、VIP 和 CBM 等数据库。检索时间范围在自建库至 2022 年 11 月 1 日，检索策略包括 MeSH 术语和/或自由文本术语，用于检索相关研究。我们还手动交叉检索了相关文章的参考文献列表，以寻找额外的数据。检索策略的细节在附录中提供。

2.2. 纳入和排除标准

研究的纳入标准是：1) 机器人和胸腔镜手术治疗 NSCLC 的临床结果的回顾性分析或病例对照研究；2) 手术时间、术中出血、术后引流、住院时间、住院费用、清扫淋巴结数量、中转开胸、术后常见并发症(肺炎、伤口感染、漏气、腹腔漏气等)的研究；3) 机器人手术和腹腔镜手术的研究在方法上是一致的(肺叶切除、肺段切除)，并且有研究的发展或发表时间。

以下研究被排除在我们的分析之外：1) 非对照研究；2) 手术方法不一致者；3) 无详细资料；4) 会议记录、信件和个案。

2.3. 数据提取和质量评估

我们建立了一个标准化的数据提取表来收集关键信息，包括研究特征(如作者姓名、出版年份、来源国和样本量)、患者特征(平均年龄或性别比例)、手术结果、术后恢复、术后并发症、住院费用和住院天数。The Newcastle-Ottawa Scale (NOS)被用来评估回顾性研究的质量。NOS 根据研究组的选择、可比性和接触情况对纳入的研究进行评估，评分范围为 0 至 9 分。6~7 分被认为是中等质量，8~9 分是高质量，而低于 6 分是低质量。所有的数据提取和质量评估过程都由两位评审员(Z.Z.J.和 J.K.H.)独立进行。任何分歧都是在第三位审稿人(L.N.)的共识下讨论和解决。

2.4. 统计学分析

二分法结果的统计学指标是比值(ORs)，连续法结果的统计学指标是平均差(MD)和 95% *CI*。平均值和标准差(SD)被用于连续变量的 Meta 分析。假设中位数、范围、四分位间距(IQR)和大样本量不能获得平均值和 SD。在这种情况下，我们使用 Hozo 等人[10]的方法来估计平均值和 SD 的近似值。异质性的评估采用了卡方(χ^2)和 I 方(I^2)检验。如果不存在异质性($I^2 < 50\%$, $P > 0.05$)，则使用固定效应模型。否则，采用随机效应模型。进行亚组分析和敏感性分析以确定异质性的来源。RevMan (5.4 版)被用于所有的数据分析。*P* 值 < 0.05 被认为具有统计学意义。

3. 结果

3.1. 研究选择

从相关的数据库中获得了 297 个研究。在去除重复的研究后，168 项研究被筛选为标题和摘要。随后，对 51 篇全文进行了资格评估，其中 32 篇因缺乏纳入标准而被排除。最终有 19 项研究[11]-[29]被纳入，进行定性和定量分析。流程图见图 1。

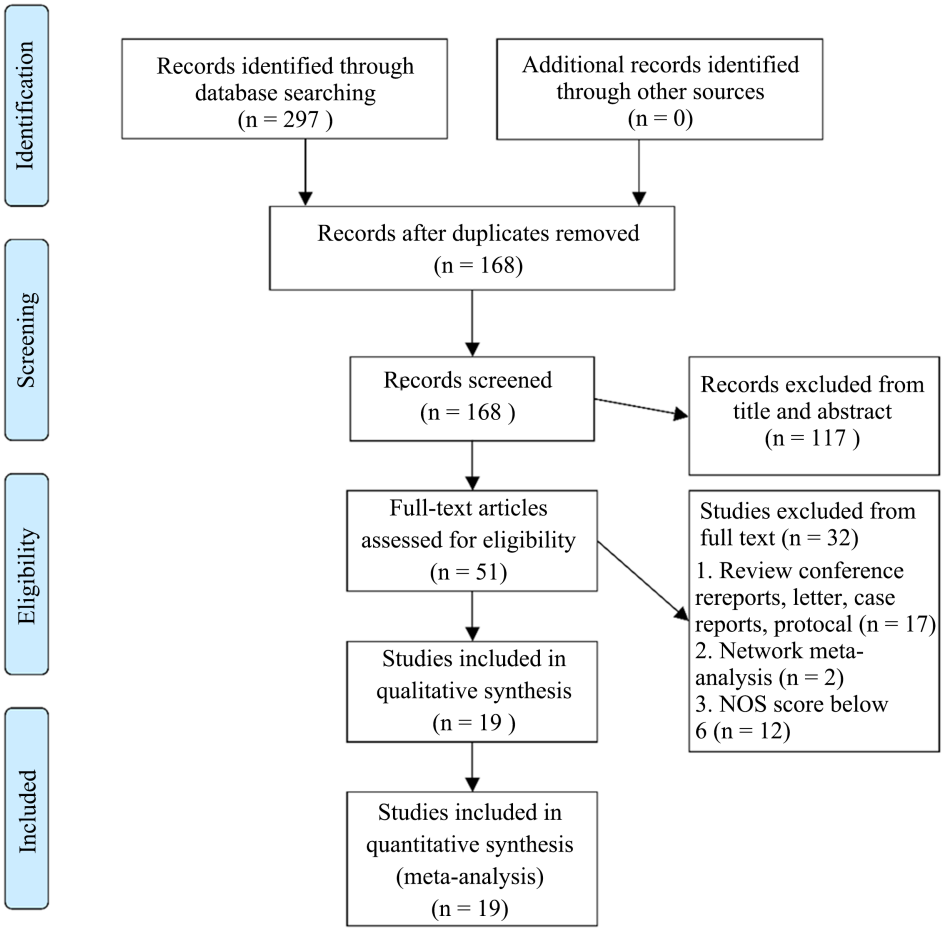


Figure 1. Systematic review flow diagram
图 1. 系统性回顾流程图

3.2. 研究特点和质量评估

这 19 项研究共纳入 22,947 名参与者(每项研究的参与者从 43 名到 5975 名不等)，9336 名接受了机器人辅助手术，13,611 名接受了胸腔镜手术，患者来自中国、日本和美国等地区。所有这些都是回顾性研究。根据 NOS，19 个回顾性病例对照研究 15 篇被评为高质量，4 篇被评为中等质量，得分如下：4 篇文章得到 6 分，5 篇文章得到 7 分，6 篇文章得到 8 分，4 篇文章得到 9 分。纳入研究的主要基线特征和一般信息见表 1。

Table 1. Characteristics of included studies
表 1. 纳入研究的特点

Author, year	Study type	Study period	Group		Age (years)		Sex (F/M)		Exposure factors	NOS
			RTS	VATS	RTS	VATS	RTS	VATS		
Seder, 2022	Retrospective	2015 ~ 2019	2133	5979	66.62 ± 9.1	66.65 ± 8.9	911/1222	2598/3377	①⑦⑨	9
Zheng, L. 2022	Retrospective	2020.12 ~ 2021.5	43	43	57.98 ± 10.70	58.26 ± 10.28	14/18	29/25	①②⑤⑥⑦⑨⑩	8

Continued

Zhang, F. 2022	Retrospective	2020.11 ~ 2021.11	54	54	60.5 ± 3.5	59.5 ± 4	23/31	21/33	③⑤⑥⑦⑩	9
Montagne, 2022	Retrospective	2012.1 ~ 2019.12	234	436	64.49 ± 10.49	65.24 ± 9.36	147/87	297/139	①⑦	6
Qu, 2022	Retrospective	2020.8 ~ 2021.4	316	316	58.48 ± 0.54	57.93 ± 0.62	140/176	123/193	①②⑤⑦⑩	8
Li, R. 2022	Retrospective	2020.9 ~ 2021.12	292	292	59.25 ± 1.83	59 ± 2	128/164	124/168	①②③④⑤⑦⑨⑩	9
Jin, 2022	Retrospective	2017.5 ~ 2020.5	157	163	-	-	-	-	①②③④⑤⑥⑦⑨⑩	8
Jian, 2022	Retrospective	2017.7 ~ 2021.8	30	32	46.97 ± 10.81	50.47 ± 12.60	12/18	11/21	①②⑤⑦⑨⑩	8
Chen, D. L. 2022	Retrospective	2016 ~ 2018	107	144	69.8 ± 4.1	69.5 ± 3.7	53/54	72/72	①②③⑤⑥⑦⑨⑩	9
Veronesi, 2021	Retrospective	2017.4 ~ 2018.11	38	39	69 ± 8.3	69 ± 7.3	21/17	23/16	①④⑤⑦⑨	7
Huang, 2021	Retrospective	2015.1 ~ 2019.12	335	350	59.89 ± 10.78	58.78 ± 9.39	148/187	142/208	①③⑤⑦⑨⑩	8
Haruki, 2021	Retrospective	2011.1 ~ 2020.4	104	286	65.5 ± 7.5	63.75 ± 8.5	59/45	175 /111	①②⑤	7
Chen, D. 2021	Retrospective	2011.11 ~ 2018.1	50	80	54.7 ± 10.3	57.7 ± 9.7	15/35	26/54	①②⑤⑦	7
Zhang, Y. 2020	Retrospective	2015.6 ~ 2019.8	257	257	53.53 ± 10.96	52.21 ± 11.89	84/173	89/168	①②④⑤⑨⑩	7
Sesti, 2020	Retrospective	2008 ~ 2013	409	409	75.5 ± 4.33	75.25 ± 3.83	176/33	188/221	⑦	6
Lee, 2020	Retrospective	2016 ~ 2018	118	49	67.5 ± 2.25	66.5 ± 3	58/60	13/36	①②③④⑤⑦	7
Cui, 2020	Retrospective	2010 ~ 2014	4537	4537	66.8 ± 9.8	66.8 ± 9.6	1955/2582	2012/2525	④	6
Bao, 2016	Retrospective	2014.9 ~ 2015.7	69	69	58.6 ± 8.8	59.9 ± 9.7	26/43	26/43	②③⑤⑦⑩	8
Mungo, 2016	Retrospective	2007 ~ 2014	53	80	65.75 ± 2.75	67.75 ± 2	-	-	③④⑤⑦	6

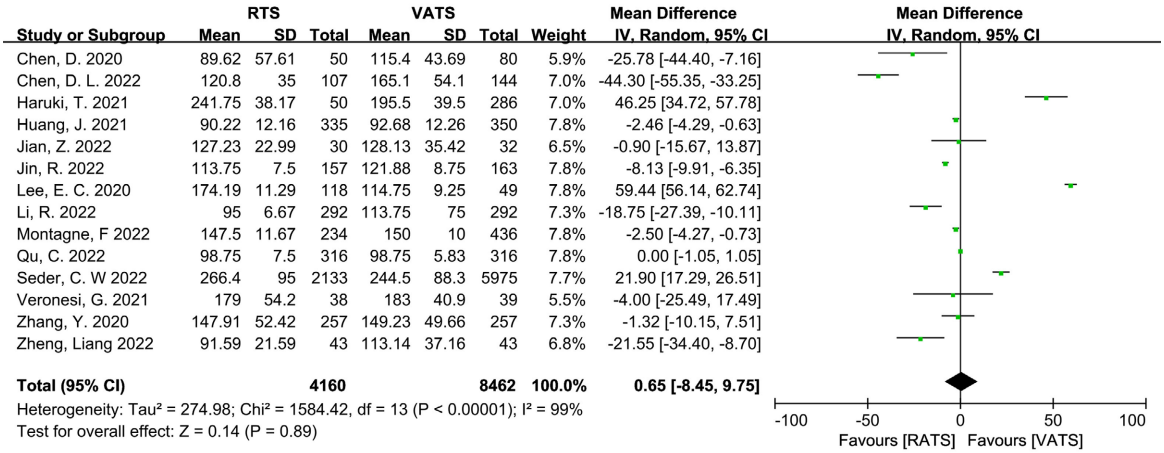
①手术时间，②术中失血量，③淋巴结清扫数量，④中转开胸，⑤引流管留置时间，⑥总引流量，⑦术后住院时长，⑧术后并发症，⑨住院总费用*。*统一单位为人民币。

3.3. Meta 分析

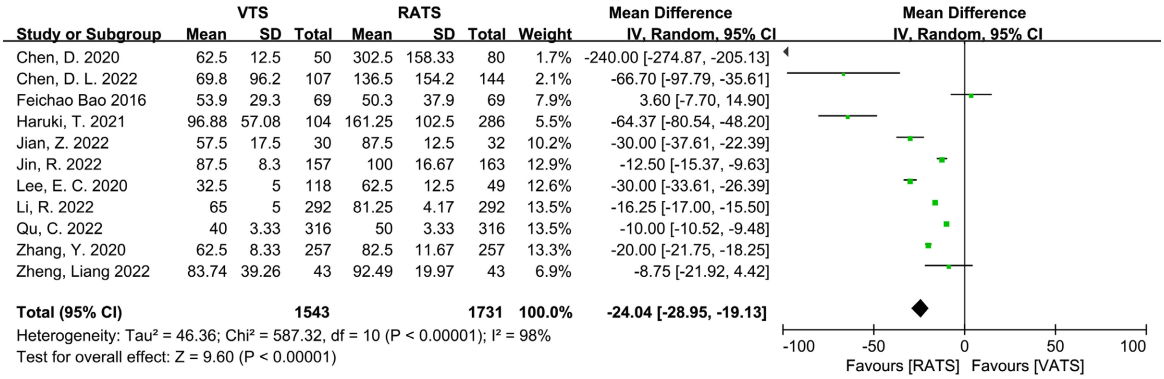
3.3.1. 手术结果：手术时间、失血量、淋巴结数量和转为开放手术

14 项研究提供了手术时间的数据。RATS 组的综合平均手术时间为 195.3 分钟，VATS 组为 211.8 分钟。使用随机效应模型(I^2 = 99%)，Meta 分析显示 RATS 组的手术时间没有明显延长(MD = 0.65, 95% *CI* = −8.45~9.75, I^2 = 99%, *P* = 0.89) (图 2(a))。

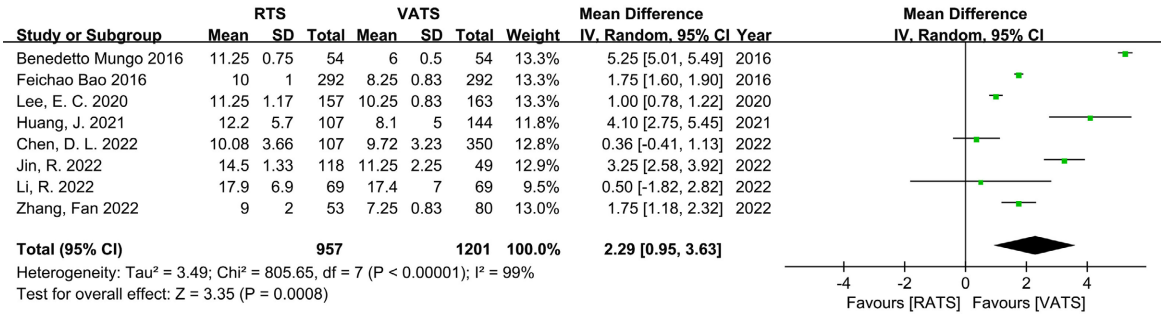
14 项研究提供了关于术中出血的数据。RATS 组的综合平均失血量为 61.5 毫升，VATS 组为 104.1 毫升。Meta 分析显示，RATS 组的胸腔引流管留置时间比 VATS 组短，这具有统计学意义(MD = −24.04, 95% *CI* = −28.95-19.13, I^2 = 98%, *P* < 0.00001) (图 2(b))。



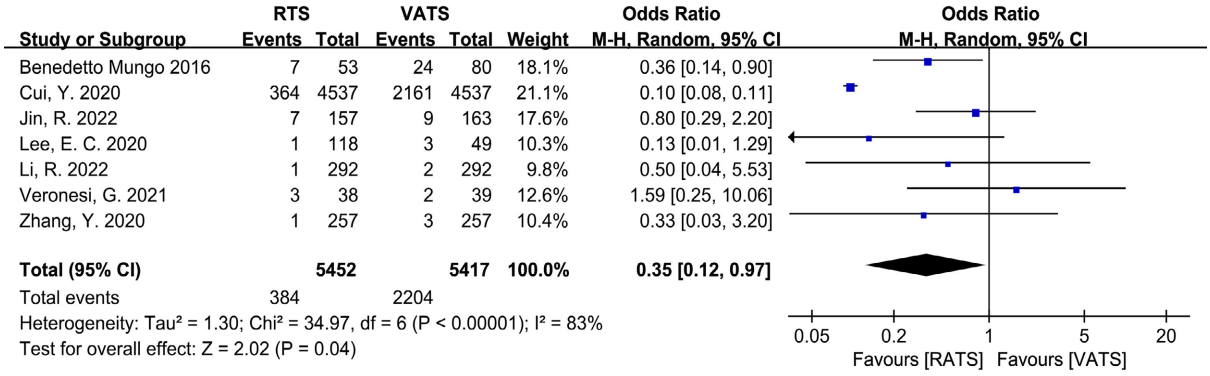
(a)



(b)



(c)



(d)

Figure 2. Forest plot of the included studies for operation time (a), blood loss (b), number of lymph node (c), conversion to open surgery (d)

图 2. 纳入研究的手术时间(a)、失血量(b)、淋巴结数量(c)、转为开放手术(d)的森林图

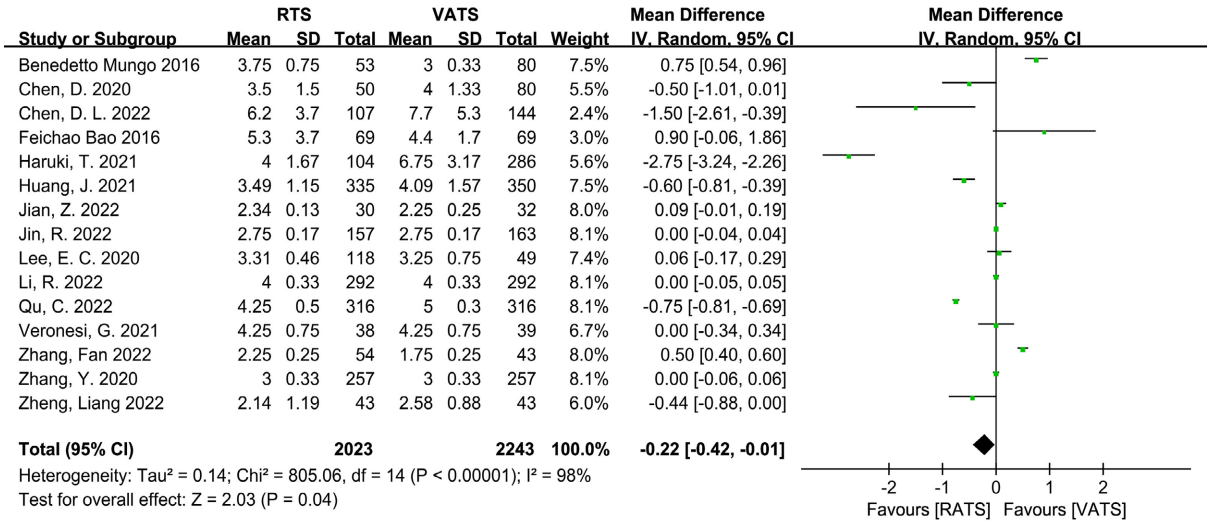
八项研究提供了关于淋巴结数量的数据。RATS 组清除的淋巴结综合平均数为 11.6 个，VATS 组为 9.4 个，Meta 分析显示，RATS 组清除的淋巴结数量明显多于 VATS 组(MD = 2.29, 95% *CI* = 0.95~3.63, I^2 = 99%, *P* = 0.0008) (图 2(c))。

七项研究提供了转为开放手术的数据。而 Meta 分析显示，RATS 组转为开胸手术的次数比 VATS 组少(OR = 0.35, 95% *CI* = 0.12~0.97, I^2 = 83%, *P* = 0.04) (图 2(d))。

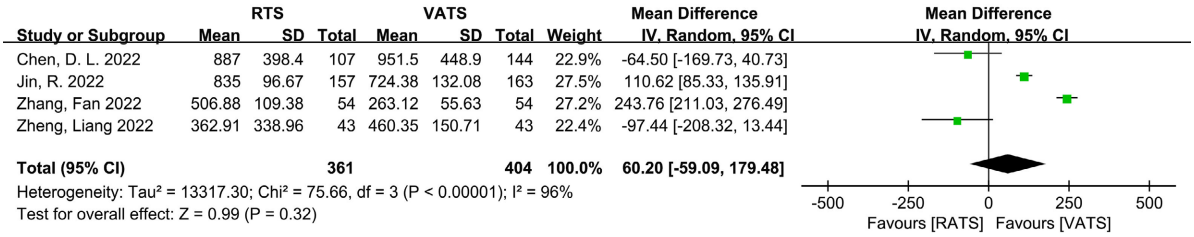
3.3.2. 术后恢复：胸管拔除时间、胸管引流总量、住院时间、总并发症

七项研究提供了关于胸管拔除时间的数据。在 RATS 组中，胸管拔除时间的综合平均数为 3.79 天，而在 VATS 组中为 4.4 天。而 Meta 分析显示，RATS 组的胸管拔除时间比 VATS 组少(MD = −0.22, 95% *CI* = −0.42~0.01, I^2 = 98%, *P* = 0.04) (图 3(a))。

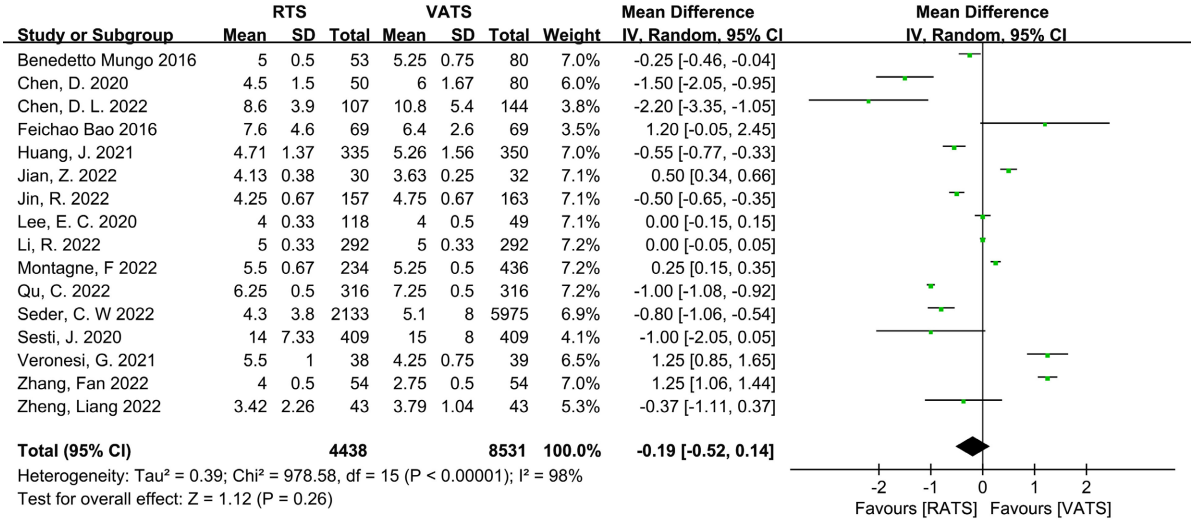
四项研究提供了关于胸腔管引流总量的数据。RATS 组的术后总引流量综合平均为 745.01 毫升，VATS 组为 715.6 毫升，meta 分析显示机器人手术和胸腔镜手术在术后总引流量方面没有明显差异(MD = 60.20, 95% *CI* = −59.09~179.48, I^2 = 96%, *P* = 0.32) (图 3(b))。



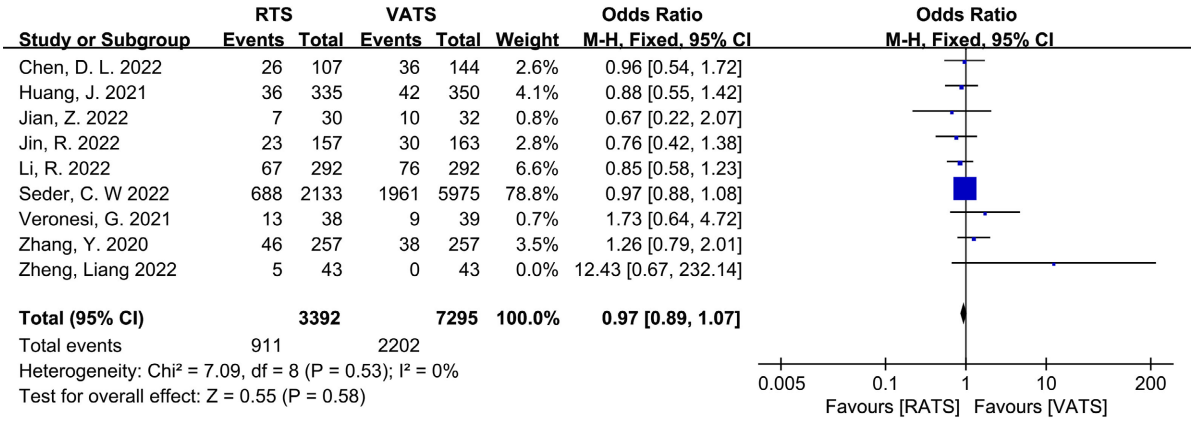
(a)



(b)



(c)



(d)

Figure 3. Forest plot of the included studies for Chest tube removal (a), total of Chest tube drainage (b), Length of hospital stay (c), total complications (d)

图 3. 纳入研究的胸管拔除时间(a)、胸管总引流量(b)、术后住院时间(c)、并发症总数(d)的森林图

16 项研究提供了关于术后住院时间的数据。RATS 组的综合平均术后住院时间为 6.6 天，VATS 组为 5.7 天，Meta 分析显示机器人手术和胸腔镜手术在术后住院时间方面没有明显差异(MD = −0.19, 95% *CI* = −0.52~0.14, I^2 = 98%, *P* = 0.26) (图 3(c))。

9 项研究提供了总并发症的数据，Meta 分析显示，机器人手术和胸腔镜手术在总并发症方面没有显著差异(OR = 0.97, 95% *CI* = 0.89~1.07, I^2 = 0%, *P* = 0.58) (图 3(d))。

3.3.3. 总成本

10 项研究记录了住院总费用。这些研究显示，机器人手术的住院总费用大大高于腹腔镜手术(85,146 元对 66,108 元)。Meta 分析显示，两组手术的总费用有显著差异(MD = 21.10, 95% *CI* = 13.21~29.00, I^2 = 100%, *P* < 0.00001) (图 4)。

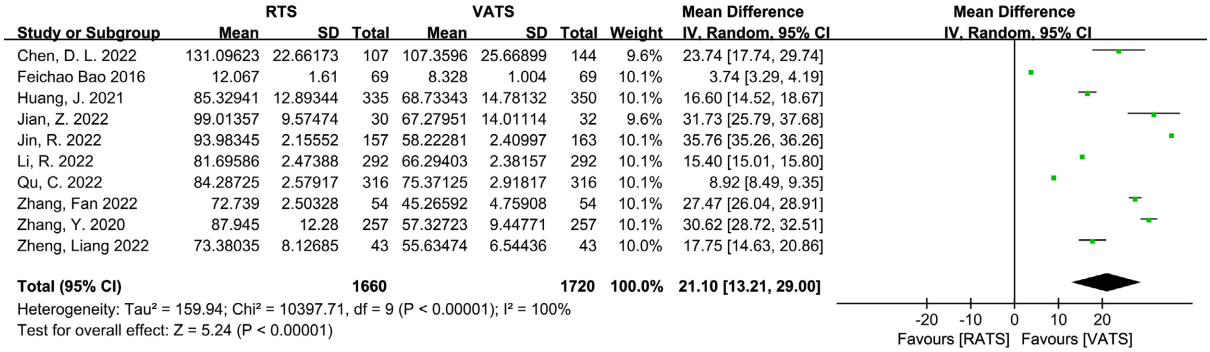


Figure 4. Forest plot of the included studies for total cost
图 4. 纳入研究的住院总费用森林图

3.4. 敏感性分析和发表偏倚

在敏感性分析中，我们通过依次排除每个研究来评估个别研究是否会影响总体结果。对于每个结果，排除每个研究后的集合结果都很相似，验证了 Meta 分析的稳定性。根据总并发症的漏斗图，没有发现发表偏倚(图 5)。

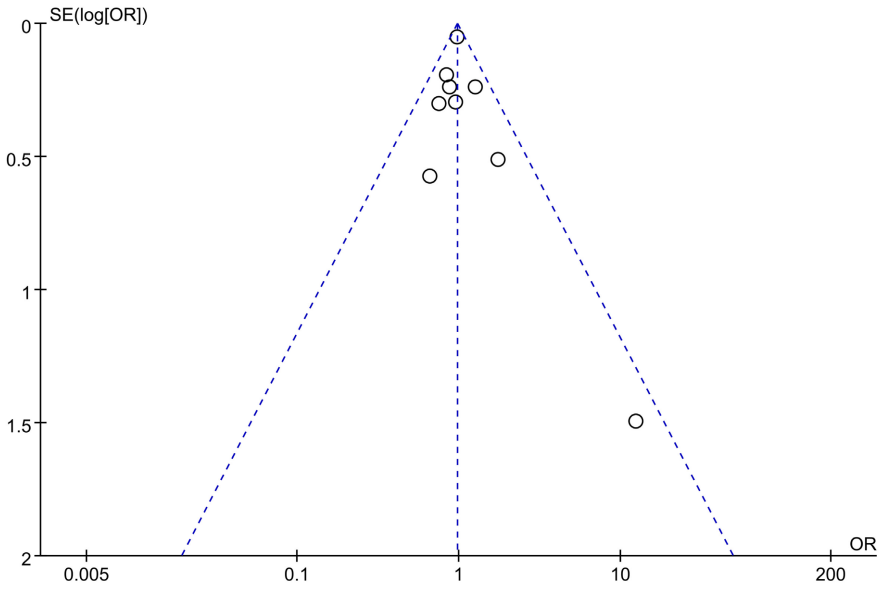


Figure 5. Funnel plot of the total complications
图 5. 总并发症的漏斗图

4. 讨论

原发性肺癌是全世界最常见的恶性肿瘤之一。随着人们健康意识的提高，伴随着低剂量螺旋 CT 的

应用筛查，越来越多的肺部结节被发现，导致非小细胞癌的手术数量与日俱增。同时，肺癌手术也被要求越来越精细化、微创化，RATS 在肺癌根治术中的研究也逐年增加。在以往的研究中，大多认为 RATS 的手术时间普遍长于 VATS [30]，也有研究指出，虽然 RATS 的手术时间增加，但对患者的预后(并发症发病率和死亡率)没有影响[31]。此外，也有学者认为机器人手术费用过高，且疗效不明确[28] [32]。因此，我们进行此次 META 分析，目的是通过比较两者的疗效，为今后的临床治疗选择提供参考价值。

Meta 分析显示，RATS 的集合平均手术时间比 VATS 短(195.3 分钟对 211.8 分钟)，但没有明显差异。这与以往的研究结果不同，可能是由于机器人手术的学习曲线比肿块切除术短[33]，以及现在的操作者更有经验和成熟。另外，面对一些复杂的情况，RATS 由于其三维成像、震颤过滤器和关节器械，在可视化和可操作性方面具有更明显的优势[34]，这使得手术难度降低，时间缩短。

术中出血量也是比较 RATS 和 VATS 时需要考虑的最重要指标之一。我们发现，RATS 的术中出血量集合平均比 VATS 少(61.5 毫升对 104.1 毫升)，且有明显差异。术中出血主要与严重的胸膜粘连和血管淋巴结分离组织引起的血管损伤有关，由于机器人手术器械的灵活性，具有放大的三维视野，更便于分离和切割血管，有利于避免对血管的损伤，从而减少失血，也在很大程度上避免了因大出血而导致的中间开胸，而机器人手术可以安全地处理一些大血管损伤[31]。中转开胸与许多因素有关，包括病人的风险评级、外科医生的经验以及术中具体情况等。

淋巴结切除的数量是 NSCLC 手术治疗的一个重要评估指标。本研究中，Meta 分析显示，RATS 的淋巴结切除集合平均数多于 VATS (11.6 vs. 9.4)，且有显著差异。系统性淋巴结清扫是肺癌根治术中最重要的步骤之一，对评估患者的预后有重要价值。以往研究的单变量分析显示，解剖的淋巴结数量是术后总生存率(Overall Survival, OS)的影响因素；对于术后无病生存率(DFS)，解剖的淋巴结数量和解剖的淋巴结数量都是影响因素[34]。有些淋巴结由于位置较深，靠近血管神经，或在其他复杂的情况下，如新辅助治疗后周围组织受损，淋巴结与周围组织界限不清，RATS 可以更容易、更安全地清扫。

在术后恢复方面，本研究发现，与 VATS 相比，RATS 的平均引流时间更短，平均术后并发症更少，且均有统计学意义；但术后平均总引流量没有统计学差异。较少的术后并发症是可以预期的，因为 RATS 具有三维视野，操作更灵活，可以过滤掉震颤，减少术中损伤，而较少的术中出血也加快了术后恢复，使患者可以更早下床，咳出肺部痰液，并使肺部复张更快，引流液更多，从而防止术后肺炎和其他并发症。然而，由于术中清理了更多的淋巴结，所以 RATS 的术后总引流量会比 RATS 多。本研究中大部分是早期肺癌，肿瘤直径较小，与较大的肿瘤相比，术中损伤相对较小，VATS 在减少损伤方面的优势不能充分体现，这大概是术后总引流和术后住院时间两项数据没有明显差异的原因。

然而，目前的机器人手术也有一些缺点。由于机器人本身的费用、维护费用以及更新软件和工具的费用，手术费用要比胸腔镜手术高。其次，自动化手术过程缺乏触觉反馈，在分离、缝合和打结过程中，操作者感觉不到直接的机械反馈[35]。

局限性

本研究仍有一些不足之处。首先，纳入的文献是回顾性的，可能存在一定的混淆偏差；其次，缺乏对术后复发、转移和长期生存风险的研究；第三，在一些研究中，患者人数太少，导致分析的可信度不足。而且由于开展机器人手术的医院综合实力不同，操作者经验水平不一，文献中收录的病例收集时间较长。在各种因素的影响下，一些结果的异质性很高。因此，对我们的一些结果应谨慎解释。总的来说，需要进行更多的前瞻性和多中心随机对照试验，并延长随访时间，以比较 RATS 与 VATS 治疗 NSCLC 的安全性和有效性。

5. 结论

RATS 具有更高的手术稳定性和安全性，随着 RATS 的发展以适应患者和医生的手术需求，RATS 比 VATS 有更多的可能性。随着机器人技术的发展和成本的降低，我们相信 RATS 将比 VATS 提供更多的临床益处。可以预见，机器人手术将成为早期 NSCLC 的标准治疗方案之一，并为患者带来更多好处。

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附录：检索策略表

Table A1. The details of the search strategies
附表 1. 详细的搜索策略表

Database	Search strategy
PUBMED	#1 "Carcinoma, Non-Small-Cell Lung"[Mesh] #2 "Carcinoma, Non Small Cell Lung[Title/Abstract]) OR (Carcinomas, Non-Small-Cell Lung[Title/Abstract])) OR (Lung Carcinoma, Non-Small-Cell[Title/Abstract])) OR (Lung Carcinomas, Non-Small-Cell[Title/Abstract])) OR (Non-Small-Cell Lung Carcinomas[Title/Abstract])) OR (Non-Small Cell Lung Carcinoma[Title/Abstract])) OR (Non-Small-Cell Lung Carcinoma[Title/Abstract])) OR (Non Small Cell Lung Carcinoma[Title/Abstract])) OR (Nonsmall Cell Lung Cancer[Title/Abstract])) OR (Carcinoma, Non-Small Cell Lung[Title/Abstract])) OR (Non-Small Cell Lung Cancer[Title/Abstract]) #3# 1 OR #2 #4 "Robotics"[Mesh] #5 "Robotic Surgical Procedures"[Mesh] #6"Robot*[Title/Abstract]) OR (Robotic surgery[Title/Abstract])) OR (Computer-assisted surgery[Title/Abstract])) OR (Robotic Surgical Procedures[Title/Abstract])) OR (Da Vinci[Title/Abstract]) #7 #4 OR #5 OR #6 #8 "Thoracic Surgery, Video-Assisted"[Mesh] #9 (Carcinoma, Surgeries, Video-Assisted Thoracic[Title/Abstract]) OR (Surgery, Video-Assisted Thoracic[Title/Abstract])) OR (Thoracic Surgeries, Video-Assisted[Title/Abstract])) OR (Thoracic Surgery, Video Assisted[Title/Abstract])) OR (Video-Assisted Thoracic Surgeries[Title/Abstract])) OR (Video-Assisted Thoracoscopic Surgery[Title/Abstract])) OR (Surgeries, Video-Assisted Thoracoscopic[Title/Abstract])) OR (Surgery, Video-Assisted Thoracoscopic[Title/Abstract])) OR (Thoracoscopic Surgeries, Video-Assisted[Title/Abstract])) OR (Thoracoscopic Surgery, Video-Assisted[Title/Abstract])) OR (Video Assisted Thoracoscopic Surgery[Title/Abstract])) OR (Video-Assisted Thoracoscopic Surgeries[Title/Abstract])) OR (Video-Assisted Thoracic Surgery[Title/Abstract])) OR (Video Assisted Thoracic Surgery[Title/Abstract])) OR (Surgery, Thoracic, Video-Assisted[Title/Abstract])) OR (VATS[Title/Abstract])) OR (VATSs[Title/Abstract]) #10 #8 OR#9 #11 #3 AND #7 AND # 10
The Cochrane Library	#1 MeSH descriptor: [non-small cell lung cancer] explode all trees #2 (Carcinoma, Non Small Cell Lung): ti, ab, kw OR (Carcinomas, Non-Small-Cell Lung): ti, ab, kw OR (Lung Carcinoma, Non-Small-Cell): ti, ab, kw OR (Lung Carcinomas, Non-Small-Cell): ti, ab, kw OR (Non-Small-Cell Lung Carcinomas): ti, ab, kw #3 (Non-Small-Cell Lung Carcinomas): ti, ab, kw OR (Non-Small-Cell Lung Carcinoma): ti, ab, kw OR (Non Small Cell Lung Carcinoma): ti, ab, kw OR (Nonsmall Cell Lung Cancer): ti, ab, kw OR (Carcinoma, Non-Small Cell Lung): ti, ab, kw #4 (Non-Small Cell Lung Cancer): ti, ab, kw #5 MeSH descriptor: [Robotics] explode all trees #6 MeSH descriptor: [Robotic Surgical Procedures] explode all trees #7(Robot* OR Robotic surgery): ti, ab, kw OR (Computer-assisted surgery): ti, ab, kw OR (Robotic Surgical Procedures): ti, ab, kw OR (Da Vinci): ti, ab, kw #8 MeSH descriptor: [video-assisted thoracic surgery] explode all trees #9 (Surgeries, Video-Assisted Thoracic): ti, ab, kw OR (Surgery, Video-Assisted Thoracic): ti, ab, kw OR (Thoracic Surgeries, Video-Assisted): ti, ab, kw OR (Thoracic Surgery, Video Assisted): ti, ab, kw OR (Video-Assisted Thoracic Surgeries): ti, ab, kw #10 (Video-Assisted Thoracoscopic Surgery): ti, ab, kw OR (Surgeries, Video-Assisted Thoracoscopic): ti, ab, kw OR (Surgery, Video-Assisted Thoracoscopic): ti, ab, kw OR (Thoracoscopic Surgeries, Video-Assisted): ti, ab, kw OR (Thoracoscopic Surgery, Video-Assisted): ti, ab, kw #11 (Video Assisted Thoracoscopic Surgery): ti, ab, kw OR (Video-Assisted Thoracoscopic Surgeries): ti, ab, kw OR (Video-Assisted Thoracic Surgery): ti, ab, kw OR (Video Assisted Thoracic Surgery): ti, ab, kw OR (Surgery, Thoracic, Video-Assisted): ti, ab, kw #12 (VATS): ti, ab, kw OR (VATSs): ti, ab, kw #13#1 OR #2 OR #3 OR #4 #14 #5 OR #6 OR #7 #15 #8 OR #9 OR #10 OR #11 OR #12 #16 #13 AND #14AND #15

Continued

EMBASE	#1 'non-small cell lung cancer'/exp OR 'Carcinoma, Non Small Cell Lung': ab, ti OR 'Carcinomas, Non-Small-Cell Lung': ab, ti OR 'Lung Carcinoma, Non-Small-Cell': ab, ti OR 'Lung Carcinomas, Non-Small-Cell': ab, ti OR 'Non-Small-Cell Lung Carcinomas': ab, ti OR 'Non-Small Cell Lung Carcinoma': ab, ti OR 'Non-Small-Cell Lung Carcinoma': ab, ti OR 'Non Small Cell Lung Carcinoma': ab, ti OR 'Nonsmall Cell Lung Cancer': ab, ti OR 'Carcinoma, Non-Small Cell Lung': ab, ti OR 'Non-Small Cell Lung Cancer': ab, ti #2 ' Robotics '/exp OR ' Robotic Surgical Procedures'/exp OR 'Robot*': ab, ti OR 'Robotic surgery': ab, ti OR 'Computer-assisted surgery': ab, ti OR 'Robotic Surgical Procedures': ab, ti OR 'Da Vinci': ab, ti #3 'video-assisted thoracic surgery'/exp OR 'Surgeries, Video-Assisted Thoracic': ab, ti OR 'Surgery, Video-Assisted Thoracic': ab, ti OR 'Thoracic Surgeries, Video-Assisted': ab, ti OR 'Thoracic Surgeries, Video-Assisted': ab, ti OR 'Thoracic Surgery, Video Assisted': ab, ti OR 'Video-Assisted Thoracic Surgeries': ab, ti OR 'Video-Assisted Thoracoscopic Surgery': ab, ti OR 'Surgeries, Video-Assisted': ab, ti OR 'Thoracoscopic': ab, ti OR 'Surgery, Video-Assisted Thoracoscopic': ab, ti OR 'Thoracoscopic Surgeries, Video-Assisted': ab, ti OR 'Thoracoscopic Surgery, Video-Assisted': ab, ti OR 'Video Assisted Thoracoscopic Surgery': ab, ti OR 'Video-Assisted Thoracoscopic': ab, ti OR 'Surgeries': ab, ti OR 'Video-Assisted Thoracic Surgery': ab, ti OR 'Video Assisted Thoracic Surgery': ab, ti OR 'Surgery, Thoracic, Video-Assisted': ab, ti OR 'VATS': ab, ti OR 'VATSs': ab, ti #4 #1 AND #2 AND #3
Web of science	#1 **TOPIC: (**non-small cell lung cancer) **OR TOPIC: (**Carcinoma, Non Small Cell Lung**) OR TOPIC: (**Carcinomas, Non-Small-Cell Lung**) OR TOPIC: (**Lung Carcinoma, Non-Small-Cell**) OR TOPIC: (**Lung Carcinomas, Non-Small-Cell**) OR TOPIC: (**Non-Small-Cell Lung Carcinomas**) OR TOPIC: (**Non-Small Cell Lung Carcinoma**) OR TOPIC: (**Carcinomas, Non-Small-Cell Lung**) OR TOPIC: (**Non-Small-Cell Lung Carcinoma**) OR TOPIC: (**Non Small Cell Lung Carcinoma**) OR TOPIC: (**Nonsmall Cell Lung Cancer**) OR TOPIC: (**Carcinoma, Non-Small Cell Lung**) OR TOPIC: (**Non-Small Cell Lung Cancer**)** #2 **TOPIC: (**Robotics**) OR TOPIC: (**Robotic Surgical Procedures**) OR TOPIC: (**Robot***) OR TOPIC: (**Robotic surgery**) OR TOPIC: (**Computer-assisted surgery**) OR TOPIC: (**Robotic Surgical Procedures**) OR TOPIC: (**Da Vinci**)** #3 **TOPIC**: (video-assisted thoracic surgery**) OR TOPIC: (Surgeries, Video-Assisted Thoracic) OR TOPIC: (Surgery, Video-Assisted Thoracic) OR TOPIC: (Thoracic Surgeries, Video-Assisted) OR TOPIC: (Thoracic Surgery, Video Assisted) OR TOPIC: (Video-Assisted Thoracic Surgeries) OR TOPIC: (Video-Assisted Thoracoscopic Surgery) OR TOPIC: (Surgeries, Video-Assisted) OR TOPIC: (Thoracoscopic) OR TOPIC: (Surgery, Video-Assisted Thoracoscopic) OR TOPIC: (Thoracoscopic Surgeries, Video-Assisted) OR TOPIC: (Thoracoscopic Surgery, Video-Assisted) OR TOPIC: (Video Assisted Thoracoscopic Surgery) OR TOPIC: (Video-Assisted Thoracoscopic) OR TOPIC: (Surgeries) OR TOPIC: (Video-Assisted Thoracic Surgery) OR TOPIC: (Video Assisted Thoracic Surgery) OR TOPIC: (Surgery, Thoracic, Video-Assisted) OR TOPIC: (VATS) OR TOPIC: (VATSs)** #4 #3 AND #2 AND #1