Heliyon 9 (2023) e20765

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Bibliometric analysis of 40 most cited articles comparing video-assisted thoracic surgery and robotic-assisted thoracic surgery in lung cancer (1997–2021)

Hasan Yavuz [a,*], Ahmet Kayahan Tekneci [b], Ali Ozdil [a], Ufuk Cagirici [a]

[a] Ege University School of Medicine, Department of Thoracic Surgery, İzmir, Turkey
[b] Izmir Ministry of Health University Tepecik Training and Research Hospital, Turkey

ARTICLE INFO

Keywords:
RATS
VATS
Bibliometric
Citations
Web of science
Impact factor

ABSTRACT

Background: In recent years, conventional thoracoscopic surgery has been accepted as the traditional treatment method in the non-small cell lung cancer (NSCLC). VATS and RATS, which are the techniques of this surgical method, have been increasing their effectiveness and applicability of late years. The aim of this bibliometric analysis is to evaluate the importance and efficiency of articles comparing VATS and RATS techniques.

Materials and methods: Studies comparing VATS and RATS published between 1997 and 2021 were identified in the Web of Science database (accessed on 31. 12. 2021). The 40 most cited studies were analyzed in terms of publication years, country of study, authors, institutions that the authors were affiliated with, journal, journal address and impact factor.

Results: While an article was cited a maximum of 187 times when the citations made by the authors were excluded from the analysis, it was observed that all publications were cited a total of 1946 times. It was seen that an average of 51. 30 ± 47. 73 (8–187) articles were cited. In the 25-year, the highest number of publications was reached in 2019, while eight articles were published this year. The Annals of Thoracic Surgery (n = 13, 32. 5 %) was the journal in which the articles in the list were published the most. Most of the articles in our study (n = 31, 77.5 %) were published in US journals. While many studies presented more than one topic and analysis, the topic of most interest in 19 (47.5 %) studies was postoperative complications.

Conclusion: This bibliometric analysis reflects important and qualified articles comparing VATS and RATS technique in thoracic surgery, but it can also be used to explain or explain the performance and results of these techniques, their positive and negative aspects, and their superiority over each other.

1. Introduction

Lung cancer is responsible for 11. 4 % of total cancer incidence and 18 % of total cancer deaths. In the world, 2.2 million patients were diagnosed as lung cancer in 2020, and 1.8 million deaths were caused by lung cancer in the same year [1]. This situation reveals that lung cancer is an important health problem. Approximately 85 % of all lung cancers are non-small cell lung cancer (NSCLC), and surgery is the most effective treatment in the early stages [2–4].

* Corresponding author. Ege University, Faculty of Medicine, Department of Thoracic Surgery, Izmir, Turkey.
E-mail address: hasanyavuzdr@gmail.com (H. Yavuz).

https://doi.org/10.1016/j.heliyon.2023.e20765
Received 22 May 2023; Received in revised form 26 September 2023; Accepted 5 October 2023
Available online 6 October 2023

Table-1
Top 40 most-cited articles in comparing video-assisted thoracic surgery and robotic thoracic surgery in lung cancer.

No.	Title	Journals	Year of Publication	No. of Citations
1	Open, Video-Assisted Thoracic Surgery, and Robotic Lobectomy: Review of a National Database	Ann Thorac Surg.	2014	187
2	Robotic assistance for video-assisted thoracic surgical lobectomy: Technique and initial results	J Thorac Cardiovasc Surg.	2006	186
3	Comparing robot-assisted thoracic surgical lobectomy with conventional video-assisted thoracic surgical lobectomy and wedge resection: Results from a multihospital database (Premier)	J Thorac Cardiovasc Surg.	2014	146
4	Long-term Survival Based on the Surgical Approach to Lobectomy For Clinical Stage I Nonsmall Cell Lung Cancer Comparison of Robotic, Video-assisted Thoracic Surgery, and Thoracotomy Lobectomy	Ann of Surgery	2017	135
5	Early Experience With Robotic Lung Resection Results in Similar Operative Outcomes and Morbidity When Compared With Matched Video-Assisted Thoracoscopic Surgery Cases	Ann Thorac Surg.	2012	121
6	Comparison of Video-Assisted Thoracoscopic Surgery and Robotic Approaches for Clinical Stage I and Stage II Non-Small Cell Lung Cancer Using The Society of Thoracic Surgeons Database	Ann Thorac Surg.	2016	107
7	Defining the Cost of Care for Lobectomy and Segmentectomy: A Comparison of Open, Video-Assisted Thoracoscopic, and Robotic Approaches	Ann Thorac Surg.	2014	99
8	Use and Outcomes of Minimally Invasive Lobectomy for Stage I Non-Small Cell Lung Cancer in the National Cancer Data Base	Ann Thorac Surg.	2016	93
9	Robotic-Assisted, Video-Assisted Thoracoscopic and Open Lobectomy: Propensity-Matched Analysis of Recent Premier Data	Ann Thorac Surg.	2017	83
10	Comparison of the Early Robot-Assisted Lobectomy Experience to Video-Assisted Thoracic Surgery Lobectomy for Lung Cancer A Single-Institution Case Series Matching Study	Innov. Tech. Cardiovasc. Surg.	2011	77
11	Nationwide Assessment of Robotic Lobectomy for Non-Small Cell Lung Cancer	Ann Thorac Surg.	2017	63
12	Robotic-assisted minimally invasive vs. thoracoscopic lung lobectomy: comparison of perioperative results in a learning curve setting	Langenbecks Arch. Surg.	2013	60
13	Transitioning from video-assisted thoracic surgical lobectomy to robotics for lung cancer: Are there outcomes advantages?	J Thorac Cardiovasc Surg.	2014	58
14	Comparing Robotic Lung Resection With Thoracotomy and Video-Assisted Thoracoscopic Surgery Cases Entered Into The Society of Thoracic Surgeons Database	Innov. Tech. Cardiovasc. Surg.	2014	48
15	Evaluation of acute and chronic pain outcomes after robotic, video-assisted thoracoscopic surgery, or open anatomic pulmonary resection	J Thorac Cardiovasc Surg.	2017	46
16	Initial Multicenter Community Robotic Lobectomy Experience: Comparisons to a National Database	Ann Thorac Surg.	2014	45
17	Comparison of robotic and video-assisted thoracic surgery for lung cancer: a propensity-matched analysis	J Thorac Disease	2016	39
18	Robotic surgery, video-assisted thoracic surgery, and open surgery for early stage lung cancer: comparison of costs and outcomes at a single institutes	J Thorac Disease	2018	38
19	Nodal Upstaging in Robotic and Video Assisted Thoracic Surgery Lobectomy for Clinical N0 Lung Cancer	Ann Thorac Surg.	2015	34
20	Hospital cost and clinical effectiveness of robotic-assisted versus video-assisted thoracoscopic and open lobectomy: A propensity score-weighted comparison	J Thorac Cardiovasc Surg.	2019	32
21	Robot-Assisted Thoracoscopic Surgery versus Video-Assisted Thoracoscopic Surgery for Lung Lobectomy: Can a Robotic Approach Improve Short-Term Outcomes and Operative Safety?	Thorac and Cardiovasc Surgeon	2016	31
22	Robotic and video-assisted thoracic surgery lung segmentectomy for malignant and benign lesions	Int Cardiovasc and Thorac Surg.	2015	31
23	Robotic-Assisted Versus Thoracoscopic Lobectomy Outcomes From High-Volume Thoracic Surgeons	Ann Thorac Surg.	2018	29
24	Propensity-score adjusted comparison of pathologic nodal upstaging by robotic, video-assisted thoracoscopic, and open lobectomy for non-small cell lung cancer	J Thorac Cardiovasc Surg.	2019	27
25	Robotic-Assisted Lobectomy for Non-Small Cell Lung Cancer: A Comprehensive Institutional Experience	Ann Thorac Surg.	2019	26
26	Robotic Versus Thoracoscopic Resection for Lung Cancer: Early Results of a New Robotic Program	J Laparasc. Adv. Surg. Techniques	2016	24
27	Thoracoscopic Versus Robotic Approaches: Advantages and Disadvantages	Thorac Surg. Clinics	2014	23
28	Long-Term Oncologic Outcomes After Robotic Lobectomy for Early-stage Non-Small-cell Lung Cancer Versus Video-assisted Thoracoscopic and Open Thoracotomy Approach	Clin Lung Cancer	2020	18
29	Understanding the financial cost of robotic lobectomy: calculating the value of innovation?	Ann Cardiothorac Surg	2019	15
30	Comparative Effectiveness of Robotic-Assisted Surgery for Resectable Lung Cancer in Older Patients	Chest	2020	15
31	Proficiency of Robotic Lobectomy Based on Prior Surgical Technique in The Society of Thoracic Surgeons General Thoracic Database	Ann Thorac Surg.	2019	14
32	Perioperative outcomes of radical lobectomies using robotic-assisted thoracoscopic technique vs. video-assisted thoracoscopic technique: retrospective study of 1075 consecutive p-stage I non-small cell lung cancer cases	J Thorac Disease	2019	14

(*continued on next page*)

Table-1 (*continued*)

No.	Title	Journals	Year of Publication	No. of Citations
33	Early outcomes of robotic versus uniportal video-assisted thoracic surgery for lung cancer: a propensity score-matched study	Eur J Cardiothorac Surg.	2018	13
34	Comparative study of anatomic lung resection by robotic vs. video-assisted thoracoscopic surgery	J Thorac Disease	2019	13
35	Robotic sleeve lobectomy for centrally located non small cell lung cancer: A propensity score-weighted comparison with thoracoscopic and open surgery	J Thorac Cardiovasc Surg.	2020	13
36	Robotic Versus Video-Assisted Thoracoscopic Lung Resection During Early Program Development	Ann Thorac Surg.	2018	12
37	Short-Term Readmissions After Open, Thoracoscopic, and Robotic Lobectomy for Lung Cancer Based on the Nationwide Readmissions Database	World J of Surg.	2019	11
38	Clinical and economic comparative effectiveness of robotic-assisted, video-assisted thoracoscopic, and open lobectomy	J Thorac Disease	2020	9
39	Video-assisted thoracoscopic surgery versus robot-assisted thoracoscopic surgery versus thoracotomy for early-stage lung cancer	J Thorac Cardiovasc Surg.	2018	9
40	Robotic Versus Video-Assisted Thoracoscopic Surgery Pulmonary Segmentectomy A Cost Analysis	Innov. Tech. Cardiovasc. Surg.	2018	8

At first, thoracotomy was necessary to gain access surgically to the lungs for the treatment method in patients with non-small cell lung cancer (NSCLC). Since video-assisted thoracoscopic surgery (VATS) lobectomy was first described in the early 1990s, interest in minimally invasive techniques has increased in the last 20 years and has become widely used in lung cancer [5,6]. Previous studies have demonstrated the benefits of VATS compared with thoracotomy, such as shorter hospital stay, better and faster recovery, fewer perioperative complications, and long-term survival for selected patients [7–11]. Robotic-assisted thoracoscopic surgery (RATS) is a new minimally invasive technique emerging as an alternative to VATS. It has some advantages over VATS, thanks to the three-dimensional optics used in RATS and robotic arms that contain tools that can facilitate complex movements. There are studies show that it affects the length of hospital stay, intra and postoperative complication rates, etc. [12–14]. On the other hand, RATS also has disadvantages such as higher costs and longer operation time [15].

The results of VATS and RATS have been one of the most studied topics, and studies in this area have increased significantly over the last decade. As seen in other areas of medicine, the trend and progress of research in the field of thoracic surgery depends on the compilation of various publications and research in this area. For such reasons, a bibliometric analysis to be conducted in the field of RATS is huge importance in terms of shedding light and providing guidance for future studies.

Bibliometric analysis, which is an effective way to survey the impact of scientific publications on the scientific community, is defined as the statistical evaluation of books, book chapters or scientific articles [16,17]. Similarly, it allows comparisons between institutions, schools and countries. It has become one of the popular research methods because it aims to reveal the research impact of the journal, article or author [18].

2. Materials and Methods

Web of Science has introduced Science Citation Index Expanded as its newest journal citation system and database [16,19]. In this database, there are more than 10,000 journals with high impact index from all fields. A comprehensive search (access date: December 31, 2021) was conducted using the keywords "Robotic Assisted Thoracic Surgery" and "Video Assisted Thoracic Surgery" in the Web of Science database, and 466 publications were reached. The 40 most cited articles in lung cancer surgery published between 1997 and 2021 comparing the results of VATS and RATS in terms of complications, postoperative hospital stay, cost, etc. were reviewed.

In the first step of the study, the articles were recorded in terms of publication years, countries, authors, the institutions the authors are affiliated with, the journal in which they were published, the country of origin of the journal, and the impact factor. All articles and journals were in English. Meta-analyses published on this subject were excluded because they were a compilation of existing articles. Journal citation reports were used to quantitatively analyze and evaluate whether the top 40 most cited articles reviewed for this study were included in the Emerging Sources Citation Index (ESCI), Science Citation Index (SCI), or Science Citation Index Expanded (SCIE). In order to evaluate the journals and articles accurately, the average impact factors of the last five years were specified.

In the second step of the study, the patient groups of the articles, the center of interest such as complications and costs of the study, and the results they obtained were evaluated.

3. Results

The 40 most cited articles comparing VATS and RATS procedures were comprehensively analyzed (Table-1). When the articles were analyzed according to the number of citations, it was seen that the first article was cited 187 times. While the articles were cited 2052 times in total, when the citations made by the authors were excluded, it was found that all publications were cited a total of 1946 times. It was seen that an average of 51. 30 ± 47. 73 (8–187) articles were cited. Here, it was seen that the first six most cited articles were cited by the authors more than a hundred times. In the time period taken into consideration, 2019 was the highest number of publications published in a year, with eight articles published (Figure-1). Thirty-seven (92. 5 %) of the articles were published in SCI

and SCIE, and three (7. 5 %) were published in ESCI journals.

Scopus and Web of Science searches showed that the list of the 40 most cited articles, most of the research (n = 30, 75 %) was carried out by institutions originating in the United States (USA). The USA was followed by China (n = 6, 15 %). Institutions in other countries such as Turkey, Italy, South Korea, Austria, Canada, Germany, and France contributed to the literature with one (2. 5 %) article (Figure-2).

"The Annals of Thoracic Surgery" (n = 13, 32. 5 %) was the journal in which the articles in the list were published the most (Table-2). Most of the journals in which the articles in our study were published (n = 31, 77. 5 %) were from the USA. The USA was followed by China (n = 5, 12. 5 %) and Germany (n = 2, 5 %), while other journals continued to publish in different countries. It was determined that all articles were published in journals in five different categories, especially in the journal categories such as surgery, respiratory system, cardiovascular surgery, and oncology.

The first four journals in which these articles were published include The Annals of Thoracic Surgery (n = 13, 32. 5 %), Journal of Thoracic and Cardiovascular Surgery (n = 8, 20 %), European Journal of Thoracic Disease (n = 5, 12. 5 %), Innovations-Technology and Techniques in Cardiothoracic and Vascular Surgery (n = 3, 7. 5 %) were found, while other journals published one article each (Table-2). Looking at the number of citations by years, the highest number of citations was seen in 2021 with 444 citations (Figure-3).

Authors named Aye RW, Farivar AS, Louie BE and Vallieres E are the authors who contributed the most to the literature with five publications in our study. These authors were followed by D'Souza DM, Kneuertz PJ, Merritt RE, Moffatt-Bruce SD, and Reddy RM with four publications. It was seen that other authors contributed to the literature with three or fewer articles. While 23 (57. 5 %) of the studies included in the citation index were multicentered, 17 (42. 5 %) were single-centered (Figure-4). The institutions that contributed the most to the literature in these articles were Ohio State University and Swedish Medical Center, with five articles each (Table-3). The most cited article in our study was cited 187 times and had the highest citation rate with 23. 37 citations per year (Table-4).

After the articles were comprehensively reviewed and the level of evidence was determined, the impact factor was determined for the journals. In our study, the journals with the highest impact factor scores were Annals of Surgery (12.041), Chest (10.131), Journal of Thoracic and Cardiovascular Surgery (5.310), The Annals of Thoracic Surgery (4.505) (Table-2). Additionally, the number of patients and time period of each study were analyzed and summarized in Table 5. This table also shows articles published as open access and not open access articles. Thirty-five of the 40 most cited articles were published as Open Access.

While many studies presented more than one subject and analysis, complications, duration of operation, duration of postoperative hospital stay, and cost were the most researched subjects with 19, 18, 17, and 16 studies, respectively. These were followed by intraoperative blood loss and lymph node sampling number with 10 studies, postoperative chest tube length of stay with eight studies, survival and transition to open operation with six studies.

In the complication comparisons in this index, no difference was found between VATS and RATS in this regard in 10 of 19 publications, while it was statistically demonstrated that RATS causes fewer complications compared to VATS in six publications. When compared in terms of the operation time, 10 publications revealed that RATS was associated with a longer operation time than VATS, five publications showed no difference between them, while Novellis et al. [20] and Qiu et al. [21] statistically demonstrated that operations performed with RATS were associated with a shorter operation time compared to VATS. In terms of postoperative length of

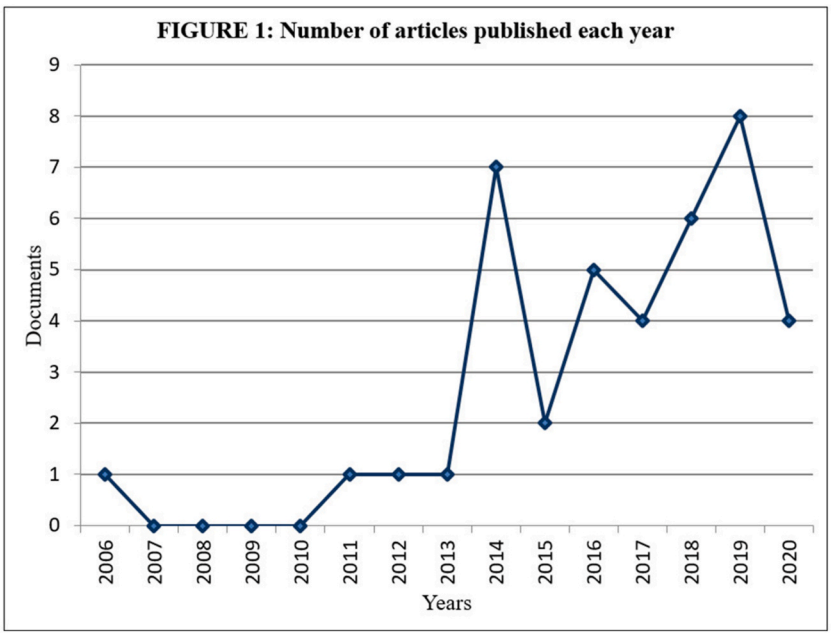

Fig. 1. Number of articles published each year between 2006 and 2021.

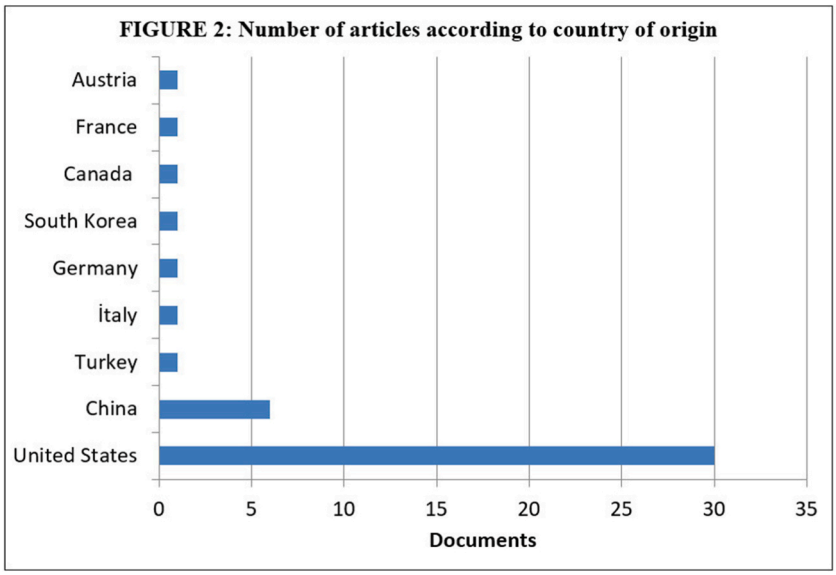

Fig. 2. Number of articles according to country of origin.

Table-2
List of Journals with The Most Cited Articles and Their Impact Factors Comparing Video-Assisted Thoracic Surgery vs. Robotic Thoracic Surgery.

No.	Journals	Impact Factor	No. of articles
1	Annals of Surgery	12.041	1
2	Chest	10.131	1
3	Journal Of Thoracic And Cardiovascular Surgery	5.310	8
4	The Annals Of Thoracic Surgery	4.505	13
5	Clinical Lung Cancer	4.417	1
6	European Journal Of Cardio-Thoracic Surgery	4.183	1
7	Annals Of Cardiothoracic Surgery	4.181	1
8	World Journal of Surgery	3.651	1
9	Journal Of Thoracic Disease	3.315	5
10	Langenbecks Archives Of Surgery	3.296	1
11	Thoracic Surgery Clinics	2.056	1
12	Journal Of Laparoendoscopic & Advanced Surgical Techniques	1.982	1
13	Interactive Cardiovascular And Thoracic Surgery	1.963	1
14	Thoracic And Cardiovascular Surgeon	1.542	1
15	Innovations-Technology And Techniques In Cardiothoracic And Vascular Surgery	1.016	3

stay, 10 of 17 publications had less duration of stay in RATS compared to VATS, while no difference was observed between them in five publications. In cost comparisons, it was statistically determined that operations performed with RATS were more costly than VATS in 14 of 16 publications, while Kneuertz et al. [22] and Upham et al. [23] found no significant difference between VATS and RATS in their general hospital cost analysis. In terms of intraoperative blood loss and lymph node sampling in the operation, it was reported that RATS was more advantageous than VATS in six of 10 publications in both comparisons. No difference was found between VATS and RATS in six studies comparing survival. Again, in the comparison of the number of transitions to open operation in six studies, it was revealed that less number of transitions to open operation was found in RATS in four publications, and there was no difference between VATS and RATS in two publications. Summary information about the most common comparisons is given in Table-6.

4. Discussion

The development of thoracoscopic surgical instruments, endomechanical stapling devices, modern imaging systems, high-resolution video monitors, robot-assisted technologies and the use of appropriate surgical equipment have enabled the development of minimally invasive surgery. Minimally invasive surgery is potentially the best approach to lung cancer surgery today due to its advantages and similar oncological outcomes. Accepted minimally invasive approaches for lung cancer are VATS, Hybrid-VATS, and RATS [24,25].

Bibliometric analysis is an analysis that provides helpful information to authors in the development of research strategies and enables identifying the scientific impact and qualities of articles [26,27]. Research findings are scattered across various journals and are not presented in a systematic format, making published scientific evidence difficult to interpret. For this reason, scientists prefer to

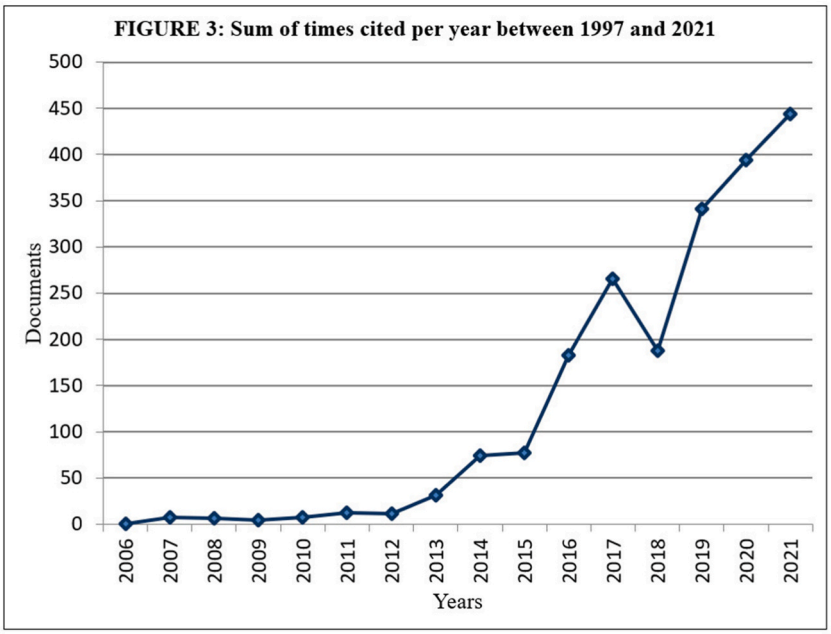

Fig. 3. Sum of times cited per year 2006 and 2021.

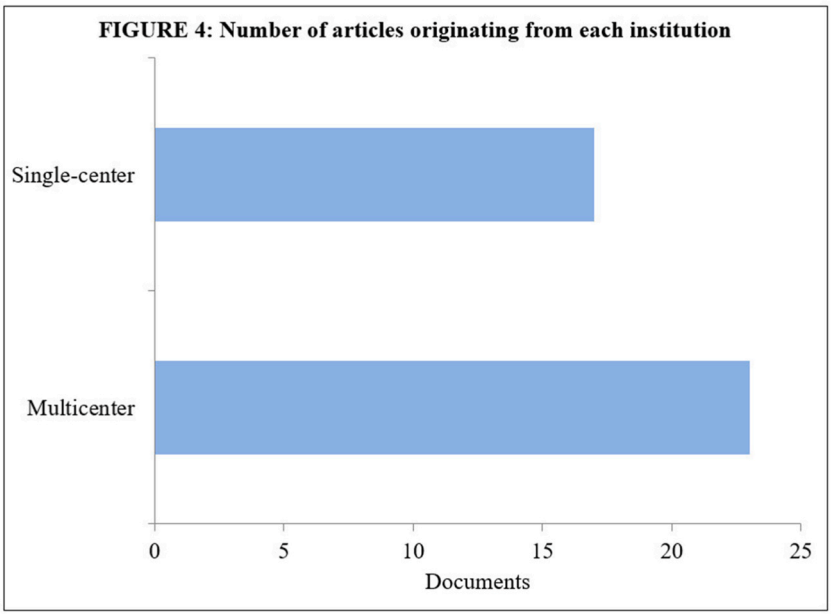

Fig. 4. Number of articles originating from each institution.

research the most cited articles that describe developments in their field of expertise. The main benefit of bibliometric analysis is to narrow the research areas of the authors and to enable the authors to access a lot of information in a short time by addressing the researched topic in a study from more than one angle.

Compared to thoracotomy, VATS has advantages such as less blood loss, smaller incisions, fewer complications, less pain, faster recovery times, less postoperative respiratory distress, and shorter hospital stays [28–31]. Kirby et al. [32], show that the oncologic outcomes of VATS are equivalent to open surgery. Although VATS appears to be a safe and effective method for the early-stage lung cancer treatment, the success of VATS depends on the skill of the surgeon and the acquisition of new technical skills. It takes a long time for surgeons to progress in the field of VATS and gain operator proficiency due to surgical instrument inadequacies, 2-dimensional appearance, and steep learning curve [33,34].

Table-3
Top 10 institutions that contributed the most to the literature and the number of articles.

No.	Organization	#	%
1	OHIO STATE UNIVERSITY	5	12.5
2	SWEDISH MEDICAL CENTER	5	12.5
3	HARVARD UNIVERSITY	4	10
4	MEMORIAL SLOAN KETTERING CANCERCENTER	4	10
5	SWEDISH CANCER INSTITUTE	4	10
6	UNIVERSITY OF MICHIGAN	4	10
7	UNIVERSITY OF MICHIGAN SYSTEM	4	10
8	DUKE UNIVERSITY	3	7.5
9	PENNSYLVANIA COMMONWEALTHSYSTEM OF HIGHER EDUCATION PCSHE	3	7.5
10	UNIVERSITY OFALABAMA BIRMINGHAM	3	7.5
Total		**39**	**97.5**

Table-4
Top 10 articles by average citation per year.

No.	Title	Journals	No. of Citations	Average Citations Per Year
1	Open, Video-Assisted Thoracic Surgery, and Robotic Lobectomy: Review of a National Database	Ann Thorac Surg.	187	23.37
2	Robotic assistance for video-assisted thoracic surgical lobectomy: Technique and initial results	J Thorac Cardiovasc Surg.	186	11.62
3	Comparing robot-assisted thoracic surgical lobectomy with conventional video-assisted thoracic surgical lobectomy and wedge resection: Results from a multihospital database (Premier)	J Thorac Cardiovasc Surg.	146	18.25
4	Long-term Survival Based on the Surgical Approach to Lobectomy For Clinical Stage I Nonsmall Cell Lung Cancer Comparison of Robotic, Video-assisted Thoracic Surgery, and Thoracotomy Lobectomy	Ann of Surgery	135	27
5	Early Experience With Robotic Lung Resection Results in Similar Operative Outcomes and Morbidity When Compared With Matched Video-Assisted Thoracoscopic Surgery Cases	Ann Thorac Surg.	121	12
6	Comparison of Video-Assisted Thoracoscopic Surgery and Robotic Approaches for Clinical Stage I and Stage II Non-Small Cell Lung Cancer Using The Society of Thoracic Surgeons Database	Ann Thorac Surg.	107	17.66
7	Defining the Cost of Care for Lobectomy and Segmentectomy: A Comparison of Open, Video-Assisted Thoracoscopic, and Robotic Approaches	Ann Thorac Surg.	99	12.37
8	Use and Outcomes of Minimally Invasive Lobectomy for Stage I Non-Small Cell Lung Cancer in the National Cancer Data Base	Ann Thorac Surg.	93	15.5
9	Robotic-Assisted, Video-Assisted Thoracoscopic and Open Lobectomy: Propensity-Matched Analysis of Recent Premier Data	Ann Thorac Surg.	83	16.6
10	Comparison of the Early Robot-Assisted Lobectomy Experience to Video-Assisted Thoracic Surgery Lobectomy for Lung Cancer A Single-Institution Case Series Matching Study	Innov. Tech. Cardiovasc. Surg.	77	7

There are publications on RATS reporting that it is feasible and safe for lung cancer [35–37]. Although it has many advantages of minimally invasive surgery, RATS also has controversial disadvantages such as high cost, difficulty in intraoperative bleeding management, long operation times, and lack of the surgeon's sense of touch. Unlike VATS, RATS has a faster learning ability starting from the first case with better maneuverability and consequently a less steep learning curve [38].

It has been determined that the operative times of RATS are uncertain or longer than VATS. There are also studies suggesting that the rate of conversion to open surgery is higher in VATS compared to RATS, and there are no significant differences VATS and RATS in terms of intraoperative and postoperative complications [39]. In the study of Kent et al., which comparing 12427 VATS patients with 430 RATS patients showed that the length of hospital stays was shorter in the RATS group [9]. Likewise, Oh et al. [40] compared 2951 VATS and RATS patients, they demonstrated that the patients had statistically significantly lower postoperative complication rates and shorter hospital stays in the RATS group. Liang et al. [39] found a lower 30-day mortality rate in RATS. Similarly, Emmert et al. [41] detected that survival was better in their robotic group than in the VATS group ($p < 0.05$). In a large Thoracic Surgery Society database study of 12378 VATS and 1220 RATS lobectomy cases from 140 centers, no difference was observed between VATS and RATS in terms of 30-day mortality (0.6 % vs. 0.8 %, $p = 0.42$) [42]. As a result, no significant superiority of VATS over RATS or RATS over VATS has been demonstrated.

Table-1 shows the first 40 articles and their information in the citation index. The fact that most of the articles that are among the top 40 most cited articles originated in the United States and China showed that most of the clinical studies were executed in developed countries and the articles published in international journals were the most cited journals. Therefore, we need to examine and check against the citation numbers of the most cited articles of our study with other studies. The number of citations may be different as Web of Science contains fewer articles compared to Google Scholar and Scopus. The number of citations of articles may vary depending on different search engines. In our study, quantitative analysis was conducted using the impact factor of the journals.

In our study, the generally known cost difference between VATS and RATS was confirmed, and 14 publications found that RATS

Table-5
Number of patients included in the 40 most cited articles and period in years indicated.

No.	Title	Number of Patients	Period in Years Referred
1	Open, Video-Assisted Thoracic Surgery, and Robotic Lobectomy: Review of a National Database	33,095	2008–2010
2	Robotic assistance for video-assisted thoracic surgical lobectomy: Technique and initial results	34	2002–2004
3	Comparing robot-assisted thoracic surgical lobectomy with conventional video-assisted thoracic surgical lobectomy and wedge resection: Results from a multihospital database (Premier)	15,502	2009–2011
4	Long-term Survival Based on the Surgical Approach to Lobectomy For Clinical Stage I Nonsmall Cell Lung Cancer Comparison of Robotic, Video-assisted Thoracic Surgery, and Thoracotomy Lobectomy	470	2002–2012
5	Early Experience With Robotic Lung Resection Results in Similar Operative Outcomes and Morbidity When Compared With Matched Video-Assisted Thoracoscopic Surgery Cases	87	2009–2011
6	Comparison of Video-Assisted Thoracoscopic Surgery and Robotic Approaches for Clinical Stage I and Stage II Non-Small Cell Lung Cancer Using The Society of Thoracic Surgeons Database	13,598	2009–2013
7	Defining the Cost of Care for Lobectomy and Segmentectomy: A Comparison of Open, Video-Assisted Thoracoscopic, and Robotic Approaches	184	2008–2012
8	Use and Outcomes of Minimally Invasive Lobectomy for Stage I Non-Small Cell Lung Cancer in the National Cancer Data Base	30,040	2010–2012
9	Robotic-Assisted, Video-Assisted Thoracoscopic and Open Lobectomy: Propensity-Matched Analysis of Recent Premier Data	5726	2011–2015
10	Comparison of the Early Robot-Assisted Lobectomy Experience to Video-Assisted Thoracic Surgery Lobectomy for Lung Cancer A Single-Institution Case Series Matching Study	203	2006–2009
11	Nationwide Assessment of Robotic Lobectomy for Non-Small Cell Lung Cancer	62,206	2010–2012
12	Robotic-assisted minimally invasive vs. thoracoscopic lung lobectomy: comparison of perioperative results in a learning curve setting	52	2001–2009
13	Transitioning from video-assisted thoracic surgical lobectomy to robotics for lung cancer: Are there outcomes advantages?	69	2011–2012
14	Comparing Robotic Lung Resection With Thoracotomy and Video-Assisted Thoracoscopic Surgery Cases Entered Into The Society of Thoracic Surgeons Database	181	2010–2012
15	Evaluation of acute and chronic pain outcomes after robotic, video-assisted thoracoscopic surgery, or open anatomic pulmonary resection	502	2010–2014
16	Initial Multicenter Community Robotic Lobectomy Experience: Comparisons to a National Database	10,645	2009–2010
17	Comparison of robotic and video-assisted thoracic surgery for lung cancer: a propensity-matched analysis	184	2014–2015
18	Robotic surgery, video-assisted thoracic surgery, and open surgery for early stage lung cancer: comparison of costs and outcomes at a single institutes	103	2015–2016
19	Nodal Upstaging in Robotic and Video Assisted Thoracic Surgery Lobectomy for Clinical N0 Lung Cancer	211	2009–2014
20	Hospital cost and clinical effectiveness of robotic-assisted versus video-assisted thoracoscopic and open lobectomy: A propensity score-weighted comparison	697	2012–2017
21	Robot-Assisted Thoracoscopic Surgery versus Video-Assisted Thoracoscopic Surgery for Lung Lobectomy: Can a Robotic Approach Improve Short-Term Outcomes and Operative Safety?	56	M*
22	Robotic and video-assisted thoracic surgery lung segmentectomy for malignant and benign lesions	99	2007–2014
23	Robotic-Assisted Versus Thoracoscopic Lobectomy Outcomes From High-Volume Thoracic Surgeons	23,779	2011–2015
24	Propensity-score adjusted comparison of pathologic nodal upstaging by robotic, video-assisted thoracoscopic, and open lobectomy for non-small cell lung cancer	1053	2011–2018
25	Robotic-Assisted Lobectomy for Non-Small Cell Lung Cancer: A Comprehensive Institutional Experience	831	2011–2017
26	Robotic Versus Thoracoscopic Resection for Lung Cancer: Early Results of a New Robotic Program	133	2007–2014
27	Thoracoscopic Versus Robotic Approaches: Advantages and Disadvantages	M	M
28	Long-Term Oncologic Outcomes After Robotic Lobectomy for Early-stage Non-Small-cell Lung Cancer Versus Video-assisted Thoracoscopic and Open Thoracotomy Approach	514	2012–2017
29	Understanding the financial cost of robotic lobectomy: calculating the value of innovation?	M	M
30	Comparative Effectiveness of Robotic-Assisted Surgery for Resectable Lung Cancer in Older Patients	2766	2008–2013
31	Proficiency of Robotic Lobectomy Based on Prior Surgical Technique in The Society of Thoracic Surgeons General Thoracic Database	5619	2009–2016
32	Perioperative outcomes of radical lobectomies using robotic-assisted thoracoscopic technique vs. video-assisted thoracoscopic technique: retrospective study of 1075 consecutive p-stage I non-small cell lung cancer cases	1075	2013–2016
33	Early outcomes of robotic versus uniportal video-assisted thoracic surgery for lung cancer: a propensity score-matched study	153	2015–2016
34	Comparative study of anatomic lung resection by robotic vs. video-assisted thoracoscopic surgery	166	2010–2015
35	Robotic sleeve lobectomy for centrally located non small cell lung cancer: A propensity score-weighted comparison with thoracoscopic and open surgery	188	2012–2017
36	Robotic Versus Video-Assisted Thoracoscopic Lung Resection During Early Program Development	138	2014–2015
37	Short-Term Readmissions After Open, Thoracoscopic, and Robotic Lobectomy for Lung Cancer Based on the Nationwide Readmissions Database	129,539	2010–2014
38	Clinical and economic comparative effectiveness of robotic-assisted, video-assisted thoracoscopic, and open lobectomy	M	2008–2015
39	Video-assisted thoracoscopic surgery versus robot-assisted thoracoscopic surgery versus thoracotomy for early-stage lung cancer	M	M
40	Robotic Versus Video-Assisted Thoracoscopic Surgery Pulmonary Segmentectomy A Cost Analysis	50	2016–2017

M*: Missing value.
Yellow rows: Not Open Access Articles.

Table-6
The most compared factors and results.

Compared Factor	Number of Studies That Made This Comparison	Result
Complication	19	VATS=RATS: 10 studies VATS > RATS: 6 studies RATS > VATS: 3 studies
Duration of Operation	18	RATS > VATS: 10 studies VATS=RATS: 5 studies VATS > RATS: 3 studies
Duration of Postoperative Hospital Stay	17	VATS > RATS: 10 studies RATS=VATS: 5 studies RATS > VATS: 2 studies
Cost	16	RATS > VATS: 14 studies RATS=VATS: 2 studies
Intraoperative Blood Loss	10	VATS > RATS: 6 studies Other data is missing
Lymph Node Sampling	10	RATS > VATS: 6 studies Other data is missing
Postoperative Chest Tube Length of Stay	8	Data is missing
Survival	6	RATS=VATS: 6 studies
Transition to Open Operation	6	VATS > RATS: 4 studies RATS=VATS: 2 studies

was more costly than VATS. However, there are also publications showing the opposite of the information that RATS is more disadvantageous than VATS in terms of operation time.

Analyzing this bibliometric study, we can conclude that RATS is a highly researched topic and its results tend to be compared with VATS. However, it is difficult to conclude the tendency of this research because the most cited articles deal with all aspects of lung resection and minimally invasive surgical procedure in lung cancer, including patient selection for VATS or RATS, the impact of the surgical technique applied on outcomes.

VATS and RATS; has strengthened its place in the practice of thoracic surgery as minimally invasive surgical techniques. However, as in our country, in many countries of the world, RATS still faces obstacles in terms of applicability due to its high cost. However, RATS should not be judged solely on cost. Analyzing the 40 articles presented in this article, it is compared to VATS in many respects and has many advantages over VATS. By analyzing this study, these advantages can be easily seen, and this method can be placed in clinics where RATS is not applied despite its high cost. Considering that the majority of the authors who will read this article are active thoracic surgeons, the article is of great importance in terms of overcoming some obstacles and improving clinical practice.

The data analysis of this study is quite objective and comprehensive, but there are limitations such as all of the included articles are in English, and the citation indexes are time limited.

Due to the advantages, they provide in the surgical treatment of lung cancer, the tendency towards minimally invasive surgical procedures has increased in recent years. RATS has gained popularity with the development of technology, despite the doubts about its high operation time and cost. The number of articles published in this field continues to increase in recent years.

This study demonstrates quantitative and qualitative analysis of the most cited articles comparing VATS and RATS procedures. As far as is known, it is the first citation analysis report in the literature on this subject. Bibliometric studies can ensure useful information for enhance research and new perspectives. This report presents research and progress related to RATS and can also serve as a guide for researchers writing papers. Studies on RATS are at a level that can change our traditional surgical approach. More cooperation between authors, institutions, and even countries, and more studies worldwide are needed to determine the advantages and disadvantages of VATS over RATS.

Declarations

Conflict of interest

None declared.

Ethical Statement

All authors declared that this study did not include human participants or animal subjects and received no financial support from any organization for the study presented. The authors declare no conflict of interest regarding the authorship and/or publication of this article. Ethics committee approval was obtained for the study.

Author contributions

Conception and design: All authors, Administrative support: Ali Ozdil, Ufuk Cagirici, Provision of study materials or patients: Hasan Yavuz, Ahmet Kayahan Tekneci, Collection and assembly of data: Hasan Yavuz, Ahmet Kayahan Tekneci, Data analysis and

interpretation: Hasan Yavuz, Ahmet Kayahan Tekneci, Manuscript writing: All authors, Final approval of manuscript: All authors.

CRediT authorship contribution statement

Hasan Yavuz: Conceptualization, Data curation, Formal analysis, Methodology, Validation, Writing – original draft. **Ahmet Kayahan Tekneci:** Conceptualization, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. **Ali Ozdil:** Supervision, Validation, Visualization, Writing – review & editing. **Ufuk Cagirici:** Conceptualization, Methodology, Supervision, Validation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

There is no funding for the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e20765.

References

[1] H. Sung, J. Ferlay, R.L. Siegel, et al., Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries, CA Cancer J Clin, 2021.
[2] M. Gürbüz, Y. Ürün, Adjuvant Treatment in Non-small Cell Lung Cancer, vol. 71, Ankara University Faculty of Medicine Journal, 2018, pp. 112–117.
[3] D.H. Johnson, J.H. Schiller, P.A. Bunn Jr., Recent clinical advances in lung cancer management, J. Clin. Oncol. 32 (2014) 973–982.
[4] S. Wei, C. Guo, J. He, et al., Effect of vein-first vs artery-first surgical technique on circulating tumor cells and survival in patients with non-small cell lung cancer: a randomized clinical trial and registry-based propensity score matching analysis, JAMA Surg 154 (2019), e190972.
[5] T.J. Kirby, M.J. Mack, R.J. Landreneau, et al., Initial experience with videoassisted thoracoscopic lobectomy, Ann. Thorac. Surg. 56 (1993) 1248–1252.
[6] W.S. Walker, F.M. Carnochan, G.C. Pugh, Thoracoscopic pulmonary lobectomy. Early operative experience and preliminary clinical results, J. Thorac. Cardiovasc. Surg. 106 (1993) 1111–1117.
[7] S. Paul, A. Sedrakyan, Y.L. Chiu, et al., Outcomes after lobectomy using thoracoscopy vs thoracotomy: a comparative effectiveness analysis utilizing the Nationwide Inpatient Sample database, Eur. J. Cardio. Thorac. Surg. 43 (2013) 813–817.
[8] S. Paul, N.K. Altorki, S. Sheng, et al., Thoracoscopic lobectomy is associated with lower morbidity than open lobectomy: a propensity-matched analysis from the STS database, J. Thorac. Cardiovasc. Surg. 139 (2010) 366–378.
[9] M. Kent, T. Wang, R. Whyte, et al., Open, video-assisted thoracic surgery, and robotic lobectomy: review of a national database, Ann. Thorac. Surg. 97 (2014) 236–242.
[10] T.D. Yan, D. Black, P.G. Bannon, B.C. McCaughan, Systematic review and meta-analysis of randomized and nonrandomized trials on safety and efficacy of video-assisted thoracic surgery lobectomy for early-stage non-small cell lung cancer, J. Clin. Oncol. 27 (2009) 2553–2562.
[11] C. Cao, C. Manganas, S.C. Ang, T.D. Yan, A meta-analysis of unmatched and matched patients comparing video-assisted thoracoscopic lobectomy and conventional open lobectomy, Ann. Cardiothorac. Surg. 1 (2012) 16–23.
[12] J.A. Morgan, M.E. Ginsburg, J.R. Sonett, M. Argenziano, Thoracoscopic lobectomy using robotic technology, Heart Surg. Forum 7 (2003) E167–E169.
[13] J. Bodner, H. Wykypiel, G. Wetscher, T. Schmid, First experiences with the da Vinci operating robot in thoracic surgery, Eur. J. Cardio. Thorac. Surg. 25 (2004) 844–851.
[14] B.J. Park, R.M. Flores, V.W. Rusch, Robotic assistance for video-assisted thoracic surgical lobectomy: technique and initial results, J. Thorac. Cardiovasc. Surg. 131 (2006) 54–59.
[15] R.M. Flores, N. Alam, Video-assisted thoracic surgery lobectomy (VATS), open thoracotomy, and the robot for lung cancer, Ann. Thorac. Surg. 85 (2008) S710–S715.
[16] A. Schubert, W. Glänzel, T. Braun, Scientometric data files. A comprehensive set of indicators on 2649 journals and 96 countries in all major science fields and subfields 1981-1985, Scientometrics 16 (1989) 3–478.
[17] F. De Moya-Anegón, Z. Chinchilla-Rodríguez, B. Vargas-Quesada, et al., Coverage analysis of Scopus: a journal metric approach, Scientometrics 73 (2007) 53–78.
[18] J. Hui, Z. Han, G. Geng, et al., The 100 top-cited articles in orthodontics from 1975 to 2011, Angle Orthod. 83 (2013) 491–499.
[19] S. Gondivkar, S. Sarode, A. Gadbail, et al., Bibliometric analysis of 100 most cited articles on oral submucous fibrosis, J. Oral Pathol. Med. 47 (2018) 781–787.
[20] P. Novellis, E. Bottoni, E. Voulaz, et al., Robotic surgery, video-assisted thoracic surgery, and open surgery for early stage lung cancer: comparison of costs and outcomes at a single institutes, J. Thorac. Dis. 10 (2018) 790–798.
[21] T. Qiu, Y.D. Zhao, Y.P. Xuan, et al., Robotic sleeve lobectomy for centrally located non-small cell lung cancer: a propensity score-weighted comparison with thoracoscopic and open surgery, J. Thorac. Cardiovasc. Surg. 160 (2020) 838. -+.
[22] P.J. Kneuertz, E. Singer, D.M. D'Souza, et al., Hospital cost and clinical effectiveness of robotic-assisted versus video-assisted thoracoscopic and open lobectomy: a propensity score-weighted comparison, J. Thorac. Cardiovasc. Surg. 157 (2019) 2018. -+.
[23] T.C. Upham, M.W. Onaitis, Video-assisted thoracoscopic surgery versus robot-assisted thoracoscopic surgery versus thoracotomy for early-stage lung cancer, J. Thorac. Cardiovasc. Surg. 156 (2018) 365–368.
[24] D.T. Bennett, M.J. Weyant, The year in thoracic surgery: highlights from 2013, Semin. CardioThorac. Vasc. Anesth. 18 (2014) 24–28.
[25] D.S. Oh, I. Cho, B. Karamian, S.R. DeMeester, J.A. Hagen, Early adoption of robotic pulmonary lobectomy: feasibility and initial outcomes, Am. Surg. 79 (2013) 1075–1080.
[26] N. Mao, M. Wang, Y. Ho, A bibliometric study of the trend in articles related to risk assessment published in Science Citation Index, Hum Ecol Risk Asses 16 (4) (2010) 801–824.

[27] O. Ellegaard, J.A. Wallin, The bibliometric analysis of scholarly production: how great is the impact? Scientometrics 105–103 (2015) 1808–1831.
[28] M. Higuchi, H. Yaginuma, A. Yonechi, R. Kanno, A. Ohishi, H. Suzuki, et al., Long-term outcomes after video-assisted thoracic surgery (VATS) lobectomy versus lobectomy via open thoracotomy for clinical stage IA non-small cell lung cancer, J. Cardiothorac. Surg. 9 (2014) 88.
[29] C. Cao, C. Manganas, S.C. Ang, S. Peeceeyen, T.D. Yan, Video-assisted thoracic surgery versus open thoracotomy for non-small cell lung cancer: a meta-analysis of propensity score-matched patients, Interact. Cardiovasc. Thorac. Surg. 16 (2013) 244–249.
[30] D. Cheng, R.J. Downey, K. Kernstine, R. Stanbridge, H. Shennib, R. Wolf, et al., Video-assisted thoracic surgery in lung cancer resection: a meta-analysis and systematic review of controlled trials, Innovations 2 (2007) 261–292.
[31] Q.Q. Luo, H. Lin, Q. Tan, J. Huang, L. Xu, Analysis of clinical application of thoracoscopic lobectomy for lung cancer, World J. Surg. Oncol. 12 (2014) 157.
[32] T.J. Kirby, M.J. Mack, R.J. Landreneau, T.W. Rice, Lobectomy—video-assisted thoracic surgery versus muscle-sparing thoracotomy. A randomized trial, J. Thorac. Cardiovasc. Surg. 109 (1995) 997–1001. ; discussion 1001–2.
[33] E.H. Belgers, J. Siebenga, A.M. Bosch, E.H. van Haren, E.C. Bollen, Complete video-assisted thoracoscopic surgery lobectomy and its learning curve. A single center study introducing the technique in The Netherlands, Interact. Cardiovasc. Thorac. Surg. 10 (2010) 176–180.
[34] R.J. McKenna Jr., Complications and learning curves for video-assisted thoracic surgery lobectomy, Thorac. Surg. Clin. 18 (2008) 275–280.
[35] B.E. Louie, A.S. Farivar, R.W. Aye, E. Vallieres, Early experience with robotic lung resection results in similar operative outcomes and morbidity when compared with matched video-assisted thoracoscopic surgery cases, Ann. Thorac. Surg. 93 (2012) 1598–1604. ; discussion 604-5.
[36] S.J. Swanson, D.L. Miller, R.J. McKenna Jr., J. Howington, M.B. Marshall, A.C. Yoo, et al., Comparing robot-assisted thoracic surgical lobectomy with conventional video-assisted thoracic surgical lobectomy and wedge resection: results from a multihospital database (Premier), J. Thorac. Cardiovasc. Surg. 147 (2014) 929–937.
[37] H.J. Jang, H.S. Lee, S.Y. Park, J.I. Zo, Comparison of the early robot-assisted lobectomy experience to video-assisted thoracic surgery lobectomy for lung cancer: a single-institution case series matching study, Innovations 6 (2011) 305–310.
[38] J. Heemskerk, W.G. van Gemert, J. de Vries, J. Greve, N.D. Bouvy, Learning curves of robot-assisted laparoscopic surgery compared with conventional laparoscopic surgery: an experimental study evaluating skill acquisition of robot-assisted laparoscopic tasks compared with conventional laparoscopic tasks in inexperienced users, Surg Laparosc Endosc Percutan Tech 17 (2007) 171–174.
[39] H. Liang, W. Liang, L. Zhao, D. Chen, J. Zhang, Y. Zhang, et al., Robotic versus video-assisted lobectomy/segmentectomy for lung cancer: a meta-analysis, Ann. Surg. 268 (2018) 254–259.
[40] D.S. Oh, R.M. Reddy, M.L. Gorrepati, S. Mehendale, M.F. Reed, Robotic-assisted, video-assisted thoracoscopic and open lobectomy: propensity matched analysis of recent premier data, Ann. Thorac. Surg. 104 (2017) 1733–1740.
[41] A. Emmert, C. Straube, J. Buentzel, C. Roever, Robotic versus thoracoscopic lung resection: a systematic review and meta-analysis, Medicine (Baltim.) 96 (2017), e7633.
[42] B.E. Louie, J.L. Wilson, S. Kim, R.J. Cerfolio, B.J. Park, A.S. Farivar, et al., Comparison of video-assisted thoracoscopic surgery and robotic approaches for clinical stage I and stage II non-small cell lung cancer using the Society of Thoracic Surgeons Database, Ann. Thorac. Surg. 102 (2016) 917–924.