Research on surgical treatment for non-small cell lung cancer from 2009 to 2018: a bibliometric analysis

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Abstract

Background The objective of this study was to analyze the scientific outputs of surgical treatment for non-small cell lung cancer (NSCLC). **Methods** We explored the research topic from the Web of Science Core Collection for period 2009-2018. Based on Cite Space IV and VOS viewer, we explored distribution of time, journals, countries/ regions, institutions, authors, disciplines, keywords, and burst terms associated with this topic. **Results** According to an analysis of 3175 papers, the European Journal of Cardio Thoracic Surgery published the most papers and the United States contributed the most publications in this area. Albain KS from Loyola University occupied the highest co-citation score. The burst terms of 'morbidity', 'elderly patient', and 'classification' were ranked first as research indicators. **Conclusions** We were able to construct a systematic analysis of studies related to surgical treatment for NSCLC by providing new perspectives and valuable information. The treatment for locally advanced NSCLC and assisted thoracic surgery were terms that appear to have developmental trends. However, further attention and innovation are still needed in this area.

1. Introduction

Lung cancer remains the leading cause of cancer-related death (a reported 18.4% of cancer deaths worldwide)[Bray, 2018 #172].¹ Non-small cell lung cancer (NSCLC) constitutes over 85% of these cases.² With regard to diagnosed cancer, lung cancer is the most frequently identified in 37 countries. It is predicted that nearly 2.1 million new lung cancer cases were diagnosed worldwide in 2018, with 1.8 million deaths.² As a result of the use of low-dose computed tomography (LDCT) and advanced resolution of CT imaging, many of those patients with early stage NSCLC can now be detected. For early stage NSCLC, surgery is the standard treatment regimen. According to the guidelines of the National Comprehensive Cancer Network (NCCN), for most patients with NSCLC, anatomic pulmonary resection is recommended.³ Furthermore, for the treatment of locally advanced NSCLC, surgical resection is still a vital component.⁴

Bibliometric analysis is a useful and effective tool to assess trends in research fields and evaluate the metrology of research studies in a specific field.⁵ This type of analysis could help investigators to gain expertise in relevant research trends.⁶⁻⁷ Although a large number of papers have investigated surgery for NSCLC, no attempts have been made to systematically evaluate the trends in this field.

In this study, we systematically evaluated research articles on surgical treatment for NSCLC from 2009 to 2018, which were published in the WoSCC (Web of Science Core Collection). More specifically, we aimed to focus on the network of different countries/ regions, institutions, authors as well as hotspots and keywords resulting from Cite Space IV analysis. We hope to provide a robust reference for studies in the field of surgical treatment for NSCLC.

2. Methods

2.1 Data:

A bibliometric analysis was performed online through the SCI-E (Science Citation Index-Expanded) of the WoSCC (Web of Science Core Collection) on December 31, 2018.⁸ A total of 3175 publications were imported into Cite Space IV Software (Chenmei Chen, Dexed University, USA) and Microsoft Excel for analysis.⁹ The study was conducted in accordance with the Declaration of Helsinki. All analyses were based on previous published studies, thus no ethical approval and patient consent were required.

2.2 Search strategy:

To identify and download all relevant research studies, two authors (HHZ and LL) used the following search terms independently: [TS = (Carcinoma, Non Small Cell Lung OR Carcinomas, Non-Small-Cell Lung OR Lung Carcinoma, Non-Small-Cell OR Lung Carcinomas, Non-Small-Cell OR Non-Small-Cell Lung Carcinomas OR Nonsmall Cell Lung Cancer OR Non-Small-Cell Lung Carcinoma OR Non Small Cell Lung Carcinoma OR Carcinoma, Non-Small Cell Lung OR Non-Small Cell Lung Cancer) OR TI = (Carcinoma, Non Small Cell Lung OR Carcinomas, Non-Small-Cell Lung OR Lung Carcinoma, Non-Small-Cell OR Lung Carcinomas, Non-Small-Cell OR Non-Small-Cell Lung Carcinomas OR Nonsmall Cell Lung Cancer OR Non-Small-Cell Lung Carcinoma OR Non Small Cell Lung Carcinoma OR Carcinoma, Non-Small Cell Lung OR Non-Small Cell Lung Cancer)] AND [TS = surgery OR TI = surgery] AND Language = English. Only original articles were included.

2.3 Analytical methods:

Through the WOSCC database, we analyzed the characteristics of all relevant research including the distribution of time/ journals/ countries/ institution/ authors/ and research areas. Moreover, Cite Space IV software was used to perform the visualization maps of the overlay journal of the research, and we presented the countries/ regions and burst keywords for the time of the retrieved articles.¹⁰⁻¹¹ In addition, VOS viewer (Van Eck & Waltman, Leiden University, The Netherlands) was used to analyze the co-cited authors, keywords, and organizations associated with the research contents. We also examined the association networks associated with surgical treatment of NSCLC from 2009 to 2018.¹²⁻¹³

3. Results

3.1 Distribution by time:

In total, 3175 publications from 2009 to 2018 matched the inclusion criteria. The overall trend of publication increased from 190 publications in 2009 to 435 publications in 2018 (Figure 1)

Figure 1. The number of relevant publications from 2009 to 2018.

3.2 Distribution by journal:

A total of 422 academic journals published articles on surgical treatment of non-small cell lung cancer. The top 10 journals contributing to related research included *European Journal of Cardio Thoracic Surgery* (IF (impact factor) 2018 = 3.847; 205 publications; 6.46%), *Lung Cancer* (IF = 4.599; 5.67%), and *Annals of Thoracic Surgery* (IF = 3.919; 5.20%) (Table 1). Of these, *Journal of Thoracic Oncology* (IF = 12.46; 4.85%) had the top impact factor, followed by *Internal Journal of Radiation Oncology Biology Physics* (IF = 6.203; 1.83%), and *Journal of Thoracic and Cardiovascular Surgery* (IF = 5.261; 2.929%). *Journal of Thoracic Oncology* was classified as Q1, while *International Journal of Radiation Oncology Biology Physics*, *Journal of Thoracic and Cardiovascular Surgery*, *Lung Cancer*, *Annals of Thoracic Surgery*, *Clinical Lung Cancer* and *European Journal of Cardio Thoracic Surgery* were classified as Q2. Finally, *Anticancer Research*, *Journal of Thoracic Disease*, and *Interactive Cardiovascular and Thoracic Surgery* were classified as Q4.

Table 1. The distribution of the top 10 journals.

Cite space IV analyzed the overlay of the journals associated with the research (Figure 2). The citing journal maps corresponded to the left-hand side, and the opposite side represented the cited journal maps. The citation links were represented by the lines from the left-hand side to the right-hand side on the map. Through the dual-map overlay of journals, three citation paths were displayed. Journals relating to areas of biology/genetics were mostly cited by articles published in immunology/biology journals, which are represented by the yellow path. Biology/genetics journals were partially cited by articles published in medical/clinical journals, which were represented by the middle pathway. Health/medicine journals were partially cited by articles published in medical/clinical journals, which were represented by the green pathway at the bottom.

Figure 2. The dual-map overlay of journals related to surgical treatment for NSCLC.

3.3 Distribution by country/region:

The 3175 publications on surgical treatment for NSCLC were contributed by 40 countries/regions (Figure 3). The top 10 countries/regions engaging in research included the United States (801), China (690), and Japan (503) (Table 2).

Figure 3. The distribution of countries.

Table 2. The distribution of the top 10 countries and regions.

3.4 Distribution by institutions:

The 3175 publications were published by nearly 2500 institutions (Figure 4). The top 10 institutions engaged in this area contributed more than 22% of the total number of publications. They included the

following: University of Texas System, Utmd Anderson Cancer Center, Harvard University, Duke University, University of California System, Seoul National University, Assistance Publique Hopitaux Paris Aphp, Memorial Sloan Kettering Cancer Center, Sun Yat Sen University, and Vrije Universiteit Amsterdam.

Figure 4. The distribution of institutions related to surgical treatment for NSCLC.

3.5 Distribution by authors:

Over 12,000 authors described surgical treatment for NSCLC. Among the top 10 authors on the list (Table 3), D’amico TA from Duke University (49 publications) ranked first, followed by Wang J from Peking University (44 publications), and Senan S from Vrije University Amsterdam Medical Center (40 publications). However, Senan S had the highest H-index value ($H = 22$).

Table 3. The distribution of authors.

VOS viewer analyzed the network of co-citation authors (Figure 5). Albain KS (2196 co-citations) was in first place, followed by Mountain CF (1986 co-citations), Douillard JY (1968 co-citations), and Cerfolio RJ (1884 co-citations).

Figure 5. The distribution of co-citation authors.

3.6 Distribution by discipline:

The 3175 papers that considered surgery for NSCLC cover a number of disciplines (Figure 6), such as oncology (45.58%), respiratory system (40.76%), surgery (31.62%), cardiovascular system (22.49%), radiology nuclear medical imaging (6.99%) and general internal medicine (4.91%). Although there was a distribution of disciplines, surgery combined with oncology was at the center of multidisciplinary research.

Figure 6. The number of publications for each of the different disciplines in surgical treatment of NSCLC.

3.7 Distribution by keywords:

The top 10 keywords extracted from the 3175 articles were as follows: survival, surgery, resection, carcinoma, chemotherapy, radiotherapy, therapy, lobectomy, management and trial (Figure 7).

Figure 7. The distribution of keywords.

3.8 Distribution by burst terms:

Through Cite Space IV, we identified burst terms which were extracted from the articles to reflect the hotspots over time. The burst terms were constructed by the time the burst status lasted and the intensity of the burst. In Figure 8, the top-ranked item was classification (2015–2018) with a burst strength of 19.0888. After 2014, the burst terms were listed as follows: “morbidity” (2014–2016; strength = 10.2686), “elderly patient” (2014–2015; strength = 7.9811), and “classification” (2015–2018; strength = 19.0888).

Figure 8. The distribution of the top 20 keywords with burst terms.

4. Discussion

4.1 General information:

In this study, we searched for surgical treatment for NSCLC-related articles published from 2009 to 2018 through the Web of Science. A bibliometric analysis was performed by Cite Space IV and VOS viewer to explore relevant research status and trends. A total of 3175 papers on surgical treatment for NSCLC have been published and a slowly increasing trend was observed over time. Among the top 10 journals, *Journal of Thoracic Oncology* (IF2018 = 12.460) had a higher IF than 10; between 5 and 10, the *Internal Journal of Radiation Oncology Biology Physics* (IF2018 = 6.203) and *Journal of Thoracic And Cardiovascular Surgery* (IF = 5.261) were on the list. Four journals had an IF between 3 and 5; they were *European Journal of Cardio Thoracic Surgery* (IF2018 = 3.847), *Annals of Thoracic Surgery* (IF2018 = 3.919), *Lung Cancer* (IF2018 = 4.599), and *Clinical Lung Cancer* (IF2018 = 4.117).

For the top 10 institutions that contributed to 704 articles, 6 of these were from the United States which accounted for 15.3% of all articles. The United States occupied first place among the countries/ regions that contributed to surgical treatment of NSCLC, with China and Japan following on from these. The United States has strong influence and advantages compared with other countries not only due to the number of publications but also because of its high centrality. Meanwhile, China, Japan and South Korea are based in Eastern Asia, and have shown interest in extending life over the past decade. These countries accounted for 41% of the total number of publications. This is mainly due to the highest incidence of lung cancer in East Asian men (above 40 per 100,000), and the incidence rates among Chinese women (22.8 per 100,000) are also quite high.¹

4.2 Citation information:

On average, the top 10 authors published 33.5 articles per person. However, according to the network of co-cited authors in VOS viewer analysis, none of these was in the top 10 list. With respect to the rank of co-cited authors, Albain KS from Loyola University Chicago Stritch School of Medicine provided a critical role in appraising the efficacy of gefitinib for combination therapy of locally advanced NSCLC.¹⁴ Mountain CF from the Division of Cardiothoracic Surgery, University of California has made significant contributions in lung cancer staging.¹⁵ Douillard JY from the Department of Medical Oncology Centre R

Gauducheau published studies on postoperative chemotherapy in patients with NSCLC¹⁶ and Cerfolio RJ from the Department of Surgery, University of Alabama elaborated on the choice of surgery for NSCLC.¹⁷

4.3 Research frontiers:

Burst terms were considered to reflect research frontiers and hotspots by analysis using CiteSpace IV. According to the frequency and time spans, we considered three frontiers of surgical treatment for NSCLC research as follows:

Locally advanced NSCLC: The decision of a treatment method for patients with locally advanced NSCLC remains an area of a debate. Chemotherapy is essential, but its usage remains controversial due to the systematic reoccurring. Recently, the therapy of antibodies inhibiting the pathway against the programmed-death 1 (PD-1) has been revolutionary for advanced NSCLC treatment.¹⁸ In PACIFIC trial, durvalumab has definitely improved progression-free survival (PFS) when compared with placebo (16.8m vs 5.6m) for patients with unresectable stage III NSCLC. It was revealed that the result of overall survival (OS) ratio has significantly increased among the durvalumab group (66.3% vs 55.6%, HR = 0.68).¹⁹ While the patient selection was not strict and the trial was not randomised, the result may be biased. Although induction therapy and immunotherapy have involved recently, for the patients with stage IIIA N2 NSCLC the role of surgery makes a significant difference, the choice of therapy remains an area of debate. A classic study reported that the perioperative mortality for the patients who accepted pneumonectomy was 27 times higher than the 1% mortality for the group that underwent lobectomy in the North American Intergroup trial (INT 0139). However, the randomized trial failed to show the benefit of the overall survival (OS) between the surgical arm and standard therapy arm (23.6m vs. 22.2m).²⁰ The individual N2 node with evaluation smaller than 3cm, the pathology mediastinal staging by EBUS+/-EUS (Endobroncheal Ultrasonography) and neoadjuvant therapy or immunotherapy combined surgery may become the characteristics for selection of patients, which could minimize morbidity and maximize benefit from resection.³ For surgical treatment of NSCLC, appropriate lymph node dissection is the standard procedure, even for N1 or N2 disease.²¹ For the moment, evaluation of lymph nodes associated with NSCLC not only provides more truthful staging of TNM but also affords insight into the most appropriate operative method.²² However, when performing invasive approaches, the technique of complete lymph node resection is still a major concern.²¹

Assisted thoracic surgery: Video-assisted thoracoscopic surgery (VATS) was first reported by Roviato.²³ Since then, minimally invasive surgical techniques have developed for the treatment of lung cancer, and VATS has evolved into different surgical methods. These include the initial three-hole or four-hole approach, to the single-hole approach, or even to robotic assisted thoracic surgery. The intention of technique development is to reduce surgical trauma. Currently, VATS has become the mainstream surgical method. Compared with traditional lobectomy, VATS has the advantages of less trauma, less pain, fewer complications, and faster recovery.²⁴ With recent technological advances, robotic-assisted thoracoscopic surgery (RATS) became an option for thoracic surgeons to overcome lung cancer. This

may led 2D of VATS convert to 3D of RATS for thoracic surgery.²⁵ Novellis et al analyzed that the number of lymph nodal stations was significantly lower in VATS than in RATS.²⁶ In another study, Huang J et al demonstrated that RATS presented the surgeons with better maneuverability and accuracy than VATS.²⁷ In addition to its safety and effective operation, Veronesi et al pointed out that 223 patients of stage III lung cancer who accepted RATS had similar survival compared with open surgery.²⁸ Even though RATS has many advantages, due to longer operative time and extensive costs it will still need some time to be commonly accepted.

However, there were several limitations to our bibliometric analysis. First, most studies written in English from the WoSCC were included. This resulted in incomplete analysis to some extent. In addition, some types of publication were not included, such as books, conference proceedings and reviews. This may lead to some limitations with respect to the field of research. Furthermore, the operational principle of the software CiteSpace is mainly based on centrality and frequency of the choice of the number of nodes. This may mean that some high-quality papers are under-rated due to the low citation frequency.

5. Conclusions

In this study, an increasing number of publications assessing surgical treatment for NSCLC have contributed to the research hotspots. The United States, China and Japan were the top three countries engaging in relevant studies. In particular, the institutions of the United States still occupy the dominant place. Albain KS, Mountain CF, and Douillard JY were selected as the best academic collaborative candidates. Even through morbidity, elderly patient, and classification were the focus and frontiers in this field. There were fewer breakthroughs with respect to progress in research technologies and methods and these still require further innovation and development.

6. Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The datasets supporting the conclusion are included in the article.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

HHZ and LL compiled the presented patient data and drafted the manuscript. LZ, JQL and DT made substantial contributions in the conception of the article. TZ and GZG participated in the design of the study, revised the manuscript, and edited the language. All authors proofread and approved the manuscript.

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Figures

Figure 1

The number of relevant publications from 2009 to 2018.

Figure 2

The dual-map overlay of journals related to surgical treatment for NSCLC.

Figure 3

The distribution of countries.

Figure 4

The distribution of institutions related to surgical treatment for NSCLC.

Figure 5

The distribution of co-citation authors.

Figure 6

The number of publications for each of the different disciplines in surgical treatment of NSCLC.

Figure 7

The distribution of keywords.

Top 20 Keywords with the Strongest Citation Bursts

Figure 8

The distribution of the top 20 keywords with burst terms.