Original Article

Bibliometric and knowledge map analysis of one lung ventilation

Zhipeng Zhong[1]^, Yantong Wan[2], Zishi Lin[3], Junyong Chen[4], Jing Ye[3]^

[1]Department of Anesthesiology, Guangzhou Women and Children's Medical Center, Guangzhou Medical University, Guangzhou, China; [2]Guangdong Provincial Key Laboratory of Proteomics, Department of Pathophysiology, School of Basic Medical Sciences, Southern Medical University, Guangzhou, China; [3]Department of Anesthesiology, Zhujiang Hospital of Southern Medical University, Guangzhou, China; [4]Department of Anesthesiology, Nanfang Hospital, Southern Medical University, Guangzhou, China

Contributions: (I) Conception and design: Z Zhong, Y Wan; (II) Administrative support: J Ye; (III) Provision of study materials or patients: Z Lin, J Chen; (IV) Collection and assembly of data: Z Zhong; (V) Data analysis and interpretation: Z Zhong, Y Wan; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Jing Ye, MD, PhD. Department of Anesthesiology, Zhujiang Hospital of Southern Medical University, 604, the Second Clinical Medical College, 253 Industrial Avenue, Haizhu District, Guangzhou 510260, China. Email: w1605@163.com.

Background: One lung ventilation (OLV) is an essential method of lung isolation to protect the ventilated lung from soiling by the contralateral lung and obtain optimal surgical exposure in thoracic surgery. This study aims to examine the trends and developments in OLV research from 1982 to 2024 through bibliometric analysis.

Methods: The literature on OLV was systematically searched in the Web of Science Core Collection database for this study. VOSviewer and CiteSpace were utilized to perform comprehensive bibliometric and visual analyses of global publication/trends, countries/institutions, authors/co-cited authors, journals/co-cited journals, co-cited references, and keywords in the field of OLV.

Results: A total of 1,682 articles and reviews on OLV research were identified, which showed an overall growing trend from 1982 to 2024. The United States was the leader in this field, accounting for the largest number of publications (n=299). Among all institutions, Yonsei University had the largest number of publications (n=23), but National Taiwan University Hospital had the highest number of cited publications (n=876). The papers related to OLV were mainly published in *Journal of Cardiothoracic and Vascular Anesthesia* (n=147) and the most productive author was Cheng YJ (n=15). After keywords analysis, "infants", "dexmedetomidine", "inflammation", and "airway management" were newly emergent research hotspots.

Conclusions: Through bibliometric and visualization methods, we undertook a comprehensive analysis in the field of OLV. The United States maintained a top position in this field, the emerging hotspots of OLV changed from basic research to clinical research and the further innovation of OLV management. This study provides new ideas for scholars in their future works.

Keywords: Airway management; bibliometric; one lung ventilation (OLV); visual analysis

Submitted Apr 18, 2024. Accepted for publication Aug 16, 2024. Published online Sep 26, 2024.
doi: 10.21037/jtd-24-645
View this article at: https://dx.doi.org/10.21037/jtd-24-645

^ ORCID: Zhipeng Zhong, 0009-0000-3903-7992; Jing Ye, 0009-0005-4109-5717.

Introduction

One lung ventilation (OLV) is a widely used lung isolation technique to protect the ventilated lung from soiling by the contralateral lung in the cases such as bronchopleural fistula, pulmonary hemorrhage and whole-lung lavage, and facilitate surgical access in procedures involving the chest cavity in clinical practice (1,2). Hypoxemia and desaturation of cerebral oxygen saturation occur frequently during OLV in thoracic surgery, the management of OLV is a challenge to the anesthetists because of two major conditions: sufficient oxygenation and lung protection should be fully considered. The research hotspots in this respect include OLV-related lung injury (3-5), the pathogenesis and prevention of hypoxemia (6,7), the basic research of hypoxic pulmonary vasoconstriction (HPV) (8), the innovation of instruments (9,10), and the update of the anesthesia for thoracic surgery (11). In recent years, the introduction of video-assisted thoracoscopic surgery (VATS) (12,13), application of OLV in pediatric thoracic surgery (14,15), nonintubated thoracoscopic lobectomy (16-18) and enhanced recovery after surgery (ERAS) (19) are emerging research directions in the field of OLV. These studies are of great help to clinical practice, not only reducing the incidence of postoperative complications and improving the prognosis of patients, but also continuously innovating the procedures of thoracic anesthesia and lung isolation methodology, and enhancing efficiency of anesthesiologists.

Currently, many articles on OLV have been published in different academic journals, but the study of its bibliometric analysis has not been reported. This research aims to reveal the research progress, future trends and hotspots of OLV research with a suitable visualization method from a bibliometric perspective.

Highlight box

Key findings

- Through a bibliometric analysis of literature in the field of one lung ventilation (OLV) spanning the last four decades, researchers have observed a progression in research focus from foundational inquiries to clinical investigations centered on advancements in equipment and methodologies, pediatric thoracic surgery, and dexmedetomidine.

What is known and what is new?

- The development of thoracic surgery has heightened the demands for anesthesia during OLV procedures. Despite the abundance of studies in the field of OLV, there remains a dearth of high-quality bibliometric analysis.
- VOSviewer and CiteSpace were employed for visual analysis to conduct a comprehensive and objective bibliometric analysis of the OLV field from diverse perspectives.

What is the implication, and what should change now?

- "Infants", "dexmedetomidine", "inflammation", and "airway management" are newly emergent research hotspots, and these can be potential direction of investigation for thoracic anesthesiologists.

Methods

Data sources and search strategies

Our bibliometric analysis was based on the Web of Science Core Collection (WoSCC, Thomson Reuters, New York, USA), the most widely used database today (20-22), through which we conducted a comprehensive review of the relevant literature on OLV with the following search strategies: topic = ("one lung ventilation" OR "single lung ventilation" OR "lung separation Techniques" OR "lung isolation techniques" OR "separation of the two lungs"), language = English, and timespan = 1982–2024.

Data collection

All results using the above formula were exported as plain text literature in txt and CSV formats. The literature retrieval was conducted on 30 June 2024 to prevent possible bias introduced by database updating.

Data analysis

All data were imported into Microsoft Excel 365, VOSviewer 1.6.18 and CiteSpace 6.1. R2. Advanced visualization and used for quantitative and qualitative analysis. Different outputs were extracted from the WoSCC, including annual researches, countries, institutions, journals, authors, keywords, and key literature citation frequencies. All raw data used here were obtained from public databases, and thus no ethical review is required.

Statistical analysis

The trend of the number of published documents and cited documents in this field each year was visualized using Microsoft Excel 365 software. Quantitative data were presented in terms of quantity and percentage. The

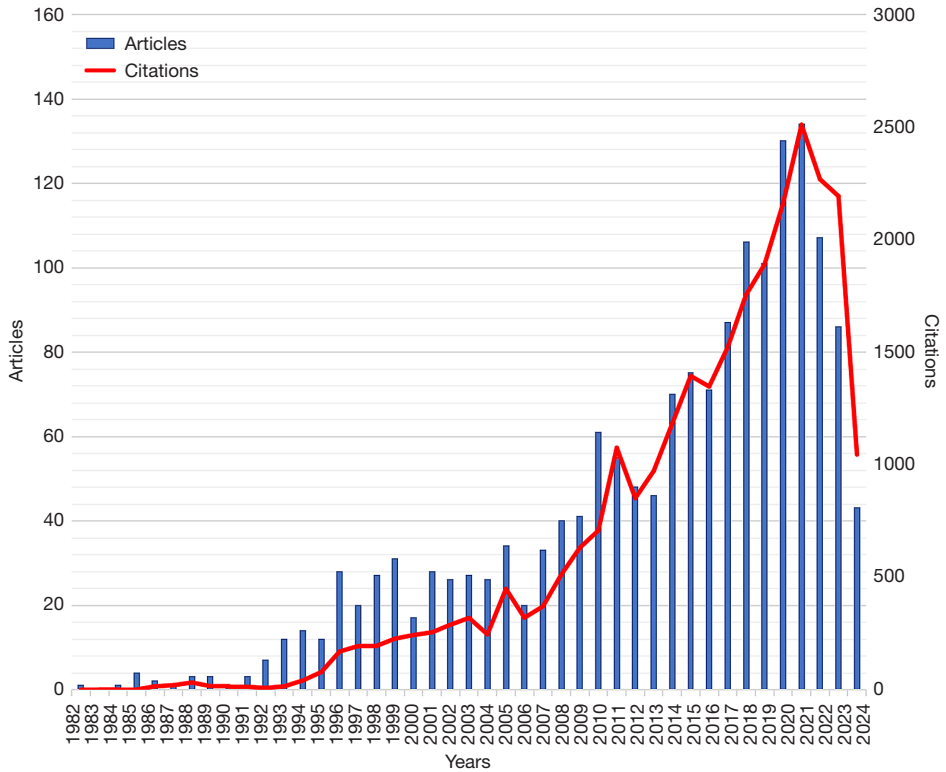

Figure 1 Trends in the publication and citation frequency of one lung ventilation-related literature [1982–2024].

Bibliometrix (R-Tool of R-Studio) was employed to analyze the information from related literature.

Results

Global publications and trends

A total of 1,682 eligible publications on OLV including 1,507 papers and 175 reviews with a citation number of 27,542 were collected from the WoSCC database encompassing the past 42 years. The publication output and temporal trend on OLV research are plotted in *Figure 1*. During the selected period, the number of articles published and annual reference frequency fluctuated, but showed an overall trend of steady growth before 2021. The highest volume of articles and citations reached 134 and 2,510 respectively in 2021.

Contribution of countries and regions to publications

The United States ranked the first regarding the number of publications (299, 23.73%), followed by China (261, 20.71%), Japan (158, 12.54%). The detailed data of the top 10 countries/regions in terms of the number of publications are presented in *Table 1*. The citation frequency of the United States (5,246 times) accounted for 24.30% of the total. Publications by Germany were cited 3,101 times, ranking second among all countries (*Table 1*). We also analyzed the cooperation between countries for each published article (*Figure 2A*). It was found that the United States was the country accounted for the highest frequency of research cooperation. Interestingly, the research of this field in Korea was only cooperated with the United States.

Contribution of institutions to global research on OLV

As shown in *Figure 2B*, most of the institutions were internal contacts and lacked of cooperation and communication with other institutions. The top 10 institutions in terms of literature output are shown in *Table 2*. Yonsei University had the most significant number of publications (23, 13.61%), followed by Stanford University (20, 11.83%) and National Taiwan University Hospital (20, 11.83%). It is worth noting

Table 1 Top 10 countries or regions in terms of the number of publications, frequency of citations, and total association intensity

Rank	Countries or regions/documents	Countries or regions/total link strength	Countries or regions/citations
1	USA/299	USA/110	USA/5,246
2	China/261	Italy/73	Germany/3,101
3	Japan/158	Germany/70	England/2,259
4	Germany/129	England/60	Canada/2,002
5	Korea/100	China/45	China/1,889
6	Italy/76	Switzerland/44	Italy/1,808
7	England/74	Sweden/40	Japan/1,655
8	Canada/65	Brazil/40	Spain/1,241
9	Taiwan/49	Canada/38	Switzerland/1,239
10	Turkey/49	Netherlands/37	Taiwan/1,149

that National Taiwan University Hospital had the strongest total association strength and the highest frequency of paper citations (n=876) in this field. This institution should have conducted extensive researches in the field of OLV.

Distribution of authors and co-cited authors

The authors of the retrieved literature were analyzed, and the top 10 authors ranked by the number of publications and frequency of co-citation were found (Table S1). Cheng, Ya-Jung from National Taiwan University Hospital published 15 OLV-related articles, ranking first among global scholars. Campos, JH and Chen, Jin-Shing both produced 13 articles, ranking joint second. All the authors are working in the department of anesthesiology except Chen, Jin-Shing, who is a thoracic surgeon. *Figure 3* visualizes the collaborative relationships between authors in literature related to OLV. As shown in the *Figure 3A*, each cluster was only connected internally, and there was almost no connection between each other, which indicated that cross-agency or transnational cooperative research in the field of OLV was insufficient. The different colors in the co-cited author relationship network of *Figure 3B* partially reflect the same characteristics among the studies of co-cited authors. The authors were divided by the co-citation frequency into 4 clusters, perhaps because their research direction was broadly similar. According to Table S1, Benumof, JL (n=468) has the highest number of co-citations, followed by Campos, JH (n=432) and Brodsky, JB (n=287). They are well-known and highly respected experts in thoracic anesthesia.

Distribution of journals

The top 10 journals with articles published on OLV, which were established by the number of articles and frequency of co-citation on OLV they published during this period are presented in Table S2. A total of 573 articles related to OLV were included in the top 10 journals with respect to the number of publications, comprising 36.9% of the overall publications. *Journal of Cardiothoracic and Vascular Anesthesia* [147, impact factor (IF) =2.894], *Anesthesia and Analgesia* (92, IF =6.627), and *Anesthesiology* (65, IF =8.986) ranked the top three, accounting for approximately one-fifth of the total number of articles. Co-citation frequency was a decisive factor for the impact of a journal in the field. *Anesthesiology* (n=4,380) was the journal with the most co-citation, followed by *Anesthesia and Analgesia* (n=3,088), and *British Journal of Anaesthesia* (n=2,205). According to the Journal Citation Reports 2021 standards, 80 percent of the top 10 co-cited journals were classified as Q1 or Q2 (Table S2), the top 5 journals in terms of number of articles also ranked the top 5 in terms of co-cited journals, indicating these journals have a high reputation in the academic field of OLV.

Highly cited reference analysis using CiteSpace

To analyze the most influential papers in this field, we listed the top 15 publications with the most citations in Table S3 in terms of the first author, title, journal, publication year, citation numbers and digital object unique identifier. "Hypoxic Pulmonary Vasoconstriction" (Sylvester *et al.*) got the highest number of citations (n=424). The main focus of

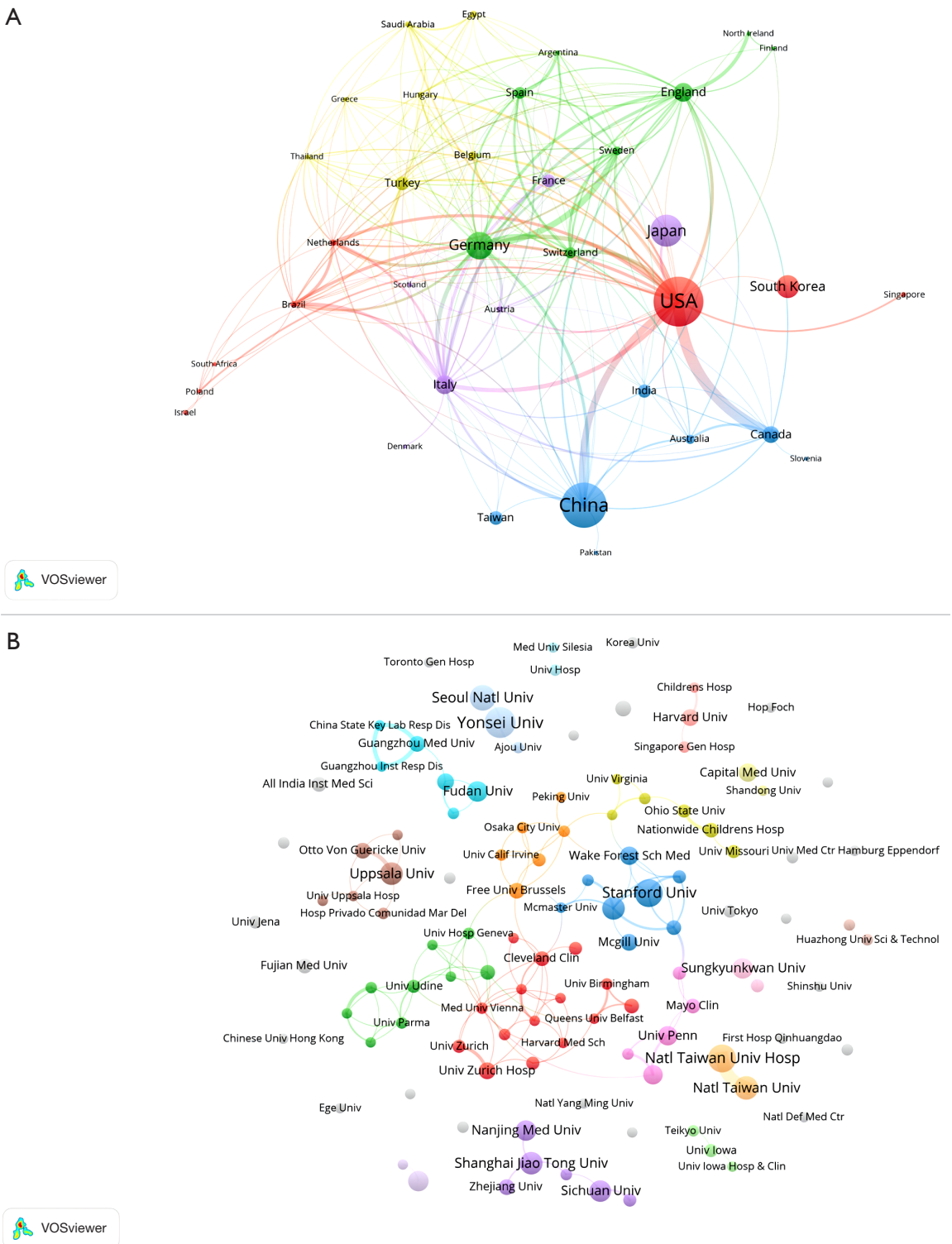

Figure 2 Visualization diagram of each country/region and institution regarding OLV applying VOSviewer. (A) Country or region visualization diagram shows that USA had the most publications and collaborations with other countries. (B) There were relatively few collaborations and exchanges among institutions from different countries/regions, and most collaborations were at a domestic level. OLV, one lung ventilation.

Table 2 Top 10 institutions in terms of number of articles issued and intensity of association

Rank	Institution/publications/original country or region	Institution/total link strength/original country or region	Institution/citations/original country or region
1	Yonsei Univ/23/Korea	Natl Taiwan Univ Hosp/15/Taiwan	Natl Taiwan Univ Hosp/876/Taiwan
2	Natl Taiwan Univ Hosp/20/Taiwan	Natl Taiwan Univ/15/Taiwan	Stanford Univ/760/United States
3	Stanford Univ/20/United States	Univ Toronto/14/Canada	Natl Taiwan Univ/718/Taiwan
4	Seoul Natl Univ/18/Korea	Med Univ Vienna/13/Austria	Mcgill Univ/614/Canada
5	Natl Taiwan Univ/16/Taiwan	Guangzhou Med Univ/11/China	Univ Toronto/544/Canada
6	Shanghai Jiao Tong Univ/15/China	Univ British Columbia/11/Canada	Otto Von Guericke Univ/544/Germany
7	Univ Toronto/15/Canada	Cleveland Clin/10/United States	Hosp Privado Comunidad Mar Del Plata/454/Argentina
8	Uppsala Univ/15/Sweden	Univ Udine/10/Italy	Royal Brompton Hosp/411/England
9	Sichuan Univ/14/China	China State Key Lab Resp Dis/10/China	Sungkyunkwan Univ/372/Korea
10	Fudan Univ/13/China	Guangzhou Inst Resp Dis/10/China	Univ Zurich Hosp/355/Switzerland

this paper was the cellular and molecular work performed to clarify these intrinsic mechanisms of HPV (23). The second most cited article was "Protective ventilation influences systemic inflammation after esophagectomy: a randomized controlled study" (Michelet *et al.*), with 270 citations. This study shows a protective ventilatory strategy influences the proinflammatory systemic response during and after a complex surgical procedure requiring a prolonged period of OLV (24). "Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery after Surgery (ERAS®) Society Recommendations" by Low was the third most cited article with 210. This review summarizes the following information, volatile or intravenous anesthetics are equally effective for maintenance of anesthesia. Intermediate-acting neuromuscular blocking agents, bispectral index (BIS) monitoring, avoiding volume overload, and lung protective strategies facilitate early extubation and reduce postoperative complications (25).

We analyzed the top 15 articles in terms of annual citation frequency (*Table 3*), which could evaluate the academic productivity, predict the development trends, and reflect the research hotspots in a field. The relationship among the studies was analyzed on CiteSpace, and was found to have a specific time factor of publication (*Figure 4A*). In this network, each node represented a referenced article, and the size of each node was proportional to the total co-referencing frequency of related articles. The clustering of the relational network of literature (*Figure 4B*) yielded totally 21 co-reference clusters. These major cluster labels included mechanical ventilation, non-intubated VATS, sevoflurane, coronavirus disease 2019 (COVID-19), positive end-expiratory pressure ventilation (PEEP), intraoperative transesophageal echocardiography, endobronchial, arterial PO_2, lung isolation techniques, cerebral desaturation, bupivacaine, endoscopic, complications-hypoxemia, esophageal, ERAS, pediatric surgery and electrical impedance tomography.

The burst test of annual citation frequency indicated a sharp increase in citations and some critical questions in the field proposed or solved in the documents. The top 25 cited outbreaks shown in *Figure 5A* started 1–4 years after publication. Among the 1,682 articles of the past 42 years, the episode concentrated from 2001 to 2022 with a high outbreak since 2009. These studies have suggested that the current research focus on OLV includes preventing lung injury after OLV and hypoxemia during OLV, and optimizing the protective ventilation strategies (6,24,26). The network of citation relationship between the top 26 cited articles was shown in *Figure 5B*. The articles of Benumof in 1987 (27) and Slinger in 1992 (28) were still cited in recent years, which implied the impressive achievements of these pioneers and foremost scholars for current understanding of OLV.

Keyword analysis

In order to analyze the frontiers of results and hot topics in the field of OLV research, we performed a keyword

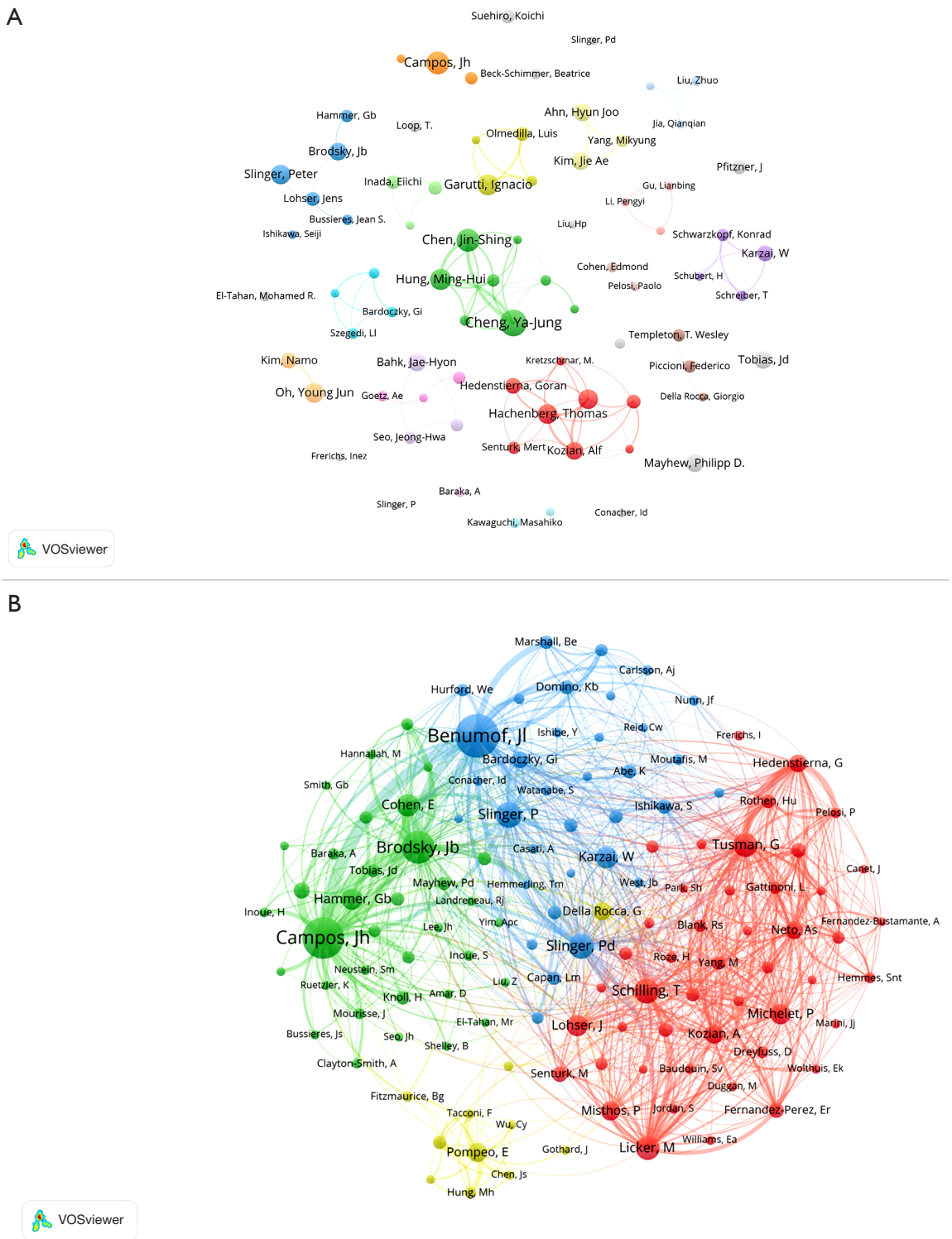

Figure 3 The collaborative network of authors and co-cited authors regarding OLV applying VOSviewer. (A) Cheng, Ya-Jung was the author with the largest number of publications. (B) Benumof, JL had the highest number of co-citations among all co-cited authors. Co-cited authors are defined as a minimum of two authors who are referenced in at least one subsequent paper, indicating their mutual citation relationship; OLV, one lung ventilation.

Table 3 Top 15 references in terms of annual citation frequency

Rank	Author	Article title	Source Title	Year	Citations	Citation/year
1	Low *et al.*	Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations	*World Journal of Surgery*	2019	210	42
2	Sylvester *et al.*	Hypoxic Pulmonary Vasoconstriction	*Physiological Reviews*	2012	424	35.33
3	Lohser *et al.*	Lung Injury After One-lung Ventilation: a Review of the Pathophysiologic Mechanisms Affecting the Ventilated and the Collapsed Lung	*Anesthesia and Analgesia*	2015	195	21.67
4	Lumb *et al.*	Hypoxic pulmonary vasoconstriction: physiology and anesthetic implications	*Anesthesiology*	2015	149	16.56
5	Michelet *et al.*	Protective ventilation influences systemic inflammation after esophagectomy: a randomized controlled study	*Anesthesiology*	2006	270	15
6	Gonzalez-Rivas *et al.*	Non-intubated video-assisted thoracoscopic lung resections: the future of thoracic surgery?	*European Journal of Cardio-Thoracic Surgery*	2016	117	14.63
7	Park *et al.*	Driving Pressure during Thoracic Surgery: A Randomized Clinical Trial	*Anesthesiology*	2019	67	13.4
8	De Conno *et al.*	Anesthetic-induced improvement of the inflammatory response to one-lung ventilation	*Anesthesiology*	2009	185	12.33
9	Karzai *et al.*	Hypoxemia during one-lung ventilation: prediction, prevention, and treatment	*Anesthesiology*	2009	179	11.93
10	Chen *et al.*	Nonintubated thoracoscopic lobectomy for lung cancer	*Annals of Surgery*	2011	150	11.54
11	Blank *et al.*	Management of One-lung Ventilation: Impact of Tidal Volume on Complications after Thoracic Surgery	*Anesthesiology*	2016	91	11.38
12	Zhao *et al.*	Evaluation of an Electrical Impedance Tomography-based Global Inhomogeneity Index for Pulmonary Ventilation Distribution	*Intensive Care Medicine*	2009	163	10.87
13	Wu *et al.*	Feasibility and safety of nonintubated thoracoscopic lobectomy for geriatric lung cancer patients	*Annals of Thoracic Surgery*	2013	112	10.18
14	Schilling *et al.*	Effects of volatile and intravenous anesthesia on the alveolar and systemic inflammatory response in thoracic surgical patients	*Anesthesiology*	2011	128	9.85
15	Yang *et al.*	Does a protective ventilation strategy reduce the risk of pulmonary complications after lung cancer surgery?: a randomized controlled trial	*Chest*	2011	125	9.62

co-occurrence analysis using VOSviewer (*Figure 6A*). The thicker line between the keyword points in each section, the more frequent co-occurrence. The OLV field was co-categorized into 6 clusters, reflecting the possible six research directions. These clusters, with apparent associations among the top 15 high occurrence keywords, were in general agreement. The red cluster included "VATS", "thoracoscopy", "hypoxemia", "thoracotomy" and "pneumothorax". In the green cluster, "thoracic surgery", "double-lumen tube", "bronchial blocker", "intubation" and "airway management" were all involved. In the blue cluster, there are "thoracic anesthesia", "lung cancer",

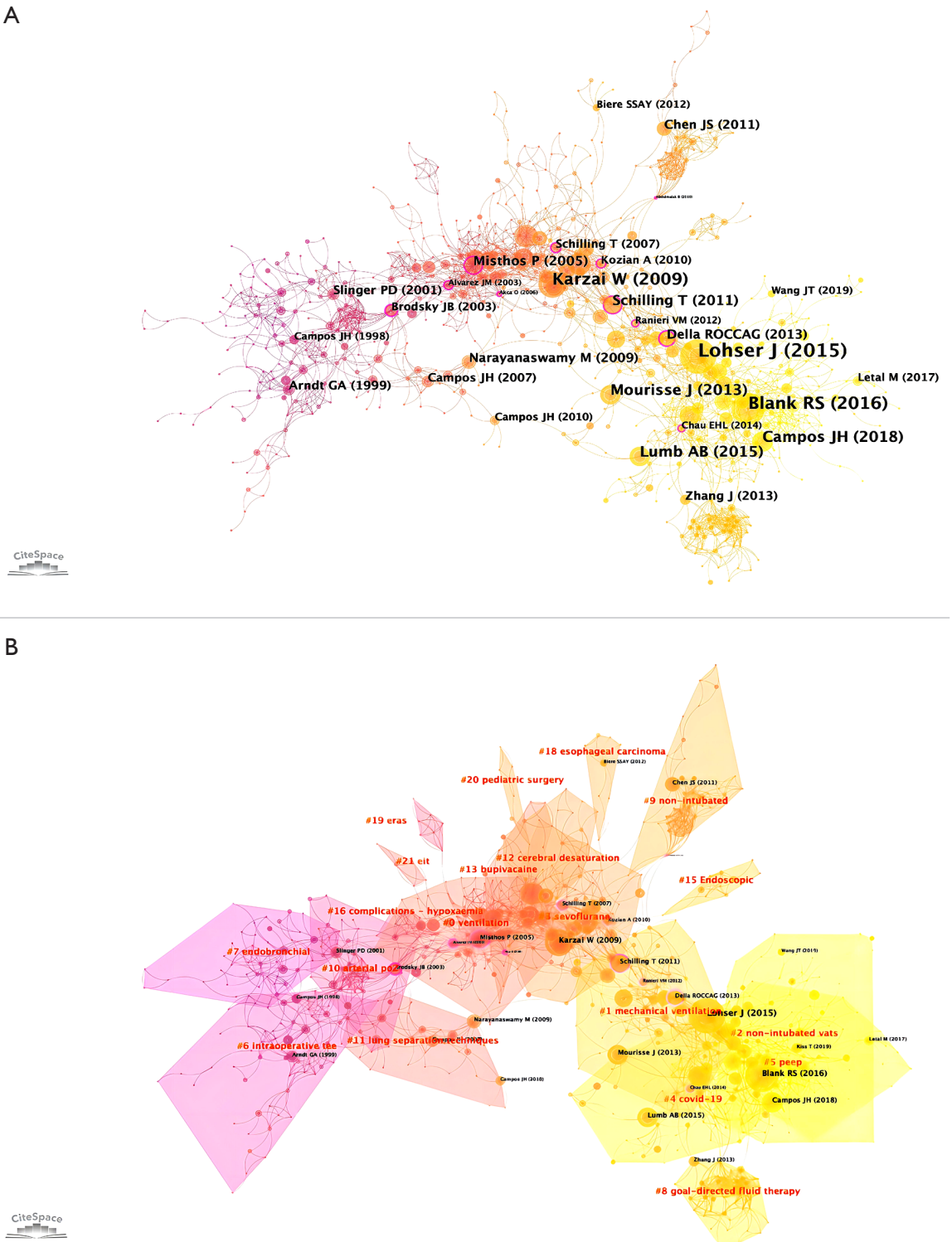

Figure 4 Literature relation network diagram by CiteSpace. (A) The article of Lohser, J in 2015 was the most frequently co-cited articles in total. The size of each node is directly proportional to the frequency of co-citations in the article. (B) Literature relation network diagram of document clustering, a total of 21 clusters.

A

References	Year	Strength	Begin	End	2000–2022
Arndt GA, 1999, ACTA ANAESTH SCAND, V43, P356, DOI 10.1034/j.1399-6576.1999.430320.x, DOI	1999	7.24	2001	2004	
Slinger PD, 2001, ANESTHESIOLOGY, V95, P1096, DOI 10.1097/00000542-200111000-00012, DOI	2001	7.14	2003	2006	
Tusman G, 2004, ANESTH ANALG, V98, P1604, DOI 10.1213/01.ANE.0000068484.67655.1A, DOI	2004	7.13	2005	2009	
Misthos P, 2005, EUR J CARDIO-THORAC, V27, P379, DOI 10.1016/j.ejcts.2004.12.023, DOI	2005	7.94	2006	2010	
Fernandez-perez ER, 2006, ANESTHESIOLOGY, V105, P14, DOI 10.1097/00000542-200607000-00007, DOI	2006	9.24	2007	2011	
Senturk M, 2006, CURR OPIN ANESTHESIO, V19, P1, DOI 10.1097/01.aco.0000192778.17151.2c, DOI	2006	8.75	2007	2011	
Schilling T, 2005, ANESTH ANALG, V101, P957, DOI 10.1213/01.ane.0000172112.02902.77, DOI	2005	7.95	2008	2010	
Michelet P, 2006, ANESTHESIOLOGY, V105, P911, DOI 10.1097/00000542-200611000-00011, DOI	2006	13	2009	2011	
Lohser JENS, 2008, ANESTHESIOL CLIN, V26, P241, DOI 10.1016/j.anclin.2008.01.011, DOI	2008	9.83	2009	2013	
Unzueta MC, 2007, ANESTH ANALG, V104, P1029, DOI 10.1213/01.ane.0000260313.63893.2f, DOI	2007	7.63	2009	2012	
Karzai W, 2009, ANESTHESIOLOGY, V110, P1402, DOI 10.1097/ALN.0b013e31819fb15d, DOI	2009	16.69	2010	2014	
De Conno E, 2009, ANESTHESIOLOGY, V110, P1316, DOI 10.1097/ALN.0b013e3181a10731, DOI	2009	10.61	2010	2014	
Licker M, 2009, CRIT CARE, V13, P0, DOI 10.1186/cc7762, DOI	2009	8.75	2010	2014	
Schilling T, 2011, ANESTHESIOLOGY, V115, P65, DOI 10.1097/ALN.0b013e318214b9de, DOI	2011	9.92	2012	2015	
Yang M, 2011, CHEST, V139, P530, DOI 10.1378/chest.09-2293, DOI	2011	7.1	2013	2016	
Mourisse J, 2013, ANESTHESIOLOGY V118, P550, DOI 10.1097/ALN.0b013e3182834f2d, DOI	2013	10.78	2015	2018	
Ferrando C, 2014, ANESTH ANALG, V118, P657, DOI 10.1213/ANE.0000000000000105, DOI	2014	7.39	2015	2019	
Futier E, 2013, NEW ENGL J MED, V369, P428, DOI 10.1056/NEJMoa1301082, DOI	2013	7.16	2015	2018	
Clayton-smith A, 2015, JCARDIOTHOR VASC AN, V29, P955, DOI 10.1053/j.jvca.2014.11.017, DOI	2015	9.14	2016	2020	
Lumb AB, 2015, ANESTHESIOLOGY, V122, P932, DOI 10.1097/ALN.0000000000000569, DOI	2015	8.07	2016	2020	
Lohser J, 2015, ANESTH ANALG, V121, P302, DOI 10.1213/ANE.0000000000000808, DOI	2015	22.82	2017	2020	
Blank RS, 2016, ANESTHESIOLOGY, V124, P1286, DOI 10.1097/ALN.0000000000001100, DOI	2016	13.8	2017	2022	
Campos JH, 2018, J CARDIOTHOR VASC AN, V32, P2330, DOI 10.1053/j.jvca.2017.12.026, DOI	2018	10.46	2019	2022	
Batchelor TJP, 2019, EUR J CARDIO-THORAC, V55, P91, DOI 10.1093/ejcts/ezy301, DOI	2019	8.26	2019	2022	
Park M, 2019, ANESTHESIOLOGY, V130, P385, DOI 10.1097/ALN.0000000000002600, DOI	2019	8.89	2020	2022	

B

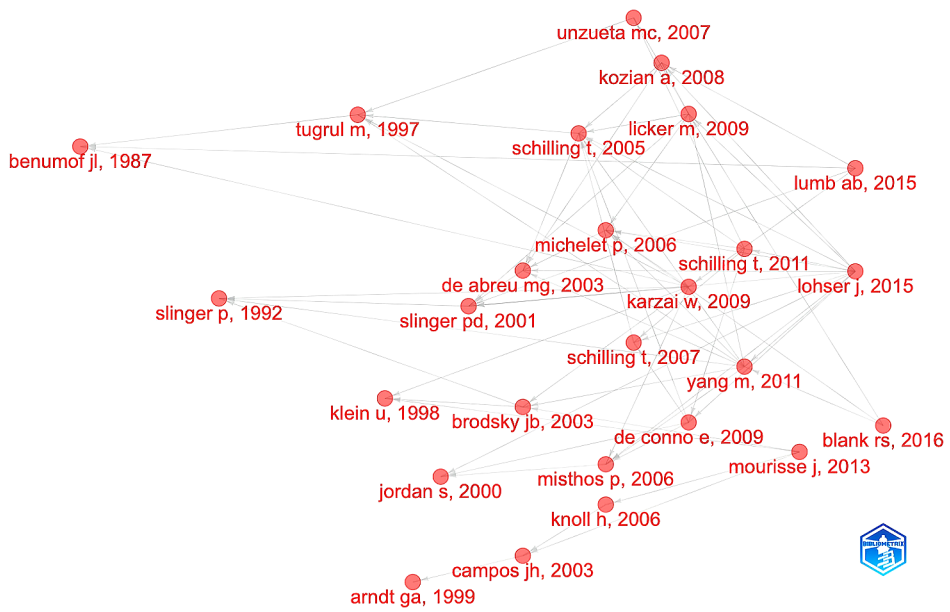

Figure 5 Visualization of the top 25 high burst of cited literature and the relationship between the highly cited articles. (A) The first three citation bursts in the field of OLV research began in 2009. The red section on the blue timeline indicates the beginning and ending year and the outbreak period. (B) The article of Benumof in 1987 was still cited in recent years. The red dots represent highly cited articles, while the grey lines depict the interconnections among them. OLV, one lung ventilation.

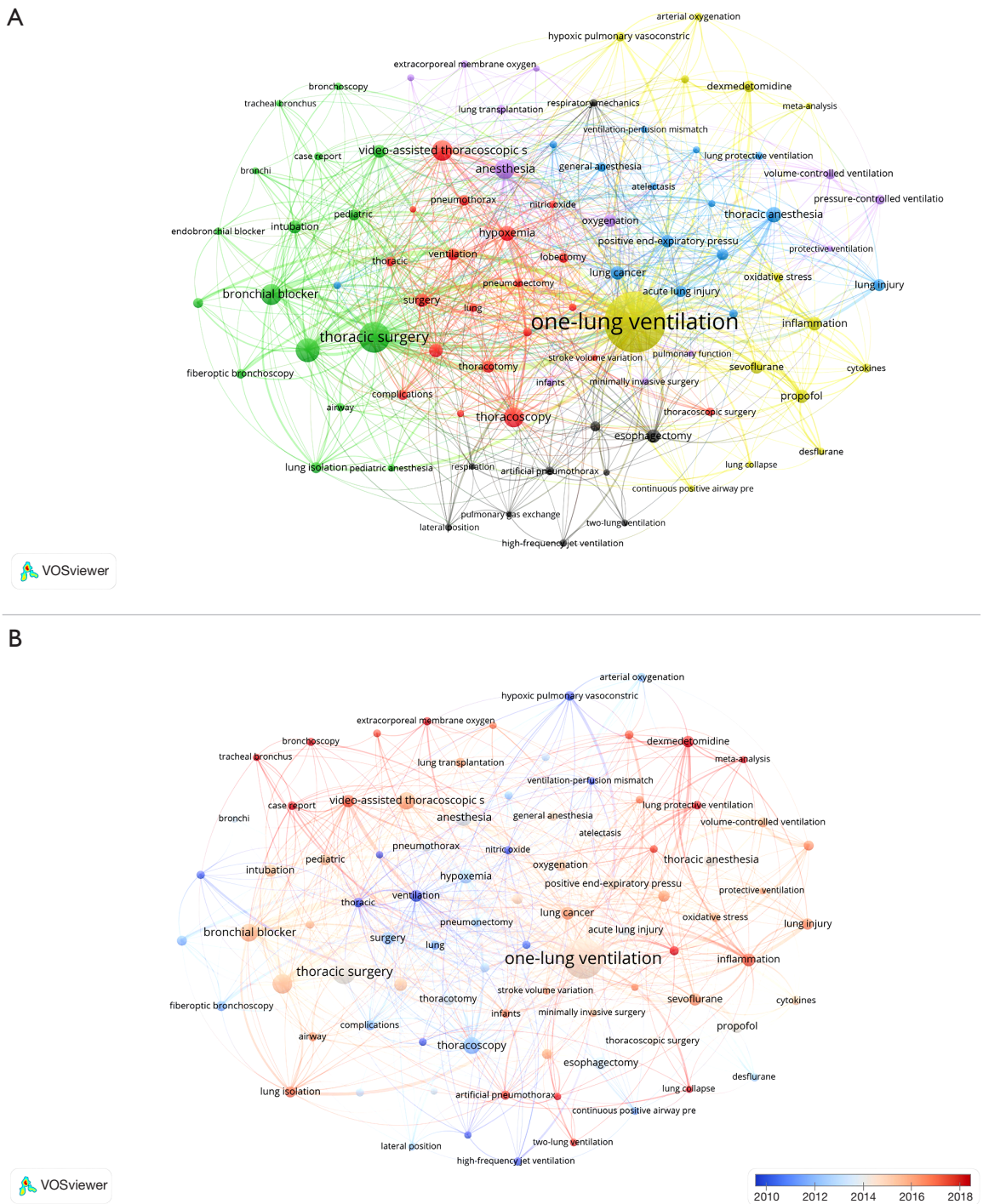

Figure 6 Keyword co-occurrence network relationship diagram. (A) The keyword co-occurrence in the field of OLV was co-categorized into 6 clusters, reflecting the possible six research directions. Nodes of varying colors represent different clusters of keywords, and the node size correspond to their frequency. (B) The latest hot keywords included "dexmedetomine", "meta-analysis", "inflammation", "infants" and "airway management". OLV, one lung ventilation.

"lung injury" and "PEEP". The yellow cluster represented "OLV", "propofol", "inflammation", "sevoflurane" and "dexmedetomidine (DEX)". The purple cluster included "anesthesia", "oxygenation", "pressure-controlled ventilation" and "volume-controlled ventilation". The smallest set is light blue and contains "esophagectomy", "esophageal cancer" and "artificial pneumothorax".

The top 20 most frequent keywords are listed in Table S4. "One-lung ventilation" was the most frequent keyword (575 co-occurrences), "thoracic surgery" (154 co-occurrences) and "double-lumen tube" (96 co-occurrences) ranked second and third. These keywords also had high association strength in the domain (all greater than 200). *Figure 6B* shows the heat network relationship diagram of keyword co-occurrence. The keywords in red represented some of the current hotspots in the field. As can be seen from the figure, the OLV research change its focus from "hypoxic pulmonary vasoconstriction", "thoracoscopy", "hypoxemia" and "hemodynamics" to "dexmedetomine", "meta-analysis", "inflammation", "infants" and "airway management" in the past decade.

Discussion

Research trends in OLV

OLV is a key component of lung isolation techniques with a long history, the first description of the apparatus constructed for separate lung ventilation and the practice in human were both reported in 1932 (29,30), but the copyrighted literature of OLV-related research in WoSCC database began in 1982. In this study, we can only analyze the current situation and development trend of OLV research in the recent four decades based on these data.

The average annual growth rate of 10.8% from 2012 to 2021 for scientific production implied a rapid rise in researchers' interest in this field. There was active collaboration between developed countries. The United States was the top country contributing to OLV studies. As the country with the second largest number of publications, China was also influential. However, in terms of the frequency of citations and total association intensity, China did not match with the centrality of other influential countries. Although countries possessed their cooperation networks, the breadth and intensity of cooperation were not ideal. From the perspective of research institutions, most cooperating institutions were limited to internal connections, and there was substantially less transnational cooperation and exchange of findings. Research institutions from other countries should break down academic barriers, which will bring obvious benefits for the long-term progress of OLV research in the field.

The authors with the largest number of publications on OLV research were primarily in the field of anesthesiology and thoracic surgery. However, back in the 1930s and 1940s, OLV was investigated by various departments, doctors from department of surgery and anesthesia or the ear, nose and throat make idea-producing connections by linking concepts (29,31,32). This reflects thoracic anesthesia has continued to grow at a rapid pace and evolved from its historical emphasis on technical implementation to pathogenesis research and related biomarkers, and now to the further innovation of OLV management.

Research focus on OLV

References citation frequency reflects the academic influence in a special field. The highly cited reference cluster analysis indicated that the focus of OLV research included the interrelationship between HPV, hypoxemia and lung injuries, management of OLV and surgical innovations. Hypoxemia, caused by the atelectasis and collapse, obligatory intrapulmonary shunt and inevitable lung injury, should always be considered as the key challenge during OLV (11). The impaired oxygenation activates the auto regulatory reflex mechanism, HPV, which diverts the blood flow toward the dependent lung in the thoracic procedure (8,33). Any factors inhibiting HPV response would exacerbate hypoxemia, for those who are intolerant to hypoxemia, the repeated episodes of OLV and reinflation would result in more severe ventilator-induced lung injury, and lead to a negative feedback loop.

There are dozens of animal and molecular biology studies which focused on the mechanism of HPV with increasing understanding about its characteristics, mediation, modulation and role, such as the start of early response, the maximal vasoconstrictor response, the reasons for the variations and how to increase PaO_2 in ventilated lung (23). However, the mechanisms of some endogenous agents which enhance or inhibit HPV, and the contributions in normal lungs with regional shunt or hypoventilation and in diseases lung of HPV remain unclear. These unknown or unsolved issues might the directions of future investigations.

In addition, the cytokine release and leukocyte recruitment on both lungs induced by OLV would give rise to not just hypoxemia, but the postoperative pulmonary complications. The basic researches about proinflammatory

responses were reportedly involved in the pathogenesis of OLV, inhibition of the cytokine is beneficial for abating the damage from oxidative stress and systemic inflammatory response, along with improvements in postoperative survival and prognostics (3,34-36). Recent studies demonstrated that the commonly used volatile anesthetics, sevoflurane and desflurane appeared to exert similar anti-inflammatory effects in lung cancer resection undergoing OLV (37-40). How to alleviate the immediate systemic inflammatory response to OLV and translate the basic research achievements to clinical practice are the future prospects.

On the other hand, the clinical studies were concentrated on pursuing how to prevent hypoxemia and acute lung injury during OLV. Preoperative lung function abnormalities, side and position of the surgery, and distribution of perfusion can predict the development of hypoxemia during OLV (6,7), adequate gas exchange to support systemic oxygen supply is a key point in the management of OLV (41). Lung injury has been described after any period of OLV, to solve this great puzzle, nearly half of highly cited articles were about the protective ventilation strategies. Historically, patients endorsed high tidal volume to prevent hypoxemia and intraoperative atelectasis during OLV. However, a study cohort finding that tidal volume is inversely related to the incidence of respiratory complications (42). The larger tidal volume and larger fluid administration are closely associated with the development of acute lung postoperative respiratory failure (43), low tidal volume, limitation of maximal pressure ventilation, and the additional PEEP resulted in a diminished systemic inflammatory, decreasing incidence of acute lung injury (24,44-46). Yang's study was the first randomized controlled trial performed on patient undergoing lung resection surgery, their finding indicated that protective ventilation strategies showed improved postoperative oxygenation and clinical outcomes as compared with conventional groups (47). Recent research suggests that driving pressure-guided ventilation during OLV decreased the incidence of postoperative pulmonary complications more than conventional protective ventilation (48). Choosing an appropriate and individual PEEP and the lowest driving pressure without affecting hemodynamic variables can obtain the best oxygenation and associate with fewer postoperative pulmonary complications (46,49,50). These practical results are transforming the management of OLV at an accelerating pace, and go always hand in hand with the basic researches.

Moreover, the fast-changing innovations of apparatus and techniques for anesthesia and thoracic surgery may have contributed to prevent hypoxemia. The two main devices used for lung isolation are bronchial blockers (BBs) and double lumen tubes (DLT) (51,52). At present, a variety of BBs are invented commercially (53), the prevalence of BBs facilitates the popularization of selective lobar blockage, reduces the OLV mediated lung injury and the incidents of hypoxemia. The citation intensity of articles about EZ-blocker (9) and Arndt tube (54) ranked in the top 25 (*Figure 5A*), which means they have received support and recognition from peers.

With respect to the most controversial technic in recent years, which was nonintubated thoracic anesthesia undoubtedly, OLV might no longer be essential for mini-invasive thoracic surgery. Despite both of the retrospective and prospective studies elucidated that the perioperative surgical outcomes for the nonintubated VATS were comparable to OLV technique, and considering that it was a valid alternative of OLV, from the other anesthetic standpoint, its indications and safety were questioned; it was a retrogress rather than a new beginning for thoracic anesthesia.

Nonintubated general anesthesia combined with an infiltration or nerve block was employed before 1930s. The active coughing reflex is not abolished; the patient requires every possible protection for the pus, blood and secretion in the lateral position. Endotracheal insufflation is only applied in certain cases such as mediastinal shift and paradoxical respiration (32). Over time, with the evolution of airway management and better understanding of anatomy and physiology, lung isolation techniques including OLV become the main prerequisite for thoracic surgery.

To prevent DLT intubation-related complications, ventilator-associated lung injury and residual muscle relaxant, Pompeo from thoracic surgery first proposed awake video thoracoscopic lung resection in 2004 (55). Thereafter, different groups, such as Chen and colleagues (16,18). He and colleagues (56,57) described techniques of nonintubated VATS of complex pulmonary or mediastinal procedures, detailed the modifications strategies of airway management, analgesia, and sedation methods. The advantages of nonintubated VATS are its idea of ERAS, the reduced stress and faster postoperative recovery times (58-60). However, intraoperative hypercapnia during spontaneous breathing, conversion to intubated general anesthesia due to mediastinal movement, acidosis, hemorrhage, etc., remain the unresolved problems, particular training for anesthesiologists is necessary (60).

Research fronts in OLV

Keywords, as a core summary of article contents, can be used to analyze the recent hotspots in OLV. As shown in *Figure 4B*, these keywords in red such as "infants", "dexmedetomine", "inflammation", "mechanical ventilation" and "airway management" represented high popularity in the field of OLV recently. With the continuous improvement and maturity of OLV technology, the exploration of OLV in infants and children for thoracic surgery increased dramatically (15). Pediatric studies on OLV included endobronchial intubation in infants with congenital airway malformation (61), data collecting in pediatric lower airway anatomy for initial insertion depth of BB's placement during OLV (15), the intraoperative protective ventilation strategies in VATS for children (14), optimization of bronchial occlusion for better surgical exposure, shorter surgical duration (62). In recent decade, DEX has attracted much attention in the field of anesthesia, and also in OLV. Some clinical study supposed that DEX may improve arterial oxygenation and intrapulmonary shunt during OLV in adults undergoing thoracic surgery (63), alleviate the intraoperative decrease in cerebral oxygen saturation and reduce the incidence of postoperative cognitive dysfunction (64,65), attenuates inflammatory and injury-induced responses to OLV by inhibiting alveolar neutrophil recruitment (66). In part, the outbreak of COVID-19 has put airway management under special attention in clinical research in the field of OLV to ensure the safety of patients and healthcare staff (67).

Limitation

We statistically and comprehensively analyzed the development status and research hotspots in OLV over the last 42 years by using three software programs: CiteSpace, VOSviewer, and R-bibliometrix. However, there are some limitations in the current study. First, we only analyzed the documents in WoSCC database and did not use databases such as PubMed or Scopus, and this may have allowed some representative available outputs in the field to be omitted. Besides, some important non-English documents might be excluded from our present analysis because our inclusion criteria were limited to English documents only. In addition, the newly published and potential influential articles were not included in the highly cited articles but this does not mean that they are not important. Therefore, future work should not only extend data collection to other databases and non-English documents, but also include the newly publications that are easily to be overlooked due to citation-based indicators.

Conclusions

OLV possesses essential research value and application prospects in thoracic surgical procedures. From the perspective of bibliometrics, we analyzed the development trend, research status and future research hotspots of OLV in the past 42 years. There is no doubt that, as a leader in medicine, the United States remains at the heart of the field of one-lung ventilation, thanks to the contributions of anesthesiology pioneers such as Benumof and Campos. Through bibliometric analysis, we found that the research focus of OLV has changed from basic research such as hypoxemia and HPV to clinical research and the further innovation of OLV management, such as the innovation of high-tech apparatus, airway management, pediatric thoracic surgery, and multimodal anesthetic administration, which provide certain reference value for clinical anesthesiologists.

Acknowledgments

Funding: This work was supported by the Science and Technology Planning Project of Guangdong Province, China (Grant No. 2016A020215120) and Natural Science Foundation of Guangdong Province, China (Grant No. 2019A1515011190).

Footnote

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-645/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-645/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Ferrando C, Mugarra A, Gutierrez A, et al. Setting individualized positive end-expiratory pressure level with a positive end-expiratory pressure decrement trial after a recruitment maneuver improves oxygenation and lung mechanics during one-lung ventilation. Anesth Analg 2014;118:657-65.
2. De Conno E, Steurer MP, Wittlinger M, et al. Anesthetic-induced improvement of the inflammatory response to one-lung ventilation. Anesthesiology 2009;110:1316-26.
3. Lohser J, Slinger P. Lung Injury After One-Lung Ventilation: A Review of the Pathophysiologic Mechanisms Affecting the Ventilated and the Collapsed Lung. Anesth Analg 2015;121:302-18.
4. Hemmerling TM, Bluteau MC, Kazan R, et al. Significant decrease of cerebral oxygen saturation during single-lung ventilation measured using absolute oximetry. Br J Anaesth 2008;101:870-5.
5. Jordan S, Mitchell JA, Quinlan GJ, et al. The pathogenesis of lung injury following pulmonary resection. Eur Respir J 2000;15:790-9.
6. Karzai W, Schwarzkopf K. Hypoxemia during one-lung ventilation: prediction, prevention, and treatment. Anesthesiology 2009;110:1402-11.
7. Campos JH, Feider A. Hypoxia During One-Lung Ventilation-A Review and Update. J Cardiothorac Vasc Anesth 2018;32:2330-8.
8. Lumb AB, Slinger P. Hypoxic pulmonary vasoconstriction: physiology and anesthetic implications. Anesthesiology 2015;122:932-46.
9. Mourisse J, Liesveld J, Verhagen A, et al. Efficiency, efficacy, and safety of EZ-blocker compared with left-sided double-lumen tube for one-lung ventilation. Anesthesiology 2013;118:550-61.
10. Lu Y, Dai W, Zong Z, et al. Bronchial Blocker Versus Left Double-Lumen Endotracheal Tube for One-Lung Ventilation in Right Video-Assisted Thoracoscopic Surgery. J Cardiothorac Vasc Anesth 2018;32:297-301.
11. Sentürk M. New concepts of the management of one-lung ventilation. Curr Opin Anaesthesiol 2006;19:1-4.
12. Umari M, Falini S, Segat M, et al. Anesthesia and fast-track in video-assisted thoracic surgery (VATS): from evidence to practice. J Thorac Dis 2018;10:S542-54.
13. Huang S, Peng W, Tian X, et al. Effects of transcutaneous electrical acupoint stimulation at different frequencies on perioperative anesthetic dosage, recovery, complications, and prognosis in video-assisted thoracic surgical lobectomy: a randomized, double-blinded, placebo-controlled trial. J Anesth 2017;31:58-65.
14. Lee JH, Bae JI, Jang YE, et al. Lung protective ventilation during pulmonary resection in children: a prospective, single-centre, randomised controlled trial. Br J Anaesth 2019;122:692-701.
15. Downard MG, Lee AJ, Heald CJ, et al. A Retrospective Evaluation of Airway Anatomy in Young Children and Implications for One-Lung Ventilation. J Cardiothorac Vasc Anesth 2021;35:1381-7.
16. Wu CY, Chen JS, Lin YS, et al. Feasibility and safety of nonintubated thoracoscopic lobectomy for geriatric lung cancer patients. Ann Thorac Surg 2013;95:405-11.
17. Gonzalez-Rivas D, Bonome C, Fieira E, et al. Non-intubated video-assisted thoracoscopic lung resections: the future of thoracic surgery? Eur J Cardiothorac Surg 2016;49:721-31.
18. Chen JS, Cheng YJ, Hung MH, et al. Nonintubated thoracoscopic lobectomy for lung cancer. Ann Surg 2011;254:1038-43.
19. Batchelor TJP, Rasburn NJ, Abdelnour-Berchtold E, et al. Guidelines for enhanced recovery after lung surgery: recommendations of the Enhanced Recovery After Surgery (ERAS®) Society and the European Society of Thoracic Surgeons (ESTS). Eur J Cardiothorac Surg 2019;55:91-115.
20. AlRyalat SAS, Malkawi LW, Momani SM. Comparing Bibliometric Analysis Using PubMed, Scopus, and Web of Science Databases. J Vis Exp 2019.
21. Wan Y, Dong P, Zhu X, et al. Bibliometric and visual analysis of intestinal ischemia reperfusion from 2004 to 2022. Front Med (Lausanne) 2022;9:963104.
22. Li X, Xiang P, Liang J, et al. Global Trends and Hotspots in Esketamine Research: A Bibliometric Analysis of Past and Estimation of Future Trends. Drug Des Devel Ther 2022;16:1131-42.
23. Sylvester JT, Shimoda LA, Aaronson PI, et al. Hypoxic pulmonary vasoconstriction. Physiol Rev 2012;92:367-520.
24. Michelet P, D'Journo XB, Roch A, et al. Protective ventilation influences systemic inflammation after esophagectomy: a randomized controlled study. Anesthesiology 2006;105:911-9.
25. Stevens JH, Burdon TA, Peters WS, et al. Port-access

coronary artery bypass grafting: a proposed surgical method. J Thorac Cardiovasc Surg 1996;111:567-73.
26. Lohser J. Evidence-based management of one-lung ventilation. Anesthesiol Clin 2008;26:241-72, v.
27. Benumof JL, Augustine SD, Gibbons JA. Halothane and isoflurane only slightly impair arterial oxygenation during one-lung ventilation in patients undergoing thoracotomy. Anesthesiology 1987;67:910-5.
28. Slinger P, Suissa S, Triolet W. Predicting arterial oxygenation during one-lung anaesthesia. Can J Anaesth 1992;39:1030-5.
29. Jacobaeus HC, Frenokner P, Björkman S. Some Attempts at Determining the Volume and Function of Each Lung Separately. (Bronchospirometry)1: Preliminary report. Acta Medica Scandinavica 1932;79:174-215.
30. Gale JW, Waters RM. Closed endobronchial anesthesia in thoracic surgery: preliminary report. Anesthesia & Analgesia 1932;11:283-8.
31. CARLENS E. A new flexible double-lumen catheter for bronchospirometry. J Thorac Surg 1949;18:742-6.
32. Hewer CL. Discussion on anesthesia in thoracic surgery. Proc R Soc Med 1930;23:771-82.
33. Tusman G, Böhm SH, Sipmann FS, et al. Lung recruitment improves the efficiency of ventilation and gas exchange during one-lung ventilation anesthesia. Anesth Analg 2004;98:1604-9.
34. Misthos P, Katsaragakis S, Milingos N, et al. Postresectional pulmonary oxidative stress in lung cancer patients. The role of one-lung ventilation. Eur J Cardiothorac Surg 2005;27:379-82; discussion 382-3.
35. Kozian A, Schilling T, Röcken C, et al. Increased alveolar damage after mechanical ventilation in a porcine model of thoracic surgery. J Cardiothorac Vasc Anesth 2010;24:617-23.
36. Leite CF, Calixto MC, Toro IF, et al. Characterization of pulmonary and systemic inflammatory responses produced by lung re-expansion after one-lung ventilation. J Cardiothorac Vasc Anesth 2012;26:427-32.
37. Schilling T, Kozian A, Senturk M, et al. Effects of volatile and intravenous anesthesia on the alveolar and systemic inflammatory response in thoracic surgical patients. Anesthesiology 2011;115:65-74.
38. de la Gala F, Piñeiro P, Reyes A, et al. Postoperative pulmonary complications, pulmonary and systemic inflammatory responses after lung resection surgery with prolonged one-lung ventilation. Randomized controlled trial comparing intravenous and inhalational anaesthesia. Br J Anaesth 2017;119:655-63.
39. Lee YM, Song BC, Yeum KJ. Impact of Volatile Anesthetics on Oxidative Stress and Inflammation. BioMed Res Int 2015;2015:242709.
40. Schilling T, Kozian A, Kretzschmar M, et al. Effects of propofol and desflurane anaesthesia on the alveolar inflammatory response to one-lung ventilation. Br J Anaesth 2007;99:368-75.
41. Low DE, Allum W, De Manzoni G, et al. Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS(®)) Society Recommendations. World J Surg 2019;43:299-330.
42. Blank RS, Colquhoun DA, Durieux ME, et al. Management of One-lung Ventilation: Impact of Tidal Volume on Complications after Thoracic Surgery. Anesthesiology 2016;124:1286-95.
43. Fernández-Pérez ER, Keegan MT, Brown DR, et al. Intraoperative tidal volume as a risk factor for respiratory failure after pneumonectomy. Anesthesiology 2006;105:14-8.
44. Licker M, Diaper J, Villiger Y, et al. Impact of intraoperative lung-protective interventions in patients undergoing lung cancer surgery. Crit Care 2009;13:R41.
45. Futier E, Constantin JM, Paugam-Burtz C, et al. A trial of intraoperative low-tidal-volume ventilation in abdominal surgery. N Engl J Med 2013;369:428-37.
46. Reinius H, Borges JB, Engström J, et al. Optimal PEEP during one-lung ventilation with capnothorax: An experimental study. Acta Anaesthesiol Scand 2019;63:222-31.
47. Yang M, Ahn HJ, Kim K, et al. Does a protective ventilation strategy reduce the risk of pulmonary complications after lung cancer surgery?: a randomized controlled trial. Chest 2011;139:530-7.
48. Park M, Ahn HJ, Kim JA, et al. Driving Pressure during Thoracic Surgery: A Randomized Clinical Trial. Anesthesiology 2019;130:385-93.
49. Li P, Kang X, Miao M, Zhang J. Individualized positive end-expiratory pressure (PEEP) during one-lung ventilation for prevention of postoperative pulmonary complications in patients undergoing thoracic surgery. Medicine (Baltimore). 2021 Jul 16;100(28):e26638.
50. Kiss T, Wittenstein J, Becker C, et al. Protective ventilation with high versus low positive end-expiratory pressure during one-lung ventilation for thoracic surgery (PROTHOR): study protocol for a randomized controlled trial. Trials 2019;20:213.
51. Clayton-Smith A, Bennett K, Alston RP, et al. A Comparison of the Efficacy and Adverse Effects of

Double-Lumen Endobronchial Tubes and Bronchial Blockers in Thoracic Surgery: A Systematic Review and Meta-analysis of Randomized Controlled Trials. J Cardiothorac Vasc Anesth 2015;29:955-66.
52. Langiano N, Fiorelli S, Deana C, et al. Airway management in anesthesia for thoracic surgery: a "real life" observational study. J Thorac Dis 2019;11:3257-69.
53. Neustein SM. The use of bronchial blockers for providing one-lung ventilation. J Cardiothorac Vasc Anesth 2009;23:860-8.
54. Arndt GA, DeLessio ST, Kranner PW, et al. One-lung ventilation when intubation is difficult--presentation of a new endobronchial blocker. Acta Anaesthesiol Scand 1999;43:356-8.
55. Pompeo E, Mineo D, Rogliani P, et al. Feasibility and results of awake thoracoscopic resection of solitary pulmonary nodules. Ann Thorac Surg 2004;78:1761-8.
56. Dong Q, Liang L, Li Y, et al. Anesthesia with nontracheal intubation in thoracic surgery. J Thorac Dis 2012;4:126-30.
57. Liu J, Cui F, Pompeo E, et al. The impact of non-intubated versus intubated anaesthesia on early outcomes of video-assisted thoracoscopic anatomical resection in non-small-cell lung cancer: a propensity score matching analysis. Eur J Cardiothorac Surg 2016;50:920-5.
58. Tacconi F, Pompeo E, Sellitri F, et al. Surgical stress hormones response is reduced after awake videothoracoscopy. Interact Cardiovasc Thorac Surg 2010;10:666-71.
59. Wang ML, Hung MH, Chen JS, et al. Nasal high-flow oxygen therapy improves arterial oxygenation during one-lung ventilation in non-intubated thoracoscopic surgery. Eur J Cardiothorac Surg 2018;53:1001-6.
60. Hung WT, Cheng YJ, Chen JS. Video-Assisted Thoracoscopic Surgery Lobectomy for Lung Cancer in Nonintubated Anesthesia. Thorac Surg Clin 2020;30:73-82.
61. Narayanasamy S, Adler E, Mahmoud M, et al. Airway management of congenital pulmonary airway malformation resection in neonates and infants: A case cohort study. Paediatr Anaesth 2019;29:808-13.
62. Huang J, Cao H, Chen Q, et al. The Comparison Between Bronchial Occlusion and Artificial Pneumothorax for Thoracoscopic Lobectomy in Infants. J Cardiothorac Vasc Anesth 2021;35:2326-9.
63. Huang SQ, Zhang J, Zhang XX, et al. Can Dexmedetomidine Improve Arterial Oxygenation and Intrapulmonary Shunt during One-lung Ventilation in Adults Undergoing Thoracic Surgery? A Meta-analysis of Randomized, Placebo-controlled Trials. Chin Med J (Engl) 2017;130:1707-14.
64. Roberts ML, Lin HM, Tinuoye E, et al. The Association of Cerebral Desaturation During One-Lung Ventilation and Postoperative Recovery: A Prospective Observational Cohort Study. J Cardiothorac Vasc Anesth 2021;35:542-50.
65. Gao Y, Zhu X, Huang L, et al. Effects of dexmedetomidine on cerebral oxygen saturation and postoperative cognitive function in elderly patients undergoing minimally invasive coronary artery bypass surgery. Clin Hemorheol Microcirc 2020;74:383-9.
66. Wu CY, Lu YF, Wang ML, et al. Effects of Dexmedetomidine Infusion on Inflammatory Responses and Injury of Lung Tidal Volume Changes during One-Lung Ventilation in Thoracoscopic Surgery: A Randomized Controlled Trial. Mediators Inflamm 2018;2018:2575910.
67. Thornton M, Reid D, Shelley B, et al. Management of the airway and lung isolation for thoracic surgery during the COVID-19 pandemic: Recommendations for clinical practice endorsed by the Association for Cardiothoracic Anaesthesia and Critical Care and the Society for Cardiothoracic Surgery in Great Britain and Ireland. Anaesthesia 2020;75:1509-16.

Cite this article as: Zhong Z, Wan Y, Lin Z, Chen J, Ye J. Bibliometric and knowledge map analysis of one lung ventilation. J Thorac Dis 2024;16(9):6123-6139. doi: 10.21037/jtd-24-645