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ORIGINAL RESEARCH

Mapping Trends and Hotspots Regarding the Use of Lung Ultrasound in the Field of Anesthesiology: A Bibliometric Analysis of Global Research

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Purpose: Lung ultrasound (LUS) is increasingly utilized in the field of anesthesiology due to its focused, quick application and the advantage of not exposing patients to ionizing radiation. This study aims to analyze the status and trends in this area from a macroscopic perspective.

Methods: A bibliometric analysis was conducted using the Web of Science (WoS) Core Collection. The analysis and visualization were performed using WoS, Excel, VOSviewer, and CiteSpace. Parameters such as publications, countries, institutions, journals, and keywords were analyzed.

Results: A total of 133 articles published over the last 10 years were analyzed to clarify the current status and future trends on the use of LUS in anesthesiology. The number of publications increased markedly from May 1, 2014, to April 30, 2024. China is the highest productive country, while the USA had the highest number of citations. In the institution, Seoul National University in South Korea published the most articles and had the highest number of citations. Kim Jin-Tae emerged as the most prolific and influential author. BMC Anesthesiology and the Journal of Cardiothoracic and Vascular Anesthesia were identified as the most popular journals in the field. Keywords such as "atelectasis", "mechanical ventilation", and "pulmonary complications" were closely related to the use of LUS in anesthesiology.

Conclusion: This study provides a comprehensive analysis of research on the use of LUS in anesthesiology, highlighting the growing interest in LUS and its relevance to pulmonary complications.

Keywords: lung ultrasound, anesthesiology, bibliometric analysis, mapping trends and hotspots

Introduction

Lung ultrasound (LUS) has been developed over the past 20 years as an effective, noninvasive, easy-to-use, portable, non-radiative, and accurate diagnostic tool that can be applied in real time for bedside assessment of patients with respiratory symptoms and signs, while LUS offers several advantages, it also has certain limitations, such as operator dependence and a limited depth of penetration, which may restrict its ability to visualize certain deep-seated lung pathologies.[1,2] LUS is used to detect, characterize, and provide an initial diagnosis or follow-up assessment, highlighting specific diagnostic features.[3] It enables the capture of images at multiple stages during surgical procedures within the operating room.[2] In anesthesiology, LUS helps monitor ventilation and pathological changes.[4] Researchers are exploring new applications, such as ultrasound-guided lung recruitment maneuvers, detection of postoperative atelectasis, and prediction of postoperative pulmonary complications.[4–8]

Bibliometrics is a technique used to assess and examine the advancement of a specific field or research domain.[9] It utilizes computer technology to present visual representations of literature analysis outcomes in a concise and comprehensible graphical format.[10] Bibliometric analysis offers a comprehensive approach to evaluating academic productivity,

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summarizing academic frontiers and hotspots, and predicting trends within a particular research field. By leveraging scientific literature databases and employing metrics, researchers can gain valuable insights into the scholarly landscape and make informed decisions regarding their research endeavors.

This study aims to analyze the bibliometric characteristics of LUS in anesthesiology over the past 10 years, exploring the history, popular research topics, and cutting-edge trends, thereby providing references for clinicians and researchers.

Methods

Data Source and Search Strategy

The data were retrieved from the Web of Science Core Collection (WoSCC). Literature on LUS in anesthesiology was evaluated using the following search formula: "(TS=(lung ultrasound) OR TS=(lung ultrasonography) OR TS=(lung sonography) OR TS=(LUS)) AND (TS=(Anesthesi*) OR TS=(Perioperative Period))". Literature published between May 1, 2014, and April 30, 2024, was included, restricted to "article" and "review" types, and in "English". All retrieved records were downloaded in "plain text" format, and relevant information (eg, title, abstract, year of publication, countries/regions, institutions, authors, journals, keywords) was extracted for further analysis.

Inclusion and Exclusion Criteria

Research related to LUS in anesthesiology, identified through WoSCC and published between May 1, 2014, and April 30, 2024, was included. Conference papers, letters, editorials, notes, and retractions were excluded. The language was restricted to English.

Data Screening and Extraction

To ensure the reliability of the results, two independent researchers meticulously selected the literature by reading abstracts and methods. Divergences in selection were resolved through discussion or consultation with specialists. All retrieved records were downloaded in "plain text" and "excel" formats. Relevant parameters, such as titles, publication years, citation counts, authors, countries/regions, institutions, journals, keywords, usage counts, and WoS categories, were extracted for further analysis.

Data Analysis and Visualization

Descriptive statistics using Microsoft Excel (V. 2021) were used to present publication trends and cumulative citations. VOSviewer (V. 1.6.20) and CiteSpace (V. 6.2.R6) software were applied for knowledge mapping analysis, including authors, institutions, countries/regions, journals, and keywords. VOSviewer conducted co-authorship analyses for countries/regions, institutions, authors, and journals, providing publication and citation counts. The relatedness of nodes in VOSviewer figures was determined by the number of co-authored publications. VOSviewer also conducted co-occurrence analysis for keywords. CiteSpace was used to analyze burst keywords.

Results

In this study, 529 records were identified in WoSCC as of April 30, 2024. A total of 401 publications were published between May 1, 2014, and April 30, 2024. After further screening for document type and relevance, 133 research publications were included. The study procedure is shown in Figure 1.

Annual Trend of Publications and Most Cited Articles

Our analysis showed a marked increase in the number of publications from May 1, 2014, to April 30, 2024, with a peak level of 133 in 2021 (Figure 2). The mean number of publications per year was 13.3, and the median was 13 (Figure 2). The top 10 references by citation frequency in anesthesiology are listed in Table 1. The most cited title, published in 2014, is "Accuracy of Transthoracic Lung Ultrasound for Diagnosing Anesthesia-induced Atelectasis in Children", cited 114 times, and published in Anesthesiology.

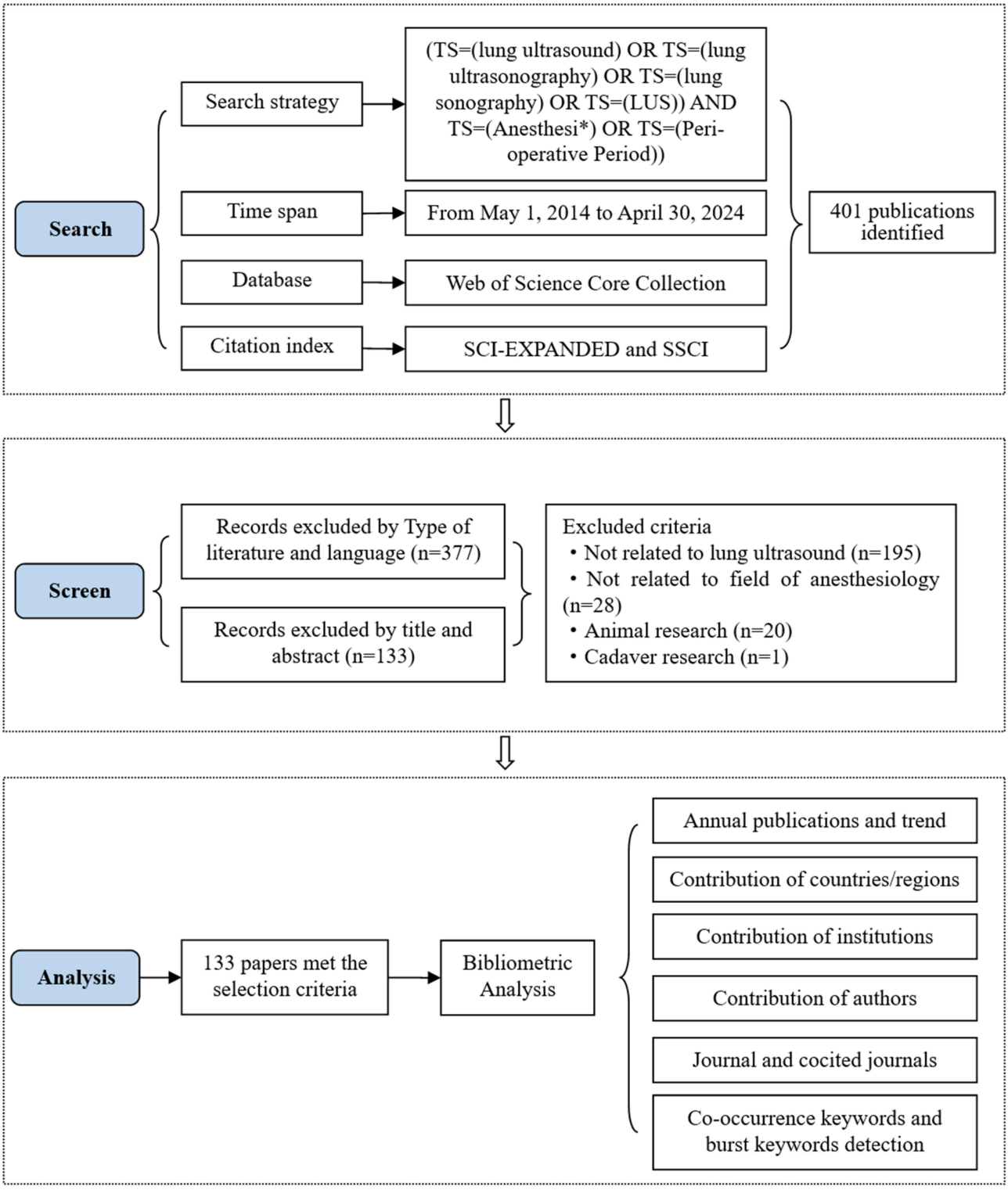

Figure 1 Study flow diagram.

Distribution Analysis by Country and Region

Country analysis was performed using VOSviewer. Our evaluation showed that the articles belonged to 31 countries or regions. China had the highest number of publications (41), followed by the USA (32) and South Korea (22), with Canada (14) and Italy (8) trailing. The USA had the highest number of citations (508), followed by Canada (264). Figure 3 shows the

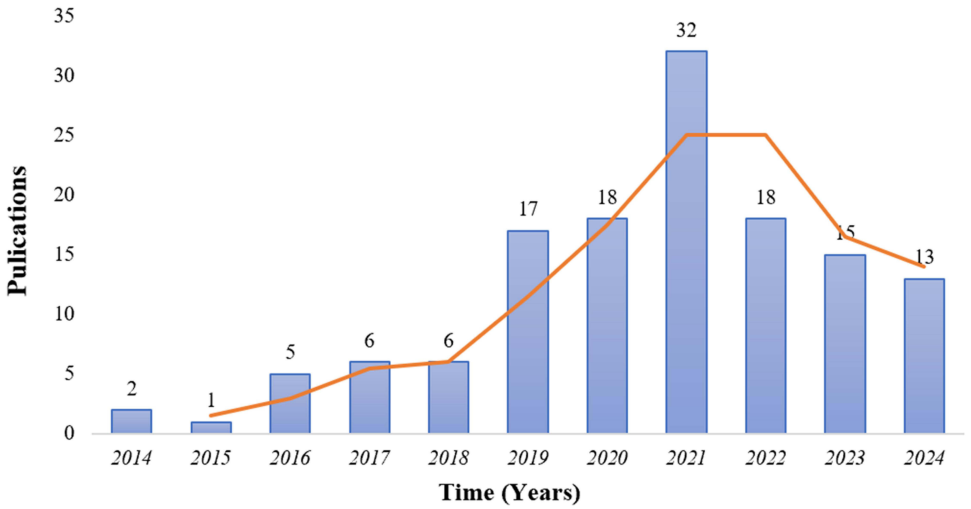

Figure 2 Number of annual research publications and growth trends.

citation relationships of countries or regions with at least one publication. Notably, numerous countries maintain strong connections with the USA. Countries in green, including Canada and Germany, are booming in this field.

Most Productive and Influential Scientific Organizations

VOSviewer identified the publication and citation numbers of scientific organizations. A total of 242 institutions published works in the last 10 years. Seoul National University published 11 articles on LUS in anesthesiology, ranking

Table 1 Top 10 Citing Literature by Citation Counts.[2,11–19]

Rank	Title	Journal	Author	Publication Year	Citations
1	Accuracy of Transthoracic Lung Ultrasound for Diagnosing Anesthesia-induced Atelectasis in Children[11]	Anesthesiology	Acosta, CM	2014	114
2	Auscultation versus Point-of-care Ultrasound to Determine Endotracheal versus Bronchial Intubation A Diagnostic Accuracy Study[13]	Anesthesiology	Ramsingh, D	2016	95
3	Lung Ultrasonography for the Assessment of Perioperative Atelectasis.: A Pilot Feasibility Study[2]	Anesthesia & Analgesia	Monastesse, A	2017	85
4	Perioperative Pulmonary Atelectasis: Part II. Clinical Implications[14]	Anesthesiology	Lagier, D	2022	47
5	Utility of Perioperative Lung Ultrasound in Pediatric Cardiac Surgery: A Randomized Controlled Trial[12]	Anesthesiology	Song, IK	2018	44
6	Electrical impedance tomography imaging of the cardiopulmonary system[15]	Current Opinion in Critical Care	Frerichs, I	2014	41
7	Performance of lung ultrasound in detecting peri-operative Atelectasis after General Anesthesia[16]	Ultrasound in medicine and biology	Yu, X	2016	39
8	Effects of positive end-expiratory pressure/recruitment manoeuvres compared with zero end-expiratory pressure on atelectasis during open gynaecological surgery as assessed by ultrasonography: a randomised controlled trial[17]	British Journal of Anaesthesia	Généreux, V	2020	35
9	Effects of neuromuscular block reversal with sugammadex versus neostigmine on postoperative respiratory outcomes after major abdominal surgery: a randomized-controlled trial[18]	Canadian Journal of Anesthesia-Journal canadien d anesthesie	Alday, E	2019	34
10	Lung ultrasound reclassification of chest X-ray data after pediatric cardiac surgery[19]	Pediatric Anesthesia	Cantinotti, M	2018	32

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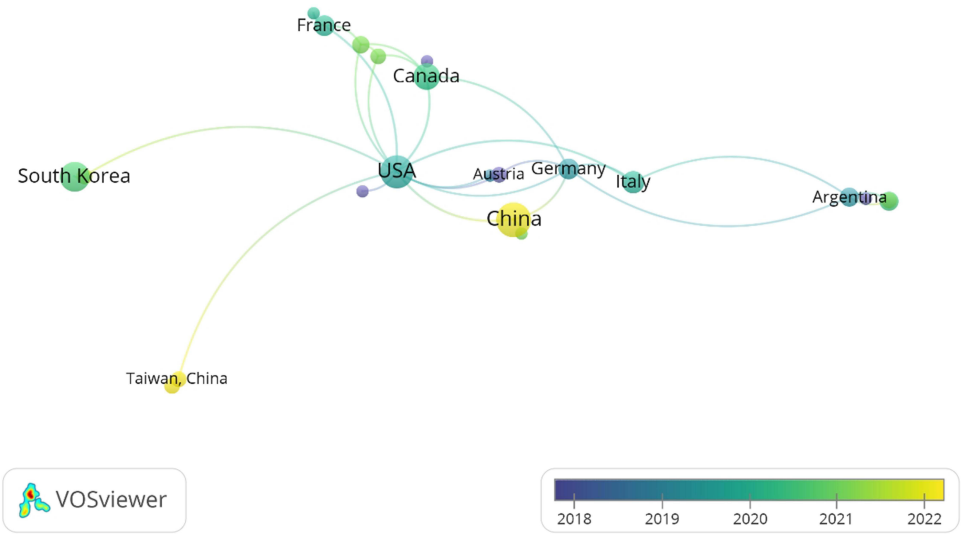

Figure 3 Network diagram of national or regional cooperation on the use of LUS in the field of anesthesiology.

first, followed by Harvard Medical School (9 articles), Shanghai Jiao Tong University (5 articles), Loma Linda University (4 articles), and Texas Children's Hospital (4 articles). The top 10 organizations are listed in Table 2. The citation rank followed a similar pattern.

Most Productive and Influential Authors

VOSviewer identified publication and citation numbers of authors. A total of 737 authors contributed. The top 10 authors are listed in Table 3. Kim Jin-Tae (8 publications) was the most prolific author, followed by Kim Eun-Hee (7 publications), Kim Hee-Soo (7 publications), Lee Ji-Hyun (7 publications), and Jang Young-Eun (6 publications). Tusman Gerardo and Acosta Cecilia M were the most influential researchers, with 152 citations each, followed by Ramsingh Davinder (150 citations) and Kim Jin-Tae (141 citations). The network diagram shows decentralized cooperative relationships among scholars (Figure 4).

Popular Journals

VOSviewer analyzed journals that published the articles (Figure 5). These articles were recorded by 59 journals, with 9 journals recording more than 5 articles. With 10 documents, BMC Anesthesiology and the Journal of Cardiothoracic and Vascular Anesthesia published the most articles, followed by the Canadian Journal of Anesthesia (8), the European

Table 2 Top 10 Institutions by Number of Publications

Rank	Institution	Count	Citations
1	Seoul National University (Korea)	11	160
2	Harvard Medical School (United States)	9	146
3	Shanghai Jiao Tong University (China)	5	34
4	Loma Linda University (United States)	4	55
5	Texas Children's Hospital (United States)	4	46
6	University of Louisville (United States)	4	27
7	Korea University (Korea)	4	16
8	Capital Medical University (China)	4	1
9	Mayo Clinic (United States)	4	56
10	Hospital for Special Surgery (United States)	3	46

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Table 3 Top 10 Authors on Use of Lung Ultrasound in the Field of Anesthesiology Research

Rank	Author	Documents	Citations	Average citations/publications	H-index
1	Kim, JT	8	141	17.63	26
2	Kim, EH	7	132	18.86	16
3	Kim, HS	7	132	18.86	26
4	Lee, JH	7	132	18.86	12
5	Jang, YE	6	88	14.67	14
6	Ramsingh, D	5	150	30.00	14
7	Adler, AC	5	72	14.40	12
8	Ji, SH	4	45	11.25	8
9	Tusman, G	4	152	38	30
10	Boublik, J	4	63	15.75	18

Journal of Anaesthesiology (7), and Pediatric Anesthesia (7). In terms of total citation number, Anesthesiology (318), Anesthesia & Analgesia (164), and the Canadian Journal of Anesthesia (119) ranked the top 3.

Keywords Analysis

Keywords serve as concise summaries of a paper's core content and essence. Through keyword co-occurrence analysis, researchers gain insights into research hotspots. In this study, VOSviewer constructed a network visualization of keyword co-occurrences from the 133 documents. Keywords with a frequency of 5 or higher were presented. The identified keywords are organized into 3 distinct clusters. The red cluster encompasses keywords pertinent to LUS, while the green cluster focuses on anesthesia-induced atelectasis. The results are presented in Figure 6. Burst words, characterized by

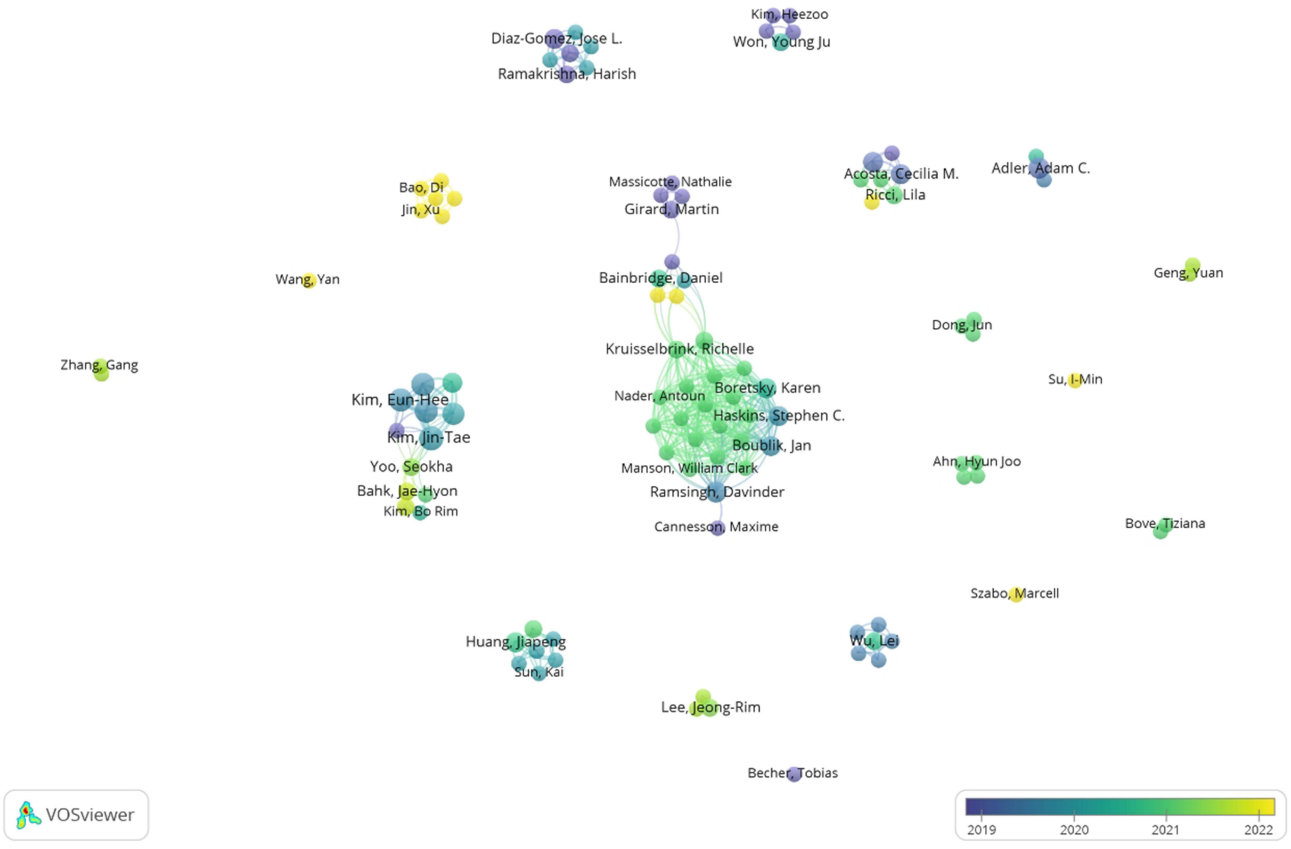

Figure 4 Network diagram between authors. The threshold for each node presented in the map is set as 2 publications.

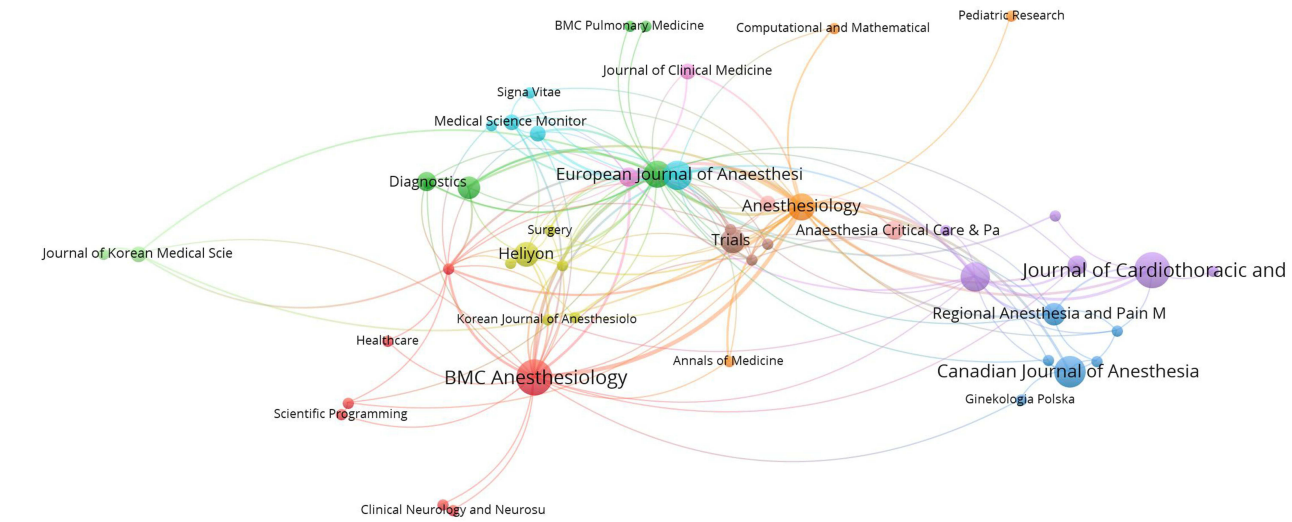

Figure 5 Co-citation characteristics of journals. The threshold for each node presented in the map is set as 1 publication.

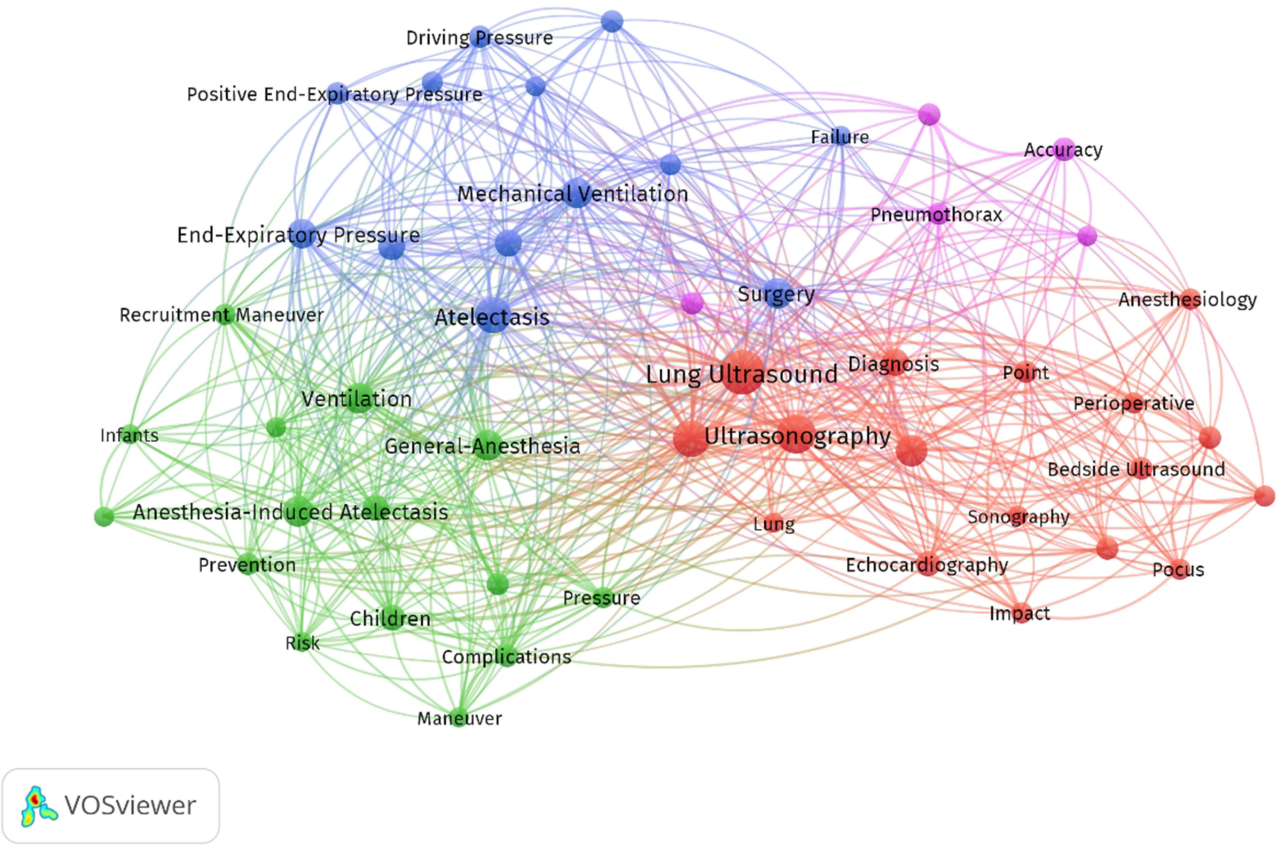

Figure 6 Mapping of the co-occurrence analysis among the keywords which occurred at least five times.

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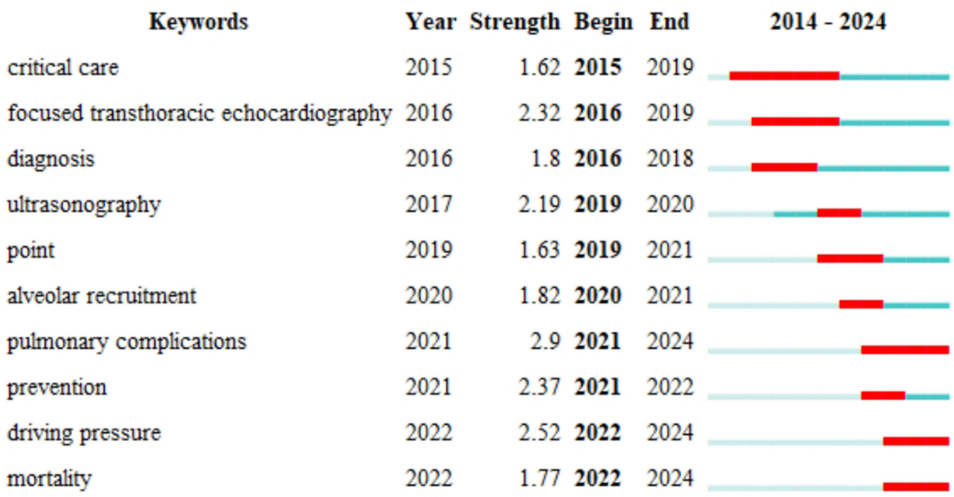

Figure 7 International Research on the Explosion Period and Intensity of Burst Words.

a high change rate over a specific period, offer insights into emerging research directions and development trends. Figure 7 shows that keywords related to LUS in anesthesiology have experienced rapid growth.

Discussion

Bibliometric analysis has emerged as an effective, objective, and reproducible tool for analyzing research output within a specific field.[20] In the present study, we analyzed 133 articles that investigated LUS. The article with the most citations on the use of LUS in the field of anesthesiology is related to pediatric anesthesia, and it was also the earliest published in the past decade.[11,12] This may be related to the wide application of LUS in the diagnosis of pediatric lung diseases. In addition, it is worth noting that the number of articles published in 2021 reached a peak, which may be related to the global outbreak of COVID-19.[21] Moreover, the number of publications in this field remains high. This result indicates the great interest of anesthetic researchers in LUS, underscores the value of LUS, and highlights its importance across the board. It is therefore likely that the emphasis on LUS will continue in the future.

China, the USA, and South Korea are the three countries with the most publications, which means that these three countries are quite interested in this topic. The coauthorship map of countries revealed global cooperation in this field, with the USA exhibiting a notably higher centrality. However, despite their substantial interest in this subject, China has slipped out of the top three rankings when evaluating the significance of their contributions against those of other countries. Therefore, China should enhance its international cooperation and carry out more comprehensive and profound research on LUS.

Seoul National University in Korea published the most articles and had the highest number of citations of all institutions, indicating that Seoul National University is the most productive and influential institution for the use of LUS in the field of anesthesiology.[4,22,23] In addition, it is important to note that 6 of the top 10 institutions in terms of the number of articles published are from the United States, and the average citation frequency of the papers published by these institutions is higher,[24] indicating that the quality of the literature on the use of LUS in the field of anesthesiology published by these institutions in the United States is widely recognized.

In terms of author contributions, 737 researchers published related articles. Professor Kim Jin-Tae, from Seoul National University in Korea, has the highest number of publications and highest number of citations, which fully demonstrates that Professor Kim Jin-Tae is the most productive and influential researcher in the field. LUS plays a crucial role in his primary research domain, which focuses on pediatric anesthesia.[25,26] Ramsingh Davinder has the highest number of citations, and his first study involved determining the location of the endotracheal tube by using LUS.[13] A large number of clinical investigations on LUS have since been conducted. However, upon analyzing the author network, it becomes evident that a small number of scholars maintain close collaborative relationships, primarily

presented on an institutional basis. Researchers who are interested in this field can pay attention to the authors with significant contributions, and at the same time, authors in this domain should also strengthen their collaboration to promote the application of LUS in anesthesiology.

The present study indicated that the 3 most-cited journals in this field were BMC Anesthesiology, Journal of Cardiothoracic and Vascular Anesthesia, and Canadian Journal of Anesthesia. Therefore, we believe these journals will continue publishing influential and advanced research in this field in the future. Experts and scholars who have a keen interest in the subject will discover a plethora of novel developments and cutting-edge research in these journals.

Keywords encapsulate the cores of papers, revealing the research hotspots.[27] Keywords co-occurrence analysis pinpoints scientific hotspots. Visual network diagrams clarify evolving trends. Burst keywords track historical development and suggest future research directions.[28] The analyses of keywords revealed that some keywords, such as "atelectasis" and "mechanical ventilation", were research hotspots in this field. However, "pulmonary complications" have been the most popular topic in recent years. In the field of anesthesiology, future research on the use of LUSs related to pulmonary complications will also involve more clinical applications.

Limitations

This study has certain limitations. First, the exclusive reliance on data from the WoSCC database presents a challenge, as it inevitably leads to concerns regarding the comprehensiveness of the analyzed data. Second, research results generally reach their peak of citations one to two years after publication or release, which can lead to a lag in the evaluation results of bibliometric analysis and may not reflect the latest research results and trends on time.

Conclusion

Our bibliometric analysis shows a significant increase in LUS research in anesthesiology over the past decade. China, the USA, and South Korea are the leading countries, with Seoul National University being the most productive institution. Key researchers include Kim Jin-Tae and Ramsingh Davinder. In recent years, the focus of research in the field has gradually shifted from the field of "pulmonary complications".

Disclosure

The authors report no conflicts of interest in this work.

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