Original Article

Visualization analysis of thoracic paravertebral block in breast surgery based on bibliometrics

Ying Han[1#], Fei Ma[1#], Li Liu[2]

[1]Department of Anesthesia Surgery, The First Affiliated Hospital of Baotou Medical College, Inner Mongolia University of Science and Technology, Baotou, China; [2]Department of Medical Examination, The First Affiliated Hospital of Baotou Medical College, Inner Mongolia University of Science and Technology, Baotou, China

Contributions: (I) Conception and design: Y Han; (II) Administrative support: F Ma; (III) Provision of study materials: L Liu; (IV) Collection and assembly of data: Y Han; (V) Data analysis and interpretation: F Ma; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work.

Correspondence to: Li Liu. Department of Medical Examination, The First Affiliated Hospital of Baotou Medical College, Inner Mongolia University of Science and Technology, Baotou 014040, China. Email: 14222751@qq.com.

Background: Breast surgery is one of the most common surgeries in the world, and pain after breast surgery is very common, representing one of the key factors affecting the quality of life after surgery. With the development of clinical techniques, thoracic paravertebral block (TPVB) has gradually become the preferred regional anesthesia technique for postoperative breast analgesia.

Methods: Using Web of Science as the data source, medical articles about the application of TPVB in breast surgery published from 1900 to 2022 were retrieved and imported into CiteSpace and VOSviewer software. Using bibliometrics and knowledge mapping visualization methods, the literature was analyzed from the aspects of publication, author, institution, country, high-frequency keywords, keyword clustering, emergence words, and so on.

Results: A total of 299 articles were included. according to the yearly numbers of articles, the trend is increasing annually. The most published authors in this field are Susan M. Steele, Roy A. Greengrass, Brian M. Ilfeld, Karmakar Manoj Kumar, and Stephen M. Klein. The League of European Research Universities, University of Toronto, and Duke University are the 3 institutions with the largest number of publications, and their cooperation degree is relatively low. Articles of American origin predominated. TPVB is the major keyword associated with the application of TPVB in breast surgery, which appears most frequently and has a high research interest.

Conclusions: The trend and characteristics of TPVB application research in breast surgery were visualized, and the studies in this field are generally increasing annually in number, providing useful bibliometric analysis for researchers to further explore in this field.

Keywords: Thoracic paravertebral block (TPVB); breast surgery; bibliometric

Submitted Nov 28, 2022. Accepted for publication Jan 10, 2023. Published online Jan 16, 2023.
doi: 10.21037/gs-22-754
View this article at: https://dx.doi.org/10.21037/gs-22-754

Introduction

Breast surgery is one of the most common operations in the world, and it has been reported that the incidence of severe postoperative pain during breast surgery is as high as 60% (1). Although the severity of acute pain after breast surgery is now known to be closely related to chronic pain, chronic pain after surgery is common and an important healthcare priority because it can affect quality of life (2,3).

General anesthesia (GA) has always been the conventional anesthesia for breast surgery, but it has many undesirable

side effects and complications, such as postoperative pain, nausea, and vomiting (4). Paravertebral anesthesia can allow to patient to remain awake, pain-free, comfortable, with normal body temperature, and minimize postoperative nausea and vomiting (5,6). Regional anesthesia using thoracic paravertebral block (TPVB) is an ideal alternative to GA in breast surgery. TPVB is firstly proposed by Hugo in 1905. TPVB is blocked under ultrasound guidance after anesthesia induction. The block area is at the incision site and near the ribs. The drugs used are ropivacaine and dexmedetomidine. TPVB can block only the somatic paravertebral nerve on the same side of the operation. In the case of providing good analgesia and sedation, the normal physiological function of the patient is less affected. It can relieve postoperative pain, reduce postoperative nausea and vomiting, and achieve the purpose of early patient mobility (7,8). In 2021, Ji *et al.* reported TPVB with GA could evidently reduce the incidence of hypotension, stabilize the circulatory rate and reduce postoperative pain (9).

TPVB has been the preferred regional anesthesia technique for postoperative analgesia since its clinical application in many surgical procedures, such as thoracic surgery, especially upper abdominal surgery. It can achieve sufficient and effective postoperative analgesia required by anesthesiologists, doctors, and patients. However, because the paraspinal space is so close to the pleura, it is an advanced technique with a potential risk of complications, and many clinicians are hesitant to use it (10). Study has also shown that due to a lack of appropriate training, the rate of regional anesthesia techniques used in breast surgery is low (11).

With the development of modern society, the incidence of breast diseases is increasing annually. The use of TPVB as an anesthesia method for breast surgery is a new research hotspot. However, there are few articles on the application of TPVB in breast surgery by bibliometrics. In this paper, CiteSpace (http://cluster.cis.drexel.edu/~cchen/citespace/) and VOSviewer (https://www.vosviewer.com/) visualization tools were used to conduct statistical and visual analysis of the literature on the application of TPVB in breast surgery from 1990 to 2022, using relevant journals of the Web of Science (http://wcs.webofknowledge.com) as data sources. Web of Science has the most extensive and comprehensive literature information. It is the most common database in bibliometric analysis (12). The purpose was to understand the research progress, grasp the hot topics, analyze the frontier trends, forecast the future development direction, and provide a reference for the related research in the field of safe behavior.

Highlight box

Key findings

- The trend and characteristics of thoracic paravertebral block (TPVB) application research in breast surgery are displayed in the form of visualization, and the studies in this field are generally increasing annually.

What is known and what is new?

- Pain after breast surgery is very common, and is one of the important factors affecting the quality of life after surgery. TPVB has gradually become the preferred regional anesthesia technique for postoperative breast analgesia.
- Our analysis highlights the characteristics of the most influential articles in the TPVB field and provides valuable insights into research in the field.

What is the implication, and what should change now?

- This study could help the researchers to understand the research progress, grasp the hot topics, analyze the frontier trends, forecast the future development direction, and provide reference for the related research in the field of safe behavior.

Methods

Data sources

Based on the Web of Science for information retrieval platform, Web of Science core collection database was selected. "Thoracic Paravertebral (All Fields) AND Breast (All Fields)" was selected as the search item, and 299 results were obtained from all the papers published by researchers from 1900 to 2022.

Research methods

In order to further analyze the application of TPVB in breast surgery, 2 researchers in our research group exported and saved the basic information of the included literature. Through bibliometrics, quantitative analysis of scientific papers was carried out using statistical methods to describe the research status and emerging trends in this field and explore the future research hotspots and directions.

CiteSpace is a document data mining and visualization software developed by Chen Chaomei's team (13). Through the integration of cluster analysis, social network analysis and other methods, the co-occurrence analysis of research cooperation, theme and field, and other concerns is

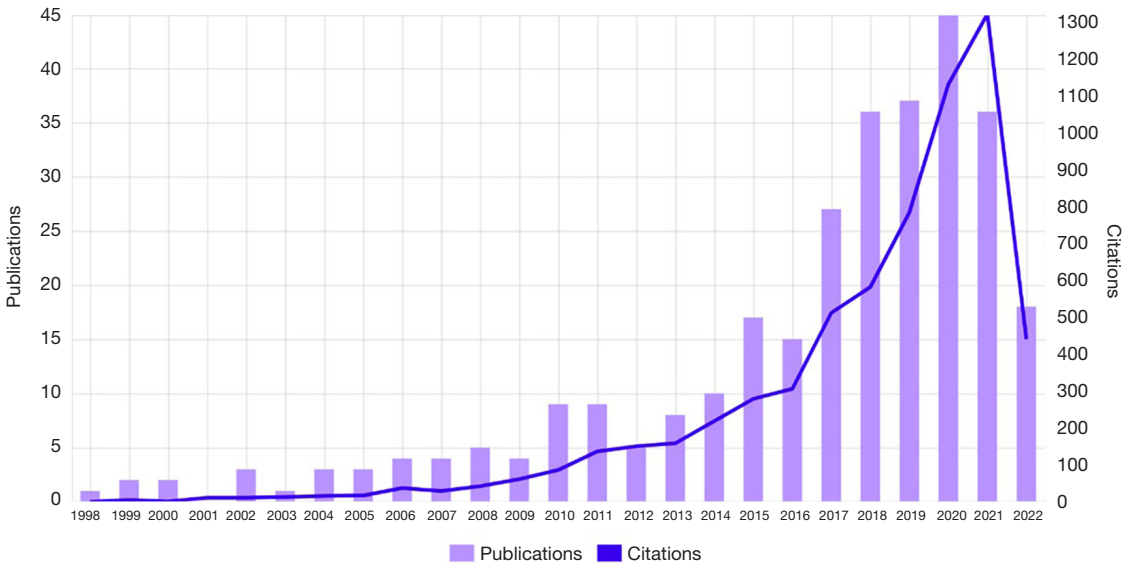

Figure 1 Time distribution of literature publication and citation.

realized. We created a visual map of the basic knowledge and research frontier of the target area so as to explore the characteristics and evolution trend of disciplinary research as well as the cross or interactive relationship between different research themes (14).

VOSviewer is a visualization software developed by Van Eck and Waltman of Leiden University in the Netherlands. By integrating the functions of word frequency analysis and co-occurrence analysis, the clustering, co-occurrence, and co-citation relationships among fields such as author, literature, and topic are presented in the form of network view, superposition view, and density view (15).

In general, CiteSpace focuses on displaying the relationship and development trend between cases in the form of tree charts and lines. VOSviewer pays more attention to deconstructing the clustering relationship and importance degree between nodes in the form of distance and density. The combination of the 2 can better explore and excavate the essence of the research field.

Results

Annual publications

The included articles were statistically analyzed according to publication time (*Figure 1*). Research on this topic has been published since 1998. From 1998 to 2022, 299 related research papers on the application of TPVB in breast surgery have been included in web of Science database, with an average annual publication volume of about 12. The highest number of articles published was 45 in 2020. Taking 2010 as the time node, the number of articles published in the first 10 years showed a wave trend of gradual rise, indicating that the application of TPVB in breast surgery has received increasing attention.

Author co-occurrence analysis

The authors and cited articles with high frequency of TPVB application in breast surgery were counted (see *Table 1*). The authors with the most publications in this field are Susan M. Steele, Roy A. Greengrass, Brian M. Ilfeld, Karmakar Manoj Kumar, and Stephen M. Klein, all of whom have published more than 5 papers in this field.

The author co-occurrence analysis function of VOSviewer software was used to draw the author cooperation network, so as to identify the core authors and the main cooperation network in the research field. VOSviewer was used to map the collaborative scientific knowledge of authors. The 212 authors included in the literature were clustered, and 5 obvious author clusters were formed. As shown in *Figure 2*, there are certain cooperative relationships among all clusters, but most of the cooperative relationships are mainly within clusters.

The application of TPVB in breast surgery has been investigated by the academic circle for a long time, and many authoritative experts and researchers have emerged

Table 1 Statistical table of high-frequency authors and their most cited literatures

No.	Author	Count	Title	Journal
1	Susan M. Steele	6	Thoracic paravertebral block for breast surgery	*Anesthesia and Analgesia*
2	Roy A. Greengrass	5	Paravertebral block anesthesia for inguinal hernia repair	*World Journal of Surgery*
3	Brian M. Ilfeld	5	Persistent Postmastectomy Pain and Pain-Related Physical and Emotional Functioning With and Without a Continuous Paravertebral Nerve Block: A Prospective 1-Year Follow-Up Assessment of a Randomized, Triple-Masked, Placebo-Controlled Study	*Annals of Surgical Oncology*
4	Karmakar Manoj Kumar	5	Thoracic Paravertebral Block and Its Effects on Chronic Pain and Health-Related Quality of Life After Modified Radical Mastectomy	*Regional Anesthesia and Pain Medicine*
5	Stephen M. Klein	5	Bilateral continuous paravertebral catheters for reduction mammoplasty	*Acta Anaesthesiologica Scandinavica*

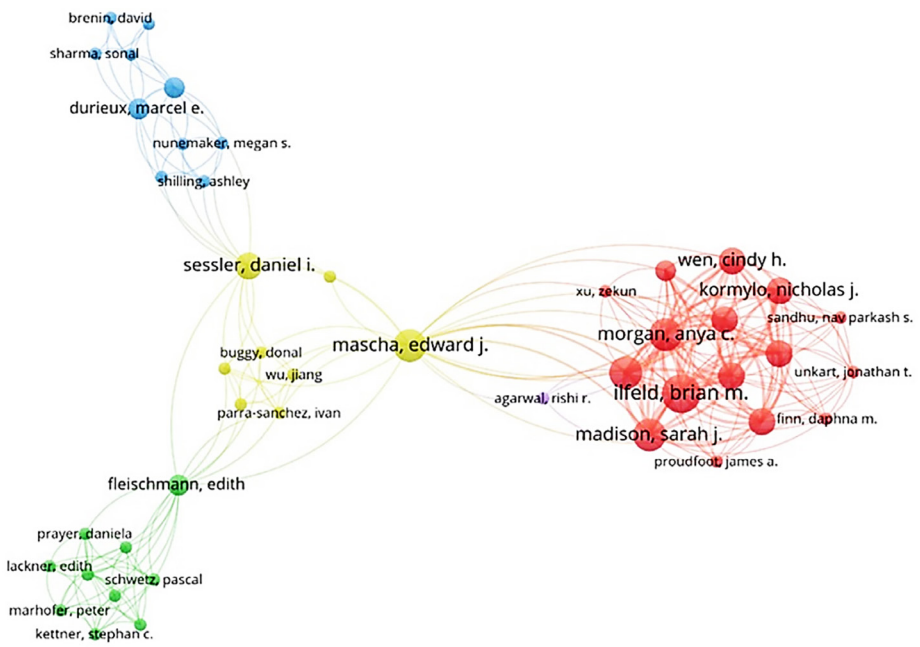

Figure 2 Collaboration network map of authors.

in every period. The researcher Lyerly, who first studied the application of TPVB in breast surgery, proposed that "*paraspinal block can be used in major breast cancer surgery, with fewer complications and low anesthesia rate. Paraspinal block significantly improves the quality of postoperative recovery of breast cancer and provides patients with the option of being discharged at any time*" (16), which lays a foundation for subsequent studies. In terms of cooperative network, TPVB's applied research in breast surgery is generally characterized by "relatively concentrated researchers with strong academic connection and recognition".

Analysis of research institutions and cooperative relationships

Research institutions are important carriers of scientific research. The statistics of the author's institution were reviewed to reveal the worldwide distribution and collaboration of research forces mainly studying the application of TPVB in breast surgery.

In this study, the top 10 research institutions in the number of publications were counted, as shown in *Table 2*. A total of 423 institutions participated in the research in this field; the top 10 institutions all published more than 6 articles, and 23 institutions published more than 5 articles.

The League of European Research Universities, University of Toronto, and Duke University were found to have published 13, 11, and 9 papers, respectively.

VOSviewer software was used to map the scientific knowledge of institutional cooperation (*Figure 3*). The cooperation of institutions in the field of application of TPVB in breast surgery was analyzed. Figure presents 2 distinct clusters centered on Duke University and the University of Toronto. The map of scientific knowledge of institutional cooperation showed that the mediating centrality of all institutions is 0, suggesting that the degree of cooperation among institutions in this field is low.

Characteristics of national cooperation network

A total of 42 countries have participated in the research on the application of TPVB in breast surgery. The top 10 countries in terms of publications are shown in *Table 3*. VOSviewer software was used to map the scientific knowledge of national cooperative networks. The nodes in *Figure 4* show that there are 18 countries with publication quantity ≥5. The United States posted the most, with 70 articles. China, India, Canada, and Egypt are the next most published countries, and the connection between nodes is relatively loose, indicating that there is less international cooperation in the application of TPVB in breast surgery. From the perspective of centrality, the United States is in the leading position in this research field, and other countries with more than 5 publications are related to it (*Figure 5*).

Table 2 Statistics of the top 10 institutions with publications from 1998 to 2022

No.	Institution	Count
1	League of European Research Universities	13
2	University of Toronto	11
3	Duke University	9
4	University Health Network Toronto	8
5	All India Institute of Medical Sciences Aiims New Delhi	7
6	Cleveland Clinic Foundation	7
7	University of California System	7
8	Columbia University	6
9	University of California San Diego	6
10	University of Texas System	6

Keywords co-occurrence

Using VOSviewer software, the visual atlas of keywords research of TPVB in breast surgery was made. A total of 810 keywords appeared in all the articles included in the study, and 53 keywords that appeared more than 10 times are shown in *Figure 6*. The font size of keywords reflects the frequency of occurrence of the word. The figure mainly presents the keyword clustering, with 4 clusters and 1,035 links. There are 9 keywords in the blue cluster, 18 keywords in the green cluster, 22 keywords in the red cluster, and 4 keywords in the yellow cluster. "Thoracic Paravertebral block" was the most frequent, appearing 113 times in total. The main keywords associated with "Thoracic Paravertebral block" were "Analgesia", "breast surgery", "postoperative analgesia", and "Pain".

Emergent word analysis

A research frontier is defined as an emergent set of dynamic changes and potential research problems. By detecting the

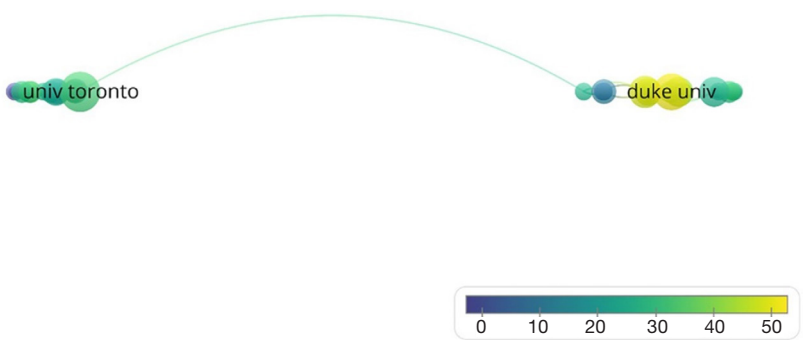

Figure 3 Cooperation map of institutions.

emergence of a keyword in a certain period of time, the research frontier in this period can be understood. *Figure* 7 shows the emergence of keywords and their influence in the application of TPVB in breast surgery. A total of 20 keywords are included, sorted by time of occurrence. The length of the red mark represents the duration of keyword emergence. The longer the mark, the longer the emergence time.

Studies with keywords of "Local Anesthesia", "Cancer", and "Surgical Management" lasted longer (>10 years). Over the past 3 years, research has included "Pecs Block", "Thoracic Paravertebral Block", "Radical Mastectomy, "Pectoral Nerve Block", "Regional Anesthesia", "Plane Block", "Modified Radical Mastectomy", and "Serratus Plane Block".

Table 3 Statistics of the top 10 countries with publications from 1998 to 2022

No.	Country	Count
1	USA	70
2	China	46
3	India	27
4	Canada	24
5	Egypt	20
6	Japan	16
7	Turkey	15
8	England	14
9	France	10
10	Ireland	10

Key words time sequence results

The evolution of temporal sequence can reflect the change and progress of the research frontier of this subject. In this study, the evolution analysis of the core keywords of the application of TPVB in breast surgery was conducted and presented in CiteSpace from the perspective of a time zone diagram (see *Figure 8*). As shown in the figure, the time period of the node in the figure reflects the first occurrence time of the keyword, and the font size represents the occurrence frequency of the keyword. To enable a more concise and clear display, the keywords in the picture are words that appear more than 40 times, and further combine the research distribution, the number of co-occurrence keywords, core keywords, and research results in each time period. The picture clearly divides the development process of TPVB application in breast surgery into 3 stages, which are as follows: "Pain", "Analgesia", "Cancer", and "Bupivacaine" before 2003, and "Anesthesia", "Double Blind", "Nerve Block", "Cancer Surgery", and "Breast Surgery" between 2008 and 2012. There is also "Breast Cancer Surgery" and "Augmentation" after 2012. Keywords covered from large to small, showing the research on the application of TPVB in breast surgery step by step detailed and specialized.

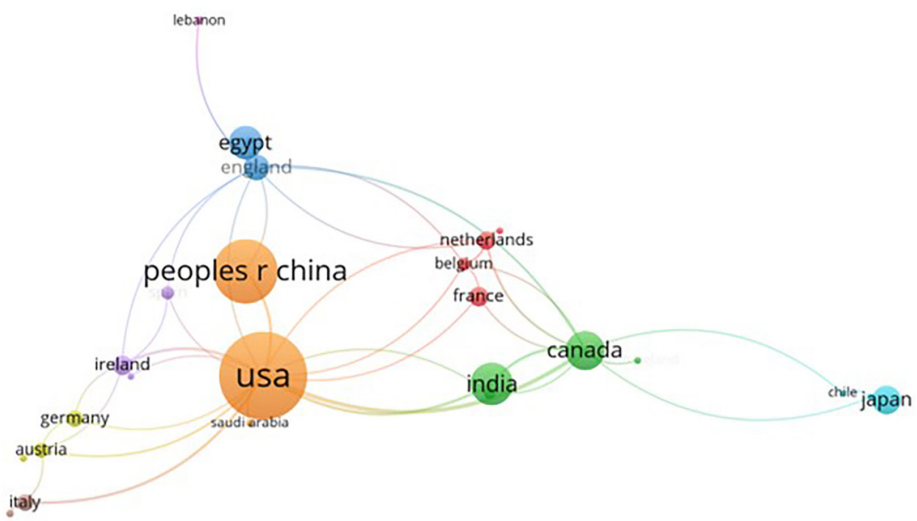

Figure 4 National cooperation map.

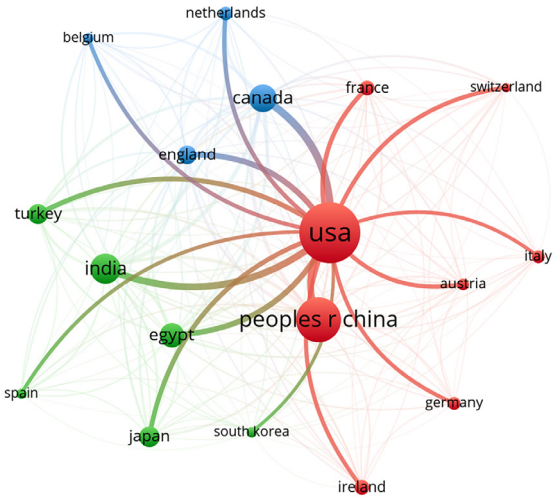

Figure 5 National cooperation map—USA.

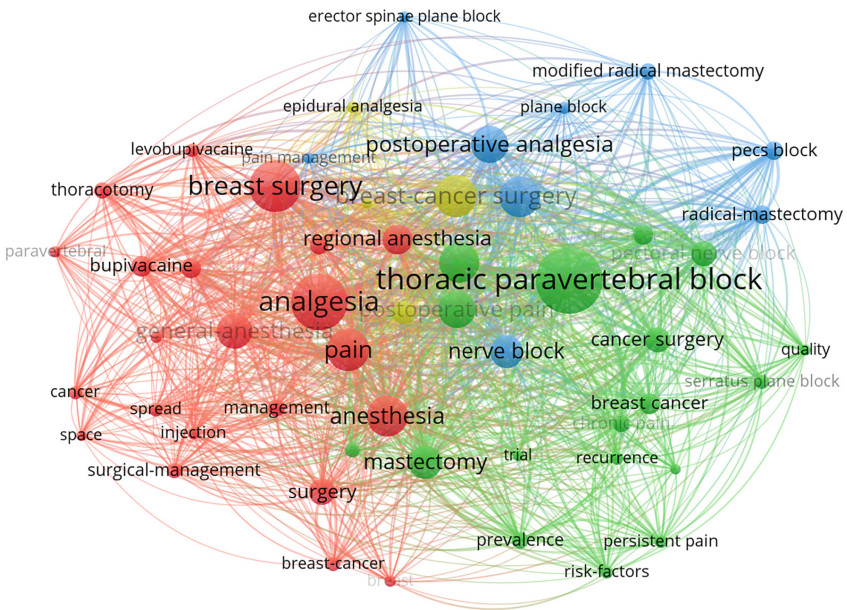

Figure 6 Keywords co-occurrence map.

Discussion

Breast cancer is the most common malignancy in women worldwide, and even in advanced cases, surgical intervention is the mainstay of treatment (4,17,18). The postoperative analgesia of breast surgery is a great challenge for anesthesiologists.

During the past decade, several protocols have been developed to improve perioperative management and optimize pain control for breast surgery patients (19). The most commonly used method is the use of local anesthesia techniques such as paraspinal block (20), intercostal block (21), erector spinal plane block, and pectoral block (22-24).

Paravertebral block has always been considered the best choice for analgesic purposes due to its simplicity and safety (25,26). In patients undergoing elective breast surgery, TPVB provides effective analgesia with minimal complications (27-30). Lidocaine 1% is used for local

Top 20 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	1998–2022
Local anesthesia	1998	2.89	1998	2008	
Cancer	1998	2.73	2000	2010	
Surgical management	1998	3.28	2003	2017	
Postthoracotomy pain	1998	2.79	2007	2012	
Breast surgery	1998	3.52	2008	2014	
Thoracotomy	1998	2.64	2010	2014	
Human cadaver	1998	2.09	2010	2017	
General anesthesia	1998	2.57	2014	2016	
Randomized controlled trial	1998	2.42	2014	2018	
Ropivacaine	1998	2.13	2014	2016	
Brachial plexus block	1998	2.4	2016	2018	
Trial	1998	4.13	2017	2018	
Pecs block	1998	4.08	2018	2020	
Thoracic paravertebral block	1998	2.84	2018	2019	
Radical mastectomy	1998	2.71	2018	2022	
Pectoral nerve block	1998	2.32	2018	2020	
Regional anaesthesia	1998	2.3	2018	2019	
Plane block	1998	2.18	2018	2020	
Modified radical mastectomy	1998	3.42	2019	2022	
Serratus plane block	1998	2.11	2019	2020	

Figure 7 Keywords emergence diagram.

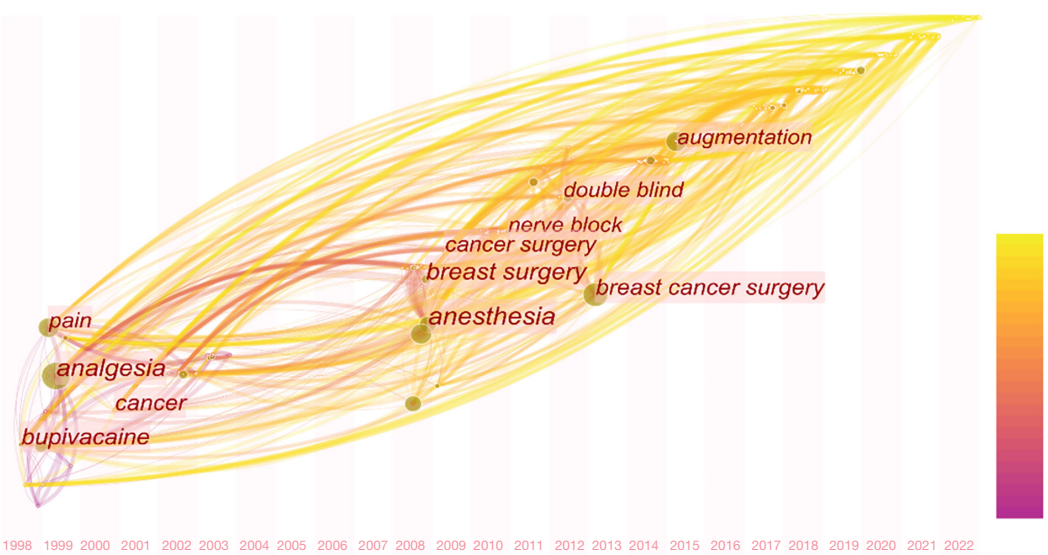

Figure 8 Keywords time zone diagram.

anesthesia in the puncture site. Dexmedetomidine with/without ropivacaine are injected to blocked area (9). There are still some complications of TPVB, like anesthetic poisoning, punctured injury of pleura or lung, nerve root injury, high plane block and even spinal anesthesia (31,32). Complications occur due to the uneven development of hospitals, the lack of ultrasound equipment and the lack of rigorous training of operators. Ultrasound equipment and technical training are necessary to improve the success rate and reduce complication of TPVB.

Due to the paraspinal space and its unique anatomical structure very close to the pleura and spine, many clinicians are cautious about using this blocking technique in daily practice (33).

Based on the core collection database of Web of Science, this paper used CiteSpace and VOSviewer to conduct visual analysis of relevant research literatures on the application of TPVB in breast surgery collected from 1990 to 2022. We used the software to draw an analytical map of authors, institutions, countries and keywords, and summarize the current situation, hot spots, and frontiers of this research field for more than 20 years.

In the past 24 years, 299 articles related to the application of TPVB in breast surgery have been included in web of Science database, and the number of articles presented a wave trend of gradual increase. The average annual number of papers is about 12, and each paper is cited 21 times on average. The most widely published author is Susan M. Steele from the Departments of Anesthesiology and Surgery, Duke University Medical Center. The author's published TPVB for breast surgery 28 was cited 193 times, proposing that "*paravertebral block is an alternative technique to cosmetic breast surgery that may provide better pain relief and reduced nausea than general anesthesia alone*". Is the most cited article in her published literature.

Universities contribute the main body of research on the application of TPVB in breast surgery. The League of European Research Universities, University of Toronto, and Duke University are the top 3 published institutions. These institutions were among the earliest to establish a full faculty of medical education. It's perfect cultivation system, affiliated hospitals, and research platform provide impetus for the application of TPVB in breast surgery. Based on the results of institutional co-occurrence analysis, it is evident that a relatively wide and close academic cooperation network has not yet been formed from the perspective of cooperation intensity. These institutions are mainly distributed in economically developed countries, indicating that the development of medical research is closely related to the local economic level and development level. The United States contributed the most documents, and there is less international cooperation in the application of TPVB in breast surgery.

"Thoracic paravertebral block" was the most frequent, with major keywords associated with "Analgesia", "Breast Surgery", "Postoperative Analgesia", and "Pain". The popularity of these keywords has continued to this day. It is the core topic of the research field. Research hotspots in the past 3 years include "Pecs Block", "Thoracic Paravertebral Block", "Radical Mastectomy", "Pectoral Nerve Block", "Regional Anesthesia", "Plane Block", "Modified Radical Mastectomy", and "Serratus Plane Block". The hits that have lasted up to now are "Radical Mastectomy" and "Modified Radical Mastectomy". It is suggested that with the development of medical research, devices, and drugs, regional anesthesia can be used to provide sufficient anesthesia for patients in radical mastectomy, which previously required GA, at a lower cost of injury, and it will be developed in the future. Postoperative pain and cognitive function are the hotspots in the future (34). There are abundant links between the early keywords and the recent keywords, indicating that the connection is still close. The progress of this subject field is being developed and inherited at the same time.

With the development of ultrasound technology, the success rate of TPVB will be greatly improved and the complications will be significantly reduced. TPVB will have a wider range of clinical applications. TPVB can not only be used for postoperative analgesia of various kinds of surgery, but also for combined GA, chronic pain, muscle disease diagnosis and treatment and complication prevention.

Conclusions

The application of TPVB in breast surgery has important research value and broad application prospect. The research in this field is generally increasing year by year. CiteSpace and VOSviewer software were used to analyze the trend and characteristics of TPVB application in breast surgery in a visual form, which provides useful bibliometric analysis for researchers to further explore in this field.

Acknowledgments

Funding: This study was supported by Scientific Research Fund of Baotou Medical College (No. BYJJ-QWB202010).

Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://gs.amegroups.com/article/view/10.21037/gs-22-754/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.

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Cite this article as: Han Y, Ma F, Liu L. Visualization analysis of thoracic paravertebral block in breast surgery based on bibliometrics. Gland Surg 2023;12(1):110-120. doi: 10.21037/gs-22-754