Bibliometric Analysis

A Comprehensive Overview of the Stellate Ganglion Block Throughout the Past Three Decades: A Bibliometric Analysis

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Background: Over the past 3 decades, clinicians and scholars have used and studied the stellate ganglion block (SGB) extensively, making this field a highly anticipated research hot spot. To the best of our knowledge, there has been no bibliometric analysis of the SGB until now.

Objective: Our study aimed to complete multiple tasks regarding SGB research: identify the collaboration and impact of countries, institutions, journals, and authors, evaluate the knowledge base, trace the trends in hot spots, and explore the emerging topics relevant to the field.

Study Design: A bibliometric analysis.

Methods: Publications that were associated with the SGB and published between the years of 1993 and 2022 were retrieved from the Web of Science Core Collection on September 21st, 2023. CiteSpace 6.1.R6 and VOSviewer 1.6.18 were used to perform bibliometric and knowledge-map analyses.

Results: This study found a total of 837 publications originating from 51 countries and 1006 institutions. These articles were published in 393 journals. The United States was the country that produced the most articles focused on SGB, and the University of California, Los Angeles was the institution associated with the greatest number of publications. The anesthesiology and cardiology journals surveyed for this study published the most articles and received the most citations. Among the authors whose works were examined, Kitajima T had the greatest number of published articles, and Lipov E was the most frequently cited co-author. Five main domains of SGB research included electrical storm and refractory ventricular arrhythmia, breast cancer and climacteric medicine, post-traumatic stress disorder, pain management, and cerebrovascular diseases. The latest hot topics involving this field focused on SGB's anti-arrhythmic and anti-cerebral vasospasm effects and its treatment of long COVID syndrome.

Limitations: Data were retrieved only from the WoSCC; therefore, publications in other databases might have been missed.

Conclusion: This comprehensive bibliometric analysis conducted a complete overview of SGB research, which was helpful in furthering our understanding of research trends and locating research hot spots and gaps in this domain. This field is developing rapidly and will garner significant and continuous attention from future scholars.

Key words: Stellate ganglion block, bibliometric, knowledge-map, VOSviewer, CiteSpace, post-traumatic stress disorder, electrical storm, hot flashes

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The stellate ganglion, a composite ganglion formed by the fusion of the inferior cervical ganglion and the first thoracic ganglion of the sympathetic chain, transmits innervation to the neck, shoulder, upper limb, and thoracic organs. The stellate ganglion block (SGB) is performed by percutaneously injecting local anesthetics into the area surrounding the stellate ganglion to interrupt sympathetic outflow and reboot the regional autonomic nervous system. SGBs have been used widely for decades to treat or ameliorate multiple symptoms and diseases, although the corresponding mechanisms have not been fully clarified (1,2).

The indications for SGBs include pain management (2), therapy for refractory arrhythmia (3), alleviating postoperative discomfort caused by breast cancer treatments (4,5) and menopause symptoms (6), mitigating post-traumatic stress disorder (PTSD) (7), treating sudden deafness (8), and relieving cerebral vasospasm-related diseases (9). In recent years, new therapeutic effects of SGBs have been unearthed repeatedly in clinical practice. For example, SGBs have been shown to effectively treat long coronavirus disease (COVID) syndrome (10), intractable hiccups (11), excessive daytime sleepiness (12), symptoms of ulcerative colitis (13), refractory eosinophilic granulomatosis with polyangiitis (14), etc. The SGB has become a novel treatment modality for many disorders.

Over the past 3 decades, SGBs have been used and studied extensively by clinicians and scholars, making this field an appealing research hot spot. To comprehensively summarize the contributions of scientific publications, obtain a systematic overview of the evolutionary process, and explore the hot spots and frontiers in the SGB field, we conducted this bibliometric analysis to provide potential enlightenment for future research. To the best of our knowledge, there has been no bibliometric analysis of the SGB until now.

Methods

Data Source and Search Strategy

Our data were obtained from the Science Citation Index Expanded of the Clarivate Analytics Web of Science Core Collection (WoSCC) database on September 21st, 2023. The search terms were "[Topic:('satellite ganglion*') OR Topic:('satellite ganglia*') OR Topic:('stellate ganglion*') OR Topic:('stellate ganglia*') OR Topic:('cervicothoracic ganglion*') OR Topic:('cervicothoracic ganglia*') OR Topic:('cervicothoracic sympathetic')] AND [Topic:(block*)]." Literature published from January 1993 to December 2022 was systematically searched. To ascertain the absence of any database updates, the search time was confined to a single day. The data, including titles, authors, journals, countries/regions, institutions, keywords, and references, were stored in bibliographic information (.bib) files and plain text (.txt) files.

Inclusion and Exclusion Criteria

In our study, only original articles and reviews written in English were included. Documents were excluded if they met any of the following criteria: 1) meeting abstracts, letters, comments, proceeding papers, notes, early-access publications, corrections, book chapters, or editorials; 2) absence of abstract or digital object identifier (DOI) number; 3) unavailable as full texts; 4) translations of articles or reviews; 5) retracted publications; or 6) duplicate literature.

Study Selection and Data Management

Two groups of authors (Y Ren and HP Li and Z Zhang and PJ Zhang) conducted study selection and data extraction independently after standard training. Any dissensus was settled by referral to a third group of authors (H Kong and Duojietai) until a consensus was reached. Titles and abstracts were first screened to select the articles, and full texts were retrieved when necessary. We processed synonyms and meaningless keywords, leaving a standardized term for analysis.

Data Analysis and Visualization

The global trend of publications and total citations over the years were graphed using Microsoft Excel 2019. VOSviewer (version 1.6.18) software was utilized to construct and visualize the relationships among the most highly productive countries, institutions, authors, co-cited authors, journals, co-cited journals, keywords, and co-cited references. The knowledge maps generated by VOSviewer exhibited a network of nodes and links that conveyed much information. The colors of nodes and lines represented different clusters or years. The size of the nodes reflected the number of their respective items or co-occurrence frequencies. The thickness of links between nodes indicated the 2 nodes' cooperation, co-occurrence, and co-citation frequencies. Nodes that exhibited elevated centrality and burstness scores were likely to possess high importance. The VOSviewer settings were as follows: the counting method was full counting, and documents with a large number of au-

thors were ignored. (The maximum number of authors per document was 25.) Thresholds (T) of items (countries/regions, institutions, journals, authors, and references) were adopted based on particular situations.

CiteSpace (version 6.1.R6), which we used as a complementary program, was also a powerful science-mapping analysis software for detecting a scientific field's trends and dynamics over time and exploring the significance of nodes, such as betweenness centrality (BC), burstness, and sigma score. Nodes with BC values exceeding 0.1 were circled by purple rings, indicating their extensive connections with others. Citation bursts, which identified publications or keywords that received pronounced attention in a specific period of time, were represented by red bars. The total link strength (TLS) index was employed to measure link strength quantitatively. The CiteSpace parameters were as follows: link retaining factor (LRF = 3), look-back years (LBY = 5), e for top N (e = 1), time span (1993-2022), years per slice (one), links (strength: cosine, scope: within slices), selection criteria (g-index: k = 20 for analyzing the co-cited references; g-index: k = 25 for analyzing the keywords), and minimum duration (MD = one).

Results

A total of 1065 papers published between 1993 and 2022 were screened. Among them, 18 were excluded for not being written in English, and 210 were excluded for not being articles or reviews. The remaining 837 papers were chosen for final bibliometric analysis. Of those paperes, 712 (85.1%) were original articles, and 125 (14.9%) were reviews.

Annual Trend of Publications and Total Citations

The annual output of papers focusing on SGB maintained stability in the first 2 decades examined in this study. However, there was a significant increase in the last 10 years. The highest yield year was 2022, with 69 relevant publications. The total citations showed a continuous upward trend, indicating growing interest in the field (Fig. 1).

Countries/Regions and Institutions

All publications were scattered throughout 51 countries/regions and 1006 institutions. The world map (Fig. 2A) illustrated that the largest number of papers originated in the United States (301 publications), followed by China (121 publications), Japan (96 publications), South Korea (53 publications), and Canada (46 publications). The United States was also the leading country in total link strength and citations (n = 8928)

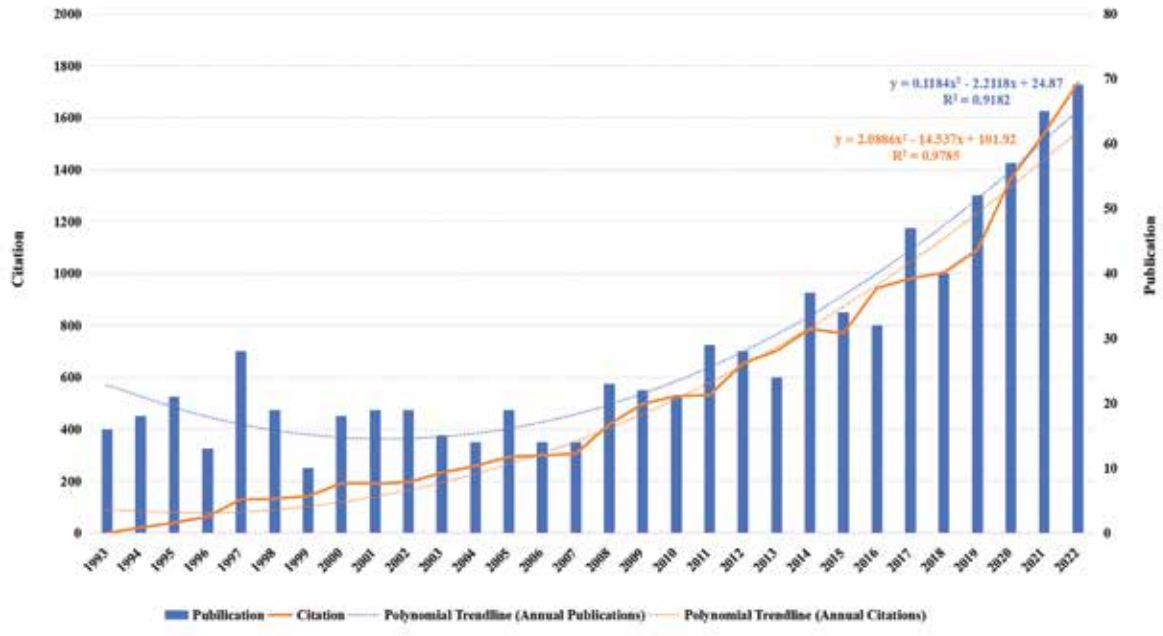


Fig. 1. *The global trend of annual publications about the stellate ganglion block and their citations from 1993 to 2022.*

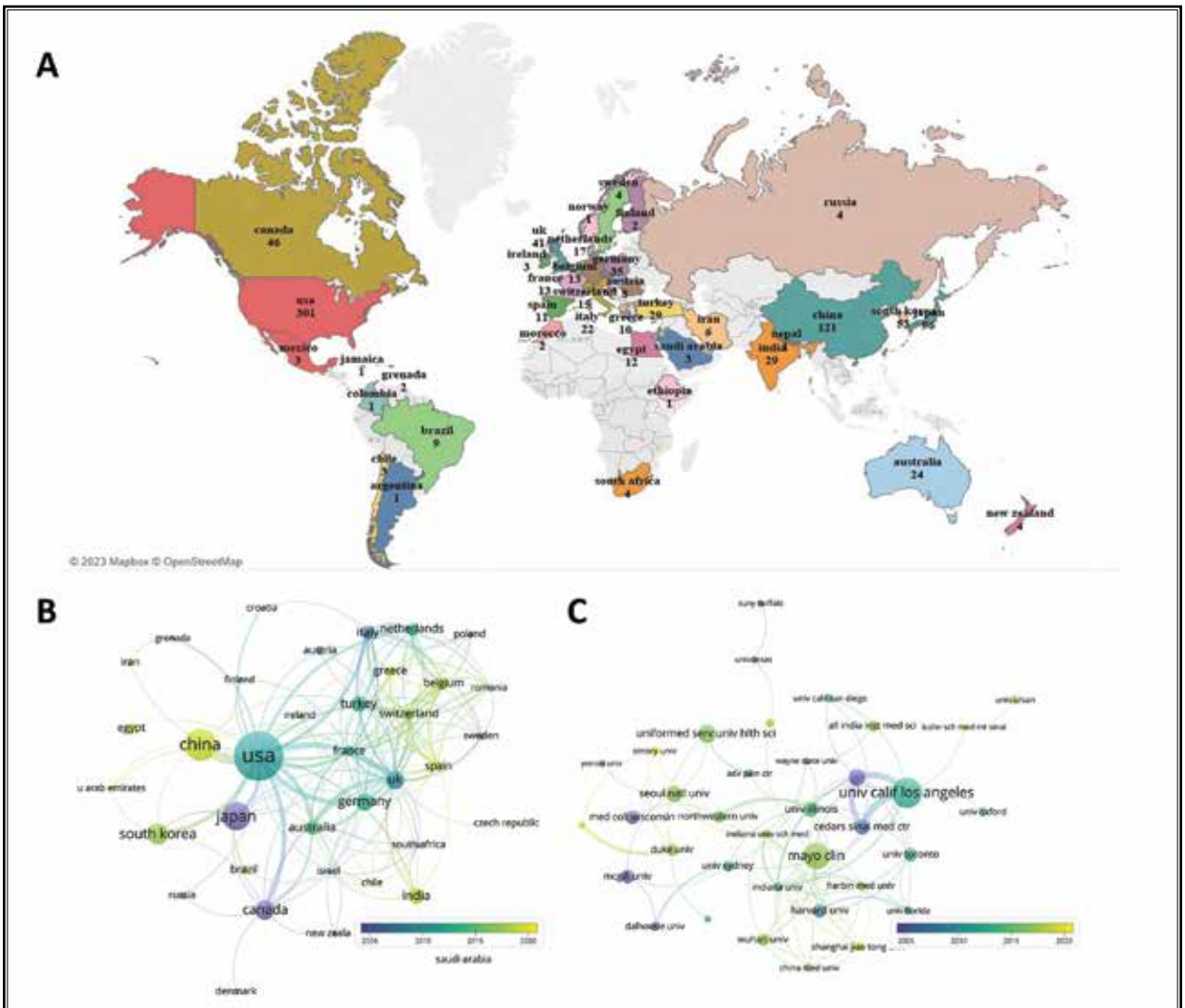


Fig. 2. *(A) World map of different countries'/regions' total publications. (B) Network visualization map of countries/regions (Threshold = 2). (C) Network visualization map of institutions (Threshold = 5).*

(Table 1). Fig. 2B shows the network map of countries/regions, showed collaborations among countries/regions and the number of publications in different countries/regions over time. Japan was a pioneer in SGB-focused papers during the early years, while papers from China, South Korea, and India showed more recent sustained emergence.

The top 10 institutions (including 11 centers) were distributed in 3 countries: 8 in the United States, 2 in Canada, and one in South Korea (Table 1). The University of California, Los Angeles and Mayo Clinic were the top 2 academic institutions for output, with the highest number of publications. Papers from the University of Southern California and the University of California, Los Angeles obtained the most citations. Fig. 2C shows intense cooperation among American institutions.

Journals and Co-Cited Academic Journals

The 837 papers were published in 393 journals. Among the top 10 most productive journals, 6 were in the field of anesthesiology and pain medicine, 3 were in the cardiovascular field, and one was in general medicine (Table 2). The top 40 journals were used to construct the citation network map (Fig. 3A). There were active citation relationships among Regional Anesthesia and Pain Medicine, Anesthesia and Analgesia, Pain Medicine, Pain Physician, and Pain Practice.

Table 1. *The top 10 countries/regions and institutions for SGB research from 1993 to 2022.*

Rank	Country/Region	Counts	TLS (1)	Citations	Rank	Institution	Counts	TLS (1)	Citations
1	United States	301	97	8928	1	University of California, Los Angeles (USA)	22	32	1326
2	China (2)	121	21	1323	2	Mayo Clinic (USA)	19	10	377
3	Japan	96	11	1040	3	Uniformed Services University of the Health Sciences (USA)	13	8	212
4	South Korea	53	11	596	4-5	Seoul National University (South Korea)	12	6	94
5	Canada	46	19	2056		University of Southern California (USA)	12	31	1483
6	United Kingdom (3)	41	57	1058	6-7	Cedars-Sinai Medical Center (USA)	11	25	1026
7	Germany	35	35	906		University of Illinois (USA)	11	14	549
8-9	India	29	14	381	8-11	Harvard University (USA)	10	9	726
	Turkey	29	20	517		McGill University (Canada)	10	4	94
10	Australia	24	31	708		Medical College of Wisconsin (USA)	10	1	404
						University of Toronto (Canada)	10	10	918

TLS = Total link strength.

1. Made using VOSviewer. The counting method used was full counting. Documents co-authored by contributors from a large number of countries were ignored. The maximum number of countries per document was 25.
2. Including publications from the Chinese mainland, Hong Kong, Macau, and Taiwan.
3. Including publications from England, Scotland, Northern Ireland, and Wales.

Table 2. *The top 10 journals and co-cited journals for SGB research from 1993 to 2022.*

Rank	Journals	Counts	Rank	Co-Cited Journals	Citations
1	Regional Anesthesia and Pain Medicine	40	1	Pain	976
2	Anesthesia and Analgesia	22	2	Circulation	961
3	Pain Medicine	19	3	Anesthesia and Analgesia	774
4	Journal of Cardiovascular Electrophysiology	15	4	Anesthesiology	701
5	Pain Physician	15	5	Regional Anesthesia and Pain Medicine	623
6	Pain Practice	15	6	Journal of the American College of Cardiology	479
7	Medicine	13	7	Circulation Research	457
8	Cardiovascular Research	11	8	Heart Rhythm	418
9	Heart Rhythm	11	9	Menopause	411
10	Acta Anaesthesiologica Scandinavica	9	10	Journal of Physiology-London	375

The top 10 journals with the most co-citations are shown in Table 2. Pain, circulation, and anesthesia and analgesia were the top 3 most frequently co-cited journals. The co-citation network constructed by the top 40 journals showed that the co-cited papers were concentrated in 4 fields: anesthesiology and pain medicine, cardiovascular medicine, neuroscience, and menopausal medicine (Fig. 3B).

Authors and Co-Cited Authors

A total of 3618 authors were involved in the SGB studies. The slots for the top 5 most productive authors were occupied by 6 individuals. Kitajima T was the most prolific author (n = 11). Yamaguchi S and Kimura Y were from the same Japanese center as Kitajima T. The other 3 authors, Lipov E, Cha YM, and Mulvaney SW, were from the United States.

Co-cited authors are authors who have been co-cited in a range of publications. Among 17745 co-cited authors, 4 authors had over 100 co-citations. Lipov E had the most co-citations (n = 191), followed by Narouze S, Hogan QH, Loprinzi CL, and Elias M (Table 3). It should be noted that the top 5 authors were all from the United States.

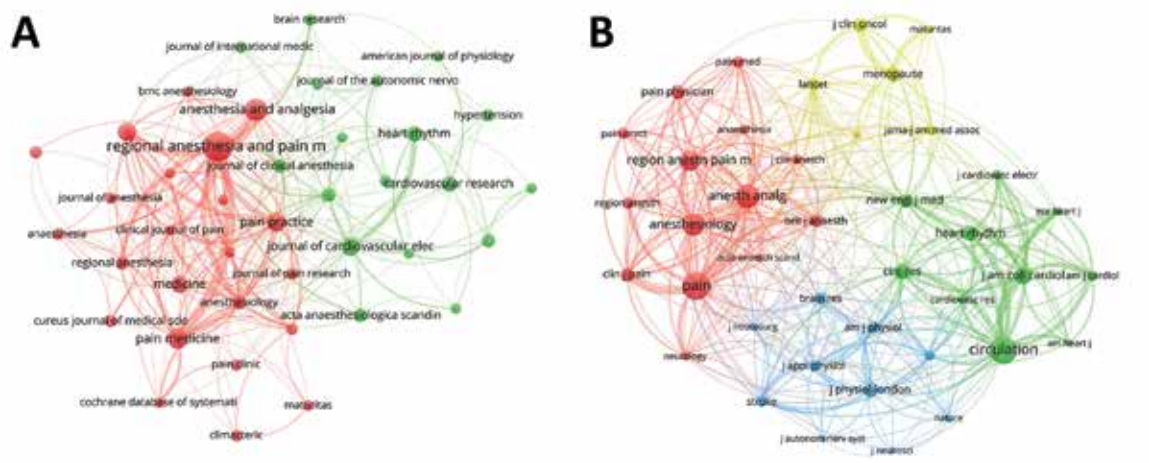


Fig. 3. *(A) Network visualization map of the top 40 most productive journals. (B) Network visualization map of the top 40 most frequently co-cited journals.*

Table 3. *The top 5 authors for SGB research from 1993 to 2022.*

Authors by Number of Articles					
Rank		**Counts**	**Rank**	**Co-Cited Authors by Number of Co-Citations**	**Citations**
1	Toshimitsu Kitajima (Department of Anesthesiology, Dokkyo University School of Medicine, Tochigi, Japan)	11	1	Eugene Lipov (Advanced Pain Centers, IL, USA)	191
2	Eugene Lipov (Advanced Pain Centers, IL, USA)	10	2	Samer Narouze (Summa Western Reserve Hospital, OH, USA)	146
3	Shigeki Yamaguchi (Department of Anesthesiology, Dokkyo Medical University, Tochigi, Japan)	8	3	Quinn H Hogan (Department of Anesthesiology, Medical College of Wisconsin, WI, USA)	128
4-6	Yong-Mei Cha (Department of Cardiovascular Diseases, Mayo Clinic, MN, USA)	7	4	Charles L Loprinzi (Internal Medicine, Mayo Clinic, MN, USA)	122
	Yoshiyuki Kimura (Department of Anesthesiology, Dokkyo University School of Medicine, Tochigi, Japan)	7	5	Mazin Elias (The Medical College of Wisconsin, WI, USA)	81
	Sean W Mulvaney (Department of Military and Emergency Medicine, Uniformed Services University of the Health Sciences, Bethesda, MI, USA)	7			

Co-Cited Reference Analysis, Timeline Analysis, and Burst Analysis

Table 4 outlines the top 10 co-cited references (11 references), including 8 articles and 3 reviews. Of those, 3 of the papers focused on refractory arrhythmias, 2 were about PTSD symptoms, 2 concerned the application of the ultrasound-guided technique in SGBs, 2 concentrated on hot flashes and sleep disturbances in breast cancer survivors, one examined vasomotor symptoms in postmenopausal women, and one elucidated the mechanism of the action of the SGB.

Timeline analysis exhibited a chronological representation of each cluster (Fig. 4A). The timeline view showed that the SGB was used for pain management in earlier years. Later, the focus of SGB research shifted to the treatment of PTSD and menopausal symptoms. Cerebrovascular disease and cardiac arrhythmia have been hot topics in the SGB field in the past decade. Because of the COVID-19 pandemic, the use of SGBs as

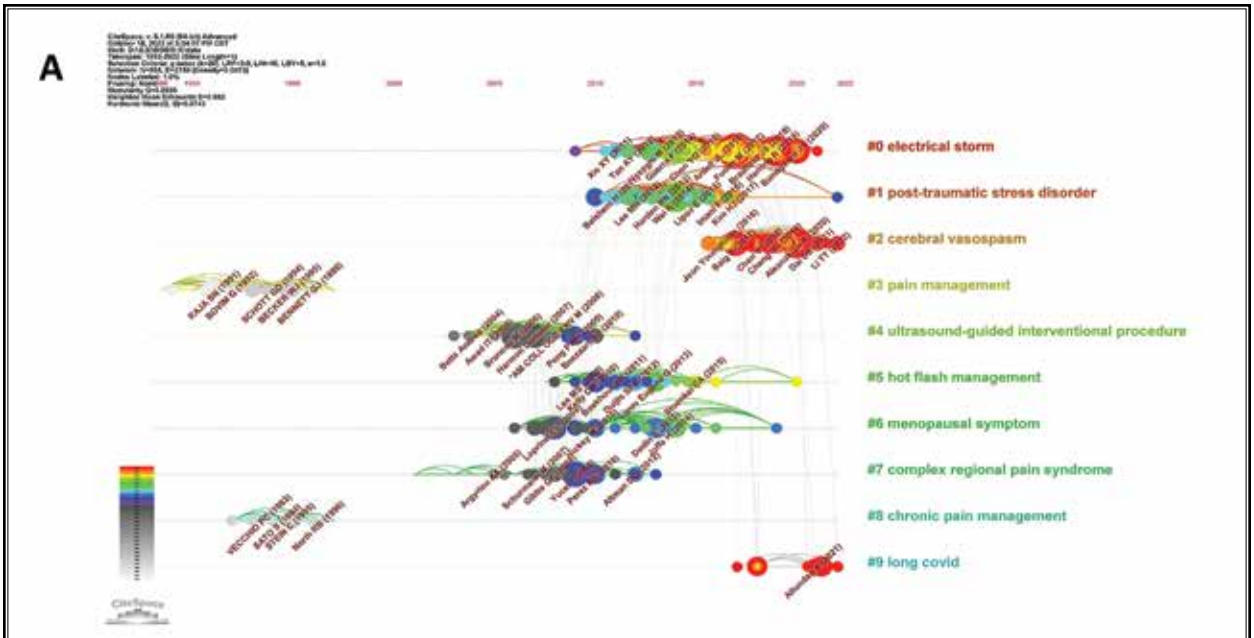
Table 4. *The top 10 co-cited references of SGB research from 1993 to 2022 (1).*

Rank	Co-Cited Reference	Title	Type	Co-Citation Counts	Centrality
1	Meng Lingjin, 2017, JACC CLIN ELECTROPHYSIOL, V3, P942, DOI 10.1016/j.jacep.2017.06.006	Efficacy of stellate ganglion blockade in managing electrical storm: A systematic review	Review	26	0.05
2	Narouze S, 2014, CURR PAIN HEADACHE R, V18, P0, DOI 10.1007/s11916-014-0424-5	Ultrasound-guided stellate ganglion block: Safety and efficacy	Review	20	0.02
3	Fudim M, 2017, J CARDIOVASC ELECTR, V28, P1460, DOI 10.1111/jce.13324	Stellate ganglion blockade for the treatment of refractory ventricular arrhythmias: A systematic review and meta-analysis	Article	20	0.01
4	Lipov EG, 2008, LANCET ONCOL, V9, P523, DOI 10.1016/S1470-2045(08)70131-1	Effects of stellate-ganglion block on hot flushes and night awakenings in survivors of breast cancer: A pilot study	Article	18	0.06
5	Tian Y, 2019, CIRC-ARRHYTHMIA ELEC, V12, P0, DOI 10.1161/CIRCEP.118.007118	Effective use of percutaneous stellate ganglion blockade in patients with electrical storm	Article	15	0.02
6	Olmsted KRL, 2020, JAMA PSYCHIAT, V77, P130, DOI 10.1001/jamapsychiatry.2019.3474	Effect of stellate ganglion block treatment on posttraumatic stress disorder symptoms: A randomized clinical trial	Article	15	0.01
7	Walega DR, 2014, MENOPAUSE, V21, P807, DOI 10.1097/gme.0000000000000194	Effects of stellate ganglion block on vasomotor symptoms: Findings from a randomized, controlled clinical trial in postmenopausal women	Article	14	0.03
8	Mulvaney SW, 2010, PAIN PRACT, V10, P359, DOI 10.1111/j.1533-2500.2010.00373.x	The use of stellate ganglion block in the treatment of panic/anxiety symptoms with combat-related post-traumatic stress disorder; preliminary results of long-term follow-up: A case series	Article	13	0.04
9	Haest K, 2012, ANN ONCOL, V23, P1449, DOI 10.1093/annonc/mdr478	Stellate ganglion block for the management of hot flashes and sleep disturbances in breast cancer survivors: An uncontrolled experimental study with 24 weeks of follow-up	Article	13	0.03
10	Gofeld M, 2009, REGION ANESTH PAIN M, V34, P475, DOI 10.1097/AAP.0b013e3181b494de	Development and validation of a new technique for ultrasound-guided stellate ganglion block	Article	12	0.02
	Lipov EG, 2009, MED HYPOTHESES, V72, P657, DOI 10.1016/j.mehy.2009.01.009	A unifying theory linking the prolonged efficacy of the stellate ganglion block for the treatment of chronic regional pain syndrome (CRPS), hot flashes, and posttraumatic stress disorder (PTSD)	Review	12	0.07

1. Made using Citespace. Link retaining factor = 3.0, maximum links per node = 10, look-back years = 5, e = 1.0. Selection criteria were based on a g-index in which k = 20.

COVID treatments has become another hot spot in the past 3 years.

Citation bursts refer to references focused on closely by scholars in a specific field at an interval of time. Fig. 4B displays the citation burst strength of the top 10 references. The strength of the citation bursts ranged from 5.68 to 10.01, while endurance strength lasted 3 to 5 years. Meng et al's (15) review of SGBs' efficacy in managing electrical storm and Lipov et al's study investigating SGBs as a treatment for breast can-



B

References	Year	Strength	Begin	End	1993 - 2022
Lipov EG, 2008, LANCET ONCOL, V9, P523, DOI 10.1016/S1470-2045(08)70131-1, DOI	2008	9.93	2009	2013	
Narouze Samer, 2007, PAIN PHYSICIAN, V10, P747	2007	8.74	2009	2012	
Higa K, 2006, ANESTHESIOLOGY, V105, P1238, DOI 10.1097/00000542-200612000-00024, DOI	2006	6.8	2009	2011	
Gofeld M, 2009, REGION ANESTH PAIN M, V34, P475, DOI 10.1097/AAP.0b013e3181b494de, DOI	2009	6.19	2010	2014	
Mulvaney SW, 2010, PAIN PRACT, V10, P359, DOI 10.1111/j.1533-2500.2010.00373.x, DOI	2010	6.92	2012	2015	
Lipov EG, 2009, MED HYPOTHESES, V72, P657, DOI 10.1016/j.mehy.2009.01.009, DOI	2009	6.92	2012	2014	
Haest K, 2012, ANN ONCOL, V23, P1449, DOI 10.1093/annonc/mdr478, DOI	2012	6.87	2013	2016	
Kang CK, 2010, ANESTHESIOLOGY, V113, P936, DOI 10.1097/ALN.0b013e3181ec53f5, DOI	2010	5.68	2013	2015	
Walega DR, 2014, MENOPAUSE, V21, P807, DOI 10.1097/gme.0000000000000194, DOI	2014	6.91	2015	2018	
Mulvaney SW, 2014, MIL MED, V179, P1133, DOI 10.7205/MILMED-D-14-00151, DOI	2014	5.91	2015	2017	
Narouze S, 2014, CURR PAIN HEADACHE R, V18, P0, DOI 10.1007/s11916-014-0424-5, DOI	2014	8.81	2017	2019	
Kumar N, 2014, ANAESTHESIA, V69, P954, DOI 10.1111/anae.12774, DOI	2014	5.77	2017	2018	
Meng Lingjin, 2017, JACC CLIN ELECTROPHYSIOL, V3, P942, DOI 10.1016/j.jacep.2017.06.006, DOI	2017	10.01	2019	2022	
Fudim M, 2017, J CARDIOVASC ELECTR, V28, P1460, DOI 10.1111/jce.13324, DOI	2017	7.67	2019	2022	
Tian Y, 2019, CIRC-ARRHYTHMIA ELEC, V12, P0, DOI 10.1161/CIRCEP.118.007118, DOI	2019	6.79	2020	2022	

Fig. 4. *Analysis of co-cited references. (A) Timeline view of co-citation references. (B) The top 15 references with the strongest citation bursts in chronological order, 1993–2022.*

cer survivors' debilitating hot flashes and sleep dysfunction received the strongest bursts among papers in the SGB field (strength = 10.01 and 9.93, respectively). The recent citation bursts' references, including Meng et al (3), Fudim et al (16), and Tian et al (17), all focusing on diseases related to cardiac sympathetic regulation, such as electrical storm and refractory ventricular arrhythmia, are currently the hot spots in the SGB field.

Key Word Detection and Burst Analysis

The network visualization map of the keywords is shown in Fig. 5A. Four clusters emerged in our co-occurrence clustering analysis. The 4 clusters, represented by different colors, are as follows: (1) anesthesia and pain management in red; (2) climacteric symptoms treatment in yellow; (3) cerebrovascular disease in blue; (4) cardiovascular diseases in green. The clusters constructed by key words were consistent with those constructed by co-cited journals.

The 20 key words showing the strongest citation burstness within the last 3 decades were selected for a one-year slice of burst analysis (Fig. 5B). Hot flashes, breast cancer, electrical storm, sympathetic blocks, and reflex sympathetic dystrophy syndrome occupied the 5 positions associated with the highest burst strength and lasted for multiple years, suggesting intense research interests and focus. The most recent key words showing citation burstness were ventricular tachycardia, ventricular arrhythmia, and electrical storm, indicating that they were current research frontiers.

Discussion

Basic Information

Over the past 3 decades, the field of the SGB has undergone rapid evolution, resulting in extensive utilization for treating a variety of disorders in clinical practice. Notably, the number of publications showed a fluctuating but generally rising trend in the first 2 decades and a sharp rise in the third decade, attesting a surge of interest in this field.

Of the countries that produced the papers examined in this study, the United States was furthest ahead in publications, link strength, and total citations, signifying a deep foundation and influence in the SGB area. American institutions and scholars occupied most spots in the respective top 10 lists generated by our software. However, Japan pioneered this field at the end of the last century. Kitajima T, Yamaguchi S, and Kimura Y, 3 of the top 5 high-yield authors from Japan, collaborated in several influential and exploratory animal experiments in the 1990s and early 2000s (18-20), providing valuable foundations and insights for later clinical studies. China, South Korea, and India entered the SGB field later than Japan and the United States did. It is worth noting that China's paper output eventually saw a rapid increase; however, the link strength and total citations among said papers lagged behind. These findings may be attributable to 3 factors. First, the delayed initiation of SGB research in China resulted in limited time for publications to accumulate influence. Second, high-quality trials are lacking, and more notable innovative discoveries are required.

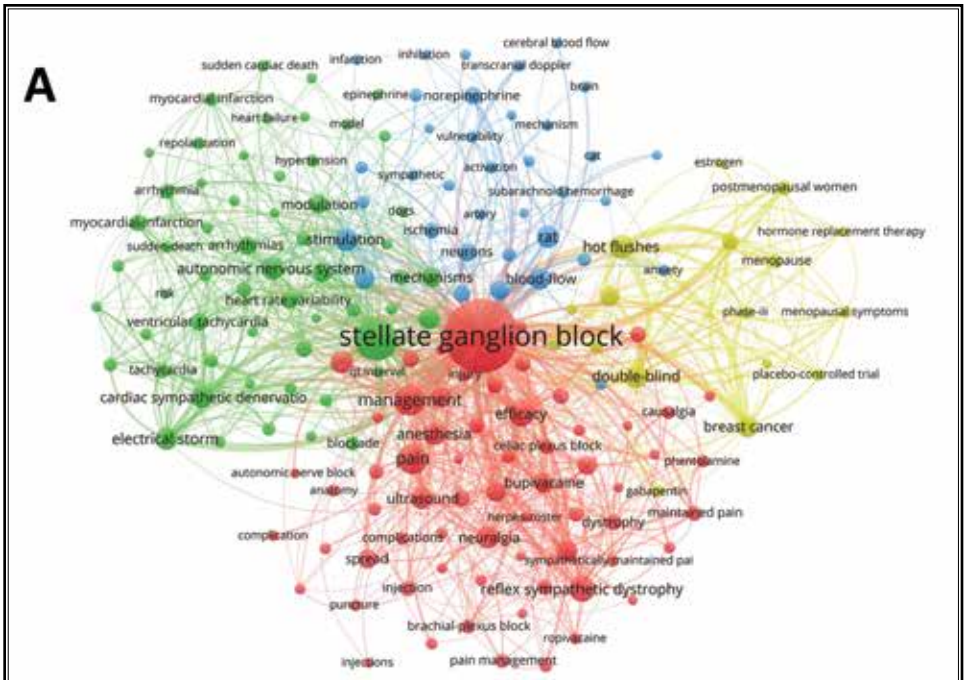


Fig. 5. *Key words analysis. (A) Network visualization map of key words (Threshold = 7). (B) The top 20 key words with the strongest citation bursts in chronological order, 1993–2022.*

Third, Chinese SGB researchers have largely not collaborated with international experts. Chinese scholars need to strengthen international academic exchanges to increase their influence. We foresee that China will have a strong presence in SGB research in the future, since approximately 70 studies were registered in the Chinese Clinical Trial Registry in the past 3 years (21).

The cooperation network map of co-cited journals displayed a detached distribution among clusters (Fig. 3B). The journals spanned several majors, including anesthesiology and pain medicine, cardiology, neurology, and climacteric medicine, implying that SGBs had versatile uses in clinical practice. The top 5 most productive and co-cited authors had significant discrepancies in research directions. For example, Lipov E and Mulvaney SW focused on the use of SGBs for PTSD (22,23); Cha YM was committed to the field of refractory ventricular arrhythmia and electrical storm (24); Loprinzi CL concentrated on hot flashes in breast cancer survivors and women in their climacteric stage (25,26); Narouze S and Hogan QH focused on the SGB technique's safety issues, advocating for puncture guided by ultrasound or computerized tomography (27,28).

Knowledge Base and Research Domains

Our co-citation analysis assessed the degree of association and similarity among papers by counting how often 2 or more papers were cited together in other articles. This analysis helped identify influential references and authors in a domain and also explored the topics and knowledge bases shared among documents. The co-citation analysis indicated several domains in the SGB field, providing us with a clear vision of the knowledge bases.

Cluster One: Electrical Storm and Refractory Ventricular Arrhythmia

Electrical storm, defined as rapidly recurrent ventricular fibrillation or tachycardia, often occurs in patients with ongoing or recent myocardial infarctions, exacerbating congestive heart failure, use of arrhythmogenic drugs, and/or electrolyte disturbances. There is a close relationship between cardiac sympathetic activity and ventricular arrhythmogenesis. In the 1970s, cases reported that the SGB technique successfully managed the idiopathic prolongation of the Q-T interval (29) and cardiac rhythm disturbances caused by central venous system disease (30). In 2017, Meng et al (3) reviewed 38 patients from 23 studies. The researchers found that SGBs significantly reduced episodes of ventricular arrhythmia and the number of external and implantable cardioverter defibrillator shocks in patients suffering electrical storm. In the same year, Fudim et al's meta-analysis (16) identifying 35 patients with refractory ventricular arrhythmia showed SGBs were associated with an acute reduction in the ventricular arrhythmia burden. Both discoveries gained comprehensive traction and promoted the advancement of subsequent research (17,31,32). SGBs have been found to effectively treat electrical storm in patients infected with COVID-19 (32). Recently, Patel et al (32) attempted to use an SGB catheter in patients with refractory electrical storm to achieve prolonged arrhythmia cessation without performing repeated blocks. A 24-hour cessation of the electrical storm was achieved in 90% of patients. Although the SGB has received significant attention in the field, randomized controlled trials are needed to confirm this technique's safety and efficacy.

Cluster 2: Breast Cancer and Climacteric Medicine

SGBs have multiple benefits for breast cancer patients. In 2008, a pilot study by Lipov et al (15) published in Lancet Oncology demonstrated that SGBs could relieve breast cancer survivors' hot flashes and sleep disturbances with few side effects within 12 weeks. In 2012, Haest et al (34) conducted a 24-week follow-up for breast cancer survivors. The efficacy of SGBs for sleep quality remained steady throughout 24 weeks, but hot flashes were lessened over time. Later, SGBs' other effects on breast cancer patients were explored and validated. SGBs were associated with fewer incidences of post-mastectomy pain syndrome (35) and breast cancer-related lymphedema (36) and improvements in postoperative recovery and analgesia (4,37).

Hot flashes, also called vasomotor symptoms and night sweats, are common in perimenopausal and postmenopausal women. Severe symptoms can significantly reduce these patients' quality of life. SGBs provide an effective nonhormonal therapy for hot flashes. The most influential research in this field is the trial by Walega et al (38), which has confirmed that SGBs are associated with decreased frequency of both moderate to severe vasomotor symptoms and objective vasomotor symptoms.

Cluster 3: Post-Traumatic Stress Disorder (PTSD)

In 2010, Mulvaney et al (39) reported that 2 patients who had PTSD experienced immediate, significant, and durable relief after their SGBs and discontinued psychiatric medication safely. After that study, Mulvaney et al (23) observed a larger population. In 2014, they select-

ed 166 service members with PTSD symptoms to receive an SGB; over 70% of patients showed an improvement in symptoms that persisted beyond 3 to 6 months. In 2020, the first multisite, randomized trial of SGBs on PTSD symptoms was published in *JAMA Psychiatry* (7). The trial demonstrated that 2 SGB treatments 2 weeks apart were effective in alleviating PTSD symptoms over the course of 8 weeks. The 3 aforementioned studies gradually verified SGBs' effectiveness on PTSD symptoms and were cited many times, with strong citation bursts in this field.

Cluster 4: Pain Management

The SGB has a long history of being used for pain relief (40). The procedure can promptly relieve acute pain, such as herpetic pain involving the trigeminal and cervical regions (41). Chronic pain and complex regional pain syndrome can also be treated effectively by the SGB technique (42,43). Additionally, the SGB has been applied as a modality for perioperative pain management. Kumar et al (44) demonstrated the SGB's analgesic efficacy as a method of postoperative pain relief. Injections of 3 mL of lidocaine for SGBs significantly decreased cumulative 24-hour tramadol consumption among patients undergoing upper limb orthopedic surgery. In recent years, the SGB has been widely explored and proven effective in other pain indications, such as migraines (45), thalamic pain syndrome (43), and chronic ulcerative colitis (13). More indications for SGBs as a pain management technique will be unearthed in the future.

Cluster 5: Cerebrovascular Diseases

The SGB has also held a place in the field of cerebrovascular research. As early as the 1950s, a case series reported the use of SGBs as a treatment for acute cerebral thrombosis and embolism (46). In 2010, Kang et al (47) used magnetic resonance angiography to investigate the direct effect of SGBs on cerebral vasculature. Significant changes were observed in ipsilateral extracranial vessels and ophthalmic arteries, whereas other intracranial vessels were relatively unaffected. The researchers followed this study closely from 2013 to 2015, with a citation burst strength of 5.69. Early SGBs improved postoperative cerebral blood flow velocity after aneurysmal subarachnoid hemorrhages (48) and benefited those with symptomatic cerebral vasospasms (49). In animal experiments, SGBs have been proven to reduce learning and memory dysfunction (50) and postoperative cognitive dysfunction (51). Clinical trials are necessary to validate SGBs' potential for protecting neurocognitive function.

Emerging Hot Spots and Research Frontiers

Burst analysis and timeline analysis of keywords and references provided clues to identifying the trend of hot subject categories. Two domains—the SGB as a treatment for ventricular arrhythmias and the SGB as a treatment for cerebrovascular diseases—were still hot topics in recent years. A number of papers regarding the 2 domains were published in 2023, reflecting the sustaining attention being paid to these topics (33,48,49,52,53). The SBG as a treatment for long COVID syndrome was another emerging hot spot. Because of the global COVID-19 epidemic, long COVID sequelae have attracted widespread attention. The symptoms take diverse, complex manifestations and are thought to be mediated by imbalances in the autonomic nervous system (54). SGBs were reported to be used as successful treatments for COVID-19-induced anosmia, dysgeusia, and olfactory and gustatory dysfunction (55-57) and could relieve long COVID symptoms in 86% of patients (10). We predict that the use of SGB for long COVID will continue to be a hot topic in the coming years.

Limitations

Our study was not devoid of limitations. Firstly, data were retrieved only from the WoSCC; therefore, publications in other databases might have been missed. Secondly, some recent publications might not have had sufficient time to accumulate citations, so quantifying their influence accurately was difficult. Thirdly, articles published in 2023 were not included, which might have weakened our ability to explore the frontiers of SGB research.

Conclusion

A 30-year span of SGB research output was evaluated by bibliometric analysis. There was a sharp increase in research yield and citations over the last 10 years. The United States dominated in terms of publication and citation quantity and had the most influential authors and articles. The 5 main aspects of SGB research included electrical storm and refractory ventricular arrhythmia, breast cancer and climacteric medicine, PTSD, pain management, and cerebrovascular diseases. All studies concerning these domains targeted the SGB's therapeutic effects. The latest hot topics involving this field focused on the SGB's anti-arrhythmic and anti-cerebral vasospasm effects and treatment of long COVID

syndrome. Given the versatility of the SGB, we believe further research will continue to explore and elucidate its therapeutic effects in other areas.

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Data Availability Statement

The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author.

Author Contributions

Y Ren and Z Zhang conceptualized the article, performed the literature, acquired, analyzed, and interpreted the data, and drafted the manuscript. Hao K and Duojietai conceptualized the article, interpreted the data, and revised the manuscript extensively. PJ Zhang and HP Li performed the literature and acquired, analyzed, and interpreted the data.

Ethics Statement

Ethical review and approval were waived because this bibliometric study involved no human participants.

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