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Trends in research on the perioperative use of acupuncture in the last 20 years: A CiteSpace-based bibliometric analysis and literature review

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Objective: Research on acupuncture-related techniques in the perioperative period has been increasing in the last 20 years. In this research, a bibliometric analysis was performed to review the application of acupuncture for perioperative medicine and to evaluate the trends in research on the perioperative use of acupuncture.

Methods: CiteSpace was used to analyze published papers on the perioperative use of acupuncture in the Web of Science database from 2001 to 2021. The research trends were evaluated based on the number of publications, keywords, journals, countries, institutions, and authors. Moreover, collaborative networks and reference co-citation network maps were analyzed.

Results: A total of 719 related studies were included in the analyses. The number of annual publications has gradually been increasing. Evidence-Based Complementary and Alternative Medicine published the most (49 articles). Regarding the cited journals, Anesthesia & Analgesia ranked first in terms of frequency (361), while Pain ranked first in terms of centrality (0.71). China (284) and the China Medical University (26) published the most. Wang Yu (21 articles) was the most active author, while Lee A (116) was the most co-cited author. The most co-cited reference was a meta-analysis of acupuncture for post-operative pain (212). The "post-operative cognitive dysfunction" cluster was new research directions that had recently emerged. Pain-related keywords had the highest frequency in keywords about indications.

Conclusion: Research on perioperative acupuncture is a promising field, and more cooperation in global scientific research is needed. Our results may help researchers in identifying potential collaborators, research frontiers, and hot topics.

KEYWORDS

acupuncture, perioperative medicine, CiteSpace, bibliometric analysis, hotspot

Introduction

There has been growing interest in the use of acupuncture-related techniques in the perioperative period [1, 2]. Perioperative acupuncture can potentially provide various clinically meaningful benefits for patients. It helps reduce the consumption of anesthetics and analgesics and reduce anesthetic and surgical complications, including pain, post-operative nausea and vomiting and hemodynamic episodes [3–7]. Furthermore, perioperative acupuncture may induce organ-protective effects on cardiac and brain function [8, 9]. Acupuncture-related techniques are minimally invasive and inexpensive, and they have attracted the attention of more researchers in perioperative medicine. As a result of increasing demand, it is necessary to examine the relevance of scientific bibliometric research in this field. Furthermore, effectively and adequately identifying scholarly publications is important for establishing the basis for subsequent analyses.

CiteSpace is a science mapping tool designed for conducting a visual analytic study of the literature of a research field, which is known as a knowledge domain [10]. Using CiteSpace, we can construct a series of networks of authors, institutions and countries and clarify the structural patterns and trends of significant developments in a research field. In recent years, the centrality analysis and burst detection functions of CiteSpace have been used to analyze other acupuncture-related fields, including arthritis, pain and imaging [11–13]. High centrality is often well-recognized as a turning point or pivotal point in a field.

Thus, this study analyzes the status, trends, and hotspots of research on perioperative acupuncture using CiteSpace to conduct a comprehensive and systematic bibliometric review of literature obtained from Web of Science (WOS) from 2001 to 2021. From the results, global publication patterns can be established to inform researchers of future research directions and issues.

Methods

Data acquisition

In this study, the WOS core collection database was adopted as the bibliographic database. The data search strategy

Abbreviations: WOS, web of science; Anesth Analg, Anesthesia & Analgesia; Brit J Anaesth, British Journal of Anaesthesia; Acupunct Med, Acupuncture Medicine; Evid-Based Compl Alt, Evidence-Based Complementary and Alternative Medicine; Neurosci Lett, Neuroscience Letter; PONV, post-operative nausea and vomiting; POCD, post-operative cognitive dysfunction; LLR, log-likelihood ratio; STRICTA, Standards for Reporting Interventions in Clinical Trials of Acupuncture; CONSORT, Consolidated Standards of Reporting Trials.

included the topic “acupuncture” or “electroacupuncture” or “laser acupuncture” or “acupressure” or “auricular acupuncture” or “transcutaneous electrical acupoint stimulation,” and it also included “pre-operative” or “post-operative” or “anesthesia” or “perioperative,” with the publication period of the literature ranging from January 1st, 2001, to December 31st, 2021. We excluded duplicate publications. There were no restrictions on the type of research. The types of publication were limited to articles and reviews (case reports/series, editorials and letters were excluded). The publishing language was limited to English. The search date was February 4th, 2022.

Methodology

CiteSpace 5.7.R5 and Excel 2019 were used to analyze the data extracted from WOS. Analysis included descriptive analysis, co-occurrence analysis and co-citation analysis. The annual number of publications, the publishing frequency of journals, countries, institutions, authors, references, and keywords were described. Based on all authors, the co-occurrence map for countries and institutions was drawn. Based on the first author, the frequency and centrality of cited authors were analyzed. The top 20 burst keywords were extracted. We applied a log-likelihood ratio (LLR) algorithm to generate clusters by the keywords of the articles or of the references to explore emerging trends and key information from the cited references. Based on cluster analysis that involved clustering co-citations of articles, a timeline map was drawn to investigate the changes in Research Topics over time. Furthermore, based on the co-citation of keywords, the top ranked keywords of indications for acupuncture-related techniques and of acupuncture techniques were extracted.

Quality control

The results for the final knowledge map were confirmed by experts in the field of perioperative medicine and acupuncture to verify the strength of the research conclusions in relation to clinical practice.

Results

Trends in publications by stage

A total of 729 papers were obtained from WOS. Seven hundred and nineteen papers were obtained after removing duplicates. The number of articles published increased from 5 in 2001 to 88 in 2021, as shown in [Figure 1](#).

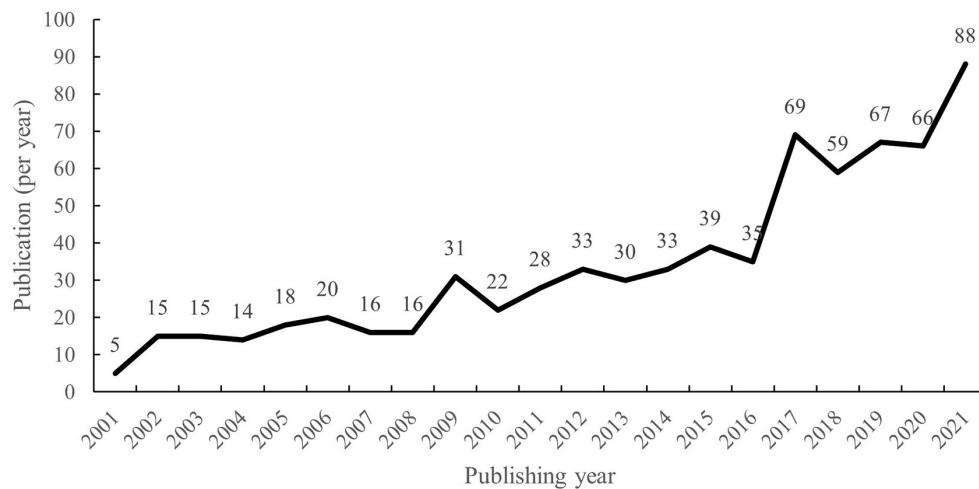


FIGURE 1
Number of annual publications on perioperative application of acupuncture related techniques from 2001 to 2021.

TABLE 1 The top five co-cited journals with the highest frequency or centrality of perioperative application of acupuncture related techniques from 2001 to 2021.

Ranking	Journal	Frequency	Impact factor	Country	Ranking	Journal	Centrality	Impact factor	Country
1	Anesth Analg	361	5.178	US	1	Pain	0.71	6.961	US
2	Anesthesiology	314	7.892	US	2	Evid-Based Compl Alt	0.63	2.629	US
3	Br J Anaesth	298	9.166	England	3	Anesthesiology	0.56	7.892	US
4	Acupunct Med	242	2.267	US	4	Anesth Analg	0.52	5.178	US
5	Pain	240	6.961	US	5	Neurosci Lett	0.3	3.046	Netherlands

TABLE 2 Top five active authors, co-occurred, and co-cited authors related to perioperative application of acupuncture related techniques from 2001 to 2021.

Ranking	Active authors (frequency)	Co-occurred authors (frequency)	Cited authors (frequency)	Cited authors (centrality)
1	Wang Y (21)	Wang Baoguo (7)	Lee A (116)	Chen L (0.21)
2	Wang Q (13)	Arne Johan Norheim (6)	Han Js (110)	Han JS (0.12)
3	Usichenko TI (12)	Zheng Man (6)	Wang SM (97)	Ernst E (0.11)
4	Li X (11)	Wang Yu (6)	Gan TJ (85)	Wang SM (0.1)
5	Wang J (11)	Li Shuqin (5)	Lin JG (68)	Usichenko TI (0.1)

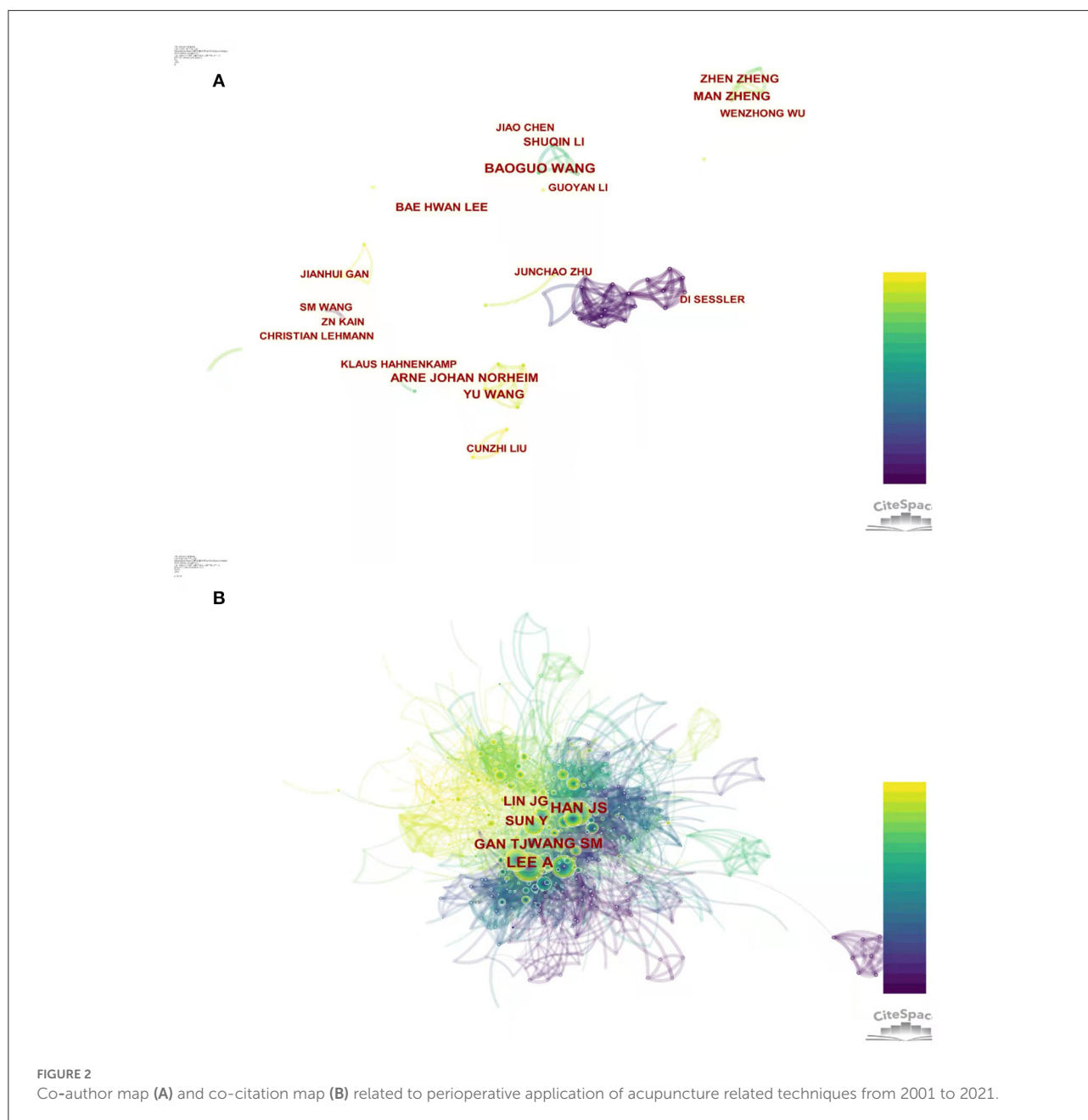
Analysis of journals

The number of journals that published the 719 articles on perioperative acupuncture was 616. Evidence-Based Complementary and Alternative Medicine published the most (49 articles). The top 5 most co-cited journals were Anesthesia & Analgesia (361), Anesthesiology, British Journal of Anaesthesia, Acupuncture Medicine and Pain (Table 1). In terms of centrality, the top journal was Pain (0.71) (Table 1). The impact factors of the top 5 journals by frequency were

between 2.267 and 9.166. The most cited journal Anesthesia & Analgesia is with an impact factor of 5.178 (year 2020).

Analysis of authors

Wang Y (Wang Yu) was the most active author in this research field, with 21 articles, followed by Wang Q (13 articles) and Usichenko Ti (12 articles) (Table 2). Co-authorship and co-citation maps were generated (Figure 2). Author with the most



co-authorship was Wang Baoguo (7) (Table 2). The most cited author was Lee A (116), followed by Han JS (110), Wang SM (97), Gan TJ (85) and Lin JG (68). Regarding centrality, the top 5 authors were Chen L, Han JS, Ernst E, Agarwal A and Usichenko Ti (Table 2).

Analysis of countries

A map of countries co-occurrence was generated. The size of the nodes in the map indicates the number of

articles published by a country, and the links (83) between nodes represent the strength and time of the cooperative relationship (Figure 3). The 719 articles were published in 47 countries. The top three countries were the People's Republic of China, the United States (USA) and South Korea. The People's Republic of China accounted for 39.5% (284/719) of the total publications, followed by the United States (158, 22.0%) and South Korea (54, 7.5%). Regarding centrality, the top five countries were the United States (0.81), China (0.32), England (0.29), Germany (0.13), and Switzerland (0.09) (Table 3).

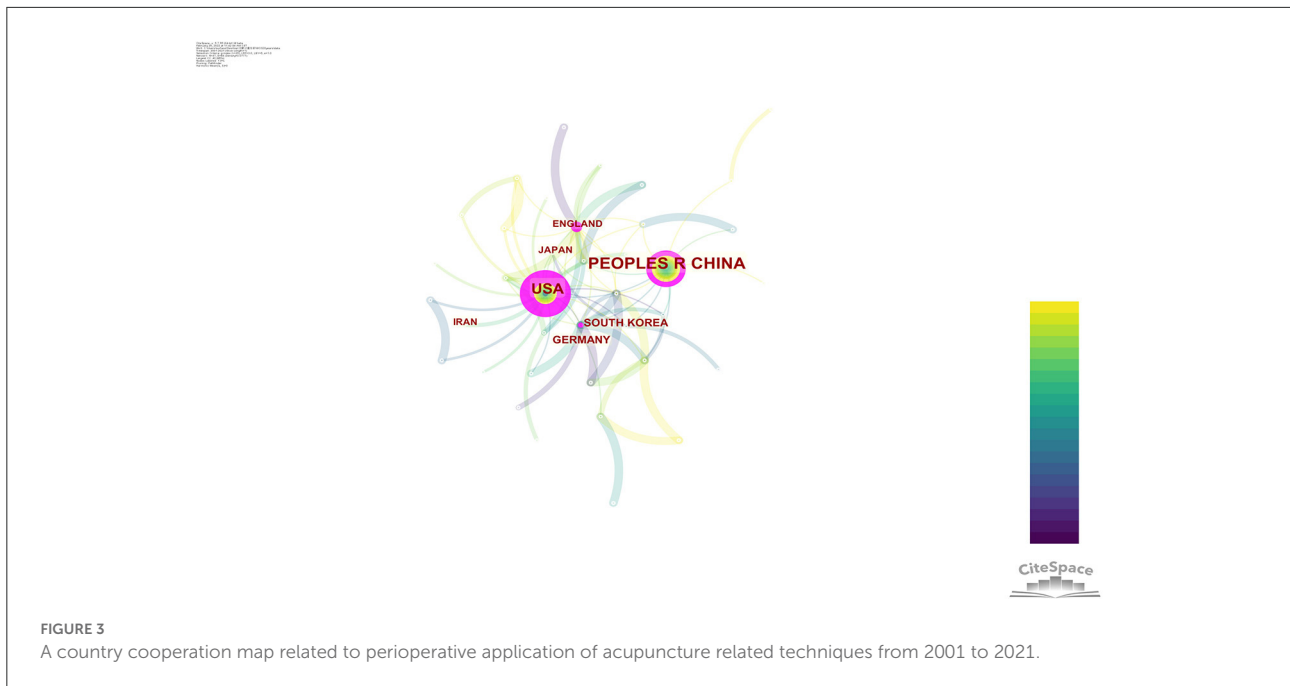


TABLE 3 Top five countries and institutions related to perioperative application of acupuncture related techniques from 2001 to 2021.

Ranking	Institutions (frequency)	Institutions (centrality)	Countries (frequency)	Countries (centrality)
1	China Med Univ (26)	China Med Univ (0.03)	Peoples R China (284)	USA (0.81)
2	Capital Med Univ (19)	Capital Med Univ (0.03)	USA (158)	Peoples R China (0.32)
3	Guangzhou Univ Chinese Med (17)	Beijing Univ Chinese Med (0.02)	South Korea (54)	England (0.29)
4	Hyung Hee Univ (17)	Guangzhou Univ Chinese Med (0.01)	England (35)	Germany (0.13)
5	Beijing Univ Chinese Med (15)	China Acad Chinese Med Sci (0.01)	Japan (29)	Switzerland (0.09)

Analysis of institutions

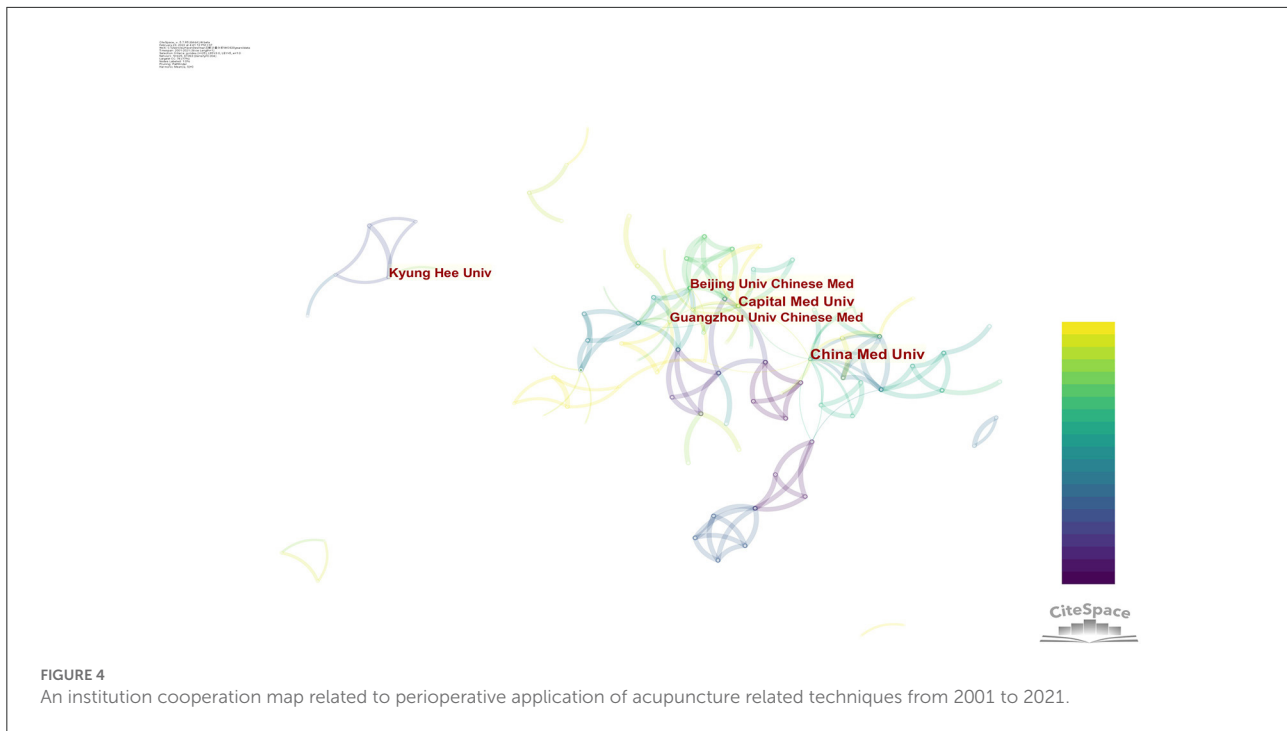
An institutional cooperation map was generated. The 719 articles were submitted by 425 institutions. The top five institutions based on the number of publications were the China Medical University (26), Capital Medical University (19), Guangzhou University of Chinese Medicine (17), Kyung Hee University (17), and Beijing University of Chinese Medicine (15) (Table 3 and Figure 4). Regarding centrality, the top 5 institutions were the China Medical University, Capital Medical University, Beijing University of Chinese Medicine, Guangzhou University of Chinese Medicine, and the Chinese Academy of Chinese Medicine and Science.

Analysis of cited references

The most frequently cited reference was a meta-analysis on optimal treatment parameters of TENS for post-operative pain [14]. Co-citation implies that two articles were cited in the same

article. It suggests that the cited literature and citing literature are related in content, indicating a literature with contents of significant influence. A total of 18,270 references were extracted from the 719 articles to analyze the cited references. We considered 2001 to 2021 as our time span and a time slice of 1. The 50 most frequently cited items that appeared were selected from each time slice to form a network diagram of cited references, with the network consisting of 805 nodes and 2,140 links. The most frequently co-cited reference was a meta-analysis on acupuncture and post-operative pain management (Table 4) [15]. The cited reference with the highest centrality was a randomized clinical trial observing the effect of neuromuscular monitoring over the P6 acupuncture point on the reduction of PONV (Table 4) [16].

Twenty-seven clusters were generated from the keywords of the cited references. We list the first 10 clusters with the largest scale. The largest group was “post-operative ileus,” which consisted of 66 reference articles. Clusters #2 “post-operative cognitive dysfunction” was new research direction that had recently emerged (Figure 5).



Analysis of co-occurring keywords

A keyword co-occurrence network containing 544 nodes and 2,218 links was generated. Figure 6 shows a network of co-occurring keywords with high frequencies (the larger the character is, the higher the frequency). The most widely used keywords related to perioperative acupuncture over the last 20 years were “acupuncture,” “electroacupuncture” and “pain.” We also extracted high-frequency keywords related to indications of acupuncture or acupuncture techniques. Pain was the indication with the highest frequency (136). Acupuncture was the technique with the highest frequency (335). Using LLR algorithm, eight clusters were generated (Figure 7). The largest group was “post-operative ileus,” which consisted of 91 keywords.

Analysis of burst keywords

Burst keywords were generated to record keywords that changed greatly within a short period of time. Such keywords are thought to be related to research hotspots or future trends. The top 20 keywords with the strongest citation bursts are presented in Figure 8. “Stimulation” was the keyword with the strongest citation burst, and it was identified as a frontier research item in the 2007–2013 period. “Systemic review,” “meta-analysis,” and “protocol” were burst keywords between 2019 and 2021.

Discussion

To the best of our knowledge, this paper is the first bibliometric study on the application of acupuncture in perioperative medicine. By retrieving data from 719 studies published between 2001 and 2021 and conducting co-occurrence and co-citation analyses using CiteSpace, we outlined the research trends and cooperation status of research on perioperative acupuncture over the last 20 years and highlighted potential hot spots for future studies.

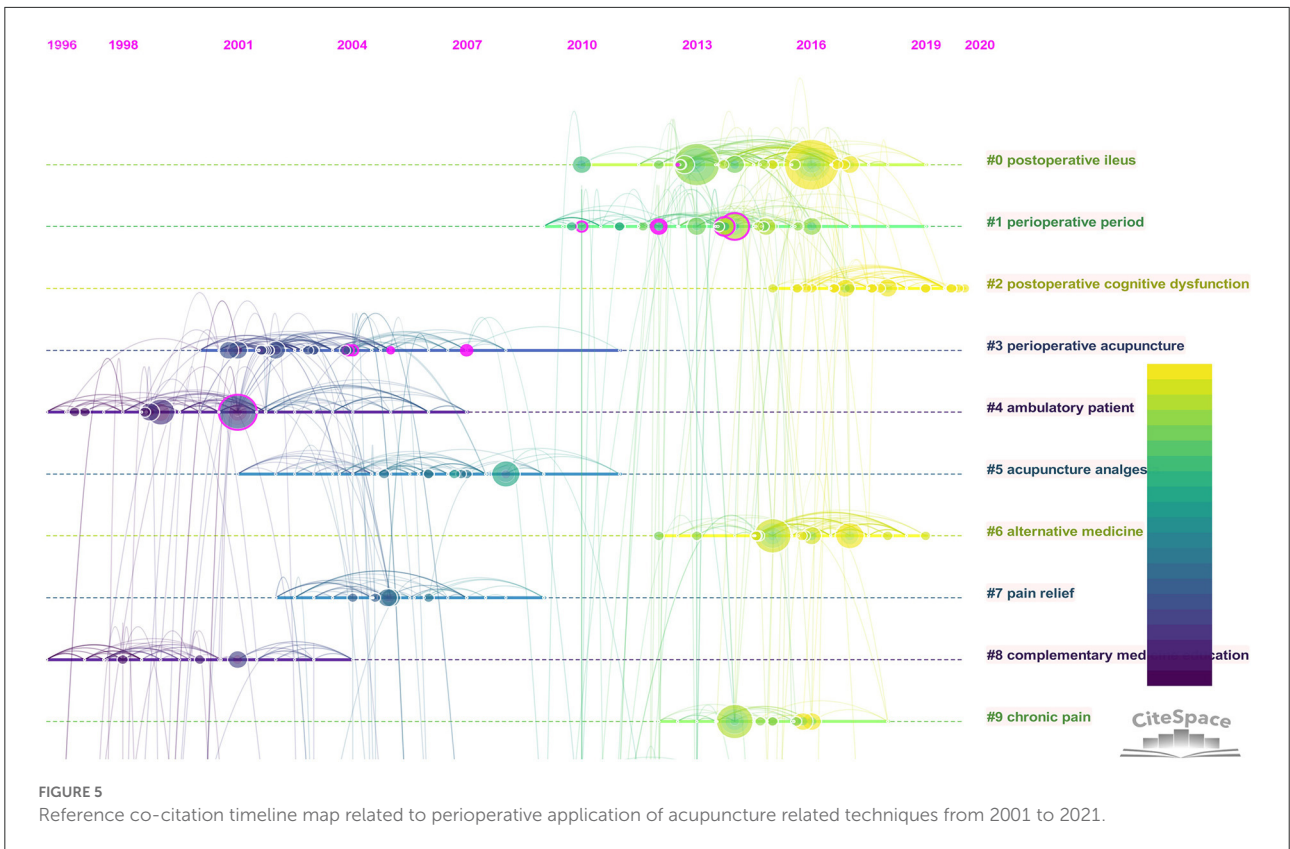
We found a general increasing trend in research on perioperative acupuncture during the last 20 years. This trend was consistent with that observed in other fields of research on acupuncture, including acupuncture analgesia [11, 17–19]. According to the current trend analysis, research on perioperative acupuncture will continue to show an overall growth trend in the next few years.

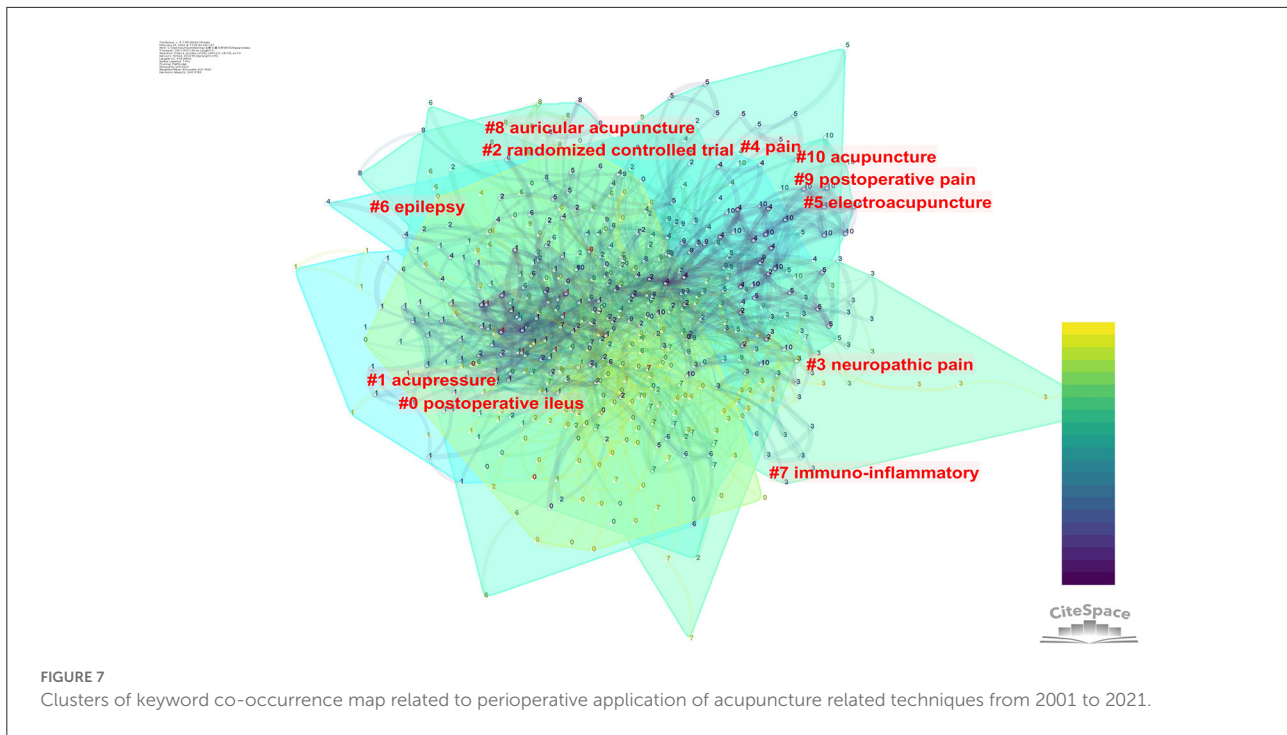
According to the frequency analysis, researchers in Asia have conducted the most studies in the field of perioperative acupuncture, but the most significant finding was found by researchers in the USA. And the cooperation among countries and institutions was weak compared with research of other fields. The linkage among countries reported in depressive disorder was 75 countries with 600 links [20], while the linkage in perioperative acupuncture was 47 countries with 84 links. Cooperation should be paid attention to in the future.

Acupuncture analgesia is one of the earliest research points in the field of acupuncture. Han [21–23], who has been engaged

TABLE 4 The top five cited articles and top five co-cited references for the highest frequency or centrality of perioperative application of acupuncture related techniques from 2001 to 2021.

Ranking	Frequency/ centrality	Reference	Representative author (publication year)	Journal
Ranking by frequency of citation				
1	212	Transcutaneous electrical nerve stimulation (TENS) can reduce post-operative analgesic consumption. A meta-analysis with assessment of optimal treatment parameters for post-operative pain	Bjordal JM (2003)	Eur J Pain
2	169	Acupuncture and related techniques for post-operative pain: a systematic review of randomized controlled trials	Sun Y (2008)	Br J Anaes
3	155	The effect of high and low frequency electroacupuncture in pain after lower abdominal surgery	Lin JG (2014)	Pain
4	145	Optimizing pain management to facilitate enhanced recovery after surgery pathways	Tan MJ (2015)	Can J Anesth
5	127	Stimulation of the wrist acupuncture point P6 for preventing post-operative nausea and vomiting	Lee A (2009)	Cochrane Database Syst Rev
Ranking by frequency of co-citation				
1	24	The efficacy of acupuncture in post-operative pain management: a systematic review and meta-analysis	Wu MS (2016)	PLoS ONE
2	21	Stimulation of the wrist acupuncture point PC6 for preventing post-operative nausea and vomiting	Lee A (2015)	Cochrane Database Syst Rev
3	19	Electroacupuncture reduces duration of post-operative ileus after laparoscopic surgery for colorectal cancer	Ng SSM (2013)	Gastroenterology
4	19	Transcutaneous electric acupoint stimulation reduces intra-operative remifentanyl consumption and alleviates post-operative side-effects in patients undergoing sinusotomy: a prospective, randomized, placebo-controlled trial	Wang H (2014)	Br J Anaesth
5	19	Mechanisms of acupuncture-electroacupuncture on persistent pain	Zhang RX (2014)	Anesthesiology
Ranking by centrality of co-citation				
1	0.52	Monitoring of neuromuscular blockade at the P6 acupuncture point reduces the incidence of post-operative nausea and vomiting.	Arnberger M (2007)	Anesthesiology
2	0.33	Electroacupoint stimulation for post-operative nausea and vomiting in patients undergoing supratentorial craniotomy	Wang XQ (2010)	J Neurosurg Anesth
3	0.30	The effects of P6 electrical acustimulation on post-operative nausea and vomiting in patients after infratentorial craniotomy	Xu M (2012)	J Neurosurg Anesth
4	0.29	Stimulation of the wrist acupuncture point P6 for preventing post-operative nausea and vomiting	Lee A (2009)	Cochrane Database Syst Rev
5	0.27	P6 acupressure may relieve nausea and vomiting after gynecological surgery: an effectiveness study in 410 women	Alkaissi A (2002)	Can J Anesth





in research on acupuncture analgesia, was among the top 5 most cited authors. This result is in accordance with the dominant position of acupuncture analgesia in the field of perioperative acupuncture. A Systematic Review and Meta-Analysis on the Efficacy of Acupuncture in Post-Operative Pain Management is the top co-cited reference by frequency (24 times). This study updates the evidence that certain modes of acupuncture improve post-operative pain on the first day after surgery and reduce opioid use [15]. And the most frequently cited reference was a meta-analysis on optimal treatment parameters of TENS for post-operative pain [14]. These findings indicate that pain remains a research field of significant influence. The most cited author, Lee A, is from Chinese University of Hong Kong, Prince of Wales Hospital. His articles provided meta-analysis and Cochrane reviews of acupuncture alleviating post-operative nausea and vomiting [24–27]. Combined with the result of co-cited reference analysis that the top 5 reference by centrality were papers providing evidence for P6 acupuncture treatment of PONV [16, 27–30], it is indicated that PONV has been a hot spot in the field of perioperative acupuncture. The effects of analgesia and preventing PONV have been validated in various populations and the underlying mechanisms remains to be elucidate.

Our results suggested that publishing in higher-impact journals is challenging for researches in the field of perioperative acupuncture. Articles about acupuncture published in top journals including science, lancet and JAMA are not rare. Thus, high-quality studies following the Standards for Reporting Interventions in Clinical Trials of Acupuncture (STRICTA)

[31–34] and the extension of CONSORT for reporting interventions in clinical trials of acupuncture are needed.

All the top 3 most cited journals are JCR1-level journals in the field of anesthesia (Anesth Analg, Anesthesiology, Brit J Anaesth), reflecting the great involvement of anesthesiologists in research on perioperative acupuncture. Anesthesiologists should explore acupuncture in a broader perspective. Cluster analysis showed that “post-operative cognitive dysfunction” has been research hotspots for researchers in recent years. Post-operative brain function has attracted great attentions. For example, there has been researches on post-operative delirium [35], post-operative cognitive dysfunction [36, 37] and the sleep mode [38]. The keyword analysis results provide hints for research frontiers. Consistent with other bibliometric studies on acupuncture, “pain” is the most common disorder that perioperative acupuncture is used for. “Randomized controlled trial” was an important research method.

In addition, a burst keyword can indicate cutting-edge Research Topics and reveal studies that have potential or are of interest. The history of research on perioperative acupuncture can be drawn from the evolution of the keywords used in these articles. For example, “ondansetron,” “non-pharmacological intervention” and “children” were the earliest words to have an impact. However, since 2019, with accumulated evidence in the field of perioperative acupuncture, systemic reviews and meta-analysis are increasing. And more people are getting aware of the importance of publishing “protocol.”

Our study has some limitations. In this study, we performed co-occurrence and cluster analyses based on data retrieved

Top 20 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2001 - 2021
droperidol	2001	6.42	2001	2005	
nonpharmacologic technique	2001	3.77	2001	2004	
children	2001	6.37	2002	2007	
prevention	2001	6.06	2002	2008	
ondansetron	2001	3.83	2002	2012	
auricular acupuncture	2001	3.54	2003	2008	
postoperative nausea	2001	4.18	2005	2013	
stimulation	2001	7.65	2007	2013	
spinal anesthesia	2001	4.38	2007	2015	
electrical nerve stimulation	2001	3.51	2007	2009	
low back pain	2001	3.66	2009	2016	
vomiting	2001	3.4	2011	2016	
efficacy	2001	3.7	2012	2013	
trial	2001	4.01	2014	2017	
metaanalysis	2001	4.22	2015	2018	
nerve stimulation	2001	3.45	2015	2018	
receptor	2001	3.56	2017	2019	
protocol	2001	5.84	2019	2021	
systematic review	2001	5.79	2019	2021	
meta-analysis	2001	4.44	2019	2021	

FIGURE 8
Top 20 keywords with the strongest citation bursts.

from WOS because it provides references that were compiled based on the requirements of CiteSpace software for formatting the references used for co-citation analysis. It includes SCI-Expanded, SSCI, A&HCI, and ESCI. And we limited the publishing language to English. Further analysis of other databases, including the CNKI and CSSI databases, and of articles published in other languages is needed.

In conclusion, Research on the perioperative use of acupuncture-related techniques is a promising field. However, more cooperation in global scientific research is needed. Additionally, researchers need to optimize their study design to publish more high-quality articles in high-impact journals. Pain has been a hot spot of research in the field of perioperative acupuncture, but the frontier issues have changed to post-operative cognitive dysfunction. Our results may help researchers in identifying potential collaborators, research frontiers, and hot topics.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

MZ, ZC, and JZ collected and analyzed the data. ZL made substantial contributions to the design of the work and critically revised the manuscript. YW helped in analyzing and interpreting the data. MZ and ZL finished the draft. All authors approved the final version of the manuscript accepted for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships

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