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REVIEW

Research Status and Prospects of Acupuncture in Perioperative Medicine Over the Past Decade: A Bibliometric Analysis

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Background: Over the past decade, acupuncture in the perioperative period has attracted great interest, and a growing number of related literature has been published.

Purpose: To analyze the general information and identify the research hotspots and trends of acupuncture in perioperative medicine in the last 10 years by bibliometric analysis.

Methods: We searched the Web of Science Core Collection for publications on acupuncture in perioperative medicine from 2013 to 2023. The articles and reviews were collected with no language restriction. CiteSpace and VOSviewer software were used for bibliometric and visual analysis of relevant literature.

Results: A total of 814 bibliographic records were retrieved. Overall, the annual number of publications showed an increasing trend. China and its institutions were in a leading position regarding the publication number. With comparatively more scientific collaboration with China, the USA ranked second. Shanghai University of Traditional Chinese Medicine was the most prolific institution. Ha, In-Hyuk had the most publications, and Han JS and Lee A were the most cited authors. *Medicine* was the most popular journal and *Journal of Clinical Oncology* had the highest impact factor. "Acupuncture", "electroacupuncture" and "postoperative pain" were the top three keywords. The most popular topics were postoperative pain, postoperative ileus, and postoperative nausea and vomiting according to the keywords and references. And the clusters of postoperative cognitive dysfunction, anxiety, and breast cancer attracted relatively more attention recently.

Conclusion: This study summarized the research status, hotspots, and trends of acupuncture in perioperative medicine in the past decade, which may aid researchers in better understanding this field. The research hotspots primarily focused on postoperative pain management and postoperative gastrointestinal function. The research of acupuncture for postoperative cognitive dysfunction, cancer-related surgery, and psychological states were the main frontiers topics and may be the focus in the future.

Keywords: acupuncture, perioperative medicine, post-operative, mid-operative, CiteSpace, VOSviewer

Introduction

The perioperative period was divided into the pre-operative, mid-operative, and post-operative periods according to the time, including the patient's preoperative preparation, surgery, and postoperative treatment.[1] Modern medicine has improved surgical safety, but reducing perioperative complications, mortality, and patient prognosis remains a pressing issue. The preoperative status of patients could affect the patient's tolerance to surgery and the risk of surgical complications.[2] Moreover, intraoperative anesthesia, operation stress, and post-traumatic inflammatory response can

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also affect the prognosis and recovery of patients.[3] Therefore, the concept of "perioperative medicine" was put forward for the prevention of surgery-related adverse events and improvement in surgical patient outcomes.[4]

Acupuncture as a non-pharmacological therapy has been used to treat a variety of diseases, especially many types of pain.[5] Acupuncture has obvious anti-inflammatory and analgesic effects on various diseases,[6] which could regulate inflammatory cytokines and immune function and treat inflammatory pain with significant anti-inflammatory and antioxidant effects.[7] The application of acupuncture therapy in perioperative medicine mainly originated from the emergence of acupuncture anesthesia, and thereafter, several studies confirmed that acupuncture therapy had many therapeutic benefits beyond pain management in the perioperative period.[8] Perioperative acupuncture aims to reduce stress response, pain, postoperative complications, and mortality, and plays a significant role in the postoperative recovery of patients.[8,9] Over the past decade, there was numerous literature related to the research on acupuncture in perioperative medicine when searching the Web of Science. In order to better understand the status and development of studies in this field, it is necessary to investigate the characteristics, hotspots, and trends of the related studies.

With the advancement of computer technology, information has become digitized, networked, and knowledge-based. Bibliometric analysis was widely used in the quantitative study of existing literature in a specific field to study the internal relationship between information through the acquisition and visual analysis of literature.[10] In recent years, bibliometric analysis has been used in the analysis of acupuncture for heart diseases,[11] gynecological and obstetrical diseases,[12] migraine,[13] and other ailments. However, no reports on the application of acupuncture therapy in perioperative medicine have been discovered. In this study, we aimed to analyze the general information and identify the hotspots and trends of the application of acupuncture in perioperative medicine across 10 recent years by bibliometric analysis.

Materials and Methods

Search Strategy and Data Retrieval

All publications were obtained from the Web of Science Core Collection on February 28, 2023. The search strategy: (TS = (Post$operat* OR pre$operat* OR intra$operat* OR peri$operat* OR Post$surgical OR pre$surgical) OR TI = (operation OR surgery OR *ectomy)) AND TS = (acupunct* OR acupoint* OR electroacupunct* OR electro-acupunct* OR auricular-acupunc* OR "auricular needle*" OR "transcutaneous electrical acupoint stimulation" OR acupre* OR moxibust*). The document types we included were articles and reviews and the time span was from 2013 to 2023. There was no restriction on language. We retrieved all files in the "Plain Text File" format, and "Full Record and Cited References" was selected for "Record Content". Articles and reviews were included in this study. The search flow is shown in Supplementary Figure 1.

Statistical Analysis Method

We used VOSviewer 1.6.18 and CiteSpace 6.1.R6 for the bibliometric analysis and Scimago Graphica for the geographical visualization. First, we conducted a series of manual checks and uniformly named identical names of the leading institutions and authors. The characteristics and knowledge map of the literature on acupuncture in perioperative medicine over the previous decade were described, and cooperation network maps of countries, institutions, authors, and journals were constructed to describe the contributions and cooperation. In addition, analyses of co-occurrence, clusters, timeline, and landscape view of keywords were used to identify the related research hotspots and trends.

The VOSviewer counting method was selected as full counting. The CiteSpace parameters were as follows: (1) time slicing: from 2013 to 2023, years per slice: 1; (2) node selection type: one at a time; (3) selection criteria: g-index: k = 25; (4) pruning: pathfinder, pruning sliced networks. In the Visualization, each node represented a unit (such as a country, institution, author, etc), and the size of the node indicated the frequency. The lines between nodes represent cooperation or co-occurrence, with thicker lines indicating more cooperation or co-occurrence between them.

Results

Annual Numbers of Publications

By searching the Web of Science Core Collection, 900 records were retrieved from 2013 to 2023. We retained articles (n = 623) and reviews (n = 191) for bibliometric analysis, with a total of 814 publications (Supplementary Figure 1). The

annual number of publications on acupuncture in perioperative medicine across 10 recent years is shown in Figure 1. In the past decade, the number of published articles shows an overall upward trend in this field, with a fluctuating increase from 2013 to 2018, and a gradual increase since 2018.

Distribution of Countries/Regions

From 2013 to 2023, 814 publications were published by researchers in 49 countries/regions. Figure 2A shows the countries/regions with the number of publications more than 20 and Figure 2B shows the annual publication number growth of the nine countries/regions on the study of acupuncture in perioperative medicine. China was top-ranked with the highest number of publications (n = 407), followed by the United States (USA) (n = 160) and South Korea (n = 58). Consistent with the number of papers, the top three countries of total citations were China, the USA, and South Korea. The number of relevant publications in China shows an upward trend, while that in the other eight countries/regions is relatively flat. A country distribution map was generated with VOSviewer and Scimago Graphica software as shown in Figure 2C. China and the USA played significant roles in the research of this field with a relatively close cooperative relationship and formed their own cooperation networks. Related research was also popular in many European countries.

Distributions of Institutions

The top 10 prolific institutions of the 814 publications that have made contributions to the research on acupuncture in perioperative medicine were analyzed in Table 1. Eight of the 10 institutions were in China, the other two were in the USA and South Korea. Shanghai University of Traditional Chinese Medicine (n=35), Guangzhou University of Chinese Medicine (n=30), and Beijing University of Chinese Medicine (n=25) were the top three most prolific institutions. Among these top 10 organizations, the University of California System had the highest total citations and mean citations per publication. As shown in Figure 3, most institution collaborations were mainly intra-national, and the thin links between the nodes indicated that the academic exchanges across institutions were not rich enough.

Analysis of Authors and Cited Authors

The authors and cited authors were analyzed in the maps in Figure 4. Table 2 lists the top 15 authors with the most publications. Ha In-Hyuk published the most papers (n = 12), followed by Chen Jian-De (n = 9), and the two were the most prolific authors in this field. H-index comprehensively analyzes the number of publications and citation frequency of scholars, which is an indicator to measure the academic influence of researchers.[14] Among the top 10 authors, Ha In-Hyuk, Chen Jian-De, and An Li-Xin had the

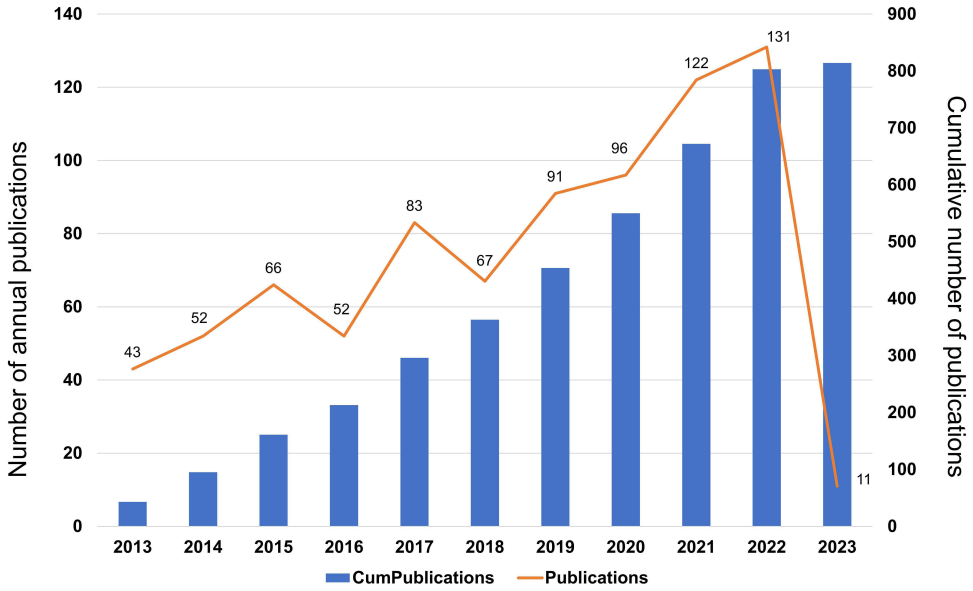


Figure 1 The annual and cumulative number of publications from 2013 to 2023.

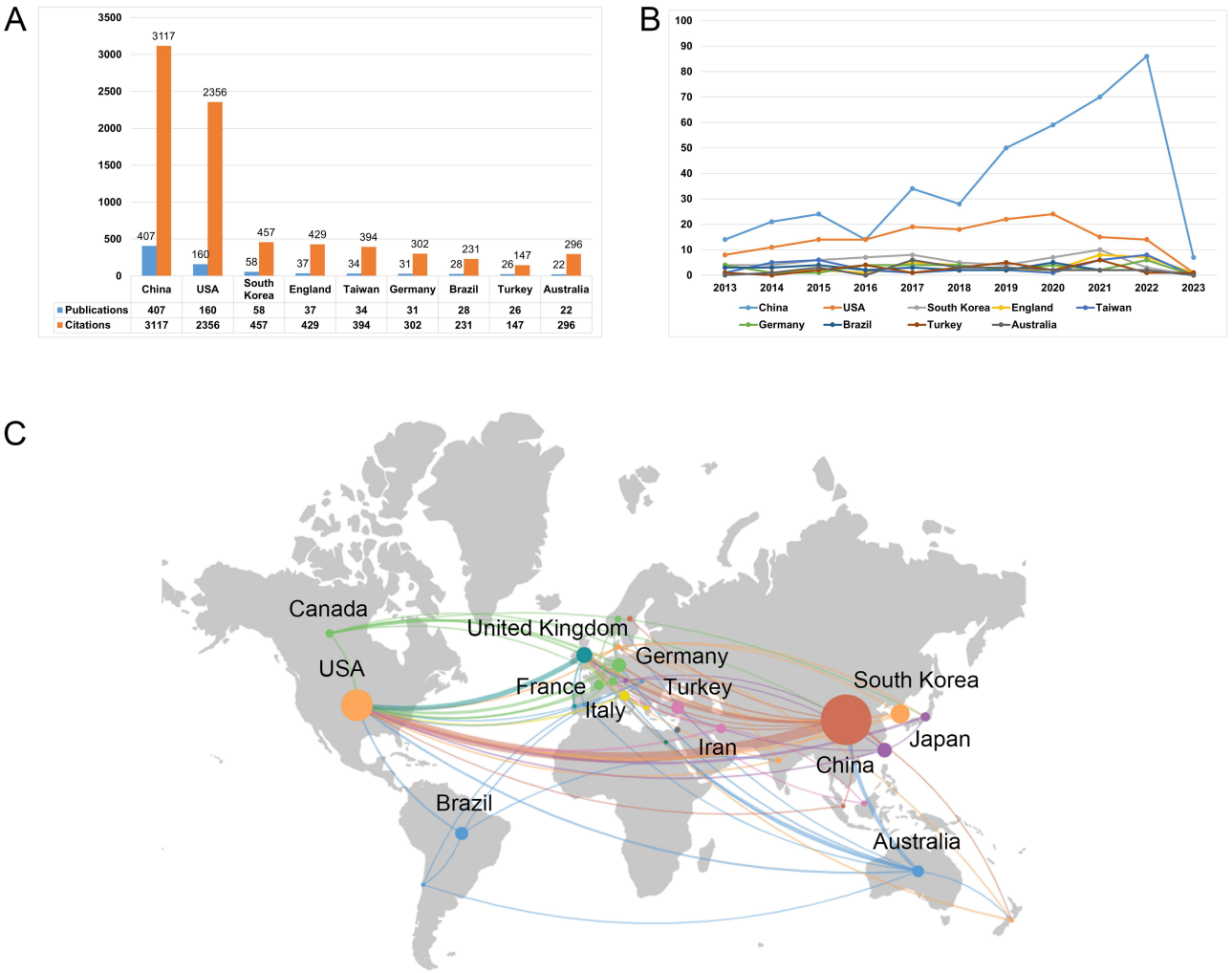


Figure 2 (**A**) The countries/regions with more than 20 publications. (**B**) The annual publication number growth of the countries/regions with more than 20 publications. (**C**) The distribution map of countries/regions.

highest H-index, indicating the high contribution of these three authors to the research of acupuncture in perioperative medicine. As shown in the author's contribution map (Figure 4A), the relationship between the authors was not close and the distribution was scattered, and the main cooperation relationship formed was mainly regional. Supplementary Table 1 shows the top 10 cited

Table 1 The Top 10 Institutions with the Most Publications

Affiliations	Publications	Citations	Mean Citations/ Publication
Shanghai University of Traditional Chinese Medicine	35	171	4.89
Guangzhou University of Chinese Medicine	30	141	4.7
Beijing University of Chinese Medicine	25	209	8.36
Capital Medical University	21	205	9.76
Kyung Hee University	21	111	5.29
Nanjing University of Chinese Medicine	19	74	3.89
Zhejiang Chinese Medical University	19	110	5.79
Chengdu University of Traditional Chinese Medicine	18	29	1.61
China Medical University Taiwan	18	264	14.67
University of California System	18	389	21.61

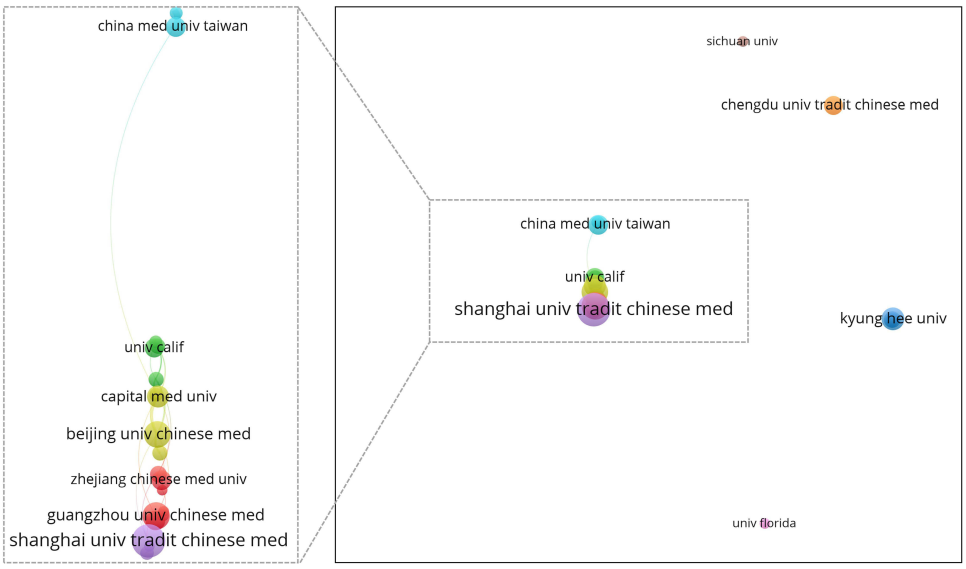


Figure 3 The distribution map of institutions.

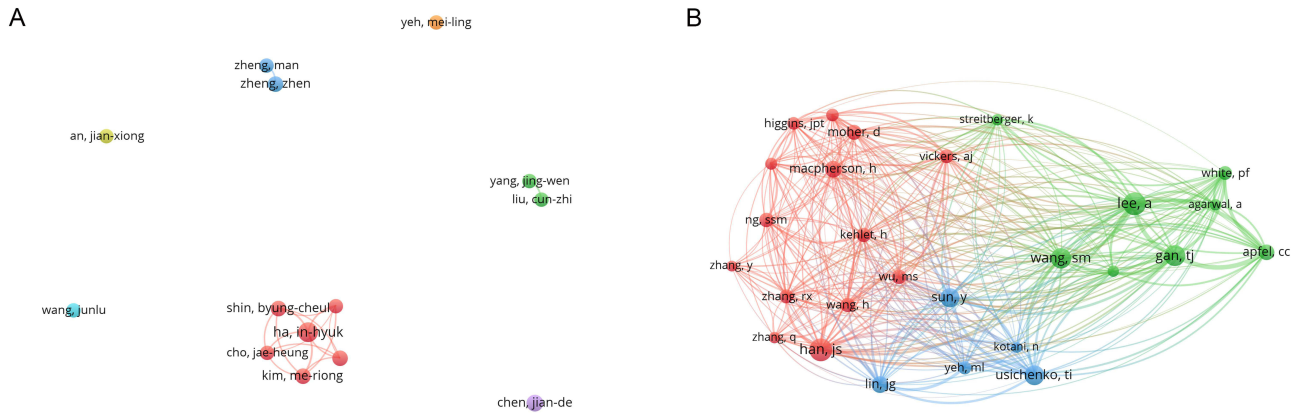


Figure 4 (**A**) The distribution map of authors. (**B**) The co-citation map of cited authors.

authors with the most citations. Han JS and Lee A were the most cited author, followed by Gan TJ, indicating the academic influence in this field. Figure 4B shows the co-citation of the cited authors with 3 main clusters.

Analysis of Journals and Subject Categories

All 814 papers were published in 303 journals. Table 3 lists the top 10 Journals with the largest number of publications, and 25% of papers were published in the top five journals. *Medicine* was the most popular journal with 63 publications, followed by *Evidence-Based Complementary and Alternative Medicine* (n = 60) and *Trials* (n = 34). Regarding citations, the top three journals were *Evidence-Based Complementary and Alternative Medicine, Acupuncture in Medicine*, and *PLoS One* (Supplementary Table 2). *Journal of Clinical Oncology* had the highest impact factor (IF = 50.717), followed by *Signal Transduction and Targeted Therapy* (IF = 38.104) and *Gastroenterology* (IF = 33.883) (Supplementary Table 3). There were 29 papers published in journals with an impact factor of more than 10. As shown in Supplementary Table 4, according to the description on Web of Science, the top 3 categories of the literature were Integrative & Complementary Medicine, Medicine/General & Internal, and Medicine/Research & Experimental.

Table 2 The Top 15 Authors with the Most Publications

Author	Publications	Citations	Mean Citations/ Publication	H-Index
Ha, In-Hyuk	12	128	10.67	6
Chen, Jian-De	9	103	11.44	6
Shin, Byung-Cheul	8	113	14.13	5
Kim, Me-Rong	8	63	7.88	4
Lee, Jun-Hwan	8	58	7.25	4
Zheng, Zhen	8	47	5.88	4
Yeh, Mei-Ling	7	189	27	5
An, Li-Xin	7	118	16.86	6
Yang, Jing-Wen	7	66	9.43	3
Liu, Cun-Zhi	7	66	9.43	3
Lee, Yoon-Jae	7	51	7.29	3
Wang, Jun-Lu	7	49	7	4
Cho, Jae-Heung	7	38	5.43	4
Zheng, Man	7	37	5.29	3
An, Jian-Xiong	7	30	4.29	4

Table 3 The Top 10 Journals with the Most Publications

Journal	Publications	Citations	Mean Citations/ Publication	IF (2022)
Medicine	63	165	2.62	1.817
Evidence-Based Complementary and Alternative Medicine	60	495	8.25	2.65
Trials	34	151	4.44	2.728
Acupuncture in Medicine	31	475	15.32	1.976
BMJ Open	15	65	4.64	3.006
International Journal of Clinical and Experimental Medicine	14	47	3.36	N/A
PLoS One	13	331	25.46	3.752
Chinese Journal of Integrative Medicine	13	112	8.62	2.626
Journal of Pain Research	13	58	4.46	2.832
Journal of Traditional Chinese Medicine	13	52	4	2.547

Analysis of Documents and Cited References

We analyzed and listed the top 10 documents and the co-cited references with the most citations (Table 4 and Table 5). As illustrated in Figure 5A, a visualization of the cited references about acupuncture in perioperative medicine was generated and 14 primary clusters were displayed, indicating the focus of relevant research. To clearly understand the development trends of acupuncture in the perioperative period, we generated the timeline visualization of the cited references (Figure 5B). The largest three clusters were #0 critical overview, #1 research progress, and #2 postoperative nausea. Notably, recently formed clusters include #9 surgery-induced cognitive dysfunction, #10 clinical efficacy, and #11 anxiety disorder, and clusters #0, #1 and #8 remain developing, indicating current research trends. In the timeline visualization, the presence of purple rings identified key nodes, indicating a centrality of at least 0.1. These nodes are listed in Supplementary Table 5. Among them, the article with the highest centrality was published by Fang et al in 2017 and showed that electroacupuncture promoted the recovery of postoperative ileus through nerve stimulation.[15] Figure 5C shows the top 20 references with the strongest citation bursts. A systematic review and meta-analysis[16] of acupuncture for postoperative pain management had the strongest citation burst. Six references related to the research of electrical stimulation on acupoints in the perioperative period showed a currently active citation burst.[17–22]

Table 4 The Top 10 Documents with the Most Citations

Rank	Document (First Author, Year)	Title	Journal	Citations
1	Garcia MK, 2013	Systematic Review of Acupuncture in Cancer Care: A Synthesis of the Evidence	Journal of Clinical Oncology	191
2	Tan M, 2015	Optimizing pain management to facilitate Enhanced Recovery After Surgery pathways	Canadian Journal of Anesthesia/Journal canadien d'anesthésie	167
3	Tick H, 2018	Evidence-Based Nonpharmacologic Strategies for Comprehensive Pain Care: The Consortium Pain Task Force White Paper	Explore-The Journal of Science and Healing	150
4	Lee A, 2015	Stimulation of the wrist acupuncture point PC6 for preventing postoperative nausea and vomiting	Cochrane Database of Systematic Reviews	129
5	Wu MS, 2016	The Efficacy of Acupuncture in Post-Operative Pain Management: A Systematic Review and Meta-Analysis	PLoS One	121
6	Tao WW, 2016	Effects of Acupuncture, Tuina, Tai Chi, Qigong, and Traditional Chinese Medicine Five-Element Music Therapy on Symptom Management and Quality of Life for Cancer Patients: A Meta-Analysis	Journal of Pain and Symptom Management	105
7	Manyande A, 2015	Non-pharmacological interventions for assisting the induction of anaesthesia in children	Cochrane Database of Systematic Reviews	102
8	Deng GE, 2013	Complementary Therapies and Integrative Medicine in Lung Cancer Diagnosis and Management of Lung Cancer, 3rd ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines	Chest	98
9	Ng SSM, 2013	Electroacupuncture Reduces Duration of Postoperative Ileus After Laparoscopic Surgery for Colorectal Cancer	Gastroenterology	97
10	Michaelides A, 2019	Depression, anxiety and acute pain: links and management challenges	Postgraduate Medicine	97

Table 5 The Top 10 Co-Cited References with the Most Citations

Rank	Document (First Author, Year)	Title	Citations
1	Sun Y, 2008	Acupuncture and related techniques for postoperative pain: a systematic review of randomized controlled trials	86
2	Wu MS, 2016	The Efficacy of Acupuncture in Post-Operative Pain Management: A Systematic Review and Meta-Analysis	64
3	Ng SSM, 2013	Electroacupuncture Reduces Duration of Postoperative Ileus After Laparoscopic Surgery for Colorectal Cancer	59
4	Lee A, 2015	Stimulation of the wrist acupuncture point PC6 for preventing postoperative nausea and vomiting	54
5	Zhang RX, 2014	Mechanisms of Acupuncture-Electroacupuncture on Persistent Pain	46
6	Wang H, 2014	Transcutaneous electric acupoint stimulation reduces intra-operative remifentanil consumption and alleviates postoperative side-effects in patients undergoing sinusotomy: a prospective, randomized, placebo-controlled trial	44
7	Kotani N, 2001	Preoperative intradermal acupuncture reduces postoperative pain, nausea and vomiting, analgesic requirement, and sympathoadrenal responses	40
8	Han JS, 2004	Acupuncture and endorphins	37
9	Zhao ZQ, 2008	Neural mechanism underlying acupuncture analgesia	37
10	Han JS, 2003	Acupuncture: neuropeptide release produced by electrical stimulation of different frequencies	36

Dual-Map Overlay visualization can display the distribution of papers in each subject, citation trajectory, the centre of gravity drift, and other information.[23] As shown in the dual-map overlay visualization (Figure 6), the literature primarily appears in two areas in the citing map on the left: the area in green with the label medicine/medical/clinical and the area

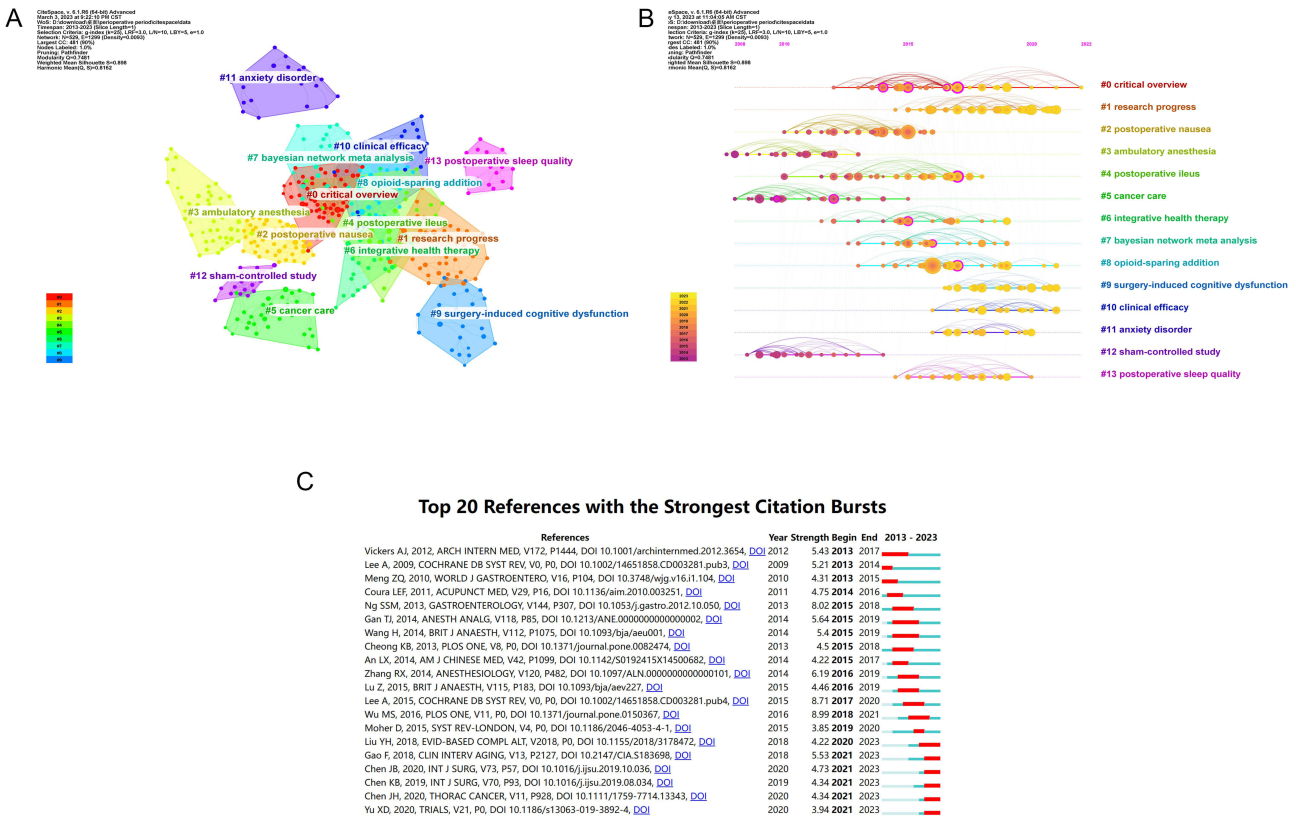


Figure 5 (**A**) The clusters of cited references in this study. (**B**) Timeline view of the cited references in this study. (**C**) Top 20 references with the strongest citation burst.

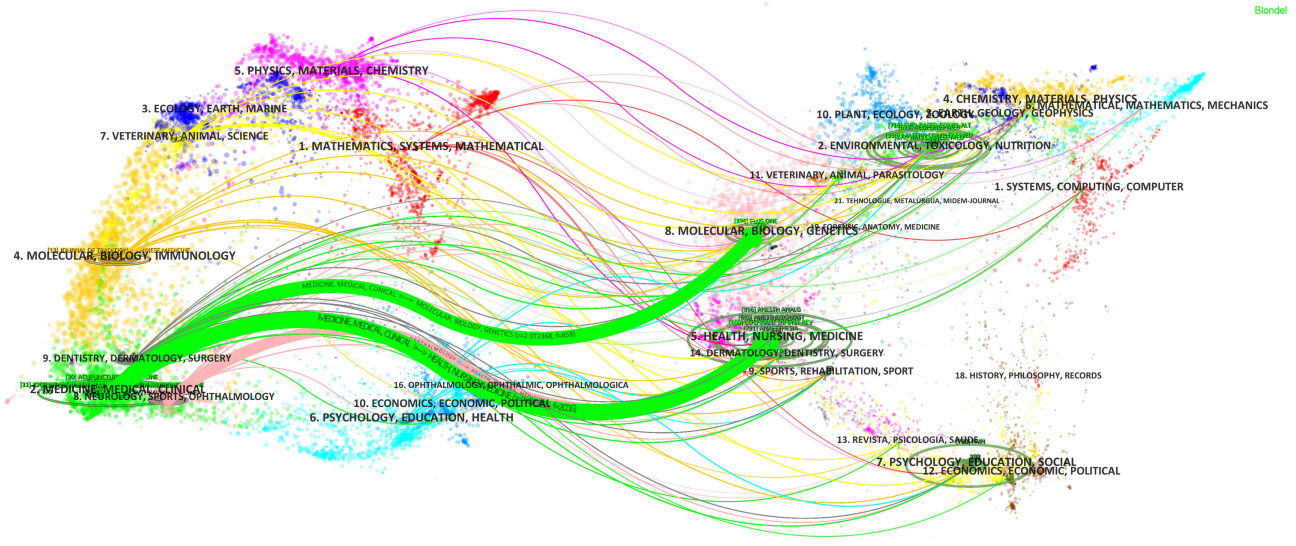


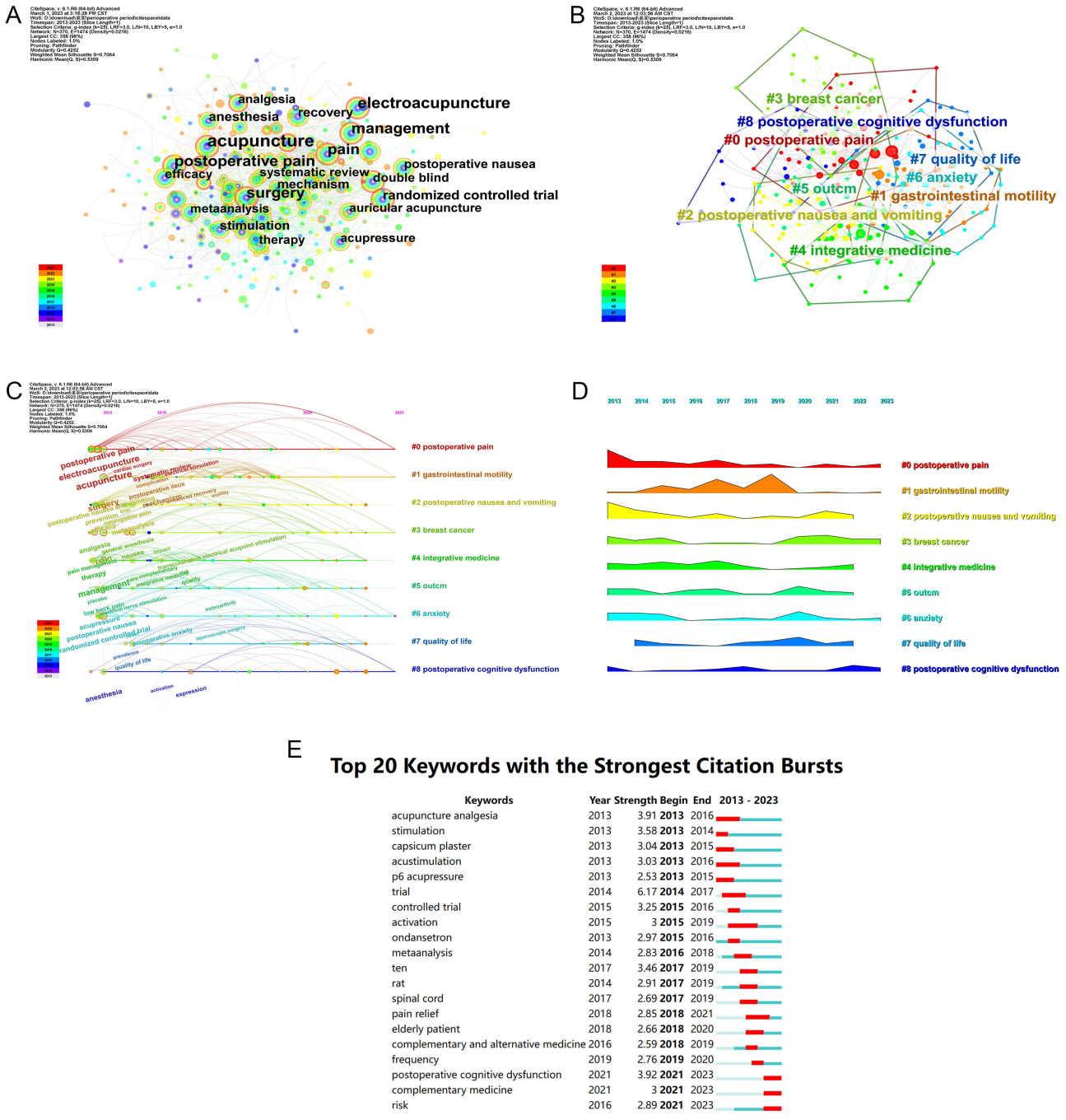
Figure 6 Dual-map overlay visualization of documents related to acupuncture in the perioperative period.
Notes: The labels on the left-hand of the map represent the discipline of the journal in which the articles appear, the labels on the right-hand represent the discipline of the cited journal in which the references cited by articles, and the curves of trajectories originating from the citing map (left) and pointing to the cited map (right) represent the citation path connecting lines that illustrate the flow of knowledge and linkages across different research fields.[24]

in pink with the label neurology/sports/ophthalmology, indicated the application fields of acupuncture in perioperative medicine. Citation curves originated from the two regions primarily pointed to two regions in green with the label of molecular/biology/genetics and health/nursing/medicine in the cited map on the right, indicating the research basis of this field.

Analysis of Keywords

Keywords summarize the research and the topic information of the article. A total of 3065 keywords from 814 publications were analyzed. The keyword co-occurrence map consisted of 370 nodes and 1474 links (Figure 7A). The top five most frequently used keywords were "acupuncture", "electroacupuncture", "postoperative pain", "management" and "surgery". Among the 20 most frequent keywords, six related to the intervention of treatment, eight related to symptoms, and six related to the type of study (Table 6).

Keywords cluster can present the structural system of related research fields. The results of keywords clustering showed Q > 0.3, and S > 0.7, indicating that the cluster structure was significant and the results were credible. The



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Top 20 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2013 - 2023
acupuncture analgesia	2013	3.91	2013	2016	
stimulation	2013	3.58	2013	2014	
capsicum plaster	2013	3.04	2013	2015	
acustimulation	2013	3.03	2013	2016	
p6 acupressure	2013	2.53	2013	2015	
trial	2014	6.17	2014	2017	
controlled trial	2015	3.25	2015	2016	
activation	2015	3	2015	2019	
ondansetron	2013	2.97	2015	2016	
metaanalysis	2014	2.83	2016	2018	
ten	2017	3.46	2017	2019	
rat	2014	2.91	2017	2019	
spinal cord	2017	2.69	2017	2019	
pain relief	2018	2.85	2018	2021	
elderly patient	2018	2.66	2018	2020	
complementary and alternative medicine	2016	2.59	2018	2019	
frequency	2019	2.76	2019	2020	
postoperative cognitive dysfunction	2021	3.92	2021	2023	
complementary medicine	2021	3	2021	2023	
risk	2016	2.89	2021	2023	

Figure 7 (**A**) Network of keywords about perioperative acupuncture. (**B**) The clusters of keywords in this study. (**C**) Timeline view of the keywords in this study. (**D**) The landscape view of the keywords clusters. (**E**) The top 20 keywords with the strongest citation bursts.

Table 6 The Top 20 Keywords with the Most Frequency

Rank	Keywords	Count	Centrality	Rank	Keywords	Count	Centrality
1	Acupuncture	237	0.01	11	Stimulation	48	0.08
2	Electroacupuncture	155	0.06	12	Postoperative nausea	47	0.06
3	Postoperative pain	129	0.09	13	Efficacy	46	0.04
4	Management	126	0.03	14	Double blind	46	0.10
5	Surgery	121	0.04	15	Therapy	44	0.05
6	Pain	108	0.06	16	Systematic review	45	0.03
7	Anesthesia	60	0.03	17	Acupressure	43	0.04
8	Randomized Controlled trial	59	0.1	18	Analgesia	43	0.05
9	Recovery	53	0.05	19	Meta-analysis	43	0.02
10	Mechanism	50	0.04	20	Auricular acupuncture	40	0.06

timeline and landscape visualization can illustrate each cluster's evolution and research process throughout time. We analyzed the top nine clusters of the keywords: "postoperative pain", "gastrointestinal motility", "postoperative nausea and vomiting", "breast cancer", "integrative medicine", "outcome", "anxiety", "quality of life" and "postoperative cognitive dysfunction" in Supplementary Table 6 and Figure 7B and arranged on a horizontal timeline in Figure 7C. The figure of the landscape shows that in the past decade, the clusters "postoperative pain", "postoperative nausea and vomiting", "breast cancer" and "anxiety" attracted more attention in the early stage. Then, the study of acupuncture for postoperative gastrointestinal motility attracted researchers' eyes. In recent years, several studies have been conducted on the clusters "postoperative cognitive dysfunction", "breast cancer" and "anxiety" (Figure 7D).

"Burst words" are the keywords that occur more frequently over a period of time and can help us explore the development trends of the field. The top 20 keywords with the strongest citation bursts from 2013 to 2023 are illustrated in Figure 7E. In terms of strength, the top five burst keywords were "trial", "postoperative cognitive dysfunction", "acupuncture analgesia", "stimulation" and "TEN". It is worth noting that the keywords "postoperative cognitive dysfunction", "complementary medicine" and "risk" had high citation bursts in recent years.

Discussion

We performed a bibliometric analysis of acupuncture in perioperative medicine across 10 recent years by searching the Web of Science Core Collection, aimed to summarize the general information and research hotspots and trends in this area. A total of 814 publications were included in this study, with 623 articles and 191 reviews. From 2013 to 2023, the annual number of publications in this field showed an overall upward trend, indicating that the attention to the application of acupuncture in the perioperative period has gradually increased.

General Information

With the expansion of the international influence of acupuncture and the confirmation of its efficacy and safety, the application of acupuncture therapies in the perioperative period has steadily garnered the interest of researchers worldwide. China, the origin of acupuncture, was the most productive country with an increasing annual publication number and the highest number of citations. Consistent with the analysis of countries, eight of the top 10 prolific organizations are located in China, which also indicated the great contributions of China in this field. The USA also made an important contribution with relatively more research cooperation with China. Moreover, several European countries contributed to research in this field and cooperated with other countries. According to the analysis of institutions, the top 10 prolific research institutions were primarily the universities of traditional Chinese medicine. Overall, the cooperation between institutions is mostly within the same country, and the cooperation is not close. Therefore, cooperation between countries and institutions should be strengthened to promote research development.

According to the contribution of the authors, Ha In-Hyuk was the most prolific author and mainly focused on the efficacy of acupuncture therapies on postoperative pain, especially after back surgery.[25–27] Chen Jian-De, who ranked second, mainly contributed to the research on the effect of acupoint electrical stimulation on postoperative

symptoms, especially the effect of electrical stimulation on nerve activity.[28–31] Ha In-Hyuk and Chen Jian-De also had the highest H-index among the top 15 prolific authors, as well as An Li-Xin. An Li-Xin and her team mainly contributed to the research on electroacupuncture (EA) and transcutaneous electrical acupoint stimulation (TEAS) in perioperative medicine.[32–35] The main cooperation network among the top 15 prolific authors included Ha In-Hyuk, Shin Byung-Cheul, Kim Me-Rong, Lee Jun-Hwan, Lee Yoon-Jae, and Cho Jae-Heung and five of whom come from South Korea. The authors with the most publications did not form close cooperation as a whole, and much of the cooperation existed in the same countries/regions or institutions. To advance the research in this field, cooperation and academic exchange should be strengthened. Moreover, Han JS and Lee A were the most co-cited authors, indicating a high academic influence of them in this field. Professor Lee made contributions to the related research of anesthesia and intensive care. The research achievements of Professor Han were influential in the study of acupuncture for perioperative pain management.

Most of the articles we extracted had low IF scores, in terms of the IF of the top 10 popular journals. Therefore, more high-quality studies are needed in this field. According to the IF in 2022, the journal with the highest IF score of the included literature was *Journal of Clinical Oncology*. This journal published a systematic review of acupuncture in cancer care, including eight randomized controlled trials (RCTs) of acupuncture for cancer-related postoperative ileus, and the review ranked first in terms of citations.[36] The journal *Signal Transduction and Targeted Therapy* ranked second, which published an article about the potential therapeutic target for postoperative cognitive dysfunction (POCD).[37] Moreover, the journal with the third highest impact factor was *Gastroenterology*, and these three journals had an impact factor of more than 30.

Research Hotspots of Acupuncture in Perioperative Medicine

The application of acupuncture therapies in the perioperative period has been widely concerned, and the research direction is gradually specified. A growing number of clinical trials and animal studies provided evidence of the efficacy and safety of perioperative acupuncture and related mechanism research. Among them, RCTs attracted more attention. In this study, we investigated the research hotspots by analyzing keywords and cited references.

Keywords summarize the research and the topic information of the article. The top five keywords with the most frequency were acupuncture, electroacupuncture, postoperative pain, management, and surgery. Notably, four keywords were relevant to pain management among the top 20. Acupuncture for perioperative pain management is among the research hotspots, as evidenced by the fact that postoperative pain was also the top cluster of keywords. The analysis of keywords and literature both revealed that postoperative pain is a classic research topic. Meanwhile, the top co-cited authors and cited reference[38] universally focused on the application of acupuncture in pain management. Professor Han JS, one of the most co-cited authors, systematically studied the mechanism of acupuncture analgesia from a central neurochemical perspective and found that different electrical stimulation on acupoints can affect the release of endogenous opioid peptides in the central nervous system to achieve analgesia,[37,39,40] providing the research basis for postoperative pain treatment with acupuncture.

Postoperative pain is one of the major adverse events after surgery, that can delay postoperative recovery and prolong hospital stay, and the analgesics for postoperative pain may lead to the occurrence of other complications.[41] Acupuncture can effectively relieve postoperative pain and reduce the consumption of analgesics,[16] which have been widely accepted in postoperative pain management, and the annual related studies have fluctuated upwards in the past two decades.[42] We classified the contents of the literature related to postoperative pain and found that EA and TEAS were the widely concerned interventions and the outcome measures were mainly the pain level, the dose of analgesic consumption, quality of life, and adverse events. The cited references with the most citations indicated acupuncture therapies were beneficial to postoperative pain management and reduced the incidence of opioid-related side effects.[38] Besides clinical trials, several animal experiments have been conducted to investigate the underlying mechanism of acupuncture for postoperative pain including peripheral and central mechanisms.[43–45]

The three biggest topics determined by keywords cluster analysis are #0 postoperative pain, #1 gastrointestinal motility, and #2 postoperative nausea and vomiting. Furthermore, according to the clusters of cited references, postoperative nausea is the third biggest cluster. Additionally, the cited references with high centrality mainly focused on anesthesia and pain management as well as postoperative ileus. Therefore, the analysis of keywords and cited references

indicated the research hotspots of acupuncture for gastrointestinal function recovery in addition to postoperative pain management. Protocols for Enhanced Recovery After Surgery (ERAS) include restoring gastrointestinal function to avoid postoperative ileus and postoperative nausea and vomiting.[46] Gastrointestinal motility dysfunction often occurs after surgery, leading to the occurrence of postoperative ileus.[47] In *Gastroenterology*, the journal with the third-highest impact factor in this study (33.88), Ng et al present data indicating that EA could reduce the duration of postoperative ileus and hospital stay after laparoscopic surgery for colorectal cancer,[48] and a recent article published in *JAMA Surgery* confirm these finding.[49] For preventing and treating postoperative nausea and vomiting (PONV), acupuncture as a safe and effective non-pharmacologic therapy attracted much attention. In the included literature, the commonly used acupuncture types for PONV were manual acupuncture, EA, TEAS, auricular acupuncture and acupressure. Concerning the acupoint, the PC6 (*Neiguan*) acupoint was utilized more frequently in studies of acupuncture for the prevention and treatment of PONV and several systematic reviews and clinical trials revealed therapeutic evidence.[50–52] As shown in the figure of the top 20 burst keywords, research on acupressure on PC6 acupoints bursted from 2013 to 2015, indicating considerable attention on related research during this period. Moreover, anxiety disorder and quality of life also attracted more attention according to the clusters of keywords and cited references.

Research Trend of Acupuncture in Perioperative Medicine

The research trend of acupuncture in perioperative medicine was identified from the timeline and landscape visualization and the strongest citation bursts of keywords as well as the cited references.

From the timeline and landscape visualization of keywords, the topics "breast cancer" and "postoperative cognitive dysfunction" have been active in the timeline recently, followed by "postoperative pain" and "anxiety", which may predict that these fields will become hotspots for future research. "Burst words" can also help us explore the frontier topics or development trends of the field.[53] Trial, postoperative cognitive dysfunction, acupuncture analgesia, stimulation, and TEN were the five strongest citation bursts of keywords according to the analysis of burst words. In particular, postoperative cognitive dysfunction had a high citation burst in the last three years. Therefore, we concluded that the research of acupuncture for POCD and breast cancer were the main frontier topic, which attracted relatively more attention in the last three years and may be promising in the next few years. In the research on POCD in the included literature, we found the majority of subjects were elderly patients or aged rats, and the acupoints of ST36 (*Zusanli*) were used frequently. Regarding the intervention, there are many studies on the improvement of postoperative cognitive function by EA, mainly focusing on the expression of neuroinflammatory response and related pathways.[54,55] Acupuncture for cancer-related surgery (especially breast cancer) has also been widely conducted recently. Among the literature included in this study, a systematic review of acupuncture in cancer care had the highest citations.[36] Patients with breast cancer often received a mastectomy, studies showed that TEAS was helpful for postoperative pain management and improved immune function in the perioperative period.[56,57] Furthermore, postoperative pain, the primary focus in this field over the past decade, has continued to evolve, and perioperative psychological state is also attracting attention currently.

The timeline visualization of the cited references illustrated the evolution of this field. Consistent with the analysis of keywords, the cluster formed by more recently cited references included #8 opioid-sparing addition, #9 surgery-induced cognitive dysfunction, and #11 anxiety disorder, which may provide a direction for follow-up research. Cluster #8 was mainly about perioperative pain management and drug consumption. Acupuncture has a potential role in reducing the prevalence of opioids or other perioperative pharmacologic agents for perioperative complications, making it an ideal candidate for integration into ERAS and other opioid-sparing procedures.[58] Cluster #9 mainly related to citing articles published in the past two years on the research of EA or TEAS in the treatment of POCD in elderly subjects. Besides, the research on acupuncture improving postoperative mental state has gradually attracted attention, forming the research trends in recent years. The key cited reference with high centrality mainly focused on anesthesia and pain management as well as postoperative ileus. In particular, the cited reference with the highest centrality was an experimental animal study on postoperative ileus,[15] and the relevant research received more attention in the early and middle stages of the last decade.

Regarding the strongest citation burst, the reference with the highest strength was a systematic review and meta-analysis, which evaluated the efficacy of acupuncture in postoperative pain management.[16] There were six references with the strongest citation bursts in recent three years related to electrical stimulation on acupoints. TEAS and EA were the important acupuncture methods, that combined the benefits of electrical stimulation and traditional acupuncture therapy. TEAS and EA were increasingly accepted in perioperative medicine and were shown to be beneficial for postoperative recovery.[28,59] Kang et al believed EA is more suitable than traditional manual acupuncture for scientific research with more standardized parameters.[60] A growing number of clinical studies have been conducted to evaluate the efficacy and safety of EA and TEAS in the perioperative period and the related mechanism research has gradually penetrated the molecular level of the central neural system.[61]

In a word, this study analyzed the general information and identified the research hotspots and trends of acupuncture in perioperative medicine in the past decade by bibliometric analysis. Most research on the application of acupuncture in perioperative medicine focused on postoperative pain management and postoperative gastrointestinal functional recovery, especially for postoperative ileus and PONV. In particular, the topic of postoperative pain management is a classic research direction and remains developing in this field. The primary frontier areas now include POCD, breast cancer, and anxiety, and these areas may also show promise in the future. Moreover, postoperative quality of life has also attracted more attention recently. Meanwhile, EA and TEAS were popular acupuncture types and may still be focused on in future research.

With the increasing application of acupuncture in domestic and foreign research, it is widely accepted in perioperative medicine and several studies have demonstrated its therapeutic effects.[9,62] However, it was still mostly used as complementary and alternative medicine in perioperative medicine. A recent commentary published in *JAMA Surgery* discussed the complementary effect of acupuncture in the multimodal approach to enhance postoperative recovery, but further studies still need to be strengthened.[63] Therefore, more rigorous and scientific research should be designed to provide high-quality evidence for the feasibility of the application of acupuncture in perioperative medicine, and the research of exact mechanisms needs to be further strengthened in the future.

Limitations

There were limitations in this study, nonetheless. First, bibliometric analysis as a quantitative study cannot evaluate the quality of the included literature. Second, given that the publications in the Web of Science are continually updated, the literature we collected may differ from the actual number included. Furthermore, the earlier an article was published, the more citations it was likely to be. Therefore, the element of time needs to be taken into account in further studies.

Conclusion

This study provided valuable information for the application of acupuncture in perioperative medicine over the past decade. Acupuncture research in perioperative medicine is a popular area of study, as evidenced by the fact that this discipline has created an upward development trend and has considerable growth potential, according to the available general data. China and its institutions were in a leading position in the number of publications. On the whole, the cooperations of related research were mainly intra-national or regional. The research hotspots of acupuncture in perioperative medicine mainly focus on postoperative pain management and gastrointestinal functional recovery after surgery, especially for postoperative ileus and PONV, and the frontier topics mainly focus on POCD, cancer-related surgery (especially breast cancer), and psychological states (especially anxiety). In the future, the cooperation and academic exchange of countries, institutions, and authors need to be further strengthened to promote the development of research in this field and more rigorous and scientific research should be designed to provide high-quality evidence for the feasibility of the application of acupuncture in perioperative medicine.

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