Review Article

Research trends of acupuncture therapy for hypertension over the past two decades: a bibliometric analysis

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Abstract: Acupuncture has already been extensively utilized to treat high blood pressure (hypertension) in several nations. Nevertheless, the bibliometric research on the worldwide usage of acupuncture for hypertension is mostly unclear. As a result, our objective for the research aimed to investigate the present state as well as developments in the global usage of acupuncture on hypertension during the last 20 years using CiteSpace (5.8.R2). The Web of Science (WOS) database examined papers on acupuncture treatment of hypertension from 2002 to 2021. We examined the number of publications, cited journals, nations/regions, organizations, authors, cited authors, cited references, and keywords utilizing CiteSpace. The record of 296 documents was obtained between 2002 and 2021. The quantity and frequency of annual publications rose gradually. Regarding frequency and centrality of citations, Circulation and *Clin Exp Hypertens* (*Clinical and Experimental Hypertension*) scored top and second respectively. China had the most publications among countries/regions, as well as the five largest institutions were also in China. Cunzhi Liu was the most productive author, while P Li was the most referenced author. XF Zhao produced the first article inside the quantity of cited references classification. 'Electroacupuncture' had a significant frequency with centrality for the keywords, which suggested electroacupuncture is a popular treatment in this field. In the treatment of hypertension, electroacupuncture has a beneficial effect on reducing blood pressure. However, because of the many different applications of electroacupuncture frequencies in research, whether the electroacupuncture frequency is connected to the therapeutic impact should be given more significant consideration. The findings of this bibliometric analysis give an overview of the present state as well as developments of clinical studies on acupuncture for hypertensive patients during the last two decades, which could assist researchers in identifying hot subjects and exploring novel directions in further study within the field.

Keywords: Cardiovascular disease; hypertension; acupuncture; bibliometric analysis; CiteSpace

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Introduction

Hypertension is a common cardiovascular disease that seriously endangers people's health and is characterized by elevated systemic arterial pressure. Not only will it cause headache, dizziness and other clinical symptoms, but it also may involve essential organs such as the heart, brain, kidney, eye, etc., further triggering multi-system lesions or dysfunction, so hypertension has become the fuse of a variety of diseases, its disability rate and mortality rate are very high, bringing great physical and mental pain to patients (1).

In recent years, the incidence of hypertension has continued to grow, with more than 1 billion people with hypertension worldwide, and it is estimated that 1.56 billion people in the world will have hypertension by 2025 (2). Its disability and case fatality rates are also growing year after year, putting people's physical and emotional health at risk. Patients with high blood pressure require long-term medication. In the clinic, commonly used drugs include diuretics, angiotensin-converting enzyme inhibitors, calcium antagonists, etc. Nevertheless, these drugs have more contraindications and adverse responses such as headaches, dizziness, orthostatic hypotension, reduced sexual function and so on (3), which restricts the clinical utilization of available antihypertensive medications (4). Moreover, it also severely affects the quality of life for patients, which reduces medication compliance (4,5) and therefore produces an unstable antihypertensive efficacy. Therefore, patients with hypertension urgently need more efficient and secure therapy choices.

Acupuncture has been used to treat symptoms associated with hypertension for several thousand years and was developed in the discipline of traditional Chinese medicine in China. Currently, acupuncture is widely used by people all over the world, and it is also one of the most widely used alternative medicine therapy approaches. As a popular alternative and complementary therapy of traditional Chinese medicine, it is more and more valued by people and widely used in the clinical treatment of hypertension (6). A great number of researches have demonstrated that acupuncture is an effective treatment for hypertension (7,8), and it has a significant therapeutic effect in the treatment of hypertension (7-9). Moreover, as a non-pharmacological treatment, acupuncture has shown fewer adverse effects than pharmacological treatment.

Bibliometrics is the research of scientific publications that employ statistics to reveal connections between published works and analyze publishing trends. Similar to how epidemiologists query patient data to assess the health state of a population, academics use data about publications to answer questions about a discipline (10). Furthermore, bibliometrics is a multidisciplinary research area that uses mathematical and statistical techniques that objectively examine various information carriers. It refers to a thorough body of knowledge that incorporates philology, statistics, and arithmetic and emphasizes quantification (11,12). CiteSpace information visualization software can discover connections within and between disciplines through analytical methods such as co-citation and co-occurrence of keywords, citations, authors, etc. Moreover, it can grasp the hot issues of current academic research and predict the development direction of the discipline. It is one of the most popular knowledge graph drawing tools available (13,14).

A bibliometric approach has recently been used to analyze general trends in acupuncture studies (15,16). The prevalence and trends of acupuncture used for treating cerebral infarction, stroke, insomnia, and low back pain have been identified worldwide (17-21). However, based on bibliometric analysis, there currently needs to be more studies on the overall trends in acupuncture therapy for hypertension. Therefore, this paper used CiteSpace information visualization software to analyze the literature on acupuncture treatment of hypertension on the WOS over the last two decades and understand the research status, hot topics, trends of acupuncture treatment of hypertension from the number of articles, keyword co-occurrence, and reference citation, to provide a reference for the treatment and future development direction of hypertension by acupuncture in the future.

Methods

Data acquisition

The publications retrieved were from the WOS including SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI and CCR-EXPANDE on May 19, 2022. There were three components to the searching approach. Initially, we compiled a list of index words related to acupuncture therapy, such as acupuncture, moxibustion, warming needle moxibustion, warming acupuncture, manual acupuncture, point application therapy, ear acupuncture, auricular acupuncture, body acupuncture, electroacupuncture, electroacupuncture, electric needle, acupuncture point. The period ranges from 2002 to 2021 encompassed all languages and document kinds. As a result of this query, 30,717 records were retrieved.

Second, the topic search for index terms related to "hypertension" such as high blood pressure, hypertension, hypertensive, hypertension, hyperpiesis, hyperpiesia, hypertonia, essential hypertension, renovascular hypertensive, primary hypertension, genetic hypertension, resistant hypertension, secondary hypertension, renal parenchymal hypertension. The settings for language, document type, and time span are the same as for the first step of the query. This query produced 477,877 records.

Furthermore, we merged the results of the initial

Table 1 The topic search queries

Set	Results	Search query
#3	296	#2 AND #1
		Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDE. Timespan =2002–2021
#2	477877	(TS = (hypertension OR high blood pressure and hypertensive OR hypertension OR hyperpiesis OR hyperpiesia OR hypertonia OR renovascular hypertensive OR essential hypertension OR primary hypertension OR genetic hypertension OR resistant hypertension OR secondary hypertension OR renal parenchymal hypertension))
		Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDE. Timespan =2002–2021
#1	30717	(TS = (acupuncture OR moxibustion OR warming acupuncture OR warming needle moxibustion OR manual acupuncture OR point application therapy OR ear acupuncture OR auricular acupuncture OR body acupuncture OR electroacupuncture OR electro-acupuncture OR electric needle OR acupuncture point))
		Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDE. Timespan =2002–2021

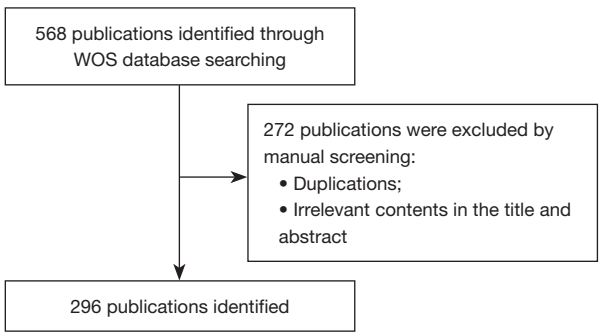

Figure 1 Flow chart of literature screening included in this study. WOS, Web of Science.

and second searches that discovered publications on acupuncture for hypertension. By this query, 568 records were generated. Literature duplicated or irrelevant to the research subject in the title and abstract was excluded. The final analysis yielded a total of 296 records. Moreover, the document types include original articles, randomized clinical trials (RCTs), cohort studies, review articles, case reports, letters, meeting abstracts, and discussions. *Table 1* and *Figure 1* displayed the topic search query.

Analysis method

In order to identify yearly publishing counts, the most popular journals, authors, institutions, and nations, bibliometric analysis was carried out using CiteSpace (5.8.R2) software. This study looked at trends and patterns in the detected publications. While this happened, methods including co-occurrence analysis of keywords, institutions, authors, and references were also used to investigate the connections between collaborations. Using bibliometric visual analysis, we could identify the theoretical underpinnings, current knowledge, and directions for future research on acupuncture as a hypertension therapy.

Import the full record plain text information into CiteSpace 5.8.R2 and set the parameters: time slicing: 2002–2021; years per slice: 1; term source: all options; node selection type: one at a time; pruning, pathfinder. The node and linkage graphs are then created. In general, such as an author, word, or institution is represented by each node on the map. The node size generally represents how frequently something occurs or is mentioned. The colored nodes indicate the years, and the colored circles extending from the node's interior to its exterior represent 2002 through 2021. In addition, the lines between nodes indicate cooperative, co-existential, or co-ingress relationships. Purple circles denote centrality, and nodes with high centrality are frequently considered significant or defining features within a specific region.

Results

Annual publications

There are 296 records in all, and *Figure 2* shows the number of publications by year. In addition, we could determine from *Figure 1* that there are numerous stages

in the study trends. In the initial period between 2002 and 2011, the annual publication count for acupuncture treating hypertension fluctuated slightly in the first phase. The publication count exhibited striking patterns of growth between 2011 and 2012. Nevertheless, from 2012 to 2017, the trend of publication volume tended to be stable, suggesting that the research field may have encountered a bottleneck and needs to be broken. Finally, from 2017 to 2020, the number of published publications has increased rapidly and continually again, from 18 references to 31 references. In general, acupuncture for hypertension has attracted increased attention over the past two decades, and the volume of literature on acupuncture treatment for hypertension has exhibited an overall rising trend.

Analysis of cited journal

The network of cited journals was generated by CiteSpace using a total of 5,870 references. *Table 2* lists the highest-ranked five journals by the number of citations as well as data on co-citation centrality. *Hypertension* ranked first in the frequency of cited journals [141], from second to fifth place in order *Circulation* [138], *Evid-Based Compl ALT* (*Evidence-based Complementary and Alternative Medicine*) [126], *Lancet* [102], and *J Altern Complem Med* (*Journal of Alternative and Complementary Medicine*) [91]. In terms of centrality, *Clin Exp Hypertens* (*Clinical and Experimental Hypertension*) (0.19) ranks highest, with *Acupunct Med* (*Acupuncture in Medicine*) (0.13), *Acupuncture Electro* (*Acupuncture & Electro-Therapeutics Research*) (0.11), *Am J Physiol-Heart C* (*American Journal of Physiology-Heart and Circulatory Physiology*) (0.11) and *Am J Cardiol* (*American Journal of Cardiology*) (0.11) rankings second to fifth in the order. Furthermore, as seen in *Figure 3*, these journals had a relatively close cooperative relationship inside the domain of acupuncture on hypertension therapy. The outer perimeter of these circles was brightly colored, which meant these journals had been valued by researchers in this field in recent years. One article got a large citation in the journal, cited in 126 records of *Evid-Based Compl ALT* (*Evidence-based Complementary and Alternative Medicine*). It performed that acupuncture treatment at specific acupuncture points causes changes in the expression of selective microRNA (miRNA) in spontaneously hypertensive rats (SHRs), which plays an excellent therapeutic role in hypertension (22). This article presented evidence in favor of using acupuncture therapy to treat hypertension.

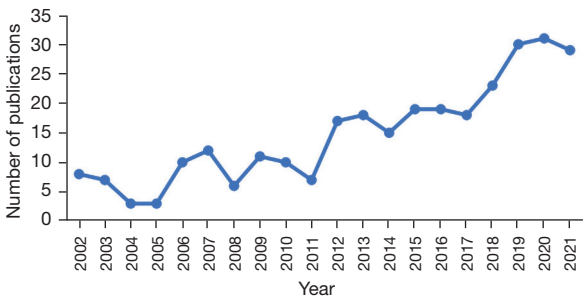

Figure 2 The annual number of publications on acupuncture for hypertension.

Analysis of countries/regions and institutes

CiteSpace was used to create a country/region distribution map (*Figure 4*). As the country of origin for acupuncture treatment, China ranked first and contributed 140 records to a total of 296 publications (*Table 3*). The United States ranked second with 73 records, meaning acupuncture is widely used in this country to treat hypertension. Furthermore, acupuncture therapy received significant attention in treating hypertension in South Korea, Japan, Malaysia, and Austria. As seen from the links between the

Table 2 Top 5 frequencies and centrality of cited Journal related to acupuncture for hypertension

Rank	Frequency		Centrality	
	Cited journal	Value	Cited journal	Value
1	*Hypertension*	141	*Clin Exp Hypertens*	0.19
2	*Circulation*	138	*Acupunct Med*	0.13
3	*Evid-Based Comp ALT*	126	*Acupuncture Electro*	0.11
4	*Lancet*	102	*Am J Physiol-Heart C*	0.11
5	*J Altern Complem Med*	91	*Am J Cardiol*	0.11

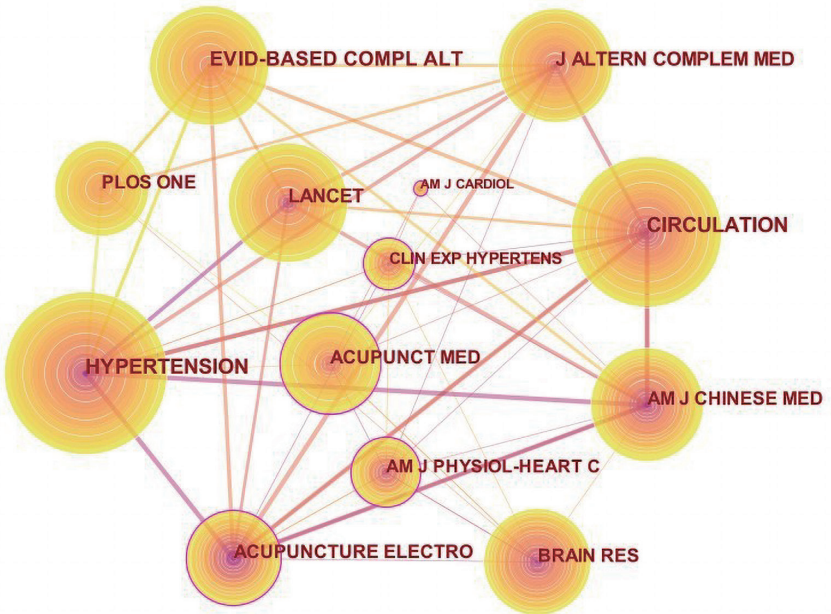

Figure 3 Cited journal maps related to acupuncture treatment for hypertension from 2002 to 2021.

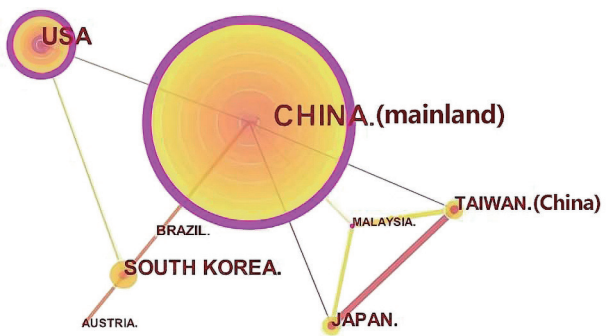

Figure 4 Map of countries/region researching acupuncture for hypertension from 2002 to 2021.

nodes in *Figure 4*, China has cooperated with the countries/region with more publications.

The institutions' distribution network included 317 nodes and 457 linkages (*Figure 5*). A total of 317 institutes examined acupuncture therapy on hypertension. The top five most productive institutions were Beijing Univ Chinese Med, Korea Inst Oriental Med, Tianjin Univ Tradit Chinese Med, Guangzhou Univ Chinese Med, and China Acad Chinese Med Sci (China). Meanwhile, the top 5 institutions in terms of centrality were Beijing Univ Chinese Med, Tianjin Univ Tradit Chinese Med, Changgung Univ, Korea Inst Oriental Med, and Chengdu Univ Tradit Chinese Med.

Table 3 Top 5 publications and centrality of country/region related to acupuncture for hypertension

Rank	Publications		Centrality	
	Country/region	Value	Country/region	Value
1	China (Mainland)	140	China (Mainland)	0.77
2	USA	48	USA	0.51
3	South Korea	27	Malaysia	0.14
4	Japan	20	South Korea	0.12
5	Taiwan (China)	16	Austria	0.07

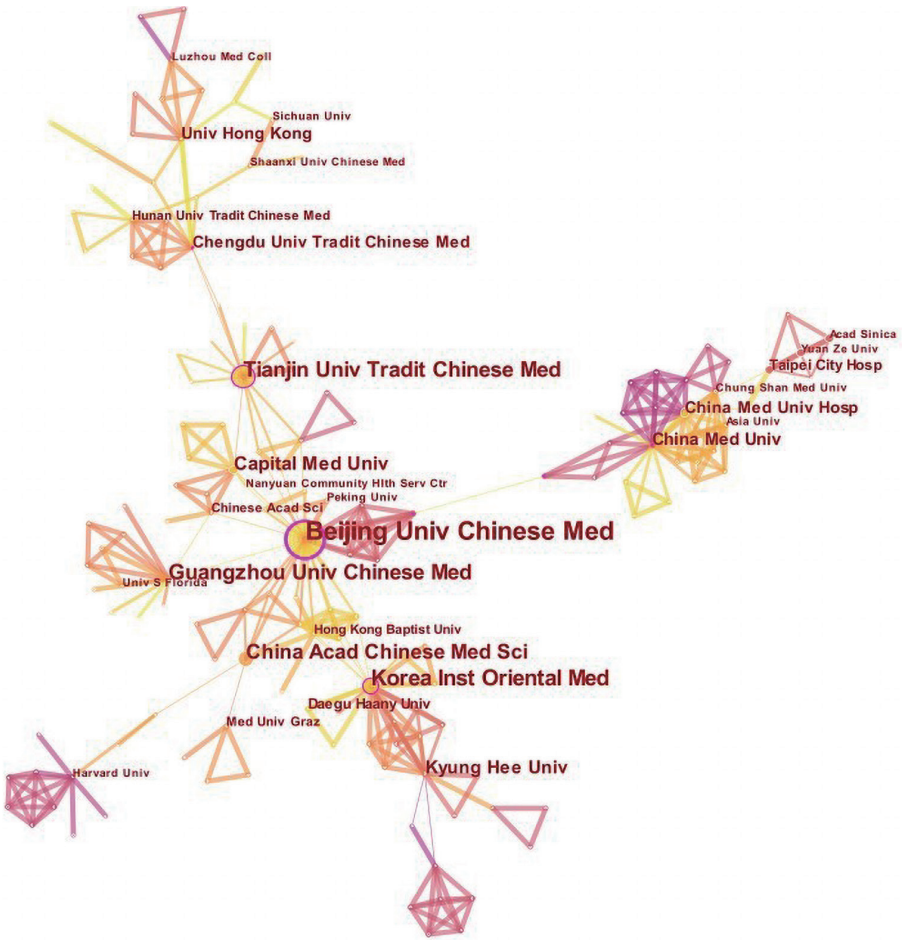

Figure 5 Map of institutions researching acupuncture for hypertension from 2002 to 2021.

Table 4 Top 5 publications and centrality of institutions related to acupuncture on hypertension

Rank	Publications		Centrality	
	Institutions	Value	Institutions	Value
1	Beijing Univ Chinese Med	36	Beijing Univ Chinese Med	0.15
2	Korea Inst Oriental Med	19	Tianjin Univ Tradit Chinese Med	0.13
3	Tianjin Univ Tradit Chinese Med	18	Changgung Univ	0.07
4	Guangzhou Univ Chinese Med	17	Korea Inst Oriental Med	0.06
5	China Acad Chinese Med Sci	16	Chengdu Univ Tradit Chinese Med	0.06

In particular, Beijing Univ Chinese Med was the institution with the largest volume of publications and the highest centrality, indicating that it was a significant institution for examining acupuncture therapy for hypertension (*Table 4*). Due to the volume of publications and centrality, acupuncture therapy for hypertension receives the most attention from institutions in China, South Korea, the United States, and other countries.

Analysis of author and cited author

The authors of 296 publications were examined, and an

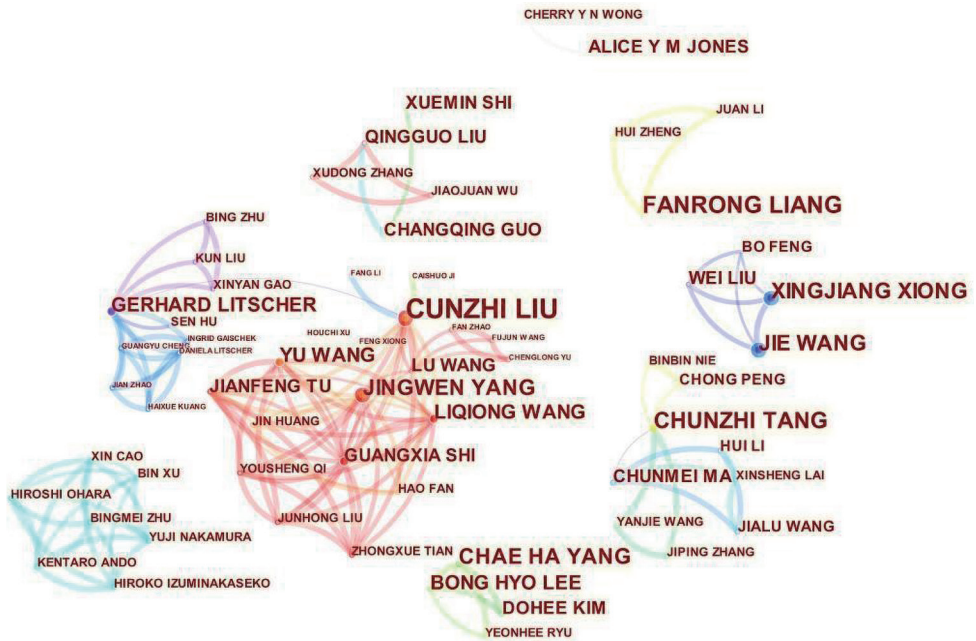

Figure 6 The network map of author related to acupuncture for hypertension from 2002 to 2021.

Table 5 Top 10 authors related to acupuncture for hypertension

Rank	Author	Frequency
1	Cunzhi Liu	11
2	Fanrong Liang	8
3	Chunzhi Tang	8
4	Jingwen Yang	6
5	Liqiong Wang	5
6	Guangxia Shi	5
7	Chae Ha Yang	5
8	Yu Wang	5
9	Chunmei Ma	4
10	Bong Hyo Lee	4

author map with 472 nodes and 756 links was constructed. (*Figure 6*). The author map displayed the productive authors and co-authors, as well as the connections between them. It also gave information on important research groups and possible collaborators, which could assist researchers in forming collaborative relationships. Regarding the volume of publications, the top five authors were Fanrong Liang, Jingwen Yang, Chunzhi Tang, and Liqiong Wang (*Table 5*). Among them, the most prolific author is Cunzhi Liu from Beijing Hospital of Traditional Chinese Medicine, affiliated with Capital Medical University, with 12 articles. However, the centrality of the collaboration between the authors is zero, and these links all showed that there is not a close collaboration between the authors in this domain, indicating that the authors could collaborate in the future to publish more excellent articles on acupuncture for the treatment of hypertension. There were 2,378 links and 791 nodes in the diagram of the cited authors (*Figure 7*). P Li had the most citations [72], followed by FA Flachskampf [63], EA Macklin [49], J Wang [China Academy of Chinese Medical Sciences, Beijing] [46], and W Zhou [45]. In order of centrality, the top 5 cited authors were P Li (0.15), DD Kim (0.12), AV Chobanian (0.10), J Wang (China Academy of Chinese Medical Sciences, Beijing) (0.09), and SC Tjen-A-Looi (0.08) (*Table 6*). Future collaborations would produce more research on acupuncture for hypertension among these authors.

Analysis of cited reference

Constructing a cited reference co-citation map produced 653 nodes and 1,540 links (*Figure 8*). The top five most referenced or occurring elements from each slice were selected to generate the network map of cited references, with a period range of 2002 to 2021 and a time slice of one.

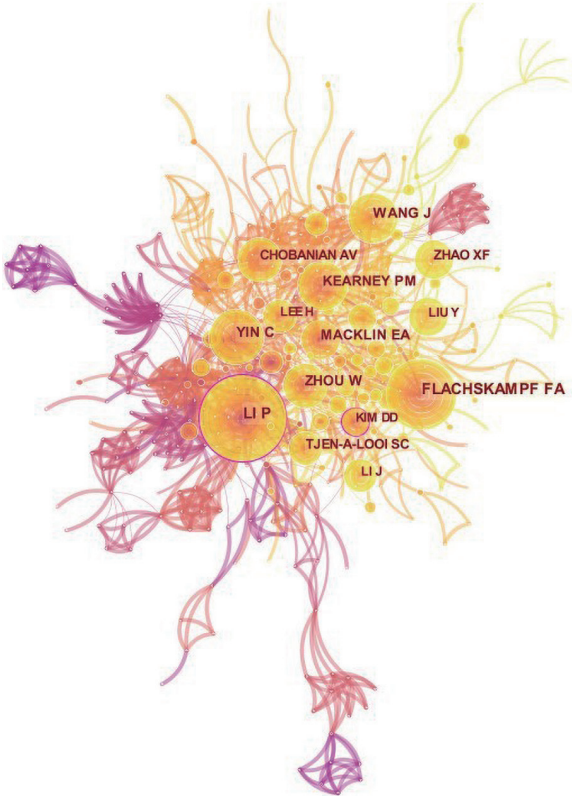

Figure 7 The network map of cited author related to acupuncture for hypertension from 2002 to 2021.

Table 6 Top 5 Frequency and centrality of cited authors related to acupuncture therapy on hypertension

Rank	Frequency		Centrality	
	Author	Value	Author	Value
1	P Li	72	P Li	0.15
2	FA Flachskampf	63	DD Kim	0.12
3	EA Macklin	49	AV Chobanian	0.1
4	J Wang	46	J Wang	0.09
5	W Zhou	45	SC Tjen-A-Looi	0.08

The publication by XF Zhao from 2015 came first regarding the frequency of citations (*Table 7*). This study adds to the body of knowledge on acupuncture treating hypertension by examining co-citation frequency and centrality.

Log-likelihood tests (LLR) were used to extract the noun phrase from the headline of this article in CiteSpace in order to identify the critical cluster of cited references. The modularity Q (0.8791) and means silhouette (0.8358) values indicated that the clusters were reasonable. Twenty-one clusters were created in the schematic diagram to reveal the study patterns and contemporary trends (*Figure 9*). "Spontaneously hypertensive rats" was the most extraordinary cluster, with 72 references. This cluster's silhouette was 0.924, indicating that the finding was significant. One of the most popular citations in this cluster was a randomized controlled experiment published by Li (23). Cardiovascular illness was the second cluster, with a silhouette of 0.904 and 54 members. "Complementary therapies" and "randomized clinical trial" were also active clusters.

Analysis of keyword

The map of keywords co-occurrence was generated and consisted of 386 nodes and 1,263 links (*Figure 10*). Though analyzing the frequency and centrality of keyword, we found the popular keywords were "blood pressure", "acupuncture", "electroacupuncture", "hypertension", "stimulation", "double blind", "mechanism", "expression", "management", "rat", "cardiovascular response" and "pain" (*Table 8*). *Figure 11* presented the top 15 terms with the most extraordinary citation surge between 2002 and 2021.

Discussion

Research trends of acupuncture for hypertension from 2002 to 2021

CiteSpace was used to conduct a bibliometric analysis on acupuncture for hypertension treatment, utilizing the Web of Science Core Collection between 2002 and 2020. Then, a summary of the overall facts and research trends in this field was provided.

Over 3,000 years of acupuncture use in China make it a crucial part of traditional Chinese medicine. The number of research papers on acupuncture in hypertension has increased steadily over the last two decades, indicating that acupuncture has excellent promise as a supplemental therapy. However, from 2020 to 2021, the number of articles published has dropped slightly, which meant the field of research might have encountered the bottleneck and needed to be broken again. The most research on acupuncture for hypertension has come from China. Acupuncture for the treatment of hypertension is presently widely accepted and the subject of active research in China, based on the volume and importance of papers. Furthermore, the United States has the second greatest centrality rating from 2002 to 2021, as well as the second largest number of publications,

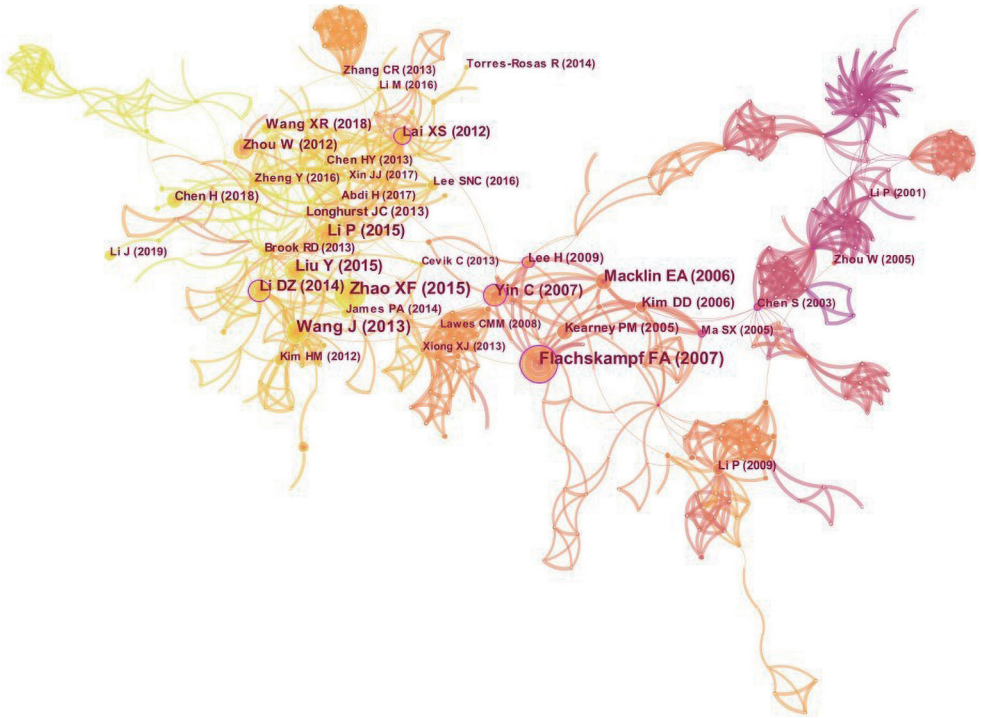

Figure 8 Map of cited references related to acupuncture for hypertension from 2002 to 2021.

Table 7 Top 5 cited reference related to acupuncture for hypertension

Rank	Frequency		Centrality	
	Cited reference	Value	Cited reference	Value
1	XF Zhao, 2015	32	S Chen, 2013	0.18
2	FA Flachskampf, 2007	32	FA Flachskampf, 2007	0.14
3	J Wang, 2013	28	C Yin, 2007	0.13
4	EA Macklin, 2006	23	X Lai, 2012	0.13
5	P Li, 2015	23	DZ Li, 2006	0.12

which meant that acupuncture is widely used in this country to treat hypertension. Four of the top five institutions in terms of publications and centrality resided in China. This suggests that China maintains strong connections with other nations and organizations involved in acupuncture studies for hypertension therapy. Collaborations enable researchers to communicate information and expertise, which is essential for developing acupuncture therapy of hypertension. As a result, more countries, organizations, and writers need to establish closer collaboration networks.

Among the authors' publications, the most prolific author is Cunzhi Liu from Beijing Hospital of Traditional Chinese Medicine affiliated with Capital Medical University, with 12 articles. Cunzhi Liu and Jingwen Yang have collaborated in several Clinical and scientific experiments on acupuncture for the treatment of hypertension in recent years (24-31). They have revealed the central hypotensive effects of acupuncture for the first time (24). They also established a research team with expertise in acupuncture treating hypertension. However, the centrality of the collaboration between the authors is zero, and these links all showed that there is not a close collaboration between the authors in this domain, indicating that the authors could collaborate in the future to publish more excellent articles on acupuncture for the treatment of hypertension. A comprehensive investigation revealed that P Li, FA Flachskampf, and DD Kim as the academics who had the most influence on the development of acupuncture therapy for hypertension. Among them, P Li was the cited author with the most publication and the highest centrality. Moreover, he was a specialist in cardiovascular responses focused on acupuncture treatment of hypertension. One of his systematic reviews pointed out that the long-lasting effect of electro-acupuncture in the treatment of hypertension might be related to the activation of the opioid system in

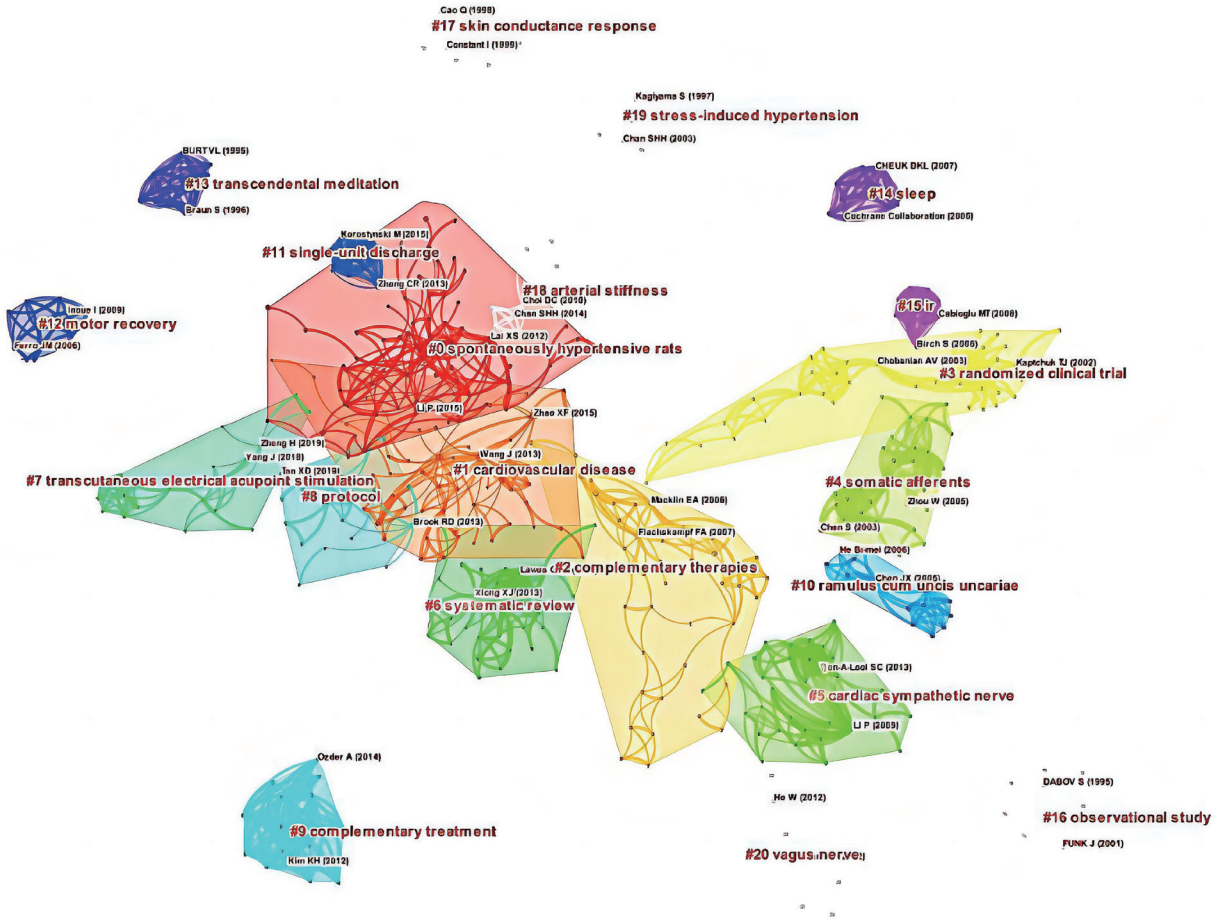

Figure 9 The network map of cited reference related to acupuncture for hypertension from 2002 to 2021.

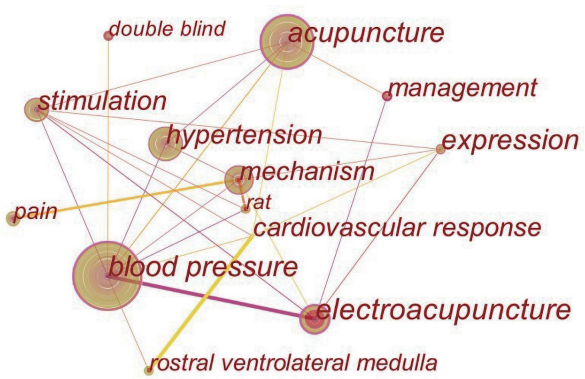

Figure 10 Map of keywords occurrence related to acupuncture for hypertension from 2002 to 2021.

Table 8 Top 10 keyword related to acupuncture for hypertension

Rank	Frequency		Centrality	
	Keyword	Value	Keyword	Value
1	Blood pressure	83	Blood pressure	0.26
2	Acupuncture	52	Acupuncture	0.25
3	Electroacupuncture	37	Electroacupuncture	0.22
4	Hypertension	35	Expression	0.19
5	Stimulation	35	Hypertension	0.18
6	Mechanism	27	Stimulation	0.17
7	Expression	17	Mechanism	0.14
8	Double blind	16	Management	0.1
9	Rat	16	Cardiovascular response	0.1
10	Management	15	Pain	0.09

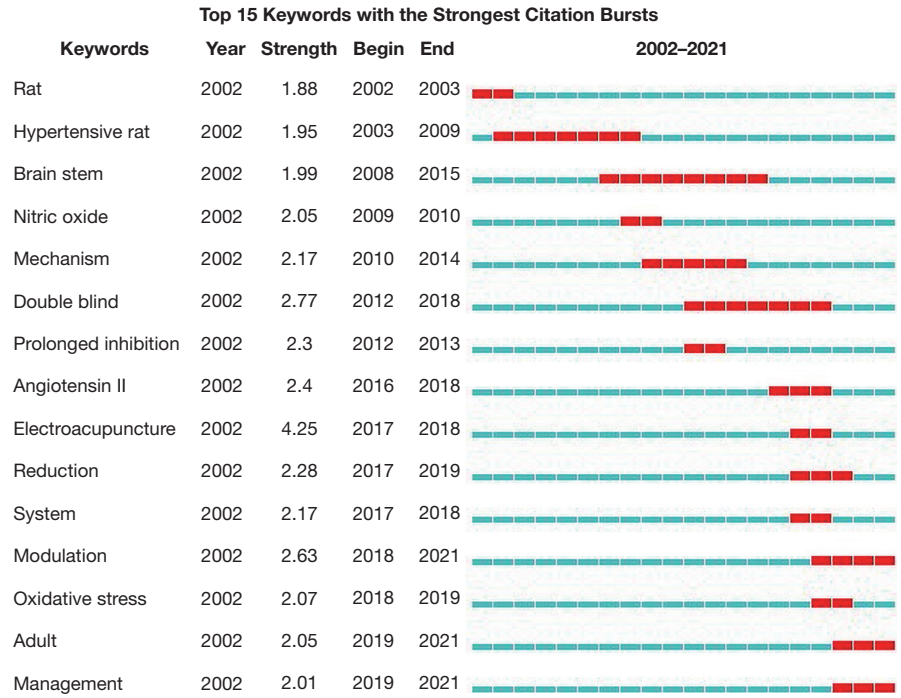

Figure 11 Top 15 keywords with the strongest citation bursts. The red bar indicates that the keyword was frequently referenced, and the green bar indicates that the keyword was rarely referenced.

the brain and inhibition of sympathetic activity and renin-angiotensin-aldosterone system (32). Through a randomized clinical experiment, FA Flachskampf, a professor at Univ Klinikum Erlangen rated second in the frequency of citations, discovered that acupuncture therapy could significantly reduce an average of 24-hour ambulatory blood pressure after six weeks of treatment (33). Furthermore, DD Kim revealed that one of the mechanisms by which ST-36 electroacupuncture reduces blood pressure is an activation of endothelial nitric oxide synthase (eNOS) and neuronal nitric oxide synthase (nNOS), and that stomach 36-point (ST-36) electroacupuncture-induced blood pressure reduction operates through the stomach meridian (34).

The first was a paper written by XF Zhao in 2015, listed in order of frequency in cited references (*Table* 7). The paper performed a systematic evaluation of the effectiveness of acupuncture therapy of hypertension, as well as a meta-analysis that demonstrated the efficacy of acupuncture as an adjuvant therapy to medicine in the treatment of hypertension (7). The article published by J Wang in 2013 ranked the fourth reference. It also conducted a systematic review to determine the therapeutic benefit of acupuncture therapy for hypertension and suggested that further extensive inquiry, large-scale, properly planned studies and randomized trials of acupuncture for hypertension were needed (35). The other three of the top 5 publications all involved randomized controlled trials of acupuncture therapy for hypertension, which validated acupuncture's effectiveness in treating hypertension from various viewpoints (23,33,36). Based on betweenness centrality (*Table 8*), the article published in 2013 by S Chen came first. Furthermore, it was interesting that the article published by FA Flachskampf, 2007 also ranked as the second reference. X Lai carried out a controlled experiment to investigate the mechanism of acupuncture for hypertension (37). The findings revealed a rise in antioxidant enzymes in the medullary of acupuncture SHRs, which might offer a partial explanation for the antihypertensive impact of acupuncture.

The increasing frequency of keywords or the rising amount of keyword bursts in citations during a specific period might be markers for identifying the most cutting-edge topics or recent developments (38). Through analyzing the frequency and centrality of keyword, research frontiers could be determined. The most recent burst keywords included "electroacupuncture", "double blind", "mechanism", "brain stem", "oxidative stress", "nitric oxide", "prolonged inhibition" and "Angiotensin II". Randomized controlled trials, the most frequent approach

for studying clinical efficacy, requires blinding in the CONSORT (Consolidated Standards of Reporting Trials) declaration (39). Nevertheless, it is not easy to enforce double blinding for both the acupuncturist and the subject. Many sham acupuncture methods are very controversial, and some research suggests that acupuncture might be effective because of the placebo effect (such as expectancy and belief) (40). The keyword "electroacupuncture" had a high frequency and centrality which suggested electroacupuncture is a popular treatment in this field (*Table 8*). Besides, it also had the highest citation strength of the burst of 4.25. Pain was ranked first on the frequency and centrality ranking list (*Table 8*), prompting us to examine the connection between pain and hypertension. According to recent studies that relate hypertension to chronic pain, greater chronic pain strength is a significant indicator of a favorable hypertension situation (41). And we found from *Table 8* and *Figure 11* that researchers pay great attention to investigating the mechanism of acupuncture in treating hypertension.

Mechanisms of acupuncture on hypertension

We studied the mechanism of acupuncture for hypertension from 2002 to 2021 and discovered that the brain function, vascular endothelium, oxidative stress response, neuroendocrine system, renin-angiotensin-aldosterone system (RAAS), genes, metabolism, and other elements all play a role in the antihypertensive mechanism of acupuncture. Tjen-A-Looi *et al.* (42) revealed that acupuncture could lower reflex blood pressure by 40–50% (7–15 mmHg) in a point-specific manner when it stimulates underpinning neural pathways between specific acupoints which transmit to brain stem areas involved in the control of the sympathetic outflow. Leung *et al.* (43) investigated the mechanism of acupuncture in lowering blood pressure from the viewpoint of oxidative enzymes. Their findings illustrated that the effects of acupuncture in treating hypertension were associated with reduced oxidative stress and increased nitric oxide (NO) bioavailability in SHRs. In addition, studies have revealed that electroacupuncture's ability to decrease cardiovascular reflex reactions lasts longer because of an opioid mechanism in the paraventricular nucleus (PVN), which is abundant in endorphinergic fibres and μ-opioid receptors (44-46). Numerous animal studies also demonstrated that acupuncture successfully lowered blood pressure by reducing plasma levels of angiotensin II (Ang II) and angiotensin-converting enzyme and angiotensin II receptors (AT1R, AT2R) (9,47,48). Additionally, there is cross-talk across several goals and systems. Acupuncture, for instance, may enhance NO to control endothelial dysfunction, as well as downregulate AT1R affirmation (49) and enhance AT2R interpretation to influence RAAS by controlling C-reactive protein (CRP) (50); or acupuncture may prevent the oxidative stress of reactive oxygen species (ROS) by constraining Ang II (51,52), resulting in an antihypertensive effect. Acupuncture could preserve target organs in contrast to its antihypertensive effects by enhancing endothelial function and inflammatory reaction.

Electroacupuncture

In the treatment of hypertension, electroacupuncture has a beneficial effect on the reduction of blood pressure (23,53). Because of the different applications of electroacupuncture frequencies in research, whether the frequency is connected to the therapeutic impact should be given greater attention. According to our analysis, electroacupuncture is the most frequently employed intervention strategy in antihypertensive studies (69.77%). The explanation for this might be that the stimulus amount and strength of electroacupuncture are consistent and regulated, removing the influence of manual acupuncture manipulative procedures. Further research is necessary to determine whether the antihypertensive mechanisms of manual acupuncture and electroacupuncture vary in any way. Electroacupuncture frequency and intensity both have a significant impact on how blood pressure is regulated. According to universal consensus, higher intensity electroacupuncture alters excitability, which raises blood pressure; on the contrary, lower intensity electroacupuncture has an inhibitory impact, which might also reduce blood pressure. Nonetheless, the effect of electroacupuncture intensity on blood pressure remains unknown. The frequency of electroacupuncture in hypertension treatment is mostly 2 Hz (73.33%). Low-frequency electroacupuncture (2 Hz) may cause a decrease in sympathetic tone, dilatation of the systemic arteriole, and a blood pressure-lowering effect (54). Consequently, selecting electroacupuncture parameters is a fundamental aspect of treating hypertension.

Effect of acupuncture for hypertension

It has been established that acupuncture as an adjuvant

therapy for hypertension is an effective non-pharmaceutical treatment (23,55). In addition, the antihypertensive effect of electroacupuncture persists for at least one month after electroacupuncture medication is discontinued (23). In comparison to medication therapies, acupuncture has less adverse effects as a nonpharmacological treatment. In addition to decreasing blood pressure, acupuncture may shield the target organ. A clinical investigation discovered that combining acupuncture with primary therapy can minimize the number of patient complaints while also improving patient compliance (56). As a therapy for hypertension, acupuncture has various advantages, including effectiveness, long-lasting effects, fewer adverse effects, target organ protection, improved inpatient compliance, etc. However, there are still certain issues that require additional research. For instance, what is the most effective acupoint treatment for hypertension? How about the applicable mechanism? Which acupuncture stimulus is most effective for hypertension?

Strengths and limitations

As far as we know, this is the first time that the scientific development of acupuncture in hypertension has been presented using bibliometric analysis, displaying contributors, collaboration networks, research hotspots, and development trends. Prospective academics could study this article to understand the present level of progress in the area and assess its future potential. And through gaining knowledge about the contributing researchers and institutions, cooperation and communication are anticipated to expand. However, there are still certain limitations in this study. First, due to the limitations of CiteSpace data analysis, we only gathered literature from the WOS databases and did not include literature from Chinese or other English databases. This finding would have been more persuasive if it had been combined with more databases. Additionally, the CiteSpace analysis is based on the number of citations, but the number of citations is influenced by various factors and cannot accurately reflect the quality of the article.

Conclusions

CiteSpace was used to generate the bibliometric analysis of acupuncture therapy on hypertension from 2002 to 2021. In the research trends, the rate of annual publishing progressively rose. Hypertension is an anomaly in blood flow dynamics associated with the cardiovascular system, and several references have been published in cardiovascular system journals. This field mentioned several papers on acupuncture treatment since it was a complementary and alternative medicine. The top five most productive countries/region were China (mainland), the United States, South Korea, Japan, and Taiwan (China), which were widely dispersed over the globe. However, more research was conducted at Chinese institutions, and the majority of active authors were generally Chinese. Apparently, Asians are more receptive to acupuncture therapies. In this article, we only examined information from the WOS where the majority of the publications were written in English. Future investigations will not exclude Chinese data in order to be more comprehensive.

Systematic reviews and clinical trials were performed using the specified references and keywords to investigate the effectiveness and mechanism of acupuncture in the treatment of hypertension. 'Electroacupuncture' had a high frequency and centrality in the keyword, which suggested electroacupuncture is a popular treatment in this field. In the treatment of hypertension, electroacupuncture has a beneficial effect on the reduction of blood pressure. However, because of the different applications of electroacupuncture frequencies in research, whether the frequency is connected to the therapeutic impact should be given greater attention. Randomized controlled trials primarily compared acupuncture and electroacupuncture to sham acupuncture, medication, and placebo.

In conclusion, this study sheds light on the emerging trend and hot topics in the research on acupuncture treatment for hypertension and offered valuable information for possible cooperation between researchers and institutions. Acupuncture appears to be effective in the treatment of hypertension, however further research is needed. As a result, more research with defined procedures and a low risk of bias is required, exceptionally high-quality randomized controlled trials.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-480/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Wang J, Xiong X. Evidence-based chinese medicine for hypertension. Evid Based Complement Alternat Med 2013;2013:978398.
2. Chow CK, Teo KK, Rangarajan S, et al. Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high-, middle-, and low-income countries. JAMA 2013;310:959-68.
3. Rantanen AT, Korkeila JJA, Löyttyniemi ES, et al. Awareness of hypertension and depressive symptoms: a cross-sectional study in a primary care population. Scand J Prim Health Care 2018;36:323-8.
4. Tedla YG, Bautista LE. Drug Side Effect Symptoms and Adherence to Antihypertensive Medication. Am J Hypertens 2016;29:772-9.
5. Gebreyohannes EA, Bhagavathula AS, Abebe TB, et al. Adverse effects and non-adherence to antihypertensive medications in University of Gondar Comprehensive Specialized Hospital. Clin Hypertens 2019;25:1.
6. Cai Y, Boyd DL, Coeytaux RR, et al. Treatment of chronic conditions with traditional Chinese medicine: findings from traditional Chinese medicine hospitals in Hubei, China. J Altern Complement Med 2015;21:40-5.
7. Zhao XF, Hu HT, Li JS, et al. Is Acupuncture Effective for Hypertension? A Systematic Review and Meta-Analysis. PLoS One 2015;10:e0127019.
8. Tanaka LY, Laurindo FRM. The Eye of the Needle: Redox Mechanisms of Acupuncture Effects in Hypertension. Hypertension 2018;71:224-6.
9. Abdi H, Tayefi M, Moallem SR, et al. Abdominal and auricular acupuncture reduces blood pressure in hypertensive patients. Complement Ther Med 2017;31:20-6.
10. Broadus RN. Toward a definition of "bibliometrics". Scientometrics 1987;12:373-9.
11. Guler AT, Waaijer CJ, Palmblad M. Scientific workflows for bibliometrics. Scientometrics 2016;107:385-98.
12. Dalpé R. Bibliometric analysis of biotechnology. Scientometrics 2002;55:189-213.
13. Chen C, Hu Z, Liu S, et al. Emerging trends in regenerative medicine: a scientometric analysis in CiteSpace. Expert Opin Biol Ther 2012;12:593-608.
14. University D, Yue UC. CiteSpace II: detecting and visualizing emerging trends and transient patterns in scientific literature. Journal of the American Society for Information Science and Technology 2014;57:359-77.
15. Ma Y, Dong M, Zhou K, et al. Publication Trends in Acupuncture Research: A 20-Year Bibliometric Analysis Based on PubMed. PLoS One 2016;11:e0168123.
16. Li TF, Kung YY, Tsai CH, et al. A bibliometric analysis of acupuncture research in Taiwan from 1988 to 2017. J Chin Med Assoc 2019;82:428-35.
17. Lee IS, Lee H, Chen YH, et al. Bibliometric Analysis of Research Assessing the Use of Acupuncture for Pain Treatment Over the Past 20 Years. J Pain Res 2020;13:367-76.
18. Chen J, Yao M, Zhao Y, et al. Use of acupuncture to treat cerebral infarction in the last 10 years: A Scopus-based literature analysis. Neural Regen Res 2012;7:2944-51.
19. Sun F, Wang J, Wen X. Acupuncture in stroke rehabilitation: Literature retrieval based on international databases. Neural Regen Res 2012;7:1192-9.
20. Pei W, Peng R, Gu Y, et al. Research trends of acupuncture therapy on insomnia in two decades (from 1999 to 2018):a bibliometric analysis. BMC Complement Altern Med 2019;19:225.
21. Liang YD, Li Y, Zhao J, et al. Study of acupuncture for low back pain in recent 20 years: a bibliometric analysis via CiteSpace. J Pain Res 2017;10:951-64.
22. Wang JY, Li H, Ma CM, et al. MicroRNA Profiling Response to Acupuncture Therapy in Spontaneously Hypertensive Rats. Evid Based Complement Alternat Med 2015;2015:204367.

23. Li P, Tjen-A-Looi SC, Cheng L, et al. Long-Lasting Reduction of Blood Pressure by Electroacupuncture in Patients with Hypertension: Randomized Controlled Trial. Med Acupunct 2015;27:253-66.
24. Wang XR, Yang JW, Ji CS, et al. Inhibition of NADPH Oxidase-Dependent Oxidative Stress in the Rostral Ventrolateral Medulla Mediates the Antihypertensive Effects of Acupuncture in Spontaneously Hypertensive Rats. Hypertension 2018;71:356-65.
25. Yang JW, Ye Y, Wang XR, et al. Acupuncture Attenuates Renal Sympathetic Activity and Blood Pressure via Beta-Adrenergic Receptors in Spontaneously Hypertensive Rats. Neural Plast 2017;2017:8696402.
26. Ma SM, Yang JW, Tu JF, et al. Gene-Level Regulation of Acupuncture Therapy in Spontaneously Hypertensive Rats: A Whole Transcriptome Analysis. Evid Based Complement Alternat Med 2019;2019:9541079.
27. Wang Y, Shi GX, Tian ZX, et al. Transcutaneous electrical acupoint stimulation for high-normal blood pressure: study protocol for a randomized controlled pilot trial. Trials 2021;22:140.
28. Fan H, Yang JW, Wang LQ, et al. The Hypotensive Role of Acupuncture in Hypertension: Clinical Study and Mechanistic Study. Front Aging Neurosci 2020;12:138.
29. Tu JF, Wang LQ, Liu JH, et al. Home-based transcutaneous electrical acupoint stimulation for hypertension: a randomized controlled pilot trial. Hypertens Res 2021;44:1300-6.
30. Fan H, Yang JW, Huang J, et al. Peroxisome proliferator-activated receptor-γ mediates the antihypertensive effects of acupuncture in spontaneously hypertensive rats. Neuroreport 2020;31:952-8.
31. Wang L, Yang NN, Shi GX, et al. Acupuncture Attenuates Blood Pressure via Inducing the Expression of nNOS. Evid Based Complement Alternat Med 2021;2021:9945277.
32. Cheng L, Li P, Tjen-A-Looi SC, et al. What do we understand from clinical and mechanistic studies on acupuncture treatment for hypertension? Chin Med 2015;10:36.
33. Flachskampf FA, Gallasch J, Gefeller O, et al. Randomized trial of acupuncture to lower blood pressure. Circulation 2007;115:3121-9.
34. Kim DD, Pica AM, Durán RG, et al. Acupuncture reduces experimental renovascular hypertension through mechanisms involving nitric oxide synthases. Microcirculation 2006;13:577-85.
35. Wang J, Xiong X, Liu W. Acupuncture for essential hypertension. Int J Cardiol 2013;169:317-26.
36. Macklin EA, Wayne PM, Kalish LA, et al. Stop Hypertension with the Acupuncture Research Program (SHARP): results of a randomized, controlled clinical trial. Hypertension 2006;48:838-45.
37. Lai X, Wang J, Nabar NR, et al. Proteomic response to acupuncture treatment in spontaneously hypertensive rats. PLoS One 2012;7:e44216.
38. Zheng K, Wang X. Publications on the Association Between Cognitive Function and Pain from 2000 to 2018: A Bibliometric Analysis Using CiteSpace. Med Sci Monit 2019;25:8940-51.
39. Altman DG, Schulz KF, Moher D, et al. The revised CONSORT statement for reporting randomized trials: explanation and elaboration. Ann Intern Med 2001;134:663-94.
40. Pariente J, White P, Frackowiak RS, et al. Expectancy and belief modulate the neuronal substrates of pain treated by acupuncture. Neuroimage 2005;25:1161-7.
41. Olsen RB, Bruehl S, Nielsen CS, et al. Hypertension prevalence and diminished blood pressure-related hypoalgesia in individuals reporting chronic pain in a general population: the Tromsø study. Pain 2013;154:257-62.
42. Tjen-A-Looi SC, Li P, Longhurst JC. Medullary substrate and differential cardiovascular responses during stimulation of specific acupoints. Am J Physiol Regul Integr Comp Physiol 2004;287:R852-62.
43. Leung SB, Zhang H, Lau CW, et al. Attenuation of blood pressure in spontaneously hypertensive rats by acupuncture was associated with reduction oxidative stress and improvement from endothelial dysfunction. Chin Med 2016;11:38.
44. Kiss JZ, Cassell MD, Palkovits M. Analysis of the ACTH/beta-End/alpha-MSH-immunoreactive afferent input to the hypothalamic paraventricular nucleus of rat. Brain Res 1984;324:91-9.
45. Lessard A, Bachelard H. Tonic inhibitory control exerted by opioid peptides in the paraventricular nuclei of the hypothalamus on regional hemodynamic activity in rats. Br J Pharmacol 2002;136:753-63.
46. Bowman BR, Kumar NN, Hassan SF, et al. Brain sources of inhibitory input to the rat rostral ventrolateral medulla. J Comp Neurol 2013;521:213-32.
47. Tian GH, Sun K, Huang P, et al. Long-Term Stimulation with Electroacupuncture at DU20 and ST36 Rescues Hippocampal Neuron through Attenuating Cerebral Blood Flow in Spontaneously Hypertensive Rats. Evid Based Complement Alternat Med 2013;2013:482947.

48. Xin JJ, Gao JH, Wang YY, et al. Antihypertensive and Antihypertrophic Effects of Acupuncture at PC6 Acupoints in Spontaneously Hypertensive Rats and the Underlying Mechanisms. Evid Based Complement Alternat Med 2017;2017:9708094.
49. Wang CH, Li SH, Weisel RD, et al. C-reactive protein upregulates angiotensin type 1 receptors in vascular smooth muscle. Circulation 2003;107:1783-90.
50. Vongpatanasin W, Thomas GD, Schwartz R, et al. C-reactive protein causes downregulation of vascular angiotensin subtype 2 receptors and systolic hypertension in mice. Circulation 2007;115:1020-8.
51. Piccoli C, Quarato G, D'Aprile A, et al. Native LDL-induced oxidative stress in human proximal tubular cells: multiple players involved. J Cell Mol Med 2011;15:375-95.
52. Touyz RM. Reactive oxygen species, vascular oxidative stress, and redox signaling in hypertension: what is the clinical significance? Hypertension 2004;44:248-52.
53. Zhang CR, Xia CM, Jiang MY, et al. Repeated electroacupuncture attenuating of apelin expression and function in the rostral ventrolateral medulla in stress-induced hypertensive rats. Brain Res Bull 2013;97:53-62.
54. Lin CF, Liao JM, Tsai SJ, et al. Depressor effect on blood pressure and flow elicited by electroacupuncture in normal subjects. Auton Neurosci 2003;107:60-4.
55. Yang M, Yu Z, Deng S, et al. A Targeted Metabolomics MRM-MS Study on Identifying Potential Hypertension Biomarkers in Human Plasma and Evaluating Acupuncture Effects. Sci Rep 2016;6:25871.
56. Cevik C, Işeri SO. The effect of acupuncture on high blood pressure of patients using antihypertensive drugs. Acupunct Electrother Res 2013;38:1-15.

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