Original Article

The research status of central venous catheterization-associated thrombosis: a bibliometrics analysis

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Background: Central venous catheters are associated with a significantly increased risk of venous thrombosis due to a variety of factors. This bibliometric study analyzed the current research status in the field of central venous catheterization associated thrombosis.

Methods: Related literatures in the Science Citation Index Expanded (SCI-E) database were identified using the search terms "central venous catheter" and "thrombosis". The CiteSpace software was used to analysis literature data including country, institution, author, and journal distribution characteristics, as well as the use of keywords, and the number of times the country, institution, author, or journal were cited. Co-occurrence maps between countries, institutions, authors, and keywords were constructed.

Results: A total of 2,810 related literature records were identified, with a total of 29,920 citations. The number of documents and the number of citations generally showed an increasing annual trend. These documents were mainly published from developed countries in Europe and North America, including USA, Britain, Italy, and France. Cooperation between institutions tended to be limited to the same country, and collaboration between authors tended to be within the same institutions. Keyword analysis demonstrated that in recent years, the research on thrombosis related to central venous catheterization has been more targeted, with an increasing focus on evidence-based medicine.

Conclusions: Future research may focus more on the prevention, early diagnosis, and treatment of asymptomatic central venous catheterization-related thrombosis.

Keywords: Central venous catheterization; thrombosis; bibliometrics; prevention

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Introduction

Central venous catheterization is a common, simple, and safe treatment for many critically ill patients, as well as those undergoing chemotherapy. It can also be used to monitor large venous and right heart pressures to provide accurate information for assessing patient conditions and the effect of treatments (1,2). Central venous catheters can be implanted through medium and large veins that can be accessed through punctures on the body surface. For example, the subclavian vein, internal jugular vein, external jugular vein, and cephalic vein can be used to access the superior vena cava, while the femoral vein and the saphenous vein can be used to access the inferior vena cava. Indeed, the catheter can eventually reach the right heart (3). However, because patients undergoing central venous catheterization are often critically ill, or in a hypercoagulable state due to factors

such as infection, inflammation, malignancy, or require long-term catheterization, the risk of venous thrombosis is significantly increased (4-6). Moreover, venous thrombosis associated with central venous catheterization is often asymptomatic and difficult to detect early (7-9). The risks of central venous catheterization-associated thrombosis include cancer, advanced age, commodities, long hospitalization, lack of sports, venous nutrition, central venous catheters insertion in the subclavian vein, left-sided central venous catheters insertion, longer duration of catheter, catheter-to-vein ratio >0.45, and type of central venous catheters (10). Once the thrombosis is formed, it can easily enter the pulmonary circulation through the venous blood flow, resulting in pulmonary embolism that can endanger the patient's life (11,12). Due to the huge number of patients using central venous catheters in recent years, the incidence of thrombosis has significantly increased. A previous study summarized that catheter-related thrombosis constituted 10% of all deep venous thrombosis (DVT) in adults and 50–80% of all DVTs among children (10). Research regarding thrombosis after central venous catheterization has mainly focuses on several aspects, including mechanisms of action, prevention, early diagnosis, and treatment (10,13). However, the current state of research in this field is unclear. Therefore, this study adopted bibliometrics to analyze the current research status of thrombosis related to central venous catheterization, so as to provide an updated reference for researchers.

Methods

Data source and search strategy

Science Citation Index Expanded (SCI-E) database was the most used database for bibliometrics analysis. English literatures published in the SCI-E database in the Web of Science Core Collection (WOSCC) from inception of database to December 31, 2021 were searched using the topic search strategy. The search terms were "central venous catheter" and "thrombosis".

Analysis

The final results of the literature search were exported in plain text format to form source files for analysis. The CiteSpace software was used to analyze the source files. The dimensions of the analysis included the following: the number of publications in each year; the number of publications in each country and the collaborations between countries; the number of articles published by each institution and the collaborations between institutions; the number of articles published by each author and the collaborations between authors; the number of articles published by each journal; the use of keywords; and the number of times each country, institution, author, or journal was cited. The CiteSpace software was also used to draw the co-occurrence maps between countries, institutions, authors, and keywords.

Statistical analysis

The CiteSpace software was used to count the number and percentage of documents. No comparative analysis between groups was performed and thus, no statistical tests were conducted and no P values were set.

Results

General information

In this study, a total of 3,011 related research literature records were retrieved, of which 201 were classified as duplicates and deleted. Finally, a total of 2,810 literatures were included. These literatures were cited a total of 29,920 times, and the average number of citations per literature was 10.65 and the h-index was 79. Among these documents 2,218 were original articles, 383 were reviews, 146 were conference papers, 83 were conference abstracts, 72 were editorial materials, 53 were online publications, 33 were letters, 18 were notes, 2 were book chapters, 2 were corrections, and 1 was a retraction (*Table 1*). The number of publications in this field generally showed an annual increasing trend (*Figure 1*), dominated by disciplines such as peripheral vascular disease, as well as hematology and oncology (*Figure 2*). The number of citations also showed an obvious increasing trend annually (*Figure 3*).

Countries

The CiteSpace V software was used to analyze the information regarding countries of publication and a visualization map was generated (*Figure 4*). The results of the analysis showed that a total of 113 countries appeared in these documents, and there were 529 collaborations among these countries. The top 5 countries with the largest number of published papers in this field are USA, Italy, Canada, Germany, and China (*Table 2*).

The top 5 countries with the highest centrality score reflecting the number of foreign collaborations are USA, Italy, UK, Canada, and Spain (*Table 3*).

Table 1 Analysis of the document types in the literature search results

Document type	Record count	% of 2,810
Original articles	2,218	78.93
Review articles	383	13.63
Conference papers	146	5.20
Conference abstracts	83	2.95
Editorial materials	72	2.56
Online publications	53	1.89
Letters	33	1.17
Notes	18	0.64
Book chapters	2	0.07
Corrections	2	0.07
Retractions	1	0.04

There was a total of 3,011 records, with 2,810 actual documents. Thus, 2,810 was used as the denominator when calculating the ratio of different types of documents.

Institutions

The CiteSpace V software was used to analyze the research institutions associated with the published literatures and a visualization map was generated (*Figure 5*). The results of the analysis revealed that a total of 482 research institutions appeared in these documents, and there were 2,731 collaborations between institutions. The literature volume analysis demonstrated that the top 5 institutions with the largest number of publications in this field are McMaster

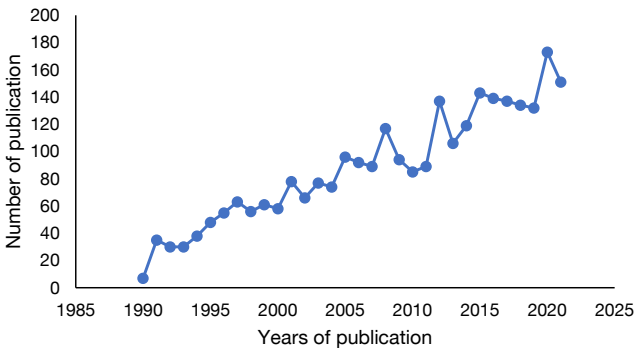

Figure 1 The annual publication of literatures related to central venous catheterization-associated thrombosis.

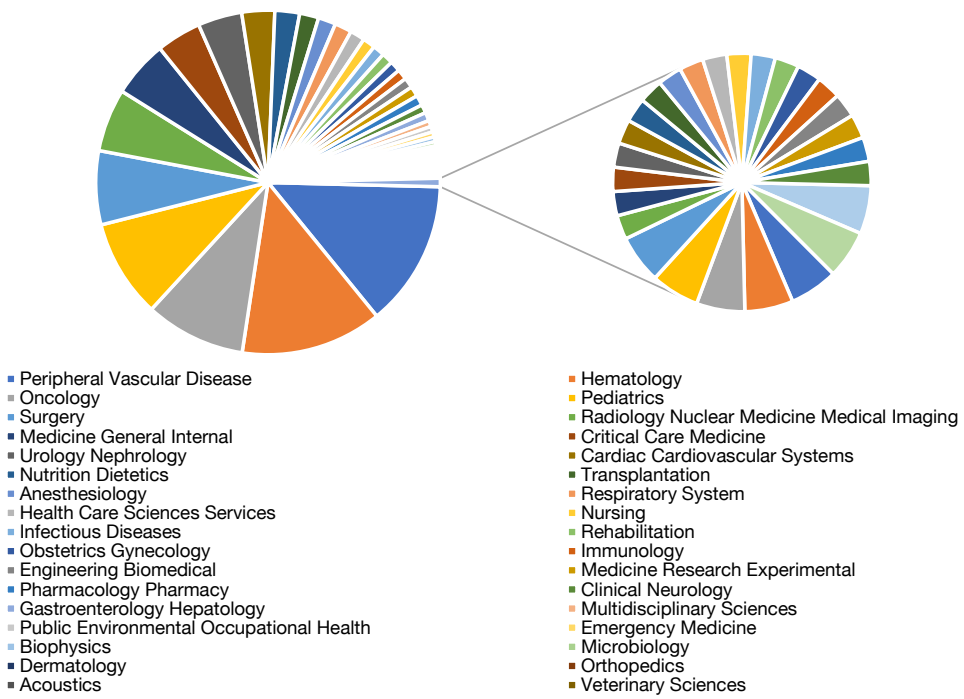

Figure 2 The distribution of literatures according to research discipline.

University, University of Toronto, Hospital of Sick Children, Mayo Clinic, and University of Michigan (*Table 4*). The top 5 institutions with the highest centrality scores are McMaster University, Johns Hopkins University, University of Toronto, University of Michigan, and University of Washington (*Table 5*).

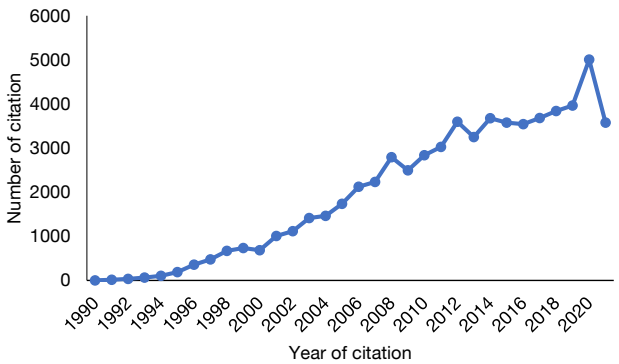

Figure 3 The annual citation of literatures related to central venous catheterization-associated thrombosis.

Authors

Analysis using CiteSpace demonstrated that the cooperation between authors was mainly limited to the same team or research institution (*Figure 6*). The top 5 authors with the

Table 2 The top 10 countries with the highest number of publications

Rank	Country	Publications
1	USA	1,015
2	Italy	256
3	Canada	229
4	Germany	184
5	China	174
6	France	171
7	England	166
8	Netherlands	97
9	Australia	93
10	Spain	74

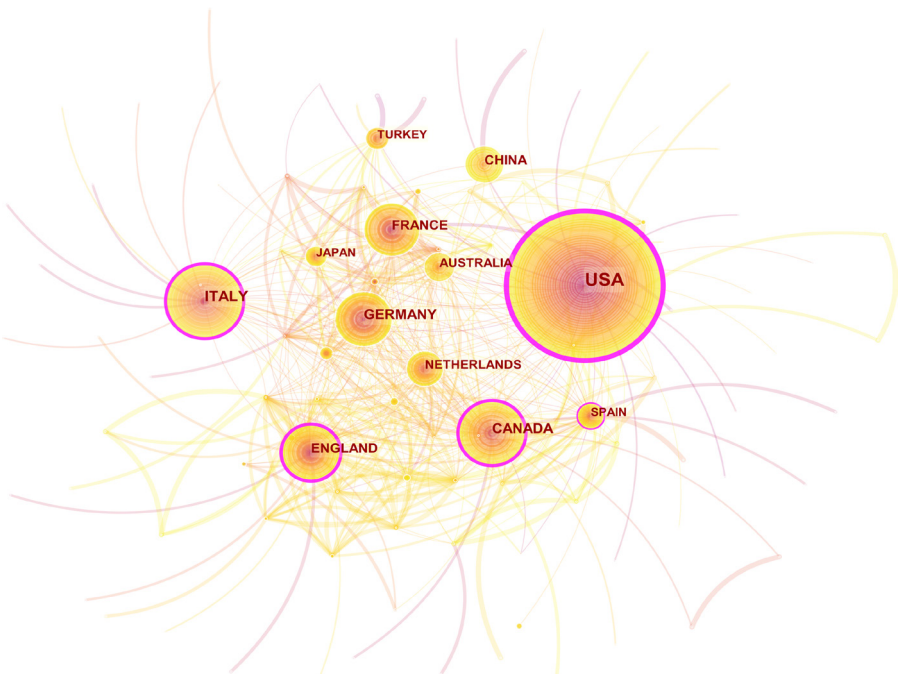

Figure 4 The country visualization map. The nodes in the figure are represented by circles. The larger the circle, the more literatures from that country. The line between the circles represents that any two countries involved in a particular publication. The denser the connections, the more collaborations in that country. As can be seen from the figure, USA, Italy, UK, Canada, and other countries have more connections with other countries, while China has published a large number of documents, with fewer connections to other countries.

Table 3 The top 10 countries for centrality

Rank	Country	Centrality
1	USA	0.57
2	Italy	0.25
3	England	0.24
4	Canada	0.23
5	Spain	0.15
6	France	0.1
7	Turkey	0.1
8	Saudi Arabia	0.08
9	Netherlands	0.07
10	Thailand	0.07

Table 4 The top 10 institutions by number of publications

Rank	Institution	Publications
1	McMaster University	56
2	University of Toronto	49
3	Hospital of Sick Children	38
4	Mayo Clinic	31
5	University of Michigan	30
6	Johns Hopkins University	29
7	Ohio State University	25
8	University of Washington	21
9	University of Pennsylvania	18
10	Duke University	17

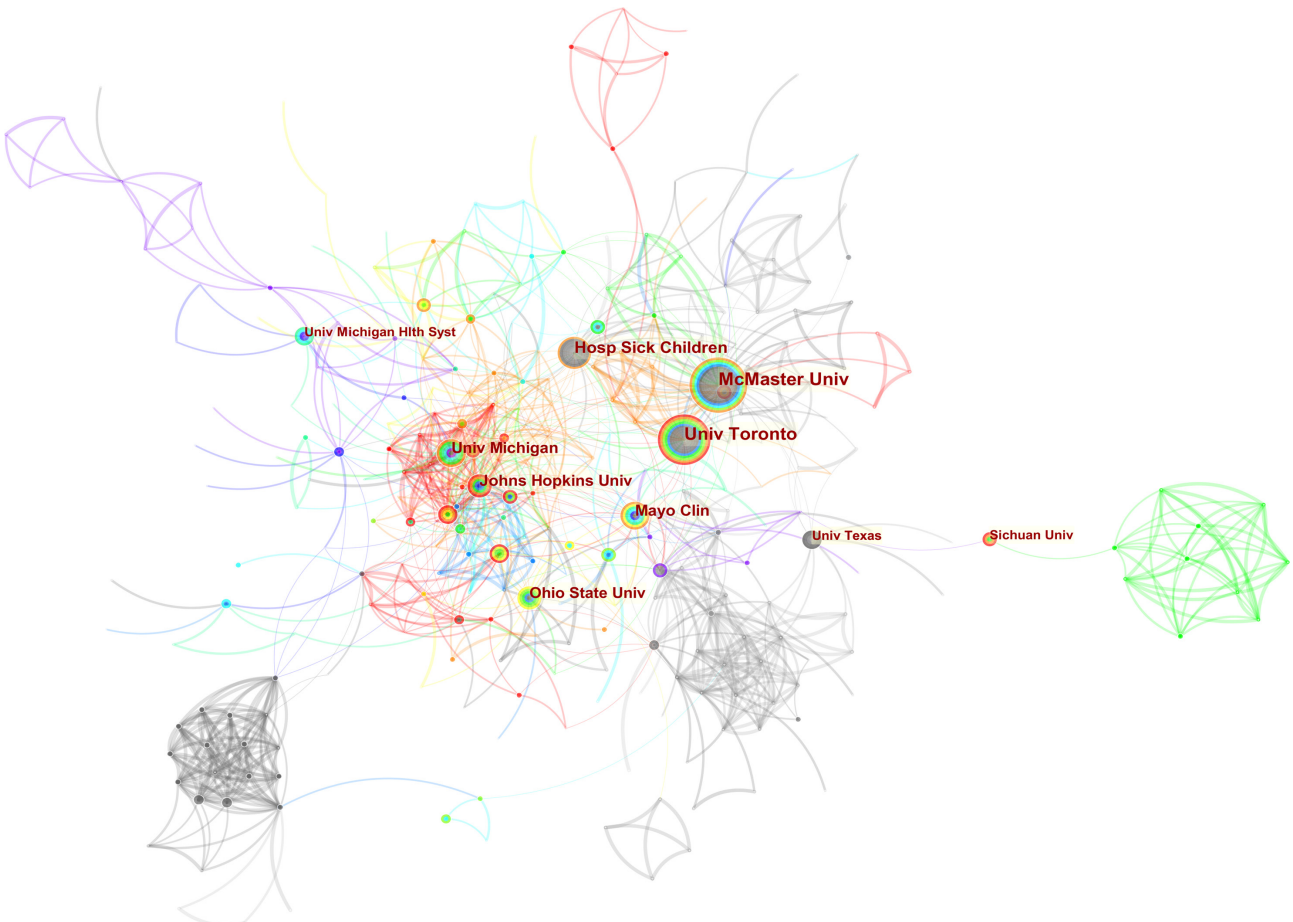

Figure 5 The institutional visualization map. The nodes in the figure are represented by circles. The larger the circle, the more literatures from that institution. The line between the circles represents two institutions appearing in a document at the same time, and the denser the connection, the more collaborations from that institution. The figure shows many connections (cooperation) between several institutions, but the sums between institutions are distributed in clusters, suggesting that cooperation between institutions may be limited to the same country.

most publications are Mauro Pittiruti, Vineet Chopra, Julie Jaffray, Maureen Andrew, and Guy Young (*Table 6*). However, all had lower centrality scores, reflecting lower cooperation between authors (*Table 7*). Authors are often cited by the same literatures (*Figure 7*, *Tables 8*,*9*).

Journals

The 2,810 articles included in this study were published from 608 journals, of which the top 5 journals with the

Table 5 The top 10 institutions for centrality

Rank	Institution	Centrality
1	McMaster University	0.05
2	Johns Hopkins University	0.04
3	University of Toronto	0.03
4	University of Michigan	0.03
5	University of Washington	0.03
6	Hospital of Sick Children	0.02
7	Mayo Clinic	0.02
8	Sichuan University	0.02
9	University of Rochester	0.02
10	Hop Tenon	0.02

Table 6 The top 10 authors by number of publications

Rank	Author	Publications
1	Mauro Pittiruti	26
2	Vineet Chopra	20
3	Julie Jaffray	13
4	Maureen Andrew	12
5	Guy Young	12
6	Claire M. Rickard	9
7	Neil A. Goldenberg	9
8	Scott A. Flanders	9
9	Elie A. Akl	8
10	Brian R. Branchford	8

Table 7 Author of centrality top 6

Rank	Author	Centrality
1	Michael B. Streiff	0.02
2	Elie A. Akl	0.02
3	Neil A. Goldenberg	0.02
4	Philippe Debourdeau	0.01
5	Mauro Pittiruti	0.01
6	E. Vincent S. Faustino	0.01

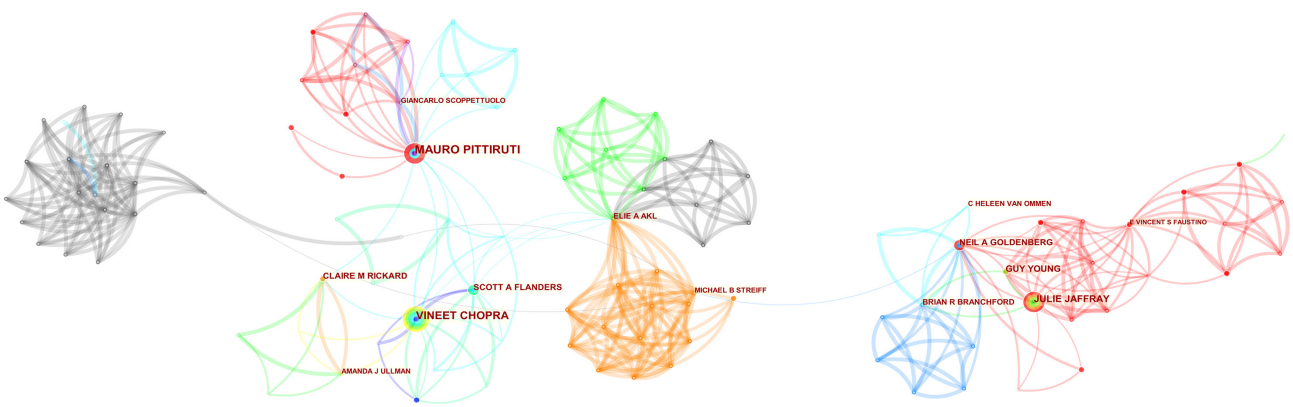

Figure 6 The author co-authorship visualization map. Each circle (or point) in the graph represents an author, and the larger the circle, the greater the number of articles published by the author. In the figure, the authors are gathered in groups, and each group represents a common research institution (or team). There are also links between clumps, representing collaborations with authors from other research institutions.

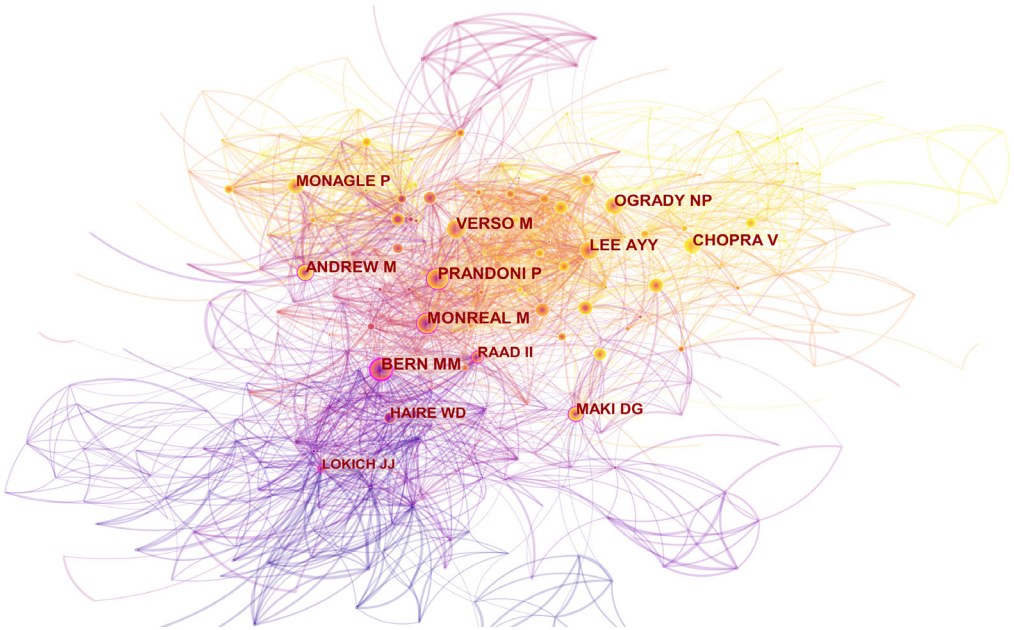

Figure 7 The author co-citation visualization map.

Table 8 The top 10 cited authors

Rank	Author	Publications
1	Murray M. Bern	294
2	Manuel Monreal	268
3	Paolo Prandoni	259
4	Melina Verso	251
5	Maureen Andrew	240
6	Vineet Chopra	237
7	Agnes Y. Y. Lee	235
8	Naomi P O'Grady	219
9	Paul Monagle	195
10	Dennis G. Maki	195

Table 9 The top 10 cited authors by centrality

Rank	Author	Centrality
1	Murray M. Bern	0.28
2	Issam I. Raad	0.15
3	Manuel Monreal	0.14
4	Maureen Andrew	0.14
5	Paolo Prandon	0.13
6	Jacob J. Lokich	0.12
7	Dennis G. Maki	0.11
8	William D. Haire	0.10
9	Vineet Chopra	0.08
10	R. Scott Evans	0.08

most published articles were *Journal of Vascular Access*, *Thrombosis Research*, *Journal of Vascular and Interventional Radiology*, *Journal of Thrombosis and Haemostasis*, and *Journal of Parenteral and Enteral Nutrition*. These top 5 journal published a total of 388 articles, accounting for 13.81% of the total literature (*Table 10*). The top 5 most cited journals were *Chest*, *New England Journal of Medicine*, *Journal of Clinical Oncology*, *Thrombosis Haemostasis*, and *Lancet* (*Table 11*). The highest cited centrality score was from *British Medical Journal* (*Table 12*).

Keywords

CiteSpace V software was used to analyze the keywords used in these included documents and a keyword co-occurrence map was constructed. The results demonstrated that these documents used a total of 482 keywords, and the number of times that any 2 keywords appeared in 1

Table 10 The top 15 journals by number of published articles

Journal	Literatures (n)	% of 2,810
Journal of Vascular Access	152	5.41
Thrombosis Research	76	2.70
Journal of Vascular and Interventional Radiology	64	2.28
Journal of Thrombosis and Haemostasis	49	1.74
Journal of Parenteral and Enteral Nutrition	47	1.67
Supportive Care in Cancer	38	1.35
Blood	37	1.32
Journal of Clinical Oncology	36	1.28
Journal of Pediatric Surgery	36	1.28
Cochrane Database of Systematic Reviews	35	1.25
Critical Care Medicine	35	1.25
Pediatric Critical Care Medicine	32	1.14
Journal of Vascular Surgery	31	1.10
Haemophilia	30	1.07
Pediatric Blood Cancer	30	1.07

Table 11 The top 10 most cited journals

Rank	Journal	Publications
1	*Chest*	1,081
2	*New England Journal of Medicine*	1,020
3	*Journal of Clinical Oncology*	843
4	*Thrombosis Haemostasis*	800
5	*Lancet*	791
6	*Annals of Internal Medicine*	770
7	*Thrombosis Research*	743
8	*Journal of Vascular Interventional Radiology*	728
9	*Journal of Thrombosis Haemostasis*	714
10	*Radiology*	689

document at the same time was 2,731 times (*Figure 8*). The top 5 keywords with the highest frequency were "thrombosis", "central venous catheter", "complication",

Table 12 The top 9 journals cited for centrality

Rank	Journal	Centrality
1	*British Medical Journal*	0.08
2	*American Journal of Hematology*	0.04
3	*Annals of Surgery*	0.04
4	*British Journal of Surgery*	0.04
5	*Annals Thoracic Surgery*	0.04
6	*Antimicrobial Agents and Chemistry*	0.04
7	*Intensive Care Medicine*	0.03
8	*Haematologica*	0.03
9	*American Surgeon*	0.03

"risk factor", and "deep venous thrombosis" (*Table 13*). The keyword with the highest centrality score was "infection" (*Table 14*). Burst analysis was conducted on the keywords with high frequency, and the results revealed that the use of high-frequency keywords showed obvious annual changes (*Figure 9*).

Discussion

The results of this study demonstrated that in the SCI-E database, the literatures related to thrombosis after central venous catheterization were mainly published after 1990. The number of published literatures generally showed an increasing trend, and the number of citations also increased year by year. These documents are mainly from developed countries in Europe and North America, including USA, UK, Italy, and France, with the majority of collaborations occurring in these countries. However, cooperation between institutions tended to be limited to the same country, and cooperation between authors tended to be within the same institution. The analysis showed that although specialized journals in the field of vascular medicine and thrombosis published more articles, the top comprehensive journals were cited more frequently. Keyword analysis showed that in recent years, research on thrombosis after central venous catheterization was more targeted and focused on evidence-based medicine.

Catheter related thrombosis can be divided into tunneled or non-tunneled catheters, peripherally inserted central catheter (PICC), implanted ports, and dialysis catheters (14). Among them, PICC-related thrombosis accounts for about 80% of all catheter-related thrombosis in tumor

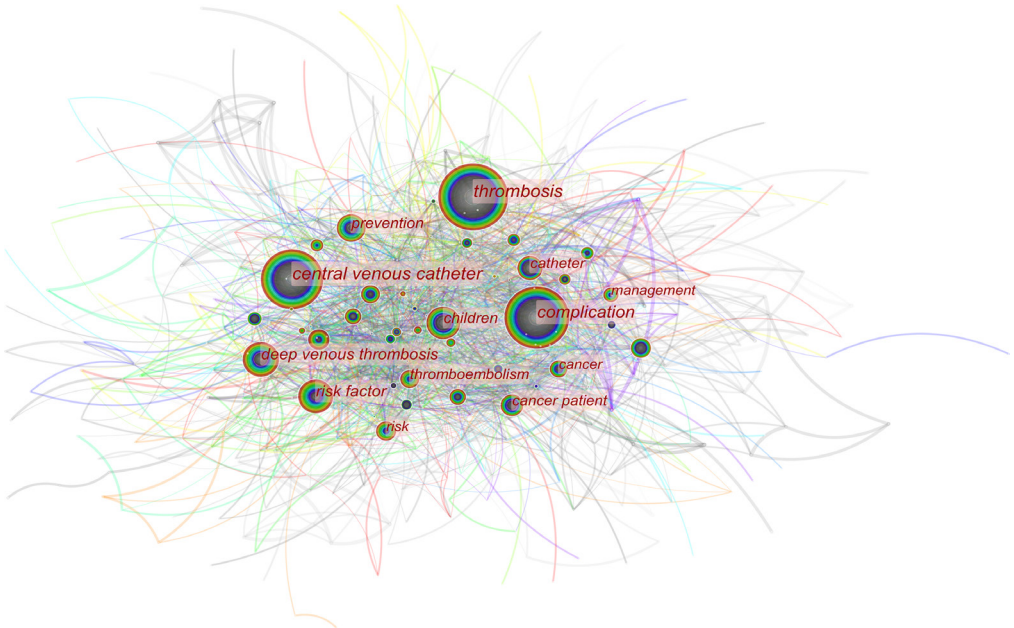

Figure 8 The keyword co-occurrence map.

Table 13 The top 10 keywords by frequency

Rank	Keyword	Frequency
1	Thrombosis	952
2	Central venous catheter	871
3	Complication	853
4	Risk factor	445
5	Deep venous thrombosis	412
6	Children	386
7	Prevention	371
8	Catheter	282
9	Cancer patient	245
10	Thromboembolism	245

Table 14 The top 10 keywords by centrality

Rank	Keyword	Centrality
1	Infection	0.09
2	Therapy	0.08
3	Chemotherapy	0.07
4	Placement	0.07
5	Molecular weight heparin	0.07
6	Heparin	0.07
7	Deep venous thrombosis	0.06
8	Catheter	0.06
9	Cancer patient	0.06
10	Cancer	0.06

patients (15). In a multicenter prospective study of 477 cancer patients who received a total of 50,841 catheter-days, 9 patients (1.9%) developed symptomatic upper extremity deep vein thrombosis (16). In another study, Lu *et al.* included 86 studies for a meta-analysis and demonstrated that the incidence of PICC-related venous thrombosis was 2.29% (17). In another study by Jones *et al.*, catheter-related deep vein thrombosis occurred in 5.5% of PICC patients (18). It should be noted that these patients received standard catheter irrigation and heparinization after PICC implantation and may also have a degree of asymptomatic deep vein thrombosis. Furthermore, PICC increased the risk of symptomatic catheter-related thrombosis by 26% compared with other central venous catheterization methods (11). This may possibly be related to the longer indwelling time of the PICC (19). Central venous catheters via the subclavian, internal jugular, and femoral veins are generally indwelling for a shorter period of time, especially after extensive PICC development. Therefore, these locations are less likely to form blood clots.

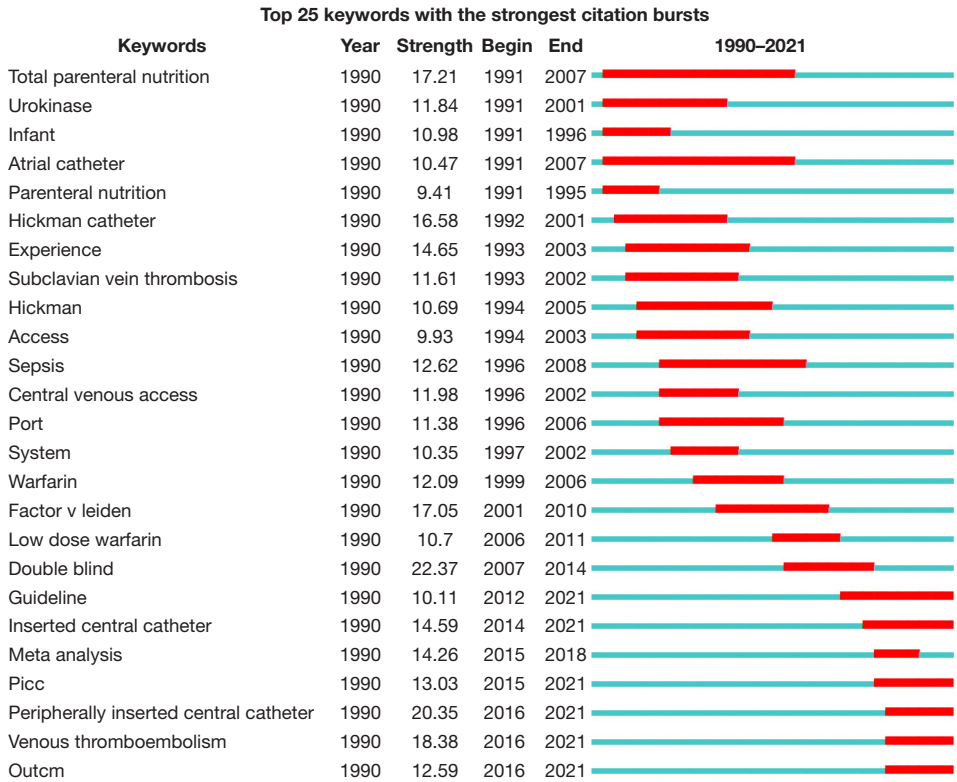

Figure 9 The top 25 keywords with the strongest citation bursts.

Despite the era of aggressive prophylaxis, some patients develop catheter-related thrombosis after central venous catheterization. In a systematic review study, Leung *et al.* analyzed the results of 25 reports and found that most of the studies considered age, malignancy, diabetes, obesity, chemotherapy, thrombophilia, and previous thrombosis as risk factors for tube-related thrombosis (20). Another study has reported that associated risk factors include successful catheterization after multiple procedures [odds ratio (OR) =2.61; 95% confidence interval (CI): 1.12 to 6.05] and fluorouracil-containing chemotherapy (OR =4.27; 95% CI: 1.3 to 14.07). Risk factors for venous thromboembolism include fluorouracil-containing chemotherapy (OR =4.54; 95% CI: 1.63 to 12.61), male sex (OR =2.03; 95% CI: 1.04 to 3.93), and increased white blood cells (OR =1.12; 95% CI: 1.00 to 1.26) (18). Of course, compared with other central venous catheterization methods, PICC also increases the risk of catheter-related thrombosis, which may be related to the large amount of fluid infusion that fills the inner port of the catheter and the distant blood stagnation (13). To reduce multiple catheter placement attempts, ultrasound guidance can be used, thereby reducing the risk of thrombosis (21,22). Other risk factors include insertion of the catheter on the left side of the body (23), catheter diameter, catheter tip location, catheter indwelling time, and type of catheter (10).

Regarding the management of catheter-related thrombosis, current opinions are relatively consistent. Anticoagulation therapy is often administered to stabilize the thrombus, which is then resolved by the body's thrombolytic system. In general, catheter-related deep vein thrombosis requires about 3 months of treatment. Initial treatment can be with intravenous anticoagulants or subcutaneous anticoagulants, and after a certain period of time, it can be gradually converted to oral anticoagulants (24). Once the patient starts anticoagulation, the catheter does not need to be removed until necessary (25).

This report presents the current research status in this field, including the distribution of countries, research institutions, researchers, and journals. The results of the keyword analysis may lead to changes in relevant research priorities. There were some limitations to this bibliometric study. First, the overall situation and changing trend of clinical research was not fully examined. Furthermore, the

study failed to distinguish the different types of thrombosis after central venous catheterization. Nonetheless, these findings suggested that future research should focus on the prevention, early diagnosis, and treatment of asymptomatic central venous catheter-related thrombosis.

Acknowledgments

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-1552/coif). The authors have no conflicts of interest to declare.

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

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