

## Review Article

# Trends in interventional therapies for pulmonary embolism: a bibliometric analysis of global research from 1994 to 2024

Bin Liu<sup>1,3\*</sup>, Haiyan Mao<sup>2\*</sup>, Yuanyuan Liu<sup>4</sup>, Ruiyuan Gu<sup>3</sup>, Yue Zhang<sup>5</sup>

<sup>1</sup>The First Clinical Medical College of Shandong University of Traditional Chinese Medicine, Jinan 250014, Shandong, China; <sup>2</sup>Outpatient Department, Shandong Provincial Taishan Hospital, Tai'an 271200, Shandong, China; <sup>3</sup>Vascular Surgery Department, The Second Affiliated Hospital of Shandong First Medical University, No. 366 Taishan Street, Tai'an 271200, Shandong, China; <sup>4</sup>Respiratory Department, The Second Affiliated Hospital of Shandong First Medical University, No. 366 Taishan Street, Tai'an 271200, Shandong, China; <sup>5</sup>Peripheral Vascular Disease Department, Affiliated Hospital of Shandong University of Traditional Chinese Medicine, Jinan 250014, Shandong, China. \*Equal contributors.

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**Abstract:** The aim of this study is to comprehensively analyze interventional therapies for pulmonary embolism (PE) and to examine the emerging trends and frontiers of research in this field. The second goal is to provide a scientific basis for the future application of interventional therapies for PE. Combination treatment of PE using interventional therapies is common in clinical practice. To evaluate the safety and efficacy of interventional therapies for PE, a retrospective analysis was conducted based on 1,345 papers on PE and interventional therapies published from 1994 to July 2024, identified in the Web of Science Core Collection database. Data along with the author's name, affiliation, country, journal title, publication year, keywords, journals, cited references, and other cited references, were collected. Visualization tools, including CiteSpace, VOSviewer, Bibliometrix, and Excel, were used to analyze the literature reports. The number of publications in the field has been increasing annually, particularly since 2020. The United States leads in publication output, with Harvard University and Professor Gregory Piazza the most prolific contributors to the field. Our analysis revealed a need for enhanced international collaboration to further progress research. The research landscape has shifted from clinical observations to evidence-based medicine, with a focus on randomized clinical trials and integration of prognostic analyses. Interventional therapies are increasingly recognized as alternative strategies, particularly for patients with high-risk PE, although the low level of available evidence remains a challenge. Furthermore, randomized controlled trials on interventions for PE are at an early stage, signaling a critical need for bolstered research support in this domain.

**Keywords:** Pulmonary embolism, interventional therapies, Bibliometrics, CiteSpace, VOSviewer, visual analysis

## Introduction

Pulmonary embolism (PE) is the third leading acute cardiovascular syndrome globally, behind stroke and myocardial infarction [1], with an estimated annual incidence of 390,000 cases in the United States [2], and an annual incidence rate of 46/100,000 [3]. Individuals presenting with PE along with high-risk features, such as hemodynamic instability and cardiac arrest, have 30-day all-cause mortality rates > 40% [4]. With developments in medical technology, interventional therapies, including

catheter-directed thrombolysis (CDT), ultrasound-assisted CDT (USCDT), pharmacomechanical CDT, and aspiration thrombectomy, among others, have become some of the most important approaches for PE treatment. These methods have shown great potential in improving therapeutic efficacy and reducing complications in patients with intermediate-high-risk PE and those with high-risk PE and contraindications to thrombolysis.

CDT involves insertion of a catheter into the pulmonary arteries via the femoral route, accord-

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ing to the 2019 European Society of Cardiology (ESC) guidelines [5]. Catheters are used for thrombus aspiration and mechanical fragmentation with in situ reduced-dose thrombolysis. These interventional procedures have achieved 87% success rates [6]. Compared with anticoagulation alone, CDT is associated with a significantly lower risk of mortality (odds ratio (OR): 0.55; 95% confidence interval (CI): 0.39-0.80). Similarly, risk of all-cause mortality is significantly higher with systemic thrombolysis than that with anticoagulation alone (fixed-effect model, OR: 1.96; 95% CI: 1.64-2.34; 20 studies) [7]; however, these findings will be influenced by publication bias, given the scarcity of research on clinical efficacy outcomes.

In this study, we examined the bibliometric features of studies on PE and interventional therapies during the last three decades, with the aims of elucidating the historical progression, current trends, and prevalent research themes in this field, thus offering a valuable reference for researchers and clinical professionals.

## Materials and methods

### Search strategy

A retrospective bibliometric analysis was performed, targeting the most influential and reputable scientific journals in the field of PE and interventional therapies from January 1994 to July 2024. This study was conducted on July 10, 2024. Literature was retrieved through the Web of Science Core Collection (WOSCC) database using topic search keywords comprising “pulmonary embolism” and “interventional therapies”. The search strategy is presented in the [Supplementary Material](#).

### Inclusion and exclusion criteria

English-language articles published between 1994 and 2024 were included. Two reviewers (L.B. and M.H.Y.) independently reviewed the literature, and discrepancies were resolved by consensus with a third reviewer (Z.Y.). Articles were considered for inclusion if they primarily focused on the investigation or reporting of PE and interventional therapies.

### Extraction and analysis of bibliometric data

Bibliometric data, including author name, affiliation, country, journal title, publication year,

keywords, journal impact factor, citing references, and cited references, were systematically gathered from articles by a team of three reviewers (Z.Y., L.B., and M.H.Y.). In case of disagreement between reviewers, the senior author (Z.Y.) mediated to reach a consensus.

### Data analysis

Articles were retrieved from the WOSCC database in plain text format. Impact factor was determined based on the Journal Citation Reports (2021). Analyses of authors, institutions, country demographics, and research focal points in the field were conducted using CiteSpace 6.3. R1, VOSviewer 1.6.20, Bibliometrix, and Excel.

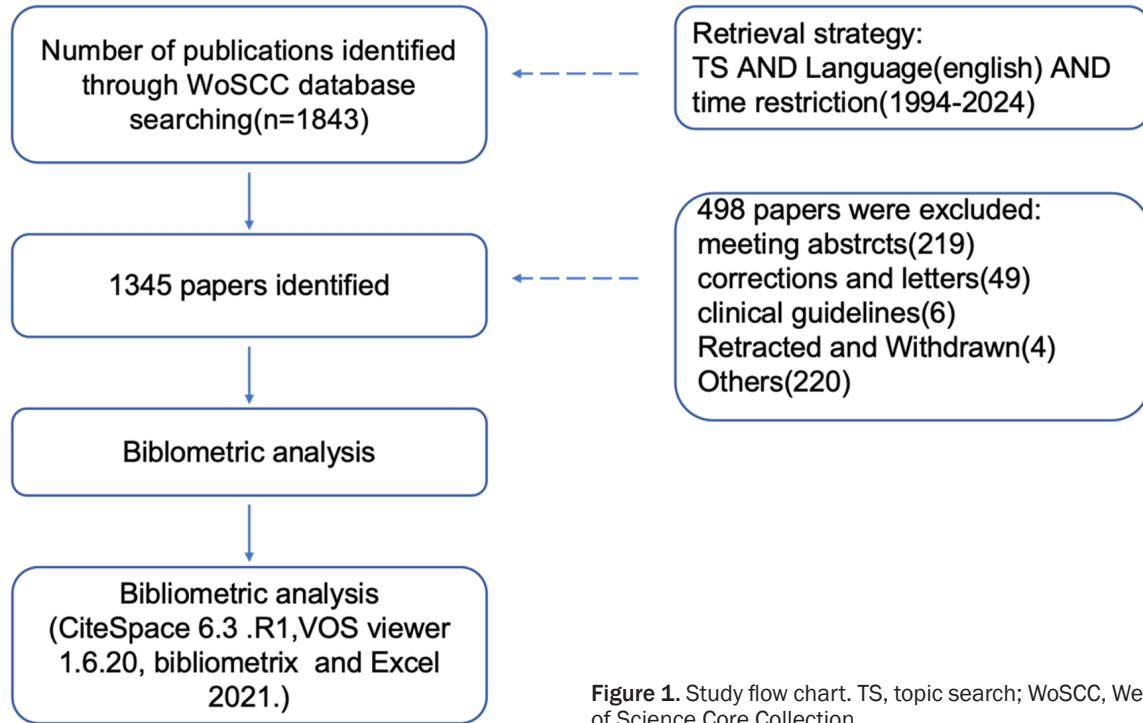
## Results

### Literature publications and citations

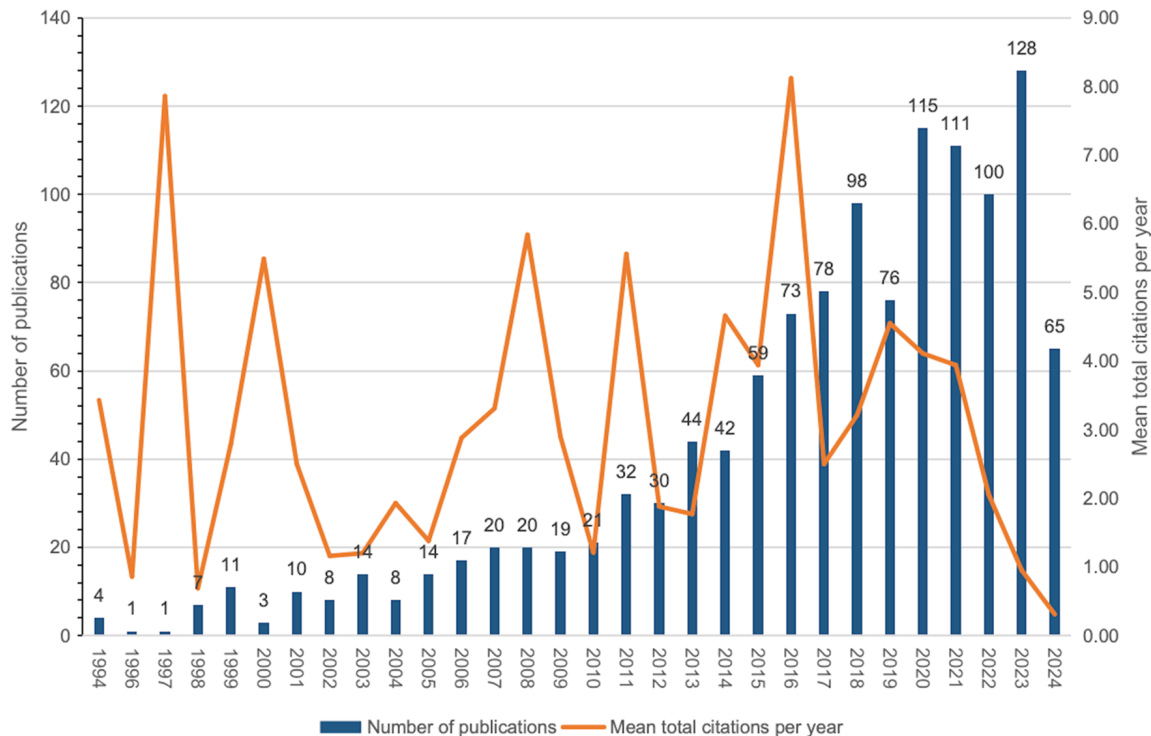
From 1994 to 2024, 1,843 papers focusing on PE and interventional therapies were identified, and following meticulous manual screening, 1,345 articles were deemed suitable for bibliometric analysis, having met specified criteria related to article type, temporal relevance, and language. The ensuing bibliometric investigation provided valuable insights into the scholarly landscape related to interventional therapies for PE. A study flow chart outlining the methodology employed in this study is presented as **Figure 1**. The systematic approach taken ensured a rigorous and comprehensive research methodology, offering a robust foundation for subsequent data analysis and interpretation.

An analysis of numbers of publications about PE and interventional therapies, as well as mean total citations, over the last 30 years was conducted to discern longitudinal trends in this field. The outcomes of this analysis are illustrated in **Figure 2**, which shows the fluctuating upward trajectory in the number of publications over the period analyzed. Notably, a substantial increase in publications was observed after 2020, with a peak of 128 papers recorded in 2023. The peak number of mean total citations per year was 8 in 2016, with 12 citations in subsequent years, indicating a surge in scholarly impact. Intriguingly, this peak in citations preceded the peak in numbers of publications

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**Figure 1.** Study flow chart. TS, topic search; WoSCC, Web of Science Core Collection.

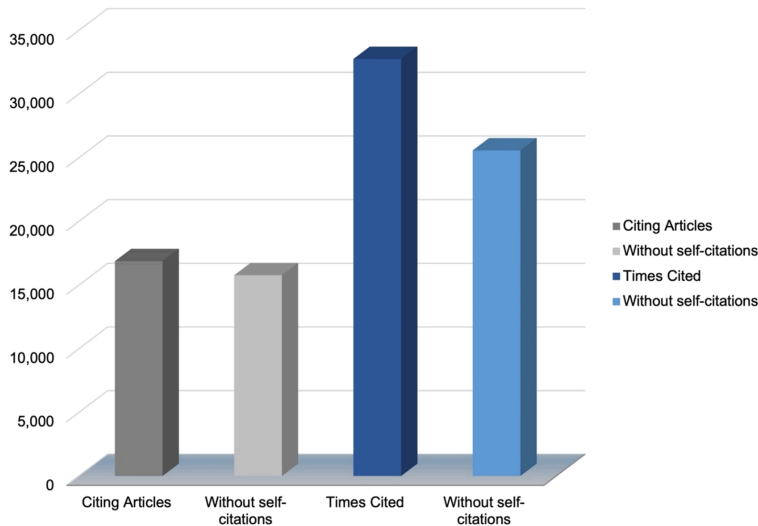


**Figure 2.** Number of annual publications and mean total citations relating to pulmonary embolism and interventional therapies from 1994 to 2024.

by five years, suggesting an accelerated uptake and recognition of research within this domain.

These findings underscore the dynamic nature of research activity and the evolving landscape

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**Figure 3.** Citing literature and cited literature.

of scholarly contributions to research on PE and interventional therapies over the past three decades.

The differences between references cited and references citing within this field are depicted in **Figure 3**. After exclusion of self-citations, the number of citing instances was 16,868, whereas there were 32,743 instances of being cited. Notably, the average citation frequency per publication was 24.24 times, indicating robust scholarly impact in this research domain. Furthermore, the calculated h-index, a metric of scholarly productivity and impact, was 84. These findings underscore the significance and influence of research contributions within the field, highlighting the active engagement and recognition within the scholarly community.

### *Productive journals and highly cited studies*

Using CiteSpace software, the Z-core function was added in advance, to merge and connect the analyzed data. **Figure 4A** illustrates the distribution of citing and cited journals, based on a dual-map overlay atlas, which was applied to delineate the relationships among journals, with citing journals positioned on the left and cited journals on the right. The color hues of the connecting lines indicate different disciplines. Notably, citing journals were predominantly relevant to the domains of clinical and molecular medicine, while cited journals primarily encompassed fields including health, nursing, and

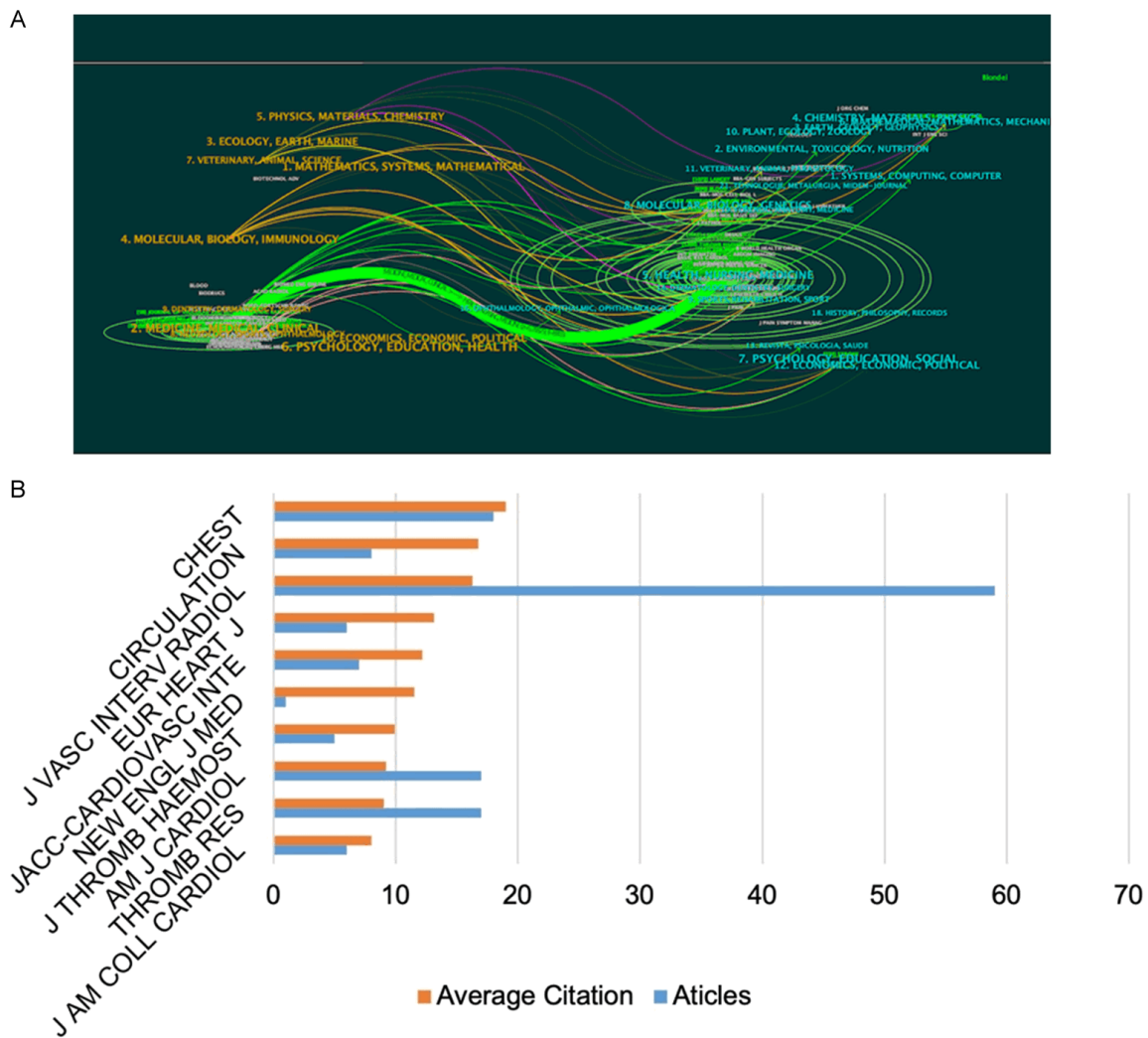
general medicine. A total of 329 journals had contributed articles or reviews within this scholarly domain. The ten most prolific journals in this specialized field are listed in **Figure 4B**, alongside their respective average citation rates and total publication counts. This analysis sheds light on the intricate interplay between various disciplines within the broader scope of scholarly communication. The top 10 most influential articles on PE and interventional therapies, considered seminal studies in this field, are presented in **Table 1**. Studying these articles will be crucial to

generating enhanced insights into the key research directions in the realm of PE and interventional therapies and will facilitate comprehensive understanding of critical research avenues in this domain.

### *Contributions of prolific authors and co-citations*

Our analysis also offers insights into the relationships among authors and international scholars. Of the 5,720 authors of the articles featuring PE and interventional therapies, notable contributors include Piazza, Gregory, Sista, Akhilesh K, Goldhaber, Samuel Z, and Kabrhel, Christopher. The top five authors have made substantial contributions in the realm of PE and interventional therapies, each authoring more than 20 papers, with two authors exceeding 28 related articles (**Table 2**). Piazza, Gregory and Sista emerged as the most prolific authors, with 29 publications each, followed closely by Goldhaber with 23, and Kabrhel with 22. A network analysis conducted using VOSviewer further revealed the distribution of prolific authors. Among the top 10 most productive authors in this domain, a significant presence of authors from Switzerland was observed, with a single author dominating; however, the majority of the top 10 co-cited authors hailed from the USA, underscoring the substantial scholarly influence originating from this region, with minority representations from Switzerland and Greece. This delineation of prolific authors and their

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**Figure 4.** A. Dual-map overlay of journals publishing research on pulmonary embolism and interventional therapies. B. Visualization map showing total numbers of publications and average numbers of citations.

**Table 1.** The top 10 co-citation references related to PE and interventional therapies

Rank	Year	First author	Title
1	2014	Kucher N [13]	Randomized controlled trial of ultrasound-assisted catheter-directed thrombolysis for acute intermediate-risk pulmonary embolism
2	1999	MW [25]	Catheter-directed thrombolysis for lower extremity deep venous thrombosis: report of a national multicenter registry
3	2015	Piazza G [16]	A prospective, single-arm, multicenter trial of ultrasound-facilitated, catheter-directed, low-dose fibrinolysis for acute massive and submassive pulmonary embolism: the SEATTLE II study
4	2020	Ortel TL [26]	American Society of Hematology 2020 guidelines for management of venous thromboembolism: treatment of deep vein thrombosis and pulmonary embolism
5	2016	Di Nisio M [27]	Deep vein thrombosis and pulmonary embolism
6	2014	Kahn SR [28]	The postthrombotic syndrome: evidence-based prevention, diagnosis, and treatment strategies: a scientific statement from the American Heart Association
7	2015	Kuo WT [29]	Pulmonary embolism response to fragmentation, embolectomy, and catheter thrombolysis (PERFECT): initial results from a prospective multicenter registry
8	2009	Kuo WT [30]	Catheter-directed therapy for the treatment of massive pulmonary embolism: systematic review and meta-analysis of modern techniques
9	1994	Semba CP [31]	Iliofemoral deep venous thrombosis: aggressive therapy with catheter-directed thrombolysis
10	2018	Tapson VF [15]	A randomized trial of the optimum duration of acoustic pulse thrombolysis procedure in acute intermediate-risk pulmonary embolism: the OPTALYSE PE trial



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**Table 2.** Top 10 prolific most authors

Rank	Author	Country	Documents	Citation	Average article citation	H-index
1	Piazza, Gregory	USA	29	1,067	56.62	14
2	Sista, Akhilesh K	USA	29	932	41.55	13
3	Goldhaber, Samuel Z	USA	23	1,051	62.04	12
4	Kabrhel, Christopher	USA	22	780	50.95	14
5	Weinberg Ido Konstantinides	USA	20	748	49.5	13
6	Stavros	Greece	19	655	38.47	12
7	Kucher, Nils	Switzerland	19	1,288	90.11	13
8	Rosenfield, Kenneth	USA	19	858	66.53	16
9	Chaer, Rabih A	USA	18	357	25.06	11
10	Tapson VF	USA	18	566	46.94	9

affiliations underscores the global distribution of scholarly contributions within the field of PE and interventional therapies.

Using VOSviewer software to read data from bibliographic database files and create a map, the maximum number of authors per document was 25. A collaborative network among authors, each having more than five publications, was generated using VOSviewer, to provide a visual representation of scholarly collaborations within the realm of interest (**Figure 5**). The visualization map revealed the presence of eight distinct clusters, indicating various collaborative groups or thematic clusters among the authors (**Figure 5A**). Notably, Kaymaz emerged as the most prominent contributor within this network, boasting the highest number of links, with a total of 86 connections, suggesting extensive collaboration with other authors. Moreover, an overlay map analysis indicated the active involvement of at least three distinct medical teams currently engaged in research on PE and interventional therapies (**Figure 5B**). This observation underscores the multi-disciplinary nature of research efforts in addressing the complexities of PE and intervention treatment, reflecting the collaborative endeavors of researchers across various medical specialties. The data in this study is not sensitive in nature and is accessible in the public domain. The data is therefore available and not of a confidential nature.

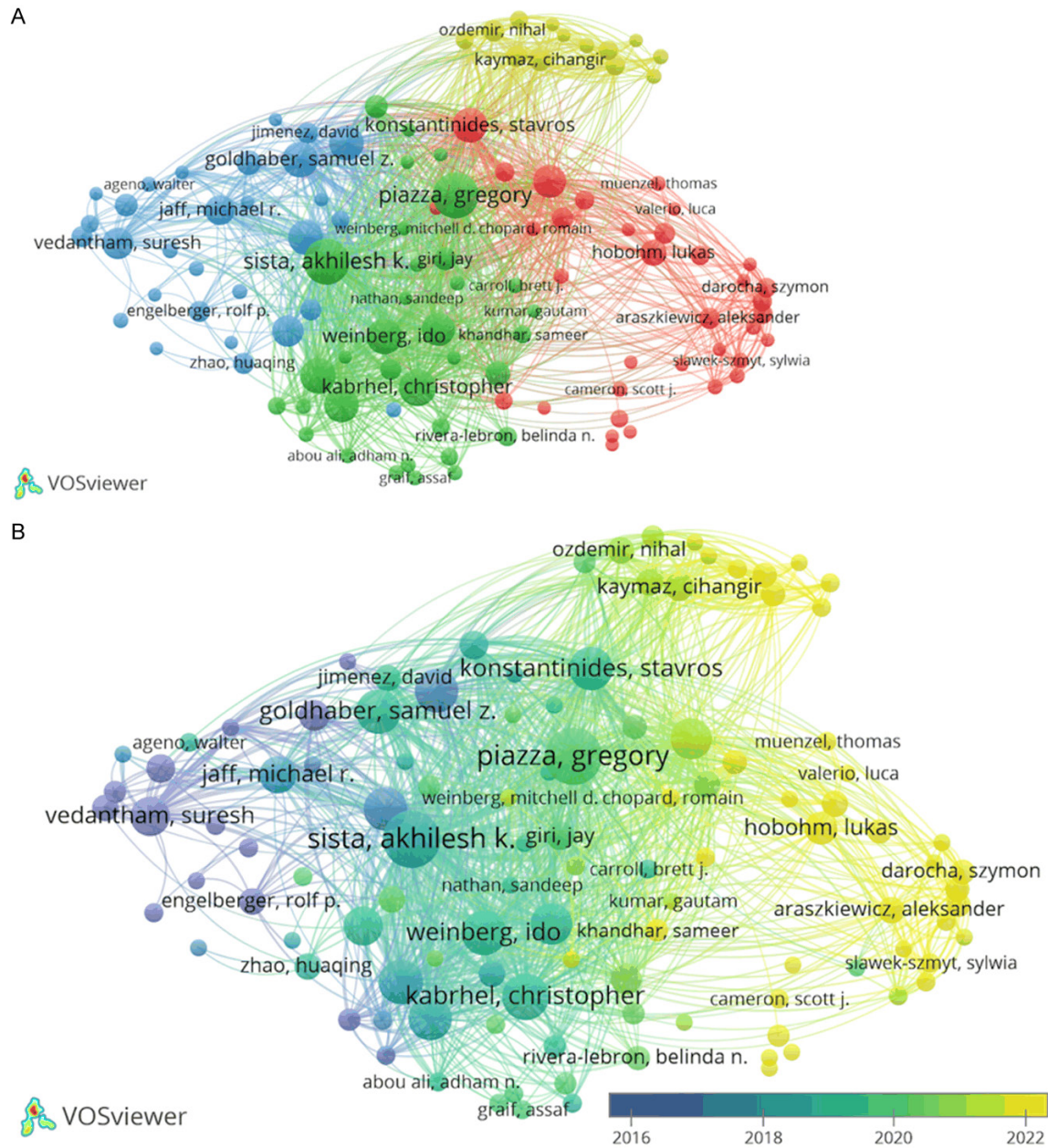
### *Distribution of countries and institutions*

Comprehensive analysis of scholarly publications on PE and interventional therapies

revealed a collaborative effort, involving 1,164 institutions from 59 countries, resulting in the co-authorship of 1,345 publications. The distribution of publications across various countries is illustrated in **Figure 6**. The United States led the pack, with 2,449 articles, followed by China (355), Germany (212), France (137), Canada (125), the UK (125), Italy (107), Spain (104), and the Netherlands (98 articles). Notably, research in this field has been prolific in the United States, Germany, Canada, the UK, and France since 1994, underscoring their longstanding engagement in PE-related research. In contrast, the involvement of China in this domain commenced notably later, with research activities beginning in 2009. This global collaboration highlights the diverse geographic contributions and the collective effort of researchers worldwide in advancing knowledge and understanding in the field of PE and interventional therapies.

A comprehensive overview of institutions contributing to publications in the field ( $n = 164$ ) is provided in **Figure 7A**. Among these, the top five institutions distinguished by their prolific scholarly output were Harvard Medical School, Pennsylvania Commonwealth System of Higher Education, Massachusetts General Hospital, and the University of Pittsburgh. These rankings underscore the significant contributions of these institutions to the scholarly discourse surrounding PE and interventional therapies. Their presence highlights the academic prowess and research excellence fostered within these renowned institutions, further solidifying their position as leaders in advancing knowledge and innovation in the field.

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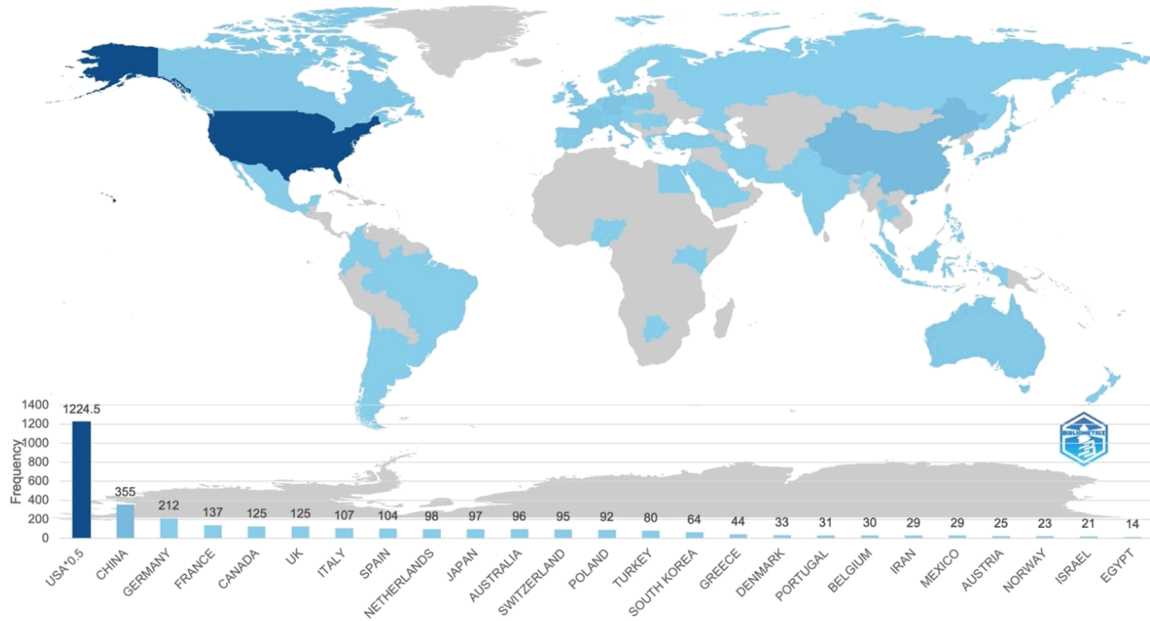
**Figure 5.** Co-authorship analysis of prominent authors in the field of PE and Interventional therapies. A. A network visualization map. B. An overlay visualization map.

The minimum number of institutional publications was set to five, and VOSviewer was used to identify 124 institutions contributing to institutional co-authorship. An institutional co-authorship network is presented as **Figure 7B**, and comprises 124 institutions arranged into 12 clusters. Recently, Chinese institutions have exhibited an increasing influence in the field of PE and interventional therapies. This trend is discernible from an overlay map depicting the historical evolution of article counts.

### Keyword analysis

Keywords with frequencies > 10 are presented in **Figure 8A**. A total of 195 high-frequency keywords were identified from 1,345 studies and categorized into four clusters. We selected three major clusters from the four clusters for analysis: Cluster 1 (red cluster): research into PE, including risk, extracorporeal membrane-oxygen, and multicenter trials; Cluster 2 (green cluster): interventional therapies, including

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**Figure 6.** Distribution of countries engaged in PE and interventional therapies research.

thrombectomy, catheter-directed thrombolysis, interventional radiology; and Cluster 3 (blue cluster): treatment of deep-vein thrombosis, include oral anticoagulant therapy, and molecular-weight heparin.

As illustrated in **Figure 8B**, interventional procedures and aspiration thrombectomy have been the longest-lasting hotspots, spanning from 1994 to the present. Burst word analysis can unveil hot research topics within a research field over a specific period; the top 25 keywords with the strongest citation bursts are presented in **Figure 8C**.

### Discussion

The evolution of interventional therapies for PE has significantly enhanced treatment outcomes over the past few decades. Initially, treatment focused on anticoagulation and surgical embolectomy, which had limited efficacy and were associated with high risks. The introduction of CDT in the 1990s marked a pivotal advance, allowing for targeted clot dissolution with a reduced risk of systemic bleeding. Mechanical thrombectomy devices further improved treatment options by providing a non-pharmacological method for direct clot removal. Recent developments have seen the integration of CDT with mechanical thrombectomy for more com-

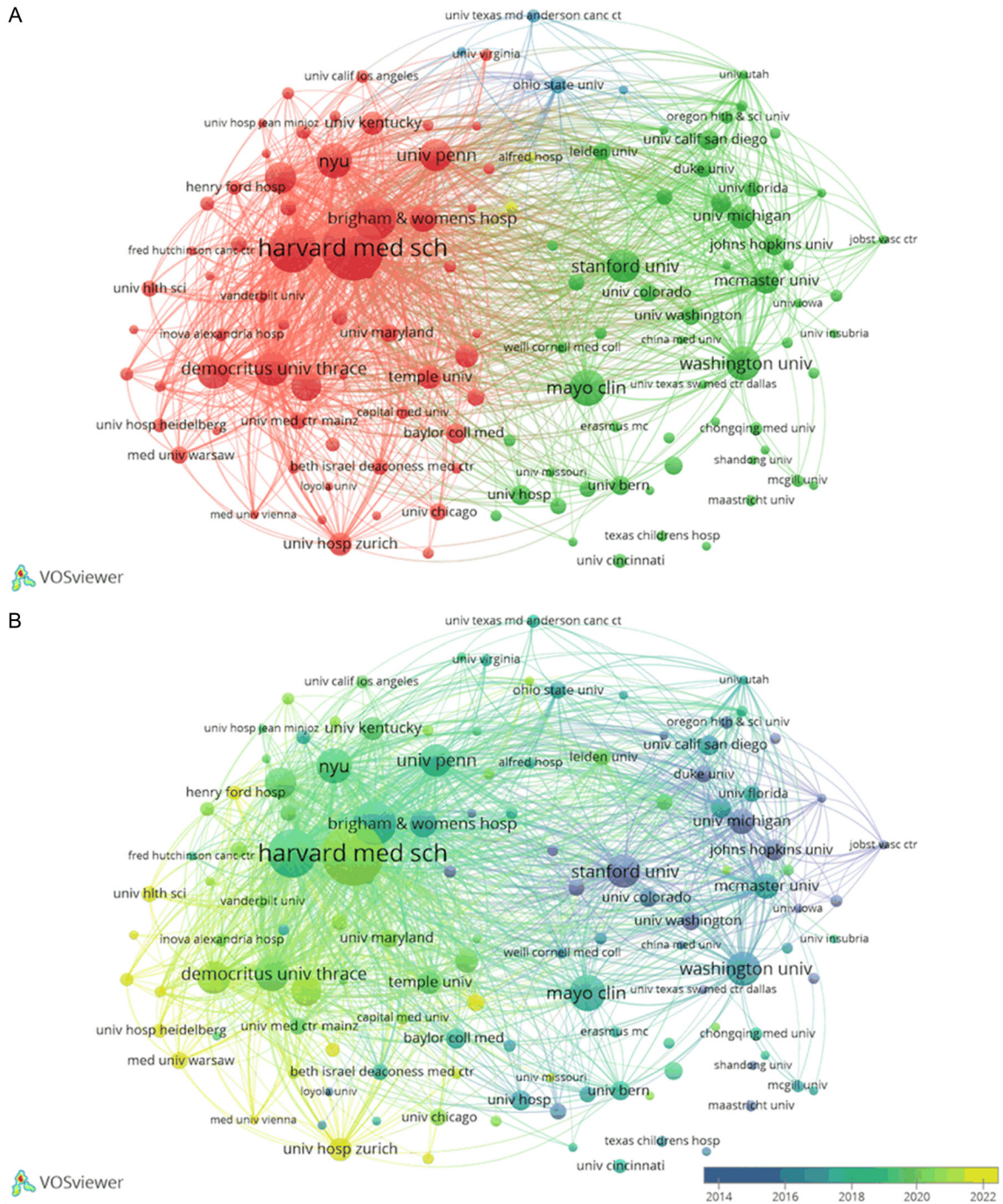
prehensive management, supported by advances in imaging and device technologies. Clinical research, including trials such as PEITHO [8], and evolving guidelines from organizations such as the American College of Chest Physicians and the ESC, have refined these interventions, leading to better patient outcomes and expanded treatment options. This progression underscores the impact of technological innovations and personalized approaches in advancing PE management.

The comprehensive bibliometric analysis conducted in this study offers valuable insights into the scholarly landscape related to PE and interventional therapies over the past three decades. We found that the numbers of studies on PE and interventional therapies published have been increasing annually, signifying a growing interest and ongoing exploration of this critical area of medical research.

Our visual analysis of distributions of publications according to country and institution indicated that the United States had the highest publication output on PE and interventional therapies, exceeding China, the second-highest contributor, by more than six-fold. Harvard University had the highest publication count in this research field, and Professor Gregory Piazza from Harvard University authored the



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**Figure 7.** A. Network visualization map of institutions. B. Overlay visualization map of institutions.

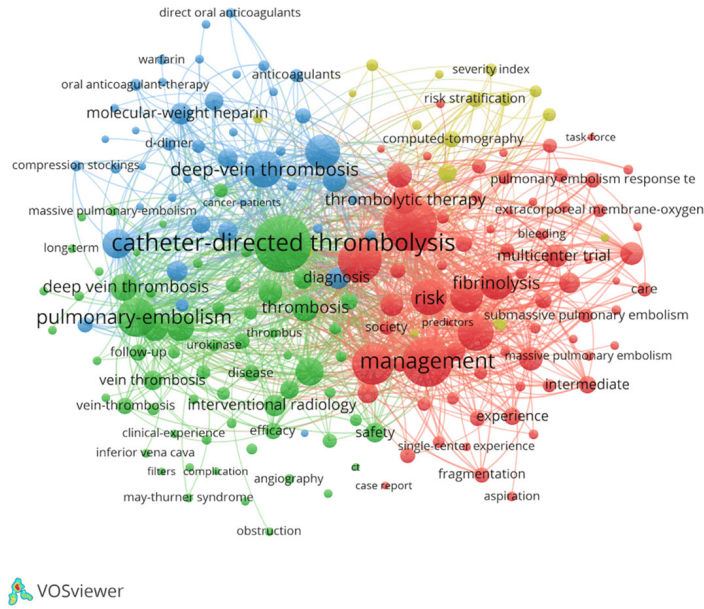
most articles, totaling 29. Keyword analysis revealed that CDT, management, and therapy constituted the central themes in PE and interventional therapies research. Among the 350 academic journals that have published articles on PE and interventional therapies, the Journal of Vascular and Interventional Radiology had

the highest publication frequency. Further, dual-map overlay of journals illustrated the thematic distribution across academic journals (**Figure 4A**).

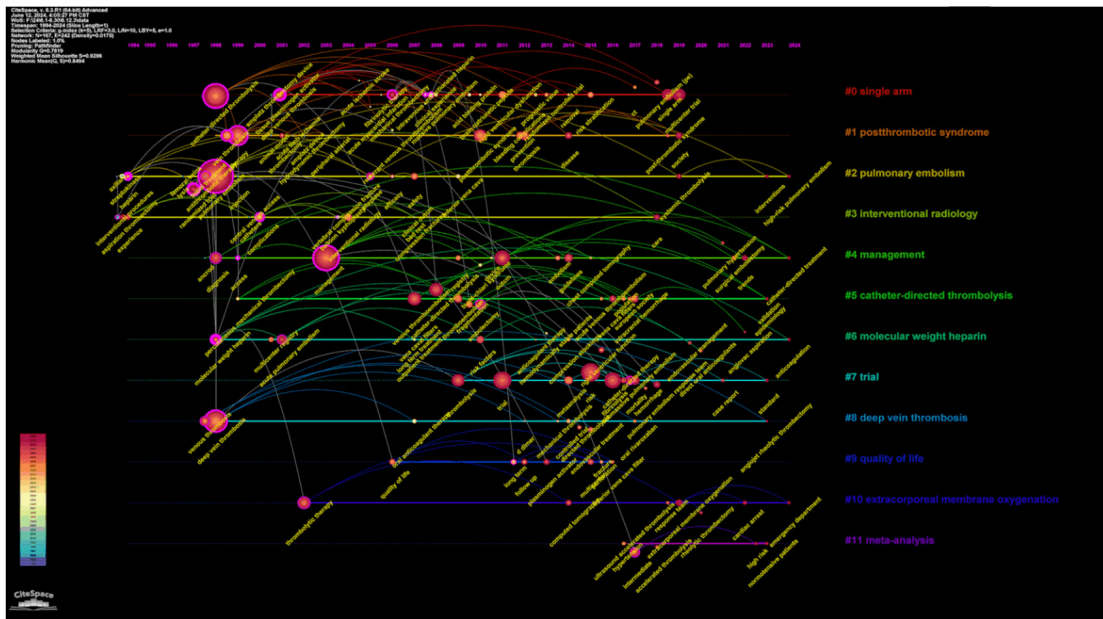
Our analysis of institutional distribution revealed a concerning trend; among the top 10

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A



B



C

Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	1994 - 2024
streptokinase	1994	9.84	1994	2006	[Red bar]
heparin	1994	9.15	1994	2011	[Red bar]
vein thrombosis	1997	8.2	1997	2013	[Red bar]
deep venous thrombosis	1998	11.83	1998	2013	[Red bar]
complications	2000	6.53	2000	2008	[Red bar]
efficacy	2000	5.05	2000	2011	[Red bar]
tissue plasminogen activator	1996	6.91	2001	2014	[Red bar]
interventional radiology	2004	5.92	2004	2018	[Red bar]
molecular weight heparin	1998	9.23	2007	2014	[Red bar]
percutaneous mechanical thrombectomy	1999	7.01	2009	2016	[Red bar]
postthrombotic syndrome	2008	9.57	2010	2015	[Red bar]
venous thrombosis	1998	6.59	2010	2015	[Red bar]
right ventricular dysfunction	2011	6.41	2011	2015	[Red bar]
thrombolysis	2011	5.4	2012	2015	[Red bar]
metaanalysis	2014	8.64	2014	2018	[Red bar]
controlled trial	2014	5.98	2014	2015	[Red bar]
multicenter registry	2001	6.08	2016	2018	[Red bar]
antithrombotic therapy	1998	5.22	2017	2019	[Red bar]
intracranial hemorrhage	2017	5.04	2017	2022	[Red bar]
multicenter trial	2019	19.21	2020	2024	[Red bar]
single arm	2019	17.81	2020	2024	[Red bar]
society	2017	6.82	2021	2024	[Red bar]
randomized trial	1997	6.92	2022	2024	[Red bar]
extracorporeal membrane oxygenation	2018	6.56	2022	2024	[Red bar]
trends	2015	6.28	2022	2024	[Red bar]

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**Figure 8.** A. Network visualization map of keywords. B. Timeline and keyword clustering display for PE and interventional therapies. C. The top 25 terms with the strongest citation bursts.

institutions, only Harvard University exhibited a centrality index  $> 0.1$ . This finding implies a deficiency in cooperation and communication among institutions, which could potentially impede research advances in the field of PE and interventional therapies. Author collaboration network analysis provided insights into influential research teams and potential collaborators, facilitating assessment of collaborative relationships. As indicated in **Table 2**, the top 10 authors in the field of PE and interventional therapies represent promising collaboration prospects, and reviewing their publications will be instrumental in comprehension of the knowledge structure in this field. We strongly advocate that countries, institutions, and authors transcend academic barriers, to foster cooperation and data exchange initiatives and propel research development and progress in PE and interventional therapies.

### *Hotspots and frontiers*

*A shift in research direction:* Cluster analysis categorized 195 frequently occurring keywords into four main clusters, as follows: Cluster 1 (red cluster): research into PE, including risks, extracorporeal membrane-oxygen, and multi-center trials; Cluster 2 (green cluster): interventional therapies, including thrombectomy, CDT, and interventional radiology; Cluster 3 (blue cluster): treatment of deep-vein thrombosis, including oral anticoagulant therapy, and molecular-weight heparin; and Cluster 4 (yellow cluster): risk stratification, computed-tomography, and severity index. The central themes and keywords extracted illustrate how research into PE has significantly evolved over the past decades. From 1994 to 2016, studies were predominantly focused on clinical observations, deep venous thrombosis, and the impact of antithrombotic therapies on mortality and bleeding in patients with PE. During this period, there were also efforts to elucidate risk factors and mechanisms underlying thrombosis and its complications in PE. The subsequent phase, from 2017 to 2020, witnessed rapid development, marked by keywords such as CDT, thrombolytic therapy, and risk stratification of PE. Since 2020, the field has undergone notable

expansion, with  $> 100$  publications annually, and an emphasis on randomized double-blind clinical trials and the establishment of PE response teams. These studies increasingly integrate randomized trial methodologies with prognostic analyses, aligning closely with the principles of evidence-based medicine.

### *Evidence-based medicine studies on interventional therapies*

The evolving landscape in the management of PE highlights the potential role of interventional therapies, particularly in patients with high-risk PE. The 2019 ESC Guidelines recommend the use of interventional therapies for patients with intermediate-high-risk PE (Class of Recommendation IIa, Level of Evidence C) [5]. Further, the American Heart Association scientific statement acknowledges the potential use of interventional therapies in patients with high-risk PE with contraindications to thrombolysis as an alternative reperfusion strategy [9]. The 2021 CHEST Guideline suggests that interventional therapies are not strongly recommended for patients with high-risk PE, because of the low level of evidence [10]. In 2022, the ESC highlighted interventional therapy as an alternative strategy for specialist centers with PE response teams, despite the lack of reliable data [11].

Currently registered randomized controlled trials of interventional therapies for PE aim to further validate efficacy. The CANARY trial [12] compared CDT with anticoagulation therapy; however, due to a small sample size and early termination, the results should be considered hypothetical. The ULTIMA trial [13] compared USCDT with anticoagulation therapy, and demonstrated the ability of USCDT to reduce right ventricular to left ventricular ratio and pulmonary artery pressure, albeit with a slightly higher risk of bleeding. In the SUNSET sPE trial [14], which compared CDT and USCDT, a more significant reduction in right ventricular to left ventricular ratio was detected in the CDT group, while the USCDT group experienced more bleeding events. Further, the OPTALYSE PE trial [15] evaluated different dosages and administration schedules of USCDT, revealing that



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lower doses and shorter durations correlated with improved right ventricular function. The SEATTLE II trial [16] assessed the efficacy of USCDT, and showed improvement in short-term hemodynamic function, but it lacked a control group. Initial findings from the KNOCOUT PE trial [10] suggest that USCDT is associated with lower bleeding rates. The PE-TRACT trial [17] is currently comparing CDT, USCDT, and mechanical thrombectomy with anticoagulation therapy, and the HI-PEITHO trial [18] is an ongoing study comparing USCDT with anticoagulation therapy, while the STRATIFY trial [19] is comparing USCDT, low-dose systemic thrombolysis, and anticoagulation therapy. The PEERLESS trial [20] is also ongoing, comparing large thrombectomy with CDT, while the FLAME trial [21] is evaluating the efficacy of large thrombectomy. Moreover, the VQPE trial [22] is assessing the impact of large thrombectomy versus systemic anticoagulation therapy on ventilation and perfusion, and the STORM-PE trial [23] will imminently evaluate the efficacy of the Indigo CAT12 device. The CATH-PE [24] and STRIKE PE trials are also ongoing studies to evaluate the Indigo CAT12 device. Most clinical data on interventional therapies to date are derived from studies lacking control groups, thus their routine recommendation for patients with intermediate to high-risk PE should await further evidence regarding their safety and efficacy.

The landscape of PE management has evolved significantly, particularly in the realm of interventional therapies. While systemic thrombolysis remains the recommended approach for patients without shock and those at high risk of bleeding, there has been a gradual expansion and refinement of interventional techniques. These therapies are increasingly recognized and studied for their potential to address the complexities of PE, offering alternatives in cases where conventional treatments may be limited.

### *Strengths and limitations*

This literature analysis employed visualization techniques to illuminate the research landscape and developmental trajectories concerning PE and interventional therapies, representing a pioneering effort in bibliometric analysis in this field. Our findings offer scholars a comprehensive understanding of prevalent research themes and emerging trends. Despite lever-

aging the authoritative WOSCC and Science Net for data retrieval, the study has inherent limitations. Primarily, its scope is confined by the selected databases, which may not encompass all relevant studies on PE and interventional therapy. Moreover, due to temporal constraints, literature published after 2024 could not be fully incorporated.

### **Conclusions**

PE and interventional therapies hold significant research value and have promising prospects for application within cardiovascular science. Visual analyses conducted using CiteSpace, VOSviewer, and Bibliometrix, indicate a rapid expansion in research output in this domain. The increasing number of publications in renowned international journals underscores the growing impact of studies in this field. The United States and China are leading the research efforts, reflecting their substantial contributions; however, despite these advances, a lack of effective collaboration among countries and institutions remains a notable impediment to further progress. Enhanced cooperation and increased data exchange among scholars and institutions will be crucial to overcoming these barriers and advancing research in PE and interventional therapies, thereby maximizing their clinical benefits and scientific understanding of cardiovascular medicine.

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### **Disclosure of conflict of interest**

None.

**Address correspondence to:** Dr. Yue Zhang, Peripheral Vascular Disease Department, Affiliated Hospital of Shandong University of Traditional Chinese Medicine, Jinan 250014, Shandong, China. E-mail: zhangyue771@163.com

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## Supplementary Material

### Supplementary data

#### *Date S1*

The search tactics: TS=((“pulmonary embol\*” OR “pulmonary thromboembolism” OR “pulmonary thrombosis” OR “pulmonary infarction”) AND (“interventional treatment” OR “Interventional therapy” OR “Interventional Radiology” OR “Catheter directed” OR “catheter based” OR “Interventional Management” OR “Catheter thrombolysis” OR “Percutaneous interventions” OR “Catheter Interventions” OR “endovascular thrombectomy” OR “aspiration thrombectomy”)) NOT (DO=(10.1016/j.chest.2015.11.026) OR DO=(10.1378/chest.08-0658) OR DO=(10.1161/CIR.0b013e318214914f) OR DO=(10.1016/j.chest.2021.07.055) OR DO=(10.1097/01.RVI.0000203418-39769.0D) OR DO=(10.1016/j.ejvs.2020.09.023)).