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# Research progress and hotspot analysis of type B aortic dissection: a bibliometric analysis from 2004 to 2023

Zhen-Yi Zhao[1,2†], Shu-Li Zhou[1,2†], Yun Peng[1,2], Can Cui[1,2] and Liang-Geng Gong[1,2*]

**Abstract**

This study aimed to analyze and visualize the research on type B aortic dissection (TBAD) over the past 20 years through bibliometric research. To reveal the development process of TBAD research and the transitions of research hotspots. Literatures was retrieved from the Web of Science Core Collection. The analysis utilized tools such as Microsoft Office Excel, VOSviewer and CiteSpace for bibliometric mapping and visualization, including assessing publication volumes and constructing collaborative networks and keyword burst graphs. A total of 1391 related articles or reviews on TBAD were included. The number of annual publications is steadily increasing. China was the top country in terms of the number of publications. University of Michigan ($n=60$) was the most productive university. The Journal of Vascular Surgery ($n=183$) was the most published and co-cited journal. Keywords burst analysis showed that "guidelines", "spinal-cord ischemia", "society", "impact", and "aortic remodeling" were the most frequently used keywords in recent years. In general, the research focus of TBAD has gradually changed from selecting the surgical method to the best clinical management and patient prognosis after thoracic endovascular aortic repair (TEVAR). Promoting positive aortic remodeling and aortic hemodynamics may be the research hotspots in the future.

**Keywords** Type B aortic dissection (TBAD), Bibliometric, Thoracic endovascular aortic repair (TEVAR), Stent-graft placement, Spinal cord ischemia (SCI), Hemodynamics

## Introduction

Type B aortic dissection (TBAD) was defined as aortic dissection involving the descending thoracic aorta beyond the left subclavian artery and its distal end, corresponding to the Debakey type III [1]. According to the 2014 European Society of Cardiology (ESC) guidelines, TBAD can be categorized into three stages: the acute stage (< 14 days), the subacute stage (> 14 days and < 3 months) and the chronic stage (> 3 months) [2]. In addition, according to the initial onset, patients were divided into noncomplicated and complicated types [3]. Acute complicated TBAD was defined as the presence of at least one of the following conditions: aortic rupture, intractable pain, rapid aortic dilation, intractable hypertension, or the presence of tissue or organ malperfusion [4]. Malperfusion syndrome is the most common complication [5]. In addition, acute uncomplicated TBAD is often treated with medical therapy. However, the 5-year follow-up results of the INSTEAD-XL trial showed that

†Zhen-Yi Zhao and Shu-Li Zhou are co-first authors.

*Correspondence:
Liang-Geng Gong
gong111999@126.com
[1]Department of Radiology, The Second Affiliated Hospital, Jiangxi Medical College, Nanchang University, Nanchang, Jiangxi Province 330006, China
[2]Intelligent Medical Imaging of Jiangxi Key Laboratory, Nanchang 330006, China

endovascular repair of acute uncomplicated TBAD has also attracted attention.

In recent years, there has been growing popularity in the utilization of bibliometric methods for analyzing the literature [6–8]. Bibliometric analysis is an approach that combines quantitative and qualitative methods for analyzing literature within a specific research field [9]. It can analyze the contribution and cooperation of publications by countries, organizations, journals, and authors, and evaluate the development and trend of research in different research fields [10].

To the best of our knowledge, there is currently no existing bibliometric analysis of TBAD in the literature. The purpose of this paper is to conduct a bibliometric analysis of publications on TBAD published in the past 20 years (2004–2023), analyze the research status of TBAD literature, facilitate the summarization and organization of literature, and help scholars understand the development characteristics and changes in this research field, while speculating on the development prospects of this field.

## Methods

### Data collection and searching strategies

All literature data were obtained from the Web of Science Core Collection (WoSCC) database, including the following editions: Science Citation Index Expanded (SCI-Expanded), Social Sciences Citation Index (SSCI), Conference Proceedings Citation Index (CPCI), Conference Proceedings Citation Index-Social sciences (CPCI-SSH), Current Chemical Reactions (CCR- Expanded) and Index Chemicus (IC). The search formula was TS= ("type B aortic dissection" OR "type III aortic dissection" OR "type B aortic intramural hematoma" OR "type III aortic intramural hematoma" OR "type B penetrating aortic ulcer" OR "type III penetrating aortic ulcer") AND (FPY = 2004–2023). Only English literature was included, and the filtering criteria included items with Reviews and Articles, and articles were excluded from "Endocrinology Metabolism", leaving 1391 remaining articles for further investigation (Fig. 1). All the data were exported as reference complete records, saved as plain text files, and stored in download_.txt format. Data collection and file downloads were completed on July 29, 2024.

### Data analysis

The 1391 documents were analyzed and visualized using Microsoft Office Excel 2022, VOSviewer (v.1.6.17), CiteSpace (v.6.2. R4), and the Bibliometrix R package (3.1.4). VOSviewer is a software for bibliometric analysis and visualization, which can construct author and journal graphs based on co-citation data or keyword graphs based on co-occurrence data [11]. A collaborative network was constructed based on the volume and relationship of publications in different countries/regions/institutions/authors. CiteSpace, which is also a software for constructing bibliometric maps. In addition, we have generated a keyword burst graph by detecting the frequency of a specific keyword appearing in different time periods, to analyze the research trends and development patterns of the keyword in specific time periods. The R package "bibliometrix" (https://www.bibliometrix.org) is mainly used for the construction of a type B aortic dissection publications global distribution network. In addition, quantitative analysis of the publications was performed using Microsoft Office Excel 2022.

Co-citation analysis is a method that uses statistical techniques to display the relationships between different academic articles based on their citation patterns. Co-occurrence analysis is a statistical method that used to identify and analyze patterns of co-occurrence or association between different items, such as words, concepts, or events, within a dataset [12].

## Results

### Annual quantitative distribution of publications

From 2004 to 2023, 1391 TBAD-related publications were identified in the WoSCC, of which 1276 (91.7%) were original research articles and 115 (8.3%) were review articles. The annual number of papers published can reflect the speed and trend of publication. As shown in Fig. 2, the growth of TBAD-related research can be divided into two stages. In the early stage (2004–2012), the annual number of publications was less than 50, but in the next 11 years, the number of publications increased rapidly. Except for a slight decline in the number of publications from 2016 to 2017, the number of TBAD articles increased annually.

### Analysis of countries/regions and institutions

The publications come from 24 countries and hundreds of institutions, with the top 10 countries located mainly in Europe ($n = 7$), Asia ($n = 2$), and North America ($n = 1$). As revealed in Table 1, among these countries, the country with the largest number of publications was China ($n = 413$, 29.69%), followed by the United States ($n = 388$, 27.89%), Italy ($n = 151$, 10.86%), and Japan ($n = 138$, 9.92%). The publications and relationships in different countries/regions of the collaboration network (Fig. 3a) indicate that there is considerable positive cooperation between different countries/regions. For example, the United States actively cooperates with China, Italy, Canada, Germany and the United Kingdom; China closely cooperates with the United States, the UK and Japan.

The top 10 institutions are located in five countries, four in the U.S. and three in China (Table 2). The top three institutions that published the most TBAD-related papers were the University of Michigan ($n = 60$, 4.31%),

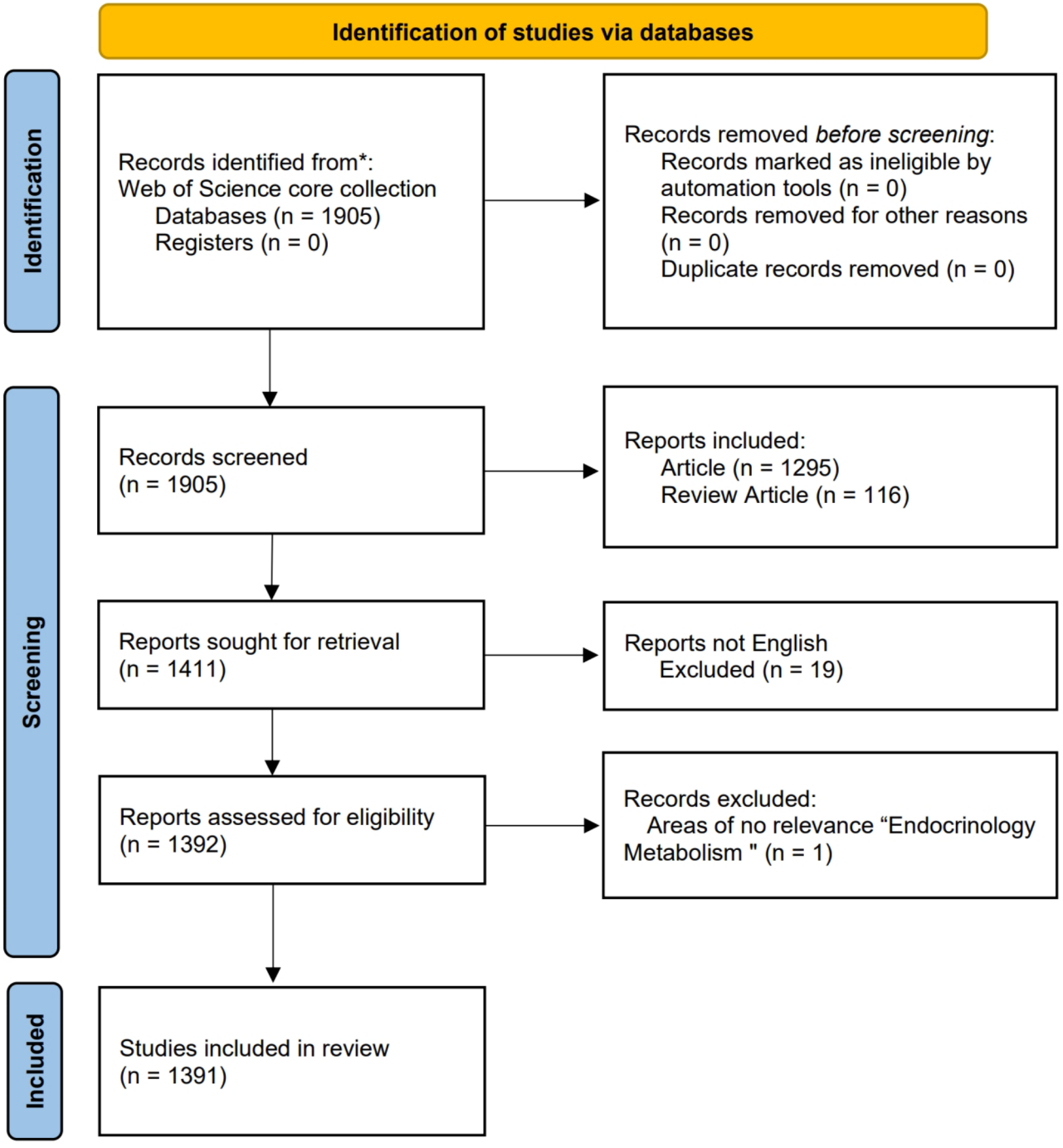


**Fig. 1** Flowchart of the searching stage in the study

Fudan University ($n = 53$, 3.81%), and Harvard University ($n = 45$, 3.24%). The collaborative network (Fig. 3b) illustrates the publication and collaboration of different institutions.

#### Analysis of journals and co-cited journals

The Journal of Vascular Surgery is the journal with the most articles on TBAD in the past 20 years (183 articles), followed by the Annals of Vascular Surgery (122 articles), the Journal of Endovascular Therapy (73 articles), Annals of Thoracic Surgery (70 articles), and the European Journal of Vascular and Endovascular Surgery (54 articles). Among the top 20 co-cited journals, 7 journals were cited more than 1000 times, of which the Journal of Vascular Surgery ($n = 5444$) was the most cited, followed by Circulation ($n = 2934$) and Annals of Thoracic Surgery

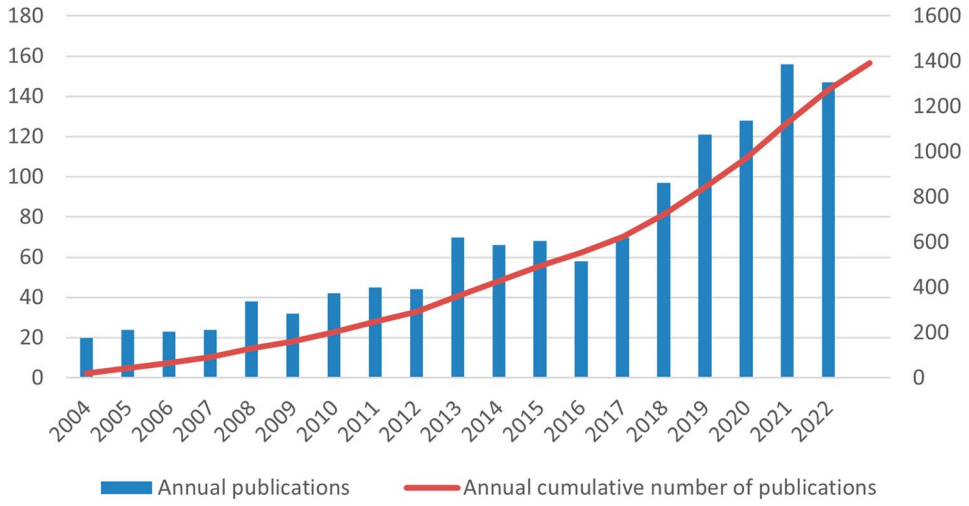


**Fig. 2** Number of articles published annually from 2003 to 2022. The horizontal axis represents the year of publication; The values on the left vertical axis are Annual publications, and the values on the right vertical axis are Annual cumulative number of publications

**Table 1** Top 10 countries/regions according to the number of TBAD publications

| Rank | Countries | Record Count | % Of 1391 | H-index | Times Cited | Average Per Item | Total link strength |
|---|---|---|---|---|---|---|---|
| 1 | China | 413 | 29.69% | 31 | 4124 | 9.99 | 69 |
| 2 | USA | 388 | 27.89% | 60 | 12,685 | 32.69 | 268 |
| 3 | Italy | 151 | 10.86% | 45 | 7975 | 52.81 | 236 |
| 4 | Japan | 138 | 9.92% | 22 | 3025 | 21.92 | 25 |
| 5 | Germany | 136 | 9.78% | 46 | 8165 | 60.04 | 213 |
| 6 | England | 101 | 7.26% | 31 | 3053 | 30.23 | 161 |
| 7 | France | 66 | 4.74% | 25 | 3312 | 50.18 | 83 |
| 8 | Netherlands | 46 | 3.31% | 24 | 2153 | 46.8 | 89 |
| 9 | Switzerland | 44 | 3.16% | 19 | 2334 | 53.05 | 77 |
| 10 | Spain | 37 | 2.66% | 20 | 2835 | 76.62 | 103 |

H-index: a composite index can be used as an indicator to evaluate the academic output quantity and level of a journal

($n = 2832$). The journal with the highest IF was the New England Journal of Medicine (IF = 96.2), followed by the Jama-Journal of the American Medical Association (63.1), the European Heart Journal (37.6) and Circulation (35.5). The details of the journals and co-cited journals in the TBAD table can be found in the Supplementary Material.

### Analysis of authors

Among the top 10 authors, all had published more than 20 articles. Trimarchi Santi and Nienaber Christoph A. were the most published authors ($n = 42$), followed by Fu Weiguo ($n = 38$). Eagle Kim A. ranked fourth in terms of the number of publications but had the highest H-index. The collaborative network (Fig. 3c) illustrates the publication status of each author and the collaboration among the authors. Spinal cord ischemia, society, impact, and aortic remodeling are the frontiers of TBAD research.

### Analysis of keywords and frontiers

As shown in Table 3, in addition to "aortic dissection" (449) and "Stanford type b aortic dissection" (298), keywords with high frequency in this study included "management" (449), "endovascular repair" (347), "thoracic endovascular aortic repair" (345), "international registry" (300), "aneurysm" (289), "outcome" (282), "repair" (249), and "stent-graft" (215). Management, endovascular therapy, and thoracic endovascular aortic repair (TEVAR) were performed more than 300 times, indicating that they are the focus of TBAD research.

Co-occurrence cluster analysis was performed on keywords that appeared more than 5 times. The thicker the line between the nodes is, the stronger the connection between the keywords. As shown in Fig. 3d, we obtained a total of eight clusters representing five research directions.

Based on the keyword co-citation network, we performed keyword emergent word detection. The top 25 keywords with the strongest citation bursts in TBAD are reported (Fig. 4). Stent-graft placement (18.53) had the

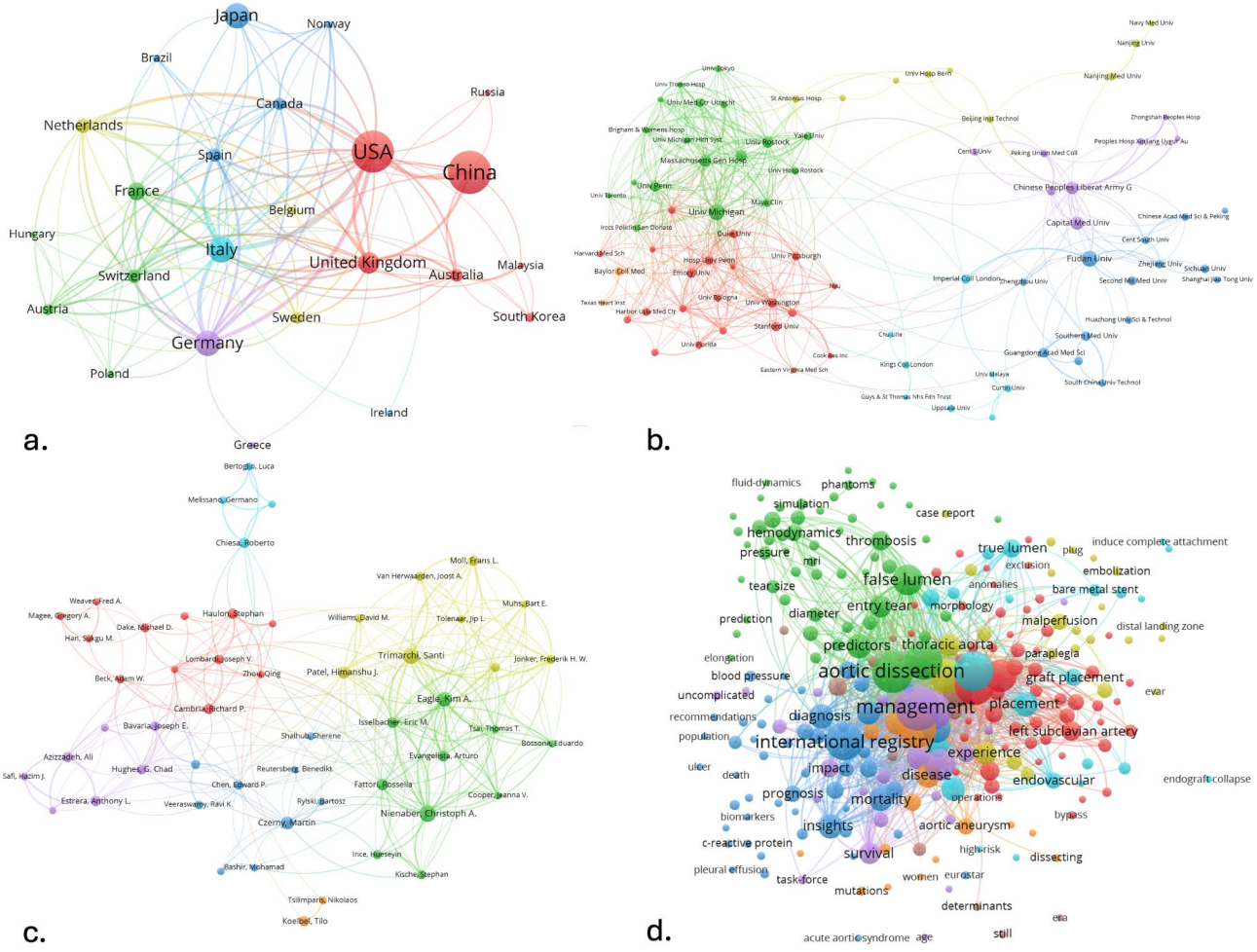


**Fig. 3** The visual map of the VOSviewer network and the cluster of keywords in the studies of TBAD. **(a)**Cooperation map of countries/regions/insitutions in TBAD. **(b)** A visual map of the VOSviewer network among institutions. **(c)** A visual cooperation map of the VOSviewer network constructed by the authors in the TBAD. **(d)** The cluster of keywords in the studies of TBAD. Nodes with different colors in the figure represent different clusters. The size of the nodes represents the number of documents, and the thickness of the lines represents the number of connections between nodes

**Table 2** Top 10 institutions according to the number of TBAD publications

| Rank | Institution | Record Count | % Of 1391 | Times Cited | Average per item | H-index |
|---|---|---|---|---|---|---|
| 1 | University of Michigan | 60 | 4.31% | 4457 | 74.28 | 33 |
| 2 | Fudan University | 53 | 3.81% | 767 | 14.47 | 14 |
| 3 | Harvard University | 45 | 3.24% | 3862 | 85.82 | 26 |
| 4 | Capital Medical University | 40 | 2.88% | 515 | 14.65 | 13 |
| 5 | University of Rostock | 35 | 2.52% | 5296 | 151.31 | 27 |
| 6 | IRCCS Policlinico San Donato | 35 | 2.52% | 2943 | 84.09 | 24 |
| 7 | University of Pennsylvania | 35 | 2.52% | 1950 | 55.71 | 21 |
| 8 | Chinese People's Liberation Army General Hospital | 34 | 2.44% | 380 | 11.18 | 10 |
| 9 | Massachusetts General Hospital | 33 | 2.37% | 3656 | 110.79 | 26 |
| 10 | Imperial College London | 33 | 2.37% | 955 | 28.94 | 16 |

strongest citation burst, followed by aneurysm (16.52), placement (13.75), and thoracic aorta (11.03). According to the burst time, stent graft repair and trial had the longest burst. At present, guidelines, spinal cord ischemia, society, impact, and aortic remodeling are the frontiers of TBAD research.

## Discussion

This study conducts a bibliometric analysis of the type B aortic dissection literature published over the last 20 years. Through statistical analysis of the number of published papers by country/region and institution, China and the United States account for more than half of the

**Table 3** Top 20 keywords in TBAD

| Rank | Keywords | Total link strength | Occurrences |
|---|---|---|---|
| 1 | management | 3193 | 449 |
| 2 | aortic dissection | 2353 | 370 |
| 3 | endovascular therapy | 2566 | 347 |
| 4 | thoracic endovascular aortic repair (tevar) | 2496 | 345 |
| 5 | international registry | 2384 | 300 |
| 6 | type b aortic dissection | 2064 | 298 |
| 7 | aneurysm | 1992 | 289 |
| 8 | outcomes | 2068 | 282 |
| 9 | repair | 1528 | 249 |
| 10 | stent-graft | 1745 | 215 |
| 11 | surgical therapy | 1451 | 190 |
| 12 | false lumen | 1468 | 184 |
| 13 | stent-graft placement | 1207 | 158 |
| 14 | dissection | 1045 | 146 |
| 15 | predictors | 817 | 103 |
| 16 | disease | 788 | 102 |
| 17 | diagnosis | 755 | 99 |
| 18 | insights | 810 | 98 |
| 19 | placement | 685 | 98 |
| 20 | aorta | 744 | 94 |

**Total link strength**: It is a comprehensive measure of all the connections between keywords and other keywords, mainly evaluated by calculating the number and/or weight of connections between them, used to assess the importance or influence of keywords in the network

total population (approximately 58%), implying a high interest in TBAD research. China publishes the most TBAD articles, but its H-index, number of citations and total link strength are lower than those of Italy, which ranks third. Chinese scholars should improve the quality of articles and strengthen cooperation with other countries. The University of Michigan (US) is the leading institution in this field. Fudan University (China) ranked second in terms of the number of publications, but its number of citations and H index were not high. Cooperation between the state and institutions is helpful for the development of academic research and further development of TBAD-related research.

A timeline of co-cited reference clusters and keyword burst analysis can reveal the main research hotspots in a certain field during a particular period and the trends of research hotspots in recent years. As shown in Fig. 5, early studies (2004–2010) focused mainly on "percutaneous separate stent endograft", "fit patient" and "endovascular management". In 1981, Volodos et al. used a homemade aortic stent for the first time to repair traumatic thoracic aortic aneurysms in Ukraine [13], and Dake et al. applied a homemade aortic stent to the descending thoracic aorta in 1994 [14]. TEVAR was subsequently developed and is widely used because its mortality rate is much lower than that of open surgery [15]. In the past, stent graft placement was often used only for patients with acute complicated TBAD. Patients with acute uncomplicated TBAD are considered not immediately life-threatening, so medical therapies such as sedation, pain control, blood pressure control, and heart rate control are often used. However, the results of a 5-year follow-up of patients with uncomplicated TBAD in the INSTEAD-XL trial, published by Nienaber Christoph A. et al. in 2013, showed no significant difference in all-cause mortality between the TEVAR and best medical treatment (BMT) groups, but aortic complications and aortic-related mortality rates were lower in the TEVAR group than in the BMT group. TEVAR can improve the long-term prognosis of uncomplicated TBAD patients [16]. In addition, with the deepening of clinical research in recent years, some scholars have found that although some patients with high-risk factors have a lower short-term risk of death, the prognosis of those treated only with medical therapy is often poor, so a subgroup has been subdivided from acute uncomplicated TBAD, namely, acute high-risk TBAD. Patients with high-risk factors are now also more recommended for TEVAR. Stent graft placement has good short-term efficacy. Moreover, compared with open surgery, it reduces trauma to patients and provides a feasible alternative for many patients who cannot tolerate surgery. Therefore, intraluminal treatment for TBAD has received sustained attention and research from the medical community. Figure 5 shows that the keyword with the highest burst intensity and the longest burst duration was "stent graft placement", which also confirmed this idea. During this period, researchers have also conducted many studies on the accompanying symptoms and complications of TBAD, including aneurysm, aortic dissection rupture, aortic intramural hematoma and ischemic complications. In the later period (after 2010), with the widespread use of TEVAR and the emergence of numerous follow-up studies after TEVAR procedures, some scholars no longer focused solely on its short-term efficacy but began to pay attention to the long-term prognosis after TEVAR [17–19]. The 5-year follow-up results of the INSTEAD-XL trial show that TEVAR has a better effect on aortic reconstruction than does drug therapy alone and has the potential to reduce long-term aortic-related adverse events. Some scholars have also studied the relevant risk factors affecting the long-term prognosis of patients after TEVAR procedures. For example, the IRAD study published in 2013 reported that TEVAR patients may also experience complex acute aortic dissection, which may manifest as symptoms such as shock, periaortic hematoma, signs of malperfusion, stroke, spinal cord ischemia, mesenteric ischemia, and/or renal failure, and analyzed the overall survival rate and the rate of further interventions [20]. This is consistent with the keyword burst graph, in which the

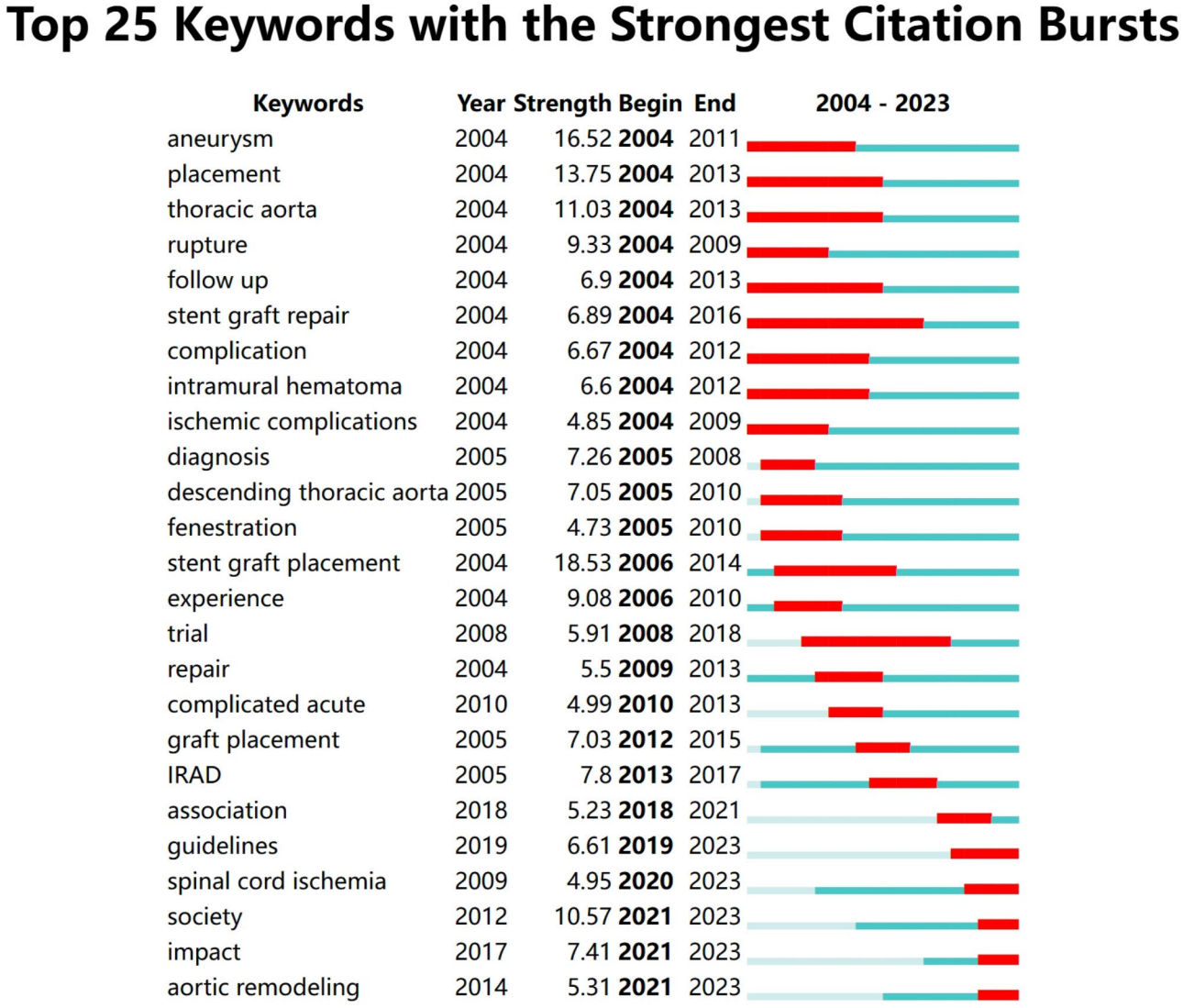


**Fig. 4** Top 25 keywords with the strongest citation bursts. The blue line is the timeline, and the red part on the blue timeline is the burst detection, indicating the start year, end year, and burst duration

keyword "IRAD" has significantly increased since 2013. In general, TEVAR is associated with lower mortality over a 5-year period than medical therapy for TBAD is, which is similar to the conclusion of the INSTEAD-XL trial. Therefore, studies have begun to focus on "clinical practice guideline", "current endovascular management" "early aortic remodeling" and "distal stent graft-induced new entry" to study patient management and long-term outcomes to achieve the best guidance in clinical practice [21–23]. Notably, we found that the annual number of articles published on TBAD was less than 50 from 2004 to 2012, but beginning in 2013, the number of articles related to TBAD increased significantly and showed an increasing trend annually. The INSTEAD-XL trial and the IRAD study may have contributed to the increase in studies related to TBAD and TEVAR.

In the keyword burst analysis and timeline of co-cited reference clusters in recent years, aside from general terms such as "society" and "impact", "aortic remodeling", "spinal-cord ischemia", "reporting standard" and "hemodynamic indicator" are worthy of investigation and discussion. In 2020, the Society for Vascular Surgery (SVS) and the Society of Thoracic Surgeons (STS) jointly released reporting standards for type B aortic dissection, which detailed the new anatomical classification of aortic dissection. The aorta is divided into 12 zones, and the new anatomical classification is combined with the Stanford classification. The location and extent of tear involvement are accurately described, which is beneficial for risk stratification and treatment of patients. In addition, the epidemiology, etiology, diagnosis, treatment and follow-up management of type B aortic dissection have

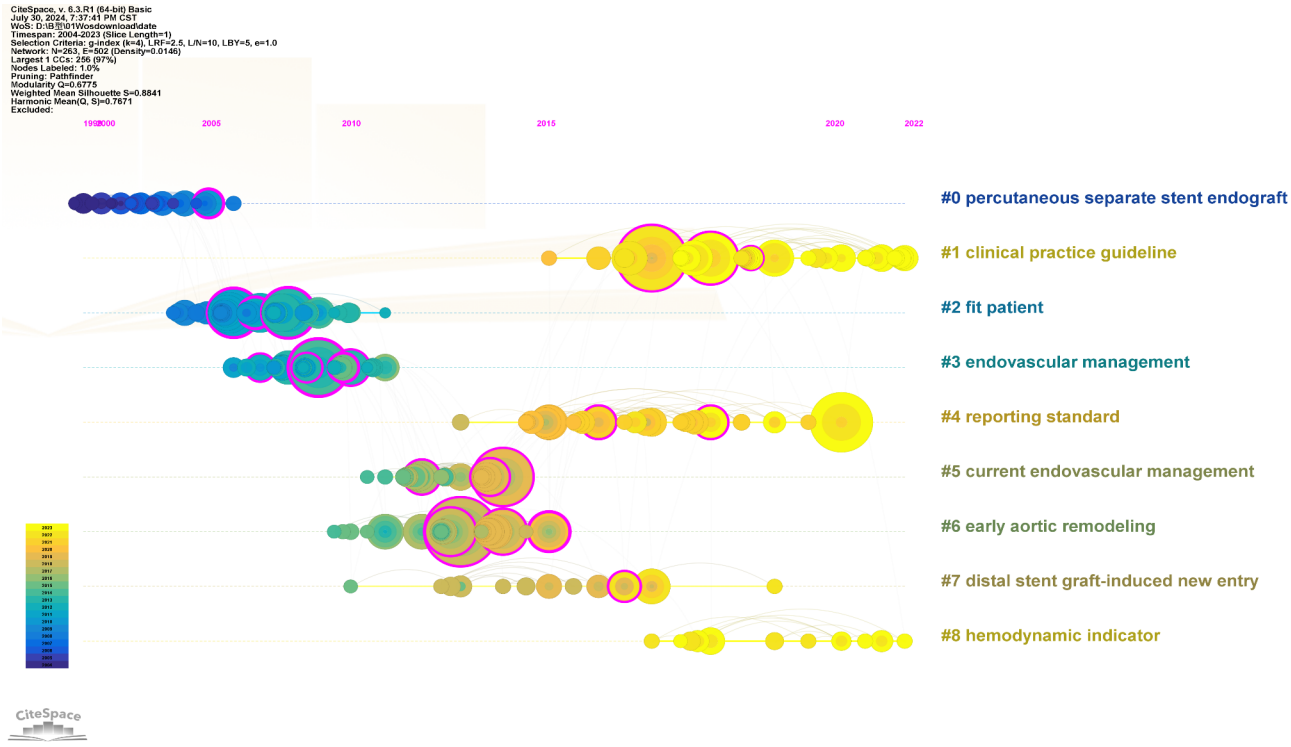


**Fig. 5** The timeline graph of co-cited reference clusters. Documents in the same cluster were placed on the same horizontal line, with the time ranging from left to right and from far to near. The cluster ID is the number after the cluster. The numbers are displayed as #0, #1, #2, #3, etc. The larger the size of the cluster is, the greater the number of members included in the cluster

been described [24]. Positive aorta remodeling is beneficial for restoring hemodynamic stability in patients with aortic disease and preventing adverse cardiovascular events. The SVS/STS guidelines define aortic remodeling as reflecting changes in the diameter or volume of the true lumen (TL) and false lumen (FL) after TEVAR or optimal medical therapy. However, there are also opinions that volumetric measurements seem impractical for clinical application at present due to the time-consuming nature, and there is a suggestion of measuring the surface area of the TL and FL as a compromise [25]. In addition, where to measure the aorta and the number of measurements to ensure the uniformity and stability of the measurement are also the focus of debate, which requires much research data demonstration and practice.

In recent years, the application of hemodynamics in aortic dissection has attracted significant attention. The occurrence and development of aortic dissection are often closely related to hemodynamic changes, including changes in flow, velocity, the pressure gradient, wall shear stress and a series of indicators. These indicators may play important roles in predicting the occurrence of aortic dissection and predicting the prognosis and outcome of aortic dissection after surgery. Among them, 4D flow MRI technology has attracted much attention because it can noninvasively visualize and quantify some unconventional hemodynamic parameters, such as counterflow and vortex, and has high spatial and temporal resolution. It has also shown potential value in evaluating the status after TEVAR and aortic remodeling [26]. More large cohort and multicenter studies are needed to verify the selection and application of hemodynamic indicators. These indicators may play an important role in predicting the occurrence of aortic dissection and predicting the prognosis and outcome of aortic dissection after surgery.

Spinal cord ischemia (SCI) is a complication of thoracic aortic disease and may occur in some TBAD patients after TEVAR [27]. The spinal cord receives blood from multiple sources, with the most important extrinsic artery being the arteria radicularis magna, also known as the artery of Adamkiewicz. Abnormal perfusion of the Adamkiewicz artery may present symptoms of spinal cord ischemia, such as paralysis and urinary incontinence. Currently, clinical strategies to prevent spinal cord ischemia include revascularization, such as left subclavian artery (LSA) revascularization, maintaining an appropriate high blood pressure, and cerebrospinal fluid (CSF) drainage; however, these strategies also have their own complications. The effectiveness and safety of these strategies require substantial clinical practice data and research support.

This study holds significant academic and social implications. The bibliometric analysis provides a comprehensive overview of TBAD research trends over the past two

decades, enabling clinicians and researchers new to the field to quickly grasp its developmental trajectory and current status. Through keyword burst analysis, it guides researchers toward emerging research directions such as aortic remodeling and hemodynamic analysis. By mapping collaboration networks, we highlight key contributors and institutions, facilitating future interdisciplinary and international research partnerships that may lead to the development of personalized treatment strategies and improved clinical decision-making. Furthermore, by identifying the most influential studies and clinical guidelines, this research serves as a valuable reference point for surgeons seeking evidence-based approaches to TBAD treatment.

Although bibliometrics can obtain intrinsic features that are difficult to find via traditional literature analysis through big data analysis, this does not mean that there are no limitations. First, the data were obtained from the WOS central database, and articles in other databases were not included, which resulted in the omission of studies published in other databases. Second, this study analyzed only the literature in English and ignored potentially important literature in other languages. Third, bibliometrics is an analysis method that includes all relevant research articles where the quality of the literature is not guaranteed and may be confounded by many factors, thereby interfering with the correct analysis of the field.

## Conclusion

This study analyzes the research status and hotspots of TBAD through bibliometrics. China and the United States are the global leaders in this field. In recent years, the research focus of TBAD has gradually changed from selecting the surgical method to the best clinical management and patient prognosis after TEVAR. Promoting positive aortic remodeling and aortic hemodynamics may be the research hotspots in the future.

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13019-025-03400-2.

Supplementary Material 1

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**Author contributions**
Z.Y.Z and S.L.Z wrote the main manuscript text. P.Y and C.C produced the figures and tables. L.G.G revised the manuscript critically for important intellectual content. All authors provided critical feedback on drafts and approved the final manuscript.

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**Data availability**
No datasets were generated or analysed during the current study.

## Declarations

**Competing interests**
The authors declare no competing interests.

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