



Analysis of Global Research Trends of Trauma-Related Arrhythmias

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Background: Arrhythmia is a common complication among trauma patients and is frequently encountered in clinical practice. It is highly prevalent in this population and is associated with an elevated risk of adverse outcomes, including myocardial infarction, cerebrovascular events, and prolonged hospitalization.

Methods: We conducted a bibliometric analysis using CiteSpace and VOSviewer to perform both qualitative and quantitative assessments of the literature, including publication volume, contributing countries and institutions, leading authors, and keyword co-occurrence patterns.

Results: A comprehensive search of the Web of Science Core Collection database was performed for publications on trauma and arrhythmia from January 2014 to December 2024, yielding 5,840 relevant articles. The annual number of publications increased steadily, peaking in 2021 (764 articles), followed by a slight decline in 2022 (756 articles). The United States was the most productive country, accounting for 2,056 articles (35.2%). The Mayo Clinic emerged as the leading institution (107 articles), and Dr. Shinsuke Miyazaki was the most prolific author (34 articles, 0.58%). Frequently occurring keywords included atrial fibrillation, spinal cord injury, post-traumatic stress disorder, blunt chest trauma, traumatic brain injury, hip fracture, head trauma, chest trauma, pelvic fracture, and spinal cord injury. Among trauma types, spinal cord injury, traumatic brain injury, chest trauma, pelvic fracture, and post-traumatic stress disorder were most strongly associated with arrhythmia development, with atrial fibrillation being the predominant arrhythmic subtype.

Conclusion: This study represents the first bibliometric analysis to map the global research landscape of trauma-related arrhythmia. It delineates current research trends, identifies key contributors and thematic foci, and offers novel insights to guide future investigations into the mechanisms, prevention, and management of trauma-induced arrhythmias, while also forecasting emerging research hotspots.

Keywords: trauma, arrhythmia, bibliometric analysis, citespace, VOSviewer

Introduction

Trauma-related arrhythmias (TRA) refer to disturbances in the heart's electrical activity following traumatic injury, manifesting as abnormal heart rate or rhythm. These arrhythmias may arise from direct cardiac trauma or from systemic physiological responses to trauma.^{1,2} Trauma represents a growing global public health burden and remains the leading cause of death among young individuals. According to global estimates,³ over 5 million people die annually from traumatic injuries, accounting for approximately 9% of all deaths worldwide. Severe trauma can trigger secondary multi-organ dysfunction involving the lungs, heart, brain, and kidneys. Clinical studies have reported that more than half of critically injured patients develop cardiovascular dysfunction within the first 48 hours after injury,⁴ including arrhythmias, impaired myocardial contractility, reduced stroke volume, and valvular damage—conditions associated with a mortality rate as high as 20% and recognized as key predictors of poor prognosis in critically ill trauma patients. The reported incidence of TRA is approximately 28%; notably, Bernal, Wolf, and Cripps observed an arrhythmia incidence of up to 44% in patients with severe trauma.⁵ TRA is further linked to adverse clinical outcomes, including myocardial infarction, cerebrovascular events, prolonged

hospitalization, and increased healthcare expenditures. In this study, we perform a comprehensive bibliometric analysis of the existing literature on TRA to identify emerging research trends, key knowledge gaps, and future directions in this field.

The term bibliometrics was first introduced by the British scholar Alan Pritchard in 1969.⁶ It refers to the quantitative study of literature systems and their bibliometric characteristics, employing mathematical and statistical methods to analyze patterns and trends in scholarly output. Three foundational laws underpin classical bibliometric theory: Bradford's law, which describes the dispersion of scientific literature across journals; Lotka's law, which characterizes the inverse relationship between the number of authors and their publication productivity; and Zipf's law, which models the frequency distribution of word usage in scientific texts. Today, bibliometrics has been widely adopted across diverse disciplines and plays a pivotal role in mapping research hotspots, tracing intellectual trajectories, and forecasting emerging trends within a given field.⁷ By leveraging objective, large-scale data from scholarly databases—including publication volumes, citation frequencies, and co-occurrence patterns—bibliometric analyses apply standardized metrics and reproducible algorithms to yield robust and unbiased insights. Visualization tools such as VOSviewer and CiteSpace enable the construction of knowledge maps that intuitively depict thematic clusters related to TRA, collaborative networks among authors and institutions, and citation linkages. Moreover, advanced techniques—including keyword co-occurrence analysis, co-citation analysis, and burst detection—can effectively identify both established research foci and nascent frontiers in TRA-related scholarship, thereby supporting strategic planning for future investigations.

Research on TRA inherently spans multiple organ systems and physiological domains. Consequently, clinicians and researchers from diverse specialties—including surgery, cardiology, emergency medicine, psychiatry, and nursing—have all contributed to the growing body of literature on TRA. However, due to their distinct disciplinary paradigms, these fields often prioritize different aspects of pathophysiology, diagnosis, and management, leading to fragmented perspectives on the condition. Traditional narrative reviews or discipline-specific analyses are limited in their ability to integrate these heterogeneous contributions into a cohesive overview. To overcome this challenge, our research team adopted a bibliometric approach to synthesize the global scholarly output on TRA in a systematic and holistic manner. We conducted a comprehensive search of the Web of Science Core Collection (WOSCC) database using predefined search terms to identify all relevant publications. Bibliometric tools were then employed to systematically categorize, quantify, and analyze the retrieved literature. The key innovation of this study lies in its use of data-driven visualizations to map the current state of TRA research, thereby offering novel insights into underlying mechanisms, preventive strategies, and therapeutic approaches. Furthermore, this approach enables the identification of emerging thematic clusters and the prediction of future research trajectories, providing a strategic roadmap for investigators in this multidisciplinary field.

Materials and Methods

Search Strategy

Given that CiteSpace and VOSviewer do not support the integrated analysis of data from multiple bibliographic databases, we conducted a comparative assessment of database coverage, data quality, and metadata completeness. Based on this evaluation, the Web of Science Core Collection (WOSCC) was selected as the sole data source for this study to ensure consistency, reliability, and analytical compatibility.

We first established predefined inclusion and exclusion criteria to guide the selection of relevant publications. The inclusion criteria were as follows: (1) records retrieved from the Web of Science Core Collection (WOSCC) database; (2) content explicitly related to trauma-related arrhythmias (TRA); (3) publication dates ranging from January 19, 2014, to November 19, 2024; (4) document type limited to “article” or “review”; and (5) language restricted to English. Conversely, studies were excluded if they met any of the following conditions: (1) sourced from databases other than WOSCC; (2) unrelated to TRA; (3) classified as document types other than “article” or “review”; (4) published in languages other than English; or (5) falling outside the scope of biomedical or clinical research.

To maximize the retrieval of relevant literature, the search strategy was iteratively refined through systematic adjustments to keywords and query syntax, ultimately yielding the following final search formula: (((((TS=(Trauma OR Traumatic OR Injury OR Injuries OR fracture OR wound shock OR traumatic shock OR Crush Syndrome OR spinal shock OR cerebral concussion OR diffuse axonal injury OR contusion OR burn OR Burns Inhalation OR Smoke

Inhalation Injury OR Splenic Rupture)) AND TS=(arrhythmia OR cardiac arrhythmia OR Arrhythmias OR Sick Sinus Syndrome OR sinus arrest OR Atrial Fibrillation OR Atrial Flutter OR Bradycardia OR Brugada Syndrome OR Atrial Premature Complexes OR atrial premature beats OR Ventricular Premature Complexes OR ventricular premature beat OR Commotio Cordis OR Heart Block OR Tachycardia OR Adams-Stokes Syndrome OR Atrioventricular Block OR Bundle-Branch Block OR Interatrial Block OR Sinoatrial Block OR Long QT Syndrome OR Andersen Syndrome OR Jervell-Lange Nielsen Syndrome OR Romano-Ward Syndrome OR Parasystole OR Pre-Excitation Syndromes)) NOT TS=(Kidney Injuries OR Acute Kidney Injuries OR Acute Renal Injury OR Liver Injury OR Drug Induced Liver Injury OR Drug-Induced Liver Injury OR Liver Injury OR Lung Injury OR Reperfusion Injury OR Reperfusion Injuries OR Ischemia-Reperfusion Injuries OR Ischemia-Reperfusion Injury)) AND TS=(Trauma OR Traumatic OR Injury OR Injuries OR fracture OR wound shock OR traumatic shock OR Crush Syndrome OR spinal shock OR cerebral concussion OR diffuse axonal injury OR contusion OR burn OR Burns Inhalation OR Smoke Inhalation Injury OR Splenic Rupture)) AND TS=(arrhythmia OR cardiac arrhythmia OR Arrhythmias OR Sick Sinus Syndrome OR sinus arrest OR Atrial Fibrillation OR Atrial Flutter OR Bradycardia OR Brugada Syndrome OR Atrial Premature Complexes OR atrial premature beats OR Ventricular Premature Complexes OR ventricular premature beat OR Commotio Cordis OR Heart Block OR Tachycardia OR Adams-Stokes Syndrome OR Atrioventricular Block OR Bundle-Branch Block OR Interatrial Block OR Sinoatrial Block OR Long QT Syndrome OR Andersen Syndrome OR Jervell-Lange Nielsen Syndrome OR Romano-Ward Syndrome OR Parasystole OR Pre-Excitation Syndromes)) NOT TS=(Kidney Injuries OR Acute Kidney Injuries OR Acute Renal Injury OR Liver Injury OR Drug Induced Liver Injury OR Drug-Induced Liver Injury OR Liver Injury OR Lung Injury OR Reperfusion Injury OR Reperfusion Injuries OR Ischemia-Reperfusion Injuries OR Ischemia-Reperfusion Injury). After obtaining the preliminary data, we preliminarily screened the literature by setting the literature type (articles and reviews) and language (English).

Data Processing

The retrieved records were exported from the Web of Science Core Collection as plain text files in the “Full Record and Cited References” format and sequentially renamed as download_1, download_2, ..., download_12. These files were then imported into CiteSpace for initial deduplication. The deduplicated dataset was saved in a newly created folder labeled “data”. A total of 5,840 unique articles were retained after deduplication. This final dataset was subsequently imported into both CiteSpace and VOSviewer to perform network-based visualization analyses and co-occurrence-based detection of research hotspots, including collaborative patterns among countries and institutions, authorship networks, and keyword clusters.

Result Analysis

Publication Time Trends

[Figure 1](#) presents the annual distribution of the 5,840 included publications on TRA. The volume of relevant literature remained relatively low prior to 2018, with fewer than 400 articles published annually. A moderate increase was observed between 2018 and 2019, with annual output rising to between 400 and 500 articles. From 2020 onward, publication counts exceeded 600 per year, peaking at 764 articles in 2021. Overall, the literature on TRA demonstrates a clear upward trend, particularly in recent years, with annual publication numbers consistently surpassing 600 since 2020. This sustained growth reflects increasing scholarly attention to TRA, underscoring its recognized role as a critical determinant of prognosis in trauma patients.

Country

A total of 5,840 articles originated from 118 countries. [Table 1](#) summarizes the top 10 countries by publication output and their respective shares of the global literature on TRA. The United States ranked first with 2,056 publications (35.21%), followed by China with 1,048 articles (17.95%). In addition to its leading publication volume, the United States also exhibited the highest betweenness centrality in the country collaboration network, indicating its pivotal role as a central hub in global TRA research.

To further examine international collaboration patterns, the country-level data were imported into VOSviewer. A minimum publication threshold of 10 documents was applied, resulting in a network of 57 countries. These countries

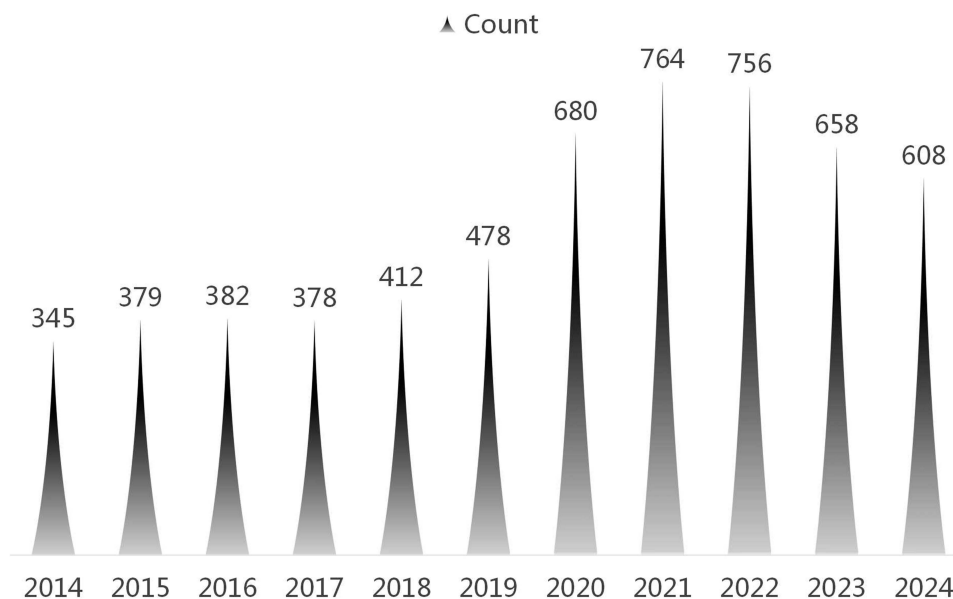


Figure 1 Annual publication outputs of 2014–2024.

were grouped into six clusters, as illustrated in **Figure 2**, with the five major clusters color-coded in red, yellow, blue, green, and purple. In this visualization, node size reflects the number of publications, while the thickness of connecting lines indicates the strength of collaborative ties. The green cluster is centered around the United States, Canada, and the United Kingdom, and further includes Chile, Ireland, India, Nepal, Pakistan, Qatar, Scotland, Slovakia, South Africa, and the Republic of Ireland. The purple cluster comprises China and Thailand. The red cluster, which exhibits the most extensive international collaboration and includes the largest number of countries, is anchored by Germany, Italy, and Israel, and additionally encompasses Austria, Belgium, Croatia, Denmark, France, Greece, the Netherlands, Norway, Poland, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey (Türkiye), and Mexico. Notably, although Israel has demonstrated recognized expertise in trauma prevention and management, its publication output in the TRA field remains relatively modest. The blue cluster consists of Japan, South Korea, and Russia, along with Argentina, Brazil, Colombia, the Czech Republic, Indonesia, Malaysia, Singapore, and Taiwan. Finally, Australia and New Zealand form the yellow cluster. Intriguingly, the top three countries by publication volume—the United States, China, and Germany—each serve as central nodes in distinct clusters, suggesting that these leading contributors not only dominate scholarly output in TRA research but also play key roles in coordinating large-scale international research collaborations.

To visualize the temporal evolution of country-level contributions, a time-based clustering analysis was performed in VOSviewer (**Figure 3**). In this visualization, node color reflects the average publication year: cooler tones (eg, blue)

Table 1 The Top 10 Countries by Documents

Rank	Country	Numbers	Ratio (%)
1	USA	2,056	35.205%
2	China	1,048	17.945%
3	Germany	427	7.312%
4	Japan	408	6.986%
5	England	375	6.421%
6	Italy	371	6.353%
7	Canada	309	5.291%
8	Australia	223	3.818%
9	France	154	2.637%
10	Netherlands	153	2.620%

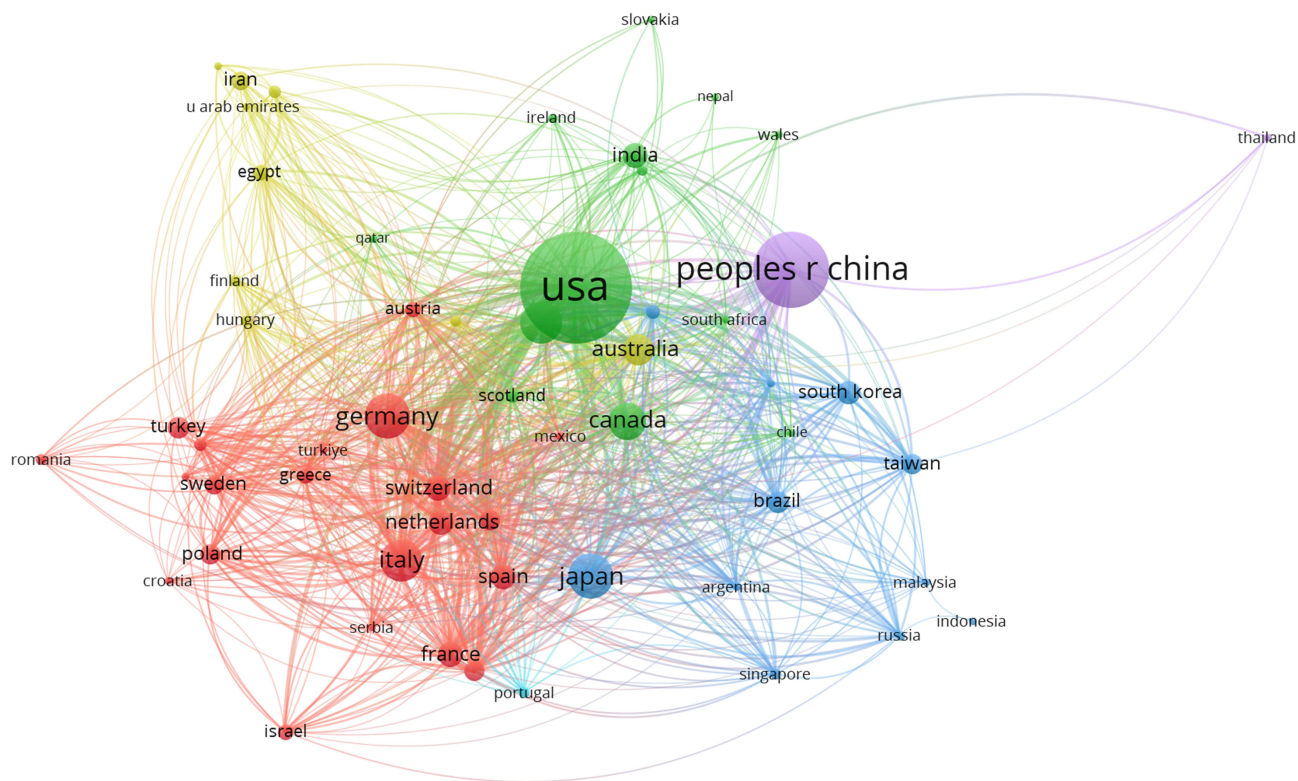


Figure 2 Cooperation network among all countries.

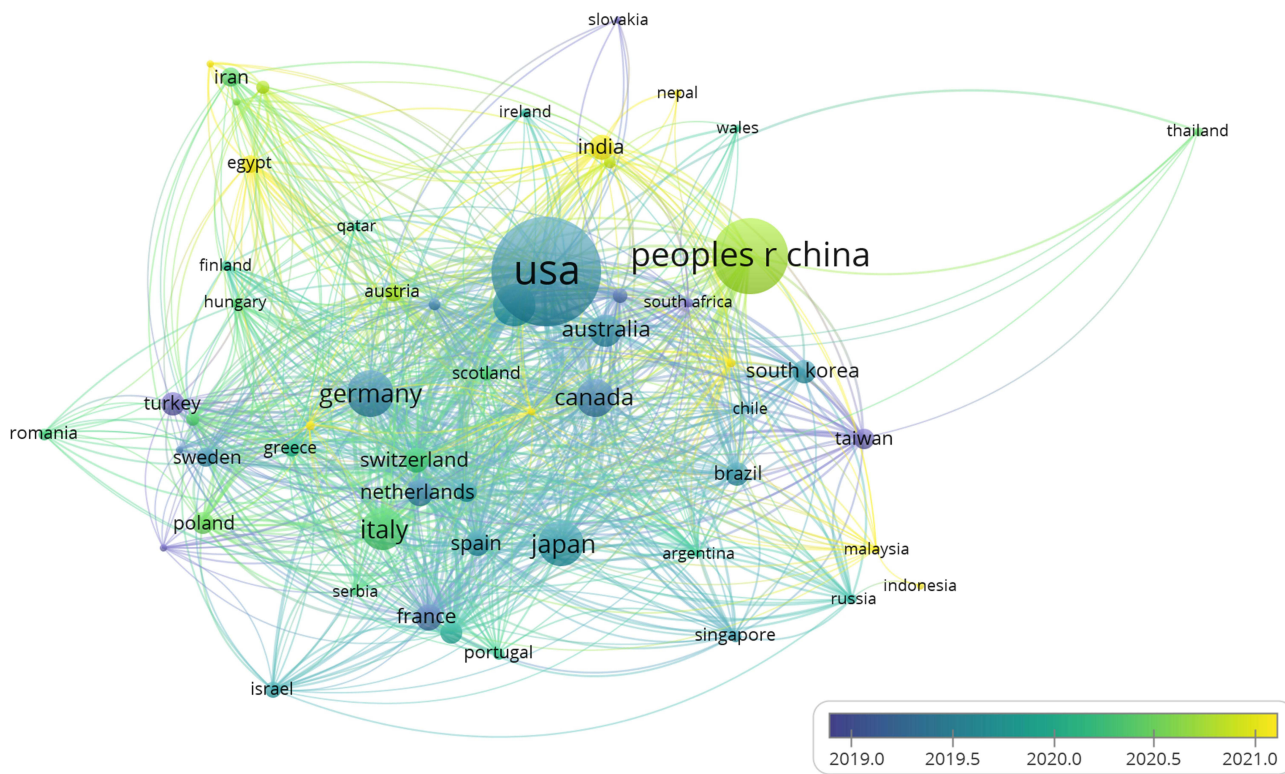


Figure 3 Cooperation network among all countries with time.

indicate earlier research activity, while warmer tones (eg, yellow) represent more recent engagement. Countries such as the United States, Germany, Israel, Canada, and Australia exhibited predominantly blue-colored nodes, suggesting their early involvement in TRA research. In contrast, China, Italy, and India displayed yellow-toned nodes, indicating more recent entry into the field. Among the top 10 most productive countries, China initiated TRA-related publications at a relatively later stage; however, it rapidly accumulated 1,048 articles, reflecting a steep growth trajectory in its research output.

Research Institution

A total of 6,915 research institutions contributed to the 5,840 included articles. Table 2 lists the top 20 institutions by publication output, along with their total link strength, average citation count per publication, and country of affiliation. The three most prolific institutions were Mayo Clinic (107 publications), Harvard Medical School (99), and the University of Washington (69). While Mayo Clinic produced the highest number of publications, its average citation count per article was relatively low. In contrast, the University of Washington ranked among the top three in publication volume and also exhibited the highest average citation count among the leading institutions. Among the top 20 institutions, 13 were based in the United States, 3 in China, 2 in Canada, and 1 each in Japan and Australia. U.S.-affiliated institutions also dominated in terms of citation impact, with the highest average citation counts observed among American institutions. The three Chinese institutions in the top 20 demonstrated substantial publication output but comparatively lower average citation counts.

To further examine institutional collaboration patterns, a co-occurrence network was constructed using VOSviewer. A minimum publication threshold of 20 documents was applied, yielding a network of 104 institutions grouped into six distinct clusters, as shown in Figure 4. In this visualization, node size corresponds to the number of publications, while the thickness of connecting lines reflects the strength of collaborative ties (ie, the frequency of co-authored publications). The largest cluster (blue) includes Mayo Clinic, Harvard Medical School, and the University of Washington. The second-largest cluster (green) comprises Shanghai Jiao Tong University, Wuhan University, and Capital Medical University. Within this green cluster, nodes are relatively small in size but interconnected by thick lines, indicating a high level of co-authorship activity despite a modest overall publication output from the constituent institutions.

Table 2 The Top 20 Institutions by Documents

Rank	Organization	Documents	Country	Citations	Total Link Strength
1	Mayo Clinic	107	USA	348	62
2	Harvard Medical School	99	USA	1329	74
3	University of Washington	69	USA	4049	58
4	Icahn School of Medicine at Mount Sinai	68	USA	1147	23
5	University of Toronto	66	Canada	1075	49
6	Stanford University	59	USA	1868	26
7	Wuhan University	59	China	1926	1
8	Capital Medical University	57	China	1718	8
9	The University of Utah	54	USA	294	47
10	McMaster University	51	Canada	484	25
11	University of Pittsburgh	51	USA	292	11
12	Johns Hopkins University	50	USA	481	46
13	Tokyo medical and dental university	49	Japan	2119	0
14	Brigham & Women's Hospital	48	USA	1041	55
15	University of Pennsylvania	48	USA	1454	32
16	Duke University	47	USA	1002	41
17	Massachusetts General Hospital	47	USA	1225	54
18	Emory University	46	USA	1945	19
19	The University of Sydney	45	Australia	1316	2
20	Shanghai jiao tong University	44	China	218	5

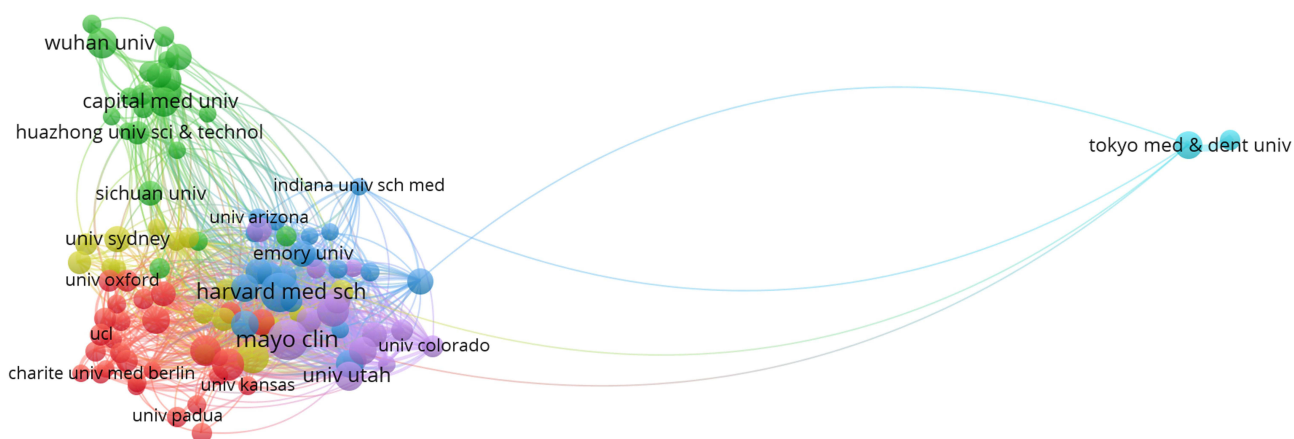


Figure 4 Cooperation network among all institutions.

To characterize the temporal dynamics and research bursts of institutional contributions, a burst detection analysis was performed using CiteSpace (Figure 5). Several institutions exhibited early research activity in the field of TRA, including Yeshiva University, Tsugaru General Hospital, Albert Einstein College of Medicine, and New York University. Among all institutions, the University of Colorado, Yeshiva University, Tsugaru General Hospital, and Albert Einstein College of Medicine demonstrated the longest burst durations, reflecting sustained periods of elevated publication or citation activity. More recently, Nanjing Medical University and the University of São Paulo emerged as active contributors, with both institutions showing strong burst strengths in terms of publication volume and citation counts. This suggests a rapid rise in their scholarly engagement with TRA research in recent years.

Authors

The 5,840 articles were authored by a total of 33,159 unique researchers. Table 3 lists the top 20 authors by publication count. The three most prolific authors were Shinsuke Miyazaki (34 publications, 0.58%), Hirao Kenzo (31, 0.53%), and

Institutions	Year	Strength	Begin	End	2014 - 2024
Yeshiva University	2014	7.07	2014	2018	
Tschiura Kyodo Hospital	2014	5.58	2014	2018	
Albert Einstein College of Medicine	2014	5.03	2014	2018	
New York University	2014	4.58	2014	2016	
Erasmus University Rotterdam	2015	5.58	2015	2017	
Erasmus MC	2015	5.08	2015	2017	
University of Birmingham	2015	4.91	2015	2017	
University of Colorado System	2015	4.7	2015	2019	
Tokyo Medical & Dental University (TMDU)	2014	7.69	2016	2018	
Institute of Science Tokyo	2014	6.7	2016	2018	
Montefiore Medical Center	2014	5.19	2016	2018	
Vanderbilt University	2017	4.83	2017	2019	
University of Utah	2018	8.32	2018	2020	
Utah System of Higher Education	2018	8.32	2018	2020	
Virginia Commonwealth University	2014	4.75	2018	2021	
University of North Carolina	2019	5.13	2019	2021	
CIBER - Centro de Investigacion Biomedica en Red	2020	6.78	2020	2022	
University of Maryland Baltimore	2020	4.84	2020	2022	
Nanjing Medical University	2021	8.52	2021	2024	
Universidade de Sao Paulo	2021	4.5	2021	2024	

Figure 5 Top 20 institutions with the strongest citation bursts.

Table 3 The Top 20 Authors by Documents

Rank	Author	Institution	Country	Documents	Ratio (%)	Citations
1	Miyazaki, S	Tokyo Medical and Dental University	Japan	34	0.58	28
2	Hirao, K	Tokyo Medical and Dental University	Japan	31	0.53	563
3	Hachiya, H	Tsuchiura Kyodo Hospital	Japan	24	0.41	55
4	Iesaka, Y	Tsuchiura Kyodo Hospital	Japan	24	0.41	178
5	Deasmundis, C	Universitair Ziekenhuis Brussel	USA	22	0.38	98
6	Nakamura, H	Osaka City University Graduate School of Medicine	Japan	22	0.38	132
7	Natale, A	Michigan State University	USA	21	0.36	103
8	Reddy, VY	Harvard Medical School	USA	21	0.36	62
9	Chierchia, GB	Vrije Universiteit Brussel	Belgium	19	0.33	1115
10	Sasano, T	Tokyo Medical and Dental University	Japan	19	0.33	181
11	Asirvatham, SJ	University of Birmingham	UK	18	0.31	243
12	Lip, GH	University of Birmingham	UK	18	0.31	344
13	Takagi, T	University of Bordeaux	France	18	0.31	1368
14	Taniguchi, H	Tokyo Ariake University of Medical	Japan	18	0.31	22
15	Deneke, T	Ruhr-Universität Bochum	Germany	17	0.29	142
16	Jais, P	Bordeaux University Hospital	France	17	0.29	100
17	Yamauchi, Y	Musashino Red Cross Hospital	Japan	17	0.29	447
18	Brugada, P	OLV Hospital	Belgium	15	0.26	133
19	Ellenbogen, K	Virginia Commonwealth University	USA	15	0.26	246
20	Okishige, K	Syowa University, School of Medicine	Japan	15	0.26	46

Hachiya Hitoshi (24, 0.41%). All three are affiliated with institutions in Japan, which accounts for 9 of the top 20 authors overall. Notably, while Japanese authors are prominently represented among high-output researchers, neither Japan nor its institutions ranked within the top ten by country- or institutional-level publication volume in the broader dataset. In contrast, four of the top 20 authors are from the United States, each affiliated with a different research institution, suggesting broad institutional engagement in TRA-related research across the US academic landscape.

To examine co-authorship patterns among researchers, a collaboration network was constructed in VOSviewer with a minimum publication threshold of five. Initially, 355 authors met this criterion; however, after excluding those without co-authorship links, the final network comprised 295 authors distributed across 19 clusters (Figure 6). The relatively large number of clusters and sparse inter-cluster connections suggest limited overall collaboration density among the most active authors in the field. The largest cluster (red) includes 58 authors, of whom 37 are affiliated with institutions in China. This cluster is centered around Kenneth A. Ellenbogen, Susan K. Kline, and other U.S.-based researchers. Notably, this cluster also features multiple collaborative ties between Chinese and US authors, reflecting active bilateral cooperation between these two countries in TRA research.

A burst detection analysis of authors was conducted using CiteSpace (Figure 7). Early bursts were observed for Hiroshi Taniguchi, Hiroaki Nakamura, Yoshito Iesaka, and Hitoshi Hachiya, indicating their pioneering publication activity in the field of TRA. More recently, strong citation bursts were identified for Vivek Y. Reddy, Luigi Di Biase, Andrea Natale, and James R. Edgerton—all affiliated with institutions in the United States—reflecting their prominent roles in recent scholarly discourse. Notably, none of the top 20 authors with the strongest citation bursts were affiliated with institutions in China, despite China's substantial overall publication output in TRA research.

Keywords

A keyword co-occurrence analysis was performed in VOSviewer with a minimum occurrence threshold of 20, resulting in a network of 406 keywords. Figure 8 displays the 20 most frequently occurring terms. The most prevalent keywords included “atrial fibrillation” (the highest frequency), “arrhythmias”, “injury”, “surgery”, “disease”, “management”, “risk”, “mortality”, “outcomes”, “complications”, “radiofrequency ablation”, “catheter ablation”, “heart failure”, “stroke”, and “myocardial injury”. These terms reflect the primary thematic foci in the literature on TRA. Notably, “atrial

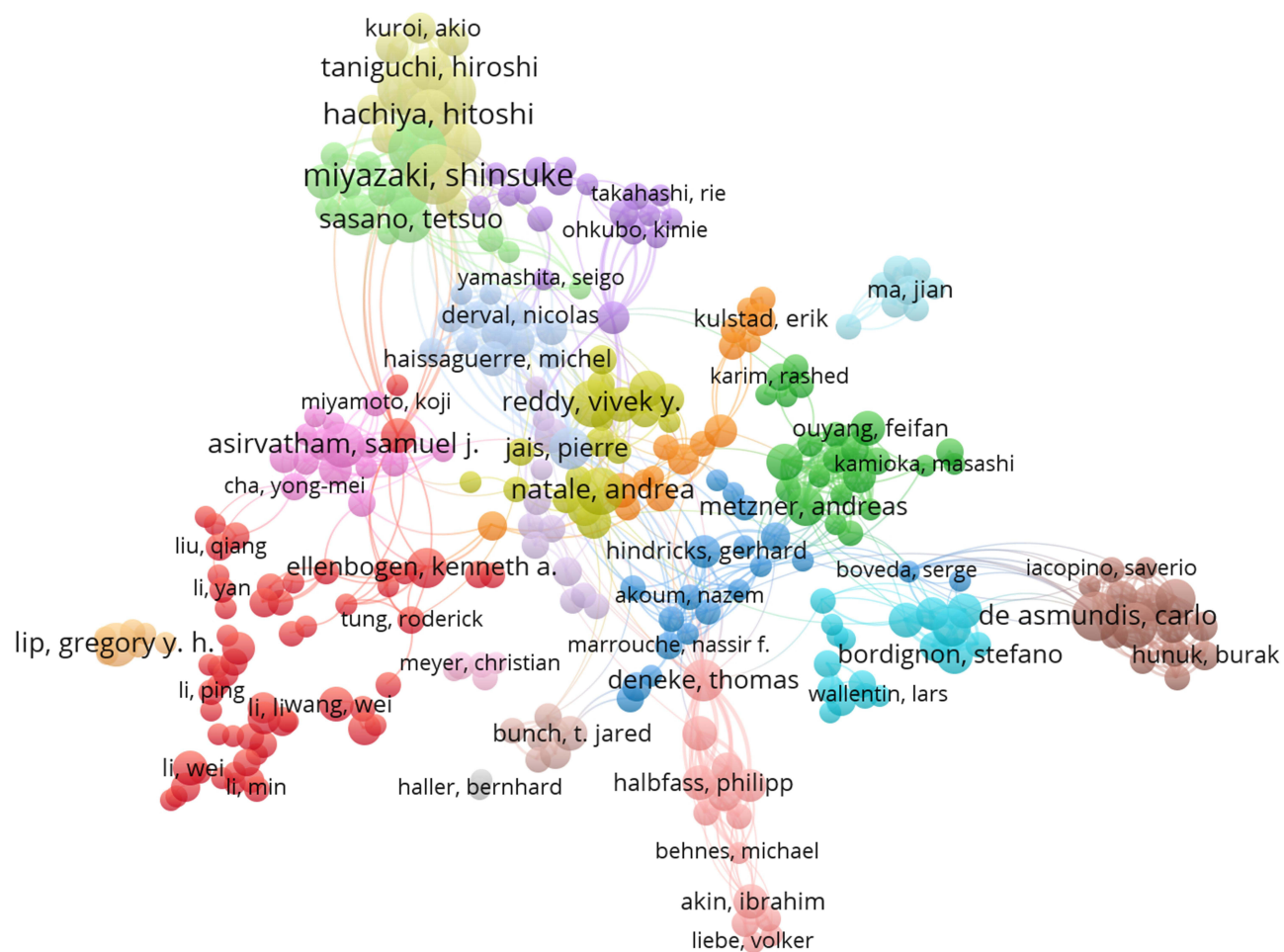


Figure 6 Cooperation network among all authors.

fibrillation” and “arrhythmias” were among the most recurrent keywords, while procedural terms such as “radiofrequency ablation” and “catheter ablation” frequently co-occurred with clinical outcome indicators including “mortality”, “complications”, and “outcomes”.

To further explore thematic associations among research foci, a keyword co-occurrence network was generated (Figure 9). The term “injury” frequently co-occurred with “brain injury”, “head injury”, “spinal cord injury”, “traumatic brain injury”, “esophageal injury”, “nerve injury”, “phrenic nerve injury”, “cardiac injury”, and “myocardial injury”. These injury-related terms commonly clustered together with “atrial fibrillation”. Similarly, the term “trauma” showed strong co-occurrence with “posttraumatic stress disorder”, “blunt chest trauma”, “traumatic brain injury”, and “trauma patients”. These trauma-associated keywords also tended to co-occur within the same clusters as “atrial fibrillation”, highlighting its prominent representation in the literature on TRA.

To examine the temporal dynamics of research foci, a keyword burst detection analysis was performed using CiteSpace (Figure 10). Early and sustained bursts were observed for terms such as “paroxysmal atrial fibrillation”, “follow-up”, “sudden death”, and “phrenic nerve injury”, indicating prolonged periods of elevated scholarly attention to these topics in the earlier phase of TRA research. In contrast, “pathophysiology” and “COVID-19” exhibited strong citation bursts in recent years, with peak activity occurring within the last few years. These terms represent the most recently emerging thematic foci in the TRA literature.

A timeline view of keyword clusters was generated using CiteSpace (Figure 11), revealing seven distinct clusters:#0 myocardial infarction,#1 hip fracture,#2 pulmonary vein isolation,#3 spinal cord injury,#4 atrial fibrillation,#5 cardiovascular system, and#6 HRs guideline.In this visualization, node size reflects keyword frequency, node color indicates

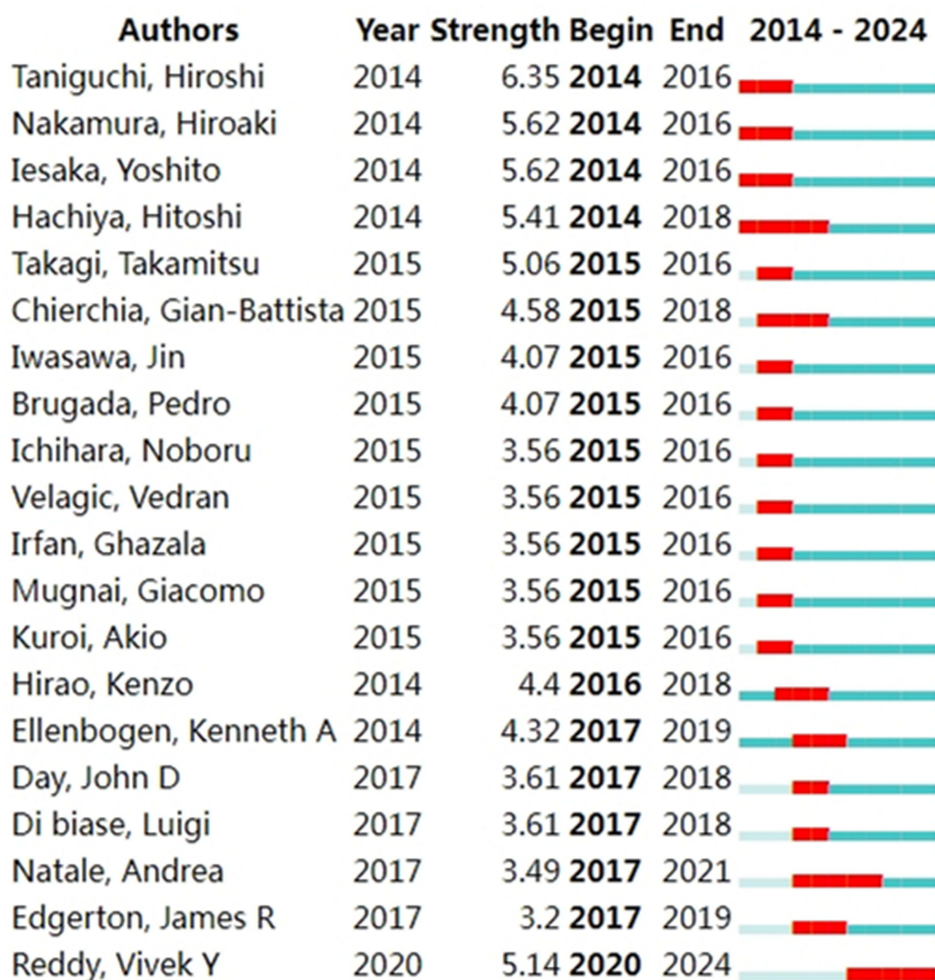


Figure 7 Top 20 authors with the strongest citation bursts.

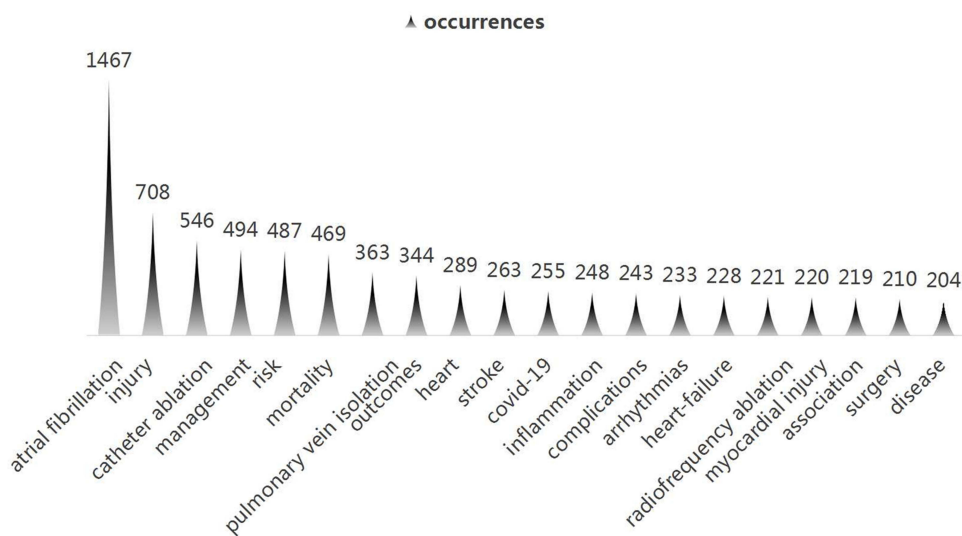


Figure 8 Top 20 keywords by frequency in TRA.

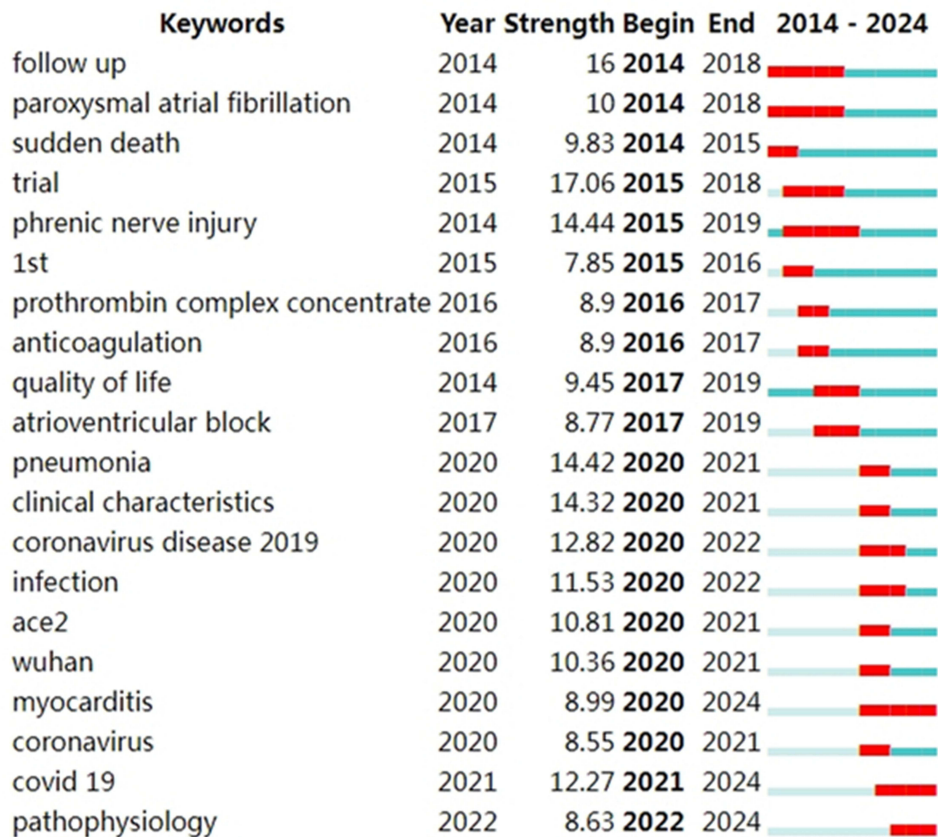


Figure 10 Top 20 keywords with the strongest citation bursts.

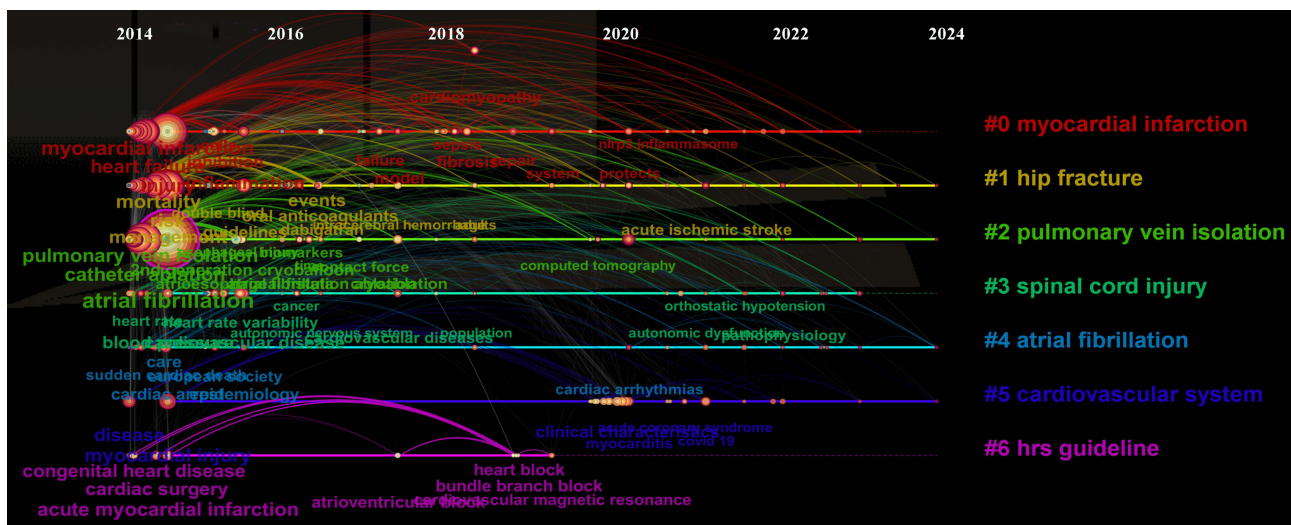


Figure 11 Timeline view of keywords related to TRA.

These ionic shifts rhythmogenesis.¹⁴ Hemorrhagic shock has also been implicated as a key s can alter myocardial membrane potentials and promote arcontributor to TRA. Reduced systemic perfusion during shock creates a mismatch between myocardial oxygen supply and demand, leading to myocardial hypoxia and subsequent electrophysiological disturbances.¹⁵ Moreover, the biphasic nature of ischemia–reperfusion injury—characterized by early ischemic insult

Table 4 Summary of the Largest 7 Clusters

ClusterID	Size	Label (LSI)	Label (LLR)	Label (MI)	Average Year
0	54	Atrial fibrillation	Myocardial infarction	Overexpressing microrna-150	2017
1	54	Atrial fibrillation	Hip fracture	Overexpressing microrna-150	2016
2	46	Atrial fibrillation	Pulmonary vein isolation	Overexpressing microrna-150	2015
3	34	Spinal cord injury	Spinal cord injury	Overexpressing microrna-150	2017
4	30	Cardiac arrest	Atrial fibrillation	Overexpressing microrna-150	2017
5	27	Systematic review	Cardiovascular system	Atrio-ventricular block	2020
6	26	HRS guideline	HRS guideline	Overexpressing microrna-150	2018

followed by reperfusion-induced microvascular dysfunction and inflammatory activation¹⁶—may further exacerbate arrhythmic susceptibility. Notably, traumatic shock is often accompanied by hypothermia, which independently impairs cardiac conduction and may synergistically increase the risk of TRA.¹⁷ In addition to hemodynamic and metabolic derangements, neurohormonal stress responses play a critical role. Pain and psychological distress following trauma commonly precipitate post-traumatic stress disorder (PTSD), which triggers a surge in catecholamine release—including epinephrine and norepinephrine.¹⁸ Excessive catecholamine exposure exerts direct “cardiotoxic” effects on cardiomyocytes: it enhances sinus node automaticity, accelerates sodium influx, and steepens the slope of Phase 4 depolarization in the cardiac action potential, collectively predisposing the heart to arrhythmias.¹⁹ Although these pathophysiological pathways have been explored at systemic, cellular, and electrophysiological levels, molecular mechanisms—particularly those involving gene regulation, non-coding RNAs, and signaling cascades—remain markedly underinvestigated in the context of TRA.

Clinical studies have identified several robust risk factors for TRA, particularly atrial fibrillation, in critically ill trauma patients. Agnihotri et al²⁰ demonstrated that patients admitted to the intensive care unit (ICU) with a Simplified Acute Physiology Score II (SAPS II) of 30 or higher exhibited a significantly elevated risk of new-onset atrial fibrillation. The same study reported odds ratios exceeding 4.0 for TRA among patients with systemic inflammatory response syndrome (SIRS),⁴ those requiring vasoactive agents, individuals sustaining injuries to three or more organ systems, and those aged 40 years or older.²⁰ Notably, patients without pre-existing cardiovascular disease had a substantially lower incidence of atrial fibrillation compared to those with comorbidities such as hypertension or congestive heart failure.^{20,21} These findings are corroborated by Brown et al,²⁰ who identified a broader constellation of clinical predictors for TRA, including advanced age, hemorrhagic shock, traumatic brain injury, higher Injury Severity Score (ISS), pre-existing cardiovascular disease, aggressive fluid resuscitation, massive transfusion requirements, and the administration of vasoactive medications. Collectively, these studies underscore that TRA arises not from a single insult but from the interplay of hemodynamic instability, systemic inflammation, injury burden, and underlying cardiac vulnerability.

Given the strong association between trauma severity and the incidence of TRA, effective management of the underlying injury remains paramount. Standard supportive interventions include fluid resuscitation, vasoactive agents, blood transfusion, hemorrhage control, sedation, analgesia, and surgical stabilization when indicated.²² Notably, limited (or permissive hypotensive) fluid resuscitation has been associated with lower mortality and reduced incidence of multiple organ dysfunction compared to conventional aggressive resuscitation in select trauma populations.²³ This strategy may attenuate cardiac preload, decrease myocardial oxygen demand, improve peripheral perfusion, and mitigate metabolic derangements such as acidosis and hyperkalemia—factors that collectively contribute to arrhythmogenesis.

Pain is nearly universal among trauma patients and represents a potent trigger for sympathetic activation.¹⁸ Emerging evidence suggests that effective post-traumatic analgesia may ameliorate immune dysregulation and reduce arrhythmic events, although the precise mechanisms remain unclear; modulation of post-traumatic stress responses may be involved. Once TRA occurs, management should be tailored to the specific arrhythmia type and clinical context. Our bibliometric analysis revealed that “atrial fibrillation” and “HRS guidelines” formed distinct but related clusters, and that “catheter ablation” appeared frequently in the literature. This pattern aligns with current clinical practice, wherein rate or rhythm control for atrial fibrillation is often guided by consensus recommendations such as those from the Heart Rhythm Society

(HRS). Catheter ablation may be considered in cases of drug-refractory or recurrent arrhythmias, particularly when hemodynamic instability persists.²⁴ In contrast, atrioventricular (AV) block in trauma patients is often transient and self-limiting, typically not requiring intervention.²⁴ However, persistent high-grade AV block may necessitate temporary or even permanent pacemaker implantation. Similarly, bradycardia and supraventricular arrhythmias secondary to hypothermia frequently resolve spontaneously with rewarming,¹⁷ underscoring the importance of targeted temperature management in this population.

This study identified a total of 5,840 publications related to TRA. Global publication output has generally increased year-on-year, with a modest decline observed between 2022 and 2024. The United States and China accounted for the largest share of publications in this field. Notably, the US exhibited the highest betweenness centrality in the international collaboration network, reflecting its central role in connecting diverse research communities. In contrast, despite its high publication volume, China demonstrated relatively limited international co-authorship. The United States, Germany, and Israel were among the earliest countries to publish on TRA, whereas China, Italy, and India entered the field at a later stage. Nevertheless, China has rapidly expanded its research output, contributing 1,048 publications to date. Institutional analysis revealed that the top three most productive institutions are all based in the United States, and the institution with the highest citation count is also U.S.-affiliated. Among the 20 most prolific authors, four are from US institutions; similarly, four of the top 20 authors identified by citation burst detection are affiliated with the US. These metrics collectively indicate that the United States has played a leading role in shaping the global TRA research landscape to date.

In this study, frequently co-occurring keywords—including “management”, “risk”, “mortality”, “outcomes”, and “complications”—reflect a strong research emphasis on the prevention of TRA and the optimization of patient prognosis. Although the precise pathophysiological mechanisms underlying TRA remain incompletely understood, several evidence-informed preventive strategies are already integrated into clinical practice. Notably, heightened vigilance is warranted in trauma patients with pre-existing cardiovascular conditions, particularly older adults sustaining craniocerebral trauma, spinal cord injury, thoracic trauma, or pelvic fractures—populations at elevated risk for arrhythmic complications. Of particular interest in our bibliometric analysis was the recurrent appearance of microRNA-150 across multiple research clusters. Clinical and experimental studies have increasingly implicated this microRNA in cardiovascular regulation. For instance, Apple et al²⁵ reported significant upregulation of microRNA-150 (alongside microRNA-223, -15a, and -24) in blood samples from 27 severely injured trauma patients compared to healthy controls, with microRNA-150 previously linked to erythropoietic regulation. Subsequent mechanistic investigations further support its cardioprotective potential: Liu et al demonstrated that cardiac-specific overexpression of microRNA-150 attenuated myocardial hypertrophy and fibrosis in transgenic mice by suppressing serum response factor (SRF).²⁶ Similarly, a team from Jinan Central Hospital found that microRNA-150 overexpression improved cardiac function and reduced cardiomyocyte apoptosis in a rat model of cardiac injury.²⁷ Additional evidence indicates that microRNA-150 exerts protective effects in murine models of heart failure and plays a critical role in preserving cardiac function post-myocardial infarction.²⁸ Conversely, microRNA-150 deficiency has been associated with exacerbated neointimal hyperplasia,²⁹ underscoring its broader role in vascular and myocardial homeostasis. Collectively, these findings suggest that microRNA-150 may contribute to endogenous protective pathways in the stressed myocardium following trauma. While direct evidence in TRA models remains limited, its consistent association with improved cardiac outcomes across diverse injury contexts positions microRNA-150 as a promising candidate for further mechanistic investigation and potential therapeutic development in TRA.

Summary

Bibliometric analysis of TRA research reveals that the United States maintains a leading global position in terms of publication volume, citation impact, and network centrality. China, although a later entrant to the field, has demonstrated rapid growth and substantial research potential. Notably, the overall number of TRA-related publications has declined in recent years, suggesting a possible plateau in research activity and underscoring the need to deepen mechanistic investigations and broaden interdisciplinary collaboration. Emerging evidence from keyword co-occurrence and burst detection highlights microRNA-150 as a recurrent molecular signature across multiple research clusters, warranting further exploration of its role in TRA pathogenesis and its potential as a therapeutic or preventive target. In clinical

practice, these findings emphasize the importance of comprehensive risk stratification and early preventive strategies. Timely identification of TRA, mitigation of modifiable risk factors, and individualized management approaches may contribute to improved long-term outcomes for trauma patients at risk of arrhythmias.

Data Sharing Statement

The data that support the findings of this study are openly available in WOS at <https://www.webofscience.com>. The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author.

Consent for Publication

The manuscript is original and has not been published elsewhere. It was not published simultaneously in other journals or platforms. All the authors approved the submission of the manuscript for publication.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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