Cardiovascular Reviews, 2024, Volume 2, Issue 2
http://ojs.bbwpublisher.com/index.php/CR
Online ISSN: 2981-8109

Bibliometric Analysis and Knowledge Mapping of Research Trends in Brugada Syndrome

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Abstract: *Background:* Brugada Syndrome (BrS) has been extensively studied over the last 30 years, warranting a review of its research landscape, including prevalent themes and potential future directions. *Objective:* By employing bibliometric analysis, this work seeks to map the current state and trajectory of BrS research, highlighting key contributors and unexplored areas while suggesting avenues for future studies which could propel the field forward. *Methods:* This paper analyzed BrS-related articles from 1992 to 2023, extracted from the Web of Science core collection, using tools like CiteSpace, VOSviewer, Pajek, and Scimago Graphica to examine research output, geographies, authors, affiliations, keywords, and citation patterns. *Results:* Out of 3,713 BrS publications, the US has been the most prolific, with the Netherlands producing the highest caliber work, and China ranking fourth in output. The University of Amsterdam emerged as the leading institution. Pedro Brugada topped the author list. The journal *Circulation* led in citations, with an impact factor of 37.8, indicative of its JCR Q1 status and elite ranking. Keyword analysis revealed 'Brugada syndrome' (2756), 'Sudden death' (1387), and 'St-segment elevation' (1200) as common terms, with 'Management,' 'Guidelines,' 'Consensus conference,' and 'Genetics' as up-and-coming topics. *Conclusions:* Stable research funding and publication rates indicate a mature phase for BrS research, with genomics, proteomics, biomarkers, clinical prediction models, and gene therapy poised as future focal points.

Keywords: Brugada syndrome; CiteSpace; VOSviewer; Bibliometric

Online publication: July 23, 2024

1. Introduction

Brugada Syndrome (BrS) is a hereditary cardiac disorder marked by atypical ST-segment elevation, with an increased risk of ventricular tachycardia or fibrillation, potentially causing sudden heart failure. Identified in 1992 by the Brugada brothers, BrS has since garnered considerable attention in electrocardiography and cardiology worldwide [1]. Research over the last 30 years has spanned BrS genetics [2], its molecular foundations [2,3], clinical features [1,4], diagnostic techniques, and therapeutic approaches [5]. Key advancements include the identification

of a critical genetic mutation, SCN5A [6,7], ongoing enhancement of risk evaluation and treatment protocols [8–10], and improvements in treatment options, including medication and defibrillator implants [11]. Nonetheless, debates over BrS diagnostic standards persist, causing diagnosis inconsistencies [8,12], and current risk prediction models lack precision, affecting the management of high-risk individuals [13]. Furthermore, incomplete knowledge of BrS's genetic diversity and complex traits complicates personalized treatment. This study aims to employ bibliometric analysis to thoroughly assess BrS research status and trends, monitor key authors' contributions, pinpoint research deficiencies, and suggest potential future study avenues, thereby propelling progress in this domain.

2. Methods

2.1. Data source and retrieval strategy

This study's statistical data was derived from the Web of Science Core Collection, specifically utilizing the "Science Citation Index Expanded (Sci-Expanded)" citation index. This study constructed a search string to include various terms related to Brugada syndrome and its manifestations, as well as ventricular fibrillation susceptibility syndrome, covering publications from 1992 to December 31, 2023, with the search executed on February 7, 2024. The study confined our document selection to peer-reviewed articles and reviews, deliberately excluding conference papers, early-access content, letters, and commentaries. Two researchers independently screened titles and abstracts, discarding irrelevant studies to maintain data integrity. The final dataset, post-verification and deduplication, comprised 3,713 records, plus the seminal 1992 paper by Brugada P and Brugada J, which was included manually. All selected documents were downloaded in a "tab-delimited file" format, opting for "Full Record and Cited References" as the record content. The overall workflow is shown in **Figure 1**.

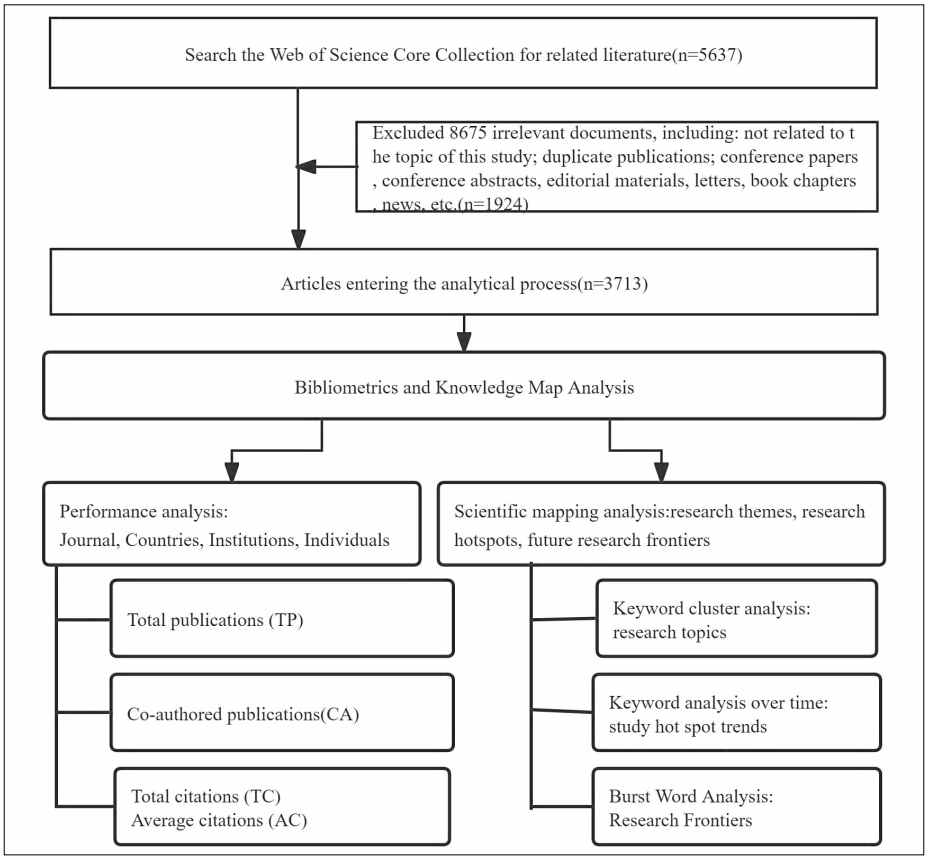

Figure 1. Literature search process.

2.2. Data cleaning strategy

The de-duplication tool in CiteSpace eliminates repeated entries, while VOSviewer's "replace" function and CiteSpace's "citespace.alias" file consolidate synonyms. This includes standardizing terms to their singular form (e.g., "cardiomyopathies" to "cardiomyopathy"), unifying variations of expression (e.g., "ventricular-arrhythmias" to "ventricular arrhythmia"), and normalizing geographical names (e.g., "England," "North Ireland," "Scotland," "Wales" to "UK").

2.3. Data analysis tools

Bibliometric analysis of publication volume, countries, authors, institutions, keywords, and co-citation networks is conducted using bibliometric analysis software such as CiteSpace [14] and VOSviewer [15]. Map drawing is carried out using software like Pajek, Scimago Graphica, and WPS. Zotero and Notepad++ are used for organizing references and documents.

3. Results

3.1. Annual publication trends and fund volume analysis

By December 2023, 3,713 studies had been disseminated, averaging 128 studies per year. In 2018, a record high of 228 studies was published. Publication growth exceeded 20% annually during 1998–2000, 2003–2005, and 2011–2013, signifying rapid progression in the field. In the last ten years, the field has seen a steady output of 187 studies annually, reflecting consistent research activity but a lack of emerging focal points. Financially, an initial $ 34,000 was allocated to this domain in 1994, with ongoing investment since 1999 reaching $ 76.7 million by 2021, though this figure is not exhaustive.

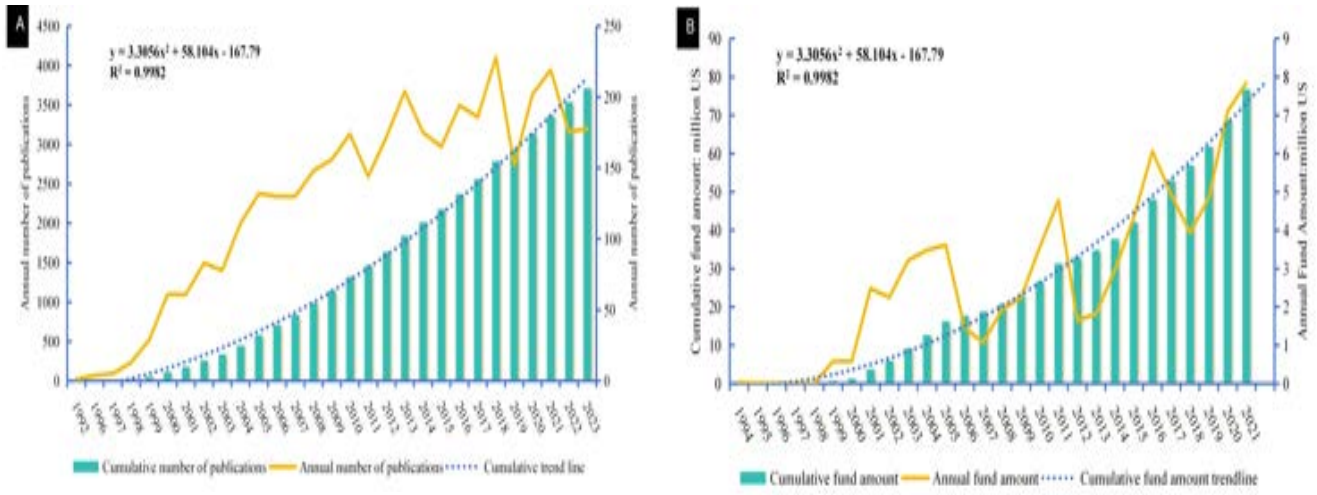

Figure 2. Trend chart of annual issuance and fund amount.The grant data comes from the public data of the National Science Foundation (NSF), National Institute of Health (NIH), EUROPA, PubMed Europe (PMC), Welcome Trust, Research Councils UK, GRB (Taiwan Government Research Bulletin), Canadian Institutes of Health Research (CIHR), Natural Sciences and Engineering Research Council (NSERC), Social Sciences and Humanities Research Council (SSHRC), excluding other grant data. The data is only queried to 2021.

3.2. National co-occurrence and citation analysis

Research on BrS has seen participation from 83 countries, with 78 forming collaborative ties. The United States leads in partnerships, boasting 1,208. It notably collaborates with Canada, European nations, Japan, and China,

as shown in **Figure 2A**. The United States, Japan, and Italy rank as the top three publishers, with 1078, 597, and 428 papers respectively, while the United States, Japan, and the Netherlands have the most citations, as per **Figure 2B**, with 57072, 23354, and 22743 citations respectively. The Netherlands, France, and Germany have the highest citations per publication, with averages of 69.13, 57.44, and 56.81, indicating the Netherlands' high-impact research. China is fourth in publication count, showing growth since 2012, but with an average citation of 19.31, suggesting a need for higher quality work and more academic interaction. Domestically, collaboration prevails, and strong international partnerships are lacking. The United States has the greatest centrality, with a value of 0.21. The summary is shown in **Figure 3**. **Table 1** indicates that America, Japan, Italy and other countries ranked as the Top 10 countries in terms of publications, with **Figure 4** supports the ranking with respective annual trend chart.

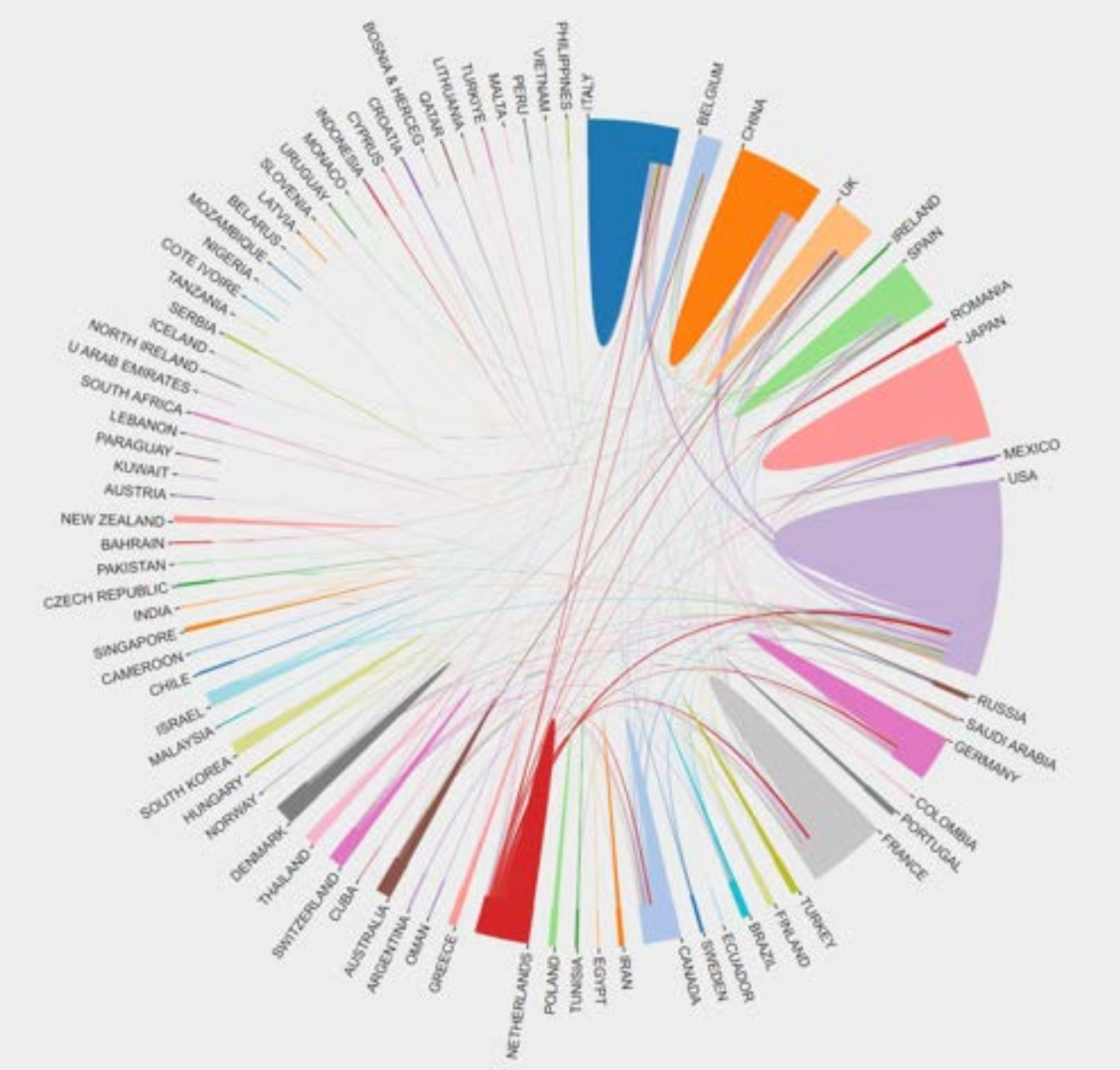

Figure 3. Geographic distribution of country cooperation.

Table 1 Top 10 countries in terms of publications

Country	Volume	Total number of citations	Average number of citations	Centrality	Strength of connections
America	1078	57072	52.94	0.21	1208
Japan	597	23354	39.12	0.07	515
Italy	428	20560	48.04	0.07	703
China	358	6913	19.31	0.09	459
Holland	329	22743	69.13	0.1	645
France	315	18094	57.44	0.17	641
Britain	302	10671	35.33	0.16	654
Germany	297	16873	56.81	0.05	629
Spain	273	13892	50.89	0.17	528
Canada	250	9336	37.34	0.06	563

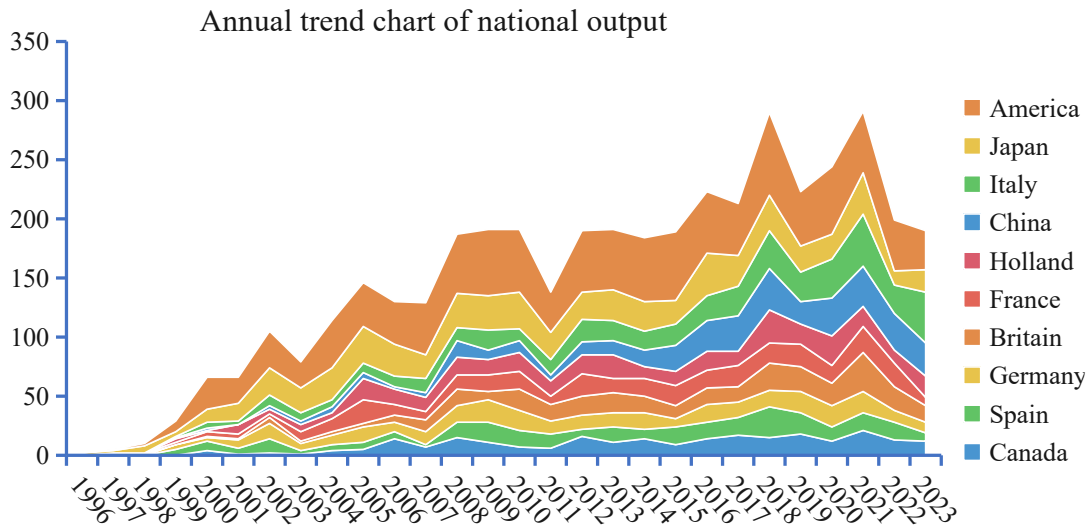

Figure 4. Annual trends in the volume of national communications.

3.3. Research institutions and author co-occurrence and citation analysis

The research involved 3,744 entities, with the top 10 publishers listed in **Table 2**. Leading the pack, the University of Amsterdam, Mayo Clinic, and Masonic Medical Research Institute published 321, 316, and 135 papers, respectively. The Masonic Institute stood out with the highest average citation of 61.28, suggesting its research holds superior quality and influence. Based on **Table 3**, a total of 14,221 authors contributed to the research, yet only 277 authored over 10 papers each. Brugada P was the most prolific, with 166 publications, followed by Antzelevitch C and Wilde AAM with 151 and 149. Antzelevitch C also had the top citation count and average amongst the top 10 authors, scoring 8,625 and 57.12 respectively. The most cited paper, "Brugada Syndrome Report of the Second Consensus Conference," provided comprehensive insights into BrS diagnosis, risk assessment, management, and genetics, offering clinicians a crucial reference for improving patient care [16]. **Figure 5** and **Figure 6** show the collaboration network map of the institution and author, respectively.

Table 2 Top 10 organizations in terms of publications

Organization	Publications	Total citations	Average citations	Publications of the first author	Citations of the first author	Average citations of the first author
University of Amsterdam	321	12522	39.01	117	3700	31.62
Mayo Clinic	316	9664	30.58	44	1195	27.16
Masonic Medical Research Institute	135	8273	61.28	70	4205	60.07
University of Barcelona	121	5801	47.94	21	1485	70.71
Vanderbilt University	188	5103	27.14	49	1447	29.53
Baylor College of Medicine	84	5082	60.5	14	226	16.14
National Cardiovascular Center	71	4816	67.83	29	1686	58.14
Nantes University Hospital	76	4269	56.17	11	371	33.73
University of Pavia	98	3794	38.71	15	891	59.4
University of Munster	46	2997	65.15	11	78	7.09

Note: All literature only takes the top 25 institutions or authors; First author refers to the first author, excluding co-authors (the same below). Only the top 30 institutions in terms of the number of publications are shown in the collaborative network map.

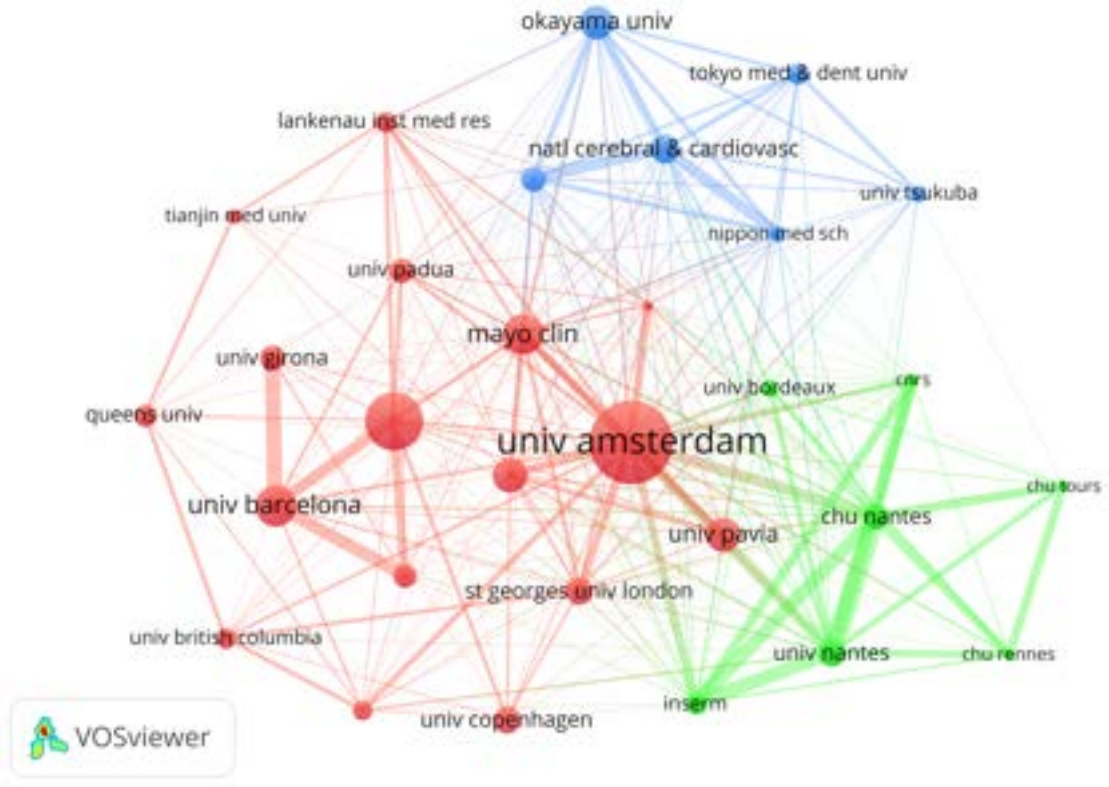

Figure 5. Institutional collaboration network map.

Table 3 Top 10 authors in terms of publications

Author	Publications	Total citations	Average citations	Publications of the first author	Citations of the first author	Average citations of the first author	Publications of the corresponding author	Citations of the corresponding author
Brugada P	166	6703	40.38	15	402	26.8	22	516
Antzelevitch C	151	8625	57.12	33	2576	78.06	68	4593
Wilde AAM	149	6951	46.65	15	900	60	31	1696
Brugada R	132	6006	45.5	3	381	127	28	559
Brugada J	124	6348	51.19	11	999	90.82	12	1311
Shimizu W	88	4661	52.97	16	514	32.13	31	1193
ProBrSt V	87	4305	49.48	11	733	66.64	12	720
Sacher F	86	2719	31.62	8	318	39.75	9	318
Ackerman MJ	78	2623	33.63	5	131	26.2	31	1174
Bezzina CR	74	2782	37.59	4	357	89.25	13	703

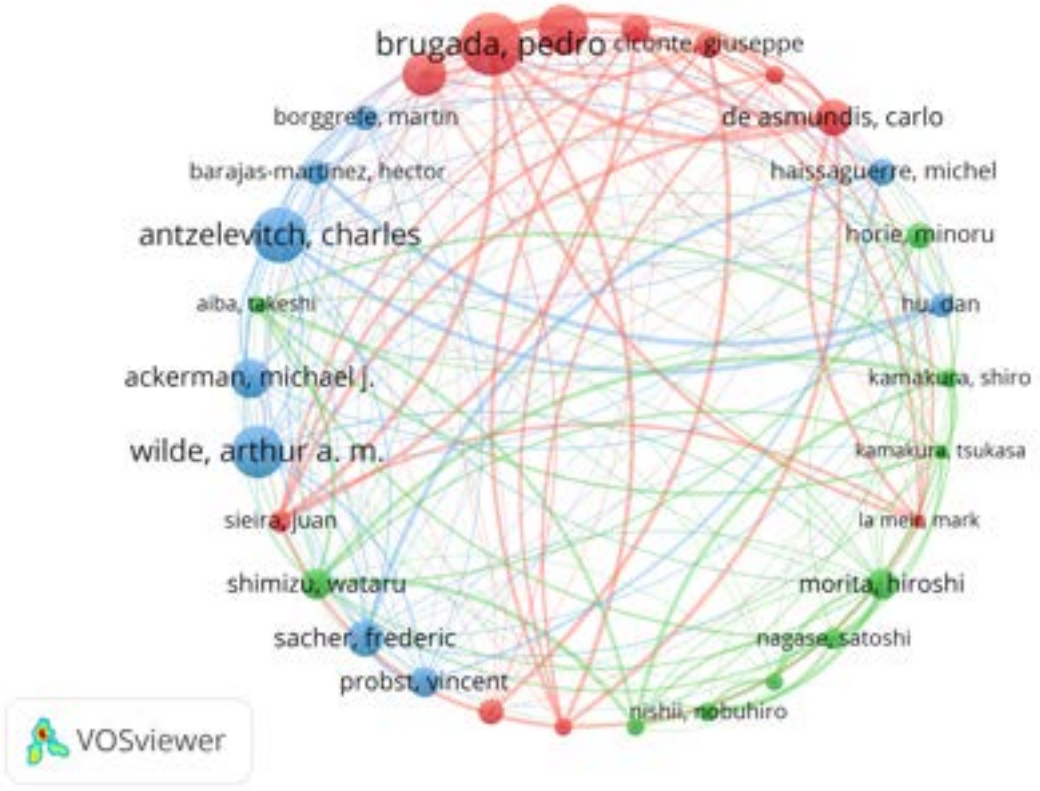

Figure 6. Author's collaborative web chart.

3.4. Publication journal analysis

Research on Brugada Syndrome (BrS) was published across 616 journals, with the leading 10 featured in **Table 4**. The journals *Heart Rhythm*, *Journal of Cardiovascular Electrophysiology*, and *Europace* topped the publication count, delivering 245, 166, and 166 papers, respectively. *Circulation* led in total and mean citations with an impact factor of 37.8, marking its status as a JCR1 zone TOP journal, and highlighting its prominence in the field. *Journal of The American College of Cardiology* and *Circulation-Arrhythmia and Electrophysiology* followed as the second

and third for average citations in the top 10, scoring 122.04 and 49.89, respectively, both also classified as JCR1 zone TOP journals. **Figure 7** supports the above statement with the web chart of issuing journals.

Table 4 Top 10 journals in terms of publications

Journal	Publications	Total citations	Average citations	IF	JCR	TOP Journal
Heart Rhythm	245	11458	46.77	5.5	2	No
Journal of Cardiovascular Electrophysiology	166	6033	36.34	2.7	3	No
Europace	166	3493	21.04	6.1	2	No
Journal of Electrocardiology	164	2913	17.76	1.3	4	No
Pace-Pacing and Clinical Electrophysiology	135	2561	18.97	1.8	4	No
Circulation	107	20863	194.98	37.8	1	Yes
Annals of Noninvasive Electrocardiology	94	1168	12.43	1.9	4	No
Circulation Journal	85	1909	22.46	3.3	3	No
Journal of the American College of Cardiology	82	10007	122.04	24	1	Yes
Circulation-Arrhythmia and Electrophysiology	81	4041	49.89	8.4	1	Yes

Note: Impact factors and JCR partitions are for 2023 data; only the top 30 journals in terms of publications are shown coupled network diagrams

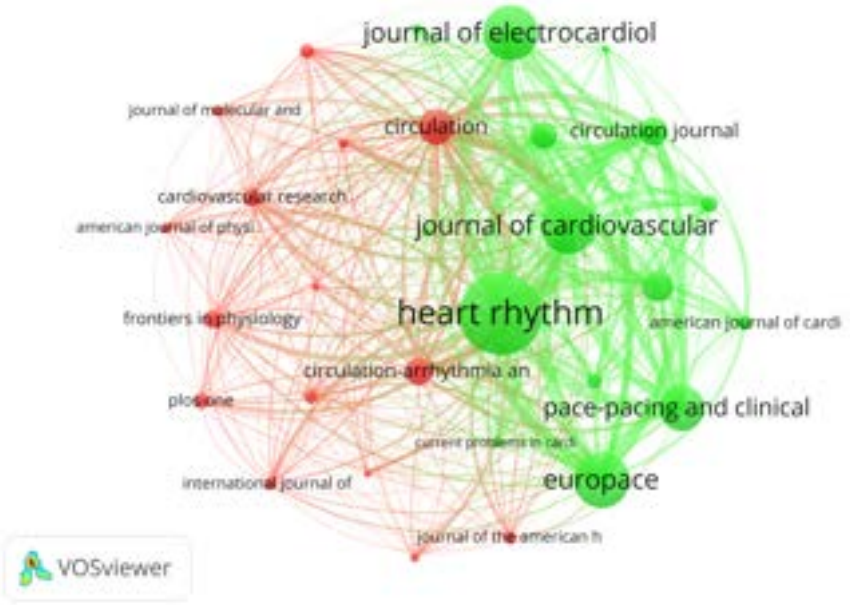

Figure 7. Analysis of issuing journals.

3.5. Keyword co-occurrence and burst change analysis

Keywords summarize research themes, and examining them can reveal the progression and focal points in an academic area over time. Using VOSviewer, we analyzed 7,055 keywords from 3,713 studies (refer to **Figure 8**). A cluster analysis on the 200 most common keywords yielded five categories: epidemiology and genetics, clinical features, risk evaluation, treatment strategies, and fundamental molecular studies. Notable terms included ‘Brugada syndrome,’ ‘Sudden death,’ ‘St-segment elevation,’ and others such as ‘Arrhythmia’ and ‘Mutation.’ Based on **Figure 9**, burst terms, indicating a sharp rise in usage within a certain timeframe, signal new shifts and important findings. Our research identified such burst terms, pointing to early clinical signs,

mid-term disease mechanism research, and later management-focused studies. Recently, genetic research has emerged as a prominent theme [14].

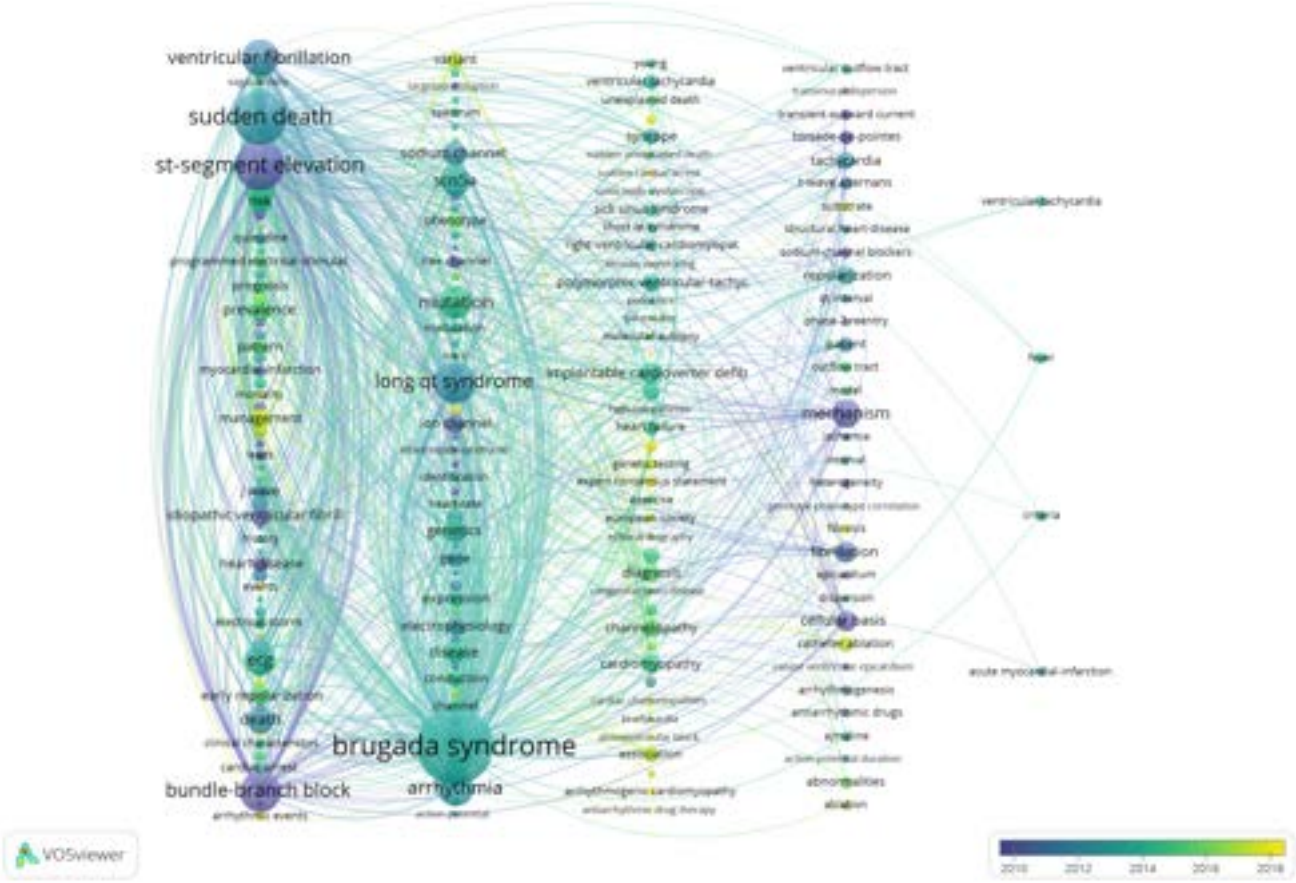

Figure 8. Keyword co-occurrence cluster analysis. Only the keywords in the top 200 occurrence frequency are shown.

Top 20 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	1996 - 2023
bundle branch block	1996	89.37	1996	2007	
st-segment elevation	1996	47.79	1996	2007	
heart disease	1996	27.43	1996	2005	
torsade de pointes	1997	11.94	1997	2009	
idiopathic ventricular fibrillation	1996	11.41	1996	2003	
marker	1999	17.79	1999	2003	
molecular mechanism	1999	11.23	1999	2003	
mechanism	1996	37.07	2000	2007	
right precordial leads	2000	24.44	2000	2007	
sodium channel blockers	2001	17.12	2001	2007	
cellular basis	2000	13.16	2004	2011	
early repolarization	2003	19.51	2012	2017	
expert consensus statement	2012	14.11	2014	2023	
management	2000	27.08	2016	2023	
catheter ablation	2004	14.6	2016	2023	
brugada phenocopy	2016	11.2	2016	2023	
guidelines	2014	19.82	2018	2023	
consensus conference	2018	13.62	2018	2023	
genetics	2016	11.93	2018	2023	
association	2006	13.83	2020	2023	

Figure 9. Analysis of bursts.

4. Discussion

In 1992, Brugada siblings initially documented a syndrome with specific clinical and EKG patterns, including right bundle branch block, ST-segment elevation without heart abnormalities, and life-threatening arrhythmias [1]. Four years later, Miyazaki T defined Brugada syndrome (BrS) and its electrocardiographic modulation through autonomic influences and drug interactions, noting that certain drugs could worsen or mitigate ST elevation [17]. Building on this, Dumaine R discovered a gene mutation (SCN5A) in 1999, connecting it to BrS's EKG traits and its heightened risks during fever [18]. Further research identified over 90 additional mutations [2,3,6,7]. In 2002, Wilde *et al.* set diagnostic benchmarks for BrS, integrating EKG, family history, and other tests [19]. The consensus on BrS was refined in 2005 by Antzelevitch and colleagues, expanding its diagnosis, management, and genetic understanding [16]. ICD therapy emerged as a go-to for BrS, but a 2015 study by Conte *et al.* revealed its limitations, including preventive success, unintended shocks in asymptomatic patients, and device complications [11]. That year, Brugada J showcased epicardial ablation as a potential cure by eliminating Brugada patterns [13]. A 2023 study confirmed ablation's efficacy in preventing ventricular fibrillation, suggesting it could supplant ICDs [10]. Barc J and a large team in 2022 exposed 21 genetic markers for BrS, revealing the role of genetic variation and identifying new mechanisms like microtubule-related transport affecting Nav1.5 [3]. Pattarapong M's team found BrS-linked variants in the Thai population [20], and Giuseppe C *et al.* linked genetic makeup to BrS severity [21]. Shohreh H developed a model to predict arrhythmic risks in BrS [3]. Recent trends point to genome-wide studies, cross-population genetics, risk models, and novel treatments as burgeoning areas of BrS research, poised for significant advancements.

While considerable progress has been made in understanding Brugada Syndrome (BrS), many mysteries persist, pointing to areas needing further investigation. These include:

(1) Genetics and molecular mechanisms: The connection between gene mutations, such as those in the SCN5A gene, and the array of clinical presentations needs clarification, as does the molecular basis for related arrhythmias [5,22].

(2) Physiological mechanisms: The precise ways in which gene mutations affect ion channels and how these perturbations cause electrocardiographic changes and arrhythmias, remain to be uncovered [2,3].

(3) Clinical diagnosis: Diagnosis is currently based on electrocardiographic patterns and family history, yet these indicators can be indistinct. Future research could leverage big data and various omics technologies to refine diagnostic criteria and discover new biomarkers [5,12].

(4) Risk stratification: There is a need for more accurate methods to identify patients at high risk. Big data and AI could help develop predictive models for risk assessment [9,23–25].

(5) Therapeutic strategies: ICDs prevent sudden cardiac death but raise issues for young patients. Investigating the long-term impact of treatments like quinidine and exploring gene editing and stem cell technologies as treatment options are critical [9,10,26,27].

(6) Epidemiological studies: More studies are needed to understand the interplay between BrS, genetics, environmental factors, and lifestyle [9].

(7) Early screening and prevention: Effective strategies are urgently required for high-risk groups to prevent sudden cardiac death, which may include genetic research and exploration of ion channel dysfunction [28,29].

Combining various scientific fields, interdisciplinary research is imperative to address these challenges in BrS. This study proposes that research will likely concentrate on genomics, proteomics, biomarkers, clinical prediction models, and gene therapy, informed by the latest advancements in big data, bioinformatics, and AI.

Author contributions

Conceptualization: Yanli Yang
Investigation: Shiliang Xi
Analysis: Yanli Yang, Shiliang Xi
Writing – draft: Yanli Yang
Writing – review & editing: Ying Li, Yanli Yang

Disclosure statement

The authors declare no conflict of interest.

References

[1] Brugada P, Brugada J, 1992, Right Bundle Branch Block, Persistent ST-Segment Elevation and Sudden Cardiac Death: A Distinct Clinical and Electrocardiographic Syndrome. Journal of the American College of Cardiology, 20(6): 1391–1396.

[2] Moras E, Gandhi K, Narasimhan B, et al., 2023, Genetic and Molecular Mechanisms in Brugada Syndrome. Cells, 12(13): 1791.

[3] Barc J, Tadros R, Glinge C, et al., 2022, Genome-Wide Association Analyses Identify New Brugada Syndrome Risk Loci and Highlight a New Mechanism of Sodium Channel Regulation in Disease Susceptibility. Nature Genetics, 54(3): 232–239.

[4] Adler A, Rosso R, Chorin E, et al., 2016, Risk Stratification in Brugada Syndrome: Clinical Characteristics, Electrocardiographic Parameters, and Auxiliary Testing. Heart Rhythm, 13(1): 299–310.

[5] Hosseini SM, Kim R, Udupa S, et al., 2018, Reappraisal of Reported Genes for Sudden Arrhythmic Death: Evidence-Based Evaluation of Gene Validity for Brugada Syndrome. Circulation, 138(12): 1195–1205.

[6] Yuan M, Guo Y, Xia H, et al., 2021, Novel SCN5A and GPD1L Variants Identified in Two Unrelated Han-Chinese Patients with Clinically Suspected Brugada Syndrome. Frontiers in Cardiovascular Medicine, 2021(8): 758903.

[7] Chen GX, Barajas-Martínez H, Ciconte G, et al., 2023, Clinical Characteristics and Electrophysiologic Properties of SCN5A Variants in Fever-Induced Brugada Syndrome. EBioMedicine, 2023(87): 104388.

[8] Brugada J, Campuzano O, Arbelo E, et al., 2018, Present Status of Brugada Syndrome. Journal of the American College of Cardiology, 72(9): 1046–1059.

[9] Aziz HM, Zarzecki MP, Garcia-Zamora S, et al., 2022, Pathogenesis and Management of Brugada Syndrome: Recent Advances and Protocol for Umbrella Reviews of Meta-Analyses in Major Arrhythmic Events Risk Stratification. Journal of Clinical Medicine, 11(7): 1912.

[10] Nademanee K, Chung FP, Sacher F, et al., 2023, Long-Term Outcomes of Brugada Substrate Ablation: A Report from BRAVO (Brugada Ablation of VF Substrate Ongoing Multicenter Registry). Circulation, 147(21): 1568–1578.

[11] Conte G, Sieira J, Ciconte G, et al., 2015, Implantable Cardioverter-Defibrillator Therapy in Brugada Syndrome: A 20-Year Single-Center Experience. Journal of the American College of Cardiology, 65(9): 879–888.

[12] Wu L, Peng J, Li B, 2020, Brugada Syndrome: Traditional Understanding and Updates. Journal of Clinical Electrocardiology, 29(3): 161–170.

[13] Pappone C, Brugada J, Vicedomini G, et al., 2017, Electrical Substrate Elimination in 135 Consecutive Patients with Brugada Syndrome. Circulation-Arrhythmia and Electrophysiology, 10(5): 803–809.

[14] Chen Y, Chen C, Liu Z, Hu Z, Wang X, 2015, The Methodological Functions of CiteSpace Knowledge Maps. Studies in Science of Science, 33(2): 242–253.

[15] VOSviewer: Visualizing Scientific Landscapes, viewed February 27, 2024, https://www.vosviewer.com//.

[16] Antzelevitch C, Brugada P, Borggrefe M, et al., 2005, Brugada Syndrome: Report of the Second Consensus Conference: Endorsed by the Heart Rhythm Society and the European Heart Rhythm Association. Circulation, 111(5): 659–670.

[17] Miyazaki T, Mitamura H, Miyoshi S, et al., 1996, Autonomic and Antiarrhythmic Drug Modulation of ST-Segment Elevation in Patients with Brugada Syndrome. Journal of the American College of Cardiology, 27(5): 1061–1070.

[18] Dumaine R, Towbin J, Brugada P, et al., 1999, Ionic Mechanisms Responsible for the Electrocardiographic Phenotype of the Brugada Syndrome are Temperature Dependent. Circulation Research, 85(9): 803–809.

[19] Behr ER, Savio-Galimberti E, Barc J, et al., 2015, Role of Common and Rare Variants in SCN10A: Results from the Brugada Syndrome QRS Locus Gene Discovery Collaborative Study. Cardiovascular Research, 106(3): 520–529.

[20] Makarawate P, Glinge C, Khongphatthanayothin A, et al., 2020, Common and Rare Susceptibility Genetic Variants Predisposing to Brugada Syndrome in Thailand. Heart Rhythm, 17(12): 2145–2153.

[21] Ciconte G, Monasky MM, Santinelli V, et al., 2021, Brugada Syndrome Genetics is Associated With Phenotype Severity. European Heart Journal, 42(11): 1082–1090.

[22] Pinsach-Abuin ML, Del Olmo B, Pérez-Agustin A, et al., 2021, Analysis of Brugada Syndrome Loci Reveals That Fine-Mapping Clustered GWAS Hits Enhances the Annotation of Disease-Relevant Variants. Cell Reports Medicine, 2(4): 100250.

[23] Honarbakhsh S, Providencia R, Garcia-Hernandez J, et al., 2021, A Primary Prevention Clinical Risk Score Model for Patients with Brugada Syndrome (BRUGADA-RISK). JACC Clinical Electrophysiology, 7(2): 210–222.

[24] Probst V, Goronflot T, Anys S, et al., 2021, Robustness and Relevance of Predictive Score in Sudden Cardiac Death for Patients with Brugada Syndrome. European Heart Journal, 42(17): 1687–1695.

[25] Morales MA, Piacenti M, Nesti M, et al., 2021, The BrAID Study Protocol: Integration of Machine Learning and Transcriptomics for Brugada Syndrome Recognition. BMC Cardiovascular Disorders, 21(1): 494.

[26] Sun Y, Su J, Wang X, et al., 2023, Patient-Specific iPSC-Derived Cardiomyocytes Reveal Variable Phenotypic Severity of Brugada Syndrome. EBioMedicine, 2024(95): 104741.

[27] Theisen B, Holtz A, Rajagopalan V, 2023, Noncoding RNAs and Human Induced Pluripotent Stem Cell-Derived Cardiomyocytes in Cardiac Arrhythmic Brugada Syndrome. Cells, 12(19): 2398.

[28] Liantonio A, Bertini M, Mele A, et al., 2023, Brugada Syndrome: More than a Monogenic Channelopathy. Biomedicines, 11(8): 2297.

[29] Li Y, Dinkel H, Pakalniskyte D, et al., 2023, Novel Insights in the Pathomechanism of Brugada Syndrome and Fever-Related Type 1 ECG Changes in a Preclinical Study Using Human-Induced Pluripotent Stem Cell-Derived Cardiomyocytes. Clinical and Translational Medicine, 13(3): e1130.