

ORIGINAL RESEARCH

Bibliometric trends in priapism research publications

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Abstract

To explore the cooperation of authors, institutions, countries and find hot topics of priapism. Papers about priapism were retrieved from the Web of Science Core Collection (WoSCC). VOSviewer and CiteSpace were used to conduct the bibliometric analyses. Network maps were generated to evaluate the collaborations between different keywords, institutions, authors and countries. A total of 2485 articles related to study of priapism were identified. We observed gradually increasing in the number of publications from 1970 to 2012, and the trend was to be relatively stable in the past ten years. Journal of Urology (322 papers) owned the highest number of publications and Journal of Urology was the most co-cited journal. Burnett, AL (106 papers) was the top most productive authors and the largest numbers of citations (1703 co-citations) during the past decades. There were active collaborations among the top authors. The USA was the leading contributor in this field with 820 papers. Cooperation between countries and between institutions was observed. The main hot topics included matters related to priapism, management, erectile dysfunction, penile erection, penis, diagnosis and high-flow priapism. This paper uses visualization tools to draw a knowledge map of priapism research, and provides a new perspective and direction for priapism research by clarifying the time series, development context, research hotspots, knowledge network structure and the status of major scholars in priapism.

Keywords

Priapism; Impotence; Erectile dysfunction; Diagnosis

1. Introduction

Priapism is a rare pathological erectile state and one of the common emergencies in andrology [1]. Its incidence is about 1.5/100,000 and it can occur at any age, including the neonatal stage, but children aged 5 to 10 and adults aged 20 to 50 are the age groups with high incidence of this disease [2]. According to the etiology and pathogenesis, it is divided into two types: high-flow and low-flow priapism. Regarding the cause of priapism, as well as induration penis plastica [3, 4], correct and timely treatment can preserve the sexual function of patients, while treatment delay will prolong the time of cavernosal ischemia, and even cause permanent damage to the cavernosal and erection dysfunction [5].

The exact etiology of priapism is unknown, but ischemic priapism and nonischemic priapism have their own etiological factors. The etiology of ischemic priapism mainly includes hemocytic and thrombotic factors, drugs, tumor, neurological factors, inflammation and infection [6]. Sick cell disease is the most common cause of ischemic priapism in children, accounting for 63% of pediatric patients. It is mainly due to the obstruction of subtunica albuginea venules caused by sickle red blood cells [7]. Persistent penile erection caused by leukemia accounts for 1% of the total incidence, which may be related to the increase in the number of white blood cells

and the increase in blood viscosity. Drugs factors are the most common cause of ischemic priapism in adults. The incidence of ischemic priapism is increased to 5%~21% due to the use of drug injection in the penile sponge [8]. 30%~50% of ischemic priapism is idiopathic and of unknown cause [9]. The etiology of nonischemic priapism can be divided into three types: traumatic, neuropathic, and post-shunting [10]. Traumatic priapism is the most common, mainly caused by perineal or penile trauma, including straddle injury, pelvic fracture, penile or perineal kick, sexual trauma, etc. Neuropriapism is common in acute spinal cord injury. Priapism after shunt is mainly caused by nonfistulatory arterial abnormalities after treatment of ischemic priapism such as metastatic penile malignancy and sickle cell disease.

The signs of priapism are obvious, the low-flow type corpus cavernosum is abnormally hard, accompanied by local severe pain, and the appearance of the penis is often bruised, which is due to venous system reflux disorder or cavernosal smooth muscle paralysis, blood stasis in the cavernous body, and tissue hypoxia [11]; The hardness of high-flow erection is generally not hard, and the skin of the penis is normal in color and elasticity. It is often caused by the rupture or continuous expansion of the arteries caused by trauma, and the overfilling of the cavernous sinus. Once the low blood flow type is diagnosed, methods such as analgesia and local

cold compress should be used. It is feasible to aspirate the intracavernous congestion or perform heparin saline lavage followed by injection of adrenergic receptor agonists [12]. Conservative treatment fails to consider the cavernosal shunting of the corpus cavernosum. Cavernous fibrosis and ED are rare in high-flow priapism, and the treatment methods include conservative treatment, drug treatment, radiological interventional therapy and surgery. The American Urological Association considers the preferred treatment to be observation [9].

Bibliometric is a statistical method used to evaluate the quality and quantity of published literature. VOSviewer is software developed by NeesJan Van Eck and Ludo Waltman at the Leiden University Research Centre for Science and Technology in the Netherlands. It can be used for clustering, stacking and density views of literature, and evaluate the research direction and hot spots of literature [13]. CiteSpace is visual analysis software developed by Professor Chen Chaomei of Drexel University and his team based on Java language to analyze potential knowledge contained in scientific literature. Through bibliometrics theory, CiteSpace conducts quantitative analysis on relevant literature and draws a series of visual maps. Study hotspots, frontiers and development trends in the research area can be detected [14]. In order to comprehensively understand this development process of priapism research around the world, find relevant researchers and institutions, and clarify the research status and development trend of priapism field. In this study, relevant literature since the establishment of the global SCI database was sorted and summarized by bibliometrics, and visual analysis was conducted by using VOSviewer and CiteSpace to explore and summarize the current global research hotspots, research frontiers and development trends of priapism. This study was therefore designed to provide research basis, new perspective and direction for the later researches on priapism.

2. Methods

An online search was conducted from the WoSCC database on Apr 17, 2022. Publications were used the search queries to get between 1970 and 2022: TS = priapism. The following criteria of papers were included:

- (1) Publications were indexed in WoSCC.
- (2) The time span is between 1970 and 2022.
- (3) Publications on study of priapism, including all type of documents.

2.1 Data Analysis

CiteSpace 5.7. R1 (Drexel University, Pennsylvania, PA, USA) and VOSviewer 1.6.15 (CWTS, Leiden, Netherland) were used to conducted co-occurrence analysis and extract high-frequency keywords and research subjects (authors, institutions, and countries) in the data set, and calculate their influence. Their knowledge maps were performed. Burst keyword detection was also conducted to investigate the new recurrent keywords. We choose the 100 most cited or found papers were to create the network. Depending on the set thresholds, using CiteSpace to analyze the distribution of research hotspots

at each stage, the timeline view can describe the trend of a field over time, and draw global priapism research hotspots in different periods.

3. Results

Finally, 2485 publications met the retrieval criteria (Table 1). The number of papers by year was shown in Fig. 1. The 2485 papers were cited 35,053 times, with an average of 14.11 citations per paper. The sources of top five financial supports include USA DHHS, NIH USA, NIDDK, NHLBI and Conselho Nacional De Desenvolvimento Cientifico E Tecnologico Cnpq.

TABLE 1. The Type of document on the research of priapism.

Ranking	Type of document	publications Numbers	N (%)
1st	Article	1443	58.07
2nd	meeting abstract	386	15.53
3rd	letter	243	9.78
3rd	review	199	8.01
4th	editorial material	132	5.31
5th	brief report	73	2.94
6th	early access	9	0.36

3.1 Main Journals

In total, 619 academic journals have published publications related to priapism. Table 2 presented the top 15 journals and cited journals contributing to priapism. Journal of Urology as the main journal published the most publications (322 publications), followed by Journal of Sexual Medicine (250 papers), Urology (116 papers), International journal of impotence research (67 papers) and British Journal of Urology international (54 publications). The most cited journal (6127 times) was Journal of Urology was, followed by Journal of Sexual Medicine (2659 times), Urology (1800 times), blood (1424 times), and international journal of impotence research (1327 times).

3.2 Analysis of Leading Institutions and Countries

A total of 94 countries and 2038 institutions were identified. Country collaboration network of priapism was observed (Fig. 2). Table 3 presented the top 15 countries contributing to priapism research. Related to priapism research, USA contributed the most publications (820 papers) followed by England (198 papers), Turkey (122 papers), France (119 papers), Italy (79 papers), and Germany (74 papers). For link strength, USA (164), England (121), Italy (81), France (76), Canada (75) and Turkey (49) were the top 5 countries.

The institution collaboration network of priapism was shown (Fig. 3). The top five most productive institutions

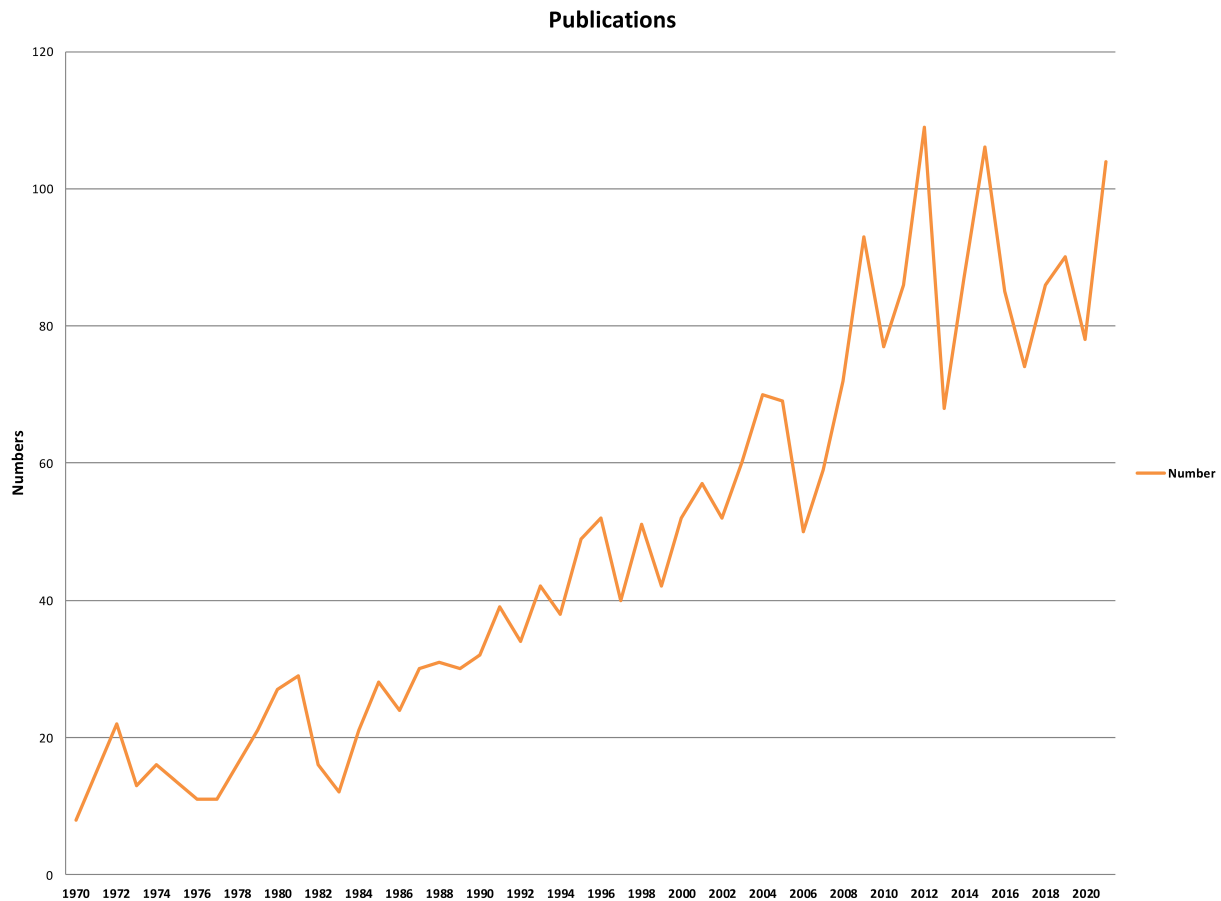


FIGURE 1. The number of publications changes with the year.

TABLE 2. The top 15 productive and cited journals on the research of priapism.

Ranking	Journal	Frequency	IF (2020)	Cited (times)
1st	Journal of Urology	322	7.45	6127
2nd	Journal of Sexual Medicine	250	3.802	2659
3rd	Urology	116	2.649	1800
4th	International journal of impotence research	67	2.896	1327
5th	British Journal of Urology international	54	5.588	806
6th	Blood	41	23.629	1424
7th	British Journal of Urology	39	1.69	599
8th	European Urology	38	20.096	691
9th	Urologia internationalis	23	2.089	285
10th	Andrologia	22	2.775	90
11th	Journal of clinical psychiatry	21	4.384	900
11th	Progres en Urologie	21	0.915	96
13 th	British Journal of haematology	19	6.998	836
13th	Journal of clinical psychopharmacology	19	3.153	219
13th	Scandinavian Journal of Urology and Nephrology	19	1.243 (2014)	149

IF, Impact Factor.

were JOHNS HOPKINS UNIVERSITY (106 papers), UNIVERSITY OF LONDON (85 papers), JOHNS HOPKINS MEDICINE (82 papers), UNIVERSITY OF CALIFORNIA SYSTEM (80 papers), UNIVERSITY COLLEGE LONDON (73 papers), respectively.

TABLE 3. The top 15 productive and cited country on the research of priapism.

Ranking	country	Frequency	Cited (times)
1st	USA	820	19275
2nd	England	198	3757
3rd	Turkey	122	1065
4th	France	119	1861
5th	Italy	79	1738
6th	Germany	74	864
7th	Canada	71	2282
8th	Spain	64	750
9th	Brazil	63	973
10th	People's Republic of China	59	459
11th	India	52	260
12th	Netherlands	35	817
12th	Austria	35	897
14th	Japan	34	534
15th	Egypt	24	545

3.3 Main Authors

A total of 8041 authors were identified. The author collaboration network of priapism was observed. According to Fig. 4, in terms of frequencies, Burnett, AL (106 papers), Ralph, D (66 papers), Muneer, A (43 papers), Bivalacqua, TJ (33 papers) and Minhas, S (32 publications) were the 5 most productive authors. The information of author citation was also analysed. For co-cited author, the 5 authors with the most citations, were Burnett, AL (1703 co-citations), Lue, T (1370 co-citations), Gladwin, MT (1323 co-citations), Kato, GJ (1175 co-citations), and Steinberg, MH (1317 co-citations). (Table 4)

3.4 Main Keywords and Clusters

3751 keywords were identified and the collaboration network of priapism as the presented in Fig. 5. The main hot keywords were priapism (748 times), management (358 times), erectile dysfunction (216 times), penile erection (129 times), penis (124 times), diagnosis (121 times), high-flow priapism (118 times) and impotence (118 times). Fig. 5b shows the changes of high-frequency keywords cited in different periods.

These keywords were classified into 7 clusters: “sickle cell disease”, “intracavernous prostaglandin”, “post-traumatic high flow priapism”, “erectile dysfunction”, “rat model”, “ischemic priapism” and “blunt perineal trauma”. The timeline view from 1970 to 2022 was shown as Fig. 6, key word time

TABLE 4. The most productive authors on the research of priapism (Top 15).

Ranking	Author	publications Numbers	Cited (times)
1st	Burnett, AL	106	1703
2nd	Ralph, D	66	814
3rd	Muneer, A	43	407
3rd	Bivalacqua, TJ	33	803
4th	Minhas, S	32	340
5th	Goldstein, I	27	1175
6th	Musicki, B	26	540
7th	Garaffa, G	24	233
8th	Zacharakis, E	23	108
9th	Lue, T	21	1370
10th	Xia, Y	20	450
11th	Munarriz, R	19	180
12th	Kadioglu, A	17	497
13th	Melman, A	16	319
13th	Lue, TF	16	670
13th	Morey, AF	16	59

evolution of each cluster. “Sickle cell disease, complication” were the initial research and the research direction has focused on “low flow priapism, high flow priapism, peyronie disease, mechanism, management” in recent years.

3.5 Burst References

We presented the top 11 co-cited references on priapism. 1 article (Montagus DK 2003) was co-cited more than 200 times, 10 articles (Brderick GA 2010; Lue TF 1986; Spycher MA 1986, Grayhack 1964, Hinman F 1960, adeyoju AB 2002, Emond AM 1980, Salonia A 2014, Witt Ma, Champion HC 2005) were co-cited more than 100 times.

Fig. 7 was shown the top 25 references with the strongest citation bursts. GRACE DA, 1968, J UROLOGY, V99, P301 was the first reference with citation bursts appeared in 1970. At the same time, most publications were found to have citations between 1970 and 1985.

4. Discussion

With priapism being a comparatively rare disease, due the low numbers of patients, many doctors are not familiar with its management. Thus, several regions have centralized the diagnosis and treatment of this rare emergency. So what are the regions and institutions that are currently active in priapism research around the world? How do members of the group cooperate with each other? What are the current research hotspots? Answering these questions cannot only fully reveal the composition and changing characteristics of researchers in the field of publishing research, but also help to understand its development law and evolution trend.

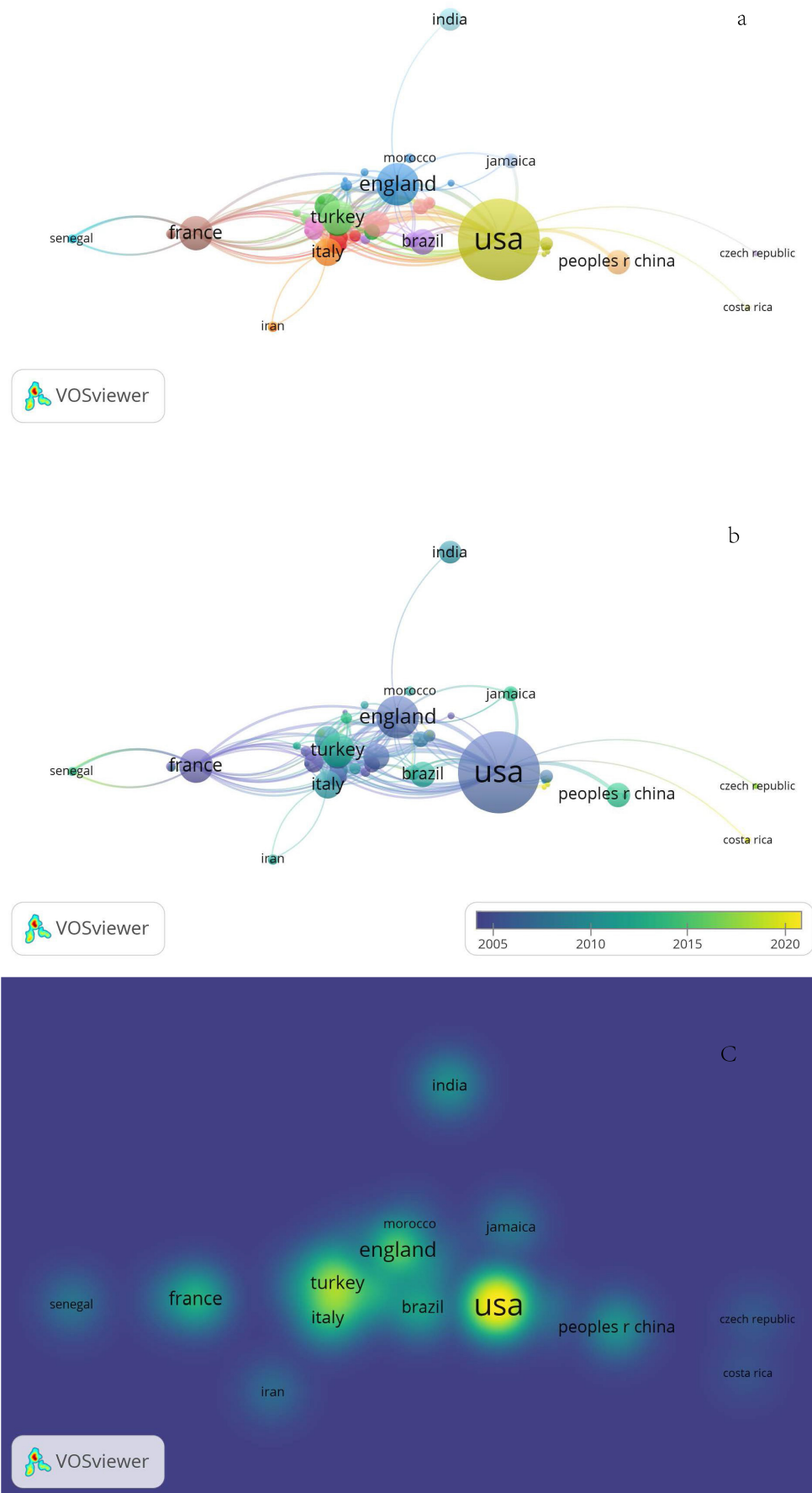


FIGURE 2. The font size of each country represents the number of articles in the country. The thickness of the lines indicates the strength of the connection. a, the country collaboration network of research on priapism. b, different colors inside the circle represent different time intervals. c, the brighter the color, the more publications for country.

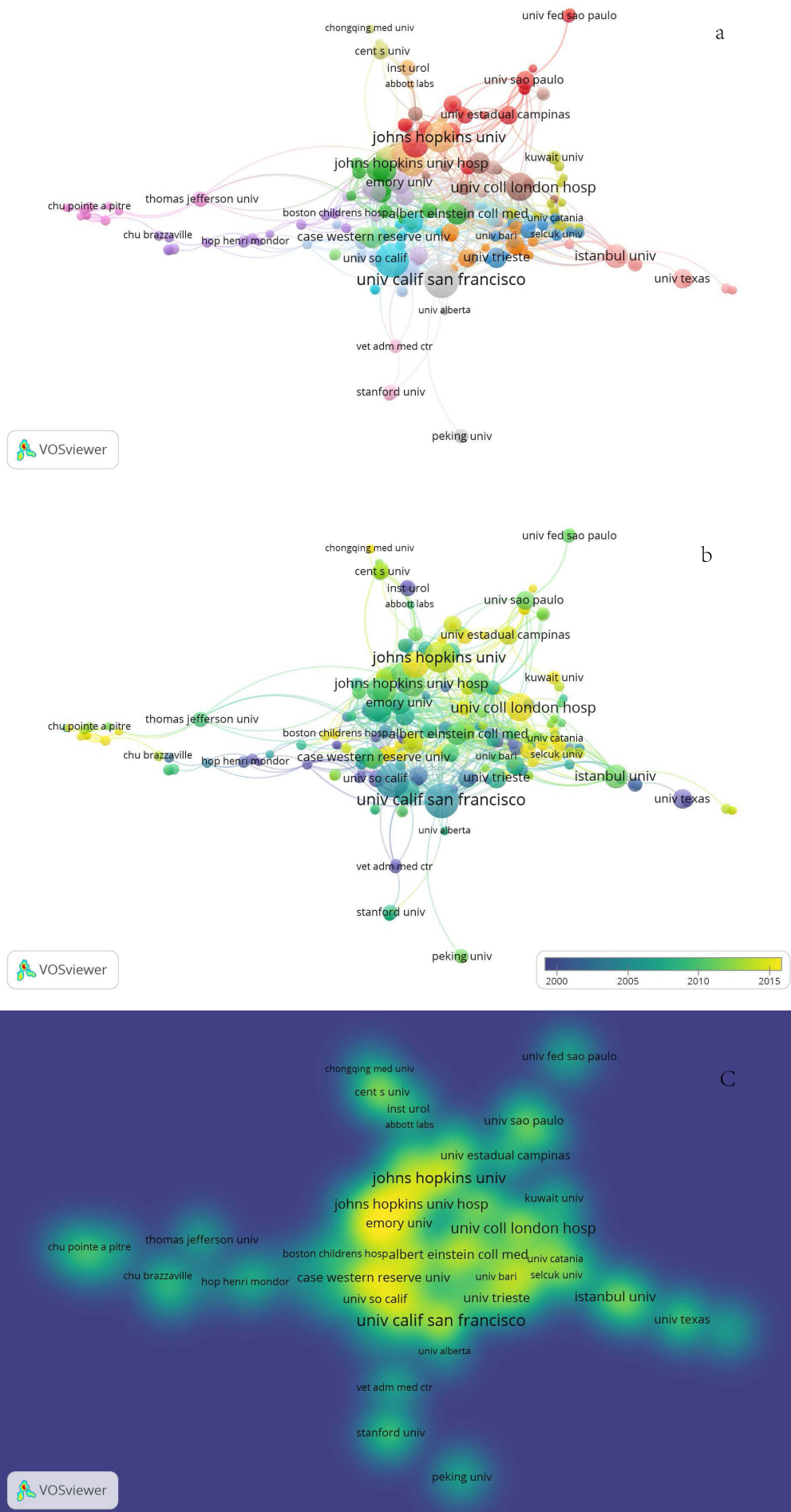


FIGURE 3. The font size of each institution represents the number of publications in the institutions. The thickness of the lines indicates the strength of the connection. a, the institutions collaboration network of research on priapism. b, different colors inside the circle represent different time intervals. c, the brighter the color, the more publications for institutions.

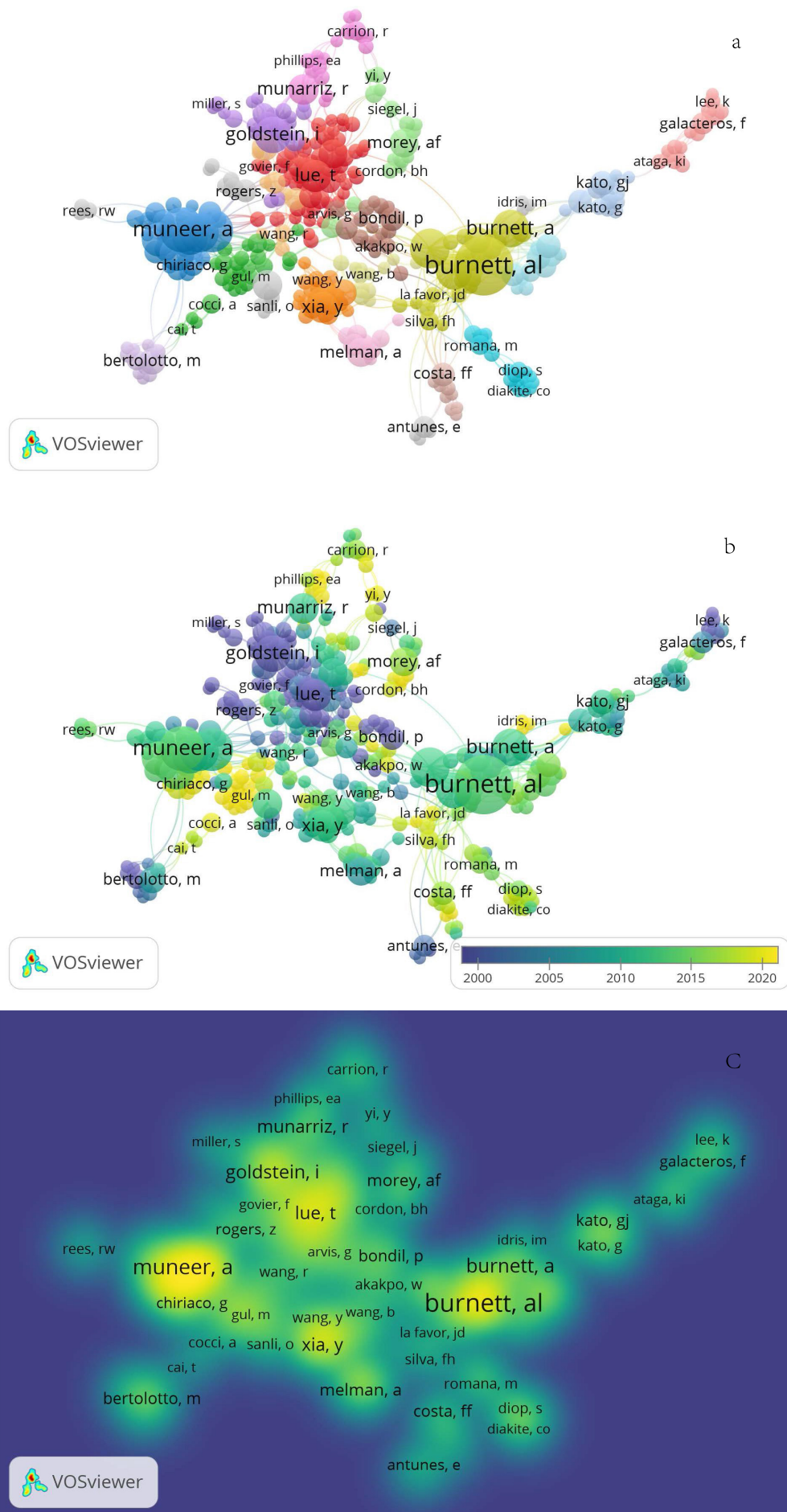


FIGURE 4. The font size of each author represents the number of publications. The thickness of the lines indicates the strength of the connection. a, the authors collaboration network of research on priapism. b, different colors inside the circle represent different time intervals. c, the brighter the color, the more publications for authors.



FIGURE 5. The font size of each key word represents the number of publications. The thickness of the lines indicates the strength of the connection. a, the keywords collaboration network of research on priapism, and the same color represents the same cluster. b, different colors inside the circle represent different time intervals. c, the brighter the color, the more publications about keywords.

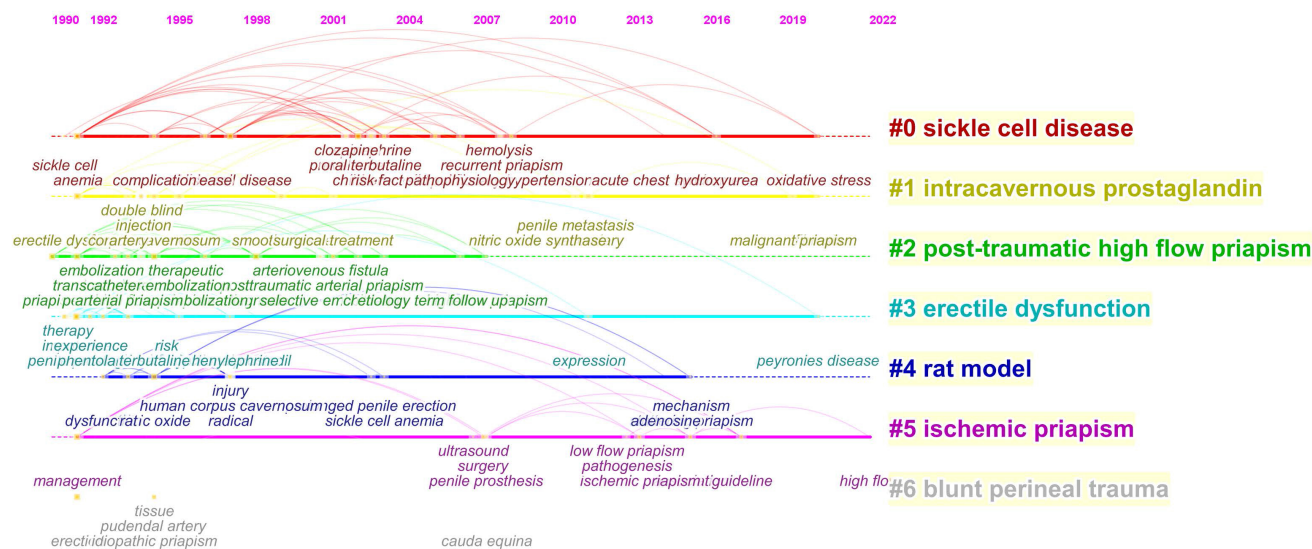


FIGURE 6. The timeline view of the knowledge map in priapism field. This view clearly presents the stage of the research in the appearance time point and time span of 7 clusters.

Top 25 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	1970 - 2022
GRACE DA, 1968, J UROLOGY, V99, P301, DOI	1968	14.713	1970	1975	
GARRETT RA, 1966, J UROLOGY, V95, P65, DOI	1966	7.3813	1970	1974	
GRAYHACK J T, 1964, Invest Urol, V1, P509	1964	5.4516	1970	1972	
HOWE GE, 1969, J UROLOGY, V101, P576, DOI	1969	10.6594	1971	1977	
MARTIN DC, 1969, J UROLOGY, V102, P221, DOI	1969	6.6713	1972	1977	
KANDEL GL, 1968, J UROLOGY, V99, P196, DOI	1968	5.3788	1972	1975	
SACHER EC, 1972, J UROLOGY, V108, P97, DOI	1972	8.4806	1974	1980	
KLEIN LA, 1972, J UROLOGY, V108, P104, DOI	1972	6.6822	1974	1979	
SEELER RA, 1973, J UROLOGY, V110, P360, DOI	1973	5.1258	1975	1981	
LAROCQUE MA, 1974, J UROLOGY, V112, P770, DOI	1974	11.6512	1976	1981	
BARRY JM, 1976, J UROLOGY, V116, P754, DOI	1976	6.5174	1979	1981	
DORMAN BW, 1976, J UROLOGY, V116, P51, DOI	1976	4.4564	1979	1983	
WEAR JB, 1977, J UROLOGY, V117, P252, DOI	1977	10.2146	1979	1983	
NELSON JH, 1977, J UROLOGY, V117, P455, DOI	1977	17.0317	1979	1985	
MOLONEY PJ, 1975, J UROLOGY, V114, P72, DOI	1975	5.8639	1979	1981	
WINTER C C, 1976, UROLOGY, V8, P389, DOI	1976	15.261	1979	1984	
EBBEHOJ J, 1975, SCAND J PLAST RECONS, V8, P241	1975	12.2156	1979	1982	
TARASUK A P, 1976, UROLOGY, V8, P141, DOI	1976	5.1864	1980	1982	
WINTER CC, 1978, J UROLOGY, V119, P227, DOI	1978	4.4412	1980	1985	
WASMER JM, 1981, J UROLOGY, V125, P204, DOI	1981	6.6106	1982	1986	
WINTER CC, 1981, J UROLOGY, V125, P212, DOI	1981	7.6019	1982	1989	
ERCOLE CJ, 1981, J UROLOGY, V125, P210, DOI	1981	7.7633	1982	1988	
BHALLA AK, 1979, BRIT MED J, V2, P1039, DOI	1979	4.6489	1983	1987	
BRINDLEY GS, 1983, BRIT J PSYCHIAT, V143, P332, DOI	1983	13.0256	1984	1991	
HAURI D, 1983, UROL INT, V38, P138, DOI	1983	6.2226	1985	1991	

FIGURE 7. The top 25 references with the strongest citation bursts in the co-citation network.

The USA was the main contributor with 820 papers. The top five countries are all developed countries and are mainly located in the Europe, Americas and Asia. Among the top 10 countries, only Turkey and China are from Asia, with relatively few published citations, although developing countries such as Africa and Asia are areas with a high incidence of priapism. We should narrow the gap with America and Europe, we can choose some measure: a. It is to realize the high incidence of priapism in developing countries and increase investment in scientific research funds. b. Strengthen the cooperation between different domestic and different research units and regions, and the government and the media will carry out related missions and education. c. It is to strengthen exchanges and cooperation with mature international scientific research teams. At present, the connectivity of research teams is weak. Strengthening communication between teams is not just a requirement for the development of disciplines, but also promotes the improvement of research quality.

A clear temporal distribution of publications in a discipline can reflect the development trend of the discipline in a specific period. Meanwhile, the number and growth rate of scientific literature can reveal the theoretical level and advance speed of research in this discipline. The findings of this study show different trends for published literature over time. The number of articles published in this research topic was relatively stable in the past 10 years after the initial stage and development stage (1970–2012). The journals published are mainly distributed in the Journal of Urology, BJU-international, Urology, Journal of Sexual Medicine and other urology and andrology journals. Because the occurrence of the disease is related to a certain proportion of hematological diseases, many articles have been published in hematological disease related journals.

Burnett AL published the most papers and cited the most times on priapism. Following Ralph D, Muneer A, Bivalacqua TJ and Minhas S were the leading authors, and they have cooperative relationships [15–18]. At the same time, it also revealed that the distribution of global research teams has obvious geographical characteristics. The study teams are mainly distributed in andrology and urology departments of European and American university teaching hospitals. Therefore, it is recommended that research teams between different regions strengthen cooperation and exchanges, and give full play to the population advantages of developing countries and technological advantages of developed countries.

Keywords are the author's condensed and highly concentrated core ideas and thoughts of the article, and are often used to detect the hot spots and focus of research in a discipline, especially high-frequency keywords as the analysis object. The high-frequency keywords co-occurrence were mainly priapism, management, erectile dysfunction, penile erection, penis, diagnosis, high-flow priapism and impotence, revealed that study concentrated in diagnosis and ED due to priapism [19–21]. Keyword cluster timeline map presented the key word time evolution of each cluster, from the initial study focus on "sickle cell disease, complication" to the current research dimension of "low flow priapism, high flow priapism, peyronie disease, mechanism, management" changes [22–24]. This revealed that the study on priapism is made at the level of mechanism explore currently; people pay more attention to

the research of erectile function. And the most frequently used keywords in recent years can be preferred by researchers to access priapism studies in this field.

In conclusion, this study used bibliometrics to objectively analyze the temporal and spatial distribution characteristics of domestic papers on priapism in the field of priapism, identified the main study hotspots and research frontiers in this area, and provided an important reference for accurately grasping the status and development trend of priapism research. At present, although China has published a large number of research papers in this field, there is little inter-institutional cooperation, which is still relatively weak. In the future, it is necessary to closely follow international research hotspots and frontiers, strengthen cooperation and exchanges, and promote the development of the discipline. It is suggested that some departments should give more financial support to the research in this field, so as to lay a foundation for promoting the diagnosis and treatment of priapism to achieve substantial progress. This was the first study to conduct a bibliometric analysis of priapism. In our study, we displayed the research status and draw visual maps, and explored trends and hotspots in this field to provide the reference for future studies.

There were several limitations in our study. First, the analysis of this article was based on papers retrieved from WoSCC; other databases such as Medline and Embase were not used. Second, only studies published in English were included. It is possible that some articles in other databases are not included, which may cause selection bias. Finally, bias may still exist despite our normalization procedures. Further studies will provide new insight into this field.

5. Conclusions

In this field, the number of publications was growing since 1970. The USA and developed regions led in this field which greatly promoted the study of priapism. High flow priapism, low flow priapism, mechanism and sexual function are the current research hotspot. In general, priapism needs to be identified as low flow priapism or high flow priapism, because the treatment options are different. Therefore, we still need to pay attention to this group, actively carry out clinical research, and promote the progress of priapism diagnosis and treatment.

AUTHOR CONTRIBUTIONS

YGZ wrote the paper; YGZ and CQM conducted the literature search and analyzed the data.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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