

A Bibliometric Analysis and Visualisation of Research Trends in Cardiac Pacemaker Battery

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Abstract

Material and or technological innovations in battery technology will be focusing on developing implants with a higher degree of safety, reliability, reduced replacements. The bibliometric analysis had been conducted to understand the active authors, organizations, journals, and countries involved in the research domain of “Cardiac Pacemaker Battery”. All published articles related to “Cardiac Pacemaker Battery” from “Scopus”, were analyzed using the VOS viewer to develop analysis tables and visualization maps. This article had set the objective to consolidate the scientific literature regarding “Cardiac Pacemaker Battery” and also to find out the trends related to the same. The most active journal in this research domain was the Pacing and Clinical Electrophysiology. The most active country was the United States of America. The leading organizations engaged in the research regarding cardiac pacemakers were the Medtronic Inc of Ireland and GreatBatch Inc of the United States of America.

Keywords: Heart, Cardiac pacemakers, Batteryless pacemaker, Bibliometric analysis, VOS viewer,

INTRODUCTION

Cardiac pacemakers are the outputs of material engineering and numerous researches across the world are going on to develop pacemakers with new materials and technology to improve performance and reduce side-effects. Cardiac pacemakers are medical devices providing electrical impulses to cardiac muscles, ensuring regular contractions, regular blood circulation and thereby reducing the chances of a heart arrest. The major causes of pacemaker implantations are Sinus node dysfunction, AV Block, Post myocardial infarction, Congenital complete heart block, Long QT syndrome, Hypertrophic cardiomyopathy, and Heart failure [1]. A pacemaker can be permanently implanted or external temporarily used [2]. Pacemakers are battery operated and depending on the active leads, there are three types of pacemakers, namely single chamber, double chamber, and biventricular pacemakers [3][4].

Material engineering is heavily focusing on the development of new battery technology or new materials for batteries in the implants. Similarly material and or technological innovations in battery technology will be focusing on developing implants with a higher degree of safety, reliability, reduced replacements. The history of material [5]–[9] used in the battery of pacemakers started with nickel-cadmium batteries and passed through Zinc-mercury battery, Lithium-Iodine battery. During the development stages, biological batteries and nuclear batteries were used and later on discarded due to various shortcomings.

Similarly, pacemaker batteries based on lithium-silver chromate, lithium-cupric sulfide, lithium-thionyl chloride were also rejected. Future batteries are being developed with lithium carbon monofluoride, and batteries with Lithium-poly carbon fluoride are offering high energy density [10]. This article points out the need for future research in material engineering of pacemaker battery, effectiveness over some time battery-less pacemaker based on wristwatch [11][12] battery-less pacemaker based on sunlight [13][14] energy harvesting and using an intra-cardiac flow-based electromagnetic energy for cardiac pacing. In other words, replacing battery power by harvesting energy from blood flow [15]. Similarly the wireless inductive power transfer system through a three-tiered, dual-sub-system, with four-coil operating on two different frequencies [16]. All these innovations in the battery of pacemakers, battery technology, and battery material will reduce the requirements for battery replacement and improve battery longevity.

This bibliometric analysis will be a useful platform for future researchers by realizing the top researchers, organizations, and countries involved in research regarding cardiac pacemaker batteries, battery technology, pacemaker battery material, and battery-less and or wireless pacemakers. This article is arranged into four sections. The first section is the introduction, followed by the discussion of the methodology by which the research was conducted. The third section deals with results and discussion. The fourth section deals with the conclusion. The following research objectives and research questions are framed for conducting bibliometric analysis systematically.

1.1 Research Objectives

- a) To consolidate the literature regarding double chamber pacemakers
- b) To find out the trends related to research in double chamber pacemakers

1.2 Research Questions

- a) Who are the active researchers working on double chamber pacemakers?
- b) Which are the main organizations and countries working on double chamber pacemakers?
- c) Which are the main journals related to double chamber pacemakers?

RESEARCH METHODOLOGY

Scopus files had been used for this article. For the article selection, the Boolean used was TITLE-ABS (Pacemaker Battery) on 16/01/2021. All the tables in this paper were created by using Microsoft Excel and VOS Viewer. Grammarly was used for spelling and grammar checks. Mendeley was used for article review and citation. This paper had been inspired by bibliometric analysis in its presentation style, analysis, and methodology from the works [17]–[23].

RESULTS AND DISCUSSION

1.1 Results

This first round of search produced an outcome of 124 documents, in eight languages, out of which 82 documents were in English. The classification of document categories is shown in Figure 1. For improving the quality of the analysis, we had selected only the peer-reviewed

articles and all other documents had not been considered. Thus after using filters “Article” and “English” the second round search produced an outcome of 55 English articles (both open access and others) and had been used to conduct bibliometric analysis and visualization using VOS Viewer. The English research articles in this domain since 1964 had been shown in Figure 2.

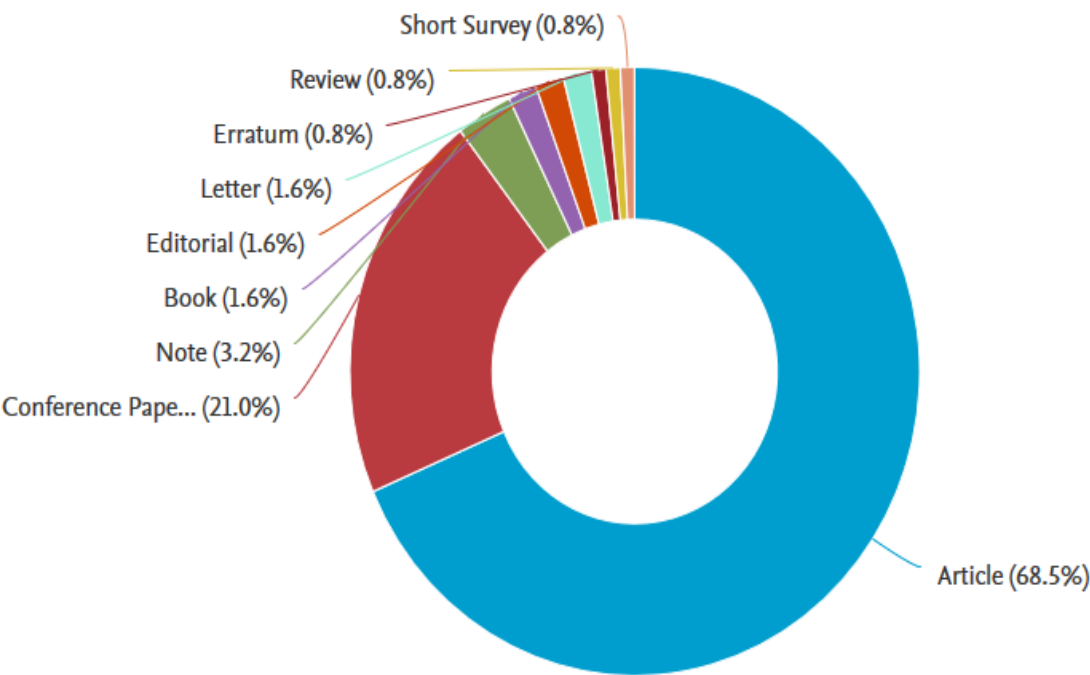


Figure 1: Classification of the documents on “Pacemaker Battery”, Source: www.scopus.com

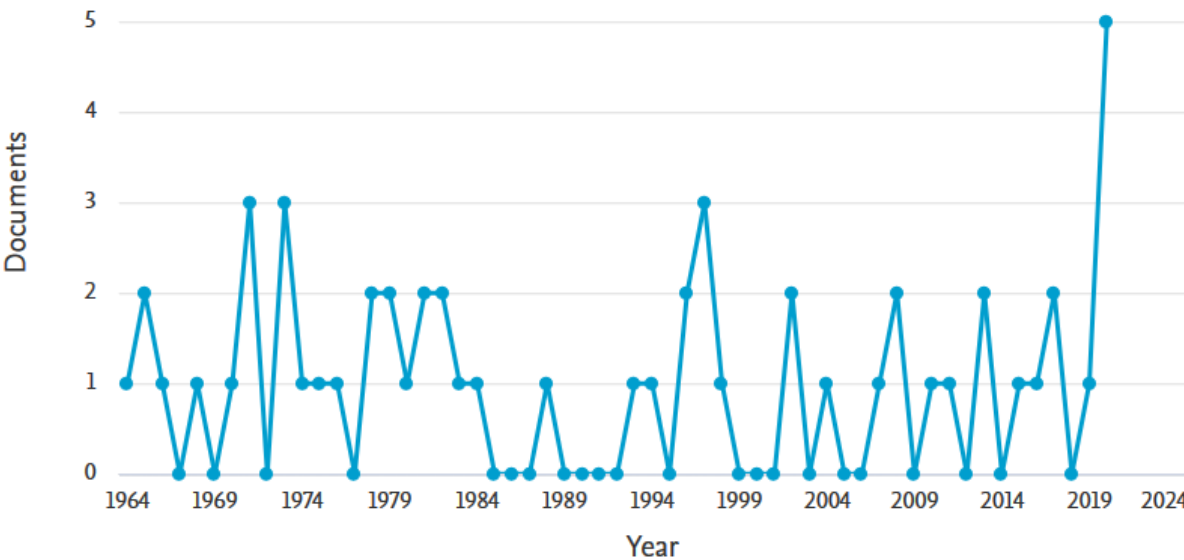


Figure 2: Period wise publication of articles, Source: WWW.scopus.com

Co-authorship analysis of top authors had been shown in figure 3. For a better presentation of the analysis, the parameters used were the minimum number of documents of an author as two and the minimum number of citations of authors as one. This combination plotted the

map of 15 authors, in six clusters. The overlay visualization map of co-authorship analysis plotted in Figure 3, points out the major researchers with their strong co-authorship linkages and clusters involved.

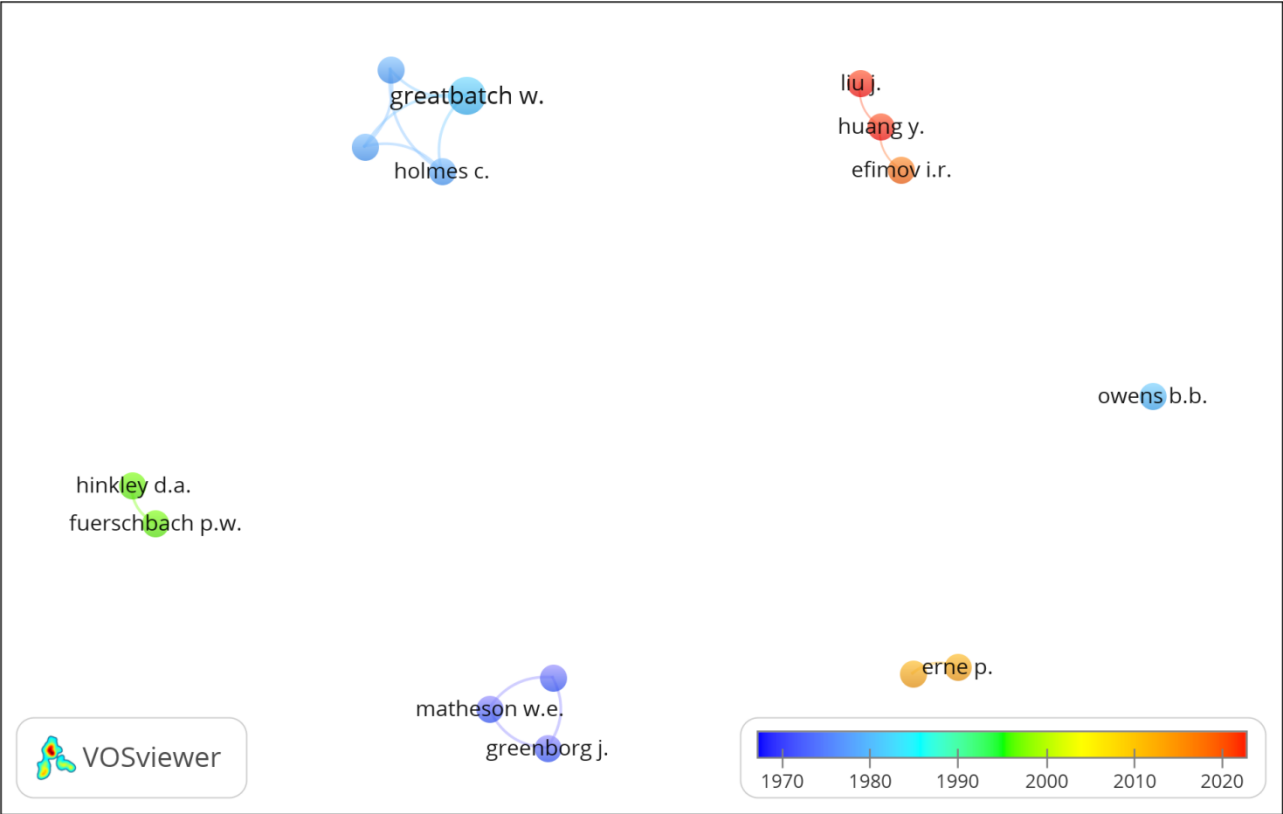


Figure 3: Co-authorship analysis on basis of authors

The citation analysis of top authors had been shown in table 1, along with co-authorship links. For the citation analysis, the parameters used were the minimum number of documents of an author as one and the minimum citations of an author as one.

Table 1: Highlights of most active authors

Description	Authors	Documents	Citations	Average citations per documents	Link strength
Authors with the highest publication, citations, and co-authorship links	Great Batch W	4	86	21.5	14

In Co-occurrence analysis, we had used all keyword analyses, by keeping the minimum number of occurrences of a keyword as 10. This combination plotted the map of 8 thresholds, in two clusters. The overlay visualization of co-occurrence analysis of keywords has been shown in Figure 4.

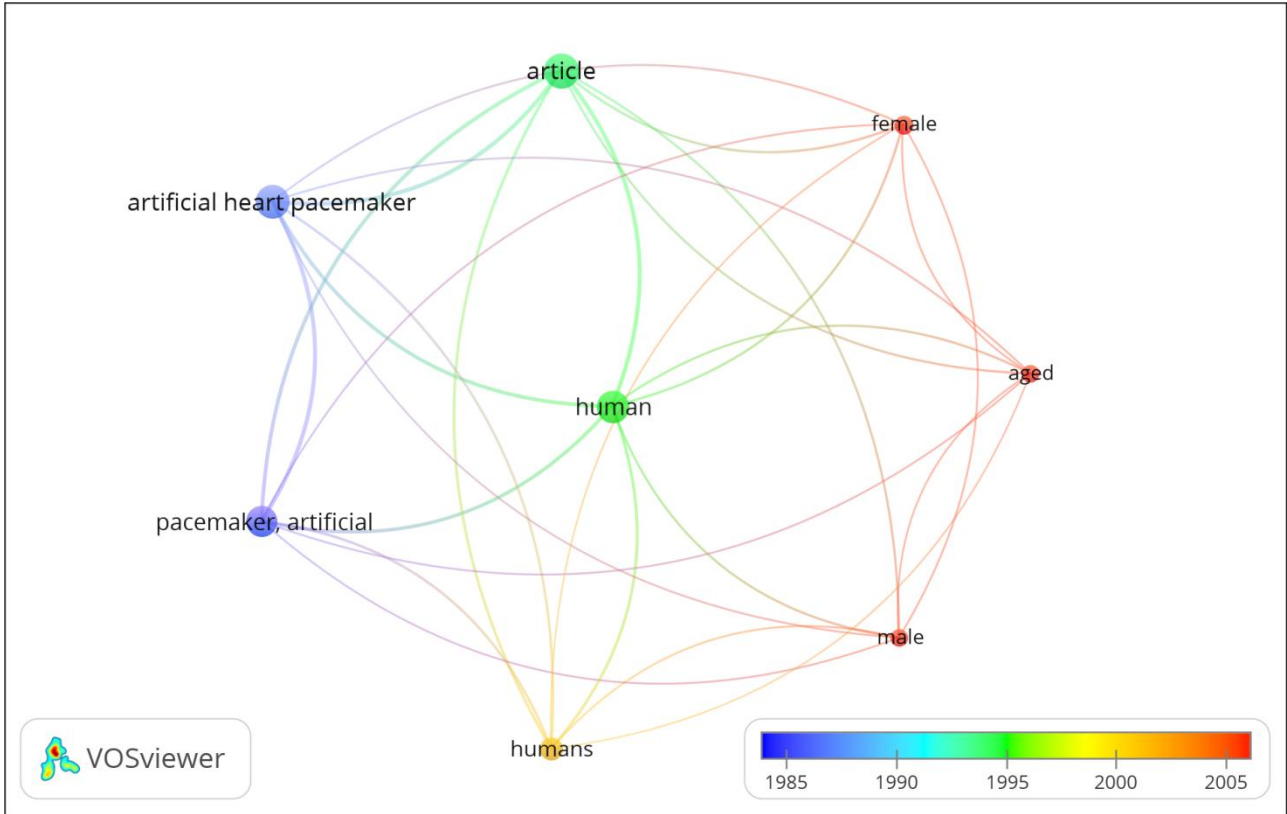


Figure 4: Co-occurrence analysis on basis of all keywords

The leading organizations engaged in research on “Pacemaker Battery” had been found out by the volume of publications and citation analysis, the parameters used are the minimum number of documents of an organization as one and the minimum number of citations of organizations as one. The leading organization in the research regarding “Pacemaker Battery”, with the highest number of publications and citations, was the Medtronic Inc of Ireland and GreatBatchInc of the United States of America. (Refer to table 2).

Table 2: Highlights of the most active organization

Organizations	Country	Documents	Citations	Average Citations per document
Medtronic Inc	Ireland	3	13	4.3
GreatBatchInc	United States of America	3	85	28.3

Co-authorship analysis of the countries engaged in the research on “Pacemaker Battery” had been shown in Figure 5. For a better presentation of the analysis, the parameters used were the minimum number of documents of an author as three and the minimum number of citations of authors as one. This combination plotted the map of 6 countries, 4 clusters. The overlay visualization map of co-authorship analysis plotted in Figure 5, points out the main countries with their strong co-authorship linkages and clusters involved.

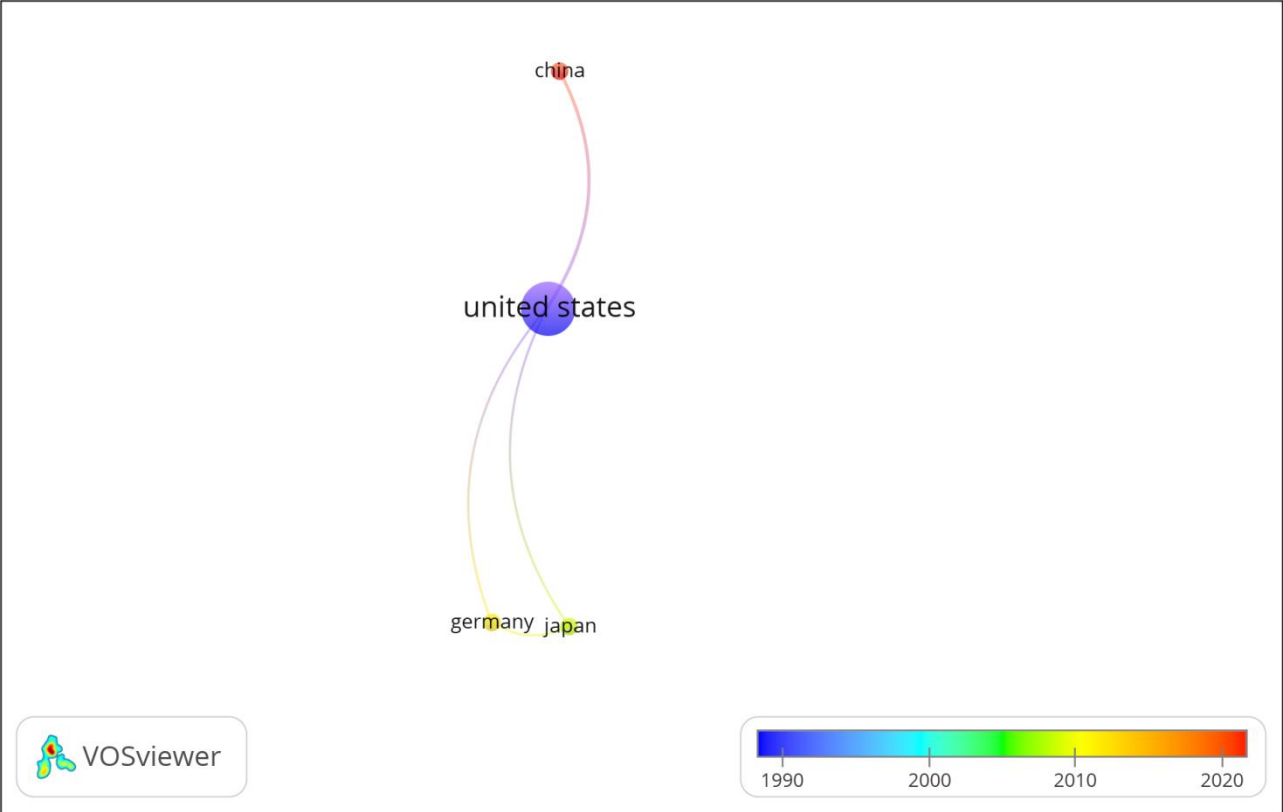


Figure 5: Co-authorship analysis on basis of countries

The citation analysis of top countries had been shown in table 3, along with co-authorship links. For the citation analysis, the parameters used were the minimum number of documents of a country as one and the minimum citations of the country as one.

Table 3: Highlights of Active Countries

Description	Country	Documents	Citations	Link strength
The country with the highest publication, citations, and co-authorship links	United States of America	26	339	9

The most active country in this research domain was the United States of America, with the highest number of publications, and citations.

Link analysis and citation analysis were used to identify the most active journal in this research domain. We have taken the parameters of the minimum number of documents of a journal as one and the minimum number of citations of a journal as one for the link analysis and citation analysis. Highlights of the most active and relevant journals related to “Pacemaker Battery” are shown in table 4. Table 4 shows the journal activity of this research domain through parameters of publication volume, citations, and co-authorship linkages.

Table 4: Analysis of journal activity

Description	Journal details	Documents	Citations	Average citations per documents	Link strength
Journal with the highest publications, and co-authorship links	Pacing and Clinical Electrophysiology	9	48	5.3	0

From the above discussion regarding the bibliometric patterns in the research regarding pacemaker Battery, this research had observed a gradual increase in research interest regarding pacemaker Battery from the starting of the millennium and the momentum is going on positively. This points out the relevance and potential of this research domain (Refer to Figure 2). The most active authors in this research domain were Great Batch W with the highest publication, citation, and co-authorship links respectively (Refer to table 1). The overlay analysis of top countries researching pacemaker battery indicates that the United States of America was the leading countries relating to the highest number of publications, citations, and co-authorship links (Refer to figure 5). The top journal of this research domain was identified as the Pacing and Clinical Electrophysiology. From these wide sources of information, researchers can focus on top journals where they can identify the most relevant and highly cited articles regarding the battery of pacemakers.

CONCLUSION

A battery pacemaker was an interesting research domain and the most active journal related to this research domain were the Pacing and Clinical Electrophysiology. The most active country was the United States of America. The leading organizations engaged in the research regarding cardiac pacemakers were the Medtronic Inc of Ireland and GreatBatchInc of the United States of America. The most active authors who had made valuable contributions related to pacemaker batteries were Great Batch B. This research domain offers a new avenue for researchers and future research can be on innovations in cardiac pacemakers.

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