BIBLIOMETRIC ANALYSIS OF EFFECT OF APPLIED MAGNETIC FIELD ON BLOOD FLOW IN STENOSED ARTERY

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Abstract: Around 50% of the deaths in the world are because of heart diseases. One of the heart diseases is Atherosclerosis which occurs due to stenosis in arteries. Researchers and medical practioners are working on how to reduce the reduction/fluctuations in blood flow in stenosed arteries. One of the methods under consideration is the application of magnetic field on blood flow in stenosed arteries.

With limited healthcare resources, Bibliometric studies help scholars and funding agencies to focus on the research area in which more attention is needed. The main purpose of this bibliometric analysis is to find the development in blood flow in stenosed arteries and to identify potential areas for further research. This paper provides an overall picture of research carried in blood flow in stenosed arteries in the presence of applied magnetic field and, in the current century. This analysis is done using mainly Scopus database along with Google scholar, data taken from Mendeley and using some graphical tools.

This survey revealed that the maximum publications are from journals and conferences and India lead the publications in this area. Blood flow and stenosis are frequently used key words and major contributions in this area are from

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computer science journals followed by mechanical journals. Medical and Engineering are two main fields in which the publications in this topic are more. The high number of citations of the journals in which the related articles are published shows the importance and thrust in this area. This paper puts a light on contribution of researchers in the area which will help medical practioners to take up the idea to next level.

Keywords: blood flow; stenosis; magnetic field; bibliometric survey.

2010 AMS Subject Classification: 93A30.

1. INTRODUCTION

Heart diseases are the deadliest diseases in both developed and developing countries. One of the main reasons of heart diseases is the reduction in blood flow to the heart and other parts through artery due to thinning of artery because of some depositions like cholesterol, fatty substances, or because of exposure to air particulate matter, in the artery, called stenosis [1]. This leads to atherosclerosis in which the nature of blood flow changes from its usual state to a disturbed flow condition [2]. The exact mechanism behind the formation of stenosis is still not known, however the problems due to this stenosis are major. As millions of people are suffering from heart ailments all over the world, it is very important to strengthen our health infrastructure to cater the need of the time. The basilar artery is one of most critical vessels that supply blood to the brain stem, cerebellum, and parts of the cerebral hemispheres [3]. It is well known that technology plays an important role in healthcare system in the current era [4]. There are several methods in place to treat stenosis. Widening the artery by inserting a stent in the artery is one of the popular and effective methods that is being used by medical practioners worldwide [5]. Researchers around the world are trying to find alternate methods to treat this life-threatening condition. The rheological behaviour of blood is complex as compared to the behaviour of simple fluids [6]. Blood behaves like an electrically conducting fluid which simultaneously exhibits magnetization property under strong magnetic field. Magnetic field causes stagnation on blood flow and hence magnetic field influence the blood flow and enhances the unsteadiness [7]. The study of blood flow in stenosed arteries has become a key research area as it is more relevant in medical field due to increase in arterial diseases and hence it is imperative to examine fluid dynamical aspects of blood flow

through a stenosed artery for the fundamental understanding of circulatory disorders [8]. This research is being taken up mainly in two different areas, Medicine and Engineering. In medical field, specialists are trying to find other suitable methods to treat the condition, one of them is by applying magnetic field practically. But a very few attempts/trials have been made in this regard as high risk is involved in all these processes to test/implement the ideas practically. In this case, science and engineering fields plays a vital role in verifying the results theoretically with the help of mathematical model. A mathematical model is a set of higher order differential equations constituted based on the physics behind the problem. With advancement in computer simulation, it is not difficult to find the solution to the problem and validate. In this way, medical and engineering fields go together to get some important results which will help in treating heart ailments.

A bibliometric survey performed using SCI database understand the basic situation and summarize the research status in the field of artificial blood vessels [9]. With limited health care resources, bibliometric studies can guide researchers and funding agencies towards areas where reallocation or increase in research activity is warranted [10]. The relations from the Bibliometric are borrowed to establish links between publications and citation relations [11]. Open access and paid access are two categories to access the publication databases [12]. These publications can be accessed through affiliated university library portals or by getting the access to individual databases. Also, various popular methods are available to retrieve data from required databases such as Clarivate, Scopus, Mendeley, SCImago, DBLP, Science Direct, Research gate and Google Scholar etc. Scopus is undoubtedly one of the biggest databases of peer reviewed journals consists of several millions of publications covering almost all field of Science, Engineering, Technology, Medicine, Social sciences, Arts, and Humanities [13]. PubMed focuses mainly on biomedical disciplines and life sciences, whereas Web of Science and Scopus are multidisciplinary [14]. With thousands of publishers and peer reviewed journals, Scopus database plays a very important role in research. This Bibliometric study is based on publicly available data in Scopus, google scholar and Mendeley, mainly from Scopus.

The objective of this paper is to give with structured information facilitating more detailed analysis as well as additional research questions. The purpose of the study is to give a broad structured and statistical review of the research done and going on in this field.

2. PRELIMINARY DATA COLLECTION

This paper considers the Scopus database as the main source.

2.1 Essential key words

The search is performed using the key words, "Blood flow" and "Stenosis" and "Magnetic field" and "Artery" in articles. Initial crucial results show that there are 1193 publications in the current century till the end of 2020. However, when we use the same key words for the same period in titles and abstracts then we get only 106 papers which is quite a small number as compared to the progress in this research area. Still, the author feels that the number of publications is less as compared to other research topics, keeping in mind the importance of this study.

A total of 1193 (including few articles in press) articles are found in the current century from 2001 to 2020. Out of 1193 publications, 385 are open access (including articles published in gold open access and in full open access journals, hybrids, open archives, and promotional publications), other 808 are from any other type of access including subscription or green OA. The author could find 5 secondary documents in Scopus and 11 in Mendeley. Also, it is noted that most of the articles are in English even though few articles in some other languages exists.

2.2 Publication trend per year

Here, for the analysis, we have taken data of last 20 years, i.e., from 2001 to 2020. However, if we check the publications in the last century, i.e., till the end of 2000, the publication count is 131 which is very less as compared to the publications in the last 20 years. In the last 20 years also, number of publications is considerably low in the first decade (217) as compared to the second decade (976), i.e., within a span of 10 years, the number of publications has increased more than four times. It shows the evolved research in the concerned area in the last decade. The year wise trend of publications in this area is as follows.

Table 1: Year wise publications

Source: https://www.scopus.com

Year	Number	Year	Number
2020	144	2010	45
2019	119	2009	29
2018	130	2008	32
2017	113	2007	28
2016	117	2006	18
2015	104	2005	20
2014	81	2004	20
2013	64	2003	8
2012	60	2002	8
2011	44	2001	9
Total (2nd decade)	973	Total (1st decade)	217
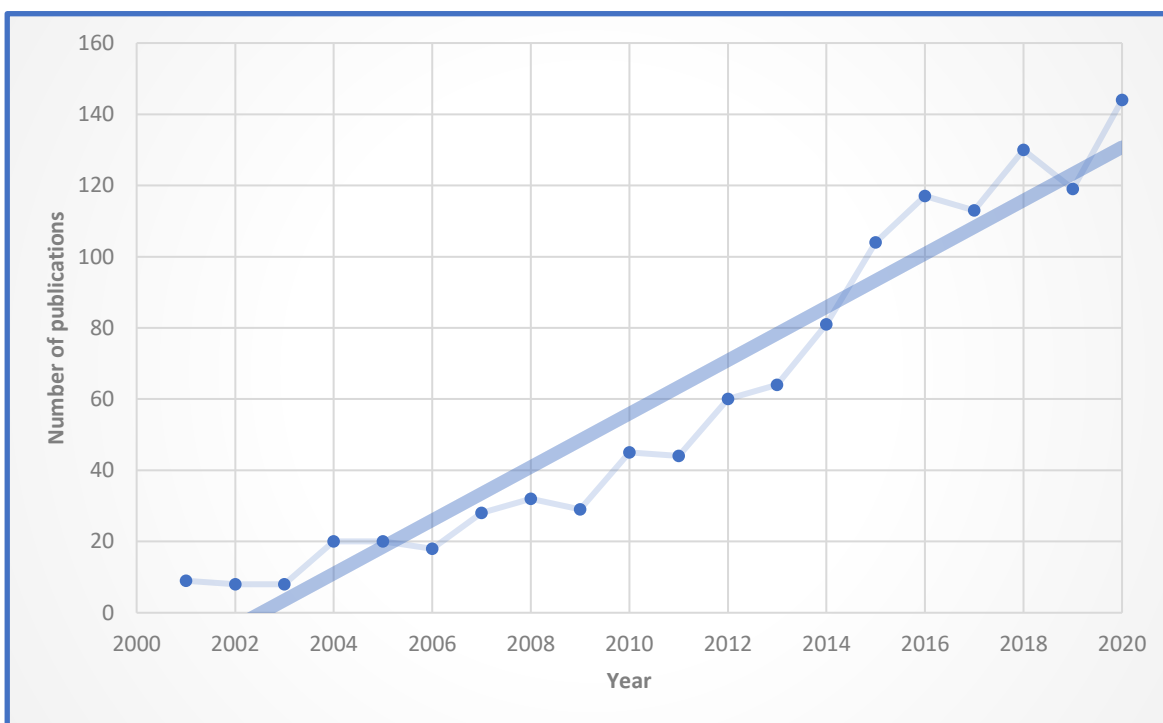
Fig. 1: Year wise publications

Source: https://www.scopus.com

2.3 Publication according to language

There are papers in several languages, namely, English, Chinese, French, etc. But publications in English language rules publications in other languages. The below table gives us the number of publications in different languages.

Table 2. Language wise publication

Source: https://www.scopus.com

Language	Number of publications
English	1181
Chinese	3
French	2
German	2
Croatian	1
Russian	1
Spanish	1

3. BIBLIOMETRIC ANALYSIS

This bibliometric analysis is done based on type of research papers, geographic region, and citation etc. Statistical analysis is carried out to complete the analysis about affiliation, author, source, funding agencies and journal, etc. to name a few.

3.1 Publication types

It is known that there are different types of publications on each research topic, namely journal article, review article, book chapters, conference proceedings, etc. in which journal articles are having high preference. Out of 1193 articles, 954 are from journals. This is 78.29% of the total publications in this area which shows strong correlation of quality of research. Table 3 give more detailed statistics about the type of publications and the graphical representation follows.

Table 3: Percentage of type of publications

Source: https://www.scopus.com

Type	Total publications	Percentage of publications
Article	934	78.29
Review	135	11.32
Conference Paper	49	4.11
Book Chapter	48	4.02
Book	21	1.76
Editorial	3	0.25
Data Paper	1	0.08
Note	1	0.08
Short Survey	1	0.08
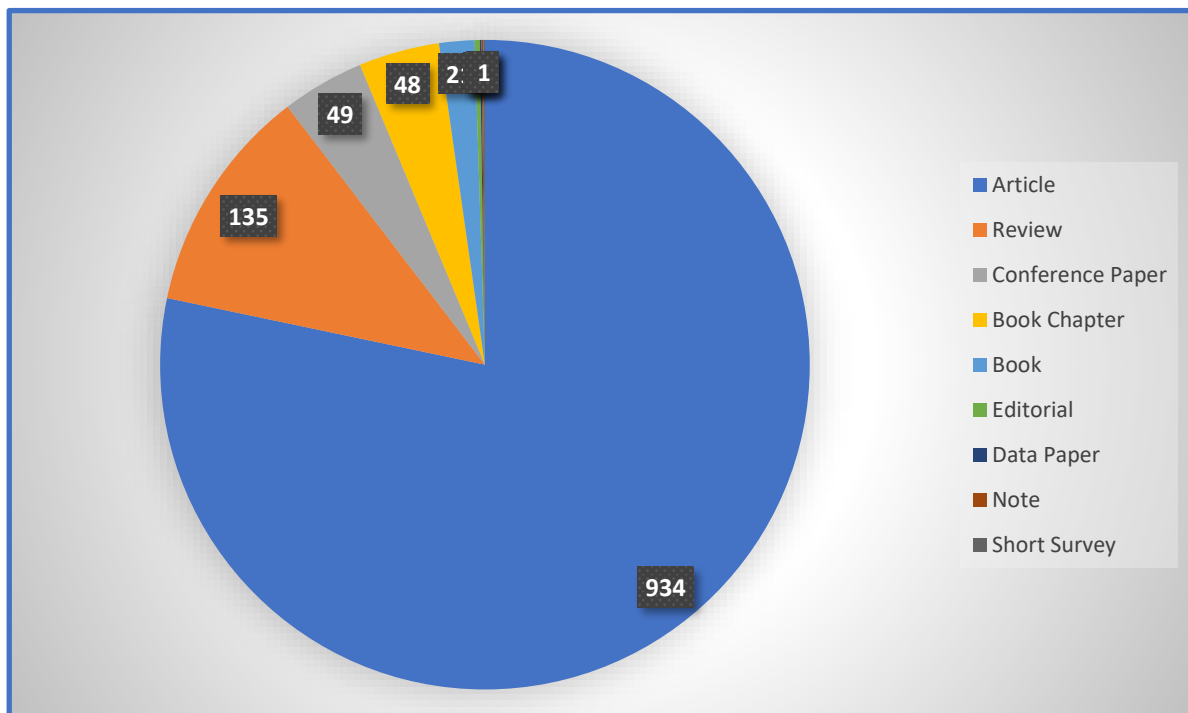
Fig. 2: Type of publications

Source: https://www.scopus.com
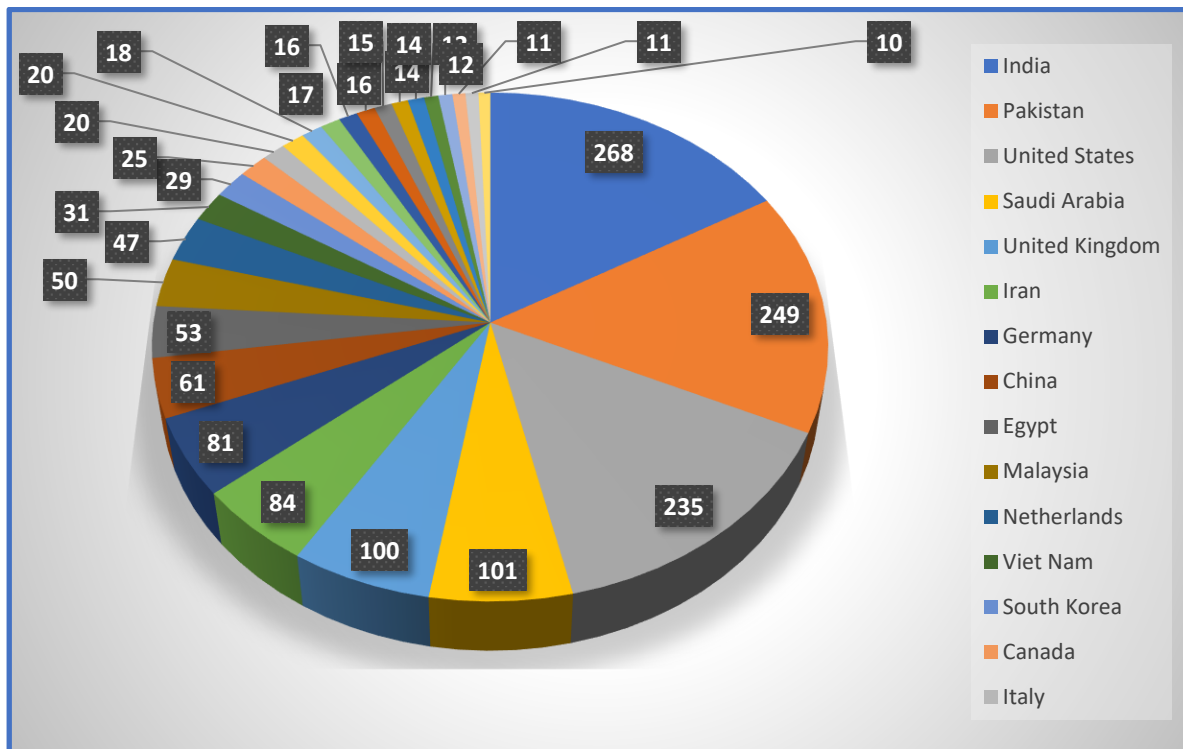
Fig. 3: Country wise publications

*Source: https://www.scopus.com*

3.2 Country wise analysis

Figure 3 depicts the geographical (country wise) representation of publications. It is observed that India, Pakistan, United States and Saudi Arabia are the top 4 countries in terms of number of publications whereas two Asian countries India and Pakistan accounts for nearly 50% of the publications with India standing on the top. There are 56 countries with minimum 10 publications.

3.3 Primary keywords statistics

Keywords play significant role in searching the publications in any database. Although the author has used only 4 key words – Stenosis, Magnetic field, Blood flow and Artery, as per the Scopus database, it is observed that there are many other keywords associated with this topic, to name a few, Human, Hemodynamic, Magnetic resonance imaging, etc. Below is a screenshot from Scopus to ascertain the same.
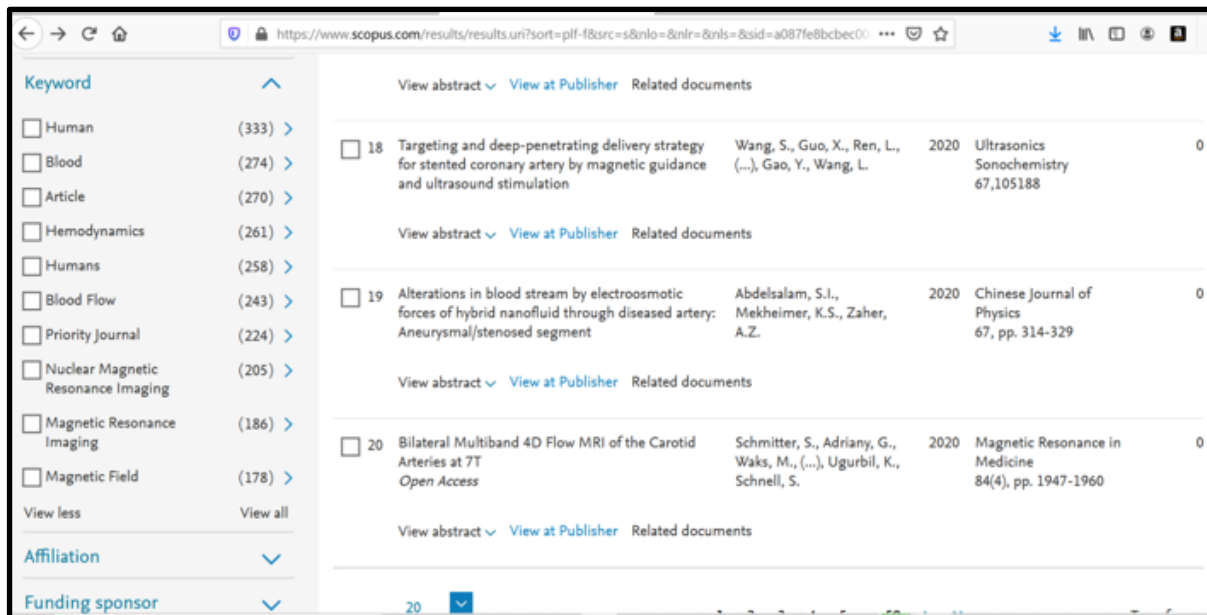
Fig. 4: Primary key words statistics

Source: https://www.scopus.com

3.4 Subject area

There are 26 different subject areas related to this topic in which articles are published. Some of them are Medicine, Engineering, Mathematics, etc. Almost 65% of the papers published are in the field of Medicine and Engineering which shows the importance of development of this area in Medical and Engineering field. This also shows the relevance of this topic in real life situations like heat attack, blood pressure, etc. More statistical details are as shown in the graph below. It is also found from the data that the physical interpretation, mathematical modelling and solution to the problem using computer simulation gives booster to this area to study the problem mathematically and then try to use the results in Medicine and Engineering.
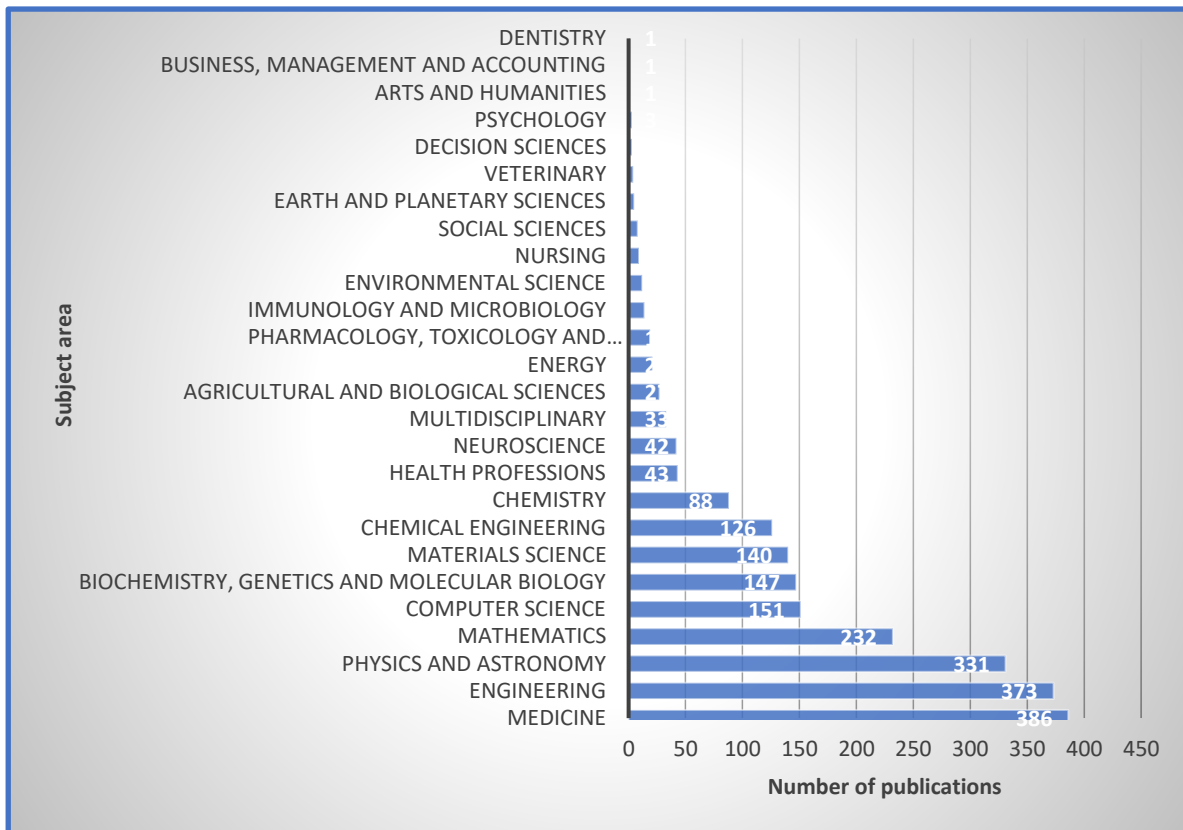
Fig.5: Publications in different subject area

Source: https://www.scopus.com

3.5 Affiliation statistics

Quaid-i-Azam University stands at the top in terms of number of affiliations of around 110, approximately 10% of the total publications in the last 2 decades. There are as many as 160 institutes having affiliation in this topic of research. This shows that vast number of institutions/universities around the world are working on this emerging topic. Fig. 6 is the graphical representation of different affiliations which has at least double-digit publications. It can be noted from the available data that except the top 5-6 affiliating institutions, others have almost the same contribution in this area of research.
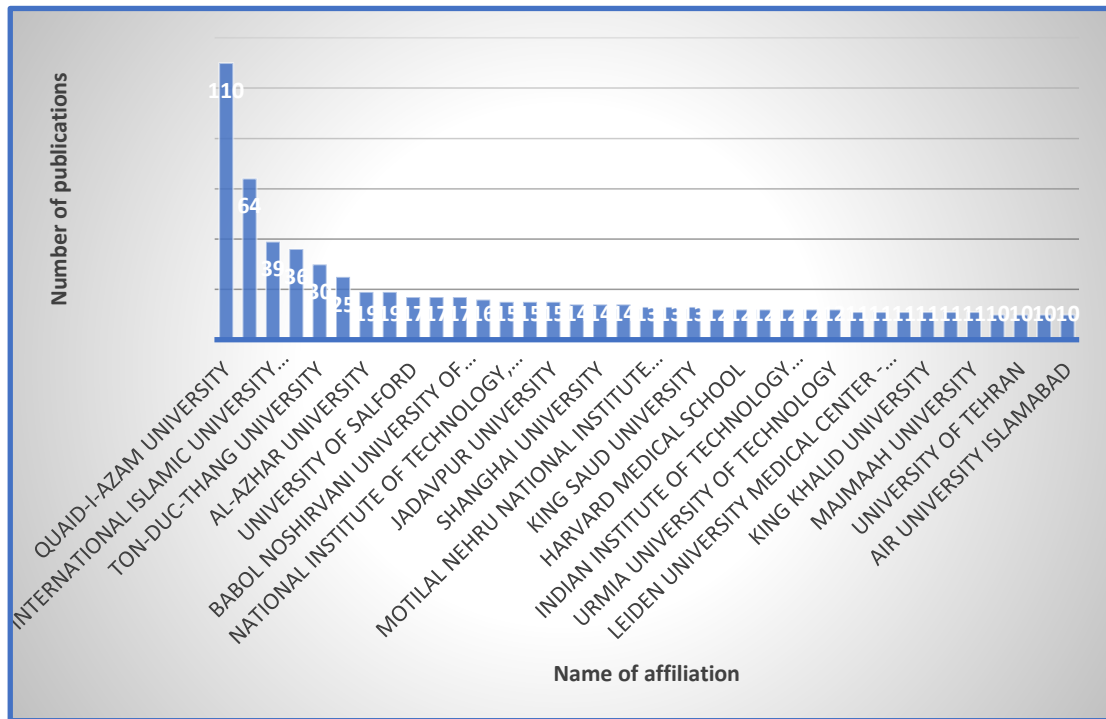
Fig.6: Details of affiliating institutes
Source: https://www.scopus.com
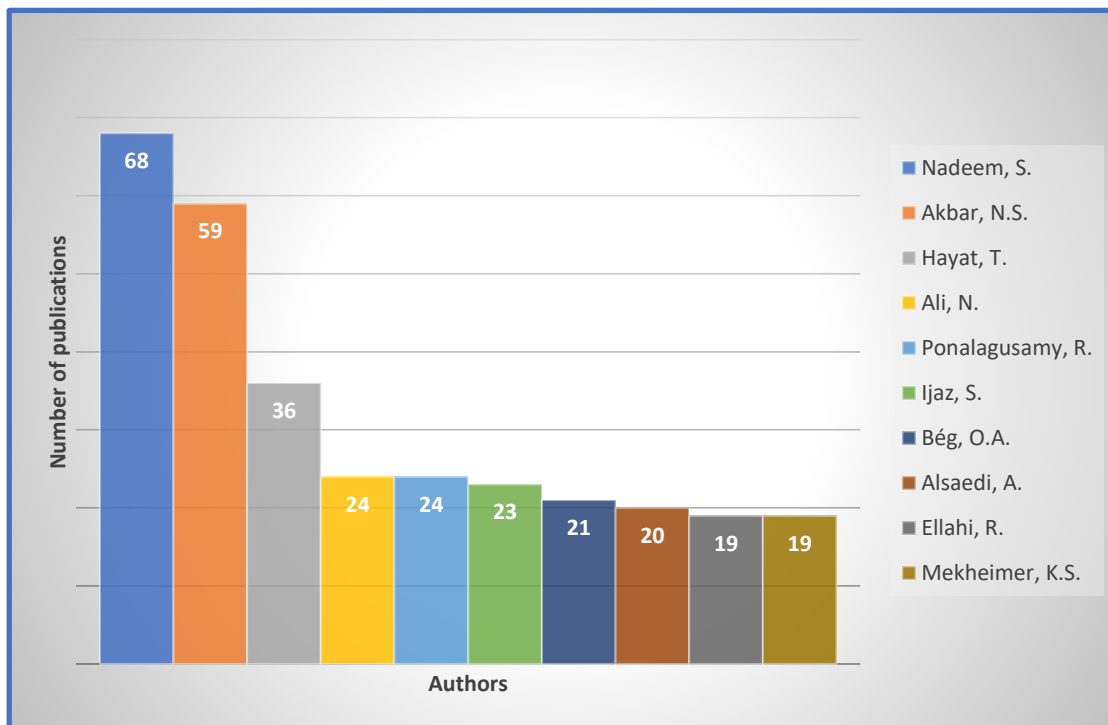
Fig. 7: Number of papers published by leading authors
Source: https://www.scopus.com

3.6 Author statistics

Around 300 researchers round the globe are working on this research area. Asian authors are playing a key role in the number of publications. Nadeem. S (68) is the researcher who is having the highest number of publications to his credit closely followed by Akbar. N. S. (59). As many as 24 authors have 10 or more than 10 publications. Remaining 272 authors contribute 653 publications. A graphical analysis of the number of publications of top 10 authors is portrayed in Fig. 7.

Also, Table 4 gives the list of authors who have minimum 10 publications in this field.

Table 3: Contribution of top authors

Source: https://www.scopus.com

Author	No. of publications
Nadeem, S.	68
Akbar, N.S.	59
Hayat, T.	36
Ali, N.	24
Ponalagusamy, R.	24
Ijaz, S.	23
Bég, O.A.	21
Alsaedi, A.	20
Ellahi, R.	19
Mekheimer, K.S.	19
Sankar, D.S.	19
Zaman, A.	18
Tripathi, D.	17
Bhatti, M.M.	15
Khan, I.	15
Shit, G.C.	15
Shahzadi, I.	13
Hendrikse, J.	11
Malik, M.Y.	11
Misra, J.C.	11
Priyadharshini, S.	11
Toghraie, D.	11
Yuan, C.	11
Sajid, M.	10

3.7 Journal statistics

The research articles in this area are published in 157 different journals which shows the widespread scope of the said research topic. Some of the good journals in which more papers are published are Journal of magnetism and magnetic material, Computer methods and programs in biomedicine, magnetic resonance in medicine, European Physical Journal Plus, etc. The below graphical representation shows the top 18 journals in which minimum 10 research articles are published.
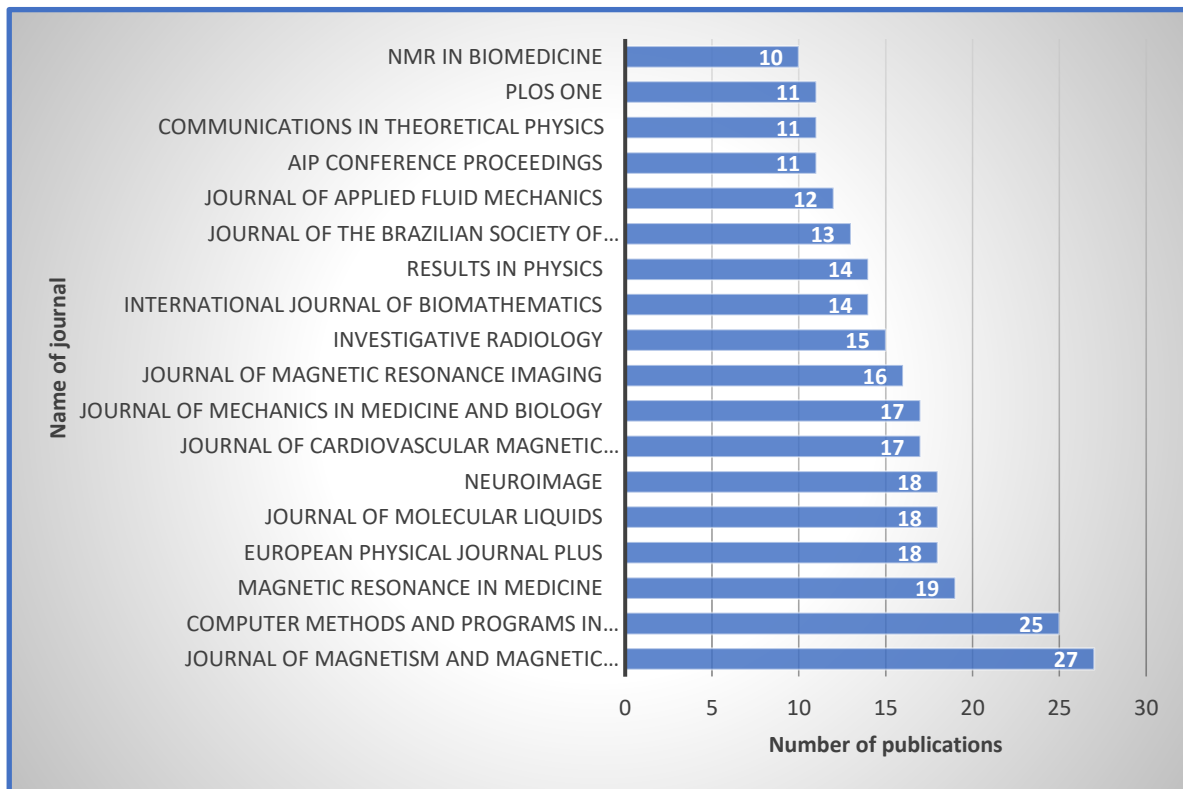
Fig. 8: Journal wise publication

Source: https://www.scopus.com

The below pi chart represents the contribution of all 157 journals. This is just to give a view of widespread coverage of research publication in so many different journals.

Fig. 9: Number of publications in different journals

Source: https://www.scopus.com

3.8 Citation analysis

The following table depicts the citation index of top 5 journals in which the papers on blood flow in stenosed arteries are published in the last decade i.e., from 2011 to 2020. This is to just to give a glimpse of popularity/quality of the journals in which papers of the said research topic are published. It is observed from the table that Neuroimage is on the top of the list with yearly citations ranging from 60000 to 115000 in the last 10 years with cite score ranging from 9.8 to 13.1. Other top journals listed in the table are also having very good number of citations and cite score. The total number of citations of these five journals in the current century is 2571712 from 58003 documents which gives us the average of 44.34 citations/publication. This high number of citations of top 5 journals in this area shows the quality of publications and it shows the importance of the research area.

Table 5: Citations and cite score

Source: https://www.scopus.com

Source	Year	Number of citations	Cite score
Computer Methods and Programs in Biomedicine	2011	3215	3.3
Computer Methods and Programs in Biomedicine	2012	3772	3.1
Computer Methods and Programs in Biomedicine	2013	4228	3.4
Computer Methods and Programs in Biomedicine	2014	5397	3.9
Computer Methods and Programs in Biomedicine	2015	5665	5.1
Computer Methods and Programs in Biomedicine	2016	5948	4.8
Computer Methods and Programs in Biomedicine	2017	7407	5.7
Computer Methods and Programs in Biomedicine	2018	8995	5.4
Computer Methods and Programs in Biomedicine	2019	10887	7.5
Computer Methods and Programs in Biomedicine	2020	13888	7.7
Journal of Magnetic Resonance Imaging	2011	13432	5
Journal of Magnetic Resonance Imaging	2012	14617	5.1
Journal of Magnetic Resonance Imaging	2013	15237	5.1
Journal of Magnetic Resonance Imaging	2014	16967	5.3
Journal of Magnetic Resonance Imaging	2015	18102	5.8
Journal of Magnetic Resonance Imaging	2016	17469	6.1
Journal of Magnetic Resonance Imaging	2017	18338	6.3
Journal of Magnetic Resonance Imaging	2018	18606	7.1
Journal of Magnetic Resonance Imaging	2019	18507	6.6
Journal of Magnetic Resonance Imaging	2020	19493	7.8
Journal of Magnetism and Magnetic Materials	2011	26379	3.3
Journal of Magnetism and Magnetic Materials	2012	27151	3.5
Journal of Magnetism and Magnetic Materials	2013	28001	3.4
Journal of Magnetism and Magnetic Materials	2014	29097	3.5
Journal of Magnetism and Magnetic Materials	2015	33025	3.6
Journal of Magnetism and Magnetic Materials	2016	33226	3.9
Journal of Magnetism and Magnetic Materials	2017	37488	4.7
Journal of Magnetism and Magnetic Materials	2018	38606	5.4
Journal of Magnetism and Magnetic Materials	2019	41089	5.2
Journal of Magnetism and Magnetic Materials	2020	43917	5.1
Magnetic Resonance in Medicine	2011	25618	5.4
Magnetic Resonance in Medicine	2012	28941	5.7
Magnetic Resonance in Medicine	2013	30211	6
Magnetic Resonance in Medicine	2014	31029	6.1
Magnetic Resonance in Medicine	2015	33298	6.6
Magnetic Resonance in Medicine	2016	32503	6.8

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Magnetic Resonance in Medicine	2017	33530	7
Magnetic Resonance in Medicine	2018	34357	6.9
Magnetic Resonance in Medicine	2019	34500	6.8
Magnetic Resonance in Medicine	2020	33095	7.1
NeuroImage	2011	61084	9.8
NeuroImage	2012	75582	10.4
NeuroImage	2013	83013	12
NeuroImage	2014	89823	12.2
NeuroImage	2015	95587	13.1
NeuroImage	2016	95569	11.3
NeuroImage	2017	100741	11.5
NeuroImage	2018	105556	9.8
NeuroImage	2019	111039	10.2
NeuroImage	2020	115091	10.6
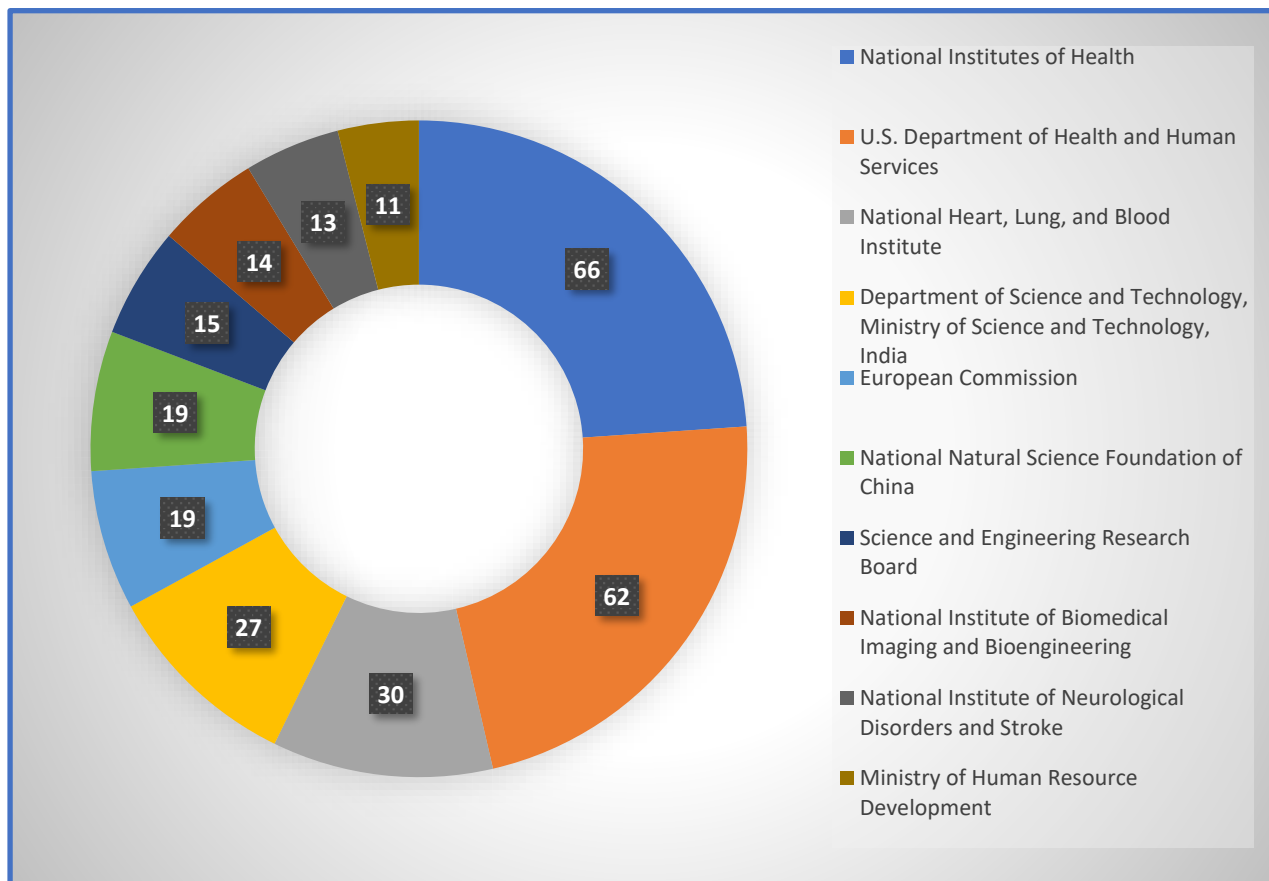
Fig. 10: Details of funding sponsor

Source: https://www.scopus.com

3.9 Funding sponsor

Funding is one important aspect researchers look for to do quality research. Funding agencies play crucial role in the progress of any research. Approximately, 56% of the articles published in this area is funded by sponsors. There is an involvement of 159 sponsors behind the publications of evolved research. Top sponsors are National institutes of health, U.S. Department of Health and Human Services, National Heart, Lung, and Blood Institute and Department of Science and Technology-India in order. The above graph shows the contribution of top 10 funding sponsors. It is observed from the data that, funding is adequately less for this topic by keeping in mind the application of the topic in real life situation. There is no doubt that the quality and quantity of research will be improved drastically with the help of financial sponsorship.

4. CONFINES OF THE PRESENT STUDY AND RESEARCH GAPS

The present study analyses mainly the publications in Scopus database. There are other big databases such as WOS, SCI, etc which we have not considered in this study. Further using Scopus database, we could not study the citation analysis of these 1193 publications which is one more important point in establishing the importance of research topic and quality of research work although we have done the citation analysis of the journals in which the papers related in this area are published. This work can be extended by taking the publications from another popular database of science, medicine, and engineering, WOS, so that we get more details about all the parameters which we have discussed in the present study. It will be very beneficial and handy for researchers and doctors if we include papers from PubMed as this research go hand in hand with medical field, and it is observed that many good publications are available in PubMed database. Comparative analysis is one more means to get the best statistical results by comparing the publications from different databases related to the said research topic.

5. CONCLUSIVE SUMMARY AND FUTURE ENHANCEMENTS

This paper gives a broad visualisation of the status of research in blood flow in stenosed arteries.

Number of publications are significantly increasing year by year which shows more and more research is going on in this area and many young researchers contributing their bit to this area. Maximum papers are in the year 2020 and expecting more in the years to come as per the trend.

Findings shows that English is the only language which is/can be used in communicating the research output in this topic to the other researchers and medical practitioners. Dominance of Asian researchers is evident from the statistics and 56% of the published research is sponsored by funding agencies. The results also shows a yearly trend in the number of publications in journals and also the citation analysis of these journals.

It is also found from the study that a significant part of research is theory based. As this topic has applications in Medicine and Engineering, it is very important to test/validate the theoretical results with experiments and experimental data. Also, we are in dearth need of survey data for validation as the data related to this area is sensitive and data privacy is an issue in collecting the data. Hence, it is very important for researchers to collaborate with hospitals, government agencies and fellow researchers, so that there won't be any issue in collecting the data and hence for validation of results.

CONFLICT OF INTERESTS

The author(s) declare that there is no conflict of interest.

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