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Pyotr Shchetinin, Anait Oganyan, Evgeniya Trautman, and Anastasiya Shchetinina

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Scientific and Technological Development of the Modern Cardiological Science: Global and Russian Trends

Pyotr Shchetinin[1, a)], Anait Oganyan[1, b)], Evgeniya Trautman[1, c)] and Anastasiya Shchetinina[2, d)]

[1] *Tomsk State University, 36 Lenina Avenue, Tomsk 634050 Russian Federation*
[2] *Siberian State Medical University, 2 Moskovsky trakt Street, Tomsk 634055 Russian Federation*

[a)]corresponding author: wospp@yandex.ru
[b)]og.aa@yandex.ru
[c)]trautmanevgeniya@ya.ru
[d)]ishchap@gmail.com

Abstract. In this article are presented the results of research aimed at defining scientific and technological development trends in cardiology, their differences in Russia in comparison with the global reality. For determination the tasks a proprietary multidisciplinary approach was applied in social-economic studies to estimate academic and technological development of cardiology, which allows integrating the results of the national and foreign theoretical research to the maximum in this area. Analysis showed that nowadays, the focus is on studying the mechanisms of originating and development of the cardiovascular diseases and studying the pathogenic basis, biological functioning of the organ system and heart under normal and pathological conditions and innovative methods of predicting and such diseases therapy. Russian scientists conduct research in the area of cardiology almost in every actual direction. Russian scientists are successfully finding solutions to the top problems in diagnostics, treatment and prevention of chronic ischemic heart disease, dyslipoproteinemia, arterial hypertension, type two diabetes, cardiomyopathy, employing modern achievements in the medical science and practice. Besides, there are remarkable scientific centers, conducting independent research and developing unique self-engineered products. Conducted classification and description of the material allows to form a conclusion about the current develop level of the studied science industry in Russia, in addition it allows to say about the degree of conformity with the develop level of the leading global practices in the field of cardiology. Attained results became a basis for drawing conclusions about the development prospects of some certain fields which study cardiovascular diseases and the therapy methods in Russian and world science.

INTRODUCTION

Traditionally cardiovascular diseases take the leading positions in the population mortality ratings all over the world. Such a negative situation was mentioned long ago, nowadays it is actively studied by the researchers from different areas and also has a special name “phenomenon of the cardiological supermortality” reflecting its significancy and fatality [1].

In general, noninfectious diseases are the main reasons of population reduction in working age, where mortality from the heart and vascular diseases are also taken into account. For example, according to the UN, mortality ratio from cardiovascular diseases in 2014 in Kazakhstan is 54 %, Belorussia – 63 %, Russia – 60 %, China – 45 %, Germany – 40 %, Italy – 37 %, USA and Brazil – 31 %, France – 28 %, Israel and India– 26 %, RSA – 18 % [2]. Such data far outweighs 20 years old data and, as we see, equalize developed and developing countries of the world.

Nowadays, ischemic heart disease, cerebral crisis and vascular diseases, caused by atherosclerosis, take up less than 70 % in the structure of the cardiovascular diseases. Ecological problems, unhealthy nutrition and lifestyle lead to a bigger rejuvenation of the average patient. On account of ageing of population and changing of the lifestyle, cardiovascular diseases occupies the developing countries more actively.

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The aim of the modern cardiology is the development of the early detection innovative methods (pharmacological, technical, interventional, invasive, etc.), healing of the heart and vascular diseases, development of the therapy and prevalence rate reduction of which is one of the most important tasks of the world science [3].

The most burning issue in the area of mortality from the cardiovascular pathologies which is characteristic for the last few decades is the most powerful driver of the modern cadriological science.

In Russia cardiovascular diseases are in the first place among all the reasons of population mortality: 950.000 people die annually. Thanks to the measures taken by the Government of the Russian Federation this number is slowly falling but, nevertheless, remains to be dangerously high exceeding this figure in the economically developed countries [4]. In 2010 this index amounted to 806, in 2011 – 753, in 2013 – 721, in 2014 – 654 cases per 100.000 of population [5]. The Ministry of Health of the Russian Federation plans to bring this index up to 650 cases per 100.000 of population before 2018. High mortality level of working age population is reflected the demographic indexes in the country and also has significant economic and social importance.

In Russia cardiovascular diseases are the most common among all the reasons of mortality population: annually 950.000 people die. Thanks to the governmental work this number is slowly falling, but, nevertheless, remains to be dangerously high, exceeding this figure in economically developed countries [4]. In 2010 this index amounted 806, in 2011 – 753, in 2013 – 721, in 2014 – 654 cases per 100.000 of population [5]. The Ministry of Health of the Russian Federation plans to bring this index up to 650 cases per 100.000 of population before 2018. High mortality level of working age population influences on the demographic indexes in the country [6].

The elderly people have a high value among those who suffer from the cardiovascular pathologies. According to different estimates, the structure of cardiovascular diseases will change insignificantly in Russia by 2025. The ischemic heart disease, hypertension, atherosclerosis and related pathologies remain the main disease types. The ratio of the chronic cardio failure will grow as the mortality from the acute myocardial infarction reduces and increase in life expectancy in Russia [7]. In the longer term the cardiovascular pathologies will have a growing tendency with increasing life expectancy all over the world. In such a case the early disease detection methods and its preventive negotiation will be determinant, in other words, so called high-tech cardiology or cardiology, as a part of “future medicine”, will go further.

METHODS AND MATERIALS

A proprietary multidisciplinary approach was applied in social-economic studies to estimate academic and technological development of cardiology, which allows integrating the results of the national and foreign theoretical research to the maximum in this area. Besides, this settles the matter of complexity and a high theoretical level of the research; also, it allows making a conceptual development model of the most important biomedicine branch – cardiology in the longer term.

The following sources of information were used in the study: analytical forecasts of international organizations (i.e. OECD, UN, WHO, UNIDO, etc.), national science and technology forecasts (the EU, Russia, the USA and others), forecasts by international professional associations in the field of biomedicine and cardiology, reports from the leading technology forecasting and foresight centers, and other strategic documents. The experts surveyed represented the major universities, R&D centers and scientific schools of Russia. The authors also conducted a patent search and analysis of the publication activity of different countries cardiology scientists. Official reports on breakthroughs in the field of biomedicine, cardiology, cardiopharmacology, cardiac surgery, and related fields were studied.

Conducted classification and description of the material allows to form a conclusion about the current develop level of the studied science industry in Russia, in addition it allows to say about the degree of conformity with the develop level of the leading global practices in the field of cardiology. Attained results became a basis for drawing conclusions about the development prospects of some certain fields which study cardiovascular diseases and the therapy methods in Russian and world science.

RESULTS AND DISCUSSION

Investigations in the field of Cardiology and Angiology are wide-spread in the world [8]. A high number of world scientific research centers are participating (USA, Japan, EU etc.). This sphere of science is also present in Russia but less developed historically. There is a small amount of the large scientific heart centers which have an opportunity to work with the modern equipment involving the progressive cardiology methods [9]. At the same

time, there are some examples of Russian scientists' achievements in this field, in particular prosthetic heart valves, nanomaterials for atherosclerotic vascular disease healing, radiotracers which do not have analogues have been invented [10].

The number of Russian publications in the sphere of Cardiology and Cardiovascular Medicine in a period of 1996-2014 in the Scopus database is 2696 works, USA – 199716, Japan – 49093, Germany – 47243, Israel – 5398. According to h-index, Russian contribution in the global research of cardiology and angiology from 1996 till 2014 is 57, USA – 482, Germany – 303, Brazil and China – 101 (Table 1) [8].

TABLE 1. Scientometrical rating of the countries across the world in the sphere «Cardiology and Cardiovascular Medicine» (1996-2014) [8].

Rank	Country	Documents	Citations per Document	H-index
1	United States	199716	27,58	482
2	Japan	49093	16,76	222
3	Germany	47243	24,62	303
4	United Kingdom	45295	25,93	299
5	Italy	39778	21,58	268
6	France	27207	23,68	263
7	Canada	25816	30,48	273
8	Netherlands	22757	31,73	256
9	Spain	17814	17,86	176
10	Turkey	15873	7,71	74
11	China	13713	15,32	101
12	Australia	12442	27,63	184
13	Poland	10925	10,33	122
14	Switzerland	10494	26,76	173
15	Sweden	9957	32,16	190
16	Brazil	9946	12,55	110
17	Belgium	8511	31,83	187
18	South Korea	8451	20,87	111
19	Greece	8435	15,63	113
20	India	7951	7,56	72
21	Austria	6983	20,76	141
22	Taiwan	5845	15,57	100
24	Israel	5398	23,41	141
25	Czech Republic	5035	11,52	84
27	Norway	3906	33,04	136
28	Portugal	2973	11,04	69
29	Russia	2696	14,53	57
37	South Africa	1761	18,01	82
59	Lithuania	238	22,8	33
66	Estonia	163	28,4	29
115	Azerbaijan	24	7,63	6
146	Kazakhstan	7	0	0
188	Samoa	1	59	1

Many publications (NCBI database) of cardiologists from different countries in the last 5 years were studied to identify research priorities in the field of cardiology [11]. It allowed summarizing that the main efforts in the cardiological science will be aimed at studying further development mechanisms of cardiovascular diseases and designing new methods of diagnostics and medical treatment based on using modern technological solutions.

Nowadays, the focus is on studying the mechanisms of originating and development of the cardiovascular diseases and studying the pathogenic basis. The researchers concentrate upon the most common and socially

dangerous diseases, i.e. the ischemic heart disease, myocardial infarction, arterial hypertension, atherosclerosis, vascular thrombosis, etc.

Studying biological functioning of the organ system and heart under normal and pathological conditions is of immediate interest. In recent times there have appeared more studies of the vascular endothelium, including its response to free radicals, interaction with immune system cells and thrombocytes, and the influence of vessel wall pathology on metabolic damage of organs in cases of ischemia.

The research of molecular mechanisms of the endothelial dysfunction development and mechanisms of microcirculation vessel hyper permeability is common. Besides, there is still long-standing interest to the process of inflammation in atherosclerosis development and organs restenosis development after angioplasty and stenting. Many scientific works are devoted to the ways of overcoming reperfusion consequences, resulting from surgical recanalization of coronary vessels. It is of great interest because it is necessary to develop innovative medicinal products to heal cardiovascular diseases.

Finally, all the above mentioned plays a key role in cardiological science, and it aims to update scientific knowledge, create innovative diagnostics methods and medical treatment using modern technological solutions.

Significant Scientific and Technological Trends of the World Cardiological Science

The genomic, proteomic and metabolome studies, informative, nanotechnological and cell technologies can be assumed to the main trends, which form a new direction in the cardiological science. The most remarkable achievements in the academic fields related to cardiology are shown in the Table 2.

TABLE 2. Some of the most remarkable achievements in cardiology and related fields [12].

	The Name of Discovery or Innovative Technology	Results
1	Study of the myocardial proteome and the development of proteomics	Not less than 177 different protein markers were discovered based on the results of the research conducted. The following markers are applied in laboratory diagnostics of cardiovascular diseases: troponin, NTproBNP, MPO, LP-PLA2 b, etc.
2	Elaboration and use of the matrix materials for artificial vessels	The usage of such material after the artificial vessel transplantation leads to careful replacement of walls by cells that increases survival rate and declines rejection.
3	Using the stem cells from the bone marrow in cardiology	A new restoration method of the damaged myocardium through its regeneration. The frequency of the following complications significantly declines by the early usage of the method.
4	Elaboration of the technology for mitral valve installation without chest rupture	Minimal invasive surgery allows saving the valve. There is no need in taking anticoagulants for life.
5	Installation of an artificial heart «AbioCor» to a patient with an extreme heart failure	A portable artificial heart apparatus is developed, which is placed completely in a patient's body. It is wireless. The infection risk decreases after the operation. The operating life is not less than 1 year. It is called to help the patients with the heart failure, whose death was inevitable.
6	Elaboration and successful use of the bioresorptive stent in practice	A bioresorptive coronary stent allows minimizing the risk of thrombus formation and, after the resolution, there is no barrier for a new one. The resolution speed of the stent is perfect not to disturb the function of an arterial wall.

Nowadays the genomic technologies (gene therapy) are considered to be a field, which can lead to the breakthrough in the healing of the hypertension, cardiomyopathy, ischemic heart disease, etc. For example, the methods of using the adenoviral vector for gene transplantation are being developed in cardiology, which can bring about myocyte hyperplasia in myocardial cells of patients, who went through infarct. The gene therapy method is designed to heal the ischemic heart disease through creating new blood vessels (angiogenesis). At the same time, the methods of angiogenesis suppression are developed for healing patients with tumors, for instance, by inhibition of the embryonic growth factor [13].

The proteomics in cardiology is considered as a high potential scientific branch. For example, the latest research proved the importance of some proteins in protecting tissues from metabolic affection by the ischemic heart disease. The attained results are actual on account of searching the approach to the cellular and molecular protection mechanisms from ischemia, originating in tissues in case of sharp misperfusion [14]. The practical cardiology can benefit greatly from metabolomics due to the introduction of the molecular profiling methods. The designed diagnostics allows detecting diseases at an early stage before any signs of symptoms [15].

Obviously significant advances in the research of cardiovascular regeneration mechanisms, molecular targets identification in order to affect the regenerative processes in cardiovascular tissues, the regenerative potential identification of the stem cells, both resident and obtained from the cord blood, adipose tissue, bone marrow, etc. Exploratory research is carried out to obtain heart cells from pluripotent cells. This branch is cutting-edge in modern cardiology and relatively soon can lead to a technological breakthrough. The result of such research will be a new medical concept, i.e. the delivery of highly effective care at early stages followed by structure and function restoration of an unhealthy organ. Interventional cardiology has developed greatly with the introduction of the increasingly in-demand minimally invasive technologies, complex and hybrid methods of care [16]. However, in recent times surgical interference is considered as a last resort in patient care. The introduction of nanotechnologies in interventional cardiology has already lead to the advances in the diagnostics of cardiovascular diseases. Nanotechnologies allow developing innovative materials for implants and, above all, for vessels which are highly compatible and enduring. The hybrid technologies, joining the nano- and cell technologies, offer prospects of a new generation of bio prosthesis for the definite repair of cardiovascular diseases, in particular, similar functional characteristics with the parameters of the native valve [17].

The main trends of science, which lead to significant advances, are the following: extension study of cardiovascular norms and pathologies in biology, investigating molecular mechanisms of diseases, mechanisms of organs regeneration and fundamental mechanisms of pathologies initiation and progression. Convergence with other academic branches (genomic, proteomic and metabolome studies and informative, nanotechnological cell technologies) can bring about a serious breakthrough. Such tendency enhances the capability of some academic fields and promises academic and technological success, which is capable to improve the quality of life of patients with cardiovascular diseases.

Status of Research in Russia. The Main Trends of the Russian Cardiological Science

Russian scientists conduct research in the area of cardiology almost in every actual direction [11]. Local researchers pay attention to urgent issues in cardiology, and at the same time Russian scientists are successfully finding solutions to the top problems in diagnostics, treatment and prevention of chronic ischemic heart disease, dyslipoproteinemia, arterial hypertension, type two diabetes, cardiomyopathy, employing modern achievements in the medical science and practice. Conducted research allows forming originating and development predictors of pathological states, estimating its severity, prognosticating the course, conducting pharmacological disease correction in time, therewith reducing the risk of cardiovascular complications development.

At present, scientific research aims to study cardiac failure problems and includes:

- searching new approaches to detect cardiovascular pathology at an early stage;
- developing remedial treatment approaches in cases of coronary and myocardial insufficiency in patients with myocardial infarction, including those who had a surgical interference.

The area of cell technologies is developing both in the context of culture methods and physiological studies at the level of an individual cell. For a long time, Russian researchers have been working together with foreign colleagues in the field of allogenic myoblasts study, i.e. donor muscle cells [18]. The task is to understand stem cells mechanism in patients affected by myocardium, to identify clear instructions to apply the method and to estimate its effectiveness.

There is great attention towards development of new medicinal products for cardiovascular diseases care. The production of Russian high-efficient second generation thrombolytics, antiplatelet and antiarrhythmic drugs has been developed and approved. Scientists have designed many new unique radiopharmaceuticals [19, 20].

For the first time in Russia cardiological help quality rating technologies with the help of the Internet technologies are developed and introduced, which use clinical quality indicators, showing cardiological patients' state of health [21]. In recent times, there have appeared many projects on the development of portable devices that monitor on-line cardiovascular system indicators and let a patient and a doctor know about the lapses on-line.

For the sustainable development of cardiological science in Russia we need to concentrate on the following problems: studying the molecular-cellular, genetic, immunological and other mechanisms of cardiovascular disease development; elaboration and adaptation of innovative models and interaction algorithm with different levels, types and forms of medical care to patients with cardiovascular diseases to requirements of practical healthcare; elaboration and implementation of the remote technologies in cardiology to help patients in isolated areas, design of portable cardiologic devices; elaboration of innovative diagnostics methods of cardiovascular diseases at early stages; elaboration of method of personified myocardial tissue engineering; progress of cardiac surgery care methods and development of methods of early rehabilitation after cardiac surgery interventions.

SUMMARY

As a result, the problem of cardiovascular diseases is the most important for modern biomedicine. The period from the end of the 20^{th} century to the beginning of the 21^{th} century was marked by the rapid increase of population cardiovascular disease incidence, which became a huge issue of the modern society. High rate of population disability and mortality in working age have a disastrous impact on the demographic rates in the world, also have a great economic and social significance. Numerous attempts have been taken to assess the expenses on the research and development activities, the pilot engineering works, the introduction of the new product production, the prevention and treatment of cardiovascular system diseases under outpatient and hospital c are. Scientists increasingly agree that the development of technology and its wide application reduces the economic costs, and improves the quality of people's life. In addition, the society is gradually becoming less worried and more friendly to the introduction of biomedical technologies of the future. Positive view and even loyalty is being shaped to the innovations in this field. It is a powerful booster for the development of modern biomedicine and its important part – cardiac sciences.

The aims of modern cardiology are to obtain new knowledge about processes, taking place in a body under norm and under pathological conditions, also the elaboration of innovative methods for early detection and cardiovascular diseases care.

Therefore, scientists from many countries focus their efforts on the area of cardiology and related fields. Traditionally, the largest world research centers in the USA, the EU, Japan and other countries set the research direction and level in the areas of cardiology and angiology.

This sphere of science is also present in Russia, but it is developed to a lesser extent. There is a small number of large scientific heart centers which have an opportunity to work at a desired level. It is proven by low publication activity in international journals, by low citation index, also by a limited number of international patents in the cardiological area. Nevertheless, as the study has shown, scientific research is conducted in Russia almost in all areas of cardiology and angiology. There are remarkable scientific centers, conducting independent research and developing unique self-engineered products. The research area is often considered to be one of the most important world scientific trends. It is necessary to focus on solving scientific issues and making efforts to develop our own existing scientific schools in order to ensure stable and advanced development of cardiology in Russia.

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