Symbiosis

ISSN: 2372-0964
DOI : http://dx.doi.org/10.15226/sojmse.2016.00117

Short Communication | SOJ Materials Science & Engineering | Open Access

The Heart and Technology

Marinkovic S[1]*, Jovanovic M[2], Kovacevic V[3], Kapor S[4]

[1]Institute of Anatomy, Faculty of Medicine, University of Belgrade, Belgrade, Serbia
[2]Clinic of Psychiatry, Clinical Center, Faculty of Medicine, University of Kragujevac, Kragujevac, Serbia
[3]Department of Cardiology, Clinical Center of Serbia, Faculty of Medicine, University of Belgrade, Belgrade, Serbia
[4]Institute of Anatomy, Faculty of Medicine, University of Belgrade, Belgrade, Serbia

Received: February 26, 2016; Accepted: March 15, 2016; Published: April 04, 2016

***Corresponding author:** *Slobodan Marinkovic, Institute of Anatomy, Faculty of Medicine, University of Belgrade, Dr. Subotic 4/2, 11000 , Belgrade, Serbia, E-mail: mocamarinkovic@med.bg.ac.rs*

Abstract

Multiple correlations exist between the heart and technology. The latter enables fine visualization of the heart, its electrical activity, and blood flow, which in turn improves diagnostics, as well as therapy in the domain of the interventional cardiology. An implanted pacemaker dictates a normal heart rhythm, whereas a defibrillator saves a life following a cardiac arrest or a threatening sudden heart death. The ischemic heart disease is treated by the coronary artery dilatation, the bypass procedure, or stem cells transplantation. The artificial valves replace the diseased ones, whilst the artificial heart or a donor's heart replaces the irreversibly damaged recipient heart. Finally, the heart participates in the emotional reactions aroused by the high technology.

Keywords: Heart; Heart disease; Artificial heart; Anatomy; Radiology; Transplantation

Introduction

Heart Technology can be considered from different but overlapping aspects. Firstly, from a presentation of the human heart which depends on the present technology [12]. Secondly, from the technologies used for a heart examination [9,14]. Thirdly, from the aspect of a diseased heart treatment, including coronary intervention, stem cell therapy, human heart transplantation, and the artificial heart transplant designed by modern technology [1,7,15,16]. And finally, from the heart's reaction to high technology [2]. The aim of our study was to discuss exactly those domains.

In order to illustrate certain points in this paper, we used photographs of some of our specimens, as well as the radiologic images of certain subjects. Some of those heart images were modified in the Adobe Photoshop.

Heart presentation

The presentation of the heart, from both the anatomical and artistic aspect, started with the ingenious scientist and artist Leonardo da Vinci in the 15^{th} century, and was continued by the famous anatomist Andreas Vesalius several decades later [12]. The wax technique inspired the Italian anatomists and artists of the 17^{th} and 18^{th} century to produce fine models of the heart and the main blood vessels Figure 1. The famous French painter Jean-Honore Fragonard made dissections of the human and animal bodies and organs following injections of the melted wax.

Development of radiologic techniques, especially in the few last decades, required a detailed knowledge of sectional anatomy Figure 2. At the same time, the formaldehyde fixed heart specimens and other body parts have gradually been replaced by other techniques, especially by those with silicon application. After inventing the plastination method, the German anatomist Gunther von Hagens modified real cadavers, including the heart and other organs, like the subjects are frozen in a certain movement. He actually made a fine art of human bodies and organs [12].

Heart Examination

Dependable scientific medical examinations of the heart started toward the end of the 19th century when the Nobel Prize

Figure 1: A wax model of the heart and major vessels. (Credit: Museum of Natural History, University of Florence , sect. Zoological "The Observatory " Italy; photo credit: Saulo Bambi - Museum of Natural History / Florence).

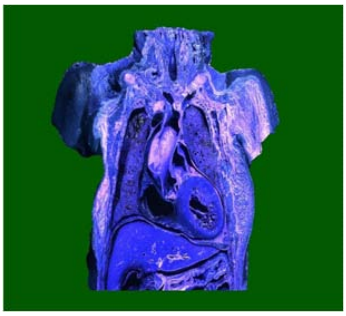

Figure 2: A coronal section of the human torso, including the heart and major vessels.

Figure 3: A photoshopped image created by a superimposition of a heart specimen, a coronary vascular cast, and a chest radiograph.

laureate, Wilhelm Conrad Rontgen, discovered the X-rays later named after him [14]. This was the first technological method to present the interior of the living human body and certain organs without surgery Figure 3. Decades later, the ultrasonography, i.e. echocardiography, was invented and, still later, Computerized Tomography (CT), Multislice CT (MSCT) Figure 4, Magnetic Resonance Imaging (MRI), diffusion tensor MRI, Positron Emission Tomography (PET) etc. [9,14]. At the same time, some older techniques improved substantially Figure 5.

An impressive achievement was reached in the field of 3D technology. The idea about 3D images of the heart and other organs appeared with the introduction of serial radiologic sections of the human body. Two main problems appeared from the very beginning: a small number of serial sections per unit and difficulties in proper software designing. Meanwhile, radiologic engineers managed to provide a larger number of sections and a higher quality of images. However, mathematicians and programmers faced two main problems. Firstly, how to reconstruct a missing layer between each two adjacent CT scans, and how to deal with the MRI images which do not present plain sections but, rather, thinner or thicker layers of tissues [9,14]? Secondly, in which way can the corresponding groups of the pixels in each of the three planes (axial, coronal and sagittal) be identified?

Fortunately, many years of hard work have produced fantastic results. Now, we have MSCT heart images showing a perfect surface anatomy, including the coronary vessels and their branches Figure 4. We can even rotate the heart image and view it from any aspect. It is the same situation with internal heart anatomy. Moreover, it is now possible to selectively present 3D images of the myocardial fiber bundles using the diffusion-tensor MRI technique [8].

All these radiologic technologies made possible a fantastic insight into heart anatomy, physiology and pathology, which in turn enabled a precise diagnosis, but also therapy in the case of interventional cardiology. In addition, certain modern radiologic images reached a high aesthetic value, so that they could be regarded as true digital artworks [8,10].

Diseased Heart Treatment

Coronary artery disease and the consecutive ischemic heart disease, i.e. the Myocardial Infarct (MI), are the leading causes of congestive heart failure in the modern population. Apart from a standard pharmacological treatment, there are modern technological methods designed to decrease both the morbidity and mortality rate in such patients.

Several decades ago, interventional cardiologists started to use percutaneous coronary intervention, commonly known as coronary angioplasty [15]. This is a non-surgical procedure used to open narrow or blocked coronary arteries in patients with stable angina or acute coronary syndrome, in order to diminish a risk of coronary thrombosis, embolism and the consecutive MI, but also to enable a quick reperfusion of an already developed

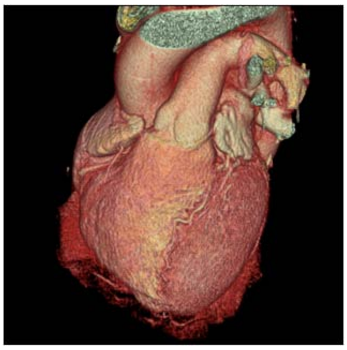

Figure 4: The anterior view of a 3D MSCT heart image.

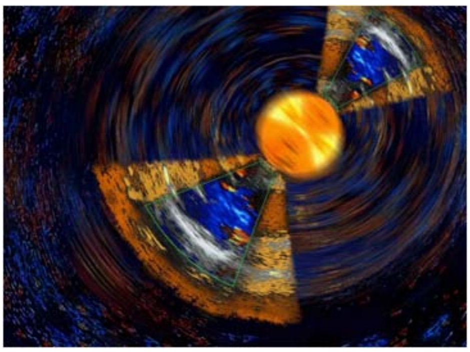

Figure 5: The heart micro-pulsar created by two echocardiographic images which were modified in the Photoshop.

ischemic area.

During the procedure, a thin, flexible catheter with a balloon at its tip is threaded through a blood vessel to the affected artery. Once in place, the balloon is inflated to compress the plaque against the artery wall. This restores blood flow through the artery. Balloon angioplasty is often combined with the permanent placement of a bare metal, drug-eluting or bioresorbable stent Figure 5. In some patients with significant left main stenosis or three vessel disease, the bypass procedures, performed by placing the arterial or venous grafts to connect the aorta with the stenotic or occluded coronary artery, can be made for a fast revascularization of the ischemic area.

In order to avoid the surgery, an effort has been made during the last years to use biological technology in the MI treatment, especially the stem cells, that is, the pluripotent cells which may differentiate virtually in any cell type of the human body, including cardiomyocytes [7,16].

However, scientists and clinicians, working either with animal models or human ischemic lesions, soon faced several problems in this field which had to be solved for a successful treatment. The first challenge was different types of cells to use: cardiac stem cells, cardiovascular progenitor cells, bone marrow-derived or adipose-derived stem cells. Secondly, in which way should the cells be prepared to enhance their survival in an infarcted area? Several methods were used in this regard: cyclic exposure of the stem cells to ischemia or inflammatory cytokine preexposure, cells transplantation with an oxygen releasing system, and genetic modulations of stem cells, i.e. a transfection of the cells with encoding genes of antiapoptotic factors and angiogenic growth factors by using nanomaterials as gene vectors (liposomes, polymers, nano gels etc.).

Subsequently, a cardiologist must select one of the several ways for stem cells administration: the coronary arteries, the venous system of the heart, or direct transplantation into the affected myocardial region. Further, stem cells engraftment and their retention in the ischemic area had to be improved by using, for example, viscous hydrogels and polyesters, as well as cell adhesion molecules (collagen, fibronectin, laminin etc.). Due to that, most of the transplanted cells (about 20 million) should survive in the ischemic area.

Although some relatively modest results have been achieved at present, it is a question of months or so when the stem cell therapy will successfully regenerate cardiomyocytes and induce angiogenesis, thus improving clinical conditions, i.e. a reduction of infarct size, improvement in ejection fraction, and a ventricular end-systolic volume.

Finally, the ideal goal in this domain would be to produce extracorporeally, by means of stem cells, the whole heart which could then surgically replace a diseased organ.

Heart Transplantation

The first human heart transplant was performed by Christian Barnard in 1967. In the modern era, about 4,500 transplantations per year are performed worldwide [5].

After a standard median sternotomy, the patient is started on cardiopulmonary bypass. The diseased heart is removed and the healthy donor heart is connected to the major blood vessels: the superior and inferior venae cavae, the aorta, pulmonary artery, and the part of the left atrium with the pulmonary veins. The cardiopulmonary machine is removed and the new heart is restarted. To prevent the patient's immune system from rejecting the donor's heart, the immunosuppressive therapy is applied for the rest of the patient's life.

Artificial Heart

In patients with a serious heart rhythm disorder, an artificial pacemaker was designed by technology. Cardiac arrest is treated by external defibrillator application, whilst a threatening sudden cardiac death can be prevented by an implantable cardioverter defibrillator. In patients with lesioned mitral, aortic, tricuspid or pulmonary valves, artificial or biological valves were invented. However, what about the patients with grave damage to the myocardium who have end-stage heart failure?

Although the described human heart transplantation is the method of choice in patients with irreversible biventricular dysfunction, the mechanical circulatory support is extremely important due to a shortage of donor's hearts and long waiting lists [1]. Two main devices are used, i.e. the left ventricular assist device and the Total Artificial Heart (TAH).

The first human TAH implant was performed by Denton Cooley in 1969, but the patient died 96 hours later. Since then, over 20,000 TAH implants were performed, and at present, a patient's median survival is about 90 days. The TAH itself is a biventricular pneumatically powered device, made of polyurethane, which is connected to an external pump. The device is usually 10 cm 10 cm × 15 cm in volume, and almost 500 g in weight. Each ventricle contains two mechanical valves to regulate the direction of flow. After cardiotomy, the TAH is implanted and connected to the main arteries and veins. The chambers of the device reach a stroke volume of 70 ml. It is understandable that long-term anticoagulants must be used in TAH patients.

Unfortunately, for the time being, the TAH is used only for bridging patients to heart transplantation. In the near future, however, such a device could be a permanent solution for patients with end-stage heart failure.

Heart Reaction to Technology

Although this matter can be considered from various aspects, including heart complications of various technologies treatment, we shall focus only on the connections of our heart and the emotions.

A year ago, when the latest generation tablet device appeared on the market, thousands of young people worldwide were anxiously queuing the whole night to obtain one of these hi-tech items. Similarly, when the young daughter of the first author of this paper recently received an "iPhone 6S Plus" as a gift, her face expressed absolute delight and her heart rate became elevated.

Our heart is an internal organ with autonomic innervation controlled by the brain limbic system, which is often stimulated by the neocortical signals. Due to that, the heart reacts to our positive or negative emotions, including physical and mental stress 13]. Listening to the music, which induces joy and amusement, reduces the heart rate and blood pressure [3]. In contrast, negative emotions, such as anxiety, anger, fear, and depression, commonly increase the heart rate but also raises blood pressure. However, there is a two-way path in heart-emotion relationships. Namely, the arterial baroreceptors inform the brain about the heart beating, which then influences cognitive-affective processing [13].

These facts may have a strong effect, among others, on both cardiologists and their patients. Thus, the measuring of the heart rate in interventional cardiologists during the procedure showed about 120 beats per minute [2]. This was most likely a result of mental stress, which is known to lead to atheroma instability, due to neurogenic and hematogenic factors, and thus to affect the health of cardiologists. Similarly, negative emotions, including stress, are associated with an increased risk of mortality in cardiac patients [4]. In contrast, positive emotions, including listening to music, improve the emotional state and lower mortality rate in cardiac patients [3,11].

Then again, it is interesting that gum-chewing reduces stress-related responses by the prefrontal cortex which in turn influences the hypothalamic-pituitary-adrenal axis, and thus exerts a beneficial effect on our cardiovascular system and emotional status [6].

Conclusions

There are obviously strong and multiple correlations between the heart and technology from high-quality radiologic images of the heart to the complex procedures in heart disease treatment which have been saving many thousands of life in the last few decades.

References

1. Cook JA, Shah KB, Quader MA, Cooke RH, Kasirajan V, Rao KK, et al. The total artificial heart. J Thorac Dis. 2015;7: 2172-2180.
2. Cook S, Stauffer JC, Goy JJ, Graf D, Puricel S, Frobert A, et al. Heart rate never lies: interventional cardiologist and Braude's quote revised. Open Heart. 2016;3(1):e000373. doi: 10.1136/openhrt-2015-000373.
3. Bradt J, Dileo C. Music for stress and anxiety reduction in coronary heart disease patients. Cochrane Database Syst Rev. 2009;15(2):5-9. doi: 10.1002/14651858.CD006577.pub2.
4. Celano CM, Millstein RA, Bedoya CA, Healy BC, Roest AM, Huffman JC. Association between anxiety and mortality in patients with coronary artery disease: A meta-analysis. Am Heart J. 2015;170(6):1105-1115.
5. Kirklin JK, Naftel DC, Bourge RC, McGiffin DC, Hill JA, Rodeheffer RJ, et al. Evolving Trends in risk profiles and causes of death after heart transplantation: A ten-year multi-institutional study. J Thorac Cardiovasc Surg. 2003;125(4): 881-890.
6. Konno M, Takeda T, Kawakami Y, Suzuki Y, Kawano Y, Nakajima K, et al. Relationships between gum-chewing and stress. Adv Exp Med Biol. 2016;876:343-349. doi: 10.1007/978-1-4939-3023-4_43.
7. Li X, Tamama K, Xie X, Guan H. Improving cell engraftment in cardiac stem cell therapy. Stem Cells Int. 2016;2016: 7168797. doi: 10.1155/2016/7168797.
8. Marinković S, Lazić D, Kanjuh V, Valjarević S, Tomić I, Aksić M, Starčević A. Heart in anatomy history, radiology, anthropology and art. Folia Morphol. 2014;73(2):103-112.
9. Marinković S, Schellinger D, Milisavljević M, Antunović V. Sectional and MRI anatomy of the human body. Thieme, Stuttgart. 2000.
10. Marinković S, Stošić-Opinćal T, Tomić O. Radiology and fine art. AJR Am J Roentgenol. 2012. 199(1):W24-6. doi: 10.2214/AJR.11.7934. 199:24-26.
11. Sanjuán P, Montalbetti T, Pérez-Garcia AM, Bermúdez J, Arranz H, Castro A. A Randomised Trial of a Positive Intervention to Promote Well-Being in Cardiac Patients. Appl Psychol Health Well Being. 2016;8(1):64-84. doi: 10.1111/aphw.12062.
12. Singer C. A short history of anatomy from the Greeks to Harvey. New York: Dover; 1957.
13. Valdera MT, Bolea J, Laguna P, Vallverdu M, Bailon R. Human emotion recognition using heart rate variability analysis with spectral bands base on respiration. Eng Med Biol Soc. 2015;6134-6137. doi: 10.1109/EMBC.2015.7319792.
14. Wicke L (2005). Atlas of Radiographic Anatomy. Elsevier, GmbH, Urban & Fisher Verlag, München.
15. Windecker S, Kolh P, Alfonso F, Collet JP, Cremer J, Falk V, et al. Guidelines on myocardial revascularization: The task force on myocardial revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) developed with the special contribution of the European Association of Percutaneous Cardiovascular Interventions (EAPCI). Eur Heart J. 2014;35:2541-2619.
16. Zhu K, Li J, Wang Y, Lai H, Wang C. Nanoparticles-assisted stem cell therapy for ischemic heart disease. Stem Cells Int. 2016;2016:1384658.