Indian Heart Journal 69 (2017) 252–254

Contents lists available at ScienceDirect

Indian Heart Journal

journal homepage: www.elsevier.com/locate/ihj

Review Article

Tele-echocardiography – Made for astronauts, now in hospitals

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ARTICLE INFO

Article history:
Received 21 July 2016
Accepted 13 January 2017
Available online 26 January 2017

Keywords:
Cardiovascular disease
Microgravity
Tele-echocardiography
Telemedicine

ABSTRACT

Telemedicine, ie 'the delivery of healthcare and sharing of medical knowledge using telecommunication systems' has penetrated every field of medicine. As a result, tele-echocardiography, the study of the heart via telemedicine started expanding. Ironically, space became the next frontier for mankind's new innovations and technology pursuit. However, the microgravity environment of space is known to be challenging to astronauts hearts. As such, new tele-echocardiography techniques have evolved. The main aim was to research a system that can be operated by a layperson but still be able to provide high yield diagnostic information in real time to specialists on earth. This spin-off space technology is recognized to have a positive impact, especially in developing countries with vast terrain. It is now utilized in hospitals and other terrestial locations where patients in remote regions can have their hearts analysed and data relayed to specialists in bigger centres for interpretation and further management.

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1. Introduction

Echocardiography has come a long way from the time it used to be a bulky machine in the hospital echocardiography units and departments. Machines nowadays have become sophisticated, compact and easily mobile, allowing them to be transported to remote locations to be used on patients there. Echocardiography is a widely applied tool in telemedicine, which is the remote diagnosis and treatment of patients by means of telecommunications technology. The functions of tele-echocardiography has been briefly summed up as mentioned below.[1] It has potential to bring real time diagnoses to remote fascilities without resident cardiologists or physicians. Studies have shown these to be accurate, cost-effective, improves patient care, enhances echocardiography quality and sonographer proficiency and promotes practise expansion. Trained echocardiography technicians and paramedics perform the procedures remotely and relay information to cardiologists and physicians in bigger towns and cities through a web based system. Using these technologies, relevant uptodate scientific information is instantly available for analysis and interaction. Evolving telemedicine technology has boosted access to echocardiography and has created a network that offers many possibilities for clinical, research and teaching activities.

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http://dx.doi.org/10.1016/j.ihj.2017.01.010

All this is ideal to give us information on the heart in a non-invasive manner, however, its main drawback remains its operator dependence, as skilled personnel are required to capture and interpret dynamic images.The lack of availability of such personnel has been a setback in offering tele-echocardiography service in certain remote regions.

As mankind expanded its domain in exploration, space medicine became the next frontier for new discoveries and innovations. The main centre of activity was on the International Space Station (ISS), a satellite holding a laboratory which orbits around the earth. Astronauts conducted research trials, studied innovative technologies and new developments here. The duration of stay in space thus got prolonged.This can be challenging from a cardiac point of view as space living will affect human hearts in terms of atrophy of heart muscles and reduced exercise capacity. They can also develop bizarre cardiac arrythmias, heart blocks as well as premature cardiac aging. Previous studies have shown the role of endothelial cell dysfunction and atherosclerosis leading to senescence of cells and the development of myocardial infarction in the environment of microgravity in space.[2] With more ambitious space exploration projects planned by NASA (National Aeronautics and Space Administration) and its partners, such as the journey to Mars and to other distant planets, it is inevitable that we study the human body and the heart's adaptation to prolonged time in space, methods to improvise and sustain space travellers during their long journey in space and also to learn about new breakthrough technologies in medicine and other fields which will ultimately benefit mankind on earth as a whole. As such, we need to develop high range technology that can study human hearts in space as well as on earth and without the need to have skilled personnel at the site to perform the procedure.

In this review paper, the authors study the impact of new technology in echocardiography made for astronauts in space with technology transfer to patients in hospitals on earth. The various benefits and challenges in telemedicine technology is also highlighted.

2. New developments

Spending long periods of time in space can put a huge strain on the human body and astronauts need to be carefully monitored for signs of ill health. The ISS now comes equipped with echocardiography machines which provide medical experts with real time access to anatomical and functional information about the astronauts hearts while being non-invasive and harmless. Such projects show the benefits of long distance tele-consultations. This was especially so with the TESSA project or Tele-Echocardiography for the European Space Agency which was designed to allow a team of expert specialists on earth to operate an ultrasound scanner on the ISS or a spacecraft, which can then beam back images of the astronauts hearts to earth.[3]

The TESSA system has been a revolutionary development in its own right and its spin-off technology on earth works based on the following mechanisms as stated below.[3]

At the patients site, the technology consists of three components. The ultrasound machine, which works in the same way as a conventional device, an ultrasound probe attached to a robotic arm and a videoconferencing system. This video system is then linked via an internet connection to the specialist expert location. On the expert's site, the same videoconference system is set-up, to allow the expert to see and speak to the patient, and also to speak to the technician holding the robotic system over the patient's body. The technician could be a nurse or another member of the medical team, as the system is designed to be guided by someone without specialist echocardiography skills.

Also at the expert's site, is a computer interface to allow for viewings of the echocardiography images in real time, and to remotely operate the ultrasound system. The expert can control all of the settings on the system, allowing them to change parameters such as the frequency of the ultrasound, gain settings and to improve the amount of details in the image. Lastly, a joystick with three degrees of freedom, which was designed by specialists to very closely resemble the probes used to carry out a conventional ultrasound, allows the specialist to move the robotic arm over the patient's body. As an example, a patient requiring an echocardiography study of the heart would lie on the hospital bed, with the nurse or technician positioning the robotic arm over their body. The patient can then discuss their concerns with the remote specialist via the videoconferencing link, and the specialist would then use the joystick to move the ultrasound probe attached to the robotic arm over their body.

The TESSA technology was groundbreaking in that the astronauts need not have the presence of an expert echocardiographer in their midst to perform this procedure on them. In other words, the operator at the side of the patient need not have any specific medical knowledge to assist the remote specialist expert during the examination. However, cardiac images could still be taken and analysed from earth by expert personnel in real time. This idea caught up to became one of the important new technology transfer tools generated by research on the ISS as a spin-off to earth.

3. Discussion

Whether for earth or space based missions, the principle of telemedicine is essentially the same: it is much easier and cheaper to move medical data around then it is to move patients around. The same principle applies to tele-echocardiography too.

3.1. Terrestial tele-echocardiography

As can be seen, this TESSA system is making an impact globally, and why not? Large countries have vast areas of remote terrain, where it is difficult for people living in these areas to gain access to medical therapy. With this technology, experts can make a diagnosis for them in their home town, give them an appropriate management plan, and if they need some intervention, they can be transported to the nearest instituition or medical centre which offers the service. The quality of images is good and it is in real time- the expert not only looks at the images, but also talks with the operator performing the procedure.

AdEchoTech, a company based in France marketed this system to more then 15 hospitals and health institutes in France and abroad, with others participating in trials.[3] It could be used in any remote location including prisons, islands, ships, oil platforms or to provide medical assistance following a natural disaster, using either an internet or satellite link. Recently, it has been made available to military garrisons based in Lebanon and Afghanistan.[3-] With this system, therapy would be made easily available, allowing the delivery of echocardiography expertise to remote populations, lowering morbidity and optimizing cardiovascular health outcomes in these communities. It also reduces the costly transportation of human resources to distant geographical areas. Thus, it comes as no surprise that the TESSA system has literally captured the hearts of many.

3.2. Challenges in tele-echocardiography

Most terrestial telemedicine delivery is offered within a hospital, between a clinic and a specific hospital or between under-resourced clinics and a metropolitan hospital.[4] Some of the challenges faced by tele-echocardiography in this setting include lack of standardization of telemedicine components, confusing medicolegal, licensure and legislation issues, privacy/confidentiality debate as well as poor reimbursement.[5] Economy and cost of employing this technology is a major factor that needs to be considered. For instance, in many countries, it is yet to be established which telecare service are paid through health insurance. Cost assumption should be regulated in a timely manner, to cater for the masses and lead to reduced production costs and lower service charges. Otherwise, in spite of all its advantages, the TESSA system could still face a drawback if this important aspect is not addressed. Ultimately, to make the system successful, there needs to be high level cooperation from all levels of staff who are designated to operate the system, from clinicians and administrators right upto sonographers, manufacturers and insurance companies.

3.3. Future innovations

Research is in progress to develop the TESSA system even further for both earth and space based applications.This new generation of technology would ideally be smaller in size and weigh less in reference to the robotic arm, but would have the same specifications.[3] This would make the system extremely mobile, easy to transport and use as well as fascilitate its access to distant regions of the world. In space, it would have a beneficial role as a compact equipment, easy to transport on shuttles and satellites as well as being user friendly at the same time. It is also expected to be less expensive to use, in order to achieve its full impact in the community. With upcoming long duration ISS stays and future manned exploration missions requiring the use of different medical tools to diagnose potential crews health problems, it is inevitable that new innovations and technologies are invented for the health and well being of astronauts in space.

The use of airflight drones for medical therapy and cardiac emergencies is being studied, firing our imagination to the marvels of modern science.[6] We also postulate that current non-invasive technologies for refractory angina such as the extracorporeal shockwave myocardial revascularization therapy can be modified for use in heart disease in space.[7] Further research is needed to study the possibility of the TESSA technology being incorporated into these upcoming innovations.

4. Conclusion

As NASA and its allies deploy satellites and spacecraft for deeper space travel, we need to analyse newer diagnostic, therapeutic and preventive therapy for cardiac disease occurring in astronauts. This can be of utmost importance in the climate of space exploration and ultimately as spin-off technologies to earth. As such, the TESSA system has potential to play an important role in mankind's ambitious technology surge forward.

Conflict of interest

The authors have none to declare.

Funding

This research did not receive any specific grant from funding agencies in the public,commercial or not-for-profit sectors.

References

1. Balasingam M, Sivalingam B. Future of tele-echocardiography. *J Nurs Health Care*. 2015;3(1):190–194http://dl6. globalstf.org/index.php/jnhc/article/view/1635/1658.
2. Versari S, Longinotti G, Barenghi L, et al. The challenging environment on board the international space station affects endothelial cell function by triggering oxidative stress through thioredoxin interacting protein overexpression: the ESA-SPHINX experiment. *FASEB J*. 2013;27:4466–4475.
3. Knight H. Sound concept: medical spin-off from ISS technology. *Engineer*. 2016;. Accessed 16 March 2016 https://www.theengineer.co.uk/soundconceptmedicalspin-off-from-iss-technology.
4. Hsieh JC, Li AH, Yang CC. Mobile, cloud and big data computing: contributions, challenges and new directions in telecardiology. *Int J Environ Res Public Health*. 2013;10:6131–6153.
5. Bruining N. The clinical need for tele-echocardiography. *Eur Cardiol*. 2014;7(2):82–83.
6. Claesson A, Fredman D, Svensson L, et al. Unmanned aerial vehicles (drones) in out-of-hospital-cardiac–arrest. *Scand J Trauma Resusc Emerg Med*. 2016;24(October (1))124 Epub 2016 Oct 12.
7. Alunni G, Marra S, Meynet I, et al. The beneficial effect of extracorporeal shockwave myocardial revascularization in patients with refractory angina. *Cardiovasc Revasc Med*. 2015;16(January–February (1)):6–1110.1016/j.carrev.2014.10.011.