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Innovative technologies used in telemedicine in patients with cardiovascular diseases (series of publications).

Abstract

Rapid technological progress, growing Internet availability across the world and commonness of tablets and smartphones make e-health an important issue not only for citizens and patients, but also for medical personnel and service providers. Advanced medical equipment, so far handled only by physicians, may in the near future become a basic tool at work of professional medical personnel, and may also be close at hand in every mobile and smartwatch, thanks to miniaturization.

Telemedicine will become more easily available than traditional medical services for subjects living in urban and rural areas. It will shorten the time spent on travelling to primary healthcare centres, and on visiting specialists. General implementation of the latest technologies may ensure better access to patient care and will reduce burden on traditional services. Telemedicine and fledgeling telenursing do very good during the COVID-19 pandemic, when physical contact with other patients and medical staff in hospitals and clinics is limited and poses an additional risk of infection.

Despite the huge scientific and organisational effort taken in the last few decades, the most common diseases occurring widely in society include cardiovascular system diseases, which are one of the main causes of death across the world. It is estimated that 17.9 million people died of cardiovascular diseases in 2015, and by 2030 more than 22.2 million people will have died. Considering medical staff shortages, of both doctors and nurses, it seems necessary to turn to innovative technologies to stop this trend. Areas of active implementation include e.g. patient consultations regarding treatment of chronic diseases, qualification for surgical diseases or the possibility of assessing endothelial function in the primary or secondary prevention of cardiovascular complications. In these areas, the use of the most advanced medical devices or telemedicine platform gain even more importance.

The main objective of the conducted studies, described in specific articles, was to assess the use of new technologies in the care of patients with cardiovascular diseases.

A series of publications includes two published original papers, one review article and one paper in centre co-authorship. 137 patients aged 46-91 years with defined cardiovascular diseases referred for the procedure of hip or knee arthroplasty and 94 healthy volunteers selected by age were qualified to the first study. A Littmann electronic stethoscope with Littmann® StethAssist™ Heart and Lung Sound Visualization Software (LStSoVs) was used in the study. The studies were conducted at the Department of Orthopaedics and Traumatology of the Military Institute of Medicine in 2018.

In the second study, the study group included 76 subjects (aged 71 ± 8.34 years, 34 women and 42 men) with known chronic arterial hypertension (for more than 5 years). An experimental set including Sonix Touch ultrasound scanner (Analogic, Peabody, MA, USA), ultrasound transducer operating at high-frequency 20 MHz was used to assess endothelial function (FMD) of the radial artery; as compared to the standard measurement of FMD of the brachial artery (with 7-12 MHz transducer). In a simultaneous examination before and after 5-minute ischaemia, a reactive response of the brachial and radial arteries was recorded. The analysis of arterial dilation was performed with the use of Brachial Analyser (BA) software (Medical Imaging Applications, LLC, Coralville, IA). The examination was performed at the Institute of Fundamental Technological Research of the Polish Academy of Sciences in 2018.

The results of the first study indicate a very high potential of the presented method. An electronic stethoscope with authorial software enables determination of phonocardiographic signals in patients with a cardiovascular disease and in healthy subjects qualified for orthopaedic surgeries. Eventually, 91 signals 52 patients with CVD (+), 39 patients with CVD (-) were analysed. In the end, the group achieved a classifier with 92% sensitivity and 97% specificity. Overall classifier accuracy was 95% LStSoV classifies normal and abnormal signals of the cardiovascular system with 95% efficacy.

The analysis of results achieved in the second study indicates a significant difference in FMD between the group of patients with hypertension and healthy volunteers assessed on both arteries. In addition, it must be emphasised that the measurement of FMD of the radial artery performed with the suggested method of high frequency ultrasonography

in hypertensive patients is not only equally correct, but also competitive for the standard measurement of the brachial artery, and this information may be useful for the risk assessment of complications in this group of patients and for further therapy.

In the third review article published in the Polish Nursing journal, authors described rapid development of telemedicine devices used across the world and in Poland, and their future use in healthcare institutions and directly by patients in the home environment. They described a modern approach to telenursing, which is possible thanks to the combination of three different areas of healthcare: technology, nursing care and specifically designed telemedicine devices. Nurses, as healthcare workers, have a key role in the improvement and maintenance of health in the society. Effective investigation into new trends and their implementation play an important role in building the position of innovative technologies and telemedicine. Regular training of medical personnel will not only result in higher availability and safety of healthcare practices, but will improve the quality of communication and information technologies, as well as the healthcare quality, aiming at professionalism of health protection.

The fourth multicentre publication was associated with the use of the Littmann electronic stethoscope together with Littmann® StethAssist™ Heart and Lung Sound Visualization Software (LStSoVs) for auscultation of the respiratory system. During auscultation, specific sounds are identified by the physician, who then associates the observed acoustic phenomena with pathological processes. The study was an attempt to develop a genetic algorithm qualification system and Support Vector Machine (SVM), which distinguishes between healthy patients and patients with crackles due to pneumonia, pulmonary fibrosis, heart failure (HF), or chronic obstructive pulmonary disease (COPD). The system was developed and tested on a set of data comprising 62 healthy (166 recordings) and 58 affected (187 recordings) subjects. A reliable system was developed, consisting of 5 wavelet classifiers characterised by approx. 95% sensitivity and 91% specificity, using 10-fold cross validation.

Based on the conducted work and achieved results, the following conclusions were made:

1. Easy access to telemedicine devices in the healthcare system will result in the development of continuous monitoring of patients with chronic diseases who require home supervision, which will reduce their visits at primary healthcare centres.

2. Easy access of the society to telemedicine devices will result in continuous monitoring of patients with chronic diseases who require intensive supervision. Nurses, as healthcare workers, have a key role in the improvement and maintenance of health by using telemedicine in their practice.
3. An electronic stethoscope with authorial software and non-standard algorithm indicates healthy subjects and patients with cardiovascular diseases qualified for orthopaedic surgeries.
4. The assessment of endothelial function on the brachial and radial artery using 20 MHz ultrasound transducer may be used to differentiate between hypertensive patients and healthy subjects, which confirmed their usefulness as auxiliary diagnostic measurements. The study results are of great importance for improving health and reducing mortality in patients at a risk of cardiovascular events.
5. Innovative technologies - telemedicine, as a young and developing field of medicine will bring many benefits, both for the patient with their family, and for the medical personnel. Telecare does not completely replace medical care, but it constitutes its effective supplementation.