Proceedings of the 3rd International Conference on Biological Engineering and Medical Science
DOI: 10.54254/2753-8818/20/20230748

Application of telemedicine in cardiovascular disease prevention and management

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Abstract. With the rapid advances of technology and wireless program, the clinical application of telemedicine is received increasingly great attention for its convivence and real-time monitoring. The present study focuses on telemedicine, which is a new tool employed the newly technology like 5G and artificial intelligence to achieve contactless but real-time monitoring patients or subjects for disease management or prevention of future medical events. Telemedicine is useful for help people that in the remote area and do not have access to good medical treatment, more professional experts, better medical examination system or sound surveillance system. It can improve equality and compensate for regional differences. Herein, we summarized trials that have been done recently, and each was compared telemedicine to traditional approaches. Lastly, depending on these reviewed trials, the present study has summarized the advantages and the disadvantages of the telemedicine. We also reviewed the future direction of development of the telemedicine and the facing challenges of telemedicine.

Keywords: telemedicine, remote monitoring, clinical trial.

1. Introduction

With the development of 5G and Internet, the telemedicine has come into use these years. The earliest telemedicine was the digital cases in hospitals, and after a long-time development, it developed with technology developing. The telemedicine nowadays typically based on computers, communications, medical technology, it can transmit, store, compare the medical data and can make patients communicate with experts online. It can collect data and images from the devices using in patients and then send them to patient's family own smart devices that they can know the state of patients all the time. The telemedicine also uses AI technology to monitor patients' state, like heartbeat, blood pressure. AI technology means artificial intelligence, it is basic based on machine learning and deep learning [1].

If AI identified the data is unusual then it would send the data and alarm doctors at no time. The telemedicine becomes especially important after post-Covid-19 area. The pandemic exposed a lot of problems to the public and government, like the lack of healthcare workers, the unevenly distribution of medical resources, the imperfect of public health service system and so on. The telemedicine can help to solve or improve these problems. Through telemedicine, patients can expose to and access to medical services that only in large cities and it also can help to monitor the patients' state so that more

DOI: 10.54254/2753-8818/20/20230748

healthcare workers could focus on the severe patients. The telemedicine can also be used in the clinical management, it can provide platforms that patients and doctors can depend on.

It can collect all patients' data and then decide how many patients need special care and how many people need specific treatment, so that the hospitals can have more rational allocation of nurses. It also can used in prevention in the past-Covid-19 area, many patients will have crown sequelae after recovery. In order to avoiding sever sickness, the patients could wear smart watch to track their data so that doctors can know the patients' heartbeat and blood pressure. Through this way, doctors can know if there is unique data and can avoid severe sickness in advance [2]. There are also some good uses about telemedicine, and this essay mainly focus on cardiovascular diseases.

2. Summary of clinical trial results of telemedicine

Prior report investigated telemedicine-based disease management [3]. Participants with class III heart failure symptoms according to the NYHA (New York Heart Association) and those who had previously been hospitalized were participated in this study. 550 patients participated in this study between Sept 6, 2007, and Oct 7, 2009. Before August 2010, 347 persons completed the following randomized access period. The period of open access ended April 30, 2012.

These 550 patients were randomized 1:1 based on a validated, secure, computerized randomization system. In control groups, they could receive all standard medical treatment. For the treatment group, they uploaded the data of pulmonary artery pressures and based on the date, they can control and adjust the medical therapy. The follow-up was called randomized access period. Participants in the treatment group received additional medical care throughout this time based on their uploaded pulmonary artery pressure, whereas those in the control group would only receive routine treatment. The period is 18 months on average, and after that period, throughout the open access phase, all patients' pulmonary blood pressure measurements were available to researchers. The rate of hospital admissions was used as the basis for the outcomes analysis. When compared to the control group, hospital admissions in the treatment group fell by 33% during the randomized access period. Compared to the treatment group's rate during the randomized access phase, the rate of hospitalizations has fallen by 48% during the open access period. As a result, treating a pressure sensor implant can significantly lower the rate of heart failure-related hospital admissions over the long run.

In another study, patients with HF who were in functional class III or IV according to the NYHA were included in the study. Patients were randomly divided into two groups. There were 274 pediatric patients, 134 in the treatment group and 140 in the control group. Both the control and treatment groups underwent optimal medical therapy. The monitored data was utilized in the treatment group to direct patient care, which is how the treatment group differs from the control group. The end point of this runway was the absence of system complications, the absence of pressure sensor failures, and the reduction of the HF occurrence rate. Among all the patients who implanted the device, only 8% of them did reach 2 safety points. The rate of it is in such a low level. In comparison to the control group, the treatment group reduced only 21% of all HF-related events, meaning that this drag did not reach the primary end point. A 36% decrease in the relative risk within an HF-related hospital visits was found in the Chronicle group in a retrospective examination of the period to first HF hospitalization. In conclusion, compared to traditional medical therapy, the number of HF-related incidents was not significantly decreased by the implanted constant hemodynamic monitor-guided therapy. To guarantee the special advantages of monitor-guided implanted continuous cardiovascular treatment for individuals with advanced HF, more leads are required [4].

Remote monitoring in patients with ICD (implanted cardioverter defibrillator) was also evaluated. Participants were those who used cardiac resynchronization treatment and those with an ICD. They were implemented with RM (remote monitoring) and FM (failure monitoring) capable equipment and were monitored for 15 months. These participants were randomized into remote groups and focus groups. Patients in the remote group were RM, including OptiVol and preset alarm management. The patients in control group were provided with standard in-office and visited them every 3 months. 176 patients in total were examined; 77% of the men were around 66 years old, and 83% of the primary

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prevention cases had an ischemic cardiomyopathy. The average LVEF (left ventricular ejection fraction) was 32+-11%. Regarding the timing of the first ICD shock, there was no appreciable variation in the number of ICD shocks between the patients in the distant group and the control group. Although the mortality in this experiment was not shown, the Kaplan-Meier measure of mortality after one year in the remote group was 8. 6% compared to 4. 6% in the control group. There is also no significant influence about mortality and HF-related hospitalizations [5].

In another recent trial, participants came from 118 locations in the US and Canada. Individuals with all ejection fractions, properly functioning NYHA Class II-IV chronic heart failure, hospitalization for current heart failure, or high natriuretic peptides. They were split into two groups of equal size at random. Based on pulmonary arterial pressure, the treatment group's hemodynamic-guided heart failure would be controlled. The control one would just receive usual care [6]. The safety was first priority for all the patients in this trial. The time of this trial was included part of the pandemic, the conclusion of it is a little complex. Deaths from all causes and incidents of complete heart failure, including coronary heart disease hospital visits and urgent heart failure hospitalizations at 12 months, are combined and measured as the study's primary outcome in every patient who received a random assignment. The devices were implanted into 1022 patients among both March 15, 2018, till December 20, 2019, with 1000 of those implantations succeeding, the success rate of implantation was very high, and this indicates an extremely high success rate. A total number of HF events in treatment group was 253 among 497 participants. 289 HF events were recorded in control group among 503 participants. A time-dependent variable-based flexibility analysis was utilized to contrast the pandemic's early and late phases because the primary endpoint varied during the pandemic. Before to the Covid-19 phase, there were 224 incidences in the control group and 177 instances in the treatment group. The per year rate of treatment group was significantly lower than control group. However, during the pandemic, the difference about the endpoint was nearly disappeared, the per year rate of control group was decreased 21 percent and there was no change in treatment group. In the overall trial the HF-guided management did not reduce hf events, but it did significantly contribution before the pandemic. Among 1022 patients in this trial, 1014 participants were free of system- or device-related problems. This trial did not show the significant conclusion about the device-based management in mortality rate and hf events. This trial did show the profit in the pre-COVID-10 period, there are more trials need to be done after the pandemic.

For the trial of LIMIT-CHF, participants were chronic patients with OptiVol and implantable cardiac defibrillators with CorVue capability. Participants were randomized in both the active and control groups. The patients who were in active group were opened their IMM (intrathoracic impedance monitoring) alarms and when the alarm altered, the diuretic would increase by 50% and lasted for 1 week. The patients who were in control group were closed their IMM alarms. There were 80 patients participated the study and 71 of them completed 1 year follow-up. The trial's endpoint was the number of times each patient was hospitalized for HF-related illnesses: in the active group, this occurred 11 times while it occurred only 6 times in the control group. There is also no significant difference in indivial participants. There are some unplanned hospitalizations in control group, but there is no unplanned visit in active group. At the final follow-up, the overall MLWHF scores in the control group considerably rose, but a tendency toward decrease was seen in the active group. In this wake, this treatment piloted by IIM alerts has not significantly reduced the emergency treatment of HF, but can positively affect patients' quality of life [7].

An independent study were conducted with participants who were implanted with a biventricular defibrillator (CRT-D) [8]. Patients that were implanted with the devices were randomly distributed in the standard arm and remote arm within eight weeks. The patients who were in remote arm would receive the remote check and in-office follow-ups. The patients who were in standard arm would just receive the in-office follow-ups. There were 865 patients included into the final analysis, the average age of them were 66+-10 years, 437 patients in the distance group and 428 in the standard group, they were followed at average 24 months. The difference between two groups were too little to achieve statistical difference. The remote group experienced a 38% decrease compared to the control

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group in the trial's composite outcome, which included 2-year rates of CV hospitalizations, CV emergency department admissions, and CV in-office follow-ups. The major endpoint's separate parts are hardly distinguishable from one group to another. While there has been no significant reduction in VC-related mortality or device-related hospitalization and risks, office visits and utilization of health care resources have been significantly reduced.

With another study with ICD, participation in this trial was open to patients with newly installed ICDs or those without cardiac resynchronization therapy who satisfied one of three criteria: recent diuretic medication, recent brain natriuretic peptide rises, or past hospitalization for HF. Two groups of individuals were created at random. The first group would receive an alarm system, when the alarm altered, then the information would transmit into text massage and would be sent to physicians. The second group would just receive standard care and no alarms. What special about the fist group was that a special algorithm was used during the study, the algorithm could review the device data and telephone contact so that it can assess symptoms and possible treatment. There were 1002 patients that were followed about 2 years. Hospitalization for cardiovascular disease and all-cause mortality served as the trial's main endpoints. The main endpoint was reached by 227 patients in the first group and 239 individuals in the second group. 59 patients in the former group died and 63 patients in the latter group died. 30% of alarms were followed by medical assistance, while 24% were not conveyed at all. The device has not significantly influenced patients with ICD with advanced HF [9]. This trial also put up an idea that whether the patients will follow physicians' treatment methods may becoming a challenge in future telemedicine field.

However, in another report of clinical trial, participants were patients who had either Class II or Class III NYHA symptoms [10]. They had an IHM-ICD implant and were randomized into two groups at random. Based on the hemodynamic data, the therapy would be administered to the patients who are in the treatment group. The patients who are in control group would just receive standard treatment and were not available to the information. The trial only managed to enroll 400 patients despite being intended to register 1300 participants due to the IHM's lead failure. The device could not overall test the endpoint of the trial. High baseline filled pressures are present in patients at high risk for decompensated HF, and they consistently rise as obstruction worsens until admission. This trial did not show much conclusion.

3. Conclusion

These eight trials are focusing on the advantages and disadvantages in the using of the telemedicine comparing with tradition clinic treatment. All these eight trials did not show any significant advantages comparing with tradition clinic treatment, only a little bit increase. The advantages of these trials are mainly in long term monitoring and the improvement of life quality. The implanted devices are not completed perfectly, many of them have led to diseases. Although the diseases were later cured, it also brought negative effects on patients. The safety of the implanted devices should be increased and the quality of the devices should be also ensured. The participants of these trials are not enough, there supports to be more people that included in these trials that could have a better and specific conclusion. There are more trials that need to be done to get more data. The programs and algorithms that needed to be programmed more intelligent so that the telemedicine can rely on less care workers. The telemedicine could combine with the VR (virtual reality) technology, depending on VR technology, experts can know better patients' symptoms and the devices can use medicine more accurate. Depend on VR technology, 5G technology, related programs, algorithms and also long-distance monitoring, the telesurgery can be better and better. There are also some challenges in telemedicine, telemedicine charges are very high, it is not yet covered by health insurance, large hospitals tend to be closed in their case banks for serious and difficult diseases, and do not disclose their own cases, so the motivation for sharing and large-scale data connection is unclear. In a nutshell, the telemedicine has developed fast in this decade, but there are a lot of things that needed to be done to complete this system, and the prospects for telemedicine are very good.

DOI: 10.54254/2753-8818/20/20230748

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