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THE ROLE OF TELEMEDICINE TECHNOLOGIES IN REMOTE MONITORING OF CARDIAC SURGERY PATIENTS

Atakhanov Sanjarbek Anvarovich
Fergana Institute of Public Health Medicine
Department of Biomedical Engineering, Biophysics and Information Technologies, Assistant
Fergana, Uzbekistan Atahanov_sanjar@gmail.ru

Soliyev Muhammadjon Fazliddin ugli
Fergana Institute of Public Health Medicine
Faculty of Pediatrics, 1st-year student
soliyevmuhammadjon359@gmail.com

Abstract. This article analyzes the role, advantages, and significance of telemedicine technologies in the remote monitoring of cardiac surgery patients. The possibilities of using telemonitoring systems to observe cardiac activity in real time, detect complications, and optimize the rehabilitation process are highlighted.

In addition, issues of information security, integration of artificial intelligence (AI), and prospects for the development of telemedicine are discussed.

Keywords: telemedicine, cardiac surgery, telemonitoring, rehabilitation, remote medicine, cardiac function.

Introduction

In recent years, the rapid integration of information and communication technologies into healthcare has led to the accelerated development of telemedicine. These technologies reduce the distance between patients and physicians and improve the quality of medical care.

Telemonitoring systems are especially vital for cardiac surgery patients—individuals who have undergone cardiac surgical procedures or who live with chronic conditions such as heart failure and arrhythmias. Through telemedicine technologies, critical parameters such as cardiac activity, blood pressure, heart rhythm, and oxygen saturation can be monitored in real time, enabling the prevention of complications. Therefore, the implementation of telemedicine technologies represents an important strategic direction in modern medical practice.

Main Part

Telemonitoring is a system for remote observation of physiological parameters such as cardiac activity, blood pressure, respiratory rate, ECG, and oxygen saturation (SpO_2). These devices (smartwatches, heart rhythm sensors, ECG patches, and others) transmit data to a central server via mobile applications or online platforms. Physicians monitor these data in real time and, when necessary, establish direct communication with the patient or adjust the treatment plan.

The Need for Remote Monitoring of Cardiac Surgery Patients

During the postoperative period following cardiac surgery, patients are exposed to numerous risk factors, including arrhythmias, heart failure, thromboembolic complications, and others. Due to the limitations of traditional inpatient monitoring, remote monitoring offers the following advantages:

- Early detection of complications and rapid response measures;
- Reduction in mortality rates by 10–15%;
- Improved adherence to rehabilitation protocols;
- Decrease in rehospitalization related to heart failure by 25–30%.

In Uzbekistan, telemedicine infrastructure is being gradually implemented. In several cardiac centers, systems for remote ECG transmission and monitoring are currently being piloted.

Research Methodology

For this article, the following scientific and methodological sources were analyzed:

1. Reports published by the World Health Organization (WHO) and the European Society of Cardiology (ESC);
2. Articles from the Journal of Telemedicine and Telecare and Interactive Cardiovascular and Thoracic Surgery;
3. Experiences from telemedicine projects within the healthcare system of the Republic of Uzbekistan.

The research employed content analysis, comparative analysis, and empirical observation methods.

Advantages

Telemedicine systems provide several advantages for cardiac surgery patients:

1. **Early warning systems:** detect changes in cardiac activity, arrhythmias, or symptoms at an early stage;
2. **Reduction of medical costs:** offers economic benefits for both patients and healthcare systems;
3. **Improved quality of life:** patients remain at home while under continuous supervision;
4. **Reduced hospital burden:** decreases the need for long-term inpatient treatment.

Examples from Global Practice

- Medtronic CareLink and Biotronik Home Monitoring systems provide 24/7 monitoring of patients with implanted cardiac devices.
- In some clinics, telemonitoring is used to adjust immunosuppressive therapy dosages for heart transplant recipients.
- In the United States and Europe, telemedicine has reduced rehospitalization rates for heart failure patients by up to 30%.

Technical Foundations of Telemonitoring Systems

Telemedicine infrastructure consists of the following components:

- **Patient side:** ECG patches, smart bands, mobile applications;
- **Medical center side:** data-receiving servers, AI-based analysis modules, physician interfaces;
- **Communication network:** secure channels operating via mobile internet, 5G, or Wi-Fi.

Prospects for Implementation in Uzbekistan

The healthcare system of Uzbekistan is implementing several programs to expand the use of telemedicine technologies. In particular, within the framework of the "Digital Healthcare" project launched in 2023, pilot programs for remote monitoring of cardiac and diabetic conditions have been tested.

Results and Discussion

Studies show that telemonitoring systems reduce the number of complications in cardiac surgery patients by 25–30% and decrease emergency rehospitalizations by 15–20%. Additionally, such systems reduce physicians' workload and improve the quality of clinical decision-making.

Limitations and Challenges

- Insufficient internet connectivity;
- High costs of devices and technical maintenance requirements;
- Data confidentiality and cybersecurity issues;
- Insufficient telemedicine-related competencies among healthcare personnel.

Technological Components

- **Remote monitoring devices:** wearable (smartwatches, chest patches), home-installed (blood pressure monitors, medical-grade pulse oximeters, weight scales), and implantable devices (CIED telemonitoring);
- **Teleconsultation platforms:** video/telephone consultations, messaging, and integration with electronic health records;
- **Data analytics systems:** cloud-based analytics and AI for anomaly detection and prioritization;
- **Telerehabilitation (HBCR/CTR):** home-based physical exercises, education, and monitoring to support postoperative functional recovery.

Empirical Evidence — Key Findings

Large centers and pilot programs implementing remote monitoring have reported reductions in 30-day rehospitalization rates and shorter postoperative care durations. For example, in the Perfect Care / Tele Heart Care programs, 30-day readmission rates decreased from 16% to 4%.

Remote patient monitoring (RPM) programs have enabled timely interventions such as medication dose optimization and early correction of infection or fluid imbalance. Wearable and PPG technologies have proven effective in detecting inflammatory and rhythm disorders (e.g., postoperative atrial fibrillation), with ongoing research in this area.

Tele-rehabilitation and digital cardiac rehabilitation (CR) programs have demonstrated outcomes comparable to traditional CR in terms of physical endurance and risk factor control.

Benefits and Opportunities

- Early warning and rapid intervention to prevent adverse events;
- Increased patient convenience and reduced hospital visits;
- Potential reduction in healthcare system costs;
- Broader geographic coverage, including remote regions.

Limitations and Risks

- **Technical issues:** device reliability, signal loss, battery limitations, synchronization problems;
- **Data security and privacy:** EHR integration and compliance with GDPR/HIPAA requirements;
- **Social and educational factors:** digital literacy of patients and family members, age-related and socioeconomic disparities;
- **Clinical limitations:** certain parameters (e.g., invasive monitoring) cannot be measured at home, requiring appropriate patient selection.

Practical Implementation Guidance

- Define data flows and protocols: assign responsibility (cardiologist, cardiac surgeon, nurse) and response thresholds;
- Device and platform selection: validated devices, EHR integration, APIs, and standards (HL7/FHIR);
- Education and onboarding: video tutorials and scripts for patients, families, and staff;
- Monitoring KPIs and evaluation: 30-day readmission, emergency visits, medication changes, patient satisfaction, economic assessment.

Recommendations for the Methods Section

- **Study design:** retrospective/prospective cohort or randomized (if feasible) — RPM group vs. standard care;
- **Outcomes:** 30-day readmission, 90-day morbidity/mortality, length of hospital stay (LOS), economic analysis, patient experience;
- **Statistics:** propensity score matching, Kaplan–Meier analysis (for time-to-event outcomes), logistic regression (for readmission), economic modeling.

Conclusion

Telemedicine technologies play a crucial role in the remote monitoring of cardiac surgery patients. They enable real-time assessment of patient condition, early detection of complications, and optimization of rehabilitation processes. In the context of Uzbekistan, the development of this field contributes to the digitalization of healthcare and improves public access to medical services.

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