



MATHEMATICAL MODELLING FOR BLOOD VESSEL BY MONITORING

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Abstract. *Accurate diagnosis of vascular diseases, particularly cardiovascular disorders, using daily monitoring techniques such as Holter monitoring, blood pressure monitoring, and heart rate monitoring, plays a crucial role in modern medicine. However, the effectiveness of these methods is often limited by several challenges, including incomplete data, device interference, short monitoring durations, and difficulties in interpreting large volumes of data. Furthermore, the variation in daily conditions and patient behavior complicates data analysis, and the lack of personalized approaches to interpretation may hinder optimal treatment. This paper discusses the key issues faced by healthcare professionals in daily monitoring for vascular diseases, and outlines necessary advancements in wearable technology, data analysis systems, multilevel monitoring, and remote monitoring technologies. The goal is to improve the precision of vascular disease diagnosis and enhance patient care through technological innovations and integration of data from diverse sources.*

Key words: *Vascular diseases, daily monitoring, Holter monitoring, blood pressure monitoring, heart rate monitoring, wearable technology, artificial intelligence, data analysis, personalized medicine, remote monitoring, cardiovascular disorders.*

Accurate diagnosis of vascular diseases using daily monitoring (Holter monitoring, blood pressure monitoring, heart rate monitoring, and other parameters) presents several significant challenges. While these methods are powerful tools for assessing cardiovascular conditions, their diagnostic accuracy is sometimes limited by various factors. Below are the key issues faced by specialists during daily monitoring:

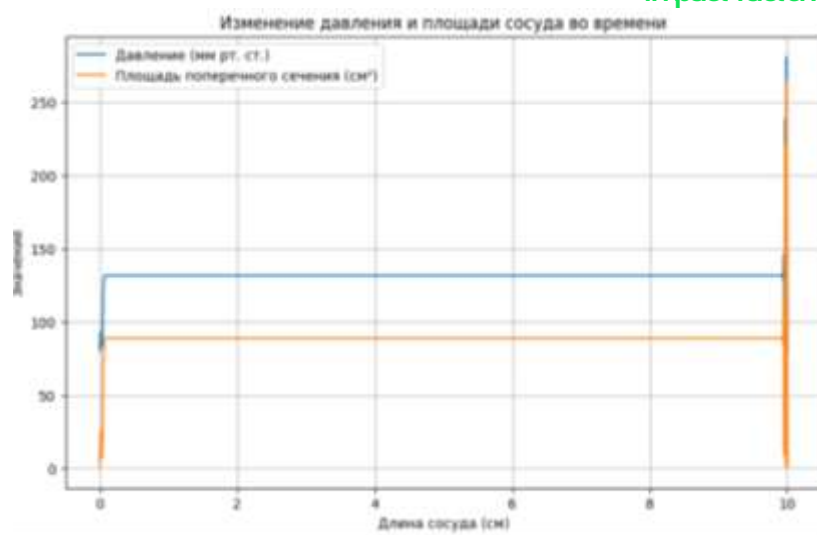


Fig.1.1. Changing pressure and surface area of the vessel

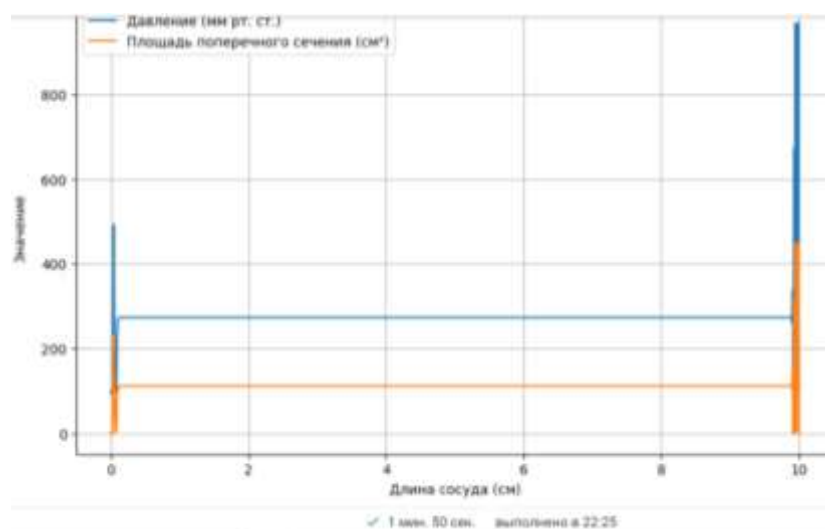


Fig.1.2. Changing pressure and surface area of the vessel

1. Incomplete Data and Interference

- **Noise and interference:** During a patient's daily activities, data can be distorted by interference (e.g., patient movement, electrical devices, or incorrect electrode placement), reducing measurement accuracy.
- **Recording gaps:** Some devices may intermittently lose signal, leading to data gaps. This complicates the assessment of arrhythmias or blood pressure fluctuations.
- **Device limitations:** Not all monitoring devices can accurately measure all necessary parameters, such as heart rate variability, blood oxygen level (SpO_2), or blood pressure during activity.

2. Limited Time Frames

- **Short monitoring duration:** Daily monitoring (24–48 hours) may be insufficient to detect rare arrhythmia episodes or other vascular issues. Some events may occur outside the observation window, making diagnosis more difficult.
- **Lack of long-term observation:** A more complete picture requires longer monitoring (several days or weeks), but this is not always practical, and prolonged use of devices causes discomfort for patients.

3. Data Interpretation Errors

- **Large volumes of data:** Daily monitoring generates massive amounts of data requiring interpretation. Automated algorithms may misclassify individual events (e.g., extrasystoles or atrial fibrillation), leading to false positives or false negatives.
- **Human factor:** Interpreting daily monitoring data demands experience and expertise. Errors in interpretation by a physician may result in misdiagnosis or improper treatment.

4. Data Variability Due to External Conditions

- **Daily routine variations:** Physical activity, sleep, stress, and food intake can significantly affect parameters like blood pressure and heart rate. Without accounting for these, it's difficult to interpret the data accurately. For example, blood pressure fluctuations may be normal during exercise but dangerous at rest.
- **Medication effects:** In patients taking drugs (e.g., antihypertensives or antiarrhythmics), monitoring results may differ from typical patterns, making it harder to detect real abnormalities.

5. Patient Discomfort and Altered Behavior

- **Patient discomfort:** Wearing a monitoring device continuously for 24 hours or more can cause discomfort. Patients may experience skin irritation or difficulty sleeping, which reduces data quality.

- **Changed behavior:** Due to wearing the device, patients may not behave as they normally would, which can distort monitoring results. For example, a patient may avoid physical activity or alter their routine to avoid disrupting the equipment.

6. Lack of a Personalized Approach

- **Generic data interpretation:** Monitoring is typically based on standardized parameters, without considering individual patient characteristics such as personal blood pressure variability, activity levels, or health conditions. This can lead to inappropriate therapy.
- **Lack of personalized recommendations:** Most devices are unable to automatically provide personalized treatment recommendations based on the data, requiring additional interpretation by a doctor.

7. Incomplete Coverage of Vascular Disease Aspects

- **Limited monitoring parameters:** Most daily monitors measure blood pressure and heart rate but cannot assess important parameters such as arterial stiffness, circulating blood volume, or inflammation levels, which are critical for vascular diagnosis.
- **Lack of information about small vessels:** Many circulatory problems are related to microvessels (e.g., diabetic angiopathy), which cannot always be assessed with standard monitoring.

Necessary Improvements and Programs

To improve the accuracy of vascular disease diagnosis using daily monitoring, the following innovations and programs are needed:

1. Development of wearable technology:

Advanced monitoring devices capable of recording data over longer periods (e.g., several weeks) and measuring a wider range of parameters, including arterial stiffness, heart rate variability, SpO₂, and metabolic indicators.

2. Automated data analysis systems:

The use of artificial intelligence and machine learning for more accurate data interpretation and identification of hidden patterns that may be missed by the human eye. These systems can also help provide personalized recommendations.

3. Multilevel monitoring systems:

Comprehensive programs that integrate data from wearable devices, lab tests, and other medical sources to create a complete picture of the patient's health.

4. Remote monitoring technologies:

Telemedicine and remote monitoring programs that allow doctors to track changes in a patient's condition in real-time and adjust treatment as needed.

Conclusion

Improving the accuracy of vascular disease diagnosis through daily monitoring necessitates not only the enhancement of diagnostic equipment and analytical methods but also the development of innovative programs to integrate diverse sources of medical data. This integration will enable more accurate diagnoses, facilitate personalized treatment plans, and improve overall patient care. By addressing the current challenges, such as data quality, monitoring duration, and device limitations, healthcare systems can enhance the precision and effectiveness of vascular disease management. Furthermore, advancements in wearable technologies, automated data interpretation using AI, and remote monitoring systems will play a pivotal role in revolutionizing the field of cardiovascular health.

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