USING AND DETERMINATION OF DAILY MONITORING SOFTWARE IN DIAGNOSING VASCULAR DISEASES

Dilafruz Nurjabova
Ph.D. student of Tashkent University of Information Technologies,
100084, Tashkent,Uzbekistan
E-mail: dilyaranur1986@gmail.com

Abstract. This article covers the possibilities of software-based daily monitoring in the early detection and control of vascular diseases. With the help of outpatient arterial pressure monitoring (ABPM), the patient's daily physiological indicators are recorded and methods for processing and analyzing data through software tools are described. Furthermore, based on mathematical modelling and algorithmic approaches, effective ways of determining blood pressure dynamics, heart rate rhythms, ischemic changes, and arrhythmias are indicated. The article states that the integration of daily monitoring with modern software systems increases diagnostic accuracy and expands the possibility of detecting vascular diseases at an early stage.

Keywords: Daily monitoring, outpatient arterial pressure monitoring, Holter ECG, software, mathematical model, heart rhythm, ischemic change, arrhythmia, diagnosis of vascular diseases.

Annotatsiya. Mazkur maqolada qon-tomir kasalliklarini erta aniqlash va nazorat qilishda sutkalik monitoring dasturiy ta‘minot asosida qo‘llanish imkoniyatlari yoritilgan. Ambulator arterial bosim monitoringi (ABPM) yordamida bemorning sutkalik fiziologik ko‘rsatkichlari qayd etilishi, dasturiy vositalar orqali ma’lumotlarni qayta ishlash va tahlil qilish usullari bayon etiladi. Shuningdek, matematik modellashtirish va algoritmik yondashuvlar asosida qon bosimi dinamikasi, yurak urish ritmlari, ishemik o‘zgarishlar hamda aritmiyalarni aniqlashning samarali yo‘llari ko‘satib o‘tiladi. Maqola sutkalik monitoring zamonaviy dasturiy tizimlar bilan integratsiyalashuvi natijasida diagnostika aniqligi oshishini va qon-tomir kasalliklarini erta bosqichda aniqlash imkoniyati kengayishini ta’kidlaydi.

Kalit so‘zlar: Kundalik monitoring, ambulator arterial bosim monitoringi, Xolter EKG, dasturiy ta'minot, matematik model, yurak ritmi, ishemik o'zgarish, aritmiya, qon tomir kasalliklari diagnostikasi.

Аннотация. В данной статье рассматриваются возможности применения программного обеспечения для суточного мониторинга для раннего выявления и контроля сосудистых заболеваний. С помощью амбулаторного мониторинга артериального давления (АБПМ) регистрируются суточные физиологические показатели пациента, описываются методы обработки и

ISSN 3030-3907

анализа данных с помощью программных средств.ннотация. В данной статье рассматриваются возможности применения программного обеспечения для суточного для раннего выявления и контроля сосудистых заболеваний. С помощью амбулаторного мониторинга артериального давления (АБПМ) регистрируются суточные физиологические показатели пациента, описываются методы обработки и анализа данных с помощью программных средств. Также будут показаны эффективные способы определения динамики артериального давления, сердечного ритма, ишемических изменений и аритмий на основе математического моделирования и алгоритмических подходов. В статье подчеркивается, что в результате интеграции суточного мониторинга с современными программными системами повышается точность диагностики и расширяется возможность выявления сосудистых заболеваний на ранней стадии.

Ключевые слова: ежедневный мониторинг, амбулаторный мониторинг артериального давления, Холтеровская ЭКГ, программное обеспечение, математическая модель, сердечный ритм, ишемические изменения, аритмии, диагностика сосудистых заболеваний.

I.INTRODUCTION

Cardiovascular diseases are currently the leading cause of death worldwide. According to the World Health Organization (WHO), more than 17 million people die from cardiovascular disease each year. The early detection, treatment, and prevention of these diseases is one of the most important tasks in medicine. Short-term blood pressure or ECG recordings measured under traditional clinical conditions do not fully reflect the patient's real daily condition. This is because the patient may be agitated in the clinic and the indicators may be distorted by temporary factors. Therefore, 24-hour monitoring methods have been introduced into medical practice [1,2,3,4,5].

There are two main types of 24-hour monitoring:

1. Ambulatory arterial pressure monitoring (ABPM) - a method of regularly recording a patient's blood pressure for 24 hours[1,2,3,4,5].

2. 24-hour ECG monitoring (Holter monitoring) - Recording of electrical activity of the heart using a portable recording device.

With the help of these methods, the physician will be able to assess the physiological and pathological changes that occur during the patient's daily life. Today, 24-hour monitoring is widely used in cardiology. We will dwell separately on the practical application of both methods[1,2,3,4,5].

II.METHODS AND ALGORITHMS

ISSN 3030-3907

ABPM records the patient's blood pressure throughout the day and night. The main practical applications of this method are as follows:

• Diagnosis of hypertension: identification of "white coat hypertension" and "latent hypertension";

• Evaluation of drug efficacy: determination of the duration and effectiveness of antihypertensive drugs;

• Prognosis: preliminary assessment of the increased risk of stroke and heart failure in patients without a physiological decrease in night pressure;

Holter monitoring is intended more for monitoring heart rhythm. It is used in the following cases:

• Detection of arrhythmias: paroxysmal tachycardia, ventricular extrasystoles, episodes of atrial fibrillation;

• Evaluation of ischemia: detection of latent myocardial ischemia by depression or elevation;

• Evaluation of treatment effectiveness: monitoring the performance of antiarrhythmic drugs or pacemakers;

• In sports and occupational medicine: monitoring of heart rhythm during physical exertion[1,2,3,4,5].

Today, 12-channel Holter monitoring is available, which provides much more information than simple 1-to2-channel systems. It is especially sensitive to detect ischemic changes[6,7,8,9,10].

24-hour monitoring is distinguished from other diagnostic methods by the following features:

1. Continuous observation - provides real-time information for 24 hours;
2. Application in daily activities - The patient continues his usual work, so the results reflect real-life conditions;
3. Assessment of circadian rhythm - allows you to compare day and night indicators;
4. Possibility of statistical analysis: average values, dispersion, variability, and level are calculated;
5. Prognostic power - allows you to preestimate the risk of hypertension, cardiac ischemia, stroke, and heart failure[6,7,8,9,10].

Table with the main types of ECG devices and programmes used for electrocardiogram-based diagnostics:

ISSN 3030-3907

Table-1.

ECG devices and programmes used for diagnostics based on electrocardiograms

Device type	Type of program	Country of origin	Possibilities	Flaws
12-channel stationary ECG machine	**CardioSoft (GE Healthcare)**	USA	Multi-channel recording, data storage and analysis capabilities, PC integration	Expensive and requires professional maintenance
Portable ECG machine	**KardiaMobile (AliveCor)**	USA	ECG recording via smartphone, arrhythmia analysis, ease of use	Limited number of channels, limited analytical capabilities
Wearable devices with ECG sensor	**Apple Health (Apple Watch)**	USA	Continuous heart rate monitoring, alerts about irregularities	Accuracy depends on proper wearing, limited functionality compared to medical devices
Holter monitor	**ZioPatch (iRhythm Technologies)**	USA	Long-term monitoring (up to 14 days), automatic data analysis	High cost, data processing time
Stationary ECG monitor	**EpiCardio (Epigenics)**	South Korea	High accuracy and ability to analyze complex rhythms	Requires inpatient placement and patient connection
Wireless ECG devices	**QardioCore (Qardio)**	USA	Continuous monitoring, data transfer via cloud services	High cost and limited analytical capabilities
Implant - integrated devices	**Merlin (Abbott)**	USA	Continuous monitoring,	Surgery required, high cost

ISSN 3030-3907

			real-time data transmission	
ECG smartphone	**ECG Dongle (Nordavind)**	Russia	Easy to use, sync with smartphone, rhythm analysis	Limited diagnostic capabilities, mobile device dependent
Home ECG Monitor	**Beurer ME90 (Beurer)**	Germany	Simple interface for home use, data transfer to doctor	Limited analytical capabilities
Diagnostic ECG machine	**QRS Diagnostics**	USA	Accurate ECG analysis, support multi-channel recordings	Training required for proper use

Table-2.

ECG devices and programmes used for diagnostics based on electrocardiograms

Device type	Type of program	Country of origin	Possibilities	Flaws
12-channel stationary ECG machine	**CardioSoft (GE Healthcare)**	USA	Multichannel recording, automatic recognition of arrhythmias, infarctions, hypertrophy, integration with PC and cloud	High cost, requires professional training to set up and use
Portable ECG machine	**KardiaMobile (AliveCor)**	USA	Arrhythmia analysis (including atrial fibrillation), smartphone compatibility , instant results	The accuracy is lower than that of clinical devices; The analysis is limited to a few types of arrhythmias

ISSN 3030-3907

Wearable devices with ECG sensor	**Apple Health (Apple Watch)**	USA	Continuous monitoring of heart rhythm, atrial fibrillation analysis, alerts about possible violations	Limited accuracy, not intended for complex medical diagnoses, requires confirmation by clinical tests
Holter monitor	**ZioPatch (iRhythm Technologies)**	USA	Long-term monitoring (up to 14 days), automatic recognition of arrhythmias and pauses, long-term recording	High cost, delay in providing analysis due to recording time
Stationary ECG monitor	**EpiCardio (Epigenics)**	South Korea	High accuracy, analysis of complex rhythms, diagnostics of coronary heart disease, infarction, arrhythmia, in real time	Requires patient connection to the device, not always convenient for outpatients
Wireless ECG devices	**QardioCore (Qardio)**	USA	Continuous monitoring, cloud analytics, mobile integration, heart rate assessment	Limited diagnostic functions, dependent on internet connection

ISSN 3030-3907

Implant - integrated devices	**Merlin (Abbott)**	USA	Continuous monitoring, automatic data transfer to the doctor, possibility of diagnosing tachycardia, bradycardia	Requires surgery for installation, high cost
ECG smartphone	**ECG Dongle (Nordavind)**	Russia	Easy to use, quick rhythm analysis via smartphone, data recording in the app	Limited analysis capabilities, requires a smartphone to operate
Home ECG Monitor	**Beurer ME90 (Beurer)**	Germany	Easy to use, data transfer to the doctor, possibility of diagnosing arrhythmias, self-monitoring of the condition	Does not provide diagnostics for complex cases, no deep data analysis
Diagnostic ECG machine	**QRS Diagnostics**	USA	Support for multichannel recording, accurate diagnosis of myocardial infarction, arrhythmia, ischemia, integration with software	High cost, training required to operate the device

ISSN 3030-3907

Table-3.

ECG devices and programmes used for diagnostics based on electrocardiograms in Uzbekistan

Device type	Type of program	Country of origin	Possibilities	Flaws	Use in Uzbekistan
12-channel stationary ECG machine	**CardioSoft (GE Healthcare)**	USA	Multichannel recording, automatic recognition of arrhythmias, infarctions, hypertrophy, integration with PC and cloud	High cost, requires training	Used in large medical centers
Portable ECG machine	**KardiaMobile (AliveCor)**	USA	Arrhythmia analysis, smartphone connection, instant results	Lower accuracy, limited diagnostic functions	Not common
Wearable ECG device (Apple Watch)	**Apple Health**	USA	Continuous rhythm monitoring, irregularity notifications, iPhone compatibility	Limited accuracy, not for complex diagnoses	Not used
Holter monitor	**Holter Monitor (BPL)**	India	Long-term monitoring (up to 48 hours), registration of	Requires professional interpretation	Used in cardiology clinics

ISSN 3030-3907

			arrhythmias, ischemia		
Holter monitor (ZioPatch)	**ZioPatch (iRhythm Technologies)**	USA	Long-term monitoring (up to 14 days), automatic recognition of pauses and arrhythmias	High cost and requires lengthy analysis	Not used
Wireless ECG device	**QardioCore (Qardio)**	USA	Continuous monitoring, integration with mobile devices, cloud analytics	Limited functionality , internet dependent	Not used
ECG machine for home use	**Beurer ME90 (Beurer)**	Germany	Self-use, data transfer to a doctor, arrhythmia diagnostics	Limited analysis capabilities	Possible in private practice
Diagnostic ECG machine	**QRS Diagnostics**	USA	Multichannel recording, diagnostics of infarction, arrhythmia, ischemia	High cost, training required	Used in large clinics

Additional explanations:

- 12-channel ECG machines and Holter monitors are most often used in large medical centres and cardiology clinics in Uzbekistan.
- Some devices, such as KardiaMobile and QardioCore, are more popular in the US and Europe, but have not gained widespread distribution in Uzbekistan.
- ECG analysis programmes such as CardioSoft and Holter Monitor are actively used for diagnostics and monitoring in the cardiology departments of Uzbekistan.

ISSN 3030-3907

In the field of diagnostics and treatment of diseases associated with blood thickening, there are several key problems and needs that require attention. Furthermore, the development and implementation of modern programmes and technologies play an important role in the timely and accurate detection of hypercoagulation-associated pathologies[6,7,8,9,10].

Problems in the diagnosis and management of blood thickening

1. Late diagnosis:

Often patients do not realize they have circulatory problems until serious complications such as thrombosis, heart attack, or stroke occur. Screening programmes for early blood thickening are not well developed.

2. Insufficient number of specialised tests:

To detect blood clotting disorders, complex and expensive tests are required, such as thromboelastography, tests for genetic mutations (for example factor V Leiden). These tests are not available in all clinics and may not be available in certain regions.

3. Low public awareness:

Many patients are not sufficiently informed about the risk factors for blood thickening, such as sedentary lifestyle, dehydration, or taking hormonal drugs, leading to increased morbidity[6,7,8,9,10].

4. Lack of a personalised approach:

Standard treatment regimens are not always suitable for each patient, as hypercoagulation can be caused by different reasons and require individual tactics. For example, the same anticoagulant may not be suitable for all patients.

5. Monitoring of patients' condition:

Monitoring the condition of patients with blood clotting diseases is difficult, especially if constant monitoring and adjustment of therapy is required.

Necessary programmes and technologies for accurate diagnostics:

1. Development of personalised medicine:

Programmes that analyse multiple risk factors for each patient according to their condition, genetic predisposition, lifestyle, and associated diseases. Such systems can recommend optimal prevention and treatment methods.

2. Telemedicine platforms:

Programmes that allow you to remotely monitor blood parameters (for example, coagulation level, SpO2, blood pressure and other important parameters). Use of wearable devices with integration into health monitoring applications (smart watches with the ability to measure heart rate and blood oxygen saturation) [6,7,8,9,10].

3. Screening programmes for early detection:

ISSN 3030-3907

National programmes that will allow all age groups to undergo screening tests to detect predisposition to thrombosis and other blood clotting disorders, especially in high-risk patients (hereditary thrombophilia, pregnant women, and the elderly)[11,12,13,14].

4. Computer programmes for coagulogram analysis:

Modern systems based on artificial intelligence for interpreting the results of blood coagulation tests, such as coagulogram, with the ability to quickly assess the risk of thrombosis and recommend therapy[11,12,13,14].

5. Integrated laboratory diagnostic systems:

Software that allows laboratories to process complex tests, such as clotting gene tests or inflammation biomarkers, more quickly and accurately. This speeds up the diagnosis process and improves the precision of treatment.

6. Risk assessment and prevention programmes:

Platforms that help doctors and patients assess the risk of hypercoagulability based on everyday data such as physical activity, nutrition, and stress levels. These programmes can generate recommendations for lifestyle changes to reduce the risk of thrombosis.

7. Programmes for automatic control of anticoagulants:

Automated systems that monitor the correct dose of anticoagulants (e.g., warfarin) based on coagulation parameters such as international normalised ratio (INR), with alerts to patients and physicians if abnormal values are detected[11,12,13,14].

8. Mobile applications for self-monitoring:

Mobile applications that allow patients to independently measure and monitor blood clotting parameters at home using portable devices and receive recommendations for adjustment of therapy[11,12,13,14].

ISSN 3030-3907

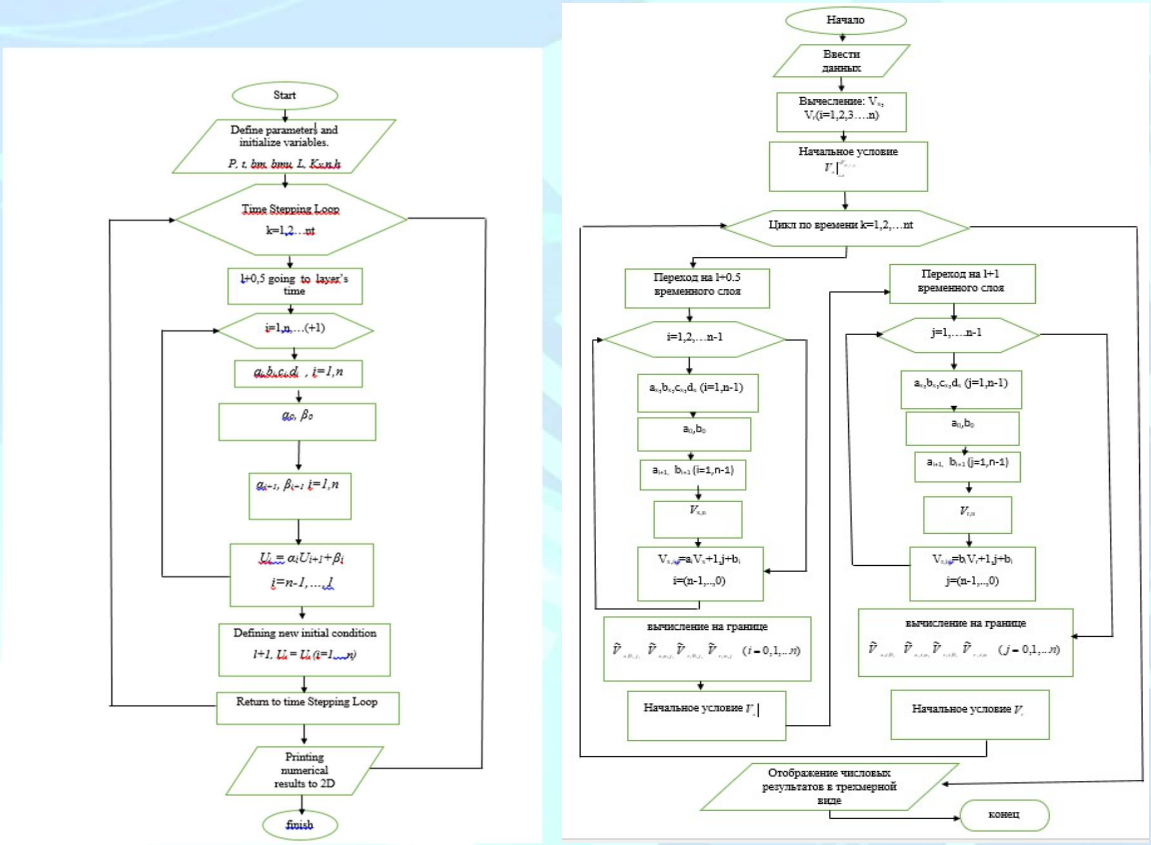


Fig. 1. Block diagram of the blood vessel algorithm for the vascular system.

The two flow charts in Figure.1. illustrate the algorithms for modelling blood vessel. Although both are designed to perform calculations on the vascular system, they differ significantly in their structure and operating mechanisms. The flow chart on the left is relatively simple and performs mainly iterative calculations over time. At the beginning of the algorithm, initial parameters and conditions are entered, and then blood flow parameters are calculated at each time step using a "time-stepping loop"[15,16,17,18,19,20,21]. At each step, the necessary values are determined using various mathematical expressions and the initial conditions are updated. Finally, the results are processed and displayed in the form of a two-dimensional graph. The main feature of this algorithm is to model blood flow in a general way and to monitor dynamic changes over time. The flow chart on the right is more complex, in which the calculation is carried out in two directions: iterating over time and over vascular segments[15,16,17,18,19,20,21]. After entering the initial conditions, the algorithm runs two cycles: one is performed by time steps, and the other by vascular segments. At each step, a wide range of parameters (*a, b, c, F, V*, etc.) is calculated, boundary conditions are checked, and the results are updated step by step. Finally, detailed results are obtained for all segments and displayed in a visual form. Although this algorithm is more complex, it allows for a deeper analysis of the physiological processes of the vascular system divided into segments[15,16,17,18,19,20,21].

ISSN 3030-3907

In general, the block diagram on the left is based on simple iterative calculations in time, whereas the block diagram on the right performs multicycle calculations in two directions - by time and by segment. As a result, the first scheme provides simple and fast modelling, while the second allows for a more detailed and in-depth physiological analysis[15,16,17,18,19,20,21]. The main differences between the two block diagrams manifest themselves in several aspects. First, if we focus on the level of complexity, the scheme on the left is simpler, performing mainly iterative calculations over time. The scheme on the right is more complex, in which, along with time, multi-cycle calculations are performed over vascular segments. From a coverage point of view, the scheme on the left models the overall blood flow process; that is, it aims at observing the overall dynamics of the process. The scheme on the right allows for the analysis of the vascular system into individual segments, as a result of which the model becomes more accurate and detailed. There is also a difference in the amount of calculation: the left scheme works faster due to the fact that it contains fewer parameters and requires relatively less computer resources. The right scheme requires more parameters and calculations, but thereby allows for a deeper reflection of physiological processes. As a result, the left scheme provides a simple graphical representation of the overall dynamics of blood flow, while the right scheme records detailed results distributed by segments. Thus, the left scheme is convenient for quick and general modelling, while the right scheme is more effective for precise and comprehensive analysis[15,16,17,18,19,20,21].

III. DISCUSSION

Accurate diagnosis of vascular diseases using daily monitoring (Holter 24-hour monitoring (monitoring of blood pressure, heart rate, and other parameters) has several significant problems. Although such methods are a powerful tool for assessing cardiovascular diseases, the accuracy of diagnosis is sometimes limited by various factors[15,16,17,18,19,20,21]. Here are the key problems that specialists face when performing 24-hour monitoring:

1. Incomplete data and interference:

- Noise and interference : During daily patient activities, interference in the recorded data (eg, patient movement, electrical devices, or improper placement of electrodes) may occur, reducing the accuracy of readings.
- Gaps in the recording: Some devices may periodically lose their signal, causing data gaps. This can make it difficult to assess arrhythmias or blood pressure fluctuations.

ISSN 3030-3907

• Limitations of devices : Not all 24-hour monitoring devices can accurately measure all necessary parameters, such as variable heart rate, blood oxygen level (SpO2), or blood pressure during activity.

2. Limited time frame

• Limited duration of monitoring: 24-48 hour monitoring may not be sufficient to detect rare episodes of arrhythmia or other vascular problems. Some events may occur outside of the observation period, making diagnosis difficult.

• Disadvantage of long-term monitoring: Longer monitoring (several days or weeks) is required to obtain a more complete picture, but this is not always practical and prolonged use of devices causes discomfort in patients.

3. Errors in the Interpretation of the Data

• Large volumes of data: 24-hour monitoring generates a huge amount of information that needs to be interpreted. Automatic algorithms may misclassify individual events, such as extrasystoles or atrial fibrillation, and this can lead to false positive or false negative results[15,16,17,18,19,20,21].

• Human factor: Interpreting 24-hour monitoring data requires experience and knowledge. Interpretation errors by the physician may lead to an incorrect diagnosis or treatment[15,16,17,18,19,20,21].

4. Data heterogeneity depending on conditions

• Changes in daily routine: Physical activity, sleep, stress, and food intake can significantly affect measurements such as blood pressure and heart rate. Without taking these factors into account, it is difficult to accurately interpret the data. For example, fluctuations in blood pressure can be normal during exercise, but dangerous at rest[15,16,17,18,19,20,21].

• Drug effects: Patients taking medications (eg, antihypertensives or antiarrhythmics) may have different monitoring results than usual, making it difficult to detect true abnormalities.

5. Poor and inadequate patient behaviour

• 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 the quality of the data[15,16,17,18,19,20,21].

• Changes in habitual behaviour: Wearing the devices can cause patients to behave differently than usual, which may distort the monitoring results. For example, the patient may avoid physical activity or change their daily routine to avoid disrupting the equipment[15,16,17,18,19,20,21].

6. Lack of a personalised approach

• General Interpretation of the Data: Monitoring is usually based on standardised parameters, without taking into account individual characteristics of each patient,

ISSN 3030-3907

such as individual variations in blood pressure, physical activity, and health status. This may lead to inappropriate therapy.

• Lack of personalised recommendations : Most devices cannot automatically offer personalised treatment recommendations based on the data received, which requires additional interpretation by a physician[15,16,17,18,19,20,21].

7. Lack of complete coverage of all aspects of vascular diseases

• Limited monitoring parameters: Most 24-hour monitors measure blood pressure and heart rate, but cannot assess parameters such as arterial stiffness, circulating blood volume, or inflammation levels, which are also important for diagnosing vascular disease[15,16,17,18,19,20,21].

• Lack of information on the status of small vessels : Many circulatory problems are related to microvessels (eg, diabetic angiopathy), which cannot always be assessed using standard monitoring.

To improve the precision of vascular disease diagnostics by daily monitoring, the following innovations and programmes are needed:

1. Development of wearable technologies:

Improved monitoring devices that can record data over longer periods of time (for example, weeks) and measure a wider range of parameters, including vascular stiffness, heart rate variability and metabolic parameters [15,16,17,18,19,20,21].

2. Automated data analysis systems:

Using artificial intelligence and machine learning to interpret data more accurately and detect hidden patterns that escape the human eye. This can also help to provide personalised recommendations.

3. Multilevel monitoring systems :

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

4. Remote monitoring technologies:

Telemedicine and remote monitoring programmes that allow physicians to track changes in a patient’s condition in real time and adjust treatment if necessary[15,16,17,18,19,20,21].Therefore, to improve the accuracy of vascular disease diagnostics based on daily monitoring, it is necessary not only to improve equipment and analysis methods but also to develop new programmes to integrate various data and improve the quality of medical care[15,16,17,18,19,20,21].

Importance in the diagnosis of vascular diseases:

• Hypertension: ABPM accurately records the daily dynamics of blood pressure and the effectiveness of treatment is monitored[15,16,17,18,19,20,21].

ISSN 3030-3907

• Ischemic heart disease: Holter monitoring detects ischemic episodes by recording latent ST-segment changes.
• Arrhythmias: indicate paroxysmal or nocturnal heart rhythm disturbances.
• Risk of stroke: Non-dipper blood pressure at night increases the risk of stroke.
• Heart failure: decreased heart rate variability (HRV) indicates the severity of the disease.

IV. RESULTS

The accurate diagnosis of blood vessel diseases using 24-hour monitoring (blood pressure, heart rate, and other parameters) presents several significant challenges. Although such methods are a powerful tool to assess cardiovascular diseases, the diagnostic accuracy is sometimes limited by various factors. Key challenges faced by specialists with 24-hour monitoring include:

1. Incomplete data and interference

• Noise and interference: During daily patient activities, interference can occur in recorded data (such as patient movement, electrical devices, or improper placement of electrodes), reducing the accuracy of the readings.
• Gaps in the recording: Some devices may periodically lose their signal, resulting in data gaps. This may make it difficult to assess arrhythmias or fluctuations in blood pressure.
• Device limitations: Not all 24-hour monitoring devices can accurately measure all necessary parameters, such as variable heart rate, blood oxygen levels (SpO2), or blood pressure during activity.

2. Limited time frame

• Limited duration of monitoring: 24-48 hours of monitoring may not be sufficient to detect rare episodes of arrhythmia or other vascular problems. Some events may occur outside of the observation period, making diagnosis difficult.
• Disadvantage of long-term observations: Longer monitoring (several days or weeks) is required to obtain a more complete picture, but this is not always practical, and prolonged use of devices causes discomfort in patients.

3. Errors in the Interpretation of the Data

• Large volumes of data: 24-hour monitoring generates a huge amount of information that must be interpreted. Automatic algorithms may misclassify individual events, such as extra systoles or atrial fibrillation, and this may lead to false positive or false negative results.
• Human factor: Interpreting 24-hour monitoring data requires experience and knowledge. Interpretation errors by the physician may lead to an incorrect diagnosis or treatment. 4. Data heterogeneity depending on conditions

ISSN 3030-3907

• Changes in daily routine: Physical activity, sleep, stress, and food intake can significantly affect parameters such as blood pressure and heart rate. Without taking these factors into account, it is difficult to accurately interpret the data. For example, blood pressure fluctuations can be normal during exercise, but dangerous at rest.

• Effects of medications: Patients taking medications (such as antihypertensives or antiarrhythmics) may experience abnormal monitoring results, making it difficult to detect true abnormalities.

4. Patient discomfort and inappropriate behaviour

• Patient discomfort: Wearing a monitoring device continuously for 24 hours or more can be uncomfortable. Patients may experience skin irritation or difficulty sleeping, which reduces the quality of the data.

• Changes in habitual behaviour: Wearing devices may cause patients to behave differently from usual, which may skew the monitoring results. For example, a patient can avoid physical activity or change their daily routine to avoid disrupting equipment.

5. Lack of a personalised approach

• General interpretation of the data: Monitoring is usually based on standardised parameters, without taking into account the characteristics of each patient, such as individual variations in blood pressure, physical activity, and health status. This can lead to inappropriate therapy.

• Lack of personalised recommendations: Most devices are unable to automatically offer personalised treatment recommendations based on the data obtained, which requires additional interpretation by a physician.

6. Incomplete coverage of all aspects of vascular diseases

• Limited monitoring parameters: Most 24-hour monitors measure blood pressure and heart rate, but cannot assess parameters such as vascular stiffness, circulating blood volume, or the level of inflammation, which are also important for the diagnosis of vascular diseases.

• Lack of information on the state of small vessels: Many circulatory problems are associated with microvessels (eg, diabetic angiopathy), which cannot always be assessed using standard monitoring.

ISSN 3030-3907

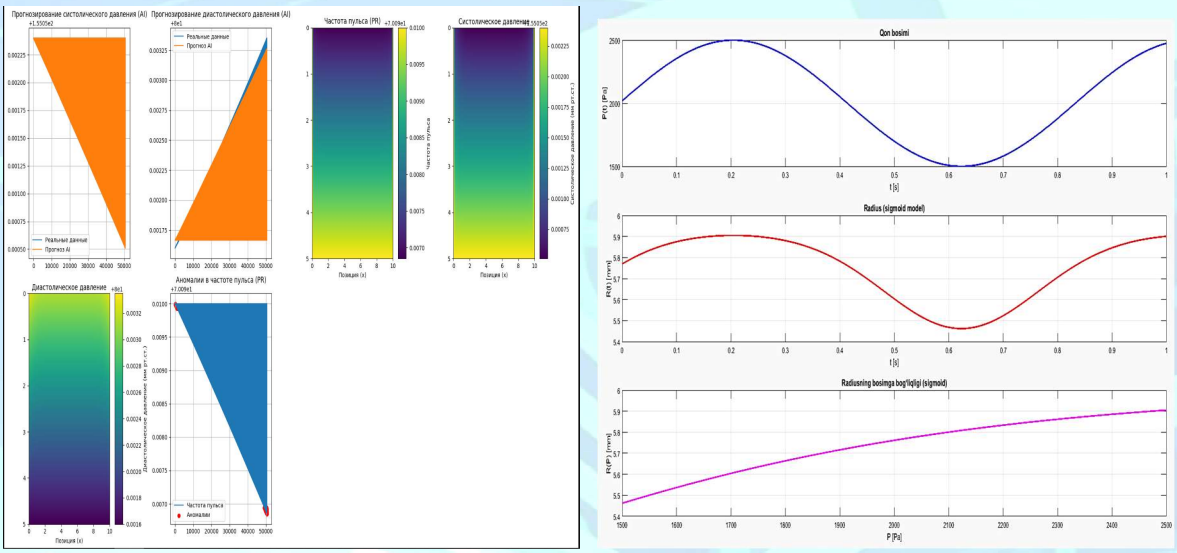


Fig.2. Predicted systolic pressure and results of blood pressure.

1. Top left graph (predicted systolic pressure). The graph compares the actual systolic pressure and the calculated (predicted) values. As can be seen, the values are close to each other, which indicates a high reliability of the model. The colour filling in the area shows the deviation between the actual and predicted values[15,16,17,18,19,20,21].

2. The second graph on the top left (predicted diastolic pressure, ADd). Here, the prediction of diastolic blood pressure (lower pressure) is presented. The actual and predicted values are in an almost linear relationship, which means that the model reflects vascular elasticity well[15,16,17,18,19,20,21].

3. Top-right graphs. By frequency (pulse, JPS): The distribution of heart rate is depicted in the form of a colour gradient. The range of lower and upper values is clearly shown. The relationship between systolic pressure and frequency is also depicted. It is clear that high-frequency indicators have a direct impact on dynamic pressure changes.

4. The graph on the lower left (diastolic pressure, ADd). The change in diastolic pressure over time or another parameter is depicted. The gradient colour distribution shows the dynamics of change[15,16,17,18,19,20,21].

5. The graph on the lower right (Diastolic pressure and pulse rate comparison).The graph shows a negative correlation between diastolic pressure and heart rate. That is, when the pulse accelerates, the diastolic pressure tends to decrease, which is also physiologically logical: At a high heart rate, the phase of cardiac relaxation (diastole) is shortened.

The modelled results are close to the real clinical data and show the relationship between blood pressure and heart rate. Forecasts of systolic and diastolic pressures are recorded with high precision. The relationship between heart rate (HR) and pressure is consistent with physiological laws. These results may be

ISSN 3030-3907

useful for predicting the cardiovascular system and early detection of various pathologies using a software model[15,16,17,18,19,20,21].

V. CONCLUSION

24-hour monitoring (ABPM and Holter) plays a very important role in the diagnosis and prognosis of cardiology. It is an effective tool for clarifying the clinical diagnosis of the patient, monitoring the effectiveness of treatment, and early detection of latent diseases. In particular, 12-channel Holter monitoring allows for comprehensive recording of the heart's electrical activity, providing in-depth analysis of ischemic disease and arrhythmias. Holter monitoring and ambulatory blood pressure monitoring (ABPM) are important diagnostic tools in the diagnosis of cardiovascular disease and they perform different functions. Holter monitoring is designed mainly to continuously record the electrical activity of the heart. It allows you to detect heart rhythm, conduction disturbances, and ischemic changes for 24–48 hours[15,16,17,18,19,20,21]. This method is very useful for detecting latent arrhythmias that are not visible on a short-term ECG. It also provides effective results in assessing the effect of drugs. However, Holter monitoring has some disadvantages: it does not measure blood pressure, but only provides information about heart rhythm, and prolonged contact of the electrodes with the skin can cause discomfort to the patient. Ambulatory blood pressure monitoring automatically records arterial pressure for 24 hours, usually every 15–30 minutes. This method is widely used in the diagnosis of hypertension, as it shows the difference between blood pressure measured in a clinical setting and observed in daily life. For example, it is very convenient for detecting ‘white coat syndrome” or “hidden hypertension”. Additionally, it allows you to assess the risk of cardiovascular disease with more accuracy by recording changes in pressure during the day and night. However, this method also has disadvantages: frequent cuff inflation can disrupt sleep, and it does not provide complete information on heart rhythm. In general, Holter monitoring plays an important role in monitoring heart rhythm and electrical activity, while ABPM plays an important role in assessing blood pressure in dynamics. Using the two together allows for a more detailed and accurate study of the state of the cardiovascular system. This software is designed to predict and analyse blood pressure, processing data obtained from daily monitoring through mathematical modelling. The graphs compare the actual values of systolic and diastolic pressure with the predicted results. Their closeness indicates the high accuracy and reliability of the model. The programme also shows the relationship between blood pressure and pulse rate and allows you to analyze how physiological processes change over time using colour diagrams. Compared to Holter ECG, the main difference of this software is that Holter monitoring

ISSN 3030-3907

records heart electrical activity for 24–48 hours and is aimed at identifying arrhythmias, ischemia, and conduction disorders. Blood pressure monitoring and modelling are designed to monitor systolic and diastolic pressure and heart rate. Holter monitoring displays the heart rhythm in a graphical form, but does not provide information about blood pressure. The blood pressure modelling programme does not show the electrical activity of the heart, but allows you to analyse the dynamics and prognosis of blood pressure through visual and colour maps. Thus, although the Holter ECG and blood pressure monitoring programme have different aspects, when used together, they allow for a deep and comprehensive assessment of the state of the cardiovascular system.

REFERENCES

1. Flynn JT, Urbina EM, Brady TM, et al. Ambulatory blood pressure monitoring in children and adolescents: update 2022: a scientific statement from the American Heart Association // Hypertension. - 2022. - Vol. 79, no. 7. -P. e114-e124.
2. Basalely A, Hill-Horowitz T, Sethna CB. Ambulatory blood pressure monitoring in pediatrics, an update on the interpretation and classification of hypertension phenotypes // Curr Hypertens Rep. - 2023. -DOI: 10.1007/s11906-022-01231-3.
3. Kim JY, Oh IY, Lee H, et al. The efficacy of detecting arrhythmia is higher with continuous electrocardiographic patch monitoring of 7 days than with Holter monitoring // J Arrhythmia. - 2023. - Vol. 39. - P. 422–429.
4. Hyun S. Evaluation of the diagnostic performance and efficacy of the 24-hour Holter monitor in arrhythmia detection: advantages and limitations // PMC. - 2024.
5. Van Vliet M. Ambulatory atrial fibrillation detection and quantification by... // Nature Digital Medicine. - 2025.
6. Abdelrazik A, Eldesouky M, Antoun I, et al. Wearable devices for the detection of arrhythmias: advancements and clinical implications // Sensors. -2025. -Vol. 25, no. 9. Article 2848.
7. Gonzalez, W., Jin, Y., Bao, T., Huang, Y. Comparison of ambulatory blood pressure monitoring and office blood pressure in primary health care of populations at high risk of hypertension // Front Public Health. -2023. -Article 985730. Frontiers
8. Cepeda M, Pham P, Shimbo D. Status of ambulatory blood pressure monitoring and home blood pressure monitoring for the diagnosis and management of hypertension in the US: an up-to-date review / Hypertension Research. -2023.
9. Lee EM. When and how to use ambulatory blood pressure monitoring // Clin Hypertens. -2024.
10. De la Sierra A. Monitoring of blood pressure in ambulances. Current status and... // ScienceDirect. -2024.

ISSN 3030-3907

11. Chia J. The role of ambulatory blood pressure monitoring in… // Heart Lung Circ. -2022.
12. Sridhar AR, et al. State of the use of the art of mobile health technologies in clinical… // Nature Medicine Sessions. -2024.
13. Nazarian S, Lam K, Darzi A, Ashrafian H. Diagnostic accuracy of smartwatches for the detection of cardiac arrhythmia: systematic review and meta-analysis // J Med Internet Res. -2021. -Vol. 23, no. 8. -e28974.
14. Varma N, et al. 2021 ISHNE/HRS/EHRA/APHRS Expert Collaborative... // Circulation: Arrhythmia and Electrophysiology. -2021.
15. Mayo Clinic. Holter monitor overview and usage in clinical practice // Mayo Clinic resources. -2024.
16. Nurjabova, D., & Ismailova, Z. (2024). DEVELOPMENT AND COUNTING PRESSURE OF ONE DIMENSIONAL MODEL OF FDM FOR BLOOD CAPILLARY VESSEL. Евразийский журнал математической теории и компьютерных наук, 4(12), 7–17. извлечено от https://in-academy.uz/index.php/EJMTCS/article/view/40809
17. Nurjabova, D. (2025). UTILIZING PREDICTION AND MONITORING TECHNIQUES WITH CORRELATION AND REGRESSION MODELS FOR THE ANALYSIS AND MANAGEMENT OF VASCULAR DISEASES. Евразийский журнал математической теории и компьютерных наук, 5(1), 14–25. извлечено от https://in-academy.uz/index.php/EJMTCS/article/view/42777
18. Nurjabova, D., Sayyora, Q., Gulmira, P. (2023). Using Discretization and Numerical Methods of Problem 1D-3D-1D Model for Blood Vessel Walls with Navier-Stokes. In: Koucheryavy, Y., Aziz, A. (eds) Internet of Things, Smart Spaces, and Next Generation Networks and Systems. NEW2AN 2022. Lecture Notes in Computer Science, vol. 13772. Springer, Cham. https://doi.org/10.1007/978-3-031-30258-9_7
19. E. Nazirova, D. Nurjabova, and S. Ismailov, "A Numerical Approach to a Parabolic Equation: The Finite-Difference Method for Blood Vessels," 2024 4th International Conference on Technological Advancements in Computational Sciences (ICTACS), Tashkent, Uzbekistan, 2024, pp. 863-868, doi: 10.1109/ICTACS62700.2024.10841039.
20. E. Nazirova and D. Nurjabova, "Development of Software, a Single-Dimensional Model for Blood Vessels," 2024 4th International Conference on Technological Advancements in Computational Sciences (ICTACS), Tashkent, Uzbekistan, 2024, pp. 856-862, doi: 10.1109/ICTACS62700.2024.10840966.

ISSN 3030-3907

21. Dilafruz Nurjabova (2024). CALCULATING THE VELOCITY OF GLOBAL BLOOD FLOW WITH COMSOLE MULTYPYSICS IN THE CARDIOVESSEL. Eurasian Journal of Mathematical Theory and Computer Sciences, 4 (2), 25-29. doi: 10.5281/zenodo.10679284

ISSN 3030-3907