

И.А. Стародубцева*¹, Ю.А. Шарапова²

¹ — Федеральное государственное бюджетное образовательное учреждение высшего образования «Воронежский государственный медицинский университет им. Н.Н. Бурденко» Минздрава России, кафедра пропедевтики внутренних болезней, Воронеж, Россия

² — Федеральное государственное бюджетное образовательное учреждение высшего образования «Воронежский государственный медицинский университет им. Н.Н. Бурденко» Минздрава России, кафедра госпитальной терапии с курсом эндокринологии, Воронеж, Россия

ДИСТАНЦИОННЫЙ МОНИТОРИНГ АРТЕРИАЛЬНОГО ДАВЛЕНИЯ КАК ИНСТРУМЕНТ ПОВЫШЕНИЯ КАЧЕСТВА ДИСПАНСЕРНОГО НАБЛЮДЕНИЯ ПАЦИЕНТОВ С АРТЕРИАЛЬНОЙ ГИПЕРТЕНЗИЕЙ

I.A. Starodubtseva*¹, Yu.A. Sharapova²

¹ — Voronezh State Medical University n.a. N.N. Burdenko Ministry of Health of Russia, Department propedeutics of internal diseases, Voronezh, Russia

² — Voronezh State Medical University n.a. N. Burdenko Ministry of Health of Russia, Department hospital therapy with the course of endocrinology, Voronezh, Russia

The Distance Monitoring of Blood Pressure as a Tool for Improving of the Quality of Follow-Up Observation of Patients with Arterial Hypertension

Резюме

В статье рассматриваются преимущества дистанционного мониторинга артериального давления у пациентов с артериальной гипертензией. Многочисленные исследования подтверждают увеличение риска сердечно-сосудистых осложнений даже при незначительном превышении показателей артериального давления. И наоборот, снижение значений артериального давления даже на 5 мм рт.ст. уменьшает риск летального исхода. В этой связи важным аспектом является не только назначение корректно подобранной антигипертензивной терапии, но и дистанционный мониторинг достижения и удержания целевых уровней артериального давления. Диспансерное наблюдение пациентов с артериальной гипертензией является эффективным инструментом профилактики сердечно-сосудистых осложнений. Однако, до настоящего времени охват динамическим контролем и достижение целевых показателей артериального давления у пациентов с артериальной гипертензией является одним из наиболее проблемных аспектов.

Результаты исследований отечественных и зарубежных авторов показывают высокую эффективность применения предлагаемых подходов дистанционного мониторинга артериального давления. Положительные результаты в отношении достижения целевого артериального давления уже через 3 месяца показаны при применении технологии телемониторирования артериального давления и дистанционном консультировании больных артериальной гипертензией. Особого внимания заслуживает технология мобильного здравоохранения (mHealth), которая обеспечивает более гибкую платформу для улучшения самообслуживания пациентов.

Ключевые слова: артериальная гипертензия, дистанционный мониторинг артериального давления, технология мобильного здравоохранения, телемедицина

*Контакты: Ирина Александровна Стародубцева, e-mail: starodubtsevairina1@gmail.com

*Contacts: Vera N. Larina, e-mail: starodubtsevairina1@gmail.com

ORCID ID: <https://orcid.org/0000-0002-4665-2966>

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Abstract

This article focuses on the distant blood pressure monitoring for patients with arterial hypertension. As numerous studies show, even slightly elevated blood pressure significantly raises the risk of cardiovascular complications. And, vice versa, a 5 mmHg decrease in blood pressure reduces the lethality risk. Therefore, it is not enough to prescribe the right medication but also it is of paramount importance to monitor patients' compliance with the treatment. Clinical observation of patients with arterial hypertension is an effective tool for the prevention of cardiovascular complications. However, to date, the coverage of follow-up and the achievement of blood pressure targets in patients with arterial hypertension is one of the most problematic aspects. Distance monitoring of blood pressure opens more opportunities for the doctor's involvement, timely assessment and adjustment of the medication. The results of domestic and foreign research show high efficacy of the distance blood pressure monitoring. Positive results regarding the achievement of target blood pressure after 3 months are shown when using the technology of blood pressure monitoring and distance counseling of patients with arterial hypertension. In particular, the article considers the technology of mobile health care (mHealth), which is a more flexible platform for a patient's continuous self-care.

Key words: arterial hypertension, distance monitoring of blood pressure, mobile health technology, telemedicine

Conflict of interests

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АГ — arterial hypertension, BP — blood pressure, FU — follow-up, RFU — remote follow-up, DBP — diastolic blood pressure, CHD — coronary heart disease, CVA — cerebrovascular accident, SBP — systolic blood pressure, DM — diabetes mellitus, CVD — cardiovascular diseases, TMRC — telemonitoring and remote consultation, RF — risk factors, COPD — chronic obstructive pulmonary disease, EML — electronic medical log, EMR — electronic medical records

Over the past 50 years, cardiovascular diseases (CVD) have been the main cause of mortality in the population [1]. According to the ESSE epidemiological study, which covered ten Russian regions, elevated blood pressure is the number one risk factor (RF) of CVD — 33.8% (Fig. 1) [2].

According to the results of the MMM17 (MAY MEASUREMENT MONTH 2017) multicenter study, controlled target BP could not be achieved in 46% of patients with hypertension who received antihypertensive therapy [3].

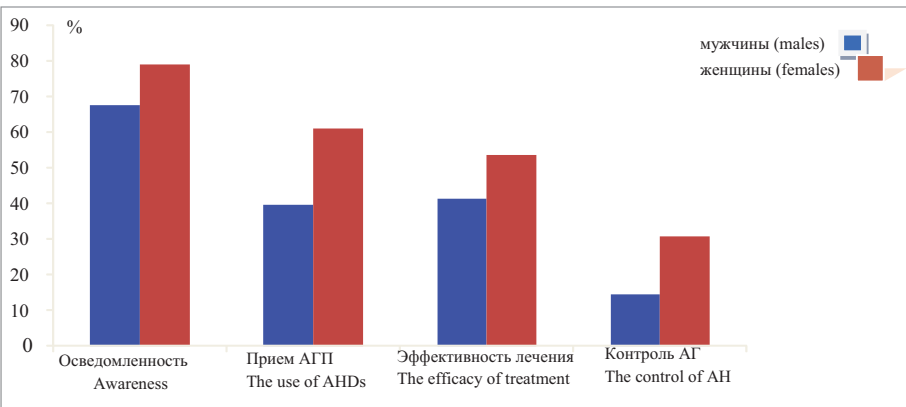


Figure 1. The trial ESSE-RF: the awareness of the presence of arterial hypertension, frequency of antihypertensive drugs uses and blood pressure control

Uncontrolled hypertension is ranked first among risk factors of mortality and is the cause of more than 50% cerebrovascular accidents (CVA) and almost half of coronary heart disease (CHD) cases. The risk of death from CVD doubles if systolic blood pressure (SBP) increases by 20 mm and diastolic blood pressure (DBP) increases by 10 mm [4].

A meta-analysis of 61 prospective observational studies (1 million adults who had not been previously diagnosed with vascular diseases, 12.7 million person-years) showed that a decrease in mean SBP by 2 mm Hg leads to a 10% reduction in the risk of death from CHD and CVA or other vascular causes [5].

According to a large-scale study by Ettehad D. et al. (2016), a decrease from the initial SBP of 130–139 mm Hg by 10 mm Hg (that is, when the level of SBP reaches less than 130 mm Hg during treatment) leads to a significant decrease in the risk of the unfavorable cardiovascular impact of hypertension: CHD — by 12%, CVA — by 27%, heart failure — by 25%, major cardiovascular complications — by 13%, and death from any cause — by 11% [6].

According to the Program of State Guarantees, 43.8 million EMS calls are made annually in Russia. According to the Moscow EMS, CVD-related calls account for 18.8% of that number, of which 60% are due to hypertensive crises [7].

Follow-up (FU) of patients with hypertension is an effective tool for the prevention of cardiovascular complications. However, the coverage of FU and the achievement of target BP in patients with hypertension remains one of the most challenging tasks.

Active preventive measures can reduce the risk of adverse cardiovascular events, subsequent disability and mortality.

Primary care physicians shoulder most of the burden in implementing preventive programs and FU [8, 9]. Given the current shortage of primary care physicians, a number of disadvantages of FU can be identified: its limited scope and low quality, which may be associated, in addition to the shortage of manpower, with a low level of their expertise [9, 10].

In this connection, improving the FU procedure in hypertension is relevant, both in terms of increasing its coverage and improving its quality (achieving and maintaining target levels of health indicators), as well as reducing the number of cardiovascular complications.

The most relevant and acceptable model is remote monitoring, aimed at the simultaneous analysis of a large number of patients using automatic or semi-automatic information summarizing. Remote follow-up (RFU) can theoretically help to reduce the number of visits associated with exacerbation of diseases, as well as unfavorable life-threatening consequences [9].

Therefore, information technologies, including RFU, for solving primary and secondary prevention problems are becoming increasingly relevant [9].

The Experience of Remote BP Monitoring in Russia

To ease the social and economic burden of NID [non-infectious diseases] at the national level as part of international cooperation, Saratov researchers from the Research Institute of Cardiology conducted a study involving the use of BP analysis in 97 hypertensive patients undergoing active outpatient treatment and 102 patients receiving standard outpatient care. The aim of the study was to compare the clinical efficacy of active outpatient care, supported by short message services and mobile telephone technology, with standard outpatient management of patients with hypertension. The study included the analysis of blood pressure, body weight and smoking history. In the group of active outpatient care, 35 (36%) patients with hypertension were excluded from the study during the year: 18 patients with hypertension lost interest in the study, 12 patients declined for technical reasons and five patients refused for an unknown reason. According to the results of one year of observations, 48 (77%) patients from the active treatment group reached the target BP level. This was more than five times higher than in the group receiving standard outpatient care ($p = 0.03$). Odds ratio of achievement and maintenance of target BP in patients receiving treatment (control group) was 5.44; 95% CI 3.2–9.9; $p = 0.005$). The introduction of active outpatient care with the support of short message service and mobile phone technology improves the quality of outpatient care for patients with hypertension. The proposed method is the most affordable way to switch from standard outpatient care to active outpatient care for patients with hypertension (Fig. 2) [11].

For the rapid implementation of effective, innovative methods in large target groups of the population and/or even among the entire population (national or population level), it is necessary to use information technology in healthcare (e-health). The use of such technologies in practical healthcare can contribute to:

- improving the medical literacy of the population, including target groups and healthcare workers on innovative methods of diagnosis, prevention and control of NID and their RF;
- remote consultations/meetings on the provision of specialized medical care, including high-tech medical care;
- monitoring the use of guidelines and their effectiveness in relation to target health indicators [12].

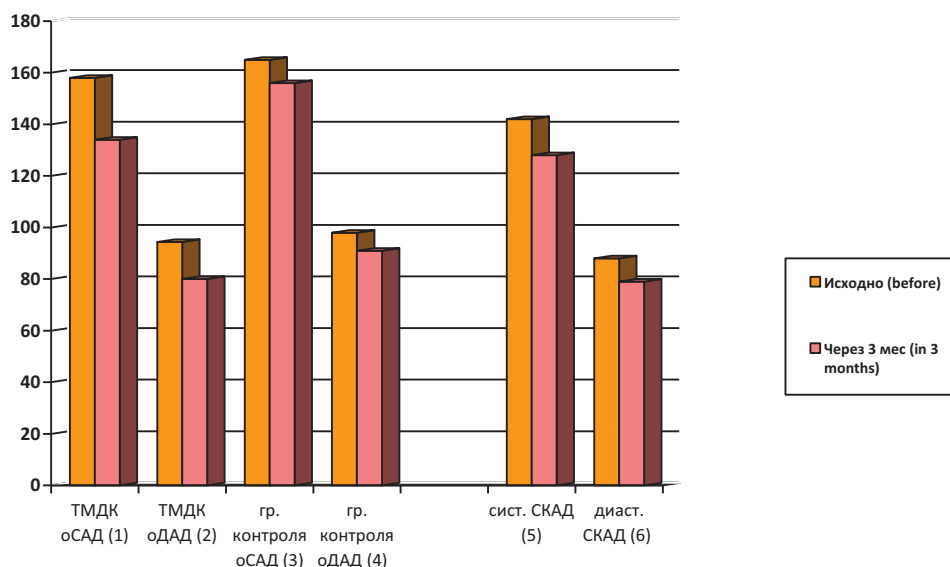


Figure 3. The indicators of «office» and home blood pressure in the study groups

Notes: of SBP — «office» systolic blood pressure; oDBP — «office» diastolic blood pressure; TMDC — telemonitoring of blood pressure and distance consultation; SMBP — self-monitoring of blood pressure. * before — исходно, in 3 months — через 3 месяца
1 — TMDC oSBP; 2 — TMDC oDBP; 3 — control group oSBP; 4 — control group oDBP; 5 — syst. SMBP; 6 — diast. SMBP

groups according to the number of EMS calls, hospitalizations, and the time spent on sick leave. After 12 months, in the main group, the target BP level was achieved in 92.2% of patients, in the control group — only in 43.3% [21].

Therefore, the domestic experience of using remote blood pressure monitoring demonstrates a number of advantages: it increases the proportion of patients with hypertension who have reached target BP values, improves adherence to treatment, reduces the duration of temporary disability and hospitalization, which is economically beneficial, primarily due to fewer requests for medical care and the preservation of human resources in the economy [20]. Based on the cost-benefit analysis of remote blood pressure monitoring in the Russian Federation, it can be concluded that the project should be considered not only effective but also fast-payback and fully viable for regional implementation [20].

Currently, there are some challenges with the implementation of remote BP monitoring in clinical practice. Several electronic medical services have been proposed to solve the monitoring problem. Although they are more patient-oriented and often effective, they still need wired connections to a personal computer with Internet access and navigation, which significantly reduces access for many elderly patients [21].

Remote BP Monitoring in Other Countries

Continuous BP monitoring over the entire FU period in patients with hypertension can be facilitated via

mobile health technology (mHealth — Mobile Health), which is a more flexible platform for improving patient self-care. The World Health Organization (WHO) classifies mHealth under both medical practice and public health practice. The mHealth application is supported by mobile devices such as mobile phones, patient monitoring devices, personal digital assistants and other wireless devices [22]. In addition, the American Telemedicine Association (ATA) considers mobile healthcare as a form of telemedicine [23].

The success of using the mHealth application directly depends on adherence to monitoring schedules and prescribed treatment procedures [24]. A group of scientists from the University of Toronto (Canada) showed that not only in hypertension, but also in other chronic conditions, the use of mHealth contributed to the improvement in indicators reflecting the general condition of the patients [25].

It is known that for accurate diagnosis of hypertension, repeated measurement of blood pressure is recommended, as demonstrated by a group of American researchers [26]. Patients were randomized into three groups. In each group, it was proposed to record the results of BP measurements in an electronic medical log (EML). In the second and third groups, SMS (Short Message Service) messages were used as a reminder to communicate with the patient, including feedback, asking them to send blood pressure measurement results. The report recommended to perform 14 BP measurements. Among 121 patients, 14 measurements were performed more often in the feedback group compared with the first and second groups. The study showed that bidirectional

automated text messaging is an effective way to collect data on the patient's BP. Only text reminders turned out to be an effective way to encourage patients to take BP measurements [26].

Electronic medical records (EMR) and smart computer systems are increasingly having an impact on established approaches in medicine [27]. As a result, the combination of extensive EMR and computer analysis allows to automate the collection of information, data synthesis and feedback from the clinician. These systems, organized in the form of a complex cloud network, allow data sharing using, among other things, mobile online access. It is likely that these approaches will increasingly have an impact on medical education. Since smart computer systems can analyze a large amount of data and share the results of the analysis with suppliers, the focus of medical training can shift for the better. Guidelines will be formed on the use of electronic systems for the treatment of patients. Considering the influence of data processing technologies on many aspects of everyday life, computer technologies adapted in the medical environment will affect the model of the relationship between the doctor and the patient, which will bring potential benefits to both individuals and large groups.

At the same time, foreign researchers also note limitations in the implementation of remote BP monitoring in practice. Clinical decision making depends on complex human factors and personal preferences. In the short term, approaches with automated data collection and machine learning will likely play a largely supporting role in the doctor-patient relationship [27]. In cases of high BP, mHealth improved patients' adherence to antihypertensive drug therapy and contributed to its decrease [27].

McGillicuddy J. W. et al. (2013) conducted a study in which 20 participants were monitored for three months using the prototype mobile healthcare. A BP self-monitoring system was used. Adherence to treatment, usability and results were evaluated. Compared with the control group, the mHealth intervention group showed a significant improvement in adherence to therapy and a significant decrease in the clinical SBP measured monthly. During the three-month trial, the doctors performed more adjustments of antihypertensive treatment in the mHealth group compared to the standard group (seven adjustments in five patients versus three adjustments in three patients) based on the information provided in the weekly reports [28].

The adherence index (degree of the patient's compliance with the doctor's recommendations), previously described by Russell C. L. et al., was used to assess the use of prescribed drugs at the recommended time [29]. Adherence to treatment increased significantly after three months of using mobile healthcare compared to standard

medical care. SBP decreased from 138 to 122 mm Hg and DBP from 88 to 81 mm Hg when using mobile healthcare; in the control group, SBP increased from 132 to 139 mm Hg and DBP increased from 76 to 79 mm Hg after three months. Limitations of the study were associated with the small sample size from one clinical center [29].

The SimCard Study (SimCard trial, 2015) was a randomized, controlled, follow-up study of 2,086 patients over 40 years of age with a high risk of CVD, who reported CHD, stroke, or diabetes mellitus or SBP ≥ 160 mm Hg. Participants in the follow-up group were monitored by health professionals using the Android application monthly; treatment was limited to two medications and lifestyle adjustment. The control group had access to free drugs in primary care centers. Compared to the control group, the comparison group showed a higher incidence of antihypertensive drug use (by 25.5%; $p < 0.001$). In addition, significant differences were found in the assessment of secondary endpoints: an increase in aspirin intake (17.1%; $p < 0.001$) and a decrease in SBP by an average of 2.7 mm Hg ($p=0.04$). This multicenter study showed that mobile technologies are potentially useful for improving adherence to treatment among resource-limited populations [30].

McInnes D. K. et al. (2014) considered the use of mobile phone text messages for veterans in nursing homes to increase their adherence to treatment and reduce the number of no-shows for appointments. To this end, two text message reminders were sent to 20 participants of the study before each of their outpatient visits to the city medical center for veterans [31]. The assessment included questionnaires before and after the visit, open-ended questions (interviews) and a review of medical records. The questions concerned social and demographic characteristics, the experience of using mobile phones (how often), the reasons for making calls on a mobile phone and sending text messages, and the barriers to using a mobile phone. The cost and cost-effectiveness of large-scale implementation were also evaluated. The study participants were pleased to receive text messages, had few technical difficulties and were interested in continuing receiving the reminders. There was a downward trend in the cancellation of visits and no-shows from 53 to 37 and from 31 to 25, respectively ($p = 0.03$). There was also a decrease in admissions to emergency departments ($p = 0.01$) and the number of hospitalizations from 3 to 0 ($p = 0.08$). Researchers concluded that text message reminders were beneficial for veterans.

Telemedicine is increasingly used for remote and timely provision of clinical care, and some studies have shown its effectiveness in treating the most common chronic diseases [32]. Tholomeus is an online telemedicine service that passed clinical testing and is certified for Internet medicine. The service facilitates a closed cycle of

communication between patients and caregivers in accordance with interdisciplinary and complex interventions. Evidence on the effectiveness of the service has been collected over the past decade in 1,471 health facilities. More than 135,000 patients have documented the usefulness of the service in improving access to medical care and improving the screening and treatment of hypertension, CVD, COPD and obstructive sleep apnea. In addition to professional diagnostic tests, the Android™ Tholomeus® app, which has been used by 3,654 consumers over the past three years, has helped to record the high incidence of impaired glucose tolerance, overweight or obesity, dyslipidemia, or uncontrolled BP among users. According to experts, the use of telemedicine in the management of chronic diseases is currently characterized by a high heterogeneity of solutions, often not supported by reliable evidence of clinical efficacy and safety. Tholomeus® meets current recommendations for software designed to be used as a medical device [32]. Today, Tholomeus® is widely used in Italy. The positive experience of Italian colleagues could help ramp up the implementation of the project in Russia. Unfortunately, the web portal is still available only in Italian and English. And this is the only obstacle that limits the ability of Russian patients to actively use the online service to assess their health status.

WHO declared the novel coronavirus disease (COVID-19) pandemic in 2020. Patients with hypertension, DM, cerebrovascular diseases, CHD and COPD are at high risk of COVID-19 complications [33, 34]. One side effect of the measures taken to curb the spread of COVID-19, which involves a range of restrictions, is the late referral in case of life-threatening conditions, as well as an increase in hospitalizations, for example, for hypertension or diabetes [35, 36].

According to the recommendations of the consensus of experts of the Russian Society for the Prevention of Non-Communicable Diseases, Specialized Commission on Therapy and General Medical Practice of the Ministry of Health of the Russian Federation and Specialized Commission on Medical Prevention of the Ministry of Health of the Russian Federation "Providing Outpatient Medical Care to Patients with Chronic Diseases Subject to Follow-Up in the Context of the COVID-19 Pandemic", it is advisable to provide patients with a high risk of complications due to hypertension with personal medical devices (telemedicine tonometers). These devices enable wireless data transmission of diagnostic results to a medical institution, taking into account the accumulated experience of remote monitoring of patients with hypertension, which is the main factor in developing heart attack, stroke and other cardiovascular complications. A telemedicine tonometer can be delivered to a patient via a courier, with the involvement of volunteers. It can also be delivered by medical professionals when

providing medical care to a patient with exacerbation of the disease (during referral to a healthcare facility, in-home medical care, discharge from the hospital, and providing first aid) [37].

Conclusion

The implementation of remote BP monitoring will significantly improve the existing model of diagnosis and treatment of patients with chronic diseases. It will also increase the number of patients observed at each therapeutic site without increasing the follow-up time and encourage the working-age population to utilize primary prevention of cardiovascular diseases. The use of active remote monitoring of patients with hypertension receiving antihypertensive therapy (both in domestic and foreign practice) enables to achieve target BP values with subsequent monitoring of health indicators, as well as timely delivery of medical care.

The data obtained demonstrate an improvement in patients' adherence to antihypertensive treatment with remote monitoring of blood pressure, as well as an increase in the population's satisfaction with the quality of medical care.

The experience of foreign clinicians proves the high efficiency of using mHealth technology for remote BP monitoring in patients with hypertension, focusing on the continuous interaction with the doctor through feedback. Clinical and economic studies, including using mathematical modeling, support the economic feasibility of the widespread implementation of remote monitoring in clinical practice due to a reduced incidence of cardiovascular complications and, as a result, reduced cost of emergency care, hospitalization, and rehabilitation.

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Стародубцева И.А. (ORCID ID: <https://orcid.org/0000-0002-4665-2966>): обзор и анализ литературных источников в отечественных и иностранных базах данных, формирование идеи и структуры, обобщение и сравнительный анализ результатов, окончательное утверждение рукописи для публикации, ответственная за все аспекты работы
Шарапова Ю.А. (ORCID ID: <https://orcid.org/0000-0002-4269-2143>): сбор, анализ и интерпретации данных, научное редактирование

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All the authors contributed significantly to the study and the article, read and approved the final version of the article before publication

Starodubtseva I.A. (ORCID ID: <https://orcid.org/0000-0002-4665-2966>): the review and analysis of literary sources in domestic and foreign databases, formation of ideas and structure, generalization and comparative analysis of the results, final approval of the manuscript for publication, responsible for all aspects of the work.

Sharapova Yu.A. (ORCID ID: <https://orcid.org/0000-0002-4269-2143>): the collection, analysis and interpretation of data, scientific editing

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