

## TELEMEDICAL SYSTEM FOR MONITORING OF BLOOD PRESSURE

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**Summary** It is increasingly clear that the traditional way of measuring blood pressure in the clinic or office frequently produces numbers that grossly overestimate a patient's true blood pressure level. This effect is often caused by so called „white coat“ syndrome. Nowadays, for this reason it becomes more popular so called home monitoring of blood pressure, that attenuates this effect. In the paper, there is described specially telemedicine system for monitoring of blood pressure. The system consists of blood monitor equipment which automatically reports results of up-to-date patient's measurements to the doctor's monitoring and decision support (MDS) system using wireless communication. The MDS system can make an evaluation for the doctor who can immediately intervene if necessary. Introduction of such a system in practice can bring considerable improvement in the treatment of hypertension.

**Abstrakt** Tradičním způsobem měření tlaku krve (TK) v ordinacích praktických lékařů a na klinikách jsou často získávány hodnoty, které značně převyšují pacientův skutečný TK. Tento efekt je většinou způsoben tzv. „syndromem bílého pláště“ (SBP). Nové technologie umožňují rozšíření domácího monitorování TK, které tento syndrom značně potlačuje. V článku je popisován návrh speciálního telemedicínského systému pro monitorování TK. Tento systém se skládá z přístroje pro měření TK, který automaticky zasílá hodnoty měření pomocí bezdrátové komunikace přímo k lékaři, kde jsou tyto hodnoty předběžně vyhodnoceny pomocí systému pro podporu rozhodování (SPR). Popisovaný systém může velmi zefektivnit léčbu hypertenze.

### 1. INTRODUCTION

Blood is carried from the heart to all parts of your body in vessels called arteries. Blood pressure is the force of the blood pushing against the walls of the arteries. Each time the heart beats (about 60-70 times a minute at rest), it pumps out blood into the arteries with different value of systolic pressure SP (highest blood pressure when the heart beats) and different value of diastolic pressure DP (lowest blood pressure when the heart relaxes). Values of SP and DP change during the whole day with dependence on person's physical and psychical activity. In Fig. 1, it can be seen systolic and diastolic blood pressure of a standard healthy patient during one day monitoring. There was a physical activity from 16:00 until 18:00.

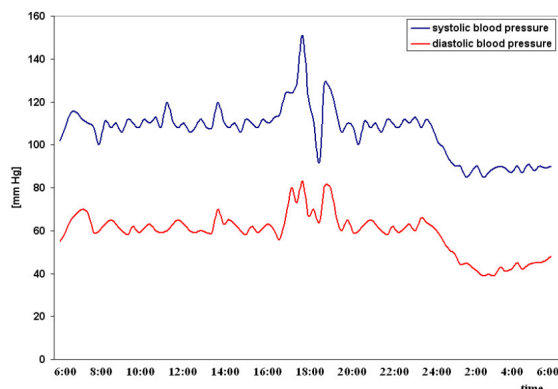


Fig. 1. Ambulant blood pressure monitoring.

For blood pressure measurement we used ambulant blood pressure tonometer (holter) Seiva, which is shown in Fig. 2.



Fig. 2. Ambulant blood pressure monitor Seiva.

Variation of blood pressure during the day is one of several reasons why it is increasingly clear that the traditional way of measuring blood pressure in the clinic or office frequently produces numbers that grossly overestimate patient's true blood pressure level. This is a major problem, since it is one of the most important and frequent measurements made by physicians.

It has been known for more than 50 years that the blood pressures recorded in the clinic are substantially higher than readings taken by the patient at home. This effect is caused by so called „white coat syndrome“ (WCS) that is characterized

by raise of blood pressure due to stress caused by presence of the doctor or measuring procedure itself. Recent studies confirm that the difference caused by WCS is of substantial magnitude; systolic and diastolic pressure measured in the primary care setting (19/11 mmHg) [1]. Self-measurement of blood pressure at home (the method preferred by patients) gives a much smaller WCS (5/6 mmHg) [2], [3].

Table I shows classification of the blood pressure values according to the British Hypertension Society [4]. Difference between measured values in the clinic and patient's true blood pressured level caused by white coat syndrome can mystify the doctor and then the patient is classified to one of the hypertension categories. Consequently, the patients are sometimes treated though they do not need any treatment.

Tab. 1. Classification of blood pressure levels of the British Hypertension Society.

Category	Systolic BP [mmHg]	Diastolic BP [mmHg]
Blood pressure		
Optimal	< 120	< 80
Normal	< 130	< 85
High normal	130 – 139	86 – 89
Hypertension		
Grade 1	140 – 159	90 – 99
Grade 2	160 – 179	100 – 109
Grade 3	≥ 180	≥ 110
Isolated systolic hypertension		
Grade 1	140 – 159	< 90
Grade 2	≥ 160	< 90

## 2. EXPERIMENTAL RESULTS

New technologies offer means to introduce home monitoring of blood pressure that attenuates the white coat effect. However, there are some potential disadvantages. Firstly, if the patients have blood pressure monitor without memory for storing values, they have to write the values themselves but this can decrease reliability of the data. Some patients write their values incorrectly due to their mental condition and capacity [5]. Possible improvement is the monitor with internal memory for measured data. To collect the data the patients have to bring their monitor to the clinic. And each of these transfers negatively affects metrological quality of that equipment. Moreover, the only way how to ensure adequate care is through regular visits of the patients in the clinician's office. This effect can be eliminated with use of Bluetooth transmission [6]. One of the internal parts of blood pressure device is

a Bluetooth module that sends the data to a patient mobile phone. The mobile phone receives the data via its Bluetooth module and then sends sms with it either to a central database or direct to the doctor. Double transmission and necessity of mobile phone with Bluetooth module are considerable drawbacks of this solution.

These disadvantages can be reduced with a special telemedical system for monitoring of blood pressure. Such a system consists of blood pressure monitor equipment which automatically reports results of up-to-date patient's measurements to the doctor's monitoring and decision support (MDS) system using wireless communication. Figure 1 shows basic principle scheme of the telemedical system.

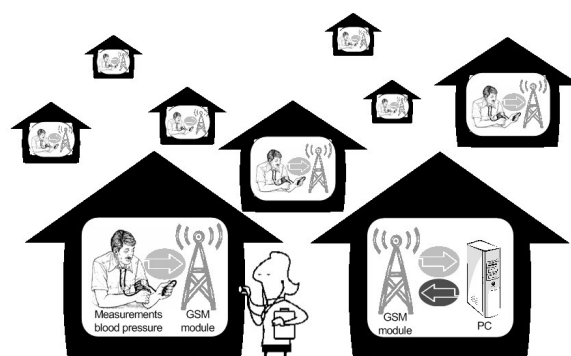


Fig. 3. Principle scheme of the telemedical system for monitoring of blood pressure.

Blood pressure monitor is a standard automatic electronic tonometer. Measurement principle is oscilometrical with the cuff on patient's arm [7]. Internal part of the tonometer is a first GSM module for sending measured values to the second GSM module in doctor's ordination. The second GSM module is connected to the MDS. Transmission is bidirectional and can be in the form of SMS or GPRS. A simple block scheme of the tonometer can be seen in Figure 2. One of the internal parts is also USB module for connection with PC.

The MDS system can make preliminary evaluation of the blood pressure for the doctor who can immediately intervene if necessary. The MDS can evaluate from the blood pressure values and oscilometrical pulsation several secondary parameters such as pulse pressure, stroke volume, cardiac output etc.[8]. Decisions of MDS are often based on some aggregations, e.g. blood pressure trends that are well known from blood pressure hollers. But these trends from telemedical system have more long-time character and are very useful for long-time monitoring of the hypertension.

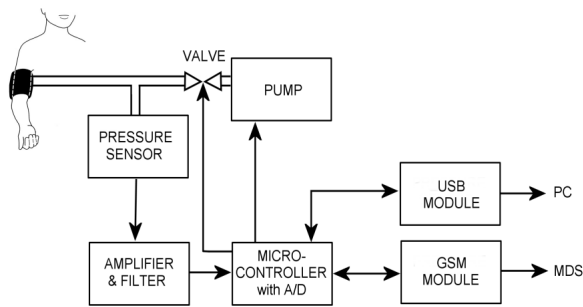


Fig. 4. Simple block scheme of blood pressure monitor.

### 3. CONCLUSION

Several similar solutions of this problem already exist but on the base of Bluetooth transmission [6]. Therefore the necessity of mobile phone with Bluetooth module is a legitimate disadvantage due to its cost. The price of tonometer using Bluetooth transmission is much higher than the price of tonometer with direct transmission via GSM module described in this paper. This solution can bring considerable saving in costs up to 50 % compared to the previous one. Therefore, introduction of the GSM telemedical system in practice can bring expressive improvement in this domain.

The reasons for routinely measuring blood pressure in adults are evident. Raised blood pressure is a common condition that does not have specific clinical manifestations until target organ damage develops. It confers a substantial risk of cardiovascular disease, much of which is at least partially reversible with treatment. Finally, screening adults to detect hypertension early and initiate treatment before the onset of target organ damage is highly cost effective [9]. The home monitoring is a very good and perspective method how to distinguish between real hypertension and sheer patient's nervousness. With this system one can hope to reach more distinct retrenchments and higher efficiency of the treatment.

### REFERENCES

- [1] LITTLE P., BARNETT J., BARNSLEY L., MAEJORAM J., FITZGERALD-BARRON A., MANT D. *Comparison of agreement between different measures of blood pressure in primary care and daytime ambulatory blood pressure.* *BMJ*, 325/2002, pp. 254
- [2] LITTLE P., BARNETT J., BARNSLEY L., MAEJORAM J., FITZGERALD-BARRON A., MANT D. *Comparison of acceptability of and preferences for different methods of measuring blood pressure in primary care.* *BMJ*, 325/2002, pp. 258-259
- [3] MCALISTER F., A., STRAUS S., E. *Evidence based treatment of hypertension -Measurement of blood pressure: an evidence based review.* *BMJ*, 322/2001, pp. 908 - 911
- [4] WILLIAMS B., POULTER N., R., MORRIS B., J., DAVIS M., MCINNES G., T., POTTER J., F., SEVER P., S., THOM MCG S. *British Hypertension Society guidelines for hypertension management 2004 (BHS-IV): summary.* *BMJ*, 328/2004, pp. 634-640
- [5] NORDMANN A., FRACH B., WALKER T., MARTINA B., BATTEGAY E. *Reliability of patients measuring blood pressure at home: prospective observational study.* *BMJ*, 319/1999, pp. 1172
- [6] TensioMed, Internet site address: <http://www.tensio-med.com>
- [7] NG K., G.: *Blood Pressure Measurement.* *Medical Electronics*, 2/1999, pp. 61-65
- [8] JÍLEK J., ŠTORK M. *Systém pro neinvazivní vyšetření krevního tlaku a hemodynamiky.* *Lékař a technika*, 3/2004, ISSN 0301-5491, pp. 33-38
- [9] LITTENBERG B., *A practice guidelines revisited: screening for hypertension.* *Ann Intern Med*, 122/1995, pp. 937-939