

CASE REPORT

# How to easily overlook hypertension in young children? Case studies

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ABSTRACT

**Introduction:** Accurate blood pressure measurement enables proper diagnosis and treatment. Oscillometric devices are popular and comfortable, but verification with auscultatory method is recommended.

**Case reports:** We present two cases of children in whom determining of the real value of blood pressure was challenging. The first was a girl with middle aortic syndrome, whose blood pressure at home was surprisingly well controlled on low doses of antihypertensive medications. The second was a boy whose diagnosis of hypertension was delayed because of false negative results of oscillometric blood pressure measurement.

**Conclusions:** The presented case studies are in line with the recommendation to confirm the results of an oscillometric method with an auscultatory one. Medical assessment should always be based on careful examination, awareness of the natural course of diseases leading to hypertension, and on a comparison between examined and expected symptoms in a particular disease.

KEY WORDS:

blood pressure, hypertension, child.

INTRODUCTION

Using accurate techniques of blood pressure (BP) measurement can provide proper diagnosis and implementation of effective treatment. The invention of oscillometric devices has made regular measurements at the doctor's office and at home quite easy. Nowadays, these devices are popular and widely used in medical practice. However, it is recommended that every measurement should be verified with the auscultatory method, which

is believed to be more accurate [1]. The aim of the case presentations is to draw the attention of physicians to difficulties in proper BP measurement in the context of making the accurate diagnosis and setting treatment.

CASE 1

A two-year-old girl with mid-aortic syndrome (MAS) diagnosed in infancy was admitted to the hospital because of elevated BP. She was also previously diagnosed

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with atrial septum defect (ASD). In the first month of age, she developed hypoxic ischaemic encephalopathy. Magnetic resonance imaging showed multiple periventricular malacic foci, mostly visible around the frontal and parietal lobes (Fig. 1). Later, extensive imaging diagnostics showed an underdevelopment of the cerebral vasculature with significant full-length narrowing of arteries (Fig. 2). The patient was qualified for conservative treatment, including a combination antihypertensive therapy (calcium channel blocker and  $\beta$  blocker), and was monitored for the treatments' effectiveness with regular BP measurements using manual assessment. At home, however, her parents used an oscillometric device validated for self-use (Omron M2 Basic, OMRON Corporation, Japan).

During the follow-up visit, at the age of 23 months, her BP, when measured with auscultatory method, was 140/100 mm Hg. At that time, the values measured by her parents at home did not exceed 105 mm Hg for systolic blood pressure (SBP). The patient was referred to hospital to confirm the real BP value and further treatment. Numerous measurements at the clinic showed the same differences; the correct value by oscillometric method (Mindray VS-900, Shenzhen Mindray Bio-Medical Electronics Co., Ltd. P.R. China, EDAN iM8, EDAN Instruments Inc., Shenzhen, China) and hypertension by auscultatory method. Due to narrow arteries in the central nervous system putting the patient at risk of ischaemia, the decision to intensify the pharmacological treatment was difficult and the consideration of other treatment possibilities (i.e. vascular surgery procedures) using magnetic resonance imaging (MRI) was necessary. MRI diagnostics in the youngest children involves general anaesthesia, so it was decided to perform invasive direct

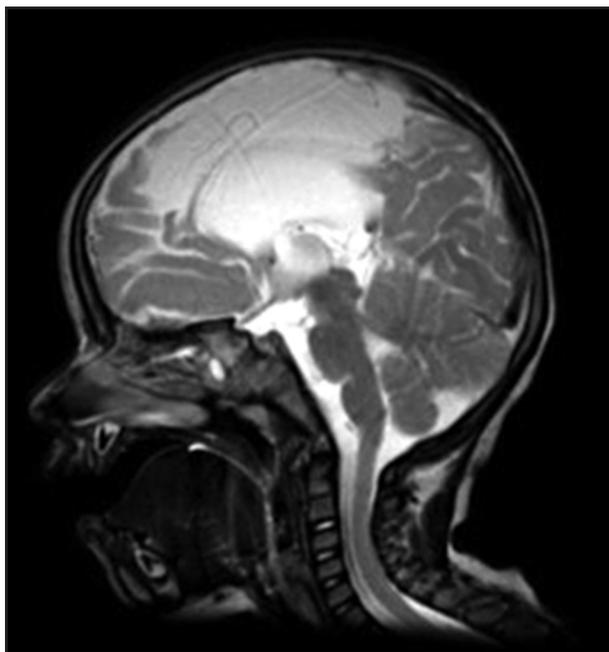


FIGURE 1. Magnetic resonance scan showing multiple periventricular malacic foci, mostly visible around frontal and parietal lobes

BP measurement using an arterial catheter connected to a pressure transducer to test the reliability of the auscultatory method. BP values of 120–200/85–100 mm Hg were measured under sedation, confirming the reliability of the auscultatory method of BP measurement (Fig. 3), and echocardiography showed hypertrophy of left and right ventricle walls. A paediatrician, nephrologist, neurologist, neurosurgeon, cardiologist, and cardiac surgeon agreed on the lack of possibility of vascular surgery procedures. The central nervous system (CNS) arteries were evaluated as being wide enough to lower the SBP to 120 mm Hg as a safe value considering the risk of CNS ischaemia. Lowering the BP was considered crucial in order to maintain a good condition of the myocardium and kidneys. The antihypertensive treatment was modified, and doses of previously used calcium channel blockers and  $\beta$  blockers were increased with good response. The patient's kidney function stabilised at the third stage of chronic kidney disease.

## CASE 2

A three-month-old patient was admitted to the hospital for therapy of *Escherichia coli* (*E. coli*) pyelonephritis. The boy was born from first pregnancy at 40 weeks of gestational age (GA), normal delivery, with a body weight of 3480 g and an Apgar score of 10 points. The prenatal ultrasound did not reveal significant changes in urinary

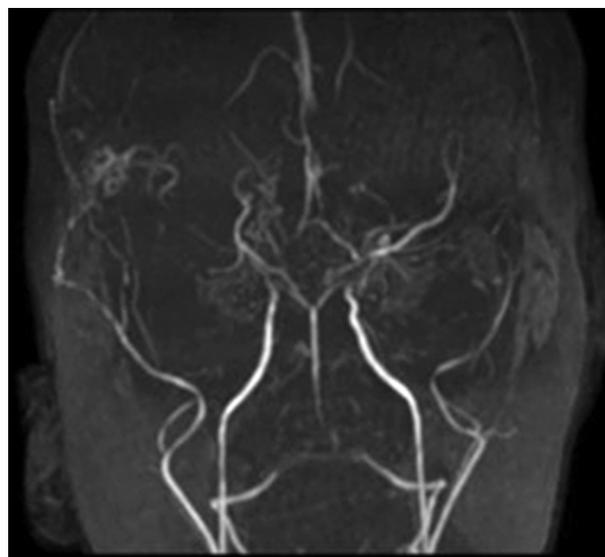
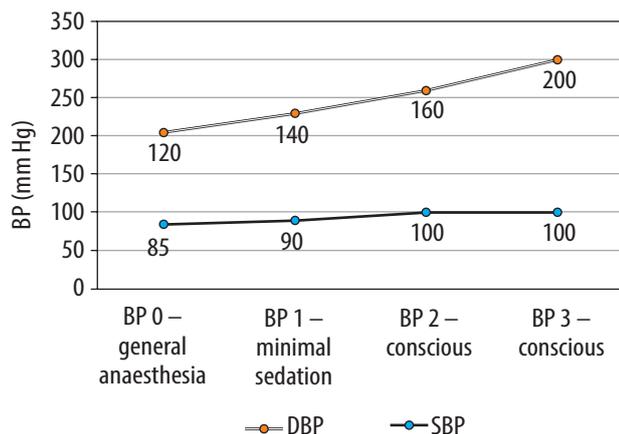


FIGURE 2. Magnetic resonance scan showing underdevelopment of cerebral vasculature with significant full-length narrowing of the arteries. Between right parietal and occipital lobes a cluster of tortuous arteries ( $10 \times 9 \times 9$  mm of total size) is visible with a similar lesion present on the left side in the upper part of the medulla oblongata (sized  $3 \times 7$  mm). The image reflects accidentally localised blood vessels rather than a vascular malformation (...) carotid and intracranial arteries are narrower than usual (the basilar artery of 1.2 mm diameter, the middle cerebral artery of 1.6 mm diameter, the anterior cerebral artery of 1.7 mm diameter, in age-matched peers are measure 3 mm, 2 mm, and 4 mm, respectively)



**FIGURE 3.** Blood pressure (BP) values in direct arterial measurement during recovery from general anaesthesia

tract; after birth hypoplasia of the right kidney was diagnosed. At the age of one month, a nephrologist measured his BP as high using the auscultatory method and referred him for diagnostic hospitalisation. Hypertension was not confirmed; however, all the measurements were assessed using an oscillometric device.

Upon admission to the hospital, apart from symptoms of a urinary tract infection (UTI), the boy was hypertensive – his measured BP values were 130–140/70–90 mm Hg. While the oscillometric assessment results (Mindray VS-900, EDAN iM8) were incoherent, giving lots of normal values throughout all hospitalisation, manual assessment showed that his BP was constantly elevated. An eventual diagnosis of hypertension was finally made, and amlodipine treatment and further diagnostics were started simultaneously. Echocardiography was inconclusive for the cause of hypertension, and only a foramen ovale was detected without signs of myocardial hypertrophy. Doppler ultrasounds of the kidneys revealed a small right kidney with significantly impaired blood flow; however, the renal arteries could not be visualised. Renal scintigraphy showed the right kidney with function of less than 3% and a normal image and function of the left kidney. Voiding cystography revealed right-sided vesico-ureteral reflux (VUR) grade IV/V, and because of the severe VUR to the inactive kidney and hypertension, a right-sided nephroureterectomy was performed at the age of five months. The procedure resolved the UTI problem; however, the patient did not recover from hypertension, although there was transient normalisation of BP after the procedure. At six months of age, computed tomography with angiography (angio-CT) revealed abnormal vasculature of the left kidney with three renal vessels measuring 2–2.5 mm in diameter. The patient was recommended continuous antihypertensive treatment with amlodipine and systematic dose adjustments according to the manual BP readings. After two months of poor response to this treatment, it was decided to change the approach to the treatment. Despite the abnormal renal arterial vascu-

lature, he was transferred to the angiotensin convertase inhibitor (ACE-I) under the strict control of kidney function. The lowest dose of ramipril was commenced, and then the dose was adjusted according to the BP values. Good control of hypertension was obtained with the dose of 1.5 mg (0.15 mg/kg), with no deterioration of kidney function.

## DISCUSSION

This paper presents two cases in which properly measured BP enabled the correct diagnosis and treatment. In the first case, it facilitated determination of how to control BP and what was necessary to safely reduce the end-organ damage. In the second case, it eventually brought diagnosis of hypertension and urinary tract malformations, despite former diagnostic procedures excluding serious disturbances.

BP measurements should be interpreted according to certain normative values. For the auscultatory method, reference values published in the Fourth Report can be applied [1]. For the oscillometric method, Polish reference values for children aged 3–18 years were developed [2]. Therefore, the BP of children below three years of age should preferably be measured manually. From clinical experience, it is possible that when an automatic result of BP measurement is abnormally high, an auscultatory measurement is required to either confirm or reject the result. That is why the guidelines recommend that every automatic result which is higher than the 90th percentile should be confirmed by an auscultatory method [3], and this remains the gold standard.

In the cases presented, the situation was difficult because normal BP results from the automatic measurement were misleading. Theoretically, treatment modification was not required; however, a prolonged incorrect diagnosis could lead to severe consequences. In the first case, chronic exposure to high BP led to organ damage affecting the myocardium and kidneys. In the second case, the organ damage fortunately had not occurred yet, but proper diagnosis was needed to prevent it.

According to the guidelines, BP should be measured at least once a year in children above three years of age without risk factors [4]. Earlier BP assessments are indicated in cases of preterm birth, low birth weight, intensive therapy in the perinatal period, congenital defects, recurrent UTI, kidney and/or urinary tract diseases, neoplastic diseases, bone marrow or organ transplantations, administration of drugs affecting BP, symptoms and diseases arising from hypertension (e.g. neurofibromatosis or tuberous sclerosis), and increasing intracranial pressure.

The need to control the first child's BP was indisputable – she had a vascular defect, which was not a risk factor for hypertension but a cause of it.

Hypertension occurs in 86% of patients with MAS [5]. The most common drug response is insufficient, and the

most efficient method is surgical treatment [6]. The relatively low BP compared to the severity of the defect and low antihypertensive drug doses questioned the reliability of automatic BP assessment.

The second child did not have clear signs of urinary tract defect. In the first month of life, only a mildly widened left kidney pelvis was noticed. Urinary tract diseases are risk factors for hypertension, but the oscillometric measurement results were misleading. Due to the physician's curiosity and determination, a successful diagnosis was established and proper treatment was initiated, and the hypertensive treatment administered reduced the risk of organ damage.

Oscillometric BP monitors are convenient tools that enable quick BP measurement. They are widely used both in ambulatory and during in-hospital treatment, particularly in patients who take antihypertensive drugs. In the oscillometric technique, the oscillating pulse wave generated inside the deflating bladder is examined to determine the BP. The mean intra-arterial pressure corresponds to the point of maximal oscillation [7]. What the device actually measures is the medium BP value followed by algorithmic calculation of the values of systolic and diastolic BP [7, 8]. Preferably, the decision to use an oscillometric monitor should be preceded by assuring proper validation of the device. The British Antihypertensive Society published the list of recommended and validated BP-measuring devices for specialist use and for self-use [9]. Only devices with A or B category should be used. For specialist use, only one validated device is preferable – Mindray Accutor Plus (Shenzhen, China). Although it would be highly appropriate in clinical practice, the device is frequently unavailable, as is the case in our centre. Thus, we can only rely on Mindray's V900 manufacturer brochure informing that the algorithm of measurement was validated, without grading. Nevertheless, in our practice, the presented cases are the only two in which we found an inconsistency between manual and oscillometric assessments. At this point, it is worth stressing that physicians managing hypertension in children should be aware of which devices are validated, and such ones should be used whenever it is possible.

There is no simple answer for the observed inconsistency of the results between manual and oscillometric methods in the cases presented. Studies point to several factors that should be considered: stiffness of the arteries and variability of size, shape, tissue depth, and bone mass of arms [7]. The developed algorithms for the technique are designed to take account of this shape variation in formulating the estimates of systolic and diastolic pressure [10]. Comparison of different commercial models with intra-arterial and Korotkoff sound measurements revealed generally good results [7].

Clinicians managing hypertension in children are undoubtedly aware of how difficult it is to measure BP in

young children. In case 1, we used an invasive method to check BP, but it is not definitely the recommended method in inconclusive cases. We only took the opportunity of scheduled magnetic resonance performed under general anaesthesia. Interestingly, due to problems with BP measurement in small children in some centres in the UK, the common practice is to check BP by using a non-invasive method (Doppler probe) [11]. When deflating a cuff, a sound informs the user about SBP. This method is not common in our practice, but due to its simplicity, it can be considered as a useful procedure in inconclusive cases as a solution to overcome the problem of overlooking hypertension in children.

## CONCLUSIONS

The presented case studies are in line with the recommendation to confirm the results of an oscillometric method with an auscultatory one. Despite normal BP readings, a physician should always be alert to the possibility of observing high BP in patients at risk for hypertension or diagnosed with hypertension. Therefore, more consideration should be given to devices used in practice. Medical assessments should always be based on careful examination, awareness of the natural course of diseases leading to hypertension, and on comparisons between examined and expected symptoms in a particular disease.

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## DISCLOSURE

The authors declare no conflict of interest.

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