

# THE IMPORTANCE OF AMBULATORY BLOOD PRESSURE MONITORING IN CHILDREN AND ADOLESCENTS

Bernardica Valent-Morić, Tamara Žigman, Orjena Žaja-Franulović, Maša Malenica and Martin Ćuk

University Department of Pediatrics, Sestre milosrdnice University Hospital Center, Zagreb, Croatia

**SUMMARY** – The objective of this study was to present our data on ambulatory blood pressure monitoring (ABPM) in children and adolescents referred to our Department because of casual BP elevation over the 95<sup>th</sup> percentile on at least 3 visits in primary care office. ABPM studies in 139 children, 94 boys and 45 girls, mean age 14.14 (range 4-19) years, were reviewed. A total of 107 (76.98%) children had hypertension according to the ABPM criteria. Primary hypertension (PH) was diagnosed in 89 (64.03%), secondary hypertension (SH) in 18 (12.95%) and white coat hypertension (WCH) in 32 (23.02%) children. In both PH and SH groups, hypertension was predominantly systolic (60.67% and 55.56%, respectively). There was no statistically significant difference in diurnal and nocturnal systolic and diastolic blood pressure (BP) loads between PH and SH groups. The non-dipping phenomenon was detected in 49.44%, 66.66% and 40.62% of children with PH, SH and WCH, respectively. The mean pulse pressure values were 60.41, 58.58 and 52.25 mm Hg in the PH, SH and WCH groups, respectively. A statistically significant difference was found in pulse pressure values between PH and WCH ( $df=55$ ,  $t=6.15$ ,  $P<0.01$ ) groups and between SH and WCH groups ( $df=31$ ,  $t=3.18$ ,  $P=0.001$ ). Target organ damage was diagnosed in 16 (17.98%) children with PH and in 5 (27.78%) children with SH. None of the children with WCH had target organ damage. ABPM is indispensable for establishing the diagnosis of hypertension in children. It is the only reliable method of WCH diagnosis.

*Key words: Ambulatory blood pressure monitoring; Hypertension; Children*

## Introduction

The recent obesity epidemic among children and adolescents has been accompanied by a rise in the number of chronic conditions traditionally considered adult diseases, including hypertension, diabetes, hyperlipidemia and the metabolic syndrome, now also seen in this population. According to recent epidemiological studies, hypertension is now a frequent diagnosis affecting up to 5% of children and adolescents<sup>1,2</sup>. However, correct diagnosis of this condition in children continues to present a challenge for

medical practitioners. Auscultation using a mercury sphygmomanometer remains the method of choice for evaluation of hypertension in children, but this technique may miss the diagnosis of white coat hypertension (WCH), masked hypertension as well as isolated nocturnal hypertension.

Over the last decade, ambulatory blood pressure monitoring (ABPM) has consistently proven its superiority over casual BP measurements for predicting morbidity and mortality in adult population<sup>3</sup>. The use of ABPM among pediatric patients has grown considerably since being first described in the early 1990s. Whereas many of its applications remain in the research area, its use in the clinical care setting is now common, as 63% of pediatric nephrologists participating in a 2005 survey reported the use of this technology in at least some portion of their practice<sup>4</sup>.

Correspondence to: *Bernardica Valent-Morić, MD*, University Department of Pediatrics, Sestre milosrdnice University Hospital Center, Vinogradska c. 29, HR-10000 Zagreb, Croatia  
E-mail: [bernardica.valent@zg.htnet.hr](mailto:bernardica.valent@zg.htnet.hr)

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The objective of our study was to present data on ABPM in children and adolescents referred to our Department because of casual BP elevation over the 95<sup>th</sup> percentile on at least 3 visits in primary care office.

## Patients and Methods

We performed a retrospective review of 139 ABPM studies obtained in our Pediatric Department between January 2006 and May 2009. All study children were referred to our Department because of casual BP elevation over the 95<sup>th</sup> percentile<sup>5</sup> on at least 3 visits in primary care office. The mean patient age was 14.14 (range 4-19) years; there were 94 (67.63%) boys and 45 (32.37%) girls.

An oscillometric device (Mobilgraf M01100120, I.E.M. GmbH, Stolberg, Germany) was used. The appropriate cuff was chosen according to current recommendations<sup>6</sup>. Monitors were placed on the child's non-dominant arm by a trained nurse who then educated the child and the parents on the monitor operation.

Monitors were programmed to obtain BP readings every 15 minutes during the day and every 30 minutes at night. The patient's self-reported wake/sleep periods were used to determine diurnal and nocturnal portions of the ABPM studies. ABPM data from the monitor were downloaded into a desktop personal computer once the device was returned. Readings were compared by the software analysis to a threshold value, thereby categorizing the readings as either normal or elevated. Threshold readings were set at the 95<sup>th</sup> percentile for the participant's sex and height, as determined by Soergel *et al.*<sup>7</sup>. Average blood pressure value, diurnal and nocturnal systolic and diastolic blood pressure load, mean pulse pressure value and dipping phenomenon were analyzed. According to ABPM results, the diagnosis of hypertension was established following the guidelines of Lurbe *et al.*<sup>8</sup>. When WCH was diagnosed, follow-up was continued without any additional tests except for those to establish target organ damage. Children with hypertension were classified as having either primary (PH) or secondary (SH) hypertension following a standardized, comprehensive diagnostic evaluation as recommended by the European Society of Hypertension<sup>9</sup>.

BP load analyses were conducted using 25% as the cutoff value. Dipping status was examined by compar-

ing the mean diurnal BP value with the mean nocturnal BP value. Percent dipping for both systolic and diastolic BP was calculated as:  $(\text{mean diurnal BP} - \text{mean nocturnal BP}) / \text{mean diurnal BP} \times 100$ . Target organ damage was defined as ocular, renal, cardiac or presence of two or more target organs in one individual. In all children, target organ damage was established during the initial standardized diagnostic evaluation mentioned above<sup>9</sup>. Left ventricular hypertrophy (LVH) was diagnosed by echocardiography. Microalbuminuria was tested by DCA 2000 Microalbumin/creatinine test (available at: [http://care.diabetesjournals.org/cgi/content/full/28/suppl\\_1/s4](http://care.diabetesjournals.org/cgi/content/full/28/suppl_1/s4)) using the first morning urine sample. For detection of hypertensive retinopathy, dilated fundus examination was used according to Scheie classification<sup>10</sup>.

Two sample T-test assuming unequal variances was used to calculate statistical differences. Statistical significance was set at  $P < 0.01$  for all calculations.

## Results

Among 139 children, 107 (76.98%) had hypertension according to ABPM criteria. Distribution of the types of hypertension according to sex is shown in Figure 1. PH was diagnosed in 89 (64.03%) children (boys 74%, girls 26%), SH in 18 (12.95%) children (boys 61%, girls 39%) and WCH in 32 (23.02%) children (boys 53%, girls 47%). In both PH and SH groups, hypertension was predominantly systolic (60.67% and 55.56%, respectively).

Table 1 shows comparison of BP load in children with PH and SH. There was no statistically significant difference in diurnal and nocturnal systolic and diastolic BP load between PH and SH groups.

The non-dipping phenomenon was detected in 44 (49.44%), 12 (66.66%) and 13 (40.62%) children with PH, SH and WCH, respectively.

The mean pulse pressure values were 60.41, 58.58 and 52.25 mm Hg in the PH, SH and WCH groups, respectively. A statistically significant difference was found in pulse pressure values between PH and WCH groups ( $df=55$ ,  $t=6.15$ ,  $P < 0.01$ ) and between SH and WCH groups ( $df=31$ ,  $t=3.18$ ,  $P=0.001$ ). There was no statistically significant difference between PH and SH groups ( $df=22$ ,  $t=1.023$ ,  $P=0.159$ ).

Target organ damage was diagnosed in 16 (17.98%) PH group children: LVH in 8, hypertensive retinopa-

Table 1. Comparison of blood pressure (BP) load in children with primary and secondary hypertension

	Percentage of daytime systolic BP load >25%	Percentage of daytime diastolic BP load >25%	Percentage of nocturnal systolic BP load >25%	Percentage of nocturnal diastolic BP load >25%
Primary hypertension (n=89)	82%	32.5%	84%	43%
Secondary hypertension (n=18)	83%	44%	78%	33%
Two sample T-test assuming unequal variances	df 22; t=-0.47; P=0.32	df 22; t=-0.28; P=0.38	df 21; t=-0.49; P=0.31	df 24; t=0.01; P=0.49

thy in 3, LVH and retinopathy in 4, and microalbuminuria in one child. In the SH group, target organ damage was detected in 5 (27.78%) children: LVH in 2, hypertensive retinopathy in 2, and LVH and retinopathy in one child. None of the WCH children had target organ damage.

In all three groups, there was a high percentage of overweight (BMI 85<sup>th</sup>-95<sup>th</sup> percentile for age and sex) and obese (BMI >95<sup>th</sup> percentile for age and sex) children: 57 (64.04%) in PH group, 9 (50%) in SH group and 15 (46.87%) in WCH group.

## Discussion

The interest in pediatric hypertension has greatly increased over the past decade, with much of the inter-

est being focused on the early and accurate diagnosis of hypertension in children and adolescents<sup>5</sup>. Until recently, PH as the most common cause of hypertension in adults was considered to be uncommon in children and adolescents. The conventional wisdom has been that hypertension in children is a relatively rare condition most commonly associated with renal disease. In real life, however, SH has become by far less common than PH. This change is primarily the result of the obesity epidemic<sup>11,12</sup>. Our results confirmed these data since we found PH to be much more common compared to SH. We also found a high prevalence of overweight and obese children in both hypertensive groups (PH and SH) as well as in WCH group.

Another important finding was the prevalence of WCH, which was similar to that recorded in adults (15%-33%)<sup>13,14</sup>, although the prevalence of WCH ranges from 10% to 60% in pediatric studies depending on the methods used for office BP measurement, the threshold limits used for office and ABPM, and characteristics of the study population<sup>15-19</sup>.

Besides the mean circadian, diurnal and nocturnal systolic and diastolic BP, an important part of ABPM study analysis is BP load (the percentage of BP measurements within a given period that are within the hypertensive range). While this serves as a measure of the overall time of exposure to hypertension and thus potentially to cardiovascular stress, the threshold at which BP load is indicative of hypertension in children is not well defined. Lurbe *et al.*<sup>8</sup> have recently suggested a staged approach, used in our study, to

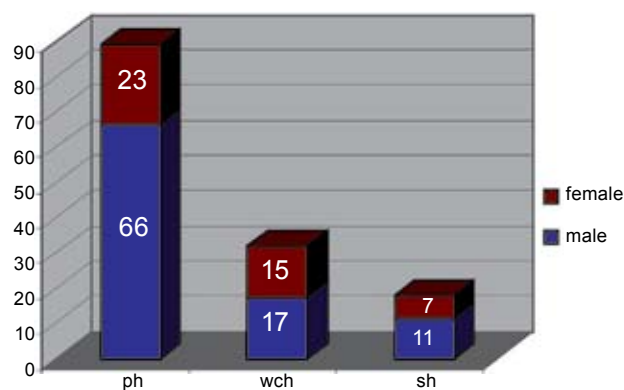


Fig. 1. Distribution of the types of hypertension according to sex (ph = primary hypertension; wch = white coat hypertension; sh = secondary hypertension).

evaluate BP load in conjunction with casual BP and mean BP. In their BP stages proposed, those with BP load of less than 25% are considered normal, whereas those with BP load between 25% and 50% and over 50% are classified into the intermediate and more severe stages, respectively. Also, some authors find BP load to be a useful parameter in differentiation between PH and SH<sup>20</sup>. Our results did not confirm statistically significant difference in diurnal and nocturnal systolic and diastolic BP load between the PH and SH groups.

Nocturnal decrease of BP ('dipping' phenomenon) is a result of physiological nocturnal fall of BP during sleep in response to the sympathetic tone reduction. Blunted nocturnal fall or so-called non-dipping phenomenon is an important predictor of mortality<sup>21</sup> and end-organ damage<sup>22</sup> in adult population. Its role in evaluating hypertension in children is still a matter of debate. Flynn and Seeman<sup>20, 23</sup> have suggested that secondary hypertension in children has the same pattern of systolic diurnal and nocturnal elevations as observed in adults. Therefore, they have proposed that this blunted nocturnal dipping could be used to identify pediatric patients that need further work-up for. Non-dipping phenomenon in our study was most common in the SH group, which is in correlation with the data mentioned.

According to current guidelines, echocardiography, retinal examinations and screening for microalbuminuria are necessary on assessing target organ damage in hypertensive children and adolescents<sup>5</sup>. In our study, children with SH were most likely to have target organ damage; like in other literature reports<sup>24</sup>, LVH was the most common target organ damage in both PH and SH groups. The higher prevalence of target organ damage in children with SH is in part due to the fact that in most cases SH is more severe compared to PH, thus carrying a higher risk of developing complications<sup>5,25</sup>.

The difference between systolic and diastolic BP is defined as pulse pressure. Elevated pulse pressure is a well known risk factor for organ damage in adults<sup>26,27</sup>. The data in children are not so extensive and there are no reference values for different age groups. Several authors report 24-h pulse pressure to be predictive of LVH in children and adolescents<sup>28-30</sup>. Our results confirm the relationship of elevated 24-h pulse

pressure and target organ damage, since there was a significant statistical difference in pulse pressure values between PH and WCH as well as between SH and WCH groups. Comparison was made between hypertensive groups and WCH group, where the latter served as 'normal' value since there was no target organ damage in this group.

In this study, we reviewed our experience with ABPM in the routine evaluation and management of childhood hypertension. We found the ABPM technique to be well accepted by children, provided it is explained well to both the child and the parents. ABPM is indispensable to establish the diagnosis of hypertension in children. It is the only reliable method for the diagnosis of WCH, thereby obviating unnecessary and expensive further diagnostic work-up.

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## Sažetak

## ZNAČENJE KONTINUIRANOG MJERENJA ARTERIJSKOG TLAKA U DJECE I ADOLESCENATA

B. Valent-Morić, T. Žigman, O. Žaja-Franulović, M. Malenica i M. Čuk

Cilj istraživanja bio je prikazati naše rezultate kontinuiranog mjerenja arterijskog tlaka (KMAT) u djece i adolescenata upućenih u našu Kliniku zbog povišenog krvnog tlaka (BP) iznad 95. percentile izmjerenog u ordinacijama liječnika primarne zdravstvene zaštite u 3 ili više navrata. Analizirali smo rezultate KMAT-a u 139 djece, 94 dječaka i 45 djevojčica. Srednja dob bila je 14,14 (4-19) godina. Prema nalazu KMAT-a 107 (76,98%) djece imalo je hipertenziju. Primarna hipertenzija (PH) utvrđena je u 89 (64,03%), sekundarna hipertenzija (SH) u 18 (12,95%) i hipertenzija bijele kute (WCH) u 32 (23,02%) djece. I u PH i u SH radilo se većinom o sistoličnoj hipertenziji (60,67% odnosno 55,56%). Nije bilo statistički značajne razlike u vrijednostima postotka povišenog krvnog tlaka iznad 95. centile (engl. *BP load*) između dnevnog i noćnog sistoličnog i dijastoličnog tlaka između PH i SH. Fenomen *non-dipping* utvrđen je u 49,44% djece s PH, 66,66% djece sa SH te 40,62% djece s WCH. Srednja vrijednost tlaka pulsa bila je 60,41 mm Hg u PH, 58,58 mm Hg u SH i 52,25 mm Hg u WCH. Statistički značajna razlika nađena je u tlaku pulsa između PH i WCH ( $df=55$ ,  $t=6,15$ ,  $P<0,01$ ), te između SH i WCH ( $df=31$ ,  $t=3,18$ ,  $P=0,001$ ). Oštećenje ciljnih organa ustanovljeno je kod 16 (17,98%) djece s PH i 5 (27,78%) djece sa SH. Oštećenje ciljnih organa nije ustanovljeno kod djece s WCH. KMAT je neophodan za dijagnosticiranje hipertenzije u djece i predstavlja jedinu pouzdanu metodu za dijagnosticiranje WCH.

Ključne riječi: *Kontinuirano mjerenje arterijskog tlaka; Hipertenzija; Djeca*