REVIEW ARTICLE

Ambulatory Blood Pressure Monitoring in Children

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Recently there have been great advances in the use of ambulatory blood pressure monitoring (ABPM) in children. A major boost has been the publication of normative data for blood pressure in children. ABPM has been able to detect significant differences in blood pressure in many disease states including chronic renal failure, polycystic kidney disease and post renal transplantation and has helped in identifying both white coat hypertension and masked hypertension. Current evidence does suggest that sole reliance on clinic blood pressure might not be always appropriate and ABPM has a definite role in pediatric hypertension.

Key words: *Ambulatory blood pressure, Child, White coat hypertension.*

Pediatric hypertension is assuming importance with steadily increasing incidence along with the worldwide obesity epidemic. Although large population based studies on hypertension are lacking from India, smaller studies have suggested prevalence between 2-5% [1]. Unfortunately accurate measurement of blood pressure (BP) is often not easy, particularly in younger children and this has led to increased use of automated devices. Despite various drawbacks, these are easier to use and it does eliminate observer bias including terminal digit preference [2]. The appreciation that multiple measurements over a 24-hour period might be a better reflection of a continuous variable like BP has resulted in the development of ambulatory blood pressure monitoring (ABPM). A portable monitor (***Fig* 1**) which can be worn on the belt or in the pocket can be programmed to undertake multiple blood pressure reading during normal daytime and nighttime activities. There has been rapid advancement in its application and ABPM has been endorsed by the Fourth Report of the National High Blood Pressure Education Program (NHBPEP) with the caveat that its use should be limited to persons experienced in this technique [2]. We will review the practicalities of the use of ABPM in children including the present evidence regarding its utility as well as limitations.

PROCEDURE

An ideal pediatric ambulatory blood pressure monitor should be lightweight, able to tolerate subject movement without excessive error reading, and should have a range of cuff size appropriate for various age groups (width of the cuff at least 40% of mid arm circumference). Despite inherent flaws (lack of validation, indirect measurement of diastolic BP), oscillometric devices are the most commonly used as they usually have a lower percentage of erroneous reading and are easier to use than auscultatory devices. Among the oscillatory devices, SpaceLabs 90207 and 90217 are the most commonly available machines. Lack of population based data has limited its routine use to children 5 year or older with height around 120 cm or greater [3,4]. Studies are lacking regarding the optimal frequency of BP monitoring without causing excessive discomfort. Most experts agree on the need for at least one valid reading per hour including sleep and hence it is usually set between 15 to 30 minutes for day time/ wake measurements and every 20-60 minutes for sleep/night time measurements. Since success rate of ABPM is also to some extent dependent on patient's activity, it is recommended that children should refrain from contact sports and vigorous exercises while undergoing this recording.

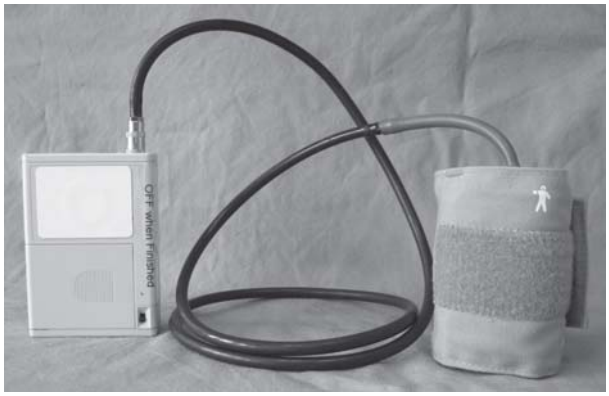

FIG. 1 *Ambulatory blood pressure monitor showing portable monitor and blood pressure cuff.*

Accurate documentation of awake and sleep period is important for correct interpretation of the readings. Some experts analyse by fixing a specific time limit for daytime and night time readings. Self reported sleep/awake times recorded in a diary or simultaneous monitoring by an actigraph (wrist device which senses motions in 3 dimensions) might be a better alternative. As utility of any test depends on reproducibility, this has been evaluated in a number of pediatric studies which have shown that ABPM has a better reproducibility than clinic BP [5], although the reproducibility of diurnal variability was not consistent. Over the last decade, data on ABPM is available on children from United States, Spain, Germany and Taiwan [3-4,6-7]. Normative data on ABPM, with 90th and 95th percentile for height and gender have also been formulated [4].

INTERPRETATION

Data collected by these monitors often needs some editing for artefacts like extreme outlier BP which can be done manually or by pre-installed pediatric softwares. Most of the data analysis software provide results as mean systolic and diastolic BP over 24-hours, daytime and night time periods. These can thereafter be compared with similar sets of ambulatory BP values such as those reported by Heidelberg group [4,8]. BP load expresses the percentage of valid measurements above a set threshold value such as the 95th percentile of BP for gender and height. As with mean BP this can also be assessed for the entire 24-hour period or for the awake and asleep period separately. In the absence of definitive pediatric data, the cut off percentage for BP load signifying hypertension is controversial. Sorof, *et al.* [9] correlated BP load in excess of 50% to left ventricular hypertrophy and this is usually accepted as cut off. Nocturnal dipping is the physiological fall of BP at night and is defined in children as greater than or equal to 10% fall in mean systolic and diastolic BP level from day to night [10-12].

WHITE COAT HYPERTENSION

White coat hypertension is defined as BP levels greater than 95th percentile when measured in clinic but normal (average BP less than 95th percentile) outside the clinic setting. It was first identified in pediatric population in 1991 and is reported to have a pre-valence of 1.2 to 62% [13,14]. A strong correlation has been found between white coat hypertension and clinic BP levels with the likelihood of white coat hypertension decreasing as clinic BP increases. It has been suggested that it is more likely in those children with clinic BP 1-10% above the 95th percentile and ABPM is likely to have greater yield in this group. Although initially it was thought to have a benign outcome recent research suggests the possibility of it being a pre-hypertension state [15].

MASKED HYPERTENSION

Masked hypertension is to some extent reverse of white coat hypertension with normal clinic BP but elevated ABP [16]. Masked hypertension has also been correlated with elevated LVM and has been shown to progress to sustained clinic hypertension [6]. Masked hyper-tension is more frequent among children with a positive family history of hypertension and those with increased body mass index.

DIURNAL VARIATION/NOCTURNAL DIPPING

Assessment of BP variability by ABPM can also be clinically useful. Absence of nocturnal dipping has been reported to be useful in differentiating secondary hypertension from primary hypertension [10] and has also been significantly correlated with various other renal conditions [11,12].

ABPM has found utility among children with both renal and non renal conditions. Among renal

disorders it has been correlated with renal scars in children with chronic pyelonephritis, renal volume and cysts in polycystic kidney disease, and likelihood of renal artery stenosis in children with neurofibromatosis [11,17]. Long-term follow-up of children with haemolytic uremic syndrome has shown abnormalities on ABPM that were not identified by clinic BP [18].

ABPM has been found to be useful even among certain non renal disorders. It has been correlated with adverse cardiac events in young patients with hypertrophic cardiomyopathy and has been found to be an effective predictor of severity in coarctation of aorta.

LIMITATIONS

ABPM does have some major limitations. Unlike adults, the limits of pediatric ABPM are not based on large population studies or on hard outcome data. Even the normative data published by Wuhl's, *et al*. [8] are statistical manipulation of previous data and in addition does not have adequate representation from all racial segments [4,8]. The algorithms used in ambulatory oscillatory monitors are usually based on adults and very few studies have been performed for validation of these monitors in children. Technical limitations have limited its clinical use to children above 5 year of age.

With increasing experience in its use, ABPM has now become an important tool in the evaluation and management of paediatric hypertension. Its use has steadily increased as suggested by a survey of 438 North American pediatric nephrologists wherein 63% were reported to be using it in their daily practice [19]. Despite its limitations, certain indications of ABPM are already generally accepted. This includes identification of white coat hypertension, particularly among those with clinic BP suggestive of stage 1 hypertension, evaluation for the presence of masked hypertension, evaluation of drug resistant hypertension and for monitoring of BP in certain group of children such as those with chronic kidney disease. Future research should be directed toward obtaining normative data in healthy non white population, correlating ABPM with well defined outcomes in youth with sustained hypertension, and evaluating the efficacy of ABPM in intervention trials in paediatric populations. In addition though there is evidence of ABPM being cost effective even in children [20], its utility in resource constrained practices and developing countries needs to be explored.

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