

Original Article

Relation of Left Ventricular Diastolic Dysfunction to 24-Hour Ambulatory Blood Pressure in Normotensive Predisposed Children

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ABSTRACT

Background: The heart is one of the most important target organs in hypertension. Due to increased after load, concentric hypertrophy of the left ventricular myocardium develops progressively, ending in left ventricular failure. For this reason, control of hypertension should be achieved as early as possible, to avoid irreversible damage to the myocardium. Therefore, it is preferable to detect earlier changes in left ventricular function, before any structural changes occur.

Objectives: This study was performed in order to correlate the findings of ambulatory blood pressure monitoring in children who are considered normotensive by conventional blood pressure measurement but who have a predisposing factor for hypertension with left ventricular diastolic function in these children.

Methods: Left ventricular diastolic function in the form of mitral valve flow velocities was performed for 17 children aged 8-13.5 years (7 boys, 10 girls) by Doppler echocardiography.

Results: All children were normotensive by conventional blood pressure measurement. However, when ambulatory blood pressure monitoring was performed, 6/17 (35%) of children were found to have elevated blood pressure loads (> 20% of readings > 95th percentile for age and sex). No significant differences were found between the groups regarding the early (E) or late (A) phases of mitral flow velocity. On the other hand, there was a significant difference between the group with normal blood pressure loads and the group with elevated blood pressure loads in the E/A ratio.

Conclusions: The use of ambulatory blood pressure monitoring is a useful method to evaluate children at risk for hypertension, e.g. those with recurrent UTI and those with a family history of hypertension. Early detection of target organ, e.g. heart affection in hypertension is also of great benefit, before irreversible damage occurs. The ratio of velocity of Early (E) and Late (A) phases of left ventricular filling may be a valuable marker, correlating with the presence of hypertension. In addition, this correlation would help establish the role of ambulatory blood pressure monitoring in the early identification of children at risk for ventricular dysfunction.

INTRODUCTION

The heart is one of the most important target organs in hypertension. Due to increased after load, concentric hypertrophy of the left ventricular myocardium develops progressively, ending in left ventricular failure. For this reason, control of hypertension should be achieved as early as possible, to avoid irreversible damage to the myocardium. Therefore, it is preferable to detect earlier changes in left ventricular function,

before any structural changes occur. Such early changes include a change in left ventricular compliance due to stiffening of the ventricular wall. This leads to changes in left ventricular diastolic filling, which is normally composed of two phases. The early (E) phase which occurs passively, as soon as the mitral valve opens, and the late (A) phase which occurs by the help of left atrial contraction. With decreased left ventricular compliance, a greater proportion

of left ventricular filling occurs with the help of left atrial contraction, due to decrease in the passive filling of the left ventricle⁽¹⁾.

Early elevation of the blood pressure is usually asymptomatic. However, if undetected, it may lead to progressive damage to target organs, including the heart and the kidneys. For these reasons, it is an advantage to use a technique that allows the detection of increased blood pressure at the earliest possible time, to allow intervention before any effects of the blood pressure elevation on the target organs. Regular measurement of the blood pressure should be a part of the routine care of children as well as adults. Measurement of the blood pressure is usually done in the doctor's office or in the hospital on one or more occasions. It is important to take the measurements with the patient under resting conditions, physically and mentally, in order to reflect the true blood pressure of the patient, without any influence of external factors. However, this will only reflect the patient's blood pressure at the time of measurement, and may not represent the patient's blood pressure throughout the day. In recent years, it has been suggested^(2,3) that continuous ambulatory blood pressure monitoring may give a true picture of the pattern of blood pressure during the day (and night). In addition, the use of continuous ambulatory blood pressure monitoring allows better monitoring of anti-hypertensive medications⁽⁴⁾. It has been suggested that the sequelae of hypertension correlate better with continuous ambulatory blood pressure readings than with intermittent blood pressure measurements^(2,5,6). The

availability of ambulatory blood pressure monitors light enough for use in children and with appropriate size cuffs has allowed improved experience with this technique in children.

AIM OF THE WORK

The aim of this work is to correlate the findings of ambulatory blood pressure monitoring in children who are considered normotensive by conventional blood pressure measurement with the results of evaluation of left ventricular diastolic function in these children. This correlation would help establish the role of ambulatory blood pressure monitoring in the early identification of children at risk for ventricular dysfunction.

SUBJECTS AND METHODS

A group of 17 normal children (10 girls, 7 boys) (ages 8-13.5 years, mean 10.5) participated in the study. They were recruited during the period from August-December, 2001. A complete history and physical examination was done. All participating children were normotensive by the usual method of measurement of blood pressure, and according to the normal levels for their age and gender. Fourteen of these children (9 girls, 5 boys) have a family history of hypertension (one or both parents with hypertension, currently under medication). Three of these children (1 girl, 2 boys) have a history of one or more attacks of urinary tract infection (UTI) treated with a course of antibiotics during the past year. Since it is an important part of their evaluation, the 3 children with a history of UTI were already investigated by

renal ultrasound and voiding cystourethrography for the presence of obstructive uropathy or vesico-ureteric reflux. None of these children had evidence of vesico-ureteric reflux on voiding cystourethrography.

Exclusion criteria: children were excluded from the study in the following cases:

1. If they had a history of blood pressure problems in the past, or if their blood pressure measurements by the conventional method exceeded the upper limits of normal for their age and gender⁽⁷⁾.
2. If they had evidence of any other renal, endocrine or cardiac disease known to affect the blood pressure.
3. If they were taking any medication which is known to affect the blood pressure.

A. Blood pressure measurements

Ideally, the blood pressure monitor is a portable oscillometric monitor. It uses disposable batteries, and it can be programmed to take timed measurements of the blood pressure at regular intervals spontaneously, throughout the day and night. However, as an alternative, we used a digital electronic blood pressure monitor which can be easily used by the parents to obtain blood pressure measurements every hour during the day and every two hours during the night. It is attached to a blood pressure cuff, which has the appropriate size. The cuff encircles the upper arm and covers 2/3 of its length, according to each child's arm length. BP loads (% of readings $\geq 95^{\text{th}}$ percentile, S & D) were evaluated. Children with $> 20\%$ of their readings $\geq 95^{\text{th}}$ percentile were considered to have elevated 24 hr bp loads, and children with $< 20\%$ of

their readings $\geq 95^{\text{th}}$ percentile were considered to have normal 24 hr bp loads.

At the beginning of the study, three BP measurements were obtained using the conventional sphygmomanometer, with the child seated comfortably and rested for 5 minutes. The mean of these three measurements was calculated and referred to as conventional blood pressure. The study was explained to the parents and the children, and they were instructed to take the blood pressure every hour during the daytime (6 am to 8 pm) and every 2 hours during the night (8 pm to 6 am). The readings of blood pressure monitoring were recorded and saved on a computer, and the findings were evaluated.

B. Echocardiography:

Left ventricular diastolic filling expressed as mitral flow velocity (cm/sec) was recorded by pulsed Doppler technique from the apical position between the mitral leaflets. From the mitral flow velocity tracing, early (E) mitral flow peak velocity, and late (A) mitral flow peak velocity (during atrial systole) were obtained. Also, the E/A ratio was calculated, and the results were compared.

RESULTS

In order to confirm that all the children participating in the study were normotensive, at the beginning of the study, three BP measurements were obtained using the conventional sphygmomanometer, with the child seated comfortably and rested for 5 minutes. The mean of these three measurements was calculated. All children who participated in the study had conventional blood pressure measurements within the

normal range. This was one of the inclusion criteria for the study.

Evaluation of blood pressure loads (defined as the percentage of readings equal to or greater than the 95th percentile for age and gender) was performed. As shown in Table 1, BP loads ranged from 0% to 42.5% (mean = 15.4%) Systolic; and from 0% to 33.3% (mean = 12.9%) Diastolic. Two children had systolic bp loads > 20%, 3 children had diastolic bp loads > 20%, and one child had systolic and diastolic bp loads > 20%. Overall, 6/17 (35%) children had blood pressure loads 20% or more, systolic or diastolic, day and/or night (Group 1) and 11/17 (65%) children had blood pressure loads < 20% (Group 2).

As shown, results of 24 hr ambulatory blood pressure monitoring allow us to

classify these children into two groups according to their 24 blood pressure loads: Group 1 with 24 hr blood pressure loads < 20% (n =11 children) and Group 2 with 24 hr blood pressure loads > 20% (n = 6 children)

Results of Doppler echocardiographic evaluation of left ventricular diastolic filling (mitral flow) for each of these two groups of children are shown in Table 2.

As shown in Table 2, there was no statistically significant difference between the two groups in the velocity of the E or the A phases of left ventricular diastolic filling. However, the E/A ratio was significantly decreased (1.09%) in the group of children with > 20% elevated 24 bp loads, compared to the group of children with < 20% elevated 24 bp loads (p < 0.05).

Table 1: Ambulatory Blood Pressure Monitoring Findings in children with predisposing factors for hypertension. Blood Pressure Loads (the percentage of readings = or > the 95th percentile for age and gender) are shown.

One child had both systolic and diastolic bp loads > 20%

BP LOADS	Range	Mean	number > 20%	number < 20%
Systolic	0%- 42.5%	15.4 %	3/17	14/17
Diastolic	0%-33.3%	12.9%	4/17	13/17
Total			6/17	11/17

Table 2: Results of Doppler echocardiographic evaluation of left ventricular diastolic filling (mitral flow) for each of the two groups of children with 24 bp loads < 20% (Group 1) and with 24 bp loads > 20% (Group 2). Both the E and the A phases

Phase	Group 1 (bp loads < 20%) n=11 MEAN (SD)	Group 2 (bp loads > 20%) n=6 MEAN (SD)
E (cm/sec)	59 (9)	56 (11)
A (cm/sec)	42 (5)	51 (8)
E/A ratio	1.4*	1.09*

* p < 0.05

DISCUSSION

It has been suggested^(2,3) that continuous ambulatory blood pressure monitoring may give a true picture of the pattern of blood pressure during the day (and night). In addition, the use of continuous ambulatory blood pressure monitoring allows better monitoring of anti-hypertensive medications^(4,8). It has been suggested that the sequelae of hypertension correlate better with continuous ambulatory blood pressure readings than with intermittent blood pressure measurement^(2,5,6).

Utilization of Doppler echocardiography is a useful method for the evaluation of left ventricular diastolic function, particularly in the early stages before irreversible damage occurs^(9,10).

This study was performed in order to correlate the findings of ambulatory blood pressure monitoring in children who are considered normotensive by conventional blood pressure measurement with the results of evaluation of left ventricular diastolic function in these children.

All children were normotensive by

conventional blood pressure measurement, but they had a predisposing factor for the development of hypertension, in the form of a positive family history in one or both parents, or the presence of a history of recurrent UTI with or without reflux. When ambulatory blood pressure monitoring was performed, 6/17 (35%) of children were found to have elevated blood pressure loads (> 20% of readings > 95th percentile for age and sex). Therefore, results of 24 hr ambulatory blood pressure monitoring allow us to classify these children into two groups on the basis of their 24 blood pressure loads: Group 1 with 24 hr blood pressure loads < 20% (n = 11 children) and Group 2 with 24 hr blood pressure loads > 20% (n = 6 children).

Doppler echocardiographic evaluation of left ventricular diastolic filling (mitral flow) for each of the two groups of children with 24 bp loads < 20% (Group 1) and with 24 bp loads > 20% (Group 2) was performed. Results show that there was no statistically significant difference between the two groups in the velocity of the E or

the A phases of left ventricular diastolic filling. However, the E/A ratio was significantly decreased (1.09%) in the group of children with > 20% elevated 24 bp loads, compared to the group of children with < 20% elevated 24 bp loads ($p < 0.05$).

This correlation would help establish the role of ambulatory blood pressure monitoring in the early identification of children at risk for ventricular dysfunction.

The use of ambulatory blood pressure monitoring is a useful method to evaluate children at risk for hypertension, e.g. those with recurrent UTI and those with a family history of hypertension. Early detection of target organ, e.g. heart affection in hypertension is also of great benefit, before severe structural damage occurs. The ratio of velocity of Early (E) and Late (A) phases of left ventricular filling may be a valuable marker, correlating with the presence of hypertension.

It should also be noted that the duration of elevation of blood pressure loads may have an important influence on left ventricular diastolic filling, as well as the

degree of elevation. It is possible that these abnormalities may be partly or completely reversible by anti-hypertensive medication. This information may be useful in the evaluation of the effectiveness of anti-hypertensive treatment, since the persistence of left ventricular dysfunction may indicate the need for additional therapy, or may indicate the presence of structural damage to the myocardium which may not be reversible with treatment.

In conclusion, accurate diagnosis of hypertension is of great value in children as well as in adults. The use of ambulatory blood pressure monitoring is a useful method to evaluate children at risk for hypertension, e.g. those with recurrent UTI and those with a family history of hypertension. Early detection of target organ, e.g. heart affection in hypertension is also of great benefit, before gross structural damage occurs. The ratio of velocity of Early (E) and Late (A) phases of left ventricular filling may be a valuable marker, correlating with the presence of elevated 24 hr blood pressure loads in these children.

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