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Evaluation of arterial stiffness in children with type 1 diabetes using the oscillometric method

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ABSTRACT

Aims: Pulse wave velocity (PWV) is an accepted evaluation method to assess vascular changes and determine cardiovascular disease risk in type 1 diabetes (T1D) patients. The aim of this study was to identify atherosclerosis risk by using oscillometric device in pediatric patients who had T1D but no end organ impairment and no cardiovascular disease findings.
Materials and methods: Pediatric patients with T1D and no determined end organ impairment and cardiovascular disease were involved in the study.
Results: A total of 72 patients with T1D containing 32 males and 40 females were included in the study. A total of 77 patients including 39 males and 38 females were evaluated as healthy control group. The average age of patients with T1D was 12.8 ± 3.7 years, their average weight was established as 43.8 ± 16.7 kg. The average age of control group was 12.3 ± 1.6 years and average weight was determined as 46.8 ± 12.8 kg. When the results obtained by pulse wave method were compared; PWV and Alx_75 values in T1D patients (respectively, 4.63 ± 0.40 and 22.9 ± 6.7) were determined significantly higher than those of control group (respectively, 4.42 ± 0.34 and 16.6 ± 6.6). A positive correlation was identified between diabetes duration and HbA1c (instant and mean) levels in patients with T1D with respect to PWV and Alx_75 values.
Conclusions: Arterial stiffness was impaired in children with T1D with no end organ impairment using oscillometric method. This impairment was related to high HbA1c levels and diabetes duration.

1. Introduction

The mortality and morbidity of patients with type 1 diabetes (T1D) is closely related to vascular complications of the illness. In T1D, macrovascular and microvascular complications can be seen (Huxley, Peters, Mishra, & Woodward, 2015; Nathan et al., 2005; Rathsman, Donner, Ursing, & Nyström, 2016; Thorn et al., 2015). While coronary atherosclerosis takes part as a leading cause, microvascular complications are responsible for kidney and eye involvement. The period giving rise to vascular complications in disease is thought to begin with endothelial dysfunction (Basta, Schmidt, & De Caterina, 2004). Endothelial dysfunction initiated by metabolic factors leads to vasoconstrictive and thrombotic changes and in addition to that, it brings about arterial stiffness in diabetes (Adji, O'Rourke, & Namasivayam, 2011).

Determining vascular changes in type 1 diabetes patients at asymptomatic early ages is very important with respect to conditions such as in directing follow-up and treatments of patient, reducing mortality and morbidity of disease and increasing life quality of patients. Therefore, a good deal of studies was carried out to identify cardiovascular disease risks in patients with diabetes. Of the frequently used methods in determining cardiovascular disease risks, carotid artery intima-media thickness (cIMT) and pulse wave velocity (PWV) are the primary ones. cIMT is considered to be a quite beneficial marker in revealing cardiovascular disease risk (Cao et al., 2007; Iglesias del Sol, Bots, Grobbee, Hofman, & Witteman, 2002; Lorenz, von Kegler, Steinmetz, Markus, & Sitzer, 2006). However, the necessity of interpreting cIMT measurement results in a different way not only in terms of methodology differences but also distinct races and societies and has made us think that the method is insufficient to establish cardiovascular risk solely (Nezu, Hosomi, Aoki, & Matsumoto, 2016). More importantly; it is recommended to be used with other evaluation

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Ethical approval: The study was carried out by obtaining Adnan Menderes University Ethics Committee Approval (approval date/num: 2015/696).

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methods since it is inadequate in determining subclinical atherosclerosis (Nezu et al., 2016).

Pulse wave analysis is another method utilized in the assessment of arterial stiffness. Pulse wave velocity (PWV) and augmentation index (Alx_75) evaluations are used as a reliable method in identifying increased cardiovascular risk (Jankowski et al., 2003; Nishijima et al., 2001; Nürnberger et al., 2002; Weber et al., 2004). Pulse wave analysis can be measured with different methods. Mostly tonometric measurement methods, also referred to as carotid-femoral pulse wave velocity (PWV), have been preferred and recommended up until today (Laurent et al., 2006). Nevertheless, all these methods are individual measurement methods and their applicability is difficult. In recent years, automated oscillometric device (Mobil-O-Graph) has taken a part in determining arterial stiffness in the literature as an easier and usable method in more extensive fields compared to other methods in terms of its reliability and implementation (Feistritzer et al., 2015; Luzardo et al., 2012; Sarafidis et al., 2014; Weiss et al., 2012).

The aim of this study was to determine atherosclerosis risk by using oscillometric device in pediatric patients with T1D, but no established end organ damage and no cardiovascular findings.

2. Materials and methods

2.1. Study group

Pediatric patients followed by Adnan Menderes University Pediatric Endocrinology Department with T1D, having no cardiovascular disease clinical findings, no determined microvascular organ damage (renal; microalbuminuria, neural; sensorial or motor loss and eye involvement) and whose diabetes period is over 1 year were involved in the study. The patients with T1D and other diseases known to cause atherosclerosis (hyperlipidemia, obesity, hypertension etc.) were excluded from the study.

Weight, height, and body mass index (BMI) measurements of patients were carried out together with detailed physical examinations. When oscillometric device was in use, measured HbA1c levels in the last one week and also average HbA1c levels were evaluated. Average HbA1c level was defined as median of all HbA1c levels measured since the patient was diagnosed with diabetes. This value was stated as HbA1c (mean) in the presentation.

2.2. Pulse wave analysis measurement

Pulse wave analysis evaluates the shape and amplitude of aortic pulse wave. Of the parameters obtained, particularly pulse wave velocity (PWV) and augmentation index (Alx_75) are associated with aortic systolic blood pressure. Pulse wave velocity (PWV) shows progression velocity of pulse in aorta. Its unit is meter/second (m/s). When vascular atherosclerosis increases, increase is determined in PWV and Alx_75 values (Laurent et al., 2006).

Peripheral blood pressure (pSBP/pDBP: peripheric systolic/diastolic blood pressure), central blood pressure (cSBP/cDBP: central systolic/diastolic), mean arterial pressure (MAP) and PWV were measured by using automatic oscillometric device (thanks to brachial wave form) (Mobil-O-Graph). The oscillometric method is based on a transfer function from the brachial pressure waves determined by oscillometric blood pressure measurements with a common cuff. The reliability of oscillometric method is shown by the compatibility of measurements carried out by both invasive procedures (Hametner et al., 2013) and similarity of measurements performed with cardiac magnetic resonance (Feistritzer et al., 2015). Other methods are carried out with individual measurements performed with aorta-femoral PWV (tonometric measurement) cuff and it reflects instant evaluation. Oscillometric method shows implementation and calibration superiority according to this procedure (Protogerou, Smulyan, & Safar, 2011).

Mobil-O-Graph device was attached to patients at the morning hours and the patients involved continued their daily activities in 24 hour recording period. The device was removed after 24 hours and recordings were transferred.

The study was carried out by obtaining Adnan Menderes University Ethics Committee Approval (approval date/number: 2015/696).

2.3. Statistical analysis

All statistical analyses were performed using SPSS (The Statistical Package for Social Sciences) Version 15.0 (SPSS, Inc, Chicago, IL, USA). Data were presented as mean and standard deviation. Whether the distributions of continuous variables were normality or not was determined by using Kolmogorov–Smirnov test. The differences between two independent groups were compared by using independent sample t-test for normal distributions or Mann–Whitney U test for non-normal distributions. Multiple regression analyses were performed for PWV and Alx_75. Correlation coefficients (r) were calculated using the Pearson correlation or Spearman's rank test, dependent on normality of distribution or not. A two-sided p value <0.05 was considered statistically significant for all analyses.

3. Results

A total of 72 patients with T1D including 32 males and 40 females were involved in the study. A total of 77 individuals composed of 39 males and 38 females were evaluated as healthy control group. Average age of patients with T1D was 12.8 ± 3.7 years, their average weight was determined as 43.8 ± 16.7 kg. Average age of control group was 12.3 ± 1.6 years, their average weight was established as 46.8 ± 12.8 kg (Table 1). Diabetes periods of patients were determined as 47.9 ± 31.7 (months), instant HbA1c values were 8.2 ± 2.0%, average HbA1c values were 8.6 ± 1.9%.

When the results obtained by pulse wave analysis method of patients with T1D were compared with those of control group; PWV and Alx_75 values were determined significantly and statistically higher in patient group. cDBP and pDBP measurements, however, were significantly and statistically identified lower in patient group (Table 2).

When the correlation of PWV and Alx_75 values was evaluated with other parameters; a positive correlation was established in T1D patients with respect to all blood pressure measurements, diabetes period and HbA1c (instant and mean) levels. Nevertheless, the highest correlation was found between PWV and HbA1c levels and the highest correlation was determined between Alx_75 and diabetes period (Table 3). We evaluated independent variables affecting PWV and Alx@75 values with multiple regression analysis. We determined the factors affecting PWV as instant and mean values of HbA1c, diabetes duration and cSBP. The variables affecting Alx@75; however, were identified as instantaneous and mean values of HbA1c, diabetes duration (Table 4).

Table 1
Anthropometric measurements of the patient and control groups.

	Type 1 DM (n = 72)	Control (n = 77)	p
Age (year)	12.8 ± 3.7	12.3 ± 1.6	0.448
Weight (kg)	43.8 ± 16.7	46.8 ± 12.8	0.055
Height (cm)	146.6 ± 19.5	144.6 ± 14.4	0.246
BMI (kg/m^2)	19.4 ± 3.6	21.04 ± 6.2	0.062

BMI: body mass index.