International Journal of Cardiology 168 (2013) 2347–2351

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Abnormal systolic and diastolic myocardial function in obese asymptomatic adolescents

Arbnora Batalli-Këpuska [a], Gani Bajraktari [b,c,*], Murat Zejnullahu [a], Mehmedali Azemi [a], Mujë Shala [a], Arlind Batalli [b], Pranvera Ibrahimi [c], Fisnik Jashari [c], Michael Y. Henein [c]

[a] Pediatric Clinic, University Clinical Centre of Kosova, Prishtinë, Republic of Kosovo
[b] Internal Medicine Clinic, University Clinical Centre of Kosova, Prishtinë, Republic of Kosovo
[c] Department of Public Health and Clinical Medicine and Cardiology, and Heart Centre, Umeå University, Umeå, Sweden

ARTICLE INFO

Article history:
Received 10 July 2012
Received in revised form 9 October 2012
Accepted 18 January 2013
Available online 14 February 2013

Keywords:
Adolescents
Obesity
Body mass index
Echocardiography
Left ventricular mass index
Left ventricular function

ABSTRACT

Structural and functional cardiac changes are known in obese adults. We aimed to assess the relationship between body mass index (BMI) and cardiac function in overweight and obese asymptomatic adolescents.
Ninety three healthy adolescents, aged 12.6 ± 1.2 years, received weight, height, BMI, waist, hips, waist/hips ratio assessment, hematology and biochemistry tests and an echocardiogram. Based on BMI, subjects were divided into: lean (L, n = 32), overweight (Ov, n = 33) and obese (Ob, n = 32).
Interventricular septal and LV posterior wall thickness were increased parallel to the BMI (L: 0.84 ± 0.1 cm, Ov: 0.88 ± 0.1 cm, Ob: 0.96 ± 0.1 cm, $p<0.001$, and L: 0.78 ± 0.1 cm, Ov: 0.8 ± 0.1 cm, Ob: 0.94 ± 0.1 cm, $p<0.001$, respectively) as were relative wall thickness (RWT) and mass index (LVMI) (L: 0.34 ± 0.05, Ov: 0.34 ± 0.05, Ob: 0.40 ± 0.04, $p<0.001$, and L: 47.7 ± 8.4 g/m^2, Ov: 51.9 ± 8.3 g/m^2, Ob: 65.2 ± 13.3 g/m^2, $p = 0<001$, respectively). LV early diastolic (E′) lateral and septal velocities (L: 15.3 ± 3.9 cm/s, Ov: 13.6 ± 4 cm/s, Ob: 10.5 ± 3.4 cm/s, $p<0.001$, and L: 12.2 ± 2.3 cm/s, Ov: 11.1 ± 2.4 cm/s, Ob: 9.8 ± 3.1 cm/s, $p = 0.003$, respectively), and systolic (S′) velocities (L: 9.2 ± 1.4 cm/s, Ov: 9.3 ± 2.3 cm/s, Ob: 8.04 ± 1.5 cm/s, $p = 0.018$, and L: 9.05 ± 2.3 cm/s, Ov: 9 ± 2.4 cm/s, Ob: 7.6 ± 1.1 cm/s, $p = 0.014$, respectively) were all reduced, only in obese adolescents. LV lateral E′ ($r = -0.44$, $p<0.001$) and S′ ($r = -0.29$, $p = 0.005$) correlated with BMI.
In asymptomatic adolescents, LV wall is thicker and diastolic function impaired and correlate with BMI. These findings demonstrate early cardiac functional disturbances which might explain the known obesity risk for cardiac disease.

1. Introduction

The prevalence of overweight and obese children and adolescents has increased dramatically over the last decades [1,2]. In the USA 31.9% (or >12.5 million) of children and adolescents aged 2–19 years are overweight and 17.1% are obese [3]. Studies have shown that increased body mass index (BMI) is associated with early structural myocardial disturbances in the form of left ventricular (LV) hypertrophy [4–8] with obesity itself considered an independent risk factor for heart failure in adults [9,10]. Similar LV structural changes have been shown in obese adolescents [11–15] but the direct relationship between isolated obesity and cardiac function remains unknown. In particular, well established markers of diastolic dysfunction, as shown by myocardial tissue Doppler velocities, have not been clearly examined and correlated with the extent of increase in BMI in adolescents. We hypothesized that in obese adolescents the extent of cardiac dysfunction is related to body mass index and therefore designed this study aiming at assessing the relationship between body mass index (BMI) and cardiac function in overweight and obese asymptomatic adolescents.

2. Methods

2.1. Study population

This study included 93 healthy subjects aged 10–15 years (mean 12.6 ± 1.2 years), selected from three secondary schools in Prishtina, between January and June 2011. Based on BMI, subjects were classified into three groups: lean (L, n = 32, with BMI of 18.5–24.9 kg/m^2), overweight (Ov, n = 33, with BMI of 25.0–29.9 kg/m^2) and obese (Ob, n = 32, with a BMI of more than 30 kg/m^2). Students were consecutively recruited as they fulfilled the BMI selection criteria. Obese and overweight were recruited first then matched with similar number of lean students. No student had any history or clinical evidence for a medical or cardiac problem and all underwent a complete transthoracic echocardiographic examination using conventional methods.

2.2. Clinical measurements

Detailed history and clinical assessment were obtained in all subjects. Blood samples were taken after an overnight fast and were analyzed. Body surface area (BSA) was calculated using the Du Bois formula [20]: $0.007184 \times (\text{weight [kg]})^{0.425} \times (\text{height [cm]})^{0.725}$ [16]. Routine biochemical tests: hemoglobin, lipid profile, blood glucose level, and kidney function tests, were performed in all subjects. Body mass index (BMI) was calculated as the weight in kilograms divided by the square height, in meters. A waist circumference

* Corresponding author at: Service of Cardiology, Clinic of Internal Medicine, University Clinical Centre of Kosova, "Rrethi i Spitalit", p.n., Prishtina, Republic of Kosovo. Tel.: +355 377 45 800 808.
E-mail address: ganibajraktari@yahoo.co.uk (G. Bajraktari).

0167-5273/$ – see front matter © 2013 Elsevier Ireland Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ijcard.2013.01.025

(WC) measurement was taken in the supine position as the distance between the lateral costal border and the iliac crest and was made to the nearest 0.5 cm.

2.3. Echocardiographic examination

A single operator performed all echocardiographic examinations using a Philips Intelligent E-33 system equipped with a multi-frequency transducer and harmonic imaging, as appropriate. Images were obtained with the patient in the left lateral decubitus position and during quiet expiration. LV dimensions in end-systole and end-diastole were made from the left parasternal cross-sectional recording of the minor axis with the M-mode cursor positioned by the tips of the mitral valve leaflets and shortening fraction was calculated. LV volumes and ejection fraction were calculated from the apical 2 and 4 chamber views using the modified Simpson's method. Interventricular septal and LV posterior wall thickness were also measured from the same recording, and cavity mass was calculated using the modified Devereux formula [17]:

$$\mathrm{LVM} = 0.8\left\{1.04\left[(\mathrm{LV\ EDD} + \mathrm{PWT_d} + \mathrm{SWT_d})^3 - (\mathrm{LV\ ESD})^3\right]\right\} + 0.6\ \mathrm{g},$$

where LV EDD is LV end-diastolic dimension, PWT is posterior wall thickness, SWT is septal thickness, and LV ESD is LV end-systolic dimension.

Indexed LV mass was calculated as the relative mass to body surface area. LV mass was also normalized for height using the ratio mass/height$^{2.7}$. Also, relative wall thickness was derived as 2×PWT/LV EDD. Left atrial diameter was measured from aortic root recordings with the M-mode cursor positioned at the level of the aortic valve leaflets.

Ventricular long axis function was studied from the apical 4 chamber view by placing the M-mode cursor at the lateral and septal angles of the mitral ring and the lateral angle of the tricuspid ring. Total amplitude of long axis motion was measured as previously described [18]. LV and right ventricular (RV) long axis myocardial velocities were also studied using tissue Doppler imaging technique. From the apical 4-chamber view, longitudinal velocities were recorded with the sample volume placed at the basal segment of the LV lateral and septal segments as well as RV free wall. Systolic (S′) as well as early (E′) and late (A′) diastolic myocardial velocities were measured with the gain optimally adjusted. Mean value of the lateral and septal LV velocities was calculated.

2.3.1. Diastolic ventricular function

Diastolic function of the LV and RV was assessed from their filling velocities using spectral pulsed wave Doppler with the sample volume positioned at the tips of the mitral and tricuspid valve leaflets, respectively. Peak LV and RV early (E wave), and late (A wave) diastolic velocities were measured and E/A and E/E′ ratios were calculated.

3. Statistical analysis

Data are presented as mean ± SD or proportions (% of patients). Continuous data was compared with two-tailed unpaired Student's *t* test and discrete data with Chi-square test. Continuous variables were compared using one-way ANOVA. Correlations were tested with Pearson coefficients.

4. Reproducibility

To assess intraobserver and interobserver variability for wall thickness, 10 randomly selected recordings that had been stored on videotape were remeasured by the same operator three months after the first set of measurements. Also, the same 10 recordings were analyzed by another operator in a blinded fashion to determine interobserver variability. Variability was assessed as the difference between two readings in % of the mean. We have also used a multivariate model, including gender, body-mass index, body-surface area, waist/hips ratio and systolic blood pressure for predicting diastolic dysfunction. Intraobserver variability for myocardial thickness proved to be 1.4% and interobserver variability was 1.8%.

5. Results

Except for BMI, BSA, waist and hips, which were significantly increased in the study groups ($p<0.001$ for all), all other demographic and biochemical parameters were not different between lean, overweight and obese adolescents (Table 1). Systolic ($p=0.001$), but not diastolic arterial blood pressure increased significantly with the increase in BMI. In multivariate analysis, none of the clinical parameters independently predicted LV diastolic dysfunction.

5.1. Left ventricular structure and function

All echo measurements of LV myocardial thickness: septal and LV posterior wall thickness, relative wall thickness, LV mass and LV mass-index were increased with increasing BMI ($p<0.001$ for all, Table 2). LV cavity dimensions and systolic function measurements (LV EDD, LV ESD, shortening fraction, ejection fraction, lateral and septal long axis amplitudes) and LA diameter were not different between groups. However, LV myocardial systolic velocities (S′) of the lateral and septal long axes were significantly reduced with the increase in BMI ($p=0.02$ and $p=0.01$, respectively, Table 2, Fig. 1). Diastolic LV long axis function in the form of early diastolic myocardial velocities (E′) of the lateral and septal long axes ($p<0.001$, and $p=0.003$,

Table 1
Clinical and biochemical characteristics of the study patients classified according to body mass index.

Variable	Lean (n=32)	Overweight (n=33)	Obese (n=28)	p value
Age (years)	12.6±1.3	12.4±1.1	12.9±1.3	0.29
Gender (F, %)	52	47	50	0.17
Heart rate (b/min)	80±14	82±13	83±16	0.23
Systolic blood pressure (mm Hg)	108±8	115±11[1]	118±12[2]	0.001
Diastolic blood pressure (mm Hg)	74±6	76±7	74±9	0.43
Body surface area (m^2)	1.56±0.16	1.71±0.16[1]	1.80±0.18[6]	<0.001
Waist (cm)	74±7	84±9[4]	89±9[3,5]	<0.001
Hips (cm)	90±8	101±9[4]	109±6[3,6]	<0.001
Waist/hips ratio	0.83±0.1	0.83±0.1	0.82±0.1	0.84
Total proteins (g/dL)	78±4	77±12	78±5	0.70
Total bilirubin (μmol/L)	15±1.3	11±3	13±6.7	0.26
Fasting glucose (mmol/L)	5.6±0.6	5.7±2.5	5.2±0.6	0.43
Total cholesterol (mmol/L)	3.8±0.7	4±0.8	4.2±0.9	0.27
Triglycerides (mmol/L)	1.1±0.4	1.2±0.5	1.1±0.3	0.64
LDL cholesterol (mmol/L)	3.6±0.6	3.9±0.7	3.8±0.4	0.09
HDL cholesterol (mmol/L)	1.4±0.2	1.4±0.2	1.4±0.2	0.85
Urea (mmol/L)	3.6±1.1	3.9±1.1	3.5±0.6	0.29
Creatinine (μmol/L)	71±9	70.6±11	70.5±12	0.95
Erythrocytes (×10^{12}/L)	3.9±0.4	3.9±0.4	4±0.4	0.68
Leukocytes (x10^3/L)	7.1±2	7.1±2.2	7.7±2.2	0.44
Hemoglobin (g/L)	12.7±0.9	12±1.2	12.4±1.3	0.08
C reactive protein (mg/L)	11±5	10±5.8	11±4.5	0.65

Legend: (1): $p<0.05$ lean vs. overweight; (2): $p<0.05$ Group lean vs. Group obese; (3): $p<0.05$ overweight vs. obese; (4): $p<0.001$ lean vs. overweight; (5): $p<0.001$ lean vs. obese; (6): $p<0.001$ overweight vs. obese.