EPICARDIAL ADIPOSE TISSUE IN CHILDREN AND ADOLESCENTS AND CARDIOMETABOLIC RISK FACTORS

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Background*: Epicardial adipose tissue (EAT) is the visceral fat depot of the heart and is commonly increased in obese subjects. EAT is related to cardiovascular risk factors in adults. but this relationship in children is not well known yet.*
Aim *of our study was to assess amount of EAT – measure by echocardiography and its association with cardiometabolic risk factors in obese and overweight children*
Study group and methods*: Our study group consisted of 25 (mean age 12.96 ±2.28) obese and overweight subjects and 24 age- and gender matched lean controls. Blood pressure and waist circumference (WC) were measured and lipids levels, uremic acid, and total proteins levels were established. Each subject underwent transthoracic echocardiogram to evaluate EAT thickness.*
Results: *In obese and overweight EAT was significantly higher ($p<0.01$) compared to normal weight control group. Obese and overweight children had significantly higher body weight (BW), BMI and waist circumference (WC) ($p < 0.01$). TAG, LDL and total cholesterol ($p < 0.05$; $p < 0.01$), systolic and diastolic blood pressure (BP) ($p < 0.05$; $p < 0.01$). Serum HDL cholesterol was lower ($p < 0.05$). In linear regression analysis EAT positively correlated with BW, BMI, WC and with systolic and diastolic BP, TAG ($p < 0.01$), and uric acid (UA) ($p < 0.01$). Negative correlation between HDL ($p < 0.01$) and EAT was found. Multiple regression analysis confirmed that body weight, BMI, BMI percentil and WC, systolic BP and TAG were the strongest independent variables correlated with EAT.*
Conclusion*: Elevated echocardiographic EAT thickness in obese and overweight children is associated with unfavourable cardiometabolic risk profile. The echocardiographic measurement of EAT is a relatively reliable method in paediatric population. However, it requires the creation of a standardized examination methodology for children age, as well as the creation of certain reference values considering the growth and development of children, their gender as well as the puberty period characterized by hormonal changes different in girls and boys.*

Key words: epicardial adipose tissue, children, adolescent, risk factor, cardiometabolic

Introduction

Recently, the extreme increase of obesity has been reported not only in adults but also in children. Recent surveys, indicate that an estimated 18 % of European school children in the 25 EU member states are overweight [1]. Obesity is a chronic metabolic disorder associated with cardiovascular disease and increased morbidity and mortality [2]. Obesity, predominantly in the upper body (android, visceral type) represents a strong and independent predictor of many consequences, such as dyslipidemia, insulin resistance, non-alcoholic fatty liver disease as well as total mortality [3, 4].

The thickness of EAT measured by echocardiography represents an independent predictor of visceral adiposity. A very good positive correlation of echocardiographic measurement of epicardial adipose tissue (EAT) with MRI measurements, which represent a golden standard for assessing visceral fat mass, were confirmed [5, 6, 7].

The accumulation of abdominal fat is in association with other cardiovascular and metabolic side effects manifested not only in adults but also in children and adolescents. It is assumed to be a better predictor of cardiovascular risk factors than the BMI [8, 9, 10, 33].

The use of echocardiographically determined EAT as an expression of the visceral adipose tissue quantity, and the use of this methodology for assessing the correlation with the cardiometabolic risk factors have been proved to be useful by many studies in adult populations [6, 11, 12, 13]. However, only a limited number of studies has been conducted on paediatric patients [8, 14, 15, 33].

The aim of our study was to assess the echocardiographic epicardial adipose tissue in obese and overweight children and its relationship to cardiometabolic risk factors.

Study group and methods

Twenty five obese and overweight subjects (12.96 ±2.28 years of age, 9 female) with BMI ≥ 85 percentil for age and gender were included in the study and were compared with 24 lean healthy subjects (12.95 ± 3.38 years of age, 12 female) matched for age and sex. Patients with secondary causes of obesity were excluded. None of the patients were taking medications or had a history of cardiovascular disease Age- and gender-matched children with BMI < 85th percentile for age and gender [16, 17] presented a control group. BMI was calculated as weight (kg) divided by the square of height (m) BMI percentiles. Waist circumference was measured according to WHO recommendations [18].

Blood pressure was measured three times according to the recommendations of European Society of Hypertension [19] by the Korotkow method. We calculated average of three measurements. Fasting blood

samples were drawn after 12 h night fasting. Fasting plasma glucose, serum triglyceride (TG), total cholesterol (TC) and high-density lipoprotein (HDL)-cholesterol (HDL-C) concentrations were measured enzymatically using an autoanalyzer ADVIA Siemens. LDL (low density cholesterol) was calculated according to Fridewald´s formula [20]. Fasting serum insulin level was measured using a SANDWICH ECLA METHOD on biochemical analyzer MODULAR Analytics E170 Roche. Uric acid and total proteins were measured by fotometric kinetic method on biochemical analyzer ADVIA Siemens. ApoA1 (apoprotein A1), ApoB (apoprotein B) were measured by Immununoturbidimetric test by biochemical analyzer ADVIA Siemens. Homocysteine was measured by fotometric method on biochemical analyzer ADVIA Siemens.

The epicardial adipose tissue (EAT) was identified as an echo-free space in the pericardial layers on two-dimensional echocardiography, and its thickness was measured perpendicularly on the free wall of the right ventricle from parasternal long- and short-axis views at end-diastole according to Iacobelis et al. [6]. We did performed the same measurement and we measured the thickness of the right ventricle at the end- systole as well. The measurement was done during three cardiac cycles. The average value from three cycles was computed and used for further statistical analysis.

Statistical analysis

The obtained data were processed using methods of descriptive and inductive statistics, depending on the type and number of simultaneously monitored variables. We commonly assumed that our data represent a random sample of the relevant population for the purpose of the inductive statistics. The significance level was set to traditional 5 %.

The first step was a one-dimensional analysis - the tabulation of all monitored variables using frequency tables. All detected problems were checked and corrected.

The second step was a two-dimensional analysis - the assessment of pairs of monitored variables. The non-parametric Kendall correlation coefficient (and the test of its significance), that is used for measurement of monotone statistical dependence (not only linear), was used for two numeric variables. Its choice was based on the fact that some variables had significantly abnormal distribution, often with extreme values, which could disvalue traditionally used Pearson's correlation coefficient. To compare numerical (e. g. BP) and categorical (e.g. obesity level) variables, description tables and the eta coefficient were used. ANOVA was used to determine the statistical significance of the mean difference. The distribution of variables was about normal.

The last step was a multi-dimensional analysis - a multiple regression, where the relation between several numerical variables was examined simultaneously.

All calculations were performed using a freeware version 8.0. of SPSS software [21].

Results

The comparison of the basic anthropometric and clinical and biochemical parameters of the study group and control group are reported in Table 1. The body weight and body mass index (BMI), BMI percentile, WC, systolic and diastolic blood pressure (BP) were significantly higher in obese and overweight subjects compared to lean control. Obese and overweight had higher values of triglycerides (TAG), LDL and total cholesterol (TC) and ApoB, compared to control groups, while HDL cholesterol was lower. Significant differencies total protein values, which were higher in children with obesity and overweight, were observed (Tab. 1).

Table 1 Anthropometric, clinical and biochemical characteristics of study group and control group

Biochemical Variables	*Overweight and obesity (BMI ≥ 85 percentil) n 25*	*Normal body weight (BMI ≤ 85 percentil) n 24*	*p-value*
Body height (cm)	163.98 ± 16.42	161.30 ± 13.15	ns
Age (years)	12.95 ± 3.38	14.21 ± 3.06	ns
Body weight (kg)	72.34 ± 19.58	50.49 ± 14.26	p < 0,01
Body mass index (BMI)	27.35 ± 3.54	18.8 ± 3.07	p < 0.01
BMI percentil	94.26 ± 3.49	36.17 ± 28.32	p < 0.01
Systolic blood pressure (mmHg)	133.41 ± 16.41	120.27 ± 17.37	p < 0.05
Systolic blood pressure (mmHg)	80.29 ± 11.48	69.73 ± 7.36	p < 0.01
Waist circumference (cm)	95.45 ± 12.60	73.13 ± 8.82	p < 0.01
Fasting glucose (mmol/l)	4.44 ± 0.5	4.38 ± 0.46	ns
Fasting insulin (μU//ml/l)	23.92 ± 13.98	14.29 ± 1.45	ns
Total cholesterol (mmol/l)	5.19 ± 1.21	4.22 ± 0.86	p < 0.05
Triglyceride (mmol/l)	0.74 ± 0.31	1.94 ± 1.11	p < 0.01
HDL cholesterol (mmol/l)	1.16 ± 0.24	1.46 ± 0,24	p < 0.05

LDL cholesterol (mmol/l)	3.13 ± 1.07	2.43 ± 0.7	p < 0.05
Uric acid (umol/l)	321.42 ± 67.47	281.92 ± 69.27	ns
Serum Creatinine (umol/l)	67.7 ± 8.88	72.41 ± 7.21	ns
Urea (mmol/l)	3.87 ± 0.66	4.5 ± 1.32	ns
Total Proteins (g/l)	75.89 ± 4.54	72.83 ± 3.55	p < 0.05
Total Bilirubine (umol/l)	8.47 ± 5.38	10.89 ± 6.31	ns
ApoA1 (g/l)	1.57 ± 0.24	1.6 ± 0.35	ns
ApoB (g/l)	0.88 ± 0.29	0.64 ± 0.19	p < 0.01
Hcy (umol/l)	7.77 ± 1.77	7.48 ± 0.64	ns

Table 1 ApoA1 – apoprotein A1; ApoB – apoprotein B; Lp(a) - lipoprotein lipase; Hcy – homocysteine; HDL cholesterol - high-density lipoprotein cholesterol; LDL - low density cholesterol; r- correlation coefficient

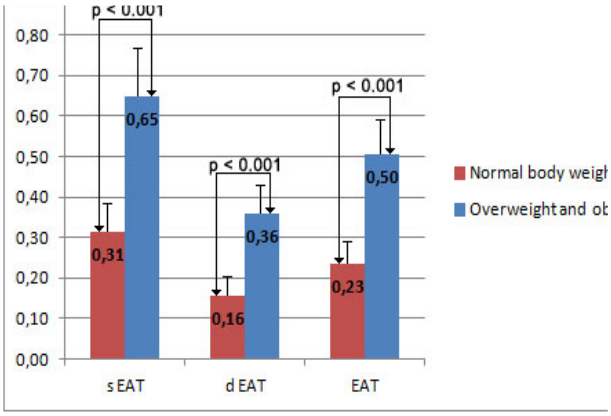
The average thickness of epicardial adipose tissue (EAT) at the end of systole, diastole and mean EAT (average value of systole and diastole) on right ventricle were significantly higher in overweight and obese children compared to EAT thickness of normal weight children (Tab. 2, Fig. 1).

Table 2 Comparisons of epicardial adipose tissue (mean ± SD) in normal and overweight and obese children

EAT	*Overweight and obesity (BMI≥85percentil) n 25*	*Normal body weight (BMI<85percentil) n 24*	*p-value*
Mean sEAT	0.31 ± 0.09	0.64 ± 0.18	p≤ 0.0001
Mean dEAT	0.15 ± 0.06	0.36 ± 0.10	p≤0.0001
Mean EAT	0.23 ± 0.07	0.50 ± 0.14	p≤0.0001

BMI – body mass index; Mean sEAT - mean epicardial adipose tissue in parasternal long and short axis in systole; Mean dEAT - mean epicardial adipose tissue in parasternal long and short axis in diastole; MeanEAT – mean EAT in short and long axis in systole and diastole; r – correlation coefficient

Figure 1 Comparison of mean, systolic and diastolic EAT between normal weight, overweight and obese children



sEAT - mean epicardial adipose tissue in parasternal long and short axis in systole; dEAT - mean epicardial adipose tissue in parasternal long and short axis in diastole; EAT – mean EAT in short and long axis in systole and diastole; r – correlation's coefficient

Simple linear regression analysis showed a positive correlation of EAT with body weight (BW) (Fig. 2), BMI, BMI percentil, WC and systolic and diastolic BP and echocardiographic epicardial adipose tissue (EAT). Positive correlation was found also between EAT and TAG, ApoB, (Fig. 2), uric acid (Fig. 3), and total proteins and negative between HDL cholesterol and EAT (Tab. 3)

Figure 2 Correlations of mean EAT and body weight

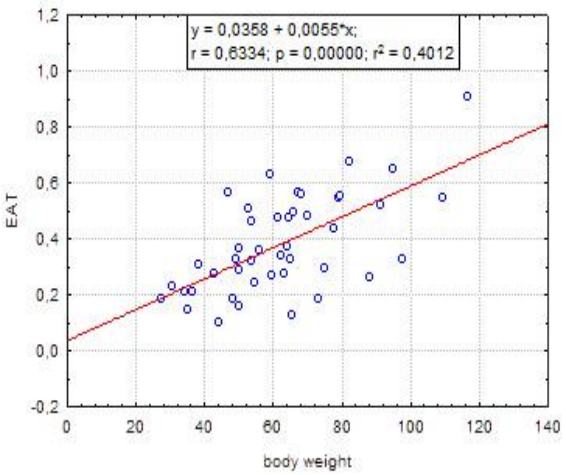
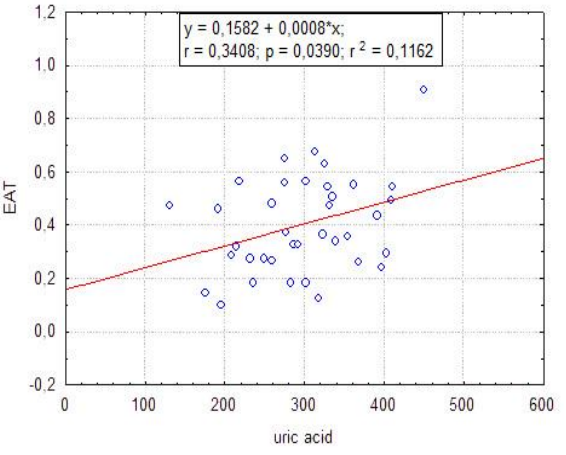


Figure 3 Correlations of mean EAT and uric acid



Multiple regression analysis confirmed that body weight, BMI, BMI percentil and WC, systolic BP and TAG were the strongest independent variables correlated with EAT (Tab. 3, 4).

Table 3 Correlation of EAT and anthropometric, clinical and biochemical characteristics

Variable	*Mean sEAT*		*Mean dEAT*		*Mean EAT*	
	r	*p-value*	*r*	*p-value*	*r*	*p-value*
Gender	0.22	ns	0.27	ns	0.24	ns
Age	-0.04	ns	-0.06	ns	-0.05	ns
Body weight (kg)	0.61	p≤0.0001	0,62	p≤0.0001	0.63	p≤0.0001
Body height (cm)	0.11	ns	0,14	ns	0.12	ns
BMI – Body mass index (kg/m^2)	0,78	p≤0.0001	0.77	p≤0.0001	0.80	p≤0.0001
BMI percentil	0.70	p≤0.0001	0.72	p≤<0.0001	0.72	p≤0.0001
Waist circumference (cm)	0.66	p≤0,001	0.67	p≤0.001	0.68	p≤0.0001
Systolic BP (mmHg)	0.38	p≤0.05	0.40	p≤0.05	0.40	p≤0.05
Diastolic BP (mmHg)	0.41	p≤0.05	0.45	p≤0.01	0.43	p≤0.01
Total cholesterol [mmol/l]	0.26	ns	0.36	ns	0.30	ns
Trigliceride [mmol/l]	0.66	p≤0.0001	0.68	p≤0.0001	0.68	p≤0.0001
HDL cholesterol (mmol/l)	-0.51	p≤0.0001	-0,46	p≤0.01	-0.50	p≤0.001
LDL cholesterol (mmol/l)	0.16	ns	0.26	ns	0.20	ns
Fasting glucose (mmol/l)	0.22	ns	0.29	ns	0.26	ns
Urea (mmol/l)	-0.23	ns	-0.36	p≤0.05	-0.29	ns
Serum kreatinin (μmol/l)	-0.31	ns	-0.19	ns	-0.27	ns
Uric acid (μmol/l)	0.38	p≤0.05	0.37	p≤0.05	0.34	p≤0.05
Total proteins (g/l)	0.37	p≤0.05	0.33	p≤0.05	0.37	p≤0.05
Total bilirubine (μmol/l)	-0,07	ns	-0.07	ns	-0.07	ns
ApoA1 (g/l)	-0.31	ns	-0.23	ns	-0.29	ns
ApoB (g/l)	0.32	p≤0.05	0.43	p≤0.01	0.37	p≤0,05
Hcy (μmol/l)	-0.20	ns	-0.09	ns	-0.16	ns

BP–blood pressure; BMI – body mass index; Mean sEAT-epicardial adipose tissue in parasternal long and short axis in systole; Mean dEAT-epicardial adipose tissue in parasternal long and short axis in diastole; Mean EAT- epicardial adipose tissue in parasternal short and long axis in systole and diastole; r – correlation's coefficient, ApoA1 – apoprotein A1; ApoB– apoprotein B; Hcy– homocysteine

Table 4 Multiple regression analysis of anthropometric and biochemical variables

Variables	*Mean EAT*	
	r	*p*
Body weight (kg)	0.917	p≤0.01
BMI (kg/m^2)		p≤0.001
BMI percentil		p≤0.05
Waist circumference (cm)		p≤0.01
Systolic BP (mmHg)		p≤0.01
Diastolic BP (mmHg)		p≤0.10
Triglyceride (mmol/l)	0.732	p≤0.01
HDL cholesterol (mmol/l)		p≤0.30
Urea acid (μmol/l)		p≤0.43
Total proteins (g/l)		p≤0.21
ApoB (g/l)		p≤0.70

BP–blood pressure; BMI–body mass index; Mean EAT-epicardial adipose tissue in parasternal short and long axis in systole and diastole; r – correlation coefficient

Discussion

Epicardial adipose tissue (EAT) reflects intraabdominal visceral fat. The method of the echocardiographic determination of EAT has been introduced for the first time by Iacobelis et al. [5]. It represents a simple and reliable marker of visceral adiposity [7, 22]. The echocardiographic measurement of EAT provides excellent reliability with MRI measurement of epicardial and visceral fat.

The echocardiographic measurement of EAT thickness as an expression of the visceral adipose tissue quantity have been studied in many adult populations studies [6, 7, 12, 13]. However, only a limited number of studies has been published in children population [8, 14, 15]. Contrary to studies on adult patients, where the echocardiographic EAT values are measured at the end of systole; echocardiographic measurements EAT in paediatric population are the values measured at the end of diastole [8, 14, 15]. Therefore, the assessment and comparison of individual echocardiographic EAT values may often be confusing, as the EAT value at the end of diastole is lower due to the adipose tissue compression [6, 7], which was confirmed in the current work as well.

Therefore, we assessed the amount of echocardiographic EAT at the end of diastole and systole and calculated the average of these values. Statistically significant correlations and differences presented in our study were confirmed for all of them. Thus, we do not assume that individual parameters could be possibly affected by matter of measuring EAT.

However, in childhood it is important to consider the growth and development of children as well as their gender. In our group of patients we found neither age nor gender correlation, similarly to the study by Mazur et al.

[8]. On the contrary, Abaci et al. [15] published the correlation between EAT and age.

We confirmed significantly higher thickness of echocardiographic EAT in obese and overweight children compared to lean controls in contrast to recently published data by Ozdemir et al. [14]**.** The obesity in our group of paediatric patients was associated with visceral adiposity assessed either by means of the WC measurement or by echocardiographic measurement of EAT. Similarly to the results of other published paediatric studies [8, 14, 15] we found a positive correlation between EAT and both BMI and WC. Thus, WC values represent a significant determinant of EAT. As EAT values are associated with visceral obesity, the echocardiographic EAT can be used as a simple, not expensive and accurate methods for the assessment of visceral fat in childhood.

Overweight and obesity predispose is associated with numerous cardiac complications such as coronary heart disease (CAD), heart failure, and sudden death through its impact on the cardiovascular system [2]. Obesity is often associated with cardiovascular risk factors such as dyslipidemia event in pediatric population; arterial hypertension is more frequent in obese and overweight subjects [2, 23].

Obese and overweight children showed significantly higher systolic and diastolic blood pressure and unfavourable lipid profile in the current study. Moreover, it was confirmed that cardiometabolic risk factors correlated with EAT already in childhood, similarly with the data published on adults [6, 7, 24, 25]. Emphasizing the fact that EAT could be a better predictor than BMI [9, 10]. Echocardiographic EAT could identify young obese who are at increased risk of developing CVD. However, this approach requires a standardized methodology, in order to use it on children population. Age and gender as well as growth and puberty period characterized by hormonal changes different in girls and boys have to be taken into account.

Nowadays, hyperuricemia is closely correlated with obesity and the body fat accumulation level [26]. There are several studies on adults demonstrating the correlation between visceral fat and uric acid [27, 28]. For the first time the correlation between uric acid and EAT in paediatric patients has been confirmed - in the present study. The uric acid values were higher in children with obesity and overweight, however this increase was not significant.

Elevated concentrations of uric acid are more frequently considered to be a new risk factor of cardiovascular diseases [26]. A large number of epidemiological studies point out a significant correlation between uric acid and cardiovascular and cerebrovascular diseases. In particular, in patients with arterial hypertension, uric acid is defined as an independent risk factor of cardiovascular diseases. In NHANES I (National Health and Nutrition Survey), uric acid was an independent risk factor for cardiovascular diseases both in men and women [30]. Uric acid can negatively affect the development and progression of cardiovascular diseases by stimulating inflammatory response in association with the pathogenesis of cardiovascular diseases [29]. System inflammation plays a crucial role in the initiation and progression of atherosclerosis and in AS plaque erosion and rupture. Inflammatory system markers in blood (e. g. hs-CRP, leukocytes, IL-1, IL-6 etc.) promote progression of AS, thus predicting the incidence of cardiovascular risk factors [29].

Uric acid plays a certain role in the presence of obesity and correlates with the amount of visceral tissue even in childhood. Excepted presented cardiovascular risk factors in obese children hyperuricemia could even more increases CV risk.

Hyperproteinemia is observed in almost 60% of obese patients [31]. It is present also in patients with type II DM [32]. In our study, we have found a significantly higher level of total proteins in obese children; while the total protein (TP) level positively correlated with EAT. Elevated values of TP in obese children could be associated with hyperalimentation which, when accompanied by reduced physical activities, is considered the most common cause of obesity in paediatric patients. However, the association between proteinemia and visceral adipose tissue has not been clarified yet.

In summary, we have demonstrated elevated echocardiographic EAT thickness in obese and overweight children in which an unfavourable cardiometabolic risk profile and hyperuricemia occurred. These cardiometabolic risk factors were associated with visceral adiposity expressed by the amount of echocardiographic EAT thickness in paediatric population. The echocardiographically measurement of EAT is a relatively reliable method in paediatric population. However, it requires the creation of a standardized examination methodology for children age, as well as the creation of certain reference values considering the growth and development of children, their gender as well as the puberty period characterized by hormonal changes different in girls and boys.

Limitations

In our study we did not study the influence of IR nor MS on EAT. Therefore more studies are necessary on paediatric population dealing with metabolic syndrome and IR and echocardiographic EAT similarly to already published studies on adults.

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This work was a part of the grant 1/0456/11 from the Scientific grant agency Ministry of education of Slovak Republic - VEGA.

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