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Sonographic evaluation of diaphragm thickness in pediatric patients with steatotic liver disease

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■ MAIN POINTS

- There is a positive correlation between anthropometric z-scores and diaphragm thickness.
- Diaphragm thickness increases in children with hepatosteatosi.
- Diaphragm thickness increases in obese children.

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■ ABSTRACT

Aim: The most common liver disease in children is metabolic dysfunction-associated steatotic liver disease. We expect increased diaphragm thickness in pediatric patients with hepatosteatosi. We aimed to compare diaphragm thickness in children with hepatosteatosi with that in the control group and to discuss the results in light of the current literature.

Materials and Methods: The study included 56 patients with metabolic dysfunction-associated steatotic liver disease and 78 healthy controls. The diaphragm measurement of the patient and control groups was performed from the anterior caudal part of the diaphragm at the end of expiration from the right and left sides.

Results: Diaphragm thickness, BMI, weight, and height Z scores were significantly greater in the group with fatty liver. We found a significant positive correlation between the stages of fatty liver and anthropometric measurement Z score values with diaphragm thickness.

Conclusion: The current study found that diaphragm thickness was thicker in pediatric patients with hepatosteatosi than that in healthy individuals and was positively correlated with anthropometric measurements. However, further studies are needed to evaluate diaphragmatic muscle function.

Keywords: Hepatosteatosi, Ultrasonography, Diaphragm thickness, Children

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■ INTRODUCTION

The most common liver disease in children is metabolic dysfunction-associated steatotic liver disease (MASLD). It occurs in patients with visceral fat, dyslipidemia, and insulin resistance. The natural history of MASLD in children has not been fully defined [1-4]. It is suggested that versican, hsCRP and IL-6 levels are higher in children with obesity than in their healthy peers and that fatty liver disease is more common as a result [5]. Han and colleagues [6] studied the molecules versican released from adipose tissue and biglycan released from macrophages. In their study on mice, the authors showed that targeted deletion of adipose tissue-derived versican resulted in decreased chemotaxis and consequently decreased hepatic inflammation. They showed that deletion of macrophage-derived biglycan decreased macrophage accumulation and chemokine/cytokine release. Inflammatory processes occurring in adipose tissue cause the early develop-

ment of insulin resistance, dyslipidemia, and hepatosteatosi in obesity [5].

Respiratory function and capacity are affected by obesity, but its pathophysiology cannot be clearly explained. The decrease in the thickness of the diaphragm, which is the main respiratory muscle that performs respiratory function, deteriorates respiratory function [7,8]. It has been shown that children with obese hepatosteatosi have higher intima-media thickness and are more prone to atherosclerosis compared with obese children without hepatosteatosi and healthy controls, and that the thickness of epicardial fat tissue increases further in obese patients with metabolic syndrome [9,10]. Given the increased frequency of hepatosteatosi in obese individuals [11], we expect increased diaphragm thickness in pediatric patients with hepatosteatosi. In order to realize this theory, which we found to be lacking in the literature, we aimed to examine the difference in diaphragm thickness in the pediatric

patient group with hepatosteatosi compared with the healthy control group and to discuss the results in light of the current literature.

MATERIALS AND METHODS

Study group: Patients with steatotic liver detected by ultrasound (US) and at least one risk factor for cardiometabolic dysfunction, such as overweight/obesity/visceral adiposity, dysglycemia, hypertension, or dyslipidemia, were diagnosed with steatotic liver disease associated with metabolic dysfunction [1]. These patients constituted the patient group of our study.

Control group: The study was conducted with healthy children of the same age group without any chronic diseases.

Patients with malnutrition, chronic liver disease, chronic lung disease, congenital heart failure, chest deformity, and myopathy were excluded from the study.

The study was approved by the University Hospital Non-Vascular Clinical Research Ethics Committee. (Approval date: 19.04.2021, Session No: 2021/15, Decision No: 05).

Our study complied with the principles of the Declaration of Helsinki. A consent form was obtained from the patients before the study began.

Selection of patient group

All patients included in this group had fatty liver disease associated with metabolic dysfunction. There was no accompanying chronic liver disease. Patients were selected consecutively from those who visited the pediatric gastroenterology clinic and were diagnosed with MASLD.

Metabolic dysfunction

MASLD was diagnosed in the presence of one of the following criteria [12-15].

- Overweight or Obesity [16],
 - Those with a body mass index between the 85th and 95th percentiles were considered overweight.
 - Those with a body mass index $\geq 95^{\text{th}}$ percentile were considered obese.
- Type 2 diabetes mellitus
- ≥ 2 metabolic disorders (increase in waist circumference according to age and gender, high arterial blood pressure, high triglyceride, low high-density lipoprotein level, presence of prediabetic findings (fasting glucose 100-125 mg/dL, postprandial glucose 140-199 mg/dL or HbA1c 5.7-6.4%), high insulin resistance homeostasis model assessment [HOMA-IR] score and increased plasma high-sensitivity C-reactive protein [hs-CRP] levels.

Radiological evaluation

The ultrasound assessment of the cases was randomly performed by a radiologist with 12 years of experience in ultrasound. An E9-LOGIQ XDclear 2.0 device (USA 2017) and a linear low-frequency sensor (Matrix clear/6-15 MHz xd) were used for ultrasound evaluation. The diaphragm was measured bilaterally at the end of expiration and from the anterior caudal part of the diaphragm. An age-appropriate convex abdominal probe was used. The distance between the peritoneal and parietal lines in the longitudinal plane was calculated in mm (Figure 1) [17,18].

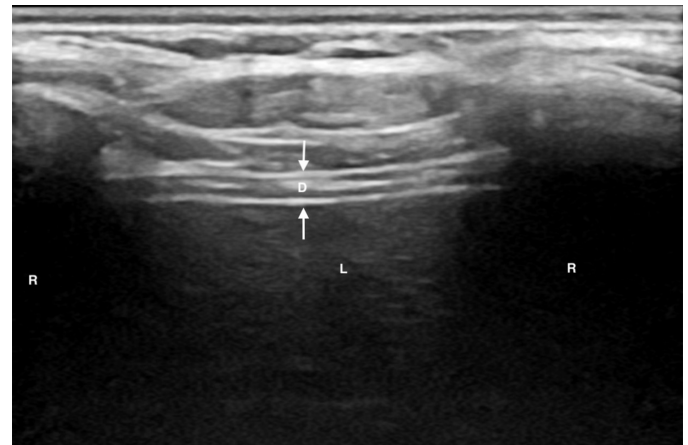


Figure 1. Diaphragm on longitudinal-plane ultrasonography. (D: diaphragm, L: liver, R: rib).

Power analysis

We could not find any study in the literature that compared the diaphragm thickness of pediatric patients with hepatosteatosi and metabolic syndrome-related liver disease with the healthy group. Therefore, assuming an effect size of 0.5, alpha: 0.12, power: 0.85, critical t-value: 1.53, 53 cases were detected in each group.

Statistical analysis

Statistical analyzes were performed using the Statistical Package for the Social Sciences (SPSS version 22.0 software (Chicago/USA). The normality of data distribution was tested using visual (histogram and probability charts) and analytical methods (Kolmogorov-Smirnov and Shapiro-Wilk tests). Descriptive analyzes were presented as percentile, mean, and standard deviation. Normally distributed numerical data were compared using the independent samples t-test, and non-normally distributed numerical data were compared using the Mann-Whitney U test. The chi-square test was used to compare the frequency rates of categorical variables.

A one-way ANOVA test was used to determine the arithmetic mean of the dependent variable between more than two independent groups. Posthoc analysis and the Scheffe test were used to determine the differences between groups with respect

to this independent variable. Correlation analysis was performed to determine whether there was a linear relationship between two numerical variables and, if so, the direction and intensity of this relationship. If these numerical data showed a normal distribution, Pearson's correlation was preferred; otherwise, Spearman's rank correlation was preferred. The p-value accepted as statistically significant was <0.05 .

A one-way ANOVA test was used to evaluate the arithmetic means of diaphragm thickness according to the degree of hepatosteatosis and the differences between the groups.

The independent Student's t-test was used to compare diaphragm thickness between groups. A Pearson correlation test was performed to determine the relationship between diaphragm thickness and anthropometric measurements.

■ RESULTS

Of the subjects included in the study, 78 were healthy controls and 56 were pediatric patients with MASLD. All patients with MASLD had hepatosteatosis. Seven patients (12.5%) were overweight and 29 patients (52%) were obese. 17 of these 36 patients (47.2%) had at least one accompanying metabolic dysfunction. Twenty patients (35.7%) were not overweight or obese and had two or more metabolic risk abnormalities. Of these, 12 patients had hypertriglyceridemia, 10 patients had hypertension, 8 patients had low HDL, 6 patients had insulin resistance, and 6 had prediabetes.

Of the cases included in the study, 56 had MASLD and 78 were healthy. The mean age of the cases was 10.17 ± 4.79 (0.1-17) years. 72 (53.7%) of the patients were male. The groups were not statistically different by age and sex ($p: 376$, $p: 122$).

When bilateral diaphragmatic thickness was evaluated in relation to age and gender, there was no significant difference ($p < 0.05$) (Table 1). Bilateral diaphragm thickness was significantly greater in the hepatosteatosis group. At the same time, height-weight measurement z scores were found to be significantly higher in the hepatosteatosis group (Table 1).

When the diaphragm thicknesses of the obese and non-obese hepatosteatosis patient groups were evaluated, the right and left diaphragms were found to be significantly thicker in the obese group ($p: 0.043$, $p: 0.048$, respectively).

When the diaphragm thickness and anthropometric measurement Z scores of the patients were compared with the healthy control group according to the stage of hepatosteatosis, the anthropometric measurement Z scores and diaphragm thickness were found to be significantly higher in the patient group with hepatosteatosis compared with the healthy cases in all stages (Table 2).

When the relationship between diaphragm thickness and anthropometric measurement scores of the patients was evaluated, moderate positive correlations were noted between diaphragm thickness and weight and body mass index z-scores. We found a weak positive correlation between height z-scores and diaphragm thickness. We found that bilateral diaphragm

thickness increased with increasing degree of hepatosteatosis (moderately positive correlation) (Table 3).

■ DISCUSSION

The diaphragm is an important respiratory muscle that plays an active role during inspiration and expiration. Ultrasonography is a safe examination method that can evaluate the function and structure of the diaphragm when performed by a competent practitioner. It provides for interpretation depending on the experience of the operator [19]. Low cost, bedside applicability, ease of application, and the ability to obtain dynamic and high-resolution images are the main advantages of US [18,20,21]. Diagnosis and monitoring of diaphragm muscle problems in intensive care patients with muscle disease are performed using routine ultrasound scanning [22]. In the intensive care unit, the use of mechanical ventilation results in diaphragmatic deformation [23]. Diaphragm ultrasound has been used as a predictive tool to identify the likelihood of extubation failure while weaning from mechanical ventilation [24]. It may also be useful for assessing diaphragm function in patients with neuromuscular disease and for demonstrating diaphragm thinning in patients undergoing mechanical ventilation [19,25].

We could not find a study in the literature evaluating the diaphragm thickness of pediatric cases with hepatosteatosis. However, there are studies reporting on the relationship between the diaphragm muscle, which is both a skeletal and respiratory muscle, and nutritional status. It has been documented that the diaphragm thickness of malnourished children is lower than that of their healthy counterparts, exhibiting a positive correlation with z scores derived from weight-height measurements [8]. In addition, epicardial adipose tissue thickness has been shown to increase in obese children compared to healthy group [26]. Our study showed that weight-height z-scores and diaphragm thickness were higher in the group of patients with hepatosteatosis than that in the healthy cases. In addition, a significant positive correlation was found between diaphragm thickness and anthropometric z-scores, which is consistent with the literature.

It has been emphasized that the increase in weight and blood pressure in adults may cause changes in epicardial fat tissue in conjunction with anthropometric markers. In a study of Spanish children, a relationship was found between body mass index, anthropometric parameters, and epicardial fat tissue. These measurements were associated with increased epicardial fat tissue thickness, which does not indicate early pathology but carries a risk of developing cardiovascular disease [26,27]. The endocardial adipose tissue of overweight children has been found to show significant positive correlations with BMI and anthropometric measurements, similar to those determined in adults [28-30]. In this study, unlike the literature, diaphragm thickness was evaluated. In patients with hepatosteatosis, weight-height measurement z-scores were significantly higher than those of the healthy con-

Table 1. Evaluation of differences in diaphragm thickness between groups.

	Female (68)	Male (66)	p
Right diaphragm thickness	1.60±0.40	1.55±0.42	0.484
Left diaphragm thickness	1.56±0.39	1.52±0.42	0.584
	Healthy control (78)	MASH (56)	p
Age	9.96±5.11	10.49±4.28	0.521
Weight Z score	-0.22±1.13	1.83±1.58	<0.001
Height Z score	-0.019±1.02	0.813±2.08	0.003
BMI Z score	-0.26±1.07	1.69±1.26	<0.001
Right diaphragm thickness	1.37±0.28	1.87±0.38	<0.001
Left diaphragm thickness	1.33±0.27	1.84±0.36	<0.001

Statistics: Independent Student's t-test. Abbreviations; MASH: Steatotic liver disease associated with metabolic dysfunction, BMI: Body mass index.

Table 2. Evaluation of diaphragm thickness according to hepatosteatosis degree.

	Healthy control (78)	Hepatosteatosis (56)			p
		Grade 1 (29)	Grade 2 (21)	Grade 3 (6)	
Right diaphragm thickness	1.367±0.284 ^a	1.837±0.407 ^b	1.876±0.360 ^b	2.033±0.377 ^b	<0.001
Left diaphragm thickness	1.334±0.272 ^a	1.817±0.414 ^b	1.846±0.331 ^b	1.950±0.320 ^b	<0.001
Weight Z-score	-0.220±1.133 ^a	1.638±1.548 ^b	2.095±1.689 ^b	1.906±1.501 ^b	<0.001
Height Z-score	-0.194±1.020 ^a	0.620±1.226 ^b	1.085±3.060 ^b	0.796±1.121 ^b	0.018
BMI Z score	-0.261±1.073 ^a	1.520±1.372 ^b	1.892±1.076 ^b	1.802±1.432 ^b	<0.001

Statistics: One-way ANOVA Post Hoc, Scheffe Tests, The difference between the mean values of a and barn is statistically significant ($p < 0.05$).

Table 3. Evaluation of the correlation between weight and height Z scores and diaphragm thickness.

		Weight Z-score (134)	Height Z-score (134)	BMI Z-score (134)	Hepatosteatosis Grade (56)
Right diaphragm thickness	r	0.510	0.176	0.515	0.569
	p	<0.001	0.042	<0.001	<0.001
Left diaphragm thickness	r	0.539	0.220	0.554	0.572
	p	<0.001	0.011	<0.001	<0.001

Statistics: Pearson's correlation. Abbreviation; BMI: Body mass index.

trol group. In the hepatosteatosis group, 29 (52%) pediatric patients were obese. The results of the study showed a positive correlation between weight-height measurement z-scores and diaphragm thickness, which is consistent with the literature. We attributed the reason for the thickening of the diaphragm muscle in the MASLD group to the fact that the patients in this group were larger than the healthy group and that the diaphragm muscle was more hypertrophied due to the increased workload stemmed from this excess weight.

Diaphragm ultrasonography provides qualitative information about the shape, movement, and changes in muscle size. The nature of this information is dependent on the practitioner's training. It also cannot provide quantitative information about diaphragm muscle function.

Limitations

These are the limitations of our study. In addition, this study is the only one to report diaphragm thickness in children pa-

tients with hepatosteatosis, making the study valuable.

CONCLUSION

In conclusion, this study showed that diaphragm thickness was thicker in pediatric patients with hepatosteatosis than in healthy individuals and was positively correlated with anthropometric measurements. This suggests that the diaphragm muscle is a useful tool for nutritional assessment. However, comprehensive studies are needed to evaluate the function of the diaphragm muscle.

Ethics Committee Approval: Kahramanmaraş Sütçü İmam University Non-Interventional Clinical Research Ethics Committee (Approval date: 19.04.2021, Session No: 2021/15, Decision No: 05).

Informed Consent: Our study complied with the principles of the Declaration of Helsinki. A consent form was obtained from the patients before the study began.

Peer-review: Externally peer-reviewed.

Conflict of Interest: There is no conflict of interest. All authors approved the final version of the manuscript.

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■ REFERENCES

- Rinella ME, Lazarus JV, Ratziu V, et al. NAFLD Nomenclature consensus group. A multisociety Delphi consensus statement on new fatty liver disease nomenclature. *Hepatology*. 2023;78(6):1966-1986. doi: 10.1097/HEP.0000000000000520.
- Lavine JE, Schwimmer JB. Nonalcoholic fatty liver disease in the pediatric population. *Clin Liver Dis*. 2004;8(3):549-58, viii-ix. doi: 10.1016/j.cld.2004.04.010.
- Huang JS, Barlow SE, Quiros-Tejiera RE, et al. NASPGHAN Obesity Task Force. Childhood obesity for pediatric gastroenterologists. *J Pediatr Gastroenterol Nutr*. 2013;56(1):99-109. doi: 10.1097/MPG.0b013e31826d3c62.
- Anderson EL, Howe LD, Jones HE, Higgins JP, Lawlor DA, et al. The Prevalence of Non-Alcoholic Fatty Liver Disease in Children and Adolescents: A Systematic Review and Meta-Analysis. *PLoS One*. 2015;10(10):e0140908. doi: 10.1371/journal.pone.0140908.
- Deveci Sevim R, Gök M, Çevik Ö, Erdoğan Ö, Güneş S, et al. Associations of Adipocyte-derived Versican and Macrophage-derived Biglycan with Body Adipose Tissue and Hepatosteatosis in Obese Children. *J Clin Res Pediatr Endocrinol*. 2024;16(2):151-159. doi: 10.4274/jcrpe.galenos.2024.2023-9-18.
- Han CY, Kang I, Harten IA, Gebe JA, Chan CK, et al. Adipocyte-Derived Versican and Macrophage-Derived Biglycan Control Adipose Tissue Inflammation in Obesity. *Cell Rep*. 2020;31:107818. doi: 10.1016/j.celrep.2020.107818.
- Peters U, Dixon A.E. The effect of obesity on lung function. *Expert Rev Respir Med*. 2018;12(9): 755–767. doi: 10.1080/17476348.2018.1506331.
- Güngör Ş, Doğan A. Diaphragm thickness by ultrasound in pediatric patients with primary malnutrition. *Eur J Pediatr*. 2023 Jul;182(7):3347-3354. doi: 10.1007/s00431-023-05024-x.
- Aylanç H, Aylanç N, Yıldırım Ş, Tekin M, Battal F, et al. Relationship between Abdominal Aortic Intima Media Thickness and Central Obesity in Children. *Horm Res Paediatr*. 2016;85(1):43-8. doi: 10.1159/000442156.
- Büyükyılmaz G, Özdemir Şahan Y. Evaluation of metabolic syndrome components, serum uric acid levels and epicardial adipose tissue thickness in pubertal children by severity of obesity. *Turk J Pediatr*. 2024;66(6):690-702. doi: 10.24953/turkjpediatr.2024.4558. PMID: 39807745.
- Yılmaz Y, Zeybel M, Adali G, et al. TASL Practice Guidance on the Clinical Assessment and Management of Patients with Nonalcoholic Fatty Liver Disease. *Hepatol Forum*. 2023;4(Suppl 1):1-32. doi: 10.14744/hf.2023.2023.0011.
- Styne DM, Arslanian SA, Connor EL, Farooqi IS, Murad MH, et al. Pediatric Obesity-Assessment, Treatment, and Prevention: An Endocrine Society Clinical Practice Guideline. *J Clin Endocrinol Metab*. 2017;102(3):709-757. doi: 10.1210/jc.2016-2573.
- Gofton C, Upendran Y, Zheng MH, George J. MAFLD: How is it different from NAFLD? *Clin Mol Hepatol*. 2023;29(Suppl):S17-S31. doi: 10.3350/cmh.2022.0367.
- Sinn DH, Kang D, Choi SC, Hong YS, Zhao D, et al. Nonalcoholic Fatty Liver Disease Without Metabolic-associated Fatty Liver Disease and the Risk of Metabolic Syndrome. *Clin Gastroenterol Hepatol*. 2023;21(7):1873-1880.e1. doi: 10.1016/j.cgh.2022.09.014.
- Fouad Y, Waked I, Bollipo S, Gomaa A, Ajlouni Y, et al. What's in a name? Renaming 'NAFLD' to 'MAFLD'. *Liver Int*. 2020;40(6):1254-1261. doi: 10.1111/liv.14478.
- Styne DM, Arslanian SA, Connor EL, Farooqi IS, Murad MH, et al. Pediatric Obesity-Assessment, Treatment, and Prevention: An Endocrine Society Clinical Practice Guideline. *J Clin Endocrinol Metab*. 2017;102(3):709-757. doi: 10.1210/jc.2016-2573.
- Şahin H, Doğan A, Ekiz T. Ultrasonographic evaluation of the diaphragm thickness in patients with multiple sclerosis. *Mult Scler Relat Disord*. 2019;36:101369. doi: 10.1016/j.msard.2019.08.011.
- Khurana, S.C. Gartner, L. Naik, B.C.H. Tsui Ultrasound identification of diaphragm by novices using ABCDE technique. *Reg. Anesth. Pain Med*. 2018;43(2):161-165. doi: 10.1097/AAP.0000000000000718.
- Fayssol A, Behin A, Ogna A, Mompont D, Amthor H, et al. Diaphragm: Pathophysiology and Ultrasound Imaging in Neuromuscular Disorders. *J Neuromuscul Dis*. 2018;5(1):1-10. doi: 10.3233/JND-170276.
- Goligher EC, Laghi F, Detsky ME, et al. 2015. Measuring diaphragm thickness with ultrasound in mechanically ventilated patients: feasibility, reproducibility and validity. *Intens Care Med*. 2015;41:642–649. doi: 10.1007/s00134-015-3687-3.
- Özçakar L, Kara M, Chang KV, et al. Nineteen reasons why physiatrists should do musculoskeletal ultrasound: EURO-MUSCULUS/ USPRM recommendations. *Am J Phys Med Rehabil*. 2015;94(6):e45–e49. doi: 10.1097/PHM.0000000000000223.
- O'Gorman CM, O'brien TG, Boon AJ. Utility Of diaphragm ultrasound in myopathy. *Muscle Nerve*. 2017;55(3):427–9. doi: 10.1002/mus.25429.
- Grosu HB, Lee YI, Lee J, Eden E, Eikermann M, et al. Diaphragm muscle thinning in patients who are mechanically ventilated. *Chest*. 2012;142(6):1455–60. doi: 10.1378/chest.11-1638.
- Matamis D, Soilemezi E, Tsagourias M, Akoumianaki E, Dimassi S, et al. Sonographic evaluation of the diaphragm in critically ill patients. Technique and clinical applications. *Intensive Care Med*. 2013;39(5):801–10. doi: 10.1007/s00134-013-2823-1.
- Laghi FA Jr, Saad M, Shaikh H. Ultrasound and non-ultrasound imaging techniques in the assessment of diaphragmatic dysfunction. *BMC Pulm Med*. 2021;21(1):85. doi: 10.1186/s12890-021-01441-6.
- Blancas Sánchez IM, Aristizábal-Duque CH, Fernández Cabeza J, Aparicio-Martínez P, Vaquero Alvarez M, et al. Role of obesity and blood pressure in epicardial adipose tissue thickness in children. *Pediatr Res*. 2022;92(6):1681-1688. doi: 10.1038/s41390-022-02022-x.
- Bertaso, AG, Bertol, D, Duncan, BB. & Foppa, M. Epicardial fat: definition, measurements and systematic review of main outcomes. *Arg Bras Cardiol*. 2013;101(1):e18-28. doi: 10.5935/abc.20130138.
- López-Bermejo, A, Prats-Puig, A, Osiniri, I, Martínez-Calcerrada, J.-M. & Bassols, J. Perirenal and epicardial fat and their association with carotid intima-media thickness in children. *Ann Pediatr Endocrinol Metab*. 2019;24(4):220-225. doi: 10.6065/apem.2019.24.4.220.
- Shin, J.-H. Is the measurement of epicardial fat in obese adolescents valuable? *Korean Circ J*. 2012;42(7):447-8. doi: 10.4070/kcj.2012.42.7.447.
- Mazur, A, Ostasinski, M, Telega, G. & Malecka-Tendera, E. Is epicardial fat tissue a marker of metabolic syndrome in obese children? *Atherosclerosis*. 2010;211(2):596-600. doi: 10.1016/j.atherosclerosis.2010.02.036.