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Original Article

Ultrasonographic measurement of palatine tonsil size and its correlation with body-mass index and hepatosteatosis in adolescents

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Abstract

Aim: To research the correlation between body-mass index (BMI) and hepatosteatosis with palatine tonsil size measured using transcervical ultrasonography (TCU) in adolescents.

Material and Method: This prospective study included 56 males and 41 females for a total of 97 adolescents. Cases were divided into three groups as those healthy according to BMI and hepatosteatosis (Group 1), those obese without hepatosteatosis (Group 2) and those obese with hepatosteatosis (Group 3). Palatine tonsil size was assessed with a 4.8-11.0 MHz linear transducer, while liver echo was assessed with a 3.5-5 MHz convex transducer. Cut-off values for variables in the groups were analyzed with Receiver Operating Curve.

Results: The mean ages in Groups 1, 2 and 3 were 159.67±24.9, 159.17±24.7 and 160.7±25.8 months, respectively. Tonsil volumes were 3.18±0.5, 3.73±0.9 and 4.45±0.7 ml in Groups 1, 2 and 3, respectively and there was a statistically significant difference between the groups (p values for Groups 1-2 0.011, Groups 1-3 <0.001 and Groups 2-3 0.002). The sensitivity and specificity of threshold tonsil volume for differentiation between groups was calculated as 50% and 90% for the threshold value of 3.73 ml between Groups 1 and 2, 86.7% and 100% for the threshold value of 3.88 ml between Groups 1 and 3 and 86.7% and 63.3% for the threshold value of 3.88 ml between Groups 2 and 3.

Conclusion: TCU is beneficial method to objectively assess palatine tonsil volume. There is a positive increasing correlation between palatine tonsil volume with BMI and hepatosteatosis in adolescents.

Keywords: Palatine; Tonsil; Size; Adolescents; Ultrasonography; Hepatosteatosis.

INTRODUCTION

Sleep-disordered breathing (SDB) is characterized by disruption of ventilation and respiration in sleep and includes a spectrum from snoring to obstructive sleep apnea syndrome (OSAS) (1). In children the etiology of SDB involves narrowing of different levels of the airway like the nasopharynx, oropharynx and hypopharynx and tonsillar hypertrophy (2). In addition to tonsillar hypertrophy in obese children, the reduction in lung volume and oxygen reserves linked to fat accumulation in soft tissue around the upper respiratory tract and around the abdomen and chest contribute to OSAS (3). To resolve airway obstruction in patients with tonsillar hypertrophy, generally tonsillectomy is performed. Knowing the size of the tonsils before surgery is very important for the success of the procedure (4).

Palatine tonsils are easily observed in the oropharynx during oral examination. However, evaluation may be difficult sometimes due to the size and location of the tongue and base of the tongue. In practice, to measure tonsil size clinical classification and lateral X-rays are used. Clinical classification is made according to the transverse extension of the tonsils toward the mid-line. However, physical examination cannot assess depth or vertical aspects and the medial nerve extending to the pharynx (5,6). It is difficult to distinguish the anterior and posterior tonsils from the pillars due to similar density on computed tomography (CT). Due to similar signal properties on T1 weighted sequences on magnetic resonance imaging (MRI), the tonsils cannot be distinguished from surrounding muscle tissue. Due to lymphoid tissue and submucosal glands contained in the tonsils they have longer T2 relaxation time compared to neighboring muscles (7). Additionally for CT there is radiation exposure and MRI requires anesthesia. In recent times studies have determined that transcervical ultrasound (TCU) is a practical method to measure the

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size of the palatine tonsils (8,9). Additionally, in the recent period there are studies evaluating the correlation of upper respiratory tract stenosis in obese children with OSAS and lymphoid tissue size and fat distribution in abdominal organs with MRI (10). To the best of our knowledge, there is no sonographic study assessing the correlation between fat accumulation in abdominal organs and tonsil size in the literature.The aim of this study is the measure the size of the palatine tonsils in adolescents with TCU and research the correlation with body mass index (BMI) and hepatosteatosis.

MATERIALS and METHODS

Study design

This prospective study assessed a total of 97 adolescents, 56 boys and 41 girls, from September 2015 to February 2017 after receiving permission from the local clinical research ethics committee. Before TCU investigation, "informed consent" was obtained from the parents of all cases accepted to the study.

Patients

BMI from 3-97% according to age and gender was assessed as healthy. Obesity diagnosis used the study data of Cole et al. (11). Exclusion criteria included rejection of participation, presence of any etiologic factor that may cause hepatosteatosis apart from obesity, fever during assessment, acute or chronic tonsillitis, tumor related to the tonsils, and trauma or surgical history. As all TCU images were at optimal quality for evaluation, no case was excluded from the study.

Ultrasound Investigation

Both investigations (transabdominal and transcervical) used an AplioTM 500 (Toshiba Medical Systems Co. Ltd., Otawara, Japan) device and were performed by a pediatric radiology expert with 6 years experience of pediatric radiology. Liver echo used as 3.5-5 MHz broad band convex probe after at least 8 hours fasting, in supine position with subcostal or intercostal approach assessed transabdominally. Hepatosteatosis was classified as mild (grade 1), moderate (grade 2) and severe (grade 3) according to echo increase.

Tonsil size was measured with a 4.8-11.0 MHz transducer. Patients lay on their back with neck extended and turned away from the investigation side. After clearly identifying the mandibular angle, the probe was placed transcutaneous in transverse and longitudinal planes under the lower chin angle and above the hyoid bone. In this position the tonsils were identified as a well-defined hypoechoic structure lateral of the root of the tongue below the submandibular gland (Figure 1, 2). Tonsillar parenchyma had a striated appearance due to linear hyperechoic and hypoechoic bands due to the crypts. The intense echogenous moving points commonly observed medial of the tonsil represent air in the pharynx.
Due to their ellipsoid shape, tonsil volume was calculated in mm3 (ml) using the formula "0.52 x length x depth x height".

Statistical Analysis

Analysis of variables used the SPSS 22.0 (IBM Corporation, Armonk, New York, United States) and Medcalc 14 (Acacialaan 22, B-8400 Ostend, Belgium) programs. Normal distribution of data was assessed with the Shapiro-Wilk test with variance homogeneity assessed with the Levene test. Comparison of quantitative data from two independent groups used the independent samples T test with bootstrap results. Comparison of quantitative data from more than two groups used the one way ANOVA test and Games-Howell test for post-hoc analysis. Comparison of categorical variables was evaluated with the Pearson Chi-Square Monte Carlo Simulation. The correlation of the classification due to calculated cut-off between variables in the patient groups with real classes

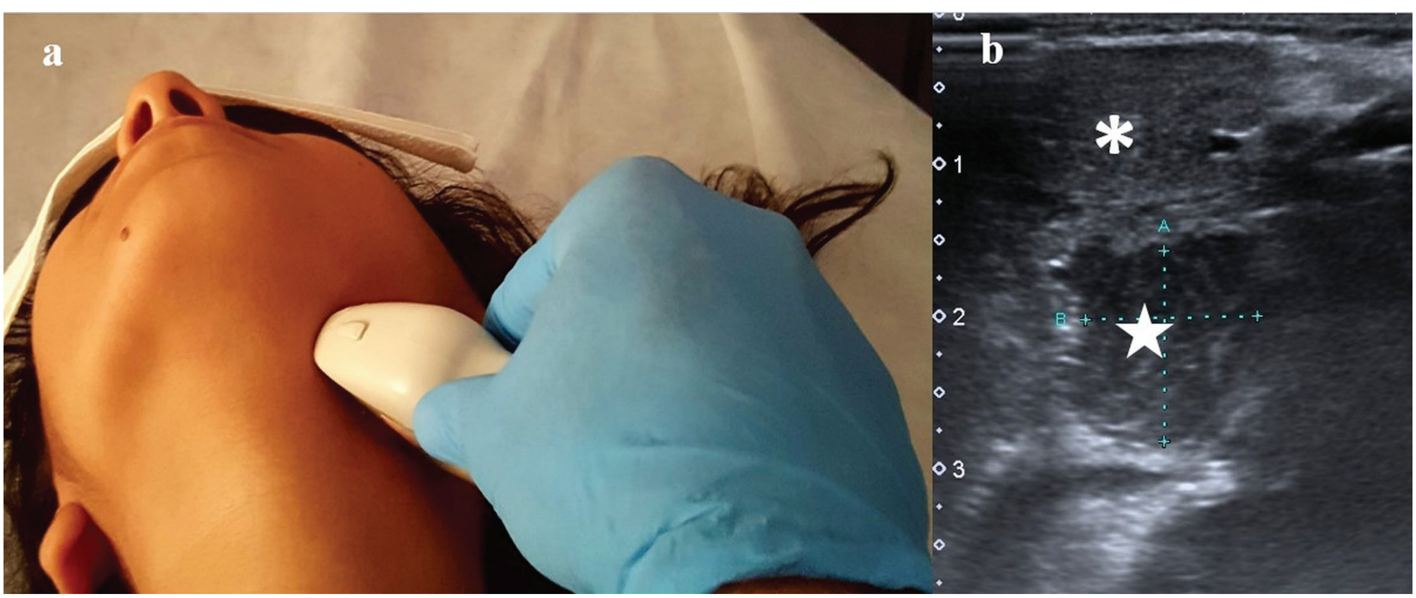

Figure 1 a, b. Measurement of tonsil size in transverse plane by means of transcutaneous approach. The probe is placed longitudinally to the mandibular angle (asterix: submandibular gland, star: left tonsil).

Figure 2. a, b. Measurement of tonsil size in longitudinal plane by means of transcutaneous approach. The probe is placed obliquely to the mandibular angle (asterix: submandibular gland, star: left tonsil

was investigated with sensitivity and specificity ROC (receiver operating curve) analysis. Quantitative data are given as mean ± standard deviation and median and range (min-max) on tables while categorical variables are given as n (%). Variables were investigated at the 95% confidence level with a p value less than 0.05 accepted as significant

RESULTS

Cases were divided into three groups as those healthy according to BMI and hepatosteatosis (Group 1), those obese without hepatosteatosis (Group 2) and those obese with hepatosteatosis (Group 3). The mean ages in Groups 1, 2 and 3 were 159.67±24.9, 159.17±24.7 and 160.7±25.8 months, respectively, with no difference between the groups (p=0.971). BMI values in Groups 1, 2 and 3 were 22.31±3, 26.70±1 and 26.76±1, respectively, with no difference identified between groups 2 and 3 (p=0.983). Tonsil volumes were 3.18±0.5, 3.73±0.9 and 4.45±0.7 ml in Groups 1, 2 and 3, respectively and there was a statistically significant difference between the groups (p values for Groups 1-2 0.011, Groups 1-3 <0.001 and Groups 2-3 0.002). The demographic data and tonsil volumes of the groups are summarized in Table 1.

Table 1. Baseline descriptive data and tonsil volume of the study population

Healthy (group 1)	34	159.67 ± 24.90	22.31 ± 2.56	3.18 ± 0.47
Obese – without hepatosteatosis (Group 2)	32	159.17 ± 24.68	26.70 ± 1.36	3.73 ± 0.86
Obese – with hepatosteatosis (Group 3)	31	160.70 ± 25.78	26.76 ± 1.39	4.45 ± 0.71
Total	97	159.84 ± 24.85	25.26 ± 2.79	3.79 ± 0.87
P value				
Comparison between groups	I-II	NS	<0.001	0.011
	I-III	NS	<0.001	<0.001
	II-III	NS	0.983	0.002

NS: not significant, SD: Standard Deviation

According to hepatosteatosis degree, the number of cases and tonsil volumes in cases with Grade 1 and 2 were n=18; 4.57 ±0.74 ml and n=12; 4.19±0.63 ml, with no difference in tonsil volumes between the grades (p=0.181). As there was only 1 case with Grade 3, they were not included in the calculations.

The results of ROC analysis found sensitivity, specificity, area under the curve and p value of threshold tonsil volume for differentiation between groups were as 50%, 90%, 0.691±0.070 and 0.006 for the threshold value of 3.73 ml between Groups 1 and 2, 86.7%, 100%, 0.933±0.035 and <0.001 for the threshold value of 3.88 ml between Groups 1 and 3 and 86.7%, 63.3%, 0.750±0.066 and <0.001 for the threshold value of 3.88 ml between Groups 2 and 3 (Figures 3-5).

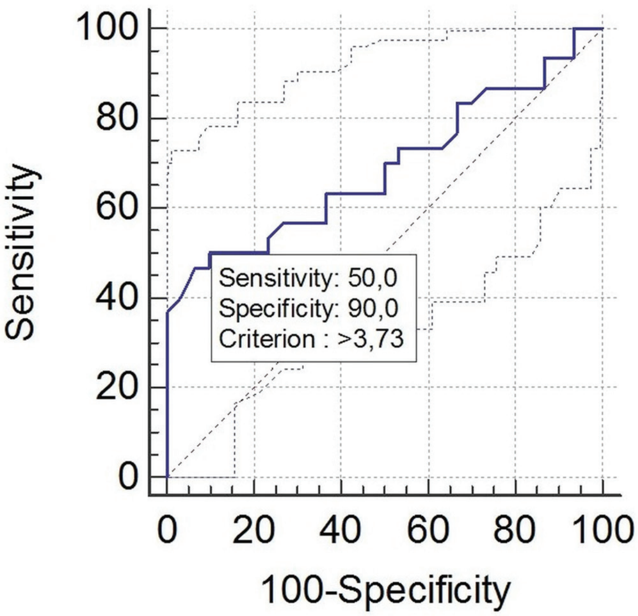

Figure 3. ROC analysis of threshold tonsil volume between Groups 1 and 2. The optimal cut-off value was 3.73 ml. The area under curve was 0.691±0.070.

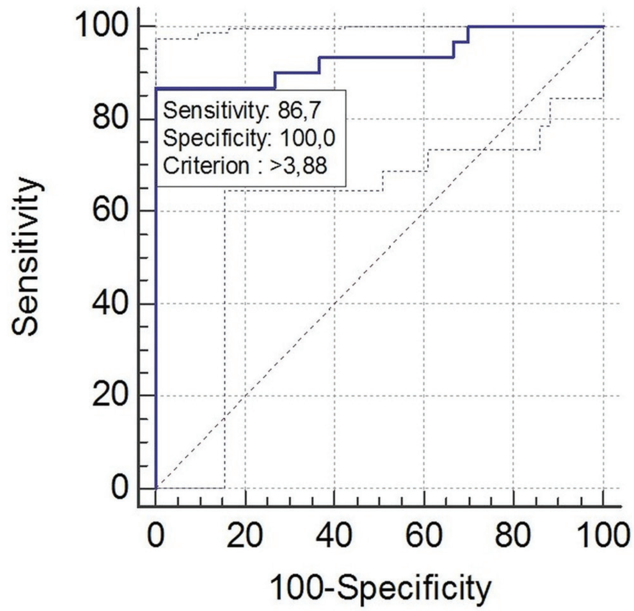

Figure 4. ROC analysis of threshold tonsil volume between Groups 1 and 3. The optimal cut-off value was 3.88 ml. The area under curve was 0.933±0.035.

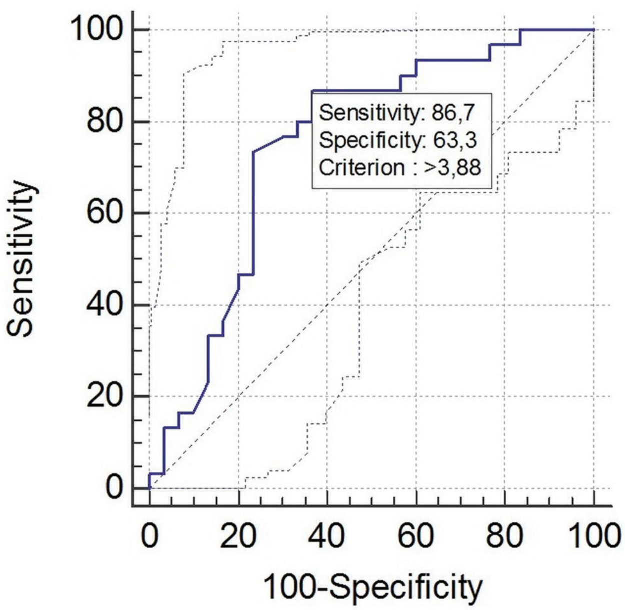

Figure 5. ROC analysis of threshold tonsil volume between Groups 2 and 3. The optimal cut-off value was 3.88 ml. The area under curve was 0.750±0.066.

DISCUSSION

In this study to assess the correlation between palatine tonsil volume in adolescents with BMI and hepatosteatosis, tonsil sizes were measured with TCU and important results obtained. The first is that there was a positive increasing correlation between tonsil volume in adolescents and BMI and hepatosteatosis. The second is that TCU is an accurate, reliable, cheap, non-invasive and easily accessible method to objectively determine tonsil volume in adolescents.

TCU is a non-invasive, cheap and easily accessible method used to investigate the size, shape, perfusion and appearance of tonsils and to diagnosis and assess distribution of tonsillar and peritonsillar infections (12). Additionally TCU may be compared with CT and MRI with acceptable limits and complements them (13). Asimakopoulos et al. compared the volume measured by TCU in cases with chronic tonsillitis and OSAS with the true volume measured after tonsillectomy and determined similar results. Before surgery, assessment of tonsil anatomy with US is stated to be beneficial to estimate response to tonsillectomy and perioperative complications (8). Studies have shown that TCU is a very effective method for the staging of tonsillitis in children and diagnosis and monitoring of peritonsillar abscess (12,14).

In recent times it was reported by Öztürk et al. that including all age groups, in healthy children mean tonsil volume measured with TCU is between 1.8-2.2 ml with a positive increasing correlation with age and BMI, which does not change according to gender (9). The same study calculated the mean tonsil volume for only adolescents was 3.42 ml. In this study the mean tonsil volume in health adolescents was measured as 3.2 ml, similar to previous sonographic measurements. However, in our study due to the low patient number, the variation according to gender and BMI was not evaluated in the healthy group.

A study of 277 pediatric SDB cases by Wang et al. compared subjective classification during oral examination before surgery with length, depth, width and volume after surgery. The parameter best correlated in subjective classification was volume and true tonsil volume was reported to vary from 2.17-4.7 ml (15). This study did not note the variation in tonsil volume according to BMI. A previous different study assessing the correlation between tonsil size, obesity and OSAS compared the subjective preoperative measurements with true volume measurements and found that on both measurements tonsil size was higher in obese OSAS cases (16). A study by Asimakopoulos et al. found in chronic tonsillitis and OSAS cases the volume measured with TCU before surgery and true values after tonsillectomy were 3.6 ml and 3.9 ml with a correlation identified (8). However, they did not report separate values for chronic tonsillitis and tonsillar hypertrophy and BMI was not noted. In this study, the mean tonsil volume of healthy adolescents at BMI limits was 3.18 ml, while it was measured in obese cases with high BMI and with and without hepatosteatosis as 3.73 ml and 4.45 ml, respectively. There was a positive increasing correlation between BMI and tonsil volume. This result is similar to previous studies with true volume values. However, in our study the presence of OSAS was not noted in obese cases, with no comparison with true volume after surgery.

A study by Kang et al. of 495 symptomatic pediatric patients in various age groups evaluated tonsil size with subjective methods. They stated that tonsillar hypertrophy and obesity in children were important factors in the etiology of OSAS (17). However, this study did not assess the presence of hepatosteatosis in obese cases. In recent times a study compared fat distribution in various regions of the body with MRI in 22 obese cases with OSAS and 22 obese cases without OSAS. The OSAS cases had a nearly 30% increase in parapharyngeal and abdominal visceral fatty tissue compared to those without OSAS. However, there was no correlation shown between the severity of OSAS and variation in body fat distribution. The same study identified an increase in tonsil volume in OSAS cases (10). In this study for the first time the correlation between tonsil volume measured with TCU in obese adolescents with hepatosteatosis was assessed and the tonsil volume was revealed to be higher in obese cases with hepatosteatosis. However, tonsillectomy was not performed and no histopathological assessment was made, so it could not be identified whether this increase in size was due to lymphoid hyperplasia or an increase in amount of fat in the tonsils. This situation will gain clarity with future studies including larger numbers of cases with different grades of hepatosteatosis and histopathological investigation of tonsillectomy material.

Among the limitations of our study are that US investigation was completed by a single user, there was no comparison with true volume, the low number of grade 3 hepatosteatosis cases, no diagnosis of steatosis degree with the gold standard of biopsy and no tonsillectomy performed.

In conclusion, TCU measurements of tonsil volume in adolescents identified a positive increasing correlation with BMI and hepatosteatosis. TCU is an accurate, reliable, cheap, non-invasive and accessible method to objectively assess the tonsil volume in adolescents.

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