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The effect of adenotonsillectomy on right ventricle function and pulmonary artery pressure in children with adenotonsillar hypertrophy

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ABSTRACT

Objectives: Adenotonsillar hypertrophy (ATH) is the most common cause of upper airway obstruction in children. Severe upper airway obstruction may have an effect on chronic alveolar hypoventilation, which consequently may lead to right ventricle (RV) dysfunction induced by hypoxemic pulmonary vasoconstriction. The investigators aimed to study RV function and mean pulmonary artery pressure (mPAP) in patients with ATH who were undergoing adenotonsillectomy by using tissue Doppler echocardiography (TDE).

Methods: The study examined 27 children with ATH who had a mean age of 8 ± 2 years. The subjects were comprised 17 (63%) males and 10 (37%) females. Hypertrophy of the tonsils was graded according to the Brodsky scale. Children having either grade 3 or 4 hypertrophied adenotonsils were recruited for the study. Adenotonsillectomy was performed on all subjects in the study group and echocardiographic examination was repeated 3 months postoperatively.

Results: Tricuspid Em significantly increased after adenotonsillectomy (17.7 ± 3.6 vs. 19.1 ± 5.5, $p = 0.04$). The RV myocardial performance index (MPI) and mPAP significantly decreased after adenotonsillectomy (RV MPI: 0.57 ± 0.13 vs. 0.40 ± 0.12, $p < 0.001$ and mPAP (mm Hg): 31 ± 9 vs. 25 ± 7, $p = 0.001$).

Conclusion: The results of this study, evaluated with the results of previous studies, demonstrated that adenotonsillectomy improved RV performance and reduced mPAP in children with ATH.

1. Introduction

Adenotonsillar hypertrophy (ATH) is an important health condition, and is seen especially during childhood. The relationship between ATH and other diseases such as cardiovascular and pulmonary disorders was reported in previous studies [1–4]. It is well known that ATH is one of the most common causes of upper respiratory tract obstruction, obstructive sleep apnea (OSA) and hypoxia in children [2]. Severe upper respiratory tract obstruction may have an effect on chronic alveolar hypoventilation, which consequently may lead to right ventricle (RV) dysfunction induced by hypoxemic pulmonary vasoconstriction. This RV dysfunction may result in increased pulmonary vascular resistance and pulmonary artery pressure (PAP) [5]. Echocardiography is one of the most important noninvasive methods to diagnose for structural heart disease in children [6]. Previous conventional echocardiography studies have shown that upper respiratory tract obstruction causes pulmonary hypertension (PH) and right ventricle (RV) dysfunction [2,7–12]. Although the standard test for the evaluation of pulmonary artery pressure is performed by highly invasive cardiac catheterization, Doppler echocardiography has been demonstrated to have a perfect correlation with cardiac catheterization [13,14]. Tissue Doppler echocardiography (TDE) also gives more detailed quantitative information about myocardial function compared with conventional echocardiography [6].

In the current study, the investigators aimed to study RV function and mean pulmonary artery pressure (mPAP) in patients with ATH who were undergoing adenotonsillectomy by using TDE.

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2. Patients and methods

2.1. Study population

A prospective trial was performed on children with ATH. The study was approved by The Ethics Committee of Erciyes University, Medical Faculty. Twenty-seven children with ATH were selected from children admitted to the clinic with complaints of snoring, mouth breathing, pausing of breathing during sleep and recurrent adenotonsillar infection for at least 6 months. All children underwent a complete ear–nose–throat (ENT) examination and flexible nasopharyngoscopy in appropriate cases for additional assessment of nasal patency and adenoid size. A lateral neck X-ray was obtained in patients for whom a nasal endoscopic examination could not be performed. Hypertrophy of the tonsils was graded according to the Brodsky scale as follows [15]: Grade I: tonsils were in the tonsillar fossa, barely visible behind the anterior pillars; Grade II: tonsils were easily visible behind the anterior pillars; Grade III: tonsils extended three-quarters of the way to the midline; and Grade IV: tonsils were completely obstructing the airway. Adenoid hypertrophy was defined as an obstruction of more than 50% of the nasopharyngeal airway [16]. Patients with adenoid hypertrophy and 3+ or 4+ tonsillar hypertrophy were enrolled in the study. Children with upper airway obstruction due to other causes such as allergic rhinitis, septum deviation, sinonasal infection and craniofacial anomalies, grade I and grade II tonsillar hypertrophy, Down Syndrome and known or suspected cardiovascular diseases were excluded from the study.

2.2. Echocardiographic examination

Two-dimension pulsed-wave Doppler and TDE were performed for all patients using a 2.5 MHz transducer (Philips, EnVisor C Ultrasound, Bothell, WA) in the left decubitus position during normal respiration according to the recommendations of the American Society of Echocardiography [17]. Echocardiographic examination was repeated 3 months postoperatively. From the apical four-chamber view, Doppler recordings were obtained with the pulsed sample volume placed at the tip of the tricuspid leaflets. The peak early (E) and late (A) velocities were measured. The mPAP levels were calculated from the echocardiographic records of the pulmonary flow trace using the Mahan Formula (mPAP = $79 - (0.62 \times$ acceleration time of the pulmonary flow trace)) [17]. All measurements were obtained by calculating the mean of three consecutive measurements and were accompanied by electrocardiographic recording upon expiration. Echocardiographic measurements were made by the same cardiologists who were blinded to the clinical information of the patients.

Pulsed-wave TDE parameters were measured by an echocardiography device with active TDE functions (Philips, EnVisor C Ultrasound, Bothell, WA). The filter settings and gains were adjusted to the minimal optimal level to reduce noise and eliminate signals produced by flows. A 3.5 mm sample volume was used. The TDE cursor was placed from the apical four-chamber view to the lateral wall of the RV. A Doppler velocity range of −20 to 20 cm/s was selected and the velocities were measured online at a sweep of 100 mm/s. Peak systolic velocity (Sm), peak early (Em) and late (Am) diastolic velocities were measured and the Em/Am ratio was calculated. The isovolumetric relaxation time (IRT) was measured from the end of Sm to the beginning of Em, the isovolumetric contraction time (ICT) was measured from the end of Am to the beginning of Sm and the time period of Sm was measured as the ejection time (ET). The myocardial performance index (MPI) was calculated using the equation (ICT + IRT)/ET. All Doppler parameters were obtained by calculating the mean of three consecutive cycles. Echocardiography measurements were made by the same cardiologists.

2.3. Statistical analysis

The number of cases was 27 for each group which was determined by power analysis using power = 0.82, $\alpha = 0.05$, $\beta = 0.20$ and $1 - \beta = 0.80$ values.

Categorical variables were presented as count and percentage. The Kolmogorov–Smirnov test was used to evaluate whether the distribution of variables was normal. All continuous variables were normally distributed. Continuous variables were presented as mean (standard deviation [SD]). A paired t test was used to detect differences between preoperative and postoperative periods. SPSS software 15.0 for Windows (Chicago, IL, USA) was used for all statistical analysis. Calculated p-values were considered statistically significant when they were <0.05.

3. Results

3.1. Hypertrophy of tonsils

Baseline characteristics of the children are shown in Table 1. The study patients consisted of a total of 27 children, 17 (63%) males and 10 (37%) females aged 8 ± 2 years. Hypertrophy of the tonsils was graded according to the Brodsky scale and it was found that 44% of children were grade III and 56% were grade IV.

3.2. The Echocardiographic findings

The echocardiographic findings of the study are presented in Table 2. Tricuspid Em significantly increased after adenotonsillectomy ($p = 0.04$). At the postoperative term, the Em value increased in 18 (67%) patients. However Em in 9 (33%) patients decreased after the tonsillectomy procedure (Fig. 1). There was no significant change in other echocardiographic parameters.

Table 1
Baseline characteristics of study patients.

n	27
Age, years	8 ± 2
Male, n (%)	17 (63)
Female, n (%)	10 (37)
Adenotonsillar hypertrophy, n (%)	
Grade III	12 (44)
Grade IV	15 (56)

Table 2
Comparison of right ventricle echocardiographic findings in preoperative and postoperative periods.

	Preoperative	Postoperative	p
Right ventricle end-diastolic diameter, mm	2.65 ± 0.34	2.55 ± 0.12	NS
Right ventricle end-systolic diameter, mm	1.76 ± 0.28	1.88 ± 0.29	NS
Tricuspid E/A	1.68 ± 0.39	1.88 ± 0.53	NS
Tricuspid TDE parameters			
Sm, cm/s	14.5 ± 2.5	14.1 ± 2.1	NS
Em, cm/s	17.7 ± 3.6	19.1 ± 5.5	0.04
Am, cm/s	11.4 ± 4.4	12.2 ± 4.9	NS
Em/Am	1.60 ± 0.44	1.72 ± 0.72	NS
E/Em	4.18 ± 1.09	3.77 ± 1.17	0.09

E, early diastolic tricuspid inflow velocity; A, late diastolic tricuspid inflow velocity; Sm, systolic myocardial velocity; Em, early myocardial velocity; Am, late myocardial velocity; TDE, tissue Doppler echocardiography; NS, not significant.