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Assessment of pulmonary artery pressure and right ventricular function in children with adenotonsillar hypertrophy using different parameters

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ABSTRACT

Objective: Our aim was comparison of preoperative and postoperative right ventricular functions of children with adenotonsillar hypertrophy (ATH) who have findings of upper airway obstruction, using new echocardiographic parameters.
Methods: Forty-one children who have admitted to our hospital with symptoms suggestive of upper airway obstruction, whose history and physical examination findings suggest upper airway obstruction and who have undergone adenoidectomy/adenotonsillectomy and 40 healthy children, all of whom between 2 and 12 years of age, were included in the study. Patient group was evaluated by pulsed wave tissue Doppler echocardiography as well as with conventional echocardiography before the operation and 6 months after the operation.
Results: Of 41 children in study group, 26 (63.4%) had adenotonsillectomy and 15 (36.6%) had adenoidectomy. Tricuspid annular plane systolic excursion (TAPSE) was significantly lower in preoperative group compared to control group (18.46 ± 1.67, 19.77 ± 1.62; $p = 0.000$, respectively). Myocardial performance index (MPI) was significantly higher in preoperative group than postoperative and control group (0.40 ± 0.07, 0.36 ± 0.06, 0.35 ± 0.07; $p = 0.032$, respectively). Tricuspid isovolumic acceleration (TIVA) was significantly lower in preoperative group than preoperative and control group (2.97 ± 0.8, 3.43 ± 0.7, 3.43 ± 0.9; $p = 0.020$, respectively). Disappearance of this difference was found between postoperative and control groups ($p = 0.984$). Pulmonary acceleration time (PAcT) was found to be significantly lower in preoperative group compared to postoperative and control group (109.68 ± 18.03, 118.93 ± 17.46, 120.0 ± 14.07; $p = 0.010$, respectively). Mean pulmonary artery pressure (mPAP) was significantly higher in preoperative group than control group (29.64 ± 8.11, 24.95 ± 6.33; $p = 0.010$, respectively). In postoperative group mPAP was found to be similar to control group (25.48 ± 7.85, 24.95 ± 6.33; $p = 0.740$, respectively).
Conclusions: TAPSE, PAcT, MPI and TIVA are useful markers for evaluation of preoperative and postoperative ventricular function in children with ATH who have findings of upper airway obstruction. We think that using these practical and easy-to perform parameters may be relevant for evaluation and postoperative follow-up of patients with ATH who have findings of upper airway obstruction. Besides adenotonsillectomy is a beneficial treatment option for these patients.

1. Introduction

Adenotonsillar hypertrophy (ATH) is one of the most common causes of upper airway obstruction, and is seen especially during childhood. Adenotonsillar hypertrophy and upper airway obstruction takes the first order among the adenotonsillectomy indications. The relationship between ATH and other diseases such as cardiovascular and pulmonary disorders was reported in previous studies. It is well known that ATH is one of the most common causes of upper respiratory tract obstruction and hypoxia in children [1,2]. Severe upper airway obstruction can result in obstructive sleep apnea and chronic alveolar hypoventilation,

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which subsequently may lead to right sided cardiac dysfunction induced by hypoxemic pulmonary vasoconstriction and the resulting rise in pulmonary vascular resistance (PVR) and pulmonary artery pressure (PAP) [3]. Previous studies have shown the adverse affects of upper airway obstruction on both LV and RV functions [4,5]. Proving that upper airway obstruction actually causes cardiac dysfunction independent of these confounding risk factors is difficult. Early recognition of RV dysfunction before pulmonary arterial (PA) hypertension develops is important for preventing further progression to heart failure and even death [6]. Thus, there is a need for a more detailed analysis of its pathophysiologic importance and for techniques that may supplement available technology in identifying early signs of RV impairment. Recently, tissue Doppler imaging (TDI) have been shown to be reliable and accurate novel techniques for evaluating global and regional ventricular function [7]. As TDI has the disadvantage of being preload and afterload dependent, a new TDI-derived index of isovolumic myocardial acceleration (IVA) has been validated to be a reliable and relatively load independent measure of cardiac systolic function [8]. In this study, we have investigated RV dysfunction and the efficacy of the adenotonsillectomy using new TDI echocardiographic parameters in patients who were thought to have upper airway obstruction secondary to adenotonsillar hypertrophy (ATH). Our aim was to determine if there were any detectable changes in RV performance parameters, especially MPI and TIVA, after adenotonsillectomy in children with ATH causing severe upper airway obstruction. Our study reveals the importance of MPI and TIVA with regard to recognition of ventricular dysfunction in subclinical period.

2. Methods

Forty-one patients (19 male, 22 female, mean age 6.06 ± 2.50 years) with history and physical examination findings suggestive of upper airway obstruction, who have undergone adenoidectomy/adenotonsillectomy due to stage III or stage IV adenoid and/or ATH between March 2011 and December 2012 were included in the study. In control group, there were 40 healthy children (22 male, 18 female, mean age $6.04 + 2.46$ years) who have admitted to pediatric cardiology clinic for reasons such as murmur, syncope, chest pain and whose echocardiographic evaluation revealed no pathologic findings, with similar age and sex distribution compared to the study group. A questionnaire was applied to the study group with the purpose of determining whether there were symptoms related to upper respiratory tract obstruction (snoring, respiratory arrest during sleep, open mouth, sleeping, suddenly waking up at night, nocturnal diuresis, mouth open navigation and sleepiness during the day) (Table 3). Parents of attendants were asked to answer the questions in questionnaire. Answers such as "always", "frequently" and "yes" were considered positive and the ones like "sometimes", "never", and "no" considered negative. Exclusion criteria were as follows; presence of additional pathologies leading to upper airway obstruction outside of ATH, heart disease with congenital origin or secondary to another disease, primary pulmonary hypertension, any systemic disease, obesity, craniofacial anomaly, and genetic syndrome or inability to obtain informed consent from family. Detailed history of the patients has been taken and detailed physical examination with height, weight, arterial blood pressure measurements were performed both in control and study group.

Degree of tonsillar hypertrophy of the study group was determined from paranasal sinus radiographs, according to the Broadsky scale, by the degree of oropharyngeal obstruction due to palatine tonsils [9]. Examination of adenoids was performed by fiberoptic endoscopy. According to this evaluation percent of obstruction of the passage by adenoids was determined and staging was performed [10]. Conventional Doppler echocardiography (CDE) and TDI values for all patients were recorded. Study group was evaluated by echocardiography preoperatively and at 6th month postoperatively. The study protocol was approved by the University of Celal Bayar Ethics Committee. Informed consent was obtained from parents of participants.

2.1. Operative management

Preoperative routine anesthetic evaluation included blood tests and chest X-ray. All children were operated as inpatient and under general anesthesia. Adenoidectomy in 15 patients and adenotonsillectomy in 26 patients was carried out by current age and cold dissection methods. With the exception of one children, who suffered mild reactionary hemorrhage, postoperative period care went smooth in all children. The average period of hospital stay was two day.

2.2. Echocardiography

Echocardiography was performed in the left lateral decubitus and supine position with an ultrasound machine GE-Vingmed Vivid 7 system (GE-Vingmed Ultrasound AS, Horten, Norway) and 3S-RS (3.5 MHz) probe. Averages of three consecutive cycles were measured for all echocardiographic data. Images were obtained from parasternal and apical positions using 2D, M-mode and Doppler echocardiographic techniques. Examinations were performed by single experienced cardiologists who were unaware of the disease presence and severity of the individuals.

M-mode echocardiographic measurements were performed according to standards outlined by the American Society of Echocardiography [11]. The following variables were measured: interventricular septum (IVS), right ventricle fractional shorting (RVFS), RV diameter and right ventricle anterior wall thickness (RVaWD). IVS and RVaWD measurements were done through the parasternal long axis at the end of diastole and subcostal 4C image at the end of diastole, respectively. RV size was measured in apical 4C image basally between septum at the level of the tricuspid valve and RV free wall (basal diameter) at the end of diastole and systole. RVFS was calculated as the percentage of decrease in the right ventricle (RV) diameter in systole compared to diastole. RV global systolic function was assessed as the tricuspid annular plane systolic excursion (TAPSE) by the 2-dimensional difference of the end-diastolic and end-systolic lines (in mm) traced between the center of the ultrasound fan origin and the junction of the RV lateral tricuspid annulus in the apical 4C view [12]. The pulmonare acceleration time (PAcT), pulmoner peak velocity (PPV) and pulmonare ejection time (PET) was obtained using the pulse wave Doppler with the pulse wave sample volume placed within the RV outflow tract. PET; systolic flow time from the beginning to the end, PAcT is the time interval between the onset of the systolic velocity and the peak systolic velocity [13]. Using this measurement, the mean pulmonary artery pressure (mPAP) was calculated by the equation (Mahan formula): $\text{mPAP} = 79 - (0.45 \times \text{PAcT})$ [14,15].

Tissue Doppler imaging (TDI) was recorded from the apical four-chamber view with the pulse wave Doppler sample volume placed on the tricuspid lateral annulus. Peak systolic (Sm) velocity, peak early (Em), the deceleration time (DT) of Em wave and peak late (Am) diastolic myocardial annular velocity, isovolumic relaxation time (IVRT), and isovolumic contraction time (IVCT) were measured. Myocardial performance index (MPI) was calculated with the Tei index formula. Tricuspid isovolumic acceleration (TIVA) for the RV was calculated by dividing the isovolumic contraction peak velocity by the time interval between the onset of this wave and its peak velocity (Fig. 1) [16,17].