The improvement of right ventricular function after adenotonsillectomy

In children with obstructive sleep apnea

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Running Title:

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Abstract

**Purpose:** Adenotonsillar hypertrophy (ATH) that causes upper airway obstruction might lead to chronic hypoxemic pulmonary vasoconstriction and right ventricular (RV) dysfunction. We aimed to evaluate whether adenotonsillectomy (T&A) in children suffering from obstructive sleep apnea (OSA) due to severe ATH could improve RV function.

**Methods:** Thirty-seven children (boy/girl: 21/16, mean age: 9.52±2.20 years), who underwent T&A for sleep apnea due to ATH, were included. We analyzed the mean pulmonary artery pressure (mPAP), the presence and the maximal velocity of tricuspid regurgitation (TR), the tricuspid annular plane systolic excursion (TAPSE), and the right ventricular myocardial performance index (RVMPI) with tissue Doppler echocardiography (TDE) by transthoracic echocardiography pre- and post-T&A. The follow-up period was 1.78±0.27 years.

**Results:** Only the RVMPI using TDE improved after T&A (42.18±2.03 vs. 40±1.86, \(P=0.001\)). The absolute value of TAPSE increased (21.45±0.90mm vs 22.30±1.10mm, \(P=0.001\)) but there was no change in the Z-score of TAPSE pre- and post-T&A (1.19±0.34 vs 1.24±0.30, \(P=0.194\)). The mean pulmonary artery pressure (mPAP) was within normal range in children with ATH, and there was no significant difference between pre- and post-T&A (19.6±3.40 vs. 18.7±2.68, \(P=0.052\)). There was no difference in the presence and the maximal velocity of TR (\(P=0.058\)).

**Conclusion:** RVMPI using TDE could be an early parameter of RV function in children with OSA due to ATH.

**Keywords:** Adenotonsillectomy (T&A); Obstructive sleep apnea (OSA); Myocardial performance index of the right ventricle (RVMPI); Tricuspid annular plane systolic excursion (TAPSE)
INTRODUCTION

Adenotonsillar hypertrophy (ATH) is relatively common in childhood, but severe ATH often causes obstructive sleep apnea (OSA), which is characterized by repetitive episodes of paused breathing during sleep typically last 20 to 40 seconds by complete and partial obstruction of the upper airway. Persistent OSA might cause chronic hypoxemia and hypercarbia, which can lead to right ventricle (RV) dysfunction, pulmonary hypertension, and cor pulmonale. We reported that some children who were scheduled for adenotonsillectomy also experienced right heart dysfunction on echocardiography without clinical symptoms. Thus, we investigated whether T&A could improve RV dysfunction in children with OSA using conventional and tissue Doppler echocardiography.
Materials and methods

Subjects

The study was conducted at the Departments of Pediatric Cardiology and Otolaryngology, Konyang University Hospital, from June 2014 to July 2015. Out of 104 children scheduled for adenoidectomy during this period, only children who had obstructive sleep apnea caused by ATH were included. Thirty-seven children who underwent echocardiography before and after adenotonsillectomy were included. According to the method of Cohen and Konak and on the Brodsky scale, adenoid and tonsil of grade III-IV have been considered to be severe ATH, respectively. We verified OSA using the snoring-tiredness during the daytime-observed apnea-high blood pressure (STOP) questionnaire revised for children. Whether children had adenotonsillectomy was determined by an otolaryngologist and was based on careful examination and detailed medical history. This study was approved by the institutional review board of Konyang University Hospital (IRB No.2018-10-015).

Echocardiographic examination

All children underwent transthoracic echocardiography conducted by a single pediatric cardiologist before and at least 12 months after adenotonsillectomy. The echocardiogram was obtained in all standard precordial positions via a 3–5-MHz transducer of Vivid E9 (General Electric, Norway) using two-dimensional, M-mode, conventional, and tissue Doppler examination according to the American Echocardiography Association guidelines. For each parameter, the average of five consecutive cycles was taken.
1. Pulmonary artery pressure

A pulsed wave Doppler of pulmonic forward flow was obtained at the end of expiration, just proximal to the pulmonary valve in the parasternal short axis view. Right ventricular outflow tract (RVOT) acceleration time (AT) was measured from the beginning of the flow to the peak flow velocity (Fig. 1).

We calculated mean pulmonary artery pressure (mPAP) using the formula: mPAP (mmHg) = 90 – (0.62 * AT\textsubscript{RVOT})\textsuperscript{9,10}. We verified the presence and the maximal velocity of tricuspid regurgitation (TR) for all subjects.

2. Tricuspid annular plane systolic excursion (TAPSE)

TAPSE was measured using the M-mode recordings from the apical four-chamber view with the cursor placed on the free wall side of the tricuspid annulus\textsuperscript{11} (Fig. 2) and was presented as a Z-score adjusted by age\textsuperscript{12}.

3. Myocardial performance index of right ventricle (RVMPI)

Myocardial performance index of right ventricle (RVMPI) was calculated, as described by Tei\textsuperscript{13}, as the sum of the isovolumetric contraction and isovolumetric relaxation times divided by ejection time. This was performed with tissue Doppler echocardiography (TDE) (Fig. 3).

Random echocardiography recordings were analyzed to determine the intra-observer variability before the study. Intra-observer variabilities were <5% for all echocardiographic parameters.

Statistical analysis
We analyzed data using the PASW Statistics ver. 18.0 (SPSS Inc., Chicago, IL, USA). Continuous variables are presented as mean±standard deviation (median). The significance of the differences in the categorical variables between the groups was analyzed using the chi-square analysis; whereas, the significance of the differences in the continuous variables was evaluated using the Mann-Whitney U test. A $P$ value$<0.05$ was considered significant.
Results

The clinical characteristics of children before and after adenotonsillectomy are shown in Table 1. Age, weight, height, body surface area (BSA), and body mass index (BMI) increased postoperatively, which seems to be caused by a change by age. There was no significant difference between heart rate, BMI, and Z-score.

The mean pulmonary artery pressure (mPAP) was normal in children with ATH and there was no difference between pre- and post-T&A results. TR was observed in 17 children before surgery and in 15 patients after surgery. There was no significant difference in the maximal velocity of tricuspid regurgitation (TRmax) pre- and post-surgically ($P=0.78$) (Table 2).

The absolute value of TAPSE increased (21.45±0.90mm vs 22.30±1.10mm, $P=0.001$) after T&A, but this change was noted because of growth. The Z-score of TAPSE did not differ between pre and post-T&A (1.19±0.34 vs 1.24±0.30, $P=0.194$) (Fig. 4).

The value of right ventricular myocardial performance index (RV MPI) by TDE significantly improved after surgery (42.18±0.33 vs 40.08±0.30, $P=0.001$) (Fig. 5).
**Discussion**

Adenotonsillar hypertrophy is the most common cause of upper respiratory tract obstruction and sleep apnea in children\(^{14}\). Prolonged upper airway obstruction during sleep leads the significant problems such as hypersomnolence, emotional lability, decreased attention, small stature, enuresis, and cardiopulmonary morbidity.\(^{15-16}\). T&A has been considered to be the first line of treatment which could improve the quality of life of children for pediatric OSA. Recently, there are many reports that show marked improvements in right ventricular function, following the surgery in children with ATH.

According to the study by Acar et al.\(^{17}\) the TAPSE value was lower than normal, and elevated three months after T&A in children with ATH. TAPSE, which is easy and fast to perform, provides information about the right ventricular systolic functions. Schmid et al.\(^{18}\) found that the TAPSE value of patients with severe interstitial lung diseases was significantly lower compared to that of the control group. In our study, the value of TAPSE significantly increased after T&A, but this was a change as children grew up. There was no difference in the TAPSE Z-value.

We obtained the mean pulmonary artery pressure (mPAP) using right ventricular outflow tract AT and TR peak velocity before and after T&A. The mPAP of our patients was in normal range even pre-adenotonsillectomy and was not different significantly pre- and post-adenotonsillectomy. However, Koc et al.\(^{21}\) and Naiboglu et al.\(^{19-20}\) cited that mPAP levels was elevated in patients with ATH, the value of mPAP were 31 ± 9 mmHg and 26.3±5.4 mmHg, respectively, that is to say, considerable pulmonary hypertension. By contrast there was not any changes of the right ventricular function in the studies of Pac et al.\(^{21}\). The cause of this varying result can be explained as follows. The severity of OSAHS could not been quantified without polysomnography so there would be a difference in the severity of
OSAHS between researchers. The duration of follow-up varied for each study and subjects may be heterogeneous.

Duman et al.\textsuperscript{22}) also reported that the RVMPI was impaired in pediatric patients with advanced ATH and improved after T&A. Similarly, Attia et al.\textsuperscript{23}) reported that RV TDE-derived MPI was significantly higher in patients with ATH compared to the control group. We observed that only the value of RV MPI by TDE in has improved children with OSA via T&A.

Evaluation of right ventricular functions by echocardiography is somewhat difficult because of the complex structural geometry of the right ventricle and changes in the contraction pattern. MPI by TDE can be easily measured from the valve annulus with pulsed wave TDE is not affected by cardiac geometry, cardiac rate, blood pressure, or ventricular geometry, as compared to conventional Doppler. So RV MPI has been found to be clinically useful to define RV function\textsuperscript{24}). MPI might be more accurate and reflective of overall cardiac dysfunction than systolic and diastolic measures alone\textsuperscript{25}). As a result, this new modality might be more sensitive for detecting subclinical abnormalities\textsuperscript{26}-\textsuperscript{27}).

In conclusion, we can say that OSA associated with marked adenotonsillar hypertrophy might cause RV dysfunction. Based on the results of this study, we deferred that RVMPI by TDE could be the earliest indicator that responds to a change of the right ventricle function in children with OSA.

The follow-up period of our study was longer than that of other investigators. However, the number of subjects was small and the diagnosis of obstructive sleep apnea (OSA) was made without sleep polysomnography.
Conflict of interest

There are no potential conflicts of interest related to this study.

Acknowledgements
References


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Table 1. Clinical characteristics of subjects before and after adenotonsillectomy

<table>
<thead>
<tr>
<th></th>
<th>PreT&amp;A</th>
<th>Post T&amp;A</th>
<th>P value</th>
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<tr>
<td>Age (years)</td>
<td>7.72 ± 2.22 (7.0)</td>
<td>9.52 ± 2.20 (9.3)</td>
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<td>BMI (kg/m2)</td>
<td>17.8 ± 3.5 (17.4)</td>
<td>19.2 ± 3.5 (19.0)</td>
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<td>Percentile</td>
<td>58.6 ± 31.6 (62.0)</td>
<td>56.5 ± 34.4 (57.0)</td>
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<td>Z score</td>
<td>0.90 ± 1.14 (0.93)</td>
<td>0.8 ± 1.19 (0.83)</td>
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<td>BSA (M2)</td>
<td>1.02 ± 0.24 (0.92)</td>
<td>1.12 ± 0.24 (1.1)</td>
<td>0.07</td>
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<td>Heart rate (/min)</td>
<td>100.1 ± 13.8 (98)</td>
<td>98.1 ± 12.62 (102)</td>
<td>0.46</td>
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<td>SBP</td>
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<td>100.2 ± 13.4 (102)</td>
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<td>53.8 ± 24.9 (51.4)</td>
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<td>DBP</td>
<td>62.4 ± 4.1 (61.2)</td>
<td>61.9 ± 9.2 (60.0)</td>
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<td>Percentile</td>
<td>68.7 ± 13.6 (70.9)</td>
<td>62.8 ± 19.8 (64.0)</td>
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Values are presented as mean ± standard deviation (median)

T&A, adenotonsillectomy; BMI, body mass index; BSA, body surface area; SBP, systolic blood pressure; DBP, diastolic blood pressure;
Table 2. mPAP and TRmax preoperatively and postoperatively

<table>
<thead>
<tr>
<th></th>
<th>Pre- T&amp; A</th>
<th>Post- T&amp; A</th>
<th>P value</th>
</tr>
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<tr>
<td>mPAP (mmHg)</td>
<td>19.6 ± 3.40 (18.7)</td>
<td>18.7 ± 2.68 (17.9)</td>
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<td>TRmax (m/sec)</td>
<td>2.1 ± 0.18 (2.2)</td>
<td>2.0 ± 0.14 (2.1)</td>
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Values are presented as mean ± standard deviation (median)
mPAP, mean pulmonary artery pressure; TRmax, the maximal velocity of tricuspid regurgitation; T& A, adenotonsillectomy
Fig. 1 Estimation of mean pulmonary artery pressure using right ventricular outflow tract acceleration time AT, acceleration time
Normal right ventricle function  Right ventricle dysfunction

Fig. 2 TAPSE measured using M-mode echocardiography from the apical four chamber view with the cursor placed on the free wall side of the tricuspid annulus TAPSE; Tricuspid annular plane systolic excursion
Fig. 3. Myocardial performance index of right ventricle (RVMPI) was calculated as described by as the sum of the isovolumetric contraction and isovolumetric relaxation times divided by the ejection time. 

RVMPI = (a-b) /b
Fig. 4. Improvement of RVMPI before and after surgery in children who underwent T&A
T&A, adenotonsillectomy; RVMPI, myocardial performance index of the right ventricle; RVMPI 1, RVMPI 1 before T & A; RVMPI2, RVMPI after T & A
Fig. 5. Z-score of TAPSE before and after surgery in children who underwent T & A

T&A, adenotonsillectomy; TAPSE, tricuspid annular planse systolic excursion; TAPSE 1, TAPSE before T&A; TAPSE 2, TAPSE after T&A