

Original article

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The improvement of right ventricular function after adenotonsillectomy in children with obstructive sleep apnea

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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 ± 0.90 mm vs. 22.30 ± 1.10 mm, $P=0.001$) but there was no change in the zscore of TAPSE pre- and post-T&A (1.19 ± 0.34 vs. 1.24 ± 0.30 , $P=0.194$). The 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.

Key words: Obstructive sleep apnea, Adenotonsillectomy, Myocardial performance index of the right ventricle

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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 seconds¹⁾ 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.^{2,3)} We reported that some children who were scheduled for adenotonsillectomy also experienced right heart dysfunction on echocardiography without clinical symptoms.⁴⁾ Thus, we investigated whether T&A could improve RV dysfunction in children with OSA using conventional and tissue Doppler echocardiography (TDE).

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Materials and methods

1. 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 adenotomectomy during this period, only children who had OSA caused by ATH were included. Thirty-seven children who underwent echocardiography before and after adenotomectomy were included. According to the method of Cohen and Konak⁵⁾ and on the Brodsky scale,⁶⁾ adenoid and tonsil of grades III-IV have been considered to be severe ATH, respectively. We verified OSA using the STOP (snoring-tiredness during the daytime-observed apnea-high blood pressure) questionnaire revised for children. Whether children had adenotomectomy was determined by an otolaryngologist and was based on careful examination and detailed medical history.⁷⁾ This study was approved by the Institutional Review Board (IRB) of Konyang University Hospital (approval number: 2018-10-015). Informed consent was exempted by the IRB.

2. Echocardiographic examination

All children underwent transthoracic echocardiography conducted by a single pediatric cardiologist before and at least 12 months after adenotomectomy. The echocardiogram was obtained in all standard precordial positions via a 3- to 5-MHz transducer of Vivid E9 (General Electric, Oslo, Norway) using 2-dimensional, M-mode, conventional, and tissue Doppler examination according to the American Echocardiography Association guidelines.⁸⁾ For each parameter, the average of 5 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: $mPAP \text{ (mmHg)} = 90 - (0.62 \times ATRVOT)$.^{9,10)} We verified the presence and the maximal velocity of tricuspid regurgitation (TR) for all subjects.

2) Tricuspid annular plane systolic excursion

Tricuspid annular plane systolic excursion (TAPSE) was measured using the M-mode recordings from the apical 4-chamber view with the cursor placed on the free wall side of the tricuspid annulus¹¹⁾ (Fig. 2) and was presented as a z score adjusted by age.¹²⁾

3) Myocardial performance index of right ventricle

Myocardial performance index of right ventricle (RVMPI) was calculated, as described by Tei,¹³⁾ as the sum of the isovolumetric contraction and isovolumetric relaxation times divided by ejection

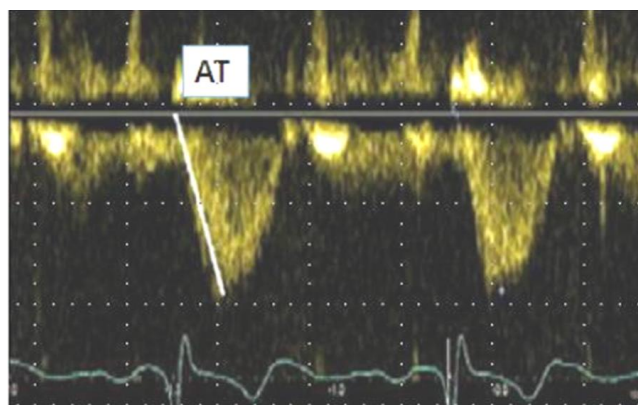


Fig. 1. Estimation of mean pulmonary artery pressure using right ventricular outflow tract acceleration time (AT).

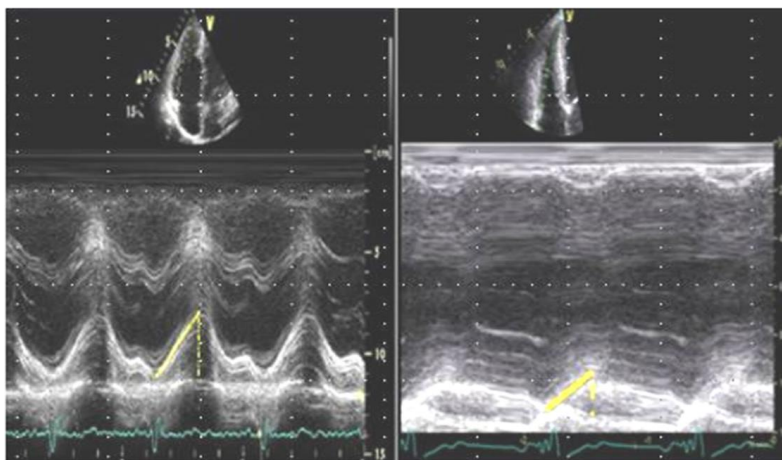


Fig. 2. Tricuspid annular plane systolic excursion (TAPSE) measured using M-mode echocardiography from the apical 4 chamber view with the cursor placed on the free wall side of the tricuspid annulus TAPSE.

time. This was performed with TDE (Fig. 3).

Random echocardiography recordings were analyzed to determine the intraobserver variability before the study. Intraobserver variabilities were <5% for all echocardiographic parameters.

3. 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.

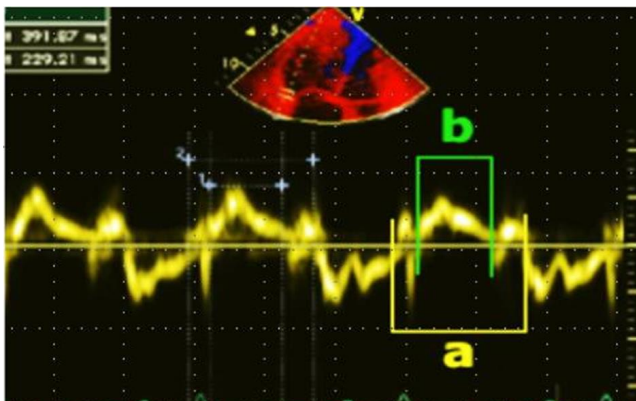


Fig. 3. Myocardial performance index of right ventricle (RVMPI) was calculated as described by as the sum of the isovolumetric contraction and isovolumetric relaxation times divided by the ejection time. $RVMPI = (a-b)/b$.

Table 1. Clinical characteristics of subjects before and after adenotonsillectomy

Characteristic	Pre-T&A	Post-T&A	<i>P</i> value
Age (yr)	7.72±2.22 (7.0)	9.52±2.20 (9.3)	<0.01
BMI (kg/m ²)	17.8±3.5 (17.4)	19.2±3.5 (19.0)	0.02
Percentile	58.6±31.6 (62.0)	56.5±34.4 (57.0)	0.24
z score	0.90±1.14 (0.93)	0.8±1.19 (0.83)	0.16
BSA (m ²)	1.02±0.24 (0.92)	1.12±0.24 (1.1)	0.07
Heart rate (/min)	100.1±13.8 (98)	98.1±12.62 (102)	0.46
SBP	99.6±8.2 (100)	100.2±13.4 (102)	0.78
Percentile	53.8±24.9 (51.4)	51.3±25.2 (50.6)	0.15
DBP	62.4±4.1 (61.2)	61.9±9.2 (60.0)	0.64
Percentile	68.7±13.6 (70.9)	62.8±19.8 (64.0)	0.45

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.

Results

The clinical characteristics of children before and after adenotonsillectomy are shown in Table 1. Age, weight, height, body surface area, 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 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 TR (TRmax) pre- and postsurgically (*P*=0.78) (Table 2).

The absolute value of TAPSE increased (21.45±0.90 mm vs. 22.30±1.10 mm, *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 RVMPI by TDE significantly improved after surgery (42.18±0.33 vs. 40.08±0.30, *P*=0.001) (Fig. 5).

Discussion

ATH 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

Table 2. mPAP and TRmax preoperatively and postoperatively

Variable	Pre-T&A	Post-T&A	<i>P</i> value
mPAP (mmHg)	19.6±3.40 (18.7)	18.7±2.68 (17.9)	0.06
TRmax (m/sec)	2.1±0.18 (2.2)	2.0±0.14 (2.1)	0.47

Values are presented as mean±standard deviation (median). mPAP, mean pulmonary artery pressure; TRmax, the maximal velocity of tricuspid regurgitation; T& A, adenotonsillectomy.

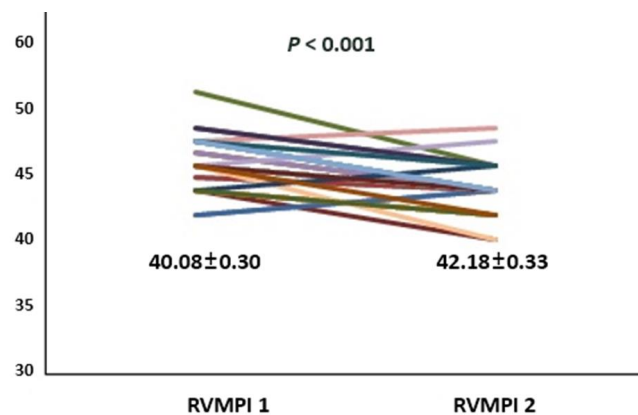


Fig. 4. Improvement of RVMPI before and after surgery in children who underwent T&A. T&A, adenotonsillectomy; RVMPI, myocardial performance index of the right ventricle; RVMPI 1, RVMPI 1 before T&A; RVMPI2, RVMPI after T&A.

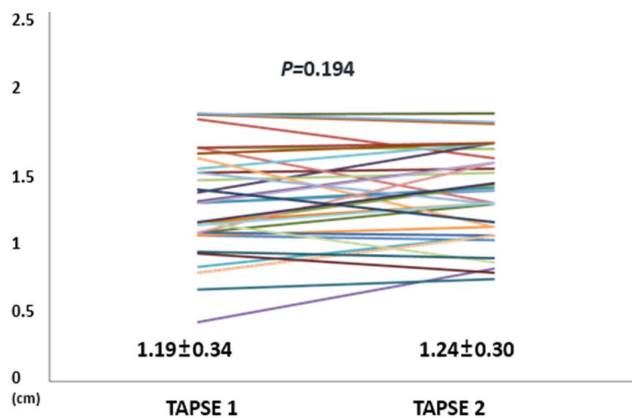


Fig. 5. The z score of TAPSE before and after surgery in children who underwent T&A. T&A, adenotonsillectomy; TAPSE, tricuspid annular plane systolic excursion; TAPSE 1, TAPSE before T&A; TAPSE 2, TAPSE after T&A.

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 shows 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 3 months after T&A in children with ATH. TAPSE, which is easy and fast to perform, provides information about the right ven-tricular 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 mPAP using RVOT AT and TR peak velocity before and after T&A. The mPAP of our patients was in normal range even preadenotonsillectomy and was not different significantly pre- and postadenotonsillectomy. However, Koc et al.,² Görür et al.,¹⁹ and Naiboglu et al.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 obstructive sleep apnea-hypopnea syndrome (OSAHS) could not be 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.²² also reported that the RVMPI was impaired in pediatric patients with advanced ATH and improved after T&A. Similarly, Attia et al.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 RV 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. SoRV MPI has been found to be clinically useful to define RV function.²⁴ MPI might be more accurate and reflective of overall cardiac dysfunction than systolic and diastolic measures alone.²⁵ As a result, this new modality might be more sensitive for detecting subclinical abnormalities.^{26,27}

In conclusion, we can say that OSA associated with marked ATH 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 RV 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 OSA was made without sleep polysomnography.

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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