Reversal of pulmonary hypertension in children after adenoidectomy or adenotonsillectomy

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A R T I C L E   I N F O

Article history:
Received 21 May 2012
Received in revised form 4 November 2012
Accepted 6 November 2012
Available online 11 December 2012

Keywords:
Adenoidectomy
Tonsillectomy
Pulmonary hypertension
Echocardiography

A B S T R A C T

Introduction: Adenotonsillar hypertrophy is a common condition in pediatric patients with upper respiratory airways complaints, and pulmonary arterial hypertension (PAH) may be one complication of that condition.

Objectives: To study the occurrence of PAH (mean pulmonary artery pressure higher than or equal to 25 mmHg) in a group of children with adenotonsillar hypertrophy and upper respiratory complaints (snoring or oral breathing), and to verify the pulmonary arterial pressure (PAP) changes after adenotonsillectomy.

Study design: Case–control prospective study.

Settings: Study conducted at São Lucas Hospital, approaching both public and private sector.

Subject and methods: Thirty-three pediatric patients with adenotonsillar hypertrophy and evidence of obstructive upper airways complaints were treated with adenotonsillectomy. All 33 patients underwent echocardiogram before and after the surgery with determination of the pulmonary arterial pressure (PAP), through either the tricuspid regurgitation or artery linear flow acceleration time estimation. Similar determinations were performed in 10 normal non operated controls.

Results: Pulmonary hypertension was verified 12 (36%) of the 33 patients with adenotonsillar hypertrophy. Adenoidectomy or adenotonsillectomy was associated to a significant 27% decrease in mean PAP (27 ± 2.8 to 20 ± 5.1 mmHg, p < 0.001) and to a non significant 26% decrease in systolic PAP (35 ± 6.2 mmHg to 25 ± 0.5 mmHg, p = 0.243). The PAP values in children with no pulmonary hypertension were not changed after the surgery.

Conclusions: In children with pulmonary hypertension associated to adenotonsillar hypertrophy, the adenotonsillectomy decreased PAP to normal values in all patients.

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1. Introduction

The most frequent cause of upper airway obstruction in the pediatric population is enlarged palate and pharyngeal tonsils. The Waldeyer’s tonsillar ring is an anatomical term describing the lymphoid tissue ring located in the pharynx and the back of the oral cavity. The palatine tonsils are located in the sides of the oropharynx between palatoglossal and palatopharyngeal arches and the pharyngeal tonsils are in the rhinopharynx [1,2].

Adenotonsillar hypertrophy (ATH) has been described as one cause of pulmonary hypertension in children; however, studies that have attempted to characterize this relation are rare, probably because the methodology involved in its study and the relatively rapid remission after resection [3]. Adenotonsillectomy is generally performed in patients with ATH and pulmonary hypertension [4,5].

Although adenotonsillar hypertrophy has been extensively described in the literature, it was not until 1965 that Menashe and Farrehi [6] described its relationship with pulmonary hypertension and Cor pulmonale. Subsequent studies have further characterized
pulmonary hypertension in association with excessive growth of palatine tonsils and the adenoidal vegetation [7–9].

The most reliable measure of pulmonary pressure is obtained via cardiac catheterization. However, this is an invasive method and not ideal as a screening tool for pediatric patients without cardiovascular symptoms. Echocardiography, conversely, is a noninvasive, low-cost and widely available for anatomic and functional evaluation of the cardiac cavities, and for the measurement of pulmonary artery pressure [10].

Since 1982, only 109 cases of increased pulmonary artery pressure due to adenotonsillar hypertrophy (ATH) have been described in the literature, mostly consisting of case reports [11]. Wilkinson et al. [12] employed echocardiography to study 92 children with adenotonsillar hypertrophy and reported hypertension in 3.3% of them. The current study sought to investigate the association between ATH and pulmonary hypertension, analyzing the data before and after adenotonsillectomy in patients with and without PH.

2. Methods

This is a prospective study approved by the Institutional Review Board at the Hospital São Lucas, Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS). Written consent was obtained for all the patients and signed by an adult guardian. Both male and female patients aged 1–16 years who had been referred for adenotonsillectomy due to ATH were selected. Patients were included if they had at least one tonsil classified as grade 3 or higher by Brodsky scale (see below) with snoring or mouth breathing, associated or not to other complaints (sialorrhea, restless sleep, witnessed apneas, enuresis or low school performance). Other variables were also evaluated such as high-arched palate, open bite or over bite, dark circles under the eyes and low weight (below the 25th percentile). Those with genetic syndromes associated with neuromuscular weakness or craniofacial malformation, subglottic stenosis, asthma, choanal atresia, deviated nasal septum, polyposis and with indications for adenotonsillectomy other than ATH were excluded. Based on an average reduction of 20% on the pulmonary artery pressure after surgery in previous studies and an estimation of 25% prevalence of pulmonary hypertension, 30 patients would be necessary (2 sided alpha = 5%, power = 80%) [13–15].

To determine preoperative echocardiographic parameters, with PAP estimation, 10 children were selected for control. Age and sex distribution were similar for both study and control groups. The controls had not clinical complaints suggestive of ATH and presented normal findings at the otolaryngological examination.

2.1. Otolaryngological assessment

Preoperative evaluation of the patients included medical history, otolaryngologic physical examination with video-assisted nasal fiber optic endoscopy, chest X-ray and echocardiography. Plain X-ray of the nasal cavity was used in 6 patients in whom nasal endoscopy was not possible due to technical reasons or due to refusal for this procedure. A questionnaire regarding airway obstruction was completed by an adult guardian of the child during preoperative preparation to estimate the impact of ATH on the patient’s quality of life. During otolaryngologic examination, the palatine tonsils were measured and classified using the Brodsky scale (1992) [16]. The degree of adenoid hypertrophy (1–4) was estimated using plain X-rays of nasal cavities and video-assisted nasal fiber optic endoscopy. The same criteria were used to evaluate the degree of obstruction due to tonsillar hypertrophy, what was later correlated with the magnitude of obstruction seen on plain X-rays of nasal cavities.

A flexible endoscope (Machida 3.2 mm), a video camera (Toshiba®), a videocassette recorder (Sony®), a video monitor, a light source (Storz®), and an image-capturing software were used for examination after the application of a topical nasal vasoconstrictor (naphazoline hydrochloride) and an anesthetic spray (5% neotetracaine).

2.2. Echocardiography

Echocardiography was performed in the Echocardiography Department of São Lucas Hospital, PUCRS, using an Acuson CV70 System (Siemens®) unit. During the exam, signs suggestive of pulmonary hypertension were evaluated by means of estimation of systolic pulmonary artery pressure, according to tricuspid regurgitation. Systolic pulmonary artery pressure (systolic PAP) was calculated using the Bernoulli formula. In patients without physiological tricuspid regurgitation, mean PAP was estimated according to the pulmonary artery linear flow acceleration time [17]. All exams were performed by the same observer, an experienced cardiologist certified by the echocardiography committee of the Brazilian Cardiology Society with extensive experience with the echocardiography unit employed in the current study. Echocardiograms were obtained 1 week before surgery and 2–24 weeks postoperatively. The observer was blinded to the results of previous exams when the postoperative echocardiogram was obtained.

Consistent with the NIH guidelines, pulmonary hypertension was considered when systolic pulmonary artery pressure was equal to or greater than 30.0 mmHg [18], and/or the mean pulmonary artery pressure, according to Roy and Couriel [19] and Lee [20], was equal to or higher than 25.0 mmHg.

2.3. Adenotonsillectomy

All patients underwent adenotonsillectomy while lying horizontally on their back, under general anesthesia, with orotracheal intubation. Adenoidectomy was performed using a conventional technique and Beckman curettes of three different sizes. The submucosal dissection technique was used in all patients.

2.4. Data management

Microsoft Excel and the Statistical Package for the Social Sciences were used for data analysis. Qualitative values were compared using the chi-square or the Fisher exact test; the Student t test for independent paired samples was used to establish the significance of the differences of pre- and postoperative values. The level of significance was established at p < 0.05.

3. Results

All subjects presented with snoring and oral breathing. Witnessed apnea was reported by parents in 45% of the cases. Restless sleep (84.4%), sialorrhea (60.6%), nocturnal enuresis and low school performance (12.1% for both). Otolaryngological examination revealed the following findings: 78% high-arched palate; 72% open bite or overbite, 45% dark circles under the eyes, 12% low weight (below the 25th percentile). The population characteristics are described in Table 1.

All subjects had at least one tonsil classified as grade 3 or 4. There was no association between the number of reported symptoms and the degree of ATH (Table 2).

There was no association between clinically suspected OSA and pulmonary hypertension (PH). The presence of other symptoms was also not individually associated with PH.
Table 1
Population characteristics.

<table>
<thead>
<tr>
<th>Demographic variables</th>
<th>ATH patients</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With HP (n = 12)</td>
<td>Without HP (n = 21)</td>
</tr>
<tr>
<td>Gender, female (%)</td>
<td>5 (41.6%)</td>
<td>15 (71.4%)</td>
</tr>
<tr>
<td>Age, average</td>
<td>6.7</td>
<td>7.1</td>
</tr>
<tr>
<td>Otolarinologic variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palatine tonsils size (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2 (16.6%)</td>
<td>1 (0.1%)</td>
</tr>
<tr>
<td>3</td>
<td>3 (25%)</td>
<td>9 (42.8%)</td>
</tr>
<tr>
<td>4</td>
<td>7 (58.3%)</td>
<td>11 (52.3%)</td>
</tr>
<tr>
<td>Adenoid size (%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1 (8.3%)</td>
<td>1 (4.7%)</td>
</tr>
<tr>
<td>3</td>
<td>5 (41.6%)</td>
<td>2 (9.4%)</td>
</tr>
<tr>
<td>4</td>
<td>6 (50%)</td>
<td>18 (85.7%)</td>
</tr>
<tr>
<td>Witnessed apnea (%)</td>
<td>4 (30%)</td>
<td>10 (47.6%)</td>
</tr>
<tr>
<td>Mouth breathing</td>
<td>12 (100%)</td>
<td>21 (100%)</td>
</tr>
<tr>
<td>Snoring</td>
<td>12 (100%)</td>
<td>21 (100%)</td>
</tr>
</tbody>
</table>

Table 2
Degree of adenoid and tonsil hypertrophy.

<table>
<thead>
<tr>
<th>Degree of hypertrophy</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenoid (%)</td>
<td>0</td>
<td>0</td>
<td>2 (6.1)</td>
<td>7 (21.2)</td>
<td>24 (72.7)</td>
</tr>
<tr>
<td>Palatine tonsil (%)</td>
<td>0</td>
<td>0</td>
<td>3 (9.1)</td>
<td>12 (36.4)</td>
<td>18 (54.5)</td>
</tr>
</tbody>
</table>

Of the 33 patients who underwent tonsils resection, 90% were submitted to adenotonsillectomy, and 10% to adenoidectomy. After surgical treatment, all patients ceased snoring and exhibited normal nasal breathing. Physiologic tricuspid regurgitation was detected in 14 (42%) of the 33 patients that underwent resection, and the systolic pulmonary artery pressure could be estimated using the Bernoulli formula. Of these 14 patients, 4 (28%) had pulmonary hypertension. Systolic PAP returned to the normal range following resection in all patients.

Mean pulmonary arterial pressure for the 19 (58%) of the 33 patients without tricuspid regurgitation was calculated using the Mahan formula (mPAP = 79 + 0.45 × pulmonary artery linear flow acceleration time). Of these, eight (42%) subjects had PH (mean PAP ≥ 25 mmHg), and their mean PAP returned to the normal range following resection. Of the 33 patients, 12 (36%) had PH before the surgery. No patient had persistent PH after adentonsillectomy.

Preoperative systolic PAP in patients with PH was 35 ± 6.18 mmHg and 25 ± 0.5 mmHg postoperatively. Preoperative mean PAP in patients with PH was 27 ± 2.78 mmHg, and 20 ± 5.07 mmHg postoperatively (p = 0.002). Preoperative systolic PAP in patients without PH was 23 ± 2.31 mmHg. In the same patients, postoperative systolic PAP was 23 ± 1.73 mmHg. Preoperative PAP in patients without PH was 18 ± 6.88 mmHg, and 17 ± 8.33 mmHg postoperatively (Table 3).

Table 3
Values of systolic and mean pulmonary arterial pressure (PAP) before and after adenotonsillectomy. Echocardiographic determination.

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic PAP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With PH (n = 4)</td>
<td>35.25 ± 6.18 mmHg</td>
<td>25.75 ± 0.50 mmHg</td>
<td>0.243</td>
</tr>
<tr>
<td>Without PH (n = 10)</td>
<td>23.60 ± 2.31 mmHg</td>
<td>23.50 ± 1.73 mmHg</td>
<td>0.923</td>
</tr>
<tr>
<td>Mean PAP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With PH (n = 8)</td>
<td>27.81 ± 2.78 mmHg</td>
<td>20.61 ± 0.07 mmHg</td>
<td>0.001</td>
</tr>
<tr>
<td>Without PH (n = 11)</td>
<td>18.00 ± 6.88 mmHg</td>
<td>17.35 ± 7.83 mmHg</td>
<td>0.837</td>
</tr>
</tbody>
</table>

* p < 0.0005.

The echocardiographic parameters, with PAP estimation, for 10 children with no respiratory symptoms, with age and sex distribution similar to the study groups, were systolic PAP 24 ± 3.51 mmHg.

4. Discussion

The current study suggests that children with adenotonsillar hypertrophy are at considerable risk for pulmonary hypertension (PH). Although PH is not always diagnosed, resolution is likely following surgical treatment. Previously, only four studies have investigated pulmonary hypertension in patients with adenotonsillar hypertrophy and evaluated the effect of adenotonsillectomy [3,13,15,21]. According to Sebusani et al. [3], who conducted a similar study regarding pulmonary hypertension in patients with adenotonsillar hypertrophy, snoring was found in 100% of the participants and oral breathing in 71%. In the study conducted by Arrarte et al. [22], the authors described 100% snoring and 96% oral breathing in children with adenotonsillar hypertrophy and referral to surgery. In our study, both symptoms were found in 100% of the patients, similar to findings reported in the literature.

Pulmonary hypertension was defined using both parameters, the systolic PAP, which is a more reliable parameter [17] (in 14 patients) and the mean PAP used only when the systolic could not be calculated (in 19 children). Previous studies found tricuspid regurgitation using echocardiography was detected in 76–86% of the patients with ATH [23]. Most studies categorized patients based only in the mean pulmonary artery pressure, even for those with tricuspid regurgitation detected. Similar to our study, Granzotto et al. [24] analyzed 45 children with formal indication to adenotonsillectomy and found a prevalence of 13.3% of pulmonary hypertension. In that study, PAP was evaluated by echocardiography only in the preoperative period.

Yilmaz et al. [13] published a study with a series of 52 patients similar to those enrolled in our study. The authors evaluated mean pulmonary artery pressure in children with adenotonsillar hypertrophy using echocardiography. Children with adenotonsillar hypertrophy who were referred to adenotonsillectomy, and a high prevalence of PH (51%) was found. However, defining PH with a cutoff value of 20 mmHg instead of 25 mmHg for the mean PAP they also included patients who, according to our criteria, would be classified as normal. In that study of the 27 patients with increased mean PAP, 9 had pressure levels between 20 and 25 mmHg. In our study, those patients with preoperative pressure within this range did not have their pressure changed significantly after surgery. It reinforces the impression that these values should be considered normal. The high prevalence found by Yilmaz may be explained by the lower cutoff point used.

Ugor et al. [21] used echocardiography to evaluate 26 children that presented with complaints that suggested upper airway obstruction. Similar to our study, systolic PAP returned to normal values after surgery. Duman et al. [15] evaluated 21 patients with ATH and a control group of 21 children without ATH using echocardiography to measure systolic PAP in the two groups. Systolic PAP was significantly higher in the group of patients with ATH (41 mmHg vs. 25 mmHg).

In our study, both systolic and mean post-operative PAP had a similar decrease of 26 and 27%, respectively. Due to a reduced number of patients classified by the systolic PAP, this difference did not reach statistical significance.

Even though other studies have demonstrated PH in children with ATH these studies have methodological limitations, such as the diagnosis of PH based only on ECG criteria or the use of lower than recommended cutoff values. This can explain the variability in the prevalence of PH in different studies.
Due to the high prevalence of PH found in our study and the significant morbidity of this condition, we consider that an echocardiogram to assess the PAP is warranted in cases in which the surgical indication or its urgency are not clearly defined.

5. Conclusion

The prevalence of pulmonary hypertension in children with adenotonsillar hypertrophy was high in this study (36%). Pulmonary artery pressure levels became normal after adenotonsillectomy in all patients with previous pulmonary hypertension, with significant differences in the mean pressure values. These findings should be taken into consideration when prescribing treatment for children with adenotonsillar hypertrophy.

Conflict of interest

None.

Financial support

None.

References