Effect of Improved Nasal Airflow After Adenoidectomy on Nasal Erectile Tissue

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Objective: To determine the effect of improved nasopharyngeal airflow after adenoidectomy on nasal turbinate erectile tissue in pediatric patients.

Design: Clinical, prospective, before-and-after study.

Setting: Pediatric Otolaryngology Clinic at Hospital da Criança Santo Antônio de Porto Alegre (Complexo Hospitalar Santa Casa de Porto Alegre).

Patients: Twenty-one 5- to 11-year-old children diagnosed as having severe nasal obstruction, with an indication for adenoidectomy.

Intervention: Adenoidectomy.

Main Outcome Measures: Acoustic rhinometry data before and 90 days after surgery. To specifically monitor erectile tissue behavior, only the volume of the nasal turbinate region was considered (depth, 2.20-5.40 cm).

Results: The volume of the turbinate region varied from 6.03 cm³ in the preoperative evaluation to 6.99 cm³ in the postoperative evaluation, representing an increase of 16% (P < .04). Multiple linear and logistic regressions did not reveal any factors other than adenoidectomy that could explain this change.

Conclusions: Because the only possible explanation for the observed erectile tissue changes was improvement in nasal airflow, we can assume that adenoidectomy favorably affects the behavior of nasal erectile structures and is associated with a decrease in turbinate size. Combined turbinate reduction and adenoidectomy should not be the rule because children may benefit from adenoidectomy alone.


Nonairflow rhinitis was initially described in patients who underwent laryngectomy and had enlarged and sometimes violaceous turbinates without any history of nasal disease or other situations that could justify such alterations. A possible triggering factor could be the change from nasal breathing to tracheostoma breathing. Cyclical temperature and humidity variations associated with the absence of nasal airflow on nasal mucosa would trigger a vasomotor reaction with loss of vascular tone, which would lead to turbinate enlargement.

The suggestion that the same phenomenon occurs in children with important nasal obstruction due to adenoid hyperplasia was first made by Ritter in 1970. However, the hypothesis could not be confirmed at the time because no appropriate tests were available. In 1994, after the advent of acoustic rhinometry, Fisher et al concluded that the nasal cycle is independent of afferent input from nasal airflow and that nasal airflow acts as a modulator rather than as an initiator of the cycling phenomenon.

Adenoid hyperplasia is one of the major reasons for surgery in childhood, and turbinate hypertrophy is a frequent associated finding. For this reason, it is essential that surgeons have a precise understanding of the main cause of nasal obstruction in each patient before a treatment decision is made. This may prevent unnecessary surgery, thus reducing postoperative morbidity and the risk of sequelae such as, in the case of turbinate surgery, atrophic rhinitis and nasal synechiae. We believe that simultaneous turbinate reduction with adenoidectomy is not required in children and that they may benefit from adenoidectomy alone.

In the past 2 decades, acoustic rhinometry has been used in studies involving nasal diseases and treatments, especially to analyze nasal congestion in various situations. Acoustic rhinometry is a fast,
painless, and noninvasive diagnostic method that requires little collaboration from the patient. The test calculates cross-sectional areas at different points of the nasal cavity, providing area and distance mapping, with information on the location of sites with increased narrowing, called minimum cross-sectional areas. It also provides information on nasal volume. Some studies have already used acoustic rhinometry to observe nasal geometry changes after treatment of nasal obstruction. The objective of this study is to assess the effect of improved nasopharyngeal airflow after adenoidectomy on nasal turbinate erectile tissue in pediatric patients.

### METHODS

Twenty-one 5- to 11-year-old children were selected from the outpatient clinic at the Hospital da Criança Santo Antônio de Porto Alegre Pediatric Otolaryngology Division between March 10, 2003, and December 18, 2006. All the children noted severe nasal obstruction and had an indication for adenoidectomy. Patients with nasal obstruction from other causes, such as significant septal deviation, nasal polyps, hypertrophy of palatine tonsils, and craniofacial malformations, were excluded from this study, as were patients who received treatment for nasal obstruction 1 month before selection for the study. Patients with allergic rhinitis were not excluded, except those in whom the disease was not controlled. All the patients underwent a clinical evaluation with a complete otolaryngology examination, nasopharynx radiography, nasal endoscopy, skin tests for respiratory allergens, and acoustic rhinometry. Radiography and endoscopy were used to document the severity of adenoid obstruction and to control for the presence of associated nasal abnormalities.

In the analysis of radiographs, the adenoid to nasopharynx ratio was used to classify adenoids as small (ratios of 0.499-0.624), moderate (0.625-0.731), or large (0.732-0.853). Nasal endoscopy analysis was based on the classification developed by Wormald and Prescott, which defines small adenoids as occupying less than 50% of the nasopharynx, medium adenoids as occupying more than 50% but less than 75% of the nasopharynx, and large adenoids as occupying more than 75% of the nasopharynx. Skin tests for respiratory allergens were performed to control for the presence of allergic rhinitis. Acoustic rhinometry was performed before and 90 days after surgery (SRE 2.100 rhinometry; RhinoMetrics AS, Lynge, Denmark). The examinations were performed following Standardization Committee on Acoustic Rhinometry recommendations.

The patient's medical history was recorded, and the otolaryngology examination was performed in the same room as the acoustic rhinometry, which enabled a period of adaptation to the environment. This is an important aspect because nasal mucosal congestion is affected by changes in temperature and air humidity and by physical activity (walking to the test location).

The tests were performed with the patient sitting down, with the head resting on the back of the chair to prevent it from moving. Children with significant adenoid hyperplasia present more nasal secretion, so all the patients were required to blow their nose before the test. Participants with abundant rhinorrhea had their examinations postponed because nasal secretions affect the accuracy of acoustic rhinometry. Three alternate measurements were performed on each side of the nasal cavity. If any errors were detected, the area-distance curve for the specific measurement was discarded and the mean of the remainders was used. Fewer than 10% of measurements were discarded, and in no case were all 3 rejected. The most common problems were caused by the patients moving their head or having difficulty holding their breath during the examination.

The surgical procedures were performed by otolaryngology residents under the supervision of a single investigator (J.F.L.N.), who revised all the cases at the end of surgery. All the adenoidectomies were performed using a sharp curette and without cauterization.

Because the study objective was to observe the behavior of erectile tissue after improved nasal airflow, the volume of the region located at a nasal depth of 2.20 to 5.40 cm, defined as the turbinate region, was determined before vasoconstriction. With children in this age group, the inferior turbinate head is located deeper than 2 cm and the adenoid is located deeper than 6.5 cm. To control possible distortions provoked by the nasal cycle, the volumes for the 2 nasal cavities were added. The paired-samples t-test was used to analyze the difference between turbinate region volumes before and after surgery (Δ turbinate region volume). Significance was established at P < .05. In addition, multiple linear and logistic regression models were used to test the effect of sex, age, ethnic group, allergic rhinitis, and size of adenoids on Δ turbinate region volume.

This project was approved by the research ethics committee at Complexo Hospitalar Santa Casa de Porto Alegre. All the parents signed an informed consent form before their child entered the study.

### RESULTS

Twenty-one children aged 5 to 11 years (mean [SD] age, 8.62 [1.83] years) were included in the study. Eleven (52%) were girls. Regarding ethnic group (skin color), 10 children (48%) were white and 11 (52%) were nonwhite. Skin test results were positive for respiratory allergens in 9 (43%) of the patients. According to the radiographs, the adenoids were large in 16 (76%) of the children and moderate in 5 (24%). Small adenoids were not observed. On nasal endoscopy, 17 participants (81%) had greater than 75% obstruction of the nasopharynx, and in 4 participants (19%) the adenoid occupied 50% to 75% of the nasopharynx. No children had less than 50% obstruction. The Figure compares turbinate region volume before and after surgery. An increase of 16% in volume was noted (P = .04). This difference was not explained by any of the study variables (sex, age, ethnic background, allergic rhinitis, and size of adenoids) according to the linear and logistic regression models (Table 1 and Table 2).

### COMMENT

Nasal patency assessment is known for its complexity. Not even a combination of clinical history, nasal cavity examination, and allergic rhinitis investigation is sufficient to objectively and precisely describe the end point analyzed in this study, which aimed to demonstrate the impact of improved nasal airflow on nasal turbinate erectile tissue. Acoustic rhinometry seems to be the ideal method for evaluating these changes because it is accurate and objective and can be easily performed in children.

Previous studies have already used acoustic rhinometry in children undergoing nasal surgery. The results obtained by those studies differ from the present findings, possibly owing to differences in the samples, variations in the technique and equipment used, and the selection...
an increase in nasal volume and in the cross-sectional area of the nasal valve region. For this reason, these data were evaluated at the 25th and 250th percentiles, respectively; the whiskers above and below the box, the 90th and 10th percentiles, respectively; and the points beyond the whiskers, outliers.

Figure. Turbinate region volume variation before and after adenoidectomy in the 21 study patients. The horizontal line in the middle of each box indicates the median; the top and bottom borders of the box, the 75th and 25th percentiles; CI, confidence interval; NA, not applicable; OR, odds ratio for the occurrence of increase in turbinate region volume after adenoidectomy.

The Δ turbinate region volume is calculated as preoperative volume minus postoperative volume at a nasal depth of 2.20 to 5.40 cm.

Table 1. Multiple Linear Regression Model of the Effect of Adenoidectomy on Turbinate Region Volume According to Selected Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>b (95% CI)</th>
<th>SD</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>0.68 (0.91-1.32)</td>
<td>1.01</td>
<td>.35</td>
</tr>
<tr>
<td>Age</td>
<td>0.13 (0.06-0.20)</td>
<td>0.27</td>
<td>.42</td>
</tr>
<tr>
<td>Ethnic group</td>
<td>-0.53 (-0.83 to 0.29)</td>
<td>1.11</td>
<td>.45</td>
</tr>
<tr>
<td>Rhinitis</td>
<td>-0.74 (-0.92 to 0.56)</td>
<td>0.95</td>
<td>.10</td>
</tr>
<tr>
<td>A:N ratio</td>
<td>-0.16 (-0.37 to 0.04)</td>
<td>3.39</td>
<td>.31</td>
</tr>
<tr>
<td>Constant</td>
<td>0.23 (NA)</td>
<td>4.19</td>
<td>NA</td>
</tr>
</tbody>
</table>

Abbreviations: A:N ratio, adenoid size to nasopharynx size ratio; CI, confidence interval; NA, not applicable.

Table 2. Multiple Logistic Regression Model of the Effect of Selected Variables on the Odds of Increasing Nasal Turbinate Region Volume

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR (95% CI)</th>
<th>SD</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1.42 (0.51-7.34)</td>
<td>1.14</td>
<td>.76</td>
</tr>
<tr>
<td>Age</td>
<td>1.02 (0.56-1.84)</td>
<td>0.30</td>
<td>.96</td>
</tr>
<tr>
<td>Ethnic group</td>
<td>0.89 (0.57-1.4)</td>
<td>1.27</td>
<td>.93</td>
</tr>
<tr>
<td>Rhinitis</td>
<td>0.66 (0.38-1.15)</td>
<td>1.09</td>
<td>.70</td>
</tr>
<tr>
<td>A:N ratio</td>
<td>13.91 (5.01-1.600)</td>
<td>4.27</td>
<td>.54</td>
</tr>
<tr>
<td>Constant</td>
<td>0.27</td>
<td>4.96</td>
<td>NA</td>
</tr>
</tbody>
</table>

Abbreviations: A:N ratio, adenoid size to nasopharynx size ratio; CI, confidence interval; NA, not applicable; OR, odds ratio for the occurrence of increase in turbinate region volume after adenoidectomy.

of different aspects for analysis in the rhinogram. Studying children after nasal adenoidectomy, Kim et al did not find any statistically significant differences when assessing the minimum cross-sectional area in the nasopharynx of children who underwent adenoidectomy, probably because they evaluated the posterior region of the nose. Another reason might be the fact that they evaluated only the changes in minimum cross-sectional area. Discrete increases in cross-sectional area in several sites of the nasal cavity may not be thought of as important changes in minimum cross-sectional area, although they do result in a significant overall increase in nasal volume. Thus, an evaluation of changes in the whole turbinate region not restricted to a specific narrowing (turbinate head) should take into account the volume of the region with the higher erectile tissue concentration instead of the minimum cross-sectional area. Similar to Riechelmann et al, Marques and Anselmo-Lima did not find any statistical difference when they compared the nasopharynx of children with adenoid hyperplasia before and after surgery and in relation to a control group composed of nonobstructed children. Millqvist and Bende claim that acoustic rhinometry is a good method for monitoring the behavior of disease or the treatment effect in the individual patient but that it is less reliable for comparison between patients.

Corey et al used acoustic rhinometry to compare the nasal cavities in different ethnic groups. They found differences only in the cross-sectional area of the nasal valve region, without any variation in nasal volume between ethnic groups. Trindade et al reported a difference in nasal volume between females and males in the nasal valve region, which became apparent in the turbinate region only after mucosal vasoconstriction. That may explain the absence of difference in volume between boys and girls in the present study because we analyzed acoustic rhinometry data only after vasoconstriction in the turbinate region. In addition, the size of the present sample may not have been sufficient to evidence the effect of the variables on the Δ turbinate region volume. Still, because the

Abbreviations: A:N ratio, adenoid size to nasopharynx size ratio; CI, confidence interval; NA, not applicable; OR, odds ratio for the occurrence of increase in turbinate region volume after adenoidectomy.

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results did not show any trend toward significance, it is unlikely that a type II error occurred.

This study shows a turbinate region volume variation from 6.03 cm³ preoperatively to 6.99 cm³ postoperatively, which corresponds to an increase of 16% in the volume of the region with the highest amount of erectile tissue. The turbinate plays an important role in the sensation of nasal patency. Even discrete reductions may result in significant relief.31,32 Hilberg et al,10 in 1995, showed that allergic patients had more variability in nasal volume than nonallergic patients. This was true even in measures performed 15 minutes apart. Therefore, it is reasonable to infer that longer intervals (eg, 3 months) could significantly affect measures. However, this does not seem to be the case in the present study because the worsening of rhinitis in the postoperative period would lead to an increase in turbinate edema, decreasing (instead of increasing) nasal volume. The inverse situation (ie, that patients were operated on at their worst rhinitis phase, so that the natural history of rhinitis or even the biological phenomenon of regression to the mean would explain the increase in nasal volume in the postoperative period) does not seem probable; all the patients were extensively evaluated for rhinitis, and the procedure was postponed in the presence of an acute rhinitis crisis. Also, acute inflammation is a contraindication to elective surgery and, thus, no patient would undergo surgery in this condition.

Seasonal variations are expected to occur in cases of intermittent allergic rhinitis and could have affected the results. However, almost half of the sample was sensitive to mites, a cause of persistent, instead of intermittent, allergic rhinitis. This is in accordance with a Brazilian population-based prevalence study33 of allergic sensitization in children. The same study showed that hay fever is not common in the region, with a prevalence of sensitized children of 1.8%. It is natural that, in the presence of perennial allergic rhinitis, variations in intensity occur as a result of changes in climatic, infectious, or other related factors in the patient’s microenvironment. Again, however, this possibility was controlled for by means of a careful interview and physical examination.

Other explanations, besides nonairflow rhinitis, may be proposed for these findings. An attractive hypothesis is that the component of excessive mucus (as seen in many of these patients) that might contain bacteria and inflammatory mediators contributes to the observed edema in the nasal turbinates. It is reasonable to assume that when nasal obstruction is relieved by adenoidectomy, the mucus effect is usually also resolved. We found at least 2 studies in the literature explaining how adenoidectomy affects nasal mucus. Shin and Heo34 showed that the decreased airflow reduces air stimulation on the nasal mucosa and causes inflammatory reactions due to an abnormal mucous membrane immunity, phagocytosis, and the bacteriologic action of the nasal secretion enzymes. Also, adenoidectomy has been shown to increase mucociliary clearance velocity significantly.35

In conclusion, improved nasal airflow after adenoidectomy leads to increased nasal turbinate region volume and is associated with a decrease in turbinate size. The results suggest that combined turbinate reduction and adenoidectomy should not be a rule because children may benefit from adenoidectomy alone.

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Author Contributions: All authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Brinckmann, Bernd, and Neto. Acquisition of data: Brinckmann and Scapin. Analysis and interpretation of data: Brinckmann, Bernd, and Neto. Drafting of the manuscript: Brinckmann, Scapin, Bernd, and Neto. Critical revision of the manuscript for important intellectual content: Brinckmann, Bernd, and Neto. Statistical analysis: Brinckmann. Administrative, technical, and material support: Scapin, Bernd, and Neto. Study supervision: Brinckmann, Bernd, and Neto.

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