Predictive Factors for Success After Transnasal Endoscopic Treatment of Choanal Atresia

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Objective: To analyze the different factors affecting the outcome of transnasal endoscopic repair of choanal atresia (CA) in children.

Design: Retrospective study.

Setting: Academic tertiary care children’s hospital.

Patients: Eighty patients (48 girls and 32 boys) aged 3 days to 17 years (mean age, 3 years 8 months) who presented with unilateral (n=53: 37 right, 16 left) or bilateral (n=27) CA and underwent surgery between September 1996 and December 2005.

Intervention: All patients underwent transnasal endoscopic surgery with telescopes and a microdebrider. Nasal tubes in neonates and nasal packing in older children were removed after 48 hours. Systematic endoscopic revision was performed under local or general anesthesia a week after surgery. Patients were then clinically and endoscopically monitored for nasal obstruction and healing for a mean follow-up of 43 months.

Results: A total of 30 patients presented with associated malformations: 9 with CHARGE (coloboma, heart disease, choanal atresia, retardation of postnatal growth and mental development, genital hypoplasia, and ear anomalies), 1 with Treacher-Collins syndrome, 1 with Kabuki syndrome, 1 with facial cleft, 1 with Down syndrome, 12 with nonsyndromic malformations, and 2 with 22q11 microdeletion. Three children had heart malformations not related to CHARGE association. One child had a congenital nasal piriform aperture stenosis. Twenty-four children had undergone previous surgery; 10 underwent a second procedure with success. Gastroesophageal reflux disease (GERD) was systematically treated in cases of restenosis. Topical mitomycin C was used in 3 patients with relapse. Two patients underwent laser treatment to reduce stenotic scarring. Of the 10 patients who needed revision surgery, 6 had bilateral CA, and 4 had unilateral CA. Age younger than 10 days and presence of GERD increased the chances of restenosis (P=.03). Postoperative stenting negatively affected the outcome. Associated anomalies and previous surgery had no effect on outcome. The bony nature of the CA and bilaterality were not significant (P=.08). However, surgeon learning curve was an important element positively influencing the results (P=.04).

Conclusions: Transnasal endoscopic repair of CA is a safe and successful technique. Predictive factors of restenosis are the presence of GERD, age younger than 10 days at the time of surgery, and insufficient postoperative endoscopic revision. However, previous surgery and associated malformations are not predictive of a poor surgical outcome.


Congenital choanal atresia (CA) is a rare cause of upper airway obstruction. Its incidence varies from between 1 in 5000 to 1 in 8000 live births. Anatomically, it consists of an enlarged vomer and medialized lateral pterygoid plate causing a complete nasal obstruction. It is more frequently unilateral (usually the right side) and seems to affect girls more than boys. Although the unilateral condition may be left undiagnosed, bilateral CA may be life-threatening, newborns being solely nasal breathers. Some CA may be associated with other congenital anomalies; however, in 50% of cases, no genetic relationship may be found.

The embryologic mechanism seems to be a combination of the persistence of either the nasobuccal membrane of Hochstetter or the buccopharyngeal membrane of the foregut, incomplete resorption of nasopharyngeal mesoderm, and locally misdirected mesodermal flow. This occurs between the fourth and 11th fetal week. Imaging has allowed a better comprehension of the nature of the nasal obstruction: In 30% of the cases, it is purely a bony obstruction; in 70%, the obstruction is a mixed bony and membranous anomaly.
Systematic preoperative cranial computed tomography is useful to assess possible associated anomalies, such as in the CHARGE syndrome (coloboma, heart disease, CA, retardation of postnatal growth and mental development, genital hypoplasia, and ear anomalies). Inner ear malformations and colobomas are red flags signaling the possible presence of other elements, including heart anomalies, mental retardation, and genital hypoplasia.

Several surgical approaches may be used to treat congenital CA. Historically, the transpalatal technique was the first one described. Then, laser and endoscopic stenting were used to treat congenital CA. Recently, transnasal endoscopic surgery has developed as a treatment approach for this indication. Powered instruments such as shavers have been introduced and rendered bony and membranous resection easier. Image-guided surgery allows a better appreciation of the resection needed and increases safety and precision in difficult anatomic cases. Postoperative stenting is another operative technique, although the type and the duration of the stenting vary greatly depending on the surgeon. The main complication of the transnasal endoscopic approach is restenosis of the choanae. Reported rates of restenosis have ranged from 9% to 36%.

To evaluate the choanal patency, we passed a flexible, 4-mm, fiberoptic endoscope nontraumatically through the passage. If no rubbing occurred on the edges of the choanae during this passage, the child was considered asymptomatic.

Comparisons of characteristics were based on the Fisher exact test for categorical variables and the Wilcoxon test for continuous variables. Tests were 2 sided, and the criterion for statistical significance was \( P < 0.05 \).

**RESULTS**

Ten of the 80 patients presented with a relapse of the nasal obstruction requiring a second surgical procedure (Table). At the last follow-up, all 10 were asymptomatic. The mean (SD) follow-up was 43 (17) months. The mean (SD) duration of hospital stay was 8.4 (5.9) days.

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**METHODS**

Eighty patients (48 girls and 32 boys), aged 3 days to 17 years (mean age, 44 months), who presented with unilateral (n=53: 37 right, 16 left) or bilateral (n=27) CA and underwent surgery between September 1996 and December 2005 were included in the study. They were all treated by the same surgeon (T.V.D.A.).

All patients underwent endoscopic surgery using rigid 30° telescopes and a microdebrider. Twenty-four to 48 hours postoperatively, nasopharyngeal tubes were placed in babies, while calcium alginate nasal packing was used for older children. Both the tubes and the packing were usually removed 48 hours after placement. Nasal washing with isotonic sodium chloride solution was performed at least twice a day. Gastroesophageal reflux disease (GERD) treatment was prescribed postoperatively. Regular endoscopic controls and washing of the nasal cavity to remove crusts and secretions were performed with the patient under local anesthesia (topical 1% lidocaine) or, if necessary, under general anesthesia in cases of granulomas or synechiae. Data concerning age at the time of surgery, associated congenital anomalies, postoperative stenting and treatment, and complications were collected.

Congenital CA relapse is defined by some authors as a choanal diameter measuring less than 50% of a normal choana. We also took into consideration clinical tolerance (dyspnea and nasal obstruction). To evaluate the choanal patency, we passed a flexible, 4-mm, fiberoptic endoscope nontraumatically through the passage. If no rubbing occurred on the edges of the choanae during this passage, the child was considered asymptomatic.

Comparisons of characteristics were based on the Fisher exact test for categorical variables and the Wilcoxon test for continuous variables. Tests were 2 sided, and the criterion for statistical significance was \( P < 0.05 \).

**UNILATERALITY OR BILATERALITY**

Six of the 27 patients who presented with a bilateral CA experienced a relapse (22%), whereas only 4 of the 53 cases of unilateral CA relapsed (8%). A significant age difference was found between these 2 groups: mean (SD) age, 25.2 (51.4) months for the bilateral CA vs 53.9 (61.8) months for the bilateral CA \( (P=.03) \). However, no significant difference was found when analyzing the difference in relapse rates of patients who presented with a unilateral or bilateral CA \( (P=.08) \).
NATURE OF NASAL OBSTRUCTION

Twenty-seven patients had a purely bony obstruction, whereas 53 had a mixed bony and membranous obstruction. Six patients with a purely bony obstruction had a relapse of the nasal obstruction after surgery (22%), whereas 4 patients with a mixed obstruction relapsed (8%). This difference was not statistically significant (P = .08).

PREVIOUS SURGERY

For 24 patients, the first study procedure was their second or third operation (30%). Five of these patients had previously undergone laser surgery; 1 also had congenital nasal piriform aperture stenosis with a central upper megaincisor; 7 patients had been treated by a transpalatal approach; and 11 had undergone previous transnasal endoscopic surgery. Two patients had been operated on several times before and were referred to our department. Seven patients who presented with restenosis and needed revision surgery were first-time surgical patients (12%); 3 had undergone previous surgery. This difference did not reach statistical significance.

ASSOCIATED ANOMALIES

Thirty-one children had an associated anomaly (39%). One of these had a facial cleft; another, Kabuki syndrome. Two children presented with a 22q11 microdeletion, and 1 had Down syndrome. Nine children had CHARGE syndrome (11%). One child had Treacher-Collins syndrome. Twelve children presented with nonsyndromic polymalformations (15%). Three children had heart malformations not related to CHARGE association. One child had a congenital nasal piriform aperture stenosis. Three patients of the 31 patients with associated anomalies experienced relapse. Differences in associated anomalies between relapse-free patients and those who had relapses did not reach statistical significance (40% vs 30%) (P = .73). One patient had undergone a tracheotomy prior to our surgery.

ANTACID TREATMENT

Fifty-four patients received systemic antacid treatment for GERD, and all 10 patients who experienced relapse were from this group. These 10 patients all had GERD diagnosed retrospectively either by 24-hour pH recording or by a finding of typical posterior laryngitis at endoscopy. Patients who presented with a relapse were more frequently undergoing antacid treatment than were relapse-free patients (100% vs 63%) (P = .03.)

AGE AT SURGERY

Patient age at surgery varied from 3 days to 17 years (median age, 16 months). The difference between median ages at surgery between the group that relapsed and the group that did not was significant (4.15 vs 18.55 months) (P = .043). We also tried to determine a threshold age, younger than which the risk of relapse was greater. In the age group younger than 1 year, 6 of 33 patients experienced a relapse (18%) (P = .30). If we consider the group of children younger than 10 days at the time of the first procedure, 4 of the 9 patients had relapses (44%). We noted that 30% of the patients whose disease relapsed were younger than 10 days compared with only 9% of those with no relapse. These differences did not reach statistical significance (P = .08).

POSTOPERATIVE STENTING

The duration of postoperative stenting was very short: the average time with nasopharyngeal tubes or calcium alginate packing in place was less than a day (0.9 day). Thirty-one patients had tubes, 6 of whom also had relapses. We found that 60% of the patients who relapsed had tubes, whereas 36% of the patients who had tubes did not relapse (P = .17). However, the mean (SD) age of this group was 11 (22) months, corresponding therefore to the youngest children. The other 4 children who experienced relapses received no stenting.

Three patients who presented with restenosis underwent revision surgery with application of mitomycin C.

LEARNING CURVE

Of the first 40 patients in the study to undergo the transoral endoscopic procedure (between September 1996 and March 2000), we had 8 relapses in this group. For the second group (April 2000 to December 2005), we had only 2 relapses. This is significant (P = .04) despite no significant differences in age or sex between the 2 groups of children.

SURGICAL GUIDELINES

Successful surgery depends on a wide range of factors. The surgical technique requires a wide resection of the vomer and/or the posterior septum to obtain a large choana. However, anatomic landmarks have to be respected: the choanal opening should be done below the tail of the medium turbinate to prevent basisphenoid lesions or bleeding. One has to follow the floor of the nasal fossa and open medially and inferiorly. Bony resection is then completed with the backbiting forceps. The edges are then smoothed using the microdebrider to prevent bony spikes that might hinder appropriate scarring. Little resection is done on the pterygoid process. Considering this technique, McLeod et al10 described, in 2003, an endoscopic procedure involving an almost complete resection of the vomer to create a wide unique choana. No stenting is then required, and neither is lateral resection.

STATISTICAL ANALYSIS

We acknowledge that interpretation of our results is subject to limitations related to our statistical analysis. Multivariate analysis was not performed because of the limi-
The limited number of relapse cases observed in our series. This small number of cases also limited the interpretation of some of our results: although certain results were not significant, we cannot exclude the possibility that some of the studied factors do influence surgical outcome.

ANATOMIC CONDITIONS

This study showed that bilaterality and bony stenosis are 2 elements that might influence the outcome. It seems that bilateral CA has a greater risk of relapse than unilateral CA, although the difference was not statistically significant. This greater risk results from twise as many possibilities of inappropriate scarring leading to restenosis of the CA. Risk is also increased by a bilateral medialization of the pterygoid processes. Surgical bony resection is usually limited in cases of bilateral CA because both pterygoid processes are medialized, and the obtained choana is therefore narrower; whereas, by definition, 1 pterygoid process is in normal position in unilateral CA and is covered by a perfect mucosal lining.

Relapse was more frequent in cases of purely bony obstruction than in other cases (22%; n=6), although the difference was not significant. This higher relapse rate may be owing to the narrower choana in cases of pure bony obstruction and the greater difficulty in obtaining a sufficient resection in this configuration.

Friedman et al11 have shown in a retrospective study that other factors may affect surgical outcome. For unilateral CA, it seems that neither the presence of facial anomalies nor the duration of stent placement had an effect on the outcome. On the contrary, for bilateral CA, children with associated anomalies or low weight at the time of surgery usually had poorer outcomes.11 In the present study, associated malformations did not seem to be associated with a greater risk of relapse compared with isolated CA: only 3 patients of the 10 who presented with restenosis had associated malformations (1 CHARGE syndrome, 1 Treacher-Colllins syndrome, and 1 unnamed association of malformations). However, the assessment of possible other malformations is mandatory for proper management.

POSTOPERATIVE STENTING

Stenting is another factor affecting successful surgery. In our experience, postoperative stenting is not necessary. It does not seem to prevent obstructive scarring; on the contrary, better results were obtained without stenting. In the present study, nasopharyngeal tubes were preferred for neonates to ensure postoperative nasal permeability for these obligate nasal breathers. These tubes were kept in place for less than 2 days. Alginate were usually used for older patients to prevent postoperative bleeding, and they were retrieved 24 to 48 hours postoperatively.

Pasquini et al12 showed that a shortened period of stenting and the use of soft stents diminish the likelihood of either granulation tissue formation or the risk of postoperative infection, both of which may induce restenosis. This conclusion seems true in the light of the findings of Samadi et al,3 who report in a retrospective study that the average duration of stent placement was 41 days, and this led to frequent revision procedures: a mean of 2.7 procedures for unilateral CA and 4.9 procedures in cases of bilateral CA. More recently, Sharma et al13 described a new stenting technique that required 2 operations and 4 weeks of stenting; 4 of the 14 patients required a repeated dilatation. Schoem,3 on the contrary, showed that no stenting was necessary for 13 patients. He affirms that stents cause discomfort, localized infection and ulceration, circumferential scar tissue formation, and injury to the surrounding normal tissue. Our research group came to the same conclusion in a previous study14: revision endoscopy to remove crusts 1 week after surgery and abundant washing of the nasal cavity with isotonic sodium chloride solution were the keys to successful management of congenital CA without stenting.

AGE

In agreement with Friedman et al,11 we have shown that for children with low weight at the time of surgery, restenosis is a more frequent occurrence than in higher-weight children. Therefore, age younger than 10 days is associated with a greater risk of relapse. The risk is increased yet again with bilateral CA, and early surgical management is crucial.

Nasal patency must be obtained quickly: a McGovern nipple or a nasotracheal tube may be necessary, but use of these devices should be temporary because they both have adverse effects. In our opinion, tracheotomy is not an option.

Children with congenital CA are usually treated in the first 10 days of life after a complete assessment to rule out the presence of associated anomalies. The normal narrowness of a newborn’s nose is a predisposing factor for postoperative obstruction. Moreover, neonates frequently present with physiologic GERD, which increases postoperative inflammation and leads to scarring and therefore restenosis.

A final possible explanation for the greater restenosis rate in babies is that vomer resection may be proportionally more limited in neonates than in older children.

USE OF MITOMYCIN C

Three patients who presented with restenosis were treated with topical mitomycin C during revision surgery. All had a satisfactory choanal patency during follow-up. The number of patients is too low to draw conclusions concerning the effect of mitomycin C on choanal scarring. Kubba et al,13 in a retrospective study, did not find any difference in the outcome when 22 patients treated with mitomycin C were compared with 24 control patients. The authors suggested that the use of mitomycin C might just be a marker of refractory disease, since it seems to be used in cases of children with poorer overall outcome.

HOSPITAL STAY

Little is said in other publications concerning the length of hospital stay. In the present study, we considered the time for presurgical assessment for neonates with bilateral CA and the first few days of postoperative nasal washing with isotonic sodium chloride solution. Efficient wash-
ing is a key element for success. Teaching parents to do it properly may require a few days. A first revision endoscopy was usually performed at 4 to 5 days after surgery to eliminate granulations, inappropriate scarring tissue, and false membranes. General anesthesia may be required for revision endoscopy to ensure a proper toilette of the surgical site. In cases of abundant granulating tissue, several endoscopic examinations may be necessary, as frequently as every week or 2 weeks. When a good choanal diameter is obtained, simple surveillance may be done in the clinic.

**LEARNING CURVE**

We noticed that restenosis was more frequent in the first half of our study, from September 1996 to March 2000 (8 patients). Starting in April 2000, only 2 children needed revision surgery for relapse. This drop in the number of necessary revision procedures is probably owing to the surgeon’s better understanding of prognostic factors: surgical resection, absence of stenting, frequent isotonic sodium chloride solution washing, revision endoscopy, and systematic GERD treatment. In addition, in agreement with the procedures outlined by Kubba et al, we used nasal steroid drops more systematically in the later part of the study than in the earlier part.

In conclusion, transnasal endoscopic repair of CA is a safe and successful technique. Predictive factors of restenosis are the presence of GERD and insufficient postoperative endoscopic revision. Patient age younger than 10 days at the time of surgery also seems to influence surgical outcome. The surgeon’s learning curve is another important element. However, previous surgery and associated malformations are not predictive of restenosis.

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Author Contributions: Dr Van Den Abbeele had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Teissier. Acquisition of data: Couloigner, François, and Van Den Abbeele. Analysis and interpretation of data: Teissier, Kaguelidou, and Van Den Abbeele. Drafting of the manuscript: Teissier. Critical revision of the manuscript for important intellectual content: Kaguelidou, Couloigner, François, and Van Den Abbeele. Statistical analysis: Kaguelidou. Study supervision: Van Den Abbeele.

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**REFERENCES**


