Hypopharyngeal Pharyngoplasty in the Treatment of Severe Aspiration Following Skull Base Tumor Removal

Experience in Pediatric Patients

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Objective: To report the surgical treatment of severe swallowing disorders associated with skull base surgery resulting in unilateral pharyngolaryngeal paralysis in pediatric patients.

Design: Retrospective case review.

Setting: Tertiary referral center for pediatric otolaryngology.

Patients: Five infants undergoing swallowing rehabilitation surgery for severe dysphagia and aspiration resulting from skull base or brainstem surgery.

Intervention: A hypopharyngeal pharyngoplasty, consisting of the partial resection of the inferior constrictor and cricopharyngeal muscles, was performed for the treatment of severe swallowing disorders. A thyroplasty was also performed if clinically significant glottic incompetence was present.

Main Outcome Measures: Functional outcomes after surgery were evaluated with a videodendoscopic swallowing study and videofluoroscopy. Postoperative clinical evaluation included respiratory, swallowing, and nutritional outcomes.

Results: A hypopharyngeal pharyngoplasty was performed following a mean period of 6 weeks (range, 1-10 weeks) after skull base surgery. In 3 patients a thyroplasty and a temporary tracheotomy were performed. Oral feeding was reintroduced after a mean period of 6 days (range, 4-20 days). Complete oral feeding autonomy was obtained after 13 days (range, 7-25 days). Postoperative swallowing assessment revealed the disappearance of pharyngeal stasis and aspiration in all patients. Three infants died because of tumor recurrence. Neither dysphagia nor bronchopulmonary infections were observed after a mean follow-up period of 33 months (range, 6-61 months).

Conclusions: Pharyngolaryngeal paralysis represents a severe consequence of skull base and brainstem surgery. This condition leads to high morbidity, particularly in the pediatric population. The hypopharyngeal pharyngoplasty, with a possible thyroplasty, may be considered to treat patients with severe pharyngolaryngeal paralysis after skull base or brainstem surgery.

All surgical procedures were approved by our institutional review board. A retrospective medical chart review was performed that included all infants referred to our department for severe dysphagia and aspiration related to unilateral laryngeal and pharyngeal palsy secondary to brainstem or skull base surgery from November 1998 to December 2008.

FUNCTIONAL ASSESSMENT

Swallowing evaluation included a videoendoscopic swallowing study with sensory testing and a videofluoroscopy with oral administration of flavored barium. Prior to surgical planning, a laryngeal electromyography (EMG) was performed to assess the severity of the nerve deficit when medical history and swallowing evaluation were not consistent. Laryngeal EMG was performed under general anesthesia with spontaneous breathing.

SURGICAL CANDIDACY

Surgical treatment for dysphagia was proposed in selected cases of lower CN deficit as a result of brainstem or skull base tumor removal. Clinically severe dysphagia or aspiration and poor prognosis of recovery (intraoperative nerve section or denervation pattern on electromyography) were used to identify candidates for surgery.

THYROPLASTY PROCEDURE

In cases of clinically significant laryngeal incompetence, a thyroplasty was performed as the first step of the procedure. To allow perioperative endoscopic control of the glottis, a tracheotomy was performed at the beginning of the procedure. According to the procedure described by Link et al,16 the true vocal cords were localized by insertion of a needle through the thyroid cartilage into the endolarynx under endoscopic control. As described by Isshiki et al,17 the medialization was performed using a cartilage graft, and the vocal cord placement was assessed endoscopically.

HYPOPHARYNGEAL PHARYNGOPLASTY AND CRICOPHARYNGEAL MUSCLE SECTION

Patients who did not require a thyroplasty were intubated via the orotracheal route. The larynx was then dissected laterally, and the superior laryngeal nerve was identified. After rotating the larynx, the pharyngeal constrictor and cricopharyngeal muscles were exposed. The inferior constrictor muscle was sectioned vertically 2 mm behind the posterior border of the thyroid cartilage alar. The muscular section was extended inferiorly to the cricopharyngeal muscle fiber (CP) and to the upper edge of the superior cornu of the thyroid cartilage. After pharyngeal mucosa section, more than 50% of the inferior constrictor and membranous pharyngeal wall was resected (gray area). ES indicates the esophagus.

RESULTS

Five infants, 2 boys and 3 girls, were referred for surgical treatment of a severe swallowing disorder after skull base surgery. Four patients were treated with surgical resection of a brainstem ependymoma, and 1 patient underwent removal of a large vagal ganglioneuroma involving the jugular foramen. In 2 cases the swallowing disorder was present prior to skull base surgery. The mean age was 23 months (range, 11-52 months). The mean follow-up period was 33 months (range, 6-61 months). During the follow-up period 3 infants died because of brainstem tumor recurrence at 6, 22, and 46 months after the hypopharyngeal pharyngoplasty procedure.

SWALLOWING EVALUATION

All patients demonstrated severe postoperative swallowing deficits associated with recurrent aspiration and dysphonia. They all required enteral feeding as a consequence of altered pharyngolaryngeal function. A deficit of the glossohypopharyngeal and vagus nerves were observed in all 5 patients. Three patients had a facial nerve deficit. The spinal accessory nerve and hypoglossal nerve removal. Clinically severe dysphagia or aspiration and poor prognosis of recovery (intraoperative nerve section or denervation pattern on electromyography) were used to identify candidates for surgery.

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POSTOPERATIVE CARE

Extubation was performed at the end of the procedure. In patients undergoing a thyroplasty, a tracheotomy remained temporarily in place to secure the airway during the postoperative period. Decannulation was performed after the glottis lumen was evaluated with flexible laryngoscopy. Oral feeding was reintroduced after videoendoscopic and videofluoroscopic examinations demonstrated pharyngeal healing and effective swallowing. Patient data are listed in the Table.

PATIENTS AND FOLLOW-UP

Five infants, 2 boys and 3 girls, were referred for surgical treatment of a severe swallowing disorder after skull base surgery. Four patients were treated with surgical resection of a brainstem ependymoma, and 1 patient underwent removal of a large vagal ganglioneuroma involving the jugular foramen. In 2 cases the swallowing disorder was present prior to skull base surgery. The mean age was 23 months (range, 11-52 months). The mean follow-up period was 33 months (range, 6-61 months). During the follow-up period 3 infants died because of brainstem tumor recurrence at 6, 22, and 46 months after the hypopharyngeal pharyngoplasty procedure.
Three patients presented with vocal fold paralysis and clinically significant glottic incompetence requiring a thyroplasty. In the 2 other patients, the paralyzed vocal fold was diagnosed in a paramedian position, and a thyroplasty was not performed.

No complications were observed. In patients requiring a tracheotomy, decannulation was achieved between postoperative days 3 and 10. Infants were discharged home or to the pediatric oncologic department in a mean of 8 days (range, 7-11 days).

**SWALLOWING OUTCOMES AND FEEDING**

Postoperative videofluoroscopy showed disappearance of pharyngeal stasis and efficient pharyngeal propulsion in all patients. Postoperative videofluoroscopy confirmed the efficiency of pharyngeal propulsion and the absence of pharyngeal stasis or laryngeal aspiration in all patients. In 4 patients, nasal reflux was observed during videofluoroscopy.

Oral feeding was introduced after a mean time of 6 days (range, 4-20 days). In infants receiving chemotherapy, normal oral feeding was proposed after the second cycle to reduce the feeding problems related to nausea and vomiting. Finally, complete oral feeding autonomy was obtained after a mean period of 13 days (range, 7-25 days), allowing the removal of the nasogastric tube after a mean period of 15 days (range, 8-25 days) and unrestricted diet within the first postoperative month. Postoperative weight gain was observed in all patients.

Feeding autonomy and airway protection remained stable over time in all patients, even in those with tumor recurrence. No patient developed recurrent dysphagia or bronchopulmonary infection. Nevertheless, some intermittent but uncommon aspirations during swallowing liquids were reported in 2 cases. In all 4 patients with initial nasal reflux, no symptoms were reported after the second month. The 3 patients treated with associated thyroplasty demonstrated a notable improvement in voice quality.

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### Table. Patient Data

<table>
<thead>
<tr>
<th>Patient No./ Age, mo</th>
<th>Diagnosis</th>
<th>Cranial Nerve Deficit</th>
<th>Preoperative Symptoms</th>
<th>Surgical Procedure</th>
<th>Postoperative Evolution (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16</td>
<td>Brainstem ependymoma</td>
<td>VII, IX, X</td>
<td>Dysphagia, NGT dep, Aspiration, Dysphonia</td>
<td>HP + TP after 6 wk Temporary tracheotomy</td>
<td>Decannulation (3) Ablation NGT (25) Unrestricted diet Tumor recurrence Died 22 mo AP</td>
</tr>
<tr>
<td>2/11</td>
<td>Brainstem ependymoma</td>
<td>IX, X, XI, XII</td>
<td>Dysphagia, Gastrostomy tube dep, Aspiration, Dysphonia</td>
<td>HP + TP after 8 wk Temporary tracheotomy</td>
<td>Decannulation (10) Ablation NGT (21) Unrestricted diet Rare liquid aspiration Tumor recurrence Died 46 mo AP</td>
</tr>
<tr>
<td>3/52</td>
<td>Jugular foramen ganglioneuroma</td>
<td>IX, X</td>
<td>Dysphagia, NGT dep, Aspiration, Dysphonia</td>
<td>HP + TP after 10 wk Temporary tracheotomy</td>
<td>Decannulation (3) Ablation NGT (17) Unrestricted diet Rare liquid aspiration Alive 61 mo AP</td>
</tr>
<tr>
<td>4/17</td>
<td>Brainstem ependymoma</td>
<td>VII, IX, X, XI</td>
<td>Dysphagia, NGT dep, Aspiration</td>
<td>HP after 5 wk Ablation NGT (5) Unrestricted diet Alive 31 mo AP</td>
<td></td>
</tr>
<tr>
<td>5/21</td>
<td>Brainstem ependymoma</td>
<td>VII, IX, X, XI, XII</td>
<td>Dysphagia, NGT dep, Aspiration, Dysphonia</td>
<td>HP after 1 wk Ablation NGT (8) Unrestricted diet Tumor recurrence Died 6 mo AP</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: AP, after procedure; dep, dependent; HP, hypopharyngoplasty; NGT, nasogastric tube; TP, thyroplasty.
COMMENT

Swallowing disorders after skull base surgery may occur due to injury to the lower CNs. They remain a major contributor to postoperative morbidity leading to a high rate of mortality. In the pediatric population, adjuvant chemotherapy is generally required, increasing the morbidity of postoperative swallowing disorders. During chemotherapy, a higher risk of vomiting associated with aspiration and pulmonary infection is observed and might be considered even higher during the myelosuppression phase.

The pathophysiologic characteristics of swallowing disorders after unilateral lower CN paralysis have been previously described. The unilateral deficit of the glossopharyngeal nerve and the vagus nerve results in a loss of sensory afferent feedback from the tongue, the lateral pharyngeal wall, and the supraglottic larynx. This results in palatopharyngolaryngeal paralysis, glottal incompetence, inadequate pharyngeal elevation, and failure of cricopharyngeal relaxation during swallowing. The main cause of aspiration is pharyngeal stasis resulting in the propulsion of the bolus to the dilated paralyzed hemipharynx rather than down the esophagus during pharyngeal contraction. Pharyngeal dysfunction, not just glottal incompetence, may result in problems with aspiration. Aspiration may occur during the pharyngeal phase of swallowing or in the post–swallowing period owing to pooling and overspill.

In most cases, the lower CN deficit is partial and/or temporary and can be treated medically with changes in diet, thickened liquids, speech therapy, salivary reduction, respiratory physiotherapy, or temporary enteral feeding. An early and accurate treatment is required in the rare cases of severe swallowing disorders associated with complete paralysis of the lower CNs.

Treatment of swallowing disorders requires a precise functional assessment of the sensory and motor functions of the larynx and pharynx. In pediatric and adult patients, functional assessment is based on a videofluoroscopic swallowing study associated with sensory testing and video-fluoroscopy. The upper esophageal sphincter and pharyngoesophageal coordination can be evaluated by manometry. However, in the case of unilateral dysfunction, manometry could be difficult to interpret and inconsistent with fluoroscopic assessment. Laryngeal EMG can be performed to assess the status of the vagus nerve. Although its interpretation is subject to debate, we believe a severe denervation pattern is associated with a poor prognosis of recovery. In this situation, early surgical treatment should be considered, particularly when adjuvant chemotherapy is needed.

Various surgical procedures have been described to treat unilateral pharyngolaryngeal paralysis in adults, but to our knowledge no study reports treatment in pediatric population. The severe morbidity associated with pharyngolaryngeal paralysis led some authors to propose early tracheotomy to reduce aspiration and facilitate pulmonary toilet. Severe cases may require a laryngotracheal separation or laryngectomy. Associated dysphagia can be treated by gastrostomy allowing nutritional support. In the pediatric population, tracheotomy and gastrostomy increase the morbidity of the adjuvant chemotherapy, as well as hospitalization duration and quality of life.

Surgical procedures proposed to address the laryngeal component only, such as medialization thyroplasty, vocal cord augmentation, arytenoid adduction, may be ineffective, with residual dysphagia and aspiration reported in 17% to 28% of cases. To reduce the pharyngeal stasis, section of the cricopharyngeal muscle has been proposed alone or in association with a laryngeal pro-
medialization laryngoplasty in 8 adults. An additional pala-
ning the combination of hypopharyngeal pharyngoplasty and
ryngeal wall. The reduction of this nonfunctional pharyngeal
parity and stasis in the dilated and insensate pha-
suted to bolus propulsion failure associated with construc-
tracheotomy. As described in the second paragraph of this
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tion, the long-term effect of fat injection remains uncer-
to respiratory obstruction in small infants. In this popula-
over, the injection of the lateral laryngeal margin could lead
the pharyngeal cavity seems to be less effective. More-
thyroarytenoid muscle. This endoscopic procedure is less
procedure seems to be inconstant,1,2,10 with residual dyspha-
ity and shorten hospitalization. The hypopharyngeal pha-
surgical treatment may be considered to reduce the disabil-
paresis after skull base or brainstem surgery.

Sato et al15 proposed reduction of the paralyzed pha-
rngeal cavity by autologous fat injection in the medial wall
of the pyriform sinus, aryepiglottic fold, false vocal fold, and
thyroarytenoid muscle. This endoscopic procedure is less
vasive than the external approach, but the reduction of the
pharyngeal cavity seems to be less effective. More-
over, the injection of the lateral laryngeal margin could lead
to respiratory obstruction in small infants. In this popula-
tion, the long-term effect of fat injection remains uncertain
due to fat resorption and declining fibrovascular support
of fat graft during homogenization.24

On the one hand, hypopharyngeal pharyngoplasty is more
vasive than previously cited procedures and might be pro-
posed in patients who had failed treatment with other, less
vasive procedures. On the other hand, in pediatric patients
the risk of aspiration is considerable with the vomiting re-
ted to chemotherapy. This potential increase in aspiration
combined with myelosuppression argues for early and ag-
gressive treatment of swallowing disorders in this popula-
tion. The advantage of the proposed procedure is to treat
in a single stage the 3 major causes implicated in dyspha-
and aspiration: pharyngeal dilatation, failure of crico-
pharyngeal relaxation, and failure of laryngeal closure.

Our experience is limited, but the results of hypopha-
rngeal pharyngoplasty seem satisfactory, with rapid feed-
ing autonomy, significant reduction of aspiration, and the
avoidance of a tracheotomy and gastrostomy in some pa-
inants. Infants can often be discharged home or to the
medical oncolgic department postoperatively in good con-
dition and within a short time. The short postoperative
hospitalization allows performing this procedure between
2 chemotherapy cycles without interfering with the che-
otherapy protocol. Long-term follow up in a larger group
is necessary to evaluate the results over time, particularly
when the procedure is performed in young infants.

In conclusion, in pediatric patients as in adults, pharyn-
golaryngeal paralysis represents a severe consequence of
skull base and brainstem surgery, with a high morbidity and
negative impact on quality of life. In most severe cases, early
surgical treatment may be considered to reduce the disabil-
and shorten hospitalization. The hypopharyngeal pha-
ryngoplasty, with a possible thyroplasty, may be considered
to treat patients with extremely severe pharyngeal paralysis
after skull base or brainstem surgery.

Submitted for Publication: February 15, 2010; final re-
vision received May 27, 2010; accepted August 25, 2010.

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Hosana. Analysis and interpretation of data: Fayoux, Bonne, and Hosana. Drafting of the manuscript: Fayoux and Bonne.

Critical revision of the manuscript for important intellectual
content: Hosana. Study supervision: Fayoux.

Financial Disclosure: None reported.

Additional Contributions: Walter Kutz, MD, at Southwestern Medical Center, Dallas, Texas, gave suggestions on the writing and the English language of the manuscript.

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