Slide tracheoplasty for the treatment of tracheoesophageal fistulas

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Abstract

Purpose: The purpose of this study is to determine the surgical outcome of slide tracheoplasty for the treatment of tracheoesophageal (TE) fistula in pediatric patients.

Methods: After internal review board approval, the charts of pediatric patients (0–18 years old) who had undergone slide tracheoplasty for tracheoesophageal fistula were retrospectively reviewed. Patient information and surgical outcomes were reviewed.

Results: Nine patients underwent slide tracheoplasty for correction of TE fistula. In five patients the original TE fistula was congenital. Other causes included battery ingestion, tracheostomy tube complications, foreign body erosion, and an iatrogenic injury. The average age at repair was 48 ± 64 months (range: 1–190). Seven patients had undergone previous TEF repair either open or endoscopically. There were no recurrences after repair. Two patients had sternal peristomeum interposed between the esophagus and trachea. There were no TEF recurrences. A single patient had dehiscence of the tracheal anastomosis and underwent a second procedure.

Conclusion: Slide tracheoplasty is an effective method to treat complex TE fistulas. The procedure was not associated with any recurrences. This is the first description of a novel, effective, and safe method to treat TE fistulas.

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technique to address complex TE fistulas. We have found success with this technique when reserving it for complex cases or previously repaired fistulas. In this report we present the novel use of slide tracheoplasty for the treatment of TE fistulas and describe the surgical outcomes of this procedure.

1. Materials and methods

1.1. Data collection and analysis

Data collection and patient selection were performed after approval by the Cincinnati Children’s Hospital Medical Center Institutional Review Board. Patients were identified who had a diagnosis of TE fistula and who had undergone repair by slide tracheoplasty. Pediatric patients (age 0–18 years old) were identified from 2000 to 2012. Demographic information, surgical data and outcomes were recorded and analyzed using Microsoft Excel (Redmond, WA). Patient gender, age at surgery and medical diagnosis were recorded. Previous surgical procedures were noted as well as intraoperative findings, surgical outcomes and complications.

1.2. Surgical procedure

Our previous publication has described the slide tracheoplasty technique [6]. Modifications have been made to address the TE fistula. Microscopic direct laryngoscopy, bronchoscopy and esophagoscopy are initially performed to verify the location of the fistula. An esophageal bougie is placed. The technique varies depending upon the surgical approach. Patients undergoing a cervical incision will be intubated orally, or in the case of an existing tracheostomy, through the stoma site. Patients requiring a sternal incision and cardiopulmonary bypass will be intubated orally with the stoma sutured shut. In these patients, cardiopulmonary bypass is established prior to the beginning of tracheal work. In both approaches, the anterior wall of the trachea is freed from surrounding tissue as distal as possible. For patients with a cervical approach, mobilization often continues into the mediastinum and to the carina. In all patients, care is taken to preserve lateral tracheal attachments to maintain the blood supply and avoid damage to the recurrent laryngeal nerves. Retraction sutures using 2–0 Prolene (Ethicon, Blue Ash, OH) are placed through the distal tracheal rings to retract the trachea. Flexible bronchoscopy through the endotracheal tube or rigid bronchoscopy can be repeated to confirm the location of the fistula. A needle is placed through the anterior tracheal in the corresponding location of the fistula. The trachea is then divided both superior and inferior to the fistula tract, leaving a small portion of the cartilage attached to the tract (Fig. 1). The trachealis of the superior and inferior tracheal segments is then separated from the esophagus and mobilized. The trachea that remains attached to the fistula is then freed of its mucosa and the cartilage portion is removed (Fig. 2). The edges of the esophageal side of the fistula are freshened in preparation of closure. The tracheal mucosa is then inverted and folded into the esophageal portion of the fistula. Closure is performed with a series of interrupted vicryl sutures (Ethicon). In cases of large fistulas, the cartilage can be kept in continuity with the mucosa and used in the closure for added support. Periosteum is harvested from the sternum and placed on top of the esophageal closure (Fig. 3).

Approximately 1 cm of the posterior wall of the inferior tracheal segment and the anterior wall of the superior segment are then divided vertically. The corners of the two segments are removed in order to achieve better approximation during closure. A running, polydioxanone (PDS) (Ethicon) is then used to close the anastomosis beginning with the posterior aspect of the trachea. The resulting, oblique anastomosis is longer than a corresponding end-to-end anastomosis, thereby distributing the tension across a longer area. Once all sutures are placed, fibrin glue is then applied across the tracheal closure. If occurring through a cervical incision, the previously placed Prolene retraction sutures can be placed around the hyoid as internal Grillo sutures. When performed through a sternotomy, the retraction sutures can be removed as the hyoid is not exposed. The patient remains intubated overnight in the intensive care unit and is generally extubated on postoperative day one. The endotracheal tube lumen should be large enough to accommodate a flexible bronchoscope containing a suction port, thereby allowing for the removal of secretions or blood. A repeat bronchoscopy can be performed in one to two weeks. Fig. 4 demonstrates preoperative and postoperative photos.

Fig. 1. The trachea is divided superior and inferior to the fistula site. A small portion of the trachea remains attached at the fistula and is used to reinforce the fistula repair.

Fig. 2. The tracheal mucosa is removed from the cartilaginous rings and folded into the denuded fistula to reinforce the closure. In some instances the cartilage can also be used to reinforce the closure site.
2. Results

Nine patients were identified who had a TE fistula repaired by slide tracheoplasty. The average age at surgery was 48 ± 64 months (range: 1–190 months). A variety of etiologies and associated anomalies were identified (Table 1). Seven of patients had undergone previous repairs including open and endoscopic procedures (Table 2). Two patients had a slide tracheoplasty as their initial procedure given the complexity of their case. One patient had suffered a foreign body erosion through a bronchi resulting in a large fistula which made repair via other techniques difficult. This patient had a slide on bypass. A second patient had a fistula in the presence of significant upper airway obstruction. In that case, the slide addressed both the fistula as well as some levels of stenosis.

Three patients had additional airway procedures performed to address subglottic stenosis. Sternal peristeum was used in two procedures (Table 3). Slides were performed either through a sternal incision with the patient placed on cardiopulmonary bypass or through the neck with normal ventilator support. There were no recurrences after surgical repair. Five patients had a fistula greater than 1 cm in length. A single patient experienced a tracheal dehiscence that resulted in a second slide procedure. That patient required a temporary tracheostomy and was eventually decannulated. Five patients had a tracheostomy; four were present preoperative and one was placed postoperative during treatment of subglottic stenosis. Three patients who did not take oral intake prior to surgery were able to eat by mouth after fistula repair.

Table 1
Demographic information for 9 patients.

<table>
<thead>
<tr>
<th>Age at surgery:</th>
<th>48 ± 64 months (range: 1–190)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female:</td>
<td>4 (44%)</td>
</tr>
<tr>
<td>Esophageal atresia:</td>
<td>3 (33%)</td>
</tr>
<tr>
<td>H-type fistulas:</td>
<td>3 (33%)</td>
</tr>
<tr>
<td>Etiology:</td>
<td></td>
</tr>
<tr>
<td>Congenital</td>
<td>5 (55%)</td>
</tr>
<tr>
<td>Battery ingestion</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>Iatrogenic</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>Tracheostomy tube erosion</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>Foreign body erosion</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>Associated anomalies</td>
<td></td>
</tr>
<tr>
<td>Esophageal stricture</td>
<td>3 (66%)</td>
</tr>
<tr>
<td>VACTERL</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>DiGeorge</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>GERD</td>
<td>4 (44%)</td>
</tr>
<tr>
<td>Tracheomalacia</td>
<td>5 (56%)</td>
</tr>
<tr>
<td>Cardiac anomalies</td>
<td>2 (22%)</td>
</tr>
</tbody>
</table>

GERD: Gastroesophageal reflux disease.
vascularized material, its durability likely exceeds that of other free
outcomes [3,5]. The long, oblique anastomosis line in this technique
fi
the large amount of available material. To our knowledge, this is the
periosteum given the ease of harvesting it from a cervical incision and
reported the use of pericardium, pleura or vein [5]. We choose to use
periosteum remains intact and the cleft does not recur. Others have
Surgical procedure and results.

Table 3

Associated procedures.

<table>
<thead>
<tr>
<th>Previous procedures</th>
<th>No. of patients</th>
<th>Total no. previous procedures</th>
<th>Endoscopic (no. pts)</th>
<th>Open (no. pts)</th>
<th>Additional airway procedures performed after slide tracheoplasty</th>
</tr>
</thead>
<tbody>
<tr>
<td>slLTP</td>
<td>2 (22%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTR</td>
<td>1 (11%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dsLTP</td>
<td>1 (11%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

slLTP: single laryngotraceheoplasty; CTR: cricotracheal resection; dsLTP: double stage laryngotraceheoplasty; APCCG: anterior posterior costal cartilage graft.

down of the anastomosis. When the slide is done through a cervical
incision, tension along the anastomosis can be decreased through the
hyoid release and use of internal retraction sutures.

While this technique carries significant benefits for TE fistula
closure, it also presents challenges and risks. Significant mobilization
of the trachea can be difficult especially in the setting of previous
surgical repairs. Despite this, previous reports have demonstrated
successful slide tracheoplasty after a previous fistula repair [9,10].
A majority of the patients in our series had undergone a previous
procedure. Despite these past operations, scarring and distorted
anatomy, slide tracheoplasty was performed in all patients. We have
found it difficult to completely free the trachea distally. Mobilization
in this area is facilitated by sternotomy and cardiopulmonary bypass
but can be difficult when performing the slide through a cervical
incision. One patient had previously underwent a tracheal resection
but still had an uneventful slide procedure. Despite this success,
cautions should be taken in those patients with a shortened trachea as
mobilization and the anastomosis may be difficult.

Freeing of the trachea also requires attention to recurrent
laryngeal nerve position. The nerves’ normal location within the
tracheoesophageal groove can be altered from previous surgery,
scarring or aberrant development. We have found that adhering
closely to the tracheal wall protects the nerves. One patient in our
series did have unilateral vocal cord paralysis. This patient had a
postoperative dehiscence requiring reoperation, wound exploration
and a repeat slide. It is unknown if the recurrent laryngeal nerve
injury occurred at the first or second procedure or whether it was a
preexisting consequence of the original button injury.

While other surgical techniques have successfully treated TE
fistulas, a subgroup of patients have recurrences, persistence or
complex fistulas. Tsai and colleagues reported a 10% recurrence rate
[8], consistent with the experience of other authors [5]. Some patients
experience multiple recurrences, making subsequent repairs increas-
ingly difficult [3]. Certain procedures, such as fistula ligation, are
associated with higher rates of recurrence [4]. The technique
presented here was not associated with any recurrences or persistent
fistulas. This despite the difficulties associated with revision proce-
dures. The difference in recurrence rate between our series and
previously published work likely results from the slide tracheoplasty
technique. Unlike other procedures, this technique offsets the tracheal
and esophageal repairs. By advancing the trachealis the esophageal
and tracheal anastomosis lines are not in continuity. Breakdown of
closure line should not affect the other closure. In contrast, other
procedures keep the esophageal and tracheal closures juxtaposed. In
that scenario, breakdown of one closure jeopardizes the other.

The use of sternal periostium in two patients highlights an
additional method to prevent recurrences. The periostium was placed
between the tracheal and esophageal walls to support the fistula
closures. We employ this technique for laryngeal cleft repair and have
found that even when one side of the fistula breaks down, the periostium remains intact and the cleft does not recur. Others have
reported the use of pericardium, pleura or vein [5]. We choose to use
periostium given the ease of harvesting it from a cervical incision and
the large amount of available material. To our knowledge, this is the
first instance of its use in repairing TE fistulas. Although not a
vascularized material, its durability likely exceeds that of other free
tissue grafts such as vein or free muscle.

The slide tracheoplasty technique also addresses the difficulty
with tension along the anastomosis, a finding noted to affect surgical
outcomes [3,5]. The long, oblique anastomosis line in this technique
disturbs the tension across a greater surface area, preventing break

Table 3

Surgical procedure and results.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No. of patients</th>
<th>Total no. procedures</th>
<th>Fistula size</th>
<th>Tracheostomy</th>
<th>Surgical outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiopulmonary bypass</td>
<td>3 (33%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sternal periostium</td>
<td>2 (22%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fistula size</td>
<td></td>
<td></td>
<td>&lt;1 cm</td>
<td></td>
<td>Recurrence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 cm</td>
<td></td>
<td>Inflection</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tracheostomy</td>
<td>VC paralysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dehiscence</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mild tracheal stenosis</td>
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</table>

This series demonstrated that slide tracheoplasty can successfully
repair complex, recurrent or persistent TE fistulas. It is a procedure
reserved for those instances and should not be employed as initial
treatment for simple fistulas that could best be addressed via other
means. In our series no patients had a recurrence. Sternal periosteum is easily harvested and provides an additional level of repair reinforcement. Repair in this manner does not prevent future airway procedures and was associated with relatively few complications. This technique offers a novel approach to treating these fistulas.

References


