Starplasty

A New Technique of Pediatric Tracheotomy

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Objective: To report a new technique of pediatric tracheotomy that reduces the problems of pneumothorax and recannulation after accidental decannulation in a recently performed tracheotomy.


Patients: Sixty-eight children aged between 2 days and 14 years.

Method: The starplasty procedure is based on the geometry of a 3-dimensional Z-plasty. The technique of the procedure is described and illustrated in detail.

Results: There were 27 short-term complications, including 4 accidental decannulations. There were no instances of pneumothorax or tracheotomy-related deaths. There were 25 long-term minor complications. There were no instances of tracheotomy-related death, suprastomal collapse, or tracheal stenosis. Thirty-eight children remain tracheotomy tube dependent, 17 underwent decannulation, 7 died of primary disease, and 6 were lost to follow-up. All 17 children who underwent decannulation have a persistent tracheocutaneous fistula.

Conclusions: I conclude that starplasty reduces the incidence of major complications and death. Its only drawback seems to be persistent tracheocutaneous fistula.


Pediatric tracheotomy remains of interest to surgeons who perform this operation. A MEDLINE computer search rendered 75 references on the subject for the 20 years between 1977 and 1997. There are many reasons why pediatric tracheotomy continues to be of compelling concern, perhaps none more than that the operation saves lives. The indications for pediatric tracheotomies reflect the changes that have occurred in the treatment of critically ill children over the last 50 years.1-3 Also, a low but predictable rate of complications persists along with the search for strategies to reduce them.4-6 Historically, pediatric tracheotomies were usually performed for acute airway obstruction due to infection. With the evolution in antibiotics, vaccinations, and the specialty of pediatric intensive care, today most of these children are treated with endotracheal intubation. Nevertheless, the need for pediatric tracheotomy has increased as a consequence of our success in the treatment of premature infants and chronically, often neurologically impaired children. It is the unresolved difficulties and changing indications that have kept this topic percolating within our literature.

The complications associated with tracheotomy can be divided into short- and long-term categories.7-9 The short-term complications that most demand attention are pneumothorax and the accidental displacement of a newly placed tracheotomy tube. Attempts to reduce the risk of pneumothorax have focused primarily on refinements of surgical technique, with careful confined anatomical dissection, identification of fascial planes between the skin and the trachea, and maintenance of hemostasis. The goal has been to control the operative field, maximizing visual exposure and minimizing trauma to the site. Despite these refinements, pneumothorax still occurs because of a fundamental design characteristic of most tracheotomy techniques that allows air from the trachea to have direct access to the tissue layers confluent with the parietal pleura.

Of even greater concern than pneumothorax is the life-threatening accidental dislodgment of a recently inserted tracheotomy tube. In a child the tolerance between a tracheotomy tube being too long, resulting in hypoinflation of a lung,
and being too short, resulting in tube displacement into the fresh tracheotomy site, is all too narrow. The tube, when it does inadvertently come out, can be difficult to replace because of several factors, including the depth of the operative site, the loss of anatomical specificity in a recent wound, the lack of illumination, and the expertise of the individual confronted with this situation.

All the variations on tracheotomy techniques have been devised in response to this ever-present problem. The most commonly practiced technique is to make a vertical incision in the anterior tracheal wall and place parallel silk stay sutures on either side of the tracheal incision (Figure 1, A). This allows the trachea to be concurrently opened and pulled to the skin surface for easier emergency reintubation. Another technique is to create a circular window in the anterior tracheal wall by excising some of the cartilage to provide wider access should tube replacement be necessary (Figure 1, B). Bjork15 suggested creating an inferiorly based flap on the anterior trachea wall that is sewn to the inferior edge of the skin incision (Figure 1, C). This technique better controls the replacement of the tube and can be effective in preventing the tube from being forced into the mediastinum by way of a fascial passage anterior to the trachea. Ellachar and colleagues12,13 designed a technique for a permanent stoma using an omega-shaped skin incision and a superiorly based tracheal flap, the construction of which results in a circumferential mucocutaneous suture line (Figure 1, D). This technique provides ready perioperative access to the airway and also isolates the trachea from the deeper tissue planes, thus reducing the risk of pneumothorax.

Important long-term complications of pediatric tracheotomy include the development of tracheal stenosis at the tracheotomy site and softening and collapse of the anterior trachea wall above the stoma.14 Much effort has been made trying to understand which technical refinements would best reduce or eliminate these problems.15-22 There has been a traditional aversion to resecting a part of a child’s anterior tracheal wall because of concerns about delayed tracheal narrowing.3 There have been similar fears about the flap tracheotomy technique as well.3 Despite these concerns, there is a paucity of information about the cause of tracheotomy-related ac-
Thirty-five children (51%) had neurologically related airway problems (chi-square test, \( P = .001 \)). Of the 38 children who remained tracheotomy tube dependent, 27 (71%) had neurologically related airway problems (chi-square test, \( P = .001 \)).

Of the 17 children who underwent decannulation, all (100%) have an obvious persistent tracheocutaneous fistula, 7 (41%) of which are closed to airflow, and 10 (59%) of which are open to airflow. Four children (24%) underwent uneventful reconstruction of their tracheocutaneous fistula.

The ideal tracheotomy technique would have the following qualities: (1) technical ease, (2) separation of the wound from tracheal secretions and airflow, (3) ready postoperative replaceability, (4) rapid maturity, (5) minimal stomal maintenance, (6) minimal tracheal deformation, (7) ready reversibility, and (8) minimal scarring.

Unfortunately, tracheotomy, like most surgical procedures, involves compromise, a relative valuation of the goals trying to be achieved. In this light, the starplasty operation fulfills the most important of the characteristics described.

The starplasty procedure is technically straightforward and its logic readily apparent, especially for surgeons familiar with performing tracheotomy. From in-
Figure 3. A, The triangular skin flaps are circumferentially undermined with scissors. B, The subcutaneous fat between the skin and the strap muscles is sharply excised. C, The strap muscles are divided in the midline. D, The thyroid isthmus is generally superior to the opening in the neck, but if it is in the way, it can be divided with cautery or incision and ligature. E, After the paratracheal fascia has been dissected off the trachea, a plus-shaped incision is made in the anterior tracheal wall with a No. 15 blade. F, The construction of the starplasty begins with sewing the tip of the right upper trachea flap to the right upper skin trough, with a 5-0 polyglactin (Vicryl, Ethicon Inc, Somerville, NJ) suture on a cutting needle. The needle is mattressed through the skin 4 mm from the notch of the trough, then through the distal tip of the tracheal flap, back through the skin again, 2 mm from the notch, and then tied. G, Next, the needle is mattressed through the upper skin flap, 4 mm from the tip, then through the upper tracheal trough, back through the skin again, 2 mm from the tip, and then tied. H-L, The remainder of the flaps are similarly sutured into place in an orderly circumferential manner.

The starplasty procedure addresses the problem of pneumothorax by isolating the tracheotomy site from the fascial layers that potentially communicate with the pleura by the use of the interdigitating tracheal and cutaneous flaps. The low but predictable risk of pneumothorax associated with standard tracheotomy, reported between 3% and 6%, is usually a consequence of the basic design of the operation and not due to technical error by the surgeon.1-9 This design flaw is highlighted in children who typically require mechanical ventilation after tracheotomy. Because pediatric tracheotomy tubes are cuffless, the pressurized air from the ventilator leaks around the newly placed tracheotomy tube and can dissect into the tissue planes around the recent trachea wound, resulting in pneumothorax and pneumomediastinum. The absence in the series of any episodes of pneumothorax, pneumomediastinum, and subcutaneous emphysema is favorable evidence that my conceptual solution to this well-recognized problem has practical relevance. It is unlikely that the starplasty design will totally eliminate pneumothorax, and when there are a large enough number of these procedures performed, an incidence of higher than 0% will emerge. Nevertheless, any decrease in this complication will save lives.

The feature of starplasty that isolates the tissue planes from the respiratory tract, thereby reducing the risk of pneumothorax, is also the quality that facilitates replacement of an inadvertently displaced cannula. Accidental decannulation has variable causes, including insecure tracheotomy ties, patient motion, and inexpert tracheotomy tube care. These variables cannot be prevented by the form of the tracheotomy; however, the design of the starplasty stoma does change a potential crisis into a controlled event. The funnel-like shape, the tissue tension that maintains the opening, and the smooth mucocutaneous suture line provide a guiding path back into the tracheal lumen. The 4 episodes of accidental decannulation with uneventful recannulation in our series support the effectiveness of the design.

Deaths of children with indwelling tracheotomy tubes, reported between 7% and 42%, are overwhelmingly the consequence of the child’s underlying illness.1-9,21,22 The 10% incidence of nontracheotomy-related mortality among our patients is well within this range. On the other hand, 1% to 3% of tracheotomy-related deaths are a consistent feature of most reports on the topic, with the 0% incidence reported by Carter and Benjamin23 being the exception. The absence of any tracheotomy-related mortality among our patients speaks well for the care they received after the operation in our intensive care unit, but may also reflect the safety of this technique.

The construction of a continuous circumferential mucocutaneous suture line leads to isolation of trachea secretions from the tracheotomy wound and thus to early maturity of the starplasty stoma. The circumferential suture line reduces the intensity of postoperative wound care but does not eliminate it. Moreover, the techniques are not entirely immune from infection because we had 2 instances of postoperative peristomal cellulitis, one of which resulted in dehiscence of the inferior portion of the stoma. While we did see 2
instances of transient tracheotomy tube plugging in which the tube had to be emergently replaced, it seems that by having a shorter period with a raw open wound, the quantity of crusting around and within the tracheotomy tube is reduced.

Early and late tracheitis, seen in 34% and 26% of our patients, respectively, is not typically reported in the literature as a complication of pediatric tracheotomy, perhaps because it is so ubiquitous or because it is not thought to be related to the performance of

Figure 4. A, The final stoma tends to be slightly vertically elliptical in shape and curved inward like the center of a doughnut. B, After the endotracheal tube has been pulled back above the tracheotomy site, an appropriately sized tracheotomy tube is gently guided into the flared, funnel-shaped stoma. C, Clinical photograph of a recently constructed starplasty. D, Clinical photograph of tracheotomy tube placement after a recently constructed starplasty.
the tracheotomy itself. The organisms that were most commonly responsible for these infections in our patients were *Staphylococcus aureus* and *Pseudomonas aeruginosa*. While we had 1 child with trachea granulations associated with tracheitis, we did not see the eschar and cast formation previously seen in children without tracheotomies with life-threatening bacterial tracheitis. It appears that the 2 processes are distinct despite their common name.

Once a stoma has matured, maintenance can be simple or frustrating, depending on the care given the stoma, the shape of the child's neck, the weather, and the sensitivity of the child's skin. The starplasty procedure has a low incidence (3%) of cutaneous peristomal granulomas. However, their occurrence suggests that even a surgically created mucocutaneous junction can be prone to an irritation and infection and highlights the necessity of careful and continuous tracheotomy care.

Most children in this series (56%) remain tracheotomy tube dependent as a consequence of their underlying illnesses. No child remains cannulated as a consequence of tracheal stenosis, anterior trachea wall collapse, or any other problem that can be attributed to the starplasty procedure (Figure 5, A and B). The absence of stenosis and anterior wall collapse is probably related to the low stomal infection rate but may also be a function of the geometry of the procedure. The superior and inferior parts of the stoma are lined with skin so that the pressure of the tracheotomy tube is not on the trachea itself. Additionally, the integrity and memory of the trachea cartilages within the triangular flaps may remain partially intact reverting to the normal anatomy following decannulation. Further animal studies may clarify the dynamics of this process.

Our main concern with the starplasty procedure is the tracheocutaneous fistula that universally persists after decannulation (Figure 6). Many (41%) fistulae completely seal off but most leak air, and some remain distinctly open with an aperture up to 2 mm in diameter. It has been previously reported that a pediatric tracheotomy tube, if left in place long enough, will result in tracheocutaneous fistulae.²⁴ Nevertheless, because the starplasty stoma is constructed as a tracheocutaneous fistula, it is not unexpected that it consistently results in a belly-buttonlike dimple that requires secondary surgical correction. This result is the compromise made for the early safety of the procedure.

For many children, especially those with chronic neurologic illness, the tracheotomy tube is permanent, and for them the starplasty procedure is truly ideal. Trachocutaneous fistula is a problem only for those who can expect decannulation, typically children with airway problems. The decision about which tracheotomy design to use for these children should be based on the expected length of cannulation. Tracheotomy intended for less than 1 month should have a temporary design. On the other hand, when the airway problem is more complex and the tracheotomy entubation is for a longer period, then starplasty procedure is appropriate.

In summary, I present my experience with 68 children who underwent starplasty, a new pediatric tracheotomy technique that is based on the geometry of a 3-dimensional Z-plasty. I describe and illustrate the steps for its successful performance in detail. The new technique is an alternative to existing methods. More importantly, it results in a quantifiable reduction
in the risk of the major early complications of pneumothorax and death from accidental decannulation. Its only drawback appears to be the need for a secondary reconstruction of a persistent tracheocutaneous fistula. Based on my experience, I recommend its consideration.

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REFERENCES