Tracheoplasty...
Reconstructing a new airway

By Patricia Waugh, R.N.

As a member of the operating room team, the O.R. nurse is often a witness to many skillful and unique surgical procedures. The Hospital for Sick Children in Toronto has seen its share of these "surgical miracles." The following is a brief description of a particularly unique procedure that began several years ago.

Attempts to repair long congenital tracheal stenosis, a rare and frequently fatal anomaly, have been arduous and elusive. However, in 1983, a tracheoplasty for complete congenital tracheal stenosis was performed, resulting in one of the few successful repairs of this defect on record.

Case Report

On February 8, 1983, Landon, a seven-month-old baby boy had been admitted to the intensive care unit at HSC from a peripheral hospital. He had been bronchoscoped and intubated and a tentative diagnosis of tracheal stenosis was made. After a short period of time in the ICU, he developed stridor and became cyanotic. Emergency bronchoscopy was performed.

On examination under a general anaesthetic, the staff ENT surgeon diagnosed long congenital tracheal stenosis when he found it impossible to pass a #3 Fr. scope into Landon's trachea. The stenosis spanned the length of the trachea to the bifurcation. This was later confirmed by tracheobronchogram **(See Figure 1).** The patient was immediately referred to Dr. S.H. Ein, a senior general staff surgeon for possible tracheal repair. Operating room time was scheduled for Landon in the cardiac theatre for the following day.

Tracheoplasty

It was necessary in this type of repair to perform a cardiopulmonary bypass. This left the entire tracheobronchial tree free for repair. A medium sternotomy was made and extended up into the neck area to allow access to the heart for insertion of by-pass cannulae and exposure of the trachea. The trachea was freed by dissection from the larynx to the carina. Arterial and venous cannulae were inserted into the aorta and right atrium respectively and bypass was initiated. The trachea was incised longitudinally down the entire length (3.5 cm) of the posterior wall. Each free edge of the split trachea was then sewn to the anterior surface of the esophagus. In essence, the arterial wall of the esophagus had become the posterior wall of the trachea. **[Figure 2(a), (b), (c) and (d)].**

To prevent the problem of the trachea collapsing, several stay stitches from the suture line on either side were sown to the mediastinal tissues for support.

Next, a red rubber catheter was passed up into the larynx and the end retrieved by the anaesthetist. An endotracheal tube (ETT) was inserted over it and passed down to the mid-portion of the trachea. Ventilation was accomplished. Irrigation of the repair demonstrated that there was no air leakage from the suture line.

At this time, bypass was discontinued and the cannulae removed. Both lungs were being well ventilated. Closure was completed with three chest drains left in the mediastinum and pericardium.

Landon remained stable in the ICU. An attempt to extubate 15 days post-op under a general anaesthetic resulted in re-intubation shortly after due to development of severe stridor. Finally, extubation was successfully achieved 29 days post-op.

Subsequent X-rays showed clear lungs and good tracheal size. Landon's stridor gradually subsided,

About the author

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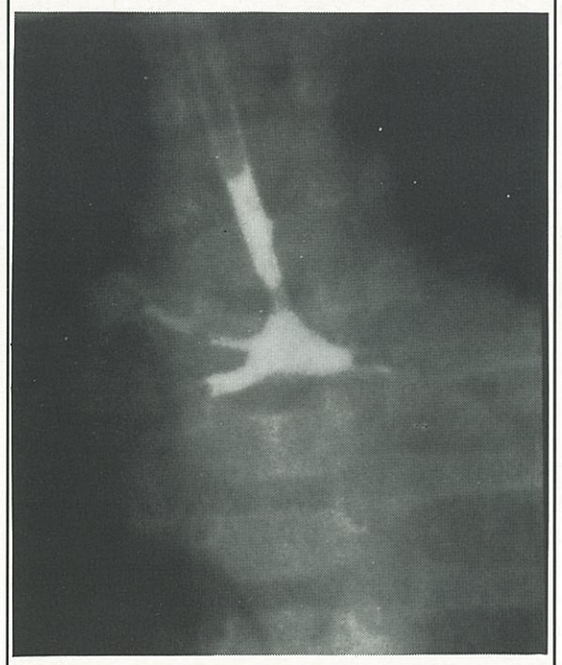


Figure 1
A tracheo-bronchogram showing very narrow trachea with normal sized bronchi.
A normal trachea should be as wide or wider than the bronchi.

but his cough remained weak. Constant suctioning and chest physiotherapy were needed to clear secretions and avoid lung complications.

On post-op day 41 Landon was discharged home where care included suctioning and bronchodilation (Ventolin) treatments.

Initially, one vocal cord unavoidably damaged during surgery, caused hoarseness. Recuperation progressed slowly and uneventfully except for one re-admission for croup in May of 1983. At this time, Landon underwent bronchoscopy. It was found that the size of his trachea was adequate for a child his size and age. The scope passed easily almost to the carina. The distal end of the trachea was slightly narrowed but adequate. By November, 1983, the uninjured vocal cord was compensating well and a normal voice had returned.

Landon is now nearing five years of age and remains active and well. His most recent annual check-up showed continuing improvement. He has the usual number of upper respiratory infections for a child his age but handles them well.

Congenital tracheal stenosis is characterized by

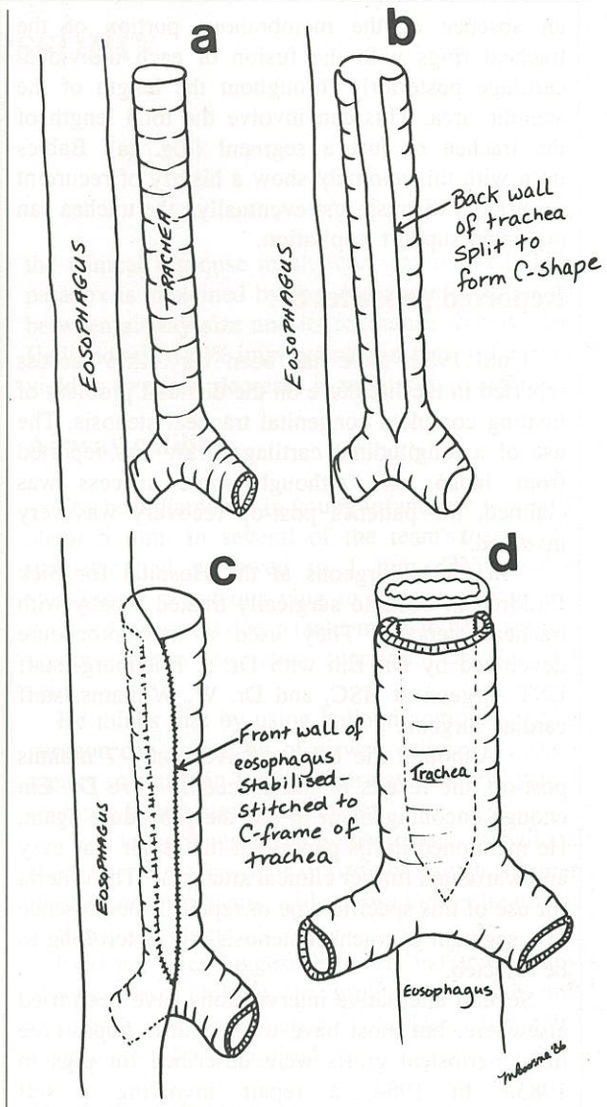


Figure 2(a)
A posterior view of anomalous fusion of cartilaginous rings.

Figure 2(b)
The surgical intervention involves splitting the posterior wall to C-shape the trachea.

Figure 2(c)
The edges of the split trachea are sewn to the anterior wall of the esophagus.

Figure 2(d)
Diagram shows anterior view of completed repair.

an absence of the membranous portion of the tracheal rings with the fusion of each individual cartilage posteriorly throughout the length of the stenotic area. This can involve the total length of the trachea or just a segment **(Fig. 2a).** Babies born with this anomaly show a history of recurrent respiratory distress, and eventually, the trachea can no longer support respiration.

Reported procedures

Until 1982, there had been very little success reported in the literature on the difficult problem of treating complete congenital tracheal stenosis. The use of a longitudinal cartilage graft was reported from Japan, and although some success was claimed, the patient's post-op recovery was very involved.[1]

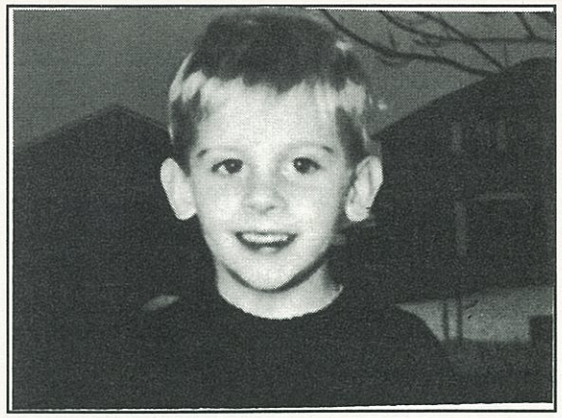
In 1981, surgeons at the Hospital for Sick Children in Toronto surgically treated a baby with tracheal stenosis. They used a new procedure developed by Dr. Ein with Dr. J. Friedburg, staff ENT surgeon at HSC, and Dr. W. Williams, staff cardiac surgeon.

Although the baby survived only 7 months post-op, the results of the procedure gave Dr. Ein enough encouragement to use the procedure again. He mentioned in his paper that the repair was easy and warranted further clinical attempts.[2] The criteria for use of this specific type of repair is the presence of a segment of tracheal stenosis that is too long to be resected.

Several alternative interventions have been tried elsewhere, but most have offered little hope. Free tibial periosteal grafts were described for pigs in 1985.[3] In 1984, a repair involving a left pneumonectomy with usage of the left bronchus as a graft to the stenosed area proved unsuccessful,[4] and although pericardial grafts have been used with some success,[5] rejection is still a problem, as are other pre and post-surgical difficulties, such as tracheomalacia (collapsing of the trachea). Many complex combinations of organic transplants and synthetic materials have been used as well with little success.

Conclusion

In tracheal reconstruction, the trachea must be rigid enough to stay open, be air tight in the mediastinum and heal promptly.[6] Meeting these requirements, however, presents considerable challenge. The approach described above is promising, as was evidenced this past December when Dr. Ein and the team successfully performed the procedure on a six-month old baby.



Landon, five years after his surgery for congenital tracheal stenosis, untill recently, a rare and frequently fatal anomaly.

References

1. Kimura, K., Mukohara, N., Tsugawa, C., Matsumoto, Y., Sugimura, C., Murata, H., Itoh, H., "Tracheoplasty for congenital stenosis of the entire trachea," Journal of Pediatric Surgery, 17:869-971, 1982.

2. Ein, S.H., Friedburg, J., Williams, W.G., Fearon, B., Barker, G.A., Mancer, K., "Tracheoplasty - a new operation for complete congenital tracheal stenosis," Journal of Pediatric Surgery, 17:872-878, 1982.

3. Cohen, R.C., Filler, R.M., Konuma, K., Bahoric, A., Kent, G., Smith, C., "The successful reconstruction of thoracic tracheal defects with free periosteal grafts," Journal of Pediatric Surgery, 20:852-858, 1985.

4. Akl, B.F., Yabek, S.M., Berman, W., "Total tracheal reconstruction in a three-month old infant," Journal of Thoracic and Cardiovascular Surgery, 87:543-546, 1984.

5. Idriss, F.S., Deleon, S.Y., Ilbawi, M.N., Gerson, C.R., Tucker, G.F., "Tracheoplasty with pericardial patch for extensive tracheal stenosis in infants and children," Journal of Thoracic and Cardiovascular Surgery, 88:527-536, 1984.

6. Grillo, H.C. et al, "Surgery of the trachea," in Current Problems in Surgery, Chicago, Year Book, 1970, pp. 4-7.

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Balloon angioplasty successfully treats narrowed tracheae

Clinical results using balloon catheter dilation (balloon angioplasty) on severe tracheobronchial narrowings in children have been so successful that a U.S. research team recommends the use of the procedure before attempting surgical dilation or resectioning.

Dr. Gary Hedlund, a radiologist at the USAF Medical Centre, Lakeland Air Force Base, San Antonio, Texas, told the Radiolological Society of North America meeting in Chicago recently that the balloon treatment allowed two children to be successfully weaned from ventilator therapy.

In all, four infants responded to the intervention. In two of the cases, airway stenosis resulted from traumatic intubation following premature birth, while in another, the distal tracheal narrowing was presumed to be congenital. In the fourth infant, balloon dilation averted a right upper lobectomy for congenital lobar emphysema.

Viable alternative

Dr. Hedlund feels that balloon dilation therapy provides a viable alternative to some of the more invasive procedures for airway stenosis in infants, primarily at the level of the distal trachea and proximal bronchi.

Surgical resection of the narrowed airway with re-anastamosis, or dilation by rigid instrumentation, are the usual treatment approaches which frequently lead to scar tissue formation and subsequent restenosis.

The advantage of the balloon method, according to Dr. Hedlund, is that it imparts a transverse-oriented force which he believes is less damaging to airway tissue than the longitudinal type of shearing force effected by bougie or rigid dilators.

The balloon method is performed under general anaesthesia after brief hyperventilation on 100% oxygen. Three 15 second dilations are usually done at each session.

The single complication recorded was a balloon rupture. Since the contrast solution contained in the balloon was nonionic and in a concentration least harmful to the lung, the results of the rupture produced no clinical or radiographic sequelae.

Improvement in the airway calibre as shown on X-ray was only evident in two of the children, though the clinical response in all four was marked. This paradox is explained by the significant relationship between airway size and its resistance to flow. Dr. Hedlund said a 50% improvement in airway diameter yields a five fold decrease in resistance to airflow.

Airway calibre

Tracheal diameters in young infants are normally about 5 mm. In several of the team's cases, the diameter had narrowed to 1 mm. "With some swelling or a mucous plug in a very narrow and diseased airway, it doesn't take much to get a serious compromise in respiratory function," Dr. Hedlund said.

He thinks that by using balloon angioplasty, the surgeon can gain a bit of airway calibre, "...which means so much in terms of airway function that it seems to have a significant effect."

Yet to be determined is the impact of balloon therapy on the airway. It is also not known whether these stenoses patients will require further treatment as they grow older.

Evidence does suggest that early balloon therapy allows these children to grow and thrive and eventually become better candidates for later intervention if it is required.

Preferred therapy

Another speaker at the Radiological Society meeting was Dr. Mervyn Cohen, Professor of Radiology at the James Whitcomb Riley Hospital for Children, Indiana University Medical Centre, Indianapolis. Balloon therapy, he mentioned, tided the first of his child patients over five years. He said that the child still has a tracheostomy, but has had no severe infections or hospitalizations for respiratory problems since the procedure was introduced.

Dr. Cohen said he would choose the balloon catheter route first, except in patients with a complete cartilage ring around the trachea. (See "Tracheoplasty...Reconstructing a new airway," page 8).

"For strictures from prolonged intubation or, as in our case, narrowing after previous surgery...I would do a balloon dilation again."