The Management of Tracheal Stenosis
With a Case Report

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Post traumatic stenosis of the intrathoracic trachea is a relatively
uncommon condition, but when it occurs it presents a grave challenge to
the thoracic surgeon. A similar condition in the major bronchi is not only
more common but equally applicable as far as treatment is concerned, and
it is from this that most of our knowledge on the subject has been obtained.

Successful repairs of ruptured or lacerated tracheas1,2 and of ruptured
main bronchi3 have been reported without the sequela of stricture, but
when there is actual tissue loss or the tear is unrecognized or not repaired,
stricture formation is almost certain.

Once stricture of the trachea is present, temporary relief of the respira-
tory distress can usually be obtained by dilatation and, if necessary, intuba-
tion, but permanent cure is most unlikely to be achieved by anything short
of definitive resectional surgery.

A fairly extensive literature on the subject of resection of stenosed
segments of the air passages has accumulated in recent years; its applica-
tility to stenosis from carcinoma and tuberculosis, as well as post traum-
atic causes, is well recognized.

Much experimental work on the replacement of these resected seg-
ments by various types of grafts and prostheses has been done, mostly
in dogs, and critical appraisal of the various methods and techniques
used suggests that we are still a long way from solving the problem
completely.

Recent work on this subject makes a review of the literature superfluous.
This has been adequately covered by Paulson,4 Abbot et al,5 Thompson
et al6 and many others. However, consideration of the many available
papers shows that certain basic facts emerge on which the principles of
tracheal surgery must be based.

Annular removal of a segment of trachea or bronchus and subsequent
repair of the defect by an autogenous graft of some kind inevitably results
in eventual stenosis of the grafted area if no prosthesis is used to prevent
contraction.6,7

The successful use of a prosthesis alone to bridge tracheal defects has
been reported in dogs,8,9 but, for reasons to be discussed later, this is not
the most suitable method. It would appear that the best results are obtained
by some technique which utilizes autogenous tissue grafts such as fascia

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Figure 1: The extent of the stricture showing superimposed graft and tantalum gauze. Figure 2: Superimposed great vessels to show the relationship of the innominate artery to the stricture.
lata,10 pleura,11 skin4, 12, 13, 14 or other structure and at the same time provides for maintenance of their rigidity by a prosthesis. Of these, full thickness skin is probably one of the most satisfactory materials because of its toughness, pliability and availability.15 Tubular types of prostheses made of metal, glass or plastic, either alone or in conjunction with autogenous grafts, have been used occasionally to bridge large defects, but the frequent failure of these forms of support lies in the fact that they must perforce remain as foreign bodies within the lumen of the trachea—a constant source of irritation and potential sepsis. Furthermore, their removal at a later date, even though the tissues are otherwise satisfactory, would appear to lead to inevitable stenosis.

The best results have been obtained when the rigidity was maintained by some latticed or open work prosthesis which allows granulation tissue extrusion through the gaps and subsequent epithelialization within the lumen, i.e., stainless steel wire,17, 18 tantalum gauze,19 etc, which eventually becomes incorporated within the new wall as an inert strut. The probable reason for the comparative success of this type of prosthesis is that a relatively inert material, like stainless steel, tantalum or plastic, once embedded completely in fibrous tissue, is unlikely to give trouble, but when part of it projects into a space, namely the bronchus, which is potentially infected, trouble in the form of chronic suppuration will inevitably ensue.

Certain other technical points in the repair seem to be important—the airtightness and watertightness of the graft during the whole postoperative course so that air will not leak out or fluid leak in,20 and, also, the avoidance of clamps on the bronchus or silk in the suturing, which experimental work on animals has shown conclusively to encourage fibrosis and stenosis.21, 22

The case which most nearly approximates ours is that described by Edgerton and Zovickian.18 Their defect was slightly larger than ours, namely 7 cm., and their hemorrhage, from the right common carotid at the site of the ligated right vertebral artery stump, occurred on the twelfth postoperative day.

Case Report

A 20 year old married white woman was involved in an automobile accident on August 11, 1955. The initial treatment was in another part of the country, and we are indebted to Dr. Lyle H. Frenzler of Bloomington, Illinois and Dr. Joe H. Henshaw of Sweetwater, Tennessee for the details of the management of the case prior to her coming under our cognizance.

She sustained a fracture of the mandible, a fracture of an ankle, severe crushing of the whole thorax (but no demonstrable bony injury), left tension hemopneumothorax and right hemopneumothorax. There was marked mediastinal widening radiologically and subcutaneous surgical emphysema in the tissues of the neck. In view of the fractured jaw and the appalling condition of the chest, tracheostomy was wisely performed, and she appeared to progress satisfactorily.

On the 14th day after the accident, the tracheostomy tube was removed and apparently breathing was not obstructed. By September 6, i.e., 26 days after the accident, the tracheostomy stoma had closed and she had marked nocturnal dyspnea. The stoma was reopened and an adult size Foregger tube was inserted through it down the bronchus with immediate relief. A short time later, she was moved to this area and admitted October 31, 1955, under our care as an emergency with extreme dyspnea.

When first seen, she was unconscious and the tracheostomy stoma was partly open, the Foregger tube having been removed a few days before. An immediate bronchoscopy through the tracheostomy stoma was performed in bed on this almost dead patient, and a complete obstruction of the trachea, about 3 cms. below the stoma, was observed. The
bronchoscopic suction tip was forced through the mass of granulation tissue and oxygen given through it. The bronchoscope was then withdrawn and a number 22 Foregger endotracheal tube was forced through the stricture; she again became conscious. Breathing through this small tube was just sufficient to keep her alive, but about nine hours later, in the early hours of the morning, she again obstructed and required further emergency bronchoscopy. This time it was possible to insert a slightly larger Foregger tube; during the next few days successively larger ones were introduced and she could breathe without obstruction.

Up to this stage the carina and main bronchi had not been visualized, but on November 5, 1955, bronchoscopy was performed with this idea in mind. The trachea at the site of the stricture admitted the 6 mm. x 40 cm. bronchoscope fairly easily and, as the carina and main bronchi were seen to be normal, it was decided to remove the Foregger tube and see how she managed. She was discharged home at her own request and arrangements were made to readmit her in five days for further bronchoscopy and assessment of the condition.

When she was readmitted on November 11, 1955, she was again having trouble getting her breath. Bronchoscopy revealed an almost similar condition as had been visualized at the second examination; again a number 22 catheter was the largest that could be inserted through the stricture. On this occasion, the granulation tissue was painted with 15 per cent. silver nitrate. During the next few days it was possible to insert larger and larger tubes through the stricture until, by November 18, 1955, a number 32 Foregger tube was in place and she had no dyspnea.

On November 21, 1955, bronchoscopy was again performed through the tracheostomy opening. The distance from the lower edge of the tracheostomy to the carina was 7½ cm.; if this, the whole lumen was filled with granulation tissue. The area was touched with silver nitrate and the Foregger tube replaced down to the carina. Posteroanterior and lateral laminagrams gave excellent pictorial confirmation of the extent of stricturing.

For the next three weeks she was comfortable, had an adequate air exchange through the Foregger tube, and was as ambulant as her injured ankle allowed. During the last 10 days of this period, she was given chloromycetin and erythromycin (which sensitivity studies of her bronchial secretions had shown to be most effective) in an endeavor to reduce the sepsis in the granulation tissue.

Bronchoscopy was again performed on December 13, 1955, i.e., four months after the original accident, and a marked change was evident. The 5 mm. x 30 cm. bronchoscope passed easily through the previously strictured area, which was now smooth and healed except for two small areas of residual granulation tissue. As there appeared to be no gross stricture, it was decided to remove the Foregger tube and see how she progressed.

With the tube removed and the tracheostomy covered over, she breathed easily and well and, for the first time, we began to feel optimistic. However, this was short lived. Three days later she again had severe dyspnea; bronchoscopy revealed stenosis almost as bad as when she was first seen. It was finally decided that only definitive surgery could offer any hope of cure, and that same evening operation was performed. Operation: Dr. Waterman; General Anesthesia: Dr. G. Finer.

With the patient in the supine position, induction of the anesthetic was begun with pentothal; within a few minutes she became extremely cyanosed and, in order to obtain an adequate airway, it was necessary to reopen the tracheostomy and pass a bronchoscope forcibly through the stricture. This was replaced by an endotracheal tube, the anesthetic continued, and a vertical incision made which encircled the tracheostomy opening and continued down over the suprasternal notch to about the fifth interspace. The internal mammary vessels were exposed and ligated on either side of the sternum in the fifth interspace; the sternum was transected at this level and the upper half was split using a Gigli saw, the two halves were spread, and the incision was carried down to the trachea itself. The whole area was embedded in extremely dense scar tissue. Running through the center of this fibrous mass, and intimately adherent to the front of the trachea, was the innominate artery. A most tedious dissection over many hours was necessary before the artery and the arch of the aorta were sufficiently freed from the tracheal wall to allow incision of the restricted area (Figure 2).

There was complete destruction of the tracheal anatomy and no tracheal rings were present in the 6 cms. or so above the carina. The tracheal lumen over and above the stricture site was opened, and the endotracheal tube was removed for a moment so that the stricture could be palpated more easily. Eventually, it was split with the finger, in the manner of a commissurotomy, and it was evident that a graft would be essential to close the defect.

A large elliptical full thickness skin graft was obtained from the outer side of the thigh, and a piece of tantalum gauze molded into a prosthesis which replaced the anterior three quarters of the trachea for the length of the stricture. The skin was then
folded in and around the tantalum gauze prosthesis and tacked to the gauze by interrupted sutures. The remaining fragments of stenosed trachea anteriorly were removed and the graft put in place and sutured in position by multiple chronic catgut sutures around the periphery of the defect. The lower edge of the graft was about 1 cm. from the carina. Before tying these sutures, the anesthetist passed an endotracheal tube of wire enforced latex down through the nose and past the graft so that it lay just above the carina (Figure 1).

Closure of the chest was performed in the usual way, and her condition at the conclusion of this procedure, which lasted nine hours and 35 minutes, was extremely good. She received 2800 cc’s. of blood during the operation.

Over the next few days her general condition remained excellent and breathing through the nasal endotracheal tube was unobstructed. However, quite suddenly, on the fifth postoperative day, she had a sudden torrential hemorrhage and died almost instantly.

Autopsy revealed a small perforation in the posterior part of the innominate artery just opposite the point where it was in contact with the graft and where so much dissection had been necessary in order to free the artery.

The graft itself was in excellent shape and, apart from a small defect inferiorly due to detachment of two or three sutures nearest the carina which probably would not have given trouble if the hemorrhage had not occurred, there was no reason to suppose that the graft would not have taken. The tantalum gauze was covered over its whole area by the full thickness graft and was nowhere in contact with the artery. The hole in the artery must, therefore, have been due to operative trauma weakening the wall during the dissection.

Discussion

This case is presented because it emphasizes certain unusual difficulties and features of sequelae of tracheal trauma. The actual mechanism of the injury in such a case is not quite clear. Thompson and Eaton1 believe it is related to a shearing force with a sudden increase in the intrathoracic pressure or to a sudden increase in this pressure with the glottis tightly closed. In cases where the moment of impact is anticipated, as in head-on auto wrecks, there is little doubt that reflex closure of the glottis occurs with consequent increase in intrathoracic pressure. In accidents where the blow is unexpected or the whole cycle of trauma occurs over an appreciable interval, however, it is difficult to believe that this is the invariable mechanism.

We believe the stricture in this case was due to severe crushing and destruction of the tracheal wall between the manubrium and the vertebral bodies. In an older person this would inevitably have resulted in a “stove in chest” with fractures of the ribs and sternum. Her youth, however, and the elasticity of the bony thorax were sufficient to withstand a sudden severe compression without bony injury.

One of us (C.F.A.C.) has in the past sustained a manubrio-sternal dislocation from a steering wheel injury—no fractures were present and the dislocation, which was complete, reduced itself in two days with posture alone. However, a severe tracheitis was present for a period after the injury, and it would seem likely that a similar but much milder injury to the trachea had occurred.

Another possibility suggested in this case was that the tracheal damage was a result of irritation from the end of the tracheostomy tube. But, in view of the gross tracheal destruction and the fact that we can find no such sequelae reported after the use of tracheostomy tubes, it seems to be unlikely.

A further point of interest is the involved area at the last bronchoscopy on December 13, 1955. Prior to this, the case had been discussed with
Jackson who advised intensive antibiotic therapy. This was undoubtedly responsible for the disappearance of the granulation tissue and apparent healing of the stricture.

**Exposure:** The most suitable exposure was considered carefully before operation. Most of the recorded cases in a similar site have been approached through a high posterolateral incision in the face down position. There is little doubt, however, that the extreme fibrosis in this case would have added to the difficulties of exposure, as access to the tracheostomy stoma was essential so that the area around it could be excised. In retrospect, it was considered that the sternal splitting approach was most suitable, but even with this the carinal region was not easily accessible.

An important point of technique is the transection of the sternum and splitting of the upper half only. There is no doubt that this results in greater postoperative stability with consequent decrease in pain and more effective coughing.

**Type of Prosthesis:** When the dissection had been completed, the space between the posterior tracheal wall and the innominate artery was a mere slit, and it was evident that a fairly rigid prosthesis would be required. It did not seem that the method advised by Gebauer, namely, wire supported dermal graft, would have been rigid enough to keep the lumen open; thus, the tantalum gauze was used instead.

**Anesthesia:** The importance of having an adequate variety of sterile endotracheal and endobronchial tubes available for direct insertion by the surgeon is emphasized. We had available two tubes connected to a Y piece which could, if necessary, have been inserted into the main bronchi if the stricture was right against the carina. Luckily, this did not occur.

A bronchoscope set up and ready before anesthetic induction is essential and undoubtedly saved this patient's life, albeit temporarily.

**Rapidity of Stricture Formation:** The most obvious conclusion to be drawn from this case is that once a tracheal stricture of this degree has developed, no amount of conservative treatment will be effective and definitive resection is mandatory. The apparent healing of the stricture and smoothness of the wall on bronchoscopy is deceptive and, if left unsupported, will inevitably stenose.

**ADDENDUM**

Since the submission of this paper, Keshishian, Blades, and Beattie have published in the J. Thoracic Surg., 32:707, 1956, an excellent article on tracheal reconstruction.

**SUMMARY**

1. Rupture or laceration of the trachea, particularly if accompanied by any tissue destruction, is nearly always followed by stricture formation.

2. The various methods and techniques for dealing with such a stricture are discussed. The best results have been obtained when the rigidity was maintained by some latticed or open work prosthesis, allowing grano-
lation tissue extrusion through the gaps and subsequent epithelialization within the lumen.

3. Dilatation and intensive antibiotic therapy may give apparent improvement in the bronchoscopic appearance, but the disappearance of granulation tissue is deceptive. The rapidity of stricture reformation is emphasized.

4. The case reported is of a young married woman with an almost complete stricture of the trachea, 6 cms. in length, just above the carina. This was the sequel to severe chest trauma.

5. The treatment was by resection of the stricture and subsequent replacement by a dermal graft reinforced by tantalum gauze.

6. Exposure problems and the anesthetic technique are discussed. Transection of the mid sternum with splitting of the upper half is a satisfactory approach.

7. It is concluded that conservative treatment of such a case is ineffective and surgery is therefore mandatory.

RESUMEN

1. La ruptura o laceración de la tráquea, especialmente si se acompaña de destrucción de tejido, casi siempre es seguida de estenosis.

2. Se discuten los diversos métodos y técnicas para tratar tal estenosis. Los mejores resultados se han obtenido cuando la rigidez se mantuvo por alguna prótesis abierta o enrejada que permita la protrusión de tejido de granulación a través de sus aberturas y así la epitelización del lumen.

3. La dilatación y la terapéutica con antibióticos, pueden dar aparente mejora según los aspectos broncoscópicos con la desaparición del tejido de granulación, pero esto es engañoso. La rapidez de la formación de la estenosis se recalca.

4. El caso que se presenta es de una mujer casada con una estenosis casi completa de la tráquea en 6 cms. de extensión justamente arriba de la carina como consecuencia de un trauma de tórax.

5. El tratamiento fue la resección de la estenosis y la substitución por un injerto dérmico reforzado con gasa de tantalio.

6. Se discuten los problemas de la exposición y la técnica de la anestesia. La transección a la mitad del esternón con división de la mitad superior del mismo, es una técnica satisfactoria para abordar la tráquea.

7. Se concluye que el tratamiento conservador en tal caso, no es efectivo y que es imperioso recurrir a la cirugía.

RESUME

1. Une rupture ou une plaie de la trachée est à peu près toujours suivie par un processus de sténose, surtout s’il y a une part de destruction tissulaire.

2. Les auteurs discutent les différentes méthodes et techniques qui peuvent empêcher cette évolution. Les meilleurs résultats ont été obtenus quand la rigidité a pu être maintenue grâce à une prothèse tissée qui per-
met au tissu de granulation de faire issue à travers les orifices et entraîne une épithélialisation de l'intérieur du conduit.

3. La dilatation associée à un traitement antibiotique intensif peut donner une amélioration apparente qui se traduit bronchoscopiquement par la disparition du tissu de granulation. Mais les résultats sont alors décevants. Les auteurs insistent sur la rapidité avec laquelle se reconstitue la sténose.

4. Ils rapportent l'observation d'une femme jeune mariée qui était atteinte d'une sténose presque complète de la trachée située juste au-dessus de la carène et consécutive à un grave traumatisme thoracique.

5. Le traitement consista en la résection de la sténose et son remplacement par une greffe dermique renforcée par un filet de "tantalum."

6. Les problèmes de la voie d'abord et de l'anesthésie sont mis en discussion. La section du sternum en son milieu avec division de la moitié supérieure de l'os est une voie d'abord satisfaisante.

7. La conclusion des auteurs est que dans de tels cas le traitement conservatif est inefficace et que par conséquent le traitement chirurgical s'impose.

ZUSAMMENFASSUNG

1. Einer Ruptur oder Verletzung der Trachea, besonders wenn sie von irgend welcher Gewebszerstörung begleitet ist, folgt so gut wie immer die Bildung einer Striktrur.


4. Der Fall, über den berichtet wird, ist der einer jungen verheirateten Frau mit einer fast kompletten Striktrur der Trachea von 6 cm Länge, gerade oberhalb der Carina, die die Folge eines schweren Brustkorb-Traumas war.

5. Die Behandlung bestand in einer Resektion der Striktrur, die ersetzt wurde durch eine mit Tantal-Gaze verstärkte Hautplastik.


7. Es wird die Folgerung gezogen, dass konservative Behandlung eines solchen Falles unwirksam ist und chirurgisches Vorgehen unerlässlich.

Reprints available at 1918 West Clinic Ave., Knoxville, Tenn.

REFERENCES

VoL XXXI MANAGEMENT OF TRACHEAL STENOSIS 388

23 Jackson, C. L.: Personal Communication.