Chapter 8: Trauma and stenosis of the larynx

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Acute laryngeal trauma

Epidemiology

There are basically two types of laryngeal trauma - penetrating wounds and blunt injuries. The blunt injuries can be high velocity or low velocity injuries. Penetrating wounds are caused by knives, bullets, wires and agricultural implements. High velocity blunt injuries are usually caused by road traffic accidents or injuries at work. The velocity, however, may be so high that the wound becomes compound. Low velocity blunt injuries rarely become compound and are due to blows with fists and as a result of sports injuries. The sports that are particularly associated with laryngeal injury are snowmobile racing, motor cycle racing, basketball, karate and injuries have even been reported due to contact with golf balls and cricket balls. Reports have also come from the sport of ice hockey where garrotting with the hockey stick is evidently practised in the professional game.

The type of individual who suffers from laryngeal trauma is usually a young male who indulges in sport, is involved in fights, or who drives cars fast and dangerously.

In North America and western Europe, the condition of laryngeal trauma was first associated with road traffic accidents. This was when no seat belts were used or lap-type seat belts were in vogue. Nowadays, the incidence in these countries of laryngeal damage from road traffic accidents is only a fraction of what it was. This is due to the crossover seat belt and the institution of speed limits and other safety features in cars, such as collapsible steering wheels, mirrors etc. In developing countries, however, when driving by a large number of people is a relatively new feature, laryngeal injuries as a result of road traffic accidents present a significant problem to the practising otolaryngologists. Furthermore, in these countries there is an improving delivery of medical care and more patients are rescued from road traffic accidents and removed from the site of the accident to the hospital, where previously they may have died at the roadside.

Biomechanics

Any classification of types of laryngeal injury is an unhelpful exercise unless it is confined to injuries to the supraglottis, the glottis, the subglottis or mixed injuries. Basically, one must consider injuries to the surrounding skeleton of the larynx, that is the hyoid, thyroid, cricoid and tracheal rings, and injuries to the internal soft tissues. Damage to both the skeleton and the soft tissues creates different problems and requires different modes of management.

Penetrating wounds tend to bounce off the more solid pieces of the larynx, that is the supporting skeleton. It would be usual for a penetrating instrument to slide off the thyroid cartilage and penetrate the thyrohyoid membrane superiorly or go between the cricoid and the thyroid inferiorly to penetrate the cricothyroid membrane. Each of these presents different functional problem.
Penetration of the thyrohyoid membrane causes bleeding in the paraglottic space and thus airway obstruction. It does not affect the voice in any way. A little bleeding or oedema will resolve with the normal scavenging macrophage process of the body but, if there is any significant amount of bleeding, then it will not all resorb and will be organized to cause some degree of stenosis of the supraglottis.

This does not happen to such an extent if the cricothyroid membrane is penetrated. The most immediate effect of this will be that air will leave the respiratory tract and will cause some surgical emphysema in the neck. The penetrating wound, however, may be covered with thyroid tissue which may act as a valve. The bleeding may fill the subglottic space causing respiratory obstruction, but it is more likely to run down the trachea through a clean cut and cause coughing.

Low velocity blunt injuries are unlikely to fracture the thyroid or the cricoid, but fractured hyoids are not uncommon in karate and basketball. Again there will be bleeding into the soft tissues of the paraglottic space and, if the ends of the fractured hyoid are in close apposition, then movement during swallowing will cause pain which may require treatment. The patient may also have swelling of the base of the tongue and some dysphagia.

Even though the thyroid and cricoid are not fractured, there may well be bleeding within the paraglottic space and bleeding within Reinke's space on the vocal cords. The interarytenoid space, which must be present to allow gliding and separation of the arytenoids, can fill with blood ultimately causing stenosis, but the problem is usually one of oedema and minimal bleeding rather than obliterative bleeding causing airway damage or later stenosis.

High velocity blunt injuries will fracture the skeleton of the larynx. The fate of the thyroid cartilage depends on its degree of calcification and, thus, on the age of the patient. If the thyroid cartilage is pushed backwards over the cervical spine, then it splays apart. A minimal injury like this with an elastic thyroid cartilage will result in no fracture, but if there is any rigidity in the thyroid cartilage or if the force is great enough, then the cartilage will usually split down the front or down the thyroid prominence. The inherent elasticity of the uncalcified cartilage will allow it to spring back into place, and there may be little damage or there may be disruption of the anterior commissure. The classically described situation of detachment of the tendon of the anterior commissure and the petiole of the epiglottis is hardly ever seen, but is so dramatic that it demands inclusion in any text on laryngeal injury. In this case, the epiglottis falls backwards and the vocal cords literally roll up on themselves towards the arytenoid. Usually in an elastic thyroid with a linear fracture down the prominence, however, there is little in the way of disruption of the anterior commissure, and there will be bleeding into the pre-epiglottic space and posterior displacement of the epiglottis. More important is the fate of the arytenoids. As the thyroid becomes compressed against the cervical spine, the arytenoids are sandwiched. This can result in them being displaced at worst, but at best there will be bleeding into the interarytenoid space and subsequent swelling.

If the thyroid is calcified and is then compressed against the cervical spine, it is unlikely to have enough inherent elasticity to return to its original position. It will, therefore, shatter rather like an egg and there will be loss of the thyroid prominence. There will be similar arytenoid injury as described above.
The cricoid is the most important part of the laryngeal skeleton. It is the only complete ring in the upper or lower respiratory tract. The thyroid, the hyoid and tracheal rings are all U-shaped with soft tissue attachments posteriorly. If the cricoid is disrupted then it will constrict. Even a linear fracture in the cricoid will cause some resorption of cartilage and reduction of the calibre of the airway at the level of the cricoid. This has severe effects on airflow as a consequence of Poiseuille's law relating the airflow to the fourth power of the radius of the airway. This is probably why high tracheostomies have such a deleterious effect on the airway. There is nothing magic about the first ring, but a tracheostomy tube put through an opening made by excision of the first ring will be contiguous with the cricoid cartilage and may result in enough resorption of that cartilage for the cricoid to stenose. It is rare that acute injuries damage the soft tissue within the cricoid but, if a high velocity acute injury damages the integrity of the cricoid cartilage, then there will be a very difficult defect to repair.

The final soft tissue injury from high velocity blunt injuries takes the form of separation of the trachea from the cricoid. This usually results in death at the roadside, but it is quite possible for enough lumen to remain for the patient to breathe long enough to come into hospital. Several tracheal rings can be damaged with this sort of injury and the cricotracheal membrane sheared off.

**Pathological consequences of injury**

**Soft tissue**

Any injury to the larynx will result in some oedema of soft tissue. This usually has no permanent effects other than in Reinke's space, where permanent oedema of the vocal cord can result or resolve into a laryngeal polyp.

Far more important is the effect of organized haematoma. This is most marked in the supraglottic space where there is the most scope for expansion of soft tissue and obliteration of the airway.

The interarytenoid area is also a very large potential space with debilitating consequences if organization occurs within the area.

The anterior parts of the vocal cords at the anterior commissure may be detached, but more commonly abrasions of the mucosa here can result in anterior web formation.

The subglottic space in children is very much more important than it is in the adult, in whom subglottic space obliteration narrowing their airway is rare. It is usually the result of disorganization of the surrounding skeleton, especially the cricoid.

Glottic competence can be lost for several reasons. The most common cause is fixation of an arytenoid in an unsatisfactory position, but it can also be made incompetent by resorption of the thyroarytenoid muscle and atrophy of the cord, and also by vocal cord paralysis due to damage to the recurrent laryngeal nerve in subglottic injuries.
Skeletal injuries

The hyoid, the only bone in the respiratory tract, may be fractured and may well heal without the patient knowing anything has happened apart from a few days of discomfort. On rare occasions, the fractured ends form a bursa which results in continual movement of the fractured edges together and this requires excision.

The thyroid cartilage, if fractured, will heal using fibrous tissue and, provided it is in a good position, this is just as satisfactory as wiring or stitching it together. If, however, it is compressed, as in a calcified thyroid cartilage, then it has to be reconstituted and held outwards with a stent.

The effects of disruption of the cricoid cartilage have already been described, and any rehabilitation of this area must involve widening the cricoid cartilage and keeping the edges apart with some material which does not resorb.

At this point, it is pertinent to point out the effect of blood on cartilage. If cartilage is allowed to stay in contact with blood for any length of time, then the blood is absorbed by the cartilage. This is especially important in the trachea where loss of the U-shaped rings perhaps causes no observable abnormality in the airway until the patient takes exercise or a deep breath. The increased velocity of airflow pulls in the weakened tracheal walls and the patient will have dyspnoea on exercise due to tracheomalacia.

If cartilage is left denuded of mucosa and is in contact with secretions, then the surface of the cartilage will become inflamed. This will result in the formation of granulations and is most frequently seen in intubation injuries where the vocal process of the arytenoid is sometimes damaged and an intubation granuloma results. Similarly, if too large an intubation tube is used, then the anterior commissure is split and cartilage becomes bared in that area resulting in an anterior intubation granuloma.

Treatment principles

Protection of the airway

This is obviously the most important feature and is probably the reason that most victims of road traffic accidents are now saved. If there is merely oedema present, with no suggestion of intraluminal bleeding or tracheal damage, then the patient can be kept at bed rest with or without steroids or steam inhalations.

More likely, however, the airway will be at risk and, rather than performing an immediate tracheostomy, the patient should be intubated. In any review of chronic laryngeal stenoses, there is always a hint of criticism in publications that anaesthetists at this point missed an acute laryngeal injury. If anyone has had a neck injury, there will be contusion and perhaps bleeding in the throat and it is quite impossible with the equipment available to him, to recognize intraluminal or skeletal damage to the larynx. Even though an endotracheal tube is not much smaller than many of the stents that are used in the later reconstruction of a larynx, neither they nor stents do anything to stop intraluminal bleeding, especially in the supraglottic area, nor to prevent webs in either the posterior or anterior glottis.
In the first aid situation, a tracheostomy may be needed but this is very much less favoured than immediate intubation.

**Protection of laryngeal function**

Although the larynx has functions related to swallowing closure and effort closure, by far its most important functions are in relation to breathing and speaking. It is these functions that should be protected as far as possible in the management of laryngeal injury. In the assessment of results of treatment, a success with regard to breathing is a patient who does not have to wear a permanent tracheostomy tube and who is able to lead a normal life with no or minimal dyspnoea. On the other hand, if the vocal cord has been damaged, a normal speaking voice is unlikely. Success in this function, therefore, can range from normal voice to audible phonation as opposed to a whisper.

Emphasis has been laid on the importance of preventing bleeding in the laryngeal spaces in the treatment of acute injury to the larynx. In this regard it is appropriate to mention the use of stents. Many stents have been described for use in laryngeal injury, but their role should be isolated to the scaffolding of a reconstituted skeletal structure. They have no part to play in stopping bleeding and the subsequent organization of laryngeal spaces. A much better technique for this is to open the spaces and obliterate them with quilting sutures. If there is any significant degree of bleeding within the larynx, then it should be opened by way of a midline approach (laryngofissure) and the spaces evacuated and quilted with 3-0 Vicryl sutures. Inserting drains into the spaces is quite useless.

If there has been damage to the skeletal structure then a principle of minimal debridement should be practised. There is not very much cartilage in the larynx and excision of any tracheal rings, and certainly of the cricoid cartilage, carries with it grave consequences. Although much of this cartilage may resorb, it is better to cover it with mucosa and see if it forms a scaffold for firm fibrous tissue. The worst that can happen is what one would achieve with debridement.

In general terms, the arytenoid will be swollen in nearly every moderately severe laryngeal trauma and so the patient should be fed with a nasogastric tube to stop inhalation from glottic incompetence certainly for a few days.

**Assessment**

**History**

The most important step in diagnosing an acute laryngeal injury is to be aware of the possibility in every patient who has had trauma to the upper half of the body. Dyspnoea and dysphonia are the main features leading to suspicion, with dysphagia and pain as lesser indicators.

**Examination**

Marks on the neck may or may not be present and their absence does not rule out a fractured larynx, but it makes such a diagnosis unlikely.
Surgical emphysema confined to the neck is almost pathognomonic of a breach in the airway. Loss of landmarks such as a thyroid prominence is also diagnostic. It should be borne in mind that any neck wound carries with it the associated possibilities of damage to the great vessels and to the cervical spine.

**Radiology**

Plain X-rays of the neck are helpful in confirming the presence or absence of air in the soft tissues. Tomography and laryngography are usually impractical in acute injuries.

**Laryngoscopy**

This should be performed in all patients. If ordinary mirror examination is impossible, flexible laryngoscopy may yield valuable information.

**Treatment**

**Penetrating injuries**

Injuries such as those due to knife wounds, wire wounds and wounds from agricultural or industrial implements will only require treatment if there is bleeding into the supraglottic area. Nearly every such case will require to have the larynx opened and the supraglottic area drained and quilted.

Bullet wounds most certainly require exploration with debridement of cartilage, which will probably also be fractured, and exploration of the neck vessels and nerves. Reconstruction will follow the same principles as outlined previously. On occasion the injuries from bullet wounds are so severe that total laryngectomy is necessary.

It is usual for patients with supraglottic injury to end up with a reasonably good voice and no permanent tracheostomy.

**Low velocity blunt injuries**

The majority of these patients do not require open exploration of the larynx, but most will require observation in hospital at least overnight in case of laryngeal oedema and airway obstruction. As well as sports injuries, similar pathological consequences can follow attempted strangulation and the inhalation of fumes during a conflagration. Provided both the airway and the voice are reasonable then these patients can be observed. If either of these functions is disturbed, however, then the larynx should be intubated and perhaps later explored and reconstructed.

Many of these patients will end up with a poor voice if the glottis has been damaged, because there may well be later minor web formation or arthrodesis of an arytenoid, but it is unusual for these patients to require a permanent tracheostomy.
High velocity blunt injuries

About half the patients who have laryngeal injuries as a result of road traffic accidents will require laryngeal exploration and reconstruction. Skeletal damage is repaired by reconstruction usually using stents, and soft tissue injuries are dealt with by reducing bleeding, evacuating spaces and using quilting sutures.

If the cricoid is injured, then primary repair should be attempted. Only when primary repair has failed should one of the many techniques applied to chronic cricoid stenosis be applied.

Separation of the cricotracheal membrane is an unusual injury and one which is dealt with fairly reasonably by dropping the larynx in the neck and freeing the trachea down to the carina, and pulling it upwards for an end-to-end anastomosis, excising and damaged tracheal rings.

Most high velocity blunt injuries will result in combined injuries to the glottis and subglottis. If only the glottis is involved then the results with regard to breathing should be good, but if the subglottis is involved, then the patient faces future surgery for chronic subglottic stenosis.

Chronic laryngeal stenosis

Epidemiology

This section will be confined to chronic laryngeal stenosis in the adult. The condition, if it manifests itself in childhood, is quite different and is considered in Volume 6.

Common causes of chronic laryngeal stenosis in western Europe and the USA are failed treatment or non-recognition of acute trauma, but stenosis is also seen as a complication of tracheostomy, intubation and partial laryngectomy. In Egypt, and other parts of the Middle East, scleroma is probably the most common cause of laryngeal stenosis. Tracheostomy is an operation performed well by nearly every medical practitioner involved in the care of trauma patients in western Europe and North America, but there are still places in the world where tracheostomies can be performed badly, leading to laryngotracheal stenosis. Other systemic diseases, such as Wegener's granuloma, polychondritis, and various types of autoimmune thyroiditis, can also damage the subglottic area resulting in stenosis, but they are rare.

While supraglottic and glottic stenosis do occur, the most common site is the subglottic area. The main cause of this is, therefore, disruption of the supporting skeleton of the cricoid and the tracheal rings. The associated soft tissue narrowing usually reflects the lack of integrity of the supporting structures.

Pathological considerations

Much the same pathological considerations apply to chronic laryngeal stenosis as to the acute injury. The soft tissue damage is due to mucosal loss and adhesions but, most
importantly, to organization of haematoma within the paraglottic, the preepiglottic and the interarytenoid space.

Glottic competence is affected by web formation anteriorly, and posteriorly an arthrodesis of the arytenoid can result in an unsatisfactory position. Furthermore, the recurrent laryngeal nerves, if they are not injured in the initial trauma, stand a very high chance of injury in the ensuing treatment of chronic laryngeal stenosis, and arytenoidectomy or cordopexy almost always forms part of the treatment of chronic laryngeal stenosis.

A factor in chronic laryngeal stenosis that does not, however, apply in the acute injury is that of tissue memory. If a cartilaginous framework has been disrupted, it heals with fibrous tissue, the fibrocytes of which have a directional memory. Thus, merely incising and separating scar tissue will lead to the tissue attempting to replace itself in its original scarred state. Reconstruction must be more sophisticated than incision and replacement. As much scarred tissue as possible should be excised, but the danger of repositioning will be ever present. This is most important in the cricoid where the interruption of the ring causes narrowing. The forces within the cricoid are altered, probably permanently, from this narrowing, and excision of the scarred area and separation of the cricoid ends with support from intervening tissue is probably the single most difficult problem in the management of chronic stenosis.

Excision of scarred soft tissue is not nearly so difficult. Wide excision of scarred tissue is, of course, necessary but grafting with split skin or mucosa usually gives good results. It must be re-emphasized, however, that no amount of satisfactory soft tissue healing will take place if the skeletal framework is disrupted or resumes its scarred altered position.

Stents are useful in supporting a reconstituted laryngeal framework and, to an extent, in separating mucosal surfaces that have been adherent. It bears repetition that stents are of little value in preventing haematoma formation within soft tissue.

**Treatment principles**

Most patients presenting for treatment for chronic laryngeal stenosis will already have a tracheostomy. They should be warned that the results of treatment of chronic laryngeal stenosis are at best unrewarding and their tracheostomy may be permanent. In the postoperative period with resultant swelling, the patient will almost certainly have to be fed with a nasogastric tube at least for some days. They should also be warned that it is unlikely that they will regain a normal voice, especially if the glottis has been damaged.

There is almost universal dissatisfaction with the surgical treatment of the systemic conditions that cause laryngotracheal stenosis, such as a scleroma, Wegener's granuloma and polychondritis. It is debatable whether these patients should be treated with any surgery other than occasional dilatations.
**Assessment**

**History**

The cause of the chronic stenosis is obviously important. If it is a result of an excessively zealous partial laryngectomy, then it is unlikely that enough tissue will be found to augment the lumen of the larynx. Again, if it is a systemic disease that has caused the laryngeal stenosis, it is unlikely that surgery has any place to play in the management. Exceptions to this might be confined segments of scleroma in the advanced fibrotic stage, but this would be a very rare occurrence.

Perhaps the most important communication to establish between the surgeon and the patient is a mutual sense of realism. Both should realize what is and what is not possible with surgery. Both should realize that dynamics of tissue healing can alter any result and this should be taken into account in timing the operation. No attempts should be made to increase the laryngeal lumen until 18 months have passed from the time of the initial injury. Finally, the patient must be quite clear as to what his objectives from surgery will be. He must evaluate how much a good voice means to him and similarly whether he wants to be rid of the tracheostomy tube so much that he is willing to undergo surgery. More minor cases should also realize that the additional scarring of surgery could, in rare instances, result in the patient having a tracheostomy for the rest of his life.

**Examination**

The surgeon should establish with mirror or flexible endoscopy the extent of the laryngeal, glottic or subglottic stenosis, but this is not always possible and is probably the least important part of the examination. Perhaps the most important part of the physical examination is in the assessment of the length of the neck and, therefore, how much trachea is available for mobilization in the neck without having to go into the mediastinum.

**Radiography**

The first investigation should be tomography and, in cases where the subglottis cannot be demonstrated, then laryngography should be used. This is perhaps the only place that laryngography now has to play in the investigation of laryngeal disease. Both laryngography and tomography will give a good idea of soft tissue scarring and distortion, but this is better shown by xeroradiography. Computerized tomographic (CT) scanning will give a very much better idea of the state of the laryngeal cartilages and should, if possible, be carried out in all instances.

**Endoscopy**

This is necessary to establish, as accurately as possible, the extent of laryngeal damage, but it is also useful to ascertain the lower extent of subglottic stenosis and to test for the state of the tracheal cartilages. These have to be examined from as high as possible without creating any splinting and with the anaesthetist blowing high airflows into the lungs using a Venturi system. In this way, tracheomalacia can be assessed.
The state of the arytenoids must be ascertained to see if they are fixed or not and oesophagoscopy should be carried out in every case.

Treatment

Supraglottic stenosis

There are three choices in the treatment of this condition: first, there is supraglottic laryngectomy; second, a laryngeal widening procedure; and third, laser excision. The author does not think there is any place now for supraglottic laryngectomy in the treatment of this condition. It defies all the basic tenets of the surgery of laryngeal trauma, namely minimal excision. There is usually nothing wrong with the supraglottic skeletal framework and the lesion is nearly always of soft tissue. The choice lies between serial excisions of the soft tissue with the laser and the laryngeal widening operation. Laser excision allows the patient to keep the tracheostomy tube and to evaluate the effect of serial excisions. An alternative is the laryngeal widening procedure where the larynx is opened in the midline and as much as possible of the submucosal scarred tissue removed. The remaining mucosa is stitched back against the laryngeal framework with quilting sutures or areas of scarred tissue are grafted either with skin or buccal mucosa.

Glottic stenosis

The anterior glottic web can be dealt with either by laser excision, by repeated endoscopic excision or by external excision and separation of the anterior glottis with a silastic or tantalum keel (McNaught keel). If an external approach is used, then the keel is kept in place for at least 5 weeks. It can then be removed with minimal reopening of the neck wound. The external approach is probably the preferred one when there is also a stenosis of the anterior parts of the false cord but, if the webbing is limited to the glottis, then laser excision or endoscopic removal is probably best in the first instance.

Posterior stenosis of the glottis is more difficult to treat. The glottis consists of roughly 50% cartilage from the medial face and vocal processes of the arytenoids and 50% of membranous vocal cord from the vocal ligament and the attached mucosa and thyroarytenoid muscle. Posterior glottic stenosis lies between the arytenoids. This is usually accompanied by fixation of at least one arytenoid. The stenosis may be excised and the arytenoid separated with a modified keel with silastic stenting on the end of it to keep the posterior glottis open. For this to succeed, both arytenoids must be mobile and capable of achieving glottic competence when the keel is removed. If the arytenoids are not mobile then one should be removed by a laryngofissure and the cord stitched laterally with stenting applied to stop further adhesions.

Subglottic stenosis

Cricoid stenosis

Enough has already been written about the biomechanics of cricoid stenosis to make it clear how a free graft in this area must work. It must keep the cricoid ring open and, to do this on a permanent basis, it must adhere to the cartilaginous ends. It is unlikely that free
bone or cartilage grafts, taken from ribs, can ever achieve this objective in a satisfactory and regulated manner. Furthermore, it is certain that allografts have no place.

Perhaps the best method is to swing down the body of the hyoid bone on a muscle pedicle of sternohyoid and hope that this, wired into the arch of cricoid, can keep it open. When this is done, the soft tissue scarring must also be removed and replaced with a skin graft and a stent applied either in the form of rolled up silastic above a tracheostomy tube, or in a modified tracheostomy tube. If a Montgomery T-tube is used for this, then the greatest care must be taken to see that it does not crust.

For greater degrees of cricoid stenosis, where the ring cannot realistically be reconstituted, then it is best to remove the cricoid leaving part of the posterior lamina on which sit the arytenoids. The larynx is then dropped and the trachea pulled up and joined to the lower end of the thyroid lamina anteriorly and to the arch of the cricoid posteriorly. This tends to give something of a lump in the back of the immediate subglottic space, but it is a fairly reliable procedure and can usually allow the patient to be extubated.

**Tracheal stenosis**

The more minor degrees of tracheal stenosis are best treated with dilatations. Very often the problem is one of tracheomalacia, rather than true stenosis, and the true stenosis cannot be seen on endoscopy or X-ray. Very often these patients are frustrated by the lack of a medical diagnosis when they know full well that they are dyspnoeic on exertion. If they are only dyspnoeic on exertion, however, they must consider very carefully whether or not to have surgery just because an operation exists to excise the weak area of trachea. This operation will almost certainly damage one or both of the recurrent laryngeal nerves and result in further surgery for vocal cord paralysis. Attempts to strengthen the tracheal wall with marlex mesh or other external devices, although intuitively attractive, are not often successful.

If a tracheal stenosis is severe enough to warrant the wearing of a tracheostomy tube, then it is a relatively easy matter to excise up to 4-5 cm of trachea and to join the trachea on to the cricoid or first tracheal ring.

Freeing the trachea into the mediastinum presents little problem, provided the operator keeps close to the wall of the trachea and does not stray outside the plane of the peritracheal fascia. Pulling the trachea up is easy because it acts as a concertina. The surgeon must remember, however, that the same pull is then applied downwards after the anastomosis. The most important part of this operation is dropping the larynx in the neck. This is done by cutting off the superior cornu of the thyroid cartilage on both sides. This releases the pull of the stylopharyngeus, salpingopharyngeus and palatopharyngeus muscles. The preepiglottic space should be entered by dividing the thyrohyoid membrane and the thyroid cartilage distracted from the hyoid. The middle constrictor should also be removed from the posterior lamina of the thyroid cartilage. There is enough slack in the false cords on the interior part of the larynx to allow several centimetres of displacement.

During this procedure, attempts should be made to find the recurrent laryngeal nerve on either side. If a damaged nerve is found, then it is best to perform a Woodman's operation.
at the time of the initial anastomosis but, if both laryngeal nerves are intact, then it can be expected that any vocal cord paralysis is due to neuropraxia and will recover.

If this manoeuvre is not enough to close the gap of an extensive stenosis, then a procedure, described over 20 years ago by Dr Grillo of Boston, can be utilized. In the UK, it is often called Barclay's procedure and consists of carrying out a right thoracotomy and removing the right mainstem bronchus from the carina, closing the hole at the carina and joining the right mainstem bronchus on to the left mainstem bronchus at a lower level. This gives several more centimeters of length to the trachea and does not result in stenosis further down.

If localized stenosis occurs further down the trachea, then laser excision can be used.

Results

The results from supraglottic stenoses are usually good. It is usually possible to remove the tracheostomy tube and leave the patient with a reasonable voice. Similarly the results from the treatment of glottic stenosis should also be good and it would be a rare event for the patient to have a permanent tracheostomy.

The results of the treatment of subglottic stenosis, however, are universally poor. Although isolated claims of remarkably good results in the treatment of this lesion are made by the occasional surgeon, they cannot be reproduced consistently by experienced laryngologists of long-standing merit. The key to the subglottis is the cricoid, and it does appear that we have not yet found a satisfactory solution to restoring the dynamic elastic forces necessary to preserve the integrity of the only complete ring in the respiratory tract.