THE MANAGEMENT OF ACQUIRED CERVICAL TRACHEAL STENOSIS

by

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF MEDICINE

in the
Department of Otorhinolaryngology
University of Natal
Durban

1993

ABSTRACT

Tracheal stenosis is not an uncommon complication of endotracheal intubation and tracheostomy. It is, however, difficult to manage. The surgeon requires a good knowledge of the anatomy, aetiology and pathogenesis, as well as all the different surgical techniques available. A retrospective study of our management, over a period of three years and nine months, was done with a review of the literature.

We were successful with only 8 of 22 patients. Rib cartilage graft tracheoplasty was successful in four of eight patients and resection and anastomoses in two of three patients. An important factor in the aetiology and prognosis, in our situation seems to be the tendency to keloid formation. Eight of the patients in our series had a tendency to keloid formation and six of them had failed surgical procedures with restenosis.

Factors that will determine the technique used are: the involvement or not of the tracheal skeleton, whether or not the stenosis is circumferential, and the length of the stenosis. Open procedures should be used when the skelton is involved and resection and anastomosis is the best technique for circumferential stenosis. A few guidelines to the management are given.

PREFACE

This study represents original work by the author and has not been submitted in any form to another University. Where use has been made of the work of others, it has been duly acknowledged in the text.

The research described in this dissertation was carried out in the Department of Otorhinolaryngology, University of Natal, under the supervision of Professor C.M.C. Fernandes.

ACKNOWLEDGEMENTS

The author wishes to express his sincere gratitude to the following persons for their assistance in the preparation of this dissertation:

Professor C.M.C. Fernandes, Head of Department of Otorhinolaryngology, University of Natal.

Colleagues, Department of Otorhinolaryngology, University of Natal.

The Superintendents of the following hospitals, for permission to review the patients' medical records:

King Edward VIII Hospital
Addington Hospital
Wentworth Hospital
R.K. Khan Hospital.

Mrs. J. Bender for the typing of the manuscript.

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CHAPTER 1

INTRODUCTION

Tracheal stenosis is a serious, late complication of endotracheal intubation and tracheostomy. It is not uncommon and has a high morbidity. The management is difficult and prolonged with a high incidence of failure. Most patients require several techniques and repeated procedures. However, a high rate of success is reported in the literature (Grillo et al 1986, Weber et al 1991, Anand et al 1992).

It is our impression that these results are not obtained at this centre. The aim of this study therefore is:

1. to determine objectively our success rate
2. to determine any possible factors involved in those cases with a poor outcome
3. to review the literature for comparisons and suggestions on the future management of this problem.

A retrospective study was done of all cases of cervical tracheal stenosis managed by our department, from January, 1989 to September, 1992.

CHAPTER 2

REVIEW OF LITERATURE

2.1 INTRODUCTION

The magnitude of the problem and the therapeutic dilemma it poses is obvious from the number of papers on the subject. There is no simple, guaranteed treatment.

The incidence of tracheal stenosis has increased markedly in recent years. This is the result of an increased incidence of treatment by endotracheal intubation and tracheostomy, in addition to improved methods of resuscitation and improved intensive care medicine. There is also an increase in the number of complex operations being done.

An understanding of the anatomy is important in the approach to tracheal stenosis. The average length of the adult trachea is 11cm. There are 18 to 22 cartilaginous rings, with approximately two rings per centimetre. The rings are C-shaped and connected posteriorly by the membranous portion of the trachea. The blood supply is shared with the oesophagus and the main bronchi. Above, the supply is from the inferior thyroid artery and below, from the bronchial vessels. The blood supply is largely end vessels and segmental, without any major longitudinal vessels. The blood vessels enter the trachea laterally (Grillo and Mathisen 1988).

The mean diameter of the adult trachea is 16mm. When this is reduced to less than half ($>$8mm) dyspnoea, even at rest, will develop. Four millimetres are thought to be the minimum diameter necessary to preserve life (Maggi et al 1990).

2.2 AETIOLOGY AND PATHOGENESIS

The majority of tracheal stenoses result from iatrogenic trauma, namely intubation and tracheostomy. Post-traumatic stenoses are uncommon (Grillo 1988). Infections like tuberculosis, histoplasmosis, diphtheria and rhinoscleroma occasionally cause stenosis. Neoplastic lesions are not usually considered in the aetiology of tracheal stenosis in the literature. However, Maggi et al (1990) reviewed 100 cases of which 34 were neoplastic and 66 non-neoplastic in origin. Of the neoplastic lesions, 12 were squamous carcinoma, 9 adenocystic carcinoma, 7 metastatic and 6 benign in origin. Of the non-neoplastic stenosis, 48% followed intubation and 32% tracheostomy. The remaining 20% were caused by malacia, tuberculosis, surgery, trauma, radiotherapy and idiopathic tracheitis.

A prospective study of the sequelae in long-term intubation in 200 patients was done by Whited (1984). He concluded that intubation times of 7 days or less have a low incidence of tracheal stenosis, with the most significant injury in the post commissure of the larynx. Beyond 10 days, there is an increase in incidence and severity. Intubation times between 7 and 10 days, are in the grey zone of change. The reported incidence following intubation ranges from 6-21%.

Andrews (1971) has done an excellent 3-year prospective study of tracheal injury in patients managed by cuffed tube tracheostomy and assisted ventilation. On removal of the tube, a bronchoscopy was done, and this was followed up by further clinical and radiological assessments, three weeks and three months later, using bronchoscopy when indicated. The incidence of symptomatic tracheal stenosis (153 patients) was 21%, 18 at the level of the tracheostoma and 14 at the level of the cuff. The disability was severe in 18 and mild in 14. These mild cases might easily have remained undetected. His observations indicated that stenosis can be anticipated before the lesion has developed, by the finding of circumferential mucosal ulceration or segmental collapse.

He also concluded that tracheostomy tubes of large diameter predispose to the development of stenosis at the level of the tracheostoma.

Tracheal stenosis may occur at four sites, namely: above the tracheostoma, at the tracheostoma, just below the tracheostoma and at the end of the tracheostomy tube (Montgomery 1989, p.445).

Suprastomal stenosis follows intubation trauma, where the site is denuded of epithelium and subsequently secondarily infected. A tracheostomy, just below the cricoid cartilage, often results in stenosis caused by persistent oedema, granuloma formation, or loss of anterior tracheal support. A hurried, emergency tracheostomy may lead to damage of the anterior tracheal wall. The result is buckling-in and anterior-posterior narrowing and stenosis.

Stenosis at the tracheostoma is mostly caused by infection complicated by the formation of polyps and granulation tissue. Local chondritis and loss of cartilaginous support follows. Other factors contributing are an overly large stoma and excessive traction or movement of the tracheostomy tube by the connection tubing, or patient movement. Cicatricial stenoses occur, resulting in an anterolateral narrowing (Wood and Mathisen 1991).

Stenosis below the tracheostoma occurs at the level of the cuff and is similar for endotracheal tubes. Direct pressure necrosis, by high-pressure cuffs, is responsible for most injuries. Within 3-5 days, shallow mucosal ulcers develop overlying the cartilaginous rings which can then deepen and become confluent, allowing exposure of the cartilage. This leads to infection with destruction of the cartilage. With continued high pressure from the cuff, the tracheal mucosa and tracheal rings can necrose, soften and fragment, forming a fibrous scar without cartilaginous support and resulting in a circumferential fibrous stricture, or tracheal malacia, an hour-glass deformity. With

shorter periods of exposure, mucosal damage may occur without destruction of the cartilage. The trachea then develops a circumferential proliferative scar with significant luminal narrowing, but with a normal external appearance. These injuries still occur with the over-inflation of low pressure cuffs (Wood and Mathisen 1991).

Injury to the trachea may also occur from pressure exerted by the tip of the tracheostomy tube. The ulceration becomes secondarily infected and a granuloma may develop. Chondritis is followed by loss of support and tracheal stenosis.

Owing to inflammation, varying degrees of thinning of cartilage may also occur in the segment between the stoma and the level of the cuff stenosis. Sometimes this area may become malacic (Grillo and Mathisen 1988).

Infection apparently plays a very important role in the development of tracheal stenosis. Squire et al (1990) studied the role of infection in the development of tracheal stenosis in a rabbit model. Stenosis developed in 85% of rabbits inoculated with staphylococcus aureus, compared to 50% of animals receiving prophylactic antibodies and 63% controls. The stenoses were also narrower in those with infection. Although this was a small number of animals (16), they concluded that bacterial infection might increase the severity of tracheal stenosis. Sasaki et al (1979), also in an animal study, found that subglottic mucosal injury in the presence of a tracheostomy, results in bacterial growth of more than 10^5 per gram, resulting in chronic mucosal ulceration and subsequent chondritis. Subglottic injury, without tracheostomy, however, results in mucosal healing without infection, within 10 days.

2.3 **DIAGNOSIS**

The majority of cases become symptomatic between two and six weeks after decanulation or extubation. A few develop symptoms after two to three months and occasionally symptoms develop whilst the tracheostomy tube is still in place. Dyspnoea

on exertion, cough, or inability to clear secretions are the early symptoms, whilst stridor develops in more severe stenoses. Respiratory distress may be precipitated by secretions, bleeding or swelling. In the case of dyspnoea, inability to clear secretions or stridor in a patient with a history of recent intubation or tracheostomy, tracheal stenosis should be suspected (Wood and Mathisen 1991).

Physical examination may reveal nothing more than dyspnoea, stridor or a tracheostomy scar; however, sometimes it may be possible to see a high tracheal stenosis with indirect laryngoscopy.

A lot of information regarding the extent and location of the stenosis is obtained by radiological investigations. A soft lateral neck view with the patient swallowing and the neck hyperextended to bring the trachea up above the clavicles, is helpful in lesions of the upper trachea (Grillo and Mathisen 1988). Linear tomography provides enhancement of anatomical detail at critical levels and may be invaluable in determining the precise length and diameter of the stenosis (Unger and Shaffer 1979). Tomograms are done in the anteroposterior and lateral planes. Fluoroscopy is useful to evaluate laryngeal function and tracheal malacia. Contrast tracheograms and computed tomography scans offer very little additional information (Wood and Mathisen, 1991). Contrast studies must be done with great caution, since the contrast agent is extremely viscous and may transform a high-grade obstruction into a complete occlusion (Unger and Shaffer 1979). Xeroradiography augments soft tissue detail and subtle cartilaginous calcification and Crysdale (1979) believes this is the radiologic technique of choice in the young child. Wood and Mathisen (1991) suggest that the tracheostomy tube be removed during the performance of radiographic studies, because the tube itself will splint a stenosis.

Bronchoscopy is essential for the definition of tracheal stenosis. Flexible bronchoscopy, outside the operating room, is contraindicated as secretions, blood,

oedema, or the bronchoscope itself, may precipitate acute obstruction (Wood and Mathisen 1991). Bronchoscopy may be done separately in complex cases or concurrently with the repair, in simpler cases, if the radiological demonstration has been adequate (Grillo and Mathisen 1988). A rigid bronchoscope is required for precise definition of the stenosis and may also be used to dilate the stenosis. Careful measurements should be made, recording the distance from the cricoid to the top of the stenosis, and from the bottom of the stenosis to the carina, as well as the length of the stenosis and the length of the trachea (Wood and Mathisen 1991). The degree of inflammation and areas of malacia must also be assessed. It is also very important to examine the larynx for any abnormality as no tracheal surgery should be done before the damaged larynx is repaired.

2.4 **MANAGEMENT**

The choice of procedure depends on the severity of the stenosis, the duration of its presence and previous therapy. Unfortunately, simple guidelines are not feasible and experience with various techniques, in a number of patients, is important to guide therapy (Weber et al 1991). A wide spectrum of therapeutical options are available, ranging from endoscopical dilatation and laser excision to open tracheoplasty with different techniques of supporting or stenting of the tracheal wall, to resection and end-to-end anastomosis. First priority, however, is the management of acute airway obstruction.

2.4.1 **AIRWAY MANAGEMENT**

Initial therapy includes elevation of the head of the bed, cool mist to thin secretions, adrenaline nebulisation and, sometimes, a short course of corticosteroids (24-48 hours). In the case of severe airway obstruction, the patient should be managed in the operating room. Here the trachea can be carefully dilated, using rigid bronchoscopes. The stenosis is dilated gently with a corkscrewing motion under direct vision. Once dilated, the airway may be evaluated safely. Repeated dilatations may be necessary before

definitive treatment. A silicone T-tube may be used to maintain the airway for longer. periods. The tube is inserted through the existing stoma. If there is no stoma, it is inserted through the area of maximal tracheal damage to preserve as much as possible of viable trachea for future reconstruction (Wood and Mathisen 1991). Granulation tissue is resected at the time of bronchoscopy. Recurrence of granulation tissue formation may be prevented by steroid injection into the site of origin (Montgomery 1989, p.450).

It may be necessary to perform an emergency tracheostomy, after rigid bronchoscopy or fibre-optic bronchoscopy, and attempted intubation has failed. Maggi et al (1990) suggested that a horizontal incision should be made in the tracheal wall, as close as possible to the stenosis, without damaging the tracheal wall.

2.4.2 **ENDOSCOPIC MANAGEMENT**

Dilatation, using rigid bronchoscopes under direct vision, is often mentioned as a treatment modality. However, the value of this procedure is doubtful and controversial. Thin or membranous strictures respond to dilatation, whereas thick, fibrous strictures do not. A firm, mature scar will not respond to dilatation (Smith, 1987). If a stricture does not respond to a limited number of dilatations (2-5), dilatation will be ineffective. There is a possibility that too frequent dilatation will result in increased fibrosis and further narrowing of the airway (Crysdale 1979). Montgomery (1989, p.452), has found tracheal dilatation to be unsatisfactory and occasionally harmful, and abandoned it many years ago. Dilatation is, however, helpful as a temporary measure until definitive surgery is done (Wood and Mathisen 1991).

Hebra et al (1991) reported a 15-year experience with 37 patients and 158 tracheal dilatations, using balloon catheters (used for angioplasty) that impart only radially directed forces and can be precisely placed and gradually inflated. Various adjunctive techniques were used, namely, removal of granulations, parenteral and local use of

steroids and intraluminal stenting. Almost all the patients had some immediate benefit; 54% achieved long-term improvement. Multiple dilatations are required to gradually improve the character of the tracheal lumen. They concluded that this is a safe and effective method and in elective cases, may delay or avoid the need for an open tracheoplasty.

Laser therapy has not achieved long-term success in most patients. The reason for a high failure rate is that many patients have full thickness injury, with destruction of the cartilage and loss of normal mucosa. If the scar is resected with the laser, the natural healing process will lead to cicatrization and restenosis. It should be used only as a palliative method to open the airway prior to definitive resection in these cases. Laser resection has proved successful in thin diaphragm-like stenoses, without underlying cartilage damage. Another indication for laser resection is the removal of granulation tissue.

Shapshay et al (1987) reported three patients with severe tracheal stenosis, who were treated by endoscopic radial laser incision, followed by rigid bronchoscope dilatations. They claimed good results, but one patient had repeated recurrences that required treatment every 3-4 months. The other two adult patients had improvement in the airway from 3-5mm and 4-6mm respectively; still a very narrow airway.

Several reports appear in the literature, concerning the use of laser excision of the stenosis and creation of a microtrapdoor mucosal flap to cover the mucosal defect. An incision is made in the superior surface of the scar with a CO_2 laser. The scar is then excavated whilst preserving the overlying mucosa. A trapdoor mucosal flap is then formed by two lateral knife or microscissor incisions. The flap is then smoothed into position. The raw undersurface adheres to the adjacent raw surface of the trachea (Dedo and Sooy 1984). The immediate coverage of the raw surface with the flap is essential, to prevent reformation of scar tissue. Beste and Toohill (1991) had success

with seven out of nine patients with stenosis. They had poor results in children under five years of age. Dedo and Sooy (1984) were successful with nine out of ten patients and reported an average increase in airway diameter of 279%. Since the microtrapdoor flap is a loose pedicle, it can cause airway obstruction by a valvelike mechanism. It is believed that a tracheostomy diverts the airflow and prevents the flap from moving. It also prevents airway obstruction (Duncavage et al 1987). This technique is indicated in small stenoses with a length of 10mm or less.

Geissler et al (1990), described a technique of endoscopic electroresection of tracheal granulomas and small areas of tracheal stenosis. The resectoscope is passed distal to the stenosis, which is then resected in a distal-proximal direction.

Factors associated with poor results or failure of endoscopic management include circumferential scarring with cicatricial contracture, scarring more than 1cm in vertical dimension, tracheomalacia and loss of cartilage and a previous history of severe bacterial infection, associated with tracheostomy (Simpson et al 1982).

2.4.3 **TRACHEOPLASTY**

Conservative open surgical methods are used, whereby the stenotic area is excised and a variety of techniques are used to augment the lumen or tracheal wall. These techniques use costal cartilage, composite nasal septum cartilage, free or composite hyoid bone graft, free periosteal grafts, myoperiosteal grafts and myocutaneous flaps, as well as certain prosthetic materials. Intraluminal stenting is commonly used to support and stabilise the reconstructed site and to act as a scaffold for epithelial coverage of the lumen (Anand et al 1992).

Suprastomal buckling-in deformities are not uncommon. These can be managed by creating a new tracheostomy as inferior as possible, followed by vertical incisions in, or possibly through, the involved cartilaginous rings at several points. It is usually

possible to replace the tracheal rings in their anatomic position. A Safe-T-tube that will completely fill the tracheal lumen is then inserted (Montgomery 1989, p.468). Unfortunately no results on this procedure are reported.

Maniglia (1979) reported his technique of conservative management, which included bronchoscopic dilatation of the stenotic segment up to a number 9 bronchoscope, followed by an open technique, whereby several longitudinal incisions are made through the stenotic segment. Intralesional triamcinolone acetonide is given and a T-tube is inserted with the tracheostomy, one normal ring above or below the stenotic segment. Successful management was achieved in 16 of 19 patients, all asymptomatic after a minimum follow-up of 6 months. However, the severity of the stenoses, pre-operatively, is not clear from the report.

Loss of anterior cartilaginous support can be approached with a vertical midline tracheal incision, beginning inferiorly at the level of the normal trachea. The fibrous and granulation tissue are resected from the stenotic area anteriorly so that the lateral walls of the trachea can be freed and retracted laterally. A Safe-T-tube that will completely fill the normal tracheal lumen is inserted and the sternohyoid muscles are used to repair the anterior tracheal wall. Occasionally, the area void of mucous membrane is too extensive for spontaneous re-epithelialisation. In these cases, a mucosal graft (buccal or septal) or a split-thickness skin graft, can be used. The graft is sutured directly to the tracheal wall or to the intratracheal portion of the T-tube. These grafts take well if the recipient site is vascular and free of scar tissue (Montgomery 1989, p.470).

Rib cartilage grafts are the most commonly used cartilage grafts in tracheoplasty. The approach is similar to the above, but the anterior tracheal defect is augmented with a rib cartilage graft. After placement of the silicone T-tube, the graft is sutured in place with interrupted sutures and with the perichondrium facing the lumen. The T-tube is

usually removed after 3-4 months, with excellent healing evident. Weber et al (1991) have reported this procedure in 11 patients, with a 75% success rate. Earlier attempts by them to use endotracheal tube stenting, with removal after 10-14 days, invariably failed because of collapse of the graft; thus the need for long-term stenting with the T-tube became obvious. The horizontal limb of the T-tube is brought out separately with normal trachea between it and the graft. Smith (1987) used rib cartilage that is grooved on the lateral edges, to help secure it in place and prevent internal displacement. The composite rib cartilage graft is ideal to use because it is easily obtained, easily carved, strong and abundant, and it has been shown that the perichondrium will promote the development of normal respiratory epithelium (Toohill 1979).

Prescott (1988), reported that failure to obtain early decannulation after laryngotracheoplasty, is probably related to a localised, chronic, low-grade infection in the tissues of the larynx and upper trachea, despite the use of perioperative antibiotics. This appeared to be exacerbated by the presence of a foreign body (stent). The source of infection is almost certainly the colonised tracheostomy site. Excision and closure of the tracheostoma at surgery, with postoperative nasoendotracheal intubation providing the necessary support for the graft, now has reduced the period to extubation to approximately two weeks.

Stenoses of up to 3cm in length can be augmented by the composite nasal septal graft. This graft provides cartilaginous support with attached respiratory epithelium (Toohill 1979). Inferior placement of the caudal end of the septum allows replacement of normal ciliary flow afforded by the respiratory mucosa of the septum (Nolph and Ganzel 1986). The disadvantages of this technique are the possibility of nasal deformity or septal perforation and the limited amount of septal cartilage available. The resorption of the nasal septal cartilage, with the replacement by fibrotic scar tissue does occur, but the fibrotic scar tissue appears to provide suitable rigidity (Duncavage et al 1989). This graft was successfully used to reconstruct high tracheal and

laryngotracheal stenosis in 11 of 16 patients, by Duncavage et al (1989). Only one of two pure tracheal reconstructions was successful.

Hyoid grafts, either as a free graft or as a muscle composite graft, have been successfully used in the repair of subglottic stenosis (Burnstein et al 1986, Nolph and Ganzel 1986). Alonso (1979) suggests the use of hyoid bone grafts as an adjunct after wedge resection of small anterior tracheal wall defects. It adds rigidity to the anterior tracheal wall when sandwiched in a bed of approximated strap muscles. Absorption of bone has been a problem with the use of free bone grafts from the iliac crest and rib (Toohill 1979).

Free periosteal grafts have been used experimentally, with conflicting results. Haugen et al (1987) concluded that there is a high risk of severe osseous tracheal stenosis when periosteal grafts are placed circumferentially around the trachea. It is not mentioned whether the inner layer was facing the lumen or not. Moutsouris et al (1989) apply the periosteal graft with the outer layer facing the lumen and this created a non-collapsible tracheal wall with perfect epithelialisation of the mucosa, at the same time inhibiting osteoplasia and the resulting stenosis. This is promising and they are busy with a long-term study to evaluate the delayed biological behaviour.

The sternocleidomastoid myoperiosteal flap for reconstruction of subglottic and tracheal defects has been described by Friedman et al (1988). Clavicular periosteum on a muscle pedicle, to provided vascularity, is used. The clavicular periosteum is fibrous, durable, will conform to the shape of the trachea, and form bone to provide stability. The size of the periosteal flap can be up to 8cm x 4cm in most patients. A stent fashioned from a rubber glove and filled with sponge is preferred, or a T-tube is used for defects longer than 6cm. These stents are removed after six weeks. They were successful with 10 of 11 patients with the average time to decanulation being 50 days, and follow-up that ranged from 12-40 months. No problem with osseous tracheal

stenosis is reported. This procedure has not yet been proven universally reliable and should be used in a large number of patients to further test its reliability.

Reconstruction of the upper trachea, with the sternohyoid rotary door flap (RDT), described by Eliachar and Tucker (1991), is an exciting and promising new technique that provides a dynamic, non-rigid, expansion and augmentation. Briefly the technique is as follows:

The flap is drawn over the sternohyoid muscle, large enough to cover the defect. A cervical midline incision is made for the medial border of the RDT. Repositioning of a pre-existing tracheostomy is almost always necessary. The midline incision is carried through the strap muscles, to expose the cricoid and trachea. The lumen is exposed through a midline incision and scar tissue may be removed. the widened tracheal lumen is then stabilised with an oversize T-tube or other appropriate stent. The RDF is now developed by a paramedian skin incision 1,5cm lateral to the midline incision. It is carried through to the investing fascia of the sternohyoid. Interrupted absorbable sutures are placed along the margins of the RDF to approximate the skin to the underlying muscle. The sternohyoid muscle is mobilised in its entire length. Veins draining the flap must be left intact. The RDF is rotated in position on its longitudinal axis. The flap is trimmed as required and several quilting sutures are placed through the muscle, fat and skin, to control post-operative oedema and to minimise the tendency of skin to separate from the surface of the muscle. The flap is then sutured in place in the anterior tracheal defect, with absorbable polyglycolic sutures. The T-tube is removed 2-8 weeks later and replaced by a tracheostomy tube for 7-14 days.

Eliachar and Tucker (1991) reported successful decanulation in 13 of 14 patients (2 subglottic and 12 tracheal stenoses). Follow-up ranged from 1-14 years, with no additional surgery required in the decanulated patients. The flap provides a dynamic support to the tracheal wall. Rotation (180°) along its longitudinal axis adds spiral torque and tension to the flap and, as an accessory muscle of inspiration, it tenses

during inspiration, which prevents collapse.

Prosthetic material is occasionally used to augment the laryngotracheal skeleton. Lindholm and Löfgren (1987) reported a three-staged procedure, based on the creation of an autogenous mucosal cyst with transplanted buccal mucosa, supported by a proplast sheet implant to support the airway. Amedee et al (1992) reported the repair of areas of tracheomalacia by supporting it with ceramic rings, sutured to the remaining cartilage. The rings are fashioned in the shape of a 220° incomplete circle, 2mm thick and 4mm wide. The tracheal lumen is not exposed. They reported success in all of 16 patients. Margolis (1992) presented the successful management of one case of subglottic stenosis by the use of a U-shaped titanic splint, sutured to the cartilage.

The use of tracheal prostheses has been complicated by the failure of lumenal epithelialisation and the development of a central stenosis of scar tissue in the lumen. Establishment of a confluent lining of respiratory epithelium is believed to be necessary for successful prosthetic tracheal reconstruction. Chopra et al (1992) reported successful seeding and growth of human respiratory epithelium onto a Dacron polyurethane prosthesis, using cell culture techniques. Prosthetic material is seldom used in tracheal reconstruction and much more research in this field is needed.

The most commonly used stent for tracheal stenosis or tracheal reconstruction is the silicone tracheal Safe-T-tube. It serves both as a stent and as a tracheostomy tube, is sufficiently dense and thick to support the trachea, but soft enough not to injure it, and it gives good support, especially to the suprasternal anterior tracheal wall. The silicone T-tube initiates little or no tissue reaction and mucus and crusts do not readily adhere to its smooth surfaces. It remains plugged most of the time and this allows for normal respiration and phonation. There is no need for frequent change and it has remained in place and plugged for more than three years, without change. An excellent review on all the aspects regarding the use of Safe-T-tubes is given by Montgomery (1989).

The use of a stent is definitely associated with infection, complicated healing and delayed canulation (Prescott 1988). Avoidance of stenting in an animal series appears to decrease infection, resulting in improved healing (Thomas and Stevens 1974).

2.4.4 **RESECTION AND ANASTOMOSIS**

The ideal treatment for severe, circumferential, tracheal stenosis is sleeve resection and end-to-end anastomosis (Montgomery, 1989 p.481, and Anand et al 1992). The principles required for success are attention to preservation of tracheal blood supply, avoidance of tension at the anastomosis, and full resection of the stenotic and inflamed area back to healthy trachea (Wood and Mathisen 1991). In young patients, a gap of up to 3cm can be closed without release techniques. The tension (over 1 000g) on the suture line, after a resection of more than 3cm, is sufficient to result in recurrence of the stenosis. More than one half of the adult trachea may be resected and successfully reconstructed (Grillo and Mathisen 1988, Montgomery 1989, p.481).

Several release manoeuvres to gain extra length are available. Dissection of the anterior tracheal plane to the level of the carina will give some mobility and should be done in all cases. Care should be taken not to inferfere with the lateral blood supply. Extreme flexion of the neck gives the greatest gain in length (total of 4cm) and is done in all cases. The position is maintained by a heavy suture from the chin to the chest. Suprahyoid or infrahyoid laryngeal release may achieve up to 5cm total length. The suprahyoid release is preferred. Manoeuvres to mobilise the carina, the hilum of the lungs and inferior pulmonary ligaments are rarely needed, as is the section and reanastomosis of the left main bronchus. By incising the annular ligaments between the tracheal rings, an additional length of 1,5cm can be obtained, but this may interfere with the blood supply (Grillo and Mathison 1988, Montgomery 1989, p.481). Only the segment to be excised, as well as a minimal amount of proximal and distal trachea, should be circumferentially dissected. Lateral traction sutures are placed midlaterally on either side, at least 1cm from the part of division. The trachea is then divided at a

point where good cartilaginous rings are present and the stenosed part is dissected out. The recurrent laryngeal nerves are safe laterally since the dissection is close to the tracheal wall. Before anastomosis, the neck is flexed and with traction on the lateral sutures, it is ensured that approximation can be effected without undue tension. The anastomosis is done with interrupted absorbable sutures, starting in the midline posterior and with the knots outside. The anastomosis is tested for an air leak by flooding the field with saline. If leaks are encountered, simple sutures are placed. The patient is extubated in theatre to confirm the adequacy of the airway (Grillo and Mathisen 1988).

Complex stenosis, involving the subglottis and upper trachea, may be managed by resecting the anterior part of the cricoid cartilage by transecting the lateral lamina bevelled downwards and backwards. The posterior cricoid plate is left intact and care is taken not to damage the recurrent laryngeal nerves. The upper trachea is bevelled in the opposite direction and the anastomosis is performed. Although these anastomoses have proved to be surprisingly competent initially, they may achieve only a percentage of a normal cross-sectional airway area, owing to the amount of disease involvement submucosally (Grillo 1981, Grillo and Mathisen 1988).

The stenosis at the tracheostomy site usually does not involve more than 2-3 tracheal rings anteriorly. These may be managed by an anterior wedge resection, leaving the posterior or membranous wall intact, an end-to-end anastomosis of the anterior part is performed (Montgomery 1989, p.497).

Grillo has done extensive work on tracheal stenosis with, by far, the largest series in the literature. Of 279 patients who underwent tracheal resection and anastomosis, 83,2% achieved good and 9,6% satisfactory results. Four percent were considered failures and the operative mortality was 1,8%. These results include all tracheal stenoses, not only cervical. Maggi et al (1990) reported a series of 28 patients who had

tracheal resection and anastomosis and good results were achieved in 74% and satisfactory results in 7,5%. Dehiscence occurred in 3,7% and restenosis in 7,5%, whilst two patients (7,5%) died postoperatively. Anand et al (1992) reported 66% success with 12 patients. Many of these required several additional procedures.

No large series involving children are available. Weber et al (1991), have managed 110 children over a 10-year period with acquired tracheal stenosis. From these, 62 required surgery which included 8 by sleeve-resection and anastomosis and 4 by wedge-resection and anastomosis, with a 75% success rate. This was comparable with their 75% success rate with rib graft tracheoplasty (12 patients). Healy et al (1988), reported success with 3 patients, ranging in age from 4 weeks to 3 years and said that between 3 and 5 tracheal rings can be resected in children, without the need for laryngeal release. However, Wiatrak and Cotton (1991) demonstrated that 6 of 8 patients, who had undergone resection and anastomosis, needed further expansion of the airway, requiring costal cartilage grafting and stenting. They concluded that the prognosis is better in older children and that, in their opinion, expansion techniques, using cartilage and stents, is the procedure of choice.

The most common complication in the past has been the development of anastomatic granulations. This problem has been virtually eliminated since the use of absorbable suture material. Separation in most cases is due to excessive tension at the site of the anastomosis. Restenosis is also related to the anastomatic tension. Major haemorrhage from the brachiocephalic artery is rare and can be avoided by deliberately not dissecting the artery. Vocal cord paralysis is rare and is avoided by dissecting close to the tracheal wall. Aspiration is more common after infrahyoid release than after suprahyoid release and usually improves after a period. Other rare complications are oedema of the larynx or a tracheo-oesophageal fistula.

Complications may be minimised by attention to the following important points. An

accurate preoperative functional and anatomical diagnosis is essential. The surgical approach should be carefully planned and the technique should be meticulous with special attention to the avoidance of tracheal devascularisation and to the anastomotic tension. If a recent operation on the trachea has been performed, or if there is marked inflammation of the trachea present, surgery should be postponed for 6-8 weeks to allow the fibrosis and inflammation to subside (Grillo et al 1986, Grillo and Mathisen 1988). Tracheal resection should not be done in an emergency but preferably following adequate preparation. Patients receiving high doses of steroids should be operated on only 3-4 weeks after interruption of the steroids (Maggi et al 1990).

2.4.5 STAGED REPAIR OF EXTENSIVE TRACHEAL STENOSES

Tracheal stenosis that involves cartilage loss and is greater than 4cm long, is difficult to reconstruct. Resection and primary anastomosis is successful in less than 50% of these cases. Biller et al (1986) described an alternative method of reconstruction, by an open technique which requires three stages. During the first stage, the stenotic segment is excised but with preservation of the posterior mucosa or scar tissue. A trough is then created by the elevation of bilateral skin flaps which are sutured to the remnant of the mucosa or scar tissue posteriorly. The trough is packed with iodinated gauze and a tracheostomy tube is inserted into the lower end. This is replaced after four days by a T-tube that bridges the gap.

During the second stage, 3-4 weeks later, pieces of Marlex mesh are implanted underneath the skin, adjacent to the trough on one side. During the final, or third stage, four weeks later, the trough is closed by reformation of an anterior wall, using the skin supported by the Marlex mesh. The donor site is closed primarily by advancing skin on both sides of the trough. Closure is done over a nasoendotracheal tube, which is removed after 48 hours. Biller et al (1986) have done 30 of these procedures over an 11-year period and were successful in 76% (23/30).

Montgomery described the technique with some modifications. A split-thickness skin graft is used to line the trough and rib or septal cartilage is used to support the pedicled skin flap that will eventually form the anterior wall of the reconstructed trachea.

2.4.6 ADJUNCTIVE MEASURES

Antibiotics and corticosteroids are commonly used as adjunctive therapy in the management of tracheal stenosis. The role of infection in the aetiology and pathogenesis of tracheal stenosis is clear, especially in the presence of a tracheostomy or stent (Thomas et al 1975, Sasaki et al 1979, Squire et al 1990). Perioperative antibiotics are used by many (Alanso 1979, Maniglia 1979, Prescott 1988). However, data supporting efficacy is lacking. Supance (1983) showed that systemic antibiotics and a steroid in an animal study was not efficacious in the prevention of subglottic stenosis. Gray et al (1987) concluded that the prolonged use of antibiotics, whilst a stent is in position, does not appear to reduce the occurrence of granulation tissue. The only advantage is that they reduce the occasional annoying odour associated with long-term stenting.

Corticosteroids are also used, especially in combination with dilatation and in the presence of granulations (Gray et al, 1987, Shapshay et al, 1987). Biemann Otherson (1974) used systemic and local corticosteroids in conjunction with intraluminal stenting in five patients, with satisfactory results. Braidy et al (1989) reported a case where an endotracheal polyp at the cuff-site disappeared within five days of treatment with beclomethasone. However, Supance (1983) showed that systemic antibiotics and a steroid were not effective in preventing subglottic stenosis in an animal study. Many more controlled studies are needed to evaluate the real value of systemic antibiotics and local and systemic corticosteroids as adjunctive measures in the management of tracheal stenosis.

2.5 PREVENTION

An understanding of the aetiology and pathogenesis is important to prevent the occurrence of tracheal stenosis. Important principles are atraumatic intubation and instrumentation of the airway, the use of soft silicone tubes with large, low-pressure cuffs, the prevention and treatment of infection, meticulous technique when doing a tracheostomy and proper tracheostomy care.

Webb et al (1973) did a prospective study to reduce the incidence of tracheal stenosis, following long-term tracheostomy. They have done only a longitudinal stomal slit in the trachea and have used atmospheric pressure foam cuff tracheostomy tubes in 92 patients, ranging from 11 to 86 years of age, followed up to 15 months. No tracheal ulceration (bronchoscopy) or stenosis resulted. Stoma stenosis can further be minimised by not making an overly large tracheal stoma (if this technique is used) and by prevention of undue leverage on the tracheostomy tube.

Suprastomal collapse of the anterior tracheal wall may sometimes be severe enough to prevent decanulation. The suprastomal anterior tracheal wall is unsupported and often becomes weakened because of the inward pressure of the tracheostomy tube and therefore collapses inward. Surgical decanulation may be needed. This includes excision of the tract and "hitching" the suprastomal trachea forward by suturing it anteriorly to the strap muscles on either side. This provides constant anterior traction on the collapsed area (Gray et al 1987, Ochi et al 1991).

Patients, especially at risk of developing severe recurrent stenosis and excessive granulation tissue, or those with a tendency towards keloid scarring (Prescott 1988, Anand et al 1992).

CHAPTER 3

PATIENTS AND METHODS

A retrospective study was done of all cases of acquired cervical tracheal stenosis, which were managed by the Department of Otorhinolaryngology, University of Natal, Durban, from January, 1989 until September, 1992. The hospitals involved in this study were:

1. King Edward VIII Hospital
2. Addington Hospital
3. R.K. Khan Hospital
4. Wentworth Hospital.

The patients' medical records were reviewed, with special attention to the following points:

1. Race, age and sex distribution.
2. Initial insult and where managed.
3. Duration of endotracheal intubation.
4. Duration of tracheostomy.
5. Associated medical conditions.
6. Time to presentation.
7. Radiological and endoscopic findings.
8. Surgical management.
9. Results of treatment.
10. Complications of treatment.

Consent for the review of these patients' medical records was obtained from the medical superintendents of the hospitals involved.

CHAPTER 4

RESULTS

4.1. PATIENTS

A total number of 22 patients were managed over a period of 3 years and nine months. Their average age was 28,77 years (ranging from 7 years to 53 years), with the highest incidence in the second and third decades (Figure I). There were 16 male and 6 female patients, and 16 of the patients were Black (Table I).

FIGURE 1
AGE DISTRIBUTION

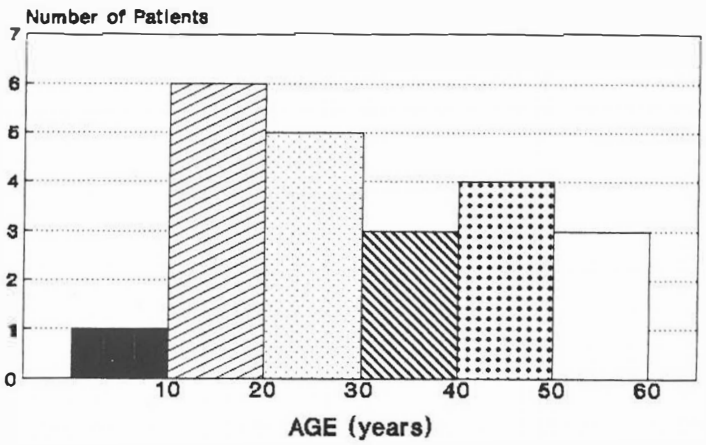

TABLE I: RACE DISTRIBUTION

BLACK	16
ASIAN	4
COLOURED	2
WHITE	0

4.2 INITIAL PATHOLOGY

Head injuries (9 patients) were by far the most common initial indication for intubation or tracheostomy. This was followed by 5 patients with adult respiratory distress syndrome (ARDS) (Table II).

TABLE II: INITIAL PATHOLOGY

Head injury	9
ARDS	5
Flail chest	2
Tetanus	2
Inhalational burns	1
Gunshot neck (tracheal injury)	1
Organophosphate overdose	1
Chronic subdural haematoma	1
Strangulation	1
Multiple fractures	1

4.3 ENDOTRACHEAL INTUBATION/TRACHEOSTOMY

Eight patients developed tracheal stenosis after endotracheal intubation only, three after tracheostomy only and eleven after endotracheal intubation, followed by tracheostomy (Table III). The average duration of intubation in the first group was 10,25 days and the average time from intubation to presentation with tracheal stenosis in these patients was 41,29 days (ranging from 18 to 63 days). One patient had stridor at extubation, after 8 days. An immediate tracheostomy was performed but endoscopy was not done. Patients with tracheal stenosis following tracheostomy presented with failed attempts at decanulation and it is difficult to determine the exact time of onset of symptomatic tracheal stenosis.

The overall average time duration from intubation or tracheostomy to presentation was 49,59 days (Table IV).

TABLE III: ENDOTRACHEAL INTUBATION / TRACHEOSTOMY

	No. of Patients	Average Duration
ETT	8	10,25 days (3-21)
Tracheostomy	3	100 days (30-210)
ETT & Tracheostomy	11	47,9 days (31-81)

TABLE IV: TIME TO PRESENTATION

Range	15 to 84 days
Average	49,59 days

4.4 ASSOCIATED MEDICAL CONDITIONS

Several associated medical conditions were present (Table V). 36% of the patients (8 of 22) had evidence of keloid formation. Five patients had infections (2 septicaemia, 2 pneumonia and one pulmonary tuberculosis).

TABLE V: ASSOCIATED MEDICAL CONDITIONS

Keloid formation	8
Septicaemia	2
Diabetes Mellitus	2
Hypertension	2
Pneumonia	2
Laryngeal stenosis	1
Tracheo-oesophageal fistula	1
Pulmonary tuberculosis	1
Pregnancy	1
Epilepsy	1

Fifteen of the 22 patients were managed in an intensive care unit (Table VI) for their initial pathology and associated medical conditions.

TABLE VI: INSTITUTION INVOLVED IN INITIAL TREATMENT

King Edward VIII Hospital	
- Surgical ward	1
- I.C.U.	6
- Respiratory unit	3
Wentworth Hospital	
- Neurosurgical ICU	6
Addington Hospital	0
R.K.Khan Hospital	2
Peripheral Hospital	4

4.5 ASSESSMENT OF TRACHEAL STENOSIS

The special investigation of patients who presented with symptomatic tracheal stenosis included at least a soft lateral x-ray of the neck and a chest x-ray. Most patients, however, had tomograms of the larynx and trachea. All the patients then had a direct laryngoscopy and rigid bronchoscopy. Seventy-seven percent (17 of 22) of the stenoses were high in the cervical trachea, in the suprastomal region, and 60% (13 of 22) were circumferential in nature, whilst 36% (8 of 22) involved the anterior tracheal wall only (Tables VII and VIII). The length of the stenoses ranged from 0,5 to 3cm and the diameter from 0mm to 6mm, with two patients having total tracheal stenosis (Table IX). Tracheal stenoses that follow after endotracheal intubation only were all circumferential, ranging from 0,5cm to 1cm in length and were situated between 1cm to 4cm below the vocal cords.

TABLE VII: SITE OF TRACHEAL STENOSES

Suprastomal	17
Cuff-site	4
Tip of tube	1

TABLE VIII: NATURE OF TRACHEAL STENOSES

Circumferential	13
Anterior wall	8
Not indicated	1

TABLE IX: DEGREE OF TRACHEAL STENOSIS

	Range	Average
Length	0,5-3cm	1,28cm
Diameter	0-6 mm	3 mm

Only one patient had more than one area of tracheal stenosis. The first stenosis developed at the site of the endotracheal tube cuff. She also had a tracheo-oesophageal fistula at this level. The second stenosis developed after tracheostomy in the suprastomal area.

4.6 MANAGEMENT AND RESULTS

Bronchoscopic dilatations and removal of granulation tissue were the only endoscopic procedures performed and a total of 106 procedures were done; an average of 4,8 per patient. The aim with this procedure was either to avoid an open procedure or, as an interim procedure, until a definitive procedure could be done. Bronchoscopic dilatation on its own was successful, only in one patient with a thin, soft, suprastomal stenosis. It was, however, also necessary after all the definitive open procedures, before decanulation could be achieved.

TABLE X: SURGICAL MANAGEMENT

Procedure	Number	Number Successful
Bronchoscopy & Dilatation & Removal of Granulations	106	1
Tracheostomy - Initial	7	-
- Failure of other procedure	3	-
Excision Fibrosis & T-tube	16	2
Rib Cartilage Graft Tracheoplasty	8	4
Resection & Anastomosis	3	2

The different surgical procedures used and their success rate are shown in Table X. Tracheostomy was performed to provide an alternative airway as part of the initial management in seven patients and after failure of other surgical procedures in three patients. In 16 patients the trachea was incised vertically, the fibrotic tissue excised and a T-tube inserted for varying periods, ranging from 4 weeks to 3 months. This procedure was successful only twice, one of which was done due to failure of a tracheoplasty procedure.

Rib cartilage graft tracheoplasty was done in eight patients with a 50% success rate. Two of those that were successful had a T-tube as stent for three months and one had a solid stent above a Chevalier Jackson tracheostomy tube, for two months. One patient had an endotracheal tube as stent for one week and his cartilage graft later collapsed inwards. This part of the graft, plus fibrous tissue, were excised and a T-tube was inserted for four months, after which he required five bronchoscopic dilatations and removal of granulations before successful decanulation. One of the patients who had a failed procedure has had a T-tube for more than five years now and is doing well and has a good voice. Follow-up in the successful cases ranges from one to eight months.

Resection of the stenotic segment with end-to-end anastomoses was done in three patients only, with two being successfully decanulated. One patient was extubated in theatre and required one bronchoscopic dilatation and the other patient required bronchoscopic dilatation and a T-tube for 16 months before successful decanulation. The one failure now has a long-term T-tube. This patient is prone to excessive keloid formation.

Tendency to keloid formation was evident in eight of the 22 patients in this series; two were successfully decanulated and six had failed procedures.

Six of the cases that had failed procedures were referred to the Thoracic Surgery Department at Wentworth Hospital, for probable resection and anastomosis, because they possibly would have required intrathoracic release manoeuvres.

Two of the patients in this series died at home, both from a blocked tracheostomy tube. The overall outcome of this series is shown in Table XI. Successful decanulation is taken as successful management.

TABLE XI: RESULTS

Decanulated	8
Referred to Thoracics	6
Tracheostomy	4
T-tube	2
Died	2
TOTAL:	22

4.7 COMPLICATIONS

The overall complications in this series are shown in Table XII. Restenosis and the formation of granulation tissue were the commonest problems occurring in 14 and 17 patients respectively.

Granulations were very common when a tracheostomy or T-tube were used. 25% of the patients decanulated (2 of 8) had persistent tracheocutaneous fistulas. Postoperative wound infection and haemorrhage were uncommon.

TABLE XII: COMPLICATIONS

Restenosis	14
Granulations - related to tracheostomy or T-tube	12
- related to open procedure	5
Blocked tube (died)	2
Persistent tacheocutaneous fistula	2
Displacement of cartilage graft	1
Postop haemorrhage	1
Postop wound infection	1

CHAPTER 5

DISCUSSION

It is clear from the results that tracheal stenosis is a difficult problem to manage. Patients require admission for long periods and need several operative procedures. This results in high costs and loss of income.

Despite the fact that this series is too small to warrant statistical analysis, some important conclusions can be made. Although patients of all ages were affected, it was more common in the second and third decades with the average age 28,77 years. Males were much more commonly affected than females and blacks much more than any other race. No white patients were affected.

A great variety of initial pathologies necessitated initial endotracheal intubation or tracheostomy. Head injuries were, however, by far, the commonest (9 of 22). Adult respiratory distress syndrome (ARDS) in five patients was the second most common and was caused by trauma in three cases and septicaemia in another two cases. Trauma was responsible for the initial pathology in 18 cases. Special attention to the prevention of tracheal stenosis should be given in these cases.

Eight patients were managed by endotracheal intubation only. The average duration of intubation was 10,25 days. Whited (1984) has shown an increase in tracheal stenosis after 10 days and that intubation should ideally be no longer than 7 days. Those patients that were managed by endotracheal intubation first followed by tracheostomy (11 patients), had an average time of endotracheal intubation of 8,4 days (5-21 days). If at all possible, one should attempt to restrict endotracheal intubation to 7 days.

Tracheostomy played a role in 14 patients, of whom three had a tracheostomy only and no endotracheal intubation. It is standard technique at this institution to remove a tracheal window during tracheostomy in adults. This probably plays a significant role in the aetiology of tracheal stenosis in these cases. Webb et al, (1973) recommended a longitudinal tracheal incision, which resulted in no tracheal stenosis in their prospective study. A tracheostomy tube that is too large will contribute to chondritis and necrosis at the tracheostome.

Bronchoscopy, immediately following extubation or decanulation, will probably assist in predicting those cases at risk of developing stenosis and, at the same time, allow removal of granulations.

Two other complications of endotracheal intubation were seen in two separate patients, namely tracheo-oesophageal fistula and post commissure stenosis. One patient developed tracheal stenosis at two levels, the first followed after endotracheal intubation and the second after tracheostomy.

Fifteen of the patients in this series were managed in intensive care units. This is where all attempts should be made to prevent the condition. Attention should be given to the following points:

1. Atraumatic intubation.
2. Good technique when doing a tracheostomy.
3. The use of a soft, silicone tube, of the correct size, with a large low-pressure cuff and the correct curvature.
4. Meticulous tracheostomy care.
5. Cuff pressure must be checked and cuff must be deflated 5 minutes, every hour.
6. Prevention of movement of the connecting tubes.
7. Prevention and treatment of infection.

Keloid formation probably played a significant role in the pathogenesis of tracheal stenosis, as 8 of the 22 patients had excessive keloid formation and in 6 of these, surgical management failed. All the patients in this series were non-white and they are especially prone to keloid formation.

Infection probably played a role in the aetiology in five patients of whom two had septicaemia, two pneumonia and one pulmonary tuberculosis.

Investigation should at least include a soft, lateral radiograph of the neck and a chest radiograph, although tomography is preferrable. This is followed by a proper endoscopic examination, which should include laryngoscopy and bronchoscopy. The following points are important in the assessment of the stenosis:

1. Situation
2. Length
3. Diameter
4. Whether circumferential or only anterior wall is involved
5. Involvement or not of the tracheal skeleton.

Most of the cases in this series were high in the suprastomal area and were circumferential. Those cases that complicated endotracheal intubation were all situated high and were all circumferential. The tracheal skeleton were abnormal in all the cases except the one that responded to bronchoscopic dilatation.

Bronchoscopic dilatation as a means of treatment is only effective in very thin stenosis, that is preferably not circumferential. It is, however, very useful as a temporary measure until definitive surgery can be done. Numerous, frequent dilatations may aggravate the stenosis because the same trauma that caused the stenosis is used to relieve it. Bronchoscopic removal of granulation tissue is important to prevent

stenosis, especially to prevent restenosis after a definitive procedure.

Laser resection was not used because a laser bronchoscope is not available in this unit. It is certainly indicated for short stenosis (less than 1cm), especially if it is not circumferential, and for webs that complicated other procedures. The microtrapdoor technique sounds promising in selective cases, although in this series, probably only one case would have benefitted from laser resection.

Tracheoplasty is a very useful procedure if done correctly in selective cases. The excision of fibrosis and stenting by a T-tube alone is not successful and the tracheal wall must be augmented. Composite rib cartilage graft is probably the best material to use for this. Factors that played a role in the 50% failures in this series are:

1. Post-operative sepsis
2. Wrong technique. In all the cases, the graft was inserted just above, and in contact with, horizontal limb of the T-tube. This may lead to unnecessary pressure on the graft and a higher incidence of infection. It is recommended that the horizontal limb of the T-tube be brought out separately through a healthy part of the trachea.
3. Duration of stenting. Those that were stented for shorter periods than 6 weeks failed. A period of three months is recommended.
4. Tendency to keloid formation was evident in two patients.

Free mucosal grafts can be used to line the inner surface of the trachea. The sternohyoid rotary door flap is a technique that was not used, but should definitely be used in future, especially for the longer stenoses and those involving, mainly, the anterior wall.

This unit had little experience in resection of the stenotic segment, with end-to-end

anatomosis, in this series. However, good results were obtained in two of the three cases done. This is clearly the procedure of choice in circumferential stenosis with involvement of the tracheal skeleton and not longer than 4cm. These patients should be extubated in theatre (Grillo 1981, Grillo and Mathisen 1988, Montgomery 1989, p.481, Maggi et al 1990, Wood and Mathisen 1991, Anand et al 1992).

The complications that caused the most problems were the formation of granulation tissue, especially when a tracheostomy or T-tube were used, and restenosis. The tendency to keloid formation was evident in six of the 14 patients with restenosis. Unfortunately two patients died at home with blocked tracheostomy tubes. Home tracheostomy care is a major problem in our community because many patients are from the lower socio-economic group and from rural areas. This forces us to keep patients in hospital for much longer periods.

CHAPTER 6

CONCLUSIONS

Tracheal stenosis is not an uncommon complication of endotracheal intubation or tracheostomy. It is, however, difficult to manage and no simple protocol can be followed. Every case should be managed on it's own merits. The surgeon requires a good knowledge of the anatomy, aetiology and pathogenesis, and all the different surgical options available. Good results depend on proper selection of patients, precise surgical technique and careful post-operative care.

Only 8 of 22 patients in our series were successfully managed. Six others were referred to the thoracic surgery department for further management. Rib cartilage graft tracheoplasties were successful in four out of eight cases and resection and anastomosis in two of three cases. An important factor in the aetiology and prognosis in our institution seems to be the tendency to keloid formation. Eight patients in our series had a tendency to keloid formation and in six of them, surgical management failed.

Factors that should determine the technique used are: involvement of the tracheal skeleton or not, whether the stenosis is circumferential or not, and the length of the stenosis. It is the author's opinion that open procedures should be used when the skeleton is involved and that resection with anastomosis is the best technique in cases with circumferential stenosis. The author suggests the following guidelines:

1. Short stenosis that is very thin and does not involve the skeleton may be managed by bronchoscopic dilatation or laser excision and the microtrapdoor technique.

2. If the skeleton is involved an open procedure should be used.

3. Circumferential stenosis, not longer than 4cm, is best managed by resection and anastomosis.

4. Stenosis that involves only the anterior wall may be managed either by rib cartilage graft-tracheoplasty, or anterior wedge resection and anastomosis, or sternohyoid rotary door flap.

5. Extensive stenosis may be managed by a staged repair and reconstruction of the trachea or by a permanent T-tube.

The author further suggests: a prospective study carried out in the intensive care unit, to determine the factors involved in the aetiology and pathogenesis in our situation, with special reference to the tendency to keloid formation, and also a prospective study regarding the surgical management of tracheal stenosis, also with special reference to the influence of keloid formation on the prognosis.

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