REVIEW ARTICLE

AIRWAY STENTS

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ABSTRACT

Airway stenting is a major component of an integrated Interventional Pulmonology service. The primary indication for stenting is malignant airway stenosis, which is not relieved following initial endoscopic intervention. However stents have also been used in a range of other airway related diseases including conditions which result in benign stenosis, fistula and malacia. Stents fall into 2 broad categories – silicone and metallic. Each is associated with advantages and disadvantages and the choice of stents depend on a number of factors including airway and disease related factors, physician choice and expertise and the available equipment within the endoscopy unit. Silicone stents require rigid bronchoscopy for placement while metallic stents can be placed using flexible bronchoscopy. Irrespective of prosthesis type, stent related complications occur and include migration, stent obstruction from mucus, tumour ingrowth or granulation tissue and stent fracture. Finally, future stent development will include novel drug eluting and biodegradable stents.
Keywords: bronchoscopy, stents

INTRODUCTION

When Charles Stent developed the first custom-made mould of teeth in the 19th century, he was not to know that his name would become synonymous with one of the cornerstones of modern medicine1. Over the last 30 years, stents have evolved from experimental interventions to essential components in many fields of medicine and surgery including cardiac, vascular, urology, ENT and pulmonology. Stents have become an integral aspect in the management of airway disease through the speciality of interventional pulmonology. Although case reports going back as far as 1915 are available in the literature, it was not until the development of the Montgomery T tube in the sixties and the Dumon stent in the mid 1980s that stenting became an integral part of the management of airway compromise from a number of benign and malignant conditions2,3. Indications Indications for airway stenting are shown in table I. The primary indication for an airway stent is to re establish patency of the airway 4. Stenting, whether for benign or malignant disease, should be considered a palliative procedure and hence should be used only when all other treatment options are exhausted or contraindicated due to patient factors such as associated irreversible co-morbid conditions5. In rare situations stents may be used as a bridge to definitive therapy. Examples of this might include cases of benign tracheal stenosis and stent placement in the setting of fistula formation6,7,8.

AIRWAY STENOSIS

Malignant disease

The most common indication for stenting is to recanalise an obstructed airway in the setting of malignant obstruction. This is most frequently secondary to primary lung malignancy. Indeed it is estimated that 20–30% of all patients with a primary bronchogenic carcinoma will pesent with malignant central airway obstruction (CAO), which may result in haemorrhage, dyspnoea, atelectasis, and pneumonia. In addition, after initial treatment, 30–50% of patients will present with local recurrences9. Other thoracic malignancies; thyroid, laryngeal and oesophageal tumours, may directly

invade the central airways causing compromise. Finally all extra-thoracic malignancies have been reported to metastasise to the airway. .

Malignant obstruction of the airway can occur through three mechanisms –extrinsic, intrinsic and a mixed pattern10. Treatment of malignant stenosis is dependent on the type and degree of obstruction. Any pathology, which results in a stenosis greater than 50% of the normal calibre may be an indication for stenting. In most centres stenting is just one component of a comprehensive airway management programme which may include mechanical debulking (rigid bronchoscope), techniques for recanalization which includes immediate effect techniques – laser, argon plasma coagulation and electrocoagulation and delayed effect techniques – cryotherapy and photodymanic therapy11,12. If, however the airway remains compromised after the use of debulking/dilatation with either mechanical debulking or accessory tools, then a stent may be indicated. Splinting with a stent is required more often in the setting of extrinsic compression from malignant nodal involvement or extraluminal tumour. However, in some situations, post debulking, the lumen remains stenosed greater that 50% and a stent may be required. In addition, in cases where an intrinsic tumour rapidly re-obstructs the lumen a decision may be made by the endoscopist to place a stent at the second intervention.

Benign stenosis

Benign tracheal stenosis can occur from a number of aetiologies. This includes airway damage from mechanical (e.g. post intubation (PITS) and post tracheostomy (PTTS)), physical injury (e.g. beam radiation and thermal burn), or chemical (e.g. acid aspiration and mustard gas) injuries 13. Tracheal stenosis secondary to intubation or tracheostomy remains a significant problem despite changes in tube technology. A number of conditions have been associated with this complication including the use of the inert materials, tube size, lateral wall pressure, movement, hypotension, local infection, use of steroids, and the duration of intubation. Although infraglottic stenosis most commonly results from endotracheal tube damage, it may occur after damage of the 1st tracheal ring or cricoid cartilage during tracheostomy

Post Intubation Tracheal Stenosis (PITS)

In the past the widespread use of high-pressure, low volume cuffs were associated with a high risk of stenosis 14. Although high volume low-pressure cuffs and/or early tracheotomy reduce the rate of stenosis at the cuff site they have not totally prevented this complication. The reported incidence of tracheal stenosis following tracheostomy and laryngotracheal intubation ranges from 0.6% to 21% and 6% to 21%, respectively. The pathogenesis for this stenosis appears to be related to the compromise of the tracheal blood supply by excessive mucosal pressure from the inflated cuff. Airway capillary perfusion pressure ranges from 22 and 32 mm Hg. Previous studies have demonstrated that there is obstruction to mucosal blood flow with lateral wall pressures exceeding 22 mm Hg, with total occlusion of flow to the mucosa over the tracheal rings and posterior tracheal wall at a lateral wall pressure of 37 mm Hg. It has been hypothesised that large volume cuffs achieve a sparing effect on capillary blood flow over the cartilaginous rings by applying pressure to the arterioles in the intercartilaginous submucosa, thus raising the effective perfusion pressure.

Post Tracheostomy Tracheal Stenosis (PTTS)

The most important reason for stenosis at the stoma site is damaged cartilage. Risks for stenosis include a large stoma and excessive force whilst placing the tracheostomy tube through the stoma. Wound sepsis and previous cervical or tracheal trauma affect healing of the stoma. In one study; wound sepsis was a causative factor in approximately 42% of the cases of stomal stenosis following open tracheostomy.

Miscellaneous

Benign stenosis can also occur in a myriad of localised and systemic diseases that may affect the airways. This includes tuberculoisis, sarcoidosis, papillomatosis and Granulomatosis with polyangiitis (previous known as Wegener's). Stenosis can occur at the anastmosis site in lung transplant recipients. The reported incidence of this complication ranges from 1.6% to 32%. Two types of stenosis have been reported – directly at the anastomosis site and distant from the site; known as segmental non anastmosis bronchial stenosis with a reported incidence of 2.5 to 3%.

Idiopathic tracheal stenosis

Rarely tracheal stenosis occurs without a definite history of trauma to the airway 15,16. Such cases of idiopathic tracheal stenosis have received attention of late with groups describing the clinicopathological features and the outcomes from a multidisciplinary airway intervention including mechanical or thermal dilatation (rigid, laser or electrocoagulation) and stent placement. In total, 18% of patients received a stent. All procedures were effective; however recurrence occurred in the majority of patients over a prolonged follow up period (87% at 5 years)

Fistula

A fistula is a non-anatomical communication between the airway and an adjoining structure 8. Fistulas can occur between the airway and the oesophagus - (tracheo-oesophageal fistula, (TOF)), mediastinum or pleura (Bronchopleural fistula, (BPF)). Fistulas can be benign or malignant and although the same principles of airway management apply as in airway stenosis, i.e. definitive treatment should be undertaken if possible prior to resorting to stent placement. However, stents may offer excellent palliation and rarely they may act as a bridge to definitive therapy. Post resection fistula can be a devastating complication of thoracic surgery. The incidence of post pneumonectomy and post lobectomy fistula ranges from 4.5% to 20%. The incidence is lower for benign conditions compared to patients with a known malignancy. Sirbu et al reported their experience with 490 patients post lung resection for non-small cell lung cancer. The overall incidence was 4.4% (22/490). Bronchopleural Fistula (BPF) after pneumonectomy occurred in 12 patients (54.6%) and post lobectomy in 9 (40.9%)17,18. The wide variability in incidence is related to a number of factors including the extent of the resection, the resection technique used and the experience of the surgeon. In addition a number of pre and post operative risk factors have been identified. Pre-operative factors include fever, steroid use, H. influenzae in the sputum, elevated erythrocyte sedimentation rate, and anemia. Postoperative risk factors which have been implicated include fever, steroid use, leukocytosis, the presence of a tracheostomy and need for bronchoscopy with excessive suctioning. This is often performed for sputum impaction and/or mucus plugging. In addition, residual tumor at the resection margins, a long bronchial stump, excessive tightness of individual sutures, extensive peribronchial, and paratracheal dissection have been associated with an increased incidence of fistulization. All these factors increase the risk of ischemic necrosis and/or pooling of secretions with subsequent colonization and bacterial overgrowth. Postoperative BPF can also be classified as acute, subacute, or chronic. The acute form is usually related to dehiscence or technical complications and requires early reoperation. The subacute and chronic forms are related to infection in immunocompromised or debilitated patients with associated comorbidities. Postoperative radiotherapy is a risk factor for late bronchopleural fistulas. Complications of BPF include pyothorax, aspiration pneumonia, spillage of contaminated secretions into thecontralateral healthy lung and adult respiratory distress syndrome (ARDS). These complications are frequently resistant to non-surgical treatment and result in significant morbidity and prolonged hospital and intensive care stays. Irrespective of the incidence, this complication is associated with significant morbidity and mortality. Patients are frequently debilitated secondary to the underlying primary diagnosis, recent surgery and in some cases neoadjuvant therapy. The mortality rate amongst patients who develop a fistula post pneumonectomy ranges from 15% to 71%.

Management depends on a number of factors including the underlying etiology, size, time of onset of the fistula post surgery and health status of the patient 19. Surgery is the treatment of choice of this condition but endoscopic techniques have been advocated as an option when surgery is not possible or has to be postponed. In patients with small fistulas, bronchoscopic options have included the use of silver nitrate, ethanol, cyanoacrylate glue, fibrin glue injection, polyethylene glycol, laser and, in cases with large fistulas, stent placement has been attempted - both silicone and metallic stents. Large dehiscences (> 8 mm) are generally considered not to be amenable to successful primary closure using bronchoscopic techniques. However, in this scenario, the role of endoscopic techniques is twofold, to act as a bridge until definitive surgical therapy, thus allowing an improvement in the patients' clinical status before surgery and, in cases that are not fit for further surgery, bronchoscopic intervention may provide adequate palliation of symptoms.

Airway Malacia

Tracheomalacia is defined as a weakness of the trachea due to atrophy of the longitudinal elastic fibers of the pars membranacea, or impaired cartilage integrity resulting in an airway that is softer and more susceptible to collapse20. Multiple interventions have been tried to improve ventilation in patients with severe obstruction secondary to malacia. Stents have also been used to try to stabilize the airway with mixed results. In addition the placement of a stent may only serve to alter the choke point therefore extending the area of malacia. Stenting may be the only available treatment option in patients who are not candidates for surgical intervention. Alternatively in surgical candidates stents may be seen as a stabilizing tool prior to definitive treatment. In addition if patients obtain a good clinical response to a stent it is likely that surgery will result in a favourable outcome. Both metallic and silicone stents have been used with most authors favouring the silicone prosthesis because they have a lower rate of complications in this particular population.

Types of stents

2 major groups of stents are currently in use –silicone and metallic stents 21,22,23. The range of metallic stents includes fully uncovered, partially covered and fully covered metallic stents. In addition stents can be grouped into straight, bifurcating (Y stents) and T tubes. Silicone stents require rigid bronchoscopy for deployment while metallic stents can be placed with flexible bronchoscopy.

Silicone stents

Silicone stents are available in all designs; straight, Y stent and T tube varieties. The gold standard stent remains the Dumon stent (Tracheobronxane®, Novatech, La Ciotat, France). These prostheses are the most widely used stents worldwide. They are made from silicone with studs on the external surface. These studs prevent migration and reduce mucosal ischemia by limiting contact with the airway wall. The stents are available in a wide range of sizes and diameters (up to 18 mm in external diameter and 60 mm in length). This ensures that the stent can be sized to the required length to encompass the stenosis and 0.5 cm of normal mucosa above and below the stenosis. This minimises the length of the stent and assists clearance of secretions and patient tolerance. The rims of each stent are polished to reduce the risk of granuloma formation. In addition, recent advances include radiopaque studs–the Dumon Gold Studded Stent (Novatech, La Ciotat, France). which improves radiographic visualisation. The Dumon silicone stent is also available in a Y design for disease at the level of the carina. Unlike the straight stent, the Y stent is more difficult to place correctly and requires a significant amount of time to position across the carina using rigid grasping forceps. In addition, hourglass stents are available and these are particularly suitable for benign stenosis. Other commercially available silicone stents include the Polyflex stent (Boston Scientific, Natick, Massachusetts, USA). This stent is made from polyethylene threads built into the silicone. The stent may adapt better to an hourglass stenosis when compared to the Dumon silicone stent; however it has a higher migration rate, as it is more easily compressed than the Dumon stent. Other silicone stents such as the Hood stent (Hood Laboratories, Pembroke, MA, USA), and the Noppen stent (MTW, Essen, Germany), are no longer commercially available. All silicone

stents require rigid bronchoscopy for placement. Finally dynamic stents are also available. These have a flexible posterior wall, which mimics the posterior wall of the trachea. This improves secretion clearance.

Self Expandable Metallic Stents (SEMS)

In contrast the metallic stents can be placed with flexible bronchoscopy. These SEMS are available as fully covered, partially covered or uncovered stents. These include the Silmet stent (Novatech, La Ciotat, France), Aero Tracheobronchial Stent (Merit Medical Systems, Inc. Utah, USA), and the Ultraflex stent (Boston Scientific, Natick, Massachusetts, USA). Although SEMS have the advantage of not requiring rigid bronchoscopy, this author believes that the addition of rigid bronchoscopy allows greater airway manipulation and management. In addition the Food and Drug Administration of the USA (FDA) advised caution with the use of metallic stents in benign disease. Many of the concerns raised by the FDA have been discussed previously – stents should only be deployed as a last option after all other treatment options have been explored. In addition, metallic stents should not be used in benign disease as their removal can be difficult and result in major airway trauma and complications. A further advantage of silicone stents is the ability to customise them at the time of procedure. The Marseille group has described a number of customisations to improve the functionality of the stent for an individual's airway. This includes cutting the stent to minimise its impact on the airway and the addition of windows in the stent using the Dutau Forceps (Novatech, La Ciotat, France). This improves ventilation of sub segmental bronchi, which would otherwise be covered24. Finally industry customised stents are available. We previously described two such scenarios where customized stents were necessary, the conical SEMS for post pneumonectomy fistula and a 28mm customised metallic stent to manage severe malacia in a patient with Marfan's syndrome associated tracheomegaly 8,25.

"T" Tube

The Montgomery T tube was first designed by W Montgomery in 1965 and has undergone minimal change since then. The T tube is now manufactured from silicone and comes in a range of lengths and diameters (Boston Medical Products, Inc, Westborough, Massachusetts, USA). It consists of three limbs and is used to treat a high tracheal and glottic stenosis. It requires a tracheostomy for placement. The three limb design allows recanalisation of the airway without risk of migration as the stent is anchored via the limb exiting the stoma. This limb can be closed to allow speaking. Alternatively it can be left open when a high tracheal stenosis still compromises the airway or opened intermittently to allow suctioning of the airway in patients with secretion retention.

Procedure Planning and Stent Placement

A decision to stent the airway should be taken by a multidisciplinary team. As previously discussed, stenting should be viewed as a palliative procedure and in the majority of cases it should be the last therapeutic option. For example in the setting of benign tracheal stenosis, surgical resection is the preferred treatment. However this may not be possible and an airway stent should be assessed as a treatment choice. It is preferable that these procedures are planned and that the patient is reviewed in clinic prior to undertaking the intervention. This allows optimisation of the medical condition and review of all available imaging. In addition the anaesthetist can assess the patient and optimise any reversible conditions. However these cases are often emergencies and are therefore performed with minimal pre assessment. Rigid bronchossopy is required for the placement of silicone stents while metal stents can be placed by either rigid or flexible bronchoscopy. The recent British Thoracic Society (BTS) guideline for advanced diagnostic and therapeutic flexible bronchoscopy in adults does not address silicone stent placement and therefore concentrates on the use of the SEMS 26. Most respiratory physicians have obtained competency in the use of the flexible bronchoscope under local anesthesia. A small proportion will place expandable stents using the flexible scope. Although rigid bronchoscopy does require general anaesthesia it has an advantage over flexible bronchoscopy in that it ensures safe and adequate

ventilation and airway control – removal of large pieces of tumour and control of haemorrhage. However the BTS guideline states that there is limited expertise with this technique amongst respiratory physicians and therefore the recommendation is to perform therapeutic procedures with a flexible scope through either a laryngeal mask or endotracheal tube. However, it is the opinion of this author that all therapeutic airway procedures should be performed with a rigid scope passed into the airway to ensure patency with adequate ventilation. However both the flexible and rigid bronchoscope should be available and most therapeutic endoscopists will utilise both scopes during a procedure.

In addition the rigid bronchoscope provides a wider spectrum of interventions; rapid airway recanalisation through immediate mechanical debulking, use of accessory tools such as laser, APC or coagulation therapy and insertion of stent either silicone or metallic. In addition the flexible scope can be passed through the barrel of the rigid scope thus allowing treatment of lesions located in the distal airway, toileting of the airway and management of disease in smaller sub segmental bronchi. If fiberoptic bronchoscopy is planned as the first intervention in critically ill patients it should be performed in the operating room and the endoscopists should be capable of proceeding to rigid bronchoscopy if the clinical and anatomical findings necessitate it.

Flexible bronchoscopy is performed using an adult bronchoscope with a large working channel (2.8 to 3.2 mm) to allow adequate suction and delivery of laser probes, balloon dilators, and stent delivery devices. Larger stent delivery catheters should be introduced under fluoroscopy after placing external radiopaque markers. Post intubation tracheal stenosis may be classified as simple or complex. A simple stenosis involves the mucosa alone while a complex stenosis is associated with cartilage instability. In the setting of a simple stenosis the stenosis should be radially incised in three locations before serial dilatation with the rigid bronchoscope. In the scenario of a simple stenosis a tracheal stent may not be required, however complex stenosis frequently require stenting to stabilise the airway. Benign stenoses at the level of the main bronchi (after sleeve lobectomy, transplantation etc) can be more difficult to dilate. The stenosis is often extremely tight and may require the use of a balloon or paediatric rigid scopes for the first dilatation.

When the tumour is located at the level of the carina it often straddles the main bronchi. In these situations it is essential to rapidly obtain a viable airway for ventilation. Once ventilatory stability is obtained then further debulking can be performed and the airway can be maintained with a Y stent.

Stent choice

The stent of choice will depend on a number of factors that includes disease and patient characteristics, airway anatomy, physician/surgeon expertise and available equipment. This author's preference is for a silicone stent. Although this necessitates rigid intubation, our unit has the ability to perform this with anaesthetic cover. As stated in the BTS guideline this allows airway stability, adequate ventilation and rapid control of haemorrhage and clot removal. In addition the silicone stent is easily customised and its position can be adjusted with ease after deployment. Finally a silicone stent can be removed with ease if the clinical situation dictates. In our unit, a SEMS is employed when there is a distorted airway with excessive tortuosity; in these situations the silicone stent does not conform to the airway anatomy and, if placed, often results in kinking with ongoing airway stenosis and high risk of complications. The SEMS more easily conforms to this type of airway. In addition, conical SEMS are particularly useful in cases where the diameter of the airway varies from distal to the proximal extremity. However, unlike the recommendation of the BTS guideline, when placing a SEMS our department utilises rigid bronchoscopy and intubation.

Once a decision is made to place a stent, the length of stenosis and required diameter needs to be measured. This can be performed with dedicated measuring forceps. The required stent size is estimated from the diameter of the rigid tube and the length can be measured using a flexible bronchoscope. The size of the stent should exceed the size of the stenosis by 1 cm therefore allowing 0.5cm clearance at the distal and proximal margin. The stent should oversize the stenosis so that there is

adequate radial force to keep the prosthesis in position. Only experienced bronchoscopists who are capable to responding and managing the early and late complications of advanced airway disease should place stents. Therapeutic bronchoscopy should be available to all patients with central airway obstruction. The recent NICE guidance in the UK advises that all cancer networks should offer this service to their patients 27.

COMPLICATIONS

Stent related complications are listed in table II 28,29. Migration All stents can migrate. This risk is highest for a straight stent, however even Y stents can alter position and there have been a few reports of T tube dislodgement. Stent migration can occur early and is usually due to incorrect stent size or as a late complication when there are changes in the stenotic calibre secondary to adjuvant treatments such as chemotherapy and radiotherapy. Migration has been reported in approximately 10% of malignant stenosis and is estimated to be double this rate for benign disease. Even if a stent migrates it is unlikely to cause life threatening complications as long as the lumen is patent. However the patient's symptoms may deteriorate with increasing cough, dyspnoea and/or stridor. When stent migration occurs it mandates repeat endoscopy and stent removal. If the airway remains stenosed then a further larger diameter stent may need to be placed. However if migration occurred due to a clinical response to antineoplastic therapy then further stenting may not be required.

Obstruction

A stent can obstruct due to inspissated secretions, granulation tissue and tumour ingrowth. Mucoid impaction is estimated to occur in 3.6% of all stents. This can lead to airway obstruction in rare cases but is more likely to result in halitosis, superimposed infection and recurrence of symptoms due to airway narrowing. Some patients appear to be more prone to mucus impaction; these include current smokers and diabetics. In addition the underlying disease process may result in muscle weakness and poor cough reflex thus increasing the difficulty to clear impacted secretions. Granulation tissue can obstruct a stent over time. This usually develops at the proximal or distal end of the stent due to the friction forces between the stent and the airway. When granulation tissue narrows the lumen to less than 50% of its normal calibre symptoms are likely to recur. Overall granulation tissue is found in 50% of all cases and becomes clinically significant in 25% of cases. This often requires further intervention including using mechanical or thermal tools to remove the granulation tissue. Occasionally the stent needs to be removed and replaced – often with a longer prosthesis. Tumour ingrowth will occur in all cases of malignant airway disease if no further antineoplastic therapy is administered. In addition when disease progression occurs, tumour growth may lead to late stent obstruction. The obstruction may occur early if a partially covered stent is used because the tumour can readily grow through the uncovered metal matrix. When disease progression occurs in the airway the case should be re-discussed at the multidisciplinary tumour team prior to planning further endoscopic treatment. Frequently the airway can be salvaged by using a longer stent. However the patient's clinical state and life expectancy may mean that a further stent is inappropriate. If a stent is replaced it usually requires a longer prosthesis and therefore a greater proportion of the airway is covered which in turn may increase the risk of mucus retention and impaction.

Stent fracture

This is an important complication that can occur with metallic stents. All metallic stents have been reported to fracture. The Gianturco stent had the highest rate of fracture, reported at 25% with an associated 12.5% rate of fistula formation. There was also a risk of wall and vascular erosion with resulting massive haemoptysis. In addition fracture can lead to the stent becoming embedded in the wall of the airway. This can make stent removal very difficult. Patient management post stent insertion.

Various different protocols have been suggested from different groups to attempt to reduce stent related complications. It is universally agreed that all patients should be given a stent pack documenting

the type and size of stent placed. This acts as an alert to other health care workers if an airway related emergency occurs. Airway clearance may be improved with inhalation. The exact nature of this has not been elucidated and indeed the requirements are likely to alter due to a number of patient and environmental factors. For example mucoid impaction may occur with greater frequency in regions with a dry arid climate. Suggested protocols include mist inhalation, nebulised saline, nebulised hypertonic saline and acetylcysteine inhalation. In addition some authors suggest humidification in the bedroom at night. The surveillance pattern is variable and may include radiological and endoscopic surveillance techniques. It is accepted that if new or worsening symptoms develop it is mandatory to reassess the stent for position and function. In addition some patients will have particular problems with mucus retention and halitosis which may be significantly relieved with direct stent toileting. Finally even if a complication is seen at surveillance it may not necessitate stent removal. This decision must be made by the endoscopist taking into account the patients symptoms, possible future complications if the stent associated complication progresses and the continued need for a stent. For example a single fracture may not require stent removal if the airway remains patent and the fracture is not in contact with the mucosa. However the development of non obstructing granulation tissue may require immediate intervention because progression may significantly compromise the airway in future.

CONCLUSION

Stents are an important tool in the palliation of airway related pathology. However they are associated with a significant complication rate and therefore they should only be used if all other treatment options are exhausted or contraindicated. Stents are grouped into metal and silicone prostheses. It is this author's practice to perform all stent deployments at the time of rigid bronchoscopy to ensure adequate ventilation and control of treatment complications such as tumour debris and haemorrhage. The role of interventional airway management has been strengthened recently by the publication of the NICE guideline, CG121 which states that all cancer networks should offer access to a team capable of providing interventional endobronchial treatments. Finally future advances in stent technology are likely to include biodegradable stents and drug eluting prostheses30,31,32.

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INDICATIONS FOR STENT PLACEMENT

Airway Stenosis
• Malignant
  ○ Primary Lung Cancer
  ○ Direct involvement from thoracic malignancies
  • Thyroid
  • Oesophagus
  • Larynx
  ○ Extrathoracic malignancy
• Benign
  ○ Post intubation (PITS)
  ○ Post tracheostomy (PTTS)
  ○ Stenosis at site of airway Anatomises
  ▪ Post transplant
  ▪ Post resection
  ○ Sarcoidosis
  ○ Tuberculosis
  ○ Granulomatosis with polyangiitis
  ○ Idiopathic Tracheal Stenosis
Airway Fistula
• Benign
• Malignant
Tracheomalacia

Table I: Indications for stent placement; PITS, Post Intubation Tracheal Stenosis; PTTS, Post Tracheostomy Tracheal Stenosis.

STENT RELATED COMPLICATIONS
Halitosis **Infection** • Stent Biofilms **Obstruction** • Mucoid Impaction • Granulation tissue • Tumour Ingrowth Migration Fracture

Table II: Stent related complications and management

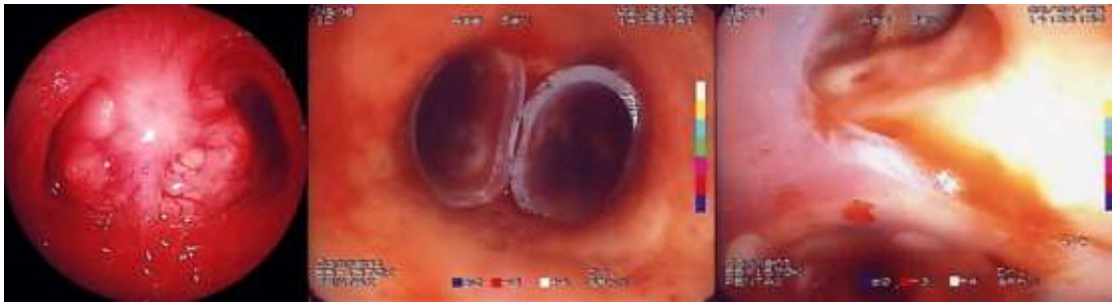

Figure I: A tumour at the level of the main carina. Post mechanical debulking, 2 silicone stents were placed. The right stent had a window cut to allow ventilation of the right upper lobe. [Courtesy Dr Hervé Dutau]

Figure II: Self Expandable Metallic Stents (SEMS). These are available in fully covered, partially cover, uncovered and custom made conical stents. Novatech, LaCiotat, France. [Courtesy Dr Hervé Dutau]

Figure III: The Dutau forceps (Novatech, LaCiotat, France). Courtesy Dr Hervé Dutau.

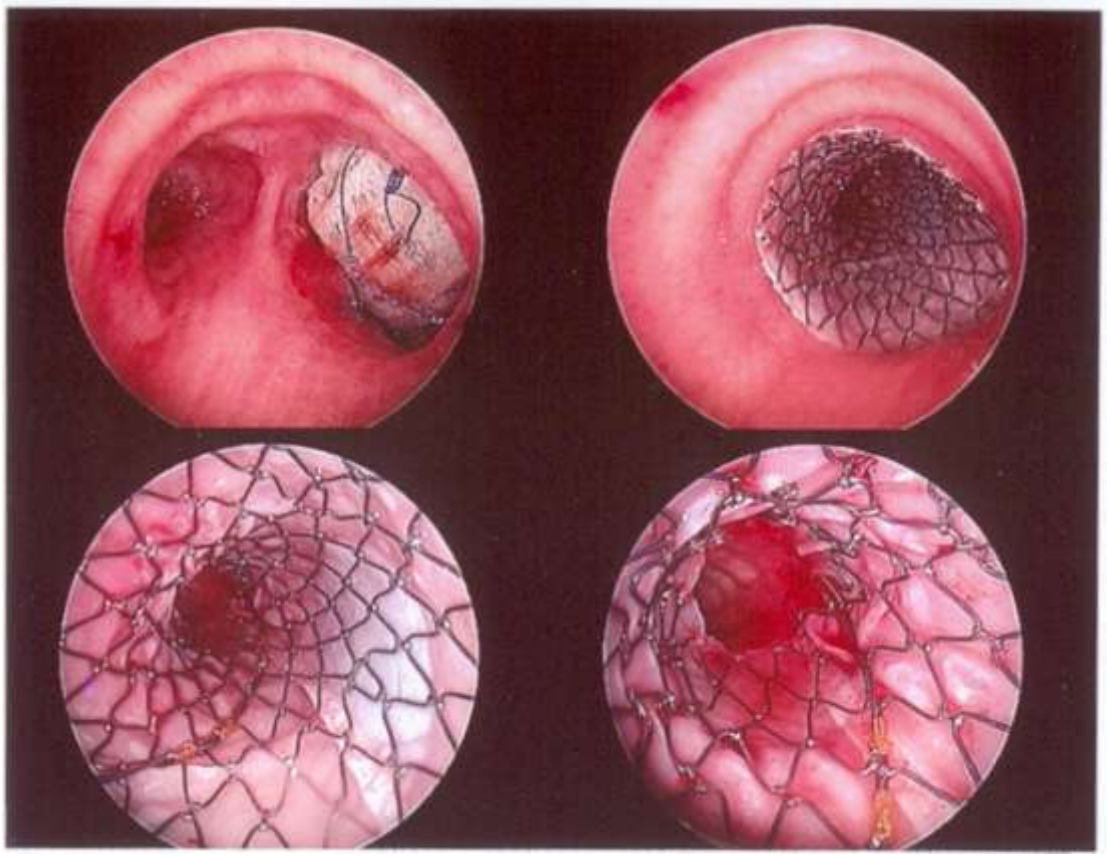

Figure IV: The use of a custom made conical stent (Silmet, Novatech, LaCiotat, France to cover a large post pneumonectomy fistula. Courtesy Dr Hervé Dutau