

Various Types of Tracheobronchial Stents: Recent Updates

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Abstract

Airway stenting is a form of palliative therapy for patients with airway obstruction due to a variety of causes, the most common being central airway obstruction (CAO) due to a malignant lesion.

Keywords: Tracheobronchial Stents; Airway Stenting; Central Airway Obstruction (CAO)

Introduction

Airway stenting is a form of palliative therapy for patients with airway obstruction due to a variety of causes, the most common being central airway obstruction (CAO) due to a malignant lesion.

Airway stents are prosthetic supports used to maintain the patency of the airways and facilitate breathing. A stent is a cylindrical and hollow structure that helps to maintain the patency of the airway lumen and provide necessary support.

Stents derive their name from the British dentist Charles Stent, who created dental splints in the nineteenth century.

Airway obstruction may occur due to a variety of malignant and benign causes, requiring the introduction of an airway stent in order to maintain the patency of the airways.

Stents may be introduced into the large and smaller airways for a number of reasons [1], the most common being, airway narrowing from external compression due to a malignant lesion, endobronchial obstruction due to a malignant tumour or a benign adenoma, a combination of endobronchial and extrinsic compression due to a malignant tumorous process, malignant infiltration causing a tracheoesophageal fistulous tract, tumour infiltration causing loss of cartilage support, benign tracheobronchial strictures causing airway narrowing, tracheobronchomalacia, fibrotic scars or bottleneck strictures, benign tumours such as papillomatosis and amyloidosis and post-transplant airway stenosis.

Airway stenting is now an important therapeutic part of endoscopic management of benign and malignant airway obstructive lesions. An emergency stent insertion into the airways often helps in the immediate relief of breathlessness in a patient with endobronchial infiltration due to any cause [2-4].

Over the long term, airway stenting has also been shown to cause a significant improvement in airflow obstruction, on lung function testing [5-7].

Studies have also shown a significant improvement after stent placement in the Eastern Cooperative Oncology Group (ECOG) performance score, in patients with lung cancer [2,8].

Various types of airway stents

An ideal airway stent would be one which had the following mechanical characteristics [9] namely, stability, availability in all the required sizes, adequate flexibility to adapt to different luminal irregularities, biocompatibility with human airway tissue so that it is non-irritating, strength to withstand external compression primarily from malignant lesions, resistance to migration from the place of insertion, easily deployable into the airway tract and easily removable and successful as a barrier to the infiltrative growth of a rapidly progressive tumor.

Unfortunately, to date, technology has been unable to manufacture an ideal stent which could incorporate all the above mentioned physical characteristics. However, it is hoped that in future, 3-D printing may help to make significant advances in the pursuit of an ideal airway stent.

Stents are made of various materials and are available in many sizes and varying shapes.

The main classes of stents include:

- Silicone
- Stainless steel
- Nitinol, and
- Hybrid stents.

The following are the types of airway stents available at present.

Montgomery T-tube

It is manufactured by Boston Medical Products, Westborough, MA, USA. It is placed using the Kelly technique. The adult stent has a vertical limb of 10 - 16 mm and a horizontal limb of 8 - 11 mm.

The pediatric stent has a vertical limb of 6 - 9 mm and a horizontal limb of 6 - 8 mm. In this stent, the horizontal limb helps to prevent the migration of the stent.

Tubular silicone stent

It is manufactured by Boston Medical Products, Westborough, MA, USA, Hood laboratories, Pembroke, MA, USA and Bryan Corporation, Woburn, MA, USA. It is inserted into the airways using a rigid bronchoscope and its size ranges from 9mm x 20mm to 20mm x 80mm. Migration of the stent is prevented by using external silicone studs and by applying direct pressure on the walls of the airways.

Silicone Y-stent

It is manufactured by Novatech, Grasse, France, and Bryan Corporation, Woburn, MA, USA.

It is placed in the airway using either rigid bronchoscopy, direct laryngoscopy with 'pull technique,' or modified laryngoscopy with 'push technique.' The stent is available in a wide range of sizes, ranging from 14 mm x 10 mm x 10 mm to 18 mm x 14 mm x 14 mm. This stent normally does not migrate after it is properly fitted because of its Y-shape.

Dynamic or Freitag stent

This stent has an outer construction made of silicone with C-shaped stainless steel support struts. It also has BA+ sulphate impregnation for increased radio-opacity. It is manufactured by Boston Scientific, Natick, MA, USA. It is inserted into the airway either by direct laryngoscopy with 'pull technique,' or modified laryngoscopy with 'push technique.'

It is available in 3 sizes, namely, 11 mm x 8 mm x 8 mm, 13 mm x 10 mm x 10 mm and 15 mm x 12 mm x 12 mm. The tracheal length of the stent is of 110mm, while the right bronchial arm is 25 mm and the left bronchial arm is 40 mm in length.

The Y-shape of the stent prevents its further migration, following its successful insertion into the tracheobronchial tree.

Merit Endotek or Alveolus stent

Alveolus stent is a fully-covered hybrid stent with a dedicated deployment device and specially designed airway measurement device.

It has a laser-cut nitinol or nickel-titanium alloy structure with a polyurethane cover.

It is manufactured by Merit Medical systems, South Jordan, Utah, USA. This stent is placed using flexible bronchoscopy under direct visualization or flexible bronchoscopy with wire-guided fluoroscopy. It may also be inserted using rigid bronchoscopy with direct visualization.

This stent is available in sizes ranging from 8 mm x 15 mm to 20 mm x 80 mm. This stent has anti-migration fins that strongly embed into the airway mucosa.

Ultraflex stent

This stent has a woven nitinol or nickel-titanium alloy structure with or without a polyurethane cover. It is manufactured by Boston Scientific, Natick, MA, USA.

It can be placed in the airways using flexible bronchoscopy with wire-guided fluoroscopy or rigid bronchoscopy under direct visualization.

This stent is available in sizes ranging from 8 mm x 20 mm to 20 mm x 80 mm.

This stent comes in a compressed state and is delivered to the desired site in the airway by slowly removing a suture that secures the stent in place. This stent has 'shape memory' and it is able to self-adjust to changes in the bronchial size without any shortening, after it has been deployed. It also deforms at cold temperatures, while regaining its original shape at higher or body temperatures.

In the uncovered ultraflex stent, pressure on the walls of the airways and formation of granulation tissue prevents migration, while in the covered ultraflex stent the proximal and distal 5 mm of the stent are uncovered, to prevent migration.

Balloon-expanding stents

These stents are made of stainless steel fully-covered in two layers of polytetrafluoroethylene.

This stent is manufactured by Atrium iCast, Maquet Getinge, Hudson, NH, USA. It is inserted into the airways using flexible bronchoscopy.

The size of this stent ranges from 5 mm x 16 mm to 10 mm x 38 mm. Migration of this stent is prevented by direct pressure on the wall of the airway.

Polyflex stent

The Polyflex stent is a hybrid self-expanding stent. It has a polyester mesh on the outer side which is covered with silicone. It is manufactured by Boston Scientific, Natick, MA, USA. It is inserted by rigid bronchoscopy under direct visualization.

The size of this stent ranges from 8 mm x 20 mm to 22 mm x 80 mm. Direct pressure of the stent on the airway wall prevents migration of the stent, after placement.

Silicone stents

Silicone is made of silicone elastomers or polydimethylsiloxane. Silicone stents are stable at high temperatures, firm, and cause very slight tissue reactivity. Silicone stents can be easily molded thereby offering greater flexibility. When silicone is combined with polypropylene, polyamide and carbon fibers, it develops greater mechanical strength and resistance [9,10].

Silicone stents are less expensive. They also have good expansile strength to resist extrinsic compression. If needed, these stents may also be altered in size by cutting a portion of it, so as to enable them to adapt well to the airway anatomy, prior to deployment.

Silicone stents are available in various shapes, sizes and diameters.

In cases of bilateral bronchial involvement, "Y"-shaped stents are indicated so as to maintain the carinal position and also to prevent migration of a distal tracheal stent.

Silicone stents can also be easily repositioned or removed, if required. However, tubular silicone stents have a risk of migration, and repositioning may be required [11].

It must be remembered that ignition during endobronchial treatments such as laser therapy is also a distinct possibility, and care should be taken to prevent that.

The three most widely used silicone stents are the tubular stent, the Y-stent and the Montgomery T-tube stent. Studies have shown a migration risk of 9.5% and obstruction due to secretions of 3.6%.

Metallic stents

In comparison to silicone stents, metallic stents have a more advantageous internal-to-external diameter ratio, resulting in a wider airway lumen on insertion.

They also have a lower chance of migration [12] and are radio-opaque, making it easy to detect them on radiography.

Uncovered metallic stents can be difficult to remove, and tumor or granulation tissue may aggressively grow through the mesh/stent orifices.

In some cases, complications such as airway or vascular perforation [13] have been reported.

Currently, the scope of uncovered metallic stents is somewhat limited. However, they are indicated in conditions such as anastomotic dehiscence following lung transplantation, where a stent may be required [14].

The most popular new generation stents are made of nitinol which is an alloy of titanium and nickel. Nitinol is a highly elastic bio-material that can undergo large changes in size and shape. Stents made of nitinol have “shape memory” that reduces the risk of airway perforation, because they do not change in length once they have expanded and are elastile enough to change in shape with coughing [15].

Hybrid stents

Hybrid stents or covered metallic stents incorporate the benefits and minimize the shortcomings of silicone and bare metal stents. These stents have incorporated the polymer and metal alloy technology to good advantage. Covered metallic stents cause minimal in-growth of granulation tissue and are easier to manipulate on insertion. The covering material over hybrid stents is usually polyurethane, polytetrafluoroethylene (PTFE) and silicone.

Some of the covered metallic stents have a small loop at the proximal end that can be grasped, causing a partial collapse of the stent, thereby facilitating its easy removal.

However, the disadvantage of the stent cover is that it sometimes allows sputum retention and subsequent obstruction, as seen with silicone stents.

Conclusion

Airway stenting is an invaluable palliative bronchoscopic procedure in the management of airway obstruction. Even so, airway stents come with their own set of complications, and medical science is yet to find an “ideal airway stent”.

In the last few years, there have been attempts to create bioabsorbable stents [16] and airway replacements using aortic allograft. These may be useful in future, for patients with complex strictures of the tracheobronchial tree.

Bioabsorbable stents are still prototypes, and their long-term success or failure rates are as yet unknown. Since, the available stents have not always been known to be suitable in every patient, many studies are now exploring the possibility of 3-D-printed airway stents [9,17,18]. This could prove to be an exciting field of research.

It is the constant endeavor of medical science to significantly reduce long-term complications arising from airway stenting. Hence, to-date, the search for an ideal airway stent continues.

Conflict of Interest

None.

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