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Tracheobronchial stents in children

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ABSTRACT

Tracheobronchial obstruction is infrequent in children and still remains a challenging matter of concern. Management alternatives vary from conservative treatment to complex surgical techniques or endoscopic interventional procedures. Airway stenting in children is relatively recent and follows the trail of the experience in adult patients. Nevertheless, there are basic differences between both age groups like the benign nature of most obstructions and the small size of the pediatric airway. These specific features raise the issues of the precise role of tracheobronchial stenting in children and the selection of the most adequate device. Stents fall into four main categories according to the material they are made of: metallic, plastic, hybrid, and biodegradable. Each type has its own advantages and drawbacks so the ideal stent is not yet available. Despite increasing experience with stenting, definite clinical criteria for their use in children are yet to be established. Even so, there seems to be a basic general agreement that stents may play a role in particular clinical settings in which there are no other therapeutic options.

Introduction

Endoluminal airway stents are manufactured artificial hollow devices that are placed in the trachea or bronchi of patients in order to maintain lumen patency. There is a large experience with airway stents in the adult population and the first reports date from nearly 100 years ago.[1] In this setting, stenting is used for both benign and, more frequently, malignant tracheobronchial obstruction. Stents may also be employed as a temporary measure to prevent restenosis when airway reconstruction has been performed[2,3] or as a palliative treatment in selected cases of acquired tracheoesophageal fistula (TEF).

Airway stenting in children follows the trail of the adult practice; but in our context, it is mainly used for treating tracheobronchial obstruction due to benign stenosis or malacia.[4,5] These conditions are infrequent in the pediatric age group but their management is challenging because of the specific characteristics of the lesion and the small size of the airway in infants and neonates.[6,7] Increasing experience with endoscopic stent placement in children, together with the availability of new types of devices, are making this technique more attractive with a significant number of reports addressing this topic. Nevertheless, most of the publications are case reports or small series of patients pointing out that airway stenting in children is, in contrast to what happens in adults, not yet a well-established procedure.[4] As a general rule, stenting is not a first-line treatment and it is usually used in very sick children when other surgical or endoscopic procedures have failed or are not indicated.[4,5]

This article is focused on the indications for airway stenting in children, the different types of devices and their technical features, stent-related complications, and ongoing research in this field. Stenting as a complementary measure after reconstructive laryngotracheal surgery will not be addressed herein.

Indications for stent placement

Tracheobronchomalacia (TBM)

Airway malacia is a rare condition in children and may be congenital or acquired. The congenital type is probably the most frequent cause of tracheobronchial obstruction in children.[7] In this setting, the tracheal wall is abnormally soft and posteroanterior collapse occurs during expiration. Segmental tracheomalacia (TM) is the most frequent situation but in some cases all the tracheae or even the bronchi can be affected. Airway malacia may be primary (isolated) or secondary to other anomalies. The latter type is more frequent and it is associated to other congenital malformations such as esophageal atresia (EA) with TEF, vascular rings, or mediastinal masses.[7] In some rare cases, it can be caused by the accumulation of metabolic products like it happens in mucopolysaccharide storage disorders.[8]

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Several issues have been addressed when trying to explain the etiology of TBM. In some instances, there can be some kind of structural anomaly in the tracheal or bronchial wall like hypoplasia, dysplasia, or a lack of normal cartilaginous support. Alternatively, the airway may show a decreased ratio between the anterior cartilage ring compared to the membranous posterior part resulting in an elliptic-shaped lumen.[9] When TM is secondary to EA with TEF, the enlarged upper esophageal pouch may compress the fetal trachea posteriorly affecting its normal development.[10] External compression to the trachea or main bronchi caused by vascular rings, enlarged pulmonary arteries, or cardiac cavities, may produce airway collapse or malacia as well.

The clinical manifestations and diagnostic work-up in children with TBM are well known and have been addressed elsewhere.[4,11,12] Patients with mild-to-moderate respiratory symptoms do not require intervention because spontaneous resolution can be expected by the second or third year of life. Children who cannot be extubated or who show severe symptoms such as apnoeic episodes ("dying spells"), cyanosis, or recurrent pulmonary infections, are candidates for surgical or endoscopic treatment.[7] Aortopexy and/or surgical relief of external compression of the airway are still the mainstay of treatment in severe TBM. Excellent results have been reported with aortopexy, especially in cases of TM secondary to EA with TEF, but with malacia involving the main bronchi it seems to be not so effective.[13–15] Pexy or suspension techniques can be performed with other mediastinal vessels, such as the pulmonary arteries, or even with the trachea and main bronchi but experience is short and information scarce.[16–18] Still, there are some cases with severe clinical symptoms in which pexy procedures have failed or are not indicated. In this scenario, the only available alternatives are a tracheostomy with a long adjustable tube together with long-term ventilatory support or the placement of a stent.[4,5] Several reports have addressed the feasibility of stenting as a therapeutic option for severe TBM in children.[5,19–22] The distinctive features of each type of stent will be discussed below.

Airway stenosis

Assuming that almost all airway stenosis in children are benign, they can be classified according to their etiology (congenital or acquired), or their morphology and biomechanical properties.[7,23]

Congenital tracheal stenosis (CTS) is a rare structural obstructive lesion of the airway usually caused by complete tracheal rings.[24] Although most of the diagnosed cases show severe respiratory symptoms, there is considerable variation in both morphology and prognosis. The CTS have been classified according to clinical aspects or the length of the stenosis.[25–27] Recently, Speggiorin et al.[28] have proposed a new morphologic classification considering bronchial involvement as well. Associated cardiovascular anomalies are frequent and may have a significant prognostic impact in patients with CTS.[29] Slide tracheoplasty has emerged as the treatment of choice in symptomatic patients and simultaneous correction of concomitant vascular anomalies is highly recommended.[24,27,30] Although some reports describe initial treatment of CTS with metallic stents,[31,32] this approach is not shared by most authors and airway stenting is confined to the management of post-surgical complications.[24,27] In a recent revision, Butler et al.[33] reported that stenting was required in 22 of 101 patients with long-segment CTS treated with slide tracheoplasty. This data demonstrates the important role of airway stenting in patients with CTS.

Acquired tracheal stenosis (ATS) is infrequent in the pediatric age group and is usually secondary to endotracheal intubation or tracheostomy tubes. A long-standing cuffed endotracheal tube may cause mucosal damage and secondary scarring resulting in a tracheal stenosis. Burns, trauma, previous airway surgery, and infectious diseases such as tuberculosis or histoplasmosis, and Wegener's granulomatosis may also be responsible for ATS.[7] In some very unusual cases, no etiology can be found so it is called idiopathic.[34] Clinical symptoms showed by patients with ATS are similar to those exhibited in any type of tracheobronchial obstruction. Management depends on the severity of the lesion and the morphologic type of stenosis. In simple stenosis, the cartilaginous framework of the trachea is not involved; but in the complex type, there is transmural damage.[7] Simple stenosis is more frequent in children and is classified into two subtypes—inflammatory and web-type stenosis. These lesions can be managed initially with endoscopic techniques such as balloon dilation or laser photoresection. In complex stenosis, also called "bottle-neck" type, surgical resection is indicated. If this treatment fails, or is not feasible, airway stenting may be a good option.[7,35,36]

Tracheal stenosis due to malignant tumors invading or compressing the airway is very uncommon in children. Neurofibromas, fibrosarcomas, and some mediastinal metastases may cause some degree of tracheobronchial obstruction that can be managed temporarily with a stent.[4]

Other indications

Stenting has been widely used as a complementary measure after airway surgery. The aim is to maintain the trachea or bronchi open during the healing process. These stents are usually endoscopically removed days or weeks after the surgical procedure.[4,37]

Bronchial stenosis after lung transplantation is another indication for stent therapy. This complication is assumed to be caused by poor local perfusion at the site of the bronchial anastomosis. Although balloon dilation may offer initial satisfactory results, stenting can be considered in order to obtain long-term bronchial patency.[4,38]

Stent types

Airway stents can be classified according to different criteria—indication, anatomical position, insertion technique, or whether they can be removed or not.[23] However, the most popular classification has to do with the type of material they are made of. In this context, stents are divided into the following four major groups: (1) metallic stents, (2) plastic or silicone stents, (3) hybrid devices, and (4) biodegradable stents.

Metallic stents

Metal mesh stents were initially developed for endovascular purposes in adult medicine. Following this experience, they have been used in other organs and are available in small sizes suitable for the pediatric tracheobronchial tree. There is a great variety of metal stents according to their specific design, stability, elasticity, radial force, and tissue tolerance.[4] From a technical standpoint they are relatively easy to place in the airway through a rigid bronchoscope, or even an endotracheal tube, with fluoroscopic control. They do not interfere with mucous clearance and migration is infrequent.[5] On the other hand, granulation tissue formation is a matter of concern and most authors consider metallic stents permanent once inserted.[12,39,40] Other reported complications are fracture due to material fatigue and erosion into the tracheobronchial wall. Ventilation and clearance of secretions are possible with this type of stent because the metallic mesh is permeable permitting its placement over bronchial openings. Metallic stents have a very good diameter/wall thickness ratio leaving an ample lumen for airflow.[4] These devices can be divided