Treatment of congenital tracheal stenosis by balloon-expandable metallic stents in paediatric intensive care unit

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Abstract

The aim of this study was to evaluate the use of balloon-expandable metallic stents in the treatment of children with congenital tracheal stenosis in whom conventional therapy has failed. From 2010 to 2011, balloon-expandable metallic stents were implanted into the trachea of eight infants aged 2–20 months in the paediatric intensive care unit. The infants had severe airway obstruction caused by congenital tracheal stenosis. Tracheal stents were placed after intraluminal balloon dilatation of the tracheal stenosis, inserted with balloon catheters and implanted into the desired position bronchoscopically. The stents were 12 to 29 mm long and 4 mm in diameter. Seven children were relieved of airway obstruction after this procedure. However, a child died due to severe sepsis after the placement of bronchial stents. No granulation tissue developed over the stents in any of the children. Stents have been in place for 1–6 months after insertion without any other complication. Balloon-expandable metallic stents are effective in relieving airway obstruction by congenital tracheal stenosis in children. This technique may provide an important remedy for congenital tracheal stenosis in children.

Keywords: Congenital tracheal stenosis • Balloon-expandable metallic stents • Paediatric intensive care unit

INTRODUCTION

Congenital tracheal stenosis is an innate narrowing of the trachea causing airway obstruction. This condition is common in children in a paediatric intensive care unit (PICU), but, in such occurrences, it presents particularly difficult problems in the PICU [1]. Treatment of an airway obstruction caused by congenital tracheal stenosis is challenging. Surgery is the standard treatment for a severe congenital tracheal stenosis, which can be in the form of tracheoplasty [2]. However, reconstructive surgical procedures may be difficult for small children with problematic respiratory symptoms. Therefore, these interventions are usually associated with several serious complications and mortality in high-risk children. Neonates with a congenital tracheal stenosis have the greatest risk of operative mortality [3]. Therefore, airway stenting may be an appealing idea for children with these problems [4]. Although Loeff et al. [5] described the use of a stent to treat a large airway obstruction caused by these conditions in a child, and, since then, a few articles have described the use of paediatric airway stents [6, 7], we have been the first to treat congenital tracheal stenosis by stents in mainland China. In this study, we report eight successful cases of congenital tracheal stenosis that were treated with balloon-expandable metallic stents.

MATERIALS AND METHODS

Eight children with congenital tracheal stenosis presenting severe airway obstruction were treated at Bayi Children’s Hospital Affiliated to the General Hospital of Beijing Military Command in Beijing, China. The mean age at the time of the initial procedure was 6.6 months with a range of 2–20 months. The diagnosis of congenital tracheal stenosis was confirmed by bronchoscopy and computer tomography. Informed consent was obtained in all cases, outlining all the complications including airway perforation, infection, dislodgement and obstruction. The balloon-expandable metallic angioplasty Rapamycin-coated stents (PARTNER; Beijing) are made of stainless steel mesh and available in various lengths and diameters. The length of the stents is based on the measured length of the abnormal tracheal or bronchial segment, and the correct diameter is estimated based on the diameter of the adjacent unaffected trachea or bronchus. All stents were placed through a 2.8-mm bronchoscope, positioned in the airway segment and expanded. Balloon expansion was achieved with a standard angioplasty syringe equipped with a pressure gauge. A pressure of 18–22 atm was applied to inflate the balloon and stent. The appropriate selected balloon diameter corresponds with the estimated diameter of the trachea or bronchus. The expanded stent and the condition of the tracheal mucosa were viewable through the bronchoscope. The position and expandability of the stent were also observed on the display. Bronchoscopic examination, performed immediately after stent placement, confirmed the proper location. A postoperative chest X-ray film provided radiographic documentation.

All children with stent placement underwent conventional radiography 1–3 days after stent placement to verify the state of expansion and the stent position. Bronchoscopic examinations...
were performed 1 week after stent placement, followed by monthly check-ups. Subsequently, patients’ families were contacted by telephone every month. Information was obtained in the following areas: technical success, clinical success, complications and long-term prognosis. Technical success was defined as successful stent placement at the appropriate location within one session. Clinical success was defined as ventilation weaning, extubation or improvement of dyspnoea after stent placement.

RESULTS

Table 1 shows the summarized information of each of the eight cases. Seven out of the eight patients had concurrent congenital heart disease and were at the time also undergoing surgical correction for their congenital heart disease. The age of the children at the time of stent placement ranged from 2 to 20 months. Three of the eight children required two stents, and five children required one stent each. Table 1 shows the list of the sites of stent placement, wherein a total of eleven stents were placed in the lower trachea and the bronchi.

Five of the eight children were weaned from mechanical ventilation, and two had long-term relief from airway obstruction. The longest follow-up period was 10 months. There have been no complications associated with dilation of the stents. However, a child died of severe sepsis 1 month after the placement of bronchial stents. After the stent placement, the child was not weaned from mechanical ventilation. At the post-mortem examination, the left bronchus was patent, the stent was mucosalized, the right bronchus was nearly clear with no granulation tissue, and the source of sepsis could not be identified.

DISCUSSION

The treatment of congenital tracheal stenosis is challenging. Treatments include tracheal resection, tracheal grafting, tracheoplasty and bronchoscopic methods [8]. Bronchoscopic methods are frequently successful in treating major stenosis of the trachea. For this condition, balloon dilation with an expandable metallic stent was used. The use of stents has recently become an option for treating large airway obstruction in children. These successes have led to their use in cases of tracheobronchial malacia, airway collapse after tracheal reconstruction and airway compromise from extrinsic compression. Although surgical repair of narrowed or collapsed large airways remains the best treatment option, airway stenting provides an alternative treatment for children who cannot handle surgery. Particularly in order to save children in PICU, we have implanted stents to treat them.

The two types of metal stents are balloon-expandable and self-expanding. These were originally intended for angiographic applications in adults. The stents are obviously not ideal for the trachea and bronchi of children because they were designed for adult arteries. Nevertheless, they can be used successfully, provided the device has the correct specifications. The type of stent used depends on the location and nature of the underlying disorder and the age of the child.

Balloon-expandable metallic angioplasty stents are now available for treating tracheomalacia and bronchomalacia in children. These stents feature small size, accurate placement and precise luminal diameter, and have great advantages [9, 10]. In this study, the application of stents was successful in treating tracheomalacia, which may occur after tracheoplasty. Severe airway obstruction in our patients and the absence of a reasonable alternative led us to consider the use of bronchoscopic stents. Similar to the self-expanding metallic stents, the wire mesh design of the balloon-expandable metallic angioplasty stents was found to preserve mucociliary clearance and to hinder the movement of the stent. In addition, the balloon-expandable metallic stents can be placed over a bronchial segment with no apparent adverse effects. None of the children in our series experienced granulation tissue, pneumonia or bronchiectasis after stent placement.

Our experience involves only a few cases with a small number of patients. The possible long-term risks of this procedure and the metallic stent in situ are restenosis by recurrent granulation tissue, failure of tracheal growth with age and tracheal erosion or penetration to the great vessels. The long-term effects of this procedure are not predictable; however, the short-term result is satisfactory. From our limited experience, balloon-expandable metallic angioplasty stents are retained for prolonged periods to relieve a tracheal obstruction. Moreover, this technique is an important remedy for difficult treatment conditions for infants and children with congenital tracheal stenosis. The long-term implications of this treatment method require evaluation for further clinical trials [11].

The main complication of using balloon-expandable stents is granulation tissue formation; thus, it is necessary to observe the role of self-expanding stents in the adult population. Moreover, none of the stents had granulation formation in our series. Rapamycin-coated stents could prevent granulation formation.
during the process [12]. The original thought about metallic airway stents is that they should be removed when they are no longer necessary. The long-term effect of balloon-expandable metallic stents in children is unknown; our longest update lasted for 6 months. As the children grow, dilations may possibly be required. The maximum internal diameter is variable with the size of each stent. When necessary, a larger stent could be implanted and expanded to provide support.

The indications for stent placement include lower tracheomalacia, bronchomalacia, the combination of tracheobronchomalacia, and midtracheal stenosis. Tracheal inflammation is not regarded as an indication. Hence, balloon-expandable metallic angioplasty stents should be applied only in cases of lower tracheomalacia and bronchomalacia untreatable by conventional means. Another accepted indication for airway stenting is stenosis after paediatric airway reconstruction. There was a significantly higher finding of airway malacia in children, laryngomalacia being the most common. Patients showed significant respiratory distress, including retraction and stridor, the most common indications for performing airway stenting [3].

In conclusion, balloon-expandable metallic angioplasty stents play a significant role in treating severe paediatric congenital tracheal stenosis. Their use should be restricted to very limited situations, in which conventional therapy has failed, to save children in PICU. Several valuable lessons have been learned from this small group of patients. The idea of stent selection and placement leads to improved future outcomes and broadens the indications for a certain procedure. In the future, absorbable or temperature-sensitive stents will have greater advantages over currently available metallic stents.

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REFERENCES