



## Operative techniques

# Use of a microporous polytetrafluoroethylene catheter balloon to treat refractory esophageal stricture: a novel technique for delivery of mitomycin C

Manraj K.S. Heran<sup>a,\*</sup>, Tuan H. Pham<sup>c</sup>, Sonia Butterworth<sup>b</sup>, Ashley Robinson<sup>a</sup>

<sup>a</sup>Department of Radiology, BC Children's Hospital, Vancouver, Canada V6H 3V4

<sup>b</sup>Division of Pediatric Surgery, BC Children's Hospital, Vancouver, BC, Canada V6H 3V4

<sup>c</sup>Division of Pediatric Surgery, Cardon Children's Medical Center, Mesa, AZ, USA

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### Abstract

**Purpose:** Endoluminal application of mitomycin C shows promise as a nonsurgical approach to treating recalcitrant stricture but requires precise delivery to prevent mitomycin-mediated injury to adjacent normal mucosa. We describe a novel technique that uses a microporous polytetrafluoroethylene catheter balloon to endoluminally deliver mitomycin C to the target tissue while minimizing nontarget drug application.

**Materials and Methods:** A newborn infant with proximal tracheoesophageal fistula and distal atresia underwent an uncomplicated repair. However, he developed recurrent esophageal stricture resistant to multiple attempts at pneumatic dilations. An image-guided endoluminal radiologic approach that uses microporous polytetrafluoroethylene catheter balloon was developed to precisely deliver mitomycin C to the mucosal lining of the stricture post-dilation.

**Results:** After uncomplicated pneumatic dilation under fluoroscopic guidance, we used a microporous balloon catheter to endoluminally deliver mitomycin C topically to the mucosa at the level of stricture. Three weeks post procedure, repeat esophagram showed resolution of the stricture with unobstructed flow of contrast material to the stomach. The patient had no observable side effects from mitomycin C application.

**Conclusion:** Image-guided therapies based on balloon dilation and drug-eluting microporous balloon techniques offer a safe, precise, and comprehensive approach to the treatment of recalcitrant esophageal strictures.

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Anastomotic stricture of the esophagoesophagostomy (EE) in infants after tracheoesophageal fistula (TEF) repair is common [1-4]. Fortunately, most strictures respond to

bougie or pneumatic balloon dilation [5,6]. Some infants have recalcitrant stricture despite multiple attempts at dilation. Mitomycin C has been shown to be effective in treating recurrent stricture [7-15]. Because mitomycin C is hypothesized to reduce stricture by interfering with collagen synthesis, it may have deleterious effects if inadvertently

\* Corresponding author. Tel.: +1 604 875 2131.

E-mail address: mheran@cw.bc.ca (M.K.S. Heran).



**Fig. 1** Droplets form on the surface of the microporous PTFE catheter balloon when pressure exceeds the threshold.

applied to normal esophageal mucosa adjacent to the target stricture site. Consequently, mitomycin C should be applied precisely only to the stricture mucosa. Various techniques have been used to topically deliver mitomycin C to the anastomotic stricture [9,11,12,14,16]. For the most part, these techniques require complex coordination and availability of specialized equipment as well as the complementary skills of interventional radiologists, endoscopists, and surgeons. We describe a novel technique that uses a microporous polytetrafluoroethylene (PTFE) balloon (ClearWay; Atrium Medical Corporation, Hudson, NH) (Fig. 1) to precisely deliver mitomycin C directly onto the esophageal mucosa of the stricture without need for concurrent endoscopy or other forms of direct visualization.

## 1. Methods

### 1.1. Clinical history

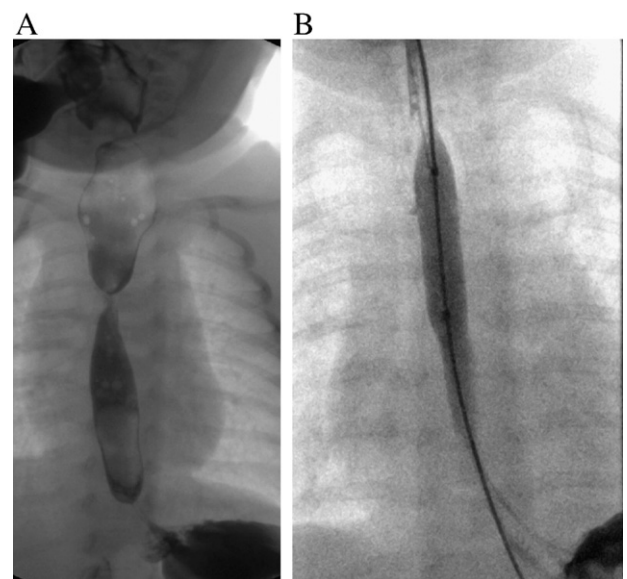
A 38-week infant was found on the first day of life to have proximal esophageal atresia and distal TEF. A comprehensive preoperative evaluation showed no other anomalies. He underwent TEF repair through a right-sided thoracotomy incision on the second day of life. The distal TEF was ligated and divided, whereas the proximal esophageal pouch was modestly mobilized. Because there was less than a centimeter gap between the proximal and distal esophageal ends, the end-to-end EE was constructed with minimal tension.

He had an uncomplicated immediate postoperative course. An esophagram on postoperative day 7 showed a patent esophageal lumen and an intact anastomosis. Per oral feeds were started, and he was discharged home postoperative day 10, tolerating full feeds on ranitidine (2 mg/kg per oral, twice daily), as per protocol after TEF repair. At day 24 of life, he returned to our emergency department for excessive regurgitation and cough after oral feeds. Repeat esophagram showed a marked stricture of the EE anastomosis and reflux of contrast from the stomach. He was started on omeprazole and underwent balloon dilation, initially with 6-mm diameter, then 8-mm diameter balloons. The anastomosis remained patent for approximately 2 weeks after the dilations; however, the stricture recurred. After the eighth dilation in 4 months without any signs of improvement, a

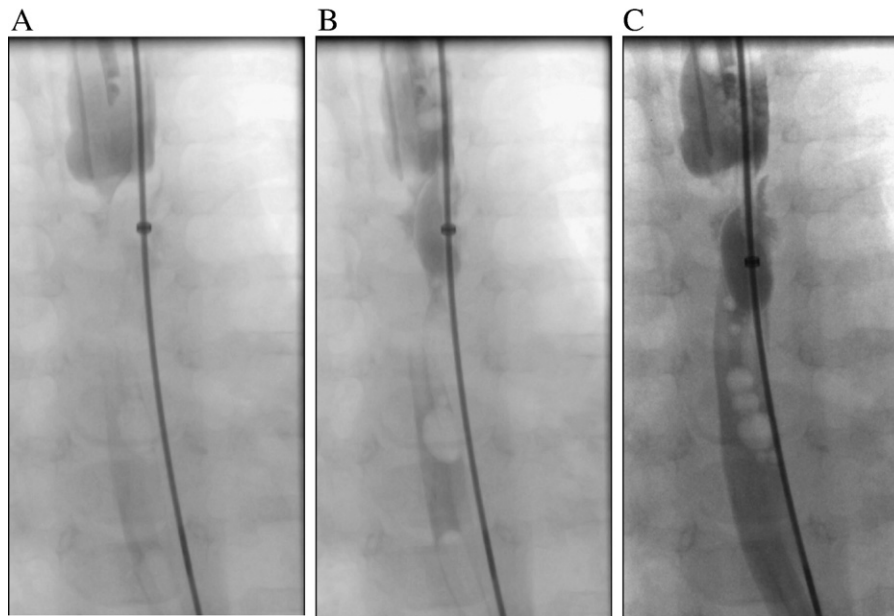
discussion with the family occurred, and the options of steroid injection of the stricture and mitomycin C application were outlined. Antireflux surgery was discussed as a possibility if the nonoperative measures failed. A decision was then made to treat the recalcitrant stricture with mitomycin C.

### 1.2. Technique

Our institutional review board granted special permission to use the ClearWay microporous PTFE balloon (Atrium Medical Corporation) to treat this patient. This balloon allows intraluminal fluid/drug to leak across its porous surface once inflated beyond its threshold volume. The patient underwent endotracheal intubation and was given a general anesthetic for the procedure. A pullback esophagram using water soluble contrast was performed to show the stricture site (Fig. 2A). Using standard fluoroscopic guidance, a 4F Bern hockey stick catheter (Boston Scientific, Natick, MA) and 0.035-in Bentson guide wire (Gyrus ACMI, Southborough, MA) were inserted into the esophagus via an oral approach and guided past the point of stricture into the stomach. After wire exchange for a 150-cm-long Amplatz Extrastiff guide wire (Boston Scientific), an 8-mm diameter, 30-mm length noncompliant balloon (Ultra-thin Diamond; Boston Scientific) was positioned at the stricture site and inflated to a pressure of 4 atm for 30 seconds. Two dilations were performed with complete effacement of the waist on the balloon (Fig. 2B). A 9F, 10-cm-long sheath was then positioned over the Amplatz wire into the upper esophagus. After this, a 7-mm diameter, 10-mm-long ClearWay (Atrium Medical Corporation) irrigating PTFE balloon catheter was positioned across the point of stricture



**Fig. 2** Stricture of the EE (A), effacement of the EE (B) after 8 × 30 mm balloon dilation.



**Fig. 3** Positioning of PTFE balloon over stricture site (A), infusion of mitomycin C (1.5 mL of 0.4 mg/mL) (B), and washout of last mitomycin C dose with contrast (C).

(Fig. 3A). The 7 × 10 mm ClearWay PTFE balloon was initially infused with a volume of 0.5 mL of mitomycin C (0.4 mg/mL) to inflate the balloon, with additional fluid volume then leaking across the porous membrane. Under digital subtraction esophagram during delivery of mitomycin C, a total of 1.5 mL (0.4 mg/mL) of mitomycin C was applied in 3 separate doses (Fig. 3B), the last being cleared with contrast (Fig. 3C). Each dose was delivered over 1 minute, whereas the balloon was inflated at sufficient pressure to achieve complete opening (1 atm). Because the balloon surface is in contact with the mucosa, mitomycin C was directly and focally applied onto the mucosa lining of the stricture. Once the PTFE balloon was deflated, it was withdrawn into the sheath and removed as a unit from the esophagus. The patient was extubated after the procedure, kept “nil PO” overnight, and resumed feeding the following day.

## 2. Results

The patient was followed up every 2 weeks on an outpatient basis for the first 6 weeks and every 6 months thereafter. Since mitomycin C application, he had no clinical signs or symptoms of recurrent stricture at 19 months post procedure. An esophagram performed 3 weeks post application demonstrated good patency of the EE anastomosis without recurrent stricture. The patient was placed on thickened breast milk and continued on omeprazole therapy. He has done well without stricture recurrence and has no observable side effects from mitomycin C application.

## 3. Discussion

Late-onset anastomotic stricture complicating repair of esophageal atresia and tracheoesophageal fistula is felt to be secondary to gastroesophageal reflux; hence, our patients all receive ranitidine postoperatively. Omeprazole is reserved for those with complications, such as the present case, and if a patient develops a stricture, radiologic guided pneumatic dilation is used. Although we recognize this considerable variation in approach to these patients, in our center, nonoperative strategies are first exhausted before undertaking an antireflux operation because these procedures not only carry a considerable failure rate but also dysphagia in this population can be significant [17-20]. Intralesional injection with triamcinolone for the treatment of persistent strictures unresponsive to dilation alone has been described for patients such as ours [21,22]. This was presented to the family as an option for treatment; however, our institutional experience with this intervention has been very infrequent with variable outcomes. In the past 5 years, we have more experience with the targeted delivery of mitomycin C in the setting of corrosive esophageal injury. Our experience with both approaches was discussed with the family and likely influenced the eventual decision.

Mitomycin C is an alkylating agent that inhibits DNA and protein synthesis. It has been shown to inhibit fibroblast proliferation and collagen synthesis. Mitomycin C is thought to prevent stricture recurrence by interfering with normal wound healing processes [23-25]. Topical mitomycin C was first used to prevent postoperative fibrosis in pediatric patients with glaucoma in the 1980s and is now extensively used to prevent subconjunctival scarring for these patients

[26,27]. In 1998, it was used to treat tracheal stenosis and is now widely used in otolaryngology to prevent fibrosis [28,29]. Mucosal application of mitomycin C has been shown to be an effective and safe treatment of recalcitrant esophageal stricture [7,9,12-15]. Concentrations of the mitomycin C described in the various anatomical regions vary; however, the concentration of 0.4 mg/mL is most commonly used in patients. Higher concentrations and long-term application (eye drops) have been implicated in complications among ophthalmologic patients [30]. In the literature, there are no reported adverse events because of a single topical application with a concentration of 0.4 mg/mL or more; however, given that it is an alkylating agent, long-term follow-up, especially for children, is required to determine overall safety.

Previously described techniques to treat esophageal stricture with mitomycin C involved dilatation of the stricture followed by endoluminal application of the drug to the dilated mucosa. These approaches often involved rigid or flexible esophagoscopy, and thus, collaboration and expertise of both the interventional radiologist and surgeon are necessary. In this report, we describe a novel interventional approach that is based entirely on balloon catheter techniques for dilation and endoluminal application of mitomycin C. The ClearWay microporous PTFE balloon catheter was originally designed to focally deliver thrombolytic medications within a thrombosed vessel. We have adapted this technology to safely and precisely deliver mitomycin C at the point of recently dilated esophageal stricture. This balloon catheter approach is simple in that both dilation and mitomycin C application can be accomplished in a single interventional setting, without need for direct visualization. Currently, application of mitomycin C using this technology is limited by balloon diameter because the largest microporous PTFE balloon available is 8 mm in diameter. However, the technique described in this report may serve as an excellent tool for children in whom esophagoscopy would be difficult because of small patient size.

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