Use of Vicryl mesh to support the esophageal wall after circular myotomy (Livaditis procedure) in long-gap esophageal atresia – an experimental study

Abstract Circular esophageal myotomy (CEM) is currently a well-accepted technique for elongation of the upper esophageal pouch in cases of long-gap esophageal atresia (EA). Esophageal pseudodiverticulum is a frequent and perhaps underreported sequela of this technique, characterized by ballooning or outpouching of the esophageal mucosa in the myotomized area. The present study was designed to seek a supplement for the CEM technique in order to avoid possible pseudodiverticulum formation in the myotomized area. We created an animal model to simulate the anatomic conditions present after primary repair of EA facilitated by CEM. Three groups of dogs underwent either cervical (1 group) or thoracic (2 groups) esophageal myectomy. In the cervical and first thoracic groups, the denuded mucosa was left without any support. In the second thoracic group, the denuded mucosal area was wrapped with polyglactin 910 (Vicryl) mesh. In all three groups the esophagus was narrowed by a Marlex mesh ring 3 cm distal to the myectomized zone, simulating a condition resulting from anastomotic narrowing. The dogs underwent barium swallows under fluoroscopy at different postoperative periods and were killed 4 or 6 months after surgery. The esophagi were removed for gross and radiologic investigation under maximal insufflation as well as for histologic assessment. The proposed canine model proved to be useful for study of the myectomized esophagus, mimicking the anatomy and conditions after CEM in long-gap EA repair. Wrapping the denuded mucosa with Vicryl mesh fortified the weakened esophageal wall, thus diminishing the likelihood of future pseudodiverticulum development. In light of the simplicity of the technique and the absence of any evident risk or complications, we recommend that the use of Vicryl mesh wrap be considered during CEM to reinforce the esophageal wall.

Key words Esophageal atresia • Livaditis procedure • Esophageal pseudodiverticulum • Vicryl mesh • Polyglactin mesh

Introduction

It is generally agreed among pediatric surgeons that establishing end-to-end continuity of the esophagus is the treatment of choice for esophageal atresia (EA). This goal, which is harder to achieve in long-gap EA, can be accomplished in certain cases by elongating the atretic upper esophageal pouch with the aid of a circular myotomy (CEM). This surgical procedure, introduced in 1969 by Livaditis et al. [7–9], provides at least 2 cm of additional length. The final results is that of an end-to-end esophageal anastomosis with a denuded muscle area 2 cm long located proximal to the anastomosis. At this muscular gap the esophageal wall consists only of mucosa and submucosa, with no other support.
The disparity in diameter between the usually well-developed upper esophageal pouch and the poorly developed lower esophagus results in a relative stenosis of the anastomosis, even when no genuine impediment to food passage is present. If and when this stenosis becomes a rigid, fibrotic stricture, a preanastomotic high-pressure zone results. This creates the fundamental condition necessary for the gradual development of a pseudodiverticulum from the mucosa in the amuscular area. The surrounding low mediastinal pressure contributes to the progression of this detrimental process. The main symptoms related to this complication are digestive: varying degrees of delay of food passage and/or respiratory dysfunction due to direct compression of the trachea or aspiration. The present study was designed to seek a supplement to the CEM technique in order to avoid possible pseudodiverticulum formation in the myotomized area.

**Materials and methods**

Two-to-four-month-old mongrel dogs weighing between 5 and 9 kg were used. All animals were observed for several days prior to operation. Their care and follow-up proceeded according to the National Law for Laboratory Animals. The dogs were anesthetized with phenobarbital sodium, intubated, and artificially ventilated with a Harvard respirator. Three groups of 10 dogs each underwent a 3-cm-long circular esophagomyectomy: the first group of the cervical esophagus, and the second and third groups of the thoracic esophagus. In all three groups the esophagus was narrowed by a Marlex mesh ring 3 cm distal to the myectomized zone.

In the first group the cervical esophagus was exposed immediately above the sternal notch and mobilized at the site of the intended muscular resection. The esophageal musculature was divided circumferentially at two levels, whereby the width of the removed muscular band measured 3 cm. The esophagus was then narrowed by a Marlex ring placed 3 cm distal to the myectomized area. In the second group the same procedure was performed in the thoracic esophagus, which was exposed via a right thoracotomy (Fig. 1A). The third group underwent the same procedure in the thoracic esophagus, but the myectomized area was wrapped with polyglactin 910 (Vicryl) mesh (Fig. 1b). Caution was taken to avoid injury to the main vagus nerves in all the operated dogs. The animals were kept fasting for the first 48 h, and fluids were administered IV or subcutaneously. Water and milk were given on the 3rd postoperative day. Broad-spectrum antibiotics were started just before surgery and discontinued after 48 h.

The dogs were carefully observed at feeding time to ascertain whether or not swallowing difficulties were present. Body weight was measured regularly and compared with that of normal animals of the same age. A barium swallow under fluoroscopy was carried out postoperatively during anesthesia in all animals. Five animals of each group were killed 4 months after the operation and 5 after 6 months. At autopsy, the operative area was examined in situ and findings were documented by macrophotography. Immediately thereafter the esophagus was removed and inflated with air (Fig. 2a) and a small amount of barium to a pressure of 30 cm H2O to outline the mucosal folds with a double-contrast technique and to determine whether or not ballooning or outpouching of the esophageal wall at the myectomized area was present. Radiographs of the specimen under this standard degree of filling were obtained (Fig. 2b).

The esophagus was then cut longitudinally and the mucosal surface examined. Finally, the specimens were fixed in 4% formalin and sectioned longitudinally. Sections of the proximal tissue were taken according to protocol from transitional areas of the intact muscularis and the denuded muscle layer, routinely processed, paraffin-embedded, sectioned, and stained with hematoxylin and eosin. Mallory staining for collagen and Verhoeff staining for elastin tissue were also performed. Immunoperoxidase stains included the following antibodies: vimentin (Dako M725), desmin (Dako A611), and α-actin (Dako N851).