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Isolated Jejunal Segment Interposition for Esophageal Replacement in Mongrel Dogs†

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= Abstract = **To test the feasibility of replacing the esophagus with an isolated jejunal segment (IJS) which is devoid of its anatomical blood supply and which is nourished by the omentum, an IJS was created and transplanted to the proximal jejunum in one dog and to the esophagus in other dogs. The dogs were observed for 2 months; then, esophagographies were performed. Also microangiograms were taken, and the IJSs were examined by microscopy. The dogs were doing well until being sacrificed, the esophagograms showed stenosis of the IJS. The microangiograms showed that an adequate blood supply from the surrounding omentum to the IJS, and microscopic examination revealed intact architecture of the jejunum and microbarium in the submucosa. This study shows that an IJS can be transplanted to a distant location and that it offers an alternative for esophageal replacement.**

Key Words: *Esophageal replacement, Isolated jejunal segment, Omentum*

INTRODUCTION

Esophageal replacement with other organs is occasionally required for children with congenital esophageal atresia or with widely involved acquired stricture of the esophagus (Mitchell *et al.* 1989). The jejunum is the ideal esophageal substitute but its precarious blood supply and the difficulty in attaing a sufficient length restricts its usage (Spitz 1984). After successful creation in rats of an isolated jejunal segment(IJS) which was devoid of its anatomical blood supply and which was nourished by the omentum (Lee and Kim 1992), the authors applied this technique for esophageal replacement.

The advantages of using an IJS are that it can be transferred a fairly large distance and can be obtained in any length because the omentum has a very long vascular pedicle and a large surface area.

This paper describes the technique for creating and transplanting an IJS and presents the findings of fluoroscopic, microangiographic, and microscopic examinations of the IJS two months after transplantation in mongrel dog, in order to explore the validity of transplanting an IJS.

MATERIALS AND METHODS

Animals

Five mongrel dogs weighing 13 kg to 14 kg were used. The animals were kept in cages and

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fed the regular dog food.

Operations

1) Fixation of the omentum to the jejunum (omentopexy): The dog were not fed for 12 hours prior to the operations. Under general anesthesia with endotracheal intubation, the skin was prepared and an upper midline incision was made and deepened to the peritoneum. A segment of the proximal jejunum (usually about 10 cm) which was fed by the same secondary branch of the superior mesenteric artery was selected. The artery and both ends of the arcade artery feeding the segment were doubly ligated. The serosa was scratched with abrasive paper (220 Cw, Daesung Co.) until the muscle layer was visible. The omentum was scratched with abrasive paper (1000 Cw, Daesung Co) until capillary bleeding was visible. The scratched surface of the omentum was wrapped around the scratched serosa of the jejunum and was secured by several interrupted 5-0 black silk sutures . The abdominal wall was closed layer by layer by a 2-0 continuous prolene suture. A 5% dextrose solution and Ringer's lactate was given intravenously for three days; then, oral intake was resumed. Cefamezine and gentamicin were given every 8 hours intravenously for three days postoperatively.

2) Creation of the isolated jejunal segment and interposition: Six weeks after the omentopexy, the peritoneal cavity was reentered under general anesthesia with endotracheal intubation. Both ends of the omentopexied jejunum were excised, and the attached mesentery was divided (Fig. 1). Bowel continuity was restored by two layer continuous sutures. The animals were made to fasted for 24 hours prior to the operations, but had free access to water.

(A) Isolated jejunal segment interposition in the jejunum: In the first dog, the IJS was interposed in the proximal jejunum. As soon as the IJS was created, the jejunum was transected about 10cm proximal to the anastomotic site for restoring bowel continuity, and the IJS was interposed (Fig. 2). Two layers of continuous 3-0 vicryl sutures were made at both ends and the abdominal wall was closed. The dog was kept NPO for 5 days. During which time a 5% dextrose solution and Ringer's lactate were given intravenously and antibiotics were administered.

(B) Isolated jejunal segment interposition in

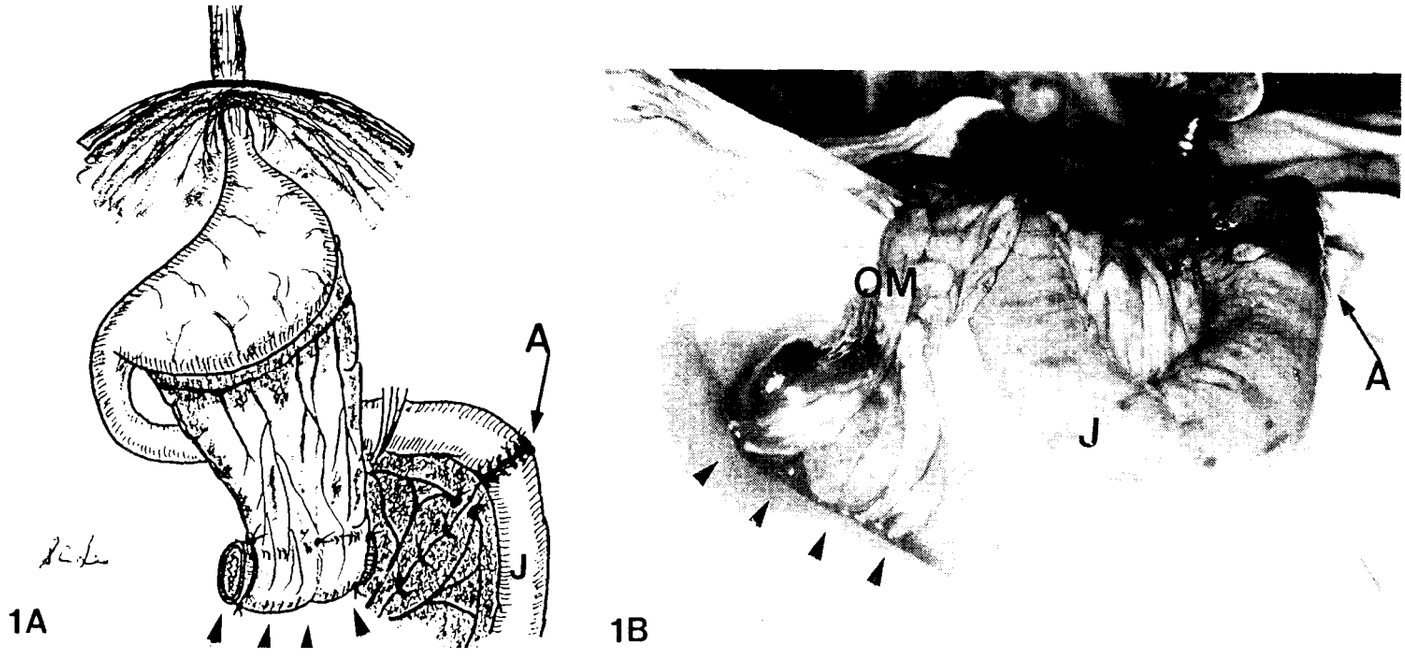

Fig. 1. Illustration of the isolated jejunal segment (IJS, arrowhead) created by division of both ends of the omentopexied segment 6 weeks after omentopexy (1A) and photograph of the IJS(1B). Bowel continuity was restored by end to end anastomosis(←A). OM:omentum J:jejunum

Fig. 2. Photograph of the IJS transferred to the proximal jejunum.

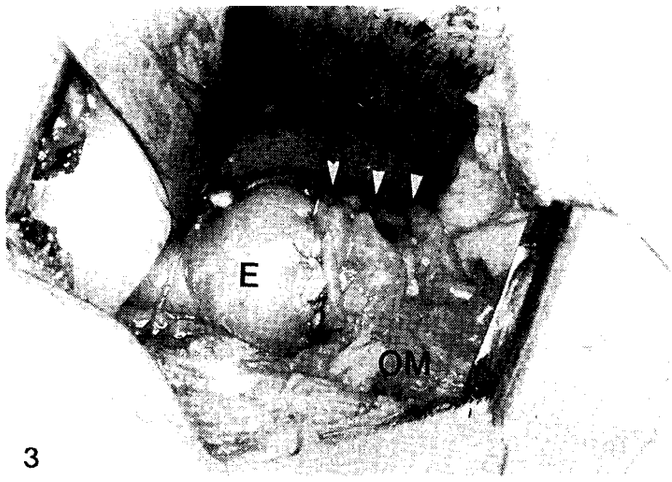

Fig. 3. Photograph of the IJS transferred to the distal esophagus(E).

the esophagus: After confirming that the first dog was doing well after IJS interpostition in the proximal jejunum, the IJS was grafted in the distal esophagus in a second and a third dog. As soon as the IJS was created, a right lateral thoracotomy incision was made through the 7th intercostal space from the costal margin. The esophagus was approached extrapleurally and about 7 cm of the distal esophagus was excised. The IJS was brought into the thorax through a stab wound made in the diaphragm, then interposed in the esophagus and both ends anastomosed in two layers (Fig. 3). A 16 Fr. chest tube was inserted and the abdomen and thorax were closed layer by layer. The dog was kept in a restraint cage for 3 days whilst negative pressure was applied to the chest tube. Then the chest tube was removed and the dog was kept in a normal dog cage. For 7 days the dog was kept NPO and fluid and antibiotics were given parenterally. Then a fluid diet was given for 2 days after which regular dog food was given.

Radiologic study:

Two months after interposition, a small bowel series was performed in the first dog and an esophagogram was performed in the esophageal replacement dog after injection of ketamine. An orogastric tube was inserted and barium was infused under fluoroscopy.

Microangiographic and microscopic study:

After radiologic study the abdomen and thorax were opened. The superior mesenteric artery was cannulated and the aorta was clamped just above and below the superior mesenteric artery, the esophagus was clamped at the distal end of the anastomosis to shut off the vascular connection from the proximal stomach and then the portal vein was transected. Warm normal saline was infused through the cannula until the portal venous drain was clear; then, the microbarium was infused until the portal venous drain contained gross amounts of barium. Next after ligation of both ends, the grafted IJS was harvested for microangiographic and routine histologic study. Preparation of microbarium and the taking of microangiograms were done as described by Kang *et al.* (1984).

RESULTS

Two dogs among the 5 omentopexied dogs died within 10 days after omentopexy. Postmortem examination revealed severe pneumonia due to inadequate postoperative care; however, the omentopexied segment was normal without causing an obstruction. A third dog was sacrificed by pentobarbital injection 7 days after the IJS interposition in the esophagus because of an abdominal wound rupture and

subsequent intraperitoneal sepsis. The grafted IJS was viable. Two dogs, one interposed in the jejunum and the other one interposed in the esophagus were alive until harvest of the IJS and had regained their respective preoperative body weights 2 weeks after interposition. These dogs had no difficulty in swallowing and were doing well.

The small bowel series revealed no passage disturbance through the grafted IJS, but mild stenosis was observed at the proximal anastomosis site (Fig. 4). The esophagogram showed proximal dilatation of the esophagus, moderate passage disturbance and stenosis of the grafted IJS (Fig. 5).

The microangiograms revealed the blood supply from the omentum to the grafted IJS (Fig. 6), and microscopic examination showed a normal jejunal architecture and the microbarium in the submucosa (Fig. 7).

DISCUSSION

Esophageal replacement is occasionally required for children. The criteria for successful esophageal replacement in children are: 1) the substitute esophagus must function as an efficient conduit; 2) gastric reflux into the conduit must be minimized; 3) the ventilatory mechanism must not be impaired; 4) the operative procedure must be technically adaptable to small children; 5) the conduit must be placed so that the child has little or no external deformity; and 6) the conduit must grow with

Fig. 4. Small bowel series done two months after transplantation of the IJS showed mild stenosis at the proximal anastomotic site but without passage disturbance.

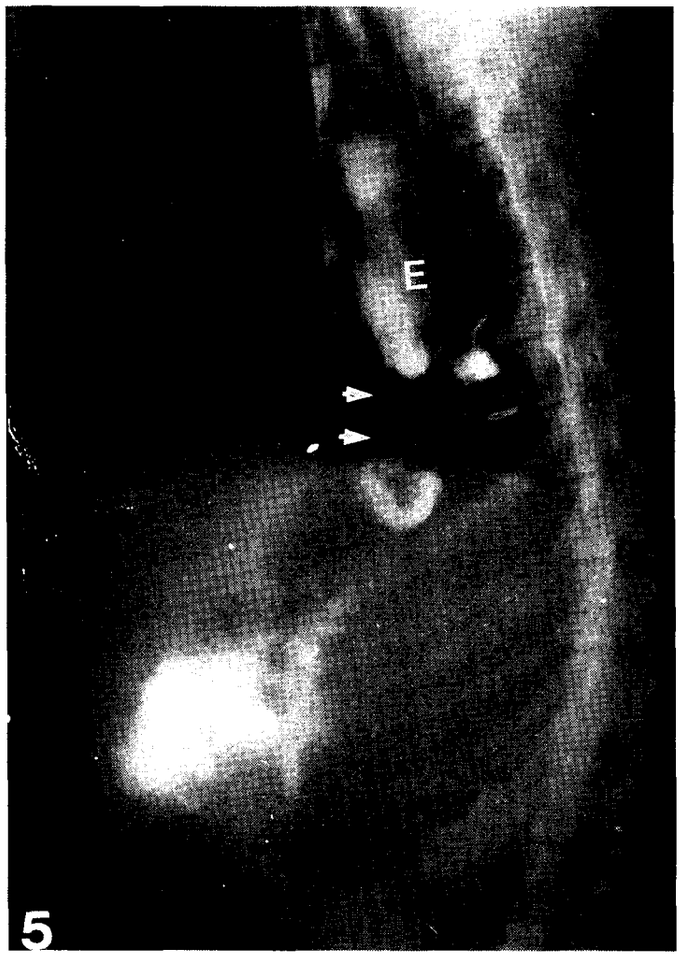

Fig. 5. Esophagogram taken two months after IJS replacement of the esophagus revealed dilatation of the proximal esophagus and stenosis of the IJS with moderate passage disturbance.

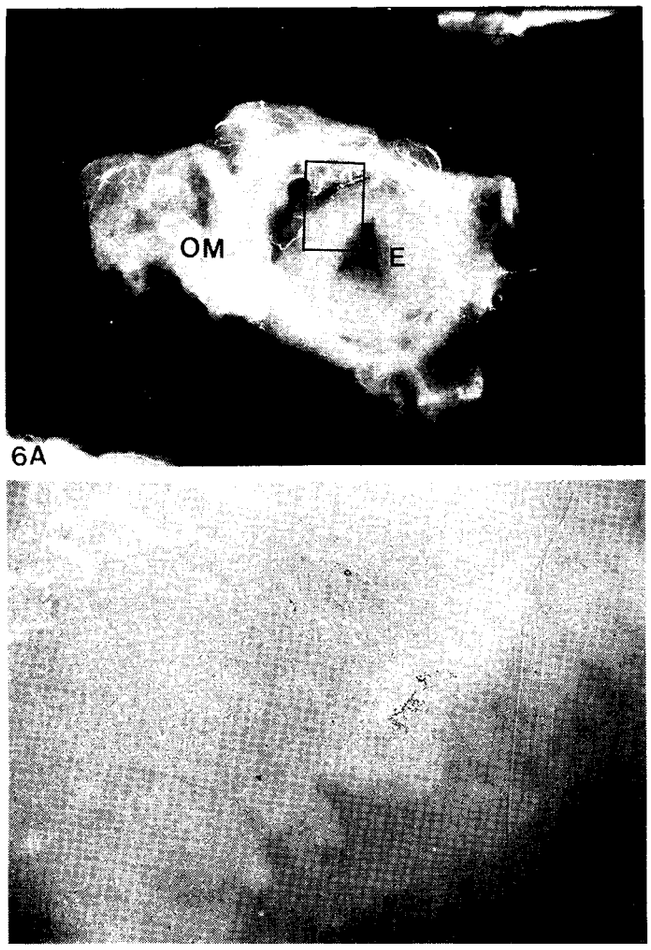

Fig. 6. Microangiogram demonstrated revascularization between the IJS and the omentum(6A;1X). Magnification of the inset of 6A shows capillary filling of microbarium into muscle layers and submucosa(6B; X40).←—B: microbarium

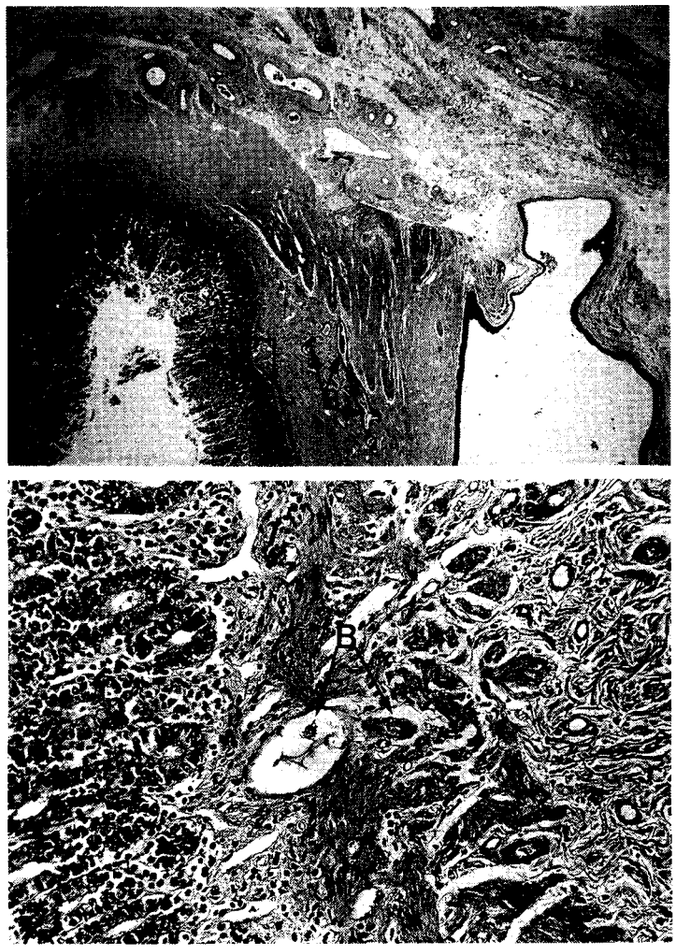

Fig. 7. Microscopic finding of the IJS two months after transfer to the esophagus after hematoxlin and eosin stain. The IJS retained normal jejunal architecture (7A, X10) and magnification(X200) of the inset of 7A demonstrated microbarium in the submucosa(7B).

the child and must function in adulthood (Anderson 1986). The techniques currently used for esophageal substitution in children are colonic interposition (Stone *et al.* 1986, Mitchell *et al.* 1989), gastric transposition (Spitz 1992), gastric tube esophagoplasty (Lindhal *et al.* 1983), and jejunal interposition (Ring *et al.* 1982, Saeki *et al.* 1988). Among these four techniques, jejunal interposition has had the lowest postoperative complication rate and a good long-term results.

The jejunum has the advantage of being a conduit of appropriate size which retains vigorous peristalsis (Mitchell *et al.* 1989). However, the vascular pedicle is invariably short and restricts the length of the jejunum that can be used. In children especially, the blood supply is even more precarious and rarely is it possible to achieve a proximal anastomosis above the level of the aortic arch. The IJS as constructed by the authors is nourished by the omentum and is free of the mesentery which means that it can be obtained in any length and can be transferrd to any location reachable by the omentum.

Recently, experience has been gained in the use of a totally free jejunal graft with immediate surgical revascularization. Fisher *et al.* (1990) have reported an 89% (42/47) success

rate with free jejunal interposition grafts. However, this procedure requires a degree of technical skill that would limit its use. Furthermore, the patients reported in this series were all adults, so the application of this technique to children remains much less clear because of the small sizes of the vessels concerned. IJS interposition does not require such sophisticated surgical skill.

In the contrast study the IJS transferred to the esophagus was more stenotic than the IJS transferred to the jejunum. During omentopexy, the serosa of the latter was more thoroughly abrased than the former. Even though it is hard to say how much injury was inflicted on the jejunal wall by abrasion, the impression is that the injury must reach the muscle layer, without any missed area to promote revascularization. Also, the omental pedicle was a little constricted in the esophageal replacement as the IJS was brought up through the diaphragm for technical ease. Foker *et al.* (1982) brought up the jejunum through the esophageal hiatus after finger dilatation of the hiatus. This technique may be useful to avoid compression of the omental pedicle. Although the dogs were doing well until 2 months after the transplant, it is speculated that they could have had symptomatic stenosis of the IJS if they had been observed for an additional several months because scar contracture progresses with time.

This experimental study revealed that isolated jejunal segment interposition for esophageal replacement is technically feasible and the revascularization is well established between the omentum and the IJS. The depth of the jejunal wall abrasion requires further study.

The clinical application of this new technique would be a jejunal replacement of the esophagus in selected cases, *i. e.*, short small bowel and anomaly of the jejunal artery or wrapping the free jejunal flap in an ischemic bed with the omentum.

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