Immediate Reconstruction of the Cervical Esophagus by a Revascularized Isolated Jejunal Segment *

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SURGICAL TREATMENT of carcinoma of the hypopharynx and cervical esophagus has been hindered by the difficulty in completely extirpating the lesion with a wide margin of safety, including usually a laryngectomy and neck dissection, and following this with a reliable one-stage reconstruction of the pharyngo-esophagus. In the past, radiation therapy has been the main method of treatment of carcinoma arising in the hypopharynx and in the postcricoid and cervical esophageal regions. A survey of eight large series reveals the uniformly disappointing results obtained with x-ray treatment.[10] Lesions of this area manifestly produce progressive dysphagia, pain in the ear, symptoms of recurrent nerve paralysis and aspiration pneumonitis, and surgical extirpation frequently is the most reliable method of providing palliation. Restoration of pharyngo-esophageal continuity upon completion of removal of the tumor represents one of the major challenges in this type of surgery. To date the procedures employed for cervical esophagus reconstruction leave much to be desired because either they are multi-staged and create a pharyngostome,[17, 18] or they predispose to the development of pharyngeal leaks and early strictures when a split thickness skin graft is used.[1, 3, 4, 11, 12] Primary reconstruction by skin graft is not always feasible after radiation therapy. The use of the laryngotracheal autograft is restricted if the lesion extends too far down in the esophagus.[16] In all surgical procedures there has always been a fear of sacrificing too much esophagus because the resultant closure by the methods available may be difficult.

An experimental study was undertaken to develop a one-stage immediate reconstruction technic utilizing a free jejunal segment completely isolated from its mesenteric blood supply. The cervical esophagus was resected in dogs and immediately replaced with a free jejunal segment which was revascularized in the neck.

Method

Mongrel dogs weighing from 30 to 75 lbs. were used. All operations were performed under general anesthesia produced by a veterinarian solution of Nembutal administered intravenously.

Separate cervical and abdominal incisions were used in each experiment. A midline incision was made in the neck from the suprasternal notch to the hyoid bone with a left lateral limb at the upper end. A skin and platysma flap was developed exposing the trachea medially and the external jugular vein laterally (Fig. 1A, B). The cervical vessels to be utilized for revascularization of the free jejunal segment were then dissected cleanly from the surrounding tissues and mobilized. The vessels employed were the superior thyroid artery and the anterior facial vein (Fig. 1B, 2A). The sternocleidomastoid muscle and the carotid sheath con-

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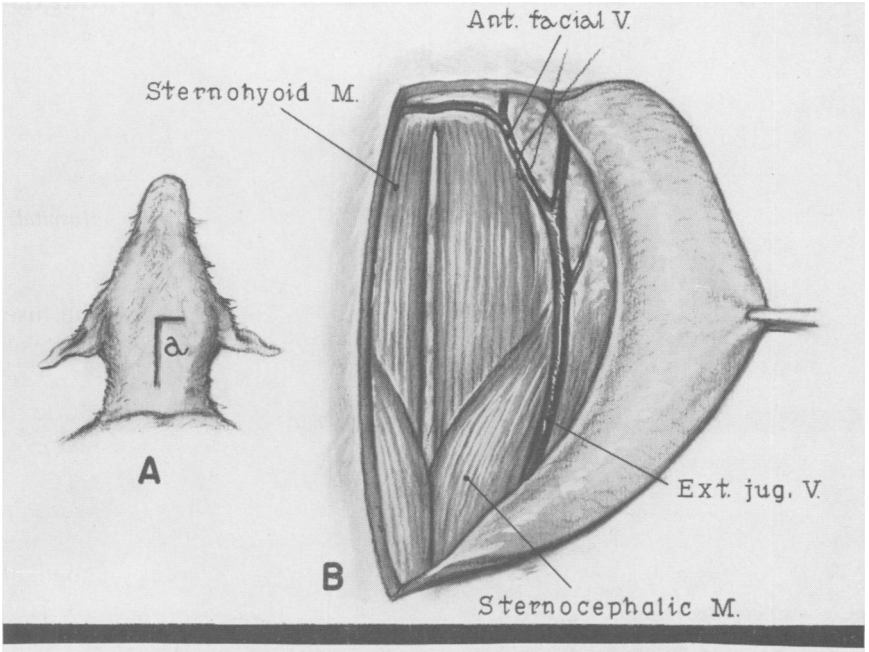

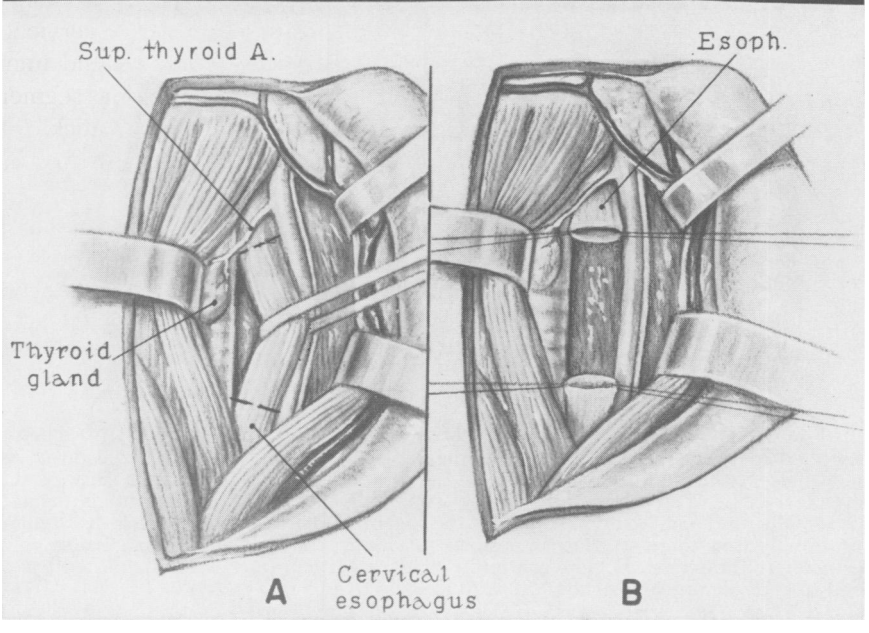

FIG. 1A (upper). Midline neck incision with a left lateral limb at the level of the hyoid bone. B. Skin and platysma flap developed to the external jugular vein laterally. The anterior facial vein is mobilized.

FIG. 2A (lower). The superior thyroid artery and the cervical esophagus are dissected and mobilized. B. The entire circumference of the cervical esophagus is resected.

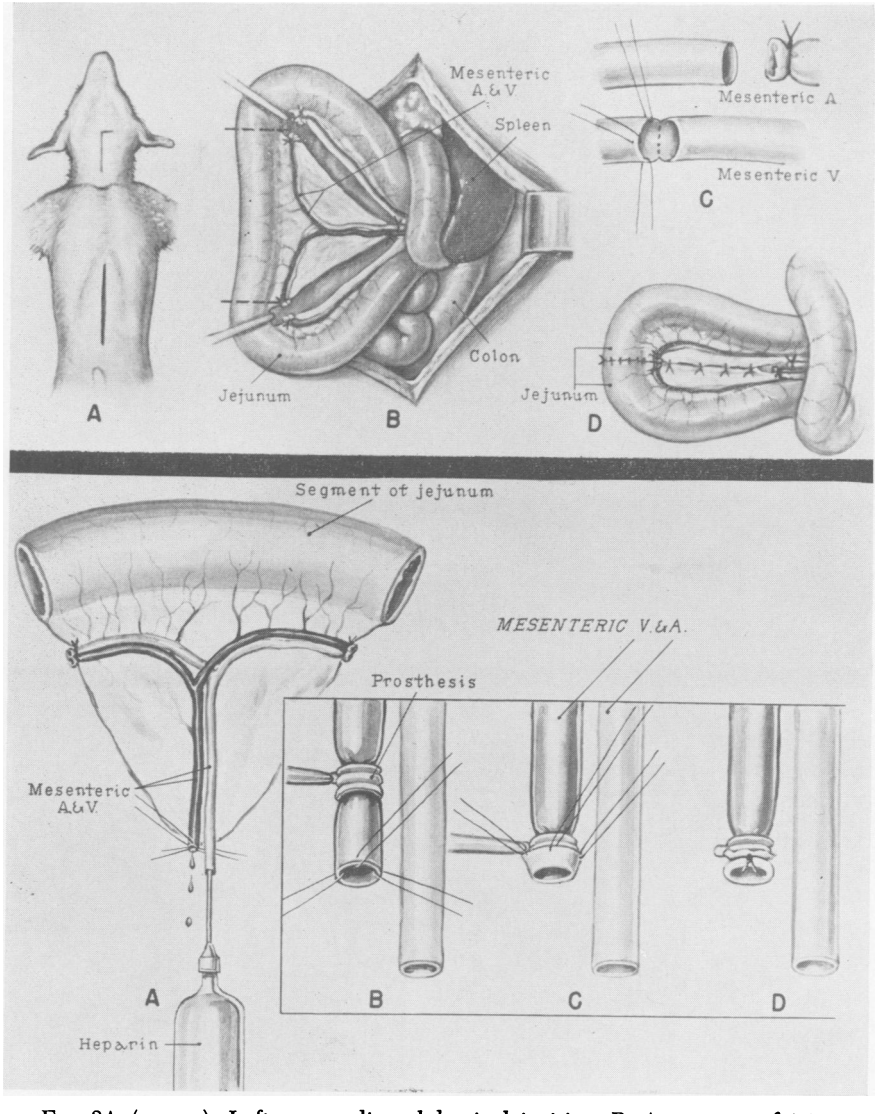

FIG. 3A (upper). Left paramedian abdominal incision. B. A segment of jejunum supplied by a single radial branch of the superior mesenteric artery and vein is removed from the peritoneal cavity after the vessels are mobilized at the base of the mesentery. C. The mesenteric artery supplying the jejunal segment is ligated proximally and cut cleanly distal to the ligature. The mesenteric vein is ligated proximally, but three traction sutures are placed in the end of the vein before it is completely transected. D. The continuity of the intestinal tract is re-established by an end-to-end jejuno-jejunostomy.

FIG. 4A (lower). The isolated jejunal segment is immediately perfused with heparin solution injected into the mesenteric artery. B, C, D. The mesenteric vein is evaginated onto the tantalum ring prosthesis and fixed to the ring with a silk tie.

tents were retracted laterally and the cervical esophagus was mobilized (Fig. 2A). After hemostasis was achieved, the entire circumference of the cervical esophagus was resected from 1½ cm. distal to the cricoid cartilage to the suprasternal notch (Fig. 2B).

A left paramedian muscle-splitting abdominal incision was made and a segment of jejunum supplied by an acceptable radial

branch of the superior mesenteric artery and vein was chosen for free transplant to the neck (Fig. 3A, B). The base of the mesentery in the region of the chosen artery and vein was infiltrated with 2 cc. of 1 per cent procaine solution in order to decrease the amount of vasospasm produced by dissection of the vessels. A 2½ inch segment of jejunum with its mesentery containing the previously mobilized artery and vein was removed from the peritoneal cavity (Fig. 3B). The continuity of the intestinal tract was re-established by an end-to-end jejuno-jejunostomy (Fig. 3D). The isolated jejunal segment was immediately perfused with heparin solution injected into the mesenteric artery in order to remove the residual blood and to prevent thrombosis anywhere in the resected specimen (Fig. 4A). The mesenteric vein was prepared for anastomosis to the anterior facial vein by evaginating it onto a highly polished, siliconized tantalum ring prosthesis. This was done with the aid of three traction sutures of 6–0 arterial silk placed in the transected end of the vein (Fig. 3C). The vein was passed through an appropriate sized ring, usually measuring 2 to 2½ mm. and then rolled onto the outer surface of the ring. It was fixed to the ring with a 4–0 silk tie secured on one of the two ridges on its outer surface (Fig. 4B, C, D).

The jejunal segment was then implanted into the defect in the cervical esophagus. The posterior half of the proximal and distal esophago-jejunal anastomoses was completed before the segment was revascularized (Fig. 5A). This was done before the revascularization in order to stabilize the segment so that the vascular anastomoses would not be compromised by undue manipulation. The esophago-jejunal anastomoses were performed by the Cameron Haight technic[6] (Fig. 5B). The venous anastomosis was then completed by attaching the proximal transected end of the anterior facial vein to the mesenteric vein over the tantalum ring prosthesis. Again, three traction sutures of 6–0 arterial silk were placed in the cut end of the vein and they were used as guides to slip the anterior facial vein over the tantalum ring. A 4–0 silk tie placed over the second ridge on the ring surface fixed the vein to the ring and to the mesenteric vein (Fig. 6A, B, C). The distal transected end of the mesenteric artery and the proximal end of the superior thyroid artery were then anastomosed by the continuous over-and-over suture technic using 12 inch lengths of 7–0 braided silk sutures, armed at each end with an .008 inch wire, ⅜ circle, taperpoint, round atraumatic needle (Fig. 6A, D, E).*

Upon completion of the arterial anastomosis, the isolated jejunal segment was revascularized and immediately became pink and displayed peristalsis. The venous anastomosis acted as an adequate run-off for the new blood supply and the viability of the jejunal segment was maintained. The anterior halves of the proximal and distal esophago-jejunal anastomoses were then completed (Fig. 7A, B). Before the neck incision was closed the mobilized anterior facial vein was secured to the surrounding tissue by a carefully placed 4–0 silk suture through its adventitia so that it would not kink and obstruct the venous run-off. The abdominal and neck incisions were closed. The neck incision was drained at its inferior angle. In order to protect the vascular anastomoses from disruption during the excitement phase of recovery from the anesthesia, the dogs were placed in a brace that completely immobilized the head and neck. The brace was removed 24 hours later.

Postoperatively the dogs were maintained on penicillin, streptomycin and achromycin intramuscularly, 1,000 cc. of 5 per cent Dextrose in saline intravenously daily, and nothing by mouth for five to seven days. If there was no leakage of mucus through

* The suture material was supplied through the generosity of the Ethicon Suture Laboratories, Inc., New Brunswick, N. J.

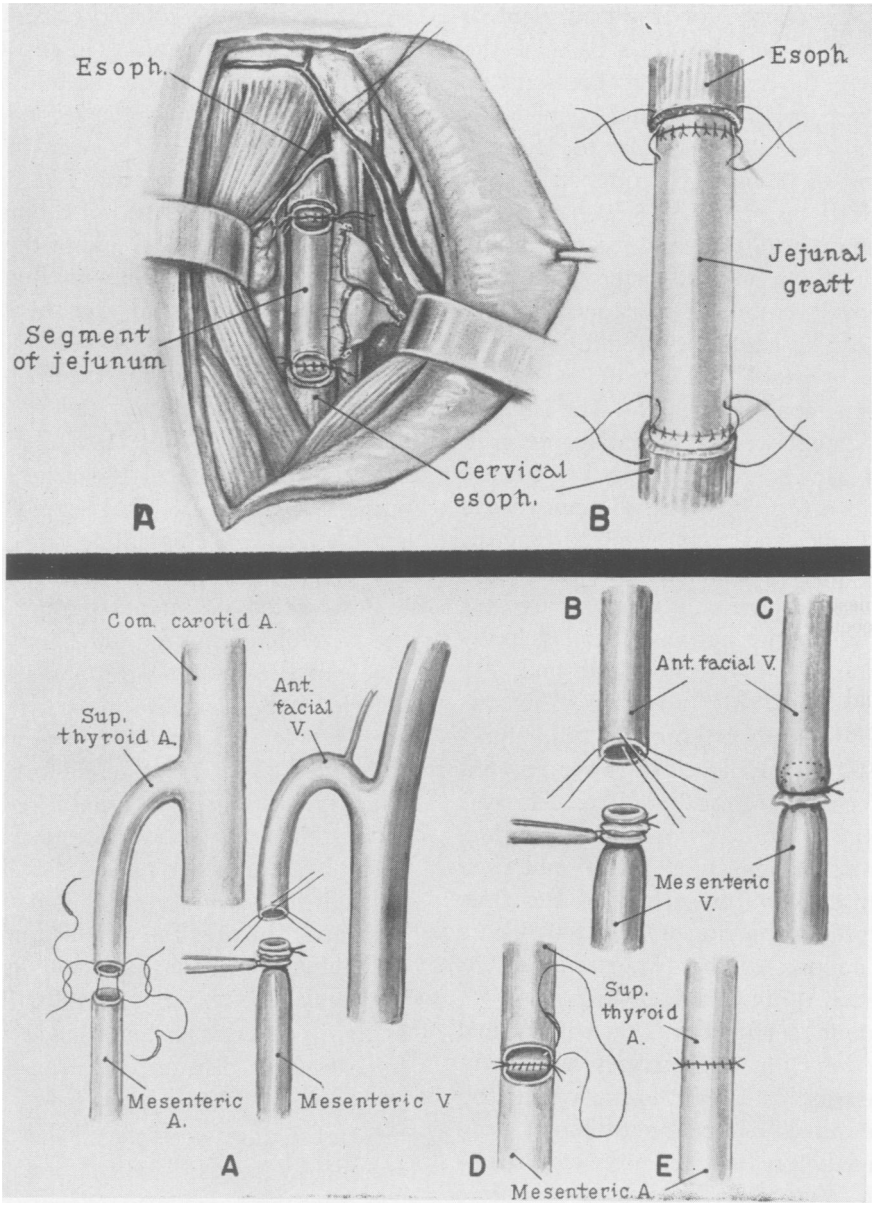

FIG. 5A (upper). The jejunal segment is implanted into the defect in the cervical esophagus. The posterior halves of the esophago-jejunal anastomoses are completed before the segment is revascularized. B. The technic of the anastomosis is demonstrated. The inner layer includes the mucosa of the esophagus and the full thickness of the jejunum. The outer layer includes the muscularis and submucosa of the esophagus and a seromuscular bite of the jejunum.

FIG. 6 A, B, C. Demonstrate the attachment of the anterior facial vein to the mesenteric vein over the tantalum ring prosthesis.

FIG. 6 A, D, E (lower). Demonstrate the anastomosis of the superior thyroid artery to the mesenteric artery by the continuous over-and-over suture technic.

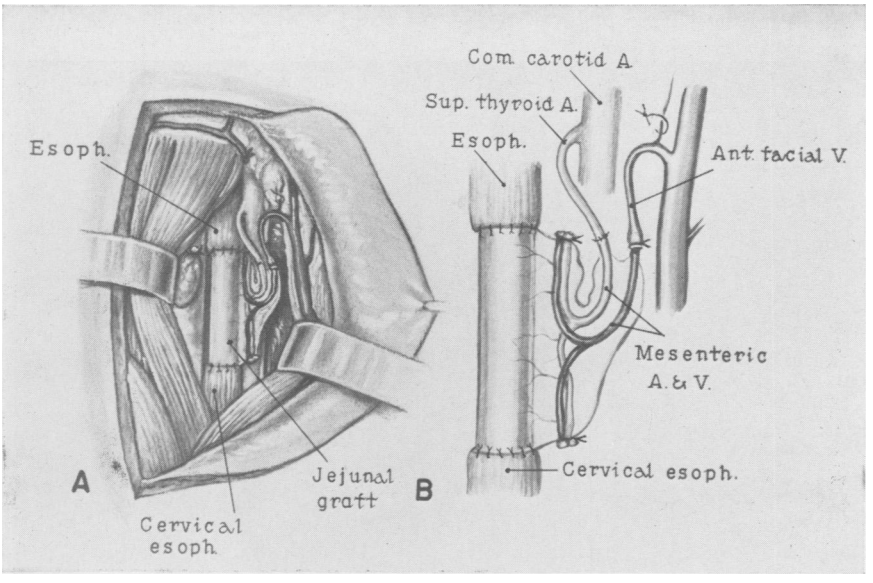

FIG. 7A. The isolated jejunal segment is revascularized and the esophago-jejunal anastomoses are completed. B. A more detailed diagram demonstrating the complete reconstruction of the cervical esophagus by a revascularized isolated jejunal segment.

the cervical incision within five days, the reconstructed cervical esophagus was viable and the dog was fed fluids and ground meat orally.

Results

This experimental study cannot be analyzed statistically because numerous changes were made throughout its course until the most effective method of immediate esophophageal reconstruction by revascularizing a free jejunal segment was developed. The technic described represents the final product of the study. Careful analysis of each failure suggested changes that eliminated flaws. The factors most important for success were 1) the development of the nonreactive tantalum ring prosthesis for the venous anastomosis, 2) the use of meticulous technic and 7–0 arterial silk sutures with .008 inch needles for the small arterial anastomosis, and 3) utilizing a brace that effectively stabilized the head and neck and prevented disruption of the vascular anastomoses during the early post-operative excitement period.

Four long-term survivors were obtained ranging from one to two years. The free jejunal segment was without blood supply in the survival experiments for a minimum of one hour and a maximum of two hours. Esophagram by barium swallow revealed good patency of the reconstructed cervical esophagus, and carotid angiography one to two years postoperatively on all survivors demonstrated the patency of the recreated arterial and venous circulation of the isolated jejunal segment.

After ten days the dogs were fed regular kennel rations and maintained their nutrition. For several months, they were disturbed by the accumulation of mucus in the pharynx and would expectorate moderate amounts of mucus early in the feedings, following which they swallowed without difficulty.

Discussion

The advantages of reconstruction of the cervical esophagus by a revascularized isolated jejunal segment are that it avoids the objectionable features of the various

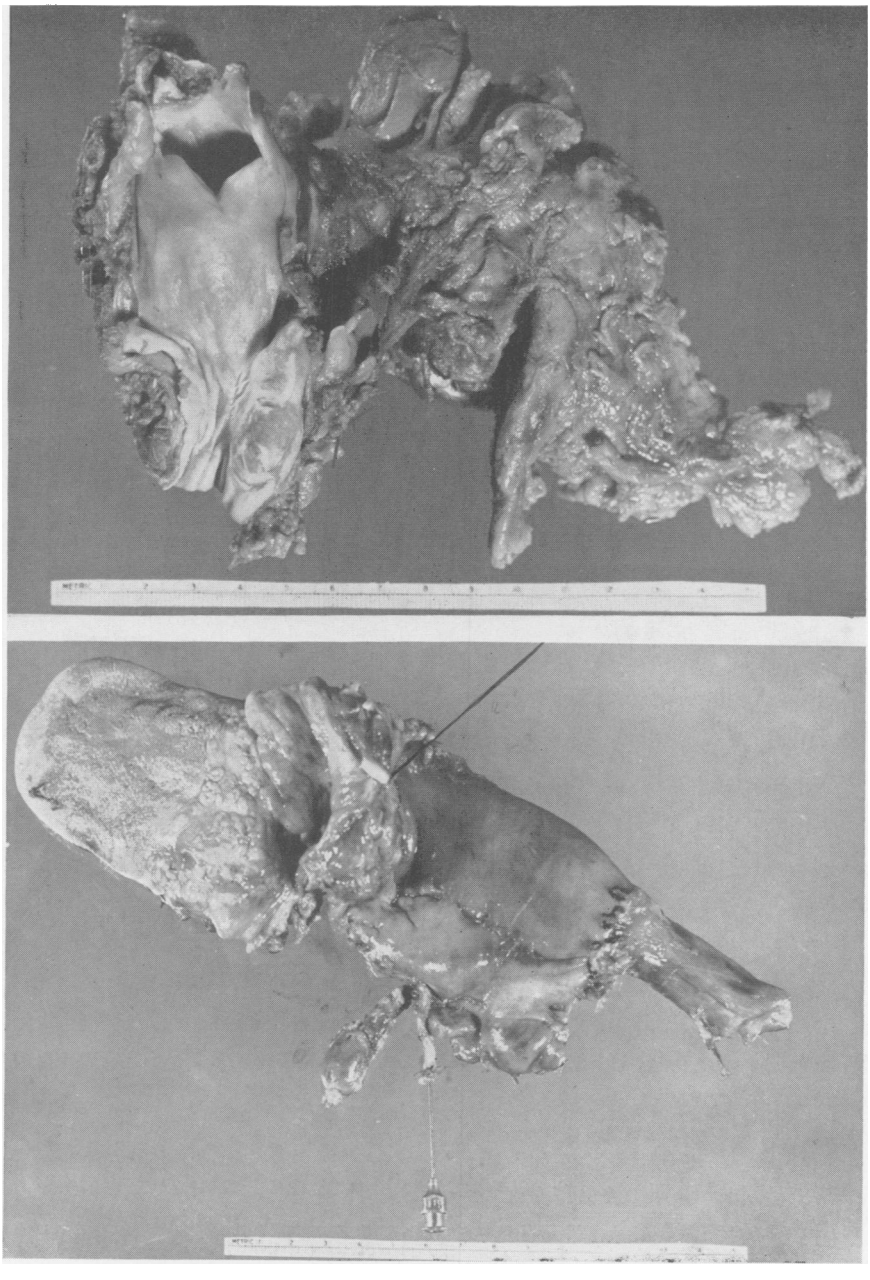

FIG. 8 (upper). Photograph of operative specimen demonstrating a laryngo-esophagectomy and right radical neck dissection for squamous cell carcinoma of the cervical esophagus.

FIG. 9 (lower). Photograph of autopsy specimen demonstrating the viability of the revascularized jejunal segment seven days postoperatively.

technics employed to date. It is a one-stage operation permitting wider excision with combined neck dissection. No pharyngostome is created. Early strictures and the high incidence of pharyngeal leaks that may accompany the procedures utilizing split thickness skin grafts are eliminated.

This technic, however, requires considerable experience and dexterity in vascular surgery. Anastomosing small arteries successfully has been a challenging problem since the early work on vascular suturing by Carrel [2] and Guthrie.[5] The technic of anastomosing small arteries, as done in this laboratory, was developed during experimental studies involving over 300 such anastomoses since 1950,[7-9, 14, 15] and has been described in detail in a previous publication.[13]

The venous anastomosis required a rigid, non-reactive, ring prosthesis to maintain its patency because the flaccidity and low pressure in small veins prevented successful suture anastomosis. Highly polished tantalum rings that were carefully defatted and siliconized proved to be a reliable prosthesis that did not stimulate tissue reaction resulting in venous thrombosis.

It is not essential that the free jejunal graft be implanted in the cervical esophagus defect in the isoperistaltic position. The graft quickly becomes adherent to the surrounding structures and active peristalsis is inhibited.

This method of cervical esophagus reconstruction is much more suitable in man than in the dog, because the vessels in the human are of larger calibre and can be anastomosed with a high incidence of success. On July 30, 1957, the procedure was carried out on a 63-year-old man with a recurrent squamous cell carcinoma of the cervical esophagus. He had symptoms of dysphagia for one year and the disease failed to be controlled by cobalt radiation therapy. Esophagoscopy showed the persistence of tumor in the right side of the cervical esophagus, and a right radical neck dissection, total laryngectomy, cervical esophagectomy down to the sternomanubrial junction and superior mediastinal lymph node dissection were performed utilizing a sternal splitting extension to the cervical incision (Fig. 8). Microscopy of the operative specimen revealed an adequate resection of the esophageal lesion with metastatic tumor involving only the paraesophageal nodes in the superior mediastinum. The defect between the pharynx and the transected end of the esophagus was immediately bridged by a free jejunal segment revascularized in the neck. The mesenteric artery was anastomosed to the left inferior thyroid artery and the mesenteric vein to the left common facial vein. The inferior thyroid artery measured 3 mm. and the anastomosis was performed with ease in comparison to these done on the vessels of the dog which usually measured 1½ to 2 mm. The patient was a diabetic with severe essential hypertension. Postoperatively he did not develop a pharyngeal leak or present any problem referrable to the reconstructed cervical esophagus. On the fifth postoperative day he sustained a cerebral vascular accident and expired on the seventh postoperative day. At autopsy, the revascularized jejunal segment was pink and viable. The anastomoses of the jejunum to the pharynx and esophagus were completely healed and the arterial and venous anastomoses were patent (Fig. 9). The jejunal segment was perfused with diodrast through the inferior thyroid artery and an x-ray showed patency of its entire vasculature (Fig. 10).

Carcinoma of the cervical esophagus may extend into the upper thoracic segment, and the paraesophageal lymph nodes in the superior mediastinum are frequently the site of metastatic disease. Extension of the resection of the cervical esophagus to include these superior mediastinal structures could be employed with this method of cervical esophageal reconstruction. The use of the free jejunal segment is not re-

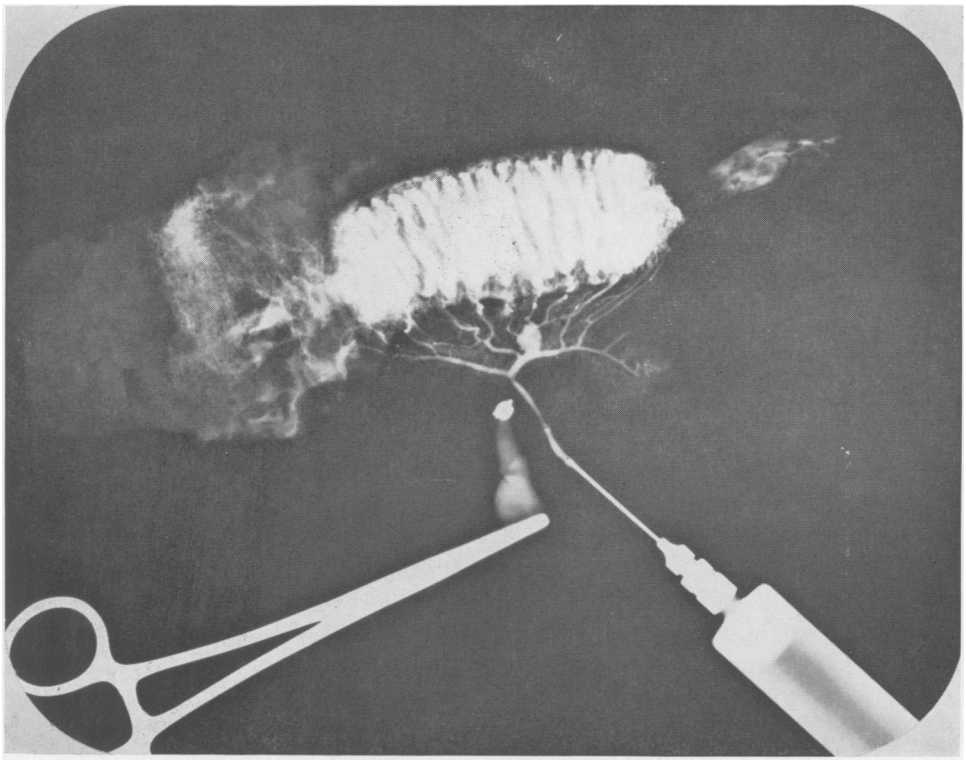

FIG. 10. The specimen in Figure 9 was perfused with diodrast through the inferior thyroid artery, and a roentgenogram showed patency of its entire vasculature.

stricted by the length of the pharyngoesophageal defect.

The basic technic of revascularizing autogenous tissue transplants, as developed in this experimental study, has numerous potential clinical applications. The vascular techniques may be utilized to augment the blood supply of long segments of bowel used for total esophageal replacement. Multiple staged plastic reconstructive procedures may be reduced to a single or two-stage procedure by the transplant of a pedicle flap that is revascularized at the recipient site. Further experimental work is being performed to explore these possibilities.

Summary

1. Restoration of pharyngoesophageal continuity upon completion of removal of tumors of the hypopharynx and cervical esophagus represents one of the major challenges in this type of surgery.

2. A one-stage immediate reconstruction of the cervical esophagus by an isolated jejunal segment revascularized in the neck has been developed in dogs.

3. The arterial and venous aspects of the operative technic are described in detail.

4. The first clinical application of this procedure in man is described.

5. The potential clinical applications of the technique of revascularizing autogenous tissue transplants are discussed.

Acknowledgment

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