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Overcoming Microsurgical Anastomotic Challenges in Supercharged Pedicled Jejunal Interposition for Pediatric Esophageal Reconstruction

Jason W. Yu, DMD, MD*; Frankie K. Wong, MD*; Kyle M. Thompson, MD†; Mario A. Aycart, MD*; Ashleigh Francis, MD*; Brian I. Labow, MD*; Joseph Upton, MD*; Amir H. Taghinia, MD, MPH, MBA*

INTRODUCTION

Management of long-gap esophageal atresia is a difficult reconstructive challenge. We have previously described our institutional experience with supercharged pedicled jejunal interposition as both a salvage and primary treatment option for these patients.[1–3] Historically, the jejunum has been considered an unreliable and difficult esophageal replacement due to its C-shaped mesentery and segmental blood supply.[4–7] "Supercharging" a pedicled segment of jejunum diminishes the risk of ischemia and improves reliability. Some adult centers have used a two-incision approach (upper midline abdominal and neck), mobilizing the jejunum intra-abdominally and passing the pedicled flap blindly through the anterior mediastinum and up into the neck.[8] This approach obviates the need for a sternotomy and allows the microsurgery to be performed in the neck. However, this approach necessitates the division of many jejunal branches to gain adequate mobility and blocks most of the flap from view following supercharging. In children with long-gap esophageal atresia, the anterior mediastinum and neck is often heavily scarred, and as such we have used an extended sternotomy and the internal mammary vessels to perform supercharged pedicled jejunal interposition. While this approach provides maximal blood supply (by minimizing the number of jejunal perforators to be divided) and excellent exposure, it necessitates microsurgery in a very challenging space.

*From the *Department of Plastic and Oral Surgery, Boston Children's Hospital, and Harvard Medical School, Boston, Mass.; and †Department of Surgery, Boston Children's Hospital, and Harvard Medical School, Boston, Mass.*

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Microvascular Anastomotic Challenges

Performing supercharged pedicled jejunal interposition has a steep learning curve. In addition to the dissection and selection of the ideal jejunal vessels to allow transposition to the neck, significant microvascular hurdles remain. Microsurgery is typically performed directly above the heart, with pediatric heart rates ranging from 100 to 150 beats per minute, combined with the repetitive respiratory movement and encroachment by the lungs, destabilizing and obscuring the field. These challenges are compounded by small vessel size ranging from 1–2 mm in diameter. The purpose of this article is to present four major methods in overcoming oscillations within the thoracic cavity for successful anastomoses.

Surgical Technique

The general surgical approach has been described previously.[1] Exposure of the neck, mediastinum, and abdomen are achieved via an extended hockey-stick incision. The cervical esophagostomy is mobilized and rerouted under the sternocleidomastoid. The internal mammary vessels are inspected, and the best side is mobilized but not divided. Substantial vein-caliber mismatch between the small mammary veins and the larger jejunal vein(s) is to be expected. If the mammary veins are absent or damaged from prior surgery, a neck vein can be mobilized, and pedicled down into the chest.

Dissection of the jejunum begins with the transverse mesocolon reflected cranially and the first loop of jejunum resting caudally to expose its mesentery. Arterial branches are identified and dissected to their origins along the superior mesenteric artery. These branches vary greatly in terms of size, branching pattern, and proximity to one another. The most proximal portion of the flap is marked for division after careful analysis of the branching scheme to optimize mobilization while dividing only a single or at most two vessels. A corresponding jejunal vein is similarly mobilized. As thrombosis seems to occur more frequently in these vessels, the entire vessel dissection is done with a heparin infusion running. After division with

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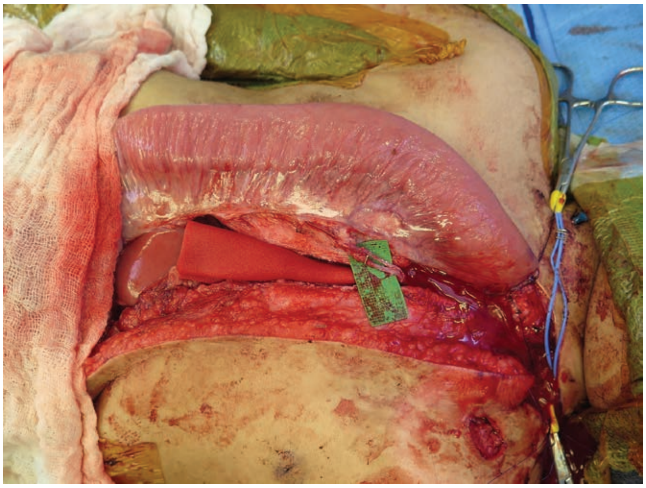

Fig. 1. Anastomosis performed with externalization of pedicled jejunum.

a GIA stapler (Covidien, New Haven, Conn.), the jejunum is delivered through a window created in the transverse mesocolon to the neck while the distal marginal arcade is left intact.

The flap is aligned without tension at the level of the internal mammary vessels that are divided once the flap has been transferred. To facilitate microvascular coaptation, we have used four different methods, alone or in combination. **(See Video [online],** which displays four different methods of overcoming microsurgical anastomotic challenges in supercharged pedicled jejunal interposition.)

1. "Dampening" of cardiac and pulmonary oscillations

One or two microsurgical wipes (absorbent sponges) are placed on the pericardium to elevate the microsurgical field and dampen the effects of cardiac motion.

2. Assistant surgeon stabilization (double-clamp method)

Microsurgical field motion is diminished, with the assistant surgeon holding the double opposing microvascular clamp in space, with a forceps. With the nondominant hand resting on the hemi-sternum, the assistant elevates and stabilizes the double opposing clamp, allowing the surgeon to perform the anastomosis.

3. Externalization of jejunum (Fig. 1)

On occasion, when there is ample flap and vessel length, the jejunum can be externalized during the microsurgical portion of the procedure. The flap and vessels rest on top of one side of the chest, yielding a stable field.

4. Microsurgical hammock (Fig. 2)

A hammock is created using a piece of Esmarch bandage. The hammock is suspended between the cut edges of the sternum, with the vessels and clamp resting above the heart.

Following anastomosis, the jejunum is assessed for signs of reperfusion and peristalsis. The esophageal and bowel anastomoses are performed to restore gastrointestinal continuity. Before closure, fluorescence imaging is employed to confirm adequate perfusion to the entire jejunal segment.

Postoperative Care

Patients are admitted to the intensive care unit until extubated and stable. The heparin infusion started intraoperatively is continued at 10 units/kg/h for several days. Daily aspirin starts postoperatively for a total of 4 weeks. Patients routinely have a swallow study and endoscopy one to two weeks postoperatively.

DISCUSSION

Medical therapies directed at lowering heart rate may attenuate the dynamic effects of the cardiopulmonary system. However, bradycardia in the pediatric population, defined as less than 100 beats per minute amongst infants, is not advisable.[9] Unlike the adult population, pediatric cardiac output is significantly dependent on heart rate, due to limited ability in increasing stroke volume. Thus, any combination of the four methods presented will

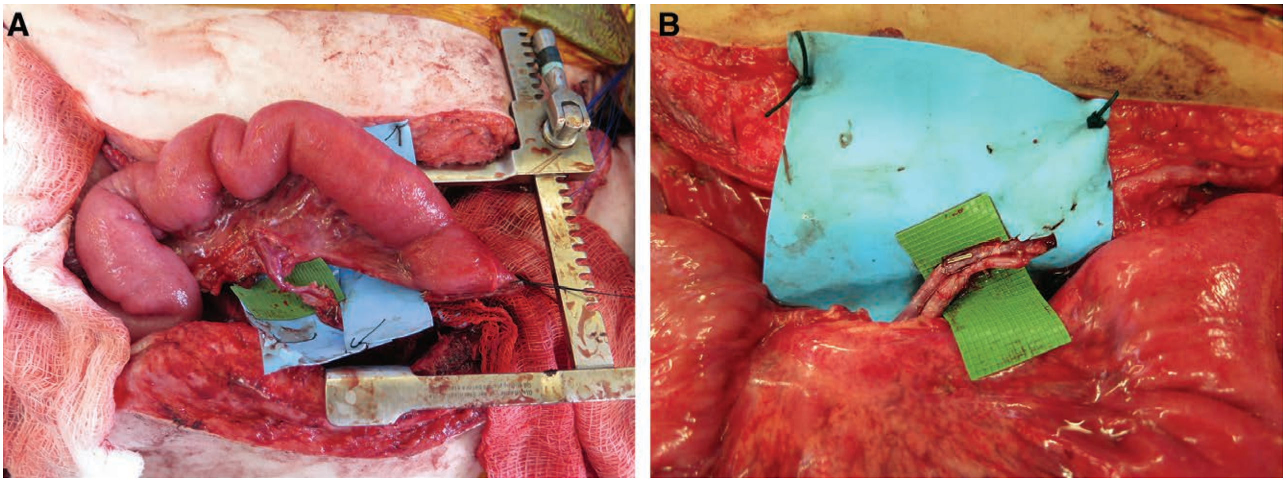

Fig. 2. The hammock technique was created using a piece of Esmarch bandage. A, Anastomosis performed using the hammock method. B, Close-up view of the hammock method.

provide optimum stability to an active and dynamic operative field. The techniques listed here are not necessarily limited to the procedures outlined herein, rather they can be applied to any microanastomotic procedure within the thoracic or intra-abdominal surgery, such as living donor transplantation, where cardiac or respiratory movement complicates microsurgery.[10,11]

None of the 44 jejunal interposition procedures performed from 2015 to 2020 experienced anastomotic leaks or flap loss. Complications do not appear to be related to technical aspects of anastomosis. One patient developed a hematoma after a staged abdominal closure, 1 week after the initial jejunal anastomosis. Two developed self-limiting chyle leaks that only required mild delays in introduction of enteral feeds.

In general, we do not employ implantable Dopplers or an exteriorized segment of jejunum for monitoring. The vessels are quite small and any changes in position introduced from the plastic sheathing of the implantable Doppler can cause kinking. The respiratory and cardiac cycles, combined with the peristalsis of the gastrointestinal tract, dampen the quality of the anastomotic signal. Furthermore, exteriorizing the jejunum would require additional length and procedures, which cause other difficulties. Instead of these options and in similar fashion to solid organ transplantation, monitoring physiologic parameters (by proxy) is done through frequent assessment of hemodynamics and blood parameters, including pH and lactate level in the first few days postoperatively. Patients routinely have swallow studies over a week postoperatively for assessment of leaks and/or strictures.

CONCLUSIONS

Supercharged jejunal interposition flaps offer a valuable treatment option in pediatric patients requiring esophageal replacement. Microsurgery in the mediastinum is challenging and can be facilitated using adjunctive maneuvers to improve stability.

Amir H. Taghinia, MD, MPH, MBA
Department of Plastic and Oral Surgery
300 Longwood Avenue, Enders 1
Boston, MA 02115
E-mail: amir.taghinia@childrens.harvard.edu

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