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The use of bi-planar tissue expanders to augment abdominal domain in a pediatric intestinal transplant recipient

Joshua Weiner^{1,4}, June Wu^{2,4}, Mercedes Martinez¹, Steven Lobritto¹, Nadia Ovchinsky¹, Christine Rohde², Adam Griesemer¹, and Tomoaki Kato^{1,3}

¹Columbia University College of Physicians and Surgeons, Center for Liver Disease and Transplantation, New York, NY 10032, USA

²Columbia University College of Physicians and Surgeons, Division of Plastic Surgery, New York, NY 10032, USA

Abstract

Intestinal transplantation is a well-accepted treatment for short bowel syndrome (SBS). However, patients with SBS often have decreased abdominal capacity, which makes size-matching of donor organs more difficult, thus decreasing organ availability. Reported approaches for addressing this problem include surgically reducing the graft size, leaving an open abdomen for a prolonged period, and co-transplanting rectus fascia as a non-vascularized allograft. Each approach has significant disadvantages. There has been one previous report of tissue expanders used intra-abdominally and two reports of subcutaneous use to increase intra-abdominal capacity prior to transplantation. We report the first use of bi-planar expander placement for this purpose. In our case, a 2-year-old male child with SBS due to malrotation was treated with tissue expanders 11 months prior to intestinal transplantation, thus allowing transplantation of a larger graft with the ability to close the abdomen safely. There were no complications, and the patient is now doing well and tolerating diet off parenteral nutrition. The use of tissue expanders prior to intestinal transplantation is a promising approach for such patients and avoids the morbidity associated with other approaches. This approach requires a multidisciplinary effort by gastroenterology, transplant surgery, and plastic surgery teams.

Keywords

tissue expander; intestinal transplantation; abdominal compartment syndrome; pediatric transplantation

³Address correspondence to: Tomoaki Kato, The Columbia University Medical Center, PH Room 14-105 New York, NY 10032, T: (212) 305-5101, F: (212) 305-5124, tk2388@columbia.edu.

⁴These authors contributed equally to this manuscript

Author contributions: Joshua Weiner: Data collection, data analysis and interpretation, drafting manuscript

June Wu: Clinical care, drafting manuscript, critical revision of manuscript

Mercedes Martinez: Clinical care, critical revision of manuscript

Steven Lobritto: Clinical care, critical revision of manuscript

Nadia Ovchinsky: Clinical care, critical revision of manuscript

Christine Rohde: Clinical care, critical revision of manuscript

Adam Griesemer: Clinical care, critical revision of manuscript, data analysis and interpretation, approval of manuscript

Tomoaki Kato: Clinical care, critical revision of manuscript, designing of project concept, approval of manuscript

Introduction

Intestinal transplantation is a well-accepted treatment for short bowel syndrome (SBS) (1, 2). SBS is defined as a condition in which there is a lack of sufficient bowel function, which can be due to lack of adequate length or intrinsic problems with gut physiology (3). It is a highly morbid condition, which can lead to malnutrition, intractable diarrhea with high-output fluid loss, and intestinal dilation with stasis/bacterial overgrowth. Complications of nutritional support with parenteral nutrition (PN) can include Intestinal Failure Associated Liver Disease (IFALD), frequent central venous catheter-related infections, and central venous thrombosis (2).

Patients with SBS due to lack of adequate length often have markedly decreased intra-abdominal capacity for several reasons, including small recipient size from malnutrition and decreased abdominal size from long-standing lack of contents, all of which make size-matching of donor organs more difficult, thus decreasing organ availability (4). If overly-large donor organs are used, one highly morbid consequence is abdominal hypertension or abdominal compartment syndrome. Avoiding this complication by leaving an open abdomen with staged closure conveys additional morbidity, especially in the setting of immunosuppression (5, 6).

One approach to avoid this problem is to surgically reduce the graft size, which presents its own set of challenges and yields a less optimal graft (7). A second approach that we have previously described is the co-transplantation of the rectus fascia as a non-vascularized allograft (8) or co-transplantation of the abdominal wall as a vascularized composite tissue graft (9) to aid in abdominal wall closure without tension. However, these modalities can be technically complex and add morbidity (8, 9), and a recent case report describes the possibility of rejection of the abdominal wall graft (10).

A third strategy is the use of tissue expander to increase intra-abdominal capacity prior to transplantation. The use of tissue expanders to facilitate abdominal surgery when there is loss of domain is well documented in the literature. In liver transplantation, tissue expanders have been used to increase abdominal domain and decrease abdominal hypertension, which helps prevent obstruction of hepatic venous outflow and portal venous inflow (11-13), and there is also one documented case of tissue expansion prior to combined liver-intestine transplantation (14). Tissue expansion (or its approximation by utilizing progressive pneumoperitoneum) has similarly facilitated repair of abdominal wall hernias with very large defects (15-17), repair of large omphaloceles (18), and reduction of long-standing large hernias in which the decreased abdominal domain can no longer accommodate the peritoneal contents without significant intra-abdominal hypertension or abdominal compartment syndrome (19). Most recently, the use of tissue expanders has been documented in the abdominal wall reconstruction of children who have had resections of large abdominal wall vascular malformations (20).

Two recent case reports have detailed the successful tissue expanders placed in the subcutaneous layer to increase abdominal domain prior to intestinal transplantation (21, 22). Surprisingly, our review of the literature revealed only a single case report of the use of

intraabdominal tissue expanders in the setting of isolated intestinal transplantation. In a brief letter to the editor in 2002, Vicente's group from Madrid described the use of tissue expansion on a 27-year-old patient with decreased abdominal domain after total enterectomy due to a large desmoid tumor. Intestinal transplantation was not initially possible in this patient due to lack of domain, so staged expansion was performed using a rounded 1000ml expander in the pelvic region of the abdominal cavity and a rectangular 700ml expander in a musculofascial pocket, which were expanded over the course of two months. An intestinal graft was subsequently transplanted without complications, and the abdomen was closed primarily (23). We have modified this approach and created a bi-planar pocket for the placement of tissue expanders to facilitate intestinal transplantation. Herein we report the first successful use of this approach in a pediatric recipient.

Case Report

Our patient is a full term male child that presented 34 months of age for transplant evaluation due to SBS. Early in life, he developed frequent episodes of bilious projectile vomiting, requiring almost weekly hospitalizations. Initial workup did not reveal the source etiology. The patient exhibited failure to thrive, requiring PN by the age of 19 months. He remained non-distended and continued to have bowel movements. At 22 months of age, the patient developed an obstructive picture consisting of abdominal distension, pain, obstipation, and hematemesis. Exploratory laparotomy at that time revealed malrotation with volvulus, and the patient underwent subtotal enterectomy, leaving 10-15cm jejunum with terminal jejunostomy and only colon from the rectum distally to a mucus fistula at the splenic flexure. He subsequently required frequent hospitalization due to PN complications and sepsis, although he was able to tolerate some enteral nutrition. He developed progressive weakness, failed to gain weight despite PN, and became anemic. On admission to our facility, his PN regimen was optimized, and his nutritional status was improved. Liver biopsy at our institution showed evidence of mild portal inflammation with associated mild ductular reaction, periportal fibrosis, and mild diffuse hepatocellular swelling consistent with IFALD (Batts-Ludwig Stage 2). He also had high output from his jejunostomy and dangerous hypoglycemia when off PN.

At our institution, upper GI series showed rapid transit of contrast from the stomach to the jejunostomy. Our multidisciplinary transplant team determined that he was an appropriate candidate for intestinal transplantation due to his central venous catheter complications, PN morbidity, and his poor chance of achieving intestinal sufficiency. However, his small abdominal cavity (a result of his relative lack of contents and his severe scarring) limited our ability to implant an adequate intestinal graft. Therefore, the patient underwent insertion of abdominal wall tissue expanders by the pediatric plastic surgery team 1 month after initial presentation to our institution.

The patient had a prior horizontal laparotomy incision. In addition, there was a gastric tube as well as a jejunostomy site on the right and mucus fistula site on the left sides of the abdominal wall respectively. Therefore, the decision was made to place horizontally-oriented tissue expanders (PMT Integra) both cephalad and caudad to the old laparotomy incision, taking care to avoid the gastric tube and colostomy tracts. The abdomen was

opened and the intra-abdominal contents freed from the peritoneal lining. Preparation of two pockets then commenced in the intra-peritoneal space, deep to the abdominal wall musculature. At the superior border of the peritoneum, a sub-muscular pocket was created between the costal margin and pectoralis muscle, keeping it in continuity with the abdominal wall musculature. Inferiorly, a sub-muscular pocket was created between the iliac crest and quadriceps and tensor fascia lata, again in continuity with the abdominal wall musculature. Further extensions were created to house the ports for injection. Off the field, ports were connected to the tissue expanders, which were first filled with 20mL of NS stained with methylene blue, and the air was removed. After preparation, the tissue expanders were then placed intra-abdominally and secured, and the ports were tunneled and secured (Figure 1). The superior expander extended into the chest wall, and the inferior expander extended into the groin. The ribs and iliac crest stabilized the tissue expanders to prevent migration and to ensure that they would expand outward instead of into the abdominal cavity, which could compress the existing short gut. Finally, the peritoneum and abdominal wall were closed. Figure 2 shows the intraabdominal aspect of the superior tissue expander. The more superior extraperitoneal aspect of this expander, which extends into the chest wall, cannot be seen on this scan.

The expanders were serially inflated with saline over the course of three months to the appropriate size. The patient tolerated expansion to 230ml and 345ml on the left and right respectively (from 60ml and 100ml initially). At that point, his abdominal cavity was large enough to accommodate an intestinal graft, and he was listed for transplantation. The patient experienced moderate abdominal pain in the initial postoperative period and briefly after each expander inflation, and the pain was adequately controlled with narcotics.

He was transplanted 9 months after tissue expander placement. During this surgery, the plastic surgery team first performed capsulotomies and removed the tissue expanders and ports, carefully avoiding the bowel. Transplantation was then performed in the usual fashion (1). At that time, recipient height, weight, and age were 93 cm (5th percentile), 15.3 kg (25th percentile), and 3 years 8 months; and donor height, weight, and age were 102 cm, 13.8 kg, and 3 years 4 months. The graft consisted entirely of small intestine, which was anastomosed to duodenum proximally and colon distally. The abdomen was temporarily closed with Gore-Tex mesh until decrease in edema permitted primary closure, which occurred without complications on postoperative day 7. He was successfully extubated on postoperative day 1, since the low intra-abdominal pressure allowed for easy spontaneous respirations. Initial immunosuppression included tacrolimus, solumedrol, and thymoglobulin, of which only tacrolimus continues.

The patient had a bowel movement on postoperative day 3 and started oral liquids on postoperative day 8. An episode of acute rejection was successfully treated by steroid bolus and he was discharged home 1 month after transplantation. He is currently tolerating oral and parenteral tube feeds via gastrostomy tube and no longer requires PN.

Discussion

This represents the second reported case (and the first pediatric case) of tissue expanders being utilized within the abdomen to increase intra-abdominal domain in preparation for intestinal transplantation. It is the first case in which intra-abdominal placement is combined with extension of the expanders into sub-muscular pockets. Due to the small stature of this malnourished patient, extending beyond the abdominal cavity was necessary to accommodate appropriately sized tissue expanders with the desired volume for effective expansion. In addition, the extension allowed the ends of the tissue expanders to be supported and anchored by stable skeletal structures (ribs and iliac crest) to minimize the risk of their migration during the expansion process. Finally, this bi-planar placement directed the force of the expansion outward on the abdominal wall vasculature, versus inwards to exert more pressure on the peritoneal contents. This latter point is also an advantage over the subcutaneous placement of tissue expanders in recent reports (21, 22).

Expansion of abdominal cavity capacity prior to intestinal transplantation is necessary for some patients with SBS because SBS both creates the need for intestinal transplantation but also decreases intra-abdominal domain, limiting the ability to accommodate an intestinal graft. This is particularly true in pediatric recipients. Other methods of facilitating bowel transplantation in this population discussed above include partial graft reduction, prolonged open abdomen with prosthetic closure, and cotransplantation of rectus fascia, each of which involves unique risks. We also note that other groups have successfully used component separation (24, 25) or skin-only closure, usually with alloderm grafts (26) and in combination with underlying absorbable mesh (27), in these circumstances. Of all these options, temporary abdominal closure with prosthetic material is the most common and has several advantages including comparative ease, speed, low cost, and lack of immunologic risk. However, temporary abdominal closure increases infectious risk, especially with prosthetic material during time of immunosuppression, and is what surgeons seek to avoid with other options (5, 6).

These are all viable and established options, but we prefer the use of tissue expanders when possible for several reasons. First, when used both to expand domain and stretch the abdominal musculature and fascia, as in our technique, they increase the likelihood of being able to close primarily or using component separation. Second, they avoid the obvious major hernia complication of biological mesh or skin-only closure. In contrast, our method better facilitates fascial closure. Finally, in cases in which patients have had prior transverse incisions, we have found it almost impossible to perform component separation subsequently as the division of the rectus abdominus causes denervation and then atrophy.

Additional advantages of using expanders in this setting include reducing postoperative infectious risk due to prolonged open abdomen, reducing the time to wound closure, avoiding long-term graft material post-transplant (for both abdominal coverage and for eventual repair of abdominal defects), and ease of performance compared to more complicated flaps at time of surgery or management of open abdomen long-term. However, the potential disadvantages of using tissue expanders include 1) increased time to transplantation given the need to perform placement of the expanders and serial expansion,

2) increased infectious risk, 3) additional anesthesia exposure, and 4) poor subsequent healing of pockets in the setting of immunosuppression. Abdominal compartment syndrome after tissue expansion is an additional risk, and it is important to monitor carefully for this condition postoperatively. We acknowledge that each patient must be considered uniquely and that the use of tissue expanders is not always the best option. However, for all of the reasons discussed above, we believe that it should be considered in cases in which it is physically possible and in which the resources and expertise exist. In our case, we note that our patient required short-term temporary abdominal closure despite the use of tissue expanders and a graft matched for weight. Rather than negating the value of tissue expanders, we believe that this fact emphasizes how important the tissue expanders were both in facilitating transplantation and allowing more rapid closure.

In this case, as in others, how quickly expansion can be achieved depends on tissue quality and elasticity and patient cooperation and tolerance. Although this patient did not undergo primary closure at the time of transplantation, the use of expanders decreased the time and morbidity of delayed wound closure. We conclude that the use of abdominal expanders in the setting of intestinal transplantation is a safe and effective means to achieve transplantation in recipients with limited abdominal domain. This technique is especially applicable in pediatric recipients to expand the options for graft size and permit bowel transplantation at an earlier time point. A multidisciplinary approach is essential to the success of this modality, and it is important to initiate early coordination between transplant and plastic surgery teams to prepare the implant sites and plan the series of joint interventions for this complex problem. Although this is only the second report of intra-abdominal tissue expander placement for isolated intestinal transplantation, the first report in a child, and the first reported case of extension of the expanders into the retrorectus space, we suggest that this technique might be beneficial to simplify post-operative wound care and may decrease time to recovery and discharge. As in all such innovations, the choice of modality is case dependent, operator dependent (familiarity and comfort with technique), and outcome driven.

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Abbreviations

SBS	Short Bowel Syndrome
PN	Parenteral Nutrition
IFALD	Intestinal Failure Associated Liver Disease

Figure 1.
Placement of tissue expanders. A) Lateral view of patient prior to placement of tissue expanders. B) Lateral view of patient after full inflation of tissue expanders 3 months later. C) Tissue expanders prior to placement. D) Placement of right upper quadrant tissue expander. E) Placement of suprapubic tissue expander placement.

Figure 2. Intraabdominal aspect of the superior tissue expander on computed tomography (CT) imaging one week after placement. The more superior extraperitoneal aspect of this expander, which extends into the chest wall, cannot be seen on this scan.