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Advances in pediatric colorectal surgical techniques

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The operative management of pediatric colorectal diseases has improved significantly in recent years through the development of innovative approaches for operative exposure and a better understanding of colorectal anatomy. Advances in transanal and minimal access techniques have formed the cornerstone of this innovation, leading to improved functional outcomes, earlier recovery, and superior cosmetic results for a number of colorectal diseases. In this regard, we have witnessed a significant evolution in the way that many of these conditions are managed, particularly in the areas of anorectal malformations and Hirschsprung disease. Furthermore, a more thorough understanding of the pathophysiology underlying encopresis and true fecal continence has led to novel and less invasive approaches to the operative management of these conditions. The goal of this review is to describe the evolution of operative management pertaining to these diseases, with an emphasis on technical aspects and relevant clinical pitfalls.

Over the past decade, the operative treatment of many pediatric colorectal diseases has improved through a better understanding of colorectal anatomy and the continued evolution of minimally invasive techniques. In regard to the latter, significant progress has been made not only in the evolution of laparoscopic technology, but also in the development of novel, entirely transanal approaches for conditions, such as refractory encopresis. For children with true fecal incontinence, significant advances have included the use of laparoscopy in the creation of continent stomas, and development of novel methods to reduce stomal stenosis. Finally, advances in laparoscopic techniques have continued to revolutionize the operative management of children with Hirschsprung disease and complex anorectal malformations (ARMs). Although many of these techniques were first described in the mid-1990s, refinements over the last decade have allowed these procedures to be used in ever more challenging cases. The purpose of this review is to describe the evolution of these technical advances while at the same time highlighting some of the clinical pitfalls and future directions that should be considered as we move forward.

Fecal incontinence

Fecal incontinence is a devastating problem that affects several children who have undergone complex colorectal operations (eg, repair of high ARMs), and others with primary conditions or injuries involving the spinal cord. Successful management of fecal incontinence hinges upon differentiating between true incontinence and that associated with severe constipation (encopresis or pseudoincontinence). This distinction is crucial as patients with pseudoincontinence often have the capacity for bowel control if an intensive bowel management program is used to control constipation.[1] In regard to children with true fecal incontinence, the evolution of operative management over the last decade has largely focused on improving cosmetic and

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functional outcomes associated with antegrade continent enema (ACE) procedures. This has included not only the use of minimally invasive techniques, but also the development of novel anastomotic flap techniques to reduce stricturing at the exit site.

Early experience with the ACE procedure

The first ACE procedure was described by Malone et al[2] nearly 3 decades ago. The original description involved amputating and reversing the appendix, and then reimplanting it into a submucosal tunnel within the cecum to create a nonrefluxing conduit.[2] Later modifications included in situ (nonreversed) implantation of the appendix and fenestration of the appendiceal mesentery to prevent the antireflux mechanism from compromising the appendiceal blood supply.[3,4] Still others proposed a less technically demanding approach for creating the antireflux mechanism, where the seromuscular layer of the cecum was simply imbricated over the base of the appendix to create a continent valve.[3,4] Although early reports of ACE procedures suggested excellent functional outcomes, complication rates were not insignificant. This was evidenced by the first multicenter review of 273 ACE procedures, where stomal stenosis was observed in 30% of all patients and leakage in 7%.[5]

Technical considerations in the prevention of stomal stenosis

The relatively high rate of stenosis in earlier reports led to the development of novel tissue-flap techniques in an effort to reduce the incidence of this complication. These have included the Y-appendicoplasty,[6] the Y–V umbilicoplasty,[7,8] the V-quadrilateral-Z (VQZ) flap,[9] and the umbilical tubular skin flap,[7] among others. The rates of stenosis using these techniques have been reportedly $< 10\%$, but meaningful comparison between these techniques is made difficult because of the marked variation in follow-up periods and different definitions used for stomal stenosis. Furthermore, there is evidence that the type of conduit and catheterization schedule may also influence the timing and rate of stenosis, making objective comparison of these techniques even more challenging.[10,11]

When choosing which technique is best suited for a particular patient, one must also consider the cosmetic implications of the techniques described in the preceding paragraphs. In this regard, a recent retrospective report found a lower stricture rate for the right lower quadrant VQZ flap (0%) when compared with using an umbilicoplasty approach (25%), thereby declaring the former "superior" in terms of conduit location and anastomotic technique. However, the VQZ technique requires a complex sequence of tissue flaps resulting in a prominent Z-shaped scar on the abdominal wall. By contrast, the Y–V umbilicoplasty results in a completely hidden orifice within the inferior fold of the umbilicus and is only noticeable during catheterization. Given that stenosis is frequently amenable to local dilation,[10] one must carefully weigh the psychological benefit of a superior cosmetic result against the marginal benefit that more disfiguring techniques may offer in reducing the incidence of an otherwise easily manageable complication.

Cecoplication, leakage, and the emergence of laparoscopy

The need to create an antireflux valve to prevent stomal leakage remains controversial and has not been examined in a prospective manner. In the 2 largest reported experiences of ACE procedures where cecoplication was routinely performed, leak rates were observed in 3% and 7% of patients, with a median follow-up of at least 2.5 years.[5,12] Several centers have since reported their experience using ACE procedures without cecoplication, and this has largely been driven by the introduction of minimally invasive techniques.[13-18] In the largest reported series to date, Nanigian and Kurzrock[15] recently described their experience with 22 patients using an entirely laparoscopic technique. They used a 2- or 3-port technique depending on whether the cecum had to be mobilized to bring the appendix up to the umbilicus. The appendix was then delivered through the umbilical port site, where it was attached as a stoma to the umbilicus using a spatulated technique. A cecoplication was not performed and they observed no leaks after a mean follow-up period of 2 years.

Further long-term follow-up is needed to establish whether leak rates associated with laparoscopic techniques remain equivalent or superior to open techniques, and to determine which patients may ultimately benefit from a cecoplication.[5,12] In regard to the latter consideration, the need for cecoplication does not necessarily preclude the benefit of using a minimally invasive approach. A hybrid approach has been described by Levitt and Peña[8] in which the base of the cecum and appendix are laparoscopically mobilized to the midline, and then exteriorized through a small inferior extension of the umbilical port-site incision. A cecoplication can then be performed with minimal added morbidity.

ACE procedures in patients with a missing appendix

In the case where the appendix is missing, the 2 main options for constructing an ACE conduit include the tubularized cecal flap[4,19] and the Monti procedure.[11] The cecal flap involves the creation of a neoappendix from a tubularized piece of cecum along its medial wall. The neoappendix is then imbricated into the cecum to create an antireflux valve. The cecum is mobilized medially so the neoappendix