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The Monti Principle: Different Uses 10 Years Later

FROM THE GUEST CO-EDITORS

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In 1980, Mitrofanoff used an anti-reflux technique based in small-caliber tubes to obtain continence in patients with neurogenic bladder. This simple and effective procedure established a landmark in the history of urinary diversions and is now frequently used in reconstructive urology and uropediatrics. Since the beginning, the tube used most commonly has been the cecal appendix. It has the advantages of being a dispensable structure with adequate caliber, length, blood supply and location. However, for a variety of reasons, the appendix is not always available, and the growing application of the Mitrofanoff principle has transformed this situation into an important problem. The search for a reliable alternative motivated the use of different tubular structures such as ureteral segments, longitudinally tapered bowel segments, tubularized gastric, cecal, vesical and cutaneous flaps. Other less common options such as the uterine tube, vas deferens and segments of the hypogastric artery have also been used. Despite the variety, none of these options obtained the same results as with the appendix.

In 1993, Yang was the first to describe the transverse tubularization of two small ileal segments that had previously been detubularized in a patient who underwent radical cystectomy due to bladder cancer[1]. During follow-up, the patient obtained adequate continence and the stoma was easily catheterized. Unfortunately, the study had no reference to the principle of the

(continued on page 2)

FROM THE EDITOR

Anthony A. Caldamone, M.D.

It is interesting how certain words become part of our pediatric urologic vernacular almost overnight. Two terms that have attained such a status are Mitrofanoff and Monti principles. The reason is that these principles are understandable and reproducible and have made a significant contribution to our management of children with complex congenital urologic disorders. They are reproducible because of their simplicity and their applicability to a variety of situations. I can recall reading the original description by Professor Monti in 1997 and remarking in a journal club how brilliantly simplistic this concept was.

This issue looks at the Monti principle now 10 years later. There is no question that it not only has stood the test of time, but has continued to grow in its applicability. Under the direction of Professors Arap and Monti, the contributors evaluate their experience with the use of the Monti principle as well as explore new applications. These applications are not limited to pediatric urology. The Monti principle has assumed and earned a major role in our management of children with complex congenital urologic abnormalities.

I congratulate Professors Arap and Monti and their contributors for putting together an outstanding review of the Monti principle as well as a look into other applications. I am certain that this issue will be a ready reference for all of us for years to come.

catheterizable tube and the technique remained unknown until 1997, when Monti et al. independently described the experimental construction of single and double tubes in dogs[2]. In this study, the animals had adequate continence and stomas were easily catheterized. Stenosis of the stoma was the most common complication observed. Since 1995, when the first patient underwent the Monti procedure, several series were reported in the literature. Recent reports on the clinical application of transversally tubularized bowel segments for urinary diversions have shown similar results to those obtained using the appendix. The procedure is now widely accepted as an alternative for urinary diversion and its applications have expanded. The technique has been used with good results for replacing the ureter, for the construction of a neovagina, for MACE procedures and for continent gastrostomy, as will be seen in this issue.

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HOW I DO IT

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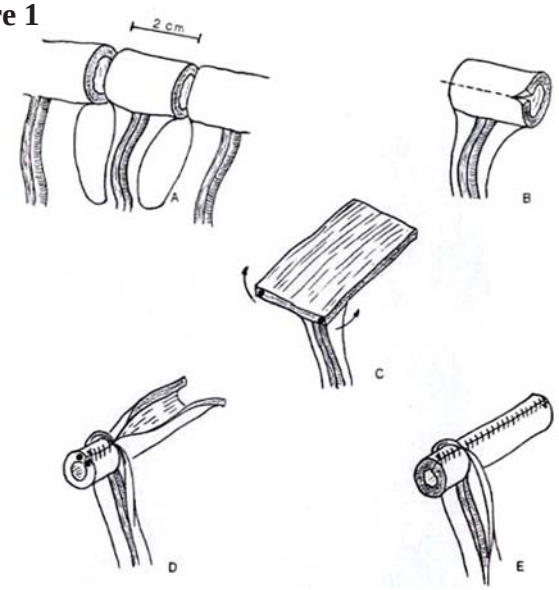
The majority of cases in which transversally tubularized bowel segments (TTBS) are utilized require bladder augmentation or construction of a reservoir, usually with an ileal or colonic bowel segment. Regardless of the segment used, an immediately adjacent segment is isolated for constructing the tube. It is important to note that it should be constructed right after the entero-enteroanastomosis, to avoid edema and technical dificulties. Two fundamental points to be defined are the caliber of the tube and whether the patient requires a single or double tube. The caliber will be determined by the length of the bowel segment isolated, which is the same as the circumference of the tube. In the original study, ileal segments of 2 cm and 3 cm in length allowed the use of 12 and 18Fr catheters, respectively. Clinically, when 3 cm ileal segments were used, the resulting tube was too wide, achieving a 24Fr catheter. Obviously this required a very long anti-reflux tunnel. We then started using shorter (2 – 2.5 cm) ileal segments and the resulting tubes permitted the use of 14Fr catheters.

The incision for detubularization of the ileum may be asymmetric with respect to the mesentery, creating a longer tube in one of the sides, which will allow an efficient anti-reflux procedure. The other side of the tube will be shorter but it must be long enough to reach the skin and then create the stoma. If it does not reach to the skin easily, a stoma location in the umbilicus may suffice as it demands a shorter tube. This will result in an excellent cosmetic result (Figure 1).

When the length of the simple tube is not long enough, a double tube may be created using two 2 – 2.5 cm ileal segments which will be detubularized asymmetrically (Figure 2). The resulting tubes are sutured together by their shorter segment, so that the mesentery will remain in the central portion of the tube. The two mesentery-free longer segments will be long enough for both an anti-reflux anastomosis and for the cutaneous stoma.

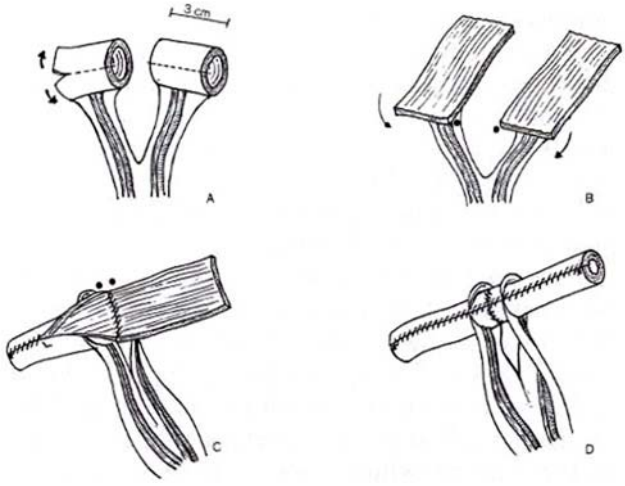
Figure 1



(A) A 2-cm ileal segment is isolated, (B) detubularized through longitudinal incision halfway on the anterior side, and (C) a pediculate flap is obtained. (D,E) This flap is then transversally tubularized with total running suture of 4-0 chromic catgut, and a tube with short and long branches separated by the mesentery is obtained.

Monti PR, Lara RC, Dutra MA, Carvalho JR: New techniques for construction of efferent conduits based on the Mitrofanoff principle. Urology 49: 112-5, 1997. Reprinted with permission from Elsevier.

Figure 2



(A) Two adjacent ileal segments, each 3-cm long, are isoloated and detubularized through longitudinal incision on their anterior side, near to mesentery implantation, and (B) two identical pediculated flaps are obtained. (C,D) These flaps are attached by the two short branches and the resulting flap is tubularized; a tube with two long branches separated by two insertions of mesentery is obtained. Running sutures with 3-0 chromic catgut are used.

Monti PR, Lara RC, Dutra MA, Carvalho JR: New techniques for construction of efferent conduits based on the Mitrofanoff principle. Urology 49: 112-5, 1997. Reprinted with permission from Elsevier.

The tube (single or double) should be the shortest possible length to avoid redundancies, and, therefore to facilitate catheterization. When a double tube is constructed, we can shorten its length by cutting one or both extremities since the mesentery is in its central portion and vascularization is centrifugal. We perform the tubularization with either 3-0 or 4-0 Vicryl running sutures over a 12Fr catheter. The anti-reflux procedure should be done preferably into the native bladder wall. Several well established anti-reflux techniques may be used for the bladder or colon. For the ileum, we prefer the serous-lined extramural tunnel[1]. One important technical detail is the fixation of the reservoir (around the tube) to the abdominal wall, thus stabilizing the continence mechanism. The stoma may be located in any part of the abdomen, according to patient's preferences and abilities. The stoma is constructed with the removal of a circumferential skin segment of 1.5 cm in diameter and 3-0 chromic catgut simple sutures. Even though there is always some degree of retraction, no patient has required stomal revision in our experience. At the end of the procedure, a 12Fr catheter is left in the tube sutured to the skin. The reservoir is drained using a large-caliber catheter, which is irrigated daily with saline. The splints are removed one week after the surgery, the large reservoir catheter is plugged after 21 days, and intermittent catheterization is started. If no problems occur, the reservior catheter is removed three days later.

Two fundamental points to be defined are the caliber of the tube and whether the patient requires a single or double tube.

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The Monti-Yang Procedure: The Indiana Experience

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The use of continent catheterizable channels in children has revolutionized lower urinary tract reconstruction. It has provided an easily performed, reliable means of bladder emptying, thus allowing surgeons to more aggressively increase urethral resistance to achieve urinary continence. While many types of channels have been reported including various nipple valves, the Mitrofanoff Principle of having a compressible tube tunneled submucosally into the bladder with good muscle backing, creating a "flap valve," has been highly successful in our hands and seems to be the technique of choice throughout the pediatric urology world.

We suspect that our experience with catheterizable abdominal wall channels at Indiana mirrors that of many other institutions. We went through a period of using the appendix, and occasionally the ureter. If these structures were not available, then we had commonly used a long segment of tapered ileum. While these techniques were successful from a continence standpoint, there were a number of concerns. The overwhelming majority of patients who undergo creation of a catheterizable channel in our experience have been patients with neuropathic bladder, usually secondary to myelomeningocele. These sedentary children are often obese, making the use of the appendix with its short, fat mesentery at times difficult. These children also have neuropathic bowel with resultant constipation and fecal incontinence for which the MACE procedure (Malone Antegrade Continence Enema) has been extremely valuable, but requires the use of the appendix. Some patients have also undergone prior appendectomy. The long tapered ileum worked well but required a large amount of small bowel in children who often had bowel used for bladder augmentation. Furthermore, the mesentery was at times difficult to manage in terms of the intravesical tunnel. As an initial alternative to a bowel channel, we found great success in continence using a continent vesicostomy, but unfortunately our stomal stenosis rate with this technique was 40%.

Given the above history, the report by Monti et al in 1997 of the Monti-Yang procedure peaked our interest and we quickly adopted the use of this technique in our children undergoing lower urinary tract reconstruction. Since that time we have now used this technique in over 220 children and herein report our experience with the first 199 patients, all of which have at least 6 months follow-up. We found complete follow up data on 187 of these children.

As Monti described, the use of a very small, reconfigured segment of ileum with its central thin mesentery allows for easy implantation into a reservoir and passage through the abdominal wall.

As Monti described, the use of a very small, reconfigured segment of ileum with its central thin mesentery allows for easy implantation into a reservoir and passage through the abdominal wall. The mucosal folds lie in the direction of the catheterization allowing easy passage of the catheter. Furthermore, the location of the mesentery can be manipulated based on where the bowel is opened. Specifically, if it is opened on the antimesenteric side, the mesentery is in the middle of the tube, but when offset, one end will be longer, which is useful in those extremely obese patients, or in those where a long submucosal tunnel is required.

For a standard Monti tube we tend to use 2-3 cm of ileum opened on the antimesenteric border and reconfigured over a 12 Fr. catheter. We run a full thickness layer using 5-0 PDS. A second Lembert layer is then performed with 4-0 or 5-0 PDS. In those patients where a longer tube is required we have not hesitated to use the Spiral Monti as described by Casale[1]. We would recommend avoiding the use of the "double Monti" tubes (2 Monti tubes sewn together), which we believe has a higher complication rate than we have seen with the spiral tube. The Spiral Monti effectively doubles the ultimate length, yet maintains the intact tube with a midline mesentery. The same double layer closure is performed. In either technique we leave the end to the abdominal wall partially open for spatulation using a skin flap. While the tube can be placed in the bowel portion of an intestinocystoplasty, we believe the native bladder is more reliable, with a more durable continence mechanism.

Results

Our overall Monti stomal continence rate is 98%. Complications can and do occur, but in our hands these have been almost identical to that of the appendicovesicostomy. In our group of 187 Monti channels (109 standard Monti, 78 Spiral Monti; unpublished data), 19% of the patients have required open revision. Skin stomal revision has been required in 9%. These are generally simple outpatient skin revisions for stomal stenosis, prolapse, or rarely for small polyps at the skin level. Channel revisions unrelated to the stoma have been required in 10.7% . Some patients have had both stomal and channel revision. Complete channel revisions were performed for channel elongation, angulation, deficient tunnel, diverticular formation or fistula. Endoscopy was performed in 9% of our Monti channels, this includes both diagnostic and therapeutic procedures.

To date we believe these two channels are clinically equivalent but with longer follow up, we acknowledge that the complication rate may be affected.

When comparing our Monti ileovesicostomy to our appendicovesicostomy experience, we found that the continence and stomal stenosis rates to be nearly identical: 98% Monti versus 97.8% appendicovesicostomy; skin revision rate for stenosis 9% Monti versus 8.2% appendicovesicostomy; and channel revision rate 10.7% Monti versus 6.4% appendicovesicostomy. The total complication rate in our 110 patients with appendicovesicostomy (including return to operating room for endoscopic procedures) was 26.4%, as compared to 28.6% for the Monti channel. This was not statistically significant. We did have a difference in mean follow-up of 50 months in the appendicovesicostomy patients, versus 28 months in the Monti group. To date we believe these two channels are clinically equivalent but with longer follow up, we acknowledge that the complication rate may be affected.

We also recently compared our results of the standard Monti channel to the Spiral Monti channel. The stomal revision rate was nearly identical being 9.4% for the standard Monti and 7.8% for the Spiral Monti. However, the channel revision rate (non-skin level) was only 8.5% for the standard Monti compared to 14.3% for the Spiral Monti. We believe this is not an inherent problem with the spiral tube, but rather due to a longer intra-abdominal portion of the channel when used with an umbilical stoma.

There are a few recommendations we have after this large experience. The length of the channel that lies between the bladder and abdominal wall should be as short as possible to avoid angulation and elongation of this segment. Ideally, we would prefer to have only the mesentery between the abdominal wall and bladder hiatus. We also feel it is very important to maximally secure the bladder to the abdominal wall with permanent sutures to prevent loss of tunnel length or tube angulation. To minimize stomal stenosis, one should avoid a circumferential anastomosis to the skin. The tube should be spatulated and a generous skin flap should be placed into the spatulation. If a small portion of mucosa is visible at the skin level, the stenosis rate dramatically decreases. We recognize that this may be less cosmetically appealing, as it may not conceal the stoma as well as other techniques.

Lastly, we have found the Monti technique to be valuable in other reconstructive procedures. We have had no problems using sigmoid as a Monti channel and have used a Monti tube tunneled into the tenia of the colon for a MACE procedure in those without an appendix. We have also successfully used a sigmoid Monti tube to create a vagina.

In summary, we have found the Monti-Yang technique to be reliable, versatile, and easily performed. We believe this technique is invaluable in reconstructing complex lower anatomic and neuropathic urinary tract anomalies.

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The Monti-MACE (Malone Antegrade Continence Enema) Procedure

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Introduction

The development and evolution of the MACE procedure will be described in an upcoming issue of Dialogues in Pediatric Urology[1]. In this paper the role of the Yang-Monti procedure[2,3] in the construction of the MACE will be considered in detail. The indications for a Monti-MACE, the surgical techniques and the results will be described.

Indications for a Monti-MACE

The main indication for the Monti-MACE is the absence of the appendix. Prior to the development of the Monti principle, the MACE conduit was constructed using a tubularized cecal or colonic flap. This technique was associated with increased complications such as ischemia of the flap, higher stoma stenosis and incontinence rates. It has now been totally abandoned by this author in favor of the Monti conduit. Another indication for the Monti-MACE is the simultaneous construction of a Mitrofanoff and MACE. Some surgeons recommend using the appendix as the Mitrofanoff and the Monti for the MACE, as they believe the appendix to be a more reliable conduit and thus recommend it should be used for the bladder. However, we reported no significant differences between the appendix and Monti as catheterizable conduits and it is now this author's practice to use the in-situ appendix for the MACE and a Monti for the Mitrofanoff[4].

One of the problems encountered in some patients, particularly those with constipation, is the time it takes for the washout to work. In an attempt to overcome this problem some surgeons have placed the MACE conduit on the left side just proximal to the sigmoid colon to reduce the length of bowel that has to be washed through. When this technique is employed it is sometimes impossible to get the appendix to the left colon and a Monti conduit is required. Recently a development embracing the principles of minimally invasive surgery and the left sided MACE has occurred. Colonoscopy is performed and with the scope in the distal descending colon a colostomy tube is inserted, as one would insert a percutaneous endoscopic gastrostomy (PEG), the Percutaneous Endoscopic Colostomy (PEC). Washouts can commence the next day and once the tract has matured the patient has a choice of keeping the tube, exchanging it for a Chait button or having a formal conduit created us-

ing the Monti technique, knowing that the MACE will work.

A further variable for the Monti-MACE is the placement of the stoma. For some patients with severe kyphoscoliosis and obesity, who are wheelchair dependent, the stoma may be best placed in the upper abdomen and it may be impossible to get the appendix there, so a Monti conduit would be required. In very obese patients the appendix may not be long enough to traverse the abdominal wall and a Monti or even a double Monti would be necessary.

One of the problems encountered in some patients, particularly those with constipation, is the time it takes for the washout to work.

Surgical Technique

The Monti conduit is constructed in the well described standard fashion. Initially the author used the ileum to create the conduit, but recently if part of the colon has to be excised at the same time, a colonic conduit is used and the early results are similar to those using the ileum. The technique to construct the conduit is also well described elsewhere in this issue, so the creation of the continence mechanism will be described in detail in this paper. Although many series are now described without creating a continence mechanism, this author believes that some form of valve needs to be constructed when a Monti conduit is used.

A seromuscular trough is created along the path of a conveniently placed taenia. Using a combination of sharp and blunt dissection the trough is widened sufficiently to allow a loose closure of the muscle over the Monti tube. The length of the trough should accommodate the full length of one of the limbs of the Monti. At one end of the trough an incision is made into the bowel lumen. The Monti tube is then anastomosed to the mucosa, end to side with interrupted absorbable sutures taking full thickness bites on the Monti. The conduit is then laid into the trough in the taenia which is closed using interrupted absorbable sutures, with each suture picking up the conduit to anchor it securely. Care should be taken to anchor the bowel to the abdominal wall to prevent kinking of the conduit. The stoma is placed at a convenient site for the patient. Even for the left sided MACE it is often possible to get the stoma to the umbilicus and in that position a V-flap is used. If the stoma is sited elsewhere on the abdominal wall a VQZ or VQC multi-flap stoma is constructed which is described in detail elsewhere. The conduit is left catheterized for 4 weeks but washouts are commenced once the patient has recovered from their postoperative ileus.

Results

In 2002 McAndrew and Malone published the Southampton experience of continent catheterizable conduits and they compared MACE to Mitrofanoff, Monti to appendix and the different stoma sites and types[4]. In summary, they found no significant differences between the Mitrofanoff and MACE or the Monti and appendix in terms of continence, catheterizability or stoma stenosis rates. There were 47 MACEs in that series, 8 of which used the Monti technique. There were 4 single tubes, 3 double tubes and one composite Monti-appendix tube in a very obese patient. All of these were continent and no conduit kinked or caused problems with catheterization from a cause other than stoma stenosis. The stoma stenosis rate was 24%, half of which responded to dilation and the others required stomal revision. Since the publication of that series a further 5 Monti-MACES have been performed with 4 using a colonic conduit. One of the colonic conduits was incontinent and had to be revised but the other 4 have all functioned satisfactorily. The left sided Monti-MACE also functions well and reduces the time taken for the washout. It is particularly useful for the constipated patient, and in the author's experience this approach has salvaged the procedure in 5 patients in whom an original cecal MACE failed.

More recently Boemers and colleagues published their evaluation of urinary and fecal continent stomas[5]. There were 28 MACES, 6 of which were constructed with a Monti tube. All of these were continent and although it is difficult to decipher what the other complication rate for this group was, the overall complication rates for the whole series were low.

Conclusions

On the basis of published results and on personal communication with many surgeons, there is no doubt that the Monti technique is readily applicable to the construction of the MACE. In certain circumstances, the left side MACE, it is the conduit of choice. The results are comparable to the appendix when it is used and superior to any local tubularized flaps.

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Bridging long ureteric defects using the Yang-Monti Principle

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Long defects of the ureter may result from chronic inflammatory diseases such as tuberculosis or bilharziasis, retroperitoneal fibrosis, iatrogenic injuries, neoplasms and radiation damage. If the ureteral loss cannot be repaired with intrinsic urinary tract tissues, partial or total ureteral replacement is indicated. Several surgical techniques have been proposed for replacing damaged ureters, including he use of synthetic materials, free autologous or pedicled grafts. Except for pedicled bowel segments, the majority of these techniques have failed to gain wide acceptance.

The feasibility of construction of a long tube from short segments of ileum was evaluated clinically[1] and experimentally[2]. The application of this procedure for ureteral replacement was explored initially in experimental animals[3] and due to excellent functional outcome, the technique was further applied in the clinical setting[4].

Operative Technique

Depending on the length of the ureteric defect, a 5 to 7.5 cm segment of the terminal ileum was isolated and continuity of the ileum was restored. The isolated ileal segment was subdivided into 2 or 3 equal parts of 2.5 cm each, with preservation of their individual blood supply (Fig. 1). Each segment was then incised along its longitudinal axis near the mesenteric border. The adjacent edges of the unfolded segments were sutured to each other using 4-zero absorbable sutures (Fig. 2). The result was a uniform plate 2.5 x 12 to 18 cm depending on whether 2 or 3 segments were used. This plate was tubularized around a 16-French Nelaton tube, using 4-zero absorbable sutures (Fig. 3).

The proximal ureter was then anastomosed to the proximal end of the ileal tube with an end-to-end anastomosis using a 4 or 5-zero absorbable sutures. The distal end of the ileal tube was implanted into the bladder using a non-refluxing ileovesicostomy employing the Lich-Gregoir principle. A silicone stent was inserted and left for 3 weeks. Before removal, the integrity of the suture line was tested by stentography or antegrade urography in patients in whom a percutaneous nephrostomy was placed preoperatively.

Thus far, 22 such procedures have been carried out. The functional outcome has been excellent. Clinical and functional evidence show that the reconfigured tube is capable of active antegrade urine propulsion from the kidney down to the bladder.

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Figure 1 – Isolation of the ileal segments

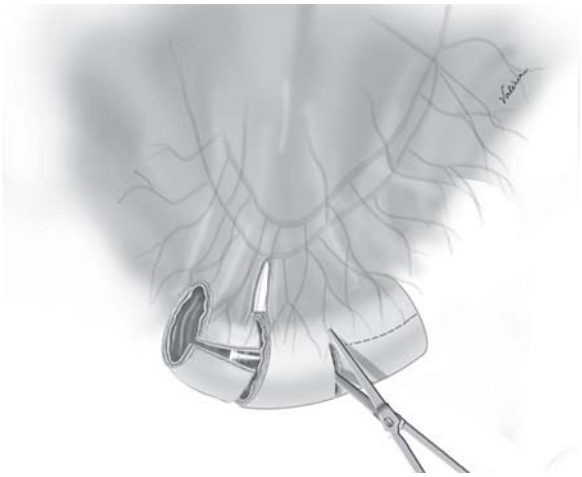


Figure 2 – Detubularization of the ileal segments

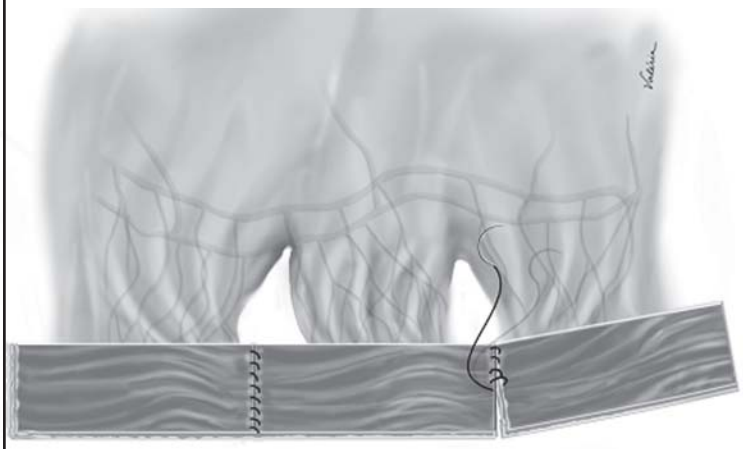
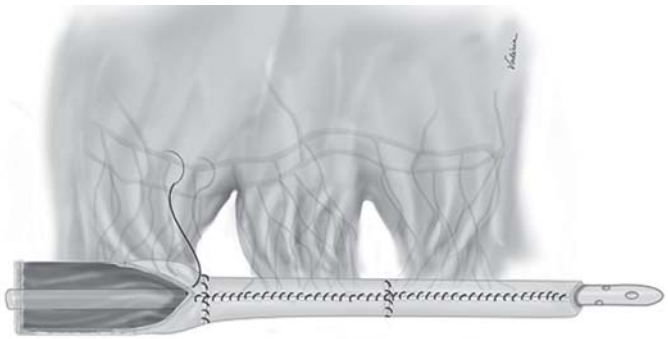


Figure 3 – Construction of the ileal conduit



Reconfigured Sigmoid In Vaginal Construction: Extending the Use of the Monti Procedure

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The best technique for the construction of a neovagina essentially depends on the anatomic structures of the patient who is to undergo the procedure. If a urogenital sinus is present, it can be used either entirely or partially in the construction of the vaginal canal. When the vagina is entirely absent, the development of the mullerian structures determines the most adequate technique. If the uterus is present and the vagina is hypoplasic, progressive dilations of the vaginal canal is usually the accepted option. For patients without mullerian structures, such as genetic males with insufficient virilization of this external genitalia, myocutaneous flaps or skin grafts are usually the best option. Bowel has been used by pediatric surgeons for vaginal reconstruction and the sigmoid is the segment of choice. The major problem with the use of sigmoid in vaginal reconstruction is the traction exerted in the vascular pedicle as it goes through the pelvic diaphragm. In addition to possible complications, such traction could also prevent the bowel from reaching the pelvis.

In 1997, Monti el al. advocated bowel reconfiguration to allow for an antirefluxing catherizable channel to the bladder. Based on that study, we decided to extend the Monti procedure to the construction of the neovagina using sigmoid segments. With the Monti technique we believe that such traction is prevented since the pedicle remains restricted to the center of the reconfigured bowel. In addition, the transverse intestinal mucous folds would become longitudinal after sigmoid reconfiguration, which could facilitate sexual intercourse.

In 2001 we reported our initial experience with the technique which was used in 10 genetic male children who were raised as females. We used two sigmoid segments that were reconfigured as initially reported by Monti. Seven patients had androgen insensitivity, two had adrenal hyperplasia and the last presented with bladder exstrophy and required sexual reassignment. Another five patients were treated between 2001 and 2005, all with androgen insensitivity.

One of the advantages of the reconfiguation technique is that it enables two wide bowel segments to become a narrower and longer segment than the individual segments. We have been using two 3 cm sigmoid segments which allow for the construction of a 12 cm-long neovagina. Such segments are reconfigured over a 30Fr rectal tube kept for 7 days. In our initial experience, patients underwent vaginal dilation on a weekly basis. Gradually we reduced the frequency of dilations and currently it is rarely used.

We have had two post-operative complications. One child had stenosis of the full distal segment, probably due to ischemia, and required a second surgical procedure. The construction of a second sigmoid neovagina was easily accomplished and the patient is doing well. The second child had stenosis in the intermediate portion of the neovagina, at the anastomosis site between the two segments. This patient underwent consecutive neovaginal dilations in the early post-operative period and is also doing well.

Children undergoing construction of a sigmoid neovagina usually produce a significant amount of odorous mucus in the first post-operative year. This may be circumvented by daily washings of the neovagina along with the use of oral prophylactic sulfamethoxazole/trimethropim. After the first year, antibiotics and washings may be reduced. Two patients had begun satisfactory active sexual life according to psychological evaluations.

The use of bowel for vaginal replacement is a reality for patients with vaginal hypoplasia or agenesis. The Monti technique can be successfully used for vaginal replacement and must be considered an effective technique for purposes other than providing a urinary catheterization channel. Tissue engineering and studies on tissue neovascularization may provide the definitive answer for organ replacement.

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Continent Gastrostomy Based on the Monti Principle

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The indications for gastrostomy as a therapeutic alternative to temporary or chronic feeding are well established. However, the procedure may lead to numerous complications, such as duodenal obstruction due to migration of the probe balloon, prolapse of the stomach, gastrocutaneous fistula, peritonitis and sepsis[1,2]. Several techniques were proposed aiming at the prevention of these problems. Among all described procedures for continence, the Monti technique motivated us to apply the same principle in the construction of a continent gastrostomy[3].

For the construction of the tube, a segment of jejunum was chosen (because it is located closest to the stomach) and implanted to the stomach with a submucous valve mechanism. The stoma was sutured to the skin through the abdominal wall. The technique was initially performed experimentally, testing the procedure on nine mongrel dogs and compared the results to the technique proposed by Webster (10 dogs)[4]. The latter utilized the Janeway principle, as modified by Moose and Spivack. Both groups were assessed for the competence of the gastrostomy in preventing leakage. The test consisted of the introduction of two orogastric probes: one for the infusion of saline up to 1500 ml and the other for the evaluation of the gastric pressure. The test was interrupted if there was leakage through the stoma. It was carried out *in vivo* and after sacrifice. In the experimental group, only one animal had leakage through the gastrostomy *in vivo*, and after sacrifice leakage was observed in two animals. In the control group, two animals had leakage *in vivo*

and after sacrifice all but one animal presented with leakage. Our conclusion was that the Monti principle was a better (more competent) valve mechanism for the construction of a gastrostomy than that used in the control group[5].

We further tested the technique in 15 patients requiring permanent gastrostomy. All patients were treated over the last five years and all had serious neurological lesions. In 13 cases the procedure was associated with the Nissen technique for the correction of gastro-esophageal reflux. As observed in the animal experiment, the mobilization of the jejunal tube was facilitated by opening the transverse mesocolon, allowing the passage of the vascular pedicle without the risk of compression. In two patients, the cecal appendix was utilized as the gastrostomy tube, since they had a cecum that enabled easy obilization to the stomach.

Our conclusion was that the Monti principle was a better (more competent) valve mechanism for the construction of a gastrostomy than that used in the control group.

We believe that the majority of patients benefited from this technique, especially because of the easy management of the gastric catheterization. With the introduction of 12Fr to 14Fr feeding tubes, the passage of a greater variety of nutrients was enabled, thereby causing these patients to gain weight. Four patients died due to causes not related with the technique. One patient died on post-operative day 20 due to sepsis secondary to pneumonia and pulmonary hypertension. Another patient died on post-operative day 15 due duodenal migration of the Foley probe balloon (placed temporarily in the stomach to model the gastrostomy tube), which led to acute gastric obstruction and pneumonia due to aspiration. The other two patients died after a longer follow-up period: one with Patau syndrome died ten months post-operatively due to cardiac complications inherent to the primary disease, and the other died one and a half year post-operatively due to extensive necrosis of the small intestine as a consequence of a volvulus and obstruction of the upper mesenteric artery, unrelated to the vascular pedicle of the jejunal tube of the gastrostomy.

This application of the Monti principle for the construction of a continent gastrostomy is an alternative for patients who may not have button-feeding devices.

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