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LOWER URINARY TRACT SYMPTOMS & VOIDING DYSFUNCTION (J SANDHU, SECTION EDITOR)

Bladder Augmentation (Enterocystoplasty): the Current State of a Historic Operation

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Abstract

Purpose of Review The goal of this paper was to evaluate the current use of enterocystoplasty, a historical operation for bladder dysfunction but with continued and increasing modern relevance.

Recent Findings Since the advent of third line neuromodulation techniques for neurogenic and idiopathic overactive bladder (OAB), the usage of enterocystoplasty has decreased. However, this procedure continues to be utilized in pediatric urology patients and the most refractory OAB patients. Adult urologist should be familiar with this operative technique in an effort to manage pediatric patients transitioning to adulthood. Minimally invasive techniques for this surgical procedure have been described with very limited outcome data.

Summary It is important for all urologists to be familiar with enterocystoplasty, both technically and with the unique needs of these patients postoperatively. Further studies evaluating the outcomes of this procedure in idiopathic overactive bladder patients and efforts to standardize recommendations for neurogenic bladder patients will help guide care in the future.

Keywords Augmentation cystoplasty · Bladder augmentation · Enterocystoplasty · Neurogenic bladder · Overactive bladder

Introduction

Augmentation cystoplasty was first performed in 1889 by von Mikulicz in a patient with bladder exstrophy [1]. However, it was not routinely performed until the 1950s when Couvelaire performed bladder augmentation to treat small, contractile bladders secondary to tuberculosis cystitis [2]. Over the years, bladder augmentation has been primarily used to treat patients with neurogenic detrusor overactivity secondary to multiple sclerosis, spinal cord injuries, and myelodysplasia. Bladder augmentation is also a treatment option for patients with idiopathic overactive bladder that have failed third line treatment options. The primary goal of augmentation cystoplasty is to create a low pressure storage reservoir in order to increase bladder capacity and compliance, protect against upper tract deterioration, improve urinary continence, and improve quality of life. Since its advent, many different tissue sources have been used, most commonly, ileum, sigmoid colon, cecum, and stomach. Multiple other human tissue grafts have been used including peritoneum, omentum, reversed seromuscular bowel grafts, lyophilized human dura, skin, preserved bladder, pericardium, and placenta [3, 4]. Synthetic materials have also been used including gelatin sponge, Teflon, polyvinyl sponge, resin-coated paper, poly-amino membrane, collagen/polyglactin membrane, and Silastic. These alternate sources for augmentation are not commonly used due to their high complication rates including metaplastic bone formation, recurrent urinary tract infections (UTIs), stone formation, bladder contractures, and fibrosis [4, 5].

Since the approval of intradetrusor injection of onabotulinum toxin A by the Food and Drug Administration in 2011 and 2013 for the treatment of neurogenic detrusor overactivity and idiopathic detrusor overactivity, respectively, the rates of augmentation cystoplasty have decreased. There were 192 augmentation procedures performed in 2000 in the United Kingdom and this number decreased to 120 in 2010. The number of intradetrusor onabotulinum toxin A injections increased from 50 cases to 4088 cases during this time period

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[6]. In this article, we review the current indications for augmentation cystoplasty with the advancement of less invasive treatment modalities. Enterocystoplasy will be referred to specifically for the remainder of this article since it is the most common form of bladder augmentation.

Indications

According to the American Urological Association (AUA) overactive bladder guideline, enterocystoplasty is indicated in patients with reduced bladder capacity and compliance or in the presence of detrusor overactivity when conservative therapies have failed. These therapies include medical treatment with anticholinergics or β3 agonists, detrusor injections of botulinum toxin, and sacral neuromodulation. Renal transplant recipients represent another important patient population for enterocystoplasty. Approximately 15% of patients with ESRD have some form of lower urinary tract dysfunction [7]. A compliant, good capacity, low pressure bladder is necessary to prevent high pressure reflux nephropathy which can lead to graft failure. The timing of enterocystoplasty with renal transplantation remains controversial. The argument for pretransplant augmentation is to decrease the incidence of systemic infections or delayed wound healing post transplantation. However, augmentation after kidney transplantation prevents the development of pyocystitis from bladder under distention while the patient is anuric. The rates of graft survival are similar between the pre and post transplant augmentation groups [8–11].

Contraindications

Contraindications to enterocystoplasty include the inability to safely use enteral segments for augmentation. These conditions include congenital bowel anomalies, inflammatory bowel diseases, radiation enteritis, and short gut syndrome. Bladder cancer and the inability to perform clean intermittent catheterization (CIC) secondary to reduced manual dexterity or cognitive dysfunction are further contraindications to perform augmentation [12, 13]. Although there is no specific guideline in place, renal impairment is a potential contraindication to bladder augmentation as patients with baseline chronic kidney disease tend to progress despite augmentation [14••, 15]. However, these findings have been controversial and there is no current designated threshold of creatinine clearance for which augmentation is considered safe. Historically, a creatinine clearance of > 40 mL/min is referenced based off prior studies [16].

Surgical Technique

Enterocystoplasty is classically performed with either coronal or sagittal bivalving of the bladder down to the trigone with subsequent anastomosis of a segment of detubularized bowel to the bladder [6]. The most common bowel segment used is the ileum which is usually taken approximately 25–40 cm proximal to the ileocecal valve [6]. When the ileum is not a viable option secondary to either a short mesentery or underlying ileal disease, the sigmoid colon is the next most common segment used for augmentation. The advantages of the sigmoid colon include its thick muscular wall, larger lumen, and longer segment of mesentery allowing for increased bladder capacity with reduced mesenteric tension [17]. However, the sigmoid colon produces larger amounts of mucus and is associated with higher rates of UTIs compared to the terminal ileum [18]. The cecum can also be used either in its tubular shape or as a detubularized segment. It is most commonly used in conjunction with the terminal ileum, and the ileocecal valve can be used as an anti-reflux mechanism [19]. However, this often leads to diarrhea and malabsorption, and therefore, this procedure is not routinely performed [20]. Gastrocystoplasty is another alternative if small or large bowel is unavailable secondary to short gut syndrome or unusable secondary to underlying bowel pathology or short mesentery. The stomach is also a viable option in patients with underlying metabolic acidosis as the stomach naturally secretes hydrochloric acid [6]. Furthermore, the stomach has reduced absorptive capacity leading to less metabolic abnormalities and reduced mucus production which combined with acid secretion reduces the risk of UTIs [6]. However, use of the stomach has been associated with hematuria-dysuria syndrome [21], ulceration of the bladder mucosa with potential perforation [22, 23], and hypochloremic hyponatremic metabolic alkalosis [24]. There is also an increased risk of malignancy which has also further reduced the rates of gastrocystoplasty [25–32].

Enterocystoplasty is classically performed via an open abdominal surgery, but advances in laparoscopic and robotic surgery make these intriguing treatment options. Laparoscopic cystoplasty was first performed in 1995 using the greater curvature of the stomach, and laparoscopic enterocystoplasty was performed in 2000 [33, 34]. A recent study by Cohen et al. demonstrated comparative outcomes in robotic and open cystoplasty in patients ranging from 3 to 25 years of age. The operative time of the robotic cystoplasty was significantly longer (623 min vs 265 min, $P < .001$). However, the post operative outcomes such as length of stay (7 days vs 6 days, $P = .335$), time to diet (4 days vs 4 days, $P = .125$), and requirements of intravenous morphine (1.23 mg/kg vs 0.56 mg/kg, $P = .091$) were comparable between both groups [35••].

Description of Author's Preferred Surgical Technique and Tips

Access to the abdomen is gained through a low midline incision. Once adhesions are released, the cecum is identified. At this point, the small bowel is evaluated for any further adhesions. An ileal segment is then harvested approximately 25 cm from the ileocecal valve. It is our preference to use a segment approximately 30–40 cm in length. An endo GIA stapler is used to complete the bowel anastomosis. The ileal segment is then irrigated. A plastic Yankaur suction is placed within the segment and the antimesenteric border of the ileum is opened. The opened ileal segment is then placed in a U-configuration and the back walls of the segment are sutured together using 2–0 Vicryl. The midpoint of the open bowel segment is then tagged with allis clamps, bilaterally, to create "dog ears". This accounts for the excess bowel, relative to bladder length that is present. A total of 2–0 vicryl sutures are used to close the "dog ear" sections. A second layer of 3–0 vicryl is used to reinforce this suture line.

At this point, we then mobilize the bladder by opening the space of Retzius and releasing the peritoneal reflections. The bladder is then filled with saline. It is our preference to create a large u-shaped cystotomy at the posterior aspect of the bladder, approximately 1 cm above the trigone. This is done instead of the bivalving technique which is completed anterior to posterior because it avoids the risk of placing the mesentery of the ileum on tension. The bladder is then anastomosed to the bowel with 2–0 vicryl. Corners are reinforced with 3–0 vicryl sutures. A 20-fr suprapubic catheter is placed prior to completing the bowel to bladder anastomosis. The bladder is then irrigated to ensure that there is no evidence of a leak (see Fig. 1).

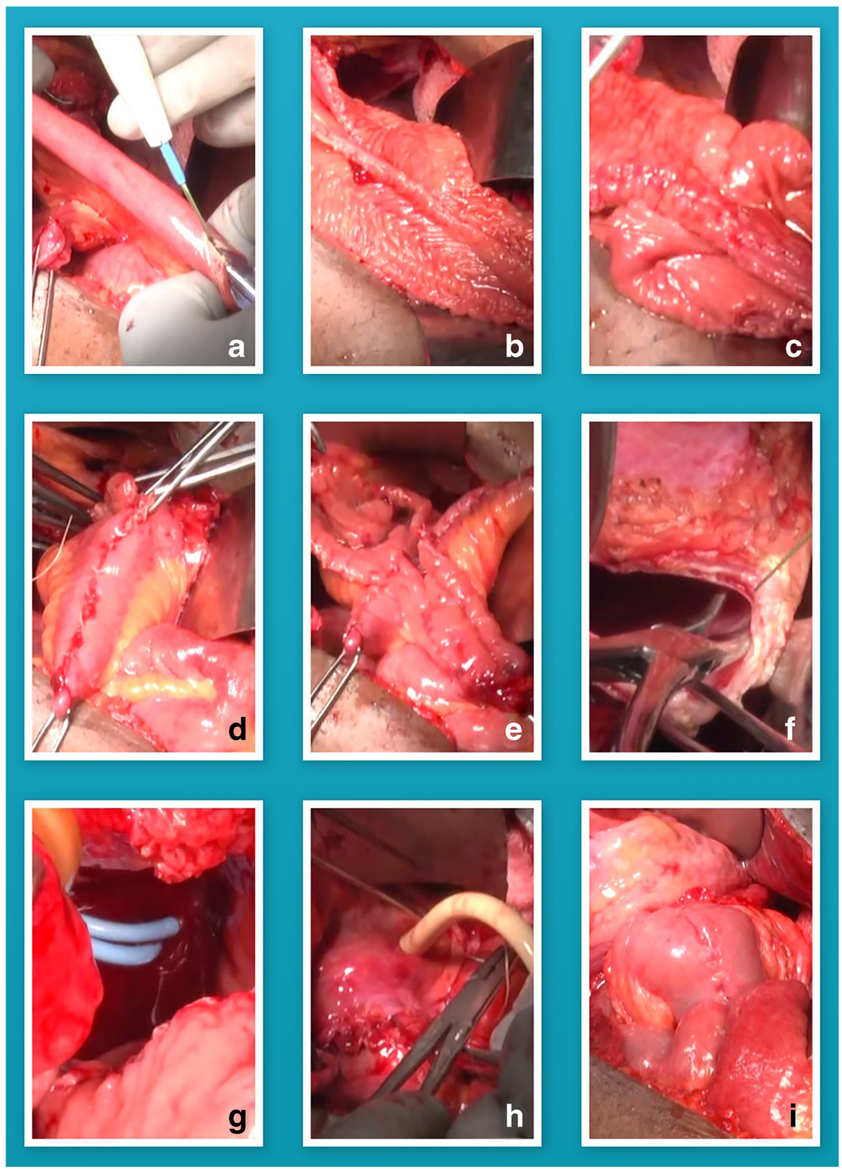

Fig. 1 **a** Detubularizing ileal segment. **b** Bowel placed in U-shaped configuration. **c** Back walls of ileum are sutured together. **d** Creation and closure of "dog ears". **e** View of augmentation prior to anastomosis with bladder. **f** Creation of U-shapedcystotomy above the trigone. **g** Anastomosis of back wall of bladder to the augmentation with stents visible in the bladder. **h** Placement of suprapubic tube. **i** Visualization of completed enterocystoplasty

Complications

Malignancy

Malignancy following enterocystoplasty was first reported in 1971 [36]. The most common variant identified is adenocarcinoma (51.6%) and the most common site is at the entero-urinary anastomosis (50%) [32••]. Prior studies have suggested that augmentation cystoplasty is itself an independent risk factor for the development of bladder cancer [37, 38]. However, follow-up studies have demonstrated similar rates of malignancy when comparing patients to age-matched controls who did not undergo enterocystoplasty [37, 39]. This implies that the underlying bladder pathology is the risk factor for the development of bladder cancer. Chronic inflammation in the setting of bacteriuria has been hypothesized to convert urinary nitrates to nitrites by colonic bacteria. Nitrites then react with secondary amines in the urine to form N-nitrosamines, carcinogens that are associated with the development of adenocarcinoma in patients with ureterosigmoidostomies [40–42].

A recent systematic review by Biardeau et al. evaluated the risk of malignancy following bladder augmentation [32••]. This review showed that a follow-up time probability to develop a malignant bladder tumor ranged from 0 to 5.5%. The mean latency for tumor diagnosis was 19 years with a majority of tumors (90%) being diagnosed after 10 years. Tumors were usually diagnosed after the onset of symptoms which include gross hematuria (70.7%), acute renal failure (12.2%), recurrent UTIs (7.3%), and symptomatic hydronephrosis with lumbar pain (7.3%). These tumors were typically at an advanced stage (35% pT3 or higher, 40% with lymph node involvement, and 59% with distant metastasis). Given the increased risk of malignancy, many authors advocate for cystoscopic surveillance beginning around 10 years after enterocystoplasty. However, there is not a clear consensus when to initiate screening and studies have suggested that surveillance may not be beneficial given the high cost of follow-up, low risk, and long latency period. Patients who develop recurrent UTIs, chronic pelvic pain, gross hematuria, persistent microscopic hematuria, or hydronephrosis warrant evaluation. Limitations to this study include the use of retrospective data from multiple studies with low statistical power and incomplete tumor staging in the articles that were analyzed [25, 29, 37, 39, 43–46].

Metabolic Complications

Reabsorption of acid and secretion of bicarbonate is the general underlying mechanism for acid-base and electrolyte disturbances that follow enterocystoplasty [13, 47]. The reabsorption of ammonium chloride and the secretion of potassium and bicarbonate lead to the electrolyte deficiencies seen in both ileo and colocystoplasty with predominant abnormalities being hypokalemic, hyperchloremic metabolic acidosis. Greenwell et al. demonstrated that 16% of patients developed hyperchloremic metabolic acidosis requiring oral bicarbonate therapy post bladder augmentation [48]. More recently, Cheng et al. showed similar data in that 15% of patients required oral bicarbonate replacement for metabolic acidosis. They also showed that there was no significant association with the development of metabolic acidosis and renal function or the use of ileum vs colon [14••].

Urinary Calculi

Urinary tract stones have been estimated to occur in 6–52% of enterocystoplasty patients [49–58]. They are significantly more common in patients who require CIC for bladder emptying and in patients with Mitrofanoff-type channel suggesting that urinary stasis is a major factor in stone formation [6, 59]. Furthermore, these stones tend to be struvite, and urease-producing bacteria (Proteus, Providencia, Klebsiella) are likely involved in stone formation. Mucus retention within the bladder and metabolic abnormalities such as hypocitraturia have also been associated with stone formation. Foreign bodies within the bladder including non-absorbable sutures and staples can also serve as a nidus for stone formation [48]. Bladder stones form around 37.5 months after augmentation and have a high recurrence rate with stone recurrence in 15–29% of patients within 2 years after treatment [60, 61]. Furthermore, 50% of patients will have stone recurrence regardless of the treatment performed [62]. Despite a significant association with urinary tract infection, 31% of bladder stones are secondary to non-infectious causes [63•]. Additional factors that can explain the presence of bladder stones include chronic metabolic acidosis, underlying chronic kidney disease, and hypercalciuria from wheelchair-dependent osteodystrophy.

Bladder irrigation with normal saline has been shown to reduce the incidence of stone formation. Husmann DA. compared the effect of high volume (> 240 mL) bladder irrigation to small volumes (60 mL and 120 mL). High volume irrigation significantly reduced the rate of stone formation, the incidence of bacterial colonization (45% vs 62% vs 84%), and the rate of symptomatic UTIs (47 vs 100 vs 127). They also evaluated the utility of correcting underlying metabolic abnormalities (hypocitraturia) or adding mucolytic agents to bladder irrigation in patients who were recurrent stone formers despite high volume irrigation and did not find additional benefit [62].

Bladder Perforation

The rate of bladder perforation following enterocystoplasty has been estimated to range from 0.8 to 13%. This is a serious complication and can be life threatening with mortality rates estimated to approach 25% [6, 13]. Perforation typically occurs at the anastomotic junction between the bladder and bowel and is most commonly the result of elevated intravesical pressures [13, 64]. These perforations are typically intraperitoneal and neuropathic patients present an especially difficult situation as they can develop clinically benign peritonitis or intra-abdominal abscesses. Other factors associated with bladder perforation include ischemic injury to the augmented segment, fixed adhesions of augment to abdominal or pelvic walls, traumatic catheterization, and bladder neck closure [6]. The largest published series showed perforation in 43 out of 500 patients (8.6%). Specific risk factors were the use of nondetubularized sigmoid colon, presence of bladder neck procedure, and a prior history of bladder perforation. One third of the perforations occurred in the first 2 yrs, another one third between 2 and 6 yrs, and the final third after 6 yrs [65]. Husmann DA. showed that substance abuse and non-compliance with bladder catheterization were significant risk factors for bladder perforation and 22% of patients with alcohol abuse/non-compliance experienced a bladder perforation vs only 2% of patients without these risk factors [62].

Upper Tract Deterioration

Deterioration of renal function is estimated to occur in up to 15% of patients post augmentation. The decline in renal function appears to be associated with baseline renal function. Initial published series showed 15% of patients with preoperative creatinine clearance of at least 15 mL/min developed end stage renal disease (ESRD) while only 4.1% of patients with preoperative creatinine clearance of $\geq$ 40 mL/min developed ESRD [15, 16]. A recent series by Cheng et al. supports this finding. They evaluated 40 adult patients (mean age of 43) who underwent augmentation cystoplasty with at least 10 years of clinical follow-up. They showed no significant difference ($P = 0.798$) between preoperative GFR (68.3 mL/min) and postoperative GFR (76.6 mL/min) highlighting the stability in renal function post augmentation. Four total patients developed ESRD and these patients' mean preoperative GFR was 24.8 mL/min which corresponds to stage IV CKD [14••]. Hubert et al. also showed either preservation or improvement in renal function in a majority of patients post augmentation. Fifteen patients had preoperative stage III or IV CKD and five of these patients improved to normal eGFR, one remained in stage III CKD, and nine progressed to ESRD [66].

Qualitative Outcomes

Continence

Urinary incontinence is common in the first few months after augmentation [67•, 68••]. However, with follow-up of 10 years and greater, continence rates are significantly improved. A total of 70–90% of patients achieve complete continence after 6 months, and the remaining 10–30% complain of mild to moderate incontinence [67•, 69•, 70••, 71•]. About 10% of patients who have undergone augmentation use pad protection [67•]. Although further surgical intervention to achieve continence is rarely required, methods used include artificial urinary sphincters, suburethral and bladder neck slings, and periurethral bulking injections [14••, 68••, 69•].

Neurogenic Bladder Patient Satisfaction

Lima et al. showed that neurogenic bladder patients have a significantly higher quality of life measured with the 36-Item Short Form Survey questionnaire after bladder augmentation in the short term. There was an improvement in general health status, vitality, social aspects, emotional factors, and mental health 6 months after augmentation cystoplasty [72]. This increase in quality of life is associated with an improvement in inconvenience, limitation, fears, and daily activities impacted by urinary symptoms.

After a follow-up of 5 to 10 years, about 50–85% of patients self-reported improved symptoms and being moderately to very satisfied after undergoing enterocystoplasty [67•, 68••, 70••]. Dependence on long-term catheterization either with clean intermittent catheterization or indwelling catheters increases greatly after augmentation in neurogenic bladder patients. Up to 90% of neurogenic bladder augmentation patients will either be partially or totally dependent on catheterization [68••, 70••]. Dissatisfaction is most commonly related to the need for catheterization, followed by persistent complications including recurrent urinary incontinence, urinary tract infections, chronic diarrhea, and mucus production [67•, 68••]. Despite the dissatisfaction related to catheterization, augmentation cystoplasty patients using CIC report a higher quality of life and better urinary symptom scores when compared to neurogenic bladder patients using intradetrusor onabotulinum toxin A with CIC or CIC alone [73••].

Idiopathic Overactive Bladder Satisfaction

Though most enterocystoplasty research has centered around the neurogenic bladder population, patients with idiopathic overactive bladder have been shown to benefit from this procedure as well. The AUA guideline for overactive bladder discusses the use of this technique when medication and third line therapies (sacral neurostimulation, posterior tibial nerve stimulation, and onabotulinum toxin A) have failed. The author has an experience of performing this procedure on eight idiopathic overactive bladder patients between 2012 and 2018 who had failed various medical and third line therapies. The median age of this population was 54.5 years old and all patients were female. The median urodynamic bladder capacity was 134.5 cc and median compliance was 39.8 cm H2O. Procedures took a median of 370 min and median blood loss was 150 cc. Statistically significant improvements were found with AUA-symptom score and AUA-symptom score quality of life at 6 months post-operatively. Post-operatively, two of the eight patients were voiding spontaneously. Though this is a small series, improved quality of life has been realized and documented in these patients. Further research with larger patient series and a longer follow-up period will help to support the use of this procedure in this patient population.

Other Patient Considerations

With a significant number of patients undergoing this operation at a young age, physicians must be prepared to counsel women of childbearing age regarding how it will affect their parturition. There have been few small series and case reports of pregnancy after bladder reconstruction. Challenges during pregnancy include difficulty with CIC, requiring continuous catheterization, and increased UTIs, requiring suppressive antibiotics [74]. Delivery also raises concern for potential complication. Both vaginal delivery and cesarean section have been described in this population with risks affecting continence arising in the former if bladder neck reconstruction or artificial urinary sphincter had been performed and potential damage to the augmentation or its blood supply in the latter [75].

Conclusion

Though enterocystoplasty decreased in popularity with increased use of third line treatment options, it is still an important procedure to make available to the appropriately selected patient. A complete understanding of potential complications must be weighed with the opportunity for significant improvement in quality of life for both idiopathic overactive bladder and neurogenic patients.

Compliance with Ethical Standards

Conflict of Interest Jeffrey Budzyn, Hamilton Trinh, Samantha Raffee, and Humphrey Atiemo each declare no potential conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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