

Outcomes of Bladder Augmentation and Bladder Neck Reconstruction in children with Bladder Exstrophy: A Single-Institution prospective Study**Mohamed Abada Hassan^{a*}, Ahmed Khairi Gabr^a, Sameh Mahmoud Shehata^a, Mohamed Abdelazim Shams^a, Ahmed Mohamed Oshiba^a**^aDepartment of Pediatric Surgery, Faculty of Medicine, Alexandria University, Alexandria, Egypt**Abstract**

Background: Bladder augmentation utilizing gastrointestinal segments, combined with bladder neck reconstruction, represents a critical surgical approach in the management of children with bladder exstrophy, particularly for addressing urinary incontinence. The primary objective of bladder augmentation is to establish a low-pressure, high-capacity urinary reservoir that optimizes functional storage.

Objectives: to assess the effectiveness, safety, and clinical outcomes of ileocystoplasty combined with a modified Young-Dees-Leadbetter bladder neck reconstruction and the creation of a continent catheterizable channel in pediatric patients diagnosed with bladder exstrophy. The research was conducted at the Pediatric Surgery Unit, Children's Hospital, Faculty of Medicine, Alexandria University, Egypt.

Patients and methods: This prospective intermediate term follow up study included 20 patients with bladder exstrophy repair but subsequently presented with reduced bladder capacity (<100 mL), urinary incontinence, and clinical indications for bladder augmentation combined with bladder neck reconstruction. All patients were studied for operative time, intraoperative complications, post-operative ileus, post-operative wound infection and the need for secondary intervention procedure and post operatively for stoma complications, bladder capacity, continence, improvement of VUR and compliance on CIC.

Results: This study included 16 males (80%) and 4 females (20%), with a male-to-female ratio of 4:1. The age of patients at the time of the operation ranged from 5 to 11 years, with a mean $\pm$ SD (7.8 ± 2) years. Mean operative time was 4.4 hours. Only 3 cases needed bilateral ureteric reimplantation. Three cases developed postoperative wound infection. Two cases developed vesicocutaneous fistula. Two cases had stoma stenosis. There is 5 fold increase in bladder capacity. All cases showed resolution of VUR. Continence rate after the procedure was 80%.

Conclusion: Bladder augmentation with bladder neck reconstruction and the creation of a continent catheterizable channel represents a safe and effective surgical approach for managing bladder exstrophy patients with urinary incontinence and reduced bladder capacity. These procedures have demonstrated significant efficacy in enhancing bladder volume, improving compliance, resolving VUR, improving continence and improving quality of life.

Keywords: Bladder augmentation; Bladder exstrophy; Mitrofanoff; Bladder neck reconstruction.

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Introduction

Bladder exstrophy (BE) is an uncommon birth defect characterized by the absence of the bladder's anterior wall, causing the inner wall to protrude outside the body. (Ebert et al., 2009) This condition occurs in about 1 out of every 50,000 newborns in the U.S. and Europe, with males being affected nearly 2.3 times more frequently than females. (Harris et al., 2023) The surgical management of classic BE began with Trendelenburg in 1906 and evolved into a staged reconstruction approach by the late 20th century. Regardless of the surgical technique, the primary objectives remain consistent: secure closure of the bladder and abdominal wall, restoration of urinary continence with a functional bladder, and achieving cosmetically normal genitalia. (Ebert et al., 2009; Purves, 2011)

Two main surgical approaches are currently used globally for BE repair: the complete primary repair of exstrophy (CPRE) and the modern staged repair of exstrophy (MSRE). The MSRE involves multiple operations—initial closure in newborns, epispadias repair between 6–12 months of age, and bladder neck reconstruction (BNR) at 4–5 years old. (Baird et al., 2007; Gearhart and Mathews, 2007).

Urinary incontinence remains a major concern that significantly impacts the quality of life for BE patients. To address this issue, pediatric surgeons often perform bladder augmentation (BA) using intestinal tissue, combined with BNR, as key surgical interventions for managing incontinence in children with BE. The primary objective of BA is to establish a low-pressure reservoir with sufficient functional capacity. This helps maintain optimal intravesical pressure, ensuring unimpaired ureteral urine flow into the bladder while protecting the upper urinary tract from potential damage caused

by high-pressure vesicoureteral reflux. (Biers et al., 2012).

In Alexandria University Children Hospital, we follow the MSRE, so we do primary bladder closure at 1-3 months of age, epispadias repair at 1 year of age and postpone BNR till 4-7 years after doing VCUG to determine bladder capacity. If the bladder capacity > 100 ml, we proceed to BNR only. If the bladder capacity <100 ml, we proceed to bladder augmentation with BNR and continent catheterizable channel either using the appendix (Mitrofanoff) or using a tubularized segment of ileum (MONTI) if the appendix is not available.

This research investigates the effectiveness, safety, and surgical results of ileocystoplasty combined with modified Young-Dees-Leadbetter bladder neck reconstruction and creation of a continent catheterizable channel (CCC) in exstrophy patients. The study focuses on children treated at Alexandria University Children's Hospital, Egypt who had undergone successful initial bladder closure but subsequently developed small bladder capacity with urinary incontinence.

Patients and methods

Patients

This prospective study enrolled 20 pediatric patients with bladder exstrophy who, despite successful initial bladder closure, presented with inadequate bladder capacity (<100 ml) and persistent urinary incontinence requiring surgical intervention. The participants underwent augmentation cystoplasty with bladder neck reconstruction at Alexandria University Children's Hospital between August 2022 and April 2024.

Ethical aspects

The study was approved by the institutional ethics committee. Informed consent was obtained from parents for utilizing the data of their children in this study while ensuring privacy and confidentiality of all participants (Alexandria University Ethical

Committee IRB No.: 00012098, EC Serial number: 0201743, date of clearance: Nov 17, 2022).

Study design

All patients were subjected to full routine clinical examination and investigative studies preoperatively to assess their fitness

for surgery and detect any associated anomalies. Ultrasound abdomen & pelvis to assess the renal cortical thickness and if there is hydronephrosis or hydroureter and voiding cysto-urethrogram (VCUG) for assessing bladder capacity and if there is VUR were done for all cases. **(Fig. 1)**



Fig.1. Preoperative VCUG showing small bladder capacity with bilateral VUR.

Perioperative evaluation include; Operative time, intra-operative bleeding, intraoperative complications. post-operative ileus, post-operative wound infection, the need for secondary intervention procedure and hospital stay.

Postoperative evaluation: Every child was evaluated every month over the course of the first 6 months after surgery as regards:

- Postoperative stomal continence, stomal stenosis (supra- and subfascial).
- Need for surgical revision, vesico-cutaneous fistula, Vesicoureteral reflux, and surgical site infection.
- Dryness outcome with CIC and nighttime dryness.

1- Cystoscopy: was done at 1 month post operative to remove JJ stents if they were used.

2- Radiological investigations:

- Ultrasound of the abdomen and pelvis at 3 months postoperatively.
- VCUG will be done at 6 months postoperatively.

Patients were admitted one day before surgery for routine clinical and laboratory evaluation. They were fasting for 6 hours before surgery.

Surgical procedure

Following anesthetic induction, a central venous line was placed and prophylactic broad-spectrum antibiotics administered intravenously. The previous midline incision was reopened, with longitudinal cystotomy

performed to access the bladder. Both ureteral orifices were catheterized with stents. A modified Young-Dees-Leadbetter BNR was performed using 4/0 PDS/Vicryl sutures over an 8F Foley catheter. A 30 cm ileal segment (maintained 20 cm proximal to the ileocecal valve) was isolated with

preservation of its vascular supply for bladder augmentation. Ileal continuity was restored through anastomosis, with careful closure of the mesenteric defect. (Partin et al., 2020; Nadeau and Herschorn, 2014) (Fig. 2).

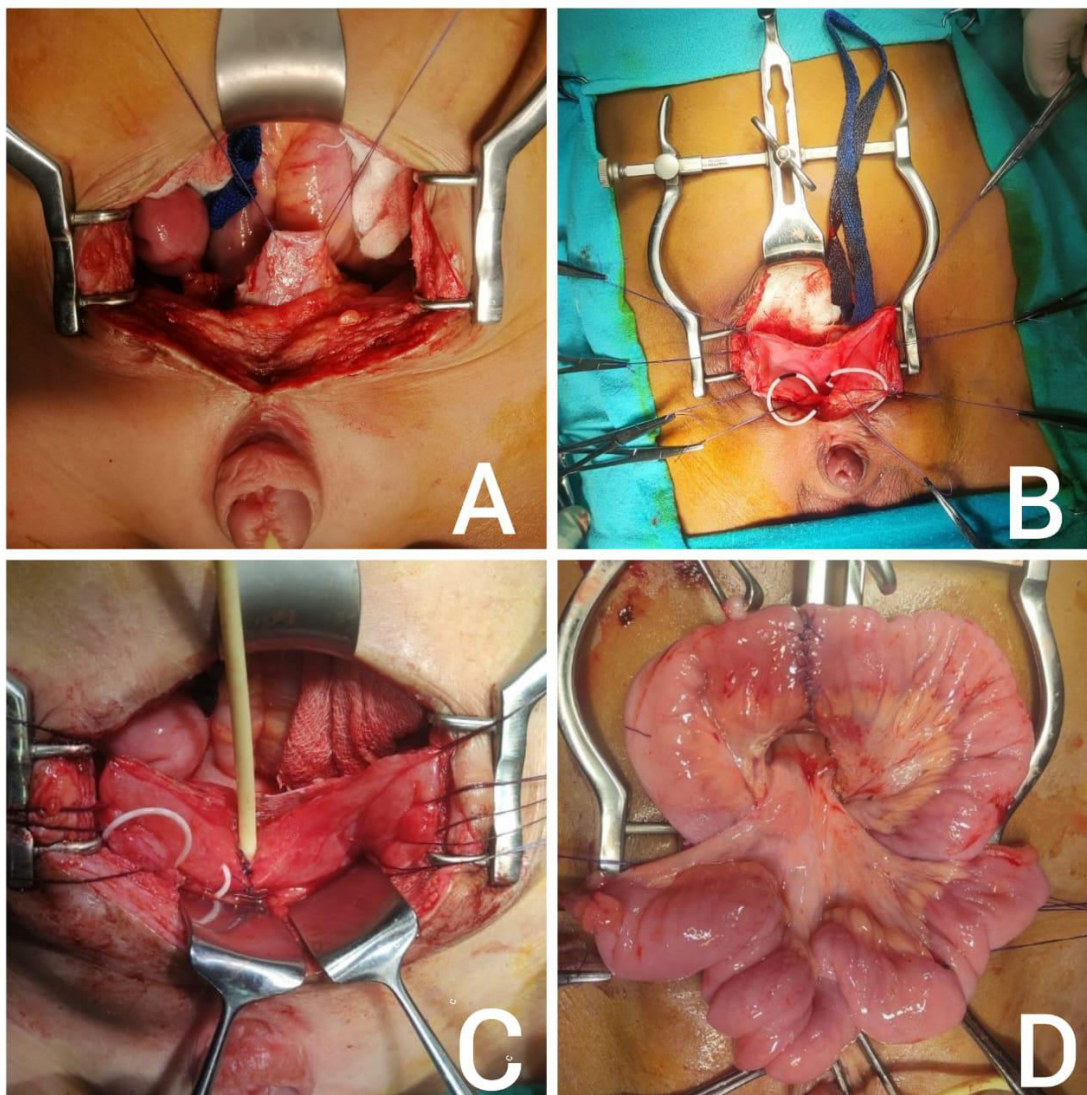


Fig.2.A. Opening the previous midline incision with stay sutures on either side of the bladder. B. Opening of the bladder longitudinally and stenting of both ureteric openings by JJ stents 4 F. C. Modified Young-Dees Leadbetter BNR over an 8 F Foley catheter. D. Isolation of the ileal segment planned to be the augment and ileoileal anastomosis.

The harvested ileal segment was reconfigured into an S-shaped loop. The antimesenteric border was then incised

longitudinally, and the adjacent edges were approximated using 3/0 Vicryl sutures. The appendix was transected at its proximal

portion while carefully preserving its vascular mesentery. The distal end was subsequently implanted into the augmented

bladder using an anti-reflux technique. (Fig. 3).

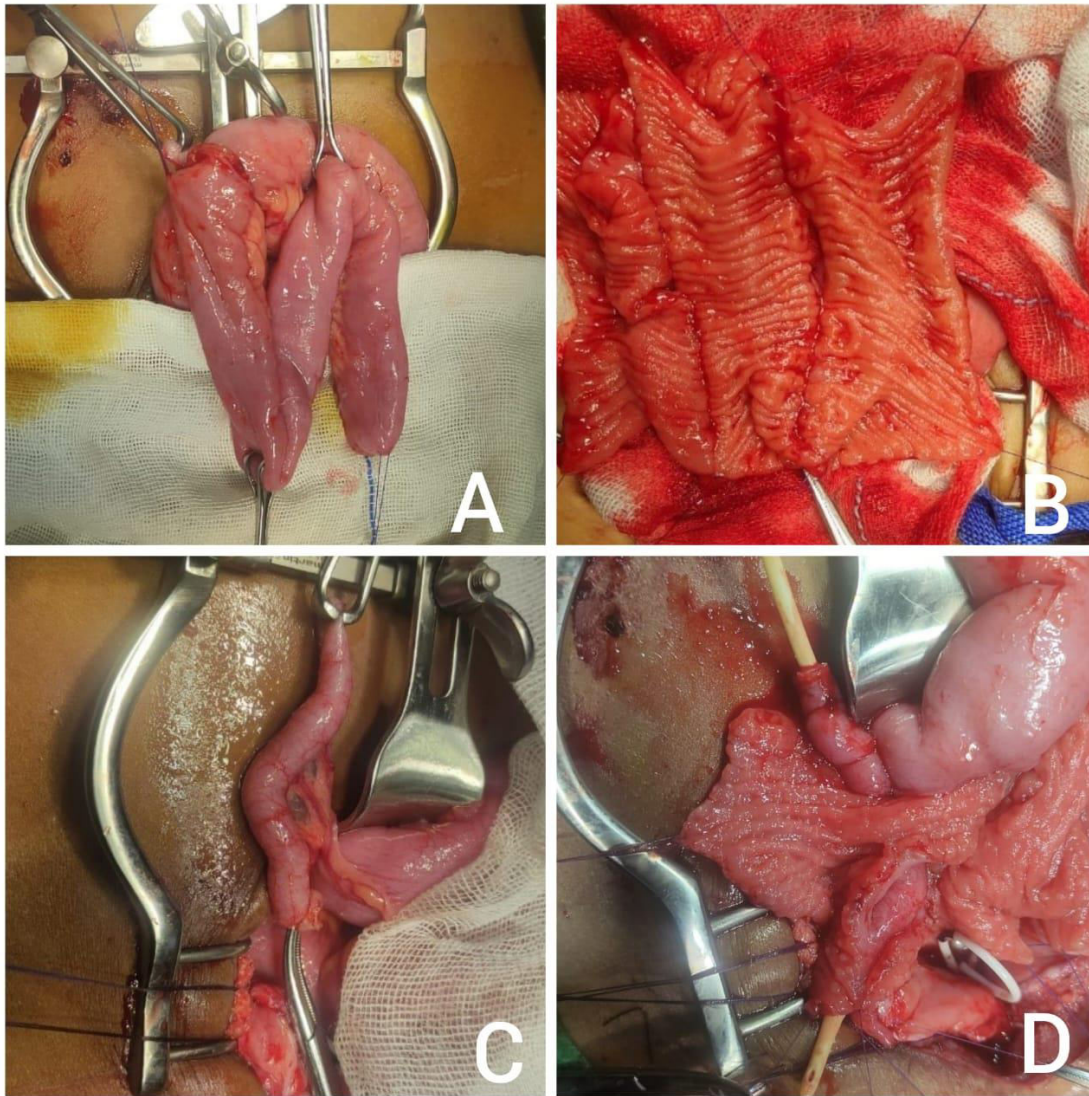


Fig.. A. Configuration of the ileal segment in S shape. **B.** Opening the ileal segment in its antimesenteric border with suturing the borders with vicryl 3/0. **C.** Division of the appendix at its proximal end. **D.** Implantation of one end of the appendix in the Augment in an anti-reflux technique.

The ileal patch was carefully sutured to the cystotomy edges using 2/0 Vicryl, beginning with the posterior aspect to complete the vesico-intestinal anastomosis. The other end of the appendix was

exteriorized and secured at the umbilical site to create the catheterizable channel. (Fig. 4). Then, the abdominal drain was inserted and the abdominal wall was closed in layers. (Fig. 5).

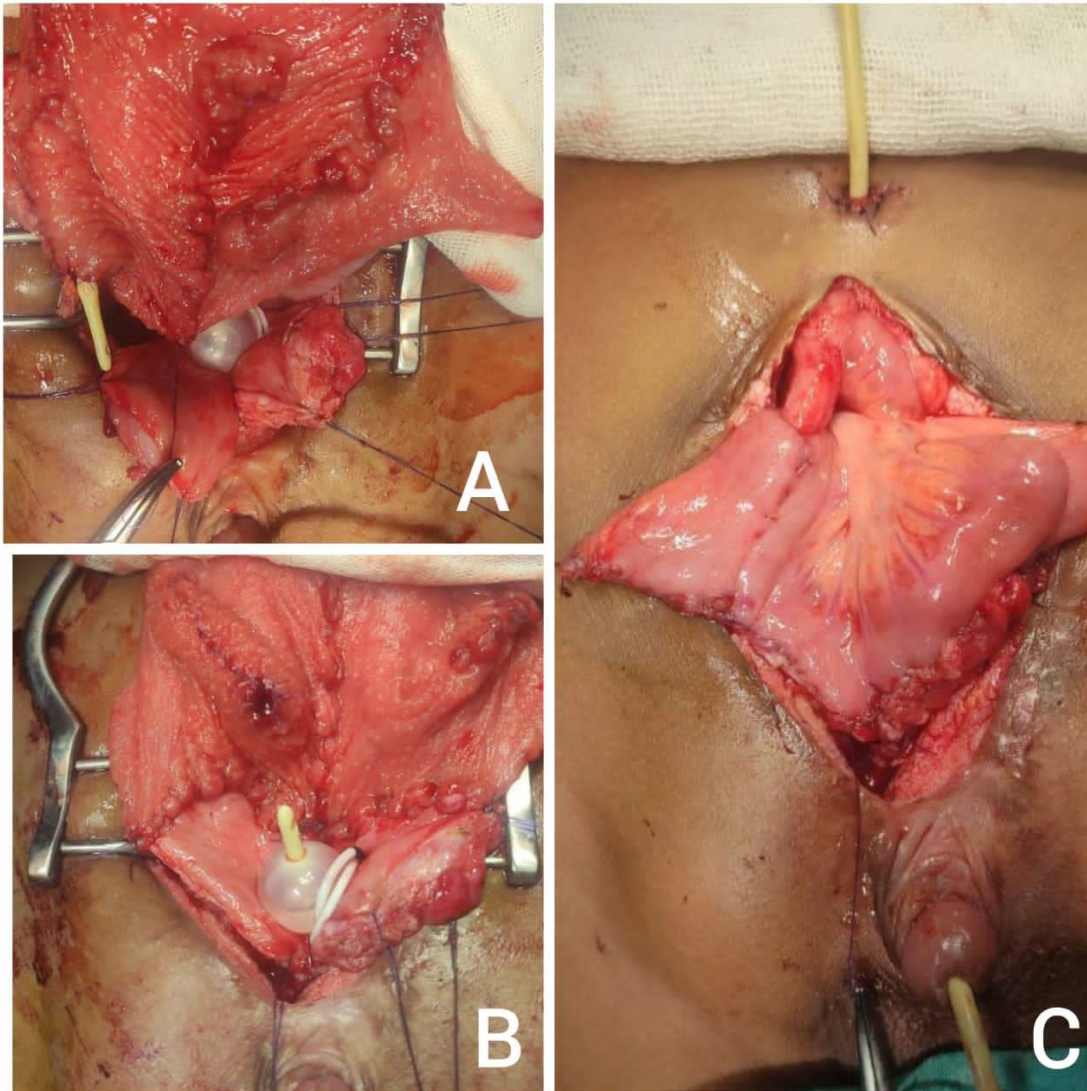


Fig.4. A. Approximation of the lower border of the ileal patch to the upper border of the bladder. **B.** Completion of the anastomosis of the posterior wall of the augment. **C.** Completion of the anterior wall of the Augment.

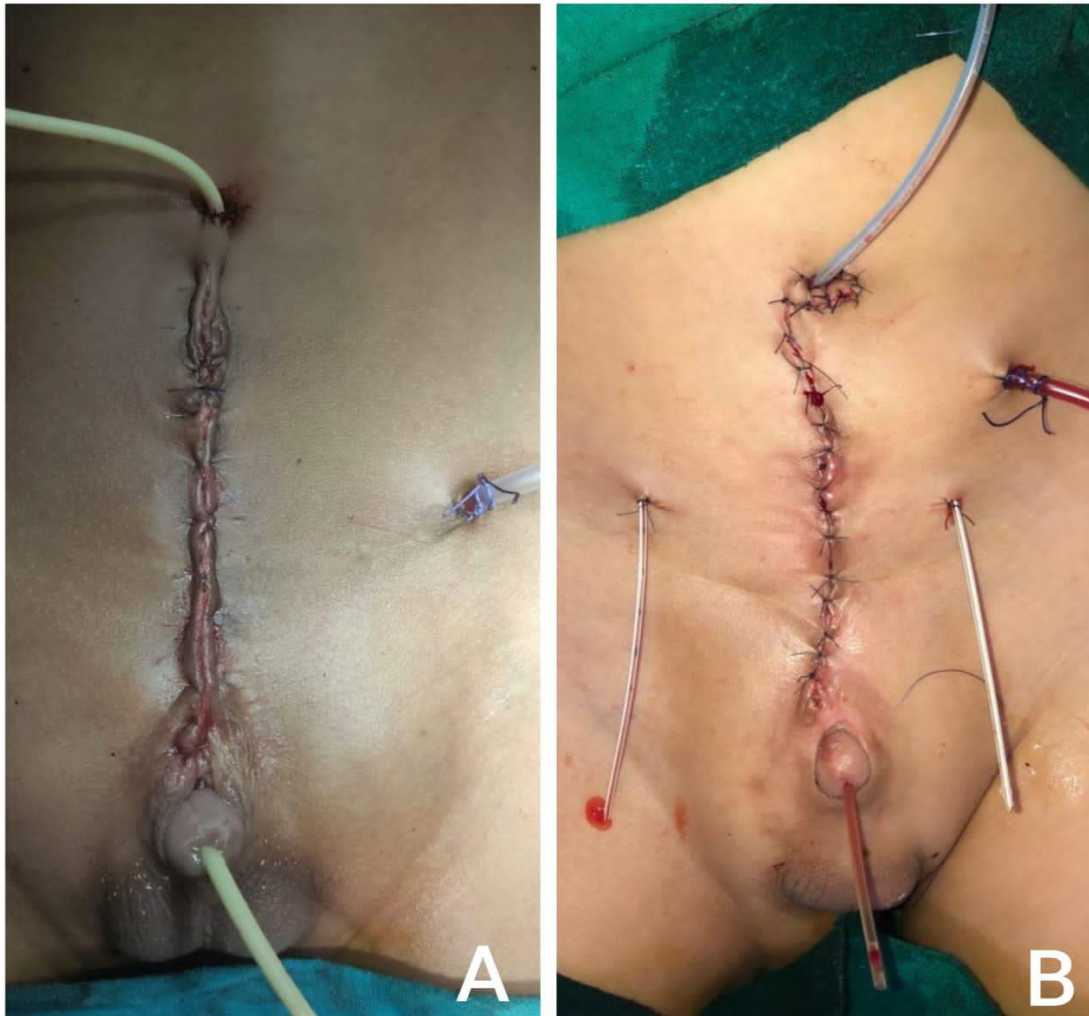


Fig.5. Closure of the abdominal wall after drain insertion.

Statistical analysis

Data was fed to the computer and IBM SPSS software package version 20 (IBM Corp., Armonk, NY, United States) was used for analysis. Number and percent were used to describe qualitative data, whilst range (minimum and maximum), mean, standard deviation, and median were used to describe quantitative data.

Results

Demographic and perioperative variables: The study involved 20 patients (16 males [80%] and 4 females [20%], ratio 4:1) with a mean age of 7.8 ± 2 years (range: 5-11 years) at surgery. Participants were monitored for an average of 19 months (range: 13-24 months). (**Table.1**).

Table 1. Demographic characteristics of the studied patients:

Demographic Variables	Male No (%)	Female No (%)
Sex (n=20)	16 (80.0%)	4 (20.0%)
Age in years Min. – Max.	5.0 – 11.0	
Mean $\pm$ SD	7.8 ± 2.0	

A standardized surgical approach was employed for all cases, utilizing a 30 cm S-shaped ileal segment for bladder augmentation combined with modified Young-Dees-Leadbetter BNR and Mitrofanoff appendicovesicostomy. The mean operative duration was 4.4 ± 0.6 hours (range: 3.5-5.5 hours). Three patients (15%)

(2 males, 1 female) required cephalotrigonal ureteral reimplantation due to anatomical constraints (narrow trigone precluding bladder neck reconstruction). Seventeen patients (85%) had sufficient trigonal width to permit standard reconstruction. No intraoperative complications were encountered in any case. (**Table.2**).

Table 2. Operative evaluation of the studied cases:

Operative Variables	
Operative time in hours	
Min. – Max.	3.5 – 5.5
Mean $\pm$ SD	4.4 ± 0.6
Need for ureteric reimplantation	
	3 (15%)

All patients resumed oral intake between postoperative days 4–6, following the return of bowel function. The average hospital stay was 10.4 ± 2.2 days (range: 9–19 days). Ureteric stents were removed between 15 – 30 days postoperatively with a mean $\pm$ SD (17.9 ± 4.98) days. The abdominal drain was removed between 7

and 15 days with a mean $\pm$ SD (8.9 ± 1.7) days. The urethral catheter was removed between 14 and 21 days, with a mean $\pm$ SD (16.1 ± 2.3) days. The Mitrofanoff catheter was removed, and clean intermittent catheterization (CIC) started between 25 and 30 days, with a mean $\pm$ SD (27.9 ± 1.6) days. (**Table.3**).

Table 3. Early post-operative evaluation of the studied cases

Hospital stay in days	
Min. – Max.	9.0 – 19.0
Mean $\pm$ SD	10.4 ± 2.2
Timing of removal of the abdominal drain	
Min. – Max.	7.0 – 15.0
Mean $\pm$ SD	8.9 ± 1.7
Timing of removal of the urethral catheter	
Min. – Max.	14.0 – 21.0
Mean $\pm$ SD	16.1 ± 2.3
Timing of removal of Mitrofanoff catheter and starting CIC	
Min. – Max.	25.0 – 30.0
Mean $\pm$ SD	27.9 ± 1.6

Timing of removal of ureteric stents in days	
Min. – Max.	15.0 - 30.0
Mean $\pm$ SD	17.9 $\pm$ 4.98

Early complications: Three cases (15%) developed surgical site infections during recovery. (Fig. 6)

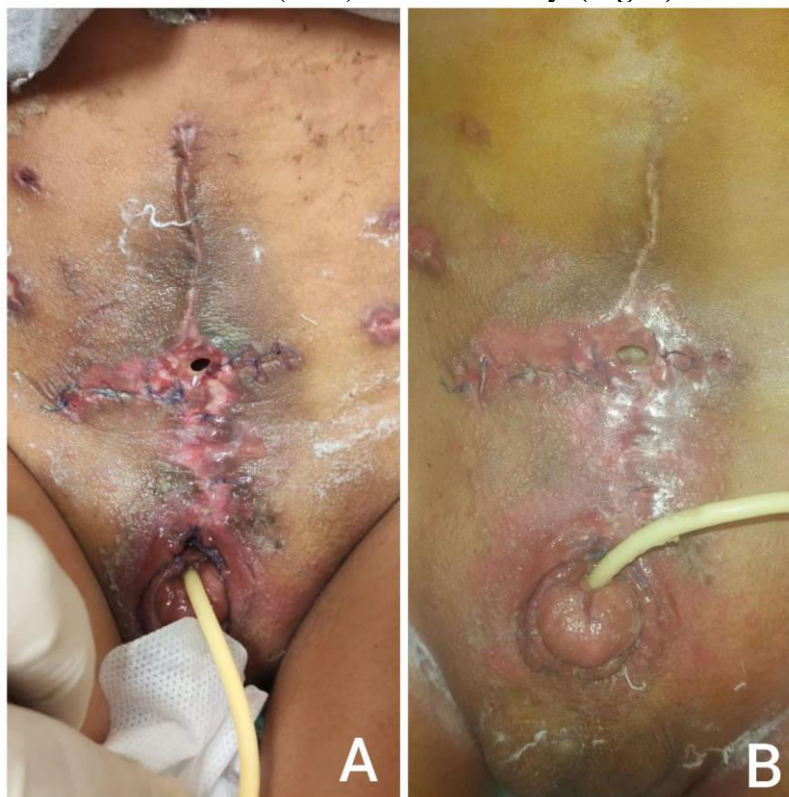


Fig.6. A. A case with wound infection with Vesico-cutaneous fistula within 7 days postoperative.

B. Same case after 21 days postoperative.

All patients maintained no leakage through their Mitrofanoff stoma during follow-up. Stomal stenosis developed in 10% of cases (n=2), which were successfully managed with examination

under anesthesia followed by calibration and maturation. An additional 10% (n=2) developed vesicocutaneous fistulae, both of which resolved spontaneously without requiring surgical repair. (Table.4)

Table 4. Late post-operative evaluation of the studied cases:

Stoma leak	0
Stoma Stenosis (needing surgery)	2 (10%)
Vesico-cutaneous fistula	2 (10%)

Late post operative complications

Only 1 patient developed a bladder stone a year after bladder augmentation. This

stone was extracted in our dedicated stone service in the adult Urology Department. Post-operative urine analysis was positive

for asymptomatic bacteriuria in 18 patients; only 2 patients had urine analysis free. Only one case developed a significant urinary tract infection and needed hospital admission and IV antibiotics.

Classification of the postoperative complications according to the Clavien-Dindo classification:

1. **Surgical Site Infections (15%, n=3)**
 - **Grade II:** Requiring pharmacological treatment (antibiotics).
2. **Stomal Stenosis (10%, n=2)**
 - **Grade IIIb:** Requiring intervention (examination under anesthesia + calibration/maturation)
3. **Vesicocutaneous Fistulae (10%, n=2)**
 - **Grade I:** Resolved spontaneously without intervention.
4. **Bladder Stone (1 patient, 5%)**
 - **Grade IIIb:** Required surgical intervention (stone extraction under anesthesia).

5. Significant Urinary Tract Infection (1 patient, 5%)

- **Grade II:** The infection required pharmacological treatment (IV antibiotics) and hospital admission, but no surgical, endoscopic, or radiological intervention was needed.

Compliance on CIC and continence results:

Sixteen patients (80%) were compliant on CIC every 3 hours, and 4 patients (20%) were not compliant. As regards daytime continence, 16 patients (80%) were dry between CIC sessions, while 4 patients (20%) were wet between CIC at resting time. During stress, 14 patients (70%) were dry, while 6 patients (30%) were wet (4 of them were wet at resting time). (Fig. 7), (Table. 5).

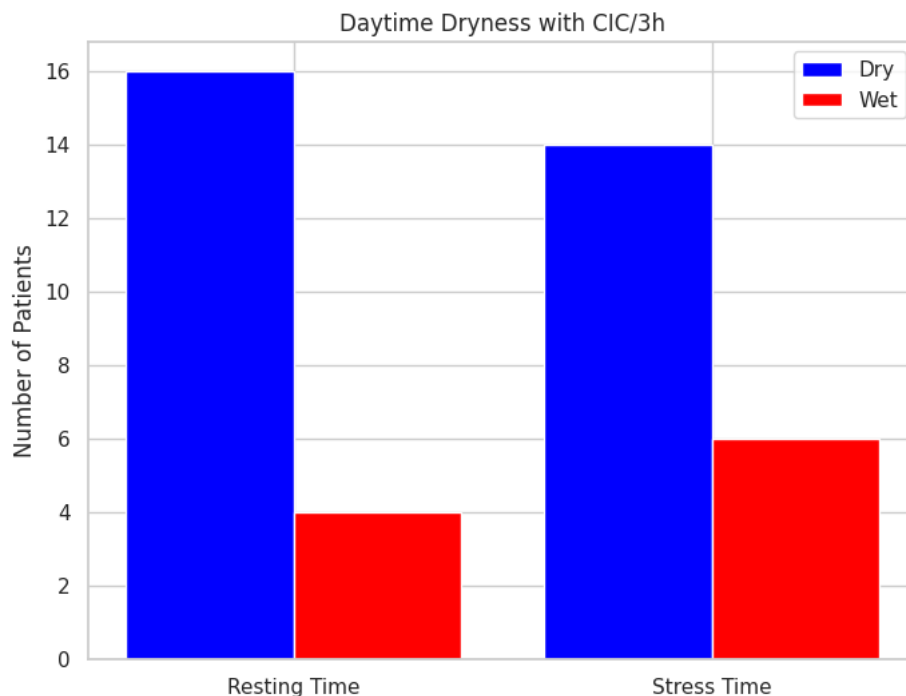


Fig.7. Daytime dryness.

At nighttime, 8 patients (40%) were dry for 6 hours without doing CIC, while 8 patients (40%) had to catheterize themselves

every 3 hours to stay dry, and 4 patients (20%) were wet before 3 hours. Regarding patient satisfaction, 7 patients were not

satisfied after the operation, 4 of them were not compliant on CIC and were wet at resting time, and the remaining 3 cases were

dry. Still, they were not satisfied with CIC. (Fig. 8), (Table.5)

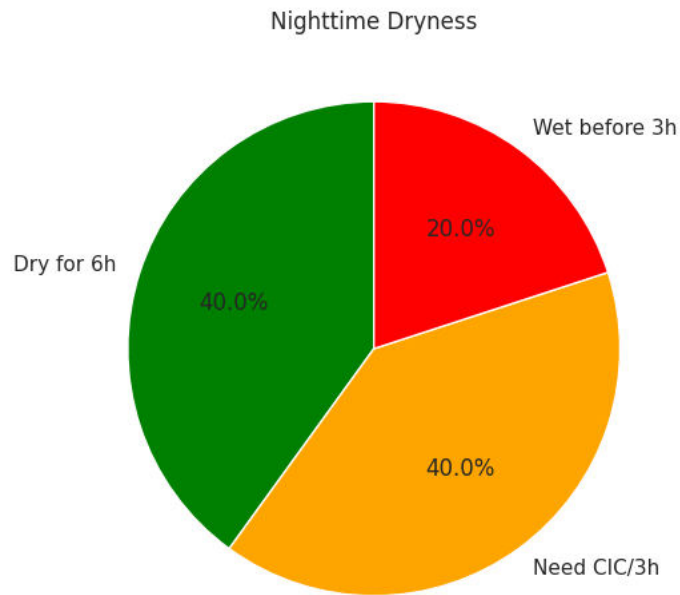


Fig.8. Nighttime dryness.

Table 5. Compliance on CIC and continence results:

Compliance on CIC	16 (80.0%)	
Daytime dryness with CIC/3h	Resting time	Stress time
Dry	16 (80.0%)	14 (70%)
Wet	4 (20%)	6 (30%)
Nighttime dryness		
Dry for 6 hours	8 (40%)	
Need CIC/3h	8 (40%)	
Wet before 3 hours	4 (20%)	
Patient satisfaction	13 (65%)	

Pre and postoperative bladder capacity

In sonography, there was no hydronephrosis nor hydroureter, and the renal cortical thickness was average in all patients before and after surgery.

Pre-operative bladder capacity in VCUG ranged from 50.0 to 70.0 ml, with a mean $\pm$ SD (60.2 ± 6.6) ml with variable degrees of

VUR (grade I-III, unilateral or bilateral). Post-operatively, bladder capacity increased significantly, ranging from 200.0 to 400.0 ml, with a mean $\pm$ SD (348.5 ± 58.33) ml with complete resolution of VUR. The increase in bladder capacity in VCUG was statistically significant at ($p < 0.001$) as shown in (Table 6 , Figs. 9-11).

Table 6. Pre- and post-operative bladder capacity in VCUG among the studied cases:

VCUG	Pre-operative	Post-perative	P-value
Min. – Max.	50.0 – 70.0	200 – 400	<0.001*
Mean $\pm$ SD	60.2 $\pm$ 6.6	348.5 $\pm$ 58.33	

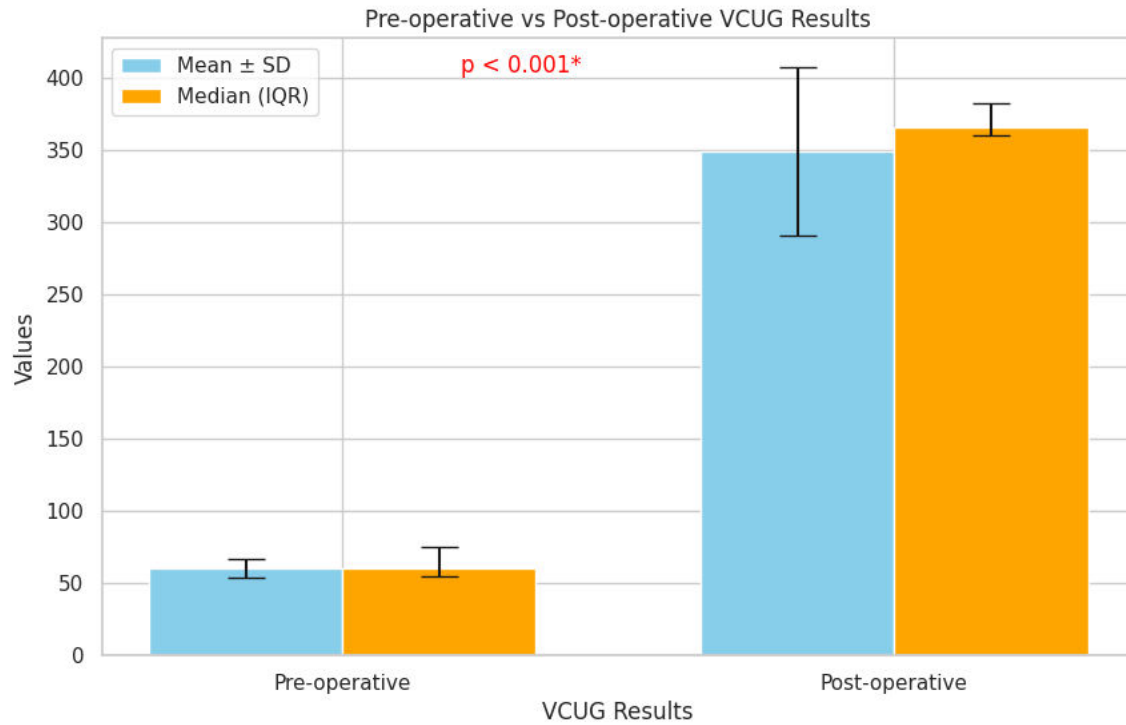


Fig.9. Pre and post operative bladder capacity in VCUG.



Fig.10. A. Preoperative VCUG of one of the cases with a bladder capacity of 50 ml (note the bilateral VUR). **B.** Postoperative VCUG of the same case with bladder capacity 400 ml with no VUR.

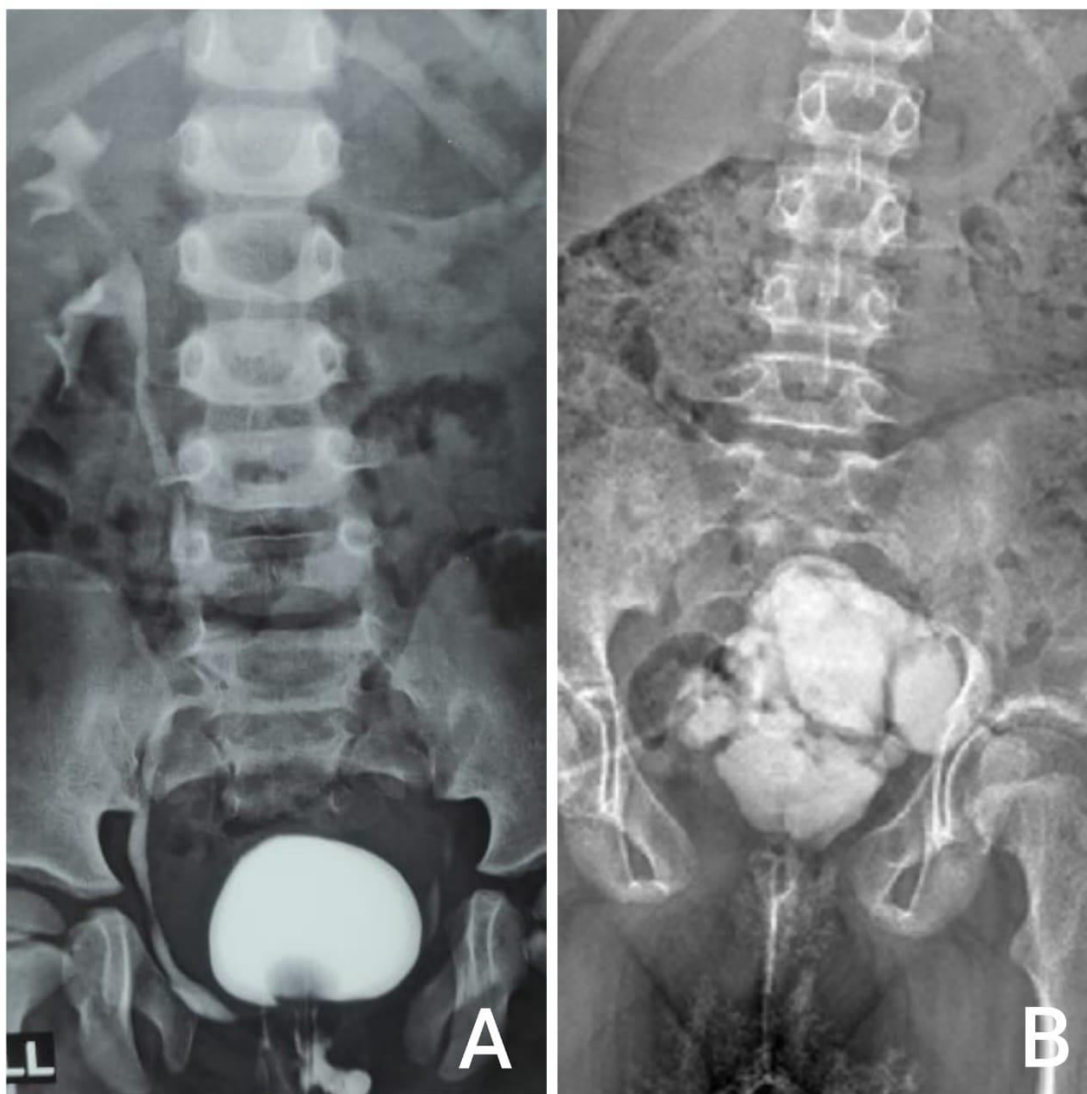


Fig.11. A. Preoperative VCUG of one of the cases with a bladder capacity of 60 ml (note the Rt VUR). **B.** Post-operative VCUG of the same case with a bladder capacity 200 ml with no VUR.

Discussion

Bladder exstrophy represents an uncommon congenital malformation characterized by a midline abdominal wall defect. This condition belongs to a broader group of developmental disorders affecting abdominal and pelvic fusion, collectively termed the exstrophy-epispadias complex (EEC). (Ludwig et al., 2009)

The standard reconstructive approach involves primary bladder closure immediately after birth, followed by epispadias repair typically performed

between 6 to 12 months of age. (Shoukry et al., 2009)

The outcomes of staged repair primarily depend on achieving adequate bladder capacity and proper outlet resistance. Following initial closure, bladder expansion potential is influenced by several factors. Notably, delayed primary closure often leads to pan-cystitis and detrusor fibrosis - pathological changes that significantly impair bladder growth and compliance. (Bhatnagar et al., 2002)

McMahon et al. noted that augmentation cystoplasty was required in

63% of cases with delayed bladder closure beyond 7 days of age compared to 36% of patients who underwent closure before 7 days of age.(**McMahon et al., 1996**) Husmann et al. showed a 40% augmentation rate in patients with bladder closure after 1 year, in contrast to 10% in those who were operated on before 1 year of age.(**Husmann et al., 1989**)

Our series included 15 cases who had primary closure in the neonatal period before 72 hours while 5 cases had delayed primary closure after 3 months due to the small bladder capacity.

Urinary continence remains the most significant postoperative hurdle for pediatric patients with the EEC. To address this, BNR was developed to replicate the natural physiological mechanisms of bladder outlet control, facilitating both continence and complete voiding function.(**Mouriquand et al., 2003**)

Bladder augmentation remains the gold-standard intervention for children with insufficient bladder capacity or treatment-resistant dysfunction. By constructing a compliant, low-pressure reservoir, the procedure preserves renal function, restores continence, and optimizes long-term patient outcomes.(**Mehmood et al., 2018**) The ileum remains the most commonly employed intestinal segment for BA procedures.(**Siebert et al., 2022**)

Lapides et al. established clean intermittent catheterization (CIC) as an effective method for bladder evacuation. The interdependence between augmentation cystoplasty and CIC is clinically paramount. When planning pediatric bladder reconstruction, the foremost consideration must be preserving the ability to perform successful CIC long-term.(**Mitchell, 2003**) The Mitrofanoff appendicovesicostomy remains the gold-standard approach for CCC creation, using the native appendix as the conduit. When the appendix is unavailable,

the Yang-Monti technique provides an effective alternative by constructing a channel from a transversely reconfigured bowel segment.(**Adamic et al., 2020**)

In this study, we aimed to evaluate the efficacy, safety, and outcomes of augmentation ileocystoplasty with modified Young-Dees-Leadbetter BNR and CCC in children born with bladder exstrophy after successful bladder closure and epispadias repair.

Our study revealed a male predominance (80%), aligning with existing literature. **Harris et al. (2023)** reported a similar male-to-female ratio (69.3% vs. 30.7%) in their cohort of 192 bladder exstrophy patients undergoing BNR. Likewise, **Maruf et al. (2020)** observed a higher prevalence of males (70.8%) than females (29.2%) in their analysis of post-reconstruction continence outcomes. The timing of bladder augmentation is an important issue to be considered.

In a multi-institutional, retrospective cohort study involving 216 patients, **Szymanski et al. (2019)** reported that the probability of bladder augmentation increased with age; by age 10 years, half of the children with bladder exstrophy underwent augmentation, and this increased to 70% by 18 years.

The mean age of patients who had bladder augmentation in our study was 7.8 years. **Bhatnagar et al. (2002)** . reported the mean age for bladder augmentation in their study was 8.6 years. **Defoor et al. (2004)** reported a mean age for bladder augmentation was 8 years in their study. In **Maruf et al. (2020)** study, the mean age was 5.9 years. We recommend this age for intervention as patients typically demonstrate sufficient abdominal muscle control for complete voiding and are mature enough for independent self-catheterization. The most frequent early postoperative complication was surgical site infection

(15%, n=3). This aligns with **Bozaci et al. (2022)** who observed a 6.7% infection rate, including one case requiring wound debridement and reclosure.

Among the main late problems of this procedure are stomal leak and/or stenosis and fistula formation. (**Surer et al., 2003**) Our results demonstrated 100% continence rates (no leakage) with the Mitrofanoff stoma. These findings align with **Harris et al. (2000)** who reported a 98% continence rate in their cohort. In contrast, **Liard et al. (2001)** observed a substantially higher stomal leakage rate of 21%.

In our study, stomal stenosis occurred in 10% of cases (2/20) who needed surgical intervention, consistent with the 10% rate reported by **Harris et al. (2000)**. However, **Liard et al. (2001)** observed a substantially higher stenosis prevalence of 39% (9/23 patients).

On the other hand, we had 2 patients (10%) who developed vesicocutaneous fistula, all of which closed spontaneously. Consistent with our findings, **Bhatnagar et al. (2011)** reported 2 out of 19 patients who developed vesicocutaneous fistula; however, different from our study, they reported that both fistulae needed surgical intervention. **Demirkan et al. (2022)** reported 6 patients (18.75%) out of 32 patients who developed vesicocutaneous fistula, and all of them were repaired primarily.

The literature reports asymptomatic bacteriuria in 50-100% of augmented bladders, with clinically significant UTIs occurring less frequently (4-43%). (**Kreder et al., 1992; Mitchell et al., 1986; Khoury et al., 1992**) Our findings align with these patterns, demonstrating 90% asymptomatic bacteriuria rate (18/20 patients). This is in line with **H Demirkan et al. (2022)** who observed 93.1% bacteriuria prevalence among CIC dependent patients.

Bladder stones represent a well-documented complication post-augmentation, with reported incidence rates ranging from 3–40%. (**Mehmood et al., 2018**) In our study, only one case (5%) developed a bladder stone at 1-year follow-up that was treated via lithotripsy (adult urology department). The stone analysis revealed it was struvite stone.

Mehmood et al. (2018) reported in his study that bladder stones developed in 4 patients (9.5%). **Szymanski et al. (2016)** assessed the stone composition of 85 cases after BA, and infectious stones represented 69.2% of bladder stones. It has been demonstrated that bladder irrigation procedures using regular saline greatly lower the risk of stone formation and lower the incidence of mucus and bacteriuria. (**Hensle et al., 2004**)

Existing literature most commonly defines continence as the ability to maintain dryness between voiding or catheterization episodes spaced ≤ 3 hours apart. (**Lloyd et al., 2012**) In our study, most patients (80%) were compliant on CIC / 3 hours, and 4 patients (20%) were non-compliant. As regards the dryness between CIC at daytime, 16 patients (80%) remained dry between CIC sessions with no dripping from the urethra, while 4 patients (20%) were wet between CIC during resting time. During stress, 6 patients (30%) were wet, while 14 patients (70%) maintained dryness.

At night, 8 patients (40%) were dry for 6 hours without doing CIC, while 8 patients (40%) needed to do CIC/3 hours to maintain dryness, and 4 patients (20%) were wet before 3 hours. The overall continence rate in our study was 80%. All continent patients have a sensation of bladder fullness and can void freely.

Similar results were reported in **Demirkan et al. (2022)** study, in which a continence rate of 78.7% with volitional voiding and CIC after bladder augmentation, BNR, and CIC. Also, **McMahon et al.**

(1996) noted that 82% continence was achieved in 17 patients with bladder augmentation compared to 56% continence in 16 non-augmented patients. **Maruf et al. (2020)** also assessed the continence rate in their work, showing that after isolated BNR, 64% were continent compared to 93% continent patients after BNR with CCC. **Bhatnagar et al. (2002)** reported that the sensation of reservoir fullness was present in patients; 9 patients (47.3%) were completely dry out of 19 patients. Two patients are totally incontinent, and the remaining 8 patients had wetting episodes. In a study conducted in 2004, **Shaw et al. (2004)** reported augmentation was required in 30 of 43 patients (70%) to achieve continence. He also stated that Bladder neck reconstruction alone resulted in continence in only a third of the cases. This showed the importance of bladder augmentation combined with BNR and CCC to achieve adequate continence in these patients.

The change in bladder capacity in VCUG after BA was good; there was a mean 5-fold increase in the bladder capacity in our study (from 60.2 ± 6.6 ml to 341.5 ± 73.4 ml, respectively; $p < 0.001$).

Consistent with our study, **Kramer (1989)** who reported a 4.8-fold increase in bladder capacity after BA in BE patients. Similarly, **Bhatnagar et al. (2011)** reported a mean 7-fold increase in bladder capacity after augmentation cystoplasty. Also, **Chang et al. (2024)** stated that there is a mean 8-fold increase in bladder capacity after augmentation cystoplasty.

BA lowers intravesical pressure and increases bladder compliance during the urine storage phase, reversing or minimizing VUR. (**Soylet et al., 2004**) It was found that all cases in our study had pre-operative mild grades of VUR (grade I to III), either unilateral or bilateral, and all of them showed resolution of VUR in post-operative

VCUG done 6 months after bladder augmentation.

This is similar to a study done in 2016 by Han-Chao Zhang et. al who reported that reflux was resolved in 24 patients (83%) out of 29 patients, improved in 3 patients (10%), but persisted in two (7%) patients. (**Zhang et al., 20016**) This is in line with **Juhasz et al. (2008)** who reported resolution of VUR after bladder augmentation in 14 patients (87.5%) out of 16 patients. **Khastgir et al. (2003)** reported complete resolution of VUR in 66.6% of patients who had VUR before augmentation, 16.6% of cases VUR down from grade IV to grade II and 16.6% of cases did not improve.

Conclusion

Bladder augmentation combined with BNR and the creation of a CCC represents a safe and effective surgical approach for managing bladder exstrophy patients with urinary incontinence and reduced bladder capacity. These procedures have demonstrated significant efficacy in enhancing bladder volume, improving compliance, resolving VUR, improving continence and improving quality of life.

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