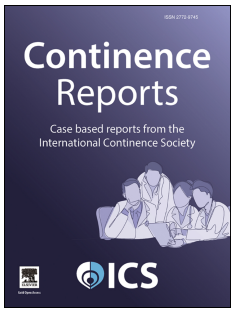
Journal Pre-proof



Urodynamic Changes Following Augmentation Cystoplasty in Pediatric Patients with Neurogenic Lower Urinary Tract Dysfunction

Mohammed Bassil Ismail, Hasanain Farhan Hasan, shaher Ihsan Ibraheem

PII: S2772-9745(25)00024-9

DOI: https://doi.org/10.1016/j.contre.2025.100101

Reference: CONTRE 100101

To appear in: *Continence Reports*

Received Date: 27 September 2025

Revised Date: 5 December 2025

Accepted Date: 15 December 2025

Please cite this article as: M.B. Ismail, H.F. Hasan, s.I. Ibraheem, Urodynamic Changes Following Augmentation Cystoplasty in Pediatric Patients with Neurogenic Lower Urinary Tract Dysfunction, *Continence Reports*, https://doi.org/10.1016/j.contre.2025.100101.

Urodynamic Changes Following Augmentation Cystoplasty in Pediatric Patients with Neurogenic Lower Urinary Tract Dysfunction

Mohammed Bassil Ismail[1] , Hasanain Farhan Hasan[2] ,shaher Ihsan Ibraheem[3]

[1,2]*Department of surgery college of College of Medicine, University of Baghdad*

[3]*medical city complex,Baghdad,Iraq*

Correspondence:

Dr. Mohammed Bassil Ismail

E-mail: mohammed_albassil@yahoo.com

Availability of data and materials

All data generated or analyzed during this study are included in this published article

Conflict of interests

The authors declare that they have no competing interests

Funding

No funding.

Ethics approval and consent to participate

The approval of ethics committee was obtained from Health Ethics Committee in college of medicine, university of Baghdad.

Author contribution

Each author made substantial equal contributions to the conception, design of the work; the acquisition, analysis, interpretation of data; and had drafted the work or substantively revised it

All authors, have read and approved the manuscript, and agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. All authors have read and approved the manuscript

Acknowledgements

Not applicable

Clinical trial

It is an original article and not a clinical trial

Urodynamic Changes Following Augmentation Cystoplasty in Pediatric Patients with Neurogenic Lower Urinary Tract Dysfunction

Introduction

Neurogenic lower urinary tract dysfunction (NLUTD) is a key factor in the etiology of recurrent urinary tract infections and is associated with vesicoureteral reflux, renal parenchymal damage, renal scarring, and progressive chronic kidney disease[(1)]. Therefore, comprehensive monitoring of patients with NLUTD is essential; particularly regarding upper urinary tract preservation .Assessment includes imaging modalities such as ultrasonography, fluoroscopy, and nuclear medicine imaging, as well as functional assessment via urodynamic studies. [(2)].

The goal of assessment is to prevent progressive renal failure by detecting and addressing reversible renal and bladder alterations before irreversible scarring develops, which would render surgical intervention ineffective. Early detection of upper urinary tract changes is crucial for long-term prevention of renal deterioration in patients with NLUTD [(3)].

Urodynamic studies remain the gold standard for diagnosing bladder and urethral abnormalities in patients with neurogenic lower urinary tract dysfunction, evaluating both storage and voiding phases. During cystometrography with infusion of saline or carbon dioxide, parameters assessed include bladder volume, compliance, sensation, and the presence of involuntary detrusor contractions. [(4)].

Bladder pressure is monitored throughout filling and emptying via pressure transducers connected to transurethral catheters, with simultaneous measurement of intra-abdominal pressure for calculation of detrusor pressure[(5)]. Normal bladder sensation during filling cystometry is assessed using three parameters: first sensation, normal desire to void, and strong desire to void, each correlated with bladder volume and patient symptoms [(6)].

First sensation is defined as the volume at which the patient first becomes aware of bladder filling. Normal desire to void is the sensation during filling cystometry at which the patient would normally pass urine if socially appropriate, achieved without urgency or leakage. [(5)].

Sphincter electromyography, performed using either surface or needle electrodes, assesses voiding coordination and detects the presence of detrusor sphincter dyssynergia (DSD). The detrusor leak point pressure (DLPP) is the maximum detrusor pressure at which urine leakage occurs during passive bladder filling without abdominal straining. In neurogenic bladders with poor compliance, persistently elevated detrusor pressures and detrusor leak point pressures exceeding 40 cm H_2O significantly increase the risk of upper urinary tract deterioration[(7)].

Urethral pressure profile (UPP) measurement assesses urethral resistance by recording pressures along the length of the urethra during slow withdrawal of a fluid-filled catheter connected to a pressure transducer. Although UPP measurement before cystometry is recommended, comparison of peak urethral pressure with detrusor pressure during cystometrography may provide clinically useful information regarding the bladder's voiding capacity. Clinical applications of UPP include diagnosis of stress urinary incontinence and urethral instability; however, its utility in the management of neurogenic lower urinary tract dysfunction remains unclear[8].

Urodynamic parameters that guide treatment decisions include neurogenic detrusor overactivity (NDO), low compliance (< 10 mL/cm H_2O), high detrusor leak point pressure (DLPP > 40 cm H_2O), detrusor sphincter dyssynergia (DSD), and vesicoureteral reflux (VUR). These findings place the upper urinary tract at significant risk for deterioration if not addressed. Additionally, urodynamic findings may not always correlate with clinical symptoms. [9].

Management of NLUTD aims to preserve the native bladder's capacity to store urine at low pressure while maintaining efficient emptying. Early intervention focuses on preventing irreversible injury to the upper and lower urinary tracts. In pediatric patients, quality of life considerations for both child and caregiver are important, including urinary continence and independence in bladder management[10]. However, augmentation cystoplasty is indicated in patients with reduced bladder capacity despite conservative management [11].

Patients and Methods

Study Design and Setting

A prospective study was conducted at the Urology Unit, Ghazi Al-Hariri Teaching Hospital, between October 2020 and October 2024. The study enrolled 80 pediatric patients aged 6 to 18 years who underwent augmentation cystoplasty (AC) for neurogenic lower urinary tract dysfunction, confirmed by preoperative urodynamic studies.

Inclusion Criteria

Patient Population

- Pediatric patients aged 6–18 years with NLUTD refractory to conservative management (antimuscarinics, botulinum toxin, intermittent catheterization)
- Normal renal function with functional upper urinary tracts
- Informed consent obtained from patient/guardian prior to augmentation cystoplasty

Clinical and Urodynamic Indicators

- Documented low bladder compliance (< 10 mL/cm H_2O) or elevated detrusor pressures (> 40 cm H_2O) on preoperative urodynamic studies with evidence of upper urinary tract risk

Prior Conservative Therapy

- Failed medical management including antimuscarinics, intermittent catheterization, and/or botulinum toxin injection

Exclusion Criteria

- Severe systemic illness (e.g., poorly controlled diabetes, advanced heart failure) precluding general anesthesia
- Coagulation disorders or inability to tolerate general anesthesia
- History of inflammatory bowel disease (e.g., Crohn's disease) contraindicating ileal use
- Severe chronic kidney disease (eGFR < 40 mL/min/1.73 m^2) or end-stage renal disease
- Severe cognitive impairment or inability to comply with postoperative care requirements

Ethics Approval and Consent

The study was approved by the Institutional Review Board (IRB) at college of medicine, university of Baghdad. Informed written consent was obtained from all patients' parents or legal guardians, with assent obtained from pediatric patients when developmentally appropriate.

Urodynamic Studies

Urodynamic studies were performed preoperatively and three months postoperatively using slow-fill water cystometry. A triple-lumen 9-Fr catheter was used for adolescent patients and a double-lumen 5-Fr catheter for pediatric patients. Patients were positioned semi-supine without sedation. Abdominal pressure was measured via a rectal catheter.

Saline infusion rate was set at 10% of estimated bladder capacity (EBC) per minute. Filling was terminated when the patient reported fullness or when substantial leakage occurred. All studies were conducted in accordance with International Continence Society (ICS) standards for urodynamic assessment.

Data Collection and Analysis

Patient data including demographics and urodynamic measurements were extracted from hospital records and analyzed. Primary urodynamic parameters assessed included bladder capacity, detrusor contractions during filling, filling pressure, and detrusor leak point pressure. Descriptive statistics (means, standard deviations, medians, and ranges) were calculated for all parameters. Intragroup comparisons between preoperative and postoperative measurements were conducted using the Wilcoxon signed-rank test with $p < 0.05$ considered statistically significant. Data analysis was performed using SPSS version 20.0 (IBM Corporation, Armonk, NY).

Results

Demographic Characteristics

Demographic characteristics of the study population are presented in Table 1. Gender was equally distributed, with 40 males (50%) and 40 females (50%). The median age was 14 years (range, 6–18 years), median weight 32 kg (range, 14–58 kg), median height 126 cm (range, 85–162 cm), and median body mass index 17.4 kg/m² (range, 10.2–27.2 kg/m²).

Table 1. Demographic Characteristics of Study Population (n = 80)

Characteristic	Value
Gender	Male: 40(50%) / Female: 40 (50%)
Age (months)	Median: 14 (Range: 6 - 18)
Weight (kg)	Median: 32 (Range: 14 - 58)
Height (cm)	Median: 126 (Range: 85 - 162)
Body Mass Index (BMI)	Median: 17.4 (Range: 10.2 - 27.2)

*Data presented as median (range)

Urodynamic Findings

Significant urodynamic changes were observed following augmentation cystoplasty, analyzed using the Wilcoxon signed-rank test ($p < 0.05$ considered statistically significant). Detailed results are presented in Table 2.

Bladder capacity increased significantly from 50.3% to 92.4% of expected capacity ($p < 0.0001$) postoperatively. Detrusor contractions during the filling phase increased from 1.2 ± 0.35 preoperatively to 1.9 ± 0.31 postoperatively ($p < 0.0001$). Contraction intensity decreased significantly from 39.0 ± 3.7 to 10.7 ± 12.8 cm H_2O ($p < 0.0001$) postoperatively.

Filling pressure decreased significantly from 35.7 ± 12.5 to 12.0 ± 7.6 cm H_2O ($p < 0.0001$) postoperatively. Detrusor leak point pressure decreased significantly from 42.5 ± 4.1 to 3.3 ± 1.8 cm H_2O (range, 0–62) ($p < 0.0001$) postoperatively. Bladder

compliance increased significantly from 5.1 ± 3.8 to 38.7 ± 4.9 mL/cm H_2O ($p < 0.0001$) postoperatively, as detailed in Table 2.

Table 2. Urodynamic Parameters Before and After Augmentation Cystoplasty

Variable	Prior to Surgery	Post-Surgery	p Value
	Mean ± SD (Range)	Mean ± SD (Range)	
Bladder Capacity Percentage	50.3 ± 18.73 (6 - 100)	92.4 ± 8.1 (58 - 100)	0.0001
Uninhibited Contractions	1.2 ± 0.35 (1 - 2)	1.9 ± 0.31 (1 - 2)	0.0001
Intensity of Contractions	39.0 ± 3.7 (0 - 142)	10.7 ± 12.8 (0 - 80)	0.0001
Filling Pressure	35.7 ± 12.5 (6 - 94)	12. ± 7.6 (4 - 46)	0.0001
Leakage Pressure	42.5 ± 4.1 (0 - 128)	3.3 ± 1.8 (0 - 62)	0.0001
Compliance	5.1 ± 3.8 (2 - 15)	38.7 ± 4.9 (6 - 181)	0.0001

Discussion

Neurogenic lower urinary tract dysfunction results from various etiologies and can lead to severe, irreversible upper urinary tract damage if not adequately managed. Early intervention has been shown to protect the upper urinary tracts long-term. In our prospective series, we demonstrated significant improvements in urodynamic parameters following augmentation cystoplasty in pediatric patients with NLUTD.

Bladder Capacity

Bladder capacity increased from 50.3% to 92.4% of expected capacity in our cohort, consistent with previously published data. Zaragoza-Torres et al. reported similar improvements from 52.8% to 95.9% of expected capacity[12]. Reis et al. documented increases from 52.8–70% to 95.9–119% of expected capacity[13]. Chen et al. reported absolute capacity increases from 115 ± 16.3 to 513 ± 31.4 mL in adult patients (mean age 36.3 ± 8.8 years) [14].

The increase in bladder capacity results from surgical reconfiguration and anastomosis of bowel segment to the native bladder, creating a larger urine reservoir and increasing surface area and volume. Bowel tissue exhibits greater elasticity than native detrusor muscle, enabling the augmented bladder to accommodate larger urine volumes at reduced pressures. This enhanced compliance improves urinary storage capacity and protects the upper urinary tracts from elevated intravesical pressures. Because bowel tissue lacks the contractile properties of smooth muscle, it is ideally suited for passive urine storage rather than active emptying.

Filling Pressure

Our study demonstrated a significant decrease in filling pressure from 35.7 to 12.0 cm H_2O postoperatively. Zaragoza-Torres et al. reported mean filling pressures of 40.8 cm H_2O preoperatively and 11 cm H_2O postoperatively. Similarly, Chartier-Kastler et al. documented filling pressure reductions from 65.5 ± 50.2 to 18.3 ± 7.9 cm H_2O[15].

Decreased filling pressure postoperatively results from multiple factors: increased bladder compliance, expanded storage capacity, and reduced detrusor overactivity. Improved compliance allows more compliant bladder wall expansion during filling, thereby reducing intravesical pressures. The larger anatomical capacity accommodates greater urine volumes without requiring elevated pressures to maintain bladder shape. In patients with NLUTD, the native detrusor muscle is often hyperactive or rigid, causing elevated pressures even with small urine volumes. Augmentation with elastically superior bowel tissue effectively reduces the pathophysiologic impact of the overactive detrusor, allowing the mechanical properties of the bowel segment to dominate.

Detrusor Leak Point Pressure

Detrusor leak point pressure decreased significantly from 42.5 to 3.3 cm H_2O in our study. Similarly, Zaragoza-Torres et al. reported DLPP reductions from 48.5 to 3.6 cm H_2O. The reduction in DLPP reflects improved bladder compliance and normalized detrusor function, indicating reduced risk of upper urinary tract injury. This finding is particularly clinically significant, as DLPP values exceeding 40 cm H_2O place patients at substantial risk for progressive renal damage [13].

Bladder Compliance

Bladder compliance increased substantially from 5.1 to 38.7 mL/cm H_2O in our study. Zaragoza-Torres et al. reported compliance improvements from 4.6 to 41.3 mL/cm H_2O. Reis et al. documented compliance increases from 3.2–4.6 to 13.7–41.3 mL/cm H_2O. The improved compliance following augmentation results from the inherent elasticity of bowel tissue compared to fibrotic native bladder tissue. Detubularization (flattening) of the bowel segment further reduces muscular contractility and spontaneous contractions. The enlarged, more compliant reservoir accommodates greater urine volumes at physiologic pressures, substantially reducing the risk of upper urinary tract deterioration.

Detrusor Contractions During Filling

Detrusor contractions during filling increased from 1.2 ± 0.35 to 1.9 ± 0.31 postoperatively. Zaragoza-Torres et al. reported similar findings with contractions increasing from 1.4 ± 0.4 to 1.8 ± 0.4[13]. The persistence of detrusor contractions after augmentation reflects the neurogenic etiology of bladder dysfunction. Although ileal augmentation improves storage capacity and compliance, the augmented segment lacks the neural regulatory mechanisms necessary to suppress detrusor overactivity. Additionally, surgical manipulation and postoperative inflammation may increase detrusor muscle sensitivity to local stimuli.

Contraction Intensity

Contraction intensity decreased significantly from 39.0 to 10.7 cm H_2O in our study. Zaragoza-Torres et al. reported similar reductions from 47.0 to 8.5 cm H_2O. The reduction in contraction intensity results from increased bladder capacity and compliance, which distribute contractile forces over a larger bladder volume, thereby reducing pressure generation per unit contraction[13].

Study Limitations

Several limitations of this study warrant discussion. First, the follow-up period is limited to 3 months postoperatively, which is insufficient to determine long-term durability of the surgical intervention. Previous studies have demonstrated that some urodynamic parameters may change over longer follow-up periods. Second, the study employed a single-site, single-arm design without a control group, limiting comparative analysis. Third, patient selection may not be representative of all pediatric NLUTD populations, as all patients selected for surgery had failed conservative management. Future studies with longer follow-up periods and comparative designs would provide additional insights into the durability and comparative effectiveness of augmentation cystoplasty.

Conclusion

Augmentation cystoplasty significantly improves urodynamic parameters in pediatric patients with neurogenic lower urinary tract dysfunction, including increased bladder capacity and compliance with reduced intravesical pressures. These improvements effectively preserve upper urinary tract function and enhance patient quality of life. The procedure remains an important surgical option for carefully selected pediatric patients with neurogenic lower urinary tract dysfunction refractory to conservative management. Long-term prospective studies with extended follow-up are needed to determine the durability of these improvements and to identify optimal patient selection criteria.

References

1. Ismail MB, Abdullhussein WQ. Efficacy and safety of sacral neuromodulation in treatment of refractory overactive bladder. *Indian J Forensic Med Toxicol*. 2021;15(1):1315-1321. https://doi.org/10.37506/ijfmt.v15i1.13597

2. Gajewski J, Cox A. Imaging techniques in the evaluation of neurogenic lower urinary tract dysfunction (NLUTD). In: *Handbook of Neurourology: Theory and Practice*. Singapore: Springer Nature Singapore; 2023. p. 1-14. https://doi.org/10.1007/978-981-16-7939-1_20-1

3. Fowler CJ, Griffiths D, De Groat WC. The neural control of micturition. *Nat Rev Neurosci*. 2008;9(6):453-466. https://doi.org/10.1038/nrn2401

4. Al-Timimi HF, Ismail MB, Al-Musawi MM. Urodynamic findings of bladder dysfunction in patients with type 2 diabetes mellitus. *Int J Res Pharm Sci*. 2020;11:2433-2437. https://doi.org/10.26452/ijrps.v11i2.2236

5. Lucas E. Medical management of neurogenic bladder for children and adults: a review. *Top Spinal Cord Inj Rehabil*. 2019;25(3):195-207. https://doi.org/10.1310/sci2503-195

6. Partin AW, Dmochowski RR, Kavoussi LR, Peters CA, Campbell MF, Walsh PC, et al., editors. *Campbell-Walsh-Wein Urology*. Volume 3. 12th ed. Philadelphia, PA: Elsevier; 2021.

7. Namey MA. Neurourology and urodynamic studies: Enhancing understanding of bladder function and disorders. *Physician Assist Clin*. 2025;4:101-114. https://doi.org/10.1016/j.cpha.2025.01.004

8. Abdul-Hameed SA, Ismail BM. The incidence of diabetic cystopathy among Iraqi diabetic patients with lower urinary tract symptoms. *Indian J Forensic Med Toxicol*. 2022;16(3):317-323. https://doi.org/10.37506/ijfmt.v16i3.18304

9. Dorsher PT, McIntosh PM. Neurogenic bladder. *Adv Urol*. 2012;2012:816274. https://doi.org/10.1155/2012/816274

10. Swatesutipun V, Tangpaitoon T. The safety cutoff storage pressure for preventing upper urinary tract damage in neurogenic bladder from spinal cord pathology and risk factor analysis. *Neurourol Urodyn*. 2022;41(4):991-1001. https://doi.org/10.1002/nau.24911

11. Roth JD, Cain MP. Neuropathic bladder and augmentation cystoplasty. *Urol Clin North Am*. 2018;45(4):571-585. https://doi.org/10.1016/j.ucl.2018.06.005

12. Budzyn J, Trinh H, Raffee S, Atiemo H. Bladder augmentation (enterocystoplasty): The current state of a historic operation. *Curr Urol Rep*. 2019;20(9):50. https://doi.org/10.1007/s11934-019-0919-z

13. Zaragoza-Torres RI, Galarza-Flores ME, Gómez-Castellanos JC, Barrera-de León JC. Urodynamic changes after bladder augmentation surgery in pediatric patients with myelomeningocele due to neurogenic bladder. *Cir Cir*. 2016;84(2):115-120. https://doi.org/10.1016/j.circen.2016.02.007

14. Reis OAF, Ito HN, De Oliveira Otávio J, De Oliveira Filho DJ, Lima EM, De Bessa J, et al. Clinical and urodynamic findings in children and adolescents with neurogenic bladder undergoing augmentation cystoplasty: a systematic review. *Pediatr Nephrol*. 2024. https://doi.org/10.1007/s00467-024-06499-y

15. Chen JL, Kuo HC. Long-term outcomes of augmentation enterocystoplasty with an ileal segment in patients with spinal cord injury. *J Formos Med Assoc*. 2009;108(6):475-480. https://doi.org/10.1016/S0929-6646(09)60095-4

16. Chartier-Kastler EJ, Mongiat-Artus P, Bitker MO, Chancellor MB, Richard F, Denys P. Long-term results of augmentation cystoplasty in spinal cord injury patients. *Spinal Cord*. 2000;38(8):490-494. https://doi.org/10.1038/sj.sc.3101033

Declarations

Ethics approval and consent to participate

The approval of ethics committee was obtained from Health Ethics Committee in college of medicine, university of Baghdad with a registration number: 217

Consent for publication

Not applicable

Availability of data and materials

All data generated or analyzed during this study are included in this published article

Competing interests

The authors declare that they have no competing interests

Funding

No funding.

Author contribution

Each author made substantial equal contributions to the conception, design of the work; the acquisition, analysis, interpretation of data; and had drafted the work or substantively revised it

All authors, have read and approved the manuscript, and agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. All authors have read and approved the manuscript

Acknowledgements

Not applicable

Please specify source of funding or grant

none

Registration of Research Studies

☒ The authors declares that this study was not a Clinical Trial

Ethics approval

☒ The authors declare that this study involves Humans and the ethics approval statement is as follow:

The approval of ethics committee was obtained from Health Ethics Committee in college of medicine, university of Baghdad with a registration number: 217