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Anorectal manometry and urodynamics in children with spina bifida: can we predict the colonic dysmotility from bladder dysfunction?

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Abstract

Introduction Spina bifida is a condition that impacts the development of the neural tube leading to urological and gastrointestinal symptoms. Both systems are influenced together due to their shared innervation and embryological origin. Despite its impact on health and well-being there has been limited research on the relationship between manometry results and urodynamic tests, in this patient population. The aim of this study was to delineate the association of neurogenic bladder/bowel dysfunction with anorectal manometry and urodynamics.

Materials and methods Urodynamics and anorectal manometry were used to analyse the neurogenic bowel and bladder dysfunctions in 29 paediatric patients with spina bifida. Those children who had previous anorectal surgical interventions were excluded from the study. Patients were grouped according to the level of spinal defect to lower or upper defect. In this study, parameters such as bladder compliance, postvoid residual volume, detrusor activity, anorectal pressures, and rectal compliance were considered. Group comparison tests were performed using standardized paediatric protocols for data analysis as well as correlation tests. A *p*-value less than 0.05 was considered significant at all levels.

Results A total of 29 patients with spina bifida were identified. Of these, 14 were male and 15 were female. Bladder function differed among the patients in the lower defect (LD, n:18) and upper defect (UD, n:11) groups. LD group exhibited lower bladder volumes (175.45 ± 106.19 mL) compared to the UD group (266.83 ± 102.54 mL, $p < 0.05$). All LD and 72.7% of UD had detrusor sphincter dyssynergia. There was positive correlation between functional bladder parameters and bowel dysfunction, such as rectoanal inhibitory reflex (RAIR) and maximum filling pressures of the bladder (rho = 0.569, $p < 0.05$). There was also a significant correlation between rectal compliance and bladder volumes.

Conclusions Association of neurogenic bowel and bladder dysfunction is a complex issue which requires personalized approach for managing the consequences. In children with neurogenic bladder dysfunction increased

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RAIR activity may be a sign for colonic dysmotility of neurogenic origin. This study may also pave the way for delineation of the mechanism under the generation of RAIR which is thought to be only intrinsic in origin. To optimize treatment modalities, full assessment with anorectal manometry and urodynamic studies should be done in patients with spina bifida.

Clinical trial registration This study was not performed on volunteer patients. Clinical study enrolment is not required as this study was obtained from urodynamics and anorectal manometry performed in patients with neurogenic bladder/bowel and during clinical follow-up.

Highlights

What is currently known about this topic? Spina bifida involves neuroembryological development that affects shared sacral innervations, causing bladder and bowel dysfunctions.

What new information is contained in this article? This research work reveals how anorectal manometry is related to urodynamic findings in children with spina bifida hence proposes

Introduction

Spina bifida is characterized by improper closure of the neural tube in 3rd and 4th weeks of gestation. The worldwide incidence rate varies from about 0.3 to 4 per 1000 births signifying critical importance of this disorder [1]. Because both the genitourinary and gastrointestinal systems share sacral innervations in the cloaca during embryogenesis, there are multiple aspects of this clinical condition that are related to this shared origin [2].

In individuals with spina bifida, the bladder and rectum function as vital storage and evacuation organs through the coordinated action of both striated and smooth muscles. Neural tube defects disrupt normal excretory pathways by affecting somatic, parasympathetic, and sympathetic nervous systems, resulting in a loss of control over voiding and defecation, and subsequently leading to urinary and fecal incontinence [3]. This abnormal innervation also causes variations in bowel motility and bladder function, which significantly impact patient morbidity and quality of life.

Moreover, neurogenic bladder dysfunction in these patients may lead to irreversible kidney damage, underscoring the importance of regular urological evaluations [4]. These assessments are crucial for early detection and management, allowing for the preservation of renal function and the implementation of appropriate renal care plans to improve quality of life. Continuous monitoring and interventions are therefore essential in the long-term care of spina bifida patients.

In spina bifida, gastrointestinal problems are often characterized by abnormal peristaltic movements in the rectum and sigmoid colon, as well as a lack of sensation in the anorectal region [5, 6]. The primary cause of colonic dysmotility in these patients is related to structural and functional disruptions in the nervous system, which impair normal intestinal motility.

However, there is very limited scientific information available to relate the anorectal manometry findings with the urodynamic characteristics of children with spina bifida [7, 8]. There is also limited knowledge regarding the correlation between neurogenic bowel and bladder dysfunctions in these patients.

To the best of our knowledge, there is no study in the literature defining the correlation between urodynamic and anorectal manometry findings in children with spina bifida. Therefore, the aim of this study was to investigate the potential correlation between anorectal manometry and urodynamic results in this patient group and to determine whether colonic dysmotility can be predicted from urodynamic findings. This may help to develop more effective treatment strategies for these patients and provide a better understanding of the disease's pathophysiological background.

Materials and methods

This is a single center, prospective, cross-sectional study and was approved by the Istanbul Medeniyet University, Göztepe Prof. Dr. Suleyman Yalcin City Hospital ethics committee with reference number 2023/0016 based on the guidelines set out in the Declaration of Helsinki. Prior to patients' participation all parents provided an informed consent, which included information on confidentiality, voluntary participation, and the option to withdraw without any repercussions. This study was not performed on volunteer patients. Clinical study enrolment is not required as this study was obtained from urodynamics and anorectal manometry performed in patients with neurogenic bladder/bowel and during clinical follow-up.

All children under follow up with spina bifida in our pediatric urology department and visited our clinics between August 2022 and March 2023 were enrolled in the study. Only, patients aged between 6 and 18 years

were included. Spina bifida patients who had undergone or had an indication for any anorectal procedures were excluded from the study. Patients with indications for any anorectal surgeries were also omitted.

The hypogastric nerve emerges between the thoracic vertebrae 11 and lumbar vertebra 2. In lesions located above lumbar vertebra 3, it is anticipated that both the hypogastric and pelvic nerves will be affected. Conversely, in lesions below lumbar vertebra 3, only the pelvic nerves are expected to be involved. Therefore, patients were categorized into two groups based on their spinal defect: upper defect (UD) or lower defect (LD), depending on whether the lesion was located above or below L3. The clinical characteristics, urodynamic test results, and anorectal manometry findings of these two groups were compared.

Detrusor overactivity alone was not considered an indication for anticholinergic treatment. Only patients with detrusor overactivity exceeding 60 cmH2O were started on anticholinergic therapy, as 60 cmH2O was chosen as the threshold based on its recognition as the normal voiding pressure in healthy children. Patients who were already on anticholinergic treatment prior to the urodynamic and anorectal manometry tests continued their treatment without interruption.

A rectal enema was administered to all patients before the urodynamic and anorectal manometry procedures. No sedation was applied to any patient prior to the procedures.

Urodynamic studies

The urodynamic evaluation in the study was conducted according to the guidelines of the International Children's Continence Society [9]. To determine each participant's expected bladder capacity, the Hjalmas formula was applied based on their age [10]. Any possible urinary tract infeciton was exluded with urine cultures before the procedure. A rectal enema was done again before the study for proper functioning of rectal balloon catheter. No sedation was used during the test.

Patients lay in a supine position during the test, accompanied by their parents. Urodynamic studies were performed by a specialist nurse and evaluated by a pediatric urologist. After the insertion of rectal balloon and cystometric catheters (6 Fr), perianal patch electrodes were placed to detect sphincteric electromyographic (EMG) activity.

The bladder was filled with sterile saline at room-temperature at a rate of 10% of the expected bladder capacity. Urodynamic studies assessed bladder capacity, compliance, maximum detrusor pressure, detrusor contractility, and EMG activity.

Bladder compliance was calculated using the formula $\Delta V/\Delta P$ (change in volume per change in pressure). Two standard points were used for this calculation in the urodynamic tracings: the first was the start of filling, and the second was either the point of urodynamic capacity or just before any contraction that resulted in leakage. The start of filling was aimed to be maintained between −5 and +5 cmH2O.

Cystometric bladder capacity was defined as the bladder volume at the onset of leakage. If no leakage occurred despite reaching over 40 cmH2O, infusion was continued up to 50% of the expected bladder capacity, at which point it was stopped.

Maximum detrusor pressure was defined as the highest detrusor pressure during detrusor contraction in overactive bladder or as the leak point pressure in patients with underactive bladder dysfunction. Any early contractions exceeding 15 cmH2O during the filling phase were noted as detrusor overactivity.

Leak point pressure was recorded as the pressure at which leakage occurred in the absence of any contractions. Post-void residual volume was routinely measured in all urodynamic studies.

At the end of the test, the remaining urine was aspirated from the cystometric catheter using a syringe and recorded as the residual volume. Detrusor sphincter dyssynergia was diagnosed when there was no relaxation of sphincteric muscle activity.

Bladder filling was continued during urodynamics until leakage occurred, or in cases of bladder discomfort, strong voiding desire, or no leakage or voiding, up to 50% beyond the expected bladder capacity, at which point it was stopped.

At least two filling cycles were performed during urodynamic studies. If significant artifacts made it difficult to interpret the results, a third filling cycle was performed.

Anorectal manometry procedure

Test for anorectal manometry was done using water-perfused eight channel latex-free catheter system (Dynosmart, Medica, Bologna, Italy). Routine rectal enema was done before the procedure. The procedure was conducted in a left lateral decubitus position to allow accurate measurement. Anal sphincter resting pressure, squeeze-pressure, push and strain pressure, RAIR and rectal compliance values were measured. Rectal compliance was measured according to first sensation volume, urge to defecate and maximum tolerable volume. Rectal sensory thresholds were evaluated by grouping them as 50 ml or less for the first sensation, 70–150 ml or less for the urge to defecate, and 160 ml or less for the maximum tolerated volume. Rectal sensory thresholds were compared according to bladder volume, bladder compliance, and spinal defect level. Vector analysis of sphincter muscle strength with pressure sensors located every 90 degrees around the catheter allowed to determine

comprehensive pressure profiling. In all patients' anorectal manometries were done with sensors P4, P5, P6, and P7 showing same direction (P4: anterior side; P5: left side; P6: posterior side; P7: right side on a patient's body).

In order to elucidate the relationship between colonic dysmotility and neurogenic bladder in patients with spina bifida, we conducted a comparative analysis of demographic data, spinal defect levels, the presence of constipation, urinary or faecal incontinence, and clean intermittent catheterization (CIC) use, spinal defect level along with anatomical and clinical factors, as well as urodynamic and anorectal manometry parameters. We compared, bladder capacity, detrusor pressures, bladder compliance, detrusor and sphincter functions, in urodynamics, RAIR, rectal pressures and rectal sensation in anorectal manometry. The evaluation of urinary and faecal incontinence, as well as constipation, was performed using the International Paediatric Continence Society and Rome IV guidelines [9, 11].

Anorectal manometry and urodynamic studies were done at different time intervals. Anorectal manometry test was performed within 1 month following the urodynamic test.

Table 1 Clinical and Urodynamic Findings In Spina Bifida Patients

		n	%
Gender	Male	14	48.3
	Female	15	51.7
Clinical Findings	Urinary Incontinence	28	100.0
	Faecal Incontinence	16	57.1
	Walking Without Support	22	78.6
Spinal Defect Level	Lower Defect	18	62.1
	Upper Defect	11	37.9
CIC Usage	No	11	37.9
	Yes	18	62.1
Constipation	Yes	19	65.5
	No	10	34.5
Faecal Incontinence	Yes	17	58.6
	No	12	41.4
Bladder Capacity	Decreased	19	65.5
	Normal	6	20.7
	Increased	4	13.8
Detrusor Activity	Overactive	23	79.3
	Decreased	2	6.9
	Normal	3	10.3
	Increased	1	3.4
Bladder Compliance	Decreased	22	75.9
	Normal	7	24.1
Sphincter Resistance	Overactive	20	69.0
	Overactive + Dyssynergy	2	6.9
	Not Assessed	7	24.1
EMG Activity	Dyssynergic	26	89.7
	Not Assessed	3	10.3

CIC: Clean Intermittent Catheterization, EMG: Electromyography

Statistical analysis

Statistical analyses were performed using SPSS software (Version 25.0). For continuous variables mean ± standard deviation (SD) was employed as a measure of central tendency while frequencies and percentages summarised categorical variables. Spearmen correlation test was done between urodynamic and manometric data according to the sample size. Comparisons between groups (LD vs. UD) were made using independent samples t-test for continuous variables and Chi-square test for categorical variables. A p-value less than 0.05 was considered significant at all levels.

Results

There was a total of 29 patients with spina bifida eligible for the study. The mean age of the patients was 9.14 ± 3.09 years. There were 14 boys and 15 girls.

When examining the clinical characteristics of the patients, most 78.6% (22/29) could walk independently without support. A total of 41.3% (12/29) of patients were receiving anticholinergic treatment during the study. The majority of patients 62.1% (18/29) adhered to CIC as their primary management strategy. Of the 29 patients, 65.5% (19/29) had constipation, and 58.6% (17/29) had faecal incontinence. Among these patients, only a small fraction 24% (7/29) suffered from faecal incontinence without constipation, whereas 34% (10/29) had both conditions co-occurring. However, only 20.6% (6/29) of patients presenting with both constipation and incontinence received treatment. When grouped according to spinal defect level, who had a LD (n = 18), while others had an UD (n = 11), (Table 1). In the UD group, the number of patients using anticholinergics was 5 and the number of patients not using anticholinergics was 6. In the LD group, there were 10 patients using anticholinergics and 8 patients not using anticholinergics. There was no statistical difference between the groups in the use of anticholinergics ($p > 0.05$).

Upon examining the urodynamic parameters of the patients, 65.5% (19/29) had a lower-than-expected bladder capacity. The average post-void residual volume was 160.55 ± 117.67 ml. Overactive urinary sphincter function was detected in 75.9% (22/29) of the patients. EMG activity was dyssynergic in 89.7% (26/29) of cases. Detrusor overactivity was found in 79.3% (23/29) of the patients, while 69% (20/29) exhibited excessive sphincter resistance. The average bladder compliance was 10.46 ± 9.80 ml/cmH2O, and the mean maximum pressure during bladder filling was 47.00 ± 29.20 cmH2O.

The study cohort consisted of 19 patients with constipation, including 11 males and 8 females, with a mean age of 9.15 ± 3.84 years. In contrast, the non-constipated group comprised 10 patients, including 6 males and 4 females, with a mean age of 9.1 ± 2.73 years. A difference

in post-void residual urine volume was found between the non-constipation group (215.80±111.11 ml) and the constipation group (131.47±113.04 ml, $p=0.043$) when cross comparisons were made. Aside from post-void residual urine volume, no statistically significant differences were observed in the urodynamic parameters between patients with and without constipation ($p>0.05$).

Upon evaluating the anorectal manometry parameters of the patients, the average resting pressure was 45.51±18.98 mmHg, the average pressure increase during the squeeze test was 47.28±29.68 mmHg, and the average pressure during the push and strain test was 43.18±43.87 mmHg. The average volume for first sensation of the rectal balloon was 45.93±26.50 ml, the average urge to defecate volume was 79.20±29.14 ml, and the average maximum tolerable volume was 119.20±37.18 ml. RAIR was detected in all patients, with the average sphincter relaxation being 63.16±14.68%.

There was no statistically significant difference in anal sphincter resting pressures, squeezing pressures, and straining pressures between patients with decreased bladder capacity and those with increased bladder capacity when compared with the urodynamic results ($p>0.05$). Similarly, no significant relationship was found between constipation and anorectal manometry values ($p>0.05$).

In this study, the results showed that children with spina bifida had a wide range of bladder volumes and rectal sensation thresholds. The patients' bladder volumes were significantly higher in the group where the rectal balloon had to be inflated to a volume above 160 ml in order to induce the maximum tolerated volume on anorectal manometry than in the group where the maximum tolerated volume was induced by inflating the rectal balloon to a volume below 160 ml. (respectively 374.67±113.74 ml, 223.82±101.87 ml, $p=0.037$). The number of patients with a maximum tolerated volume above 160 ml on anorectal manometry was 6, while the number of patients with a maximum tolerated volume below 160 ml was 19. In 4 patients, this value could not be calculated. The mean age of patients with a maximum tolerated volume below 160 ml was 8.6±2.83 years, while the mean age of patients with a maximum tolerated volume above 160 ml was 12.33±2.5 years ($p>0.05$). Although there was a difference in age between the groups, it was not statistically significant. On the other hand, no statistically significant difference was found between bladder compliance, detrusor activity, and rectal sensation thresholds ($p>0.05$).

Table 2 Spearman Correlation Analysis between filling Phase Maximum Detrusor pressure and Urodynamic/Anorectal Manometry Parameters in children with Spina Bifida

Parameters	Maximum Detrusor Pressure*	
	Spearman's rho (ρ)	*p*-value
Resting Pressure	-0.197	0.305
Pressure Increase	0.124	0.522
Straining Pressure	0.098	0.613
First Sensation Volume (ml)	0.006	0.977
Urge to Defecate Volume (ml)	0.091	0.666
Maximum Tolerable Volume (ml)	0.128	0.543
RAIR	**0.569****	**0.001**
P4 Pressure	-0.231	0.227
P5 Pressure	-0.224	0.243
P6 Pressure	0.053	0.783
P7 Pressure	-0.151	0.434

RAIR: Rectoanal Inhibitory Reflex. *: Maximum Detrusor Pressure Average 47±28.69 cmH2O. **: A *p*-value below 0.05 signifies statistical significance, as determined by Spearman's correlation test. The correlation coefficient, rho (ρ), reveals the strength and direction of association between variables—values near 1 or -1 indicate strong relationships, either positive or negative, respectively. A value near 0 suggests a negligible association. Focus on statistically significant findings, particularly the RAIR's correlation with detrusor pressure, to understand their clinical relevance in spina bifida

During anorectal manometry, pressure averages from sensors (P4, P5, P6, P7) showed no statistically significant differences between the groups. Additionally, a positive correlation was linked with RAIR and maximum detrusor pressure during bladder filling in urodynamic test results (rho=0.569, $p=0,001$). All patients experienced rapid positive RAIR following rectal balloon inflation of ten millimetres (Table 2).

When we divided the patients into two groups as LD and UD according to the level of spinal defect and analysed their clinical characteristics, 61.1% (10/18) in the LD group and 54.5% (6/11) in the UD group had faecal incontinence. Analysis showed that CIC use was not significantly associated with the level of spinal defect ($p>0.05$). There was also no statistical difference between the number of CICs per day and the level of spinal defect ($p>0.05$).

When the bladder volumes, bladder compliance, and spinal defect levels of the patients were compared according to rectal sensation threshold, it was found that 88.9% (16/18) of the patients with LD were able to report the first rectal sensation at volumes above 50 ml and 55.6% (6/11) of the patients with UD were able to report the first sensation at volumes below 50 ml during the rectal compliance test. There was a significant association between the first sensory threshold induced by inflation of the balloon in the rectum on anorectal manometry and spinal lesion levels ($p=0.033$), (Table 3).

When evaluating urodynamic assessments based on spinal defect levels, there was no statistically significant difference in cystometric bladder capacity and residual urine volumes between the two groups. The LD group had more urinary sphincter overactivity and dyssynergy in EMG activity than the UD group (respectively, *p* values were 0.000 and 0.045). Detrusor overactivity was found

Table 3 Key findings on bladder volume, compliance, spinal lesion level, and sensation thresholds in children with Spina Bifida

Sensation Threshold	Metric	Cystometric Bladder Capacity (ml) Below Threshold	Cystometric Bladder Capacity (ml) Above Threshold	*p*-value
	Average	209.44	275.89	0.143
First Sensation Volume (< 50 ml vs. >50 ml)	SD	119.74	96.79	
	Median	195.00	254.00	
	Average	260.79	217.91	0.396
Urge to Defecate Volume (< 70 ml vs.70–150 ml)	SD	88.50	138.11	
	Median	246.00	200.00	
	Average	374.67	223.82	**0.037***
Maximum Tolerable Volume (< 160 ml vs. >160 ml)	SD	113.74	101.87	
	Median	346.00	228.50	
Sensation Threshold		**Compliance Value (ml/cmH2O) Below Threshold**	**Compliance Value (ml/cmH2O) Above Threshold**	
	Average	10.13	12.69	0.662
First Sensation Volume (< 50 ml vs. >50 ml)	SD	8.84	12.28	
	Median	8.00	8.45	
	Average	12.55	10.39	0.681
Urge to Defecate Volume (< 70 ml vs.70–150 ml)	SD	12.52	6.13	
	Median	7.41	9.11	
	Average	12.97	11.41	0.277
Maximum Tolerable Volume (< 160 ml vs. >160 ml)	SD	4.06	10.70	
	Median	11.30	8.00	
Sensation Threshold	**Spinal Defect Level**			
		LD	**UD**	
First Sensation Volume (< 50 ml vs. >50 ml)	n (%)	8 (44.4) vs. 10 (55.6)	8 (88.9) vs. 1 (11.1)	**0.033***
Urge to Defecate Volume (< 70 ml vs.70–150 ml)	n (%)	3 (21.4) vs. 11 (78.6)	6 (54.5) vs. 5 (45.5)	0.098
Maximum Tolerable Volume (< 160 ml vs. >160 ml)	n (%)	1 (33.3) vs. 2 (66.7)	8 (36.4) vs.14(63.6)	0.713

Notes: $p < 0.05$ indicates statistical significance. A lower p-value signifies stronger evidence against the null hypothesis, suggesting a real effect

Table 4 Integrated Overview of Urodynamic Findings with spinal defect level comparisons in children with Spina Bifida

Parameter	Overall Findings (Mean ± SD)	Lower Defect (*n*:18)	Upper Defect (*n*:11)	*p*-value
Bladder Capacity (ml)	Decreased: 19 (65.5%) Normal: 6 (20.7%) Increased: 4 (13.8%)	Decreased: 10 (55.6%) Normal: 5 (27.8%) Increased: 3 (16.7%)	Decreased: 9 (81.8%) Normal: 1 (9.1%) Increased: 1 (9.1%)	0.449
Residual Urine (ml)	160.55 ± 117.67	180.11 ± 118.40	128.55 ± 114.56	0.251
Urinary Sphincter Function	Overactive: 22 (75.9%)	Overactive: 17 (94.4%)	Overactive: 3 (27.3%)	**<0.001***
EMG Activity	Dyssynergic: 26 (89.7%)	Dyssynergic: 18 (100.0%)	Dyssynergic: 8 (72.7%)	**0.045***
Detrusor Activity	Overactivity: 23 (79.3%)	Overactivity: 13 (72.2%)	Overactivity: 10 (90.9%)	0.447
Bladder Compliance Value (ml/cmH2O)	10.46 ± 9.80	10.65 ± 9.85	10.14 ± 10.18	0.736
Filling Phase Max Pressure (cmH2O)	47.00 ± 29.20	49.83 ± 35.70	42.36 ± 13.51	0.686

*$p < 0.05$ indicates statistical significance

in 72.2% (13/18) of patients with LD and 90.9% (10/11) of patients with UD. The decrease in bladder compliance was observed in 72.2% (13/18) and 81.8% (9/11) of the patients with LD and UD, respectively. The detrusor activity, maximum detrusor pressure and bladder compliance analysis for the LD and UD groups did not show statistical significance during urodynamic testing ($p > 0.05$), (Table 4).

When analyzing the manometry results of patients based on spinal defect levels, no significant difference was found in anal sphincter resting pressure, squeeze pressure, push and strain pressure, or RAIR values ($p > 0.05$).

Discussion

Spina bifida is associated with several complications, including neurogenic bladder dysfunction, reduced bladder capacity, decreased compliance and increased postvoid residual volume. This condition may lead to an increase in bladder pressure, urinary retention, and recurrent infections of the urinary tract, which in the long follow up could be quite deleterious for the upper

urinary tract [12]. It is important to maintain optimal bladder and kidney function. While performing intermittent urodynamics for this population to proactively protect upper urinary tract.

Decrement in motility of the rectum/sigmoid, loss of sensation in the anorectal area, or incompetence of the anal sphincter has been opined to be responsible for the faecal incontinence among children with spina bifida. The quality of life of children with spina bifida depends on the proper functioning of their gastrointestinal system [13, 14]. This makes them feel uncomfortable and antisocial, all of which can affect normal daily life and general social functioning. All these contribute to the worsening of urinary dysfunction as well. In this study, 19/29 of the patients had constipation, 17/29 had faecal incontinence and 18/29 were performing CIC. Treating gastrointestinal dysfunction may improve the overall quality of life and health outcomes of children diagnosed with spina bifida.

Anorectal manometry has contributed significantly to the recognition of gastrointestinal dysfunction among people with spina bifida. It involves the use of functional data of the anorectal region to recognize and, afterwards, to treat the bowel dysfunction. Such testing may be important for patients in whom inadequate rectal compliance, tone, and reflexes are responsible for gastrointestinal symptoms, and correction of the problem could allow development of patient-specific interventions [14–16]. To the best of our knowledge, there has been no studies assessing anorectal manometry findings together with urodynamic results in order to predict one dysfunction while evaluating the other in children with spina bifida. The gap of the studies in the literature implies the novelty of this study, signalling the need for more investigations on the bladder bowel dysfunctions' interplay in spina bifida patients [13, 17].

The location of the spinal defect may affect the mechanisms that control urine storage, as upper-level lesions tend to result in sphincter overactivity [18–21]. Furthermore, in this study it was supported that detrusor-sphincter dyssynergia was more pronounced among patients with LD. The observation of a higher average bladder volume in the LD group compared to the UD group provides significant insights into the mechanisms of bladder contractility and innervation. The reason for this observation might be more pronounced neural involvement of sacral plexus in patients with lower defects as these nerves mainly control bladder sphincter function. On the other hand, the lower volume required to trigger the first sensation in anorectal manometry in UD patients, when compared to LD patients, may suggest increased rectal neuronal sensitivity. The reduced average bladder volume and the heightened sensitivity to rectal stimuli observed in UD patients indicate that, as the level of spinal defect increases, hypersensitivity to external stimuli may develop. This hypersensitivity manifests as continuous urinary leakage and reduced bladder capacity, while in the rectum, it may lead to faecal incontinence. Further investigation into the underlying physiological innervation networks in these patients is warranted to clarify these findings.

In this study, the statistical significance of the correlation between RAIR and bladder pressure during filling may be interpreted as the neurological insult causing increase in intravesical pressure during filling phase in the bladder may cause increased RAIR activity in the colon in these patients. This observation is novel for the neurogenic bladder bowel dysfunction due to spina bifida. Also, it is important as it provides possible predictive models for understanding colonic motility disorders based on urodynamic tests. This finding also implies that there is a significant relationship between maximum detrusor pressure and RAIR, which support previous research regarding the interrelations occurring between the urinary bladder and the defecation system [22–24].

As shown in the study, the relationship between bladder volume and first sensation volumes in rectal compliance assessment supports this connection, as well. On the other hand, variations in sensation thresholds and bladder volumes indicate that the severity of neurogenic dysfunction and the level of spinal lesion determine perception or sensation by the urinary bladder; therefore, affecting its control mechanism and capacity [25, 26]. These findings call for an inclusive understanding of dysfunctions pertaining to both the bowel and bladder; hence comprehensive evaluations on functional aspects along with neurological factors are essential in this patient group.

The role of rectal distension in children with non-neurogenic lower urinary tract symptoms and constipation has been investigated by Burgers et al. It was found that rectal distension affected urodynamic parameters in 70% of children with lower urinary tract symptoms, independent of constipation, and bladder responses could not be predicted based on clinical symptoms. Burgers et al. have also showed that bladder contraction increased in some patients with rectal distension and decreased in others [27]. In anorectal manometry, rectal distension is created with balloon inflation during the RAIR test. The changes in the bladder contraction and increased responsivity to RAIR test in our study may be attributed to this bladder-bowel cross-talk triggered by rectal distension. In the studies on pathophysiology of RAIR, the generation of RAIR reflex has been mainly attributed to the activity of intrinsic Cajal cells [28]. The changes observed in the bladder in response to rectal distension during the RAIR testing procedure, in anorectal manometry, indicate that extrinsic factors, potentially mediated by the

autonomic nervous system, may also play a role in the development of this reflex. To the best of our knowledge, there is no information in the literature on the effect of extrinsic innervation in the generation of RAIR reflex. The results of this study contribute to the existing literature on this topic adding new possible pathophysiological background of neurogenic bowel dysfunction. The relationship between rectal sensation, bladder volumes, and RAIR, may indicate presence of an afferent pelvic neuronal network capable of sustaining overlapping stimuli from pelvic organs and their bidirectional cross-talk.

Anorectal manometry catheter measures the sphincter 360 degrees with 90-degree intervals. It is important to note that there may be differences in the pressures exerted on the anterior side of the sphincter facing the bladder from other directions. This may be attributed to a shared spinal pathway between urinary and gastrointestinal systems. However, no statistically significant difference in vectoral pressures were observed in this study but average pressures were noticed to be lower in the anterior part of the sphincter adjacent to bladder. It is possible that the sample size of patients included in the study may be insufficient to yield a dependable evaluation of the data.

As the functions of anal sphincter and detrusor share common sacral innervation, treating spina bifida patients for bladder and bowel problems requires a multidisciplinary approach. Furthermore, in order to improve management approaches and patient outcomes, impaired neural networks affecting both bladder and bowel control mechanisms should be delineated thorough urodynamic and anorectal evaluations [25, 26, 29, 30]. This complexity of needs in these patients highlights the importance of a holistic approach for proper care.

The primary limitation of this study is its cross-sectional design. Another limitation is the relatively small patient population and the lack of homogeneity in the age distribution of the study population. Although expressing bladder capacities as a percentage relative to age might have been more meaningful, using metric values for statistical analysis is another constraint of the study. Additionally, the lack of advanced imaging, neurophysiological, and histological assessments to demonstrate the neural connections between the colon and bladder is another limitation. Furthermore, the study is limited by the failure to compare the bladder volumes and bowel tolerable volumes of the patients, irrespective of age. The fact that the majority of patients were on anticholinergic medication, which could affect colonic motility, might have introduced limitations in the interpretation of manometric parameters. This evaluation was impossible due to the cross-sectional nature of the study.

Conclusion

This study demonstrates the positive correlation between RAIR and maximum detrusor pressure during bladder filling in spina bifida patients. There is also a negative correlation between cystometric bladder capacity and rectal sensation in these children. These confirm that there is cross-talk between the pelvic floor sensory network, which spans between the bladder and bowel. This correlation may also give us the conclusion that colonic dysmotility may be identified with determination of urodynamic parameters in children with spina bifida.

The findings of this study may help in better understanding of the ongoing pathophysiological processes in the bladder, simultaneously in the colon in neurogenic bladder and bowel dysfunction. It is clear that we need further studies to delineate this correlation. However, this present study may pave the way for clear understanding of the neurogenic consequences of pelvic organ disorders. To the best of our knowledge, this study is the first report in the literature in defining this correlation between urodynamic and anorectal manometry parameters in spina bifida patients.

Abbreviations

CIC	Clean intermittent catheterisation
EMG	Electromyography
LD	Lower defect
RAIR	Rectoanal inhibitory reflex
SD	Standard deviation
UD	Upper defect

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Not appleciable.

Author contributions

Study design was completed by AIA. The data collection and manuscript preparation were performed by RBE and AIA. Data analysis was performed by ŞKÖ. Critical revisions were performed by all the authors.

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Data availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.You can also reach data from https://drive.google.com/drive/folders/1fE-G1lWmTEhlTbFlHxzImmtjQ7q6fwtL?usp=sharing.

Declarations

Ethics approval

Ethics committee of, Istanbul Medeniyet University, Göztepe Prof. Dr. Suleyman Yalcin City Hospital, 2023/0016, 01.03.2023.

Consent for publication

I and all the authors give consent for the publication of identifiable details, which can include photograph(s) and/or videos and/or case history and/or details within the text ("Material") to be published in the BMC Urology.

Ethics statement

All procedures in studies involving human participant were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all

individual participants included in the study. Prior to patients' participation all parents provided an informed consent, which included information on confidentiality, voluntary participation, and the option to withdraw without any repercussions. Informed consent was obtained from all individual participants included in the study.

Informed consent
Informed consent was provided by the parents of all patients for both interventions and publication.

Competing interests
The authors declare no competing interests.

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Publisher's note

individualized treatment choices for the purpose of better clinical outcome.

Keywords Spina bifida, Anorectal manometry, Urodynamic, Neurogenic bladder, Neurogenic bowel, Children