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ORIGINAL ARTICLE

Pelvic floor tonicity affects urodynamic measurements in children with myelomeningocele

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Abstract

Objective. In a cystometry procedure in a child with myelomeningocele (MMC), a pressure increase in the abdominal pressure (P_{abd}) tracing was detected during filling. This pressure alteration was not related to other known events (straining, talking, rectal contractions). This study was conducted to investigate this phenomenon. *Material and methods.* Forty-three children with MMC were enrolled in the study. A slow and gradual pressure increase associated with the bladder filling was sought in the P_{abd} tracings. End filling and initial P_{abd} gradient more than 3 cm H_2O were considered as increased P_{abd}. If the defined pressure event occurs, the bladder was evacuated for verifying the filling–pressure relation. Age, gender, study position, pelvic floor tonicity and cystometric capacity were correlated with the pressure alteration. *Results.* P_{abd} increase was noted in 18 (41.8%) children. The mean P_{abd} gradient between end and initial filling was 4.78 ± 1.63 cm H_2O in these children. No statistically significant difference was noted for age, gender and study position. Statistically significant differences were noted with decreased pelvic floor tonicity and high values of cystometric capacity ($p = 0.003$ and $p < 0.001$, respectively). *Conclusions.* The pressure increase is thought to be a consequence of a posterior positional change in the bladder during filling die to decreased pelvic floor support in MMC. This pressure alteration was more obvious with increased bladder capacity. Urodynamic studies of children with MMC should be carefully evaluated for the presence of this phenomenon to prevent low measurement of the detrusor pressure, compliance and detrusor leak point pressure values.

Key Words: *abdominal pressure, myelomeningocele, pelvic floor tonicity, urodynamics*

Introduction

Urodynamic studies provide valuable information about the bladder functions of children with myelomeningocele (MMC). Detrusor pressure recording is the main goal of urodynamic studies, giving information about bladder dynamics in the storage and emptying phases. Accurate detrusor pressure recording is mandatory for diagnosis and treatment modalities. Detrusor pressure (P_{det}) is estimated by real-time subtraction of abdominal pressure (P_{abd}) from vesical pressure (P_{ves}), recorded by indwelling catheters in to the rectum and the bladder. For accurate P_{det} measurement, abdominal pressure changes surrounding the bladder must be equally detected by both rectal and vesical catheters [1,2]. Because of its close proximity to the bladder and easy access, the rectum is the best location for abdominal pressure recording [2].

In standard urodynamics procedures, there should be no pressure change in the rectal pressure that is not detected simultaneously by the vesical catheter. However, a slow and gradual pressure increase in P_{abd} tracing during filling was detected in a routine cystometry study of a child with MMC. The authors retrospectively investigated their previous studies and found that this pressure alteration was not related to other pressure events (straining, talking, rectal contractions) and it presented only in urodynamic studies of children with MMC. To verify and document this phenomenon, which went against urodynamic logic, a

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prospective study was designed to investigate the possible factors that contribute to this pressure alteration.

Material and methods

The study included 43 consecutive children with MMC, in 2010. Parents were informed about the urodynamic procedure and written informed consent was obtained.

Study protocol

In the cystometries, slow and gradual pressure increase during filling was sought in the P_{abd} tracings. Since small pressure fluctuations in P_{ves} and P_{abd} tracings were commonly observed during urodynamics, it was decided that an end filling and initial abdominal pressure gradient constantly greater than 3 cm H_2O constituted increased abdominal pressure (i-P_{abd}). A pressure gradient of 3 cm H_2O or less was considered to be unchanged abdominal pressure (u-P_{abd}). Pressure alterations due to rectal contractions, catheter movement or straining were carefully noticed and the study was repeated. If the defined pressure change was noticed during filling, the bladder was evacuated to verify the volume effect on P_{abd} tracing while recording was continued (Figure 1).

Age, gender, study position, pelvic floor tonus and cystometric capacity were correlated with the pressure alteration. Pelvic floor tonicity in the children was evaluated by rectal digital examination and visual inspection [3]. Since bladder capacity changes with age, the ratio of maximal cystometric capacity to estimated bladder capacity (MCC/EBC) was used as the cystometric capacity parameter in the children.

Urodynamic study

Urodynamic procedures were performed by a single clinician (GG). Filling cystometry was performed according to the International Continence Society (ICS) and International Children's Continence Society (ICCS) protocols, using the same equipment (MMS Urodynamics Systems, The Netherlands) [4,5]. The study position of the child (sitting or lying) was determined according to each child's age, neurological and anatomical condition. No sedation was applied in the procedures. In the cystometries, 6 or 7 Fr double-lumen bladder catheters and fluid-filled balloon rectal catheters with a small hole were used. The rectum was emptied with repeated enemas in all children, and digitally checked for the presence of faecal mass or gas before the procedure. Abdominal pressure distribution to P_{ves} and P_{abd} tracings was checked periodically during the study. The upper border of the symphysis pubis is considered to be the reference height level for both catheters. The bladder was checked for residual urine after all catheters were introduced. Saline at 25°C was infused at a physiological filling rate (kg/4 in ml/min) or 5–10% of predicted bladder capacity [6]. Pelvic floor musculature activity was measured with surface electrodes. Estimated bladder capacity (EBC) in children was calculated according

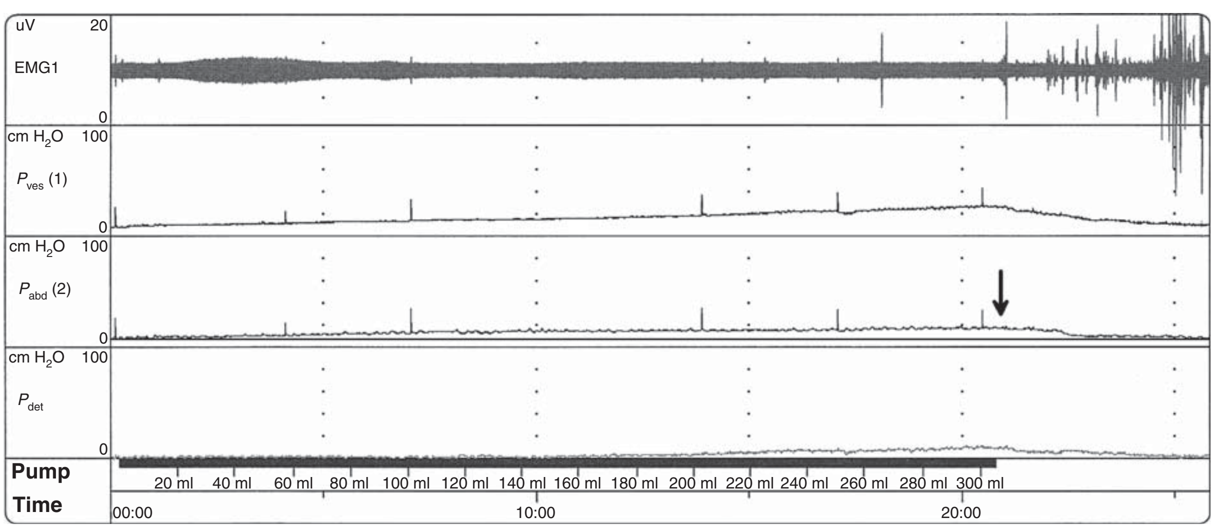

Figure 1. Cystometry of a 12-year-old girl with myelomeningocele (MMC). The study was performed in a lying posture. Decreased pelvic floor tonicity was noticed in her examination. Initial vesical (bladder) pressure (P_{ves}) and abdominal pressure (P_{abd}) values were measured at 9 cm H_2O. A gradual and slight increase on the P_{abd} (18 cm H_2O) tracing was noticed during filling. Filling was stopped at 12 cm H_2O detrusor pressure (P_{det}) at 305 ml of bladder volume (arrow). The bladder was evacuated with a syringe and recording continued. P_{abd} reached the initial value. End filling pressure gradient on P_{abd} tracing was measured as 9 cm H_2O. (Note the dotted line and P_{abd} tracing at the end filling point). EMG = pelvic floor electromyography.

to the Koff formula: EBC = (Age + 2) × 30 ml; in infants it was calculated as: EBC (ml) = 7 × weight (kg) [7,8].

Statistical analysis

Data were analysed with commercially available statistical software (SPSS® version 11.5). The normal distribution assumption for continuous data was controlled with the Shapiro–Wilk test prior to group comparison. Mean, standard deviation and percentages were used for descriptive statistics. Group comparisons were performed using the independent t test for continuous data, Mann–Whitney U test for non-continuous data and chi-squared test for categorical data. Values of $p < 0.05$ were considered statistically significant.

Results

The study consisted of cystometries of 43 consecutive children (23 female, 20 male) with MMC. The mean age was 5.19 years (range 3 months to 15 years) in the study group. Pressure gradients between end filling and initial abdominal pressure values were increased in 18 children (41.8%) and unchanged in 25 (58.1%). The mean pressure gradient in the i-P_{abd} group was 4.78 ± 1.63 cm H_2O (Table I).

The mean age of children in the i-P_{abd} group was 4.28 ± 2.87 and in the u-P_{abd} 5.77 ± 4.12 ($p = 0.354$) (Table I). No statistically significant difference in proportion of males and females or study position between the groups was detected ($p = 0.313$ and $p = 0.781$, respectively) (Table I). A statistically significant difference was found for pelvic floor tonicity between the groups, in that the vast majority of the P_{abd} increase was detected in children with decreased pelvic floor tonicity ($p = 0.001$) (Table I, Figure 2). Cystometric capacity had statistical significance in the pressure increase. The mean MCC/EBC ratio was 1.10 ± 0.26 in the i-P_{abd} group and 0.64 ± 0.34 in the u-P_{abd} group ($p < 0.001$) (Table I, Figure 3). In the u-P_{abd} group, three children had increased cystometric capacity and decreased pelvic floor tonus. These children had small bladders and bilaterally high-grade vesicoureteral reflux with overdilated upper urinary tracts on cystography.

Table I. Frequencies (%) and significances for the group comparisons of each variable.

	u-P_{abd} (n = 25)	i-P_{abd} (n = 18)	p
Age	5.77 ± 4.12	4.28 ± 2.87	0.354
Gender			
Female	15	8	0.313
Male	10	10	
Position			
Sitting	5	3	0.781
Lying	20	15	
Pelvic floor tonicity			
Decreased	11	16	0.003
Normal	14	2	
Cystometric capacity (MCC/EBC ratio)	0.64 ± 0.34	1.10 ± 0.26	<0.001

u-P_{abd} = unchanged abdominal pressure; i-P_{abd} = increased abdominal pressure; MCC/EBC = ratio of maximal cystometric capacity to estimated bladder capacity.

Discussion

Study measurements in children can be affected by a lack of cooperation, bladder catheter diameter, study position, preparation of the rectum, filling medium and the use of sedation [6]. However, pressure recording can be disturbed even in standardized conditions. Rectal contractions reveal the weak point of urodynamic pressure recording: the rectal catheter and abdominal pressure recording. Rectal contractions are distal colonic activities occurring next to the bladder, which are only detected by the rectal catheter as pressure fluctuations. These pressure alterations disturb the measurement of P_{det} and interpretation of the urodynamics [9,10]. Attempts have been made to resolve this unpredictable pressure event by replacing the rectal catheter with vaginal or enteric stomas, but these locations were avoided owing to low-pressure transmission variations between these structures and the bladder [2]. Thus, neurourologists and urodynamics experts conclude that abdominal pressure recording can be problematic in some instances. Rectal contractions have been classified as a physiological artefact of urodynamics [1,2].

However, rectal contractions are not unrelated pressure alterations that only the rectal catheter can detect. This study found that the bladder can affect the rectal catheter and the P_{abd} tracing by filling. This phenomenon may be related to the movement and anatomical location of the bladder during filling in children with MMC.

Bladder position change during filling has previously been discussed in the English literature. Fokdal et al. investigated the effect of filling on bladder movement using computed tomography in adults [11]. They observed that the bladder expands mostly in the anterior–cranial and partially posterior directions in the lower abdomen during filling. Kristiansen et al. also investigated the shape and position of bladder during filling, using magnetic resonance imaging [12]. They found that the bladder moves in the cranial and anterior directions when filling. Kristiansen's group

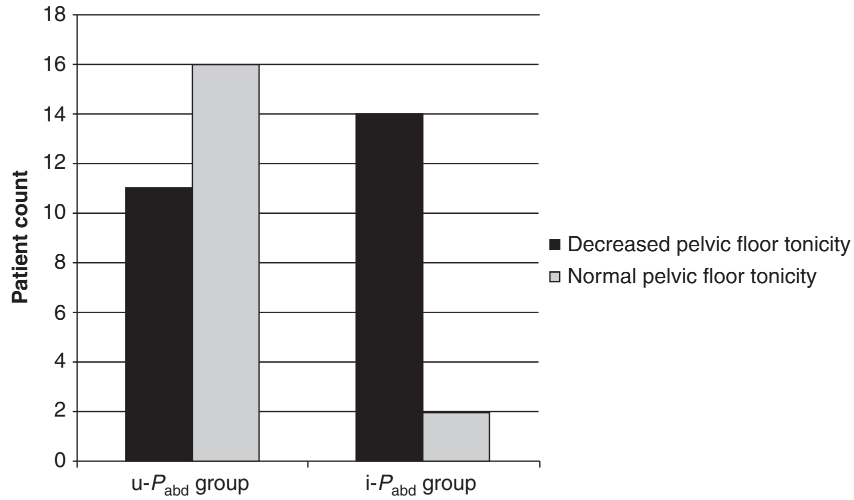

Figure 2. Pelvic floor tonicity was statistically significantly different between i-P_{abd} and u-P_{abd} groups ($p = 0.003$). Children with decreased pelvic floor tonicity were almost equally distributed in both increased abdominal pressure (i-P_{abd}) and unchanged abdominal pressure (u-P_{abd}) groups. However, normal pelvic floor tonicity was commonly observed in the u-P_{abd} group.

also investigated the effect of body position and bladder shape in four recumbent positions: supine, right side, prone and left side, but did not notice any difference in the shape or position of the bladder in various postures.

In humans, the pelvic floor supports the pelvic organs and plays an important role during filling, maintaining the position of the bladder in the lower pelvis. During the intra-abdominal pressure rise, the pelvic floor muscles contract to maintain support to the pelvic structures, including the bladder. Integrity of pelvic floor tonicity maintains the upward movement of the pelvic organs [6]. It may be surmised that an intact pelvic floor maintains

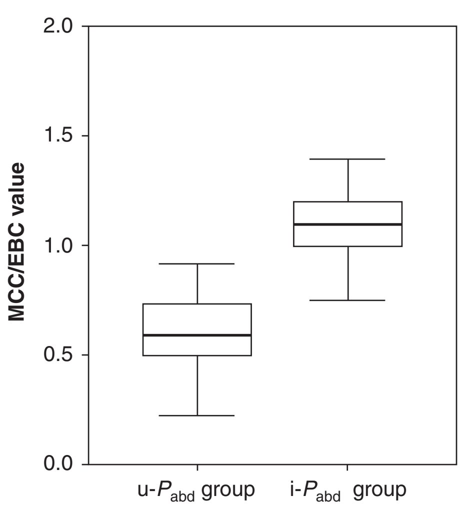

Figure 3. Cystometric capacity [ratio of maximal cystometric capacity to estimated bladder capacity (MCC/EBC ratio)] was statistically significantly different between increased abdominal pressure (i-P_{abd}) and unchanged abdominal pressure (u-P_{abd}) groups ($p < 0.001$). As reduced pelvic floor tonicity affects the P_{abd} tracing, this pressure increase is likely to be higher with increased bladder volume.

the dynamic relation between the bladder and the rectum in the lower pelvis. Thus, despite the close anatomical proximity of these two structures, bladder enlargement does not affect the rectal catheter during urodynamic measurements. However, this anatomical and dynamic integrity between the pelvic floor and lower abdominal organs can be disturbed in children with MMC. Bladder filling may lead to posterior movement of the bladder and pressure to the rectum and the rectal catheter, owing to decreased pelvic floor support. This phenomenon will be displayed in urodynamics as a slow and gradual elevation in the P_{abd} tracing. In this study, this pressure increase was much higher in children with increased cystometric capacity. It is likely that a greater volume in the bladder will lead to more posterior dislocation and a greater pressure increase in the P_{abd} tracing. This volume–pressure relationship was confirmed in three children's cystometries. These three children had decreased pelvic floor tonicity upon examination and increased cystometric capacity in their urodynamics. However, contrary to the authors' theory, no pressure change was detected in their urodynamic studies. Bilaterally overdilated refluxing upper urinary tract was noticed with small bladders in their voiding cystographies, so these upper urinary tracts can make space for the infusion volume. Therefore, depending on the anatomical relationship, this indicates that only the volume within the bladder, rather than the volume in the whole urinary tract, can affect the rectal catheter.

There was no correlation between P_{abd} alterations and study posture, but this study proved the effect of posture on pressure change during a procedure (Figure 4), showing a posterior movement of a fully filled bladder by a change in position in cystometry.

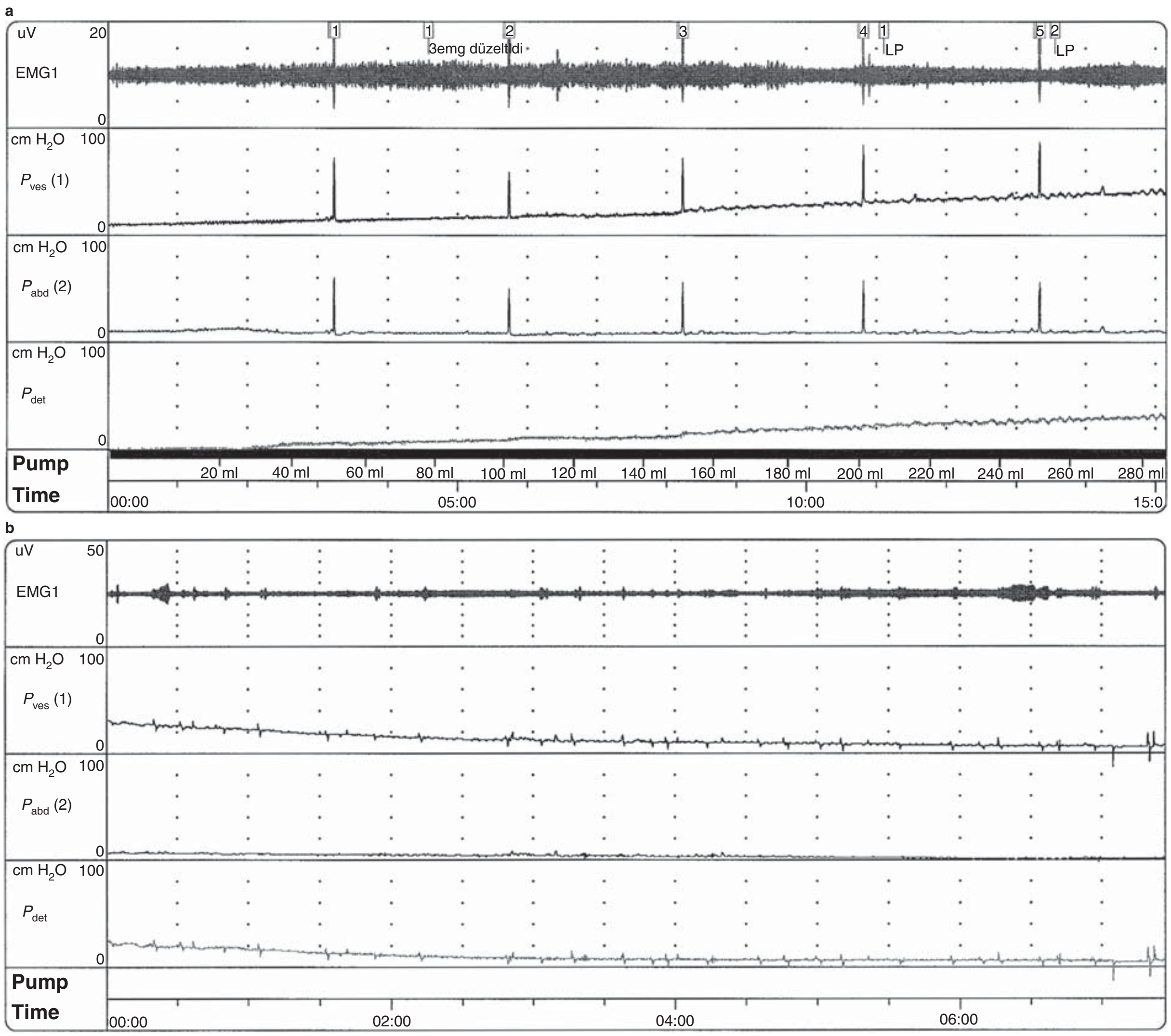

Figure 4. Cystometry of a 7-year-old girl with myelomeningocele (MMC). Decreased pelvic floor tonicity was noticed in her examination. (a) Cystometry was performed in a sitting position. There was no gradual rise in the abdominal pressure (P_{abd}) tracing in this posture. (b) To verify the relation between pelvic floor tonicity and bladder position, the child was repositioned to a lying posture, reference height was readjusted to the new symphysis pubis height and the bladder was evacuated. Pressure decrease in both vesical (bladder) pressure (P_{ves}) and P_{abd} tracings was shown by the bladder emptying.
EMG = pelvic floor electromyography.

In conclusion, the rectal catheter can detect bladder expansion as a slow and gradual rise in P_{abd} tracing due to pelvic floor deficiency in children with MMC. This finding is does not fit urodynamic design and logic. If this phenomenon is considered to be a real pressure event in the urodynamics of children with MMC, it may be classified as a new urodynamic artefact. This phenomenon may lead to the misinterpretation of urodynamic parameters, such as low detrusor pressure and detrusor leak point pressure measurements, underestimation of poor bladder compliance, and management options.

Therefore, it is advisable to carefully interpret initial and end filling abdominal pressures to prevent a possible bladder expansion effect on rectal catheter and P_{abd} tracing in urodynamic measurements of children with MMC.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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