CORRELATION OF HEIGHT TO WIDTH RATIO OF BLADDER IN CYSTOGRAM WITH BLADDER PRESSURE IN CHILDREN OPERATED FOR NEURAL TUBE DEFECT

THESIS SUBMITTED TO

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DECLARATION

I hereby declare that **'Correlation of height to width ratio of bladder in cystogram with bladder pressure in children operated for neural tube defect'** embodies the original work carried out by the undersigned in All India Institute of Medical Sciences Jodhpur.

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CERTIFICATE

This is to certify that the thesis titled **'Correlation of height to width ratio of bladder in cystogram with bladder pressure in children operated for neural tube defect'** is the bona fide work of Dr Shrilakshmi, carried out under our guidance and supervision, in the Department of Paediatric Surgery, All India Institute of Medical Sciences, Jodhpur.

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LIST OF ABBREVIATIONS

AUC	Area Under the curve
BOP	bladder outlet procedure
cmH_2O	centimeter of water
99mTc-DMSA	Technetium-99m Dimercaptosuccinic acid
IQR	Interquartile Range
HWR	Height to Width Ratio
MCC	Maximum Cystometric Capacity
MDP	Maximum Detrusor Pressure
MMC	Myelomeningocele
PAUC	pressure adjusted area under curve
PMC	Pontine Micturating Centre
ROC curve	receiver operating characteristic curve
SPSS	Statistical product and service solutions
TEFP	theoretical end filling pressure
UTI	Urinary tract infection
VUDS	Video Urodynamic Study
VUR	Vesicoureteric reflux
UDS	Urodynamic Study

SUMMARY

INTRODUCTION:

Abnormality of the spine in the form of spina bifida or spinal dysraphism has been present as long as the human race itself. Spina bifida is associated with abnormalities of the brain including Arnold Chiari Malformation type II and hydrocephalus along with abnormalities of the spine which could lead to loss of sensation, motor dysfunction, and bowel, and bladder dysfunction. The most common cause of neurogenic bladder in children is due to spinal dysraphism. The neurogenic bladder can be in the form of failure to store or failure to empty the urine or a combination of both. It has been found that 90% of newborns with meningomyelocele have normal upper urinary tract. Up to 60-80% of children will show signs of upper urinary tract deterioration or reflux, leading to recurrent urinary tract infection, renal scarring, and end-stage renal disease requiring dialysis or renal transplantation if the bladder is not treated. Advancement in diagnostic tools such as urodynamic studies (UDS), implementation of bladder management strategies, and treatment of urinary tract infection has brought a dramatic change in the mortality due to neurogenic bladder. McGuire et al suggested that when urethral leakage pressure is more than 40 cmH_2O (centimeter of water), urethral peristalsis does not effectively empty the upper tracts, which leads to hydronephrosis and upper urinary tract deterioration.

The important purpose of urological follow-up in children with neural tube defects is early detection of unfavorable bladder and initiation of medical management of high-pressure bladder to avoid future bladder surgery. Follow-up is essential with regular renal ultrasound, video or non-video urodynamic study and voiding cystourethrogram (VCUG) whenever required. But video- urodynamic study (VUDS) is difficult to perform in children, done only in a few institutions due to the invasive nature of the procedure and difficulty in interpretation. It requires specialized equipment and needs specialized manpower to interpret the study.

Kumano Y et al (2020) studied objectively the shape of the bladder and correlated the height-to-width ratio (HWR) of the bladder in cystogram at maximum cystometric capacity with maximum detrusor pressure based on the fact that neurogenic bladder is vertically elongated bladder. In the study, it was suggested that an HWR cut-off point

of 1.40 could be used as a simple screening tool for high-pressure bladder in this population. (8).

Hence, we are attempting to objectively define the bladder deformity using height to width ratio, which is a ratio between the maximum height and maximum width of the bladder at maximum cystometric capacity. We intend to find the correlation of height to width ratio with detrusor leak point pressure or end filling pressure in urodynamic study.

AIMS AND OBJECTIVES:

The study aims to find out the correlation between height width ratio (HWR) of the bladder in cystogram with bladder pressure in children operated for neural tube defects. The objectives of the study are to measure bladder pressure in children operated for neural tube defects using a video-urodynamic study, calculate the height-to-width ratio of the bladder at maximum cystometric capacity using cystogram and correlate between height to width ratio of the bladder in cystogram and bladder pressure in children operated for neural tube defect.

METHODOLOGY:

After approval of the IEC, from March 12th, 2021 to September 2022, the study was conducted in the Department of Paediatric Surgery and Neurosurgery of All India Institute of Medical Sciences Jodhpur for eighteen months. It is a prospective observational study. All the children operated on for neural tube defects, of less than eighteen years of age, coming to the Department of Pediatric Surgery and Neurosurgery, AIIMS Jodhpur were included in the study. Children with a history of bladder surgery or any known bladder pathology other than the neurogenic bladder, inaccurate VUDS due to an uncooperative child, and children with grade three to five vesicoureteric reflux were excluded from the study. Parents or legal guardians of patients operated for neural tube defect meeting the inclusion criteria of the study were informed regarding the study and voluntary informed written consent was taken for participation. Once the urine culture of the patient showed no growth of the organism, the video-urodynamic study was conducted, measuring maximum detrusor pressure (MDP) at the end filling phase or at detrusor leak point pressure. Height to width ratio (HWR) was calculated as the ratio between the maximum height and maximum width of the bladder at maximum cystometric capacity (MCC) of the bladder. ROC curve was drawn between MDP and HWR, and a correlation was identified between the same. A p-value of less than 0.05 was considered significant.

RESULTS:

During the study period, from March 2021 to September 2022, fifty- three children who were operated on for neural tube defects underwent a video-urodynamic study in our institute. Out of fifty- three children, fifty-one met the inclusion criteria. Two patients had high-grade vesicoureteric reflux and were excluded from the study. Twenty- six (50.9%) children were males and twenty-five (49%) children were females. The age group included in the study varied from seven months to seventeen years. The median age was four years with an interquartile range of three to 5.5 years. The majority of the children, thirty-seven (72.5%) were between one to five years. Children as young as seven months also underwent a video-urodynamic study.

Sixteen children had MDP of more than 40 cmH2O, with slight male predominance. No significant change in the MDP was noted across the gender. (P=0.61). Ten patients who were continent on CIC had no significant change in the maximum detrusor pressure. Thirty- five patients (68.6%) had urinary complaints, either storage or voiding complaints. Out of them, ten patients had voiding complaints, including straining, intermittent voiding, and incomplete voiding. Five of them had an MDP value of more than 40 cmH2O, but it was not statistically significant. Similarly, twenty patients had storage complaints in the form of incontinence, hesitancy, and increased frequency of voiding. Eight of these patients had MDP of more than 40 cmH2O, with a p-value of 1. Among forty- three patients who had renal ultrasound reports available at the time of the urodynamic study, six patients had upper tract abnormality in the form of hydronephrosis or hydroureteronephrosis, with three patients out of six showing bladder wall thickening. Four out of six patients demonstrated maximum detrusor pressure of more than 40 cmH2O at MCC, however, it was not statistically significant.

The mean value of the maximum detrusor pressure among the patients with upper tract abnormality was 49.6 cmH2O and among the patients without upper tract abnormality was 30 cmH2O. Though there is a difference in the MDP between the two groups, it was not statistically significant

Thirty- five children had MDP less than 40 cmH2O at maximum cystometric capacity, with a median age of four years (IQR: 2-5). The median value of MDP in this group was 20 cmH2O, with IQR between 13.5 and 27 cmH2O. On calculating HWR, the median value among this group was 1.3, with IQR between 1.15 and 1.45. The remaining sixteen children had MDP of more than 40 cmH2O at maximum cystometric capacity. The median age in this group was four years (IQR: 3-9 years). The median value of MDP among the patients was 52 cmH2O (IQR: 46.5, 58). HWR in this group was 1.45 (IQR- 1.37, 1.72). The HWR value was significantly higher among the patients with an MDP value of more than 40 cmH2O ($p = 0.004$).

The scatter plot shows positive correction between HWR and MDP, with Pearson's product correlation coefficient $r = 0.412$ ($p = 0.002$). This is suggestive of a bladder with high pressure having higher HWR, which correlates with a vertically elongated bladder in a cystogram.

On interpreting the results using the area under the curve, the sensitivity and specificity of the HWR to discriminate high-pressure bladder was 93.7% (95% CI 69.8- 99.8) and 45.7% (95% CI 28.8-63.4) respectively. The area under the curve was 0.746 (95% CI 0.605- 0.858), with a cut-off value of 1.22. ($p < 0.001$). With higher sensitivity and low specificity, HWR can be employed as a screening tool to potentially identify the high-pressure bladder.

CONCLUSION

We conclude that height to width ratio of the bladder in cystogram can be used as a screening tool to diagnose high-pressure bladder, with a cut-off value of 1.22, a sensitivity of 93.7%, and a specificity of 45.7% to detect high-pressure bladder. This could help to mobilize the children with high-pressure bladder and seek necessary medical aid to prevent irreversible renal injury in children with neurogenic bladder, especially in a resource-poor setting. Video urodynamic study has to be performed to confirm the diagnosis and plan for further management.

INTRODUCTION

Abnormality of the spine in the form of spina bifida or spinal dysraphism has been present as long as the human race itself. In the work of Goodrich JT, multiple terracotta figures can be seen from the past, which is suggestive of the survivors of spina bifida dating back to 200AD (1). Spina bifida is a neural tube defect involving abnormal development of the spinal cord, meninges, and vertebral arches (2). Pieter van Foreest in the year 1587 was the first one to describe neural tube defect, and in 1610, the publication regarding the surgical ligation of the sac of the myelomeningocele was released. It was Nicolas Tulp who coined the term "spina bifida" which is in use to date (3). Surgical closure of the defect is to be done, especially within 48 hours of life which is a common practice (4). It is a simple procedure, however, attention is to be given to counseling the family and ruling out the associated life-threatening anomalies. The surgery aims to preserve the neurological function, hence attention is to be given to preserving the vascular supply of the placode and meticulous closure of the placode, carefully separating the neural tissue, to look at tethering of the cord and appropriate closure of the wound (5). Spina bifida is associated with abnormalities of the brain including Arnold Chiari Malformation type II and hydrocephalus along with abnormalities of the spine which leads to loss of sensation, motor function, and bowel and bladder dysfunction (2).

The most common cause of neurogenic bladder in children is spinal dysraphism. Other causes of neurogenic bladder include total or partial sacral agenesis, caudal regression syndrome, traumatic or neoplastic spinal lesions, and anorectal or cloacal malformations (6). The neurologic effect of neural tube defects on the lower urinary tract varies and cannot be predicted by the observed level of anomaly. The neurogenic bladder can be in the form of failure to store or failure to empty the urine or a combination of both (2). In neurogenic bladder, failure to store urine occurs due to detrusor muscle hyperactivity or poor compliance which leads to elevated bladder pressure and incontinence. Failure to empty the bladder is secondary to the hypotonic neurogenic bladder (7).

Occult spinal dysraphism include tethered cords, posterior spina bifida, lipoma with dural defect, intradural lipomas, terminal myelocystocele, limited dorsal myeloschisis, filar lipoma, tight filum terminale, persistent terminal ventricle, neuroenteric cyst, dermoid cysts or sinuses, diastometamyelia, diplomyelia, caudal regression syndrome and cauda equina syndrome. Open spinal dysraphism includes meningocele, myelomeningocele (MMC), rachischisis and hemimeningocele.

Disruption in the communication between the bladder and brain, specifically Pontine Micturating Centre (PMC) is the reason for the development of neurogenic bladder. PMC plays a pivot role in detrusor contraction and bladder voiding, by controlling urethral sphincter relaxation. When the feed-forward inhibition of the PMC is lost, the bladder loses its ability to maintain low pressure during the filling phase, leading to reduced bladder contractility and elasticity. This can be evident with low bladder compliance which is the single, most important risk factor for upper urinary tract deterioration (8).

It has been found that 90% of newborns with meningomyelocele have normal upper urinary tract. But 60-80% of children will show signs of upper urinary tract deterioration or reflux, leading to recurrent urinary tract infection, renal scarring, and end-stage renal disease requiring dialysis or renal transplantation if the bladder is not treated [(6), (7)]. A systematic review regarding the outcome of meningomyelocele patients in adults demonstrated that 37% (8-85%) of the patients were continent, renal damage was seen in 25% of the children and end-stage renal failure was present in 1.3% (9). Children born with spina bifida hardly reached adulthood earlier due to the severity of the urologic complication. Advancement in diagnostic tools such as urodynamic studies, implementation of bladder management strategies, and treatment of urinary tract infection has brought a dramatic change in the mortality due to neurogenic bladder. Objectives of management of neurogenic bladder include protecting the upper urinary tract and improving quality of life by achieving continence by school age.

McGuire et al suggested that when urethral leakage pressure is more than 40 cmH_2O (centimeter of water), urethral peristalsis does not effectively empty the upper tracts, which leads to hydronephrosis and upper urinary tract deterioration (10). Hence early urodynamic evaluation is essential to determine the frequency of follow-up studies and the timing of initiation of bladder therapy programs. (6). Based on urodynamic study (UDS), 4 subtypes of the neurogenic bladder have been identified for management as follows: Overactive sphincter with overactive detrusor or underactive detrusor, underactive sphincter with overactive detrusor or underactive detrusor (6).

Both leak point pressure exceeding 40cm H_2O and the presence of detrusor-sphincter dyssynergia are associated with poor prognosis for the upper urinary tract and development of vesicoureteric reflux as a pop-off mechanism [(7),(8)]. Other factors known to indicate bladder hostility are hyper-reflex contractions, high storage pressures and voiding pressure, poor bladder compliance, and small-capacity bladder (7).

The important purpose of urological follow-up in children with neural tube defects is early detection of unfavorable bladder and initiation of medical management of high-pressure bladder to avoid upper tract deterioration. Follow-up is essential with regular renal ultrasound, video or non-video urodynamic study and voiding cystourethrogram (VCUG) whenever required. But the video-urodynamic study is difficult to perform in children, done only in a few institutions due to the invasive nature of the procedure and difficulty in interpretation. It requires specialized equipment and needs specialized manpower to interpret the study.

As per the guidelines, a urodynamic study needs to be performed once the phase of spinal shock after the surgery has subsided, usually within two to three months and then yearly as per the need. A normal urodynamic study (UDS) includes an appropriate capacity bladder, with normal compliance, with an increase in sphincter activity during filling and complete silencing of the sphincter during bladder emptying. As per International Children's Continence Society, detrusor overactivity is any involuntary detrusor contraction during filling, which could be spontaneous or provoked (11).

Clean intermittent catheterization (CIC) is often started soon after birth, as it reduces the risk of upper urinary tract deterioration and reduces the need for augmentation in the future. Anticholinergic medication is started as per the requirement following UDS. Interpretation of the video-urodynamic study becomes (VUDS) difficult and normal value does not exist especially for neonates and infants (6).

A voiding cystourethrogram (VCUG) provides information only on the shape of the bladder, the presence or absence of vesicoureteric reflux (VUR), and trabeculation at maximum cystometric capacity (MCC). It is done in all institutions and can be interpreted easily. It has been traditionally known and accepted that the neurogenic bladder has the appearance of a Christmas tree pattern, a vertically elongated bladder with a wide base that tapers superiorly towards the dome and trabeculated bladder due to high storage and voiding pressure and poor compliance of the bladder (12). It is originally described in cystography. Very few efforts have been made to objectively define bladder deformity in the neurogenic bladder. In the year 2020, Selby B et al established a grading system for bladder trabeculation (13). Anderson et al postulated that in patients with neurogenic bladder due to spinal cord injury, radiographic evidence in form of bladder trabeculations appears within 24 months of injury. It is to be noted that all patients with hydronephrosis or VUR had bladder trabeculation and it could be an early form of deterioration (14). A significant relationship exists between low compliance, bladder deformity, and upper urinary tract deterioration, hence early detection of bladder deformity and compliance need to be done to prevent upper tract deterioration. However, further studies are required to establish the correlation between bladder trabeculation, bladder pressure, and upper urinary tract deterioration.

Kumano Y et al (2020) studied objectively the shape of the bladder and correlated the height-to-width ratio (HWR) of the bladder in cystogram at maximum cystometric capacity with maximum detrusor pressure based on the fact that neurogenic bladder is vertically elongated bladder. In the study, it was suggested that an HWR cut-off point of 1.40 could be used as a simple screening tool for high-pressure bladder in this population (15).

Hence, we are attempting to objectively define the bladder deformity using height to width ratio, which is a ratio between the maximum height and maximum width of the bladder at maximum cystometric capacity. We intend to find the correlation of height to width ratio with maximum detrusor pressure at the detrusor leak point or end filling point in the video- urodynamic study.

REVIEW OF LITERATURE

PROGRESSION OF NEUROGENIC BLADDER IN PATIENTS WITH NEURAL TUBE DEFECT:

Neural tube defect in children is associated with spinal abnormalities, leading to loss of sensation, motor dysfunction, and bowel and bladder dysfunction leading to neurogenic bladder. The most common cause of neurogenic bladder in children is neural tube defects. Hence urologic follow-up of the patients operated on for neural tube defects is essential.

Robert Martin Spellman and Charles J.E. Kickman in 1962, while sharing their experience in managing patients of myelomeningocele, explained that during follow-up, upper urinary tract abnormality occurred in equal frequency between the patients who underwent surgical repair of myelomeningocele and those who did not. The aim of the treatment strategy should be to eliminate urinary infections, eliminate residual urine, control urinary incontinence, and preserve renal function by eliminating vesicoureteric reflux and hydronephrosis. Hence, they suggested uroprophylaxis using sulfonamides and timed voiding, and applying suprapubic pressure to reduce residual urine yielding encouraging results. It reduced the incidence of acute renal sepsis and hydronephrosis and VUR in the cohort.

The principle of management to reduce the incidence of urinary tract infection was to reduce the stasis of the urine in the bladder by timed voiding and uroprophylaxis (16).

In 2007, Tom Jong published an article regarding the management of neurogenic bladder in patients with spina bifida. They demonstrated that renal scarring and renal failure are important issues requiring attention, with the reported death of 20% of the children due to renal failure in the first year of life. Risk increases exponentially in patients with an overactive pelvic floor with detrusor sphincter dyssynergia if not addressed earlier in life. Up to 50% of children with spina bifida aperta and 25% of children with spina bifida occulta have detrusor sphincter dyssynergia, leading to upper urinary tract damage and recurrent urinary tract infection (UTI) (17).

ROLE OF URODYNAMIC STUDY IN NEUROGENIC BLADDER:

While explaining the role of urodynamic studies as a diagnostic tool and to monitor the response to therapy in children with neurogenic bladder, McGuire EJ et al in 1981 followed up forty-two myelodysplastic patients for fifteen years. They studied extensively using voiding cystourethrogram, intravenous pyelogram (IVP), and urodynamic studies.

Discoordination between the detrusor and external sphincter occurs frequently in patients with spinal cord lesions. Most of the patients in the study showed fixed urethral pressure during bladder filling and voiding. A low resting urethral pressure was associated with incontinence and high resting urethral pressure was associated with upper tract abnormality and vesicoureteric reflux. If the detrusor muscle response to the bladder filling cannot be modified, then the high urethral closing pressure results in upper tract deterioration and reflux. It is to be understood that upper tract deterioration is associated with high urethral closing pressures or elevated intravesical pressures (10).

Tom Jong suggested that to avoid upper tract abnormality and recurrent urinary tract infection, early evaluation with urodynamic studies, urine analysis, and renal ultrasound is required. A multidisciplinary team should be involved in the management of patients with neurogenic bladder. Clean intermittent catheterization, antimuscarinic medications, and prophylactic antibiotics are to be administered to improve the quality of life and achieve dryness. An appropriate surgical procedure can be performed according to the pathology and the need of the patient (17).

Faezeh Javadi Larijani et al in 2013, stressed the need to diagnose and manage the neurogenic bladder. Early diagnosis and management are required during infancy to avoid renal injury. Initial evaluation includes renal ultrasound, urine analysis, and culture, urodynamic studies followed by voiding cystography needed. Medical management included anticholinergics, antibiotics, and clean intermittent catheterization according to the evaluation (7).

While discussing abnormal urodynamic parameters in patients with myelomeningocele, Sager C et al in 2016 found that majority of children had abnormal urodynamic parameters on initial urological evaluation. This included reduced cystometric capacity in 21.6%, detrusor overactivity in 55%, end-filling detrusor pressure of more than 20 cmH_2O in 43.3%, inefficient bladder voiding in 98.3% and indirect dyssynergic patterns in 28.8%. The high-risk video urodynamic findings were observed in twenty-eight cases (46.6%). Among them, 13% of patients had a pressure of more than 20 cmH_2O at maximum cystometric capacity and among infants, more than 40% had a pressure of more than 20 cmH_2O at maximum cystometric capacity. Up to 30% of the children had a reflex contraction during filling which suggests the presence of detrusor sphincter dyssynergia, which is one of the key predictors of urinary tract deterioration. If this is left untreated, 70% of children will develop urinary tract deterioration. 99mTc- DMSA (Dimercaptosuccinic acid) scan was abnormal in 30% of the children which led to therapeutic actions being initiated. Nevertheless, the other complementary imaging methods did not always show alterations, especially renal/bladder ultrasound. Therefore, it is considered essential to perform urodynamic studies in the early evaluation of the urinary tract to initiate medical management in patients operated on for neural tube defects (18).

Several earlier studies, including a study from McGuire et al and Timberlake et al, stressed the importance of performing urodynamic studies in children operated for neural tube defects. Several parameters determine the upper urinary deterioration including end-filling pressure of more than 40 cmH_2O and bladder trabeculation. Maximum detrusor pressure at maximum cystometric capacity or leak point of more than 40 cmH_2O plays a key role in upper renal dilatation and VUR. Early treatment with CIC and antimuscarinic agents is necessary for patients with abnormal findings [(10), (19)]. In a study by Sibel Tiryaki et al in 2021, they suggested that apart from maximum detrusor pressure, other parameters like pressure adjusted area under curve ratio (PAUC), upper mean static pressure (UMSP), and theoretical end filling pressure (TEFP) can be employed to predict upper urinary tract deterioration and renal scar formation(20).

In a cross-sectional study by Prakash et al in 2017, they found a positive correlation between bladder wall thickening (>3.05mm) and palpable bladder lump, delayed age at presentation, significant PVR, and trabeculated bladder. Mean detrusor leak point pressure was similar in all the patients, with or without bladder wall thickening. Bladder wall thickening had a significant effect on upper urinary tract deterioration in the study, with a sensitivity of 80% and specificity of 73%. It was suggested to be used as a tool in the follow-up of the neurogenic bladder. The study also found that detrusor leak point pressure of more than 40 cmH_2O is detrimental to the upper tract. The positive and negative predictive value of detrusor leak point pressure to determine upper tract deterioration was 78% and 64% respectively. The study re-established the necessity for aggressive intervention if any of the risk factors exist to prevent upper tract damage (21).

It is also important to follow up on the neurogenic bladder with regular urodynamic studies. Arthur Mourtzinos et al, in a review article regarding management goals in patients with MMC, suggested that urodynamic findings in neurogenic bladder change frequently during longitudinal follow-up, especially in the first year of life. Up to 37% of children with MMC had changes in external sphincter during the first 3 years of life, necessitating follow-up with UDS every six months. Nearly 48% of patients with tethered cords have poor urodynamic measurements, and the release of tethered cords improves the urodynamic outcome. As these patients with spina bifida grow into adolescence and adulthood, the risk of upper urinary tract deterioration increases. Hence regular surveillance needs to be carried out, using renal ultrasound, serum creatinine, UDS, voiding cystourethrogram, and nuclear medicine function scan (22).

Two modes of treatment were described by Frimberger et al in 2012 for neurogenic bladder, expectant and proactive approach. The expectant management includes regular follow-up with clinical examination and renal ultrasound. If they are found abnormal, urodynamic studies are conducted and patients are started on clean intermittent catheterization and antimuscarinic agents. Proactive management involves early urodynamic evaluation and initiation of CIC and antimuscarinic agents accordingly. Proactive management of neurogenic bladder reduces the need for surgery by two third and helps to achieve continence (23).

IMPORTANCE OF VIDEO-URODYNAMIC STUDIES:

A urodynamic study plays a major role in the management of neurogenic bladder, but it was in 1996 when McGuire et al explained the importance of video-urodynamic study (VUDS) in place of UDS. They stressed the importance of the correlation between structure and function in some pathologies of the bladder like neurogenic bladder in myelomeningocele, where enough information cannot be gathered by UDS.

Patients with spinal cord injury or myelomeningocele have complex voiding problems, which results in poor compliance and detrusor sphincter dyssynergia, which can be better diagnosed using VUDS. The major clinical problem in these patients was incontinence with low urethral closing pressure and urinary retention, upper urinary tract deterioration, and the development of VUR in those with higher urethral closing pressure (24). The study did not focus on the objective measurement of bladder deformities that are observed in the neurogenic bladder.

While studying the effects of botulinum toxin on the morphology of the bladder in cystogram, Ronaldo Alvarenga Álvares et al in 2014 assessed the outcomes following administration of the botulinum toxin using urodynamic parameters, the shape of the bladder, round, pear-shaped, or pine shape, presence or absence of diverticula and bladder capacity. The study suggested significant improvement in the continence of the patients which was also evident in urodynamic parameters including maximum cystometric capacity, volume at which reflux occurs, and compliance. But no significant responses were appreciated for botulinum toxin pertaining to bladder shape and the status of diverticula. They concluded that cystography parameters cannot be used to assess the response to the treatment and urodynamic study is a must for the follow-up. It was postulated that it could be due to the permanent changes in the bladder wall in response to a high-pressure system which would not respond to conservative management (25).

A study by A T Scher et al, in 1979-1980, found a significant difference in the capacity of the bladder and shape, including the contour of the bladder when assessed using cystography and intravenous pyelography. Up to 32% of the patients with neurogenic bladder had the erroneously wrong capacity and contour when cystography was done. It could be due to a combination of factors that lead to a reflex contraction in the bladder. Hence, they believed that the cystographic appearance of the bladder alone should not be used to diagnose small-capacity trabeculated bladder. (19)

Lauren E. Corona et al, in 2019, studied urodynamic parameters and imaging parameters that might predict the requirement of augmentation cystoplasty in children operated for myelomeningocele. Detrusor leaking point pressure/ end filling pressure of more than 40 cmH_2O and the presence of VUR on VCUG were two independent risk factors that predict the risk of augmentation in these patients. No other bladder deformity was predictive of disease progression (26).

An expert panel consisting of five pediatric urologists, including Christian Sager et al, discussed the issues faced in the management of spina bifida patients and addressed the recommendations for the management of the patients in 2022. In the update, they stressed the importance of performing a cystogram in the follow-up of the neurogenic bladder. They strongly recommended an initial evaluation of the patients to identify the status of the detrusor sphincter and type of neurogenic bladder. With adequate medical management of the neurogenic bladder, it is possible to prevent renal parenchymal damage. The update recommends early initial evaluation and follow-up with urodynamic study and voiding cystourethrogram. Voiding cystourethrogram provides information about the structure of the lower urinary tract and VUR. Video urodynamic study, which combines VCUG and urodynamic study in one single study, could be performed. Renal ultrasound also needs to be done in these children to detect hydronephrosis. However, it was noticed that no significant changes were present in the video-urodynamic parameters with an increase in the bladder wall thickness, but renal deterioration was noted in patients with small capacity bladder, poor compliance, and raised detrusor leaking point pressure. The expert panel recommends renal ultrasound every two to three months in the first year of life, followed by six months till the age of two years, then yearly till puberty. Urodynamic study and VCUG or VUDS need to be performed yearly till puberty is reached. In patients with urologic and neurologic stability, follow-up can be done with yearly renal ultrasound with an estimation of post-void residual urine. This article stresses the importance of early urological evaluation and follow-up of the patients operated on for neural tube defects (27).

CHALLENGES WHILE PERFORMING UDS IN CHILDREN

Performing a urodynamic study and interpreting the results in children can be difficult. It is an invasive procedure, that creates anxiety in children. It requires specialized equipment and setting, requiring manpower trained in performing the urodynamic study in children. The voiding phase of the study can be compromised, as children may not be able to void with the catheter in situ. It is also to be noted that the smaller-sized catheter (6Fr) may not be available in all centers and the larger-sized catheter can cause bladder outlet obstruction, making it difficult to void. It can result in raised leak point pressure. Bladder filling has to be kept as close to the natural filling as possible for the fear of causing detrusor hypertonicity. Hence performing and interpreting urodynamic studies in children can give fallacious results (28).

While discussing the management of neurogenic bladder, in 2017, Opoku P et al mentioned that pediatric neurogenic bladder can lead to renal failure if left untreated. Hence early diagnosis and active management of the bladder are essential. The treating doctor should strive to provide the facilities even in resource-poor settings and necessary investigations including urodynamic study should be performed without fail (29).

In contrast to a VUDS, a voiding cystourethrogram (VCUG) is performed in all the centers with ease and is commonly available even in limited resource settings. VCUG is employed in the follow-up of patients with neurogenic bladder to identify VUR. In addition, VCUG provides information regarding the capacity of the bladder and structure and deformity of the bladder including trabeculation at maximum cystometric capacity.

MORPHOLOGY OF THE BLADDER IN DETERMINING THE BLADDER PRESSURE:

In the patients who sustained acute spinal cord injuries, Anderson et al reported that 70% of them developed radiographic evidence in form of bladder trabeculations within 24 months of injury. It is also to be noted that all patients with hydronephrosis or VUR had bladder trabeculation and detection of bladder trabeculation could be a precursor for renal deterioration (14).

Ogawa T, in 1991 defined bladder deformity and correlated the severity of bladder deformity in neurogenic bladder with upper urinary tract deterioration, including hydronephrosis and VUR. They classified bladder deformity subjectively in VCUG into four grades, depending on the shape of the bladder and trabeculation. Incidence of upper urinary tract deterioration was 2% in grade zero, 8% in grade one, 52% in grade two, and 62% in grade three indicating that high pressure and low compliance bladder are detrimental to upper urinary tract deterioration (30). Bladder deformity was classified into different grades without any objective method to describe the deformity. Hence, the classification is purely depending on the subjective perception of the bladder deformity rather than objective measurement.

“Christmas tree bladder” or “pine cone bladder” had been used in the past to describe the neurogenic bladder. It is vertically elongated with a wide base that tapers towards the dome with an irregular bladder wall due to trabeculation. It is due to loss of bladder sensation, inability to initiate voiding, and detrusor-external sphincter dyssynergia (12).

In an illustration of 50 patients with the neurogenic bladder in 1960 by Richard et al, they described the bladder deformity in patients with neurogenic bladder using cystourethrogram. The changes in the bladder are due to changes in the muscles of the bladder wall due to neurogenic lesions and secondary to obstruction due to the effect on the sphincter. The shape of the bladder varies according to the appearance of the bladder wall. It can be smooth-walled, or irregular-walled due to the presence of trabeculation, saccules, and diverticula. The shape of the bladder was classically described as a pine tree or hourglass shape. The pine tree bladder has an irregular wall with a wide base, tapering near the dome of the bladder. Hourglass bladder has to be differentiated from other congenital causes of a similar appearance. It was also noted that the size of the bladder depends on the level of the lesion. Deviation of the bladder towards one side can also be noticed due to asymmetrical innervation of the bladder. A few other changes noticed in the bladder included a funnel-shaped urethra due to bladder neck widening, saccular posterior urethra, and incompetent ureteric orifice leading to VUR. Though possible explanations have been given for the changes, no objective measurement has been provided (31).

The degree of bladder trabeculation as a marker of outlet resistance in the neurogenic bladder was studied by Khoury et al in 2007. The degree of bladder trabeculation was considered while making surgical decisions for augmentation cystoplasty and the need for concomitant bladder outlet procedure (BOP) in patients with neurogenic bladder and incontinence. Bladder trabeculation was graded as mild and severe trabeculation. Mild trabeculation was the minimal irregularity of the bladder wall, and severe trabeculation was elongated bladder with sacculation and diverticula. No objective definition was described. The presence of severe trabeculation in incontinent neurogenic bladder indicates high intrinsic outlet resistance and the grade of trabeculation was considered during the surgical decision (32).

Another attempt to define and validate an objective method of the grading system for bladder trabeculation was done by Blake Selby et al in 2020. The presence of trabeculation indicates high storage pressure and poor compliance of the bladder, observed in cystoscopy and cystogram, which necessities aggressive intervention. Urodynamic evaluation has been accepted and has well-defined multiple parameters which could predict the deterioration of the upper tract, however, the cystogram does not have validated parameters that can be used as an objective measurement to determine the status of the bladder in the neurogenic bladder as has been discussed earlier. The authors developed objective grading of the trabeculation of the bladder and validate the grading in the study. The psychometric scientific methodology was used to define the grades of bladder trabeculation. Trabeculation was graded from zero to two, with grade zero being smooth-walled bladder, grade one being bladder with shallow cellules or diverticula or saccules without neck and grade two being bladder with deep cellules or diverticula or saccules with the neck. This created an objective measure of bladder trabeculation that are reproducible with high inter and intra-rater reliability. It helps to improve communication between the clinician and radiologist regarding the status of the bladder wall. However further study is required on the subject of the association of bladder trabeculation with upper tract deterioration, incontinence, compliance, the pathological course of the bladder trabeculation and risk of fibrosis of the bladder wall, response of the trabeculation to botulinum injection (13).

It was Yohei Kumano et al in 2020, attempted to define the deformity of the bladder by defining height to width ratio of the bladder at maximum cystometric capacity. The ratio however did not take into consideration of the presence or absence of bladder trabeculation. They observed that the HWR was significantly higher for high-pressure bladders than for low-pressure bladders. The sensitivity and specificity of the HWR for discriminating children with high-pressure bladder from all children were 87% and 56.9%, respectively with a cut-off score of 1.4. Hence the parameter can only be used as a screening tool in the settings where VUDS is not available for children operated for MMC. But VUDS is still needed to be performed in patients with high risk and initiate further treatment (15).

Hence, we conducted the study in our population of operated patients of neural tube defect, to assess the urodynamic parameters and renal ultrasound, calculate the height-to-width ratio in cystogram and identify the correlation between the two to assess if the height-to-width ratio can be used as a screening tool to identify the high-pressure bladder.

AIM AND OBJECTIVES

AIM:

To find out the correlation between height to width ratio of bladder in cystogram with bladder pressure in children operated for neural tube defect

OBJECTIVES:

1. To calculate height to width ratio of bladder at maximum cystometric capacity using cystogram in children
2. To measure bladder pressure in children operated for neural tube defect using VUDS.
3. Correlate between height to width ratio of bladder in cystogram and bladder pressure in children operated for neural tube defect.

MATERIALS AND METHODS

<u>The study setting:</u>

All the patients operated for neural tube defect, who were admitted or being followed up under Department of Paediatric Surgery and Department of Neurosurgery, All India Institute of Medical Sciences Jodhpur, Rajasthan were recruited for the study.

<u>Study design:</u>

Prospective observational study

<u>Study duration:</u>

After approval of the IEC, from March 12^{th}, 2021 to September 2022, for a duration of eighteen months.

<u>Sample size:</u>

Time bound purposive sampling

<u>Study participants:</u>

Inclusion criteria:

All the children operated for neural tube defect, less than eighteen years of age, coming to Department of Pediatric Surgery and Neurosurgery, All India Institute of Medical Science Jodhpur.

Exclusion criteria:

- Children with a history of bladder surgery or known bladder pathology other than neurogenic bladder
- Inaccurate VUDS due to an uncooperative child.
- Children with grade three to five VUR.

Prospective observational study was done under the Department of Pediatric Surgery and Neurosurgery, AIIMS Jodhpur. Parents or legal guardian of patient operated for neural tube defect who were admitted or being followed up under Department of Pediatric Surgery and Neurosurgery, All India Institute of Medical Sciences Jodhpur, meeting the inclusion criteria, were informed regarding the study and voluntary informed written consent was taken from the parents or legal guardian for participation.

Data collection includes the following:

- Detailed history and clinical examination of the patients who are operated for neural tube defect was taken, including age, sex, bowel and bladder habits, practising intermittent catheterisation, treatment history and details of renal ultrasound report.
- Presence of hydronephrosis, hydroureteronephrosis and bladder wall thickness was given special attention in the ultrasound report.
- Urine analysis and culture sensitivity was done prior to the video-urodynamic study in all the patients since these patients are prone for urinary tract infection.
- Standard fluid cystometry was done.
- Maximum detrusor pressure, which is the detrusor pressure at maximum cystometric capacity or at the leak point was calculated during bladder filling.
- Bladder shape and presence or absence of vesicoureteral reflux (VUR) was evaluated at maximum cystometric capacity (MCC).
- The height to width ratio was calculated as the ratio between maximum height and maximum width of the bladder in cystogram at MCC.
- Age, sex, practicing CIC, renal ultrasound report, VUDS variables including maximum detrusor pressure and capacity of the bladder, along with HWR was compared, analysis was done and AUC was drawn between HWR and MDP.

VIDEOURODYNAMIC STUDY: STANDARD FLUID CYSTOMETRY

- After obtaining sterile urine culture, patient was administered antibiotic prophylaxis to prevent UTI.
- Bowel preparation was done using enema or bowel washes for optimal study.
- During cystometry, patient should be awake, unanesthetized, neither sedated, nor taking any drugs that affect the bladder function. It is to be noted that none of the patients were on anticholinergic agents prior to the urodynamic study.
- Standard fluid cystometry was done with children in the supine position using a 6-Fr double-lumen urodynamics catheter and a rectal balloon catheter.
- In girls, after initial inspection of perineum, urethral catheter is inserted, catheter is advanced until urine is obtained.
- In boys, foreskin is retracted and catheter is introduced after lubricating with an anesthetic jelly, into the urethra, holding the penis in vertical position.
- Bladder filling at a rate of less than 10% of predicted bladder capacity per minute to mimic physiological bladder filling. Faster filling of the bladder can lead to uninhibited bladder spasm which can alter the detrusor pressure due to contractility.
- Koff's formula was employed to calculate bladder capacity, given by (age in years+2) *30 ml in children more than one year (33). For infants, expected bladder capacity was calculated using weight*7ml (34).
- During filling, fluoroscopic screening was performed on reaching 50% of the expected bladder capacity and at maximum cystometric capacity, either after reaching expected bladder capacity or at leak point, to see if VUR or diverticula or other abnormalities are present. Child was turned oblique on both sides to ensure minimal reflux was not overlooked.
- If reflux appears, images were taken in the oblique projection.
- If bladder appears normal, one image was taken in the frontal projection, at the end of filling.
- Maximum cystometric capacity (MCC) was defined as maximal tolerable cystometric capacity of a patient or bladder capacity when leaking begins.

- Maximum detrusor pressure (MDP) was defined as the maximum detrusor pressure at end-filling or at leak, End Filling Pressure (EFP) or Detrusor Leak point pressure (DLPP) respectively.
- Study was repeated in children when the study was interrupted due to uncooperative child. If the child continues to be uncooperative in spite of the maximum efforts, these children were excluded from the study.
- Height to width ratio of the bladder was calculated at the maximum cystometric capacity as the ratio between the maximum height and maximum width of the bladder as depicted in figure 1:

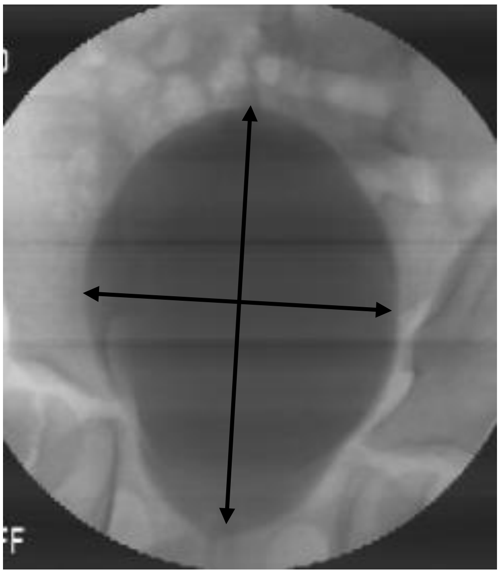


Figure 1: HWR= maximum height/ maximum width of the bladder at maximum cystometric capacity.

ETHICAL CONSIDERATION

Data collection was initiated after obtaining ethical clearance (certificate number **AIIMS/IEC/2021/3404)** from the Institute's Ethics Committee.

Patient were considered for study after due consent taken from parent or legal guardian.

The data collected have been kept confidential.

STATISTICAL ANALYSIS

Data was analyzed using IBM SPSS version 26.

Nominal data was described using frequency and percentages and compared using Chi Square test or Fisher's Exact test as applicable.

Ordinal data was described using median and interquartile range and compared using Mann Whitney U test.

Continuous data was described using mean and standard deviation and compared using independent sample t test.

A p value of less than 0.05 was considered as significant.

OBSERVATIONS AND RESULTS

During the study period, from March 2021 to September 2022, fifty- three children who were operated for neural tube defect underwent video- urodynamic study in our institute. Out of fifty- three children, fifty-one met the inclusion criteria. Two patients had high grade vesico-ureteric reflux and were excluded from the study as per the criteria. Twenty- six (50.9%) children were males and twenty- five (49%) children were females. Age group included in the study varied from seven months to seventeen years. Median age was four years with interquartile range (IQR) of three to 5.5 years. Majority of the children, thirty- seven (72.5%) were between one to five years. Age of the patients included in the study is shown in the table 1. Children as young as seven months also underwent video-urodynamic study.

Children included in the study had undergone operation for neural tube defect, including spina bifida aperta and spina bifida occulta. The distribution of the patient according to the preoperative diagnosis is as shown in the figure 2.

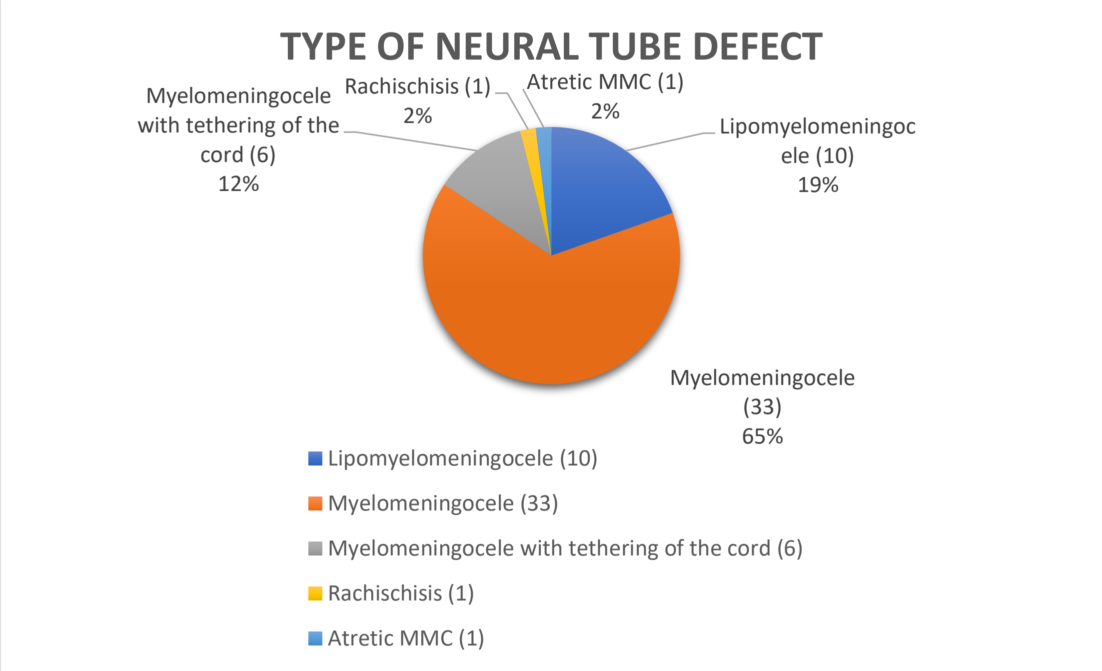


Figure 2: Distribution of the patients who underwent video- urodynamic study as per the pre operative diagnosis.

Majority of the children, thirty-three patients (65%) had myelomeningocele without tethering of the cord and six patients (12%) had myelomeningocele with tethering of the cord. Of the remaining patients, ten children (19%) had lipomyelomeningocele and one patient each had rachischisis and atretic myelomeningocele.

Abnormal bowel habit in the form of constipation was present in twenty patients (39.22%). All the patients were advised appropriate bowel management with dietary modification, laxatives and bowel wash as per the need of the patients.

Urinary complaints were present in thirty- five patients (68.6%). Twenty- five patients had storage complaints, including frequency, incontinence, enuresis. Remaining eleven patients had complaints with voiding in the form of straining or intermittency or incomplete voiding.

Table 1: Demographic details of the patients included in the study

Variables		No. of patients	Percentage
Gender	Male	26	50.98
	Female	25	49.02
Age (yrs)	≤1	1	1.96
	1-5	37	72.55
	6-10	5	9.80
	>10	8	15.69
Urinary complaints	Yes	35	68.63
	No	16	31.37
Bowel habit	Constipation	20	39.22
	Normal	31	60.78
CIC	Yes	10	19.61
	No	41	80.39

None of the patients were on anticholinergic agents prior to the urodynamic study. Ten patients were on clean intermittent catheterisation and were continent on intermittent catheterisation.

Forty- three patients out of fifty-one had renal ultrasound report available at the time of urodynamic study. Two of the patients with high grade VUR were excluded from the study as discussed earlier. Among the rest of the patients, six patients had upper tract abnormality in the form of hydronephrosis or hydroureteronephrosis. Four patients had bilateral hydronephrosis and two patients had unilateral hydroureteronephrosis. Three out of six patients with abnormal upper urinary tract were found to have increased bladder wall thickness with thickness ranging from 4-9.5mm.

Expected bladder capacity was calculated using Koff's formula and slow filling of the bladder was done till the maximum cystometric capacity. Eight children (15.6%) had small capacity bladder. Small capacity bladder is defined as the bladder with bladder capacity less than 50% of the expected bladder capacity. (11)

As discussed earlier, maximum detrusor pressure (MDP) was described as the maximum detrusor pressure recorded at the maximum cystometric capacity or at the leak point, as can be named end filling pressure (EFP) or detrusor leak point pressure (DLPP) respectively. Sixteen children had MDP of more than 40 cmH_2O and remaining thirty- five patients had MDP of less than 40 cmH_2O. Figure 3 is representative of MDP value in the study cohort.

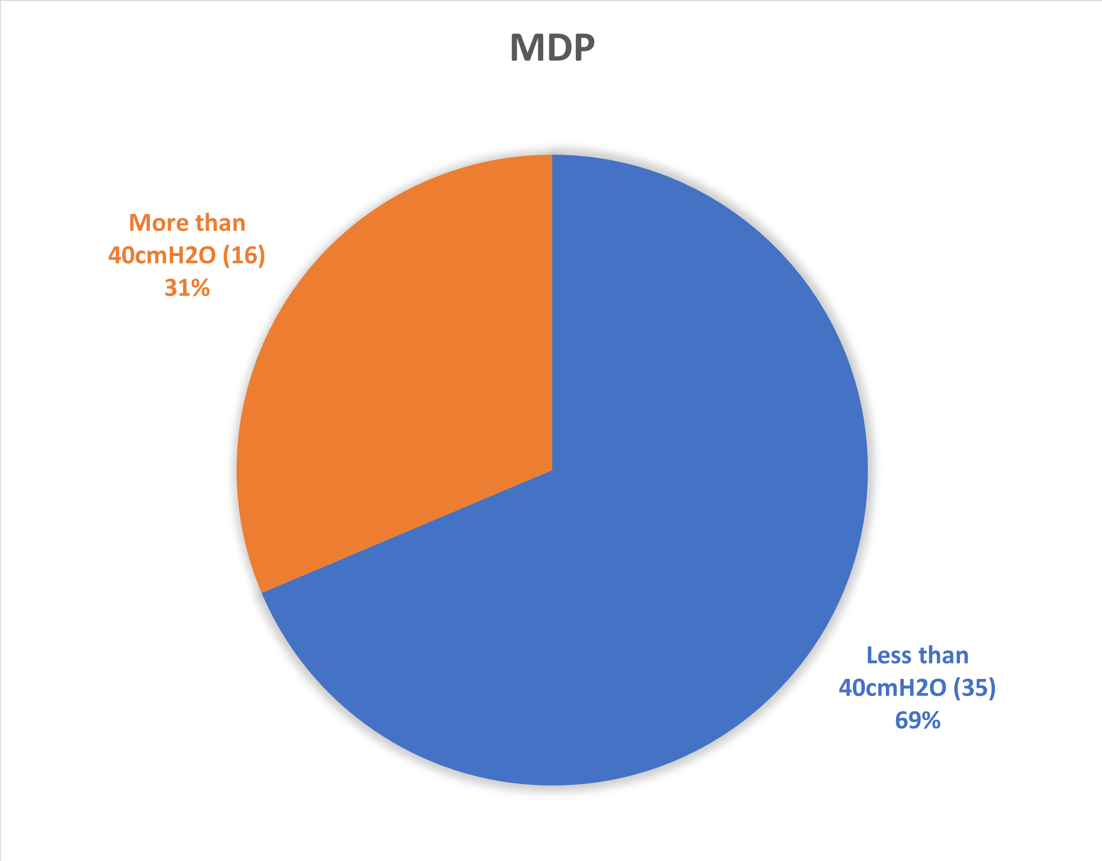


Figure 3: Maximum detrusor pressure

Out of fifty one patients, sixteen patients had MDP values of more than 40 cmH_2O, with slight male predominance. No significant change in the MDP was noted across the gender. (P=0.61). Table 2 shows the distribution of MDP in the study population.

Table 2: Distribution of the MDP among the study population

<table>
<tr><td rowspan="3">Gender</td><td colspan="4">MDP</td><td colspan="2" rowspan="2">Total</td><td rowspan="6">P= 0.610</td></tr>
<tr><td colspan="2"><40</td><td colspan="2">≥40</td></tr>
<tr><td>N</td><td>%</td><td>N</td><td>%</td><td>N</td><td>%</td></tr>
<tr><td>Male</td><td>17</td><td>48.57</td><td>9</td><td>56.25</td><td>26</td><td>50.98</td></tr>
<tr><td>Female</td><td>18</td><td>51.43</td><td>7</td><td>43.75</td><td>25</td><td>49.02</td></tr>
<tr><td>Total</td><td>35</td><td>100.00</td><td>16</td><td>100.00</td><td>51</td><td>100.00</td></tr>
</table>

Patients of different age group were included in the study, with majority of the patients belonging to one-to-five-year age group, amounting to 72.54% (37 patients). Among the patients with high pressure bladder, eleven patients (68.75%) belonged to the same age group. In our study, around 70% of the patients were diagnosed with high pressure bladder between one to five years of age. (Table 3)

Table 3: Distribution of MDP among the study population according to age

Age	MDP				Total		
	<40		≥40				
	N	%	N	%	N	%	
<1 year	1	2.85	0	0.00	1	1.96	P= 0.4
1-5 year	26	74.28	11	68.75	37	72.54	
6-10 year	4	11.42	1	6.25	5	9.80	
>10 years	4	11.42	4	25.00	8	15.68	
Total	35	100.00	16	100.00	51	100.00	

Ten patients who were continent on CIC had no significant change in the maximum detrusor pressure compared to patients who were not practising CIC. Table 4 depicts the MDP of the patients as per the practise of intermittent catheterisation among the patients.

Table 4: MDP distribution among the study subjects as per the practise of clean intermittent catheterisation

CIC	MDP				Total		
	<40		≥40				
	N	%	N	%	N	%	
Yes	7	20.00	3	18.75	10	19.61	P= 1
No	28	80.00	13	81.25	41	80.39	
Total	35	100.00	16	100.00	51	100.00	

In our study, thirty- five patients had urinary complaints, either storage or voiding complaints. Ten patients had voiding complaints, including straining, intermittent voiding and incomplete voiding. Five among them had MDP value more than 40 cmH_2O, but it was not statistically significant. (Table 5). Similarly, twenty patients had storage complaints in the form of incontinence, hesitancy and increased frequency of voiding. Eight of these patients had MDP of more than 40 cmH_2O, with p value of 1. (Table 6)

Table 5: Distribution of maximum detrusor pressure among the patients according to voiding complaints

VOIDING COMPLAINTS	MDP				Total		
	<40		≥40				
	N	%	N	%	N	%	
Yes	5	14.28	5	31.25	10	19.6	P= 0.277
No	30	85.71	11	68.75	41	80.3	
Total	35	100.00	16	100.00	51	100.00	

Table 6: Distribution of maximum detrusor pressure among the patients according to storage complaints

STORAGE COMPLAINTS	MDP				Total		
	<40		≥40				
	N	%	N	%	N	%	
Yes	17	48.57	8	50.00	25	49.01	
No	18	51.42	8	50.00	26	50.98	P= 1
Total	35	100.00	16	100.00	51	100.00	

Among the patients with small capacity bladder, only two patients had maximum detrusor pressure more than 40 cmH_2O at the maximum cystometric capacity. The p value was not statistically significant among the subjects.

Table 7: Distribution of maximum detrusor pressure as per the maximum cystometric capacity (MCC)

MCC	MDP				Total		
	<40		≥40				
	N	%	N	%	N	%	
Small capacity bladder	6	17.14	2	12.5	8	15.69	P= 1
Normal	29	82.86	14	87.5	43	84.31	
Total	35	100.00	16	100.00	51	100.00	

Two of the patients with high grade VUR had bilateral hydroureteronephrosis in the renal ultrasound. These patients were excluded from the study as per the exclusion criteria described for the study. As discussed earlier, among the remaining patients, forty- three patients had renal ultrasound report available at the time of urodynamic study, six patients had upper tract abnormality in the form of hydronephrosis or hydroureteronephrosis, with three patients out of six showing bladder wall thickening. Four out of these patients demonstrated maximum detrusor pressure of more than 40 cmH_2O at MCC, however it was not statistically significant with p value of 0.076. (Table 8)

Mean value of the maximum detrusor pressure among the patients with upper tract abnormality was 49.6cmH_2O and among the patients without upper tract abnormality was 30 cmH_2O.Though there is difference in the MDP among the two groups, it was not statistically significant, with p value being 0.171. (Table 9)

Table 8: Distribution of MDP among the patients as per the renal ultrasound findings. N=43

USG-KUB findings	MDP				Total		
	<40		≥40				
	N	%	N	%	N	%	
Abnormal	2	6.90	4	28.57	6	13.95	P= 0.076
Normal	27	93.10	10	71.43	37	86.05	
Total	29	100.00	14	100.00	43	100.00	

Table 9: Mean value of MDP among the patients according to ultrasound findings

USG-KUB findings	MDP			p value
	Mean	SD	SEM	
Abnormal	49.66	29.24	11.93	0.171
Normal	30	18.57	3.053	

Presence of upper tract abnormality is evident in the patients with higher MDP, especially more than 40 cmH_2O, however it was statistically non-significant.
Bladder wall thinking was noted among three patients in the renal ultrasound (N=43). Though two out of three patients with increased bladder wall thickness had MDP of more than 40 cmH_2O, it was noted that increased bladder wall thickness did not predict the abnormal urodynamic parameters. (Table 10)

Table 10: Distribution of MDP among the patients as per the presence of bladder wall thickness in our cohort

Thickened bladder wall	MDP				Total		
	<40		≥40				
	N	%	N	%	N	%	
Present	1	3.45	2	12.50	3	6.98	P= 0.243
Absent	28	96.55	12	75.00	40	93.02	
Total	29	100.00	14	87.50	43	100.00	

All the patients included in the study underwent video- urodynamic study. Using cystogram, Height to Width Ratio (HWR) of the bladder was calculated at the maximum cystometric capacity. Vertically elongated bladder will have higher HWR than the round shaped bladder. No consideration of other deformities has been done while calculating HWR.

Thirty- five children had MDP less than 40 cmH_2O at maximum cystometric capacity, with median age of four years (IQR: 2-5). Median value of MDP in this group was 20 cmH_2O, with IQR between 13.5 and 27 cmH_2O. On calculating HWR, median value among this group was 1.3, with IQR between 1.15 and 1.45.

Remaining sixteen children had MDP of more than 40 cmH_2O at maximum cystometric capacity. Median age in this group was four years (IQR: 3-9 years). Median value of MDP among the patients was 52 cmH_2O (IQR: 46.5, 58). HWR in this group was 1.45 (IQR- 1.37, 1.72). The HWR value was significantly higher among the patients with MDP value of more than 40 cmH_2O, with p value being 0.004. (Table 11)

Table 11: Value of HWR among the study population N=51. HWR is significantly higher among the patients with high pressure bladder

Variables	Total		MDP				p value
			<40		≥40		
	Median	IQR (Q1,Q3)	Median	IQR (Q1,Q3)	Median	IQR (Q1,Q3)	
Age (yrs)	4	3,5.5	4	2,5	4	3, 9	0.339
MCC (ml)	124	98, 162	120	101.5,155.5	156	97.75,180.25	0.311
MDP (cmH_2O)	26	17, 42	20	13.5,27	52	46.5,58	**<0.0001**
HWR	1.3	1.2, 1.55	1.3	1.15,1.45	1.45	1.37,1.72	**0.004**

Scatter plot diagram of MDP and HWR was drawn as shown. (Figure 4)

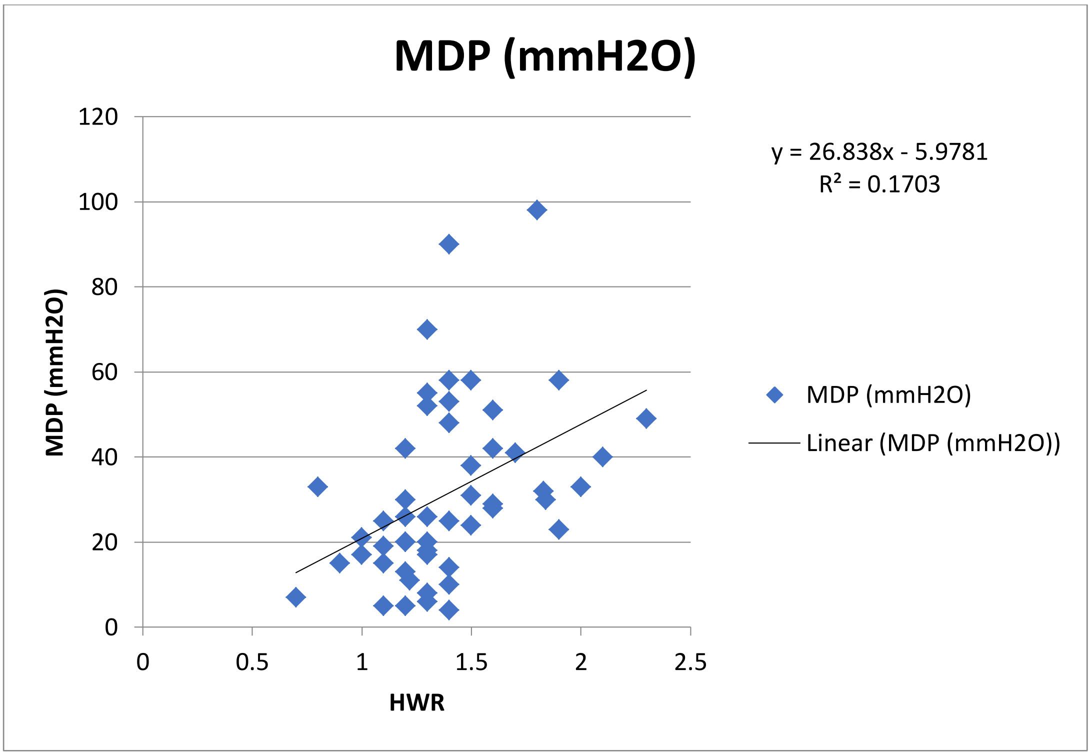
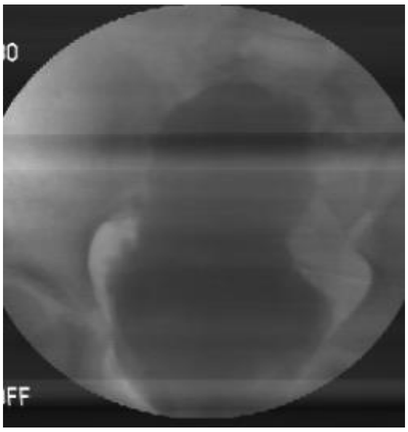


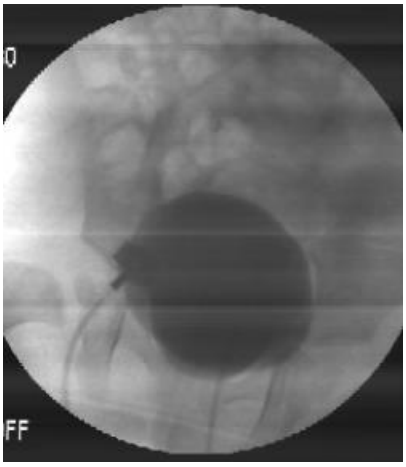
Figure 4: Scatter plot diagram of HWR on horizontal axis and MDP in vertical axis.

The scatter plot shows positive correction between HWR and MDP, with Pearson's product correlation coefficient r=0.412. The p value is 0.002, which is statistically significant. This is suggestive of the positive correlation between HWR and MDP, i.e., bladder with high pressure had higher HWR, which correlate with a vertically elongated bladder in cystogram.



Example 1: Eight-year-old female, operated previously for myelomeningocele with tethering of the cord, with complaints of straining while micturition. Renal ultrasound is normal. VUDS was suggestive of normal capacity bladder, with MDP of 49 cmH_2O and HWR of 2.3. Bladder has appearance of classical “Christmas tree bladder”.

Example 2: Three-year-old female, operated previously for myelomeningocele, with complaints of increased frequency of micturition. Renal ultrasound is normal. VUDS was suggestive of normal capacity bladder, with MDP of 40 cmH_2O and HWR of 2.1.



Example 3: One year old male, operated for atretic MMC, with complaints of occasional straining while micturition. Renal ultrasound is normal. VUDS was suggestive of normal capacity bladder, with MDP of 15 cmH_2O and HWR of 0.9.

Above mentioned examples are suggestive of higher HWR in patients with high bladder pressure compared to children with low bladder pressure.

On interpreting the results using area under the curve, sensitivity and specificity of the HWR to discriminate high pressure bladder was 93.7% (95% CI 69.8- 99.8) and 45.7% (95% CI 28.8-63.4) respectively. Area under the curve was 0.746 (95% CI 0.605- 0.858), with cut off value of 1.22. ($p < 0.001$) (figure 8)

With higher sensitivity and low specificity, HWR can be employed as a screening tool to potentially identify the high-pressure bladder. However, it cannot confirm the diagnosis, which would require uro-dynamic study.

When a cut-off value of the HWR was 1.4 to discriminate higher pressure bladder, sensitivity of the HWR fell to 50% and specificity was 74.29%. Though the specificity increased, sensitivity was less when HWR was 1.4. Hence the cut off value of 1.22 was used as to use HWR as a screening tool to identify high pressure bladder.

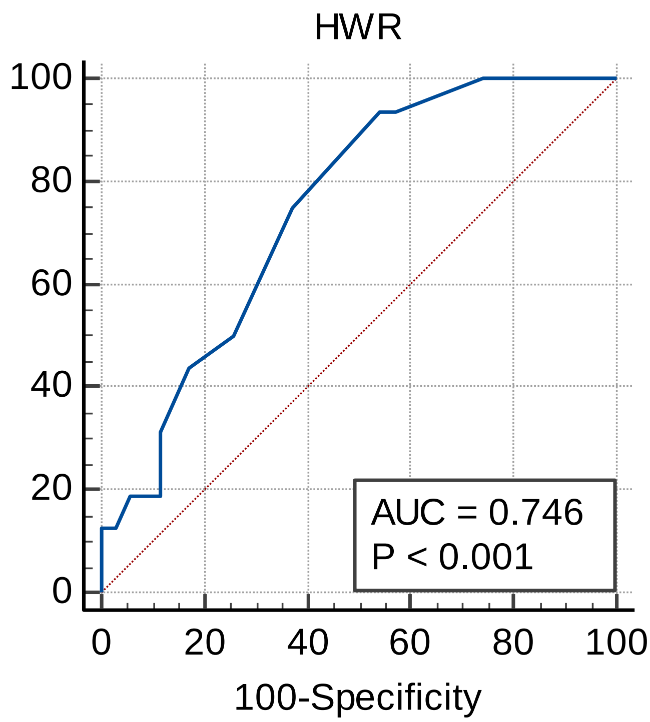


Figure 5: Evaluation of the cut-off value of the HWR using the receiver operating characteristic curve. Area under the curve Z 0.746 (95% CI 0.605- 0.858)

DISCUSSION

The most common cause of neurogenic bladder in children being spinal dysraphism requires early diagnosis and intervention to prevent upper tract deterioration. High storage pressure and poor compliance of the bladder can lead to upper tract deterioration and recurrent urinary tract infection, landing the patient in end-stage renal disease. Hence urologic follow-up of these patients is necessary to ensure prevention of the renal injury.

In a study from 1962, Robert Martin Spellman implemented a few principles in the management of neurogenic bladder in children operated for myelomeningocele to reduce the storage pressure and reduce the residual volume of urine. This included initiation of uro-prophylaxis, timed voiding, and applying suprapubic pressure to facilitate adequate voiding. Implementation of measures to reduce bladder storage pressure and residual urine showed significant improvement in hydronephrosis, VUR, and urinary tract infection (16). It necessitates the need to identify the patients with high risk and diagnose neurogenic bladder to intervene at the right time to improve the condition of the patients. It was in 1981, McGuire et al, studied the significance of the urodynamic study to diagnose neurogenic bladder and to use it as a tool for follow-up of children with neurogenic bladder. This study demonstrated an increased risk of VUR and hydronephrosis among patients with high urethral closing pressure and intravesical pressure of more than 40 cmH2O (10). Further studies done later emphasized the risk of upper tract deterioration with maximum detrusor pressure of more than 40 cmH2O. Hence in the present study, detrusor pressure at the maximum cystometric capacity or at leak point of more than 40 cmH2O was considered an independent risk factor for upper tract deterioration. Out of fifty- one patients who were included in this study, sixteen patients (31.3%) had MDP of more than 40 cmH2O, with slightly male predominance (M: F=9:7). Majority of the patients included in the study belonged to the age group of one to five years. Thirty-seven patients belonged to the same age group and eleven patients out of them had high-pressure bladder, amounting to 68.75% of all the patients with high-pressure bladder. The majority of the diagnosis of the high-pressure bladder in our study cohort is done in the one-to-five-year age group, which could be due to uneven distribution of the patients according to the age where a majority of the patients who underwent VUDS belonged to the same age group. Further study is required with a larger sample size and longer follow-up duration.

It is important to follow the patients operated on for neural tube defects with renal ultrasound, urodynamic study, and voiding cystourethrogram. Sager C et al have found abnormal urodynamic parameters on initial urologic evaluation, including maximum cystometric capacity, detrusor overactivity, and maximum detrusor pressure in the majority of patients operated on for myelomeningocele. More than 70% of these children will progress to upper tract deterioration if left untreated (18). In our study, forty- three patients (84.31%) had renal ultrasound reports available at the time of the urodynamic study apart from the patients with VUR. Six of these patients, i.e., 13.95% of the patients had upper tract deterioration in the form of hydronephrosis or hydroureteronephrosis and 50% of them (three patients) had increased bladder wall thickness. Four out of six patients (66.67%) with upper tract deterioration had maximum detrusor pressure of more than 40 cmH2O. Though not statistically significant, it is to be noted that the mean value of maximum detrusor pressure in the patients with upper tract dilatation was 49.6 cmH2O and in patients without upper tract dilatation was 30 cmH2O. This result demonstrates that a high-pressure bladder has a higher risk of upper tract deterioration, in the form of hydronephrosis and VUR.

Apart from the high storage pressure, poor compliance of the bladder is also detrimental to upper tract deterioration. Bladder wall thickening in renal ultrasound is indicative of poor compliance of the bladder. In a study by Prakash et al, apart from detrusor leaking pressure of more than 40 cmH2O, bladder wall thickening was an important detrimental factor for upper tract dilatation (21). But in our study, bladder wall thickening was not associated with abnormal urodynamic parameters. It is also to be noted that the number of patients with bladder wall thickening noted in our cohort was small, i.e., only 3 patients. A few studies done in the past had equivocal results regarding bladder wall thickness and bladder pressure. Study by Tanaka H et al and Sekerci CA et al, has concluded that bladder wall thickness is predictive of abnormal video-urodynamic parameters [(35), (36)]. A similar study with better methodology, by Kim WJ et al in 2015, found no changes in the video-urodynamic parameters with bladder wall thickness apart from bladder trabeculations similar to our study (37).

Among the patients who underwent video-urodynamic study in the present study, none of them were on anticholinergic agents as it is the institutional protocol to administer anticholinergic agents depending on the urodynamic study. Before the video-urodynamic study, the urine culture of the patient was ensured to be sterile and antibiotic prophylaxis was administered. Earlier studies by EK Johnson et al and Neha Malhotra et al suggest that antibiotic prophylaxis is required while performing a voiding cystourethrogram or urodynamic study if associated risk factors are present [(38),(39)]. The neurogenic bladder acts as a risk factor to develop UTI following urodynamic study due to significant post-void residual volume and practice of intermittent catheterization. It is due to that the patients with neurogenic bladder have significant post-void residual urine and a high risk of VUR. These factors along with the practice of CIC increase the risk of urinary tract infection during the video-urodynamic study. Hence patients underwent a video-urodynamic study once the urine culture was suggestive of no growth.

Patients presenting in the neonatal period were initiated on clean intermittent catheterization at the earliest. As per the observation from previous studies, better compliance was noted among the parents along with the achievement of continence when intermittent catheterization was initiated at the earliest, especially in the neonatal period (6). A study by Wael Elzeneini et al in 2018, demonstrated a reduced incidence of renal scarring and hydronephrosis when the intermittent catheterization of the children was done at the earliest, especially in the neonatal period (40). With the introduction of intermittent catheterization in the neonatal period, around ten patients were compliant with intermittent catheterization. Though seven patients among them (70%) had maximum detrusor pressure of less than 40 cmH2O, it was not found to be statistically significant, which could be due to the small sample size of the study. However, parents have to be motivated for intermittent catheterization to achieve continence. In our institute, we have been trying to implement early initiation of intermittent catheterization, especially in the neonatal age group to achieve better compliance as suggested by recent studies.

Twenty patients (39.22%) had abnormal bowel habits in the form of constipation. To avoid fallacious readings in the urodynamic study, bowel preparation was done using an enema before the study. Patients with chronic constipation were started on bowel management by dietary modification, laxatives, or bowel washes as per the requirement of the patient.

As suggested by McGuire et al in a study in 1981, low resting urethral pressure was associated with incontinence, and high resting urethral pressure was associated with upper tract abnormality and VUR. Patients with low resting urethral pressure might be more symptomatic due to incontinence, however, upper tract deterioration is associated with high urethral closing pressures or elevated intravesical pressures (10). In our study, thirty- five patients had urinary complaints including storage and voiding complaints, out of which twenty-five patients had storage complaints in the form of incontinence, hesitancy, and increased frequency of voiding. The remaining ten patients had voiding complaints in the form of straining, intermittent voiding, and incomplete voiding. Even though high storage pressure was found in eight patients with storage complaints and five patients with voiding complaints, it was not statistically significant. Urinary complaints of the patients can reflect the bladder pressure in patients with neurogenic bladder, however, it is not accurate. The presence of symptoms points towards a high-pressure bladder necessitating a urodynamic study to understand bladder pressure during filling and voiding, but cannot conclude regarding the diagnosis and type of neurogenic bladder.

Similarly, a small capacity bladder, defined as a bladder with a capacity less than 50% of the expected bladder capacity shown to play a significant role in determining renal deterioration (18). In our study, eight patients (15.68%) had small capacity bladders with two of them having maximum detrusor pressure of more than 40 cmH2O. It was not statistically significant that the small capacity bladder is associated with the high-pressure bladder, hence playing no significant role in upper tract dilatation. This could be explained by the theory proposed by McGuire et al, that patients with low resting urethral pressure are known to have incontinence and increased frequency of micturition, resulting in a small capacity bladder. A bladder with low resting urethral pressure is known to have no upper tract dilatation (10).

The urodynamic study provides necessary information regarding the storage pressure and voiding pressure of the bladder which are required to diagnose and follow up the patients with neurogenic bladder. Performing urodynamic study is difficult and a tedious task in children, but if the neurogenic bladder is left untreated, it can lead to irreversible and silent renal injury. In 2017, Opoku P et al suggested that it is imperative to perform a urodynamic study even in a resource-poor setting to diagnose and actively management of the neurogenic bladder in children. (29). But performing a urodynamic study is difficult in children and can provide fallacious results due to several factors, including subject error or observer error. Errors can also arise due to the non-availability of age-appropriate consumables like smaller-sized catheters for children (28). All the above-mentioned factors make it difficult to follow the guidelines for the management of neurogenic bladder, especially in resource-poor centers.

It was in 1996, when McGuire et al stressed the importance of video-urodynamic study in place of UDS, to correlate between structure and function in some pathologies of the bladder where enough information cannot be gathered by UDS, including neurogenic bladder in myelomeningocele patients (24). The video-urodynamic study is now considered the standard care of management to diagnose and for follow-up of patients with neurogenic bladder.

Voiding cystourethrogram, which is to be performed for the follow-up of the patients with neurogenic bladder only provides information regarding the shape of the bladder, presence or absence of trabeculation, and VUR. It should ideally be done whenever upper tract dilatation is present. VCUG performed easily in children and interpreted without much difficulty is done in most of the centers.

Neurogenic bladder is classically defined as “Christmas bladder” or “pine cone bladder” in cystogram, which is a vertically elongated bladder with a wide base that tapers towards the dome with an irregular bladder wall due to trabeculation. The low compliance and high outlet pressure in the bladder lead to vertical elongation of the bladder with trabeculation.

The bladder appears vertically elongated in the neurogenic bladder due to the morphology of the muscle of the bladder. Layers of the detrusor muscles are arranged longitudinally in the innermost layer, in a circular fashion in the middle layer, followed by longitudinally in the outermost layer. The smooth muscles of the bladder elongate and rearrange in the wall during the filling phase of the bladder, giving a vertically elongated appearance. Hence the bladder with a larger volume gives the appearance of an elongated bladder even in normal children [(41), (42)]. Earlier studies have demonstrated that no relationship exists between bladder volume, shape and contour of the bladder, and urodynamic parameters (26). In our study, we found no significant difference in the bladder volume depending on the bladder pressure though the high-pressure bladder appears vertically elongated. Vertical elongation of the bladder has been demonstrated to be due to high intravesical pressure, which induces changes in detrusor smooth muscles and extracellular matrix (43).

Multiple studies in the past have tried to correlate the deformity of the bladder with storage pressure. Ogawa T et al in 1991 graded bladder deformity from grade zero to three, based on appearance. No objective method was used in the study. They found a higher risk of upper tract deterioration, i.e., up to 62% in patients with high-grade bladder deformity (30).

Similarly, trabeculations which can be seen in the cystogram was also used to define the degree of bladder deformity and correlate with bladder storage pressure and upper tract deterioration. Diagnosis of trabeculation needs to be done using cystoscopy, however, it can also be appreciated in cystograms. The severity of bladder trabeculation can alter the decision of the management of neurogenic bladder. Several studies in the past, especially by Khoury et al and Blake Selby et al tried to establish an objective measurement of trabeculation in the cystogram for effective management of neurogenic bladder. Khoury et al suggested that the presence of severe trabeculation in the neurogenic bladder indicate high intrinsic outlet resistance and should be considered during surgical decision (32). It was in 2020 when Blake Selby et al tried to establish an objective measurement of bladder trabeculation using grades ranging from zero to two. This objective measurement of bladder trabeculation provides a tool that is reproducible with high inter and intra-rater reliability. However further study is required to check the reliability of the grading to determine upper tract deterioration (13). But appreciating trabeculation in the cystogram is a relatively subjective measurement that depends on the observer. Hence this variable has not been considered in this study.

Another remarkable work by Yohei Kumano et al in 2020, defined an objective tool to measure bladder deformity. Considering the theory of the vertically elongated appearance of the bladder in the neurogenic bladder, the height-to-width ratio was defined as the ratio of the maximum height of the bladder to the maximum width at the maximum cystometric capacity. They observed that the height-to-width ratio (HWR) was significantly higher for high-pressure bladders with sensitivity and specificity of the HWR for discriminating children with high-pressure bladder were 87% and 56.9%, respectively with a cut-off score of 1.4 (15).

When we used a similar method of height-to-width ratio to describe the bladder deformity and correlate the ratio with maximum detrusor pressure, it was found to be statistically significant. Patients with low-pressure bladder had a median HWR of 1.3 (IQR- 1.15,1.45) and patients with high-pressure bladder had a median HWR of 1.45 (IQR- 1.37,1.72). The HWR was significantly higher in patients with high-pressure bladder, with a p-value of 0.004. The scatter plot in the present study showed positive correction between HWR and MDP, with Pearson's product correlation coefficient r=0.412. The p-value is 0.002, which is statistically significant. This is suggestive of a higher ratio of height to width of the bladder with high bladder pressure. It correlates with the old school of thought that the high-pressure bladder is vertically elongated.

On plotting the ROC curve, the area under the curve (AUC) was 0.746 (95% CI 0.605- 0.858). If a cut-off value of HWR of 1.22 was selected to determine high-pressure bladder in children, the sensitivity will be 93.7% and the specificity will be 45.7%. When a cut-off value of HWR of 1.4 was used, the sensitivity and specificity of HWR to determine high-pressure bladder was 50% and 74.29% respectively. With 1.4 as the cut-off value of HWR, though the specificity has increased, the sensitivity is only 50%, making it not ideal as a screening tool for high-pressure bladder. To use HWR as a screening tool, a cut-off value of 1.22 has been considered since the sensitivity is 93.7%. Higher sensitivity is suggestive that HWR can be used as a screening tool to identify the high-pressure bladder, however low specificity prevents us from using a cystogram in the place of VUDS. Hence, though the high-pressure bladder appears vertically elongated in cystogram, VUDS is a must for diagnosis and follow-up of patients with neurogenic bladder. It is also to be noted that changes in the bladder shape and appearance of trabeculation will take time to appear in the high-pressure bladder. In a study by Ronaldo Alvarenga Álvares et al, it was noted that the response of the bladder to botulinum toxin could not be assessed using a cystogram, however, could only be appreciated using a urodynamic study (25). Hence the bladder deformity takes time to appear though pressure changes are present in the bladder. The treatment of the patient should not be delayed by waiting for the deformity of the bladder to appear in a cystogram. Video- urodynamic study has to be performed to diagnose and for follow-up of neurogenic bladder. In the resource-poor setting, where VUDS or UDS is not available, height to width ratio of the bladder in the cystogram can be used as a screening tool to identify high-pressure bladder. If the height of the bladder is more than 1.22 times the width of the bladder, it is considered to be a high-pressure bladder, requiring further evaluation. It is very important to identify high-pressure bladder to initiate medical management in these patients to avoid upper tract deterioration. In the present study, though the association of the upper tract dilatation with maximum detrusor pressure was not present, (p= 0.076), the mean value of MDP was higher among the patients with upper tract dilatation. Hence regular follow-up of the patients with renal ultrasound, UDS, and VCUG or VUDS is necessary to prevent renal injury.

The limitations of the study were mainly due to the relatively small sample size. The calculation of the height-to-width ratio does not take into consideration the trabeculation. The presence of trabeculation also indicates a high-pressure bladder necessitating surgical intervention. Another limitation was due to including patients belonging to a wide range of age groups, ranging from seven months to seventeen years. There is no established nomogram for age-adjusted HWR and bladder pressure. Follow-up was not a part of the present study protocol, hence progress of upper tract deterioration, the effect of the medical management, and clean intermittent catheterization could not be assessed. AUC for MDP and HWR was 0.746, which is a reasonable value, but not strong to conclude that HWR can be used to diagnose high-pressure bladder.

CONCLUSION

Objective measurement of the bladder deformity in the neurogenic bladder was done using height to width ratio to describe the vertically elongated “Christmas tree bladder”. In the study cohort, 31.3% of the children had high-pressure bladder, with maximum detrusor pressure measuring more than 40 cmH2O. The median value of height-to-width ratio was 1.3 among the patients with an MDP value less than 40 cmH2O and 1.45 among the patients with an MDP of more than 40 cmH2O, indicating higher HWR among the patients with higher MDP. A positive correlation was present between HWR and MDP of the patients, with Pearson’s product correlation coefficient r=0.412. In the present study, it was found that height to width ratio of the bladder in cystogram can be used as a screening tool to diagnose high-pressure bladder, with a cut-off value of 1.22, with a sensitivity of 93.7% and specificity of 45.7% to detect high-pressure bladder. This could help to mobilize the children with high-pressure bladder and seek necessary medical aid to prevent irreversible renal injury in children with neurogenic bladder, especially in resource-poor setting. Video urodynamic study has to be performed to confirm the diagnosis and plan for further management.

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APPENDIX-I

ETHICAL CLEARANCE CERTIFCATE

अखिल भारतीय आयुर्विज्ञान संस्थान, जोधपुर

All India Institute of Medical Sciences, Jodhpur

संस्थागत नैतिकता समिति

Institutional Ethics Committee

No. AIIMS/IEC/2021/ 3569

Date: 12/03/2021

ETHICAL CLEARANCE CERTIFICATE

Certificate Reference Number: **AIIMS/IEC/2021/3404**

Project title: **"Correlation of height to width ration of bladder in cystogram with bladder pressure in children operated for neural tube defect"**

Nature of Project:	**Research Project Submitted for Expedited Review**
Submitted as:	**M.Ch. Dissertation**
Student Name:	**Dr. Shrilakshmi**
Guide:	**Dr. Arvind Sinha**
Co-Guide:	**Dr. Manish Pathak, Dr. S. Bhaskar, Dr. Kirtikumar Rathod, Dr. Rahul Saxena & Dr. Avinash Jadhav**

Institutional Ethics Committee after thorough consideration accorded its approval on above project.

The investigator may therefore commence the research from the date of this certificate, using the reference number indicated above.

Please note that the AIIMS IEC must be informed immediately of:

- Any material change in the conditions or undertakings mentioned in the document.
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research.

The Principal Investigator must report to the AIIMS IEC in the prescribed format, where applicable, bi-annually, and at the end of the project, in respect of ethical compliance.

AIIMS IEC retains the right to withdraw or amend this if:

- Any unethical principle or practices are revealed or suspected
- Relevant information has been withheld or misrepresented

AIIMS IEC shall have an access to any information or data at any time during the course or after completion of the project.

Please Note that this approval will be rectified whenever it is possible to hold a meeting in person of the Institutional Ethics Committee. It is possible that the PI may be asked to give more clarifications or the Institutional Ethics Committee may withhold the project. The Institutional Ethics Committee is adopting this procedure due to COVID-19 (Corona Virus) situation.

If the Institutional Ethics Committee does not get back to you, this means your project has been cleared by the IEC.

On behalf of Ethics Committee, I wish you success in your research.

Dr. Praveen Sharma
Member Secretary

Member secretary
Institutional Ethics Committee
AIIMS Jodhpur

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E-mail : ethicscommittee@aiimsjodhpur.edu.in; ethicscommitteeaiimsjdh@gmail.com

APPENDIX II

All India Institute of Medical Sciences, Jodhpur, Rajasthan

INFORMED CONSENT FORM

Title of study: CORRELATION OF HEIGHT TO WIDTH RATIO OF BLADDER IN CYSTOGRAM WITH BLADDER PRESSURE IN CHILDREN WITH NEURAL TUBE DEFECT

Name of PG Student: Dr Shrilakshmi,
Mobile no.: 9449918911

Patient/Volunteer registration no________________________________

I, _______________ S/o or D/o _________________R/o_____________ give full, free, I, _______________ S/o or D/o ________________ R/o_____________ give full, free, voluntary consent for my child to to be included in the study "CORRELATION OF HEIGHT TO WIDTH RATIO OF BLADDER IN CYSTOGRAM WITH BLADDER PRESSURE IN CHILDREN WITH NEURAL TUBE DEFECT".

The nature and procedure of which has been explained to me in my own language to my full satisfaction. I confirm that I have been explained regarding the study.

I understand that my consent is voluntary and am aware of my right to opt my child out of the study at any time without need for explanation regarding the same.

I understand that the information collected about me and any of my medical records may be looked at by responsible individual from AIIMS JODHPUR. I give permission for these individuals to have access to my records.

Date : ________________ Place : ________________

Signature/Left thumb impression

This to certify that the above consent has been obtained in my presence.

Date:
Place:

Signature of the PG resident:

Witness 12. Witness 2

____

Signature Name: ________________________	Signature Name: _____________________
Address : ______________________	Address : ____________________

परिशिष्ठ–3

अखिल भारतीय आयुर्विज्ञान संस्थान, जोधपुर

रोगी सूचना पत्रक

अध्ययन का शीर्षक: : " बाल चिकित्सा सर्जिकल रोगियों में न्यूरल ट्यूबल डिफेक्शन के लिए चुने गए बच्चों में ब्लॉडर दबाव के साथ CYSTOGRAM में BLADDER की लंबाई के अनुपात का सुधार”

पीजी छात्र का नाम: **डॉ. श्रीलक्ष्मी**
मोबाइल। नंबर: 9449918911

रोगी / स्वयंसेवक पंजीकरण नं।____________________________________
I, _______________ S / o या D / o _________________ R / o _____________ पूर्ण, मुक्त, मेरे बच्चे को अध्ययन में शामिल करने के लिए स्वैच्छिक सहमति " बाल चिकित्सा सर्जिकल रोगियों में न्यूरल ट्यूबल डिफेक्शन के लिए चुने गए बच्चों में ब्लॉडर दबाव के साथ CYSTOGRAM में BLADDER की लंबाई के अनुपात का सुधार” जिसकी प्रकृति और प्रक्रिया को मुझे समझाया गया है। अपनी पूरी संतुष्टि के लिए अपनी भाषा में। मैं पुष्टिकरता हूं कि मुझे अध्ययन के संबंध में समझाया गया है।
मैं समझता हूं कि मेरी सहमति स्वैच्छिक है और मुझे अपने अधिकार काअध्ययन करने के अधिकार के बारे में किसी भी समय स्पष्टीकरण केबिना स्पष्टीकरण के अधिकार के बारे में पता है।

मैं समझता हूं कि मेरे और मेरे किसी भी मेडिकल रिकॉर्ड के बारे मेंएकत्रित जानकारी को AIIMS JODHPUR के जिम्मेदार व्यक्ति द्वारादेखा जा सकता है। मैं इन व्यक्तियों को अपने रिकॉर्ड तक पहुंचने कीअनुमति देता हूं।

तारीख : ________________
स्थान : ________________

____
हस्ताक्षर / बाएं अंगूठे का निशान

यह प्रमाणित करने के लिए कि मेरी उपस्थिति में उपरोक्त सहमति प्राप्तहुई है।
तारीख : ________________
स्थान : ________________

____
पीजी छात्र के हस्ताक्षर

साक्षी 1	गवाह 2
हस्ताक्षर	हस्ताक्षर
नाम	नाम:
पता:	पता :

APPENDIX IV

All India Institute of Medical Sciences, Jodhpur, Rajasthan

Patient Information Sheet

Protocol No: Sponsor: Nil

Principal Investigator: Dr Shrilakshmi

Name of Participant:

Title: CORRELATION OF HEIGHT TO WIDTH RATIO OF BLADDER IN CYSTOGRAM WITH BLADDER PRESSURE IN CHILDREN OPERATED FOR NEURAL TUBE DEFECT"

Aim of study: To find out the correlation of the height to width ratio of bladder in cystogram with bladder pressure in children with neural tube defect

Centre: Study will be carried out in All India Institute of Medical Sciences, Jodhpur under the supervision of Dr. Arvind Sinha.

Study procedure: After taking consent, detailed history and clinical examination of the patient will be done. Standard fluid cystometry will be done. Maximum Detrussor Pressure (MDP) will be calculated. Bladder shape and vesicoureteral reflux (VUR) will be evaluated at maximum cystometric capacity (MCC). Patients with Grade III-V will be excluded. The Height to Width Ratio (HWR) of the bladder will be calculated by the maximum height/maximum width of the cystogram appearance at MCC. Age, sex, VUDS variables, and HWR will be compared.

Confidentiality: The identity of each patient will be kept confidential.

Risk: Enrolment in the study will not pose any additional risk to the patient. Patient can withdraw from the study at any time without offering reasons. Not participating in study will not lead to any treatment being denied.

For further information / questions, the following personnel can be contacted:

Dr. Shrilakshmi ,
Junior Resident,
Department of Paediatric Surgery,
All India Institute of Medical Sciences, Jodhpur
Phone number: 9449918911
email address: shriaithal96@gmail.com

APPENDIX V

अखिल भारतीय आयुर्विज्ञान संस्थान जोधपुर, राजस्थान

रोगी सूचना पत्र

प्रोटोकॉल संख्या: प्रायोजक: शून्य

प्रधान अन्वेषक: डॉ. श्रीलक्ष्मी

प्रतिभागी का नामC

शीर्षक: बाल चिकित्सा सर्जिकल रोगियों में न्यूरल ट्यूबल डिफेक्शन के लिए चुने गए बच्चों में ब्लॉडर दबाव के साथ CYSTOGRAM में BLADDER की लंबाई के अनुपात का सुधार।

अध्ययन का उद्देश्य: बाल चिकित्सा सर्जिकल रोगियों में तंत्रिका ट्यूब दोष वाले बच्चों में मूत्राशय के दबाव के साथ सिस्टोग्राम में मूत्राशय की चौड़ाई के अनुपात के संबंध का पता लगाने के लिए।

केंद्र: डॉ० अरविन्द सिन्हा की देखरेख में अखिल भारतीय आयुर्विज्ञान संस्थान, जोधपुर में अध्ययन किया जाएगा।

अध्ययन प्रक्रिया: अध्ययन में शामिल सभी रोगियों को उचित सहमति और अध्ययन में भाग लेने की इच्छा के साथ

रोगी का विस्तृत इतिहास और नैदानिक परीक्षण किया जाएगा। मानक द्रव सिस्टोमेट्री किया जाएगा। अधिकतम डेट्रॉसर दबाव ;एमडीपीद्ध की गणना की जाएगी। मूत्राशय के आकार और vesicoureteral भाटा (VUR) का मूल्यांकन अधिकतम सिस्टोमेट्रिक क्षमता (MCC) में किया जाएगा। ग्रेड III-V वाले मरीजों को बाहर रखा जाएगा। मूत्राशय की ऊंचाई से चौड़ाई अनुपात (HWR) की गणना MCC में सिस्टोग्राम उपस्थिति की अधिकतम ऊंचाई / अधिकतम चौड़ाई द्वारा की जाएगी। आयुए लिंगए टन्वै चर और HWR की तुलना की जाएगी।

गोपनीयता: प्रत्येक रोगी की पहचान गोपनीय रखी जाएगी।

जोखिम: अध्ययन में नामांकन से मरीज को कोई अतिरिक्त खतरा नहीं होगा। रोगी बिना किसी कारण के किसी भी समय अध्ययन से हट सकता है। अध्ययन में भाग नहीं लेने से किसी भी उपचार से इनकार नहीं किया जाएगा।

अधिक जानकारी/ प्रश्नों के लिए. निम्नलिखित कर्मियों से संपर्क किया जा सकता है:

डॉ. श्रीलक्ष्मी
जूनियर रेजिडेंट,
बाल चिकित्सा विभाग,
अखिल भारतीय आयुर्विज्ञान संस्थान, जोधपुर
फोन नंबर: 9449918911, ईमेल पता: shriaithal96@gmail.com

APPENDIX VI

All India Institute of Medical Sciences, Jodhpur, Rajasthan

PROFORMA

PATIENT ID

• Name:

• Age:

• Sex:

• Diagnosis:

• Bowel habit:

• Bladder complaints: Yes/No-

• If yes, frequency/ incontinence or straining/ incomplete voiding

• Practicing CIC- yes/ no

• Anticholinergic agents- yes/ no

• USG:

Right Kidney	APD	
	Cortical Thickness	
Left Kidney	APD	
	Cortical thickness	

- Type of hydronephrosis:
- Status of ureter:
- VUDS:

Detrusor overactivity during filling phase	
Maximum cystometric capacity (MCC)	
Expected cystometric capacity	
Maximum Detrusor pressure	
Presence or absence of relfux	
Height to width ratio of the bladder at MCC	

MASTER CHART

name	GENDER	AGE	DIAGNOSIS	bowel habit	frequency/ incontinence	straining/ incomplete voiding	CIC	Anticholinergic	USG- KUB findings	Maximum cystometric capacity (MCC)	Expected bladder capacity	Maximum detrussor press/ leak point pressure	Height to width ratio of the bladder	VUR
Mahima	Female	11 years	MMC	normal	no	no	NO	no	NA	328	390	11	1.22	Absent
kavya somani	Female	5 years	lumbar MMC	constipation	yes	no	YES	no	NA	87	210	5	1.2	Absent
Narayan Sharma	MALE	12 years	MMC with tethering of cord	incontinence	yes	no	NO	no	normal study	159	400	52	1.3	Absent
Devendra	MALE	5 years	lumbar MMC	normal	no	no	NO	no	NA	163	210	55	1.3	Absent
Garvik Choudhary	MALE	1 year	atretic MMC	normal	no	yes	NO	no	Normal	93	90	15	0.9	Absent
samita	Female	17 years	lipoMMC	no	yes	no	YES	no	normal study	299	500	7	0.7	Absent
kalpesh	MALE	14 years	MMC	normal	yes	no	NO	no	normal	107	480	24	1.5	Absent
b/o muli devi	MALE	2 years	MMC	normal	no	no	NO	no	normal	118	120	38	1.5	Absent
Navika	Female	1 year	MMC	constipation	yes	no	YES	no	normal	40	90	8	1.3	Absent
Mukesh	MALE	12 years	lipoMMC	normal	yes	no	NO	no	Left HDN with trabeculated thick walled bladder	223	420	58	1.4	Absent
kalpesh	MALE	3 years	MMC	normal	no	yes	NO	no	normal	153	150	58	1.5	absent
gorav	MALE	4 years	thoracolumbar MMC	normal	yes	no	NO	no	normal	106	180	23	1.9	Absent
Manish	MALE	3 years	lipo MMC	normal	no	no	NO	no	NA	151	150	10	1.4	Absent
Devansh	MALE	3 YEARS	MMC with tethering of cord	normal	no	yes	YES	no	right hydroureter	166	150	42	1.2	Absent
sunita	Female	6 years	MMC with tethered cord	constipation	no	no	YES	no	thick walled urinary bladder (4.5mm) with prominent PCS	212	240	28	1.6	Absent
Sonal	Female	8 years	MMC with tethered cord	constipation	no	yes	YES	no	NA	245	250	49	2.3	Absent
manish kumar	MALE	4 years	lipoMMC	constipation	yes	no	NO	no	NORMAL	112	180	31	1.5	Absent
LAXMI	Female	4 years	lumbar MMC	constipation	no	yes	NO	no	normal	161	180	41	1.7	Absent
Tamanna	Female	5 years	MMC	constipation	yes	no	NO	no	NA	124	210	6	1.3	Absent
Angel	Female	5 years	MMC	constipation	yes	no	NO	no	solitary left kidney with prominent PCS and ureter	78	210	14	1.4	Absent
lakh singh	MALE	15 years	MMC	constipation	yes	no	NO	no	normal	160	500	20	1.2	Absent
sonal	Female	8 years	MMC	normal	no	yes	NO	no	NA	289	300	29	1.6	Absent
najami khanam	Female	4 years	lipoMMC	normal	no	yes	NO	no	NA	180	180	30	1.84	Absent
sunita	Female	5 years	MMC	normal	no	yes	NO	no	NORMAL	210	210	32	1.83	Absent
Kavita	Female	4 years	MMC	constipation	yes	no	NO	no	normal	154	180	20	1.2	Absent
lalit kumar	MALE	5 years	MMC	constipation	yes	no	NO	no	normal	154	210	30	1.2	Absent
CHINTU	MALE	3 years	MMC	normal	yes	no	NO	no	normal	83	150	70	1.3	Absent
Diksha	Female	4 years	lipomyelocele with diastometamyelia	constipation	yes	no	NO	no	normal	110	180	20	1.3	Absent
vinta kumari	Female	3 years	MMC	constipation	yes	no	NO	no	normal	97	150	51	1.6	Absent
rajveer	MALE	3 years	lipoMMC	constipation	yes	no	NO	no	normal	88	150	25	1.4	Absent
b/o Saroj	Female	3 years	MMC	normal	yes	no	NO	no	normal	98	150	40	2.1	Absent
josna kanwar	Female	3 years	MMC with tethered cord	constipation	yes	no	NO	no	normal	110	150	19	1.1	Absent
jasmine	Female	1 year	MMC with tethered cord	normal	no	no	NO	no	normal	75	90	13	1.2	Absent
kishor	MALE	5 years	MMC with diastometamyelia	NORMAL	no	no	NO	no	normal	250	210	18	1.3	Absent
palak	Female	2 years	lipoMMC	normal	no	no	YES	no	Normal	109	120	33	2	Absent
sourab	MALE	1 year	rachischisis	normal	yes	no	YES	no	normal	63	90	33	0.8	Absent
b/o suguna	Female	4 years	MMC	normal	yes	no	NO	no	normal	127	180	4	1.4	Absent
rama	MALE	1 year	MMC	normal	no	yes	NO	no	Normal	98	90	17	1	absent
Anamika	Female	4 years	LS- MMC	normal	no	no	NO	no	Normal	105	180	25	1.1	Absent
Shankar	MALE	4 years	MMC	Normal	no	no	NO	no	Normal	89	180	90	1.4	Absent
Hitesh	MALE	2 years	MMC	Normal	no	no	NO	no	Normal	150	120	26	1.3	Absent
B/o Lakhi	Female	3 years	MMC	normal	no	no	NO	no	Normal	80	150	53	1.4	Absent
Mohd Hasnain	MALE	3 years	MMC	normal	no	no	NO	no	normal	137	150	26	1.2	Absent
Priyansh	MALE	2 years	LipoMMC	NORMAL	no	no	NO	no	Normal	120	120	21	1	Absent
Reshma	Female	7 motnhs	MMC	normal	yes	no	YES	no	normal	40	90	5	1.1	Absent
Noor Fathima	Female	1.5 yeara	MMC	constipation	no	yes	YES	no	Normal	100	105	42	1.6	Absent
Dhruv	MALE	7 years	MMC	no	yes	no	No	no	normal	157	270	17	1.3	absent
akshit	male	4 years	mmc	constipation	yes	no	no	no	normal	101	180	48	1.4	absent
sher khan	male	17 years	MMC	constipation	no	no	no	no	b/l HDN	543	550	98	1.8	absent
Ashish snehi	male	7 years	MMC	no	no	no	no	no	Normal	146	270	15	1.1	absent
Mukhesh	female	12 years	lipo MMC	constipation	yes	no	no	no	Thick walled urinary bladder (9.5mm), b/l HDN, L>>R	280	420	58	1.9	Absent
nikita	Female	2 years	lipoMMC	constipation	no	yes	YES	no	bilateral HDUN	129	120	33	1.4	PRESENT
KHUSHI	Female	5 years	lumbar MMC	constipation	yes	no	YES	no	Bilateral dilated and tortuous ureters with moderate bilateral hydroureteronephrosis	175	210	23	1.4	PRESENT