ORIGINAL RESEARCH

# Neurogenic Bladder Scoring System: Identifying Patients at Risk for Renal Deterioration and Need for Surgical Intervention

Sigfred Ian R. Alpajaro, MD and David T. Bolong, MD, FPUA

*Section of Urology, Department of Surgery, University of Santo Tomas Hospital*

Myelomeningocele (MMC) is almost universally associated with neurogenic bladder dysfunction (NBD). Renal decline and eventual failure are the most pervasive issues. Unfortunately, no unifying system based on basic clinical, ultrasonographic and urodynamic factors can guide the urologist in treatment in timely treatment decisions.

***Objective***: This aimed is to develop a scoring system predictive of progressive renal deterioration and need for surgery in MMC patients with NBD.

***Materials and Methods***: A previous analysis identified factors that portend poor long-term outcomes (progressive renal deterioration and eventual need for surgery). Based on the odds ratio obtained, a scoring system was created, with parameters including UTI, hydronephrosis, thickened bladder wall, low bladder compliance, elevated Detrussor Leak Point Pressure, Christmas tree bladder pattern, and vesico-ureteral reflux. The discriminatory ability of the model was assessed by the area under the receiver operating characteristic (ROC) curve.

***Results***: The total risk score of each patient ranged from 3 to 41 (mean 17.28 ± 10.84). Mean score for non-surgery group is 10.02 ± 6.52 (Range: 3 - 33) while for surgery group, the mean score is 24.53 ± 9.37 (Range: 5 - 41). The mean score of the groups were statistically significant, having a p-value of <0.00001. Surgery group showed a higher total risk score as compared to the non-surgery group. The area under the curve is 0.908 (Std. Error=0.04; 95% CI: 0.84 - 0.98) showing a good discriminatory power. The positivity cutoff point was set at a score of 14, since there is good sensitivity (87.50%) and good specificity (72.50%) at the said cutoff point. The likelihood ratio for a positive result is equal to 5.0, while the likelihood ratio for a negative result is 0.15.

***Conclusions***: We have developed a clinically applicable scoring system with the aim of identifying MMC patients with NBD who are at risk for renal deterioration and eventual surgery in the future. Patients who have scores beyond the cut off point should be offered a more aggressive management. More experience with its use in the clinical setting is necessary to further validate the system.

***Key words***: myelomeningocele, spina bifida, scoring system

## Introduction

Myelodysplasia, or more commonly, spina bifida pertains to incomplete closure of the vertebral column and malformation of embryonic neural tube, and associated with neurogenic bladder dysfunction (NBD).[1,2] Myelomeningocele (MMC) accounts for most cases of myelodysplasia, where neural roots or segments herniate through vertebral defect.[1,3] The incidence of MMC in the general population ranges from 0.3 to 4.5/1,000 births.4 Its pathophysiology involves folic acid deficiency or maternal exposure to hyperthermia, teratogens (alcohol) and certain medications (Valproic acid). [4-7]

Up to 82% of patients with myelodysplasia are initially seen due to recurrent urinary tract infections.[8] Renal decline and eventual failure are the most important issues in myelodysplasia. If inadequately managed, renal damage in virtually all NBD cases is inevitable, with mortality rates reaching 20%.[9]

Among the well-studied urodynamic factors are elevated Detrussor Leak Point Pressure (DLLP) >40cm H20 and Detrussor External Sphincter Dyssenergia (DESD).[10-14] Voiding cystourethrogram (VCUG) findings of vesico-ureteral reflux (VUR) and a trabeculated "Christmas tree" bladder pattern have also been correlated with renal compromise.[13,15] Finally, ultrasonographic findings of thickened bladder wall, and hydronephrosis have been linked to renal decline on follow-up.[15-17] Vesico-ureteral reflux in MMC is often due to elevated bladder pressures, and back pressure and potential for ascending infections are also a definite risk for renal compromise.[18]

It can never be overemphasized that early urological and nephrologic management decisions impact long-term outcomes in patients with NBD, and management must start before consequences of bladder dysfunction become established. [15] Without proper management, elevated bladder pressures, coupled with recurrent urinary tract infections unavoidably lead to upper urinary tract decline within 3 years in up to 58%.[19-21]

In 2014, the authors of this study identified clinical, urodynamic, and laboratory prognosticators of poor outcomes in long term follow up of MMC patients with NBD.[22] Risk factors of renal decline and eventual need for corrective surgery were specifically identified, namely: UTI at presentation, Hydronephrosis on ultrasound, Thickened bladder (>3.3mm on ultrasound), low bladder compliance (<10cmH20), elevated DLLP (>40cmH20), christmas tree bladder pattern and VUR on VCUG.[22] Individual odds ratio for the endpoint of renal deterioration and need for surgery were computed.

Currently, there seem to be no available screening tool that is encompassing, and aims to measure and predict risk for renal deterioration in MMC patients presenting with NBD. An ideal screening tool should be sensitive, disease-specific, easy to interpret and use in the clinical setting, and multidimensional, thus allowing the physician to gauge what he ought to measure.[23]

With regards to NBD, related screening tools/questionnaires available are the Actionable Bladder Symptoms Screening Tool (ABSST), which is a screening instrument to identify patients who could benefit from lower urinary tract assessment and/or possibly treatment. [23,24] A screening test for NBD but used for multiple sclerosis patients was also developed.[25] The 3-item OAB Awareness Tool (OAB-V3) was found sensitive and specific to OAB patients, and has good clinical utility.[26] A urodynamic score to detect pre- and postoperative neurological deficits in children with a primary tethered cord has also been suggested. [27] A urodynamic scoring system, particularly developed in pediatric cystometrogram, was introduced to assess bladder behavior, although not necessarily predict clinical consequences of its findings.[28] Finally, a numerical scoring was assigned to bladder capacity, contractility and dyssynergia, and correlated change in bladder shape, the presence of uninhibited contractions and the presence of dyssynergia to renal deterioration, and was predictive of VUR and dyssenergia. However, the said system is not as widely used.[29]

This study aimed to develop a scoring system predictive of progressive renal deterioration and need for surgery in MMC patients with NBD.

## Materials and Methods

*Patients*

From 1989 to 2013, a total of 201 patients diagnosed with neurogenic bladder secondary to myelomeningocele were seen and followed up by a pediatric urologist at a tertiary hospital. One hundred and seventy-eight had records that were accessible for review, and were included in a review to determine the prognosticating factors for poor outcome in MMC patients with NBD.[22]

All patients included in the review had data on initial presentation and complaint (recurrent UTI, incontinence) as well as classification of disease (upper motor neuron vs lower motor neuron). Information on baseline ultrasonography of the kidney, ureters, and bladder (KUB), voiding cysto-urethrogram (VCUG), and baseline and at least 1 follow-up videourodynamics were accessed. Data on medical and surgical interventions were evaluated.

The following parameters were reviewed:

The patients' baseline characteristics:

- Patients' initial complaint and presentation (UTI, incontinence, or both), and classification of upper or lower motor neuron disease.

- Diagnostic modalities and work-ups:
  - o ultrasound at presentation- hydronephrosis (grade (low-grades 1,2 and high-grade 4,5) and bilaterality), bladder wall appearance (normal or thickened (>3.3mm)).
  - o Videourodynamics at the baseline and latest follow-up- Compliance (normal or low(<10mmH20)), Detrusor Leak Point Pressure (DLLP) (normal or high (>40mmH20)), Bladder (normal, acontractile, or overactive), Sphincter (synergic, acontractile or dyssenergic).
  - o VCUG information: reflux (presence, grade (low-grades 1,2 and high-grade 3,4), and bilaterality), bladder pattern (smooth, globular vs "Christmas tree" pattern), and bladder neck (closed, initially closed then opens, open all the time).

Endpoints to which all parameters were compared are the following: 1. Need for surgical intervention due to progressive renal deterioration (i.e. vesicostomy, autoaugmentation, enterocystoplasty), 2. Continence (dry) or incontinence (wet), 3. Renal status (same, improved, deteriorated), and 4. Follow-up Urodynamics (same, improved, deteriorated)

*Development of Scoring System*

Based from the aforestated study, significant prognosticators correlated to the endpoint "need for surgery" were identified.

**Table 1**. Summary of identified risk factors of poor long-term outcomes in MMC patients with NBD with need for surgery as endpoint:[22]

| Parameter | Odds Ratio |
|---|---|
| UTI at presentation | [OR = 3.1 (95% CI: 1.3 - 8.5)) |
| Hydronephrosis on US High Grade | (OR = 6.3, 95% CI: 3.8 - 14.7) |
| Hydronephrosis on US | (OR=12.3 (95% CI: 2.7 - 121.6) |
| Thickened Bladder Wall on US | (OR=6 (95% CI: 2.9 - 12.5) |
| Low Compliance on Urodynamics | (OR=2.7(95% CI: 1.2 - 6.3) |
| Elevated DLLP on Urodynamics | (OR= 2.1(95% CI: 1.1 - 4.4)) |
| Christmas Tree Bladder Pattern on VCUG | (OR=5.0 (95% CI: 2.5 - 10.2) |
| Unilateral Reflux on VCUG | (OR= 4.1 (95% CI: 1.6 - 10.3) |
| Bilateral Reflux on VCUG | (OR= 9.6 (95% CI: 4.1 - 23.8) |

The weight of score assignments for the system was based on the odds ratio derived from the previous study. The scoring criteria are summarized in Table 2.

From the cohort of 178 patients used from the previous study. Using One ROC Curve Power Analysis, a sample of 40 from each group yields 79% power to difference of 0.1078 between the area under the ROC curve (AUC) under the null hypothesis of 0.9078 and an AUC under the

**Table 2**. Proposed neurogenic bladder scoring system.

| | | | | |
|---|---|---|---|---|
| Name: | | Age: | | |
| Date: | | AMD: | | |
| Instructions: Encircle where applicable. Add total scores of the corresponding items you choose | | | | |
| Clinical Presentation | UTI at Initial Consult | (+) 3 | | (-) 0 |
| | | High Grade (3,4) | Low Grade (1,2) | None |
| Ultrasonography of the Kidney and Bladder | Hydronephrosis on Ultrasound | 12 | 6 | 0 |
| | | Thick (>3.3mm) | | Normal (<3.3mm) |
| | Thickness of Bladder Wall on Ultrasound | 6 | | 0 |
| | | <10cmH20 | | >10cmH20 |
| Video-Urodynamic Parameters | Bladder Compliance | 3 | | 0 |
| | | >40cmH20 | | <40cmH20 |
| | Detrussor Leak Point Pressure | 2 | | 0 |
| | | Bilateral | Unilateral | None |
| | Vesico-Ureteral Reflux | 10 | 4 | 0 |
| | | Christmas-tree bladder pattern | | Smooth, globular |
| | Bladder Wall Pattern | 5 | | 0 |
| | T O T A L | | | |

alternative hypothesis of 0.8000 using a two-sided z-test at a significance level of 0.05000. With that, 40 patients who underwent surgery and 40 patients who did not undergo surgery were randomly selected, and the proposed scoring system was used.

*Statistics*

Mean and standard deviation (SD) were used to summarize numerical data. Stata/ SE version 12 was used for the analysis of the data. The discriminatory ability of the model was assessed by the area under the receiver operating characteristic (ROC) curve. An area of 1.00 under the ROC curve reflects perfect discrimination while an area of 0.50 reflects absence of discrimination.

## Results

The mean age of the patients included was 10.2 years (1.8-28). Of the 80 patients, 33 (41.2%) were males and 47 (58.8%) were females.

The total risk score of each patient ranged from 3 to 41 (mean 17.28 ± 10.84). Mean score for non-surgery group is 10.02 ± 6.52 (Range: 3 – 33) while for surgery group, the mean score is 24.53 ± 9.37 (Range: 5 – 41). The mean score of the groups were statistically significant, having a p-value of <0.00001. Surgery group showed a higher total risk score as compared to the non-surgery group.

The area under the curve is 0.908 (Std. Error=0.04; 95% CI: 0.84 – 0.98) showing a good discriminatory power (Figure 1).

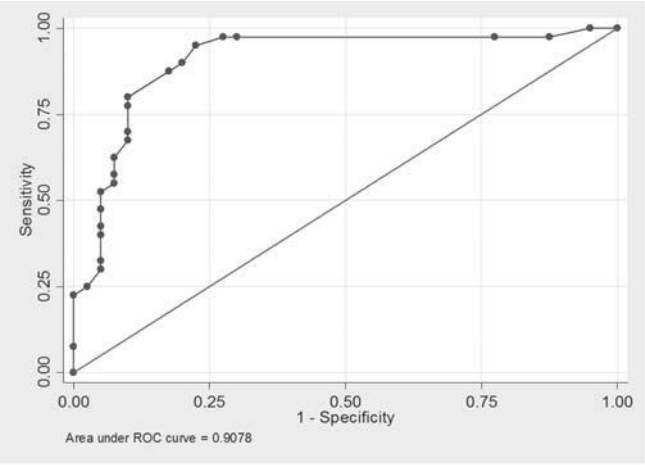


**Figure1.** Receiver operating characteristic curve.

Table 2 shows the specificity and sensitivity of the test using several cutoff points. The positivity cutoff point was set at a score of 14, since there is good sensitivity (87.50%) and good specificity (72.50%) at the said cutoff point. The likelihood ratio for a positive result is equal to 5.0, while the likelihood ratio for a negative result is 0.15.

**Table 2**. Specificity and sensitivity of the test using several cutoff points.

| Cutoff value | Sensitivity (%) | Specificity (%) |
|---|---|---|
| >=3 | 100.00 | 0 |
| >=5 | 100.00 | 5.00 |
| >=6 | 97.50 | 12.50 |
| >=8 | 97.50 | 22.50 |
| >=9 | 97.50 | 70.00 |
| >=10 | 97.50 | 72.50 |
| >=12 | 95.00 | 77.50 |
| >=13 | 90.00 | 80.00 |
| >=14 | 87.50 | 82.50 |
| >=16 | 80.00 | 90.00 |
| >=18 | 77.50 | 90.00 |
| >=19 | 70.00 | 90.00 |
| >=20 | 67.50 | 90.00 |
| >=21 | 62.50 | 92.50 |
| >=22 | 57.50 | 92.50 |
| >=23 | 55.00 | 92.50 |
| >=24 | 52.50 | 95.00 |
| >=25 | 47.50 | 95.00 |
| >=26 | 42.50 | 95.00 |
| >=29 | 40.00 | 95.00 |
| >=30 | 32.50 | 95.00 |
| >=32 | 30.00 | 95.00 |
| >=33 | 25.00 | 97.50 |
| >=35 | 22.50 | 100.00 |
| >=41 | 7.50 | 100.00 |
| >41 | 0 | 100.00 |

## Discussion

At least 10% of patients with NBD deteriorates and require surgery even after maximal anticholinergic dosage and adequate clean intermittent catheterization. [2] It is imperative that timely identification of risk factors for poor long-term outcomes be done, and aggressive approach to work-up and treatments be instituted to prevent irreversible morbidity. Briefly, we review each parameter used in our scoring system.

*UTI.* Up to 81.5% of MMC patients may have asymptomatic bacteuria, and risk factors may be due to poor emptying and introduction of bacteria during CIC. [30] UTI is a usual common manifestation, in that 50% of children with MMC have their first UTI by 15 months of age, and up to 20% may have at least 1 episode per year.[31,32] Coupled with other risk factors such as VUR, the presence of bacteria in the urine may lead to febrile UTIs. [33] With inadequate drainage, bladder residue and retained bacteria lead to recurrent urinary tract infections, precipitating a cycle of transmural inflammation, fibrosis, and further bladder decompensation, and promoting upper tract damage with pyelonephritis due to resultant high intravesical pressures and frequent VUR in MMC .[15]

*Ultrasonographic Findings*

*Hydronephrosis.* Ultrasonography is readily obtainable and one of the initial imaging employed in MMC. Because of high intravesical pressures in NBD, drainage of urine into the bladder is impaired, and pressure transmission to the upper tract may occur even in the absence of VUR, resulting to hydronephrosis. [11,12] *Bladder wall thickness,* with a cut off value of >3.3mm has been suggested to be correlated with unfavorable urodynamic factors such as elevated DLLP and storage pressures. [14]

*Urodynamic Factors*

*DLLP*. In the landmark study of McGuire and colleagues, it was defined that detrusor leak point pressures (DLLP) greater than 40 cm H2O results to upper tract damage in up to 70% of patients. [10] At such pressure, glomerular filtration rate decreases and pyelocaliceal and ureteral drainage become impaired, leading to obstructive hydronephrosis and/or vesicoureteral reflux. [10,34] Closely connected is *low bladder compliance* (<10mmH20), which reflect high pressure, and usually hostile, hypertonic or small, fibrotic bladder.

*VCUG Factors*

*Vesico-ureteral reflux*. Over 50% of MMC patients may have VUR.[35,36] If left unchecked, this results to upper tract pressure elevation and also serves as a conduit for ascension of bacteria which may promote further renal scarring.[15] *Bladder pattern*, specifically "Christmas tree" pattern is suggestive of a trabeculated, low compliance, high-pressure bladder that puts the upper tracts at risk.[37]

Scoring systems as a guide in clinical practice are not new in urology. The ability to have a numerical data to guide the clinician in management is always valuable. Perhaps the most popular is the International Prostate Symptom Scoring, which is used in Benign Prostatic Hyperplasia. The Dysfunctional Voiding Scoring System (DVSS) is a validated tool for voiding dysfunction in children,[38] Other related scoring tools previously described in the urologic setting include ABSST and 3-item OAB Awareness Tool (OAB-V3), among others. [23-29]

However, there is no scoring system that specifically focuses on identifying MMC patients with NBD who are at high risk for progressive renal deterioration and eventual surgery. With a myriad of laboratory and diagnostic procedures available for NBD, there is no unifying guideline that summarizes our work-up findings and potentially providing a concrete pathway for a clinical decision. The choice to perform reconstructive or corrective surgery to allay the damaging high intravesical pressures in patients with NBD, is often a decision of the parents and the surgeon, and this usually happens when renal deterioration has set in.[9] It would be more ideal to have the decision to correct the problems before complications sets in, and a scoring system that can rationally and objectively measure the need to intervene early is essential.

The parameters used in the scoring system presented are readily available. Detection of UTI with urinalysis and or culture is routine, as is the case for ultrasonography of the kidney, ureters, and bladder. Urodynamics is part and parcel of evaluation of neurogenic bladder, while VCUG is often integrated as part of video-urodynamics or necessitated as an individual work up during other indications (i.e. febrile UTI). Thus, the authors feel that majority, if not all MMC patients, will have the data necessary to accomplish the scoring system.

With regards to setting the cut-off point in the scoring system, the ROC curve provides a guide at which point has the highest sensitivity and specificity. In reality, setting the cut-off point may be flexible, based on benefit/cost that the clinician wants. The specificity and sensitivity of different cut-off points depicted in Table 2 can serve as a guide should one decide to adjust the cut-off value. In general, one must maximize the number of true positives (correctly diagnosed to be in need of surgery) with an acceptable false positive rate (falsely diagnosed requiring surgery). If we set the cut off at a very sensitive level (i.e. >=10), unnecessary surgeries might be an issue. The authors are aware that further application to clinical practice of the scoring system is necessary to establish its true utility. As we apply the system to our patients and we get longer follow up on them, the potential of adding or deleting items, or reviewing the odds risk of the parameters are always a possibility.

## Conclusions

The authors developed a clinically applicable scoring system with the aim of identifying MMC patients with NBD who are at risk for renal deterioration and eventual surgery in the future. Patients who scored beyond the cut off point should be offered a more aggressive regimen (either early corrective surgery or closer follow-

up schedule). More experience with its use in the clinical setting is necessary to further validate the system.

## References


1. Stuart B. Bauer. Neurogenic bladder: etiology and assessment. Pediatr Nephrol 2008; 23: 541–51.

2. Mourtzinos A, Stoffel JT. Management goals for the spina bifida neurogenic bladder: A review from infancy to adulthood. Urol Clin N Am 2010; 37: 527–35.

3. Javadi F, Mastaneh L, Hajizadeh N, and Assadi F. Preventing kidney injury in children with neurogenic bladder dysfunction. Int J Prev Med 2013; 4(12): 1359–64.

4. Rothenberg SP, da Costa MP, Sequeira JM, Cracco J, Roberts JL, Weedon J, et al. Autoantibodies against folate receptors in women with a pregnancy complicated by a neural-tube defect. N Engl J Med 2004; 350: 134–42.

5. Czeizel AE. Primary prevention of neural-tube defects and some other major congenital abnormalities: recommendations for the appropriate use of folic acid during pregnancy. Paediatr Drugs 2000; 2(6): 437-49.

6. Moretti ME, Bar-Oz B, Fried S, et al. Maternal hyperthermia and the risk for neural tube defects in offspring: systematic review and meta-analysis. Epidemiology 2005; 16(2): 216-19.

7. Laurence KM. Neural tube defects: a two-pronged approach to primary prevention. Pediatrics 1982; 70: 648-50.

8. Stuart B. Bauer. Neurogenic bladder: etiology and assessment. Pediatr Nephrol 2008; 23: 541–51.

9. Tom P. V. M. de Jong & Rafal Chrzan & Aart J. Klijn & Pieter Dik. Treatment of the neurogenic bladder in spina bifida. Pediatr Nephrol 2008; 23: 889–96.

10. McGuire EJ, Woodside JR, Bordin TA, Weiss RM. Prognostic value of urodynamic testing in myelodysplastic patients. J Urol 1981; 136: 205–9.

11. Bauer SB, Hallet M, Khoshbin S, Lebowitz RL, Winston KR, Gibson S, Colodny AH, Retik AB. Predictive value of urodynamic evaluation in newborns with myelodysplasia. JAMA 1984; 252: 650–2.

12. Jameela A Kari, Sherif M El-Desoky, Faten Basnawi, and Ohood Bahrawi. Vesicoureteric reflux in children. Urol Ann 2013; 232–6.

13. Kapoor R and Agrawal S. Meningomylocele: An update. Indian J Urol 2007; 23(2): 181–6.

14. Tanaka H, Matsuda M, Moriya K, Mitsui T, Kitta T, Nonomura K. Ultrasonographic measurement of bladder wall thickness as a risk factor for upper urinary tract deterioration in children with myelodysplasia. J Urol 2008; 180(1): 312–6.

15. Carla Verpoorten & Gunnar M. Buyse. The neurogenic bladder: medical treatment. Pediatr Nephrol 2008; 23: 717–25.

16. Bauer SB. Urodynamics in myelodysplasia. Bladder and bowel dysfunction in myelodysplasia symposium, 3 April 2003, Aachen, Germany

17. Hopps C, Kropp K. Preservation of renal function in children with myelomeningocele managed with basic newborn evaluation and close follow-up. J Urol 2003; 169: 305–8.

18. Seki N, Akazawa K, Senoh K, Kubo S, Tsunoda T, Kimoto Y, Naito S. An analysis of risk factors for upper urinary tract deterioration in patients with myelodysplasia. Br J Urol 1999; 84: 679–82.

19. Satar N, Bauer SB, Scott RM, Shefner J, Kelly M, Darbey M. Late effects of early surgery on lipoma and lipomeningocele in children less than 1 year old. J Urol 1997; 157: 1434–7.

20. Smith ED. Urinary prognosis in spina bifida. J Urol 1972; 108: 815–7.

21. Perez LM, Khoury J, Webster GD. The value of urodynamic studies in infants less than one year old with congenital spinal dysraphism. J Urol 1992; 148: 584–7.

22. Alpajaro SI, Bolong DT. Analysis of Prognosticating Factors at Initial Presentation of Neurogenic Bladder in Patients with Myelomeningocele. Phil J Urol 2015; 25(1): 14-31.

23. Linda Cardozo & David Staskin & Brooke Currie & Ingela Wiklund & Denise Globe &( Manuel Signori & Roger Dmochowski & Scott MacDiarmid & Victor W. Nitti & Karen Noblett .Validation of a bladder symptom screening tool in women with incontinence due to overactive bladder. Int Urogynecol J 2014; 25: 1655–63.

24. David Bates, Jack Burks Denise Globe Manuel Signori, Stacie Hudgens, Pierre Denys' Scott MacDiarmid ,Victor Nitti, Ib Odderson, Amy Perrin Ross and Michael Chancellor Development of a short form and scoring algorithm from the validated actionable bladder symptom screening tool. BMC Neurology 2013; 13: 78.

25. Burks J, Chancellor M, Bates D, Denys P, DeRidder D, MacDiarmid S, et al. Development and validation of the actionable multiple sclerosis bladder health screening tool. Int J MS Care 2013; 15(4): 182–92.

26. Blaise Julien Meyrat , Stéphan Tercier, Nicolas Lutz, Bénédict Rilliet, Margarita Forcada-Guex, Olivier Vernet. Introduction of a urodynamic score to detect pre- and postoperative neurological deficits in children with a primary tethered cord. Child's Nervous System 2003; 19(10); 716-21.

27. Coyne KS1, Margolis MK, Bavendam T, Roberts R, Elinoff V. Validation of a 3-item OAB awareness tool. Int J Clin Pract 2011; 65(2):219-24. doi: 10.1111/j.1742-1241.2010.02561.x

28. MacNeily AL, Leonard MP, Metcalfe PD, Casale A, Guerra L, Steinbok P and Garton H. Development of an Objective Score to Quantify the Pediatric Cystometrogram. J Urol 2007; 178: 1752-7.

29. McLorie GA, Perez-Marero R, Csima A, Churchill BM. Determinants of hydronephrosis and renal injury in patients with myelomeningocele. J Urol 1988; 140(5 Pt 2): 1289-92.

30. Cullerésa R Conejero J, Sugrañesb I. Romeoc P, and Pérez MG. Characteristics of urinary tract infections in different patient subpopulations and depending on the bladder emptying system. Actas Urol Esp 2010; 34(3): 251–7.

31. Filler G, Gharib M, Casier S, Lödige P, Ehrich JH, Dave S. Prevention of chronic kidney disease in spina bifida. Int Urol Nephrol 2012; 44(3): 817–27.

32. Whiteneck GG, Charlifue SW, Frankel HL, et al. Mortality, morbidity, and psychosocial outcomes of persons spinal cord injured more than 20 years ago. Paraplegia 1992; 30(9): 617–30.

33. Seki N, Masuda K, Kinukawa N, Senoh K, Naito S. Risk factors for febrile urinary tract infection in children with myelodysplasia treated by clean intermittent catheterization. Int J Urol 2004; 11: 973-7.

34. Wu HY, Baskin LS, Kogan BA. Neurogenic bladder dysfunction due to myelomeningocele: Neonatal versus childhood treatment. J Urol. 1997;157:2295–7.

35. Connor JP, Betrus G, Fleming P, Perlmutter AD, and Reitelman C. Early cystometrograms can predict the response to intravesical instillation of oxybutynin chloride in myelomeningocele patients. J Urol 1994; 151: 1045-7.

36. Snyder HM 3d, Kalichman MA, Charney E, and Duckett JW: Vesicostomy for neurogenic bladder with spina bifida: followup. J Urol 1983; 130: 724-6.

37. Kapoor R and Agrawal S. Meningomylocele: An update. Indian J Urol 2007; 23(2): 181–6.

38. Farhat W, Darius J. Ba G. The dysfunctional voiding scoring system: Quantitative standardization of dysfunctional voiding symptoms in children. J Urol 2000; 164: 1011–5.