ICS Teaching Module: Detrusor Leak Point Pressures in Patients With Relevant Neurological Abnormalities

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Aims: This manuscript serves as a scientific background review; the evidence base, for the presentation made available on ICS website to summarize current knowledge and recommendations for the measurement and use of the DLPP. **Methods:** This review has been prepared by a Working Group of The ICS Urodynamics Committee. The methodology used included comprehensive literature review, consensus formation by the members of the Working Group, and review by members of the ICS Urodynamics Committee core panel. **Results:** DLPP has been recommended and utilized in the urodynamic evaluation of N-LUTD for many years, but it lacks standardization and there are numerous pitfalls in its measurement. EFP and LPP associated with N-DO are frequently and mistakenly reported as DLPP. The information that high DLPP predicts UUTD originates from retrospective cohort studies of a low level of evidence (LoE 3). Existing data confirm that patients with lower DLPP do better than patients with higher DLPP in terms of their upper urinary tract. However, there appears to be no reliable 'safe/no safe' cut-off for DLPP since there are other urodynamic factors that influence UUTD such as bladder compliance and more. **Conclusion:** Although higher DLPP is associated with a greater risk of UUTD, there is no reliable cut-off level to undoubtedly discriminate the risky group, including the traditional cut-off level of 40 cm H_2O. Therefore, DLPP should not be used as the sole urodynamic parameter. Future research should be directed to standardization of the technique and better classification of DLPP cut-offs in N-LUTD. *Neurourol. Urodynam.*

Key words: detrusor leak point pressure; neurogenic bladder; urodynamics

INTRODUCTION

Detrusor leak-point pressure (DLPP) testing originates from observations of videourodynamic studies of children with myelomeningocele (MMC) and urinary incontinence secondary to impaired bladder compliance. McGuire retrospectively evaluated this group of children with the aim of finding predictors for upper urinary tract deterioration (UUTD).[1–3] This concept has been further applied to different etiologies of neurogenic lower urinary tract dysfunction (N-LUTD) in adults.[4] The International Continence Society (ICS) defines the DLPP as the lowest detrusor pressure at which urine leakage occurs in the absence of either a detrusor contraction or increased abdominal pressure.[5] The value of DLPP to predict UUTD is not known very precisely, and the measurement of DLPP lacks standardization and carries pitfalls. For example, although DLPP measurement has been recommended in neurological patients with reduced bladder compliance, some authors measure DLPP during involuntary detrusor contractions.[5]

The ICS Urodynamics Committee presents the teaching module "detrusor leak point pressures in patients with relevant neurological abnormalities" to serve as a standard education of good urodynamic practice for everyone involved in indicating, performing, and analyzing urodynamic testing in general and more specifically, for those caring for patients with N-LUTD. The teaching module consists of a web-casted presentation, in combination with this manuscript, which is available on the ICS website. The presentation explains testing requirements, clinical workup, and analysis. The presentation and this manuscript contain experts' opinion where evidence is unavailable, especially for the clinical practice aspects, and is marked with: "EO" (expert's opinion).

This module reviews the value of DLPP measurement in predicting UUTD in N-LUTD in light of the existing literature. Our purpose is to standardize and improve the method of DLPP measurement in patients with N-LUTD to minimize performer- and patient-dependent variations.

MATERIALS AND METHODS

All the requirements and instructions for the measurement of DLPP described in this section follow the ICS reports on Good Urodynamic Practices (GUP)[6] and urodynamic equipment performance.[7] The International Children's Continence Society (ICCS) report on the standardization of terminology of lower urinary tract function in children and adolescents has been taken into consideration for the measurement of DLPP in children.[8] DLPP is obtained during a standard cystometry and no specific other equipment or specific patient preparation is needed to determine DLPP. DLPP uses detrusor pressure;

Prof. Christopher Chapple led the peer-review process as the Associate Editor responsible for the paper.
Potential conflicts of interest: Nothing to disclose.
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Received 25 November 2015; Accepted 25 November 2015
Published online in Wiley Online Library (wileyonlinelibrary.com).
DOI 10.1002/nau.22947

consequently, it cannot be obtained via a single channel cystometry and, therefore, both vesical and intra-abdominal pressure must be recorded.

Technique

The measurement of DLPP is a part of cystometric evaluation in patients with N-LUTD. Traditionally, the patient is positioned supine and the bladder emptied. A small cystometry catheter (≤10 F) is inserted into the urethra and standard urodynamic equipment used to measure vesical pressure via a pressure transducer with a rectal probe to monitor intra-abdominal pressure changes.[9]

In suitable patients, the study can also be performed in the sitting position according to ICI recommendations, because this is reported to have a higher sensitivity for the diagnosis of filling phase abnormalities (recommendation Grade B).[10] No evidence is available on the influence of positioning of patients with N-LUTD on the DLPP. The size of the catheter has an influence on the DLPP and it has been shown that using progressively larger catheters increases DLPP.[11] According to the ICI 2013, there is evidence of level 3 that, in general, flow rate during voiding is reduced with a urodynamic catheter in the urethra and that this reduction is partially caused by the size of the catheter. Use of, as thin as possible, "one-catheter systems" (dual lumen if fluid filled) for filling and pressure recording during urodynamic testing is recommended with a level of evidence 4.[10] This recommendation may correspond to 5–8 F double lumen cystometry catheters during water cystometry. The consequence of this recommendation is that DLPP is also done with a 5–8 F transurethral catheter. Another consequence is that when cystometry is performed via a suprapubic catheter, the DLPP will theoretically be underestimated if compared with published data, as this can also indirectly be deduced from a study where catheters were removed and reinserted during cystometry.[13]

A cystometry filling rate is not standardized in the ICS GUP but is usually done with a rate dependent on age (from 20 ml/min in children to 30–60 ml/min in adults).[6] There is some evidence that fluid temperature may not be relevant for the outcome of cystometry; however, the influence on DLPP has not been studied.[14,15]

Detrusor adaptation to volume (compliance) may however, be challenged if relatively high filling rates are used.[9] The ICS classifies infusion rates as physiologic and non-physiologic and no longer wishes to divide the filling rates as slow if <10 ml/min, medium if 10–100 ml/min, or rapid if >100 ml/min, although almost all investigations are performed using medium filling rates within a wide range.[5] It is advised to learn the day-to-day bladder capacity by using voiding (or catheterization) diary volumes before the study, although particularly large or small capacities might affect the desired filling rates. For this reason, we recommend a slow filling rate in adult neurogenic patients with a known hypocompliant bladder (EO).

According to the ICCS, filling rates (per minute) of 5–10% of known or predicted capacity may be used in children. Infusion pump devices rather than gravity-type infusion systems are recommended to avoid iatrogenic bladder pressure increases during filling and inaccurate interpretation by pressure transducers.[9–11] The ICCS also reports that the use of natural fill (ambulatory) cystometry provides a true physiological filling rate and offers a more accurate representation of bladder activity than traditional cystometry in children and may be the technique of choice in pediatric urodynamics if time and equipment are available.[8]

According to an expert review, urinary leakage (in the absence of fluoroscopy) is best detected by having one person observing for leakage and another observing the recording and marking pressures using an event marker. However, the authors also stated that fluoroscopy visualization of contrast around the catheter is more accurate than observing the meatus or observing urine falling onto a sheet.[9]

It is suggested that the cystometry for patients with N-LUTD may be stopped when P_{det} exceeds 40 cm H_2O or the maximum volume recovered at intermittent catheterization is reached or if a detrusor contraction occurs.[3] When cystometry ends without leakage, the end filling pressure (EFP) should be noted. If leakage occurs with an episode of neurogenic detrusor overactivity (N-DO) any time during filling cystometry, we suggest that it should be noted as N-DO LPP. A similar definition in non-neurogenic patients has recently been proposed as the "detrusor overactivity leak point pressure" in women with urgency incontinence.[16] The bladder volume at which leak occurs should also be noted, as it may be important for a particular patient to organize their clean intermittent self-catheterization (CIC) regimen.

Basic Pathophysiology and Clinical Implications of DLPP in Patients With N-LUTD

DLPP is the pressure that overwhelms bladder outlet resistance, causing urinary leakage. DLPP is a reflection of the resistance of the bladder outlet or external sphincter.[1] McGuire's pioneering work has stated that patients with MMC and a LPP >40 cm were at risk of developing UUTD and this cutoff has been traditionally accepted without a high level of evidence.[2] It was shown in another study that reduction of outlet resistance may improve bladder storage in the long-term and may preserve the upper tracts.[12] Combs et al., however, reported that several of their patients with DLPPs of >40 cm H_2O (followed over a long period) showed no deterioration in their upper tracts, while by contrast some individuals undergoing successful bladder augmentation required an artificial urinary sphincter, despite apparently good outlet resistance before surgery.[13] These authors suggested that absolute values of DLPP reported previously were unreliable because the technique lacked standardization. Another retrospective study has challenged the single cutoff level of 40 cm H_2O[17] showing that UUT involvement rates are 18% in children with a DLPP below 20 cm H_2O; 38% between 20 and 40 cm H_2O; and 28% above 40 cm H_2O, respectively. The authors concluded that determining the cut-off value of the DLPP as 20 cm H_2O instead of 40 cm H_2O showed a higher sensitivity to predict the risk group for UUT deterioration (Table I). They also suggested that children with MMC and a DLPP between 20 and 40 cm H_2O should be closely monitored, since 38.4% of children in their study had UUT deterioration at the age of 3.[17]

In spite of the ICS definition, DLPP is sometimes referred to as the elevation of the detrusor pressure during contractions leading to leakage. In fact, this is not DLPP but is N-DO LPP. However, the (clinical) significance of N-DO LPP versus DLPP in

TABLE I. UUT Involvement According to Different DLPP Cut-Off Values[17]

DLPP	Percentage of patients with upper tract involvement	Sensitivity (ROC analysis)
>40 cm H_2O	18/64 (28.1%)	51.4%
>30 cm H_2O	24/88 (27.3%)	68.6%
>20 cm H_2O	33/102 (32.3%)	91.4%

TABLE II. Recommendations of the ICS Teaching Module for the Measurement, Clinical Utilization, and Future Research on DLPP

(1) Measuring and reporting of DLPP should be a part of cystometric evaluation of children and adults with N-LUTD to help predict (and prevent) UUTD (Grade B/C)
a. The recommendations of the ICS and the ICCS should be followed for cystometric equipment and technique
(2) Discrimination of high-risk (UUTD) patients is, however, not very precisely possible on the basis of DLPP (Grade B/C)
(3) DLPP should not be used as the sole parameter to decide on invasive therapies such as bladder augmentation and sphincterotomy
a. UUTD in N-LUTD does not only depend on DLPP but will also depend on other factors such as bladder compliance; volume where leakage occurs; and detrusor contraction duration and amplitude, with all of these related to CIC obtained volumes. On the other hand, the resistance of the bladder outlet to the involuntary rise in detrusor pressure is another important parameter for deterioration
b. The traditional cut-off for DLPP of 40 cm H_2O may have too low a sensitivity for the prediction of UUTD
(4) Future research should be directed to standardization of the technique and better classification of DLPP cut-offs in N-LUTD
a. The predictive value of LPP may differ according to underlying etiology of N-LUTD such as MMC, MS, or SCI
b. Cystometric readings should be sub-classified according to the presence of neurogenic DO (overactive detrusor contractions with or without leakage)
c. EFP should be taken into consideration if the leakage does not occur during cystometry, however, the clinical relevance of EFP is unclear

N-LUTD has not been investigated. Frequent DO episodes with high LPP are plausibly a similar risk for future upper tract changes. The duration of the bladder contraction during an N-DO episode and DLPP >75 mmH_2O is reported to have a significant association with hydronephrosis.[4,18] In a study with spinal cord lesion patients, the total duration of DO contractions appeared as the only statistically significant urodynamic variable that correlated with upper tract dilatation or with vesicoureteral reflux.[18] Although DLPP is a measure of outlet resistance, treatment of patients with a high DLPP is directed toward reducing the vesical pressures and increasing the bladder capacity. Reducing the number and amplitude of overactive detrusor contractions and improving bladder compliance, for example, with antimuscarincs, botulinum neurotoxin, or bladder augmentation is the mainstay of treatment. The clinical implication of DLPP is to help estimating how much and how long the urinary tract system will be exposed to high pressure in-between bladder emptying periods (with or without CIC) in the patient's daily life.

End Filling Pressure (EFP)

Another problem with the utilization of DLPP is that a significant number of patients with N-LUTD do not leak during studies. It is generally accepted that the filling phase finishes when the detrusor pressure remains over 40 cm H_2O without leakage. In a recent study of 80 children with MMC and a median age of 7 years (range 2–17), the majority of children with MMC did not leak during urodynamics but bladder wall thickness as well as urinary levels of TGF-b 1, NGF, and TIMP-2 were found to be significantly increased when DLPP or EFP was greater than 40 cm H_2O in this cohort.[19] Alternative methods, such as biomarkers, may become available to predict UUTD.

A recent study has challenged the predictive value of EFP in predicting UUTD in a cohort of children who underwent bladder neck surgery (different types of slings) without augmentation for neurogenic incontinence.[20] Seventeen children with sustained EFP >40 cm for more than 1 year despite anticholinergics were included in the study. During a mean follow-up of 39 months, new hydronephrosis or VUR developed in six (35%), whereas all new hydronephrosis resolved with medical treatment, as did two out of three new VUR cases. The other patient with VUR had successful suburetric injection.

The authors concluded that despite a sustained EFP >40 cm, upper tract changes developed in only 35% of patients, and resolved with medical management or minimally invasive interventions, and suggested that EFP should not be used as an independent indication for augmentation.

CONCLUSION

Although the causative relationship between the pressure within the urinary tract and UUTD has been acknowledged for a long time, there are still many caveats regarding the standardization of urodynamic measurements and their predictive roles. According to the fifth International Consultation on Incontinence, DLPP in patients with N-LUTD is considered a relevant parameter with the recommendations of grade B/C.[10] It has been stated that DLPP is not consistently defined throughout the literature and that lack of standardization is hindering comparison of studies.

Using a single "safe-unsafe" cut-off at 40 cm H_2O may not reflect clinical reality and as McGuire suggested, a clinical management approach with an "as low as" reasonably achievable detrusor pressure over the entire daily volume range is advisable.[21]

The clinical recommendations on the basis of this review of DLPP are summarized in Table II. Better standardization of DLPP measurements as well as better definition of urodynamic capacity where leakage occurs and of EFP as well as of leak point pressure at overactive detrusor contraction will be helpful. The bladder volume at which leakage occurs is very important in order to adapt patients to CIC. Furthermore, EFP and N-DO LPP should be separated from DLPP in urodynamic investigations, and the definition should include the difference between these terms in order to prevent any confusion. Prospective follow-up studies in patients with N-LUTD to evaluate the predictive value of these parameters for upper tract deterioration are recommended. This manuscript has summarized the practice and interpretation of DLPP from a clinical perspective.

ACKNOWLEDGMENT

We would like to thank the members of the ICS Urodynamics Committee core panel for establishing the teaching module and reviewing the manuscript.

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