

Neurogenic lower urinary tract dysfunction: the role of urodynamics

The main aim in managing neurogenic lower urinary tract dysfunction is preservation of the upper tracts by ensuring optimal bladder function.

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Before the 1980s, patients with spinal cord injury died mainly from urinary tract complications, particularly renal failure, but also stone disease and infections. Even today patients with neurogenic lower urinary tract dysfunction (NLUTD) present a significant challenge to clinicians.¹ The chief management objective remains preservation of the upper tracts by ensuring optimal bladder function. Bladder dysfunction remains a major cause of morbidity, and urodynamic studies (UDS) offer critical information which guides medical and surgical care and undoubtedly impacts positively on patient quality of life. This article focuses on the role of urodynamics and its interpretation in this setting, and gives some index case studies to illustrate its role.

Aetiology and classification of NLUTD

Many causative factors are responsible for neurogenic bladder dysfunction. Congenital causes include neural tube defects, most commonly myelomeningocele (spina bifida) and tethered spinal cord (spina bifida occulta) as well as sacral agenesis, anorectal malformations and cloacal anomalies. Acquired causes include, among others, spinal cord trauma and tumours.

Classifying neurogenic bladders according to the level of the neurological insult is difficult because neurological diseases do not respect these anatomical boundaries and mixed lesions are common. It is, however, useful to differentiate broadly between an overactive upper motor neuron-type bladder and an atonic lower motor neuron-type bladder.

Among the many different classification systems of neuropathic bladders, we find the 'functional classification' simple and clinically useful.¹ It is based on evaluating the two primary functions of a normal bladder: firstly, to store sufficient volume of urine at low pressure; and secondly, to efficiently empty the bladder. Pathology can then be classified into either failure to store urine (because

of problems with the bladder itself, the outlet, or both) or failure to empty (because of problems with bladder function, outlet resistance or a combination). A schematic example of the functional classification is shown in Fig. 1.

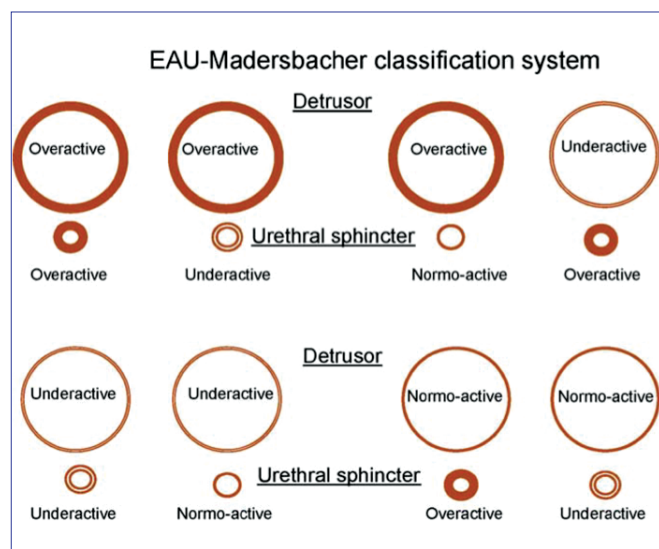


Fig. 1. The European Association of Urology (EAU)-Madersbacher classification system.

Investigation and diagnosis

Prior to urodynamic assessment a comprehensive history, physical examination and urinalysis (to exclude infection) are required. History should focus on past and present bladder, bowel and sexual function. Examination attempts to define the level of the neurology that usefully predicts bladder function. Imaging studies to exclude upper-tract dilatation (ultrasound) and assess bladder capacity and reflux (cystogram) are indicated, in addition to measurement of renal function (serum creatinine).

Types of urodynamic studies

Before discussing the various types of and indications for UDS, it is important to remember Victor Nitti's three principles of UDS:²

- A study which does not duplicate symptoms is not diagnostic.
- Failure to record an abnormality does not rule out its existence.
- Not all abnormalities recorded on UDS are clinically significant.

Terminology used in this paper conforms to the updated standardised terminology produced by the International Continence Society.³ A similar document is available for paediatric practice.⁴ The practical and technical aspects of performing UDS are beyond the scope of this article and the reader is referred to textbooks listed under Suggested reading.

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Non-invasive urodynamics

Volume voided chart

On the chart, also called a bladder diary, the patient records fluid intake, time and volume of voids, incontinence episodes and catheterisation episodes. When documented for 2 - 3 days, these details can give information about functional bladder capacity.

Flow rate and residual

This is a non-invasive way of measuring the amount of urine passed within a period of time, expressed in millilitres per second (ml/s). One can also evaluate the graph shape (normal bell-shaped v. staccato- or plateau-shaped) to gain insight into voiding problems. Use two consecutive measurements with a voided volume of at least 150 ml and combine with ultrasound to assess postvoid residual volume. Electromyography (EMG) can assess sphincter function. A maximum flow rate (Q_{max}) in men of more than 15 ml/sec is normal and less than 10 ml/sec is considered abnormal.

Invasive urodynamics

Cystometrogram

This investigation measures the pressure-to-volume relationship of the bladder during filling and voiding, usually recorded on a graph. It aims to assess the bladder's sensation, capacity, compliance and detrusor activity. During bladder filling the first sensation of bladder filling (which correlates with 50% capacity) through to the strong desire to void (correlating roughly with 90% capacity) are recorded, along with sensations of urgency. Maximum cystometric capacity (when a patient with normal sensation cannot delay micturition any longer) must be correlated with functional capacity, which is the largest volume voided recorded in a voiding diary. A normal capacity is between 300 and

500 ml. Bladder compliance describes the relationship between the change in volume and change in detrusor pressure and is expressed in millilitres per centimetre of water (ml/cmH₂O) with 20 being the normal value. Normal detrusor function (or 'stable' bladder) shows no change in detrusor pressure during filling while overactivity shows involuntary detrusor contractions, which may be spontaneous or provoked by certain actions such as coughing.

Pressure flow studies simply depict the relationship between volume and pressure during micturition and thus can differentiate between obstruction and hypocontractility. They can also identify patients with abnormally high pressure voiding and consequently normal flow rates, but cannot identify the site of obstruction.

Leak-point pressures are important parameters to record when performing cystometry in neurogenic patients. The detrusor leak-point pressure (DLPP) is the lowest detrusor pressure reading at which leakage is observed in the absence of increased abdominal pressure or detrusor contraction. This is very important as a high DLPP (over 40 cmH₂O) may indicate that the upper tracts are at risk of deterioration because the bladder has lost the ability to fill while maintaining low pressure. According to the functional classification, this could either be due to problems with the outlet (detrusor-sphincter dyssynergia (DSD)) or problems with the bladder. With increasing pressures inside the bladder the increasing volume of urine has only two options: to leak out via the urethra or to reflux back up towards the kidney via the ureter. The higher the pressure needed to overcome the urethral outlet, the more likely the urine is to cause upper tract damage.

Invasive UDS is indicated to evaluate and characterise NLUTD. It should be used early in the management and repeated to avoid upper tract deterioration. In the paediatric setting children with meningomyelocele should first undergo UDS in the neonatal period.

Classifying neurogenic bladders according to the level of the neurological insult is difficult because neurological diseases do not respect these anatomical boundaries and mixed lesions are common.

When performing urodynamics in patients with spinal cord lesions above T6 level, one runs the risk of precipitating autonomic dysreflexia. This usually presents with hypertension associated with bradycardia, dizziness or headache and profuse sweating and is caused by an uninhibited sympathetic outflow in response to a stimulus below the level of the injury, for example overfilling of the bladder or high detrusor pressures. Care should be taken to avoid this by using slow filling. If autonomic dysreflexia occurs, the study should be stopped and the bladder emptied; hypertension should be treated.

Electromyography (EMG)

Normally the urethra opens and is continuously relaxed during voiding so that micturition takes place at normal pressure with maximum flow. Modern urodynamic machines include patch electrodes (like those used for electrocardiograms (ECGs)) for assessment of pelvic floor neuromuscular tone (through which the urethra runs). This non-invasive assessment is a useful adjunct to urodynamics. Its biggest role is to diagnose DSD. This is a common finding in neurogenic bladders and is evidenced by lack of the normal relaxation (graphically a 'quiet trace') of the external urethral sphincter during contraction of the detrusor to void.

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Video-urodynamics

This modality combines cystometry with fluoroscopic imaging of the lower urinary tract and enables the urologist to evaluate the anatomy together with function. This is important when identifying leak point pressures and DSD, but can also detect vesico-ureteric reflux, diverticulae and stones. In patients with incontinence, the anatomy of the bladder neck and urethral hypermobility may be demonstrated.

Case studies

This section aims to describe UDS patterns that are commonly seen in clinical practice. Fig. 2 illustrates the typical UDS setup and catheter arrangement. A dual lumen catheter is placed in the bladder to infuse sterile saline and simultaneously measure intravesical pressure via the second channel. A rectal catheter acts as a control to subtract the contribution of intra-abdominal pressure from true detrusor pressure. This detrusor pressure is a computer-derived value displayed in real time.

The cystometrogram measures the volume/pressure relationship as shown in Fig. 3a. A normal cystometrogram is shown in Fig. 3b. Here the 3 top lines represent the vesical, abdominal and computer-derived or true detrusor (vesical minus abdominal) pressure. The 4th line (in yellow) represents urine flow during a normal micturition reflex at the end of the study. The normality of the study is confirmed by low pressure filling to a normal capacity, indicating a normally compliant bladder, with an appropriate rise in detrusor pressure during the micturition reflex and attendant bell-shaped uroflow.

Fig. 4 illustrates the importance of the derived detrusor value. This trace shows that the rise in vesical pressure (Pves) is accompanied by a simultaneous rise in abdominal pressure (Pabd) and hence is cancelled out on the Pdet or the derived detrusor trace. This represents an artefact, probably a cough and not an uninhibited detrusor contraction.

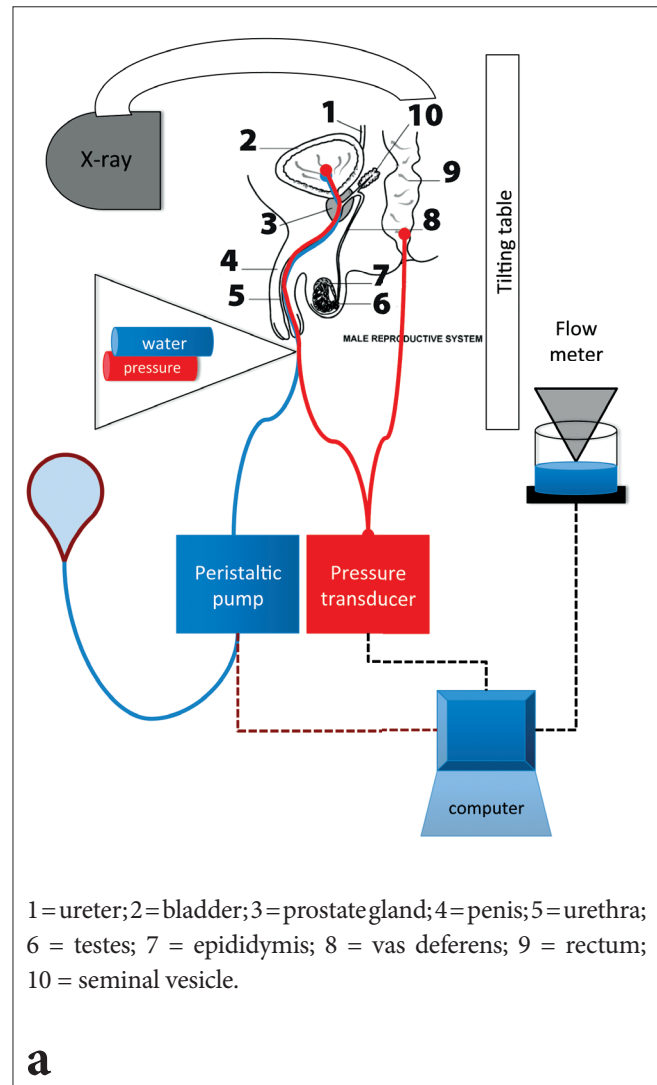


Fig. 2. a. Typical UDS setup. Dual lumen catheter to allow simultaneous infusion and pressure measurement, and a separate rectal catheter as a control for intra-abdominal pressure and thus allowing computer-derived true detrusor pressure. b. Dedicated paediatric urodynamic and sonar suite at Red Cross Children's Hospital.

Neurogenic LUTD

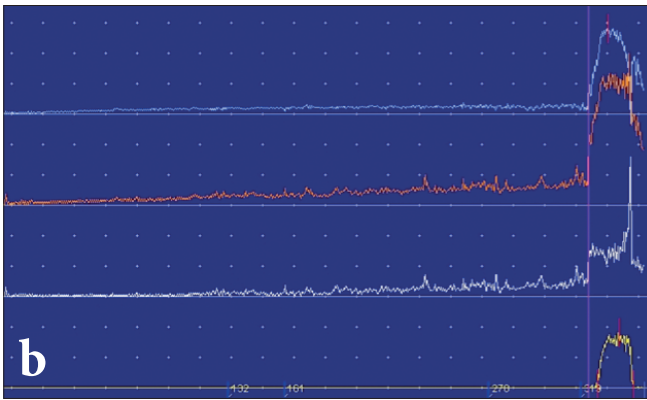
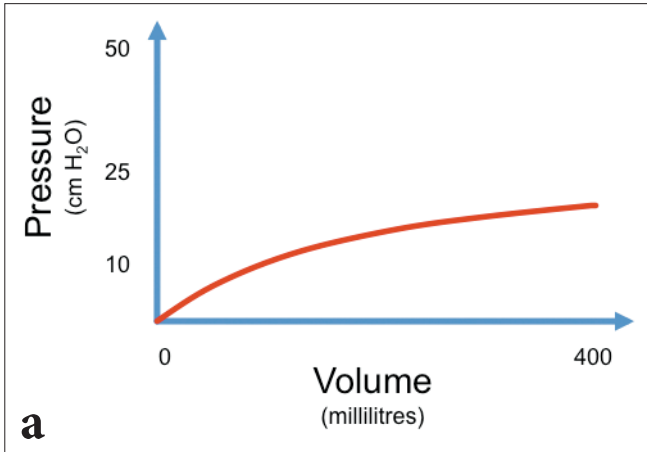


Fig. 3. a. Cystometrogram measures bladder volume/pressure relationship; b. Normal cystometrogram: vesical, abdominal and derived traces.

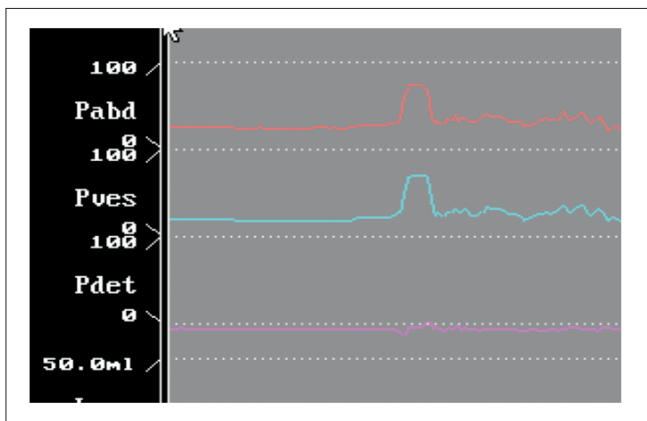


Fig. 4. Artefact shown by a rise in vesical pressure (Pves) accompanied by a rise in abdominal pressure (Pabd) without a computer-derived rise in true detrusor pressure (Pdet).

Fig. 5 demonstrates the cystometrogram of a patient with a neurogenic bladder secondary to myelomeningocele. It shows, from top to bottom, the vesical, detrusor (calculated by computer) and abdominal traces. Compared with the normal trace in Fig. 3, there is a steep rise in pressure with bladder filling. This represents a typical poorly compliant bladder. The

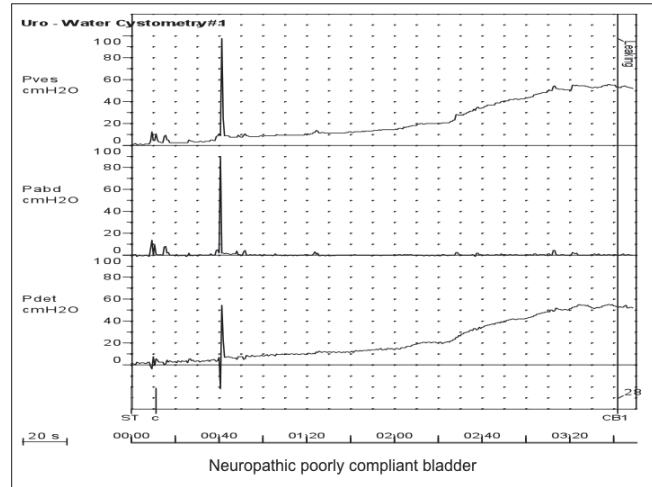


Fig. 5. Typical steep trace of a poorly compliant bladder, with reduced capacity and elevated detrusor leak point pressure (DLPP).

capacity is usually reduced and the DLPP is elevated above the danger threshold of 40 cmH₂O. Above this value urine flow from the kidneys is impaired. Additionally, there are small waves of detrusor instability throughout the study. Bladder sensation is reduced and other sensations (e.g. autonomic dysreflexia) and incontinence occur.¹

Fig. 6 shows marked neurogenic detrusor overactivity with reduced compliance and attendant urine incontinence with each wave of instability. This overactivity would be expected to improve with anticholinergic therapy.

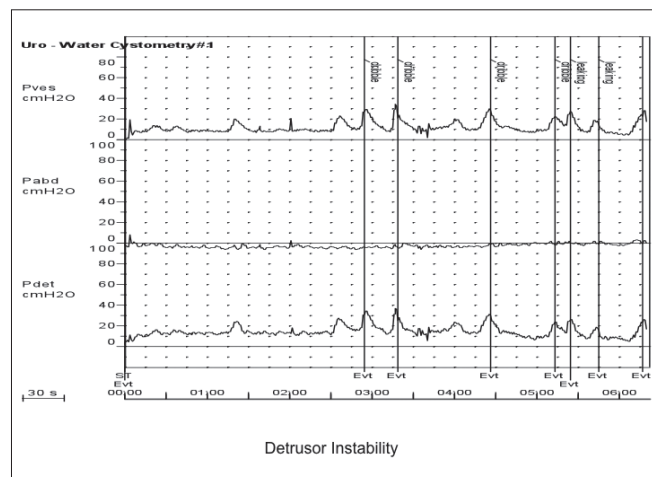


Fig. 6. A patient with neurogenic detrusor overactivity with decreased bladder compliance as well as involuntary detrusor contractions leading to urine leaks.

At the other end of the neurogenic bladder spectrum is the atonic bladder with an underactive detrusor that shows increased capacity and compliance on UDS. Fig. 7 demonstrates such a bladder. Typically filling exceeds >1.5 times the expected capacity with reduced sensation of bladder filling noted by the patient.

Neurogenic LUTD

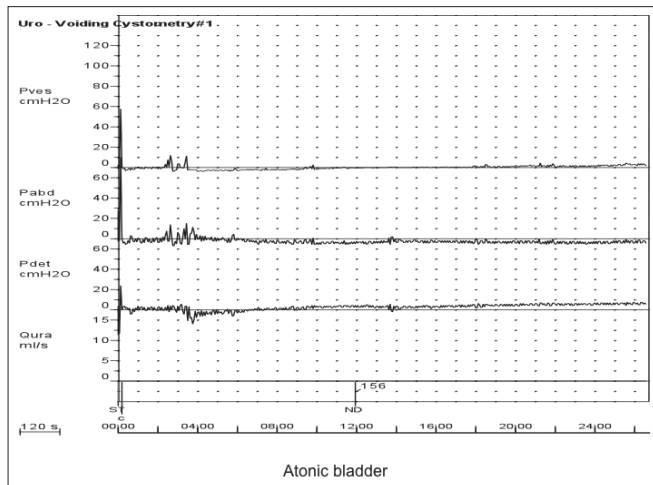


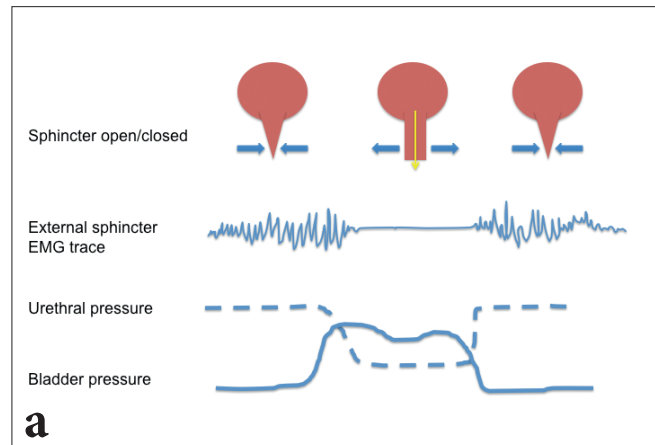
Fig. 7. A patient with an atonic or underactive detrusor with increased capacity (700 ml), increased compliance and reduced sensation during filling.

In addition to standard UDS, EMG data can easily be obtained with non-invasive patch electrodes. The additional information derived from EMG is an attempt to diagnose DSD. DSD occurs when the bladder contracts against a closed pelvic floor (the external urethral sphincter). This usually accompanies a poorly compliant bladder with a high DLPP. DSD represents the most serious consequence of the neuropathic bladder as it produces a so-called 'hostile bladder' that threatens the upper urinary tracts. Fig. 8a schematically shows the normal EMG trace during the micturition reflex. Note that the EMG trace of the pelvic floor is said to be 'quiet' (i.e. relaxed) during the detrusor contraction. Fig. 8b demonstrates DSD. Here the sphincter is hyperactive during an attempted micturition.

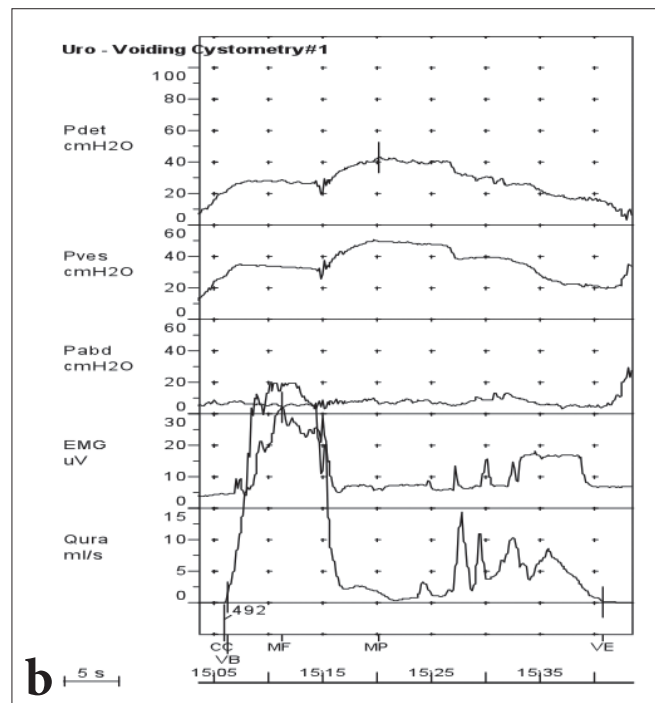
Conclusion

UDS plays an important role in the diagnosis, treatment planning and surveillance of patients with NLUTD. In South Africa these services are underdeveloped and underutilised, which results in preventable morbidity. It is hoped that this overview of UDS will prompt doctors to refer more patients for comprehensive assessment.

References and suggested reading available at www.cmej.org.za



a



b

Fig. 8. a. Schematic representation of normal ('quiet') EMG trace during the micturition reflex. b. Detrusor-sphincter dyssynergia (DSD) is shown by the hyperactive sphincter/pelvic floor (EMG) trace during micturition.

IN A NUTSHELL

- Neurogenic bladders can cause morbidity (infections, stones, incontinence) and mortality (renal failure, urosepsis).
- Urodynamic studies (UDS) are functional studies of the lower urinary tract; they evaluate both the storage and the emptying functions of the bladder.
- Different types of neurogenic bladders exist and the characteristics of a particular bladder may change with time.
- History should pay attention to bladder, bowel and sexual function.
- Examination should define neurology and exclude infection and upper tract dilatation.
- UDS can be simple and non-invasive (bladder diary, flow rate) or invasive (cystometrogram, video-urodynamics).
- A cystometrogram measures the relationship between bladder filling and pressure. Parameters used to characterise the bladder are capacity, compliance, detrusor activity and sphincter activity.
- Detrusor leak-point pressure (DLPP) over 40 cmH₂O predicts upper tract deterioration in neurogenic bladders.