Leak point pressures: how useful are they?

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Purpose of review
The present article reviews the literature from the last 12 months relevant to our understanding of leak point pressures.

Recent findings
Literature is reviewed regarding leak point pressures.

Summary
There remains a need for larger randomized trials, investigating urodynamic parameters with relation to effective surgical management of urinary stress incontinence.

Keywords
abdominal, detrusor, leak, point, pressure

INTRODUCTION

The present review aims to discuss literature over the last 12 months and will put this within the context of our current knowledge base of leak point pressures (LPP).

Urodynamic studies (UDS) involve the assessment of the function and dysfunction of the lower urinary tract (LUT) by any appropriate method [1]. UDS can be either noninvasive, such as flow tests, or invasive, the principle methods being filling cystometry and pressure flow (voiding) studies. They are performed to define LUT dysfunction (LUTD) in patients with bothersome LUT symptoms (LUTS), usually before an invasive intervention or as part of long-term surveillance, as in some groups of patients with neuro-urological LUTD, such as in meningomyelocele (MMC) children and adults. The aim of UDS is to reproduce the patients' LUTS while taking objective measurements, to come to a urodynamic diagnosis and plan management accordingly. UDS are performed for a variety of indications, including assessment of urinary incontinence and neuro-urological disorders. UDS are normally performed in a standardized and reproducible manner, according to Good Urodynamic Practice [2], with a specific UDS question, or questions, in mind. For urinary incontinence, the questions are usually whether either urodynamic stress incontinence or detrusor overactivity incontinence can be demonstrated before interventions such as a mid-urethral sling or sacral nerve stimulation, respectively. NICE certainly recommends UDS in patients before surgery for stress urinary incontinence (SUI), 'except for the small group who have pure SUI' [3].

Bladder storage function is assessed by filling cystometry, throughout which bladder pressure is measured. Storage ability is assessed by measuring bladder capacity, bladder compliance, bladder sensation, USI, and the presence/absence of detrusor overactivity.

Urethral storage function can be assessed by measuring urinary LPP. LPP is the pressure at which a urinary leak occurs during UDS. LPPs were first described by McGuire in an attempt to evaluate the effect of urethral function on upper urinary tract function (UUT) and in relation to urinary incontinence. There are two types of LPP measurement: detrusor LPP (DLPP) and abdominal LPP (ALLP). Both are measured during filling cystometry, but are used in very different contexts.

DETRUSOR LEAK POINT PRESSURE

DLPP is defined as the lowest detrusor pressure at which urinary leakage occurs in the absence of a detrusor contraction or an increase in abdominal pressure [1]. DLPP is performed during filling

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KEY POINTS

- Standardized urodynamics according to good urodynamic practice remain an essential element of investigation of urinary incontinence.
- Detrusor leak point pressure measurement is helpful to guide management in patients with neuro-urological conditions.
- There is as of yet no consensus as to how useful abdominal leak point pressure is in guiding operative management of SUI and its effectiveness.

cystometry, as the bladder is filled, the urethra is examined for leakage. At the point that leakage occurs, the detrusor pressure is recorded, this is the DLPP. The main determinant of a normal low detrusor pressure, during bladder filling, is the compliance of the bladder, which in turn is dependent on the visco elastic properties of the detrusor muscle, normal bladder wall composition, and normal neural mechanisms. However, if bladder compliance is abnormal then detrusor pressures are high during filling and may interfere with normal drainage of urine from the kidneys to the bladder.

DLPP was originally described by McGuire [4] in the evaluation of low-compliance bladders in children with MMC. McGuire found that MMC patients with a DLPP over 40 cmH_2O had a higher risk of UUT deterioration than patients with a DLPP less than 40 cmH_2O. This is because the higher pressures were being transferred to the UUT leading to hydronephrosis and impaired renal function, sometimes made worse by associated vesico-ureteric reflux, However, in these children, urethral function is often impaired, and this acts as a safety mechanism in children who, if they had good urethral function would be at risk of UUT deterioration because of their poor bladder compliance. However, if the outlet pressure is normal, then there will be a high detrusor pressure, and leakage will occur at higher pressures, and this is dangerous for kidney function.

Although UDS should be performed according to Good Urodynamic Practice, there is no standardization of the technique of measurement of DLPPs, such as how to record urine leakage, which can be recorded visually, via a flowmeter or seen radiologically. Measurement of detrusor pressure can either be by a urethral or suprapubic catheter, but the calibre of catheter has not been standardized. This is very important, particularly if small children are being investigated, as if a relatively large catheter is being used, the DLPP will be artefactually increased. Furthermore, the rate of bladder filling has not been standardized and it is well known that artificially fast filling may reduce bladder compliance and raise the detrusor pressure. Therefore, in any comparison between studies, these factors must be borne in mind.

Neuropathic patients are at particular risk of UUT deterioration, either from poor compliance or from detrusor overactivity, either of which can, in the presence of reasonable urethral function, lead to a high DLPP. The ability to quantify the urethral resistance to leakage allows the risk of UUT damage to be assessed. In a patient with high LPP, the threshold for intervention will be lower. Wang *et al.* [5] calculated a urodynamic risk score including a DLPP more than 40 cmH_2O, bladder compliance of less than 9 mL/cmH_2O and evidence of an acontractile detrusor, in children with neurogenic LUTD. They found these three factors to be the main UDS risk factors for UUT dilatation, and suggested that a patient with these risk factors would need to be monitored more closely.

ABDOMINAL LEAK POINT PRESSURE

ALPP is defined as the intravesical pressure at which urine leakage occurs because of increased abdominal pressure in the absence of a detrusor contraction [1]. This is measured during the UDS assessment of women with bothersome SUI. ALPP can assess urethral dysfunction and forms part of the diagnosis for urodynamic SUI. Raised abdominal pressure does not cause leakage in a functionally and anatomically normal urethra. Leakage is caused by an increase in abdominal pressure when there is an incompetent urethra.

There are thought to be two types of SUI, either urethral hypermobility or intrinsic sphincter deficiency (ISD): urethral function can be assessed during video UDS and been classified according to the Blaivas criteria, with ISD being type three. ALPP can also help distinguish between these types.

ALPP was originally described by McGuire [4] and was based upon Valsalva LPP (VLPP). They noted that 75% of women with SUI and a VLPP less than 60 cmH_2O had ISD, whereas most patients with a VLPP more than 90 cmH_2O had urethral hypermobility. Following this, a VLPP of less than 60 cmH_2O is thought to represent ISD, VLPP of 60–90 cmH_2O is said to be equivocal and VLPP more than 90 cmH_2O suggests urethral hypermobility. An ALPP >150 cmH_2O suggests incontinence is unlikely to be because of the urethra not being able to contain urine.

As with DLPP there is no agreed standard way of performing ALPP. There is no consensus on how full the bladder should be at the point of carrying out

ALPP. To measure ALPP, filling is stopped and the patient is asked to increase their intra-abdominal pressure by coughing, or by blowing into a syringe (Valsalva manoeuvre), until the patient leaks and the lowest pressure at which this happens is recorded as the ALPP. Increasing the volume at which the Valsalva manoeuvre is carried out, does not appear to affect the ALPP result. However, underfilling may result in not enough volume for a satisfactory effect, and overfilling may induce detrusor overactivity thus giving a false reading. Filling to volumes of 250–300 mL appears to be the most accurate in distinguishing between hypermobility of the urethra and ISD [6].

The pressure can be measured from either the abdominal (rectal or vaginal) or bladder pressure line. In theory, the absence of a urethral catheter would allow a more meaningful measurement of ALPP, but would mean the bladder catheter being removed and reintroduced to allow filling cystometry to be completed. Hence, any urethral catheter present during ALPP measurement should have the smallest diameter possible, so as to minimize its effect on ALPP measurement. Weissbart *et al.* [7▪] found that 32 of 169 men undergoing postprostatectomy urodynamics failed to leak whereas the 7fr catheter was in-situ, all 32 leaked without the catheter.

When comparing methods of inducing leakage, ALPP appears to be higher with a cough compared to Valsalva, possibly because of reflex contraction of the pelvic floor during coughing. Coughing is perhaps a more frequent cause in everyday life of SUI, however using cough ALPP measurement, the exact pressure at which leakage occurs can be difficult to determine because of the rapid changes of pressure, and the assumption that leakage is at the peak of the cough spike is often made (Fig. 1).

Another difficulty possibly encountered is the presence of an anterior wall prolapse. This may artificially elevate the ALPP by absorbing some of the force of the abdominal contraction, therefore the patient may not leak until pressures are higher. The ALPP measurement in patients with significant cystocele may need to be treated with caution. Furthermore, UDS are invasive investigations and patients are understandably anxious about having a clinician examining the perineal region for incontinence. This may lead to contraction of the pelvic floor, thereby not reproducing the normal circumstances in which the woman leaks. Factors such as catheter size, bladder volume, patient anatomy and the precise method of determining ALPP will all affect the result and should be interpreted cautiously.

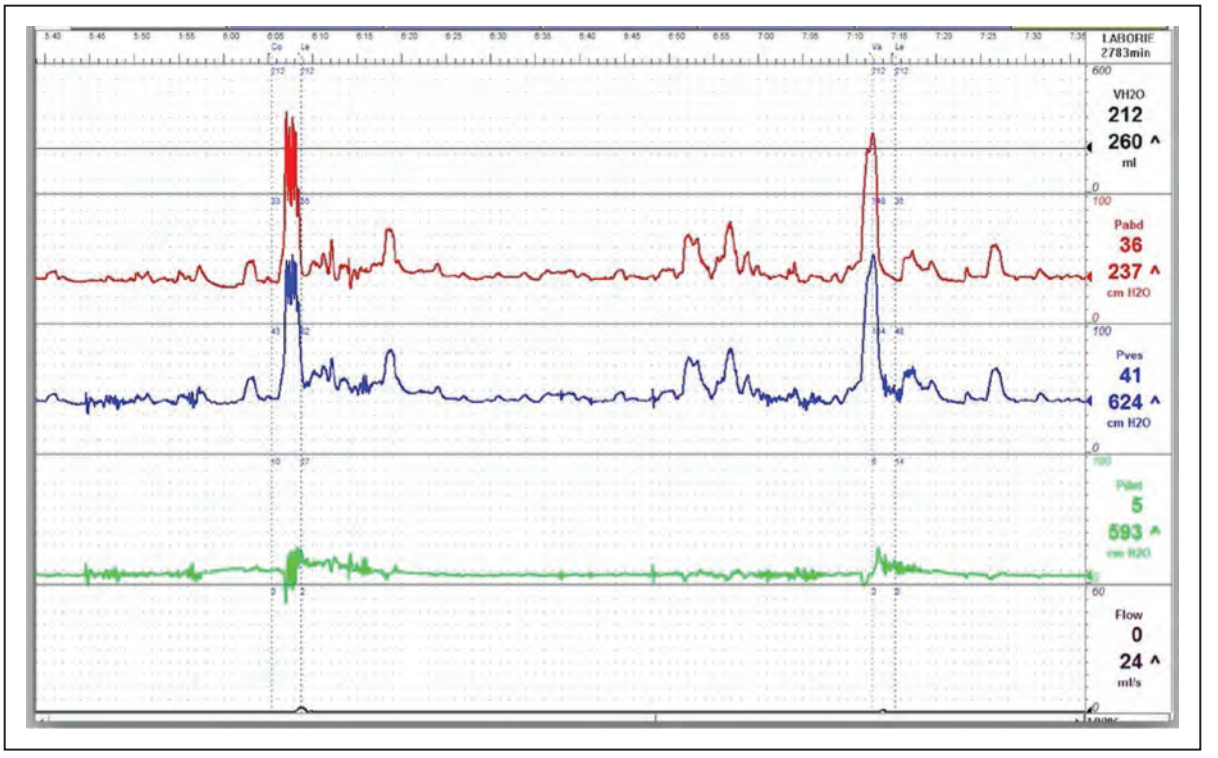

FIGURE 1. Demonstration of urodynamic trace showing cough and Valsalva leak during filling cystometry. It can be seen that it is difficult to ascertain the exact pressure at leakage with a series of three coughs as seen here.

ALPP can be used in conjunction with other urethral studies to differentiate between ISD and hypermobility. The urethra may be examined during coughing to look for mobility. The Q-tip test, now no longer in favour, was used to assess the degree of movement of the urethra during coughing or straining. This test was thought to be inaccurate and invasive. However, a paper in 2014 again examined this relationship, and found a significant correlation between Q-tip angle and grading of urodynamic SUI on video UDS [8▪]. The paper had several flaws; a small numbers retrospective review, in patients with pure SUI. Pure USI accounts for less than 5% of patients in whom we perform UDS for urinary incontinence [9], therefore it is difficult to determine if this would be applicable to our general population. However, clinical examination remains a key element in the UDS examination.

Urethral pressure profilometry is thought to be a more objective way of measuring urethral function. Urethral pressure is defined by the ICS as the fluid pressure needed to just open a closed urethra. The urethral pressure profile is a graph indicating changes in the intraluminal pressure along the length of the urethra. Although low maximum urethral closure pressures (MUCP) are associated with SUI, there is no absolute cutoff figure below which the urethra can be implicated as the cause of incontinence. There are many continent women with low MUCP and incontinent women with high MUCP readings. A combination of a low MUCP and a low ALPP may add weight to the diagnosis of ISD but cannot definitively prove it. Guerette *et al.* [10] found cutoff values of less than 60 cmH_2O ALPP and less than 40 cmH_2O MUCP were the most predictive factors of surgical success, showing high sensitivity and specificity.

NICE recommends that when conservative measures fail and surgery is being considered for the treatment of SUI, all surgical options should be discussed [3]. UDS should be considered in all patients other than those with pure SUI [3] (a small percentage of patients [9]), therefore most patients will have had UDS. Yet, there remain important urodynamic questions – does the diagnosis of urethral hypermobility versus ISD predict a successful surgical outcome? Can ALPP assist in decisions regarding type and relative success of surgery? There is evidence on the one hand to support its use, and on the other to dismiss it.

In the developed world, the most common operation for SUI is a mid-urethral sling (MUS). Despite this surgical procedure being less invasive, with a shorter hospital stay than other options, long-term follow-up data [11] still shows approximately 20% recurrence of urinary incontinence. Therefore, any UDS parameters that may be useful in predicting operative failure are important.

Whether diagnosing ISD is helpful in predicting surgical outcome remains controversial, many papers have been written with varying results. A recent systematic review by Iancu and Peltecu [12▪▪] found that a low preoperative VLPP was predictive for a higher risk of failure following a MUS. The studies involved only followed up patients for a maximum of 6 years with median follow-up being much lower. Nager *et al.* [13] used data from the TOMUS trial (Trial of MUS) for a multivariate analysis of surgical outcome and preoperative urodynamic findings. ALPP and MUCP were the only parameters consistently associated with objective failure, but there was no absolute cutoff value. Patients with ALPP and MUCP in the lowest quartile had a twofold increased risk of objective failure after 1 year of follow-up, and for every 10 cmH_2O increase in ALPP and MUCP, there was a 7 and 12% reduction in failure rate, respectively. Han *et al.* [14▪▪] recently retrospectively reviewed 12-year follow-up data and preoperative UDS data in patients who underwent a TVT. They found a VLPP less than 60 cmH_2O was the only independent factor able to significantly predict recurrence of incontinence. Despite small numbers ($n = 88$), this appears to be an important paper, as it is one of the few to look at long-term follow-up data.

Conversely, Ryu *et al.* [15▪] studied 204 patients before placement of MUS and found preoperative VLPP was not related to cure rate or quality of life. Rodriguez *et al.* [16] also found no difference in cure rate when grouping women into different levels of ALPP before MUS placement. Nager *et al.* [17] also found ALPP did not predict success after Burch or autologous sling placement after 24 months follow-up. Constantini *et al.* [18] studied 145 patients randomized to TVT versus TOT and found no significant differences in objective cure rates with ALPP or MUCP.

A newer use of ALPP is in the management of men with postprostatectomy incontinence. Barnard *et al.* [19▪] determine the VLPP threshold permitting success in the use of the male sling (AdVance). They questioned the use of pad weighing tests to determine severity of incontinence, using, as an example, a very active young man potentially have the same pad weights as a nonactive elderly man, but commenting that the severity of incontinence in this example would vary by exercise and activity and may not necessarily reflect the underlying severity of sphincter dysfunction. Some surgeons believe in using severity of incontinence as a decisive factor in selecting between the artificial urinary sphincter

and the male sling, with the milder incontinence group being usually offered a sling. The group investigated 46 patients with postprostatectomy incontinence with preoperative video UDS. They found a VLPP cutoff of less than 100 cmH_2O could predict treatment failure. Although this may be a potentially useful adjunct to assessing severity of sphincter dysfunction, we believe that the actual question remaining unanswered is whether we are correctly selecting an appropriate procedure for postprostatectomy incontinence based upon incontinence severity. We eagerly await the results of the MASTER trial, which is currently recruiting and is randomizing patients with postprostatectomy incontinence to either male sling surgery or an artificial urinary sphincter regardless of severity of incontinence.

DISCUSSION

So, how useful are LPPs? The answer appears to be that the evidence remains controversial. Questions continue to be asked as to whether there is value in acquiring an accurate diagnosis of either urethral hypermobility or ISD, and whether this alters clinical management or predicts surgical effectiveness. LPPs were one of the variables examined in a Cochrane review in 2002 and the suggestion was that a large definitive trial should be carried out to determine the place of UDS in patients with incontinence [20].

Although this question is as yet to be definitively answered, our opinion is that accurately performed UDS remain incredibly important before surgical management of SUI. Evidence appears to be continuing to emerge that ALPP is a useful adjunct, along with MUCP, in determining underlying anatomical causes of SUI, enabling an informed discussion with patients, and in particular choosing an operation from those available.

DLPP appears less controversial, but again has limited repeat validity of the originally suggested cutoff values. What is clear is that UDS remain a crucial part of the baseline study of neuro-urological conditions and its continued safe management in order to protect renal function long-term and manage continence in a holistic setting.

CONCLUSION

LPPs are widely used UDS parameters that remain a controversial area. There is evidence, particularly for ALPP, both for and against its use. What is clear is that standardized UDS remain an important part of the diagnostic pathway for urinary incontinence, particularly when considering interventions, to enable appropriate and informed patient management.

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Conflicts of interest

K.W. and H.B. declare no conflicts of interest. P.A. declares that he consults for Astellas, Ferring, Pfizer, Proctor and Gamble, and Chiltern: lectures for Astellas, Ferring, and Pfizer and is an investigator for Astellas and Ferring.

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