The underactive bladder: Diagnosis and surgical treatment options

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The underactive bladder: diagnosis and surgical treatment options

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Abstract: The underactive bladder (UAB)/detrusor underactivity (DU) is a relatively common condition. It is difficult to diagnose and can be difficult to manage. The aim of this review is to provide a review of the diagnosis and different surgical treatment options for UAB/DU. A comprehensive literature review using medical search engines was performed. The search included a combination of the following terms, UAB, DU, TURP, reduction cystoplasty, bladder diverticulectomy and sacral neuromodulation (SNM). Search results were assessed for their overall relevance to this review. Definitions, general overview and management options were extracted from the relevant medical literature. DU affects up to 45% of men and women >70 years of age. The symptoms of DU overlap significantly with overactive bladder (OAB) and bladder outlet obstruction (BOO). Urodynamic findings include low voiding pressure combined with slow intermittent flow and incomplete bladder emptying. Non-operative management for DU is acceptable; only 1 in 6 male patients may need a TURP and acute urinary retention (AUR) is rare. TURP for DU is feasible and is associated with good short and medium term outcomes, but over time, there is a return to baseline symptoms. Bladder diverticulectomy can also improve DU, but there is a paucity of guidelines on patient selection. SNM provides excellent outcomes for DU, but patient selection is important.

Keywords: Bladder diverticulectomy; transurethral resection of the prostate (TURP); sacral neuromodulation (SNM), underactive bladder (UAB)

Introduction

Underactive bladder (UAB) is a common and poorly understood condition, with limited treatment options. It is frequently misdiagnosed as overactive bladder (OAB) and bladder outlet obstruction (BOO). It can only be reliably diagnosed with invasive pressure flow studies (PFS). It is estimated that the prevalence of detrusor underactivity (DU) is about 9% to 23% in men <50 years old, increasing to about 48% in men >70 years old, in older women the prevalence is about 12% to 45% (1). In our institution, we reported that about 23% of patients being evaluated for voiding dysfunction with urodynamics, were found to have DU (2).

This review discusses the issues around diagnosis of the UAB, and offers a suggested algorithm. We will also look at the roles of surgical treatments such as transurethral resection of the prostate (TURP), reduction cystoplasty, bladder diverticulectomy, and sacral neuromodulation (SNM) as part of the management paradigm.

Methods

A comprehensive literature inquiry using the following medical search engines were performed; PubMed, Ovid, Science Direct and Google Scholar. The search included a combination of the following terms: UAB, DU, TURP, SNM, bladder diverticulum and bladder diverticulectomy. Search results were assessed for their overall relevance to this review. Definitions, general overview and management

Table 1 Aetiology of UAB

Type	Cause
Idiopathic	Old age
Iatrogenic	Pelvic surgery
Myogenic	BOO
	Diabetes
Neurogenic	Parkinson's disease
	MS
	MSA
	Guillain-Barre syndrome
	Spinal cord injury
	Congenital abnormality

MS, multiple sclerosis; MSA, multisystem atrophy; UAB, underactive bladder; BOO, bladder outlet obstruction.

Table 2 Possible sequelae of UAB

Complications
Recurrent UTIs
Overflow incontinence
Bladder stones
Renal impairment
Bothersome symptoms
Decreased QoL
Chronic valsalva voiding—hernia, vaginal prolapse and haemorrhoids

UAB, underactive bladder; UTI, urinary tract infection; QoL, quality of life.

options were extracted from the relevant medical literature.

Diagnosis of UAB

The International Continence Society defines DU as "a contraction of reduced strength and/or duration, resulting in prolonged bladder emptying and/or failure to achieve complete bladder emptying within a normal time span" (3). UAB has also been defined based on symptoms as "a symptom complex suggestive of DU and is usually characterized by prolonged urination time with or without a sensation of incomplete bladder emptying, usually with hesitancy, reduced sensation on filling, and a slow stream" (4).

Unlike OAB, the clinical diagnosis of UAB is difficult due to the presence of overlapping symptoms and it can be difficult to distinguish UAB from OAB or BOO. Both voiding and storage symptoms may be present in UAB patients. In one study, the most commonly reported presenting symptoms in those identified with DU are urgency (63.3%), weak stream (61%), straining to void (57%), and nocturia (48.1%) (2). Sensation of urgency can be due to a sensory deficit which causes late recognition of bladder fullness and insufficient time to void (5). DU can only be diagnosed with pressure-flow urodynamic studies.

It can be easy to misdiagnose patients with UAB presenting with storage symptoms as having OAB if voiding symptoms are not elicited too. Indeed, Hoag *et al.*, reported that (12.7%) patients with DU, were mistakenly treated with anticholinergics, prior to urodynamic evaluation making their symptoms worse (2). It is impractical for all patients with suspected DU to undergo urodynamic studies, instead clinicians should have a high degree of suspicion when a patient has both storage and voiding symptoms. Non response to treatment or worsening of symptoms after OAB medications, especially if the post void residual (PVR) >150 mL, should alert the clinician to the possibility of UAB as an alternative diagnosis.

Elderly patients with OAB who had successful Onabotulinum toxin A (Botox) bladder injections in the past, who suddenly present with urinary retention on the same dose, may have developed UAB as part of their ageing process. Clinicians should also ask about risk factors for UAB and DU (*Table 1*) and possible sequelae (*Table 2*). Sometimes, UAB, OAB and BOO can coexist with each other and make diagnosis and treatment more complicated. A diagnostic algorithm for LUTS is suggested (*Figure 1*).

Urodynamic diagnosis of DU

Both UAB and BOO can impair bladder emptying resulting in a raised PVR. Clinical evaluation, with the aid of imaging or cystoscopy may support a diagnosis of one or the other. However, cystoscopic appearance of obstruction does not predict who will progress well with removal of prostatic tissue. Urodynamics can help with identification of obstruction and its severity as indicated by the detrusor pressure at peak flow (PdetQmax), and a high voiding pressure with low flow is usually seen.

During urodynamics, a typical finding of DU is low voiding pressure (PdetQmax) combined with slow intermittent flow and incomplete bladder emptying (*Figure 2*).
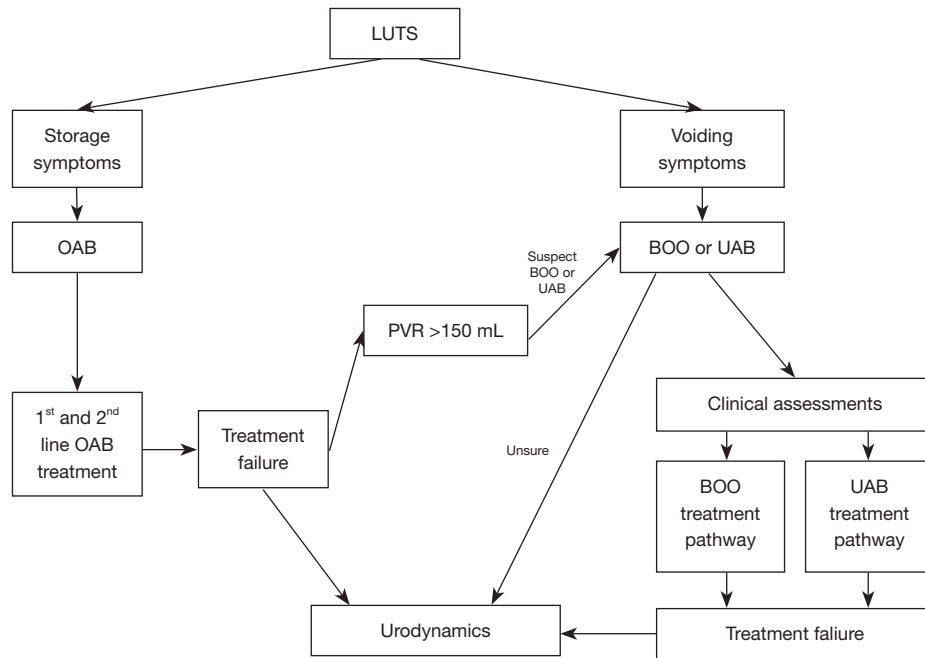
Figure 1 Diagnostic flowchart. LUTS, lower urinary tract symptoms; OAB, overactive bladder; BOO, bladder outlet obstruction; UAB, underactive bladder; PVR, post-void residual.
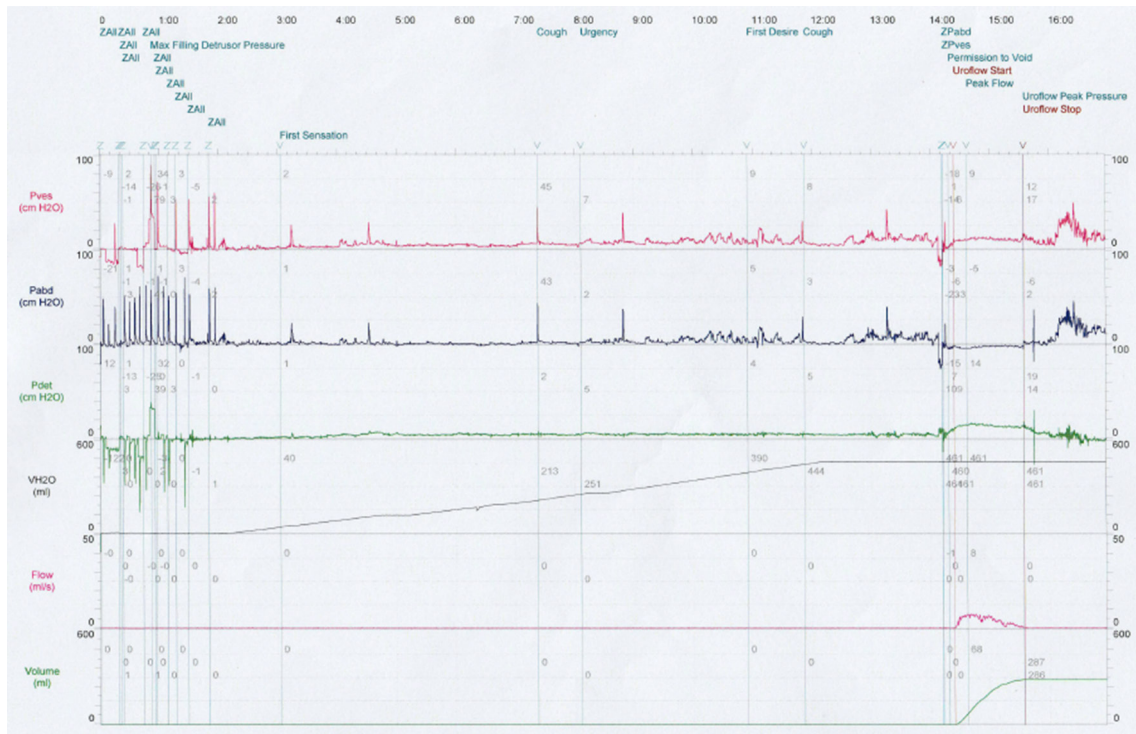

Figure 2 Urodynamic tracings of DU. Urodynamics of male patient with DU. During voiding phase, Qmax was 8 mL/sec, PdetQmax was 30 cmH$_2$O, voided volume was 288 mL and residual volume was 170 mL. BCI was 70. DU, detrusor underactivity.
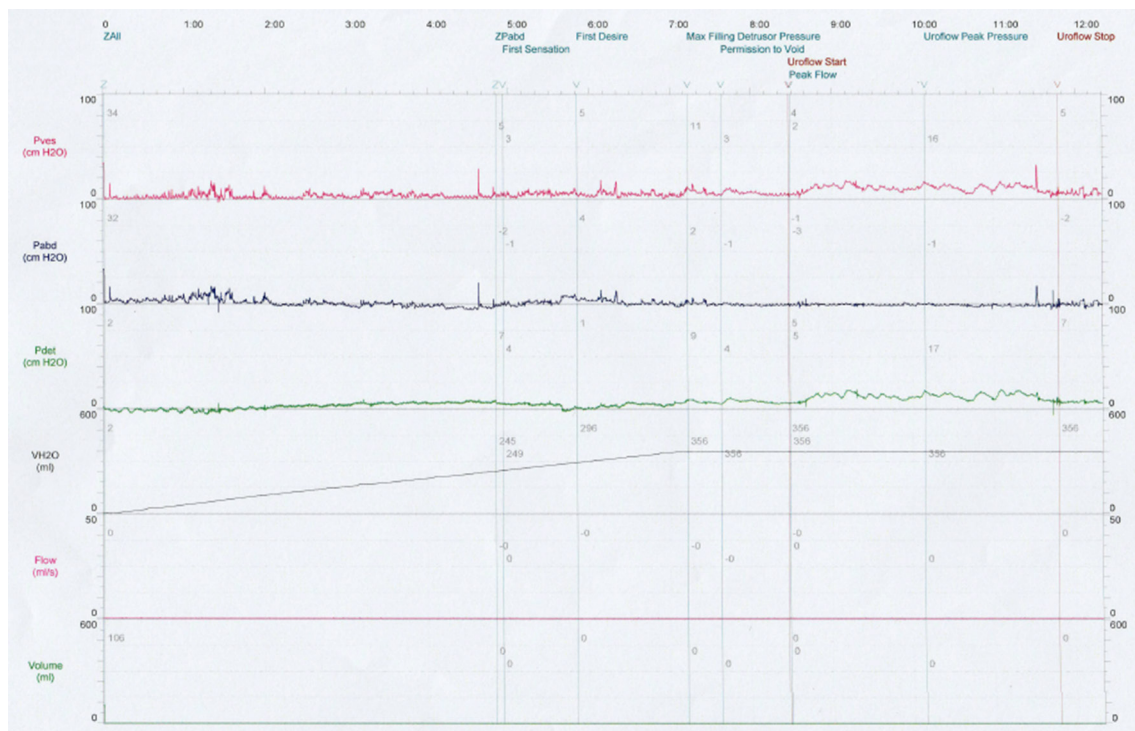
Figure 3 Urodynamic tracings of DU (non-voider). Urodynamics of female patient with DU. Patient was unable to void, Pdet during attempted voiding was 18 cmH$_2$O and residual volume was 358 mL. DU, detrusor underactivity.

Inadequately sustained detrusor contraction during voiding can also be seen. In non-voiders, minimal bladder contractility can be seen with no volume voided, during the voiding phase (*Figure 3*). Sometimes abdominal straining may be seen. Agreement is still being reached regarding the optimal method to diagnose DU during urodynamics. Several methods have been proposed and each has its own advantages and limitations. These are listed in *Table 3*. It must also be noted that if DU and BOO co-exist, diagnosis can be difficult as both conditions impact on the PdetQmax, an essential component of diagnostic formulas.

Chronic urinary retention (CUR) in men

There is a lack of consensus regarding the definition of chronic urinary retention (CUR) and it can be caused by either BOO or UAB or both. CUR is defined by the International Continence Society as 'a non-painful bladder, which remains palpable or perusable after the patient has passed urine' (3). Abrams *et al.*, described it as a post void residual (PVR) volume of >300 mL as he considered that to be the volume when the bladder is easily palpable

suprapubically (4,6). The Italian Association of Urologists defined it as PVR > one-third of total bladder volume and the UK LUTS guidelines defined it as PVR >1,000 mL. This confusion leads to the difficulty of interpreting and designing trials to study patients with CUR, as such most clinical trials of benign prostatic hyperplasia (BPH) treatment exclude patients with CUR, despite up to a quarter of men with BPH having CUR.

CUR is classified as low pressure or high pressure (6). Low pressure CUR patients have an end filling pressure of <25 cmH$_2$O on urodynamic studies. These patients typically have voiding symptoms of hesitancy, slow stream and sensation of incomplete emptying. High pressure CUR patients have an end filling pressure of >25 cmH$_2$O and complain of more urinary urgency and enuresis. Half of high pressure CUR patients develop upper tract dilatation and altered renal function.

The outcome of men with CUR has been reported. Bates *et al.*, conservatively managed 93 men with low symptom score and CUR (mean PVR =363 mL) for 5 years (7). 31/93 (30%) had TURP at a median of 30 months because 14 had worsening lower urinary tract symptoms (LUTS),

Table 3 Diagnostic tools for evaluation of detrusor underactivity (DU)

Methods	Advantages	Disadvantages
Bladder contractility index BCI = PdetQmax + 5Qmax DU = BCI <100	Easy to use	Not validated in women; cannot measure contraction sustainability
Watts Factor WF = [(pdet + a) (vdet + b) − ab]/2π	Not affected by bladder outlet obstruction (BOO); measures bladder power	Complex formula; impractical to use clinically; cannot measure contraction sustainability; diagnostic thresholds not established
Mechanical flow occlusion Stop test Continuous occlusion test	Measures isovolumetric contraction strength	Cannot be done in those with sphincter weakness or elderly; painful and impractical
Maastricht-Hannover nomogram DU ≤25th percentile	Quantifies relationship between detrusor contractility and BOO	Not validated in women
Urodynamic cut-offs e.g., PDetQmax <40 cmH$_2$O Qmax <15 mL/sec	Easy to use	No accepted normal ranges

8 had increasing PVR, 7 had acute urinary retention (AUR) and 2 had raised serum creatinine. 75% of the men improved post TURP. 5/93 (5.4%) men had recurrent UTIs and 2/93 (2.2%) needed to do self-catheterization. The authors concluded that complications are uncommon and patients can be conservatively managed but outpatient review is prudent. Ghalayini *et al.*, reported a randomised control trial comparing TURP to clean intermittent self-catheterization (CISC) in men with CUR (8). Seventeen patients were randomised to the TURP arm and 21 men to CISC. They were reviewed at 3 and 6 months. HRQoL and IPSS improved in both groups. This study suggests the benefit of CISC in treating patients with CUR.

However, neither of these studies distinguished between high pressure and low pressure CUR patients. It is likely that most of the treatment benefit was seen in high pressure CUR patients. It is well known that patients with high pressure CUR do well after a TURP (9). To date, there is very little literature that looks at the management of low pressure CUR, UAB and DU; who should we treat and when.

Surgical treatment options for DU

TURP

A common urological dilemma is: will a TURP be of

benefit to a patient with DU and chronic urinary retention, including in the absence of BOO? To answer this question, we must look at the natural history of untreated DU, then examine the short term and long term outcomes of TURP in these patients. Thomas *et al.*, observed 69 men with DU for 13.6 years. The mean age of the men was 57.5 years, during follow up 11/69 men (16%), needed a TURP (8 of them for worsening LUTS and 3 for AUR). No identifiable causes were found for the AUR. Furthermore, 2/69 men (2.9%), needed to commence CISC (10).

The short term outcome of TURP in men with DU seems to be good. Potts *et al.*, performed bladder outlet procedures in 21 of their 139 patients with DU and without BOO (11). They defined success as no future retention, need for catheterizations or surgery. At 6 months post TURP, 86% of patients had improved. Another study from Japan examined if pre-TURP voiding dysfunction affects the outcome of TURP (12). 37/92 (40%) of their patients had DU and were followed up at 3 months post-op with IPSS, QOL index, Qmax and PVR. All these parameters showed statistically significant improvement. 26/37 (70.3%) patients reported good/excellent efficacy and 6/37 (16.2%) reported poor/worse efficacy. A possible mechanism for short term symptomatic improvement in men with DU treated with TURP, is that the surgery reduces the bladder outlet resistance and allows easier abdominal straining and

hence improved bladder emptying.

The long term results in these men seem to show a reversal of symptoms back to pre-op baseline. The same Japanese study followed their group of patients for 12 years post TURP (13). IPSS and QOL index were obtained at 3 months, 3 years, 7 years and 12 years post op. Patients with DU showed an improvement in IPSS up to 7 years but this improvement disappeared by 12 years. Thomas *et al.*, followed 22 of their patients with DU who had TURP for 11.3 years and performed urodynamic studies for comparison (14). Symptoms were unchanged from pre-TURP baseline. Urodynamic studies showed no change in detrusor contractility and there was still small but significant improvement in PdetQmax and BOOI (bladder outlet obstruction index). This confirms that the benefit of TURP in reducing outlet resistance is maintained for a long time. The detrusor contractility had not worsened, yet the symptoms had reverted back to baseline. A possible explanation is that the efficiency of abdominal straining worsens as these men age and the symptoms return over time.

This data suggests that DU is not a contraindication for TURP; in fact most patients will get short term improvement in their symptoms likely due to the decrease in outlet resistance, but this improvement tends not to be sustained over a longer time. If the DU and CUR is untreated, about 1 in 6 patients may need a TURP, and the incidence of AUR is low (4%).

Reduction cystoplasty

The surgical reduction of bladder capacity is an uncommonly performed procedure. Thorner *et al.*, examined reduction cystoplasty, in 8 patients with DU, large mean bladder capacity of 2,555 mL and high PVRs (>600 mL). In this group of patients, 50% of patients had a BCI <100, and 75% had a BOOI <40. Three patients underwent synchronous bladder diverticulectomy and three underwent suprapubic prostatectomy in addition to cystoplasty. After 1 year, 7/8 (88%) had a successful outcome and only 1/8 (12%) was unchanged and still needed to do CISC (15). The authors stated that the ideal patient was one who had a large bladder capacity but still retained some detrusor contractility on urodynamics, and had no urethral obstruction.

Bladder diverticulectomy

An acquired bladder diverticulum is usually as a result of chronic BOO or neurogenic voiding dysfunction. As the diverticulum is lacking detrusor muscle, it may contribute to poor detrusor contraction, chronic retention of urine, recurrent UTI, haematuria, abdominal pain and is at risk of malignant transformation. However, most bladder diverticula are typically asymptomatic and found during cystoscopy investigating other lower urinary tract symptoms. If the diverticulum is considered a source of the symptom the patient should undergo video urodynamics. This will provide information about location, size, reflux, and emptying of the diverticulum upon voiding. In addition, upper tract imaging with ultrasound, should be performed to rule out hydronephrosis or ureteral obstruction.

Asymptomatic patients may be monitored with urine cultures and endoscopic surveillance. Surgical management of the bladder diverticula is only necessary when the patient is symptomatic or has a recurrent infection, stones, urinary obstruction and vesicoureteral reflux. The data reporting on the effect of diverticulectomy on chronic urinary retention is limited to small studies and case reports only (15-18).

Adot Zurbano *et al.*, examined the pre-operative variables of patients with BPH/BOO and compared the outcome in those who underwent TURP *vs.* combined TURP and bladder diverticulectomy. They found that the duration of detrusor contraction was the only pre-operative parameter significantly altered by the presence of a bladder diverticulum. They reported that diverticulectomy improved bladder contractility in patients with BOO and a diverticulum (16). This data suggests that patients with chronic retention, DU and a bladder diverticulum might benefit from combined diverticulectomy and bladder outlet surgery. However, some questions remained unanswered. There are still no specific guidelines on which diverticulum to operate on, based on size of diverticulum and preservation of detrusor contractility. Also how do we detect contractility in the non-diverticulum part of the bladder and is it accurate to do this by placing the transducer line in there during the voiding phase of the urodynamic study.

Bladder diverticulectomy has the additional benefit of the reduction in risk of bladder cancer. Chronic irritation of intra-diverticular urine may be the cause of a bladder cancer arising in the diverticulum. The incidence of a transitional cell carcinoma arising in a diverticulum ranges from 0.8% to 14.3% (19,20). Cancer of a diverticulum has traditionally been associated with poor outcomes compared to bladder cancer arising not from a diverticulum (21).

The optimal approach for diverticulectomy has evolved over time. Open surgery was the standard approach when

it was first described by Hugh Hampton Young. More recently, it has been replaced by laparoscopic and robotic assisted laparoscopic surgery (22,23). The latter techniques have the advantages of reduced post-operative pain, smaller incisions and reduced hospital stay (23). As most bladder diverticula arise at the ureterovesical hiatus, care must be taken not to damage the ureter. If that should happen a reimplant may be necessary. Endoscopic incision of a bladder diverticulum involves resection of the diverticular neck converting a tight-neck to a broad-neck, facilitating bladder emptying. Fulguration of the diverticular mucosa has also been described with some success and these techniques are recommended to be reserved for unfit patients (24).

SNM

SNM was approved by FDA for treatment of non-obstructive urinary retention (NOUR) in 1999. The exact mechanism of action is unknown but it is postulated that SNM inhibits the inappropriate activation of the 'guarding reflex', thus facilitating voiding (25). NOUR is a term that describes the situation of the inability to empty the bladder with no physical obstruction to the urine flow. It can occur as a result of neurological disorders or it can be idiopathic. UAB and DU are newer terms that fall under NOUR. Thus, most SNM studies report the outcome of interventions for NOUR rather than UAB/DU.

In the only randomised control trial so far, Jonas *et al.* randomised 68 patients who had successful peripheral nerve evaluation (PNE) to SNM and control groups (26). Success was defined as >50% reduction in catheterised volume or elimination of catheterisation. At 6 months, 83% of the implant group had success compared to 9% of the control group. A meta-analysis in 2010 included this RCT and 13 other observational studies and found a statistically significant increase in voided volume of 299 mL and a decrease in mean PVR of 236 mL (27). They concluded that SNM is an effective option for treatment of NOUR.

Many SNM trials report a success rate of 70–80% for urinary retention patients and this is often higher than the success rate for OAB patients. This can be misleading as readers may think that SNM will work in such a high proportion of patients with urinary retention. In fact, the patients have been screened during the trial phase (with either PNE or a staged trial) and only the responders get the permanent implant and are followed up. Perhaps it is more clinically relevant to look at the response rate

of patients during the trial phase, as an indicator of how effective SNM is. *Table 4* shows results of SNM trials in patients with NOUR. The response rate during the trial phase ranges from 33–90% and the success rate ranges from 55–100%. Many of the studies do not report the response rate to the trial phase at all. The response rate (mean 54.2%) is certainly lower than the success rate (mean 73.9%). This highlights the fact that SNM may not work for everyone and that patient selection is important.

Rademakers *et al.*, used the Maastricht-Hannover nomogram to identify 18 men with DU (<25th percentile on the nomogram). These men were then treated with SNM. Success was seen in 20% of men below the 10th percentile and in 86% of men between the 10th and 25th percentile (42). Therefore, patients with more preserved bladder contractility have a higher success rate than those with lower contractility. It may be prudent to do urodynamic studies on UAB patients to determine their bladder contractility. Patients with an acontractile bladder have a lower response rate to a trial of SNM, and these patients can be counselled about their expectations.

Scheepens *et al.*, did a randomised cross over trial involving 12 patients with urge incontinence and 13 with urinary retention, to compare unilateral versus bilateral lead insertion. There was no significant difference in improvement found but two patients could only void with bilateral leads (43). Therefore, most patients will only need a unilateral lead during their trial. The prominent dorsal commissure in the sacral cord presumably has a powerful integrating function at a segmental level.

Urinary retention patients take longer to respond to a SNM trial compared to OAB patients. Elneil *et al.*, carried out a staged trial on 24 women with CUR and assessed them over a period of 8 weeks. The mean onset of restoration of bladder sensation and voiding was 9 days. By day 17, 90% had restoration of sensation and 80% voided. This implies that a staged trial may go up to 4 weeks to maximize the chances of a response (44).

In summary, SNM is a good treatment option for patients with UAB. Patient selection is important. The ideal patient should have preserved bladder contractility on pre-op urodynamics. BOO should be excluded and an MRI of the brain and spine should be done to exclude a neurogenic cause, which may result in a lower response rate (45). A neurogenic condition may also require ongoing MRI surveillance and this will preclude the patient from having SNM treatment as the device is MRI incompatible. A subgroup of women with Fowler's syndrome seems to

Table 4 Studies of SNM in patients with non-obstructive urinary retention

Study	No.	Type of test	Response rate: test phase (%)	Success rate: permanent SNM (%)	Follow up (months)
Shaker et al., [1998] (28)	20	PNE	90 (18/20)	100 (18/18)	15
Swinn et al., [2000] (29)	38	PNE	66 (25/38)	75 (9/12)	N/A
Siegel et al., [2000] (30)	177	PNE	N/A	70	18
Jonas et al., [2001] (26)	177	PNE	38 (68/177)	71 (17/24)	18
Aboseif et al., [2002] (31)	32	PNE	63 (20/32)	85 (17/20)	24
Bross et al., [2003] (32)	24	PNE	33 (8/24)	N/A	N/A
van Voskuilen et al., [2006] (33)	42	PNE	N/A	76 (32/42)	64
Goh et al., [2007] (34)	29	PNE and staged trial	48 (14/29)	N/A	N/A
van Kerrebroeck et al., [2007] (35)	31	PNE	N/A	71 (21/31)	60
De Ridder et al., [2007] (36)	82	PNE	76 (62/82)	55 (34/62)	43
Datta et al., [2008] (37)	60	PNE	N/A	72 (43/60)	48
White et al., [2008] (38)	40	Staged	70 (28/40)	86 (24/28)	40
Al-Zahrani et al., [2011] (39)	41	PNE and staged trial	39 (16/41)	88 (14/16)	51
Peeters et al., [2014] (40)	93	PNE	N/A	73 (68/93)	47
Saber-Khalaf et al., [2015] (41)	21	staged trial	66 (14/21)	100 (11/11)	34
Mean			54.2 (273/504)	73.9 (308/417)	

No., number of patients; PNE, peripheral nerve evaluation; N/A, not available.

have a higher reported response rate of 68–77%, and SNM should be the preferred treatment (29). If they can, patients should learn to do CISC prior to a trial of SNM as that will make assessment of response much easier by looking at the bladder diary and also act as a back-up plan should the trial fail. A staged trial should be between 2 to 4 weeks. Bilateral leads should be considered in selected patients, especially those who show a partial response to unilateral lead placement.

Conclusions

UAB is a prevalent condition. There is no reliable symptom complex due to UAB having overlapping symptoms with other bladder conditions. One should have a high degree of suspicion of UAB if there are risk factors or in treatment failures for LUTS. Urodynamics is essential for diagnosis of UAB/DU. Surgery like TURP or bladder diverticulectomy may be effective in some patients. SNM is probably the most effective treatment at present but patient selection is important. Hopefully, more treatment options can be available as further research is directed into this field.

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Footnote

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