Surveillance urodynamics for neurogenic lower urinary tract dysfunction: A systematic review

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Abstract

Introduction: Baseline urodynamic characterization in patients with neurogenic lower urinary tract dysfunction (NLUTD) allows detection of unsafe storage and voiding pressures and optimization of these parameters through medical or surgical intervention. Surveillance urodynamics (sUDS) studies are performed in the ambulatory setting after baseline characterization, with the goal of monitoring bladder function. How often this study should be performed and the circumstances that should prompt repeated studies are unknown. The primary objective of this review is to evaluate the evidence supporting sUDS in the setting of NLUTD as assessed by whether the study leads to 1) change in patient management; 2) determination of new findings not suggested by imaging or symptoms; and 3) demonstration of superior outcomes compared to observation. The secondary objective is to review sUDS practice patterns among urologists in their assessment of NLUTD.
Methods: PubMed, EMBASE, and Cochrane Library databases were reviewed for English-language literature published between January 1975 and March 2018.
Results: Twenty-eight independent articles (1368 patients, 9486 patient-years of followup) were included. Given heterogeneous data, 49% of 263 subjects were asymptomatic, yet demonstrated sUDS abnormality prompting treatment. Eight cross-sectional studies (four spinal cord injury [SCI], two NLUTD, two spina bifida) surveyed urologists regarding current sUDS patterns; 53% of 498 respondents perform sUDS between one and three years.
Conclusions: Evidence supporting optimal surveillance for NLUTD is lacking. Level 2b–4 evidence suggests that sUDS is likely to modify patient treatment and often demonstrates findings that modify treatment in the absence of symptoms or imaging changes.

Introduction

Baseline urodynamic characterization (UDS) is the gold standard for the evaluation of lower urinary tract dysfunction. The prognostic value of UDS for maintenance of bladder function and protection from upper urinary tract (UUT) deterioration is mentioned in several studies in patients with neurogenic lower urinary tract dysfunction (NLUTD).[1,2] Surveillance urodynamic studies (sUDS) are performed in the ambulatory setting after baseline characterization, with the goal of maintaining safe lower urinary tract parameters. Although it is well-known that clinical examination alone is not sufficient to determine individual urological management strategies in patients with NLUTD,[3] data demonstrating the value sUDS in the setting of NLUTD is lacking.[4] Similarly, optimal frequency of sUDS is unknown. Whether sUDS studies should be regularly scheduled or performed based on a change to patient symptoms is also undetermined.

Clinical practice guidelines suggest regular evaluation for patients at high risk of UUT deterioration, but there is a lack of consensus regarding specific risk stratification or frequency of sUDS evaluation (Table 1).[5-10] Furthermore, there is no consensus if sUDS should be scheduled regularly or repeated for new patient symptoms or imaging changes. Consequently, practice patterns vary with regard to sUDS frequency[11-17] and healthcare utilization data suggests low uptake of sUDS use in NLUTD within the U.S. and Canada.[18,19]

The primary objective of this review was to evaluate the evidence supporting sUDS in the setting of NLUTD as assessed by whether the study leads to 1) change in patient management; 2) determination of new urodynamic findings not suggested by either physical examination, imaging change, or patient symptoms; and 3) demonstration of superior outcomes compared to surveillance without regular UDS. The secondary objective was to review current sUDS practice patterns among urologists in their assessment of NLUTD.

Methods

This systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement[20] and registered in PROSPERO bank of systematic reviews as 76662. We conducted a search

Table 1. Surveillance urodynamic guideline statements

Guideline	Population	UDS surveillance suggestion
European Association of Urology guidelines on neuro-urology 2013, 2016[5,6]	NLUTD	Urodynamic investigation is a mandatory baseline diagnostic and in high-risk patients, should be done at regular intervals
NICE guidelines. Urinary incontinence in neurological disease: Assessment and management, 2012[7]	NLUTD	Consider urodynamic investigations as part of a surveillance regimen for people at high risk of upper urinary tract complications (for example, people with spina bifida, spinal cord injury, or anorectal abnormalities)
Adult urodynamics: AUA/SUFU guideline, 2012[8]	NLUTD	Clinicians should perform a cystometrogram (CMG) during initial urological evaluation of patients with relevant neurological conditions with or without symptoms and as part of ongoing followup when appropriate
Consortium for Spinal Cord Medicine. Bladder management for adults with spinal cord injury: A clinical practice guideline for healthcare providers, 2006[10]	SCI	Generally, a urological evaluation is done every year, although there is no consensus among doctors on the frequency this type of exam should be performed or the range of tests that should be included
A proposed guideline for the urological management of patients with spinal cord injury. UK guideline, 2007[9]	SCI	Urodynamics are recommended when: upper urinary tract safety is an issue; recent onset incontinence has occurred; previous urodynamics showed detrusor-sphincter dyssynergia with sustained raised vesicle pressure or low compliance; before and after a change in bladder management; onset of UTIs or urinary tract stones; presence of VUR; high PVR

AUA: American Urological Association; NICE: National Institute for Health and Care Excellence; NLUTD: neurogenic lower urinary tract dysfunction; PVR: post-void residual; SCI: spinal cord injury; SUFU: Society for Urodynamics and Female Urology; UTI: urinary tract infection; VUR: vesicoureteral reflux.

of the PubMed, EMBASE, and Cochrane Library databases for English-language literature published between January 1975 and March 2018. Medical subject heading (MeSH) terms included: 1) neurogenic lower urinary tract dysfunction; 2) neurogenic bladder; and 3) urodynamic(s). Each of these terms was crossed with: 1) long-term care; 2) long-term surveillance; and 3) long-term followup (Table 2). Only studies related to NLUTD and urological followup were included in this review article. Studies were also identified by hand search of reference lists and review articles.

Studies were included if they presented: 1) findings related to one of the four previously mentioned inquiries; 2) pediatric or adult data relating to sUDS; 3) published since 1975; and 4) written in English. sUDS was defined as ≥2 studies performed after baseline UDS characterization. We excluded review articles and studies not available in full-text format (Fig. 1). All articles were graded according to the Oxford Centre for Evidence-based Medicine guidelines.[21]

Results

Initial records identified through database search included 659 articles; 31 additional records were identified through other sources. The study selection procedure is described in Fig. 1. During the data extraction process, articles were excluded if the detailed full review revealed that they did not meet the initial criteria and articles were added from the referenced bibliographies if they met the inclusion criteria. At the end of this full review, 28 of the 690 articles met our final criteria (Tables 3, 4).

All reviewed articles focused on NLUTD secondary to either spinal cord injury (SCI), multiple sclerosis (MS), or spina bifida. Results could not be combined due to heterogeneity of underlying pathology. sUDS was performed on a regular, specific interval (1–2 years) in nine studies and based on altered symptoms or imaging findings (recurrent urinary tract infection [UTI], increased incontinence between catheterization, or alarming features on ultrasound) in nine articles (predominantly MS). Individual findings for SCI, spina bifida, and MS patients are provided in the following sections.

Table 2. MeSH permutations used

Search term	Concepts
Neurogenic bladder Neurogenic lower urinary tract dysfunction	Neurogenic and Bladder [Keywords] or Neurogenic and lower and urinary and tract and dysfunction
	and
Urodynamics	Urodynamic (Urodynamics, Urodynamic study, Urodynamic evaluation)
	and
Long-term care Long-term surveillance Long-term followup	Long-term and care or Long-term and Surveillance or Long-term and Followup
	or
Hydronephrosis Vesicoureteral reflux End-stage renal disease Chronic kidney insufficiency Chronic kidney insufficiency	Hydronephrosis or Vesicoureteral and reflux or End-stage and renal and disease or Chronic and kidney and insufficiency or Chronic and kidney and insufficiency

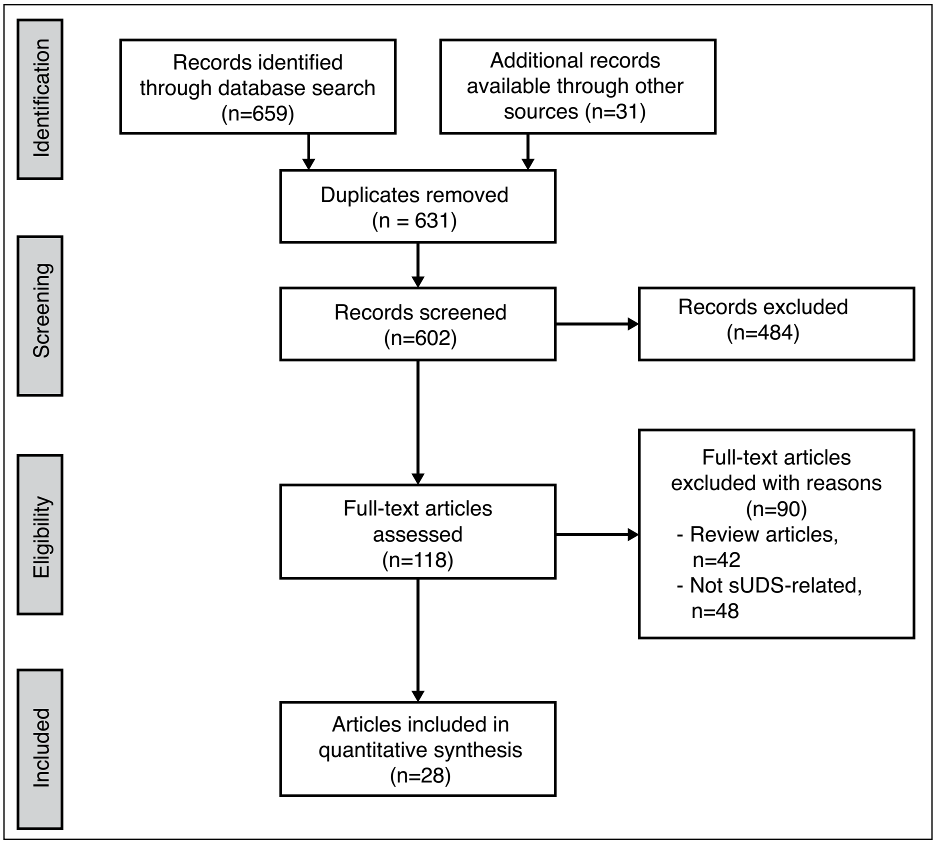

Fig. 1. Flow diagram of search strategy. sUDS: surveillance urodynamics.

SCI

Five articles meeting level 4 evidence addressed sUDS in the SCI population (Table 3). Studies included 470 adults and 28 pediatric patients with 2393.4 and 107.3 patient-years of followup, respectively. Four of five articles performed sUDS based on regularly timed studies defined on a specific interval (1–2 years) while one article performed surveillance based on altered symptoms or imaging findings (recurrent UTI, increased incontinence between catheterization, or alarming features on ultrasound).

The impact of annual sUDS on adjustment of patient treatment was addressed by Linsemeyer et al.[22] The authors performed a cross-sectional review of 96 individuals with stable traumatic SCI undergoing annual UDS evaluations. Changes in the urodynamic parameters and autonomic dysreflexia were determined by comparing the current study with the prior year. The main outcome measure was whether or not there was a need for intervention based on the UDS results. Overall, 47.9% of individuals required at least one type of intervention based on annual UDS: 82.6% were urological interventions (medication changes were most common, comprising 54.3% of urological interventions); 13.0% were non-urological interventions; and 4.3% were a combination of non-urological and urological interventions. The need for intervention was not influenced by the type of bladder management, the length of time post-injury, or level of injury. Only 5.2% of patients reported new-onset urological symptoms since their prior annual evaluation.

Nosseir et al[23] also advised that reliance on clinical symptoms to prompt sUDS leads to failure to detect a large number of treatment failures in the SCI population. The authors reviewed 80 SCI patients with at least one followup visit per year for a minimum of five consecutive years. The focus was to determine how frequently the treatment regimen had to be modified due to annual sUDS results. Over a mean followup of 67.3 months, the treatment strategy had to be modified in almost all patients. If authors had relied solely on clinical symptoms or imaging findings, 68.75% of treatment failures would not have been detected.

Conversely, Edokpolol and colleagues[24] established a safe lower urinary tract with baseline UDS, and subsequently performed annual renal ultrasonography for surveillance. sUDS was repeated only when patients presented with new symptoms or alarming radiological changes. Subjects were followed for a mean duration of 6.8 years. sUDS was repeated in 40% of subjects during the study period. After repeat sUDS for new onset of symptoms, bladder management was not changed in 64% cases. The dose or type of anticholinergic was increased or changed in 32% cases, and one subject received bladder augmentation. In four other subjects, the regimen was modified based on symptoms without repeating sUDS. Two new cases of pelvicaliectasis were present at the time of final ultrasound. One case was secondary to an obstructing stone and the second was due to refractory bladder pressures in a non-compliant patient. The authors concluded that an ultrasound-based surveillance approach is efficacious in SCI patients and suggest that annual sUDS may be unnecessary.

Spina bifida

Seven articles meeting level 2b–4 evidence addressed sUDS in the spina bifida population (Table 3). Studies included 120 adult and 587 pediatric patients with 1248 and 5208 patient-years of followup, respectively. Five of seven articles performed sUDS based on regularly timed studies defined on a specific interval (1–2 years) while two articles performed surveillance based on altered symptoms or imaging

Table 3. Surveillance UDS in the setting of NLUTD

Author	Pathology	No. of pts	Study type/ quality	FU period (yrs)	UDS interval (yrs)	Regular or prompted by symptom	Percentage of studies that adjust treatment	Superior outcome compared to conservative management	New upper urinary tract deterioration	Percentage of studies that demonstrate sUDS change in asymptomatic pts
Linsenmeyer et al[22]	SCI	96	Level 4, cross-sectional	2	1	Regular	47.9% of studies prompt treatment change	No control group	None	43% of patients had asymptomatic sUDS deterioration (46-5/96)
Nosseir et al[23]	SCI	80	Level 4, retrospective cohort series	5	1	Regular	96% of patients underwent treatment change	No control group	None	69% of patients had asymptomatic sUDS deterioration
Schops et al[40]	SCI	246	Level 4, retrospective cohort series	6	6	Regular	40.6% of patients underwent treatment change	No control group	1% hydronephrosis, 5% low-grade reflux	Symptoms not tracked
Edokpolol et al[24]	SCI	48	Level 4, retrospective cohort series	6.8	Irregular*	Symptom-based	Treatment adjusted in 34%; in 10%, treatment changed for symptoms without repeating UDS	No control group	New hydronephrosis (2%)	sUDS performed only for symptomatic change
Chao et al[41]	SCI	28 ped	Level 4, retrospective cohort series	3.83	1–2					
Tarcan et al[27]		Regular	39% of patients underwent treatment change	No control group	None	Symptoms not tracked				
Edelstein et al[29]	SB	25 ped	Level 4, retrospective cohort series	9.1	1	Regular yearly until toilet-trained, then symptom-based	32% of patients underwent treatment change	No control group	None	24% of children had asymptomatic UDS deterioration (6/25)
Spindel et al[25]	SB	148 ped	Level 2b, retrospective cohort series	4.5	1	Regular or when imaging revealed upper urinary tract changes	80% of patients in observation and 15% of patients in early intervention required treatment change	Less UUT deterioration in regular sUDS and intervention	UUT deterioration in 80% of patients in observation and 15% of intervention arm	Symptoms not tracked
Kaufman et al[30]	SB	214 ped	Level 4, retrospective cohort series	13	Irregular	Performed for imaging changes or incontinence at school age	37% of patients underwent treatment change	No control group	37% of patients had upper urinary tract deterioration	Symptoms not tracked; all 37% that required sUDS underwent this for imaging changes
Almodhen et al[26]	SB	37 ped	Level 4, retrospective cohort series	5	1	Regular	35% of patients had change to voiding patter, CIC, or medication	No control group	8%, none post-puberty	Symptoms not tracked; 10% had imaging or renal scan changes

*Based on patients symptoms or sonographic findings (not regular intervals), CIC: clean intermittent catheterization; DESD: detrosure external sphincter dyssynergia; FU: followup; MS: multiple sclerosis; NLUTD: neurogenic lower urinary tract dysfunction; OR: odds ratio; ped: pediatric; SB: spina bifida; SCI: spinal cord injury; sUDS: surveillance urodynamics; UDS: urodynamic study; UUT: upper urinary tract; yrs: years.

Table 3 (cont'd). Surveillance UDS in the setting of NLUTD

Author	Pathology	No. of pts	Study type / quality	FU period (yrs)	UDS interval (yrs)	Regular or prompted by symptom	Percentage of studies that adjust treatment	Superior outcome compared to conservative management	New upper urinary tract deterioration	Percentage of studies that demonstrate sUDS change in asymptomatic pts
Hopps et al[31]	SB	84 ped	Level 4, retrospective cohort series	10.4	Irregular	Based on imaging or symptom change	56% of patients underwent treatment change	No control group	Rarely (2/84)	sUDS performed only for symptomatic change
Veenboer et al[17]	SB	120	Level 4, cross-sectional	10.4	Irregular	Based on imaging or symptom change	25.8% had unsafe bladder requiring treatment change	No control group	Not tracked	OR of any sUDS abnormality given patient symptoms is 0.64
Ciancio et al[32]	MS	22	Level 4, retrospective cohort series	14	2.9	Symptom-based	55% of patients had a change to UDS pattern and all were offered treatment	No control group	None	27% of patients had asymptomatic sUDS change
Wheeler et al[34]	MS	18	Level 4, retrospective cohort series	2.1	Irregular	Symptom-based	55% of patients underwent treatment change	No control group	None	Prompted by changing or persistent symptoms
Blaivas et al[36]	MS	41	Level 4, retrospective cohort series	Variable	Irregular	Symptom-based	30% had changing UDS pattern or imaging change requiring treatment	No control group	None	Bladder symptoms correlated poorly with any single urodynamic finding
Goldstein et al[35]	MS	9	Level 4, retrospective cohort series	Variable	Irregular	Symptom-based	44% had changing UDS pattern requiring treatment change	No control group	None	Prompted by changing or persistent symptoms
Schoenberg et al[33]	MS	33	Level 4, retrospective cohort series	2.5	Irregular	Symptom-based	36% had changing UDS pattern requiring treatment change	No control group	None	Prompted by changing or persistent symptoms
Bemelmans et al[37]	MS	40	Level 4, retrospective cohort series	2.5	Irregular	Single point	88% had UDS abnormality requiring treatment change	No control group	None	50% of asymptomatic patients had UDS abnormalities requiring treatment

*Based on patients symptoms or sonographic findings (not regular intervals). CIC: clean intermittent catheterization; DESD: detrosure external sphincter dyssynergia; FU: followup; MS: multiple sclerosis; NLUTD: neurogenic lower urinary tract dysfunction; OR: odds ratio; ped: pediatric; SB: spina bifida; SCI: spinal cord injury; sUDS: surveillance urodynamics; UDS: urodynamic study; UUT: upper urinary tract; yrs: years.

findings (recurrent UTI, increased incontinence between catheterization, or alarming features on ultrasound).

NLUTD management in pediatric spina bifida differs from adult pathology in the magnitude of UDS evolution in the early years of life. Spindel et al[25] performed a retrospective review of 79 pediatric patients that underwent annual sUDS with synergic outlets and biannual sUDS for dyssynergic outlets; 37% of patients had demonstrable changes in external urethral sphincter function over time. There was a 32% chance of having a change in external sphincter function during the first 12 months of life, a 6% chance during the second 12 months, and a 2% chance during the third 12 months. Furthermore, Almodhen et al[26] demonstrated that total cystometric bladder capacity, maximum detrusor pressure, and detrusor leak point pressure increase significantly in patients with myelomeningocele following puberty on annual sUDS.

Although several pediatric studies demonstrate benefit of regular surveillance[26,27] compared to expectant management,[28] Edelstein et al[29] provided the only prospective controlled study. Authors compared urological outcomes of a cohort of children who were at risk for urological deterioration on the basis of bladder-sphincter dyssynergia

Table 4. Practice patterns of surveillance UDS

Author	Population	UDS strategy
Elliott et al[13]	Spina bifida	A survey was mailed to all 169 clinics listed by the Spina Bifida Association of America; 59% obtained routine UDS, commonly at intervals of 1– 2 years
Veenboer et al[17]	Spina bifida	A questionnaire was sent to all 365 urologists in the Netherlands regarding current assessment of adult spina bifida patients. Video UDS investigations (UDS) were performed on a regular basis (1–2 years) by 24.3%; the remainder performed the study for symptomatic changes
Blok et al[12]	NLUTD	A questionnaire was mailed to members of the Canadian Urological Association; 75% of respondents undertook urodynamic study and 11% (n=9), video UDS; this was performed annually or every other year
Rikken et al[16]	NLUTD	A questionnaire was mailed to 304 certified urologists of the Dutch Urological Association; 12% of respondents completed regular urodynamic studies every 1–2 years
Bycroft et a[l4]	SCI	12 Spine Injured Units in the U.K. and Eire were sent a questionnaire addressing basic practice relating to urological outpatient followup and UDS; Six units did not perform routine UDS; in four units that perform routine sUDS, range of frequency of UDS was from 1–3 years
Razdan et al[15]	SCI	A mailed questionnaire was sent to the 269 American members of the Society for Urodynamics and Female Urology (SUFU); 65% of respondents performed surveillance video UDS every 1–2 years; the remaining 35% did not consider routine UDS needed and completed a cystogram if the patient had recurrent UTIs or deleterious upper urinary tract changes on US or other imaging study
Kitahara et al[14]	SCI	A Japanese version of the 14-item questionnaire survey carried out in U.S. was mailed to 770 members of the Japanese Neurogenic Bladder Society (JNBS); cystometry was performed yearly by 174 (52.3%) respondents for the evaluation of vesicourethral function
Al Taweel et al[11]	SCI	Questionnaire distributed to urologists working in Saudi Arabia and registered at the Saudi Medical Association; 62% repeat the study every year; the remaining 20% will do it every two years, and 12% will do it whenever the patients' symptoms deteriorate
Cameron et al[18]	SCI	Used a 5% Medicare sample to review data from over 7000 SCI patients. During the two-year period, 35.7% of patients saw a urologist and 6.7% had UDS
Welk et al[19]	SCI	1551 SCI patients were followed for a median of five years after discharge from a rehabilitation hospital; the proportion of patients who had regular UDS at least once every two years was 10%

NLUTD: neurogenic lower urinary tract dysfunction; SCI: spinal cord injury; UDS: urodynamic study; UTI: urinary tract infection.

and/or high filling or voiding pressures. Those at risk were either observed until radiological deterioration occurred, or were placed on prophylactic intermittent catheterization with or without anticholinergic medication based on annual sUDS. During the followup period, 80% of children in the observation group developed radiological evidence of UUT deterioration (inadequate bladder emptying, reflux, and/or hydronephrosis). In contrast, only 15% of children in the intervention group demonstrated deterioration.

Controversy exists regarding the use of regularly scheduled sUDS compared to performing studies for symptomatic or radiological change. Kaufman et al[30] reviewed 214 children presenting to a spina bifida clinic in a 13-year period. UDS were performed when UUTs deteriorated or in incontinent school-age children. On radiographic study, there was evidence of UUT deterioration in 79 children, including hydronephrosis in 34, hydronephrosis and vesicoureteral reflux (VUR) in 19, and reflux only in 26. Followup studies performed after clean intermittent catheterization and pharmacological therapy were instituted revealed resolution or improvement of UUT deterioration in 69%, while bladder compliance improved in only 42%. The results suggest that although radiological surveillance of patients with myelomeningocele allows recognition of UUT changes, the effects of elevated outlet resistance on bladder compliance are not as readily reversible as the initial radiographic findings.

Conversely, Hopps et al[31] established a risk classification scheme to stratify the surveillance approach. High-risk patients underwent prompt UDS evaluation. Low-risk patients were followed closely at 2–4-month intervals with serial physical examination, UUT imaging, and urine culture. Conversion from low- to high-risk occurred with new-onset hydronephrosis, febrile UTI, urinary retention, or incidental finding of VUR at the time of evaluation for continence. After a mean followup of 10.4 years, renal deterioration occurred in only one kidney of the high-risk group and one kidney in the group that converted from low- to high-risk, representing 1.2% of all renal units.

Although controlled studies are currently lacking, use of symptom- or imaging-provoked sUDS in adult spina bifida patients may be beneficial. Veenboer et al[17] performed a cross-sectional review of 120 adult spina bifida patients (median age 31.5 years) to determine characteristics associated with a hostile lower urinary tract on sUDS. In the multivariable model, unsafe bladder was significantly associated with being wheelchair-bound (odds ratio [OR] 5.36; $p<0.008$). Conversely, it was highly unlikely to find an unsafe bladder in asymptomatic patients that were not wheelchair-bound (negative predictive value 1.00). The authors concluded that if an adult patient with spinal dysraphism is not wheelchair-bound, unfavourable findings at sUDS are unlikely. If these patients are asymptomatic, these findings are even more unlikely. In these patients, it is probably not necessary to perform routine UDS without symptoms or imaging prompting the study.

MS

Six articles addressed sUDS in the adult MS population (Table 3). Studies included 163 adults with 528 patient-years of followup. Five of six articles performed sUDS based on changing patient symptoms (recurrent UTI, increased incontinence between catheterization, or alarming features on ultrasound).

The changing clinical course of MS is a hallmark of the disease. Ciancio et al[32] followed 22 adults with repeat UDS performed because of new or persistent LUTS. Overall, 55% of patients experienced a change in their urodynamic patterns and/or compliance during a mean followup of 42 months. In the largest retrospective series, Schoenberg and Gutrich[33] performed repeated UDS evaluations on 33 symptomatic patients during a 2.5-year period and found differences in 12, all of whom changed from having detrusor hypocontractility to having detrusor hyperreflexia. Wheeler, Goldstein, and Blaivas et al[34-36] also found temporal changes in the urodynamic patterns in the majority of patients.

Several authors have demonstrated poor correlation between UDS findings and patient symptoms in the MS population. Ciancio and colleagues[32] found that 43% of MS patients with no new urological symptoms developed a change in the urodynamic pattern and/or compliance on followup UDS evaluation. Similarly, in a prospective study by Bemelmans et al,[37] 52% of patients demonstrated urodynamic abnormalities without symptoms. However, the incidence of positive urodynamic findings in patients with lower urinary tract complaints was 98%. The latter finding suggests that UDS evolution may be present without symptoms, but is highly likely if voiding symptoms exist.

Fortunately, the rate of UUT deterioration in MS with NLUTD is low. In a meta-analysis of 1882 patients with MS, only 1% demonstrated UUT tract abnormality.[38] Fletcher et al[39] investigated the prevalence of renal ultrasound abnormalities over time in MS patients with LUTS. The authors defined UUT damage as the presence of hydronephrosis, caliectasis, cortical scarring, or stone formation. Over a nine-year period, 173 patients had both UDS and renal ultrasound. Of these, 5.8% of subjects had abnormalities at initial ultrasound, whereas at followup, renal ultrasound (RUS) abnormalities were seen in 12.4% of patients. Overall, there were seven patients who developed new abnormalities. The authors concluded that the development of UUT abnormalities as determined by RUS overall is low, although older patients and those with abnormal compliance may merit closer supervision.

Current practice patterns

Eight cross-sectional studies (all level 3, four SCI, two NLUTD, two spina bifida) surveyed urologists regarding current practice patterns of sUDS in the setting of NLUTD (Table 4); 53% of 498 respondents and 39 specialty clinics in seven countries reported that they perform sUDS between 1–3 years using pooled estimate weighted average. The most common practice pattern was sUDS every 1–2 years.

These results were in contrast to two retrospective cohort series that demonstrated the actual use of sUDS among SCI patients was substantially less frequent than reported practice patterns suggest. Cameron et al[18] observed a 6.7% use of sUDS in American SCI patients over a two-year period despite over 35% urological consultation in the same period. Similarly, Welk et al[19] observed only 10% use of sUDS in Canadian SCI patients over a two-year period.

Discussion

Change in patient management based on sUDS

Table 3 demonstrates heterogeneous data (level 2b–4) with variable underlying pathology, variable stimulus for adjusting treatment, and variable conditions for prompting sUDS. Although pooled-estimate meta-analysis is not possible given heterogeneity, sUDS has a tendency to adjust patient treatment often. A weighted average of results demonstrated that surveillance adjusted treatment in 48.4% of patients.

Determination of new findings in asymptomatic patients without imaging changes

Similarly, clinical and methodologic heterogeneity of data limits the ability to perform pooled-estimate meta-analysis (Table 3) with respect to this question. Despite this, sUDS has a tendency to provide new findings that are not suggested by patient symptoms or imaging changes. A weighted average of results demonstrated that surveillance determined findings that prompted treatment in 48.9% of asymptomatic patients without imaging changes. However, after establishing a 'safe' lower urinary tract, prompting sUDS with imaging change or new symptoms did not appear to be associated with adverse outcomes in the short-term.[23]

Does sUDS demonstrate superior outcomes compared to long-term followup without UDS?

There are currently no high-quality studies available to support or refute this premise. Available evidence is primarily level 4 without control groups. A single level 2b study is available within the pediatric population.

What are the current sUDS practice patterns among urologists in their assessment of NLUTD?

The most common self-reported practice pattern of sUDS in the management of NLUTD is every 1–2 years. Within the U.S. and Canada, healthcare utilization data suggests that the actual rate of sUDS in the neurogenic population ranges from 6.7–10%. The difference between self-reported practice patterns and actual use highlights the need for consensus in surveillance standards.

Conclusion

Available evidence supporting optimal surveillance protocols for NLUTD is lacking. Qualitative findings from level 2b–4 evidence suggest that sUDS is likely to modify patient treatment, and often leads to new findings not suggested by physical examination, imaging findings, or new patients symptoms. Establishing a risk-benefit ratio of these findings is not possible due to lack of control groups. There is currently no evidence that demonstrates regularly scheduled sUDS has superior outcome compared to sUDS performed for symptom or imaging change.

The most common practice pattern of surveyed urologists was to repeat sUDS every 1–2 years. Review of currently available guidelines (Table 1) demonstrated two conventional approaches for UDS. The primary approach is to stratify into risk groups with baseline UDS. Low-risk groups are those that have safe storage parameters, including high capacity, high compliance, and low storage pressure. High-risk groups include parameters that place UUT at risk, including detrusor-sphincter dyssynergia with sustained raised vesicle pressure or low compliance, before and after a change in bladder management; onset of UTIs or urinary tract stones; or presence of VUR or high post-void residual. sUDS is typically reduced in the former to a lengthy interval (although no consensus exists to define this interval). The latter group is typically investigated and followed at a more closely defined and regimented schedule, such as regular sUDS every 1–2 years.

An alternative to this approach is to establish a baseline with UDS followed by on-demand sUDS if patient presentation evolves during the course of followup. Findings such as new-onset hydronephrosis, reflux, deterioration in renal function, increased infection frequency, or urinary calculi formation prompt sUDS evaluation.

The optimal sUDS strategy in surveillance of NLUTD has not yet been established and will likely require further data to establish a validated protocol. This review demonstrated that existing literature is limited by small enrollment studies with heterogeneous populations completed over a time course that is extensive. There is clearly a need for further high-quality studies to determine the optimal surveillance strategy of UDS with NLUTD.

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This paper has been peer-reviewed.

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