

# Overnight Ambulatory Urodynamics Change Patient Management Strategies and Improve Symptomatic Outcomes

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## Abstract

**Objectives** To determine the diagnostic value of overnight ambulatory urodynamics (aUDS) and to assess if a urodynamic diagnosis of detrusor overactivity (DO) or nocturnal enuresis resulted in a change in patient management and an improvement in their urinary symptoms.

**Methods** A retrospective review of 25 consecutive patients (28% male) with a median age of 38 years (range 18 to 86) having overnight aUDS for bothersome urinary symptoms of primarily nocturia and/or nocturnal enuresis following non-diagnostic conventional urodynamics between November 1998 and August 2018. Urinary symptoms were assessed before overnight aUDS and again after urological treatment following any changes in urodynamics diagnosis and treatment. Six patients were excluded as follow-up data were not available.

**Results** Twenty-four patients (96%) presented with nocturia and 20 (80%) presented with nocturnal enuresis. DO was demonstrated in 19 (76%) patients (mean pressure 69.1±53.3 cmH<sub>2</sub>O). UUI was demonstrated in 16 (80%) out of the 20 patients who complained of nocturnal enuresis. Of the 19 patients with follow-up data, following overnight aUDS a change in urodynamic diagnosis was made in 15 patients (79%); 16 patients (84%) also had their clinical diagnosis and subsequent management changed; and 15 patients (79%) reported an improvement in their urinary symptoms following these changes in diagnosis and treatment. There was a significant improvement in ICIQ-OAB (120±44 versus 32±53,  $P < 0.0001$ ) scores following the changes to clinical management post-overnight aUDS.

**Conclusion** In our study cohort, change in primary diagnosis following overnight aUDS led to a significant change in treatment care pathway and resulted in significant improvement in urinary symptoms at follow-up.

## Introduction

Conventional urodynamics (UDS) are considered the gold standard investigation for lower urinary tract symptoms (LUTS)[1,2]. Conventional UDS require rapid bladder filling and are performed in an unnatural environment. In a sub-group of patients who have failed medical therapy, conventional UDS are unable provide a urodynamic diagnosis that correlates with the patient's presenting symptoms of nocturia and /or nocturnal enuresis. Ambulatory

### Key Words

Nocturia, nocturnal enuresis, overnight ambulatory urodynamics, urinary symptoms, quality of life

### Competing Interests

None declared.

### Article Information

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urodynamics (aUDS) are recognised by the International Continence Society (ICS) as an important second-line diagnostic tool for providing a definitive diagnosis in patients who had previously had a non-diagnostic or symptomatically contradictory conventional UDS[3]. In our specialist centre, aUDS can be performed overnight while the patient is sleeping. In contrast to conventional UDS, aUDS allows for natural (orthograde) bladder filling and a more natural environment. The patient can be catheterised and connected to the urodynamics recording equipment and then allowed to go to sleep so that their bladder function and any urinary incontinence can be assessed overnight and improve the likelihood of a diagnostic test.

The aims of this study were to determine the diagnostic value of overnight aUDS in patients presenting with isolated symptoms of nocturia and/or nocturnal enuresis following non-diagnostic or symptomatically contradictory conventional UDS and to assess if a change in patient diagnosis and/or treatment following overnight aUDS led to a symptomatic improvement in patients.

## Materials and Methods

### Study Population

Twenty-five consecutive patients (28% male) having overnight aUDS for bothersome urinary symptoms of primarily nocturia and/or nocturnal enuresis seen at our tertiary referral centre between November 1998 and August 2018 were identified from our prospectively acquired database and retrospectively reviewed. None of the patients had an underlying neurological disorder or history of previous treatment with radiotherapy. Their median age was 38 years (range 18 to 86). All patients had previously had conventional pressure flow studies or video UDS (vUDS). All overnight aUDS tests were performed following multidisciplinary team review when conventional UDS were non-diagnostic or when the conventional UDS diagnosis was contradictory to the patient's primary presenting symptom(s) of nocturia and/or nocturnal enuresis. None of the patients had any daytime symptoms and therefore daytime aUDS were not performed as this was felt to not be indicated and a waste of resources and time for all involved. Six patients were excluded because follow-up data were not available.

Before proceeding to conventional urodynamics (filling cystometry and pressure flow studies) all patients had received (as appropriate) lifestyle advice, continence therapist input re bladder training  $\pm$  pelvic floor muscle exercise, medications (as indicated by clinical diagnosis). Those progressing to overnight aUDS wished to consider more invasive treatments for their isolated nocturia or nocturnal enuresis symptoms, and it is a requirement of

our NHS system and NICE guidance that a urodynamic diagnosis is made before these more invasive treatments.

### Urodynamics Procedures

aUDS studies were performed as per the ICS guidelines[1,3] using the MMS Solar LUNA module (Medical Measurement Systems, Gladbeck, Germany). A flow rate, post-void residual and urinalysis were performed before the test. After residual urine was measured, a 4.5fr bladder catheter (Mediplus 5716, Wycombe, United Kingdom) and a 4.5fr rectal balloon catheter (Mediplus 5410, Wycombe, United Kingdom) were inserted for the measurement of intravesical and abdominal pressures, respectively. A conductance leak pad sensor (Digitimer Pe-Que Sensor Pad, Welwyn Garden, United Kingdom) was used on all patients reporting symptoms of nocturnal enuresis. After zeroing the fluid filled pressure measurement transducers and flushing the measurement lines with saline, a cough was used to ensure good cancellation and accurate pressure measurement readings. The patients were then taken to a private ward side room and advised on the use of the LUNA module events buttons to mark urgency and leakage and to activate the flowmeter to record voiding. The patients were encouraged to perform their normal nightly routine known to be provocative for their typical nocturia and/or nocturnal enuresis symptoms. The median study duration was 16 hours (range 13 to 18). The urodynamicist returned to the ward in the morning to remove the pressure lines and download the overnight aUDS data from the LUNA module. A cough was again used to ensure good cancellation before removal of the pressure lines and the patient was asked whether they had experienced their typical overnight symptoms during the test. The on-call urology specialist registrar was available for advice or to review the patient if there were any issues overnight—in particular, with the pressure lines.

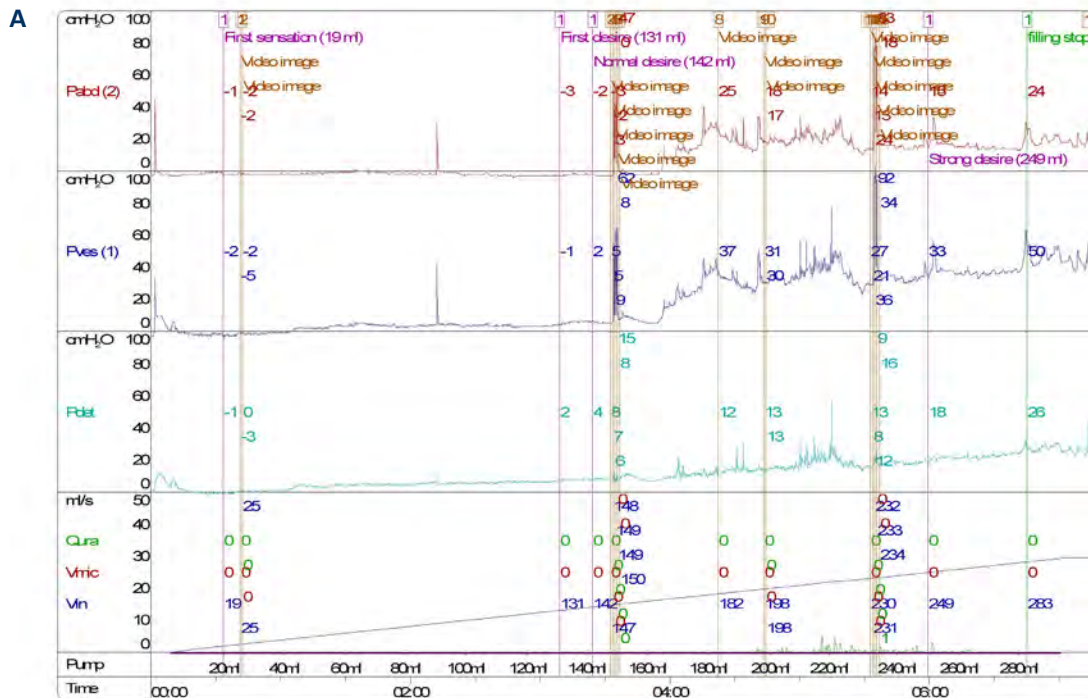
All conventional UDS, vUDS and overnight aUDS studies were analysed by an experienced urodynamicist and reviewed at a multidisciplinary team meeting to ensure accuracy of diagnosis and to determine treatment options.

### Assessment of Urinary Symptoms

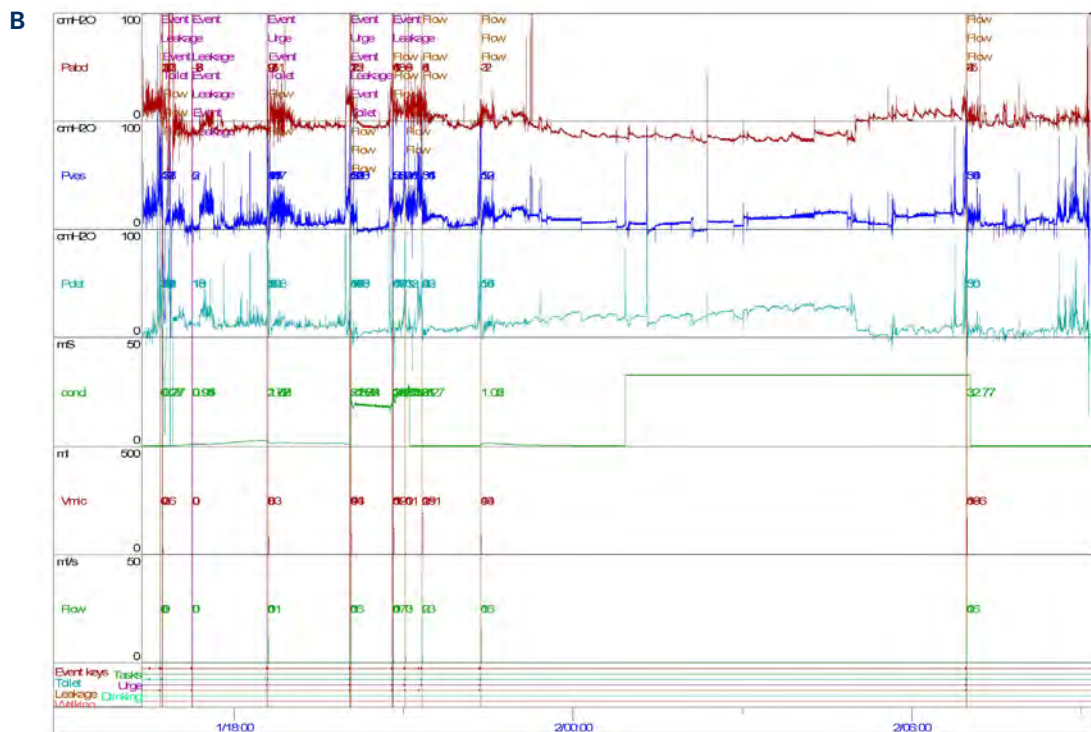
Urinary symptoms were assessed using ICIQ-OAB scores in all patients before and after the changes to clinical management post-overnight aUDS. ICIQ-OAB scores were extrapolated from medical records in 5 patients treated at UCLH prior to 2010. This extrapolation was based on the detailed history of daytime frequency, nighttime frequency, urgency, and urgency urine leak, plus bother related to these symptoms available in the notes.

**FIGURE 1.**

An 18-year-old female patient presenting with daytime frequency, urgency, and nocturnal enuresis (2 pads per 24 hours)



vUDS trace showing a reduced 326 mL capacity bladder limited by pain due to loss of compliance (end-fill pressure 26cmH<sub>2</sub>O), with no DO or SUI demonstrated.



Whole overnight aUDS study trace

*continued on page 205*

**FIGURE 1.**

An 18-year-old female patient presenting with daytime frequency, urgency, and nocturnal enuresis (2 pads per 24 hours), *Cont'd*



Extrapolated overnight aUDS trace showing high pressure DO (up to pp145cmH<sub>2</sub>O) and 220 mL leak

### Statistical Analysis

Data are expressed as median IQR and *P*-values were calculated using a 2-tailed paired Student *t* test for pairwise comparisons of parametric data, unless otherwise stated. Categorical data are expressed as number (percentage) and compared with the Fisher exact test. *P* < 0.05 was considered statistically significant. Analysis was performed using SigmaPlot 12.5 (Systat Software Inc, San Jose,US) statistical analysis package.

### Results

Following overnight aUDS, all studies were evaluable (as determined by replication of the patients' nocturnal symptoms and good quality trace) and a definitive UDS diagnosis of DO was made in 79% (*n* = 19) of 24 patients presenting with nocturia (mean DO pressure 69.1 ± 53.3 cmH<sub>2</sub>O) and in 90% (*n* = 18) of the 20 patients presenting with nocturnal enuresis. UUI (median pad weight gain 103 mL, IQR 45–205) was demonstrated in 80% (*n* = 16) of the 20 patients presenting with nocturnal enuresis. Of the remaining patients, 5 had a diagnosis of sensory urgency confirmed and 1 patient was diagnosed with reduced functional capacity due to high PVRs. A change in the primary UDS diagnosis occurred in 80% (*n* = 20) of patients following aUDS.

### Sub-Group Analysis of 19 Patients With Post aUDS Treatment Follow-Up Data

All 25 patients attended for their initial post nocturnal aUDS review, at which time the outcome of the nocturnal aUDS was discussed along with their new clinical diagnosis and treatment recommendations. Six patients failed to attend for further follow-up, whilst 19 proceeded with treatment recommendations and had ongoing follow-up data available for review. DO was demonstrated in 14 of the 15 patients who presented with nocturnal enuresis, and the final patient was found to have a reduced functional capacity due to high PVRs. Of the remaining 4 patients who presented with isolated nocturia symptoms, 1 was found to have DO, and the remaining 3 patients had a diagnosis of sensory urgency confirmed.

Therefore, 84% (*n* = 16) of this patient sub-group had their clinical diagnosis and management changed following aUDS. In the 15 patients who had DO demonstrated, 3 were treated with a clam cystoplasty, 5 were treated with intravesical botulinum toxin injections, and the remaining patients were treated with combination medical therapy. Of the 3 patients with confirmed sensory urgency, 1 was treated with reduced fluid intake, 1 was treated with desmopressin, and the final patient was treated with cognitive behavioural therapy.



The patient diagnosed with reduced functional capacity due to high PVRs had their catheterisation technique reviewed by the urology clinical nurse specialist and was advised to catheterise more often.

These treatment changes led to a statistically significant improvement in the reported urinary symptoms of daytime frequency, nocturia, and nocturnal enuresis in 79% of patients (Table 1). There was a significant improvement in ICIQ-OAB ( $120 \pm 44$  versus  $32 \pm 53$ ,  $P < 0.0001$ ) scores following the changes to clinical management post-overnight aUDS (Table 2). Sixty-one percent (11 out of 18) of patients had resolution of their nocturia and 73% (11 out of 15) of patients had resolution of their nocturnal enuresis.

## Discussion

This exploratory study is the first to demonstrate that overnight aUDS is an extremely useful final stage diagnostic tool in patients with isolated nocturnal symptoms in whom conventional or video urodynamics have been non-diagnostic or symptomatically contradictory. All overnight aUDS studies were evaluable, and we were able to make a definitive diagnosis in all patients. DO was demonstrated in 79% of patients presenting with nocturia and/or nocturnal enuresis. UUI was demonstrated in 80% of patients presenting with nocturnal enuresis. Of the others, their original diagnosis of sensory urgency was confirmed

in 5 patients, and 1 patient was found to have a reduced functional capacity due to high PVRs. The finding of reduced functional capacity and high PVRs was not identified on routine flow rate and post-void residual or conventional pressure flow studies and appears to have been a nocturnal phenomenon of unknown cause. Although there are no other overnight aUDS datasets for comparison, we reproduced patients' symptoms in all studies, compared with published daytime aUDS datasets, which reported rates of 72% to 77%[4,5]. Equally, previous daytime aUDS studies have demonstrated that clinical outcomes are improved in 40% to 79%[4,6] following treatment modification. This is similar to the 61% of patients who had resolution of their nocturia and the 73% of patients who had resolution of their nocturnal enuresis following treatment modification.

Nocturia is defined by the ICS as the complaint of waking to pass urine during the main sleep period[7]. The prevalence of nocturia increases with age[8]: approximately 50% of adults between the ages of 50 and 79 have nocturia, and it is estimated that men aged between 70 and 79 get up at least twice per night to pass urine[9]. If there are 2 or more episodes per night, nocturia can be a significant problem[10], affecting both sleep onset and ability to return to sleep[11]. Nocturia is strongly associated with poor quality of life[12], mainly due to fatigue caused by sleep disturbances[11]. Nocturia is often multifactorial. It can be caused by reduced functional

**TABLE 1.**

Urinary symptoms pre- and post- changes in diagnosis and treatment following overnight aUDS

Urinary Symptoms	Pre-Overnight aUDS	Post-Overnight aUDS	P-Value
Isolated nocturia, n(%)	4(21)	0(0)	–
Isolated nocturnal enuresis, n(%)	1(5)	1(5)	–
Both nocturia and nocturnal enuresis, n(%)	14(74)	4(21)	<0.001

**TABLE 2.**

Urinary symptoms ICIQ-OAB score pre- and post- changes in diagnosis and treatment following overnight aUDS

Symptom	Pre-Overnight aUDS ICIQ-OAB, (Mean±SD)	Post-Overnight aUDS ICIQ-OAB, (Mean±SD)	P-Value
Isolated nocturia (n = 4)	80±46	0±0	–
Isolated nocturnal enuresis (n = 1)	120	80	–
Both nocturia and nocturnal enuresis (n = 14)	131±40	38±59	<0.001

bladder capacity, increased nocturnal urine output, or can result from primary sleep related disorders such as obstructive sleep apnoea, which affects nocturnal urine production and consequently provokes nocturnal bladder symptoms[13]. Nocturnal polyuria should be excluded as a cause, as this can be an indicator of a worsening underlying pathology[14]. Sleep disorders should also be excluded, as patients with a primary sleep disorder, such as restless leg syndrome, may awaken due to this and then void but recall only waking to void when presenting clinically[15].

Nocturnal enuresis is defined by the ICS as the complaint of involuntary voiding that occurs at night during the main sleep period[7]. Although nocturnal enuresis is considered as a physiological finding in children less than 5 years old, it is abnormal in adults[16]. In adults, the prevalence of nocturnal enuresis is reported as 0.5% to 3%[17–19]. Typically, an adult presenting with isolated symptoms of nocturia and/or nocturnal enuresis will be managed by a primary care physician following history, physical examination, bladder diary, and urinalysis. However, assessment (with uroflowmetry and post-void residuals, cystoscopy and urodynamic evaluation) and treatment by a urologist may be required for those with the very bothersome or persistent symptoms[20]. Hirasing et al. found that only 12% of adult men and 29% of adult women presenting with nocturnal enuresis had concomitant daytime incontinence[19], meaning that about 71% to 88% of patients with nocturnal enuresis will have a non-diagnostic conventional daytime urodynamic assessment.

Annually at our centre we perform 75 to 100 aUDS studies and 1 to 2 overnight aUDS studies. The 25 patients having aUDS were accrued over a 20-year period – and account for < 1% of our aUDS studies. During this time period, we have had 3 separate lead principal clinical scientists performing and interpreting both our aUDS and our overnight aUDS using a standardised technique and reporting pro forma, with no loss of continuity of care, and 1 change of aUDS equipment to a more modern version of the previous. Although both aUDS and overnight aUDS are the most accurate urodynamic diagnostic tests available, it takes 2 to 4 hours to perform an aUDS or 12 to 16 hours to perform an overnight aUDS (in addition to the cost of a ward side room overnight) and 1 to 2 hours to interpret the results (versus 30 to 60 minutes in total for UDS/vUDS). Within the United Kingdom health care system, invasive treatment options such as intra-vesical botulinum toxin and sacral neuromodulation are offered only following a proven urodynamic diagnosis of DO. We do not perform invasive urodynamic assessment prior to non-operative intervention, as per NICE guidance[2]. Overnight aUDS is neither cost- nor time-effective as a

first-line assessment tool. It should therefore be reserved for patients with significantly bothersome isolated symptoms of nocturia and/or nocturnal enuresis contemplating invasive treatment in whom conventional and/or vUDS have been non-diagnostic or contradictory to patient symptomatology.

There are some limitations of this study. Whilst this was a retrospective study, we consecutively reviewed all patients who had an overnight aUDS over a 20-year time period, and this is the largest dataset presented worldwide to date. Although sleeping with a urinary catheter in situ is not part of the natural environment, and tests were performed in a ward side room, our patient cohort tolerated this well, and all episodes of UII corresponded with large flooding leaks detected on the leak pad sensor. The patients reported that the urodynamic findings correlated with their typical nocturnal urinary symptoms and did not report that the 4.5fr urinary catheter used during the aUDS influenced the test. Although overnight aUDS is a time-consuming and expensive test, aUDS in general have been shown to be well tolerated[21] with 85% of patients happy to attend for further studies. Only 18.6% of patients experience mild to moderate de novo dysuria and 1.1% experience asymptomatic bacterial UTI following aUDS[22].

There was no daytime aUDS performed in this group for the reasons cited in the methods section of this paper, and therefore there is no ability to compare daytime aUDS findings with overnight aUDS findings. If daytime aUDS permitted diagnosis (which we felt highly unlikely in the absence of symptoms—which is after all the goal of UDS—to reproduce symptoms and assess the underlying pathophysiological cause), then overnight aUDSs would have been avoided.

Extrapolation of urinary symptoms detailed in the notes of 5 early patients to retrospectively form an ICIQ-OAB score is also a weakness. Whilst the notes were detailed in terms of daytime frequency, nighttime frequency, severity of urgency and urgency incontinence, and bother, the actual ICIQ-OAB was not contemporaneously completed by the patient, and this may introduce a degree of inaccuracy into the extrapolated score.

Overnight aUDS is a complex challenging test and as such should be performed only at specialist centres and reserved for highly selected patients with isolated nocturnal urinary symptoms following a non-diagnostic conventional or vUDS.

## Conclusion

This is the first study to show that overnight aUDS studies are a useful clinical assessment technique in patients with isolated nocturnal symptoms. DO

was demonstrated in 79% of patients presenting with nocturia and in 90% of patients presenting with nocturnal enuresis. Of patients presenting with nocturnal enuresis, 80% were also demonstrated to have a diagnosis of UUI. Following overnight aUDS, the clinical diagnosis and subsequent management

pathway was changed in 84% of patients. This resulted in a significant improvement in symptomatic outcomes. A total of 61% of patients had resolution of their nocturia, and 73% of patients had resolution of their nocturnal enuresis.

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