Streszczenie w języku angielskim – lek. Karolina Garbas

Title

Identification of prognostic factors for detrusor underactivity in patients with lower urinary tract symptoms

Abstract

Introduction

Detrusor underactivity (DU) is one of the most frequently diagnosed urological dysfunctions in patients presenting with lower urinary tract symptoms (LUTS). Among men younger than 50 years its prevalence is estimated at 9–28 %, and this proportion increases in older age groups. Despite its documented frequency, DU remains poorly understood, and universally accepted standards for its diagnosis and management have yet to be established. According to the International Continence Society (ICS), DU is defined 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"*. Clinical recognition is challenging because its presentation overlaps with that of overactive bladder (OAB) and bladder outlet obstruction (BOO).

During the storage phase, patients with DU may experience urgency, increased daytime frequency, and nocturia or, conversely, infrequent voiding. If bladder sensation is heightened, frequent voiding and urgency predominate; when sensation is diminished, the urge to void is absent, voiding occurs only sporadically, and - in severe cases - overflow incontinence may develop. In the voiding phase, DU presents as hesitancy, a weak urinary stream, reliance on abdominal straining, and a persistent sensation of incomplete bladder emptying, thereby clinically mimicking BOO. Accurate differentiation is crucial, because patients with DU derive less benefit from surgical treatment than those with BOO.

According to ICS guidelines, invasive urodynamic testing—comprising cystometry and pressure-flow study (PFS)—remains the diagnostic gold standard for DU. In practice, however, diagnostic criteria are not fully standardized and vary among centers and across existing recommendations. The examination requires specialized equipment, is time-consuming, and its results can be reliably interpreted only by experienced functional-urology specialists. The procedure is also associated with patient discomfort and a risk of urinary-tract infection, and it

demands close patient cooperation during bladder filling and voiding. In elderly individuals or those with physical or cognitive limitations this cooperation may be difficult, leading to prematurely terminated studies or inconclusive findings. Consequently, a proportion of patients decline UDS, and the demand for non-invasive, less costly and more easily available diagnostic alternatives continues to grow, particularly when PFS is inaccessible or unacceptable to the patient.

Objective

The aim of this work was to identify non-invasive predictors of DU that can be assessed without performing an invasive PFS in men (study 1) and women (study 2) with non-neurogenic lower urinary tract symptoms (LUTS); and to undertake a systematic review (study 3) providing a critical appraisal of the non-invasive diagnostic methods for DU in men with non-neurogenic LUTS available in the current literature.

Materials and Methods

A retrospective observational study (Study 1) enrolled 229 men with non-neurogenic LUTS who had undergone a PFS in one of two reference urodynamic centres and in whom DU and/or BOO had been confirmed. The medical records were reviewed for comorbidities, ongoing pharmacotherapy, the Core Lower Urinary Tract Symptoms Score (CLSS), uroflowmetry (UFL) findings and PFS results. Eligibility criteria comprised age ≥ 18 years, LUTS with DU or BOO verified on PFS, a pre-PFS UFL with voided volume > 150 mL, and written informed consent. Patients were excluded if they had a positive urine culture, neurogenic bladder, chronic prostatitis, painful bladder syndrome/interstitial cystitis, bladder cancer, prostate cancer, bladder calculi, prior surgery for benign prostatic hyperplasia, or incomplete clinical data. DU was diagnosed when the bladder contractility index *(BCI = Pdet@Qmax + 5 × Qmax)* was < 100, and BOO when the bladder outlet obstruction index *(BOOI = Pdet@Qmax − 2 × Qmax)* exceeded 40. Logistic regression was applied for both univariate and multivariate analyses; the latter used stepwise variable selection based on univariate significance, with clinically relevant covariates retained owing to their established association with DU.

The second retrospective observational study (Study 2) included 88 women with non-neurogenic LUTS who underwent UFL and PFS and were diagnosed with DU or BOO. Clinical data analysed comprised comorbidities, medication history, CLSS results, physical examination and pelvic organ prolapse staging using the Pelvic Organ Prolapse Quantification System (POP-Q). Women aged ≥ 18 years with LUTS, a voided volume > 150 mL on UFL and DU or BOO

confirmed on PFS were eligible. Exclusion criteria were a positive urine culture, neurogenic bladder, painful bladder syndrome/interstitial cystitis (PBS/IC), bladder cancer, incomplete data or inconclusive PFS. DU was defined by a projected isovolumetric pressure 1 *(PIP1 = Pdet@Qmax + Qmax)* < 30, whereas BOO was diagnosed when the female bladder outlet obstruction index *(BOOIf = Pdet@Qmax − 2.2 × Qmax)* exceeded 18. Continuous variables were compared with the Mann–Whitney U test, categorical variables with Fisher's exact test, and associations were subsequently evaluated by logistic regression - first univariable, then multivariable with stepwise selection (entry/removal threshold p = 0.20), retaining only statistically significant predictors.

The systematic review (Study 3) was conducted in accordance with PRISMA guidelines. In June 2024, the Medline, Scopus, and Web of Science databases were searched for publications on non-invasive diagnostic methods for DU in men with non-neurogenic LUTS. Only full-text, original articles in English published after 2000 were eligible if they evaluated any non-invasive diagnostic technique for DU in men, used PFS as the reference standard, and reported diagnostic accuracy parameters. Methodological quality and risk of bias were assessed with the Quality Assessment of Diagnostic Accuracy Studies 2 (QUADAS-2) tool.

Results

The final multivariable model for predicting DU rather than BOO in men with non-neurogenic LUTS comprised ten variables encompassing clinical symptoms, CLSS questionnaire, UFL parameters, and free-flow curve morphology. Independent predictors of DU on PFS were: more prevalent intermittency (OR 2.33, 95 % CI 1.08–5.00; p = 0.03); less prevalent nocturia (OR 0.27, 95 % CI 0.12–0.61; p < 0.002); less prevalent weak stream (OR 0.14, 95 % CI 0.05–0.42; p = 0.0004); a lower CLSS score for abdominal straining (OR 0.67, 95 % CI 0.48–0.94; p = 0.02); a higher CLSS score for slow stream (OR 1.81, 95 % CI 1.24–2.63; p = 0.002); a higher CLSS score for incomplete emptying (OR 1.31, 95 % CI 1.05–1.63; p < 0.02); a lower PVR ratio (OR 0.20, 95 % CI 0.05–0.87; p = 0.03); and the presence of a fluctuating (OR 2.00, 95 % CI 0.99–4.05; p = 0.05), fluctuating-intermittent (OR 3.09, 95 % CI 1.39–6.86; p < 0.006), or intermittent free-flow curve (OR 8.11, 95 % CI 0.80–82.50; p = 0.076). The model achieved a Harrell's C-index of 0.783. Using the derived clinical criteria, the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for urodynamically confirmed DU were 75.8 %, 62.4 %, 71.9 % and 67.0 %, respectively.

In women (Study 2), the predictive model identified the following independent determinants of DU in non-neurogenic LUTS: sensation of incomplete emptying (OR 3.52; 95 % CI 1.27–9.79;

p = 0.016), hesitancy (OR 2.06; 95 % CI 0.71–5.98; p = 0.18), pelvic organ prolapse stage < POP-Q 3 (OR 0.15; 95 % CI 0.03–0.75; p = 0.02) and prolonged time to Qmax on uroflowmetry (OR 1.05; 95 % CI 1.02–1.09; p = 0.004). This model achieved a C-index of 0.78. Using a probability threshold of 0.30, the derived clinical criteria demonstrated a sensitivity of 86.8 %, specificity of 46 %, PPV of 55 % and NPV of 82.1 % for urodynamically confirmed DU.

The systematic review (Study 3) included 18 studies comprising 7 390 participants, of whom 3 194 had urodynamically verified DU. Investigated non-invasive tests involved clinical variables, ultrasound parameters, biomarkers, uroflowmetric indices, symptom questionnaires and artificial-intelligence (AI) or machine-learning models. The DUA-SQ symptom questionnaire demonstrated the highest accuracy, with a sensitivity of 95.8 % and a specificity of 95.4 %. Ultrasonographic measurement of detrusor muscle thickness (DMT) combined with bladder capacity achieved 100 % specificity but had limited sensitivity (42 %). Uroflowmetric "saw-tooth" and "interrupted" curves yielded 80 % sensitivity and 87 % specificity. Among biomarkers, serum adiponectin reached 79 % sensitivity and 90 % specificity, whereas the urinary nitric oxide/adenosine triphosphate (NO/ATP) ratio attained 88.5 % sensitivity and 88.9 % specificity. AI-based predictive models displayed sensitivities of 65.9–79.7 % and specificities of 68.9–88.7 %. Owing to substantial heterogeneity and overall low methodological quality, a meta-analysis was not feasible.

Conclusions

The sex-specific predictive models developed in this thesis provide a non-invasive alternative to invasive urodynamic testing for differentiating DU from BOO in patients with non-neurogenic LUTS. They can be implemented during the initial outpatient visit by combining a structured history, CLSS symptom assessment, physical examination and UFL, offering a rapid and cost-effective approach particularly suitable for individuals unwilling or at high risk for invasive diagnostics. Following external validation, these models may facilitate earlier diagnosis, timely initiation of appropriate therapy and better symptom control in DU and BOO. The critical appraisal of non-invasive diagnostics—including ultrasound metrics, biomarkers, UFL analysis, symptom questionnaires and AI-driven algorithms—confirms their diagnostic potential and superior safety profile compared with conventional urodynamics. Nevertheless, none of these modalities is free from limitations such as variable accuracy, lack of independent validation or non-standardised testing conditions. By compiling and evaluating the current evidence, this work serves as a practical reference for clinicians seeking contemporary non-

invasive strategies for diagnosing DU and highlights the key knowledge gaps that must be addressed to develop personalised diagnostic tools tailored to individual clinical profiles.