Urodynamic studies

Introduction
- Urodynamic studies are essential for characterizing storage and voiding dysfunctions and choosing the most suitable treatment.
- Urodynamic findings should be reported according to the recommendations and terminology of the ICS (International Continence Society).

Uroflowmetry
- **Definition:** a non-invasive urodynamic study that should be repeated 2-3 times to provide reliable information. Its performance, coupled with ultrasound PVR measurement, is mandatory before carrying out further urodynamic studies.
- **Parameters recorded:** voided volume, maximum flow rate ($Q_{\text{max}}$), average flow rate ($Q_{\text{ave}}$), flow time, voiding time (including interruptions), time to maximum flow. The most important parameter is the $Q_{\text{max}}$, which is considered abnormal at values below 15 mL/s. For proper assessment of the $Q_{\text{max}}$, voided volume should be $>$150 mL.
- **Possible pathological findings:**
  - *Low voided volume.*
  - *Low flow:* uroflowmetry does not distinguish between low flow caused by obstruction and that caused by underactive detrusor, although a $Q_{\text{max}} < 10$ mL/s in a male patient with LUT symptoms secondary to BPH is usually indicative of obstruction. Nevertheless, a normal $Q_{\text{max}}$ does not rule out obstruction (due to high detrusor pressure to compensate for obstruction).
  - *Hesitancy, post micturition dribble.*
  - *Abnormal patterns:* intermittent flow, flow plateau (suggestive of stenosis of the bladder neck or urethra), fluctuating flow, hyperflow curves (suggestive of stress UI).

Filling cystometry
- **Definition:** invasive urodynamic study assessing the relationship between pressure and volume during bladder filling until permission to void is given. Unlike ambulatory urodynamic studies, conventional cystometry uses artificial non-physiological filling.
- **Preparation:**
  - The rectal ampulla must be empty (enema performed the night before).
  - All medication with LUT activity should be suppressed 48 h before the procedure.
  - Antibiotic prophylaxis should be administered.
  - The bladder should be completely emptied before filling is begun.
  - Bladder filling should be performed at a slow pace with distilled water at 37° to avoid inducing detrusor contractions.
- **Parameters recorded:**
  - *Intravesical pressure* (measured with a urinary catheter).
  - *Abdominal pressure* (measured with a rectal or vaginal catheter).
  - *Detrusor pressure* (intravesical pressure – abdominal pressure).
  - Filling volume.
  - *First sensation of bladder filling.*
  - *First desire to void.*
  - *Normal desire to void.*
  - *Strong desire to void.*
  - *Cystometric capacity* (with normal desire to void).
  - *Maximum cystometric capacity* (with strong desire to void).
  - *Bladder compliance* (relation between change in volume and change in detrusor pressure).
  - *Competence of urethral closing mechanism* during filling.
• **Provocative maneuvers:** coughing, anal contraction, rapid filling, use of cooled or acid medium, postural changes, hand washing, etc. These are used to induce overactivity. *Cold water test:* to distinguish between lesions of the upper and lower motor neurons.

• **Possible pathological findings:**
  
  - **Abnormal sensations:**
    - Increased, reduced, absent, or non-specific bladder sensation (the subject is conscious of filling due to the sensation of abdominal fullness or vegetative symptoms).
    - Bladder pain upon filling.
    - Urgency.
  
  - **Detrusor overactivity:** presence of involuntary contractions during filling. All involuntary activity of the detrusor, either spontaneous or induced, before *permission to void* is given is abnormal. Types of overactivity:
    - *Phasic/terminal:* phasic when there is one (or more) typical ascending-descending pressure curves that may or may not produce incontinence; *terminal* when there is one curve at the end of filling that cannot be suppressed and leads to complete voiding.
    - *Idiopathic/neurogenic:* idiopathic if there is no definite cause (this term replaces that of *instability*); neurogenic if there is a known neurological cause (this term replaces that of *hyperreflexia*).
  
  - **Incontinence:**
    - *Due to detrusor overactivity:* leakage associated with an involuntary contraction.
    - *Due to incompetent urethral closure:* leakage without detrusor contraction.
    - *Due to urethral relaxation:* leakage associated with urethral relaxation without ↑ abdominal pressure or hyperactivity.
    - *Stress incontinence:* leakage associated with ↑ abdominal pressure without detrusor contraction. The term *genuine stress incontinence* is discouraged.
  
  - **Abnormal cystometric capacity:** increased or decreased.
  
  - **Abnormal bladder compliance:** increased or decreased.

### Pressure-flow study

- **Definition:** invasive urodynamic study assessing the relationship between bladder pressure and urinary flow during voiding from the point at which *permission to void* is given or uncontrolled voiding occurs. Usually conducted in combination with filling cystometry and videourody-namics.

- **Nomograms:** unlike free uroflowmetry, the pressure-flow study distinguishes between underactive detrusor and LUT obstruction. To assess the different degrees of obstruction, there are several nomograms:
  - *Schäfer* nomogram.
  - *Abrams and Griffiths* nomogram.
  - *Rollema and Van Mastri-gt* nomogram (URA – *urethral resistance index*).
  - *ICS* nomogram: recommended to standardize data for comparison.

- **Preparation:** see “Filling cystometry.”

- **Parameters:** in addition to urinary flow parameters (see “Uroflowmetry”), intravesical, abdominal, and detrusor pressure are all recorded, as in the filling cystometry. Data on premicturition pressure, opening pressure, opening time, maximum pressure, pressure at maximum flow, minimum voiding pressure, and flow delay are of special interest. The amount of residual urine after voiding is also measured.

- **Possible pathological findings:**
  - Overactive, underactive or acontractile detrusor.
  - Bladder outlet obstruction: high pressure with decreased flow.
    - Due to overactive urethra:
      - *Dysfunctional voiding:* intermittent contractions of the external sphincter during voiding in neurologically normal individuals.
- **Detrusor sphincter dyssynergia (DSD):** involuntary contraction of the external sphincter simultaneously with detrusor contraction. Flow may not appear.
- **Non-relaxing urethral sphincter obstruction:** external or internal (bladder neck).
  - Due to anatomical obstruction: BPH, urethral stenosis.
  - High post void residual (PVR).

### Other urodynamic studies

- **Assessment of urethral function during filling cystometry:**
  - **Urethral pressure profile:** graph indicating intraluminal pressure throughout the urethra.
  - **Abdominal leak point pressure:** intravesical pressure at which a leak is produced when there is an ↑ in abdominal pressure without detrusor contraction.
  - **Detrusor leak point pressure:** minimal detrusor pressure that produces a leak without bladder contraction or an ↑ in abdominal pressure. If this is >40 cm of H2O, there is a risk for the UUT. In this case, video-urodynamics can rule out VUR.

- **Electromyography:** collects data on the activity of the external urethral sphincter, striated periurethral muscle, anal sphincter, or striated pelvic floor muscles. Possible findings: absence of a response to stimuli (bladder filling, involuntary detrusor contractions, cough, Valsalva maneuver, etc.), detrusor-sphincter dyssynergia, non-relaxing sphincter.

- **Video-urodynamics:** in combination with filling cystometry and the pressure-flow study, this constitutes the gold standard in urodynamic investigation of neurogenic dysfunction of the LUT. To the two aforementioned studies it adds a morphological assessment of the LUT and the UUT.

- **Ambulatory urodynamics study:** uses physiological bladder filling, and reproducing the subject’s every day activities. Indicated when artificial filling does not reproduce symptoms.

- **Neurophysiological studies:** EMG of pelvic floor and external urethral sphincter, pudendal nerve conduction studies, latency of the bulbocavernosus reflex, evoked potentials of the glans or clitoris, sensory tests of the bladder and urethra.

### Voiding diary

- **Definition:** this is considered to be a semi-objective test of LUT function; registering voids for at least 2-3 days ensures greater reliability. Although it is not a true urodynamic study, this tool is mentioned here because it is used prior to more objective studies and together with uroflowmetry.

- **Parameters recorded:** time, voided volume, volume of liquid drunk, episodes of urgency with/without incontinence. The volume of urine when there is an episode of incontinence can be quantified by weighing the absorbent pad used (pad test).

<table>
<thead>
<tr>
<th>Hour</th>
<th>Voided vol</th>
<th>Urgency ± incontinence</th>
<th>Vol liquid drunk</th>
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- **Possible pathological findings:**
  - High daytime or nighttime urinary frequency.
  - Reduced or increased voided volume.
  - Episodes of urgency and incontinence.
  - Nocturnal polyuria.
  - Polydipsia.