Use of urodynamics to diagnose continence problems in children

Childhood urinary incontinence is common, and can persist throughout childhood and carry on into adulthood. Recent data in the UK suggests a 2.5% prevalence of enuresis (bedwetting) and 2.9% prevalence of daytime urinary incontinence at 14 years of age (Heron et al, 2017; National Institute for Health and Care Excellence, 2010). Failure to adequately diagnose and treat urinary incontinence can lead to psychological distress and emotional problems (Joinson et al, 2007). It can be caused by physical (anatomical or neurological) conditions that may lead to serious problems if left untreated. Recent data suggests that daytime urinary incontinence is associated with depressive symptoms, peer victimisation, poor self-image and problems with peer relationships in adolescence (Grzeda et al, 2017). Urinary incontinence increases children’s need to go to the toilet, meaning they miss parts of school lessons and may fall behind academically (Whale et al, 2018). However, significant improvements in health-related quality of life have been found at three months after the start of treatment for functional urinary incontinence in children (EQUIT et al, 2014).

Appropriate investigation and management of incontinence is required. Detailed history-taking combined with examination may be sufficient to diagnose the problem but a significant number of children do not respond to the prescribed treatments – in such cases, further investigations with urodynamics should be considered. All children with known spinal cord pathology and lower urinary tract anatomical abnormality should have urodynamic studies, as these conditions can pose a risk of irreversible damage to the kidneys. Urodynamic studies are an objective measure of bladder function, improving diagnostic accuracy. The International Children’s Continence Society has published guidelines on urodynamic investigations in children.

Cystometry should be considered in children who do not respond to treatment and those with neuropathic bladder or anatomical anomaly.
Clinical Practice

Review

Table 1. Overview of urodynamic investigations

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Suitable patients</th>
<th>Information obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder and bowel diary (frequency-volume chart, micturition time chart)</td>
<td>All patients presenting with continence problems</td>
<td>• Drinking and voiding behaviour</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Drinking: type, volume and timing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Voiding: timing, desire to void, incontinence episodes, voided volumes (range and MVV)</td>
</tr>
<tr>
<td>Nocturnal bladder diary</td>
<td>Patients with nocturnal enuresis</td>
<td>• Frequency of enuresis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pattern of wetting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Volume of wetting</td>
</tr>
<tr>
<td>Uroflowmetry (non-invasive urodynamics)</td>
<td>• Patients not responding to treatments</td>
<td>• Storage: total bladder capacity (MVV+PVR)</td>
</tr>
<tr>
<td></td>
<td>• Patients with recurrent urine infections</td>
<td>• Voiding: MVV, flow rates (Qmax), flow pattern</td>
</tr>
<tr>
<td></td>
<td>• Patients with large PVR urine volume</td>
<td>• Uroflowmetry + post-void ultrasound: PVR urine volume</td>
</tr>
<tr>
<td></td>
<td>• Patients with suspected/known lower urinary tract anatomical anomaly or spinal cord abnormality</td>
<td>• Uroflowmetry + pelvic floor EMG: any pelvic floor activity during voiding</td>
</tr>
<tr>
<td>Cystometry (invasive urodynamics; also known as pressure-flow studies)</td>
<td>• Patients with known pathological diagnosis where the bladder may be at risk of damaging the kidneys (neuropathic bladder or anatomical anomaly)</td>
<td>• Measurement of bladder (detrusor) pressures during storage phase and relationship between pressure and flow during voiding</td>
</tr>
<tr>
<td></td>
<td>• Patients not responding to treatments</td>
<td>• Video-urodynamics: imaging of bladder and urethra during filling and voiding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ambulatory urodynamics: monitoring of bladder over longer period of time</td>
</tr>
</tbody>
</table>

EMG = electromyography; MVV = maximal voided volume; PVR = post-void residual.

sophisticated studies requiring catheter insertion that need to be performed in specialised paediatric centres (cystometry). Table 1 provides an overview of the different investigations. Guidance on performing urodynamic studies in children has been published by the International Children’s Continence Society (ICCS) [Bauer et al, 2015].

Normal bladder function

When taking a detailed history and performing urodynamic investigations in children, it is important to have a clear understanding of how the bladder functions to be able to identify the nature of bladder dysfunction.

For the bladder to store urine, the detrusor muscle located in the wall of the bladder needs to remain relaxed, while the urethral and sphincter mechanisms must remain contracted. If the bladder contracts during the storage phase, this is referred to as detrusor overactivity, which gives rise to symptoms of bladder overactivity (urinary urgency, frequency and small voided volumes). Incompetence of the external sphincter mechanism leading to leakage during storage is referred to as stress urinary incontinence (leakage is related only to exercise and increases with abdominal pressure), but this is rare in children.

The voiding phase involves coordinated contraction of the detrusor muscle and opening of the urethral and sphincteric mechanisms. Lack of coordination can be seen in some neurological conditions (for examples, spina bifida, transverse myelitis) and can have potential adverse consequences for the kidneys. Obstruction of urine flow can occur if there is:

- Anatomical abnormality to the urethra – for example, posterior urethral valves, meatal stenosis;
- Dysfunctional voiding – voluntary contraction of the pelvic floor muscles during voiding.

Bladder diaries

Also referred to as frequency-volume charts or micturition-time charts, bladder diaries objectively record and document bladder function. They should be completed at home by the parent/carer with the child, over a period of at least 48 hours. Ideally, a seven-day bowel diary – describing bowel opening pattern, frequency, discomfort, stool consistency (using the Bristol Stool Chart) and soiling episodes – should also be completed at the same time, as the treatment of constipation has been found, in some cases, to lead to the resolution of urinary incontinence.

The diary makes it easy to review total fluid intake and pattern of drinking, enabling clinicians to encourage more normal patterns and advise on which fluids to avoid (notably caffeinated, fizzy or blackcurrant drinks).

Indications

Bladder diaries are part of the initial assessment of lower urinary tract symptoms. They can also be used to help plan individualised toileting plans and assess progress.

Procedure

Bladder diaries should record voiding for at least 48 hours, but the days do not need to be consecutive. Diaries should record:

- Data on fluids – intake, type, volume and timing;
- Voiding information – times, volumes (recorded using a measuring jug), desire to void (on command, normal, urgent);
- Any episodes of incontinence.

Bladder diary templates can be accessed on the website of the children’s bowel and bladder charity ERIC (www.eric.org.uk).

It is vital to give children and parents clear instructions on how to complete the bladder diary if it is to yield reliable and useful information.

Interpreting results

Completing a bladder diary can be very informative for families. Clinicians will need to interpret fluid intake and voiding values by comparing them with normal age-based values. ICCS has defined normal values for urinary frequency during childhood and for expected bladder capacity (EBC) based on the child’s age (Austin et al, 2014) (Table 2). Comparison with normal
values may indicate areas of dysfunction and be used to confirm the diagnosis and inform treatment.

When calculating bladder capacity, the first void of the day should be excluded; the largest volume should be described as the maximal voided volume (MVV). A small MVV may suggest a small-capacity bladder. If it is seen with evidence of urgency and symptoms of urgency, this may be caused by bladder overactivity. Infrequent voiding with a normal-to-large MVV and urgency may be due to voiding postponement. Findings can be used to explain the condition and start bladder training (urotherapy), including advice on fluid intake and voiding frequency.

**Nocturnal bladder diaries**

Nocturnal bladder diaries should be completed over seven consecutive nights. The data collected should include timing, frequency and volume of wetting (calculated by weighing nappy), and any lifting or waking of the child. These diaries can be helpful in understanding enuresis severity, planning treatment and monitoring the response to medications such as desmopressin, which is commonly used to treat nocturnal enuresis. The total nocturnal urine production is the volume leaked overnight added to the first void in the morning; a urine output of >130% EBC is defined as nocturnal polyuria (Austin et al, 2014).

**Uroflowmetry**

This non-invasive and inexpensive test, which can be performed in toilet-trained children, measures the volume of urine passed in a unit of time (usually ml/sec). The child sits on or stands by a commode and voids into a container connected to a flow-meter. Uroflowmetry provides information on the voiding phase: volume voided, flow rate and pattern, and bladder emptying when combined with post-void ultrasound.

**Indications**

Uroflowmetry should be considered in:

- All children and young people who are unresponsive to initial bladder management therapies;
- Those with recurrent urine infections;
- Those with suspected/know neurological or lower urinary tract anatomical anomalies.

It can also be used to monitor the response to treatment.

**Procedure**

Uroflowmetry can be misleading if not performed correctly. For it to be representative, it is important to obtain at least two uroflow curves. The accuracy of the result is improved if the voided volume is >50% EBC. It is important to record:

- Whether the child had a normal/strong desire to void;
- Whether the void was similar to their usual void;
- Any incontinence;
- The position used to void;
- Fluid intake during the assessment period.

Direct observation of voiding can also give information on toileting position and whether the child is straining.

Further information on voiding can be obtained from post-void ultrasound scanning, which will measure post-void residual (PVR) urine - that is, urine remaining in the bladder after voiding. This must be performed immediately (no longer than five minutes) after the void. Understanding whether the bladder empties properly is important, as treatment with an anticholinergic medication in a child with abnormal bladder emptying can make emptying worse and increase the risk of urine infection. PVR volumes in neurologically intact children can be highly variable, so the test needs to be repeated with at least two further voids if emptying is abnormal. Table 2 shows normal paediatric bladder emptying values by age (Chang et al, 2013).

The use of pelvic floor electromyography (EMG) leads, which are applied to the skin around the anus, will provide additional diagnostic information about the behaviour of the pelvic floor during voiding. It should be relaxed to allow an uninterrupted flow of urine, so any activity in the pelvic floor during voiding is abnormal. This can be due to dysfunctional voiding or detrusor-sphincter dyssynergia in patients with known neurological abnormality. Pelvic floor EMG can also provide information on bladder neck dysfunction by determining the time delay between the start of pelvic floor relaxation and the start of actual urinary flow.

The child should be adequately hydrated and provided with a private, comfortable, warm environment with appropriate supports (foot stool, toilet seat) to allow them to assume the correct toileting position. The child should be encouraged to void when they ‘normally’ would respond to the desire to urinate.

In children who are not toilet-trained, a four-hour voiding observation can be performed. This involves:

- Placing a sensor in the child’s nappy to detect when wetting has occurred;
- Weighing the nappy to measure volume voided;
- Performing post-void ultrasound to measure PVR urine volume.

**Interpreting results**

Uroflowmetry provides information on:

- The child’s total bladder capacity (MVV + PVR);
- How the urine is passed;
- Whether the bladder is emptied adequately.

The urinary flow rate depends on the pressure generated by the detrusor pushing the urine out and the resistance to

<table>
<thead>
<tr>
<th>Table 2. Terminology and normative measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Terminology</strong></td>
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<tr>
<td>Expected bladder capacity (EBC)</td>
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<td>(expressed in ml)</td>
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<td>Voiding frequency in children aged 4 years +</td>
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<td>Night-time urinary volume</td>
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<td>Normal maximum flow rate</td>
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<td></td>
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<tr>
<td>Normal bladder emptying</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>
Clinical Practice

Review

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urinary flow. Flow rate (Qmax) depends on adequate bladder contraction, adequate relaxation of sphincteric mechanisms, and a patent urethra; it can be influenced by compensatory mechanisms such as abdominal straining. The maximum flow rate is a quantitative measurement of bladder outflow and can be used to detect obstructed urinary flow. Table 2 gives normal paediatric maximum flow rates by age (Yang et al., 2014).

The urinary flow pattern is not diagnostic but can guide towards a specific condition. The normal flow pattern is bell-shaped; other patterns can be suggestive of bladder conditions:

- Tower-shaped flow – overactive bladder;
- Staccato-shaped flow – dysfunctional voiding;
- Interrupted-shaped flow – underactive detrusor with abdominal straining;
- Plateau-shaped flow – static bladder outlet obstruction (anatomical or functional).

Cystometry

Cystometry (also known as pressure-flow studies), a specialist investigation that is not commonly performed in children, records pressure in the bladder during the storage phase and means the relationship between pressure and flow during voiding can be studied.

Indications

Cystometry is useful in monitoring detrusor pressures in patients with known lower urinary tract anatomical abnormality and spinal cord disorders, as these conditions have the potential to damage the kidneys. Elevated pressures must be identified and treated, and cystometry performed again to check the pressures have gone down to normal. Cystometry can also be considered in patients with significant incomplete bladder emptying or stress urinary incontinence, and in those who have not responded to conventional treatments.

Procedure

Cystometry is invasive, involves the use of expensive equipment and requires trained practitioners to perform the procedure and interpret its results. The child needs to have two catheters inserted: the first is placed in the bladder, either via the urethra or a catheterisable channel (for example, Mitrofanoff), the second is placed in the rectum; both are then secured with tape.

Careful consideration is required regarding the placement of catheters in children. Those who do not normally self-catheterise will need either a general anaesthetic, sedation or nitrous oxide during placement. The bladder is filled through the bladder catheter ‘physiologically’ (5-10% of known/predicted bladder capacity). The bladder catheter also measures pressure (detrusor pressure plus abdominal pressure), while the rectal catheter measures abdominal pressure. The pressure generated by the detrusor is calculated by subtracting the rectal pressure from the bladder pressure.

“Urodynamic tests allow clinicians to better understand the cause of incontinence”

Combined cystometry and fluoroscopy is known as video-urodynamics. The bladder is filled using contrast, so the urinary tract can be seen during storage and voiding. Images can then be obtained of the bladder, urethra, any vesico-ureteric reflux, level of any outflow obstruction during voiding, and how well the bladder base is supported.

Cystometry can also be performed with 'natural fill' (allowing the bladder to fill naturally); it is then known as ambulatory urodynamics. Catheters are placed and the child is monitored over a number of hours, voiding on the uroflowmetry machine and completing a diary. This can be useful in evaluating therapy and when conventional cystometry has not shown the incontinence.

The success of cystometry depends on adequate preparation of the parent/carer and child; both need to understand the procedure and the carer should understand why it is being done. Preparation may include discussion, providing written information, and involving play specialists who may use story books, dolls and/or visits to the department. Support from a play specialist may also be required during the investigation. It is important that the study is carried out in a child-friendly environment and the parent/carer is given the choice to be present.

Interpreting results

The quality of the pressure traces is crucial to understanding and interpreting cystometry results. Abnormalities during the storage phase can be caused by detrusor overactivity, loss of bladder compliance, lack of sensation and leakage of urine with increases in abdominal pressure (stress incontinence). During the voiding phase, recording detrusor voiding pressures and urine flow can lead to diagnosing bladder outlet obstruction (high-pressure voiding with poor flow) or underactive detrusor (low-pressure voiding and low flow).

Conclusion

Urinary incontinence in children requires careful assessment, accurate diagnosis, sensitive explanation and individualised treatment. Urodynamic investigations should be performed in children with neuropathic bladders or anatomical bladder outflow obstruction, and considered in children who are not responding to treatment. When properly performed, urodynamic tests can provide very useful objective information on bladder function, allowing clinicians to better understand the cause of incontinence and suggest the most appropriate treatment plan.

References


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