Urodynamics
Lower urinary tract dysfunction produces a huge burden on sufferers in particular and on society in general. Lower urinary tract symptoms have a high prevalence in the community: 5% of children aged 10 wet the bed, while 15% of women and 7% of men have troublesome incontinence; and in elderly men of 75, benign prostatic hyperplasia occurs in more than 80% of individuals, with benign prostatic enlargement coexisting in up to half this group and half of these having bladder outlet obstruction.

The confusion felt in many people’s minds as to the role of urodynamics has receded for the most part. The need to support the clinical assessment with objective measurement has become accepted by most clinicians specialising in the care of patients with lower urinary tract symptoms (LUTS). Since the first edition of this book in 1983, urodynamics has become more widely accepted. In the last 20 years the number of urodynamic units in Britain and Europe has increased rapidly and almost every hospital of any significance embraces urodynamic investigations as an essential part of the diagnostic armamentarium of the urology and gynaecology departments. Further, specialists in geriatrics, paediatrics and neurology recognise the importance of urodynamics in the investigation of a significant minority of their patients.

Despite the technological innovations that have seen the introduction of computerised urodynamics, the development of neuro-physiological testing and the introduction of new techniques such as ambulatory monitoring, the objectives of this book remain unchanged. Urodynamics may appear complicated, and one of the objectives of this book is to put the subject over simply but in enough detail to allow urodynamic investigation to be accepted, on its own merit, as a fundamental contribution to the management of many patients. To do this means not only describing the tests but also showing in which clinical areas they help management and in which they are pointless. It means concentrating on the common clinical problems and on the presenting symptom complexes, not the diagnosis; and it means pointing out any limitations and possible artifacts of investigation.

We hope that a clinician with no previous experience in urodynamics will, after reading this book, appreciate both the value and limitations of the subject, and will have obtained the necessary practical advice on the use of the appropriate equipment in the correct situations. Because this book is based on personal experience, references in the text are relatively few.
The scientific basis of urodynamics does not change and the principle reason for producing the 3rd edition has been the publication in 2002 of the new ICS terminology report 2002 together with the ICS reports on “Good Urodynamic Practice” (2002).

Bristol Urological Institute
2005

References

### List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>AUDS</td>
<td>ambulatory urodynamic studies</td>
</tr>
<tr>
<td>BOO</td>
<td>bladder outlet obstruction</td>
</tr>
<tr>
<td>BPE</td>
<td>benign prostatic enlargement</td>
</tr>
<tr>
<td>BPH</td>
<td>benign prostatic hyperplasia</td>
</tr>
<tr>
<td>BPO</td>
<td>benign prostatic obstruction</td>
</tr>
<tr>
<td>DFV</td>
<td>dysfunctional voiding</td>
</tr>
<tr>
<td>DSD</td>
<td>detrusor sphincter dyssynergia</td>
</tr>
<tr>
<td>DUA</td>
<td>detrusor underactivity</td>
</tr>
<tr>
<td>GP</td>
<td>general practitioner (family physician)</td>
</tr>
<tr>
<td>ICS</td>
<td>International Continence Society</td>
</tr>
<tr>
<td>IDO</td>
<td>idiopathic detrusor overactivity</td>
</tr>
<tr>
<td>ISC</td>
<td>intermittent self-catheterisation</td>
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<tr>
<td>LUTD</td>
<td>lower urinary tract dysfunction</td>
</tr>
<tr>
<td>LUTS</td>
<td>lower urinary tract symptoms</td>
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<tr>
<td>MCUG</td>
<td>micturating cystourethrography</td>
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<tr>
<td>MUCP</td>
<td>maximum urethral closure pressure</td>
</tr>
<tr>
<td>NDO</td>
<td>neurogenic detrusor overactivity</td>
</tr>
<tr>
<td>$P_{\text{abd}}$</td>
<td>abdominal pressure</td>
</tr>
<tr>
<td>$P_{\text{det}}$</td>
<td>detrusor pressure</td>
</tr>
<tr>
<td>PFS</td>
<td>pressure-flow studies</td>
</tr>
<tr>
<td>$P_{\text{ves}}$</td>
<td>intravesical pressure</td>
</tr>
<tr>
<td>PVR</td>
<td>post-void residual</td>
</tr>
<tr>
<td>$Q_{\text{ave}}$</td>
<td>average flow rate</td>
</tr>
<tr>
<td>$Q_{\text{max}}$</td>
<td>maximum flow rate</td>
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<tr>
<td>TURP</td>
<td>transurethral resection of the prostate</td>
</tr>
<tr>
<td>UDS</td>
<td>urodynamic studies</td>
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<td>urine flow studies</td>
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<td>UPP</td>
<td>urethral pressure profile</td>
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<td>USI</td>
<td>urodynamic stress incontinence</td>
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<tr>
<td>VUDS</td>
<td>videourodynamic studies</td>
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<td>VUR</td>
<td>vesico-ureteric reflux</td>
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Measurement Units

<table>
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<tr>
<th>Quantity</th>
<th>Unit</th>
<th>Symbol</th>
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<tr>
<td>volume</td>
<td>millilitre (ml)</td>
<td>V</td>
</tr>
<tr>
<td>time</td>
<td>second (s)</td>
<td>t</td>
</tr>
<tr>
<td>flow rate</td>
<td>millilitres/second (ml/s)</td>
<td>Q</td>
</tr>
<tr>
<td>pressure</td>
<td>centimetres of water (cmH₂O)</td>
<td>P</td>
</tr>
</tbody>
</table>

Urodynamic Qualifiers

- Intra vesical (bladder): ves
- Intra urethral: ura
- Detrusor: det
- Abdominal (usually rectal): abd
## Contents

**Preface** ................................................................. v
**List of Abbreviations** ............................................ vii

**Chapter 1**  Principles of Urodynamics ........................ 1
**Chapter 2**  Anatomy and Physiology ............................ 7
**Chapter 3**  Urodynamic Techniques .............................. 17
**Chapter 4**  Patient Assessment ................................... 117
**Chapter 5**  Urodynamics in Clinical Practice .................. 147
**Chapter 6**  Management of Lower Urinary Tract Dysfunction .... 171
**Chapter 7**  Organisation of the Urodynamic Unit ............... 185

**Appendix 1, Part 1**  List of ICS Standardisation Committee Reports 1973 to 2002 ........................................... 197
**Appendix 1, Part 2**  The Standardisation of Terminology of Female Pelvic Organ Prolapse and Pelvic Floor Dysfunction ........................................... 199
**Appendix 1, Part 3**  The Standardisation of Terminology of Lower Urinary Tract Function: Pressure-Flow Studies of Voiding, Urethral Resistance and Urethral Obstruction ........................................... 213
**Appendix 1, Part 4**  Standardisation of Ambulatory Urodynamic Monitoring ........................................... 232
**Appendix 1, Part 5**  The Standardisation of Terminology in Lower Urinary Tract Function ........................................... 246
**Appendix 1, Part 6**  Good Urodynamic Practices: Uroflowmetry, Filling Cystometry and Pressure-Flow Studies ........................................... 267
**Appendix 1, Part 7**  The Standardisation of Terminology in Nocturia ........................................... 289
Appendix 2, Part 1  Frequency-V olimeter Chart .......................... 297
Appendix 2, Part 2  Patient Information Sheet ............................. 298
Appendix 3, Part 1  Urodynamics Data Sheet: Full Version ............ 301
Appendix 3, Part 2  Urodynamics Data Sheet: Shortened Version ... 318
Appendix 4, Part 1  ICIQ Modular Questionnaire ...................... 323
Appendix 4, Part 2  ICIQ UISF (Urinary Incontinence Short Form) .. 330
Index .................................................................................... 333
Chapter 1

Principles of Urodynamics

Urodynamics has two basic aims:

- To reproduce the patient’s symptomatic complaints during urodynamics, and
- To provide a pathophysiological explanation by correlating the patient’s symptoms with the urodynamic findings.

Implicit in these aims is the acceptance that whilst the patient’s symptoms are important, because they bring the patient to the clinician, they are often misleading. Most patients with lower urinary tract dysfunction present to their doctor with symptoms, but in all branches of medicine symptoms have been shown to be misleading to a varying degree. Were symptoms reliable, further investigation would not need to precede active management. At one time, the elderly male patient with lower urinary tract symptoms (LUTS) would automatically have been offered a prostatectomy and, similarly, a woman with LUTS would have had an anterior repair with or without a hysterectomy. Most of the published literature indicates that the symptoms of lower urinary tract dysfunction (LUTD) are unreliable. Previously, clinicians appreciated the need for some investigations and chose to assess the lower urinary tract using “static” investigations, such as intravenous pyelography (IVP) and cystourethroscopy. However, the lower urinary tract, both during filling and emptying, is a dynamic system. Hence it is appropriate to use dynamic investigations for the investigation of lower urinary tract problems.

The statement “the bladder is an unreliable witness” was made by Bates in 1970 in one of the early papers on urodynamics (Bates et al., 1970). Two important papers appeared in 1980. One by a gynaecologist, Gerry Jarvis (1980) found that of 100 patients diagnosed by their symptoms as having stress incontinence, only 68 were shown to have urodynamic stress incontinence. This was supported by the findings of Powell (working in the Bristol unit; Powell et al., 1980) that only 50% could be shown to have urodynamic stress incontinence. Both authors also looked at patients with apparent overactive bladder symptoms presumed to be the result of detrusor overactivity. Jarvis confirmed this diagnosis in only 51% of cases, while Powell showed detrusor overactivity in only 33% of such patients. Further work in women has shown that in women presumed to have urodynamic stress

References
incontinence, 12% had another cause for their stress incontinence. In most patients, factors such as change of posture, leading to the apparent stress incontinence, provoked detrusor overactivity, leading to the reported incontinence. Clearly in this group of patients, with apparent stress incontinence, surgery would have been unsuccessful in at least the 12% who were suffering from an altogether different type of problem. These papers illustrate the difficulty of assessing women with lower tract dysfunction by symptoms alone. As in women, LUTS in the males are of poor diagnostic value. Furthermore, the findings from IVP and cystoscopy have been shown to be poor indicators of bladder outlet obstruction. Both Abrams (1978) and Andersen (1979) have shown that the symptoms of apparent prostatic obstruction are misleading. Of the many symptoms that the textbooks attribute to prostatic outlet obstruction, they could show that only slow stream and hesitancy bore any correlation with the urodynamic findings of obstruction, that is, high voiding pressure and low urine flow rate. Because symptoms have been shown to lack diagnostic specificity in all clinical groups, it is not surprising to find that when surgery was based on symptoms alone the results were less than satisfactory. The decision to recommend prostatic surgery was previously indicated by an assessment of symptoms backed by the findings from IVP and cystourethroscopy. Early audit of prostatectomy assessed by these means showed a cure rate of only 72%, poor for an elective procedure. Urodynamic studies provided alternative explanations for many symptoms and, when dynamic investigations of function (urodynamics) rather than static investigations of structure (IVP and cystoscopy) were used in preoperative evaluation, the results of surgery improved to 88%.

The preceding discussion relates to men and women who are neurologically normal and therefore able to appreciate sensation from their lower urinary tract. In patients who have neurological conditions affecting the lower urinary tract, it is common for sensation to be absent or abnormal, making their symptomatic complaints even more difficult to interpret. Faced with the unpalatable fact that patients submitted for surgery without objective confirmation of their condition did rather poorly, surgeons reacted in different ways. Some became ostrich-like, and dismissed those who published these results as poor surgeons bereft of clinical acumen and operative skills, while making no effort to assess their own results. Others, who had always been uneasy about patient assessment by symptoms and non-functional studies, such as intravenous pyelography, seized the opportunity to study these large groups of patients by urodynamic means. Hence in the 1970s there was a rapid expansion of clinical and research urodynamics. The wider acceptance of urodynamics has allowed us to look at LUTS from a different perspective.

The Urodynamic History

Despite the shortcomings of the patient's symptoms for diagnosis, they are important. They trouble the patient sufficiently for him or her to seek medical help, and LUTS should be assessed in a systematic way.

Some quarters have taken a nihilistic approach to urodynamic investigations because of the alleged inadequacy of this method of assessment and on the premise that if the patient's symptoms are improved by an intervention (e.g., an operation), then nothing else matters! However, because the patient's symptoms and the objective urodynamic findings bear little relationship to each other, this approach has several major drawbacks. Already mentioned are the less than adequate results from elective surgery, when only symptoms were considered in diagnosis. Second, there is a well-established, very large placebo effect in patients with LUTS. The symptoms of men with proven bladder outlet obstruction, secondary to
benign prostatic hyperplasia, can be improved by placebo treatment to such an extent that 40% to 60% of men in the placebo arm of drug studies consider themselves considerably improved.

Nevertheless, doctors and nurses familiar with urodynamic techniques and with a functional appreciation of bladder and urethral physiology are able to take a history from a patient that gives a much more accurate picture of the patient's real problems. The significance of individual symptoms and groups of symptoms is discussed in detail in Chapter 4.

The Urodynamic Physical Examination

Patients referred for urodynamics will have been examined in a general way, either in the hospital clinic from which the referral emanated, or by the patient's general practitioner (primary care physician). Hence the urodynamic staff should concentrate its efforts on a physical examination that will shed light on the patient's symptomatic complaints and the underlying pathophysiological processes that could have caused these complaints. One of the great advantages of the Bristol unit is that adequate time is given for close questioning, the relevant physical examination, an unhurried urodynamic investigation and practical advice. The importance of the urodynamic physical examination is discussed in detail in Chapter 4. Urine examination should be performed in all patients, and radiology and endoscopy have their indications, as will be discussed in Chapter 4. Urodynamic studies should follow only when careful investigations have been performed to exclude other pathologies that might mimic lower urinary tract dysfunction.

The Aims of Urodynamics

The objectives of any test can be achieved if the appropriate questions that the test is designed to address are posed. Therefore, at the outset, it is important to ask the following question:

“What do I want to know about this patient?”

Urodynamic studies have their limitations. It may be useful for the clinician to answer this question in terms of the filling and voiding phases of the micturition cycle and in terms of the bladder and the urethra. In this way, the urodynamicist can ask the next relevant question, which is:

“Which urodynamic investigations need to be performed to define this patient’s problems?”

This question will concentrate the clinician's thought processes on eliminating those investigations which cannot help to make the diagnosis or indicate the line of management. For example, if a young male patient has had a urethral stricture and restricturing has to be excluded, then urine flow measurement will be the only required test.

Once the questions that need to be answered have been defined and the relevant urodynamic tests selected, the next question should be:

“Is the investigation likely to be of benefit to the patient?”

This question, again, can be answered by an analysis of the possible benefits to the patient, in terms of the increased knowledge generated by the test, and the influence this knowledge
will have on his or her clinical management. Even when knowledge does not appear likely to improve the quality of life of that patient, there may still be an overall benefit to them if knowledge in a difficult area without effective treatment techniques can be increased. An increase in knowledge may, at a future date, result in the introduction of effective treatment. A good example would a young woman who cannot void adequately. When often normal voiding cannot be re-established, intermittent self-catheterisation is a good treatment, although it is resented by many patients. However, routine investigations usually contribute little to effective management, although neurophysiological testing may show abnormal sphincter activity. Hence investigations may show the cause, although the clinician does not have the means to reverse these abnormalities.

The benefits of the investigations must be set against the potential harm the tests could do. Fortunately, urodynamics are a relatively harmless investigation, although there is a small incidence of urinary tract infection (1% to 2%) and some discomfort. Then, there is the question of whether the information gained by the tests offsets their financial cost. Also important in deciding the benefit-risk analysis of the investigations will be the answers given to the following questions.

"Is urodynamics able to make a reliable diagnosis?"

This is a complex question within which the fundamental query is whether the tests themselves are reliable and reproducible. Three factors greatly influence the value of urodynamics:

- The urodynamic technique should be free of technical artefacts.
- The results of investigations should be reproducible.
- The clinician should be properly trained and able to interpret the results of urodynamics.

From a technical point of view, the tests must clearly be carried out in a careful way, eliminating all possible artefacts. This aspect of urodynamic studies is discussed extensively in Chapter 3. The patient's own bioconsistency is another problem. We know that symptoms vary considerably with time, but we do not have much information as to whether or not urodynamic findings vary. This problem is best dealt with at the end of the urodynamic tests by asking:

"Did the urodynamic studies reproduce the patient's complaints and did the complaints correlate with known urodynamic features?"

In the Bristol unit, we have always laid great emphasis on the clinician, who is aware of the therapeutic possibilities of subsequent treatment, being present during urodynamics. The clinician can then be sure whether the sensations felt by the patient and the findings demonstrated by urodynamics are typical of the patient's everyday symptoms and whether any urodynamic abnormalities can account for these. Occasionally during urodynamic studies either the patient complains of an unrepresentative symptom, for example, urgency, or there is a urodynamic abnormality noted which does not correlate with the patient's symptoms. These discrepancies can be detected and interpreted as artefacts, if the clinician is present. However, if the urodynamics is delegated to a technician they may be reported on their face value, leading to a possible bias in the report that may influence subsequent patient management.
In some instances more than one abnormality can be seen, therefore it is important to ask:

"Can urodynamics decide which is the most significant abnormality if more than one is detected?"

Multiple abnormalities are commonly seen in patients with neurogenic vesicourethral dysfunction. They are also often seen in non-neurological patients, such as in women with mixed incontinence. Treatment should be directed to the most significant or troublesome abnormality. Hence, once again, the correlation between the patient’s symptomatic complaint and the urodynamic findings are most important. This correlation allows the clinician to advise on which abnormality is the most significant and should therefore receive management priority.

As well as seeking answers to the above questions the urodynamicist needs to define the indications for urodynamic investigation, and these can be viewed in a slightly different way:

- To increase diagnostic accuracy above that which can be achieved by nonurodynamic means.
- To make a diagnosis on which a management plan can be based. Overactive bladder symptoms are usually treated empirically on the assumption that detrusor overactivity is the cause, if a patient fails conservative and medical therapy, urodynamic proof of detrusor overactivity is required prior to invasive surgery.
- If there are coexisting abnormalities, to provide evidence to determine which should be treated first. In female mixed incontinence, determining which form of incontinence is most bothersome can be difficult. By careful assessment of the patient during urodynamics, it is usually possible to decide which is the predominant problem and thereby establish the treatment priority.
- To define the current situation, knowing the likely abnormalities, as a baseline for future surveillance. In spinal cord trauma, it is usual to perform urodynamic after spinal shock has resolved. These baseline urodynamics establish whether there is a detrusor contraction in reaction to bladder filling and whether or not detrusor-sphincter-dyssynergia (DSD) has developed. DSD, as discussed later, is a dangerous condition that can lead to poor bladder compliance, upper tract dilatation and renal impairment.
- To predict problems that may follow treatment interventions. Elderly men with prostatic obstruction and co-existing detrusor overactivity (DO) should be warned that whilst their urine flows and other voiding symptoms will be improved by TURP, OAB symptoms due to DO may persist.
- To provide evidence that influences the timing of treatment. In patients with neurological disease (e.g., meningomyelocele) being treated by antimuscarinics, ultrasound may show the development of upper tract dilatation. Urodynamics are vital to confirm whether or not poor bladder compliance is the cause. If so a procedure such as ileocystoplasty will be required.
- To exclude abnormalities which might interfere with the management of that patient. In neurological patients with stress incontinence, who are being considered for the implantation of an artificial sphincter, the urodynamic demonstration of poor bladder compliance would indicate the need for treatment of the bladder condition as well as implanting
the sphincter. Failure to deal with the bladder would be likely to produce worsening bladder compliance with effects on upper tract drainage.

- To assess the natural history of lower urinary tract dysfunction. Our unit, by investigating men and women studied more than 10 years ago is providing important evidence as to the natural history of voiding dysfunction in men and OAB and DO in both men and women.

- To assess the results of treatments designed to affect lower urinary tract function. Simple urodynamics tests, such as urine flow studies, should be used to audit the result of surgeries to relieve bladder outlet obstruction, for example after optical urethrotomy for urethral stricture.

After a brief description of the anatomy and physiology of the lower urinary tract in Chapter 2, subsequent chapters discuss urodynamic techniques (Chapter 3) and their applications (Chapters 5 and 6).

References


