W10: LIVE WEBINAR: Basic Urodynamics - An Interactive Workshop

Workshop Chair: Marcus Drake, United Kingdom

Start	End	Topic	Speakers
1300	1315	Welcome and introduction to Urodynamics	Marcus Drake
1315	1330	Physics for the Urodynamicist	Andrew Gammie
1330	1430	Practical Session 1	Marcus Drake Arturo Garcia-Mora Laura Thomas Rachel Tindle
1430	1500	Break	None
1500	1555	Practical Session 2	Marcus Drake Arturo Garcia-Mora Laura Thomas Rachel Tindle
1555	1600	Questions	All

Aims of Workshop

This workshop aims to provide a practical course offering an interactive 'hands on' environment for practitioners to improve their skills in urodynamics. The use of recorded tests, access to equipment and small groups means that individual problems can be addressed. At the end of the workshop delegates should feel more confident in their practice.

Learning Objectives

Learn how to set up urodynamic equipment.

Target Audience

Urology, Urogynaecology and Female & Functional Urology

Advanced/Basic

Basic

Suggested Learning before Workshop Attendance

ICS Good Urodynamic Practices; ICS Fundamentals series; ICS urodynamics e-Learning modules

Introduction

Prof Marcus Drake

Urodynamics is the umbrella term that covers investigations of lower urinary tract function. The term encompasses the following investigations: uroflowmetry, cystometry (standard and video), urethral pressure profilometry and ambulatory urodynamics. Standard cystometry is the commonest investigation for storage and voiding symptoms. Cystometry aims to reproduce a patient's symptoms and, by means of pressure measurements, provide a pathophysiological explanation for them.

Detrusor pressure is measured indirectly from vesical and abdominal pressures using the formula: $p_{ves} - p_{abd} = p_{det}$. Abdominal pressure is measured to allow for the effect of increases in abdominal pressure, for example straining, on vesical pressure. Cystometry has two parts: filling and voiding. Both are normally performed as part of every investigation, with some exceptions, for example in patients unable to void, when filling cystometry alone would be carried out.

During cystometry there is a constant dialogue between the investigator and the patient so that any symptoms experienced during the test can be related to urodynamic findings. A full report is produced following a urodynamic investigation, which will normally include history, examination, urodynamic findings and suggestions concerning management. The report should state whether the patient's symptoms were reproduced and whether voiding was felt to be representative.

Physics for the urodynamicist – an introduction

Andrew Gammie

<u>Pressure</u>

- Pressure can be measured by the height of a column of fluid that it supports. In urodynamics, the unit of pressure has been standardised as the *cmH_2O*.

- There are usually two pressure transducers associated with urodynamic equipment, measuring intravesical pressure p_{ves} and abdominal pressure p_{abd}. The detrusor pressure, p_{det}, is derived by subtracting p_{abd} from p_{ves}.

- Pressure transducers are not perfect instruments, therefore it is important to check their calibration to ensure that accurate pressure measurements are made.

- In most urodynamics, the transducers are remote from the patient. Patient pressures are transmitted to the transducers via water-filled catheters. There must be:

    - No bubbles of air between patient and transducer
    - No water leaks
    - A good connection between transducer dome and transducer diaphragm.

- Good urodynamics is carried out by making measurements relative to atmospheric pressure. This is achieved in a water-filled system by zeroing the equipment with the transducers closed to the patient and open to atmosphere. The transducers should be level with the symphysis pubis.

- Pressure measurements may also be made by using air-charged catheters. With these, there is a practically weightless connection between the patient and the external transducer. This means there is no need to flush air from the system nor is there any need to place anything at a reference level. However, it is still important to set the baseline pressure of these devices to atmospheric pressure, and these catheters are regarded as not yet fully validated.

Flow

- Urine flow rate in urodynamics is measured using a flowmeter which can either be mounted on a stand or a commode. Urine is directed onto the sensor by a funnel.

- One type of flowmeter is the *load cell* flowmeter. A collection vessel is placed onto a weight sensor, which monitors the volume going into the vessel by measuring the increasing weight. The electronics converts the changes of volume with time into urine flow rate *Q.* This is measured in ml/s.

- Another common type of flowmeter is the rotating disc flowmeter. In this device, there is a rotating disc at the mouth of the collection vessel. Urine hits the disc and slows it down. The amount of energy required to bring the disc back to speed is proportional to the flow rate *Q*. The electronics then calculates the volume voided in units of ml.

- Both these flowmeters will measure flow rate accurately but it is important to examine the flow trace in order to correct for any artefacts that have occurred during voiding:

    - Knocking the flowmeter may produce 'spikes' on the trace which need to be ignored.
    - Moving the urinary stream will produce artefactual fluctuations in the flow trace.
    - If making simultaneous measurements of pressure and flow, it may be necessary to correct for the time delay between the stream exiting the urethral meatus and it being recorded by the flow meter.

References for equipment and measurement issues

Air filled, including "air-charged," catheters in urodynamic studies: does the evidence justify their use? *Abrams P, Damaser MS, Niblett P, Rosier PF, Toozs-Hobson P, Hosker G, Kightley R, Gammie A. Neurourol Urodyn. 2016 Aug 31. doi: 10.1002/nau.23108.*

ICS teaching module: Artefacts in urodynamic pressure traces (basic module). *Gammie A, D'Ancona C, Kuo HC, Rosier PF. Neurourol Urodyn. 2015 Sep 15. doi: 10.1002/nau.22881.*

International Continence Society guidelines on urodynamic equipment performance. *Gammie A, Clarkson B, Constantinou C, Damaser M, Drinnan M, Geleijnse G, Griffiths D, Rosier P, Schäfer W, Van Mastrigt R; International Continence Society Urodynamic Equipment Working Group. Neurourol Urodyn. 2014 Apr;33(4):370-9. doi: 10.1002/nau.22546.*

Urodynamic features and artefacts. *Hogan S, Gammie A, Abrams P. Neurourol Urodyn. 2012 Sep;31(7):1104-17. doi: 10.1002/nau.22209.*

Setting up equipment
Rachel Tindle

<u>External, Water-filled Non-Disposable Transducers:</u>
Disposables required:

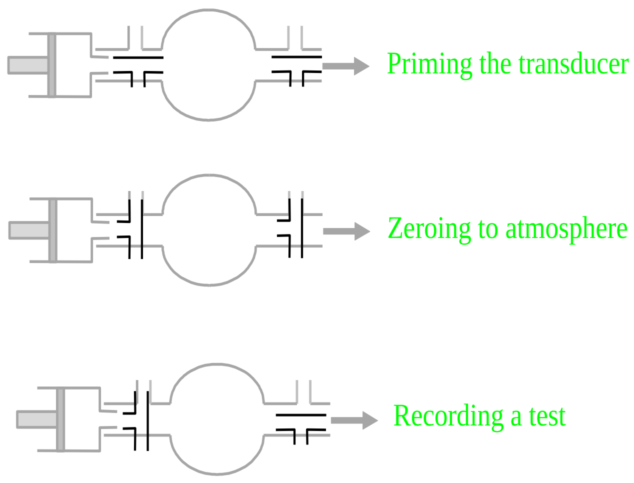
- Syringes, Three way taps, Domes, Manometer tubing/catheter to patient, Sterile water or physiological saline

The lines to the patient need to be primed with sterile water to remove air bubbles, and thus create a continuous column of water between patient and transducer. This can be done before the start of the test. The use of two three-way taps either side of the dome makes it easier for troubleshooting (checking zero and flushing) before and during the test, without introducing unnecessary air into the system.

- <u>Prime System</u>: Flush sterile water through the whole system, with both three way taps open before the domes are attached to the external transducers. A small flush after attachment is also advised.
- <u>Zero to Atmosphere</u>: Position the taps so that the transducer is open to the atmosphere and closed to the patient and syringe. The “zero” or “balance” option on the urodynamic equipment is then selected. Pressures will now be read relative to atmospheric pressure.
- <u>Set reference height:</u> The pressure transducers need to be placed at the upper edge of the symphysis pubis to avoid artefactual pressure measurements due to the hydrostatic pressure effect. If the patient changes position during the test, the height of the transducers should be changed to the new level of the symphysis pubis.
- <u>For recording</u>: The tap to the syringe remains off. The other tap is open to the transducer and the patient, but off to atmosphere. A cough test can now be performed. If the height of one cough peak is less than 70% of the other, the line with the lower value should be flushed with water and the cough test repeated.

Three way tap settings for cystometry are illustrated below:

3 way tap settings for cystometry



<u>Air-charged catheters</u>

To measure pressure the air-charged catheters need to be connected to their individual pressure transducer units. This can be done with the catheters already inside the patient. The switches on the transducer units are turned to the “open” position and the “zero” or “balance” option on the urodynamic equipment is then selected. The switches on the transducer units are then moved to the “charge” position and the catheters will record pressures inside the patient relative to atmospheric pressure. ‘Zero’ should not be done when patient pressures are being read, as these pressures are never truly zero.

<u>Checking Calibration:</u>
A simple check of calibration for external pressure transducers (before connection to the patient) is to simply move the end of the filled pressure line through a known vertical distance (e.g. 20 cm) above the transducer dome and the pressure reading on the urodynamic equipment should change by the same amount (i.e. 20 cmH_2O). For air-charged or catheter tip transducers, calibration can be checked, if necessary, by submerging the catheter tip in a known depth of sterile water. Again, the pressure reading on the equipment should change by the value of that depth.

Running a Test
Dr Arturo Garcia Mora

Before test:
Identify the urodynamic question, i.e. what symptoms are we trying to reproduce?

History:
• Symptoms
  ○ Duration
  ○ Stress/urge/other incontinence
• Degree of leakage
  ○ Pad usage
• Voiding difficulties
• Quality of life
• Past medical history
• Medication e.g. anticholinergics
• Allergies (latex)
• Parity (where relevant!)
	Frequency Volume Chart (Bladder Diary):
	• Fluid intake – caffeine / alcohol
	• Voided volumes
	• Voiding frequency
	• Nocturia?
	• Post-void residual (if measured)
	
	Decide whether they actually need the test
	
	If so, what special considerations: Paediatric, Neurological, Stoma etc

➔ Use these to inform the urodynamic test, i.e. to make it individual to the patient

Also before the test:
- Check reference level & zero
- Check vesical and abdominal pressures are in normal range
- Initial cough to test both lines

If any problems delay starting the test until quality has been fully addressed

During Test:
Using annotation marks while running the test is helpful

Quality Control	***Artefacts***	***Tailoring***
		Expected cystometric capacity
Presence of physiological signals	Drift of baseline pressures	Void volume expected
Regular coughs / deep exhalations	Position changes (both fill and void)	Supine to fill overactive bladder
	Rectal contractions	Void position
Can check zero if needed	Tube artefacts: leaks & knocks	Filling speed changes
	Pump artefacts	Running water as provocation
		Stress testing if required Cough while sitting/standing Crouching Exercises VLPP

After test:
Writing a report:
- Were the symptoms reproduced?
- Was the voiding typical? Was there a residual?
- Leakage – was it on first cough? On an overactive wave? How much leaked?
- History, Examination, summary of FVC as above
- Description of test with filling speed and position as well as any problems encountered.
- Urodynamic diagnosis and management suggestions.

Troubleshooting
Laura Thomas
Troubleshooting is a form of problem solving, defined by Wikipedia as "the systematic search for the source of a problem so that it can be solved". Troubleshooting is necessary if there are concerns about the quality of a urodynamic test while it is in progress. There is little that can be done to correct poor traces retrospectively; therefore quality assurance checks should be performed both before and during the investigation. Any problems with quality assurance should be addressed as soon as they are noted; the test can be paused while troubleshooting is performed.
The following information provides a guide to common problems that are encountered during setting up and running a test, when quality control is not satisfactory.

<u>At the start of the test:</u>
Pressure readings outside acceptable range:
According to the International Continence Society (ICS) standardisation report on 'Good urodynamic practices'[1], vesical and abdominal pressure measurements should both be within the range of 5-20 cmH_2O if measured with the patient supine, 15-40 cmH_2O, if sitting and 30-50 cmH_2O if standing.

***Troubleshooting in water filled systems*:**
If pressures are outside the acceptable range:
- If vesical and abdominal pressures are similar, but outside the acceptable range: check the height of the transducers. The ICS reference height is the upper edge of the symphysis pubis.
    - If the reference level is not correct, adjust accordingly.
- If only one pressure is outside the acceptable range:
    - Flush catheter
    - Check that zero has been set correctly on the relevant transducer
    - Consider resiting catheter

Unequal transmission of pressure between vesical and abdominal lines
- Flush lines
- Check whether there is any air in the dome over the external transducer
- Check taps are in the correct position
- Consider resiting catheter

<u>During the test:</u>
Fall in pressure of vesical or abdominal line during filling:
Neither the vesical or abdominal pressures should decline during filling. Vesical and abdominal pressures should be constantly monitored during the test and, if the pressures are noted to drop, then attempts should be made to correct this:
- Flush line – this may be enough to restore pressure
- If pressures continue to fall, check for leaks:
    - Check taps and all connections have been adequately tightened
    - Check lines – occasionally there may be a manufacturing fault

Unequal transmission of pressure between vesical and abdominal lines
See above

If lines stop recording and the pressures drop dramatically:
This is probably because one of the catheters has fallen out or become compressed
- Reposition or resite catheter
- If vesical catheter has fallen out before Q_{max}, consider refilling and repeating the pressure/flow

Troubleshooting with air charged catheters:
If any problems arise with quality control:
- Try 'opening' them, and 'recharging' the catheters, ensuring that the patient coughs between charges to remove air from the catheter
- While 'open' the zero level can be checked
- Try moving the catheter position, in case the balloon has become trapped or compressed
- If this fails – catheter will need to be changed

Interpreting Urodynamic Traces
Prof Marcus Drake

At the end of the workshop you should be able to:
1. Identify resting baseline pressures (p_{ves}, p_{abd}, p_{det}) and understand their significance
2. Recognise normal artefacts and discuss causes of artefacts.
3. Determine where pressure measurements can be reliably taken from on a trace.
4. Explore a systematic approach to trace interpretation within your own scope of practice

Urodynamic trace interpretation is complex. To become competent in elements of interpretation the urodynamic practitioner will need to be trained, supervised, and assessed in the set-up and use of urodynamic equipment, demonstrate an understanding of how to assure quality control, and have the ability to critically analyze the results of the investigation with the urodynamic traces. All interpretation should be undertaken within the context of the patients' presenting urinary symptoms.

Understanding 'normal', or, in simple terms, what a normal urodynamic trace should look like during a urodynamic investigation, can provide a strong foundation for developing skills in interpretation. This is based on normal pattern recognition, and an understanding of how the traces are displayed – axes for scale and time, and the framework of normal values / urodynamic parameters. Developing and using a systematic approach to trace interpretation can be simple. Approaches to developing such a system are outlined below.

Guidelines to reviewing and interpreting urodynamic traces

The initial void (prior to catheterisation) is a very important baseline measurement as it provides flow rate, flow pattern, voided volume, residual urine measurements, and the voiding time. It is important to ask the patient whether their void is normal for them, and whether they feel their bladder has emptied completely. This helps to establish a baseline for comparing values from their voiding cystometry.

Consider the following characteristics when you are reviewing a trace:
1. What are the p_{abd}, p_{ves}, and p_{det} resting pressures at the beginning of filling cystometry? The vesical and abdominal pressures are 'real' and can differ between patients depending on their size and position during filling.
2. Describe what you see, what is your analysis of the filling cystometry – consider artefacts (physical or physiological). Fine artefact can be caused by talking and breathing, and it is important to be able to identify these as normal artefacts during an investigation.
3. What are the p_{abd}, p_{ves}, and p_{det} resting pressures at the end of filling cystometry? Consider whether there are normal pressure changes during filling, is the bladder compliance normal? Normal detrusor function allows the bladder to fill with little or no change in pressure.
4. What information can you get from the voiding cystometry? Is it normal / abnormal – consider voiding pressures, voiding time, flow pattern, residual urine?
5. Quality control – is the quality good / bad?
   Consider the annotation of the trace – are all bladder events recorded (e.g., first desire, urgency, detrusor overactivity, leak), regular coughs / quality checks.
6. What are the overall findings – do they correlate with patient symptoms?

References:

The standardisation of terminology of lower urinary tract function: Report from the standardisation sub-committee of the ICS. *Abrams P, Cardozo L, Fall M, Griffiths D et al. Neurourol Urodyn. 2002. 21: 167-178.*

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