ICS 2014 Rio de Janeiro

W32: Basic Urodynamics - an interactive workshop

Workshop Chair: Marcus Drake, United Kingdom

21 October 2014 14:00 - 17:00

Start	End	Topic	Speakers
14:00	14:15	Introduction	• Marcus Drake
14:15	14:45	Practical Session 1	• Marcus Drake • Andrew Gammie • Arturo Garcia Mora • Hashim Hashim
14:45	15:15	Practical Session 2	All
15:15	15:30	Physics in a nutshell	• Andrew Gammie
15:30	16:00	Break	None
16:00	16:30	Practical Session 3	All
16:30	17:00	Practical Session 4	All

Aims of course/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.

Basic Urodynamics – An interactive workshop

W32 1400 hrs Tuesday 21st October 2014

Chair: Mr Marcus Drake

Foreword
Mr Marcus Drake

W32 is an interactive workshop. After a brief introduction you will rotate around four stations during the course of the afternoon. The workshop numbers have been restricted deliberately to enable interaction and to afford individual attention. In addition to the four stations, a short lecture will give an overview of physics relevant to urodynamics.

The four stations are: Setting up equipment, Running a test, Interpreting traces and Troubleshooting.

A urodynamic trainer and functioning urodynamic machine will be available to enable "hands on" experience with simulated tests. Example traces will be used to illustrate teaching points.

Setting up equipment
You will have the opportunity to practise setting up equipment in preparation for cystometry. A piece of urodynamic training equipment will be provided to enable "hands on" practice. The practical methods to ensure a urodynamic test is performed in line with Good Urodynamic Practice (Schäfer) will be discussed. These will include: how to set zero, how to remove air from the system and set the reference level.

Running a test:
This station will take the urodynamicist from taking a history through to the problems and solutions encountered during a urodynamic test. It will also cover elements of writing a urodynamic report.

Troubleshooting:
The general principles of troubleshooting will be discussed with traces that illustrate common artefacts. You will be taught how to recognise different artefacts and how to correct them in order to produce a quality test.

Interpretation of traces:
The principles of trace interpretation will be discussed and there will be the opportunity to look at sample traces and to practice interpretation.

Before the Course

The course is aimed at those with some experience of urodynamics, who do not consider themselves experts. It is suggested that some reading is done around the subject to gain maximum benefit from the workshop.
The course tutors will endeavour to meet individual needs, as much as possible, within the time constraints of the workshop.

Introduction

Mr 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.

Setting up equipment

Mr Andrew Gammie

Before urodynamic studies are undertaken it is important to understand how the equipment functions, which disposables are required and how to check calibration. There are a number of different urodynamic machines in use and it is important for the Urodynamicist to develop a good working relationship with the supplier. Before urodynamic equipment is purchased it is advisable to ensure that a service contract can be put in place and that service engineers are readily accessible for any problems, queries or planned preventative maintenance.

Cystometry is performed using pressure transducers which are sited either externally or internally. External transducers are currently more common and require a fluid filled system of catheters and tubing that can transmit pressure from the patient to the transducer. Water is normally used as the fluid, although air-filled systems are also available. Alternatively, transducers are mounted on the catheters themselves, using catheter tip transducers.

<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 length of the system, with both three way taps open before the domes are attached to the external transducers.

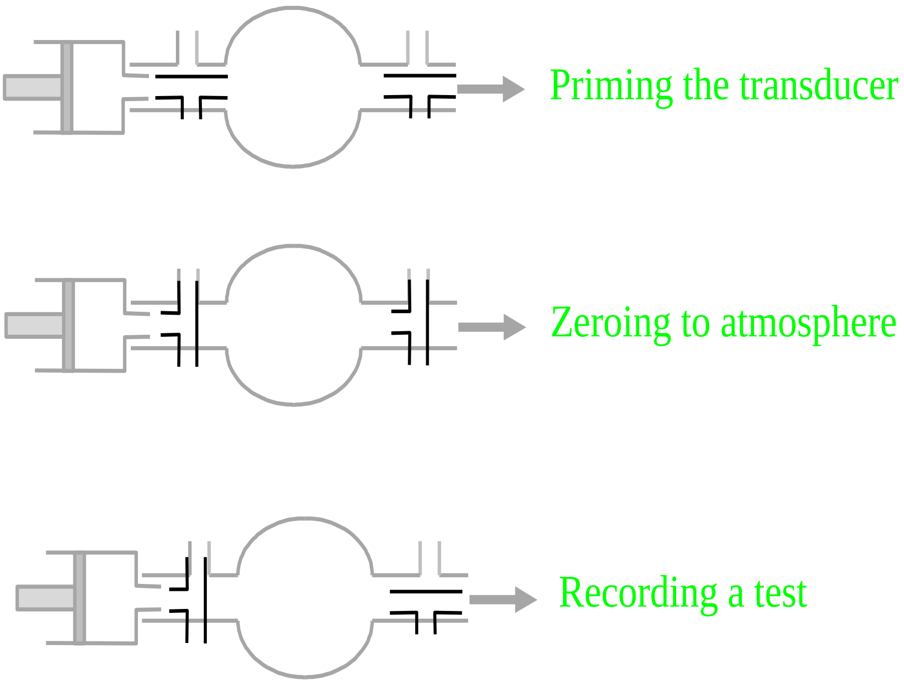
- <u>Zero to Atmosphere</u>: This is done by positioning the taps so that the transducer is open to the atmosphere and closed to the patient. The “zero” or “balance” option on the urodynamic equipment is then selected. Any subsequent pressures will now be read relative to atmospheric pressure.

- <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



Catheter tip transducers

To measure pressure relative to atmospheric pressure, the transducers need to be connected to the urodynamic system while outside the patient with nothing touching the sensing element of the catheters. The "zero" or "balance" option on the urodynamic equipment is then selected. The transducers can then be introduced into the patient and will be recording pressures relative to atmospheric pressure.

Air-charged catheters

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.

Checking Calibration:

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?

<table>
<tr>
<td rowspan="2">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!)</td>
<td>Frequency Volume Chart (Bladder Diary):
Fluid intake – caffeine / alcohol
Voided volumes
Voiding frequency
Nocturia?
Post-void residual (if measured)</td>
</tr>
<tr>
<td>Decide whether they actually need the test

If so, what special considerations:
Paediatric, Neurological, Stoma etc</td>
</tr>
</table>

➔ 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
Presence of physiological signals Regular coughs / deep exhalations Can check zero if needed	Drift of baseline pressures Position changes (both fill and void) Rectal contractions Tube artefacts: leaks & knocks Pump artefacts	Expected cystometric capacity Void volume expected Supine to fill overactive bladder Void position Filling speed changes 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
Mr Hashim Hashim

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 control checks should be performed both before and during the investigation. Any problems with quality control should be addressed as soon as they are noted; the test can be paused while troubleshooting is performed.

The following information provides only a guide to common problems that are encountered during setting up and running a test, when quality control is not satisfactory. The unexpected can always happen, but problems can be solved if troubleshooting is performed in a systematic manner.

At the start of the test:

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 be within the range of 5-20 cmH_2O if measured with the patient supine, 15-40 cmH_2O, if measured sitting and 30-50 cmH_2O if recorded 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 in a systematic manner
    - 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, ‘recharging’ the catheters, ensuring that the patient coughs between charges to remove air from the catheter
- While ‘open’ the zero level can be checked
- If this fails – catheter will need to be changed

Interpreting Urodynamic Traces
Mr 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 artefact, and discuss causes of artefact.
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 it 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 patients 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.*
Good urodynamic practices: Uroflowmetry, filling cystometry, and pressure-flow studies. *Schäfer W, Abrams P, Liao L, Mattiasson A et al. Neurourol Urodyn. 2002. 21: 261-274.*

Physics for the urodynamicist – an introduction
Mr Andrew Gammie

Pressure

- Pressure can be measured as the height of a column of fluid. To describe pressure you simply need to specify what the fluid is and the height to which it goes. In urodynamics, the unit of pressure has been standardised as the cmH_2O.

- Intravesical pressure can be measured by putting a catheter into the bladder, connecting it to a vertical tube filled with water and measuring the height that the fluid reaches relative to the bladder. However, although this is an accurate method of measuring pressure, it does not easily permit a record to be made of how pressure changes with time or bladder volume.

- Continuous recordings of pressure can be made by using a pressure transducer. The diaphragm of the transducer has a series of strain gauges bonded underneath it. Strain gauges are devices whose electrical resistance changes when they are deformed. Pressure on the diaphragm deforms the strain gauges underneath and this provides an electrical signal whose strength depends on how much the diaphragm has been deformed. This signal is displayed as a pressure reading on the computer monitor or on a chart recorder.

- There are usually two pressure transducers associated with urodynamic equipment. One to measure intravesical pressure p_{ves} and one to measure abdominal pressure p_{abd}. The pressure exerted by the detrusor smooth muscle, p_{det}, is derived by the urodynamic equipment electronically subtracting p_{abd} from p_{ves}.

- Pressure transducers are not perfect instruments but the urodynamic equipment manufacturer/distributor will have selected transducers that are suitable for measuring pressures accurately during urodynamics. However, as time goes on, the calibration of the transducers can alter and, therefore, it is important to regularly check their calibration to ensure that accurate pressure measurements are always made.

- In most urodynamics, the transducers are attached to the urodynamic equipment and are remote from the patient. Pressures inside the patient are transmitted to the pressure transducers via water-filled pressure catheters. To ensure appropriate pressure measurements there must be:

    - No bubbles of air in the water connection between the patient and the transducer
    - No water leaks
    - A good connection between the transducer dome and the diaphragm of the transducer if using non-disposable transducers.

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

- Pressure measurements may also be made in urodynamics by using catheter-tip pressure transducers or air-charged catheters. With catheter-tip devices, the pressure sensor is actually sited within the body so there is no fluid-filled catheter between the patient and the equipment. With air-charged catheters there is a practically weightless connection between the patient and the external transducer. This means that both these systems are simpler to use compared to the external water-filled devices because 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.

<u>Flow</u>

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

- One common type of flowmeter is the *load cell* or *gravimetric* flowmeter. A collection vessel is placed onto a weight sensor. Urine is directed into the collection vessel, via a funnel, and the weight sensor effectively monitors the increasing volume of fluid going into the vessel by measuring the increasing weight. The electronics of the flowmeter converts the changes of volume with time into urine flow rate Q. This is measured in the units of ml/s.

- Another common type of flowmeter is the rotating disc flowmeter. In this device, the collecting vessel has a motor inside it which rotates a disc at the mouth of the collection vessel at a constant speed. Urine is directed into the collection vessel and when it hits the disc, it slows it down. The electronics of the flowmeter puts more energy into the motor to bring the disc back up to its original speed. The amount of energy required is proportional to the urine flow rate Q provided the stream hits the disc fairly perpendicularly. The electronics of the flowmeter then calculates the volume voided.

- Both these flowmeters (and other less common ones) will measure flow rate accurately but it is important to examine the flow trace after it has been produced 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 relative to the flowmeter will produce artefactual fluctuations in the flow trace – *the wag factor*.
    - 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 – *the lag factor*.