Basic Principles of Urodynamics

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with grateful acknowledgement of

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Good Urodynamic Practices: Uroflowmetry, Filling Cystometry, and Pressure-Flow Studies

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Schafer W
Abrams P
Liao L
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Spangberg A
Sterling AM
Zinner NR
Van Kerrebroeck P

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Topics covered

- Pressure
- Transducers
- Different types of transducer
- Issues with bladder pressure
- Flow measurement
- Pressure-flow tests

What is pressure?

Force per unit area

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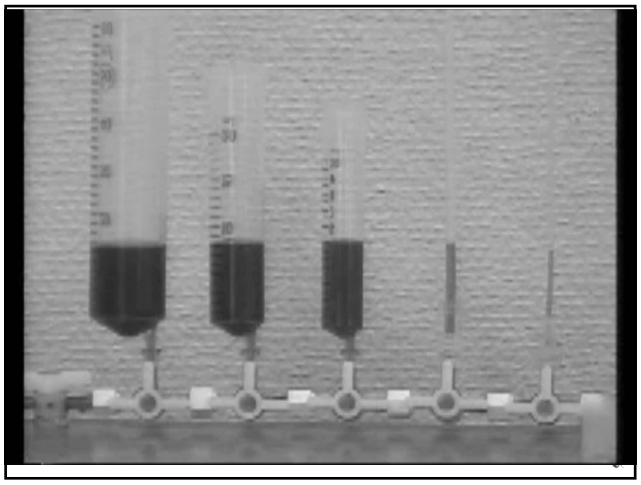
Pressure in columns of fluid

Why is level of fluid in the tube higher than the balloon?

The pressure inside the balloon is transmitted up the tube and supports a column of water

What, apart from pressure, dictates the height of fluid in the tube?

- Gravity?
- Atmospheric pressure?
- Viscosity?
- Tube width?



Diameter of tube does not matter

Pressures on holiday

Does the density of the fluid determine the height to which the fluid goes?

Density matters

Thus we need to state pressure both in terms of a height and also in terms of a particular fluid

Unit of pressure

cm H_2O

1 cm H_2O = 0.74 mm Hg

100 cm H_2O = 74 mm Hg

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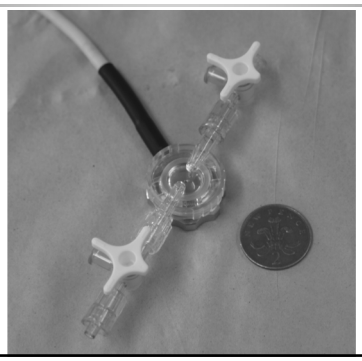
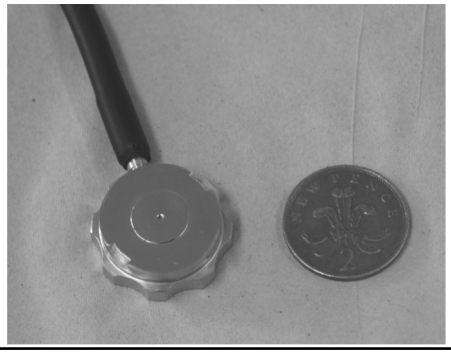
- Transducers
- Different types of transducer
- Issues with bladder pressure
- Flow measurement
- Pressure-flow tests

External pressure transducer with dome and taps



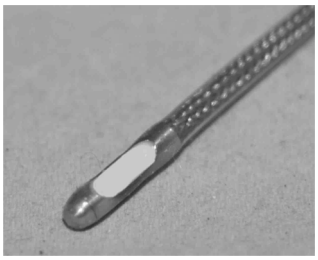
External pressure transducer without dome



Transducer types

- Catheter tip
- Air filled
- Water filled

Catheter-tip pressure transducers



Catheter-tip pressure transducers

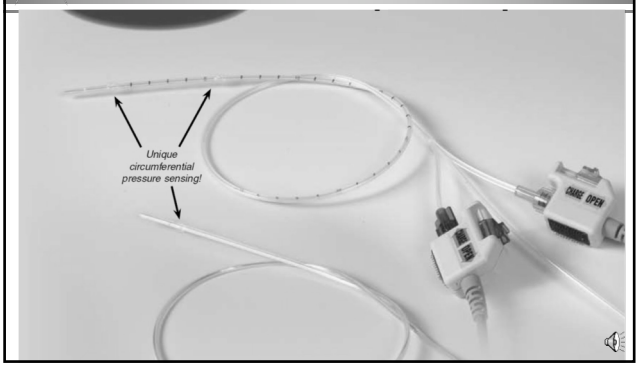
Also known as:

- Catheter-mounted pressure transducers
- Microtip transducers
- Solid state transducers

Catheter-mounted pressure transducers

- No fluid connecting the patient to the equipment – only wires
- No flushing
- No need to set anything at a reference level

T-DOC



Air-charged catheters

- No water connecting the patient to the equipment – only air
- No flushing
- No need to set anything at a reference level
- No substantial comparisons with water-filled lines

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Movement artefacts

External pressure transducer

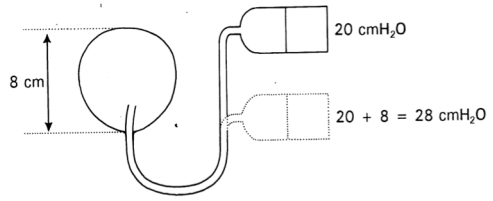


Fig. 3.31 External pressure transducers measure pressure according to their position (outside the body) in relation to the bladder: the lower position (dotted lines) also records the 8 cm pressure head of the bladder itself. The position of the catheter in the bladder does not change the pressure measurement.

Catheter-mounted pressure transducer

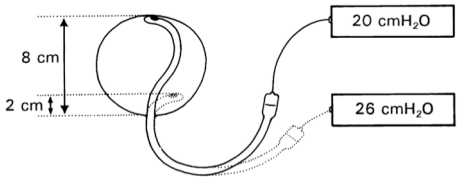
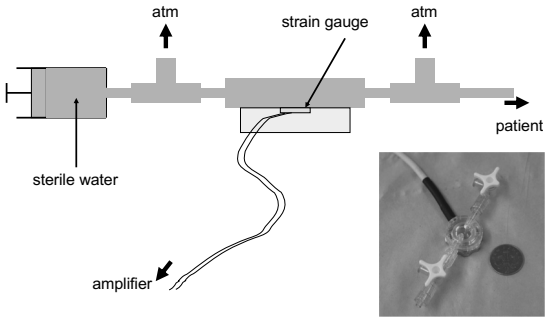


Fig. 3.32 Catheter tip transducers measure pressure according to the position of the transducer within the bladder. When the transducer is high in the bladder (solid lines) the pressure is lower (20 cmH_2O); when the transducer is lower in the bladder the pressure is higher (26 cmH_2O = 20 cm H_2O *plus* the 6 cm column of urine on top of the transducer).

Recommendation - Pressure

- It is recommended that for intravesical and abdominal pressure recording, external pressure transducers connected to water-filled tubes and catheters should be used.
- If microtip or air-filled catheters are used, any deviation from standard zero and reference level should be minimised and taken into account at the time of analysis

Measuring bladder pressure with a water-filled line



Position of the bladder relative to the transducer

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Setting the reference height of water-filled systems

Recommendation - Pressure

- We need to know the reference height of the transducers
  - Compare readings on the same patient
  - Check for realistic pressures
  - Equal reference for p_{abd}, p_{ves} relative to bladder
- The ICS standard reference height is the upper edge of the symphysis pubis

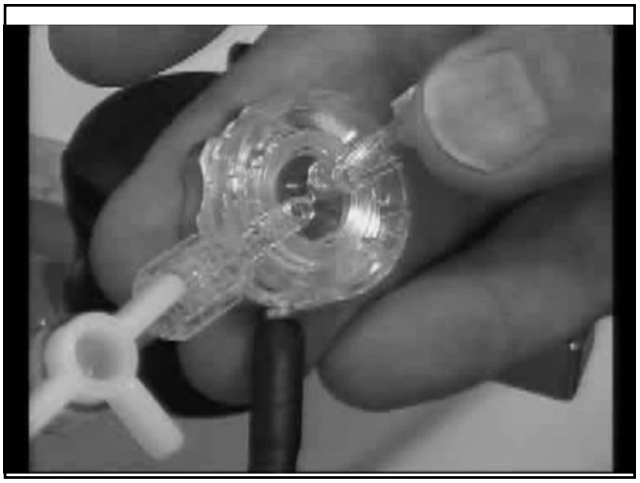
Calibration

- Urodynamic equipment is not perfect and its accuracy can alter with time. Therefore, regular checks of its calibration are essential
- 0 to 50 cmH_2O before clinic

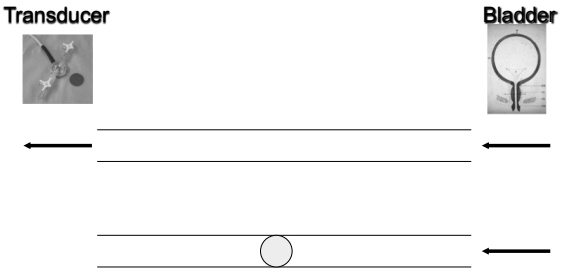
Checking calibration

Measurement issues with water-filled lines

- Reference height
- Movement artefact
- Pump artefact
- Air in the system



Effect of air in the system



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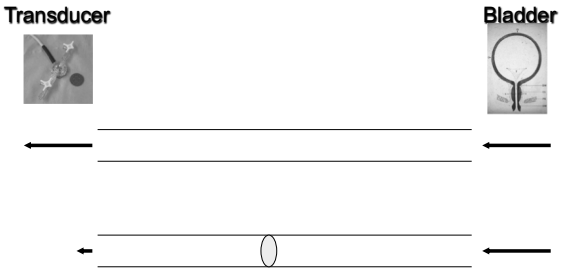
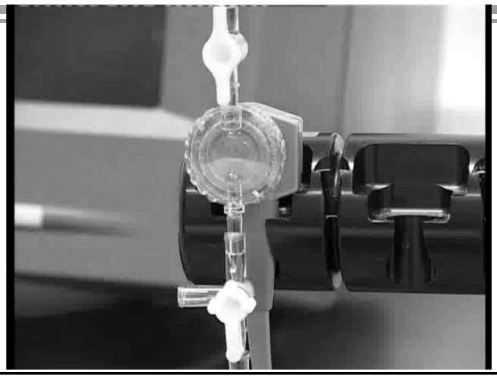


Flushing a water-filled line



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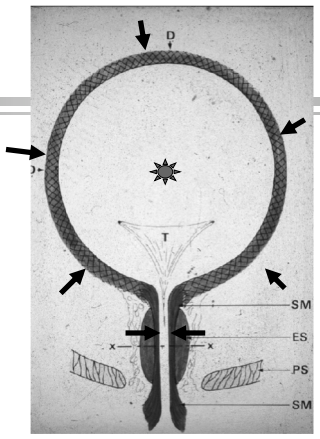
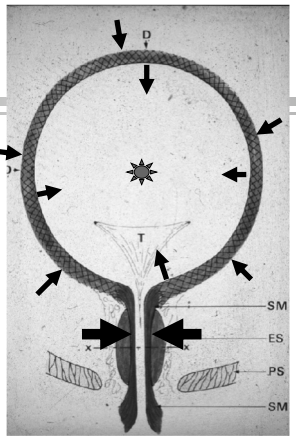
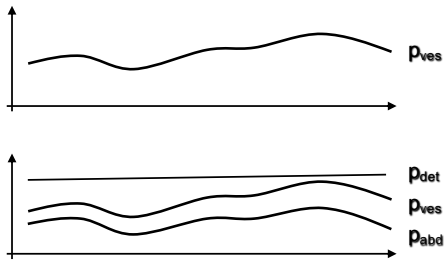




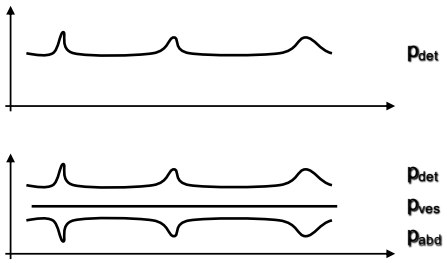
Definition of detrusor pressure

$$p_{det} = p_{ves} - p_{abd}$$

Why subtract?

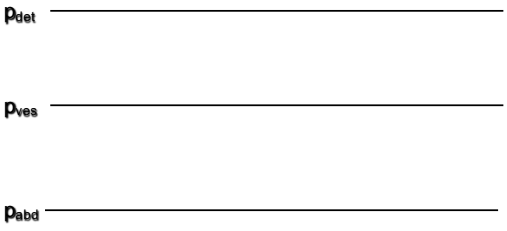


Why not just display detrusor?

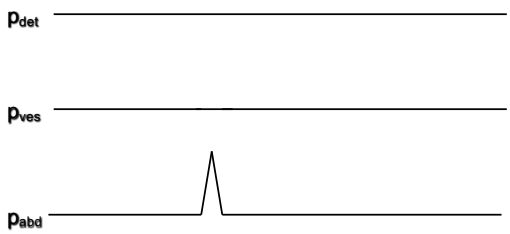


Why then display all three?

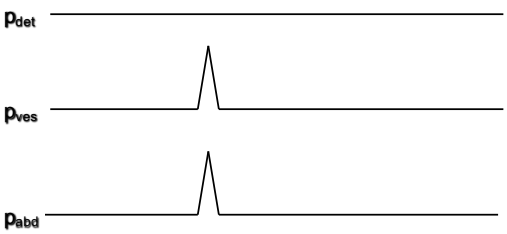
Quality control



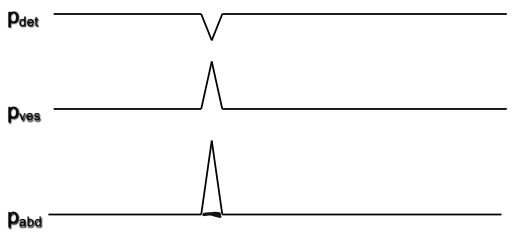
Quality control



Quality control



Quality control



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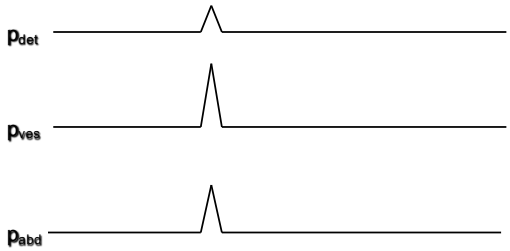

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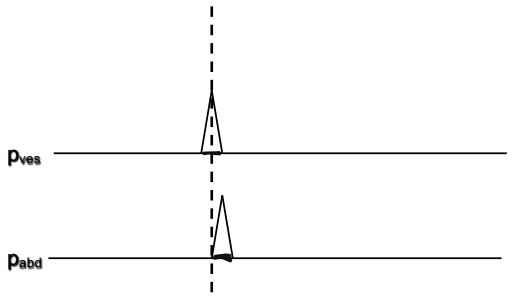

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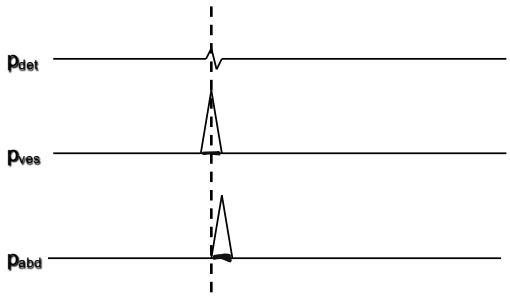

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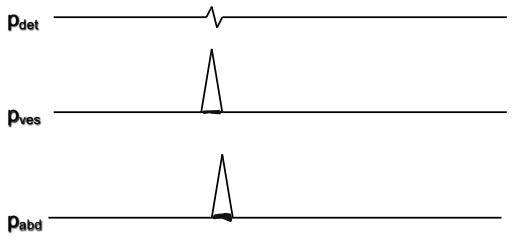

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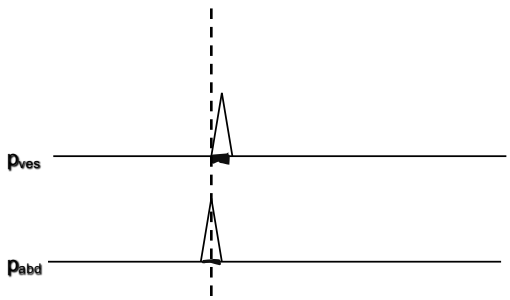

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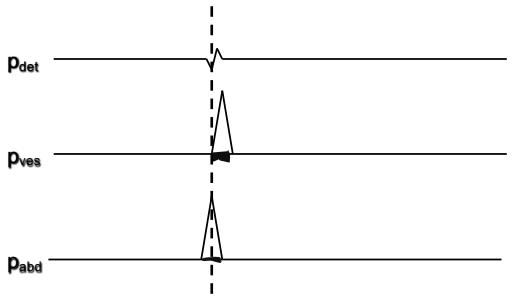
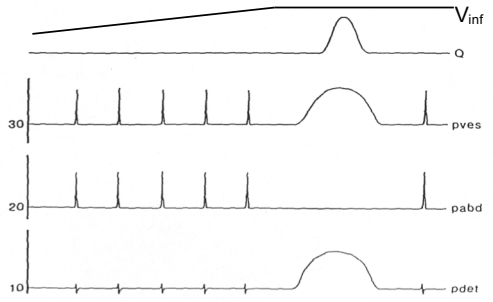


Normal cystometry



Recommendation - Pressure

- It is recommended that there is strict adherence to the ICS standardisation of zero pressure and reference height
  - Zero pressure is the surrounding atmospheric pressure
  - Reference height is the level of the symphysis pubis

Reasons to zero to atmospheric pressure

- **It produces a scientifically meaningful parameter**
- **Has a role in quality control**
- **When comparing with other centre's data, it is necessary to compare like with like**
- **Some measurements (eg VLPP) are made on the intravesical or abdominal pressure not detrusor pressure**

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Pressures at beginning of filling cystometry

	Minimum	*Maximum*
p_{ves} (cm H_2O)	5	50
p_{abd} (cm H_2O)	5	50
p_{det} (cm H_2O)	-5	5

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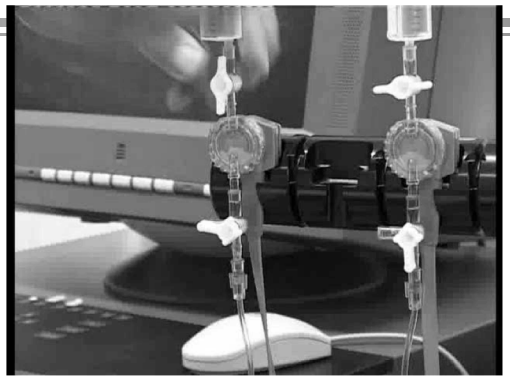
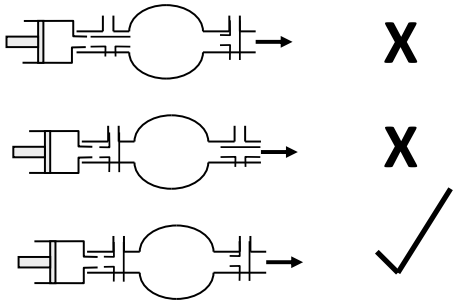
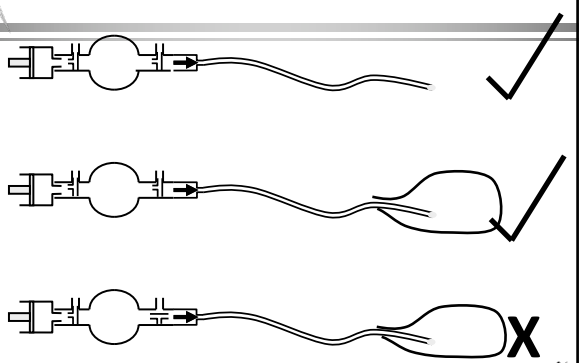
Zeroing to atmosphere



Zeroing to atmosphere



Zeroing while connected



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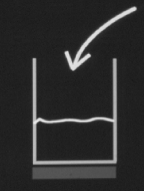
Free flow rate measurement

Uroflowmetry

Load cell flowmeter

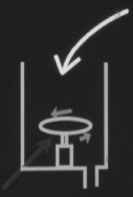


Change in weight with time
is related to
Change in volume with time

Differentiate

Flow rate (Q)

Rotating disc flowmeter



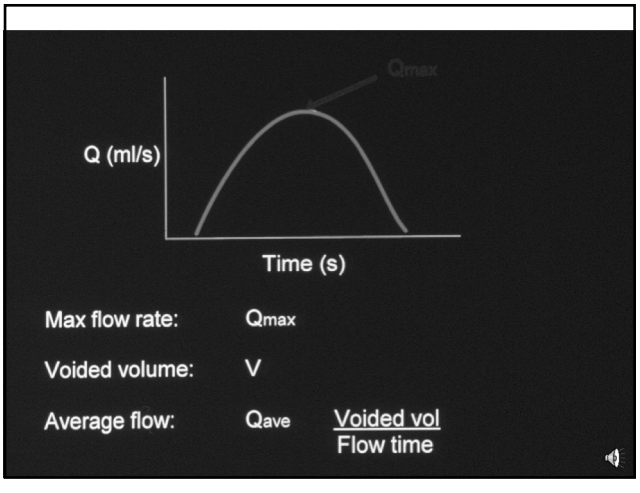
Urine hits disc and slows it down

Electronics puts more energy in to get disc back to original speed

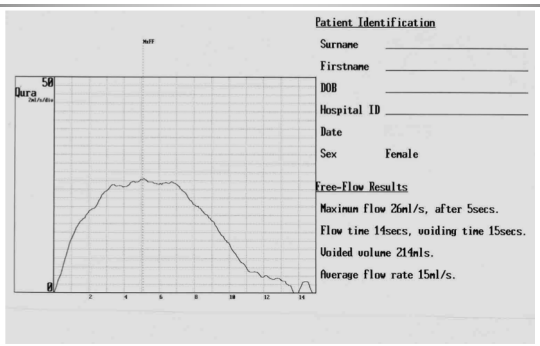
If stream hits disc perpendicularly, this amount of energy a flow rate Q

Integrate Q

Volume



Free flow rate measurement



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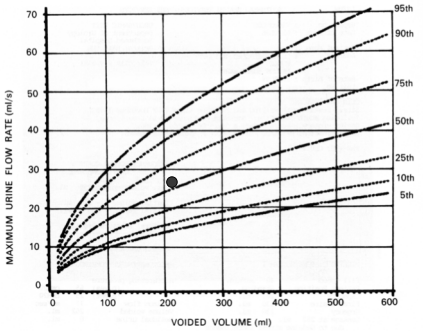
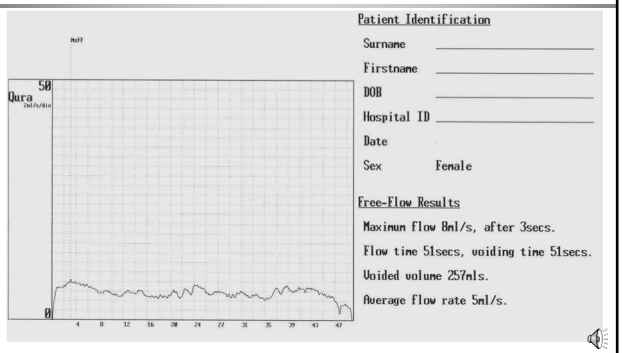
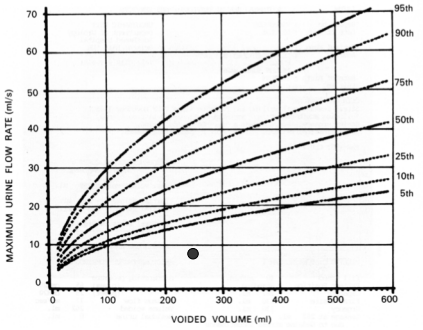
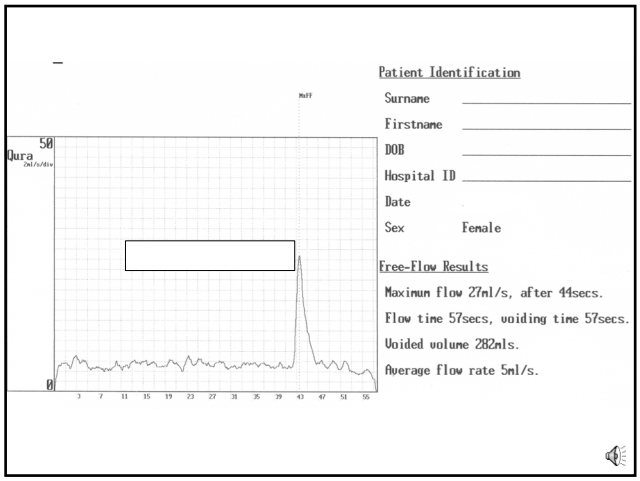


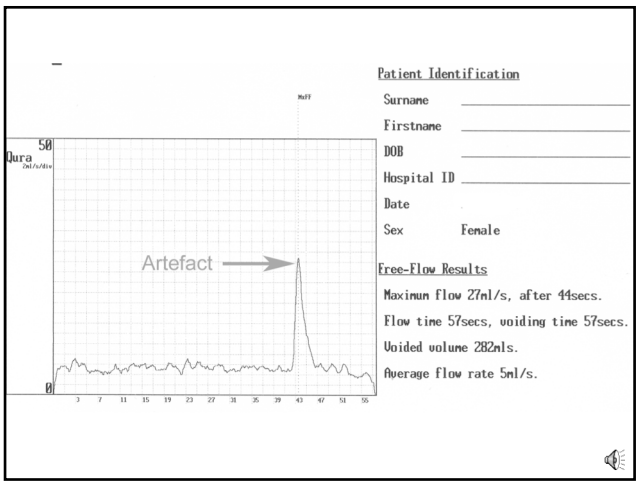
Free flow rate measurement

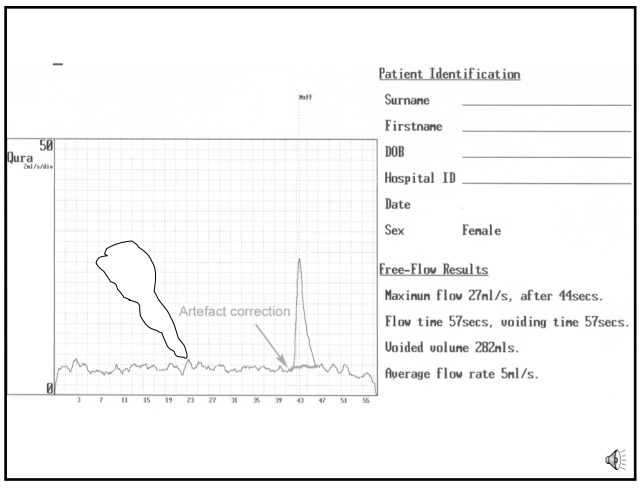


Free flow rate measurement









Free flow rate measurement

- **What does it tell us?**
- **Whether there is a problem with voiding**
- **It DOES NOT tell us whether any problem is due to outflow obstruction or poor detrusor contractility**

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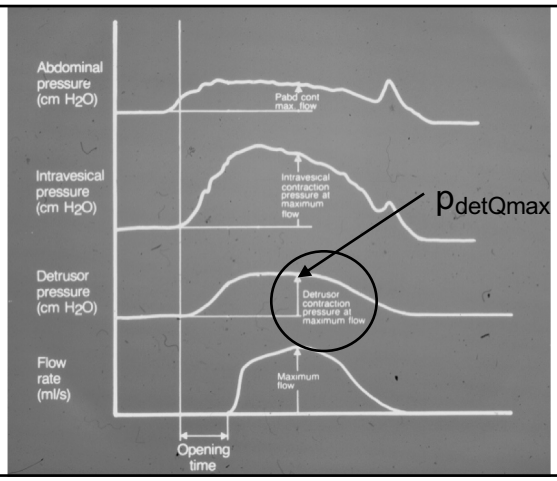
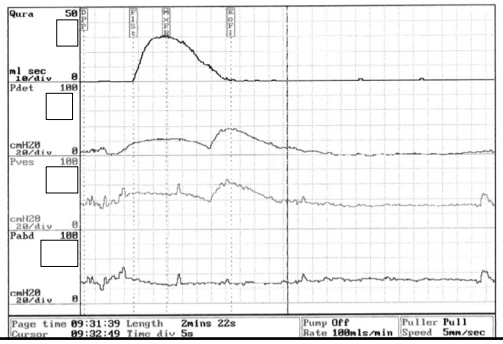
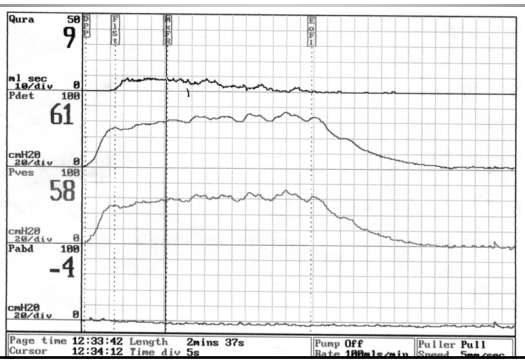


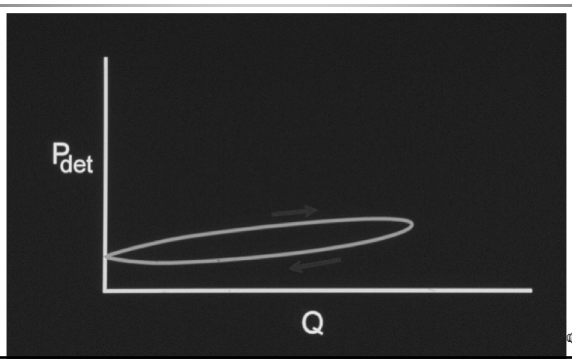
Normal pressure-flow (female)



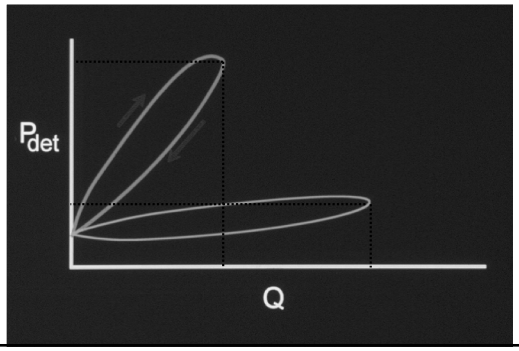
Outflow obstruction (female)



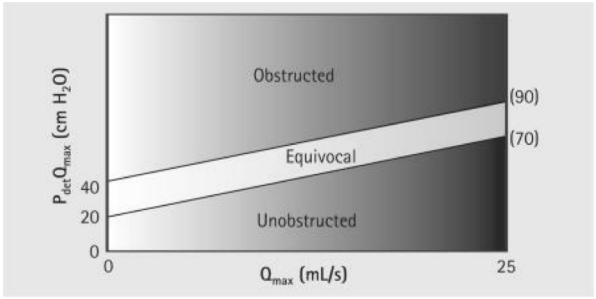
Normal pressure-flow plot



Obstructed pressure-flow plot



ICS nomogram



BOOI (Abrams-Griffiths number)

$p_{detQmax} - 2Q_{max}$

< 20 non obstructed
> 40 obstructed

Topics covered - summary

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