







Quality Assessment & Artefact Recognition


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Urodynamic Features and Artefacts

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ICS Teaching Module: Artefacts in Urodynamic Pressure Traces (Basic Module)


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Aims: To present the ICS Teaching Module on artefacts in urodynamics pressure traces. **Methods:** Slides from three urodynamics centres were assembled. Descriptions and labels were agreed by the authors and the module presented at the ICS Annual Scientific Meeting in Brazil 2014. **Results:** Ten artefacts that should be recognized while using water-filled urodynamic systems are presented and remedial action described. **Conclusions:** This manuscript serves as scientific background for the slide set made available on the ICS website. By following the guidelines in this teaching module, good quality urodynamics can be more readily achieved. *NeuroUrol. Urodynam.* 36:35–36, 2017.
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Quality Control Criteria: ICS 2002

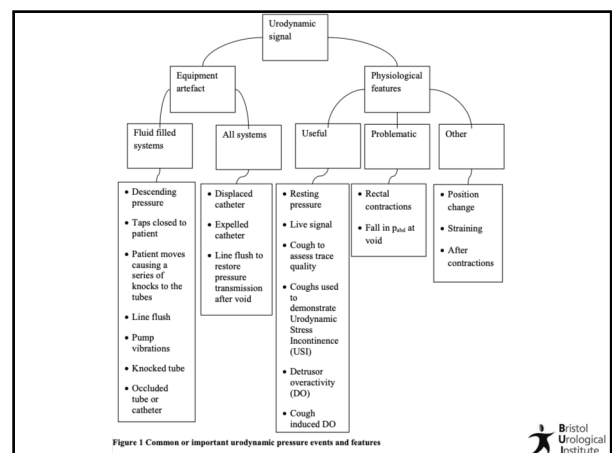
- Resting values for abdominal, intravesical, and detrusor pressure are in a typical range.
- The abdominal and intravesical pressure signals are “live,” with minor variations caused by breathing or talking being similar for both signals;
 - these variations should not appear in the detrusor pressure signal (P_{det}).
- Coughs are used (every 1 min or, e.g., 50 ml filled volume) to ensure that the abdominal and intravesical pressure signals respond equally.
 - Coughs immediately before voiding and immediately after voiding should be included.

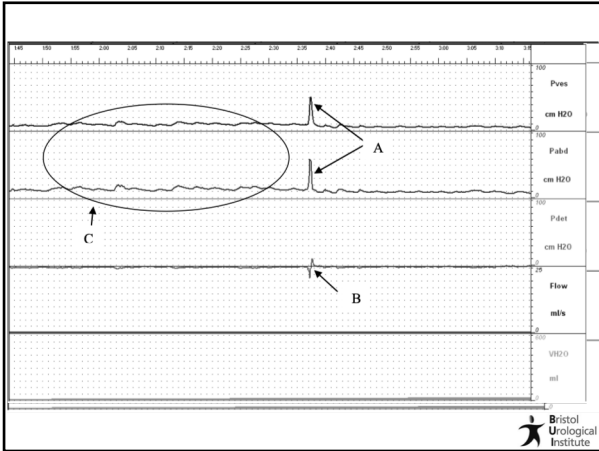


Study Methods

- 200 urodynamic traces
- Laborie water-filled system
- Catheters:
 - 7 Fr filling, epidural p_{ves} , slit balloon p_{abd}
- Pressure events automatically detected
 - i.e. deviations > 10cmH₂O from resting
 - >10,000 events detected and classified
 - random selection of 200 traces manually checked for accurate classification







Initial Resting Pressure

- pves and the pabd pressure at the beginning of the cystometry
- Gentle flushing of both catheter channels and/or filling 20–30 mL of the bladder, before the initial resting intravesical pressures are considered to be “established.”
- Prevent reading measurements from a kinked catheter in an empty bladder with the catheter holes blocked with (insertion) gel and/or pushed against the bladder surface

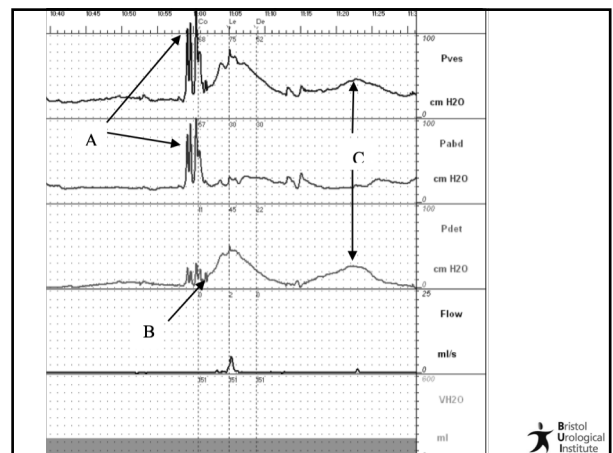
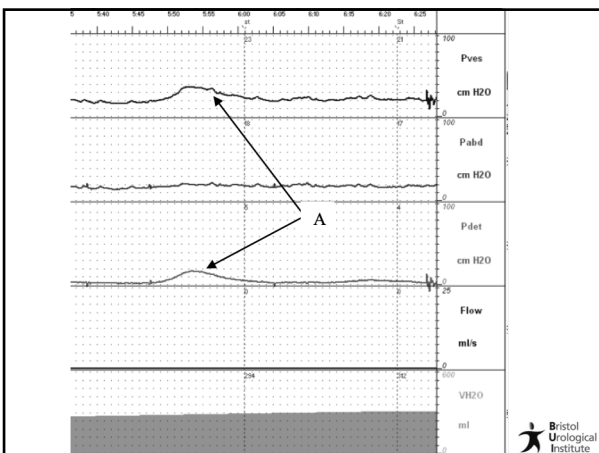
Initial pves and pabd Pressures

- pabd and pves are similar and > 95% lie in the following ranges:
 - lying 0-18 cmH₂O,
 - sitting 15-40 cmH₂O,
 - standing 20-50 cmH₂O
- These data give initial detrusor pressure readings between -5 and +5 cmH₂O (97%, 97% and 96% in the 3 positions).

Sullivan et al 2011 NAU

Dead Signal

- A signal that is not showing small pressure fluctuations and is not adequately responding on straining, patient movements, or coughing
- GUP2002: A good pdet signal requires only that pves and pabd show the same fine structure and quality of signals before filling, during filling, and after voiding



Cough associated detrusor overactivity (NEW)

- Reported when the onset of the DO (with or without leakage) occurs immediately following the cough pressure peak.
- “Cough induced DO” is sometimes reported, although the precise (patho-)physiology and/or relevance remain speculative.



Cough Test

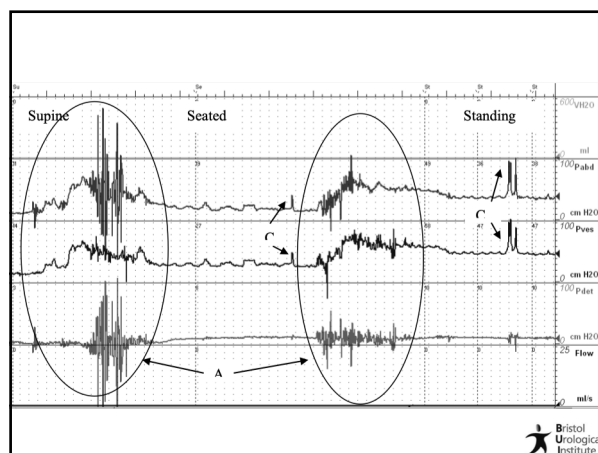
Suggested NEW definition:

One or more sets of rapidly repeated voluntary cough signals used to test for USI



Cough pressure peak (NEW)

- Recognizable during post-test evaluation as a phasic positive pressure change observed in pves and in pabd.

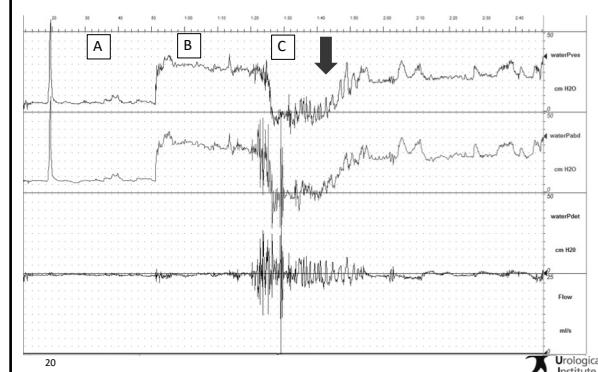


Position Change

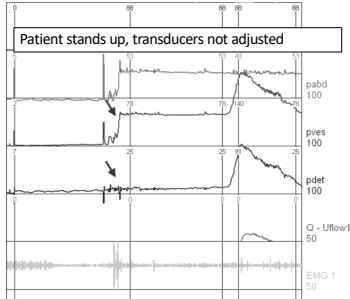
- **Suggested NEW definition:**
A change in patient position is characterised by a change in the resting pressures of pves and pabd of equal magnitude on both, usually between 8 and 35 cmH₂O.
- **Position change (NEW):**
A change in patient position, either active or passive (eg. tilting), is visible on the cystometry trace by a lasting change of equal magnitude in both pves and pabd.
Note: A position change should be (is readily) noted during the test.
Position change should be followed by readjustment of the external pressure sensors height to the standard so that the pves and pabd-values are similar to the pressure values before the position change.
A position change should not affect pdet.
The position change pattern should be recognized during post-test evaluation of the cystometry.
- **Remedial action:**
Whenever the patients position changes, adjust pressure transducers ensuring they are in line with the upper edge of the symphysis pubis – this action has not been taken in the screenshot provided.



Patient position change (water filled)



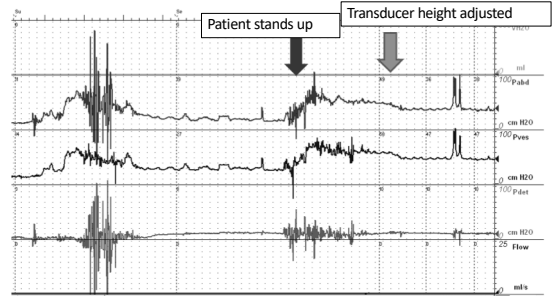
Patient position change (water filled)



21



Patient position change (water filled)

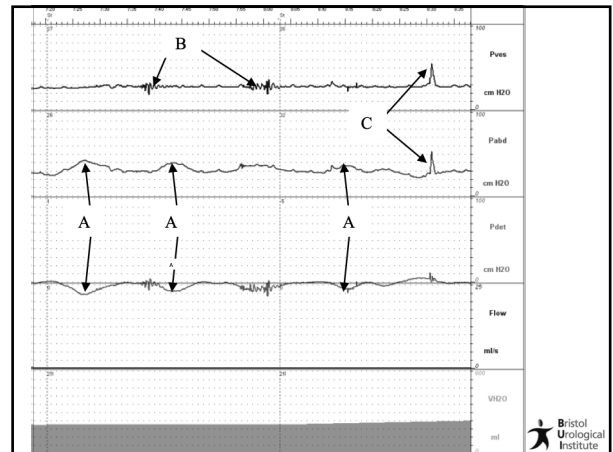


22



Patient Position Change

- **Effect observed.**
 - A lasting change in pves and pabd of equal magnitude on both, usually between 8 and 35 cmH₂O. It is often accompanied by noisy signals as the lines are knocked.
- **Cause of artefact.**
 - A change in patient position. In the example, the patient has begun supine, stood up, then sat down on the commode at a position below the level of the transducer. The level of the transducers was then adjusted to the level of the symphysis pubis.
- **Remedial action.**
 - Ensure the transducers are moved to the level of the symphysis pubis after any patient position change. Transmission of pressure should also be checked after patient movement.



Rectal Contraction

- **Accepted published definition:**

"Rectal contractions are usually of low amplitude and may or may not be felt by the patient. The value of p_{abd} shows a phasic rise with no change in the p_{ves} signal – a potentially confusing fall in p_{det} results from the electronic subtraction"
- **Rectal contractions (NEW):**

Rectal contractions are temporary phasic increases in p_{abd} without synchronous change in p_{ves} resulting in negative deflections of p_{det}.
- **Remedial action:**

None, but take care not to identify such p_{det} decreases as DO

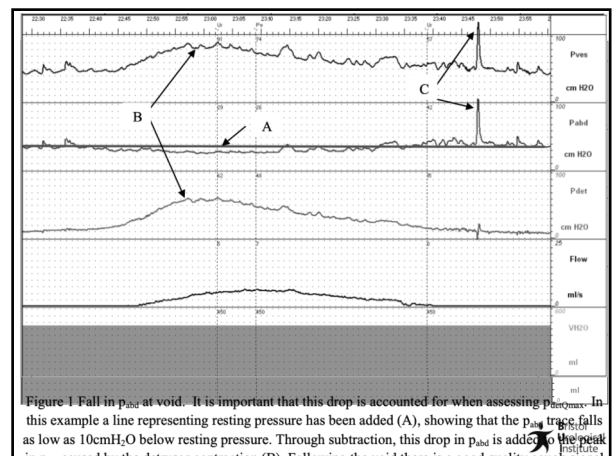
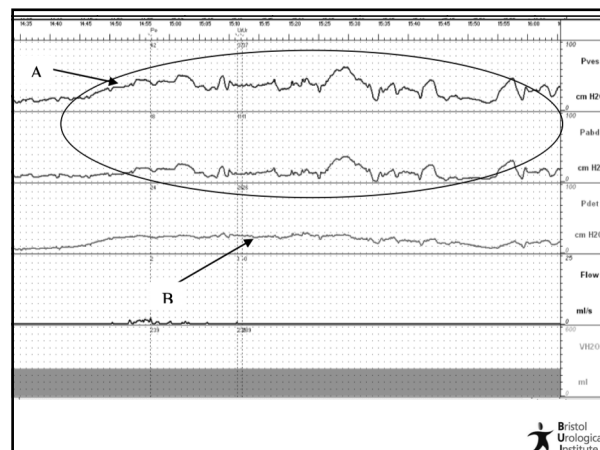


Figure 1 Fall in p_{abd} at void. It is important that this drop is accounted for when assessing p_{ves,max}. In this example a line representing resting pressure has been added (A), showing that the p_{abd} trace falls as low as 10cmH₂O below resting pressure. Through subtraction, this drop in p_{abd} is added to the peak (B). Following the void, the p_{abd} trace rises (C). Full text of the figure is available in the original document.

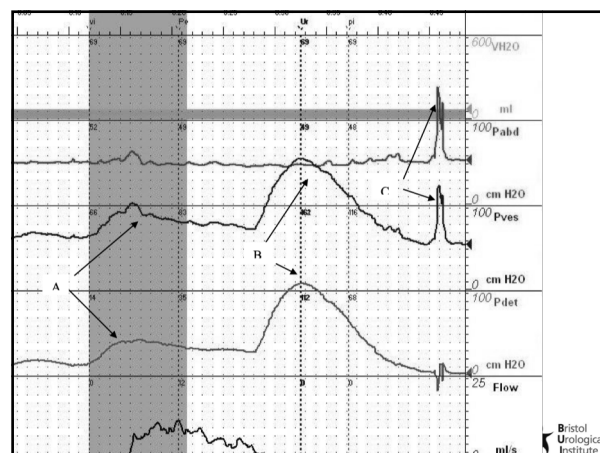
pabd Fall during Voiding

- Suggested NEW definition:**
 A measurable drop in p_{abd} to below the previous resting pressure while voiding.
- Dropped pabd at void (NEW):**
 A drop in p_{abd} during voiding is reported during the voiding time, p_{abd} decreases below the previous resting pressure (as a consequence of pelvic (and abdominal) muscle relaxation).
 Note: this phenomenon will affect the pressure-flow analysis result, because it affects p_{det} . This observation should be differentiated from expelled catheter (that usually results in a much larger pressure drop).
- Remedial action:**
 Adjust $p_{detQmax}$ accordingly when calculating Bladder Outlet Obstruction Index (BOOI). A drop in p_{abd} will be seen as an increase in p_{det} and therefore $p_{detQmax}$ should be adjusted by subtracting the drop in p_{abd} before calculating BOOI. For example if p_{abd} has fallen by 8cmH₂O then $p_{detQmax}$ must manually be reduced by this amount.



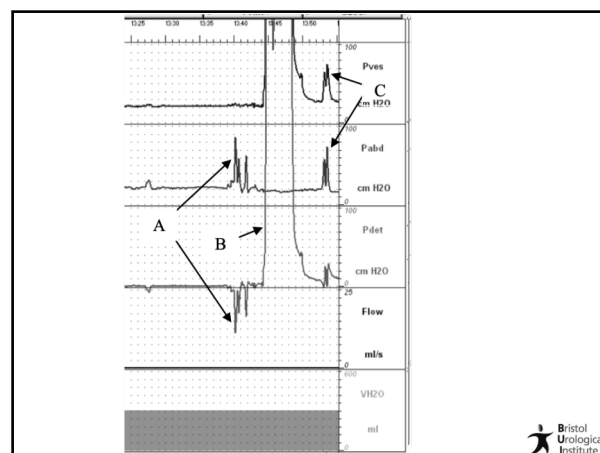
Straining during Voiding

- Suggested NEW definition:**
 Abdominal straining is defined as a temporary increase in both p_{ves} and p_{abd} pressure, lasting more than 2 seconds
- Straining (NEW):**
 Observable as a temporary increase in both p_{ves} and p_{abd} pressure. Straining may be associated with (patient-active) position change (such as repositioning from leaning backwards to upright). Note: A short abdominal strain peak may in retrospect be indistinguishable from a position change or a cough.
- Remedial action:**
 It can be necessary to ask the patient not to strain, in order to observe whether there is an underlying detrusor contraction, and in men to facilitate the diagnosis of bladder outlet obstruction.



After Contraction

- Suggested NEW definition:**
 An after-contraction is a detrusor pressure increase after flow ceases at the end of micturition
- After-contraction (NEW):**
 An after-contraction, is a continued or new detrusor pressure rise immediately after flow ended. It is important to note if this occurs with the complete emptying of the bladder.
- Remedial action:**
 None



Poor Pressure Transmission (PPT)

- **Suggested NEW definition:**
PPT has occurred when the ratio of the smaller to larger cough signal peaks on p_{ves} and p_{abd} is less than 70%
 - Poor pressure transmission (NEW):
Poor pressure transmission has occurred when the cough/effort pressure peak signals on p_{ves} and p_{abd} are not nearly equal.
- Causes**
- Tap not open to pressure transducer and/or patient, or tap open between syringe and pressure transducer
 - An air bubble in a tube or catheter between the pressure transducer and catheter
 - A tube or catheter becomes kinked or occluded if, for example, the patient sits on it
 - The catheter in the bladder rests against the bladder wall and cannot pick up pressure accurately
 - The catheter in the bladder becomes displaced from the bladder into the urethra

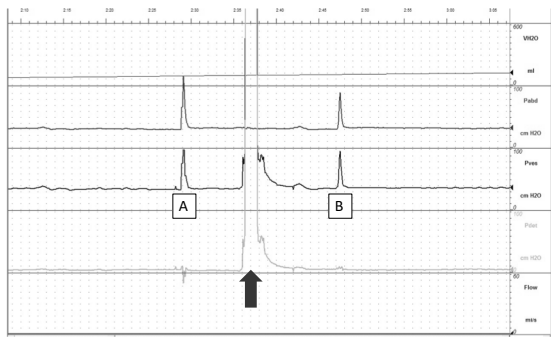


PPT: Remedial Action

- Check that the tap attached to the syringe and the pressure transducer (which allows the catheter to be flushed) is closed to the syringe.
- The tap between the pressure transducer and patient should be open to the pressure transducer and to the catheter, but closed to atmosphere.
- Flush the affected catheter to remove any trapped air bubbles and check for leaks (if tap positions were correct).
- Check that the tube or catheter is not kinked and that the patient or equipment is not occluding it.
- If the problem is seen in the p_{ves} trace, infuse a further 50ml into the bladder and check pressure transmission again.
- If all has failed, reposition or replace the affected catheter.



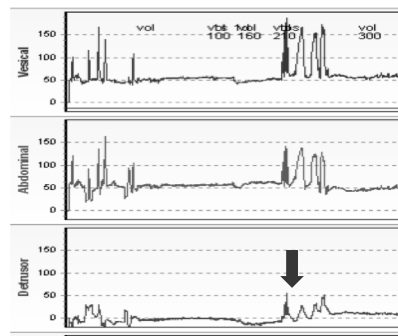
Poor cough response



35



Poor cough response



36

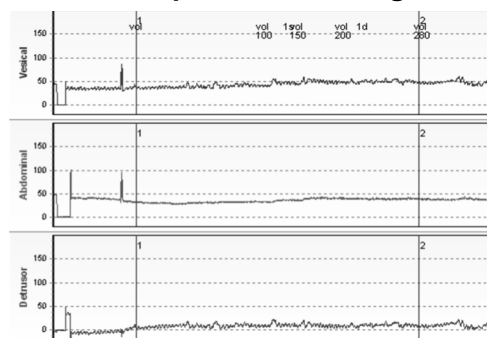


Poor Cough Response

- **Effect observed.**
 - One cough spike is visibly smaller than the other, despite a cough affecting p_{ves} and p_{abd} equally.
- **Cause of artefact.**
 - Usually an air bubble in the water-filled line, reducing the transmission of pressure from patient to transducer.
- **Remedial action.**
 - Flush the line through with water, pushing the air bubble from the tube. The next cough should be registered equally on both traces. If not, flushing should be repeated.



Poor response to live signal

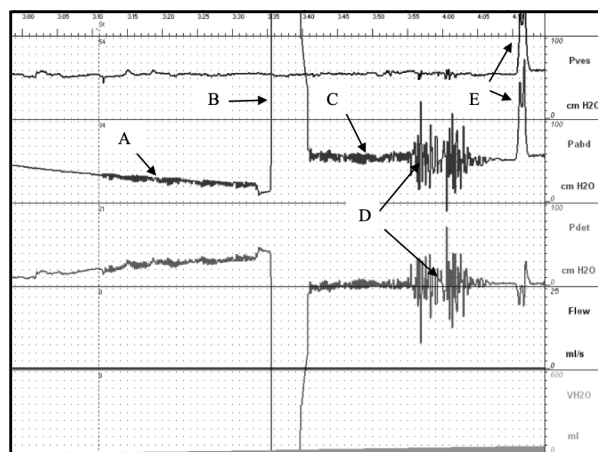


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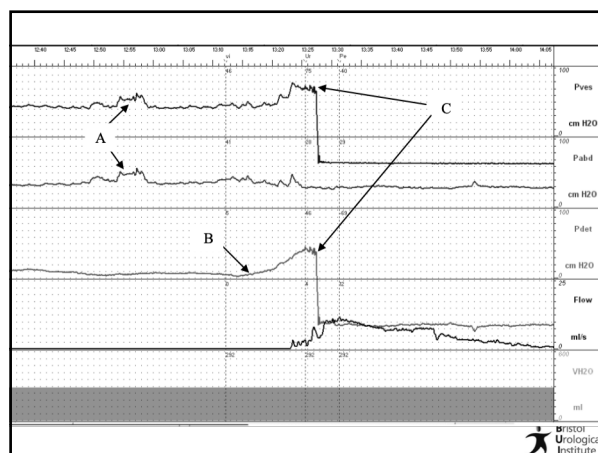
Poor Response to Live Signal

- **Effect observed.**
 - Live signal is observed on one trace (in this case pves) and on pdet, despite a previous cough test being satisfactory.
- **Cause of artefact.**
 - Usually an air bubble in the water-filled line, reducing the transmission of pressure from patient to transducer, in this case in the abdominal line. It could also be the pump or patient causing noise on the affected line.
- **Remedial action.**
 - Check that there is no interference on the affected line by visual inspection and stopping the pump. If it is still present, flush the line through with water (not visible on this trace), pushing the air bubble from the tube.



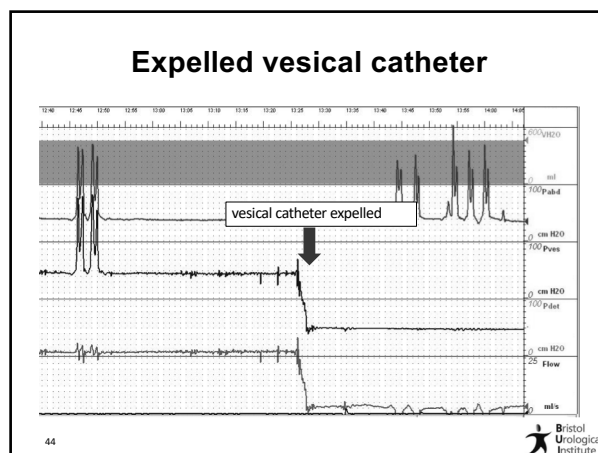
Descending Pressure

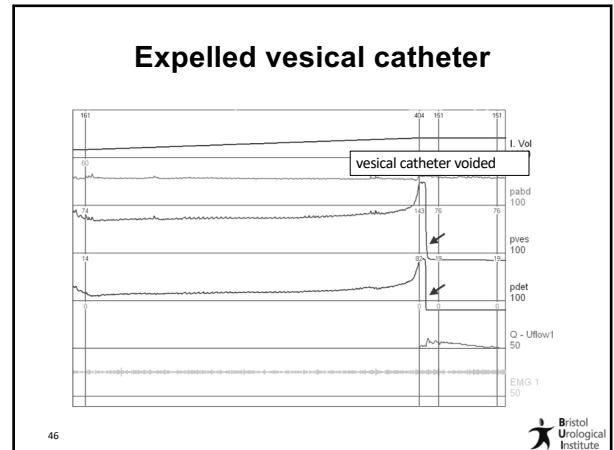
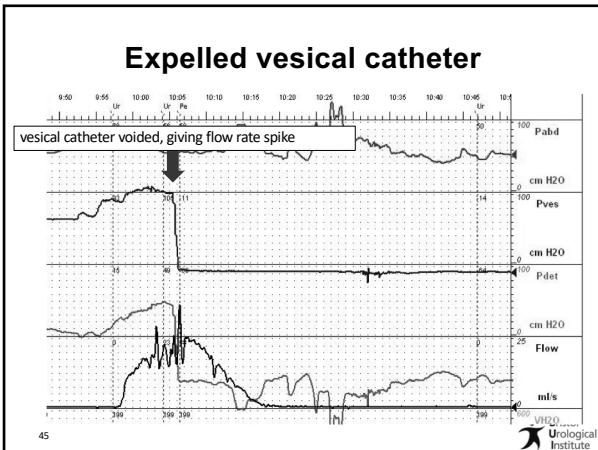
- **Suggested NEW definition:**
Descending pressure occurs when there is a gradual fall in pressure in either p_{ves} or p_{abd} , and is associated with poor pressure transmission.
- **Pressure drift (NEW):**
Continuous slow fall or rise in pressure, that is physiologically inexplicable.
- **Remedial action:**
Check tap positions and affected tube for leaks and remedy, then flush to restore transmission of pressure and remove any trapped air.



Expelled Pressure Measuring Catheter

- **Suggested NEW definition:**
When a catheter is expelled there is a sudden drop in either p_{ves} or p_{abd} , usually to well below zero.
- **Expelled Catheter (NEW)**
When a catheter is expelled, this is observed as a sudden drop in either p_{ves} or p_{abd} , usually below zero. Expelled catheter is usually simply visible during the test and should provoke correction or repetition of the test. Should also be used in post-test evaluation.
- **Remedial action:**
If the urodynamic question cannot be answered because of the expelled catheter, a new one should be inserted, the patient refilled and the voiding phase repeated.





Expelled Vesical Catheter

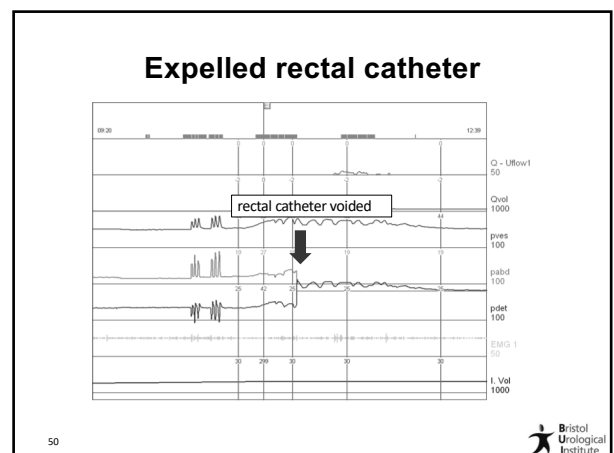
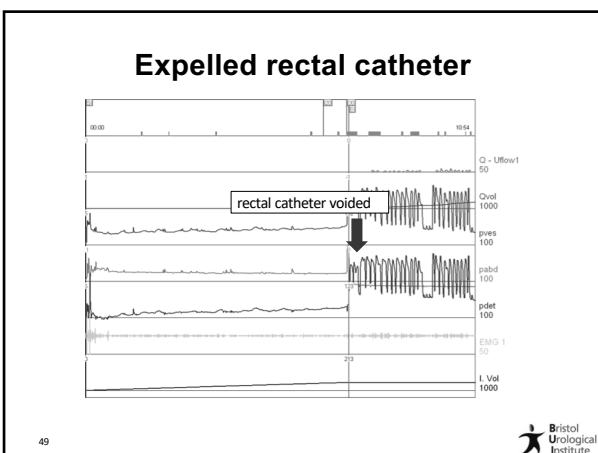
- **Effect observed.**
 - A sudden drop in pves, usually to well below zero, with no response to transmission checks.
- **Cause of artefact.**
 - The vesical catheter is expelled from the patient, normally by the pressure of voiding.
- **Remedial action.**
 - Recatheterise and repeat the test, if the urodynamic question has not been answered.

Displaced Catheter

- **Suggested NEW definition:**

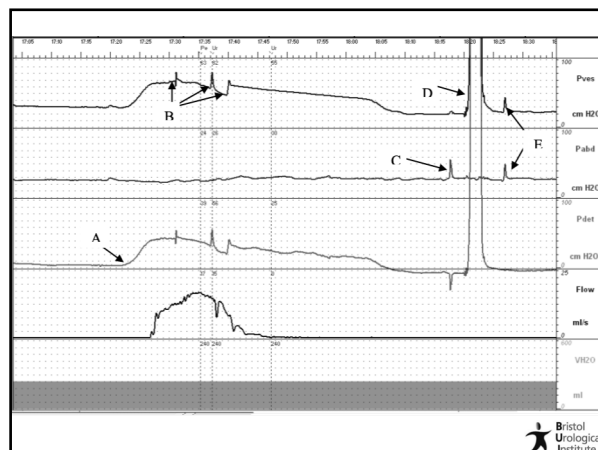
A displaced catheter results in a deterioration in pressure transmission with or without a change in pressure, and can occur during filling or voiding
- **Remedial action:**

Either flush the pves catheter if using a water filled system or if displacement occurs during voiding adjust the position of the catheter and repeat the fill/void sequence, if clinically indicated.



Expelled Rectal Catheter

- **Effect observed.**
 - A sudden drop in pabd, usually to well below zero.
- **Cause of artefact.**
 - The abdominal catheter is expelled from the patient, normally by the pressure of valsalva or straining.
- **Remedial action.**
 - Recatheterise and repeat the test, if the urodynamic question has not been answered



Flush of Pressure Measuring Catheter

- **Suggested NEW definition:**
A catheter flush is characterised by a sudden increase in pressure to a value above 200 cmH₂O, and maintained for between 2 and 7 seconds, followed by a sudden drop in pressure.
- **Remedial action:**
The patient should be asked to provide a cough signal following the flush to check that satisfactory pressure transmission is restored. If pressure transmission is not restored, check the affected tube and catheter for kinks or for incorrect tap positions.

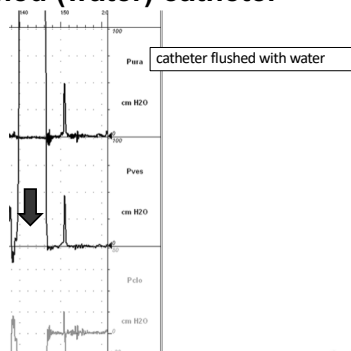


Catheter Flush (New)

- When one of the catheters is flushed during the test a steep pressure rise is observed in that pressure line for one or two seconds followed by an immediate fall to resting pressure.
- Wash away entrapped air, or the gel used during insertion or urethral mucus, from the measuring hole.
- Rectal catheter can only be flushed when an open or a punctured balloon catheter is used, and flushing should definitely not be done if a closed balloon is used (which is not ICS standard).
- A catheter flush should be marked accordingly, but flushes are normally unnecessary after the cystometry has continued after the first milliliter of filling.



Flushed (water) catheter



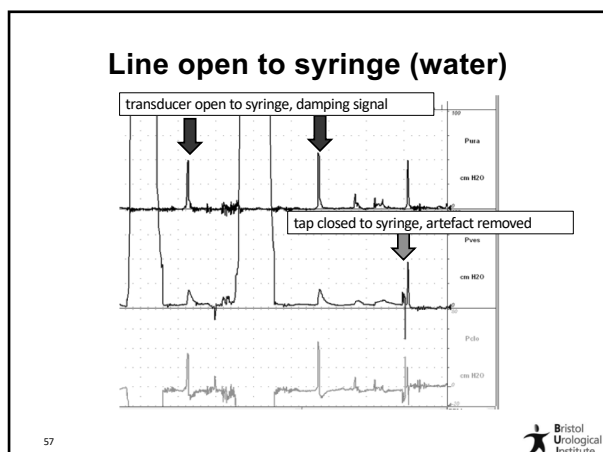
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Flushed Catheter

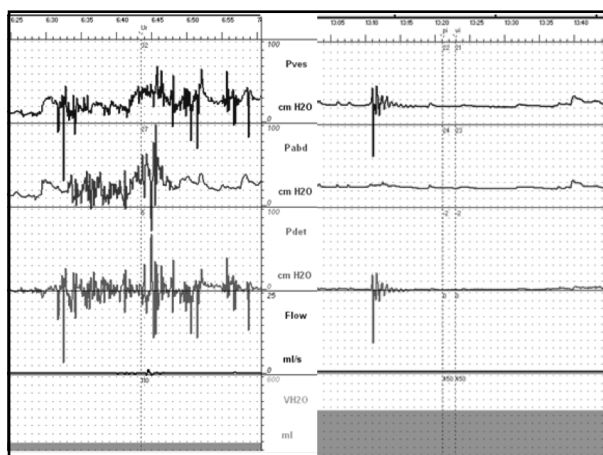
- **Effect observed.**
 - An abrupt large increase in a single pressure trace, maintained for some seconds, followed by a sudden normalisation of pressure.
- **Cause of artefact.**
 - Water is pushed through the transducer dome in order to remove air from the catheter and tubing.
- **Remedial action.**
 - Check for good pressure transmission after the flush. Ignore the high pressure generated when analysing trace.





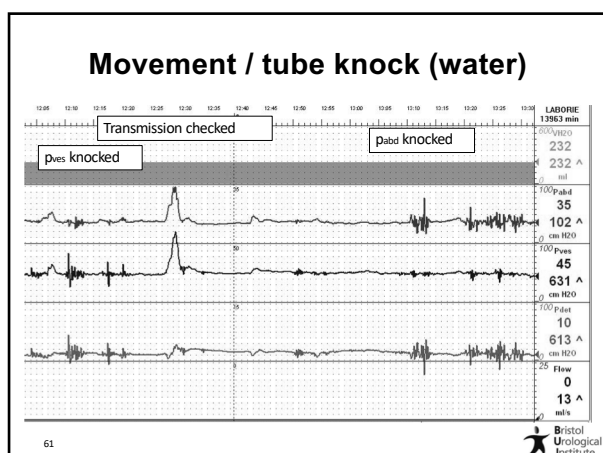
Line Open to Syringe

- **Effect observed.**
 - Repeated flushes of the line do not restore a good response to a cough signal.
- **Cause of artefact.**
 - The syringe inadvertently remains connected to the water line, and acts as a damper on the signal. Since an air bubble is not the problem, flushing fails to resolve it.
- **Remedial action.**
 - Set the taps correctly, so the syringe is not connected to dome. Repeat the cough test for good pressure transmission.



Pressure Measuring Catheter Knock

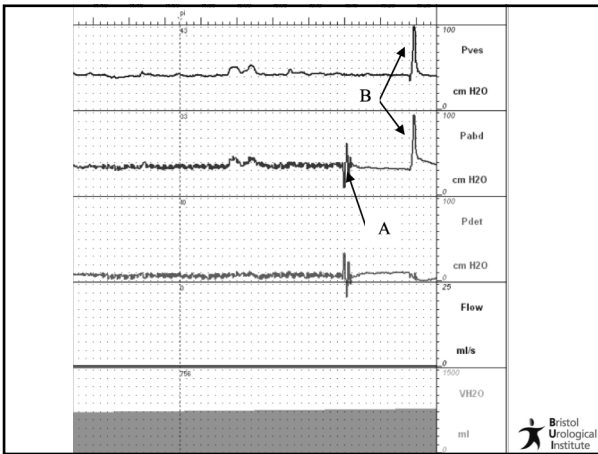
- **Suggested NEW definition:**
Knocking of one or both tubes causes high frequency, short duration pressure spikes visible in p_{ves} , p_{abd} or both, but with spikes always visible in p_{det} .
- **Tube knock (NEW):**
Tube knock is observable as high frequency, short duration spikes visible in p_{ves} , p_{abd} , or both, and with spikes also usually visible in p_{det} .
- **Remedial action:**
Movement can introduce an error in pressure transmission, so following any movement the patient should be asked to provide a cough signal



Movement/Tube Knock

- **Effect observed.**
 - High frequency, short duration pressure spikes visible in p_{ves} , p_{abd} , or both, with spikes always visible in p_{det} .
- **Cause of artefact.**
 - Knocking of one or both tubes. In the example, the knock is first on the p_{ves} line, then on the p_{abd} line.
- **Remedial action.**
 - Ensure tubes are away from the cause of the knock. Ignore these spikes when analysing the trace.

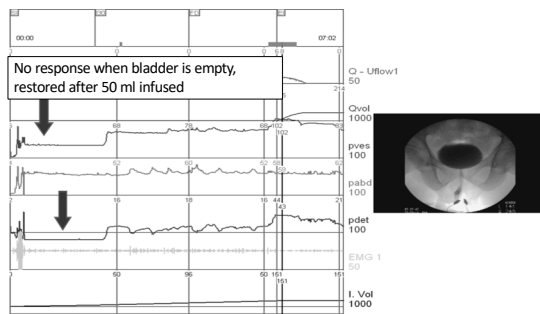




Pump Vibration

- **Suggested NEW definition:**
Pump vibrations give constant frequency oscillations of small but constant amplitude, visible on the affected trace and p_{det} .
- **Pump vibrations (NEW)**
Pump vibrations are visible as stable frequency oscillations of small but constant amplitude if the filling tube touches the pressure connecting tube (when a two catheter system is used) and the pump is switched on (switching of the pump can ascertain the situation).
- **Remedial action:**
Rearrange pressure and filling tubes as necessary, so as not to touch each other. If occurring in a double lumen catheter, pressure readings should be taken with the pump switched off.

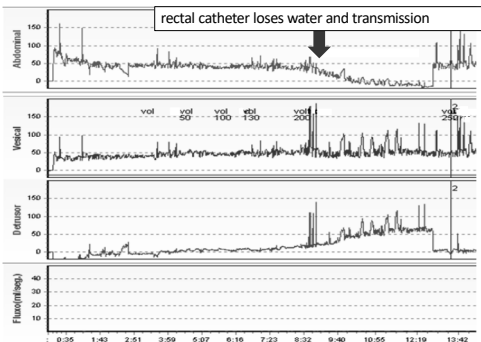
Empty bladder (poor response)



Empty Bladder (Poor Response)

- **Effect observed.**
– Response of the intravesical catheter to a pressure transmission test is poor when bladder volume is low.
- **Cause of artefact.**
– When the bladder is empty, the catheter may touch the bladder wall, so pressure changes within the lumen cannot be registered.
- **Remedial action.**
– Fill the bladder slightly (e.g. 50 ml) and test the pressure transmission again.

Empty rectal catheter (water)



Empty Rectal Catheter

- **Effect observed.**
– Deterioration in abdominal pressure transmission, with or without a change in pressure, during filling or voiding.
- **Cause of artefact.**
– Reduction of water in the rectal balloon. The balloon fails to connect effectively with the rectal wall as a result.
- **Remedial action.**
– Refill balloon and test for good pressure transmission again.

10 Common artefacts in water-filled systems

Artefact: 'Something ...that is not naturally present but occurs as a result of ...the procedure' (Oxford)

- Movement / tube knock
- Patient position change
- Expelled vesical catheter
- Expelled rectal catheter
- Flushed catheter
- Line open to syringe
- Empty bladder (poor response)
- Empty rectal catheter
- Poor cough response
- Poor response to live signal



Conclusions

- Minimising all equipment artefacts and ensuring the quality of pressure recording makes the trace easier to interpret and enables clear identification of pathophysiological features.
- Other pathophysiological events are used in diagnosis, such as the presence of involuntary contractions characteristic of DO, poor bladder compliance during filling and increased or decreased bladder pressures during voiding.

