140

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THE ACCURACY OF URODYNAMICS PRESSURE MEASUREMENT WITH WATER-FILLED SYSTEMS

<u>Hypothesis / aims of study</u>
Water-filled catheters are the ICS recommended method for pressure measurement in urodynamics. Poor technique, however, results in low quality measurements [1,2]. This study aims to quantify the inaccuracy of measurement in water-filled systems, with a view to recommending better practice. Fast moving, dynamic signals are not part of this study, being dealt with elsewhere.

<u>Study design, materials and methods</u>
Papers examining quality of measurements were reviewed, and technical data from manufacturers gathered. Measurements from urodynamic equipment were analysed to quantify inaccuracies. The total possible error was estimated by the root sum of squares of individual errors.

<u>Results</u>
The different inaccuracies that may occur when measuring pressure with a water filled system are summarised in Table 1 below. Design of domes results in differences of 2.5 – 4.0 cmH_2O between the pressure measured at tap opening and pressure at the centre of dome (Fig. 1). The assumption that body density is equivalent to water leads to further inaccuracy (Fig. 2). The total inaccuracy in measurement may reach up to 9 cmH_2O on p_{det}, although if good practices are followed, this error can be reduced to approximately 1 cmH_2O.

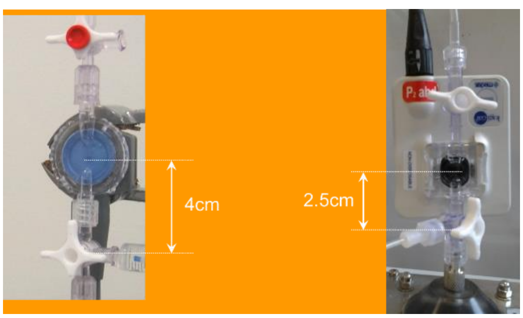

Figure 1. Potential error due to reference point use on dome

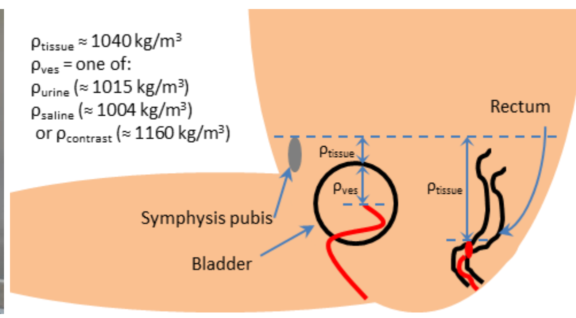

Figure 2. Illustration of errors due to assumptions of tissue density

<u>Interpretation of results</u>
Most sources of inaccuracy can be mitigated by good practice, although some resulting from the measurement technology used cannot be removed. It is clearly possible for water-filled systems to result in highly inaccurate readings if used without observing standard good practice. If, however, good technique is used, then water-filled systems can be expected to be accurate to approximately 1 cmH_2O, which is acceptable for the clinical setting.

<u>Concluding message</u>
Water-filled systems, while being the recommended method, are subject to a potential inaccuracy of up to 9.4 cmH_2O on p_{det}. Good practice can reduce this inaccuracy to a tolerable level, i.e. 1.4 cmH_2O. Particular care must be taken with calibration, zeroing and setting reference levels.

Results

Measurement factor	*Source of error*	*Error (cmH_2O) (p_{ves}/p_{abd}) p_{det}*	*Method of mitigation / Recommended good practice*	*Final potential error on p_{det} (cmH_2O)*
Calibration error	Reference signal not exact	(0.9) 1.3	Minimise noise when calibrating. Do not use internal calibration	1.3
Position error	Height of transducers not at symphysis pubis	(3) 0	Set reference level with care	0
Dome empty when zero set	Full dome has atmosphere at tap, not at transducer face[Fig 1]	(2.5 – 4.0) 0	Zero when dome full	0
Dome off when zero set	Placing dome adds pressure offset	(10–50) 0–40	Mount dome before setting zero	0
Zero set inside patient, not atmosphere	Intraabdominal pressure is greater than atmosphere	(5 – 10) 5	Zero to atmospheric pressure only	0
Tap not level with dome	Full dome has atmosphere at tap[Fig 1]	(2.5 – 4.0) 0	Use tap for reference level, or keep dome and tap horizontal	0
Body density assumptions[3], Fig 2]	Water-filled systems assume body density = water density	(0.4, 0.6) 0.2	Cannot be mitigated	0.2
Subtraction error on strain	p_{abd} is not exactly perivesical pressure	(6) 6	Better position of rectal balloon, caution with Valsalva / straining pressures	0
Digitisation	Limited resolution of digital systems	(0.3) 0.4	Cannot be mitigated	0.4
Nonlinearity / hysteresis	Imperfect transducers	(0.3) 0.4	Cannot be mitigated	0.4
Temperature	Transducer output varies with temperature	(3.7) 0	Calibrate regularly at temperature of use	0
Zero drift	Transducer zero point varies with time	(1.3) 0	Warm up transducer before use, recheck zero during long tests	0
Live signal variation[1]	Reference points on trace not at true resting pressure	(5) 5	Ensure markers are placed away from artefacts	0
Air in system, faeces, tube compliance	Reduces pressure transmitted	Unknown, variable	Regular checks for good pressure transmission	0
Total of potential errors:		**(11.3) 9.4**	**← Root sum of squares →**	**1.4**

Table 1. Summary of possible errors, with values attainable after mitigation

References

1. Hogan S, Gammie A, Abrams P. Urodynamic features and artefacts. Neurourol Urodyn 2012; 31:1104–17.
2. Sullivan, J. MD Thesis, Bristol 2008.
3. Ask P, Hok B. Pressure measurement techniques in urodynamic investigations. Neurourol Urodyn 1990; 9:1-15.

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