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Gammie A[1], Hogan S[2], Abrams P[1]
***1.** Bristol Urological Institute, **2.** University of Glamorgan*

THE ASSESSMENT OF PRESSURE TRANSMISSION

Hypothesis / aims of study

During urodynamics testing, the quality of transmission of pressure is tested by the patient coughing regularly [1]. The high frequency of this pressure signal acts as a test, both for the presence of air bubbles and equal pressure response from intravesical and abdominal pressure sensors. The most quoted reference for what constitutes as acceptable quality for pressure transmission states that the lower signal needs to be greater than 70% of the higher signal [2]. However, this value of 70% was empirically derived. This study aimed to assess whether this figure is justified for use in urodynamics quality control.

Study design, materials and methods

A simulated cough signal of 74 cmH_2O and duration 0.7 s was passed from a water-filled pressure chamber down a catheter, also filled with water. Then, a pressure signal to simulate a detrusor contraction of height 31 cm H_2O and duration 4.7 s was passed down the catheter. The received signals and the original signals were compared using a two channel urodynamics machine (Aquarius; Laborie, Mississauga, Canada) fitted with transducer domes (MX848 with three way taps). Air was progressively introduced into the catheter in order to dampen the transmitted signals, while pairs of the above simulated cough and detrusor contraction signals were successively passed down the system. A fast sampling frequency of 100 Hz was used in order to ensure true peaks were recorded. The system's calibration was verified to be within 1 cmH_2O of true pressure and was zeroed to atmospheric pressure at the lower dome tap. A total of 26 pairs of simulated cough and contraction signals were compared, measuring the maximum pressure recorded above that immediately preceding the simulated cough or contraction.

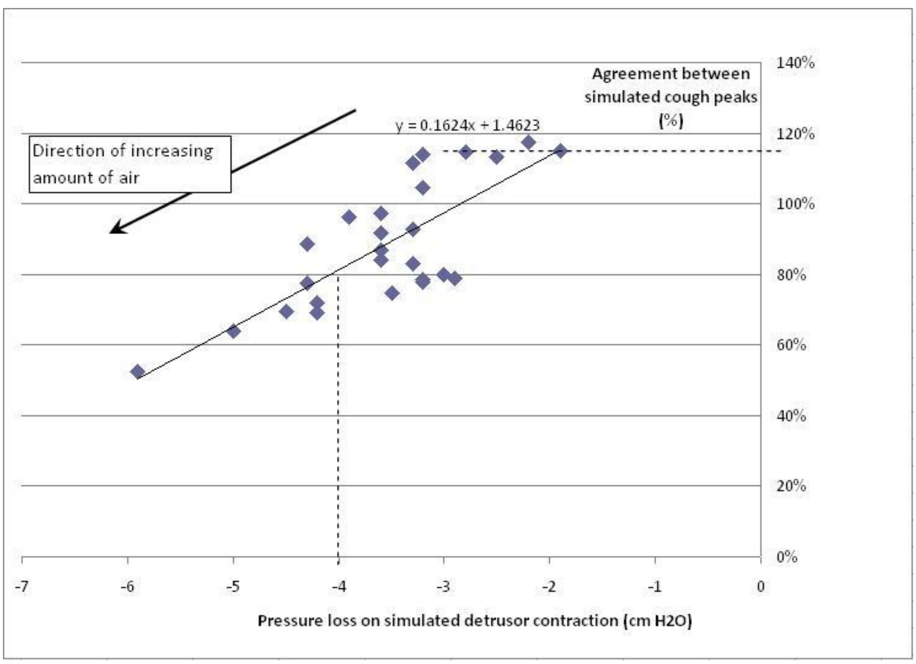

Figure 1 Error in simulated detrusor contraction signal as a function of simulated cough signal agreement

Results

The percentage agreement of the maxima of the transmitted and received cough signals was plotted against the difference recorded in the simulated maximum detrusor contraction pressure (Figure 1). The arrow shows the direction of increasing amount of air inserted. A regression line was plotted to determine the trend of error in a clinically required value (in this case, a detrusor contraction) compared with the test signal from a cough. The equation for the regression line (linear, least squares) is y (%) = 16.2x + 146.

Interpretation of results

The agreement between transmitted and received cough signals exceeds 100% when there is no damping, causing 'ringing' of the signal. This is when the high frequency response of the system adds a reflection of the pressure wave to the measured value, a characteristic of underdamped systems. This effect is short lived, so that sampling systems may or may not catch the peak of this ringing effect. Also, the signals will be transmitted at different speeds through different catheters, so exact peaks may not be sampled together. These factors will need to be taken into account when using a cough to test transmission, since an accurate system can result in unequal cough signals due to these effects.

The initial drop of 2 cmH_2O observed between transmission and reception was present even when the system had no air at all. It was assumed therefore that this was an artefactual drop in value and applied to all signals, although we can suggest no cause for this. Analysis thus considered deviation from that point, rather than from zero, as being due to the dampening of the transmitted pressure by the presence of air.

If the ICS acceptable error in the contraction is taken as a 2 cmH_2O drop from best response, this being the range of error quoted as acceptable for sensors [1], the level of cough agreement at this point is approximately 80%, shown by the vertical dotted line in Figure 1. The horizontal dotted line is the maximum recorded for an undamped catheter, 115%. When two cough signals are recorded together, the ratio between the damped signal and an undamped one, i.e. the threshold of an acceptable cough test, will therefore be 69%.

It should also be noted that systems using water-filled domes open to atmosphere through connecting taps will always be in error by the vertical distance between the tap opening and the dome. This can vary from 2.5 cm up to 4 cm. The error will be cancelled out by subtraction in p_{det} if both transducers are oriented correctly, but will introduce an error in the values for p_{abd} and p_{ves}. This will be of relevance to the assessment of resting pressures and valsalva pressures. When reporting study technique, therefore, it should be stated what type and orientation of domes were used, or whether domes with only air were used for setting zero. The sampling rate, and thus the likelihood of missing true peaks, should also be stated.

Concluding message

This laboratory data suggests that the figure for acceptable reduction of a cough signal by the presence of air in a water-filled measurement catheter should indeed be 70%, although sampling errors will confound this value.

When stating that a system has been 'zeroed to atmospheric pressure', it should be stated whether the system was filled with air alone, or if filled with water, which pressure domes were used and in which position the open tap was relative to the dome.

References

1. Schäfer et al., Neurourol. Urodyn. 2002; 21:261-274
2. Sullivan et al., BJU Int. 2003. 91:201-207

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