81

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COMPARISON OF INVASIVE AND NON-INVASIVE BLADDER PRESSURE MEASUREMENTS BY CALCULATION OF THE BLADDER OUTLET OBSTRUCTION INDEX (BOOI)

Hypothesis / aims of study

Non-invasive isovolumetric bladder pressure ($p_{ves,isv}$) can be estimated from the penile cuff pressure required to interrupt flow ($p_{cuff,int}$), and this was used with a proposed modified ICS nomogram to compare non-invasive classification of obstruction with classification from an invasive pressure flow study (PFS)(1). However, the use of discrete categories for the invasive classification ("obstructed" or "not obstructed") did not facilitate a more detailed analysis of the errors between the invasive and non-invasive techniques. The aim of this study was to avoid this limitation by comparing the non-invasive and invasive measurements as continuous variables allowing a more detailed analysis of the measurement errors. An additional aim was to assess the predictive accuracy of the non-invasive classification when combined with flow rate.

Study design, materials and methods

Data from the previous study (1) were used to calculate the invasive bladder outlet obstruction index, BOOI(PFS) (= AG number). The non-invasive equivalent, BOOI(Cuff), was calculated using the same correction factors that were used to construct the modified ICS nomogram(1). 144 patients referred for investigation of LUTS at two centres provided $p_{det,Qmax}$ and Q_{max} from an invasive PFS, along with $p_{cuff,int}$ and $Q_{max,cuff}$ from a separate non-invasive cuff test(1).

For the invasive data: $BOOI(PFS) = p_{det,Qmax} - 2xQ_{max}$

For the non-invasive data: $BOOI(CuffTest) = p_{cuff,int} - 4xQ_{max,cuff} - 40$

{-40 removes the mean abdominal pressure; and the extra $-2xQ_{max,cuff}$ compensates for the mean isovolumetric pressure rise(1).}

Data were plotted and analysed using the technique of Bland-Altman(2). The differences between the two estimates of BOOI were compared with the calculated error, estimated from the summation of the known sources of error (using variance component analysis).

To assess predictive accuracy, positive predictive value (PPV) and negative predictive value (NPV) were calculated using the criterion BOOI > 40 cm H_2O to classify obstruction. They were also calculated for the subset of patients where a flow rate criterion of <10ml/s as an additional indicator of obstruction agreed with the non-invasive classification.

Results

Figures 1 and 2 demonstrate the relationship between BOOI(PFS) and BOOI(Cuff) using the Bland-Altman method of analysis. (●) indicates $Q_{max,cuff}$ <10 ml/s; (○) $Q_{max,cuff}$ >= 10 ml/s.

Fig 1 BOOI(Cuff) v BOOI(PFS)

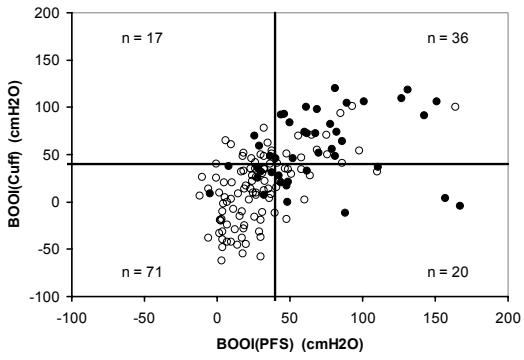

Fig 2 BOOI(Difference) v BOOI(Mean)

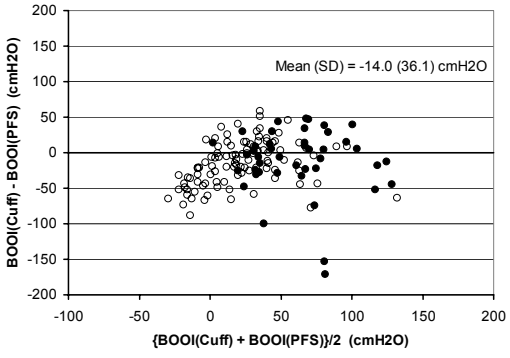

Table 1 summarises the estimated variability for the different factors contributing to the overall variability of BOOI(Cuff) – BOOI(PFS). The variation in Q_{max} and the subtracted repeat estimates for the BOOI(PFS) are from reference (3).

Table 1. Estimated error components for the different factors contributing to the overall error, with summation of variances used to calculate total estimated error.

Variable	**Standard Deviation (SD) (cm H_2O)**	**Variance (SD^2) (cm H_2O^2)**
Abdominal pressure + height	9	81
Isovolumetric pressure rise	10	100
Additional 2xQ_{max} (3)	4	16
Cuff pressure measurement	20	400
Subtracted repeat invasive PFS BOOI (3)	20	400
Total (Estimated)	**32**	**∑= 997**

The random variability of the difference between measurements was estimated to be 32 cm H_2O (Table 1). This is close to the standard deviation of 36.1 cm H_2O from the Bland-Altman plot (Figure 2), which reduces to 31.7 cm H_2O if the 2 obvious outlying points are excluded. There is also a systematic mean (95% CI) difference of -14 (6) cm H_2O.

The horizontal and vertical lines at BOOI = 40 cm H_2O divide Figure 1 into 4 quadrants. Patients above the horizontal line are obstructed by the non invasive measurements. Patients to the right of the vertical line are obstructed by the invasive PFS (the 'gold standard'). Both methods agree that patients in the top right of Figure 1 are obstructed and patients in the bottom left are not obstructed. The number of patients in each quadrant is shown in the figure. For the non-invasive test, PPV = 68% (36/53) and NPV = 78% (71/91).

For 69% (100/144) of patients, the non-invasive BOOI classification agreed with classification using a flow rate criterion of $Q_{max,cuff}$ < 10 ml/s as an indicator of obstruction (Figure 1: closed circles above horizontal line, open circles below). Restricting the analysis to these patients gave PPV = 88% (23/26) and NPV = 86% (64/74).

Interpretation of results

The results demonstrate a reasonable quantitative agreement between the non-invasive and invasive estimates of BOOI considering the approximations made and other sources of variability. The magnitude of the variability between the two measurements can be accounted for by known contributory factors. The systematic difference, mean (95% CI) of -14 (6) does not include zero and we do not have an obvious explanation for this effect. Classification of obstruction using the non-invasive criterion gave results that compare favourably with results for flow rate measurements alone. When the non-invasive classification was combined with classification from peak flow rate, measured during the same test, 2/3 patients were classified more accurately, with PPV and NPV approaching 90%.

Concluding message

BOOI derived from non-invasive data is in moderate agreement with invasive measurement. The limitations of the accuracy are consistent with the known sources of variability. The predictive accuracy in classifying obstruction is comparable to that achieved with flow rate alone but when combined with a flow rate criterion of < 10 ml/s, recorded during the same test, an identifiable 2/3 of patients were correctly classified with a predictive accuracy approaching 90%.

References

1. Non-invasive bladder pressure: the case for using a modified ICS nomogram. Neurourol Urodynam 2003; 22: 367 – 368.
2. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986; i: 307 – 310.
3. Variability of pressure-flow studies in men with LUTS. Neurourol Urodynam 2000; 19: 637 – 656.

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