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CLINICIANS ARE NATURAL BAYESIANS – WHAT ABOUT UROLOGISTS?

Hypothesis / aims of study

Invasive pressure-flow studies are the only reliable way to diagnose bladder outlet obstruction (BOO). However, for many men with lower urinary tract symptoms (LUTS), the decision to treat BOO is made in the prostate assessment clinic (PAC) without the benefit of PFS. In the clinic, any of a number of tests may be applied; flow rate is important, but symptoms, digital rectal examination and PSA will all be considered. Individually, none of these tests are sufficient to diagnose BOO, but a number of methods (for example, linear discriminant models and neural networks) have been proposed for combining multiple parameters to give more accurate diagnosis. Unfortunately, the input parameters for these models are fixed: all the required parameters must be available, while new parameters that weren't included in the original model cannot be accommodated.

Bayes' theorem can be seen as a mathematical representation of the way people think and come to conclusions based on evidence. One begins with some preconception of the likely outcome (the *a priori* probability), but this is reviewed in the light of each new piece of evidence. Bayes' theorem simply suggests the proper way to modify the probability of a given outcome based on the new evidence; if the evidence is generally in support of the outcome, the probability will get higher, and vice versa.

For clinicians, the diagnostic process is a real-world application of Bayes' theorem. Based on the patient's age, gender, medical history, and the prevalence of obstruction in the population, the urologist would form an opinion - an *a priori* probability of obstruction. This mental picture of the pathology is altered by the new information provided by the tests, and the diagnosis gradually develops [1]. The aim of this study was to apply Bayes' theorem to the prostate assessment clinic, and assess the added value beyond a simple flow rate alone.

Study design, materials and methods

In a retrospective study, reports from PAC and from conventional pressure-flow studies were sought for 95 patients who underwent a pressure-flow study between 3rd September 2001 and 19th August 2002. The following additional parameters (as available) were taken from the records: *Peak flow rate; Post-void residual volume; PSA; IPSS score; IPSS quality of life*.

43 cases were excluded due to inadequate flow measurements (eg. voided volume < 150 ml), or because there were not at least two of the additional parameters recorded. The remaining 52 were analysed using Bayes' Theorem, for each patient using flow rate plus whichever additional parameters were available.

In order to apply Bayes' theorem, it is only necessary to know the probability of obstruction given each new piece of evidence in isolation. This can be calculated from the distributions for obstructed and non-obstructed populations; for each parameter these were determined from the literature.

The final outcome of the calculation (P, the *posterior* probability of obstruction) is in the range 0 to 1, but for the purpose of comparison we assumed obstruction for P > 0.5. To assess the benefit of Bayes' theorem, we treated the urodynamic classification of the patient according to the ICS nomogram as the gold standard. We then compared the predictions of Bayes' theorem with those of flow rate alone, using Q_{max} < 10 ml/s as the criterion for obstruction [2]. Since we are comparing identical patients using two different test regimes, the chi-squared statistic (with trend) was used to compare the relative diagnostic values.

Results

The results are presented in figure 1. The diagnostic value of Q_{max} alone (chi-squared = 12.5, p < 0.001), was better than that for the Baysian model (chi-squared = 5.4, p = 0.02).

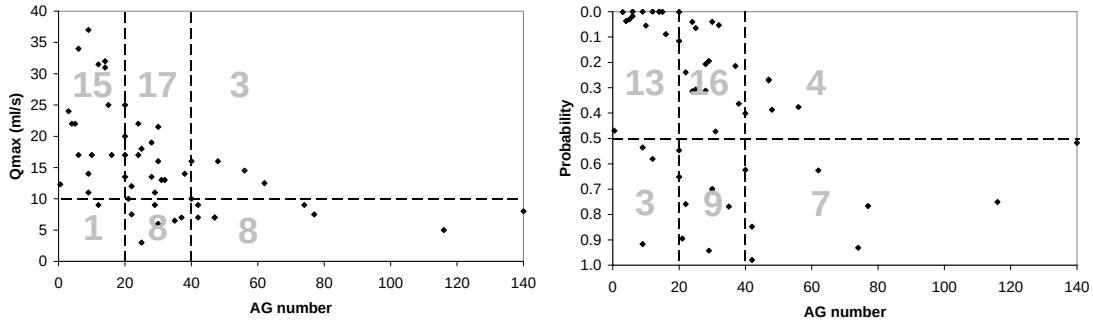

Figure 1 The relation of AG number with (*left*) Q_{max} and (*right*) posterior probability from Bayes' theorem. Vertical lines indicate obstructed, equivocal and unobstructed groups according to the ICS nomogram. Horizontal lines indicate the decision threshold, with patients below the line being indicated obstructed. The numbers of subjects in each group are given.

NOTE: for easier comparison, the Y axis of the second graph is inverted. In both graphs, the obstructed patients should be towards the bottom of the graph.

Interpretation of results

As has been well-shown previously [2], a flow measurement has a clear value in the diagnosis of BOO. However in our study there was no added diagnostic value from residual volume, PSA, IPSS score and IPSS quality of life using the Bayesian approach. One possible interpretation is that certain tests (such as IPSS) are not specific to BOO, or even that the additional parameters have no diagnostic value at all, though this seems unlikely.

A striking observation from figure 1b is that while the diagnostic value is no better than flow rate, the separation of the groups (of unobstructed men in particular, *top left*) is better. This may be because the additional parameters are redundant – ie. they are strongly correlated with flow rate, therefore duplicating information that is already contained in the flow rate measurement. The effect is to make obstructed men appear more obstructed, and vice versa.

All the additional tests were not available in all the patients. However, it would be expected that the urologist would select the most appropriate tests for a given patient. A key benefit of the Bayesian approach is that it is not contingent on having a specific set of measurements. While Bayes' theorem was applied in a sequential order similar to that followed by a clinician, the actual order for the calculations does not matter. This is to be expected; it would seem unreasonable that the outcome depends on the order in which the tests are applied.

The initial *a priori* probability was set to 0.5, although this could be altered if the prevalence of BOO is known to be different in the population attending the clinic. In our study, only one fifth of the patients were unequivocally obstructed according to the ICS nomogram. This reflects our selection criteria for pressure-flow studies, which are indicated for only about one quarter of all men. The effect of starting with a lower initial *a priori* probability would be to reduce each of the *posterior* probabilities, but the pattern would remain identical.

Concluding message

Flow rate has a well-established role as a screening test, yet a range of other tests are carried out in the prostate assessment clinic. Using a Bayesian model we have shown that these additional tests do not provide much additional diagnostic power in the determination of BOO. We conclude that although well-used in prostate assessment clinics, a battery of simple tests is not a replacement for pressure-flow studies; these remain the only reliable means of diagnosing bladder outlet obstruction.

[1] *BMJ* 2005;330;1080-1083.
[2] *British Journal of Urology* 1996; 77: 813-18.

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