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THE URINARY DROP SPECTROMETER: A POSSIBLE ALTERNATIVE TO CONVENTIONAL UROFLOWMETRY?

Hypothesis / aims of study

The urine stream breaks into drops after leaving the meatus [1]. Based on this fact, in the late 1960's, an electro-optical instrument to investigate the external urine stream was built. It was thought to be the ideal non-invasive method to investigate flow without disturbing its dynamic properties [2], enabling both the study of the pattern of flow and other conventional parameters such as voided volume and flow rate. At the time, relative accuracy obtained was limited to about 15%. The aim of this study was to determine if the drop spectrometer could still have a use in urodynamics thirty years on, possibly by increasing its accuracy by using digital rather than analogue processing.

Study design, materials and methods

An existing drop spectrometer was used, composed of a light source, a collimating lens, a refocusing lens, 2 slotted plates to shape the light beam and a photodiode. As the drops break the plane of light, a variation in the output of the photodiode is observed. This signal is collected by an analogue-to-digital converter and processed in software. Two programs were implemented to calculate flow rate, volume and to determine the cessation of flow:
(a) assuming spherical drops and calculating drop volume from the maximum diameter (a simulation of the original drop spectrometer) and;
(b) assuming that the velocity of drops in close proximity have the same velocity (so taking an average of velocities over 100 drops). This takes into account the variation in the shape of the drops as they fall from the meatus to the receptacle.

Both programs were tested on 12 sets of data (volumes ranging from 90 to 536ml) recorded with the drop spectrometer. The data were obtained by simulating the urinary stream with a calibrated flow device giving a fixed 15 ml/s flow. The volume and flow rate were also measured by a weight transducer uroflowmeter for comparison.

Results

Table 1 presents the average standard deviations, absolute and proportional errors for the 12 test cases using the two different programs. The agreement between the drop spectrometer and the uroflowmeter is given in Figure 1 using the method proposed by Bland & Altman. All programs successfully detected the end of flow and although errors may have existed in the calculated volume, the flow rate curves were very similar to the ones given by the conventional uroflowmeter (Figure 2).

	program (a)	program (b)
Mean ± SD of absolute error (drop spectrometer - actual volume) in ml	-59.2 ± 39.8	1.2 ± 9.8
Mean ± SD of the Proportional Error (%)	16.4 ± 7.7	5.6 ± 6.9

Table 1 – Mean standard deviation, absolute and proportional errors for the 12 tests.

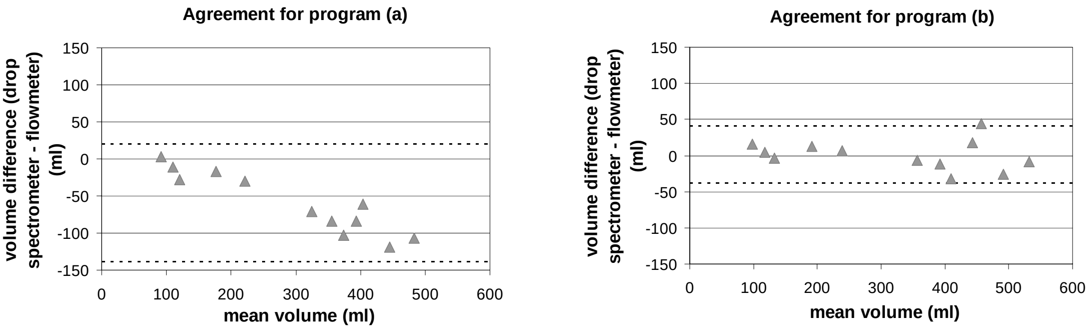

Figure 1 – Agreement between drop spectrometer and volume as given by the weight transducer flowmeter. The dotted lines show the limits of agreement (2 SD around the mean).

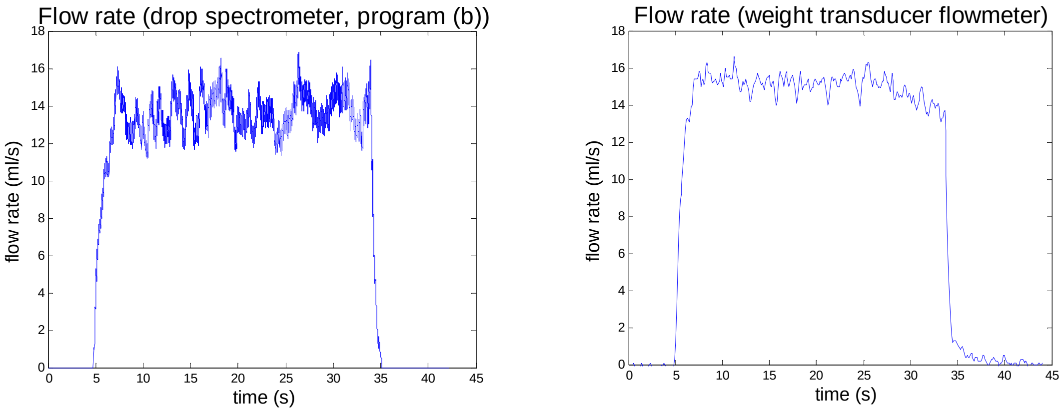

Figure 2 – Comparison of flow rate calculated by drop spectrometer and measured by weight transducer uroflowmeter.

Interpretation of results

For the 12 cases tested, the drop spectrometer gave encouraging results, particularly using program b, which was the solution retained. The measured errors approach the 5% recommended in the ICS document on *Good Urodynamic Practice*. An advantage of the drop spectrometer is its sensitivity as this enhances changes in flow rate (usually not observed when using conventional flow meters). This can be seen clearly at the end of flow in Figure 2. Indeed, a drop by drop estimation of the instantaneous flow rate, individual drop volume and individual drop velocities can be obtained, which can be useful for the diagnosis of certain types of urethral obstruction [3]. Currently, the drop spectrometer suffers from one obvious drawback: a non-linearity in the light beam causing a variation in output across the width of the plane of light. This may account for some of the errors in the results.

Concluding message

A net improvement has been obtained compared to the analogue processing of the drop spectrometer output [2]. Furthermore, information about individual drops can be more readily collected, which could lead to enhanced diagnostics if this level of accuracy turns out to be useful. It is also thought that the drop spectrometer could serve as a complementary instrument to detect cessation of flow in pressure-flow studies where short time response is required. If it was to replace conventional uroflowmeters used in these pressure-flow studies, further investigation of the non-linearity of the light beam would have to be undertaken, and this is our next task.

References

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