Comparison of Fiberoptic, Microtip, Water and Air-charged Pressure Transducer Catheters for the Evaluation of Urethral Pressure Profiles

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Urodynamic evaluation of the upper or lower urinary tract requires the use of catheters and pressure transducers, which transform pressure changes into electrical signals that are amplified and recorded in a special recording devise. The most common monitoring devices are external transducers and require fluid-filled lines for connection. The disadvantages with the water filled catheters include time consuming calibration and set-up, necessity to re-zero when the patient changes positions during testing and artifacts of the pressure wave form owing to kinks or bubbles in the lines. They are also point sensors and look at pressures unidirectionally, which are sufficient in the bladder, however, are poor for urethral pressure accuracy. Solid state microtipped transducer catheters eliminate most of the above mentioned disadvantages, however, they still have debris on the sensor surface. Fiberoptic catheters have similar limitations in the urethra as above, are expensive to retrofit existing systems and have inherent artifacts, which will be discussed later. Recently, an " air charged " balloon technology has been used in intrauterine pressure monitoring. We adapted this technology to a catheter for use in lower urinary tract urodynamic evaluations and have compared the results to the other technologies described above for reproducibility of static urethral pressure profiles. The T-DOC® AIR-CHARGED Catheter is the first commercially available circumferential pressure-monitoring catheter for urodynamic evaluations. The results of this experiment in the following paper.

Objective: The purpose of this study was to evaluate the reproducibility of pressure measurements using the present urodynamic catheter technologies for urethral pressure profiles.

Methods: Female Cadaveric urethral model with placement of a TVT Sling urethropexy was utilized to provide a reproducible model for multiple passes of all four catheter types. The Dantec urodynamic machine with puller for urethral pressure profiles was used for reproducibility of passes through the urethra. The sequence of catheters used in this trial were the T-DOC® AIR-CHARGED Catheter, microtip catheter, water filled catheter, fiberoptic catheter and then back to T-DOC® AIR-CHARGED Catheter to assure no changes in pressure in the model from start to finish. Recordings of UPP maximum urethral closure pressure data were done with transducer position done at the 12 and 6 o'clock positions.

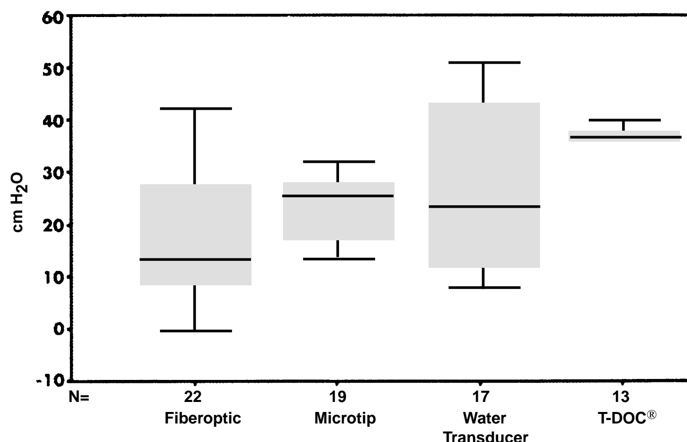
Results: Each pressure transducer catheter was placed in the TVT prepared cadaveric urethra with all maximum urethral pressures being measured and recorded. The microtip catheter had a total of 19 readings using the same cadaver. The range of values was 14 cmH2O to 54 cmH2O. (please see Table 1).

Table 1. Catheter Values

	Range of Values	Mean	Standard Deviation
Water Transducer	8.0 - 51.0	26.29	15.41
Microtip	14.0 - 54.0	24.21	9.36
Fiberoptic	0 - 42.0	17.18	12.27
T-DOC® Air-Charged	36.0 - 40.0	37.23	1.30

The mean value was 24.21 cmH2O with a standard deviation of 9.36. The fiberoptic catheter had a total of 22 readings using the same model. The range of values were from 0-42 cmH2O. The mean value was 17.18 cmH2O with a standard deviation of 12.27. The water transducer catheter had a total of 17 readings using the same model. The range of values was from 8 cmH2O to 51 cmH2O. The mean value was 26.29 cmH2O with a standard deviation of 15.14. The T-DOC® AIR-CHARGED Catheter had a total of 13 readings using the same cadaveric urethra at the beginning and the end of the experiment. The range of values was 36 cmH2O to 40 cmH2O. The mean value was 37.23 cm H2) with a standard deviation of 1.30 cmH2O. Please see Table 2.

Table 2. Reproducibility of Urethral Pressure Measurements: Standard Deviations



The mean T-DOC® catheter measurements were statistically different than all three of the other catheters ($p<0.01$) using the t-test. These tremendous inconsistencies give rise to totally different clinical interpretation of the results ranging from a normal urethra to a urethra that represents intrinsic sphincter deficiency. These changes were most obvious with changes in rotational position. The fiberoptic and microtip catheters even had a tremendous deviations even over the same area of the urethra. The water filled catheters were consistent on directional passes, however, on rotation to other sites they had significant variations. The T-DOC® AIR-CHARGED Catheter had the only reproducibility in the urethra with minimal changes on rotation or directional passes.

Conclusion: This study compares a newly designed pressure measurement system which involves microair charging of a balloon which is circumferentially placed around the catheter at appropriate locations. A miniature air-filled lumen communicates the pressure signal to an external semiconductor transducer in the cable. This design utilizes all the advantages and theory of water-filled balloons with none of the disadvantages of water-filled hydrostatic head pressure and frequency response as well as caloric

changes in pressure. This design is the ultimate for elimination of directional artifactual sensing and due to its small concentric balloon, in theory can accurately monitor urethral pressures, thus allowing us to see the pathophysiology within. In my own practice usage, I've seen several cases of urethral instability leading to and prior to detrussor instability, detrussor sphincter dyssynergia, intrinsic sphincter deficiency and extremely consistent urethral pressure profile using the dual sensor catheter, thus visualizing some significant pathophysiology. The catheter is inherently inexpensive, easy to use ("plug and play") and is disposable. The "air charged" catheter is also light weight and highly flexible with minimal stiffness, thus minimalizing reaction forces on the catheter decreasing torque outside the urethral meatus which could contribute to artifactually higher pressures. In this study the T-DOC® AIR-CHARGED pressure transducer catheter showed only reproducible data within the urethra, no matter how many passes or directional changes. The water filled had the next best directional consistency, however, had wide deviations on rotation. The fiberoptic and microtip technology catheters had poor reproducibility. Although extremely promising, further IRB comparative studies on live patients needs to be accomplished and are underway at present.

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