Profiled Vessel Model for Simulating Bladder Cystometrogram

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Introduction

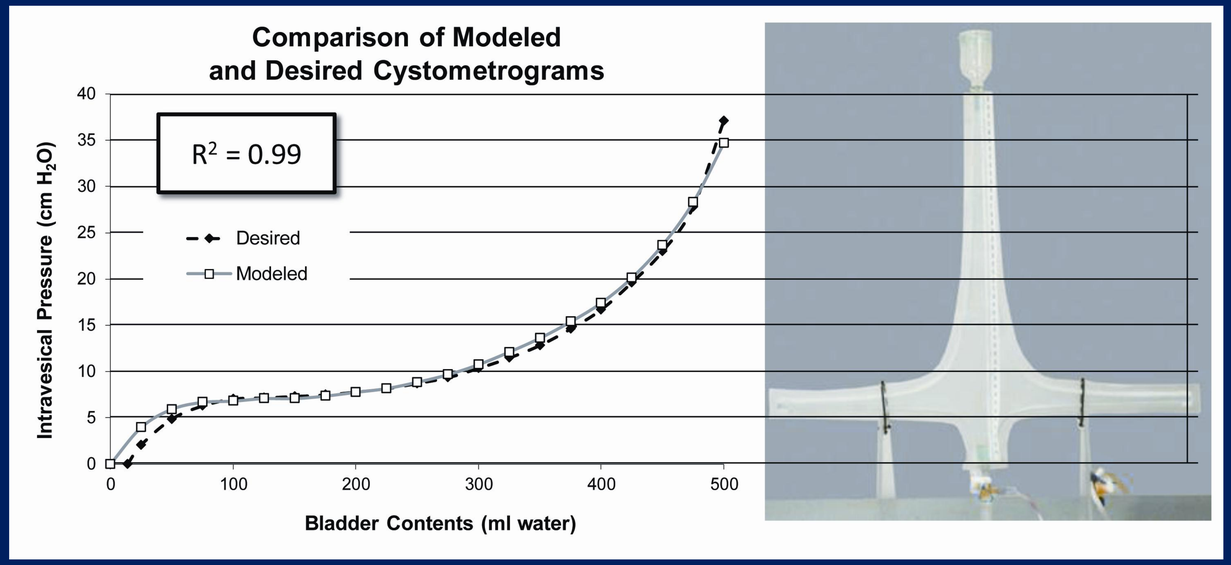
- During experiments on urinary drainage systems and catheters, and their interaction with intravesical (bladder) pressure and retained urine volume, the need arose for a bladder model exhibiting the pressure-volume characteristics of a typical bladder cystometrogram.
- Bladder pressure- volume curves show great variability between subjects;[1] we chose to emulate a curve from a physiology textbook[2] ("desired curve").
- After unsatisfactory attempts to analytically fit the desired curve with polynomials, we chose a step-by-step numerical solution.

Methods

- The physical shape of a vertical, symmetrical container, open to atmosphere at the top, which exhibits, through simple hydrostatics, a pressure-volume curve (cystometrogram) similar to the desired curve was computed.
- Using digital calipers, pressure and volume values were extracted from the desired curve at intravesical pressures of 0-10, and at 12, 14, 18, 22, 28 and 34 cm H_2O for construction computations.
- For pressure test comparisons, pressure values were extracted at 25 ml increments from the same curve.
- Beginning from 0 cm height of the profiled vessel (0 cm H_2O hydrostatic pressure), the difference in desired bladder volume between that pressure data point and the next was sequentially used to calculate the required model bladder cross sectional area between the corresponding height and the next height.
- Assuming flat, parallel, transparent Plexiglas front and back plates 2.54 cm apart, a 1:1 paper printout of a smoothed profile to achieve the computed volumes was made.
- Strips of a thin (1/32” thick), flexible polystyrene plastic stock sheet were glued according to the printed profile to make the sidewalls.
- A 3-way stopcock was inserted in the bottom.

Results

- The model was tested by filling with water in 25 ml increments (0 to 500 cc) using a 30 ml syringe (Omniflex, B. Braun Medical Inc., Bethlehem, PA), with pressure at the stopcock outflow measured to the nearest 0.1 mm Hg from a pre-calibrated electronic transducer (TruWave, Edwards Lifesciences, Irvine, CA) connected to a Component Monitoring System (Philips Healthcare, Andover, MA).
- Measured model results and desired curve pressures and volumes were plotted. (Figure).
- Comparing pressures at 25 ml volume increments (25-500 ml), produced an R^2 value of 0.99 using online statistical software.[3]



Conclusions

The constructed bladder model has a pressure volume curve very similar (R^2 0.99) to the desired values, between 25 and 500 ml.

References

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