Virtual ACS 2021 Surgeons and Engineers: A Dialogue on Surgical Simulation Meeting

Promoting Technology and Collaboration

Retropubic Trocar Modified with a Load Cell to Measure Force

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Background: The Midurethral Sling surgery involves blind passage of a sharp steel trocar within millimeters of the urethra and bladder, and 2-5 centimeters from the bowel and iliac and obturator vessels: injuries are well documented. Safe procedures involve maintaining constant trocar contact with the suprapubic bone, which can be difficult for a teaching surgeon to assess when a resident performs.

Technology Overview: This force-sensing trocar was developed through collaboration between a pelvic surgeon and two biomedical engineers. We modified a retropubic TVT trocar (Ethicon, 810041BL) with a load cell (Futek LCM200) retaining the original dimensions and recording unidirectional force exerted on its handle.

Potential Application in Surgical Simulation and Education: Two pelvic surgeons performed bilateral retropubic passage of the force-sensing trocar on a thiel-embalmed cadaver and a physical model on two different occasions. The physical model was created by segmenting a Midurethral Sling candidate's MRI, 3D-printing, and filling with thermoballistic gel. Cross-correlation analyses on time- and amplitude-normalized force time histories revealed high correlations between model forces measured on different occasions; and between model and cadaver forces. Paired t-tests on maximal amplitude (F_{max}) and root-mean-squared amplitude (F_{rms}) from force time histories revealed no significant differences between model trials on different occasions (F_{max}: p=0.786 and p=0.253 for right and left passages, respectively; F_{rms}: p=0.327 and p=.277 for right and left passages, respectively); and few significant differences between model and cadaver trials (F_{max}: p=0.036 and p=0.286 for right and left passages, respectively; F_{rms}: p=0.053 and p=.101 for right and left passages, respectively). This suggests high test-retest reliability of the model/trocar system, and adequate biofidelity of the simulation model.

Potential Opportunities to Collaborate: In our next collaboration, this novel force-sensing trocar will be used to test the role of force in injury to vital organs. Expert surgeons and PGY1-4 residents will perform retropubic trocar passage on the simulation model using the force-sensing trocar. Unidirectional force will be supplemented with motion capture data, recording contact between the tip of the trocar and bone.