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A CATHETER INSERTION FORCE ASSESSMENT TOOL: DESIGN AND PRECLINICAL RESULTS

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Introduction: Urethral catheterization is among the most common procedures performed in healthcare settings. There is no standardized approach to Foley catheter insertion and iatrogenic urethral injury is thought to occur in 3.2 per 1000 male catheterizations [PMID27654098]. Furthermore, traumatic insertion contributes to catheter associated urinary tract infections (CAUTI) [PMID20156062]. Incorrect catheter insertion force profiles may be a measurable proxy for insertion trauma. A recent study found providers with greater than 25 years' experience exert significantly less insertion force than their less experienced colleagues [PMID19254403], unfortunately subjective self-reporting rather than quantitative measurements were used. We present the design and preclinical results of a low-cost device intentionally designed to quantitatively measure urinary catheter insertion force *in situ*.

Methods: The one degree-of-freedom catheter insertion force assessment tool utilizes two 780g load cells to selectively capture the insertion force. The clip, a spring-assisted design, provides force for the jaws to close and clamp on the catheter. The load cells are calibrated with the jaws and clips on, using different calibration weights. The handle houses the electronic components, including two load cell amplifier HX711 with Teensy 3.1 board, and Bluetooth modem for the wireless data transmission. A silicone benchtop model [Male Catheterization Model from vendor Life/form®] and a 14Fr plastic Foley catheter [Self - Cath® from Coloplast] are utilized for the data collection.

Results: A picture of the assessment tool design and build appear in Figure 1 with a cost of $84 and calibrated accuracy of +/- 0.2g. The device successfully collected insertion force-time data at 115.2 kHz with the silicone model as the data shown in Figure 2. Each peak value is associated with a push of the insertion process.

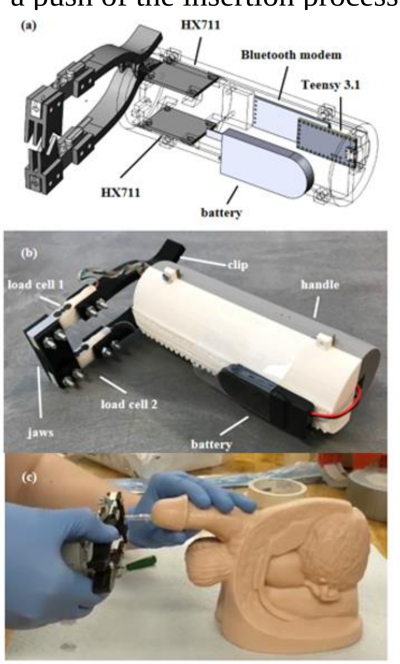

Figure 1: The device and its components as (a) designed, (b) built, and (c) used.

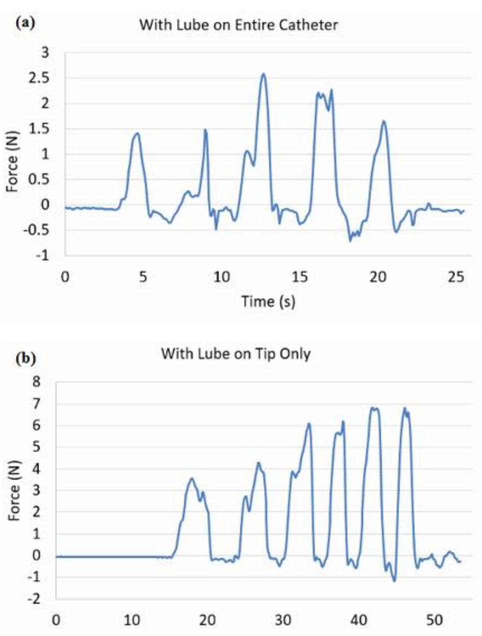

Figure 2: The insertion force measurements for a full insertion cycle. (a) With lube on the entire catheter, the maximum force is around 2.5N. (b) With lube on only the tip of the catheter, the maximum force is around 7N.

Conclusion: We present the design of an inexpensive catheter insertion force measurement device for scientific research purposes, which could be developed into a training tool in the future. These data demonstrate the ability of our device to measure the typical dynamic range of forces on a Foley catheter during insertion in a benchtop model. Next, we will record measurements in more simulators, cadavers and patients to validate and improve simulators and standardized insertion protocols. In the future, the design could be updated to account for the sterilization standard required for a clinical study.