Sensor platforms for bladder and bowel research

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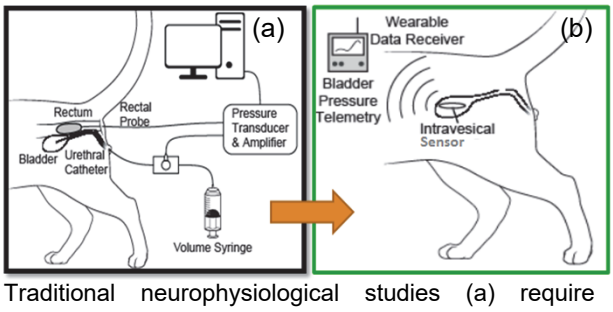
Introduction

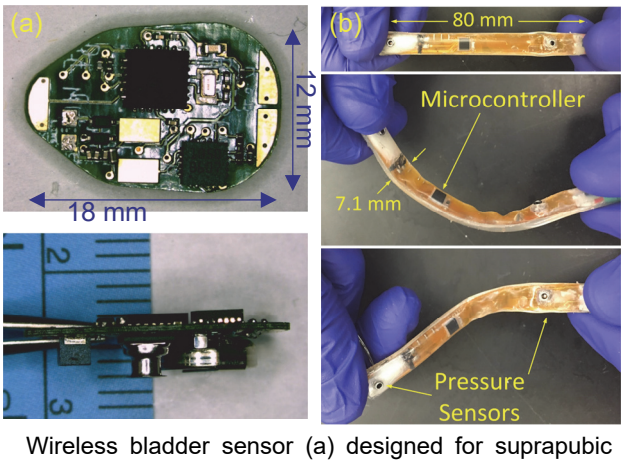
- Functional studies of pelvic organs require measures of neural and organ activity under physiologic conditions
- Few tools exist to enable conscious monitoring of bladder and bowel activity in specific animal models
- Custom wireless sensors for animal studies
  - Sensing organ pressure & volume
  - Form factor appropriate for the anatomy



Traditional neurophysiological studies (a) require anesthetized preparations. Wireless sensors enable conscious recordings of physiologic organ function (b).

Methods

- Initial studies used wired sensors
  - Focus on surgical implantation, sensor modalities, and device form factor[1,2]
  - Wireless functionality demonstrated previously[3]
- For bladder sensor
  - Lumen pressure
  - Urine volume & concentration
- For bowel sensor
  - Dual pressure sensors in separate regions
  - Stool volume & composition
- Pressure sensing using a gel-filled compliant media interface
- Dielectric measurements of organ contents using platinum mesh electrodes



Wireless bladder sensor (a) designed for suprapubic insertion into a feline bladder. The bowel sensor (b) was longer with a flexible form factor that is more appropriate for porcine models.

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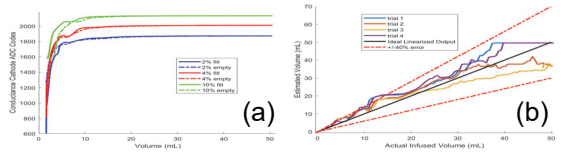
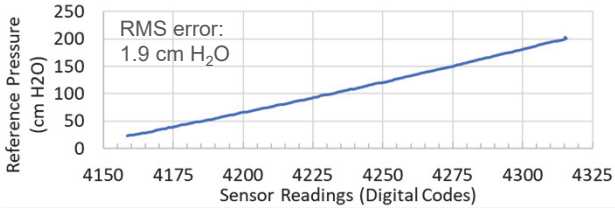
[1]I McAdams et al. IEEE Eng Med Biol Conf. 2018
[2]A Smiley et al. IEEE Eng Med Biol Conf. 2018
[3]A Basu et al. Jour Eng Medicine, 2018

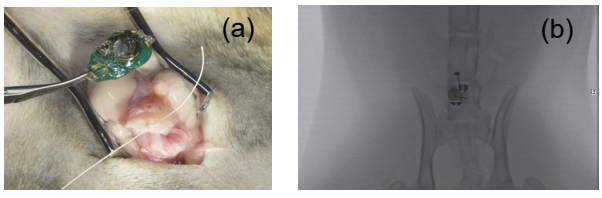
Results – Bladder Sensor



Volume sensor variation with feline urine concentration (a) was partly corrected with a concentration sensor (b). Low overall volume accuracy was sufficient to estimate bladder state (e.g. bladder half full vs bladder empty).

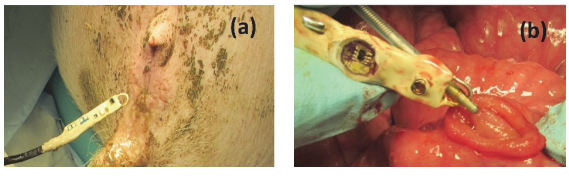


Pressure sensor calibration curve with linear response and 1.9 cm H_2O root mean square error.

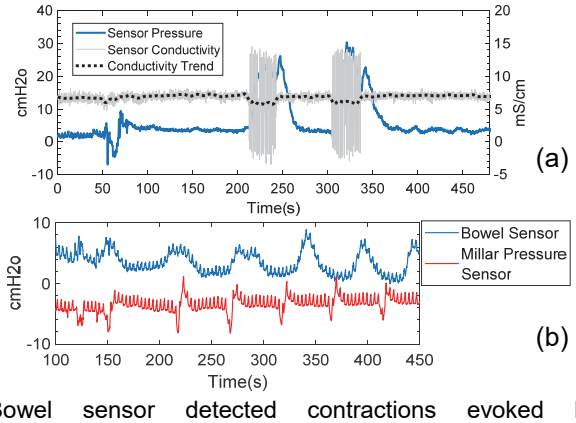


Chronic implantation of sensor in small (20 mL) feline bladder (a) showed retention at 30 days (b). A 25% loss in bladder capacity occurred with no change to animal behavior, possibly due to tissue adhesion post-surgery.

Results – Bowel Sensor



Prototype wired bowel sensors were tested acutely in pigs (a). Sensors were held in place in the bowel using mucosal clips (b).



Bowel sensor detected contractions evoked by stimulation in proximal colon (a) and local phasic contractions in transverse colon separately from a distal manometry catheter (b). Data from anesthetized adult male Yucatan pig. Data generated in collaboration with Drs Larauche and Million et al. (SPARC, UCLA).

Conclusions

- In vivo demonstration of wireless bladder and bowel sensor platforms confirmed feasibility of surgical insertion
- Multiple sensor modalities can be used to assess organ function and correct for physiologic variance