Miniature Raman Spectroscopy Probe May Differentiate Each Tissue from the Skin to the Spinal Cord During Epidural Needle Placement

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Background: Neuraxial anesthesia and epidural steroid injection techniques require precise anatomical targeting to ensure successful and safe analgesia. Epidural steroid injections are effective for symptomatic relief of radiculopathy and neuraxial anesthesia decreases labor and delivery as well as perioperative pain. However, the traditional loss of resistance technique has a relatively low sensitivity and specificity for epidural space localization. While ultrasound and fluoroscopy can localize epidural needles relative to bone, they are unable to identify tissues at the needle tip. We previously showed that Raman spectroscopy can differentiate each tissue from the skin to the spinal cord with a high degree of accuracy and precision in an ex vivo animal model. We hypothesized that real-time needle-tip spectroscopy may aid epidural needle placement and tested the ability of a 500um outer diameter Raman spectroscopy probe to identify the same tissues in a live animal model.

Methods: We developed a 500 micrometer outer diameter Raman spectroscopy probe compatible with 17-gauge Tuohy epidural needle and low cost Raman spectroscopy system. We sought to validate the probe and system in a live swine model. The miniature probe within an epidural needle was inserted in the spinal column at the midline between spinous processes and lateral to the midline in order to mimic the two commonly used approaches to epidural space localization. Raman spectroscopy (RS) data was recorded continuously during epidural needle insertion. The probe in needle was advanced at 1 mm increments starting at the skin, through the epidural space, and ending at the spinal cord in order to acquire data from all tissue types along each of the two trajectories. Data was recorded during multiple midline and lateral insertion points. Simultaneous x-ray imaging was used to capture needle

tip position along each trajectory. At the completion of the experiment, spine tissue was removed and tissue along each needle trajectory was dissected and underwent H & E staining and identification by a qualified pathologist.

Results: While initial results appear to corroborate prior data showing that RS can differentiate each tissue from the skin to the spinal cord, final analysis of the Raman spectrographic data acquired from the 500 um RS probe during insertion in a live animal model is pending. Data analysis will be completed by the annual STA meeting in January 2017.

Conclusions: A prior study demonstrates Raman spectroscopy can distinguish the tissues encountered during epidural needle insertion using a two millimeter RS probe in an ex vivo swine model. A miniaturized RS probe, compatible with an epidural needle may prove useful during needle placement by providing evidence of its anatomical localization.

References:

Anderson TA, Kang JW, Gubin T, Dasari RR, So PT. Raman Spectroscopy Differentiates Each Tissue From the Skin to the Spinal Cord: A Novel Method for Epidural Needle Placement? Anesthesiology. 2016 Oct;125(4):793-804.