

## Epidural Ultrasound Catheter Development and Prototype Testing in Swine: A First Look!

**Presenting Author:** Neil G. Feinglass MD, FASE, FCCP

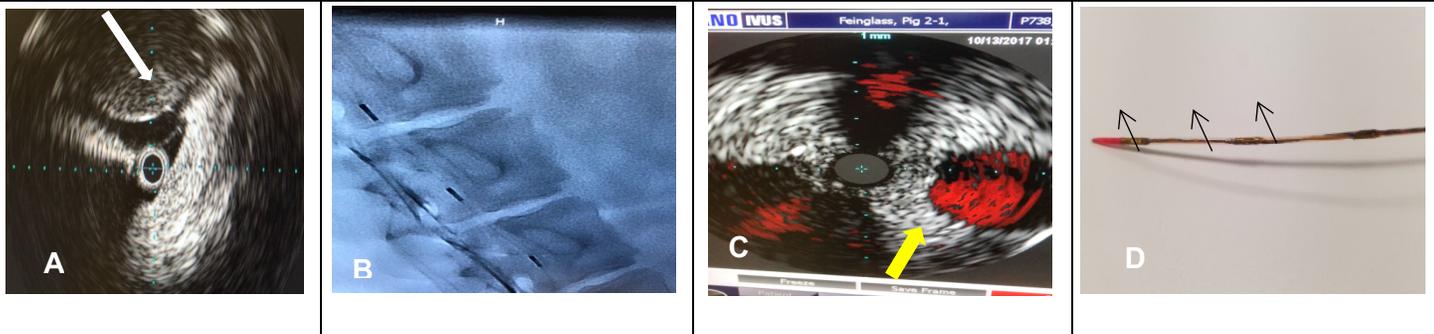
**Co-Author:** Christopher B. Robards, MD

**Introduction:** Spinal Ultrasound and Surface Ultrasound Neuraxial Imaging has been limited by the boney skeleton which is challenging for the sonographer and current technologies<sup>1</sup> The miniaturization of ultrasound catheters has now advanced producing images that guide the clinician through difficult invasive procedures<sup>2</sup>. This study demonstrates the first known successful ultrasound images from within neuraxis in a live swine model using a multi-array engineered ultrasound catheter prototype proof of concept design.

**Methods:** After approval by Mayo IRB and IACUC review (2) 60kg adult pigs were anesthetized and placed in lateral position. Biplane fluoroscopy confirmation with the addition of epidural contrast Iohexol 3 cc (Omnipaque-140 GE Healthcare Marlborough, MA) administration confirmed Epidural placement of the Touhy needle and catheters. The catheters were engineered from intracoronary ICE catheters (Volcano Eagle Eye Platinum Catheter San Diego, Ca.) such that the catheter had a plurality of mechanical transverse arrays (three) able to produce images at multiple spinal levels and display onto the ultrasound console (Volcano Corporation). Each catheter (20MHz, 0.056", 5F) offers transverse imaging planes at 3 independent levels.

**Results:** Epidural imaging was achieved in the swine model from lumbar region to the thoracic regions without incident. A significant amount of epidural fat was identified in the epidural space and the Intrathecal placement was not achieved. All images obtained are viewed from the epidural space (Fig 1).

**Fig.1. Images from the pig experiment**



**A.** 2-dimensional image with spinal cord viewed in short axis. **B.** Fluoroscopy with catheter inserted with 3 US-arrays visible. **C.** Epidural space with epidural veins and flow identified (arrow). **D. Prototype catheter V1.** 3 ultrasound arrays indicated (arrows).

The epidural ultrasound catheter identified the spinal cord and Dura Mater of the pig throughout the neuraxis. 2 out of 3 arrays produced images due to presumed soldering issues. Other anatomic structures including large epidural venous vascular collections were identified. A proprietary doppler color flow mode (Volcano Corp) distinguished the flow pattern of red blood cells to be continuous further confirming the identification of these structures as venous.

Pulsatile smaller tortuous structures that moved in and out of the ultrasound plane were viewed in close proximity to the spinal cord. The application of color flow doppler did not enhance our characterization of possible arterial vessels). Fluid and fat containing spaces were seen near the cord with no discernable

intrathecal space. Further attempt to identify the rudimentary intrathecal space by passing the Touhy needle and catheter through the dura mater was not successful. This finding was consistent with other studies that have reported anatomic differences between man and swine.<sup>3</sup>

Final examination of the relationship of the ultrasound catheter to the Intraspinal anatomic structures was validated by surgical laminectomy after euthanasia of the animal. The dissection revealed the ultrasound catheter epidural placement adjacent to the spinal cord. No traumatic injury could be recognized to the spinal cord, dura, or vasculature or exiting nerve roots.

#### **Discussion/Conclusion:**

1. Percutaneous epidural ultrasound is feasible with miniaturization of the ultrasound catheter transducers.
2. Spinal cord, dura mater, epidural veins, epidural fat and arterial vascular structures could be identified.
3. The neuraxis (Lumbar to Thoracic) regions were effectively imaged in continuity.
4. No traumatic injury to the spinal cord post study could be identified.
5. Future refinement could lead to potential low-cost diagnostic devices for assessing spinal cord therapies and viability which heretofore have been difficult to achieve.

#### **References:**

1. Anesthesiology 6 2011, Vol.114, 1459-1485. doi:10.1097/ALN.0b013e318210f9f8
2. Seward JB, Packer DL, Chan RC, Curley M, Tajik AJ. Ultrasound Cardioscopy: embarking on a new journey. **Mayo Clin Proc.** 1996; 71: 629–635.
3. Eur Spine J (2010) 19:1104–1114