ABSTRACT #06

Optical Coherence Tomography Imaging Of Paraspinal Neurovascular Structures: Preliminary Animal Studies

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Introduction: Multiple neurologic complications have been reported with spinal transforaminal injections. Besides intraneural injection, a cause of injury is compromised perfusion in a spinal nerve radicular artery. [1] Upon injection, steroid material or air can embolize and occlude the radicular artery, and infarct the spinal cord. Current fluoroscopy techniques are limited by inability to image the spinal nerve root/ radicular artery, unreliability of the blood aspiration test, and discontinuous target imaging.

Optical coherence tomography (OCT) is a non-invasive imaging modality, which can be used to image through non-transparent biological tissues. OCT is an interferometry-based optical analog of B-mode ultrasound, and is able to achieve real-time in situ visualization of tissue microstructure with very high-resolution (less than 10 microns) with a penetration depth of 1-2 mm in most structures.[2]

In the absence of direct imaging, present transforaminal injection procedures cannot image key target structures, entail uneliminated neurologic risk, and may lead to potential failure of intended therapeutic effects. With a view toward needle tip vision with an OCT needle-shaped endoscope, we conducted animal studies to explore how paraspinal neurovascular structures might appear at the needle tip of such a device.

Methods: With institutional animal care committee approval, we conducted *ex-vivo* and *in situ* OCT image studies in a euthanized dog, pig, and rabbit. Image data were gathered on characteristic OCT image features of critical structures, including spinal nerve roots, dura, and brachial plexus. The images were obtained with two forward-imaging OCT systems: (1) a Fourier domain OCT forward-imaging imaging system developed at the California Institute of Technology, and (2) an Imalux NIRIS system (Cleveland, Ohio) with a portable 2.7 mm diameter probe.

Results: In a 25 kg euthanized pig, excised dura was punctured with a 17-gauge Tuohy needle. FDOCT dural images of the puncture showed a subsurface cone-shaped defect, widest at the outer dural surface, and narrowing to a point. In a 4 kg rabbit *in situ* study, puncture of the dura with a 26-gauge needle is imaged with the Imalux system as a discontinuity, which fills with CSF fluid.

With an FDOCT system, we demonstrate imaging of a radicular artery, with an evident muscularis layer, on the surface of a porcine spinal nerve root. This is the critical feature that a pain interventionalist must recognize in order to avoid intravascular injection. For larger vessels, such as the subclavian artery, OCT imaging can reveal the three layers of the arterial wall.

For a transversely imaged brachial plexus nerve, OCT imaging reveals multiple myelinated nerve fibers fascicles occupying the interior of the nerve, confirmed by H&E histologic staining. In a longitudinal OCT image, the nerve fibers are seen as dark tortuous tubular structures that parallel the course of the nerve.

Discussion: High-resolution OCT imaging may be useful in the identification of neurovascular structures in the vicinity of the needle tip. If such an OCT needle-shaped catheter endoscope were on the verge of piercing a nerve or vessel, the operator could slightly withdraw the tip to a position that would not result in injury.

REFERENCES

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