A novel MRI thermometry-based Nd:YAG interstitial thermal therapy system: initial experience in an *in vivo* swine brain model. Torchia MG*, Tyc R†, Eluik A†, Qureshi S†.

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Background: Thermal (both heat and cryogenic) therapies for the treatment and destruction of cancerous solid tumors have a long history of success. Most of these therapies employ a probe or fiber configured to emit somewhat uniformly from the source, thereby creating a spherical or ellipsoidal thermal "front." This makes control of the deposition of heat (or cold) difficult to control precisely to the contours of the tumor. We have previously reported on the development of a side-firing, internally cooled probe as a means of addressing this issue. These experiments report on the first *in vivo* testing of the probe in normal brain tissue.

Purpose: A novel laser interstitial thermal therapy (LITT) system has been developed which utilizes a 2.4mm side-firing MRI-compatible probe for the coagulation of tissue. The probe contains an internalized Joule-Thomson effect-based cooling system. The system is supported by advanced software for trajectory planning, treatment boundary delineation, and real-time thermal damage threshold control by MR-thermometry. This purpose of these experiments was to determine the effectiveness and early safety of this probe (and system) in normal brain tissue.

Methods: Swine (n=5) (50 kg) were anesthetized using azaperone, xylazine, and isoflurane and mechanically ventilated. Initial MRI images (T1) were obtained to define the trajectory and probe placement depth for positioning into the frontoparietal region. In the operating room, a 13 mm burr hole was created at the entry point and a frameless trajectory guide (Navigus) was attached to the skull. Pigs were returned to the MRI and the trajectory finalized and confirmed using a gadolinium-filled plastic wand inserted into the lumen of the trajectory guide. Following manual probe insertion (without realtime MR guidance), probe position was confirmed by MRI. Circumferential treatment boundaries (two slices) were delineated from T1 images taken perpendicular to the probe axis in plane with the laser exit at the probe tip. PD/T2 images were obtained at these same positions. Lesions were created using a range of Nd:YAG laser parameters (60-75 watts, 0.4-0.7s on/2.5s off) while monitoring lesion size and thermal damage threshold by real-time MR thermometry (GRE). Following lesion creation, images were taken every hour (PD/T2 and contrast-enhanced T1). After fours hours the pigs were euthanized and the brain removed and placed in buffered formalin for further processing and staining with H&E.

Results: One lesion was created in each of the five pigs. Only three lesions were available for histological examination. One pig succumbed unexpectedly due to a cardiac arrhythmia and the lesion did not develop over a sufficient time for histological or MRI analysis. In a

second pig, the brain tissue was inadequately fixed and the tissue was not able to be sectioned. Of the three examined lesions, the size of the lesion based on the thermal damage threshold MRI images taken at 4 hours underestimated the size of the lesion on histology (outer rim of mild vacuolization of neuropil) by approximately 30%. Histological examination also demonstrated that the treatment boundary demarcation zone was approximately 0.5mm wide. Cracking of the sapphire probe tip was seen after removal from the brain.

Conclusions: The novel side-firing LITT system provided suitable lesion formation in normal *in vivo* brain tissue to warrant additional definitive studies in a tumor model. Future development will include analysis of the thermal shock characteristics of the probe tip and adjustments of the algorithm variables for calculation of real-time thermal damage threshold.