demonstrates that a previous epidural hematoma that was surgically evacuated may form scar tissue in the epidural space protecting against new hematoma formation.

F08 Neural Stimulation: Non-Interventional (TENS, Transcranial)

(392) Effects of alternating current trans-cranial stimulation on pain related depression and neuropathic pain in industrial limb injuries including CRPS

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Trans-cranial stimulation has been shown to have a positive effect on depression and chronic nociceptive pain. Current research on Trans-Cranial Alternating Current Stimulation (tACS) suggests that it can induce changes in the rhythm and synchronicity of neuronal network activity.[1] This clinical series assesses the anti-depressive capabilities of tACS on depression induced by neuropathic pain and assesses the analgesic properties of tACS on neuropathic pain induced by traumatic industries nerve injuries to the limbs. In order to test this, a cohort of 10 patients between the ages of 18 and 65 with sub-acute or chronic neuropathic pain features directly resulting from traumatic industrial nerve injury to the limbs were recruited which included cases of direct nerve trauma and CRPS. The primary outcome (depression severity caused by neuropathic pain) as well as the secondary outcome (neuropathic pain characteristics) were assessed via two pain metrics, one visual analog and one ratio scale, as well as an abbreviated depression questionnaire. The results of the series showed an average decrease of 19.17% in pain intensity ($p=0.0015$, ES = -1.1126, $r= -0.2176$), 32.82% decrease in pain unpleasantness ($p=0.0039$, ES = -1.2285, $r= -0.2349$), 19.87% decrease in global pain ($p=0.0109$, ES = -0.9238, $r= -0.1876$), and a 53.70% decrease in depressive symptom severity ($p=0.0028$, ES = -0.9160, $r= -0.1863$). Statistical analysis involved a paired t-test which showed statistical significance ($p< 0.05$) for all outcome measurements and calculated effect size. The results of this clinical series strongly suggest that tACS merits further research as a treatment method for pain induced depression as well as neuropathic pain resulting from traumatic nerve injury. (1. Ali, J Neurosci, 2013.) Supported by a grant from Nexalin Technology, Inc.

(393) Neuropathic pain reduction with scrambler therapy treatment

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An increase in accidental deaths related to prescription opioids prompts the identification of novel strategies to treat chronic pain at a low risk to patients and their communities. Scrambler therapy has recently emerged as a viable treatment option for patients with neuropathic pain. This non-invasive cutaneous electro-stimulation shows promise and should be considered in addition to pharmacological and non-pharmacological interventions to treat pain. The use of 16 electrical currents that produce normal nerve action potentials effectively replaces "pain" information with "non-pain" signals. We examined the efficacy of scrambler therapy as a means to treat various forms of neuropathic pain in a pilot study. Our findings suggest that scrambler therapy can significantly reduce pain intensity ratings in patients with chronic pain over time (n=25). This group includes 16 female and 9 male patients ranging from age 28-83. Types of pain treated include idiopathic peripheral neuropathy (11), complex regional pain syndrome (CRPS) (5), radiculopathy (4), neuropathic groin pain (2), trigeminal neuralgia (2), and postherpetic neuralgia (1). A striking reduction in pain was observed during and immediately following treatment ($p=0.03$), additionally across multiple treatment visits over two weeks ($p=0.02$). Across all patients and visits, the mean ($\pm$ SEM) pre-, during, and post-stimulation pain ratings were 3.6 ± 1.4, 2.0 ± 0.9, and 1.9 ± 0.8, respectively. Fifteen reviewed patients were also treated for pain in a secondary area; in most cases, this area's baseline pain was lower than the primary area. For secondary areas of pain, no significant pain reduction was observed across visits ($p=0.1$) or stimulation timeframe ($p=0.4$). Further treatment of patients experiencing chronic pain with scrambler therapy will bring to light any additional interaction between pain reduction over the course of individual and multiple visits. By demonstrating reduction in pain, our findings help to validate and identify the appropriate clinical situations in which to use scrambler therapy.

F09 Neural Stimulation: Interventional (Peripheral Nerve, Spinal, Deep Brain, Cortical)

(394) Use of spinal cord stimulators for veterans in the VHA MSD cohort

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Spinal cord stimulator (SCS) implantation is a commonly used pain management option to treat severe pain conditions, including some musculoskeletal disorders (MSDs). Few large studies have examined the demographic and clinical characteristics of patients receiving SCSs or the characteristics of facilities that perform SCS implantation. There are no studies addressing these issues in the Veterans Healthcare Administration (VHA). We used the data from the VHA funded MSD cohort study (MSD; n=5.1 million) to identify veterans who underwent SCS implantation from 2000-2014. Descriptive statistics were used to characterize veterans who did/did not receive a SCS. A total of 2,477 temporary and permanent SCS implantations were identified. Between 2000 and 2010, implantations increased steadily; however, that trend reversed in 2011. Compared to those who did not receive SCSs, those who did were more likely to be under age 45 (37.7%), male (90.3%), and White (82.2%). Their pain diagnoses were consistent with those generally indicated for SCSs (e.g. postlaminectomy syndrome-lumbar region, thoracic or lumbosacral neuritis or radiculitis, and lumbago). Veterans receiving SCSs had higher pain intensity ratings (Mean=5.28) and were more likely to receive opioid therapy; specifically 89.4% of the veterans who received SCSs received opioids in the year prior to implant and 64.5% had received long-term opioid therapy. Veterans receiving SCSs had lower rates of comorbid medical conditions and alcohol use disorder, but higher rates of mood and anxiety disorders. A majority of SCSs were implanted by neurosurgery, anesthesiology, and pain medicine, and most implantations were at large tertiary facilities. Implantations also frequently occurred at the facility where the veteran received his/her MSD diagnosis (73.31%). These findings suggest that VHA providers are using SCSs to treat patients experiencing treatment-refractory pain consistent with common indications for SCSs. The study also suggests that demographic, clinical, and facility characteristics influence veterans' likelihood of receiving SCSs.

(395) Brainstem activity and connectivity is modulated by respiratory-gated auricular vagus afferent nerve stimulation (RAVANS) in migraine patients – an fMRI study

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Respiratory-gated auricular vagal afferent nerve stimulation (RAVANS), an optimized version of transcutaneous vagus nerve stimulation, may be beneficial for migraine though its mechanisms of action are unknown. Our aim was to use functional MRI (fMRI) to evaluate brainstem response to RAVANS. Sixteen subjects with episodic migraine (35.75 ± 13.45 years, interictal) and 16 age-matched healthy controls (36 ± 13.75 years) were randomized to receive RAVANS or sham stimulation during a 6-minute fMRI scan, with cross-over stimulation following 30minutes. Electrodes were placed in vagal-innervated ear regions. RAVANS stimulation at 30Hz (0.5s duration) and gated to exhalation was delivered with current intensity set to achieve moderate (but not painful) sensation. Sham stimulation used disconnected electrodes. Brain response to non-painful airpuff stimulation to ophthalmic (V1) territory on the forehead was also assessed. FMRI was performed at 3.0Tesla (Siemens Tim Trio, TR/TE=2.5s/30ms, 43 slices, slice thickness=3.12mm, matrix=84x84, FOV=220mm, FA=90°). An event-related general linear model analysis was used, while functional connectivity was computed using seed-based connectivity analysis for a nucleus tractus solitarius ROI defined based on the peak activation voxel. All group-level brain maps were cluster corrected for multiple

comparisons. Repeated-measures ANOVA models were used for post-hoc ROIs, significant at p<0.05. Compared to SHAM, RAVANS activated an ipsilateral pontomedullary region consistent with nucleus tractus solitarius. During RAVANS, NTS connectivity was found to a network of brain regions, including anterior insula, putamen, midbrain, and thalamus. A significant INTERVENTION effect (RAVANS > sham) was found for NTS connectivity to left and right anterior insula, and putamen. Furthermore, pontine raphe response to airpuff stimulation to V1 territory was greater following RAVANS, but not SHAM. RAVANS effectively activates ipsilateral NTS. Regulation of NTS connectivity to known pain-modulatory brain regions, and increased sensory processing in raphe nuclei, may constitute an underlying analgesic mechanism.

(396) Winding the Spotted Snake: feasibility of spinal cord stimulation after extensive spine surgery

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Scoliosis corrective surgery is indicated in severe debilitating spine pain that is refractory to conservative measures. Recent advances in high-frequency spinal cord stimulation (HF-SCS) make this an attractive treatment option in this population. However, most interventional pain physicians would not consider a trial/implant given well known post-surgical changes and instrumentation present. Here we present a successful implantation of an SCS/IPG in such a patient. This case involved a 34 year-old female with scoliosis corrective surgery (Harrington rods T5-L3). Patient presented with severe lower back pain with radiation to bilateral hips. Symptoms remained refractory despite extensive physical rehabilitation, pharmacological (duloxetine, gabapentin, hydrocodone/ibuprofen, fentanyl patch) and interventional (trigger point, lumbar/caudal epidural steroid, lumbosacral facet injections) therapies. Pre-operative workup included thoracolumbar X-rays and psychological assessment (which found no barriers to implant). Epidural needles were advanced under fluoroscopic guidance to enter the epidural space at the L3-4 interspace. Two 8-contact SCS leads (Boston Scientific) were inserted into the dorsal epidural space. Increased resistance to passage of the leads within the epidural space was noted throughout the case. A small zone of obstruction to passage of the lead was observed surrounding each laminar hook, consistent with formation of a dense fibrotic capsule around the instrumentation. This required navigation of the leads ("winding the spotted snake") around these zones of obstruction. Brief paresthesias were noted at various points as the leads were advanced, but they resolved promptly without sequelae. Despite these challenges, the contacts were navigated within the dorsal epidural space to their final positions spanning T8-T10 vertebral bodies with a minimal increase in surgical time. Recent advances in HF-SCS make this a viable and life-changing treatment for spine pain patients previously considered non-candidates. The post-surgical changes (surgical fibrosis/adhesions) do present unique challenges warranting a careful informed consent discussion with the patient.

(397) Fluoroscopically-guided radiofrequency neurotomy technique for the treatment of genitofemoral neuralgia

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Genitofemoral neuralgia (GFN) is a pain syndrome that causes burning, tingling, and numbness along the groin and medial thigh. The etiology is thought to be nerve entrapment or iatrogenic injury. GFN has been noted following surgeries such as inguinal herniorraphy, appendectomy, caesarian section, lymph node biopsy, hysterectomy, vasectomy, and urethral sling surgery. GFN has been treated with medications, surgical neurotomies, and with various ablative interventional procedures. These interventional procedures have been performed blindly, with CT guidance, or with ultrasound guidance. In this article we present the case of a 48-year-old-woman with GFN who responded to anesthetic nerve blockade of the genitofemoral nerve and subsequent fluoroscopically-guided genitofemoral radiofrequency neurotomy. She experienced complete relief of her symptoms immediately post-procedure and had 95% pain relief at 1.5 month-follow-up. To the knowledge of the authors, this is the first technical description of a fluoroscopic guidance technique for genitofemoral neurotomy.

(398) Fully-implantable, wireless technology for optogenetic control of bladder sensory neurons

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Bladder pain and dysfunction are sources of profound debilitation for millions of people in the United States with interstitial cystitis/bladder pain syndrome, overactive bladder, and neurogenic bladder. Current treatments for these disorders are often ineffective and do not address the underlying pathology. A substantial barrier to the development of improved therapeutics is insufficient access to peripheral mechanisms by which the bladder can be controlled. Our preliminary efforts have aimed at developing a suite of technologies that use a combination of peripherally-implanted, wireless optoelectronic systems for monitoring and control of bladder activity. Our hardware and interfaces use soft, fully-implantable microscale devices with advanced design features specifically configured for essentially permanent interfacing with the pelvic nerve. This technology has provided unique access to bladder functionality, thus enabling novel insight into the mechanisms of bladder control and pain. We have shown using this new technology the ability to wirelessly electrically stimulate and record bladder function through pelvic nerve activity. Additionally, we have shown the ability control bladder function through the viral delivery of excitatory and inhibitory optogenetic channels. This work was supported in part by a grant from GSK (GlaxoSmithKline).

(399) Patient-specific computer models of spinal cord stimulation for chronic pain management

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The primary indication for spinal cord stimulation (SCS) is neuropathic limb pain refractory to conventional medical management. Although SCS has been used for decades, clinical outcomes have remained largely unchanged during this time. Most innovation has focused on the stimulator and electrode designs and programming features. However, these device modifications have not been met with the expected improvements in pain relief. Considerably less attention has been given to the inter-patient variability in spine anatomy and electrode positions. We postulate that to understand the direct neuromodulatory effects of SCS and to improve clinical outcomes, it is necessary to adopt a patient-specific approach that accounts for inter-patient variability. We developed a patient-specific computer model for a patient implanted with a SCS system for chronic pain management. This computer model had two components: 1) a finite element model derived from preoperative and postoperative anatomical imaging, and 2) electrical models of the spinal cord axons. For several sets of stimulation parameters, we measured the patient's sensory and discomfort thresholds as well as the corresponding areas of stimulation-induced paresthesias. In the computer model, we calculated which spinal cord axons were activated at these clinical thresholds. At sensory threshold, the patient-specific computer model consistently predicted activation of $\geq$ 7.3 μm-diameter myelinated axons within the dorsal column. This activation included the dorsal column somatotopy corresponding to the paresthesia coverage indicated by the patient. With regards to stimulation thresholds, the computer model also correctly predicted the effect of changing waveform parameters (e.g. pulse width) and stimulation configuration (e.g. bipolar, guarded cathode). These results suggest that patient-specific computer models may provide a novel approach that would enable providers to customize the lead location, optimize the stimulation parameters, and further refine the lead design. This work was supported by the Louis Stokes Cleveland Veterans Affairs Medical Center, Cleveland, Ohio.

(400) Single lead spinal cord stimulation of the C2-C5 nerve roots for persistent pain secondary to schwannoma resection

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A 44-year-old female with history of right C5 nerve-root schwannoma status-post surgical resection one year earlier presented with right-sided shoulder, inferior jaw, and neck discomfort. She