Motor Evoked Potential Monitoring during Cryoablation of Musculoskeletal Tumors

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ABSTRACT

Purpose: To describe the use of intraprocedural motor evoked potential (MEP) monitoring to minimize risk of neural injury during percutaneous cryoablation of perineural musculoskeletal tumors.

Materials and Methods: A single-institution retrospective review of cryoablation procedures performed to treat perineural musculoskeletal tumors with the use of MEP monitoring between May 2011 and March 2013 yielded 59 procedures to treat 64 tumors in 52 patients (26 male). Median age was 61 years (range, 4–82 y). Tumors were located in the spine (n = 27), sacrum (n = 3), retroperitoneum (n = 4), pelvis (n = 22), and extremities (n = 8), and 21 different tumor histologies were represented. Median tumor size was 4.0 cm (range, 0.8–15.0 cm). Total intravenous general anesthesia, computed tomographic guidance, and transcranial MEP monitoring were employed. Patient demographics, tumor characteristics, MEP findings, and clinical outcomes were assessed.

Results: Nineteen of 59 procedures (32%) resulted in decreases in intraprocedural MEPs, including 15 (25%) with transient decreases and four (7%) with persistent decreases. Two of the four patients with persistent MEP decreases (50%) had motor deficits following ablation. No functional motor deficit developed in a patient with transient MEP decreases or no MEP change. The risk of major motor injury with persistent MEP changes was significantly increased versus transient or no MEP change ($P = .0045$; relative risk, 69.8; 95% confidence interval, 5.9 to > 100). MEP decreases were 100% sensitive and 70% specific for the detection of motor deficits.

Conclusions: Persistent MEP decreases correlate with postprocedural sustained motor deficits. Intraprocedural MEP monitoring helps predict neural injury and may improve patient safety during cryoablation of perineural musculoskeletal tumors.

ABBREVIATIONS

CI = confidence interval, MEP = motor evoked potential, RR = relative risk, SSEP = somatosensory evoked potential

Percutaneous cryoablation is increasingly used to treat musculoskeletal tumors, most commonly for palliation of painful metastases, with developing indications to treat oligometastatic disease or benign bone tumors (1,2). Iatrogenic nerve injury during cryoablation is a known complication of ablation procedures (3). The risk of inadvertent ablation of neural structures is greatest when treating musculoskeletal tumors, given their frequent proximity to the central neuraxis or peripheral neurovascular bundles.

The incidence of nerve injury following musculoskeletal cryoablation is unknown. A recent series (3) reporting nerve injury after thermal ablation (including cryoablation and radiofrequency ablation) described four injuries over a 3-year period at a practice where

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M.R.C. received research support from GE Medical Systems (Waukesha, Wisconsin), Thermedical (Waltham, Massachusetts), Galil Medical (Arden Hills, Minnesota), and Siemens (Erlangen, Germany), and is a paid consultant for Covidien (Mansfield, Massachusetts). None of the other authors have identified a conflict of interest.

J Vasc Interv Radiol 2014; 25:1657–1664

http://dx.doi.org/10.1016/j.jvir.2014.08.006

about 30 bone ablation cases are performed annually, suggesting an incidence of 4%. Their review of the literature (3) yielded 22 additional nerve injury cases reported in 11 articles, although the authors suggested that neurologic complications are likely underreported. Moreover, as the use of musculoskeletal tumor ablation continues to expand, the incidence of neurologic complications will likely increase. Although the low-attenuation ablation zone may be monitored radiographically during cryoablation to avoid neural structures (4,5), conspicuity of the ice ball considerably decreases within high-density cortical bone and sclerotic tumors, as well as within low-density fat surrounding many bone and soft-tissue tumors.

Intraoperative neurophysiologic monitoring has become routine practice to prevent neurologic compromise in many complex operations, typically involving the spine (6–10). This monitoring has more recently been used to avoid peripheral nerve injury during orthopedic surgery (11). Motor evoked potentials (MEPs) and somatosensory evoked potentials (SSEPs) are techniques frequently used to assess the integrity of motor and sensory pathways, respectively. As they directly monitor the corticospinal tracts, MEPs may be superior to SSEPs in detecting evolving motor tract injury (12). These techniques have shown variable sensitivity and specificity for predicting neural injury during spinal surgery (10,12,13). Two cases of SSEP monitoring during skeletal cryoablation have been reported in the literature (3,14), but we are aware of no systematic study of the value of neurophysiologic monitoring in this setting. The purpose of the present study was to describe the use of intraprocedural MEP monitoring to minimize the risk of neural injury during percutaneous cryoablation of perineural musculoskeletal tumors.

MATERIALS AND METHODS

This single-center, retrospective study was approved by our institutional review board and compliant with the Health Insurance Portability and Accountability Act. The need for patient informed consent was waived. Our institutional tumor ablation database was searched for ablation cases performed with intraprocedural MEP monitoring between May 16, 2011, and March 15, 2013. Fifty-nine cryoablation procedures were performed to treat 64 perineural musculoskeletal tumors in 52 unique patients.

Patient, Procedure, and Tumor Characteristics

Patient and procedural characteristics are presented in Table 1. Tumor locations and histology are listed in Table 2. Most tumors were located in the spine (42%) or pelvis (36%). The most common tumor histologies were renal-cell carcinoma (27%), colorectal carcinoma (9%), and multiple myeloma/plasmacytoma (8%). Median tumor size was 4.0 cm (range, 0.8–15.0 cm). A total of 33 of the tumors (52%) had previously been treated with radiation therapy.

Table 1. Patient and Procedural Characteristics (N = 52)

Characteristic	Value
Age (y)	
Mean	61
Range	4–82
Sex	
Male	26 (50)
Female	26 (50)
Procedures	59
Single tumor, single session	45 (76)
> 1 Tumor treated, same session	7 (12)
Tumor treated again in separate session	3 (5)
Additional tumor treated in separate session	4 (7)

Values in parentheses are percentages.

Neurophysiologic Monitoring

The decision to include intraprocedural neurophysiologic monitoring was made by one of seven interventional radiologists based on subjective estimation of risk to the adjacent neurologic structures on preprocedural cross-sectional imaging typically obtained within 1 month of the procedure. In general, monitoring was performed when the musculoskeletal tumor was within 3 cm of the spinal cord, a nerve root, or a major peripheral motor nerve. Intraprocedural MEP monitoring was conducted by a neuromonitoring technologist from the Department of Neurology supervised by a physician neurophysiologist (Fig 1a). Transcranial MEPs were generated by electrical stimulation (400–600 V; 50–75-ms pulse duration; 0–5 pulses at 1–3 ms) over motor cortical regions by using a constant voltage transcranial stimulator (TCS-4; Cadwell, Kennewick, Washington). Electromyographic responses were recorded from subcutaneous needle electrodes positioned over the appropriate muscle groups supplied by neural structures at risk of injury (Fig 1b). Waveforms were recorded on a neurophysiology workstation. The interventional radiologist determined which neural structures were vulnerable to injury and which muscle groups to monitor in collaboration with the neurophysiology team. For tumors near the brachial or lumbosacral plexuses, monitoring was performed at the segmental level of interest and at the levels above and below the vulnerable level. For tumors in the cervical region, the deltoid (axillary nerve, C5/C6), biceps (musculocutaneous nerve, C5/C6), extensor digitorum communis (radial nerve, C6–C8), and hypothenar (ulnar nerve, C8–T1) muscles were recorded. For tumors in the thoracolumbar spine, bilateral lower-limb muscle groups were monitored, including the vastus medialis/vastus lateralis/rectus