CLINICAL STUDY

Ablation Zones and Weight-Bearing Bones: Points of Caution for the Palliative Interventionalist

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ABSTRACT

Purpose: To evaluate and classify underlying mechanisms of adverse outcomes after percutaneous computed tomography (CT)–guided cryoablation for palliation of painful musculoskeletal metastatic disease.

Materials and Methods: Data were collected for patients who underwent CT-guided percutaneous palliative cryoablation for painful musculoskeletal metastatic disease between January 2010 and December 2012. Cases with adverse outcomes or suboptimal response were identified and classified according to the Society of Interventional Radiology (SIR) classification system for complications by outcome and according to underlying mechanism of the outcome as delineated on follow-up examination.

Results: There were 61 patients who received ablation for painful musculoskeletal metastatic disease. Six patients with adverse outcomes were identified. Two were minor complications (A, n = 1; B, n = 1), and four were major complications (C, n = 1; D, n = 3). Four patients incurred sequelae related to damage of ancillary structures included in the ablation zone, and two patients developed complete fractures after ablation of lesions in weight-bearing bones.

Conclusions: Complete cryoablation of a painful musculoskeletal metastatic lesion may lead to ancillary damage of adjacent structures or fracture in weight-bearing bones.

ABBREVIATION

PMMA = polymethyl methacrylate

The efficacy of percutaneous cryoablation as a palliative intervention in the setting of painful musculoskeletal metastases has been well described (1–5). Similarly, the effects of tissue density and character, probe number and proximity, duration and number of freeze-thaw cycles, and temperature-induced cell death have been defined in several nonosseous clinical and bench scenarios (6–14). However, preclinical data regarding these parameters in bone are sparse and largely from the surgical literature (15–18). Events involving the bone-neoplasm interface contribute significantly to patient pain (19,20). As a result, the interventionalist must balance the potential for maximal pain relief through marginal ablation with potential lethal or nonlethal temperature changes beyond the visualized or predicted ablation zone as well as consider the stability of the residual ablation bed when it applies to weight-bearing bones. For purposes of improved patient selection and outcome, a retrospective analysis of cases that resulted in adverse events after computed tomography (CT)–guided percutaneous cryoablation for painful musculoskeletal metastatic disease over 2 years was performed.

MATERIALS AND METHODS

This study was approved by the institutional review board and is compliant with the Health Insurance Portability and Accountability Act. The radiology

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department percutaneous ablation database (n = 61) was retrospectively searched for cases of cryoablation performed to treat painful osseous metastatic disease with adverse outcomes between January 1, 2010, and December 1, 2012 (n = 6). Patient demographics, tumor specifics, procedure technical parameters, follow-up imaging, and patient outcomes were analyzed. Adverse events were recorded, described, and classified according to the Society of Interventional Radiology (SIR) classification system for complications by outcome (21) and according to the underlying mechanism as demonstrated on follow-up imaging. Intent-to-treat analysis was employed when considering subjects to be included in this report.

All procedures were performed with CT , and five of six patients had general anesthesia. Patients were positioned to maximize safe access to the tumors. In all cases, 17-gauge cryoprobes from Galil Medical (Arden Hills, Minnesota) with variable predicted ablation zones were used. All cases were performed by a single operator. Probe selection and number varied according to lesion characteristics. Each lesion underwent two 10-minute–5-minute freeze-thaw intervals, with images obtained at 8 minutes into the freeze cycle each time (22). There were no probe manipulations between cycles.

Pain was quantified using a visual analogue scale 1–3 days before the procedure (during consultation) and following the procedure at 24 hours by the primary operator as part of routine clinical practice. Clinical manifestations were also documented by the primary operator as part of follow-up clinic visits or, in the cases of the fractures, the emergency department. Unrelieved pain, new pain, or neuropathic symptoms on history and physical examination were indicators of potential adverse events. All patients had follow-up images, five of which clearly delineated the cause of their symptoms. Follow-up images were compared with images obtained before and during the procedure. The mechanisms of these complications delineated reproducible categories.

RESULTS

Six patients (three men and three women; average age, 60.7 y ± 13.8) presented in two categories of adverse outcomes. The primary tumors ablated for pain control were renal cell carcinoma (n = 1), breast (n = 1), adenocarcinoma of unknown primary (n = 1), melanoma (n = 2), and lung (n = 1). All tumors were lytic. All patients experienced initial symptomatic relief (**Table**).

Ablation Zones

Symptomatic Osteocartilaginous Damage. Two patients incurred damage outside the predicted lethal ablation zone to adjacent osteocartilaginous structures. The first patient was a 58-year-old woman with stage IV breast cancer referred for palliative management of a refractory 4.8 cm × 3.5 cm × 3.3 cm metastatic lesion in the left acetabulum. After ablation, 3.5 cm^3 of radiopaque polymethyl methacrylate (PMMA) was instilled to the ablation bed without difficulty. The patient reported immediate relief after the procedure. However, 1 week after the procedure, the patient described a symptom complex comprising a persistent "dull ache" involving her left hip. Magnetic resonance (MR) imaging performed 1 month after the procedure delineated sequelae from an ablation zone that extended across the articular surface and involved the superolateral portion (4 mm) of the femoral head (**Figs 1a,b** and **E1a,b** [available online at *www.jvir.org*]). The patient's symptoms resolved over time, and the outcome was classified as a minor complication (B).

The second patient was a 48-year-old woman with stage IV melanoma. The patient developed a painful metastatic lesion to the left proximal lateral tibial plateau measuring 3.6 cm × 3.4 cm × 3 cm (**Fig E2a,b** [available online at *www.jvir.org*]). Her pain was refractory to radiation therapy and resulted in wheelchair use. The patient described swelling and discomfort around the left knee 1 week after the procedure; she characterized the pain as pulsating, full, and 3/10 in severity. MR imaging performed 2 weeks after the procedure demonstrated a rounded area of

Table. Patient Demographics

Age/Sex	Primary Tumor	Size	Location	Initial Pain Relief on VAS	Classification*
53/F	Lung	2.6 cm × 2.7 cm × 2.1 cm	Right supraclavicular	5 (8–3)	Neuropathy/D/unanticipated
72/F	Renal cell	8 cm × 3 cm × 4 cm	Proximal left femur	7 (10–3)	Fracture/D/anticipated
52/F	Breast	4.8 cm × 3.5 cm × 3.3 cm	Left acetabulum	7 (8–1)	Osteocartilaginous injury/B/unanticipated
78/F	Adenocarcinoma	8.5 cm × 3.8 cm × 5.5 cm	Proximal right femur	8 (9–1)	Fracture/D/anticipated
42/F	Melanoma	3.4 cm × 3.6 cm × 3 cm	Proximal left tibia	6 (8–2)	Osteocartilaginous injury/B/unanticipated
67/M	Melanoma	2.5 cm × 2.4 cm × 2.3 cm	Intramuscular right gluteal	8 (8–0)	Neuropathy/C/anticipated

F = female; M = male; VAS = visual analogue scale.
*Per Society of Interventional Radiology (SIR) Clinical Practice Guidelines.