MSK Ablation: Can We Push the Treatment Boundaries?

The evolving landscape of musculoskeletal interventional oncology treatment for the management of painful bone metastases.

By Jack Jennings, MD, PhD

Over the last 2 decades, percutaneous image-guided thermal ablation has emerged into an effective option for the management of benign and malignant bone tumors. Increasingly, interventional radiologists are asked to provide minimally invasive therapies for palliation and curative treatment of bone lesions. Osseous metastatic disease is very common in patients with breast, prostate, and lung cancer, with nearly 85% having bone metastases at the time of death.[1] Complications from skeletal metastasis include severe intractable pain and pathologic fractures, which can lead to decreased mobility with resultant reduction in performance status and quality of life. The national economic burden for patients with bone metastatic disease in the United States is nearly 17% of the total direct medical cost estimated by the National Institutes of Health.[2]

Palliation of painful bone metastases is problematic and often exhausts traditional local and systemic therapies, including opioid and nonsteroidal analgesics, radiotherapy, surgery, and chemotherapy. Although radiation therapy remains the gold standard for treatment, meta-analyses have shown that 1 month after radiation, < 30% of patients experience complete pain relief, and there is pain recurrence in nearly 60% at a median 15 weeks after radiation therapy.[3] With this advancement, the interventional radiologist has become an integral component of the patient's multidisciplinary team of medical, orthopedic, and surgical oncologists and can offer a palliative, focal treatment alternative to conventional therapies.

DETERMINING THE PATH TO TREATMENT

The most common osseous lesions we see for potential treatment follow the pattern of the most common metastatic disease sites: the spine and pelvis, followed by long bones and ribs/chest wall. Soft tissue metastases or recurrent primary soft tissue lesions (including desmoids) are also commonly treated with percutaneous ablation. Prior to any treatment plan, patients must be evaluated to determine whether the treatment is for pain palliation or local tumor control, especially in patients with oligometastatic disease. However, these lines can blur because local control is also desired in palliative ablations. This is especially true in spine lesions, where local tumor control is a goal, as it achieves more durable pain palliation and reduces the risk of metastatic spinal cord compression and resultant paralysis. This principle of local tumor control for even palliative lesions could be applied to all lesions for improvement of pain response durability. These patients should all be seen in clinical consultation with a thorough physical examination and thorough imaging review.

It is the responsibility of the interventionalist to have all necessary imaging (often both CT and MRI). The lesion size, adjacent critical structures (eg, nerve and spinal cord), available armamentarium of ablation tools to dictate the ablative modality (eg, cryoablation, radiofrequency, microwave, MRI-guided focused ultrasound), and number of required probes/ablations will determine whether ablation and local control are feasible. Imaging evaluation will also determine the need for thermoprotective techniques to enhance safety and minimize undesired thermal injury to surrounding vital structures as a result of no-target ablation. For example, in larger tumors (> 5 cm in size), the treatment goal is often to ablate the bone–soft tissue tumor interface that is thought to be the source of pain, not necessarily the entire tumor.

CURRENT TECHNOLOGIES AND ADVANCEMENTS

As musculoskeletal (MSK) interventional oncology (IO) treatments have evolved over the past decade, techniques have advanced from the early days of radiofrequency ablation and then cryoablation. Ablative techniques are being combined with cementoplasty and osteosynthesis (ie, percutaneous screw fixation) for lesion or pathologic fracture stabilization, particularly in the weight-bearing bones including the spine, pelvis, and long bones. This—in conjunction with cutting-edge technology like CT, cone-beam CT navigation, and robotics—has advanced the field and allowed for more challenging cases to be treated in the interventional radiology suite.

Likewise, new nonthermal ablation technologies have recently been developed that deliver pulsed electric fields (ie, high-voltage electrical energy altering cell transmembrane potential) to disrupt cell homeostasis. This in turn causes apoptosis and release of antigens that may stimulate an immune response, resulting in systemic abscopal treatment effect. This technology may be additive and synergistic with immunotherapy and other standard of care therapies.

A similar technique involving pulsed electric fields is reversible electroporation, which uses high-intensity electrical pulses across the cell membrane to create temporary cell membrane damage and increase permeability with pore formation. This technique is used with concurrent treatment with chemotherapeutic agents such as bleomycin to allow local therapy to the tumor but with lower drug concentrations and limiting nontarget toxicity. This is being done in the MSK IO space for treatment of metastatic spinal cord compression in patients who have exhausted all other treatment options. Because this technology is nonthermal, it allows ablation near sensitive structures, including neurovascular bundles and the spinal cord. Early results of electrochemotherapy have shown pain and neurologic benefits and decreased tumor size in patients who were previously resolved to paralysis.

At its infancy is combined cryoablation and checkpoint inhibitors/immunotherapy, which has a synergistic effect on modulating the immune microenvironment and causing an antitumoral immune response. This is being used in both experimental and clinical settings for bone and soft tissue lesions.

One of the more studied histologies is melanoma. Studies have demonstrated the potential synergy of cryoablation in patients with unresectable melanoma as it can evoke tumor-specific immune responses by releasing tumor antigens after progression on immune checkpoint inhibitors.

CONCLUSION

The track record for MSK IO over the past 2 decades has been continued growth and adoption, with increasing potential for new and exciting technologic and therapeutic advances. Imaging companies continue to develop ablation planning, navigation, confirmation, and postablation lesion follow-up software to allow us to be more prescriptive and precise in our approach and more precise in our ablations. This will allow for a model similar to our radiation colleagues.

Substantial advances in percutaneous image-guided, minimally invasive MSK oncologic interventions for management of patients with osseous and soft tissue metastases offer a robust armamentarium for interventional radiologists to achieve safe and effective treatment in a multidisciplinary treatment setting. Such interventions may shift the patient management paradigm in modern-era practice.

Familiarity of interventionalists with these procedures and progressive incorporation in clinical practice, as well as continued technologic advances in equipment design and procedural guidance, will further enhance our role in the management of patients with bone and soft tissue metastases. We will also need to continue to advance our multidisciplinary combined treatment of tumors with our medical, radiation, and surgical oncologists to provide state-of-the-art personalized quality cancer care for osseous and soft tissue metastatic disease to improve patient quality of life and prolong or prevent skeletal-related events and their associated morbidities. ■

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Jack Jennings, MD, PhD
Vice Chair, Procedural and Clinical Quality
Professor, Radiology
Chief, Musculoskeletal Radiology
Director, Musculoskeletal and Spine Interventions and Procedures
Mallinckrodt Institute of Radiology
Washington University School of Medicine
St. Louis, Missouri
jackwjennings@wustl.edu
Disclosures: Consultant to and medical advisory board for Stryker, Boston Scientific, Varian, and Bard/BD.