A Radiologist's View of Tumor Ablation in the Radiology Suite

Sharath K. Bhagavatula, MD[a], Jason Lane, MD, MPH[b,*], Paul Shyn, MD[a]

KEYWORDS

• Tumor ablation • Non–operating room anesthesia (NORA) care
• Interventional radiology • Anesthesiology • Collaboration

KEY POINTS

- There are a wide variety of tumor ablation techniques (eg, radiofrequency ablation, microwave ablation, and cryoablation) now available to treat tumors in a wide variety of locations in the body.
- Image guidance (eg, ultrasound, CT, MRI) allows interventional radiologists to target and treat tumors in a safe and effective manner.
- Collaboration and communication between the anesthesiologist and radiologist is critical to safe and successful tumor ablation in the radiology suite.

INTRODUCTION

Percutaneous thermal ablation techniques offer a minimally invasive alternative to surgery in which a needle probe is placed into a tumor and the offending tissue is killed by heating or cooling under image guidance. Typically, the tumor and a surrounding cuff of normal tissue, the ablation margin, are ablated. The usefulness and indications for these procedures have steadily increased as data demonstrating the safety and efficacy of ablation have grown.[1,2] Anesthesiologists are essential in effective periprocedural and procedural management. In this article, we describe common ablation techniques, image guidance modalities, and implications for anesthesiologists.

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[a] Department of Radiology, Brigham and Women's Hospital, Harvard Medical School, 75 Francis Street, Boston, MA 02115, USA; [b] Department of Anesthesiology, Vanderbilt University Medical Center, 1301 Medical Center Drive, 4648 TVC, Nashville, TN 37232, USA
* Corresponding author.
E-mail address: jason.lane@vanderbilt.edu

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ABLATION TECHNIQUES

The most common percutaneous thermal ablation modalities currently used are radiofrequency ablation (RFA), microwave ablation (MWA), and cryoablation (CA).

Radiofrequency Ablation

RFA is a heat-based thermal ablation modality.[3] The RFA probe applies an electric current that travels through the patient to a grounding pad placed elsewhere on the patient's body (typically on the abdominal wall or leg, away from the procedural site). The current concentrates at the needle tip, resulting in localized heating at this location. When the tissue reaches temperatures exceeding 50°C, tissue coagulative necrosis occurs.[3] The duration of an ablation procedure depends on the number and size of tumors to be ablated, difficulty of the probe placement, and image guidance modality. Procedures generally last between 1 and 3 hours.

RFA is most commonly performed under ultrasound or computed tomography (CT) guidance. Although the ablation margin is not usually well-visualized with these modalities, image guidance remains essential to ensure accurate needle placement and to limit complications. Additionally, indirect signs of tumor ablation, such as formation of gas bubbles or subtle tissue attenuation changes, may be used to estimate the ablation zone. Recent advances in contrast-enhanced ultrasound imaging also have shown the ability to depict the ablation zone.[4] MRI is used less frequently because it is more expensive and time consuming, but it may be useful in ablation of tumors that are otherwise not visible by CT or ultrasound imaging. MRI often provides greater anatomic detail of adjacent structures, and therefore may be preferred for ablation close to critical structures. PET/CT guidance is also less common, but is increasing in usefulness and will likely play a greater role given its potential for immediate evaluation of the ablation margin and residual tumor.[5]

Microwave Ablation

MWA also involves the placement of a needle probe into the tumor under image guidance. The probe acts as an antenna that transmits microwave energy into the surrounding tissue; this energy results in rapid molecular realignments (dielectric hysteresis), which cause rapid tissue heating and destruction.[6,7] Unlike RFA, no grounding pad is required to be placed on the patient's body surface. MWA typically creates a more uniform ablation zone with more rapid heating relative to RFA, partly because the microwaves are capable of passing through charred and necrotic tissues more effectively. MWA has also demonstrated better clinical outcomes in the treatment of larger tumors (>5 cm) compared with RFA.[8]

MWA is also most commonly performed under ultrasound or CT guidance owing to relative ease of use and lower cost. MR and PET/CT guidance are being used with increasing frequency for the same reasons discussed for RF ablation guidance.

Cryoablation

CA relies on rapid cooling of tissue to kill tumors.[9,10] Cooling is achieved by rapid expansion of a gas (eg, argon) within the needle probe, with temperatures of at least −40°C resulting in effective ablation. After cooling, tissue is thawed for several minutes. Cycles of freezing and thawing result in cell death by multiple mechanisms, including direct immediate cellular toxicity, delayed apoptosis, and ischemic damage.[9] Each freezing and thawing cycle is repeated at least twice with each cycle lasting 5 to 20 minutes. CA typically takes longer than RFA and MWA owing to the requirement for multiple freeze–thaw cycles and use of multiple probes.