Introduction

Interventional Oncology has evolved and grown into a distinct subspecialty of Interventional Radiology and ablation technologies are a critical component of this growth. From the early beginnings of alcohol ablation to latest addition of irreversible electroporation, ablation has changed cancer management in ways that could not have been imagined just a few decades ago.

Image guided ablation can be broadly classified as chemical, thermal and non-thermal.

Chemical Ablation

Chemical ablation involves the injection of alcohol or acetic acid, following needle placement in the tumor. Alcohol has been used widely as a chemical ablation agent and induces cytoplasmic dehydration, denaturation of cellular proteins and micro-vascular thrombosis leading to coagulation necrosis. The main limitation of chemical ablation is the lack of uniform distribution of the injected material in the tumor.

Radiofrequency Ablation

Radiofrequency ablation, is a thermal ablation technique, where alternating current is delivered to the tumor tissue via a needle electrode. Grounding pads are required on the patient to complete the circuit. The current agitates tissue around the tip, causing water molecules to oscillate around a 180° axis creating frictional heat, which leads to coagulation necrosis. At 45 °C-50 °C protein denaturation and loss of cell structure occurs. Thermal coagulation occurs at 70 °C and tissue desiccation and necrosis at 100 °C. RFA still remains an appealing ablation treatment option in several parts of the world due to the extensive experience and literature and low cost compared to other technologies.

Microwave Ablation

Microwave generators operate at either 915 Mhz and 2450 Mhz. The ablation antenna agitate water molecules in tissue, producing friction and heat, inducing cellular death by coagulation necrosis. Microwave technology has some advantages compared to RFA. The heating is active and does not rely on electrical current. MW ablation is less susceptible to heat sink effect and grounding pads are not required for MW ablation. Higher intratumoral temperatures can be achieved in faster ablation times. Because of these advantages, microwave ablation is rapidly replacing RFA in the United States.

Cryoablation

Cryoablation works on the principle of the Joule-Thompson effect, by creating unique freeze and thaw cycles. The Joule-Thomson effect describes the change in temperature of a gas resulting from expansion or compression of that gas in a small chamber at the distal end of the cryoprobe; expansion creates a heat sink during the freeze cycle and compression creates a heat source during the thaw cycle. The freezing process results in both intracellular and extracellular ice formation, both of which lead to cell death. Intracellular ice crystals cause cell death through direct damage to the cell membrane and organelles while extracellular ice crystals cause a change of osmolality within the extracellular space and, in turn, to cell dehydration and death. The temperature necessary to cause reliable cellular necrosis depends on both the cell type and the thermal history of the tissue, with estimates ranging from −35 °C to −20 °C. Cryoablation produces a well demarcated ice ball, which allows for precision in its application. It can be performed under MR guidance and several probes can be placed simultaneously.

Irreversible Electroporation

Irreversible electroporation is a nonthermal ablation technique that uses high voltage low energy DC current which creates nano-pores in the cell membranes, disrupting the cell’s homeostasis and causing it to undergo apoptosis. Due to the nonthermal nature of this treatment, the collagen matrix in the vessel walls and bile ducts is not affected, allowing for re-epithelization and preservation of vessel and duct function after treatment. With this capability IRE becomes a valuable addition to the ablation arsenal making
percutaneous ablation possible in complex locations like the pancreas. IRE has a steeper learning curve and requires general anesthesia and muscle relaxation, Cardiac gating is standard and a minimum of 2 probes are required for a treatment.

The impact of ablation in oncologic management is no longer based on anecdotal evidence or case reviews. Cancer patients are usually referred to an Interventional Oncologist by other specialties such as surgical and medical oncology. In spite of this handicap, research in IO continues to grow. Retrospective and randomized controlled trials have paved the way for organ specific indications and a place in standard of care treatment algorithms. Early signals of immune response in animal models after cryoablation and IRE give a window into the opportunities for synergies ahead.

Even with all the exciting growth, more research is needed to improve accuracy and outcomes of ablation. Navigation systems and fusion software are becoming more prevalent and have the potential to play a major role in improving outcomes. Relying on enhancement or the lack of might not be the most accurate and reliable way to assess treatment success and we need better response assessment criteria.

As medicine shifts its focus to minimally invasive treatment options with less morbidity and shorter hospital stays, Interventional Oncology and image guided ablation will continue to play a major role in the advancement of cancer care.

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