Percutaneous ablation of focal malignant lesions in the liver: how, when and why

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Learning objectives

We aim to review the clinical indications for percutaneous ablation of focal malignant lesions, and to provide a concise set of pros and cons for each approach and the best available information on which technique to choose in each particular case and how to perform it.

We go through the physical principles for these methods, and the technical breakthroughs that enable the radiologist to treat more of these lesions, in shorter procedure times and with less complications, and continue to gradually improve the outcome for these patients.
FOCAL MALIGNANT LESIONS OF THE LIVER

Focal Malignant Lesions of the Liver can either be primary or metastatic. Hepatocellular carcinoma and metastatic colorectal carcinoma are by far the dominant entities in these patients respectively. Hepatocellular carcinoma is the fourth most common cause of death caused by cancer worldwide. Surgical resection is the elective course of action; however, only 5% to 15% of patients with HCC or hepatic metastasis are foreseeable candidates for curative surgery.

Limiting factors for surgical treatment include the number of tumors, lesions too large for resection, unresectable locations of the tumor or vascular invasion, insufficient functional reserve of the liver, or any of a number of general contraindications for surgery.

The average 5-year survival rate after successful resection for both HCC and metastasis is no higher than 40%. In the best cohorts, and most of these patients will develop recurrence of tumor, and face a fatal outcome.

ALTERNATIVES TO SURGERY

Several minimally invasive techniques have been developed in the field of interventional radiology as an alternative to surgery. The most prevalent of these in our environment are: percutaneous ethanol injection (PEI), hepatic arterial chemoembolization, and physical ablation techniques including radiofrequency and microwave ablation. Laser techniques and crioablation are less widely employed.

Percutaneous ethanol injection has been reported to be relatively successful in small HCCs but is not very useful for metastasis.

Chemoembolization is often reserved for unresectable tumors as a palliative technique without curative intentions.

Radiofrequency and microwave ablation are the most prevalent approaches in the present and, with their particular advantages and pitfalls, constitute the standard of care and consistently improve the survival rate in these patients.
CLINICAL INDICATIONS

Several different protocols are available that may differ in the details of the indications they provide.

As these protocols evolve they all follow the same general principles and usually become more and more inclusive and aggressive in the treatment of these lesions due to the good clinical results obtained and the increased availability and experience applying these techniques.

As a general rule, percutaneous ablation can be used to treat a single or a few lesions of the liver, whether primary or metastatic, to serve as a bridge towards hepatic transplantation, as a coadyuvant to systemic treatment, or as a palliative approach in large and painful lesions near the capsule with good results diminishing pain even when a complete ablation is out of the question.

ETHANOL ABLATION

Ethanol injected percutaneously directly to the lesion causes dehydration of the cytoplasm and coagulative necrosis, then inducing a fibrous reaction.

Within the vessels, ethanol induces platelet aggregation and endothelial necrosis, thus leading to thrombosis and local ischemic necrosis.

Pros:

It's an inexpensive technique, easy to perform and with minimal technical requirements, and it has classically shown good clinical results, specially in primary malignant liver tumors.

Cons:

The size and shape of the necrosis induced depend on various factors out of the radiologists control, such as local vessel, histological characteristics or the presence or absence of a capsule for the lesion.
Clinical results for metastatic disease are not as favorable as they are in the case of HCC.

**RADIOPHREQUENCY ABLATION**

An alternating current is induced in the patient, and conducted through the tips of the electrodes at the end of the ablation needle, thus creating mechanical ionic agitation and frictional heat in the surrounding tissue, with an approximately spherical shape of up to 5cm in diameter.

Minimal target temperature is about 50ºC to 60ºC and up to 100ºC, above which coagulative necrosis occurs in living tissue.

**Pros:**

It's a very widely used technique, well known, relatively safe and with good clinical results.

Ablation shape is usually very close to a sphere, and the extent and margins of necrosis are well understood and fairly evident when performing this technique under US guidance. Several repeated ablations can be performed in the same procedure to treat larger lesions.

**Cons:**

A single ablation is in the 10-20 min. range, since thermal heating is slow and it can be affected by blood vessels in the proximity and thermic conduction throughout the tissue.

Subcapsular tumors tend to produce more pain and the longer time necessary becomes an issue for percutaneous procedures with local anesthesia. Also, ablation of tumors close to the larger portal triads must be careful, to ensure that no damage is induced to the biliary structures.

**MICROWAVE ABLATION**

Coagulative necrosis is induced in the tissue by means of an electromagnetic wave in the microwave range generated at the tip of the ablation needle, through the movement of the atomic dipoles that this wave induces as it changes the local electromagnetic field.
Pros:

A faster heating speed than radio-frequency based techniques minimizes the effects of heat dissipation through adjacent blood vessels, thus enabling us to treat those lesions that are close to major vascular structures without the dramatic loss of efficacy shown by the radio-frequency techniques.

Tissue necrosis is very uniform, and less dependent on poor heat transmitting regions.

No conducting pads are necessary, no electrical current goes through the patients body, which means pacemakers are no longer a contraindication as they are when using radio-frequency.

Cons:

Up until now, technical hurdles for these approach included the large diameter of the needle, the need for a special and dedicated cooling system, and the backwards undesired thermal effects.

Recent technological breakthroughs are eliminating these inconveniences, and rendering this a safe and apt technique, that will surely become more prevalent in years to come.
Fig. 4: HCC (3cm) of the II-III segments. Microwave ablation is decided, since the lesion is adjacent to the left portal vein. Image shows the ecography performed at the beginning of the session with the needle going through the tumor and it’s tip one centimeter away from it's edge, being placed for ablation.

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Fig. 5: Figure shows the hyperecogenic region of ablation, discretely ovaly shaped, and growing backwards.

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Fig. 6: Control CT in the arterial phase of the lesion which underwent ablation in figs 1 and 2 shows no enhancement where the tumor previously was that may suggest the presence of tumoral presence, not even in the area most adyacent to the left porta.

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Fig. 7: Portal phase of the same CT as fig 3 shows portal permeability distal to where the ablation was performed.

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**Fig. 2:** Conventional and new antennas with a choke device for reflected microwaves.

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**Fig. 3:** Time and ablation areas.

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**Fig. 1:** Physical principles of RF

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Fig. 8: Ultrasound shows a hyperecogenic lesion where a RF ablation was performed. No flow is seen within the lesion with the power Doppler.

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Fig. 9: RF ablation was performed in the VIII segment. Five months after the procedure MRI with contrast in an arterial phase shows the hypointense region where RF was performed, and the hyperintense adjacent region where tumor is still present and has regrown.

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Fig. 11: Contrast CT in the portal phase, same patient as Fig 10, shows how the lesion is much less visible in this phase, showing the importance of an adequate study of these lesions.

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Fig. 10: Contrast CT in the arterial phase shows an enhancing lesion that proved to be a metastasis. RF ablation was later performed.
Conclusion

Percutaneous ablation of focal lesions of the liver is a very widely used and very successful procedure both in primary and metastatic lesions.

As new technologies and studies have developed, radiophrequency ablation has become the most prevalent approach amongst a number of different options available.

Microwave ablation has seen some major breakthroughs in the last few years and we will probably see it grow in the future due to its speed, increased accuracy and relative lack of contraindications.

Radiologists must know the general founding of these procedures and their indications, and how they compare to each other in different parameters.


