Liver Ablation – The Who, What, When, Where, and Why

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Introduction

Percutaneous liver ablation is classically done for both primary and secondary liver tumors. The most common indications include Hepatocellular carcinoma (HCC) and metastatic disease from the colon. Additional indications include the management of benign hepatic lesions such as hemangiomas and hepatic adenoma. Several imaging modalities (US, CT, MRI) can be used to complete the procedure. The choice of ablative technique will also vary (radiofrequency, microwave, etc.) depending on the structure and location of the hepatic pathology. It is important for a resident to know the basic steps and equipment involved.

Patient Selection

Indications

- HCC
  - Per the Barcelona Clinic Liver Cancer (BCLC) group recommendations [1], percutaneous ablation is recommended as an alternative to surgery for either:
    - Stage 0: single liver lesion measuring <2 cm (very early stage)
    - Stage A: solitary lesions >2 cm or early multifocal disease characterized by up to 3 lesions measuring less than 3 cm (early stage)
- Liver Metastases
  - Per expert consensus [2], percutaneous ablation is recommended when a patient is not a candidate for surgical resection or has failed other therapies. Additionally recommendations suggest that:
    - Lesion size < 3 cm, but with allowance to < 5cm when lesions are well located
    - Lesion number < 5, but with allowance to < 9 in select cases
- Benign Liver Lesions
  - Select applications of percutaneous ablation are recommended for benign liver lesions for either:
    - Prevention of rupture and/or hemorrhage
    - Potential malignant degeneration (most commonly in adenomas)

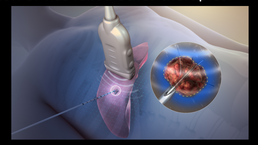


Figure 1: RF Ablation of Tumor [3]

Contraindications

- General: Uncontrollable bleeding, (abnormal coagulation studies), infection, poor ECOG performance status <3, Child-Pugh Score C

Figure 6: Choice of Image Guidance

1st Line
Ultrasound (US) and Computed Tomography (CT)

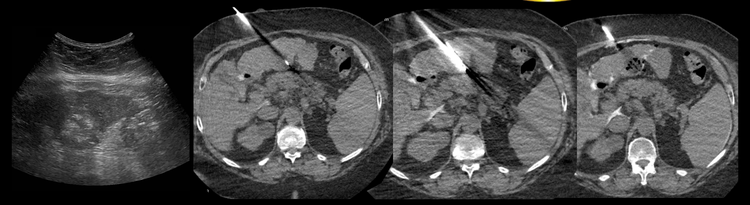
→

2nd Line (poor US-visibility or CT occult)
Magnetic Resonance Imaging (MRI), Contrast-Enhanced Ultrasound (CEUS) and PET/CT

Real-time registration between modalities has been shown to improve technical success of the procedure [9]

Figure 7: Procedural Technique

1. Sedation and local infiltration of anesthesia at puncture site
2. Place probe into the center of the lesion, confirm location using image-guidance
3. Activate probe to generate desired ablative properties
4. Ensure replacement of lesion with ablation zone, > 5 mm around circumference
5. Confirm appropriate ablation using post-procedure imaging technique based on planning imaging protocol



Procedure Details

Table 1: Most employed treatment modalities for percutaneous liver ablation

	Radiofrequency Ablation (Thermal)	Microwave Ablation (Thermal)	Cryoablation (Thermal)	Irreversible Electroporation (Non-thermal)
Mechanism	Needle electrode and grounding pad generate high frequency alternating electric current	Antenna delivers electromagnetic energy at microwave frequencies (915 – 2.45 Ghz)	Rapid reduction of tissue temperature promotes destruction of cellular architecture though formation of intracellular and extracellular ice crystals	Needle electrodes deliver high voltage electrical pulses that create nano-sized pores in the cell membrane -> leads to loss of homeostasis and cell death
Additional Details	- First technique to come to prominence but has variable outcomes due to tissue charring (alters tissue anatomy and conductivity) -Susceptible to "heat-sink effect" [3]	- Less susceptible to heat sink effect, faster ablation and ability to treat larger tumors than RFA	- Evidence suggests that RFA is superior - Risk of cryoshock (multiorgan failure, DIC, high mortality) and excessive bleeding	- No heat-sink effects - Preservation of the extracellular matrix and collagenous structures in ablation zone
Treatment time	5-10 minutes/probe	5-10 minutes/probe	15- 30 minutes/probe	50-100 microseconds/pulse 50-100 pulses typically used

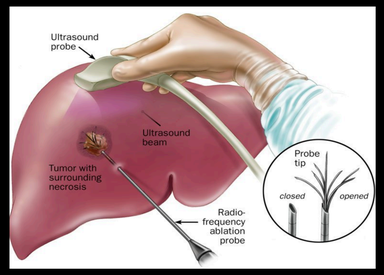


Figure 2: Schematic of Radiofrequency Ablation[5]

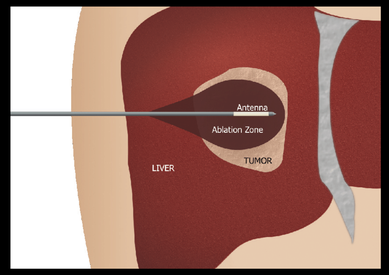


Figure 3: Schematic of Microwave Ablation[6]

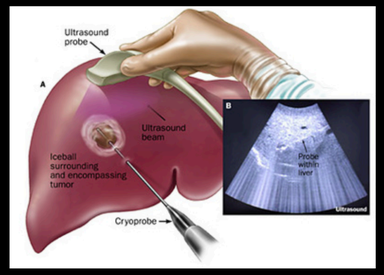


Figure 4: Schematic of Cryoblation[7]

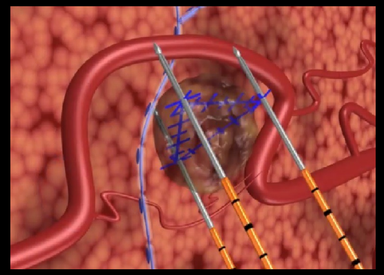


Figure 5: Schematic of Irreversible Electroporation for pancreatic tumor[8]

Complications

Infectious
- Hepatic Abscess (0.3 -2%)
  - Prevention: Potentially prophylactic antibiotics
  - Management: Antibiotics if smaller, Drainage if larger or refractory to antibiotics alone

Vascular
- Hemorrhage (<2%, depending on hepatic parenchymal status & location of tumor)
  - Prevention: Correct coagulopathy, minimize passages through hepatic capsule and avoiding major vessels
  - Management: Conservatively if venous, Transfusion/embolization or surgery if arterial
- Portal venous thrombosis (1.7%), Hepatic venous thrombosis (1.4%)
  - Prevention: Avoid vascular structures, choose ablative options that minimize "heat-sink"
  - Management: Potentially systemic anticoagulation or local thrombolysis

Biliary
- Bile leakage, Biloma formation, Cholangitis, Abscess
  - Prevention: Choose ablative options that minimize "heat-sink," active biliary cooling via drainage tube
  - Management: Potentially percutaneous or endoscopic drainage for severe cases

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Percutaneous Liver Ablation: Equipment, Technique, and Imaging

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- Liver Metastases
  - Per the, percutaneous ablation is recommended as an
- Benign Liver Lesions

Femoral or Radial Artery Access (Table 1).
- A micropuncture kit can be used (Figure 1) which includes an 18G needle, .018 w… …ural (Figure 2).
- The puncture site is localized below the inguinal ligament over the femoral head …
- Sheaths: (Figure 3a and 3b …

Fig 1: Micropuncture kit

Fig 2: Superficial femoral artery (Puncture the skin at zone 5 and enter artery at Zone 3.

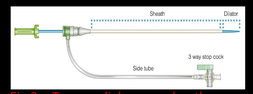


Fig 3a: Trans-radial access sheath

Figure 3b: Trans-femoral access sheath

Fig 4a: Manifold

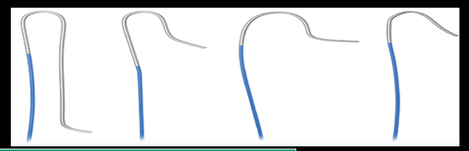
Fig 4b: Tuohy-Borst Adapter

3-D rotational angiography showing a 3 mm recurrent aneurysm – treated with clipping previously

…wire, t… …5 J wi… …30-90 is placed in the carotid artery to support further stroke…

Diagnostic:

- Catheterization:
  - Diagnostic catheters include Simple vs Complex Curve catheters (Figure 5).
  - Contrast injection Rates and Imaging Frame Rates for Common Selective Catherization (table 2), commonly manual hand injection is also done as per operator preference.
  - Type of Contrast used in Neuroangiography (visipaque is mostly used in renal insufficiency) (table 3), often further diluted.
  - Bi-plane positioning for Cerebral vessel visualization (Table 4), standard views include AP/Transorbital and Lateral. Rotational 3D angiography has now become gold standard.
  - Glidewires include: 0.035 / 0.038 inch
  - Microcatheters: (0.021 to 0.027 inch) and Microguidewire (0.014 vs 0.018 inch) → used for superselective microangiography.



Simple Curve Catheters	Complex Catheters
e.g: Vert 45, Berenstein 90	e.g: Vitek, Simmons I-II

Figure 5: simple vs complex curve catheters

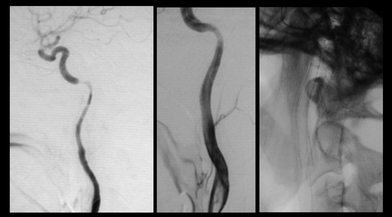
Product Name
Omnipaque 240
Omnipaque 300
Isovue 200/300
Visipaque 320

Table 3: Types of Contrast

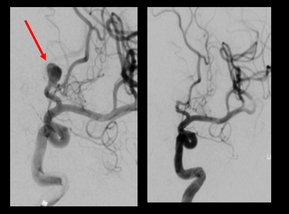
	Femoral Access Technique	Radial Access Technique
Access site bleeding	3 – 4%	0 – 0.6%
Artery complications	Pseudoaneurysm, retroperitoneal bleed	Rare local A-V fistula, painful hematoma
Ambulation	2-4 hours	immediate
Extra costs	Closure device vs. manual compression	TR-band

Table 1: comparison between femoral vs radial access technique

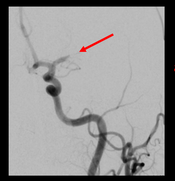
Table 4: Bi-plane positioning for Cerebral Vessel Visualization



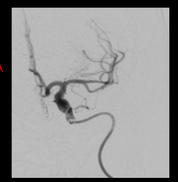
ICA Dissection causing hypoperfusion stroke, treated with stenting



Ruptured ACOM Aneurysm treated with coiling



Digital Subtraction angiography showing MCA Clot, with Trevo XP 4x20 device and Penumbra Aspiration



Vessel	Contrast injection Rate (mL/s)/total mL	Framing rate (frames/second)
Aortic arch	20/40	3
Extracranial ICA (catheter in CCA)	4-5 / 7-8	2
Cerebral Angiogram (catheter in CCA)	7- 8 / 11 – 12	2 - 3
ECA (catheter in ECA)	4 – 5 / 6 – 7	2
Posterior Cerebral Angiogram with catheter in vertebral artery	6 – 7/ 9 - 10	2

Table 2: Contrast Injection Rates and Imaging Frame Rates for Common Selective Catherization

Stroke Intervention Tools:
- Long Sheath Catheters vs. Balloon-guide Catheter (Figure 9): Typically 0.088 Internal diameter. Examples: Infinity LS, Neuron max, Shuttle.
- Aspiration Catheters: Catalyst 6, Penumbra ACE catheters, etc.
  - Connected to aspiration tubing and pump (Figure 10)
- Microcatheters (.021-.028): Headway, Marksman, Prowler Select, etc.
- Stent-Retrieval Devices (3-6mm) (Figure 12): ex. Trevo, Solitaire FR, Penumbra 3D.

Procedure: The sheath is placed in the carotid artery, microwire and catheter are advanced to cross occluded vessel, stent device is deployed, +/- balloon inflated, and suction thrombectomy performed. In contrary stent device may not be utilized by all operators.

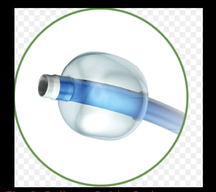


Fig. 9: Balloon Guide Catheter

Fig. 10: Aspiration tubing and Pump

Fig 11: Clot from Thrombectomy

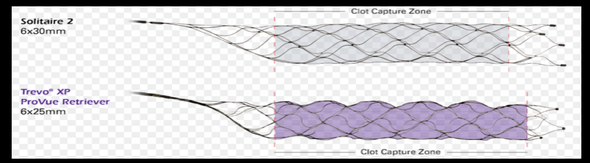


Fig 12: Stent- Retrieval Devices

Complications

- Neurological complications:
  - Stroke (1%), TIA (2.5%), Thromboembolism, and Perforation.
- Non-neurological complications:
  - Renal failure (0-0.15%), arterial occlusions requiring intervention (0 - 0.4%), AV fistula (0.01 – 0.22%), hematoma (groin, retroperitoneal) (0.25-1.5%).

- Increase in length of procedure, number of catheter exchanges and amount of contrast used is associated with higher rates of complications[5].

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