Role of cross sectional imaging in diagnosis of complications after thermal ablation of hepatic tumors

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Background

Introduction:

Ablation of a tissue means destruction of the pathological portion of the tissue or organ using thermal energy aiming to get complete satisfactory cure of the underlying disease. It may be done through heating or cooling. Temperature either above 50 °C (122 °F) or below - 40 °C (- 40 °F) is efficient in cell destruction.

Thermal ablation of the tumors is well settled as an efficient less invasive therapeutic method compared to the surgery in treatment of certain tumors, essentially in cases unfit for surgical intervention like advanced recurrent disease, multiple lesions or in small localized accessible lesions to avoid the risk of surgery and associated higher morbidity and mortality.

The liver tumors are very common indication for thermal ablation either primary tumors (like hepatocellular carcinoma) or metastatic lesions (like colonic carcinoma deposits). Ablation could be used as neoadjuvant or adjuvant therapy before or after surgery or in combination with radiotherapy or chemotherapy.

Advantages of thermal ablation of tumors:

- Effective treatment for small tumors.
- Minimally invasive with no large skin incisions.
- Lower morbidity and mortality risk.
• Less painful
• Short hospital stay
• Easily repeated in recurrent or residual lesions
• Higher survival compared to surgery.

**Types of thermal ablation:**

**Heating types:**

• Radiofrequency (RF) electric current
• Microwave ablation
• Laser-induced thermotherapy (LITT)
• High-intensity focused ultrasound (HIFU), under trials however it is more common in China

**Cooling type:**

Cryoablation (Cryosurgery or Cryosurgical ablation)

Radiofrequency ablation (RFA) is the most common type. It is guided by imaging (CT or US). A needle inserted through the skin and targeted to the tumor core. High-frequency electrical energy is applied through this needle to heat the tumor and produce cellular destruction. On the long run the successfully ablated lesion will be replaced by non viable scaring and fibrosis. RFA is used in management of neoplastic lesions of some organs like liver, bone, kidney, lung and others.

Microwave ablation is also commonly used in hepatic tumors ablation as it has many advantages of the RFA and also it overcomes some of RF limitations.

RFA and microwave ablation are still the most common methods of thermal ablation compared to the other types.

**Indications of thermal ablation of hepatic tumors:**

1. Hepatocellular carcinoma.
   • Small lesions according to Barcelona Clinic Liver Cancer (BCLC) classification
   • A single lesion < 5cm or 3 nodules < 3cm each, no evidence of vascular invasion or extrahepatic deposits. Child-Pugh class A or B.
- Patients unfit for surgery or transplantation.

2. Liver metastases:

- Few colorectal deposits in patients unfit for segmentectomy or lobectomy.
- Deposits of other primary tumors like breast & endocrine tumors.

**Contraindications for thermal ablation:**

Absolute contraindications:

- Lesions located < 1cm far from the CBD or near the hepatic hilum, to avoid biliary obstruction.
- Intrahepatic biliary dilation, to avoid complicated cholangitis.
- Exophytic lesions, to avoid peritoneal tumor seeding.
- Refractory coagulopathy.

Relative contraindications:

- Bilioenteric anastomosis, for risk of hepatic abscesses.
- Superficial subcapsular lesions, for risk of complications.
- Lesions adjacent to stomach and bowel loops, for risk of thermal injury.
- Lesions adjacent to the gallbladder, for risk of cholecystitis or perforation.

Lesions near the blood vessels aren't absolutely contraindicated because the vascular wall is protected by the flow; however leakage of heat by the blood flow may lead to incomplete ablation of the lesions.

**Patient Preparation:**

1. Proper evaluation of patient's records, clinical history, physical examination.

2. Inspection of the prior imaging studies of the lesions to

- Revision and confirmation of the referred diagnosis
- Confirm indications and accessibility of the lesions.
- Proper staging of the tumor using Triphasic MDCT or contrast enhanced dynamic MRI study for HCC, regarding hepatic deposits US, CT or MR of the abdomen is used.
• CT study of the chest or whole body PET-CT may be used to exclude remote metastasis.
• Careful assessment of the number, size, location of each lesion and relations to adjacent structures and organs.

3. Laboratory tests:

• Tumor markers: AFP level for HCC and carcinoembryonic antigen for colorectal deposits.
• Coagulation profile: Complete blood count, platelet count, prothrombin time (PT), and international normalized ratio (INR). PT ratio >50% and platelet count >50,000 /mL are considered adequate for the procedure.

4. Medications.

• Antiplatelet medications: Aspirin, ticlopidine, clopidogrel and nonsteroidal anti-inflammatory drugs are recommended to be stopped 10 days before liver intervention, to be resumed 48-72 h after the procedure.
• Anticoagulant drugs: warfarin should be stopped 5 days before the procedure and could be resumed on the day after intervention. However heparin and similar medications should be stopped 12-24 h before ablation.

Post-ablation:

• Bed rest for 1-2 h
• Monitoring of vital signs. If stable, the patient can go home on the next day.
• Evolution of response by dynamic CT or MRI 1-2 months later.
• Successful ablation shows non enhancing area with or without a peripheral enhancing rim (representing reactive hyperemia followed by local fibrosis).
• Incomplete ablation may shows peripheral non uniform irregular or nodular contrast uptake.
• Regular follow-up by imaging to detect any recurrence, newly developed lesions or metastasis.

Findings and procedure details

Different Cross sectional imaging studies are efficient tools in detection, early diagnosis and follow up of the complications of different thermal ablation techniques used for liver lesions. MDCT, CTA, MRI, MRA and MRCP are the main techniques used for this issue.
Complications of thermal ablation

Major Complications

1. Liver abscess (Cases 1 & 2).
2. Gall bladder rupture (Case 3).
3. Vascular injury due to adjacent ablation with secondary occlusion (Cases 4 & 6).
4. Bile duct injury and Biloma (Case 5).
5. Pleural effusion and complicated empyema (Case 7).
6. Hemorrhage (Case 8).
7. Ascites and deteriorated liver functions (Case 9).
8. Diaphragmatic injury (Case 10).
10. Rupture of lesion.
11. Tumor seeding along the track of the electrode.
12. Massive skin burns.

Minor Complications

1. Pain.
2. Fever.
3. Skin burn not requiring surgical intervention
4. Focal non significant segmental biliary obstruction.
5. Asymptomatic Minimal pleural effusion.

* Images for this section:
Fig. 1: Case 1: Axial CT scan following intra-operative RFA of HCC located within segments VII & VIII, the procedure was complicated by large abscess with internal air/fluid level.
Fig. 2: Case 2: Axial CT scan of the liver shows intraparenchymal abcess with internal air lucency following microwave ablation of HCC.
Fig. 3: Axial CT cuts of a case of perforated gall bladder after RFA of hepatic deposit from colonic carcinoma, the lesion was adjacent to the gall bladder.
**Fig. 4:** Case 4: Status post ablation of a lesion within the caudate lobe adjacent the hepatic hilum with secondary injury of the stump of the right portal vein that appears amputated & none enhanced with secondary perfusional contrast distribution of the right hepatic lobe.
Fig. 5: Case 4 (Continues): Upper cut of the same case shows the totally occluded right portal vein by the ablated region associated with segmental biliary dilation as well.
Fig. 6: Case 5: A Male patient 66y old post RFA (A) axial arterial phase image demonstrating the left hepatic lobe focal lesion before ablation (yellow arrow). Note that the lesion is intimately related to the left hepatic duct. (B & C) axial T1 and T2WIs, (D & E) coronal T1 and T2 WIs obtained 1 month after the ablation. The ablated zone (red arrows) is seen communicating with the biliary tree with Multiple irregular shaped cystic lesions are seen within the left hepatic lobe representing biliary collections (Biloma) secondary to left hepatic duct injury
**Fig. 7:** Case 5 (Continues): Axial T1 3D THRIVE during the arterial phase (A) and delayed phase (B) showing patchy arterial phase enhancement of the liver parenchyma then it becomes rather homogenous in the delayed phase. This is most probably secondary to arterio-portal shunting and injury to the segmental portal vein branches. (C) 3D volume rendered MRV image for the portal venous system confirms patent main left portal vein branch (white arrow).
Fig. 8: Case 6: 65 year old male post Microwave ablation A. axial T1, B. axial T2WIs, C. diffusion WI (b 1000) and D. ADC map obtained 1 month after the ablation. The ablation zone in the right hepatic lobe elicits high T1 and low T2 signal (coagulation necrosis). It appears of low signal in DWIs and high signal in ADC map. Note the surrounding ill defined parenchymal area of low T1 and high T2 signal that also appears hyperintense in the diffusion WIs which represents perfusional changes secondary to right portal vein occlusion.
Fig. 9: Case 6 (Continues) : Axial T1 3D THRIVE dynamic study in the arterial (A), portal (B) and delayed phases (C). The ablation zone is non enhancing while the surrounding parenchyma shows patchy ill defined enhancement during the arterial phase that regressed in the portal and delayed phases. (D) Color coded perfusion map and time intensity curve shows progressive enhancement of the parenchyma (red curve) with non enhancing ablation zone (blue curve).
**Fig. 10:** Case 6 (continued): (A) 3D volume rendered MRV image and (B) MIP MRV for the portal venous system show patent main and left portal veins with occluded right portal vein.

**Fig. 11:** Case 7: A female 48 Y old with colon carcinoma underwent microwave ablation of hepatic dome metastatic lesion shows moderate right side pleural effusion.
Fig. 12: Case 7 (continuous): 4 weeks later, follow up CT scan of the chest shows complicated Empyema
Fig. 13: Case 8: female Pt 39y old underwent RFA of small subcapsular HCC that complicated with encysted subcapsular hematoma.
Fig. 14: Case 9: Free ascites with deteriorated liver functions developed after microwave ablation of small HCC at the hepatic dome.
Fig. 15: Case 10: A case of intra operative RFA of large hepatic metastatic lesion from right colonic carcinoma shows internal breaking down with air formation denoting
abscess formation associated with mild subcapsular hematoma and injury of the right diaphragmatic copula that seen elevated with subsequent right lower lobe lung collapse.
Conclusion

Thermal ablation is a crucial therapeutic tool for primary and secondary hepatic tumors, awareness of its complications and their impact on patient’s survival and outcome is mandatory for both General and Interventional radiologists to avoid increased mortality and morbidity. Cross sectional imaging tools have an important role in detection of these complications and guiding for proper management.

Personal information

References