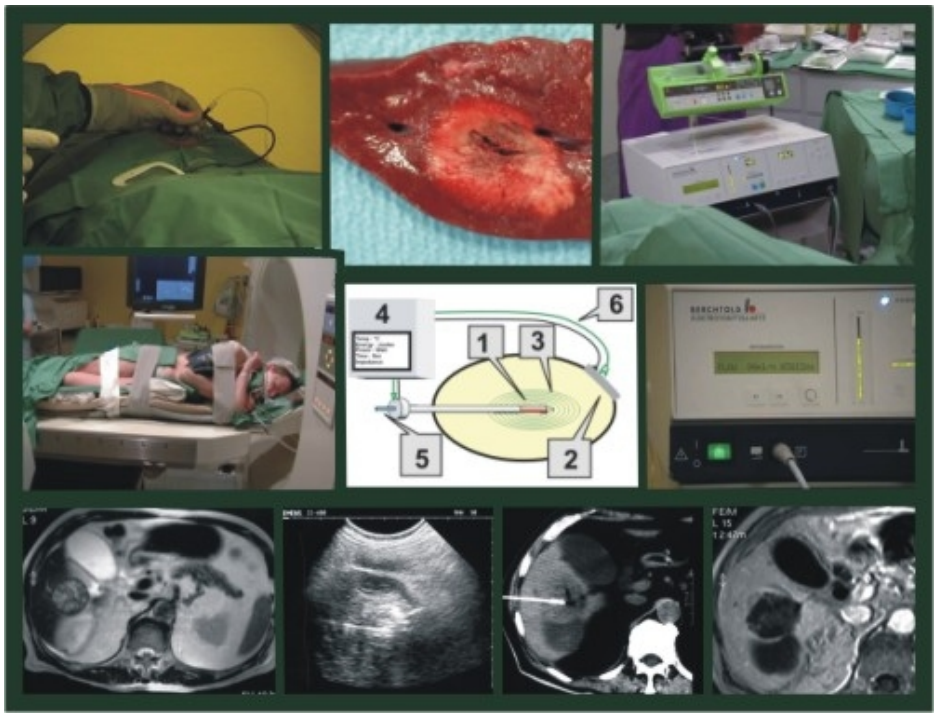

Radiofrequency liver tumor ablation with a wet electrode Dupas BM; Gangi A; Frapas E; Guth S; Le borgne J; Imbert JP (ECR 2002)

Any questions or to submit cases please send us the mail at following addresses
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A special note of gratitude goes to Stephen Ferron, Petra Gangi and Nathalie Chalus for checking the presentation.

Abstract

- Purpose: To evaluate the efficiency and the complications of radio frequency ablation of liver tumors with a wet electrode under CT and ultrasound guidance.
- Method and materials: 170 patients underwent percutaneous RF ablation of 224 liver tumors using a wet electrode with simultaneous saline interstitial infusion at the tip (through side holes) during ablation (Berchtold, Tuttlingen, Germany): 86 patients had hepatocellular carcinoma, 69 colorectal metastases, 12 breast cancer metastases, 1 stromal tumor metastases, 1 melanoma metastases and one cholangiocarcinoma. Patients were not considered operative candidates. Treatment response was evaluated with helical CT and/or MRI 24 hours after treatment, 1 month and every 3-4 months. Patients were followed for up for 6 to 24 months (mean 11 months).
- Results: one month after treatment, complete necrosis was obtained in 95.7 % of the lesions < 2,5 cm, 76 % of the lesions ranging from 2.5 to 3.5 cm, and 54 % of the lesions > 3-5 cm (maximum 9 cm). Margins of necrosis were irregular but well delineated. Repeat treatment was performed when partial necrosis was achieved or when local recurrence or new lesions were observed. Major complications occurred

- in 7 patients with HCC: 3 liver abscess (with one death) and 4 seedings, one in patient with metastases.
- Conclusions: the wet electrode technique allows an effective and easy radio frequency destruction for lesions < 2.5 cm, the results are encouraging for lesions > 3.5 cm with overlapping method. Additional advantages of wet electrode, are low cost, hypertonic saline infusion and bipolar electrode possibilities.

1) introduction

Radio frequency Ablation (RFA) is becoming the most commonly used and perhaps most promising minimally invasive modality for hepatic tumors ablation: most patients with primary (hepatocellular carcinoma) and secondary liver cancer are not candidates for curative resection. Many recur after resection and all of them are potential candidates for combined treatment: chemotherapy, surgery and RFA. All the authors agree that tumors < 3 cm are potentially curatively treatable by RFA. But objectives to treat bigger tumors remain topical, thanks to combined treatments and progress in RF devices. The goals of this poster presentation are to describe and to evaluate the efficacy, the adverse effects and complications of RFA for liver tumors with a wet electrode. In addition it demonstrates the advantages of the C T guidance. This presentation also assesses the future interest of 5 % hypertonic saline infusion and bipolar technique with this type of wet electrode.

2) material and methods

- PATIENTS
  - RFA of unresectable primary and metastatic liver tumors was applied to treat 224 tumors in 170 patients. All patients had tumors proven at pathologic histology:
    - Hepatocellular carcinoma: n=86
    - Metastases: n=83
    - Colorectal (n=69), breast (n=12)
    - Stromal tumor (n=1), melanoma (n=1)
    - Cholangiocarcinoma: n=1
  - Number of tumors was ranged from 1 to 5 in a same patient.
  - The greatest diameter of the tumor measured 9 cm (range 1-9 cm).
  - All patients with liver metastases were treated by systemic chemotherapy before RFA

- SALINE ENHANCED RF ABLATION
  - RF Generator (375 kHz): ELEKTROTOM HiTT (Berchtold, Tuttlingen, Germany
  - Needle Electrodes
  - Diameter/Shaft Length/active zone: 14 g/ 150-200/ 15-20 mm. The holes in the distal part of the electrode (active zone) serve for saline infusion through the needle, into the surrounding tissue.
  - Power applied: 40-50 W. Perfusion of sterile saline solution was achieved by using a pump

        - 0.9 % NaCl: rate of 105 ml/h
        - 5 % NaCl: rate of 70 ml/h
    - When the impedance increased the perfusion rate increased (bolus) automatically for 1.2 seconds with simultaneous power decrease to 5 Watts (Computer controlled generator). The emerging low flow of the perfusion solution is heated together with the tumor environment to boiling point (the calculated inflow and partial evaporation of saline solution physically prevent any overheating of the needle electrode above the limit of 100 °C). Two dispersive grounding pads were placed on the abdominal wall of the patients. Mean energy dose applied for 5 minutes was 14500 Joules
    - RF ablation time was 10-25 minutes for each tumor

- ASSESSMENT OF TREATMENT

Treatment response, complications and diagnosis of new liver and/or distant metastases were evaluated with helical CT and/or MRI after 24 hours, 1 month and every 3-4 months. Patients were followed-up 6 to 24 months (mean 11 months)

- ABLATION PROCEDURE
    - RFA was performed percutaneously (166 patients) and intra-operatively (4 patients).
    - Antibiotic prophylaxis was no systematic.
    - Percutaneous RFA was performed with conscious sedation.
    - Repeat treatment was performed when partial necrosis was obtained or when local recurrence or new metastases were observed. Multiple lesions were often treated in a single session.

Berchtold Radiofrequency Ablation System

surface area of the electrode ’s active tip (with holes for saline infusion)

CT guidance

3) Results

One month after treatment, complete necrosis was obtained in 95.7 % of the lesions < 2,5 cm, 76 % of the lesions ranging from 2.5 to 3.5 cm, and 54 % of the lesions > 3-5 cm (maximum 9 cm). Margins of necrosis were irregular but well delineated. Repeat treatment was performed when partial necrosis was achieved or when local recurrence or new lesions were observed. Major complications occurred in 7 patients with HCC: 3 liver abscess (with one death) and 4 seedings, one in patient with metastases.224 LIVER TUMORS (170 patients) Follow-up: 30 days after RFA

Diameter of tumors	number of sessions/lesions (repeated treatment)	Complete tumor necrosis
< 2.5 cm	1.2	97.5 %
2.5 to 3.5 cm	1.9	76 %
> 3.5 cm	2.2	54 %

- Complications overall occurred in 9.5 % 224 LIVER TUMORS (170 patients) Follow-up: 30 days after RFA:
  - Subcapsular hematoma, intrahepatic hematoma, pneumothorax, hemothorax, pneumonia, pad skin burn, central hyperthermia (>38¡C), pains > 3 days.
  - Major complications in 8 patients (4.7%)
    - HCC
      - Abscess n=3 (one death)
      - Seeding n=4 (4.6 %)
    - Metastases
      - Seeding n=1

4) discussion

NEEDLE ELECTRODE WITH SALINE ENHANCEMENT RFA TECHNOLOGY

- Advantages of a wet electrode:
  - The application under US and CT guidance is very easy.
  - Multiple treatments create overlapping regions of tissue destruction
  - Low cost of the needle
  - The infusion of NaCl improves the thermal conduction and electrical
  - Conductivity: NaCl minimizes the dehydrating effects of RF energy and continuous saline injection surrounding the electrode tip reduces local carbonization and therefore increasing the size of the tumor necrosis.
  - Interest of 5 % saline injection:
    - decrease of perfusion rate (70ml/h)
    - hypertonic saline allows to obtain a significant decrease in tissue impedance.
- Inconveniences of a wet electrode:
  - Irregular areas of necrosis.
  - With 0.9 % saline infusion, a great volume is necessary (105ml/h) for several applications in a single session.
  - Risk of needle obstruction by coagulated tissue.
  - Risk of sub-capsular and/or extra-capsular diffusion of NaCl solution,
  - when tumors are near the capsule: the side holes must be localized within parenchyma (> 1 cm inside).

CT GUIDANCE

Better planning before treatment than US. The needle tip is localized and placed with precision, thus decreasing the risk of injury to the adjacent structures. Overlapping can be effective without obscuration of the target by the vapor bubbles formation. Control of the treatment is better for large tumors and upper segments (4,7,8), which are difficult to visualize.

PERCUTANEOUS RFA PROCEDURE

The most important is safety and efficacy.

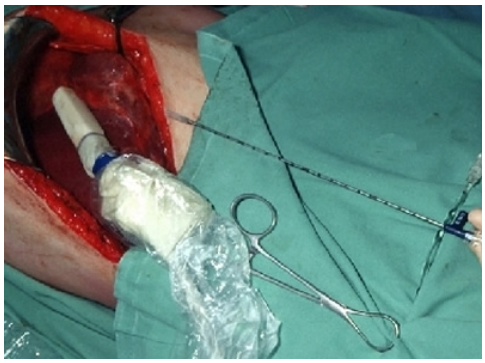
- Advantages: Minimal invasive. Conscious sedation. No importance of previous operations. Short hospitalization, fast recovery.
- Inconveniences: Staging limited to pre operative investigations. Risk of tumor track seeding, Tumors too adjacent to other organs (colon, stomach, gall bladder)

INTRA OPERATIVE RFA PROCEDURE

Advantages: Good tumor staging, location of tumors missed by CT and seen on per operative US. Prevention of bleeding and track seeding. Associated Pringle maneuvers. see percutaneous versus operative cases.

Inconveniences: General anesthesia. Invasive procedure. Difficult if patients had previous operations. Ultrasonography guidance during RFA is less precise than CT because of the target obscuration produced by vapor bubbles. see guidance cases

Combined treatment: Resection and RFA for unresectable tumors with possibility of curative treatment.

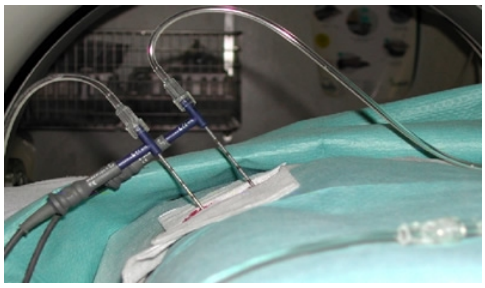


THE FUTURE: BIPOLAR TECHNIQUE WITH 5 % SALINE INFUSION

Advantages see bipolar cases

- No pad skin burn.
- Decrease of saline volume infused.
- Duration of treatment: 50 % reduction.
- Areas of necrosis more regular

- Decrease of the risk of thermal injury to adjacent non-vascular structures, perihilar structures, stomach, colon, and diaphragm.

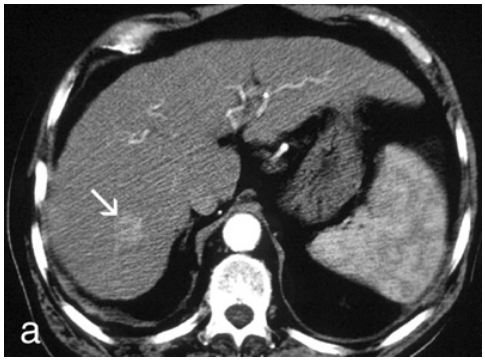


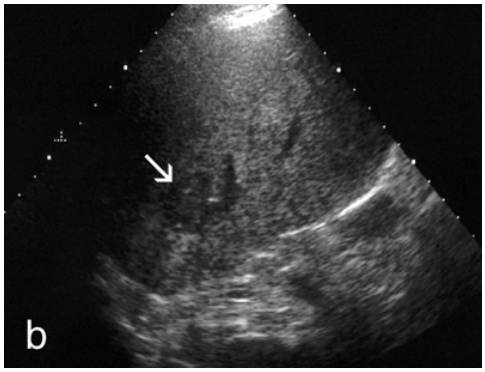
5) Cases

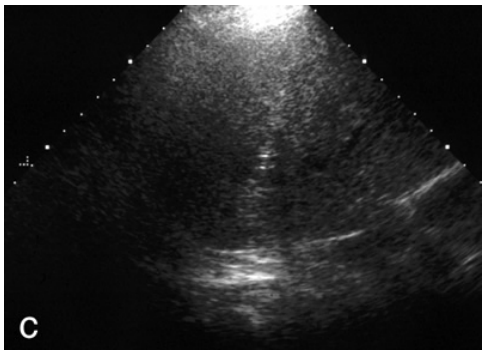
CT versus Son. guidance

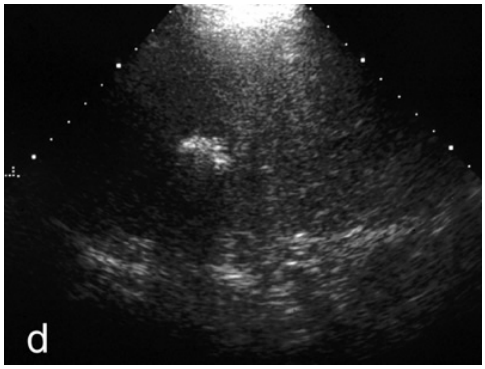
case: Sonography versus CT guidance

Case 1: Sonography versus CT guidance. Peroperative RFA







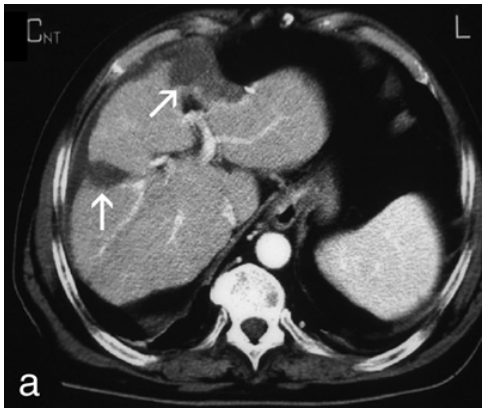


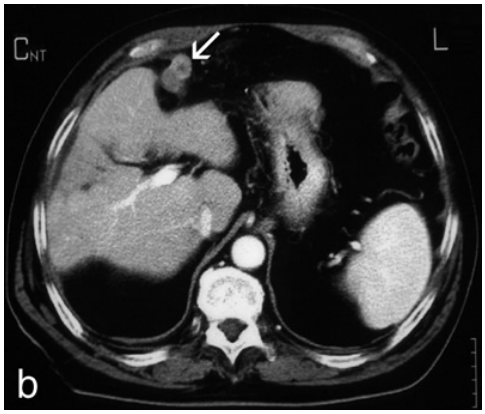
A 2.5 cm-diameter HCC nodule in a 70-year-old-man. (a)early-phase CT scan obtained before RFA shows an enhancing tumor in the right lobe (arrow). (b)the same nodule on US (arrow). (c)The needle is introduced into the nodule with US guidance. (d)During RFA the nodule became hyperechoic owing to vapor and CO2 bubbles produced during treatment. (e)Sonogram obtained immediately after RFA.

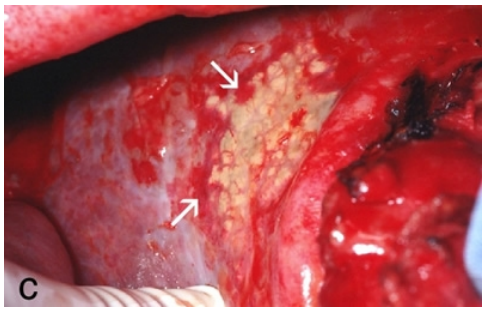
percutaneous versus op

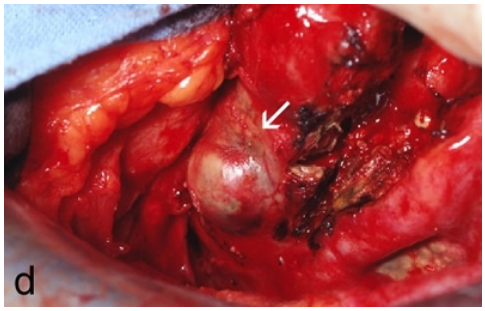
percutaneous versus operative radiofrequency ablation

Case 1: percutaneous versus operative radiofrequency ablation



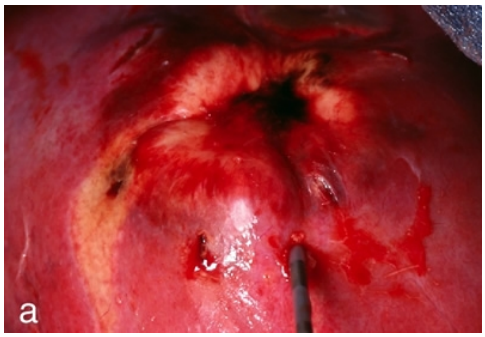






Combined treatment of HCC in a 67-year-old-man.News lesions 11 months after segmental liver resection (II,III).(a)Post RFA treatment image shows complete necrosis of both new lesions (arrows).(b)But a daughter nodule was (arrow)difficult to RFA treatment,with a risk of adjacent stomach injury.(c)Per-operative view of the post-percutaneous RFA complete necrosis (arrows).(d)The resection of the nodule (arrow) was easy -same nodule as in (b)-and resection became a less risky chirurgical procedure.

Case 2: Peroperative RFA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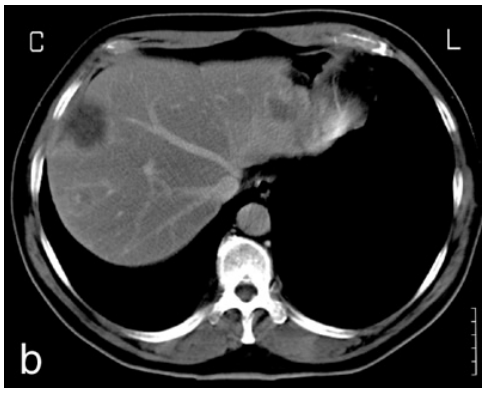
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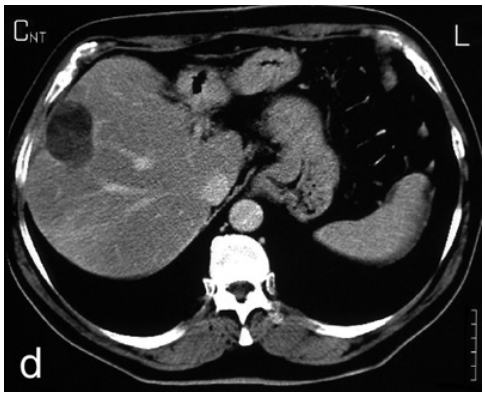
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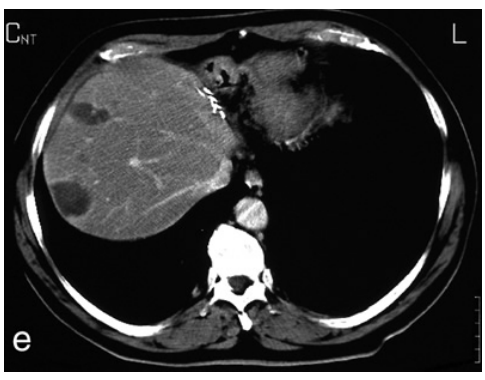
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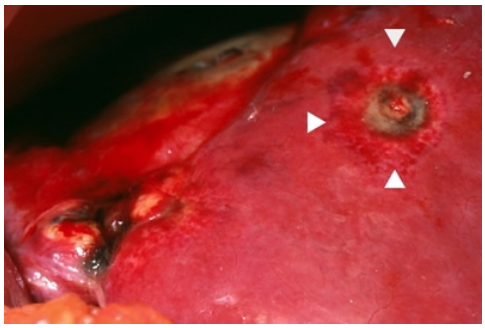
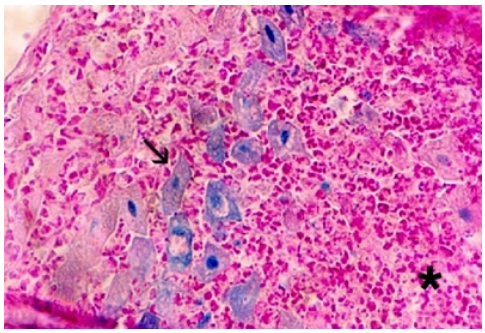
Peroperative RFA of hepatic metastasis (rectal cancer)in a 52-year-old-woman:coagulation of the lesions of the right liver and surgical resection of the left segments (II,III). Thermal destruction of the right nodule (a)seen on the preoperative CT (b)and visual assessment of thermal lesions in two subcapsular nodules (c) not seen on preoperative CT.Ten months later CT shows no enhancement in the tumor areas (d,e).



Per operative RFA:region of central coagulation around the tip of the needle and a narrow rim of hemorrhagic necrosis. (arrowheads)

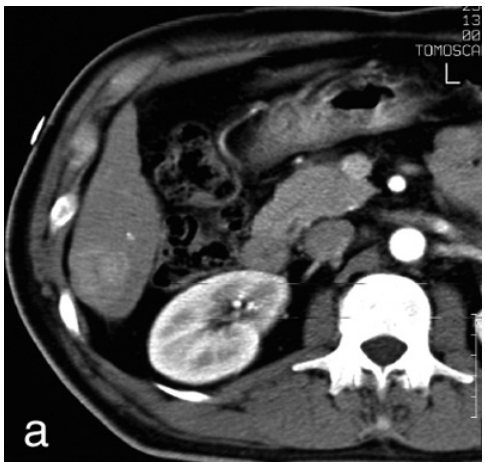


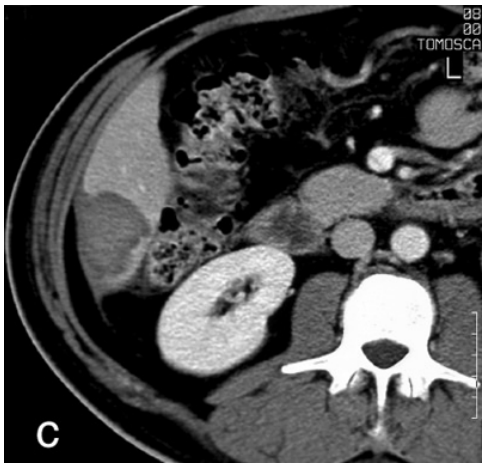
Histopathologic view (Perls, original magnification x 200)in a rat liver model 6 days after USPIO high dose intravenous injection and radiofrequency: coagulative necrosis (*) neutrophils and inflammatory reaction (arrow)with macrophages (iron uptake). Normal surrounding liver parenchyma.

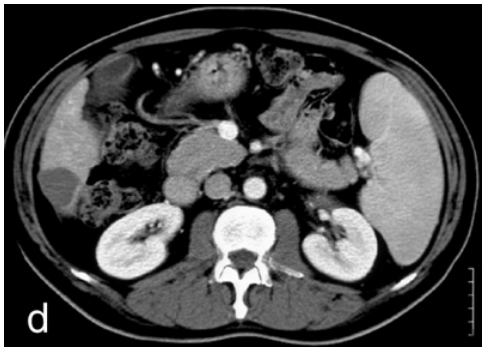
Complete ablation after radiofrequency ablation

Complete ablation after radiofrequency ablation

Case 1

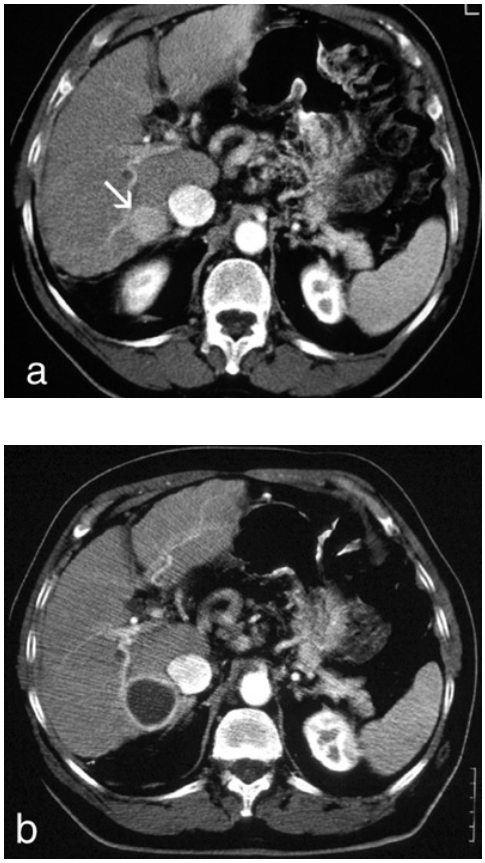






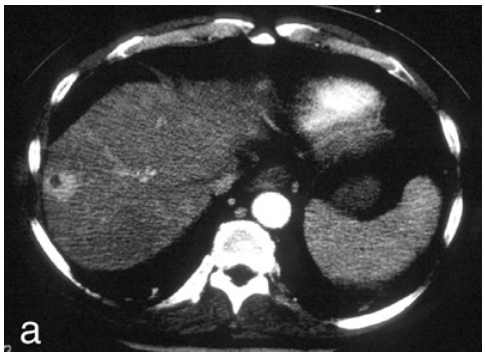
Encapsulated HCC of the segment VI pre (a)per (b)and 24 hours post RFA (c)in a 47-year-old-man (HIV positive).(d)CT scan obtained 9 months later shows complete treatment,without new nodules.

Case 2



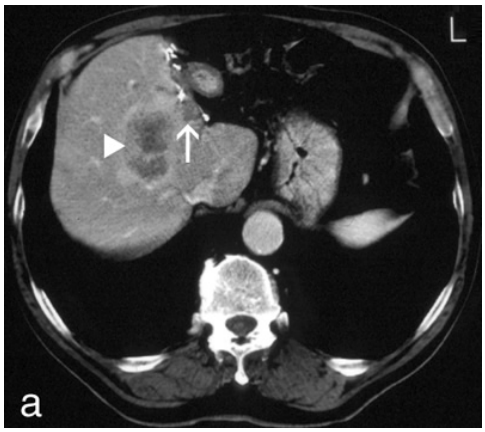
(a)An encapsulated 2 cm-diameter HCC nodule in a 72-year-old-man (arrow):enhancing tumor on arterial phase.(b)CT scan obtained 30 days after RFA shows the avascular tumor,with inflammatory peripheral enhancement:smooth,thin and regular rim of enhancement. No recurrence 24 months later.

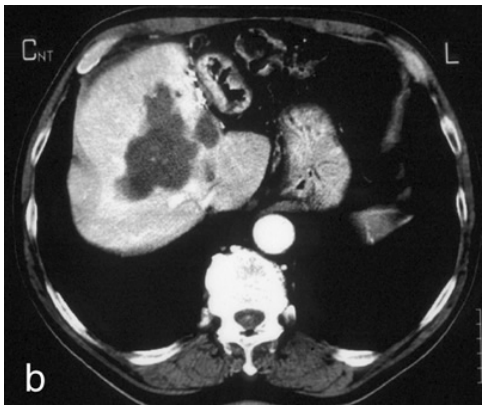
Case 3



Complete ablation in a 59-year-old-man with HCC.(a)CT scan obtained before ablation (b)and 12 months after RFA:subsequent scans show that the defect had gradually decreased in size.

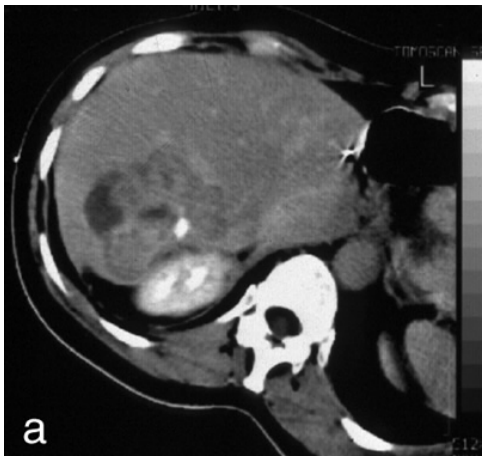
Case 4

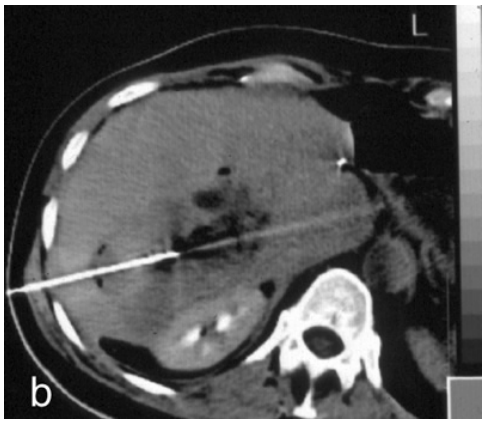


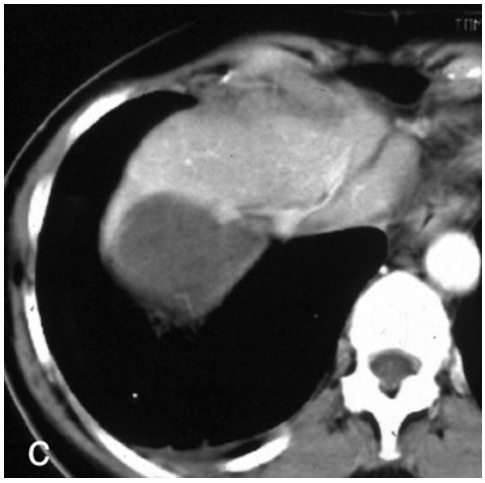


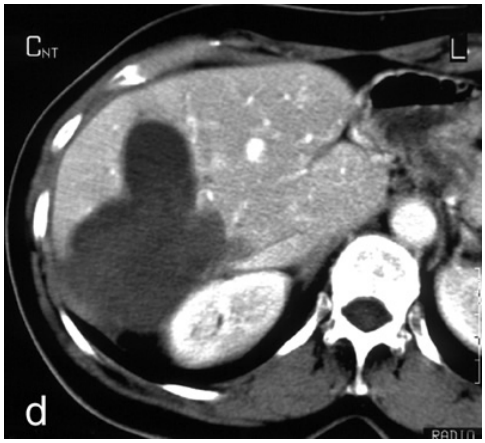
Successfully treated colorectal new metastasis in a 57-year-old-man 7 months after left hepatectomy. (a)Pre RFA treatment CT scan shows a small nodule (arrow)and a large nodule (arrowhead).(b)CT scan obtained 11 months after percutaneous RFA:irregular area of necrosis,without local regrowth.

Case 5



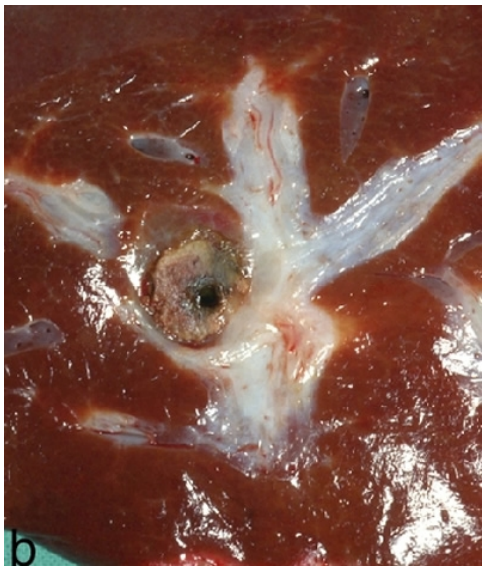






Large tumor (colorectal metastasis)9 cm in diameter (a)were treated by overlapping ablations.(b)No regrowth 6 months later,the tumor has become avascular (c,d).

Case 6

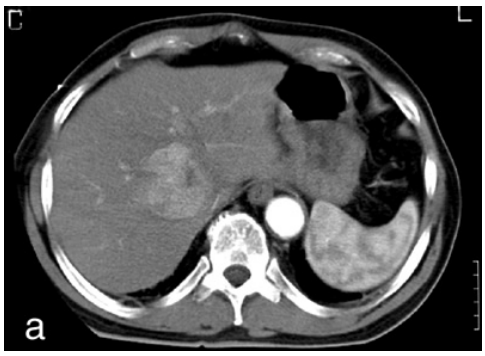


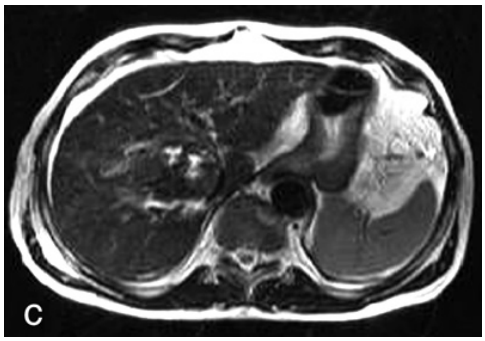
(a,b)Complete radiofrequency-induced necrosis (arrow)seen on macroscopic view 6 months after peroperative RFA of a left lobe colorectal metastasis in a 37-year-old-woman.Pretreatment CT scan (c)showed a 2 cm-diameter nodule (arrow). Surgical resection of the left lobe was decided on 6 months later,for new metastasis in the left lobe (arrowheads). Microscopic examination confirmed the necrosis within the zone of ablation with apparent cell death

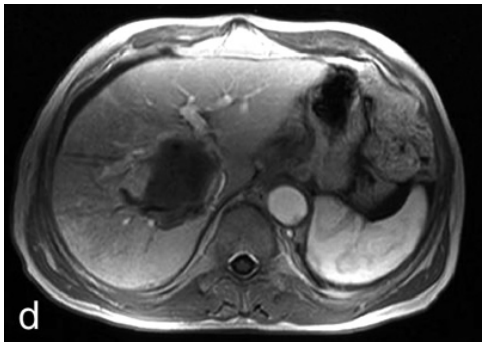
Incomplete ablation

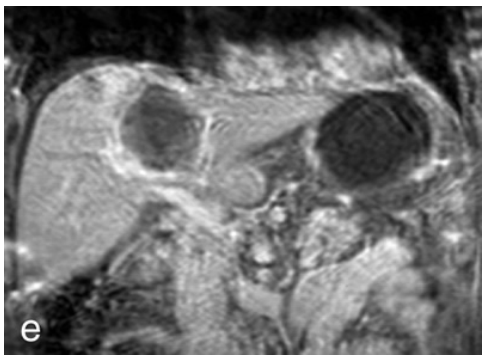
incomplete ablation

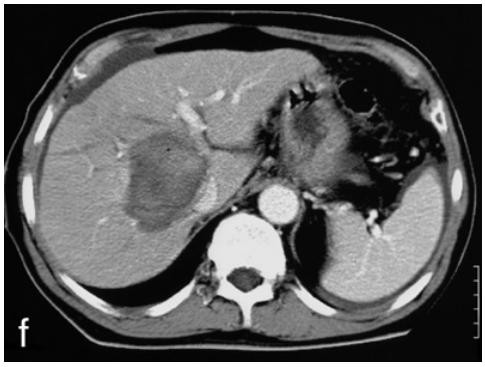
Case 1: incomplete ablation









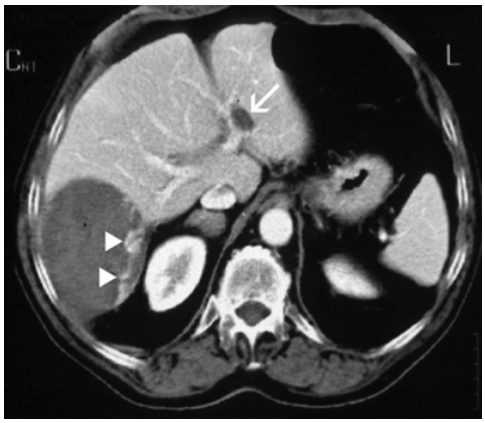


Imaging evaluation of RFA of hepatocellular carcinoma .(a,b)Arterial phase CT scan obtained before ablation shows a hypervascular HCC in the right lobe. (d)Axial T2-weighted MR image obtained immediately after RFA shows the low-signal-intensity tumor with a high-signal-intensity rim caused by acute peritumoral hyperemia (d)Axial fat-suppressed and (e)coronal view with Gadolinium immediately after RFA. (f)Portal-phase CT scan obtained 24 hours after RFA shows the central hemorrhage and the avascular tumor,indicating 90%ablation .

Case 2: incomplete ablation

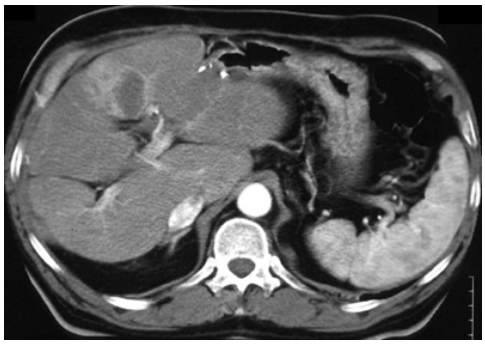
Portal-phase CT scan:local regrowth in contact with a large vessel,one month after RFA of a colon liver metastasis : heat-sink effect.

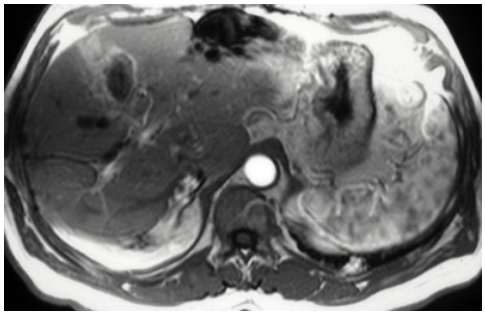
Case 3: incomplete ablation



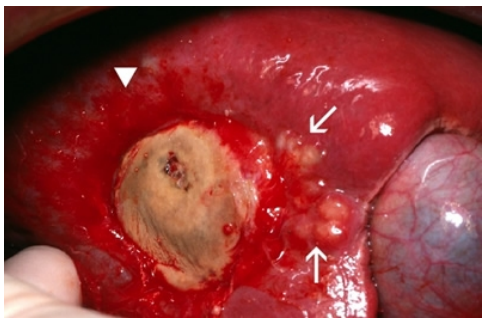
CT scan obtained six months after RFA of two nodules in a 74-year-old-man with HCC.Complete ablation of the nodule of the left lobe (arrow).But portal phase CT scan shows local regrowth (arrowheads)in the largest nodule with contrast enhancement corresponding to progressive tumoral disease

Case 4: incomplete ablation





Colon metastasis in a 67-year-old-man.(a,b)Arterial-phase CT scan and MRI obtained six months after RFA :ablation defect with an irregular lateral area of enhancement.Three months later CT scan confirmed unsuccessful treatment.

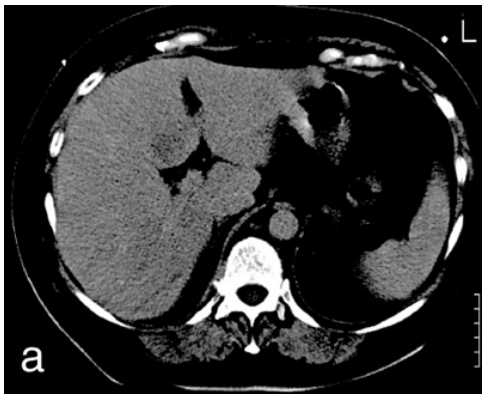


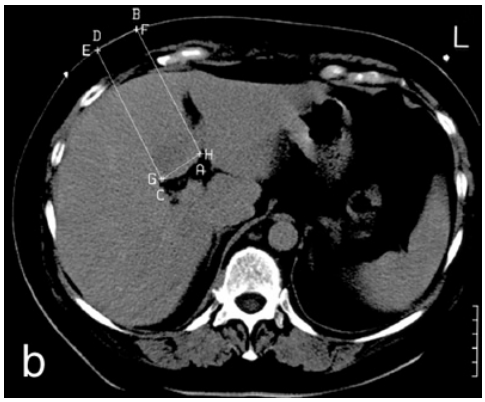
Recurrence of metastasis.Per-operative view 3 months after RFA:post-RFA tumor necrosis (arrowhead)with daughter nodules, not seen on CT scan (arrows).

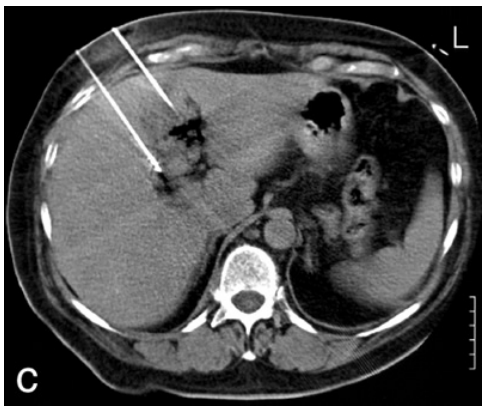
bipolar radiofrequency

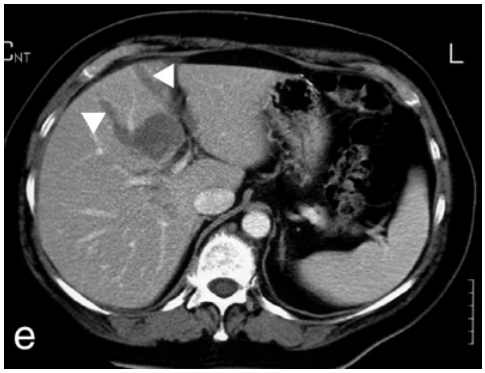
bipolar radiofrequency ablation

Case 1: Bipolar Technique



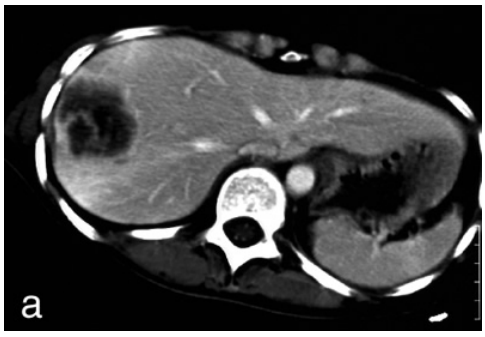


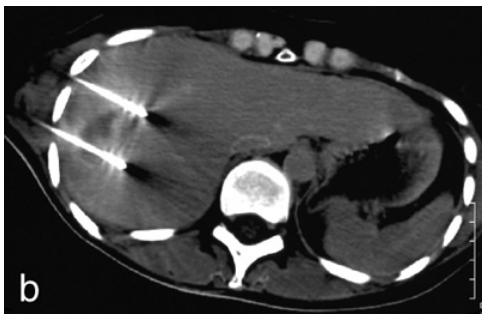


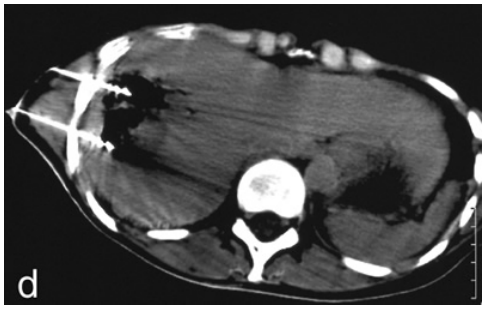


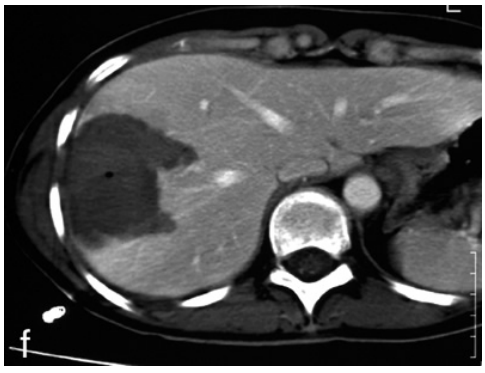
Bipolar Technique:(a)Colorectal metastasis of the segment IV in a 53-year-old-woman with residual tumor after chemotherapy (b)planning before RFA treatment.(c)The second electrode (or ground)is placed within 3 cm of the active electrode.This results in heat being generated not only at the active electrode but also adjacent to the ground needle and between the two electrodes. (d)CT scan obtained 4 months after RFA with complete ablation. (e)The electrode track had been cauterized (arrowheads).

Case 2: Bipolar Technique







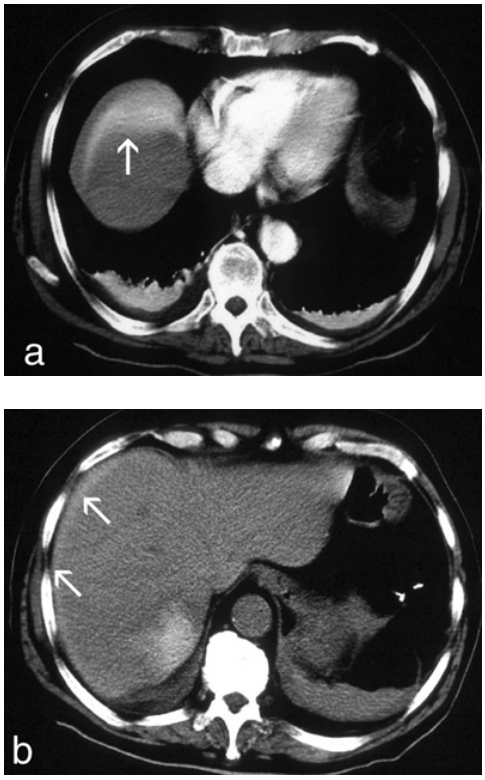


Bipolar Technique: (a)Sub capsular liver metastasis (5 cm-diameter)in a 42-year-old-woman. (b,c,d,)Bipolar technique under CT guidance.(e,f). The resulting area of thermal lesion is larger than when a conventional monopolar electrode system is used and the induced coagulation necrosis is elliptic rather than spherical.

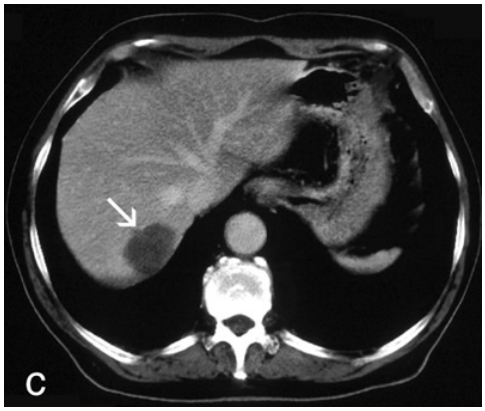
6) Complications

complications of radiofrequency ablation

Case Complication 1: HEMATOMA

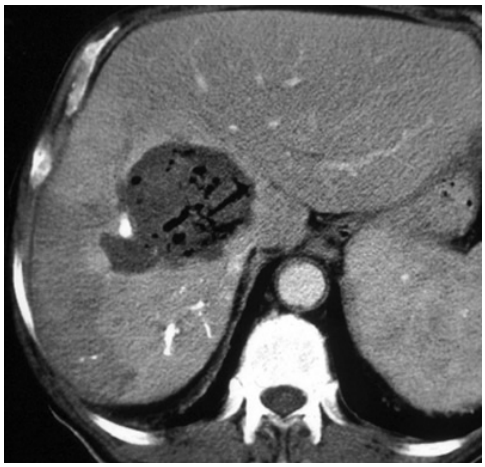


(a,b)Elongated subcapsular hematoma (arrows)24 hours after percutaneous RFA of a subcaptular colorectal metastasis in segment VII.



(c)Four months later,complete necrosis of metastasis (arrow) and spontaneous disappearance of the hematoma.

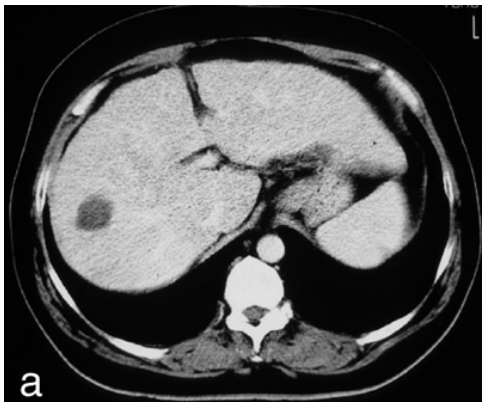
Case Complication 2: ABSCESS

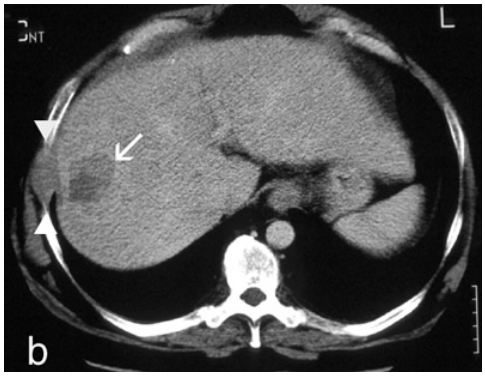


Hepatic abscess 8 days after percutaneous radiofrequency coagulation of an hepatocellular carcinoma. Prophylactic antibiotics had not been given.

Case Complication 3: GROUND PAD SKIN BURN

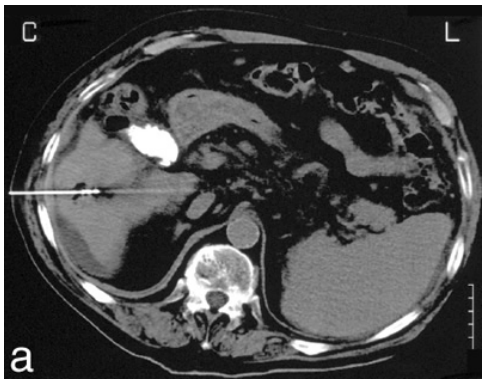
Case Complication 4: SEEDING

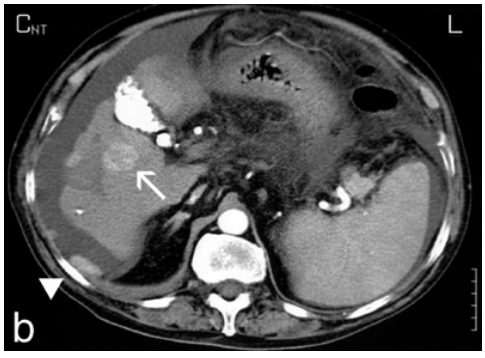


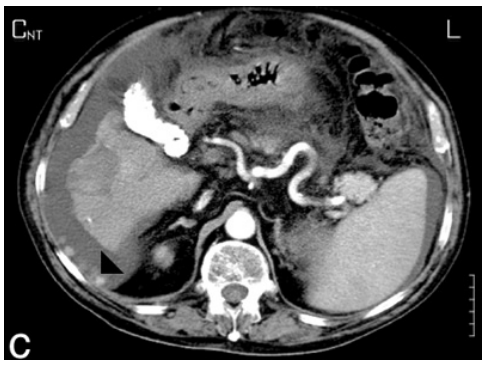


Seeding :abdominal wall implantation HCC after percutanous RFA in a 44-year-old-man. (a)CT scan obtained 3 months after RFA treatment with successful ablation. (b)12 months later,CT scan shows marginal recurrence of HCC (arrows) and on a parietal wall seeding (arrowheads).The electrode track had not been cauterized.

Case Complication 5: SEEDING

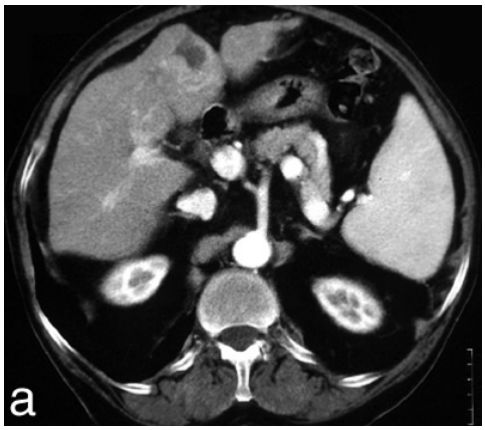


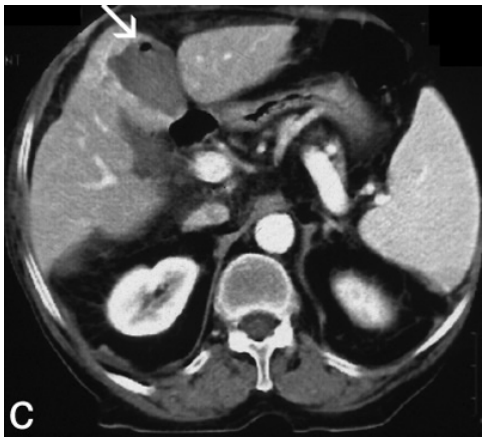


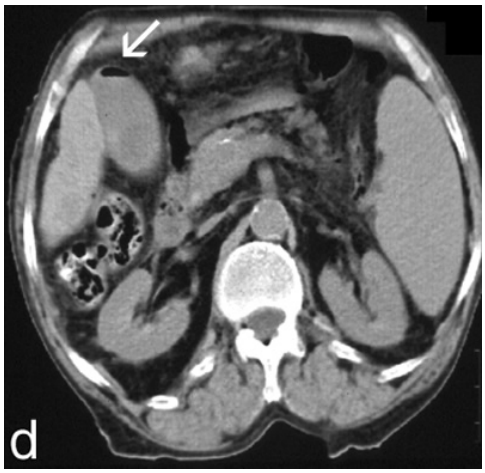


Intraperitoneal seeding of HCC post-percutaneous RFA.(a)Needle placed during RFA procedure.(b,c)Arterial-phase CT scan obtained 6 months after ablation shows an enhancing nodule (arrow)that represented marginal recurrence,moreover enhancing intraperitoneal nodules (arrowheads).

Case Complication 6: TRANSIENT PNEUMOBILIA

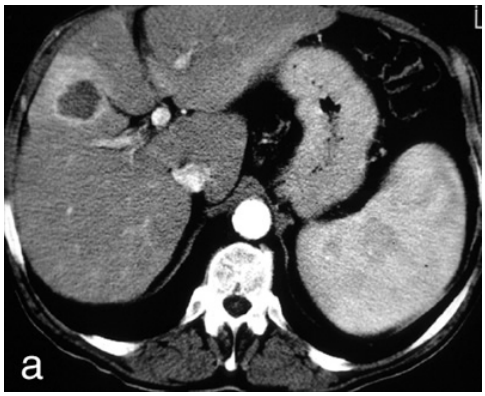


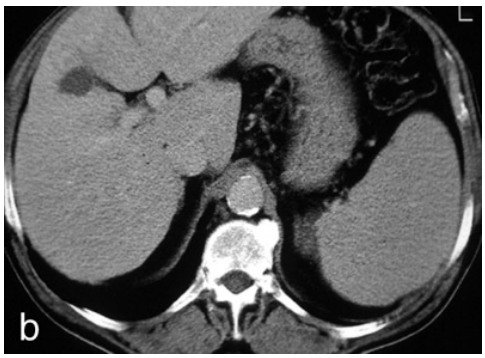




Transient pneumobilia in an asymptomatic patient 24 hours after RFA for a colon metastasis in segment 4 :(c)gas in the area of necrosis (arrowheads)and peripheral enhancement indicates hyperemia,(d)gas in gall bladder (arrow).

Case Complication 7: Hepatic perfusion disorder after RFA





Hepatic-perfusion disorder after RFA in a 55-year-old-man with HCC.(a)CT scan obtained 24 hours after RFA shows transient subcapsular high-attenuation due to arterioportal shunt.(b)Area of necrosis,with complete ablation obtained 12 months later.

7) Conclusion

RFA with wet electrode technique and 5% saline infusion was determined to be a safe, effective and well-tolerated procedure for patients with unresectable hepatic malignancies. Bipolar technique is promising in the future, however further research in this field is needed to determine the indications and long-term results and to determine whether RF treatment can provide advantages for patient.

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