Post Hepatic Percutaneous Radiofrequency Ablation Imaging - The Expected and the Unexpected

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Learning objectives

To review the expected and unexpected liver cross-sectional and ultrasound imaging findings post RFA

Background

Percutaneous radiofrequency ablation (RFA) is an effective and safe procedure for the treatment of primary liver malignancy and metastatic liver disease. Electrodes that conduct a high frequency alternating current are placed in the lesion under imaging guidance, either by cross-sectional imaging or ultrasound, resulting in thermal cell destruction due to coagulation necrosis.

Fig. 1: Electrode positioning (black arrow), guided by CT.
References: Department of Radiology, Hospital Universitário de Coimbra

This technique's increased use requires that radiologists become familiar with its expected and unexpected results. Post RFA imaging should assess complications as well as treatment results and evolution. Perhaps the most important change to recognise is persistent/recurrent disease. Severe complications of thermablation such as biliary injury, hepatic collections (abscesses and haematomas) and liver failure occur in less than 1% of cases. [(1)] Biliary strictures, liver failure, vascular injury and hepatic abscesses are the most common RFA complications.

Baseline imaging is important for lesion characterization and post-RFA follow-up. Contrast US, CT or MRI are used for treatment planning and follow-up.

The authors describe the normal post treatment appearance as well as the appearance of possible complications and persistent disease.

Images for this section:

Fig. 1: Electrode positioning (black arrow), guided by CT.

Findings and procedure details

1.Ablation zone

The treated area, also known as the **ablation zone**, should contain the original lesion and a 5-10mm peri-lesional margin, equivalent to a R0 resection. The shape varies and depends, in part, on the proximity to vessels due to the heat sink effect.

Scar formation leads to lesion retraction over the following year. If the lesion is near the liver capsule, capsule retraction can occur. The normal scar continues to show well demarcated borders without enhancing components.

Normal appearance	
CEUS	- Most often hypoechoic (it can be hyperechoic and rarely isoechoic)
(Figs. 2 and 3)	- Homogenously unenhancing
	- Thin (<3mm) smooth enhancing ring (peri-lesional hyperenhancement on arterial phase)
CT	- Hypodense non-enhancing, well demarcated, area larger than the original lesion
(Fig. 4)	- May present gas bubbles, resulting from coagulation necrosis
	- If haemorrhage has occurred hyperattenuating heterogeneous areas can be present (homogeneity increases as times progresses)
MRI	- Heterogeneous due to haemorrhage and necrosis - hypointense T2WI and hyperintense T1WI
(Figs. 5-7)	- Becomes increasingly heterogeneous as blood products decay
	- High signal intensity in water sensitive sequences indicate necrosis or biloma

Fig. 2: Hyperechoic lesions post RFA (blue circle). Note posterior attenuation shadow, probably due to gas within the lesion.
References: Department of Radiology, Hospital Universitário de Coimbra

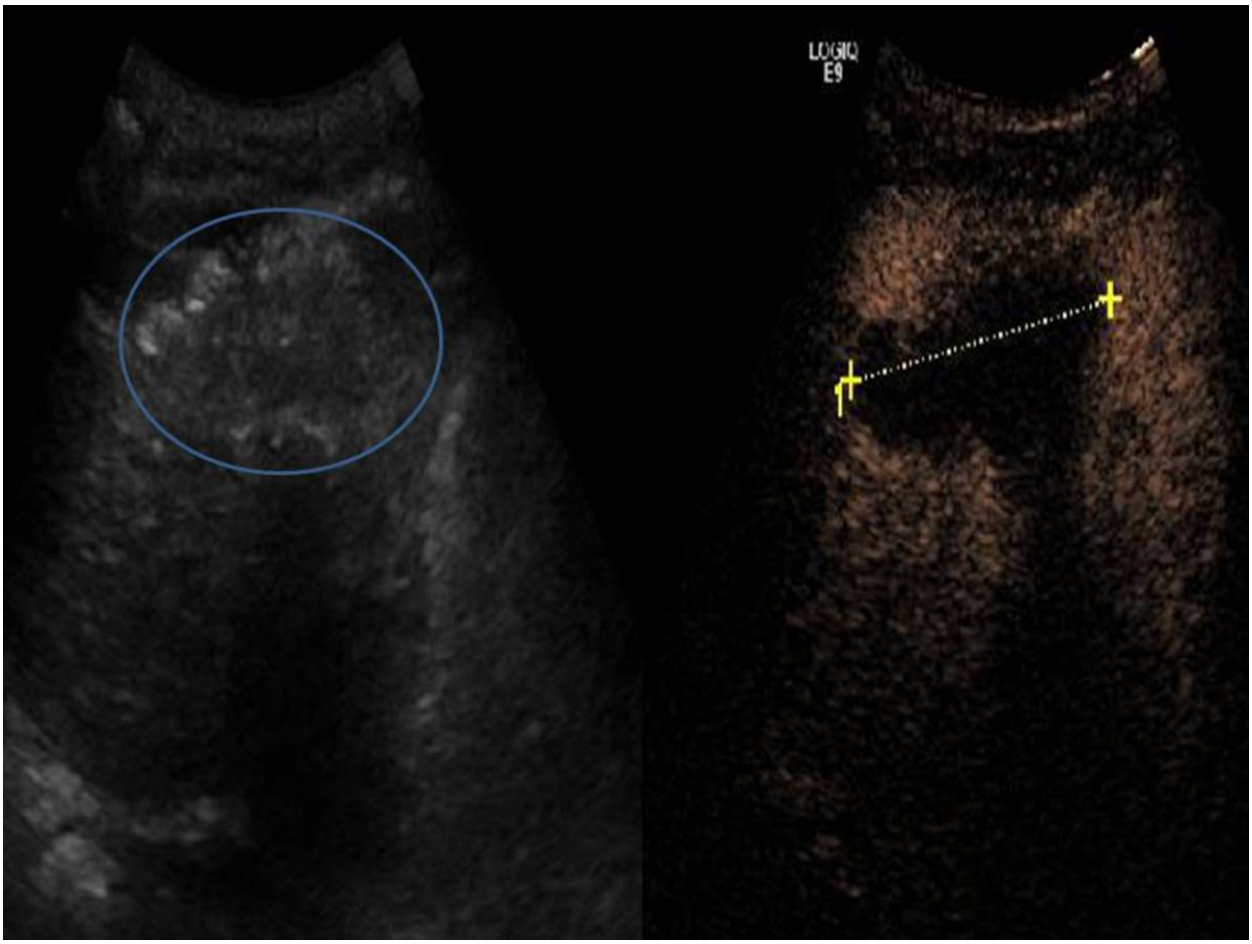

Fig. 3: On the left US image, a hypoechoic lesion (blue circle) can be identified after RFA. On the right,a post contrast US image showing no contrast uptake (callipers), indicative of exclusion.
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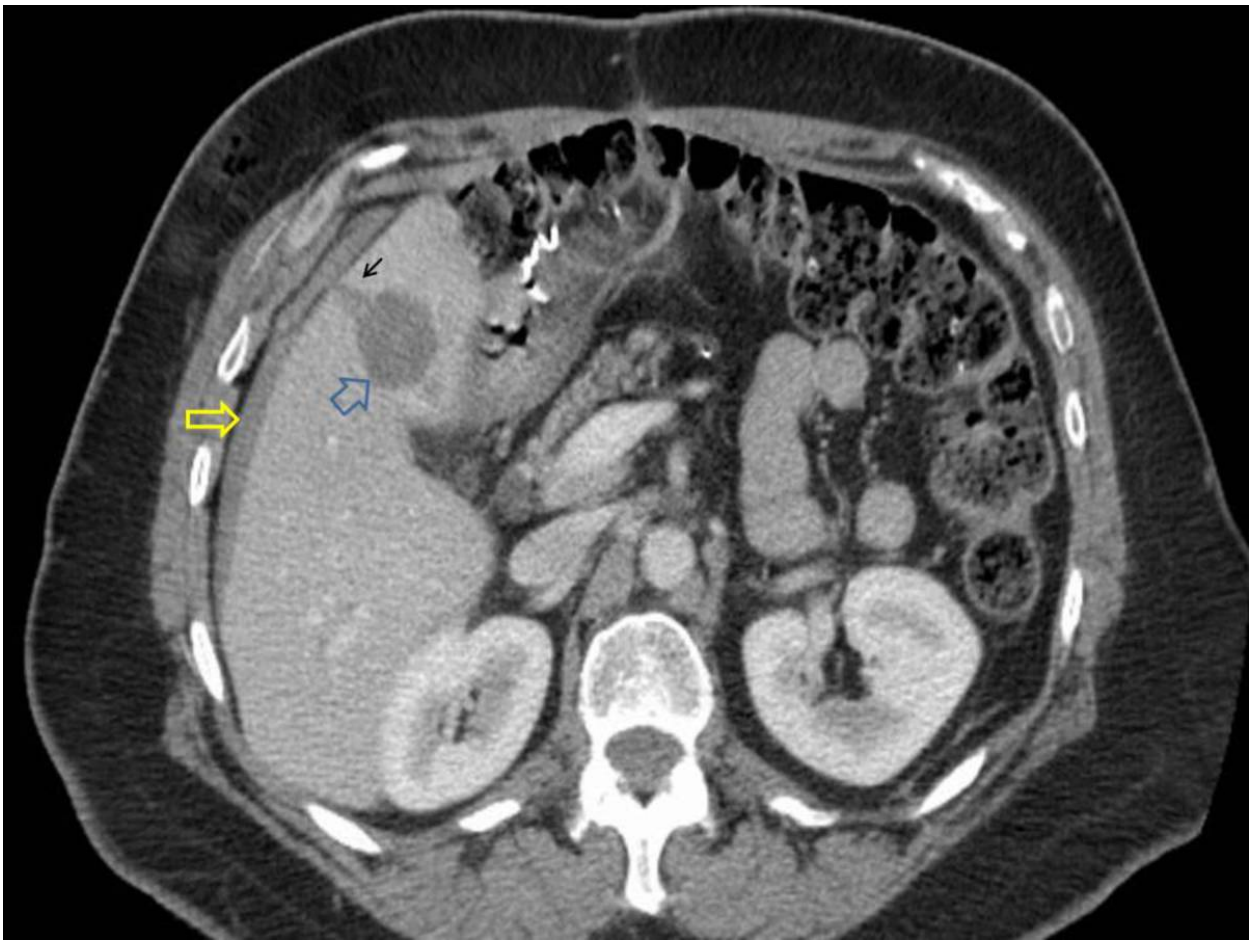

Fig. 4: Enhanced axial pos-contrast CT image. A hypodense lesion is seen (blue arrow)- corresponding to lesion exclusion. The electrode tract is visible (black arrow). A slight sub-capsular haematoma is seen (yellow arrow).
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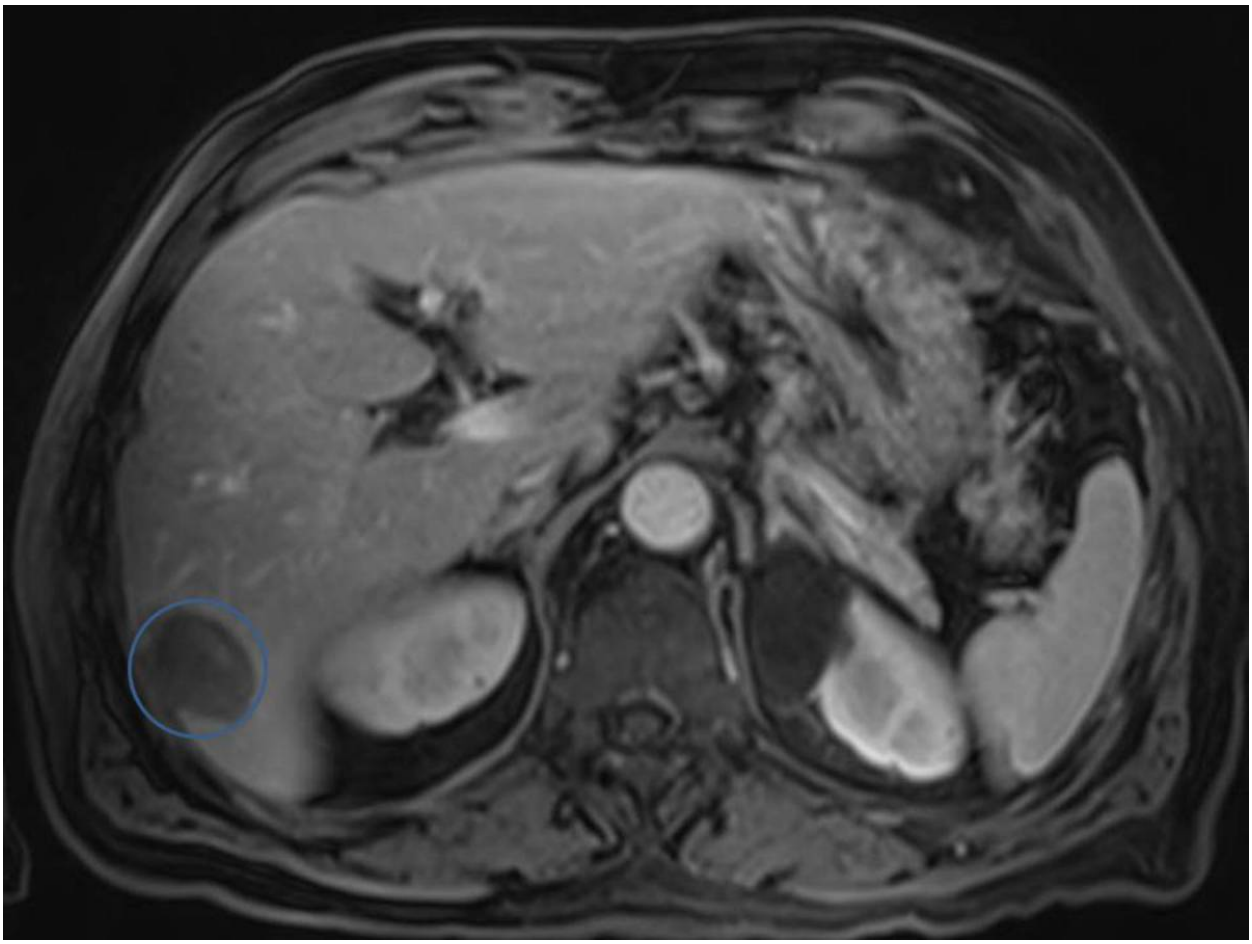

Fig. 5: T1WI post-gadolinium image showiing hipointense lesion without clear contrast uptake (blue circle). The slight high T1 signal in the centre of the lesion is due to acute haemorrhage.
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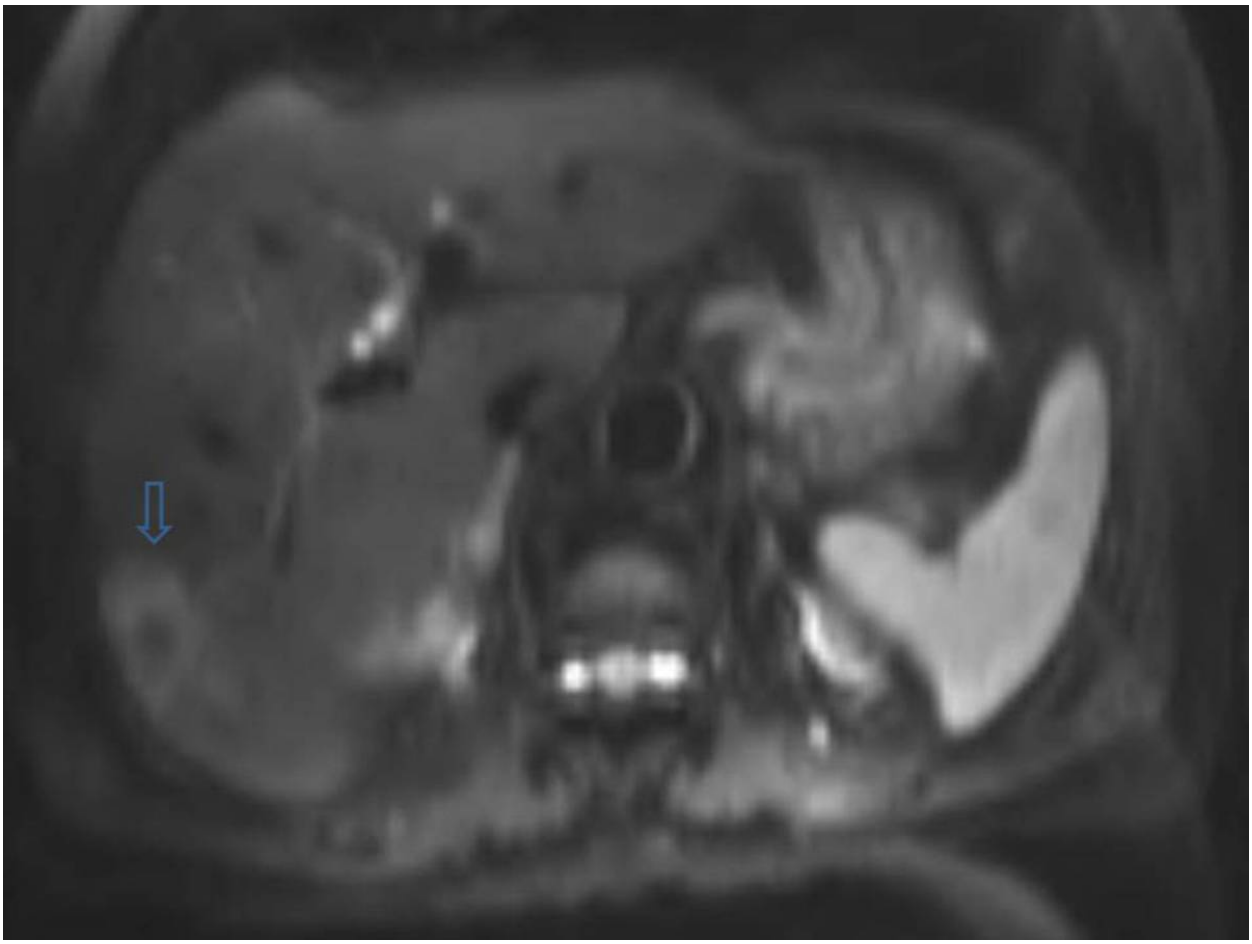

Fig. 6: DWI showing area of high signal intensity (blue arrow). Please se Fig. 7 for ADC showing no restricted diffusion.
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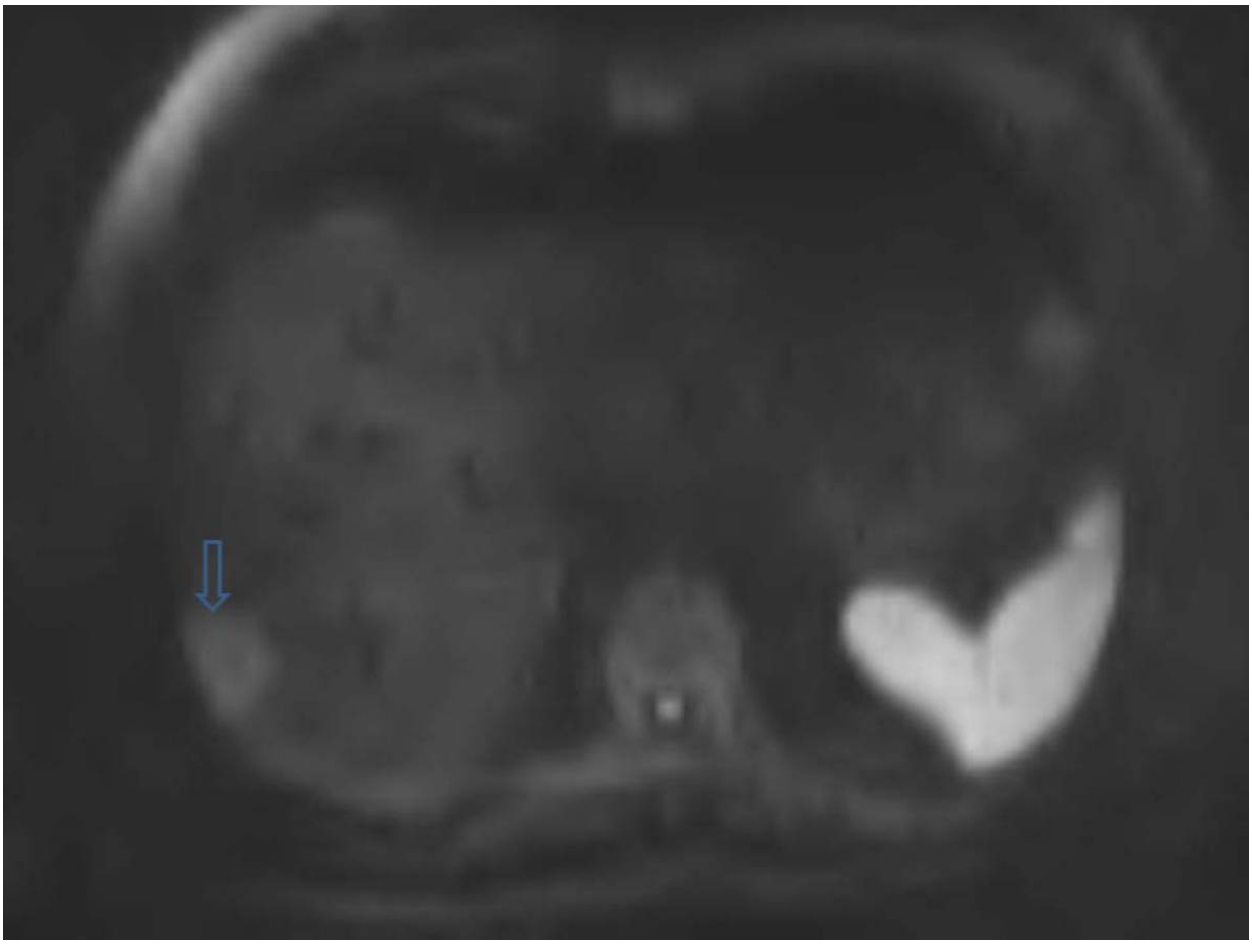

Fig. 7: ADC map showing no loss of signal intensity (blue arrow) compared to DWI (Fig. 6). Thus, there is no restricted diffusion only "T2 shine through"
References: Department of Radiology, Hospital Universitário de Coimbra

2. *Peri-ablation enhancement ring*:

Peri-ablation enhancing ring

	Normal	Persistence / Recurrence
CEUS (Figs 8 and 9)	- Usually absent in successful therapy (CEUS is not very sensitive to increased flow through vessels) - If present usually <3mm thick	- Eccentric, nodular or crescent shape enhancement of treated margin - Followed by washout - Usually thicker than 3mm
CT	- Peri-lesional hipodense rim which demonstrated	- Thick irregular or nodular marginal enhancement

(Figs 10 and 11)	smooth marginal post-contrast enhancemen - Normal for up to 9 months after treatment - Due to peri-lesional oedema/inflammatory change	
MRI	- Smooth regular high signal intensity on water sensitive sequences - Peri-lesions enhancement better assessed by subtraction sequences - Gradually reduces over time and should resolve	- Moderately hyperintense on T2WI whereas necrotic tissue would be hypointese T2WI - Residual disease can manifest itself as an interface disruption between the ablation zone and the hepatic parenchyma
FDG PET/CT (Fig. 12)	- Inflammatory ring will be FDG-avid, decreasing over time - Resolving approximately 6 months after thermoablation	- Useful for detecting residual disease in FDG avid tumours - Focal area of tracer uptake, which is eccentric

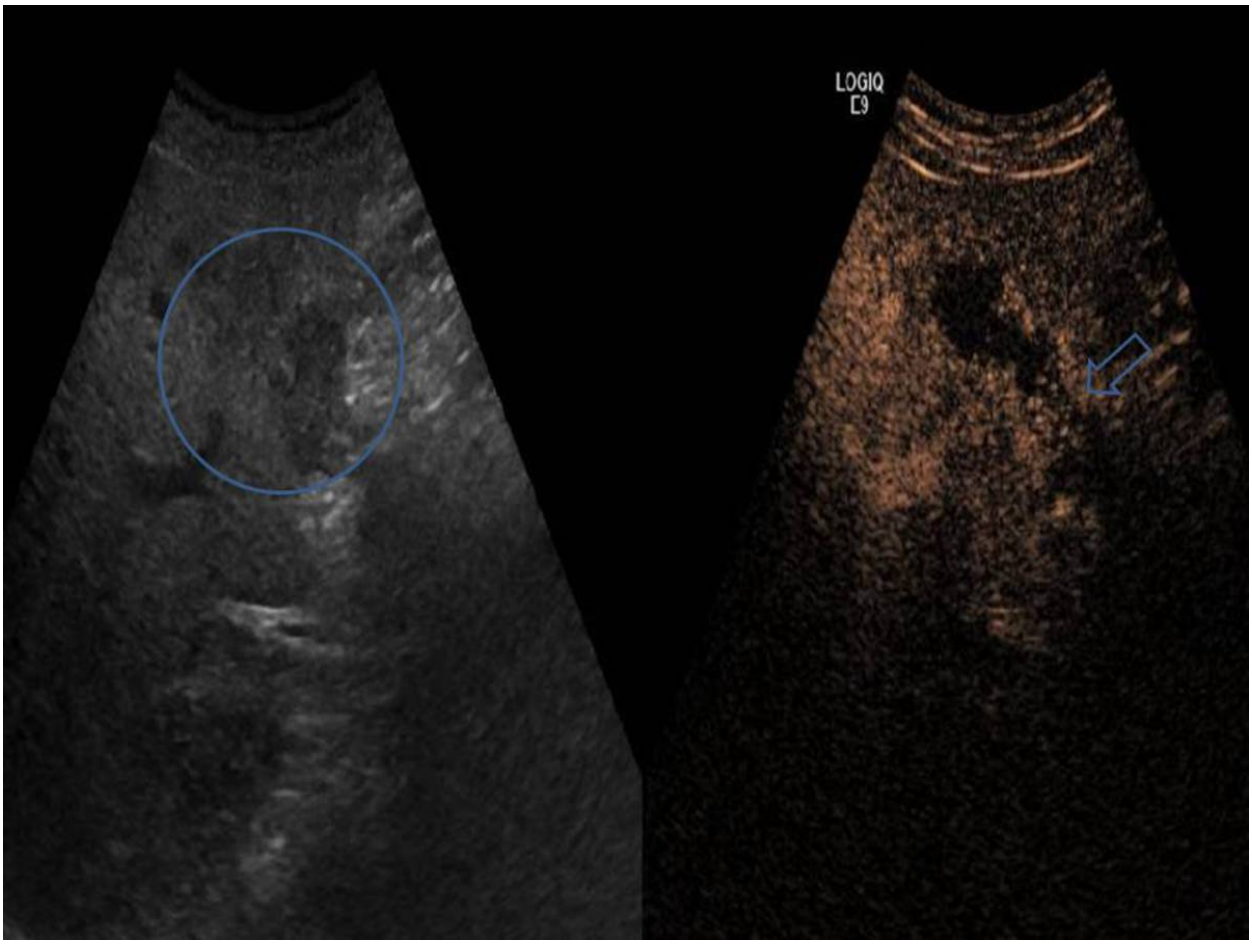

Fig. 9: On the left handside a non-contrast US image shows a hypoechoic liver lesion (blue circle). On the right handside a post contrast US image shows and enhancing nodule (blue arrow) within the inferior lesion margin suggestive of persistent disease.
References: Department of Radiology, Hospital Universitário de Coimbra

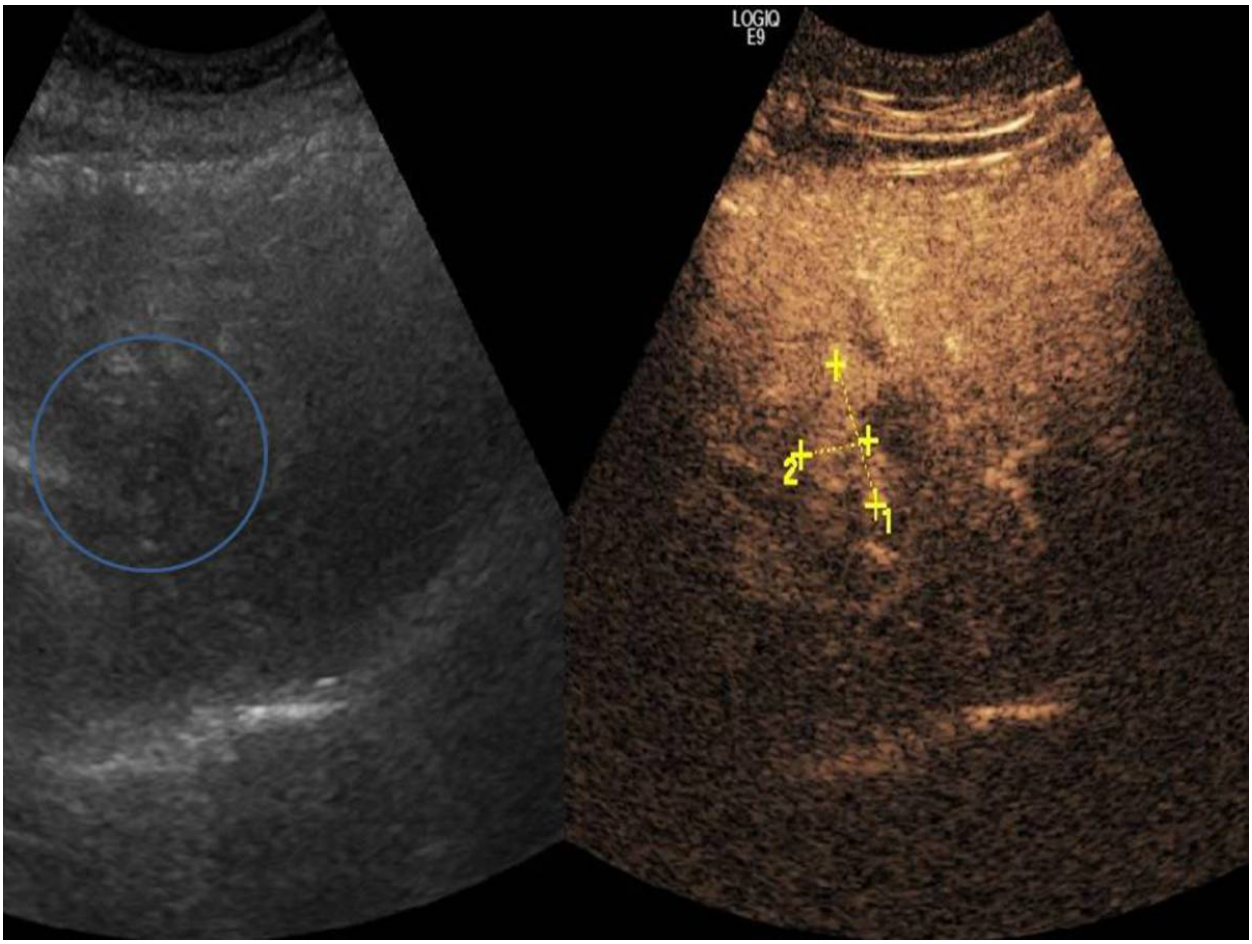

Fig. 8: On the left handside a non-contrasted US image shows a hyper/isochoic lesion (blue circle). On the right a post contrast US image shows thick (1.2cm) excentric peri-lesion enhancement (between callipers)suggestive of persistent tumour.
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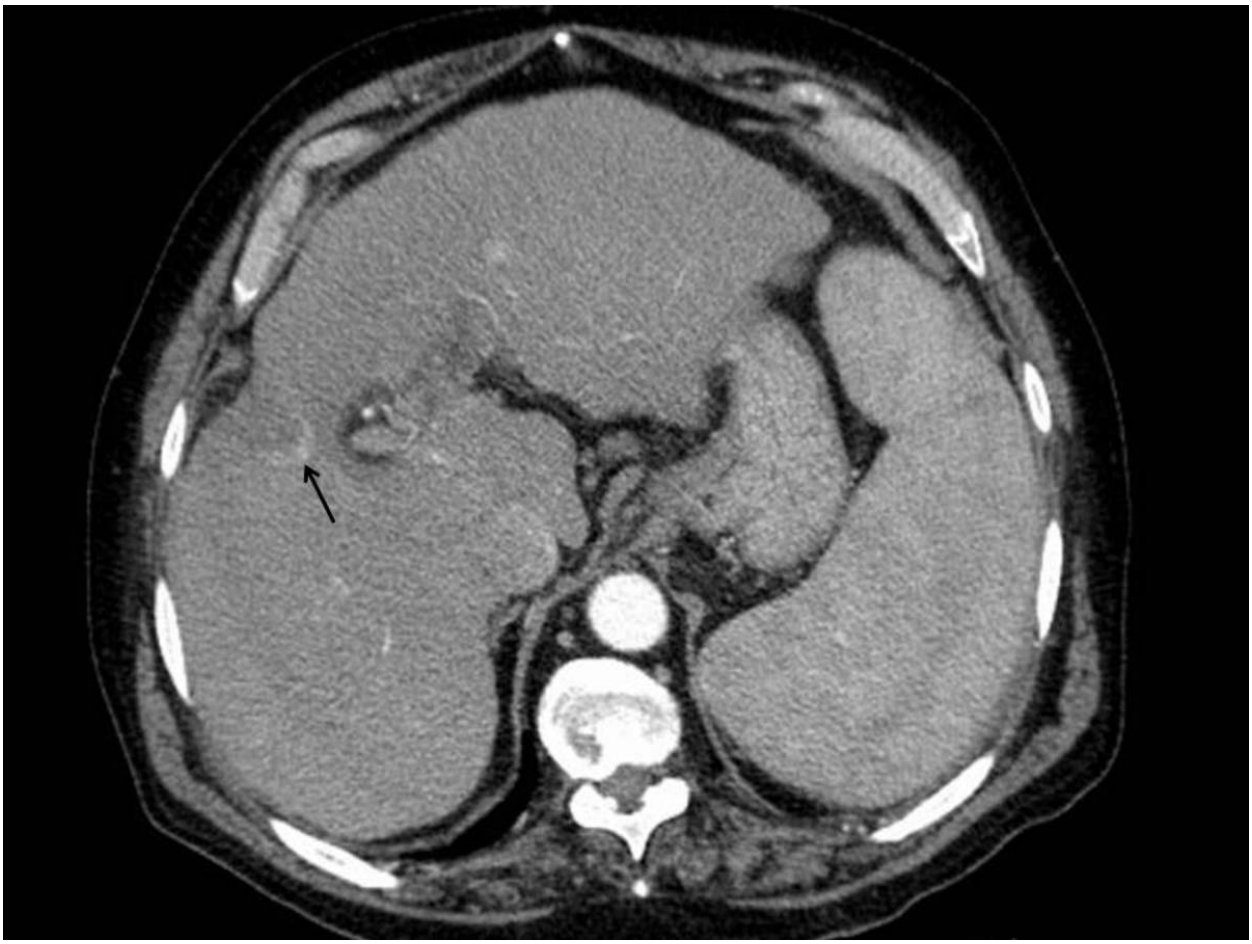


Fig. 10: Post contrast axial CT image, showing eccentric marginal thickening (black arrow), in keeping with recurrent tumour.
References: Department of Radiology, Hospital Universitário de Coimbra

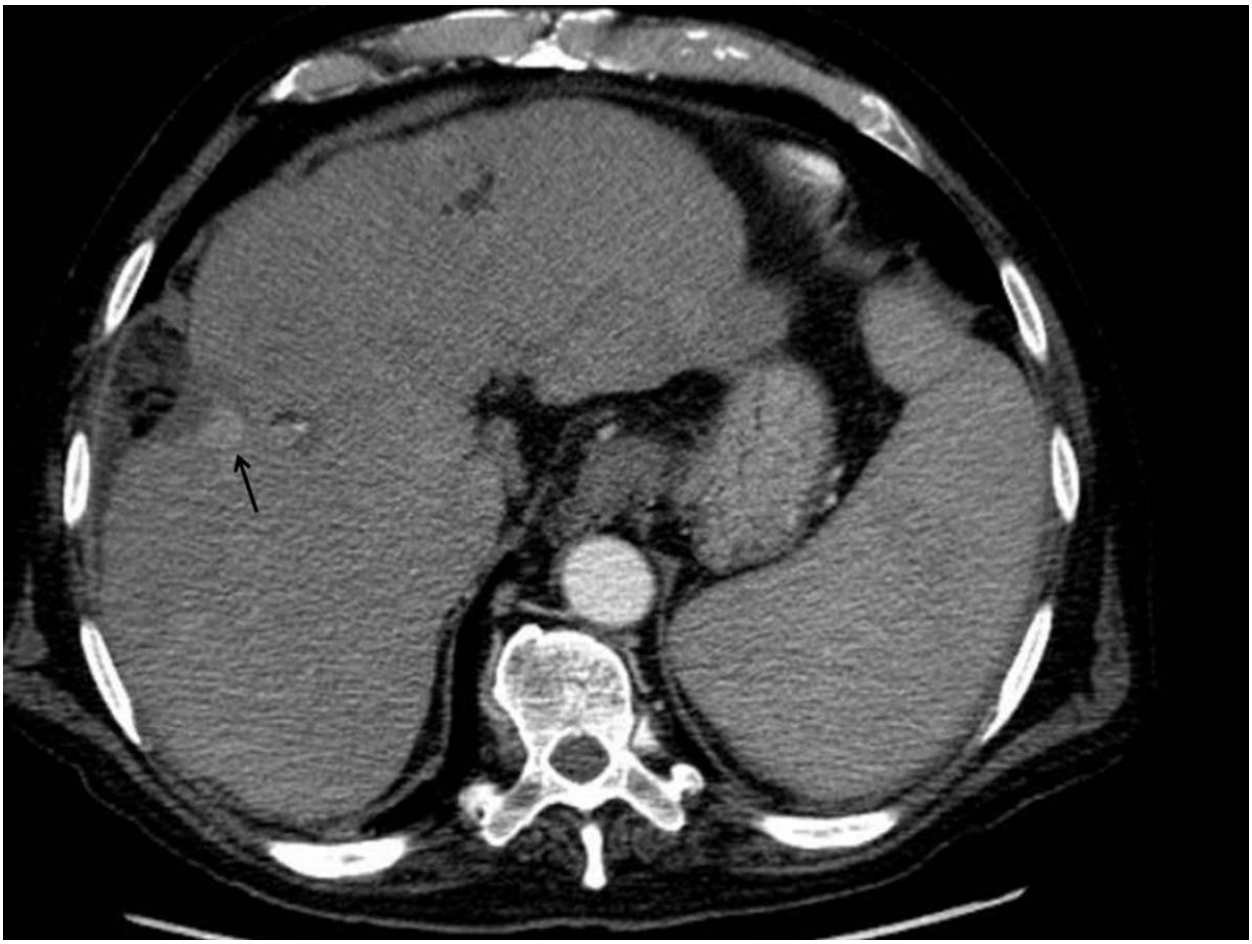


Fig. 11: Post-contrast axial CT image showing nodular thickening of the margin of a treated lesion (black arrow), in keeping with recurrence
References: Department of Radiology, Hospital Universitário de Coimbra

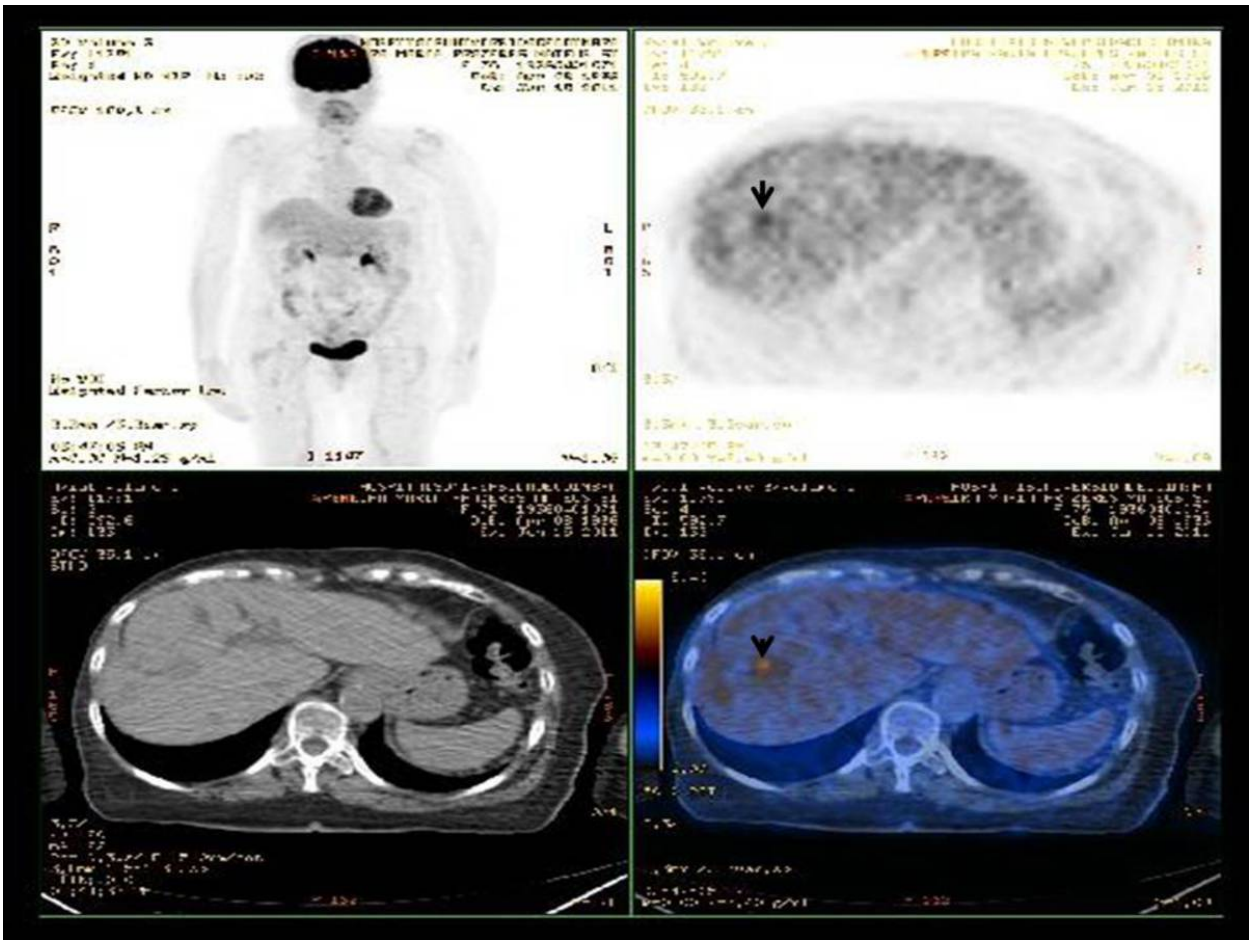


Fig. 12: FDG PET CT showing avid nodular lesion (black arrow) in the periphery of a previously treated lesion, in keeping with recurrence.
References: Department of Radiology, Hospital Universitário de Coimbra

Due to better soft-tissue contrast MRI is better at detecting residual disease than CT (sensitivity 89% MRI vs 44% CT).[2]

FDG-PET CT can be used to resolve equivocal findings identified in CT or MRI if the tumour is known to be FDG avid. However, perilesional inflammatory changes, which are FDG avid, can obscure residual disease. As inflammatory changes take approximately 48 hours to develop PET/CT should be performed within the first 2 days or approximately 1 month after thermoablation (when peri-lesional changes begin to improve) to avoid false positives.

Residual disease is likely if a margin of 5-10mm is not achieved.

Residual tumour mimics include post-ablation inflammation (neovascularity and oedema) and perfusion anomalies. Comparison with previous imaging is essential in evaluating residual disease.

Recurrent disease implies the development of new lesions more than 6 months after successful treatment. It can be intra or extra-hepatic.

Signs suggestive of disease recurrence	
CT	- Size and morphology change
	- Changing/irregular margins
	- Enhancing nodules or asymmetric thickened margins
MRI	- Restricted diffusion (treated tumours do not show restricted diffusion)
	- Low ADC values in areas of high T2 signal intensity are suggestive of tumour
	- Enhancing nodules or asymmetric thickened margins
FDG PET/CT	- New areas of FDG uptake
Risk factors for recurrence[2]	- Large tumours
	- Location: adjacent to liver capsule, diaphragm or vessels (heat sink effect)
	- Aggressive tumour histology

3. *Abaltion tract*:

Usually seen as a hipodense, non-enhancing linear tract on CT. On MRI it has mildly high signal intensity on T2. It can also present peri-tract linear enhancement (Fig. 4).

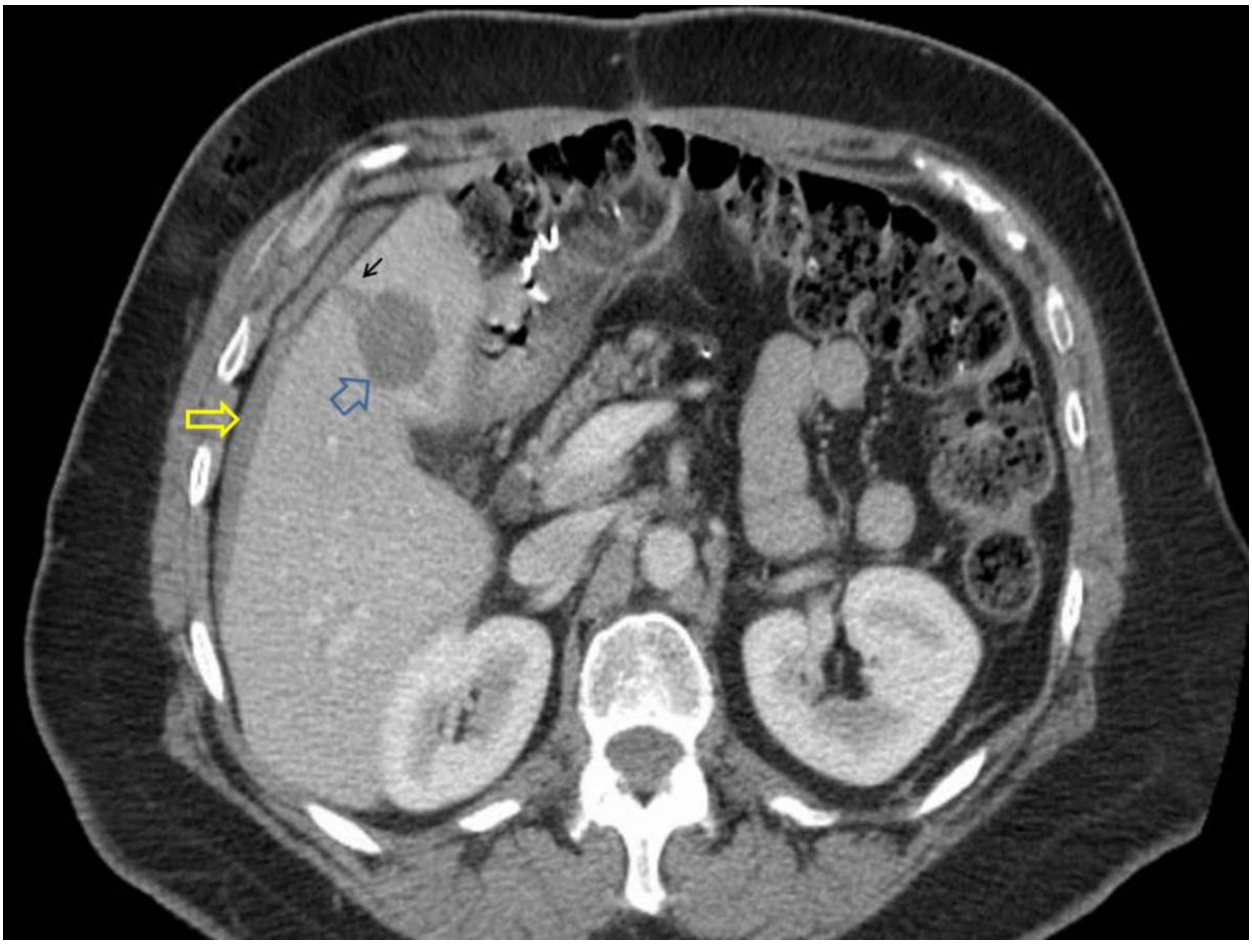


Fig. 4: Enhanced axial pos-contrast CT image. A hypodense lesion is seen (blue arrow)- corresponding to lesion exclusion. The electrode tract is visible (black arrow). A slight sub-capsular haematoma is seen (yellow arrow).
References: Department of Radiology, Hospital Universitário de Coimbra

Tumour seeding is rare and presents as enhancing soft tissue masses along the electrode tract.

Risk factors for tumour seeding	Superficial / subcapsular tumour
	Large-gauge electrode
	Multiple punctures or repositioning
	Prior biopsy
	Poor tumour differentiation
	Aggressive histology

4. *Billiary dilatation*

Central location (<10mm of a central bile duct) is considered a contra-indication for RFA.

Transient biliary duct dilatation, gallbladder wall oedema and haemobilia are considered normal. These require follow up because if they persist treatment may be necessary.

Post-ablation transient peripheral biliary dilatation is common and thought to be due to biliary stasis, which resolves with the decrease in lesion size and inflammation. If changes progress or persist biliary injury should be considered irreversible (Fig. 13).

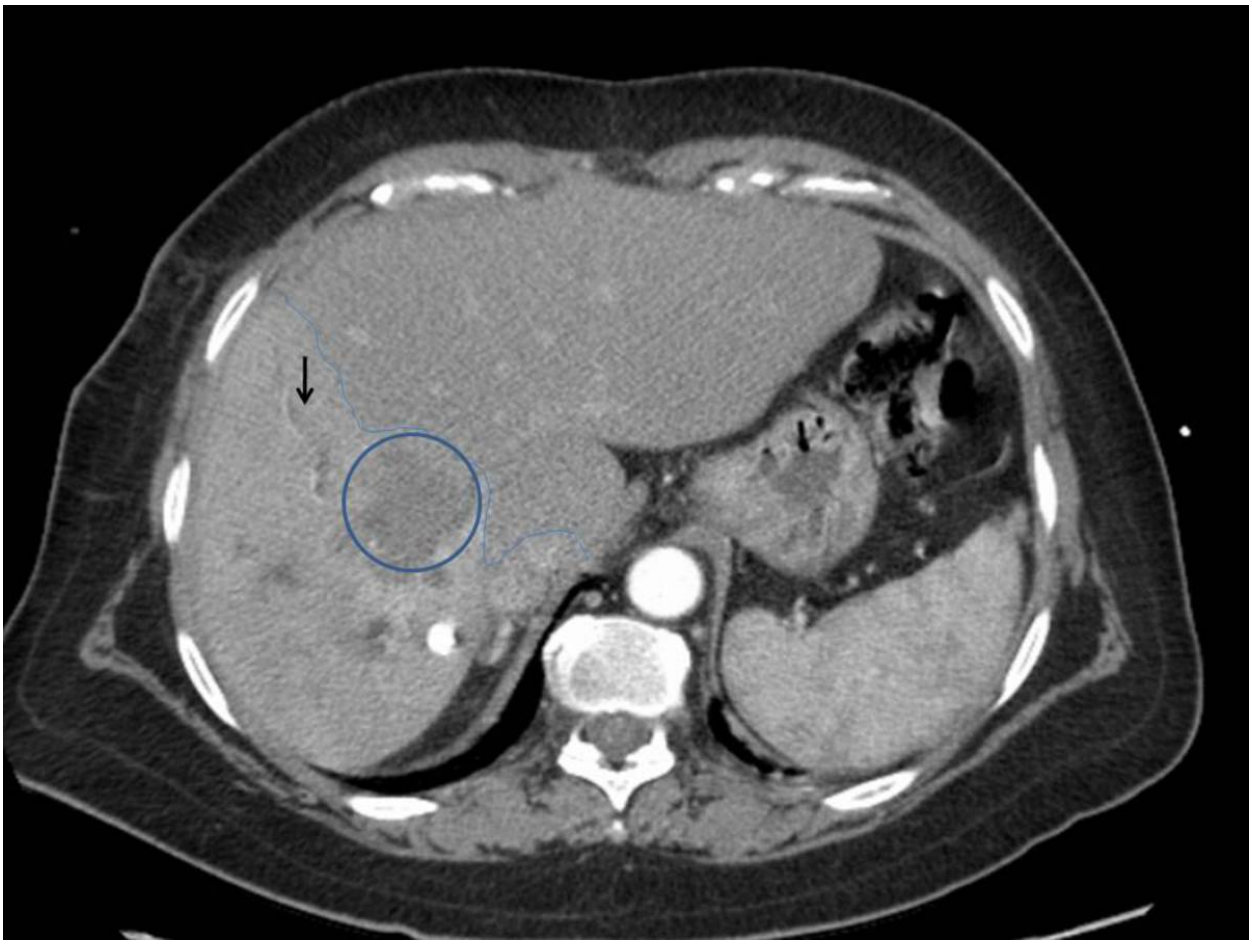


Fig. 13: Axial post-contrast CT image, in arterial phase, a showing hypodense nodular lesion without significant enhancement, in keeping with a treated lesion. Associated with it there is clear attenuation difference (blue line) as well as biliary dilatation (black arrow)
References: Department of Radiology, Hospital Universitário de Coimbra

Biliary strictures can develop in the vicinity of the ablation zone. Central biliary obstruction is rare, as the heat sink effect of the large vasculature adjacent to central ducts is protective. It can be complicated by hepatic atrophy and increases risk of cholangitis. Biliary dilatation and stenting may be needed for management of symptoms and/or complications.

Bilomas appear as liquid collections within or adjacent to the ablation zone or electrode tract, that develop after treatment. If symptomatic drainage can be required.

Biloma imaging appearance	
US	Hypoechoic collection
CT	Hipodense crescent, oval or round shaped non-enhancing collection
MRI	Communication with dilated bile ducts sometimes seen
PET/CT	Low avidity / photopeanic collection

Bilary fistulas are a rare consequence of thermoablation.

Haemobilia presents on CT as layering of hyperdense material (blood) after RFA of lesions in segments adjacent to the gallbladder, usually due to electrode mechanical trauma. On MR the signal intensity changes with increased haemoglobin degradation. This tends to resolve spontaneously.

5. *Collections*

Abscesses (Figs 14-15) take a few weeks to develop and appear similar to normal ablation zone containing gas; however patients are septic and the hipodense area on CT appears enlarged compared to the post-treatment imaging. On MRI the collection present high T2 signal and low T1 signal with peripheral enhancement post-contrast. Thickened enhancing biliary ducts indicate associated cholangitis.

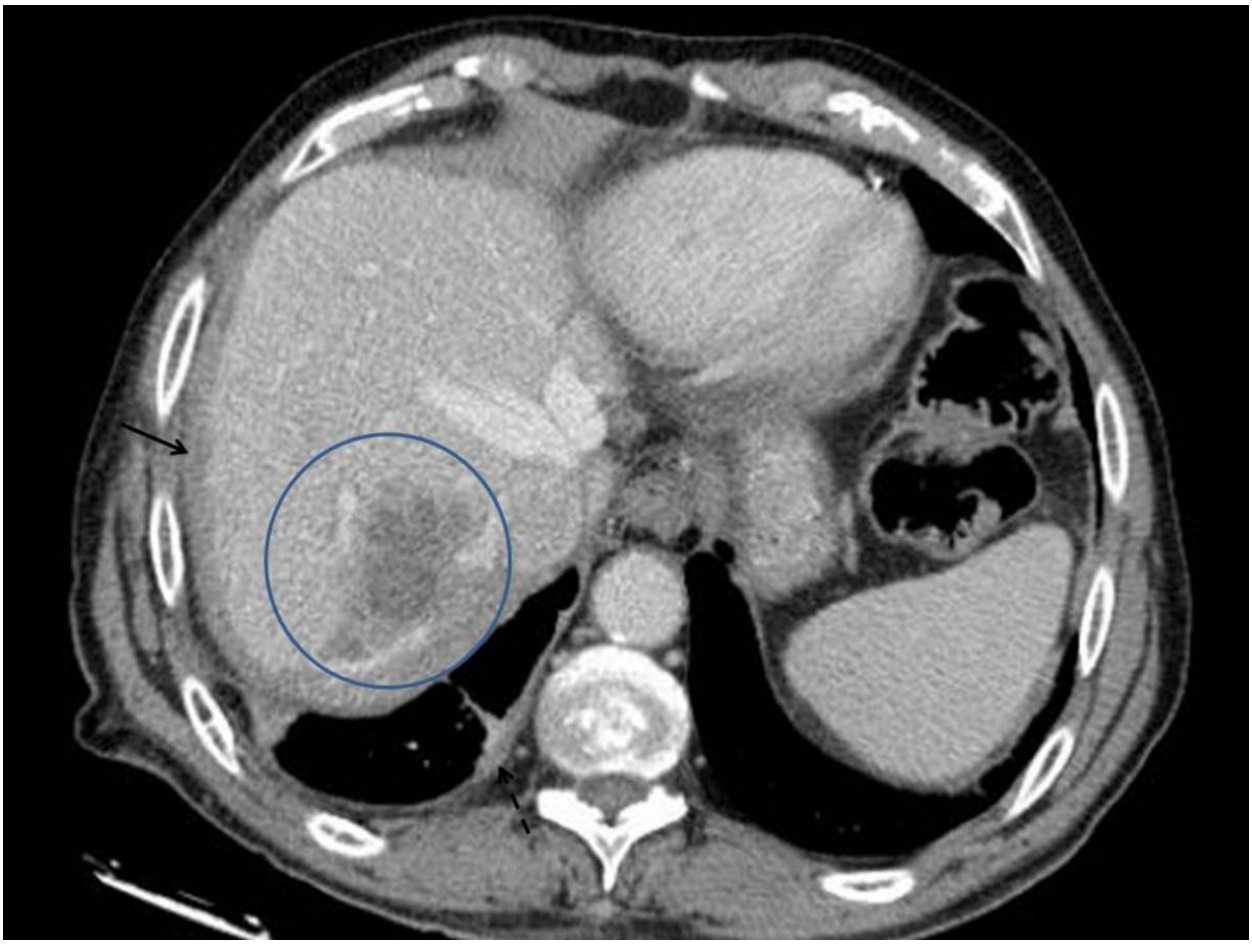


Fig. 14: Post-contrast axial CT image, showing post RFA changes, with a hypodense non-enhancing lesion, in keeping complete lesion ablation (blue circle). Notice slight pleural effusion (black interrupted arrow), probably related to diaphragmatic irritation.
References: Department of Radiology, Hospital Universitário de Coimbra

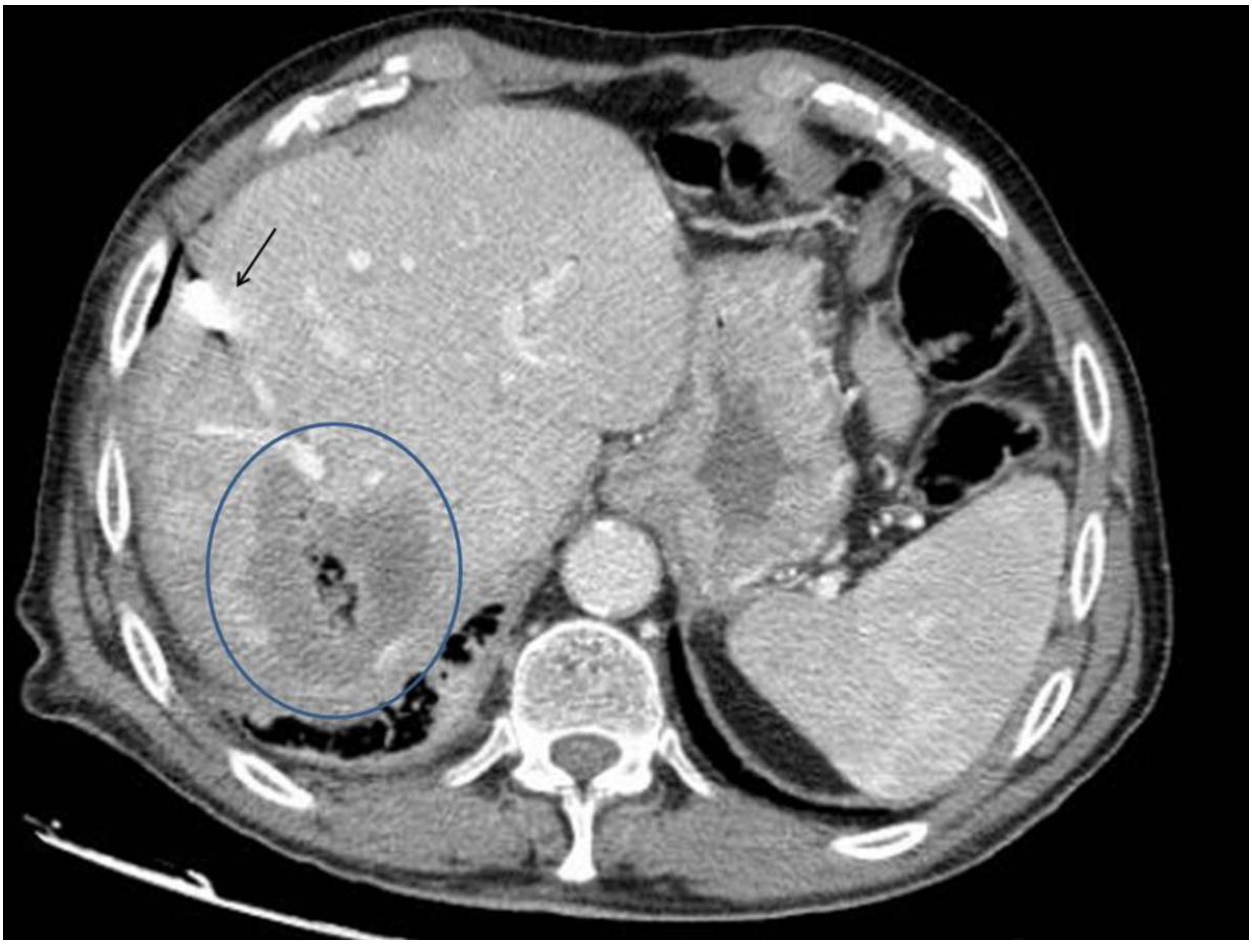


Fig. 15: Post contrast axial CT image, of the same patient depicted in Fig. 14, but 2 weeks later. This shows an increase in the size of the lesion as well as gas within the lesion, changes in keeping with an abscess. Note drain being positioned (black arrow)
References: Department of Radiology, Hospital Universitário de Coimbra

Risk factors for abscess formation[3]	Biloenteric fistulas
	Biliary intervention
	Previous biliary infection
	Diabetes mellitus

Post-ablation syndrome presents with low fever and myalgia, it occurs approximately 10 days after termoablation, however the ablation zone should not be increased.

Peri-hepatic or **subcaspsular haemorrhage** (Figs 16 and 17) is usually due to mechanical vessel injury, especially after multiple punctures. The appearance of haemorrhagic changes varies with the clot evolution and degragation of blood products.

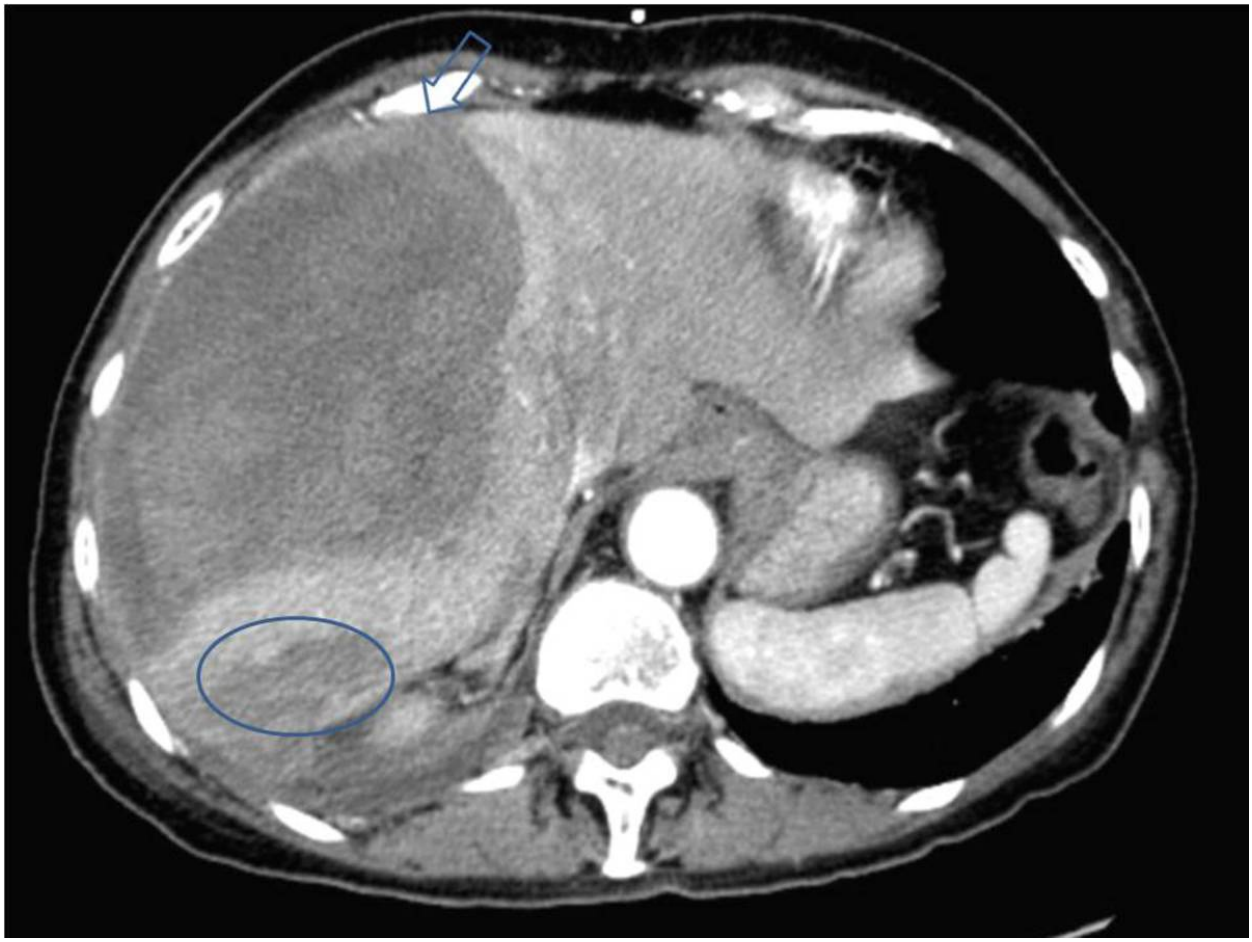


Fig. 16: Post-contrast axial CT image depicting a subcapsular heterogeneous collection, in keeping with a large sub-capsular hematoma (blue arrow). Notice also intra-parenchymal heterogenous collection in keeping with a intra-hepatic haematoma (blue circle).Compare with Fig. 17.
References: Department of Radiology, Hospital Universitário de Coimbra

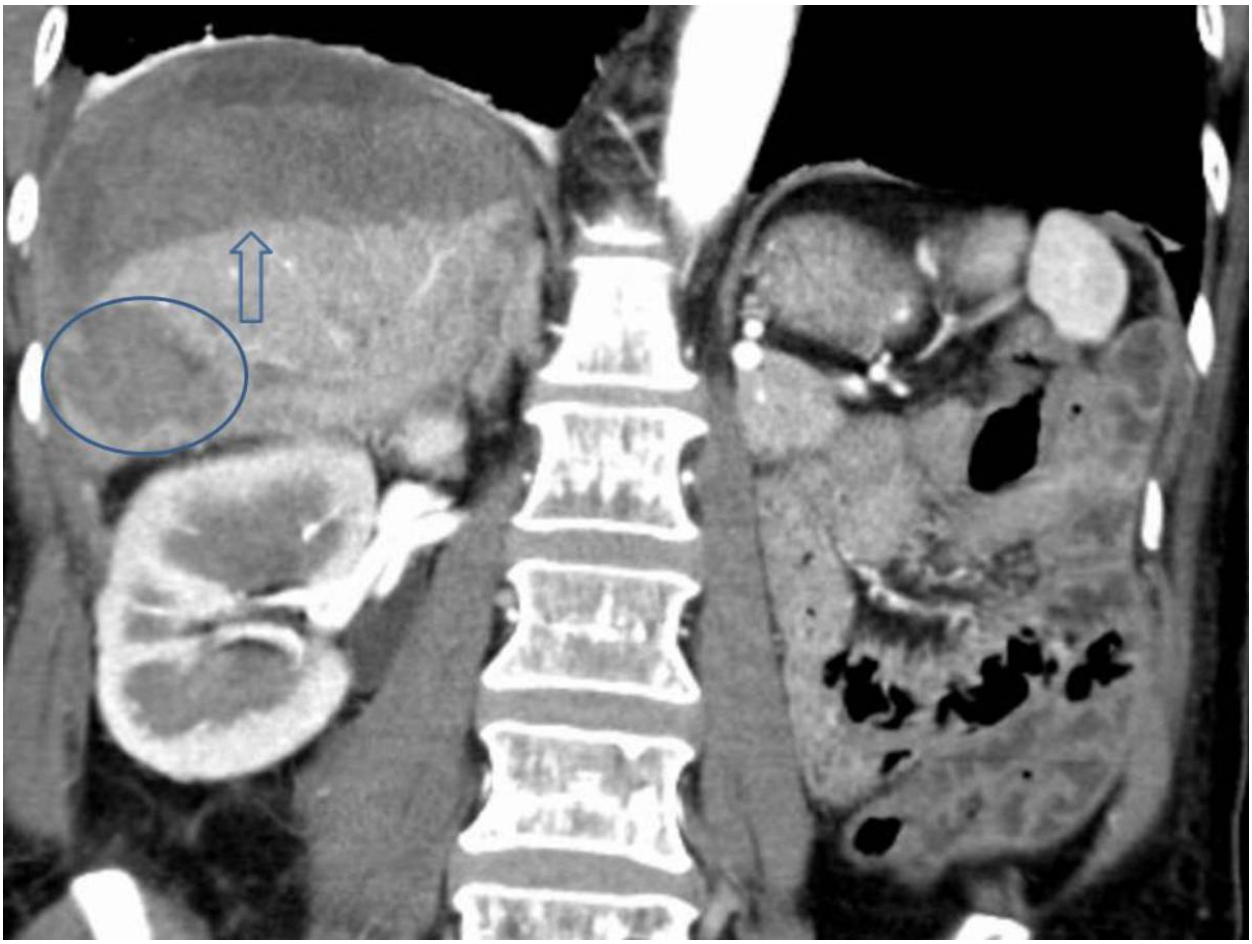


Fig. 17: Post-contrast coronal CT reconstruction depicting a subcapsular heterogeneous collection, in keeping with a large sub-capsular hematoma (blue arrow). Notice also intra-parenchymal heterogenous collection in keeping with a intra-hepatic haematoma (blue circle).Compare with Fig. 16.
References: Department of Radiology, Hospital Universitário de Coimbra

Haemorrhagic foci should be monitored and can be associated with a reactive pleural effusion. If the patient is haemodynamically stable and the haemorrhagic focus does not increase in size, resolution should occur with time.

Risk factors for haemorrhage	Use of large probes
	Multiple punctures
	Mechanical injury to vessels
	Thermal injury to lesions feeding vessels
	Hypervascular lesions

Superficial tumour location

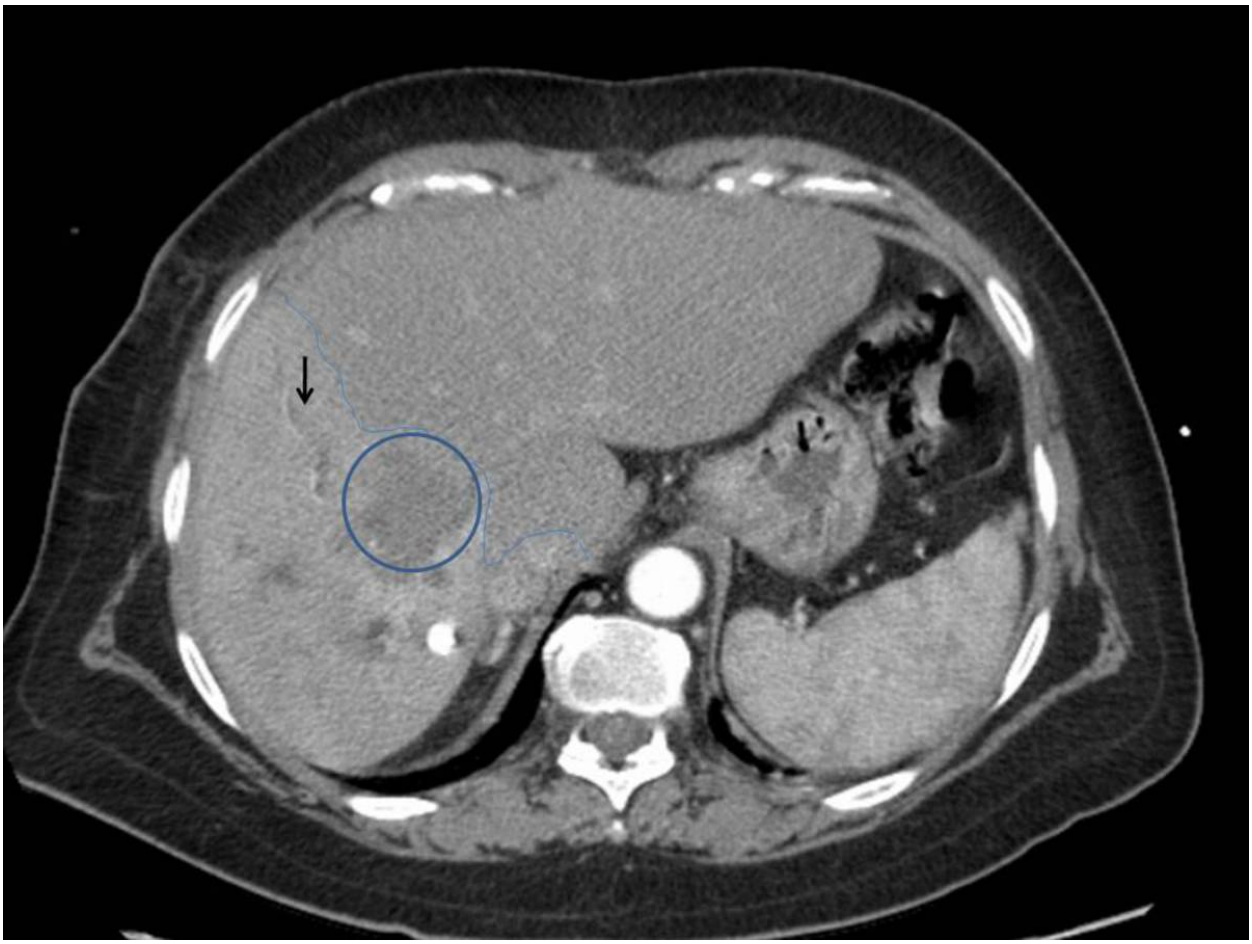
Ascites (lack of tamponade)

Impaired coagulation due to liver failure

6. *Vascular changes*

Vascular complications are rare due to the heat sink effect, in which the moving blood decreases the local temperature. These changes occur either by mechanical trauma or thermal injury.

Transient hepatic attenuation/intensity differences (Fig. 13), identified in the arterial phase, can be seen next to treated tumours and result from vascular injury. These are normally wedge shaped areas that become isodense with the liver in the portal phase and should not be confused with enhancing tumour. Even though transient intensity differences usually do not present morphologic anomalies, occasionally high signal intensity can be seen on T2WI. These changes tend to resolve within 6 months.



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Gas within the portal venous system can be normal during the first day after the ablation procedure, however continued gas within the porta is indicative of continued tissue necrosis.

If **arterio-venous fistulas** have been formed there is early venous portal opacification on both arterial post contrast CT and MR. These can cause or worsen portal hypertension.

Hepatic artery pseudoaneurysms present as outpouching of the hepatic artery and can be difficult to identify on imaging. When in doubt angiography should be used for diagnostic confirmation and treatment.

Hepatic artery and **portal vein thrombosis** appear as unenhancing vessels. These can cause liver infarction which appears as non-enhancing hepatic parenchyma, however this is extremely rare.

7. *Soft tissue changes*

Stranding of the peri-hepatic fat, haematomas or enhancing soft-tissues in the abdominal wall and peri-hepatic fat result from the local trauma caused by the introduction of the probe. When lesions are close to the diaphragm, perforation can result with subsequent pleural effusion and atelectasis. If there is diaphragmatic injury a self-limiting haemothorax can occur.

When the lesions being ablated are close to the gastro-intestinal tract thermal or mechanical injury can occur, with bowel wall inflammation, perforation or abscess formation. Due to the lack of mesentry and decreased mobility, the colon is the most prone segment to these types of injury (Fig.18).

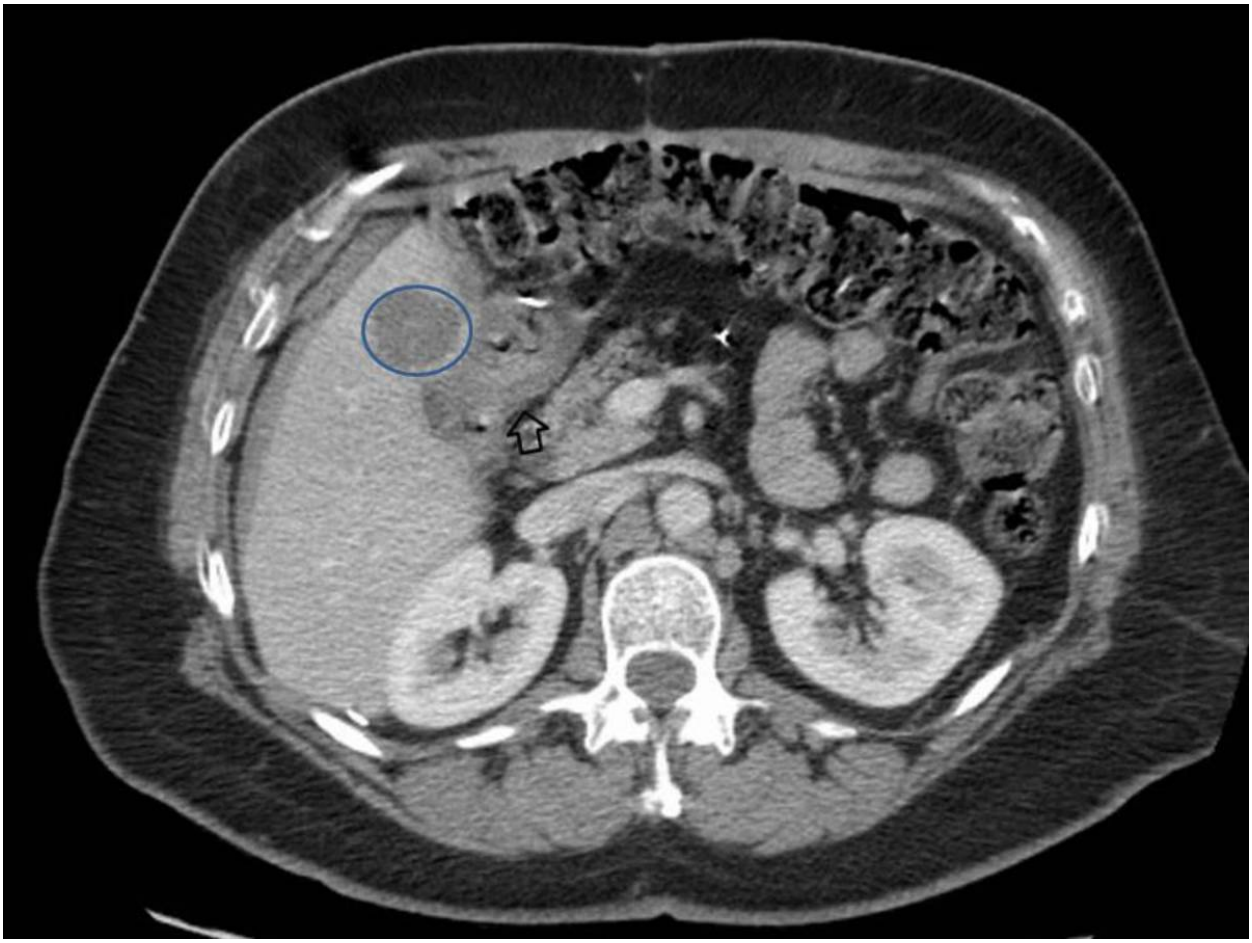
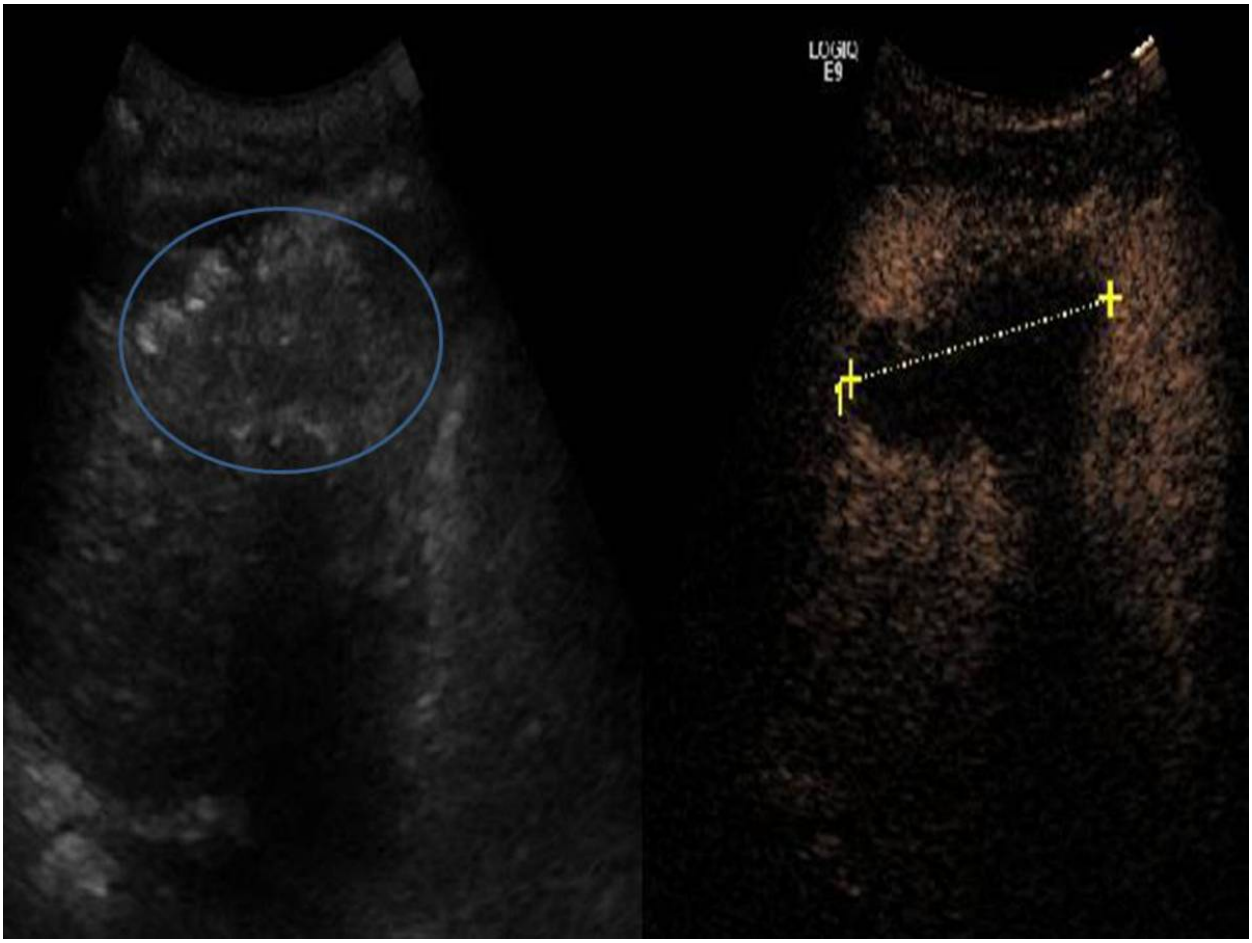


Fig. 18: Post-contrast axial CT image, showing hypodense unhencing lesion in the liver (blue circle). Adjacent to it is a thickened duodenum, secondary to thermal injury.
References: Department of Radiology, Hospital Universitário de Coimbra

Images for this section:



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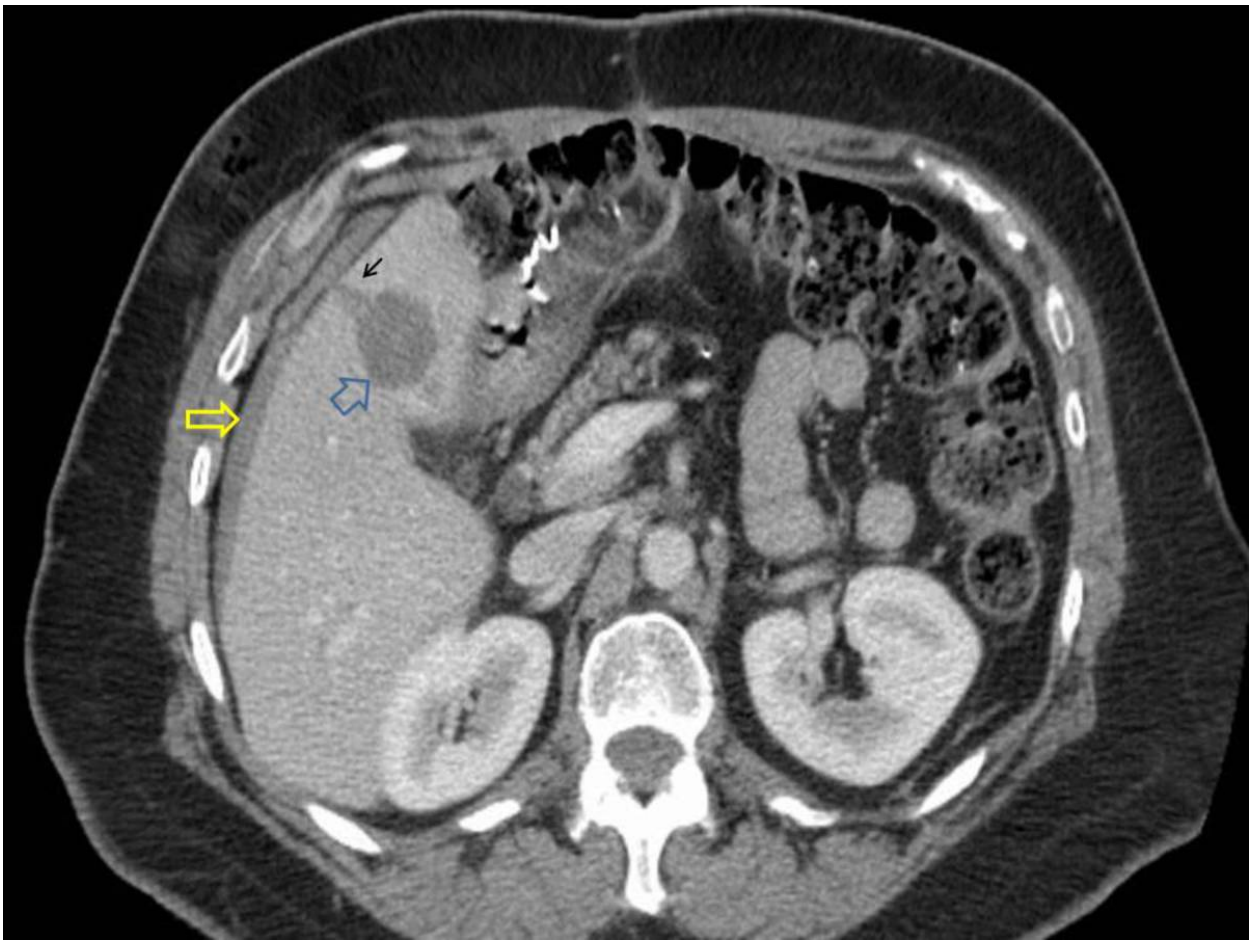

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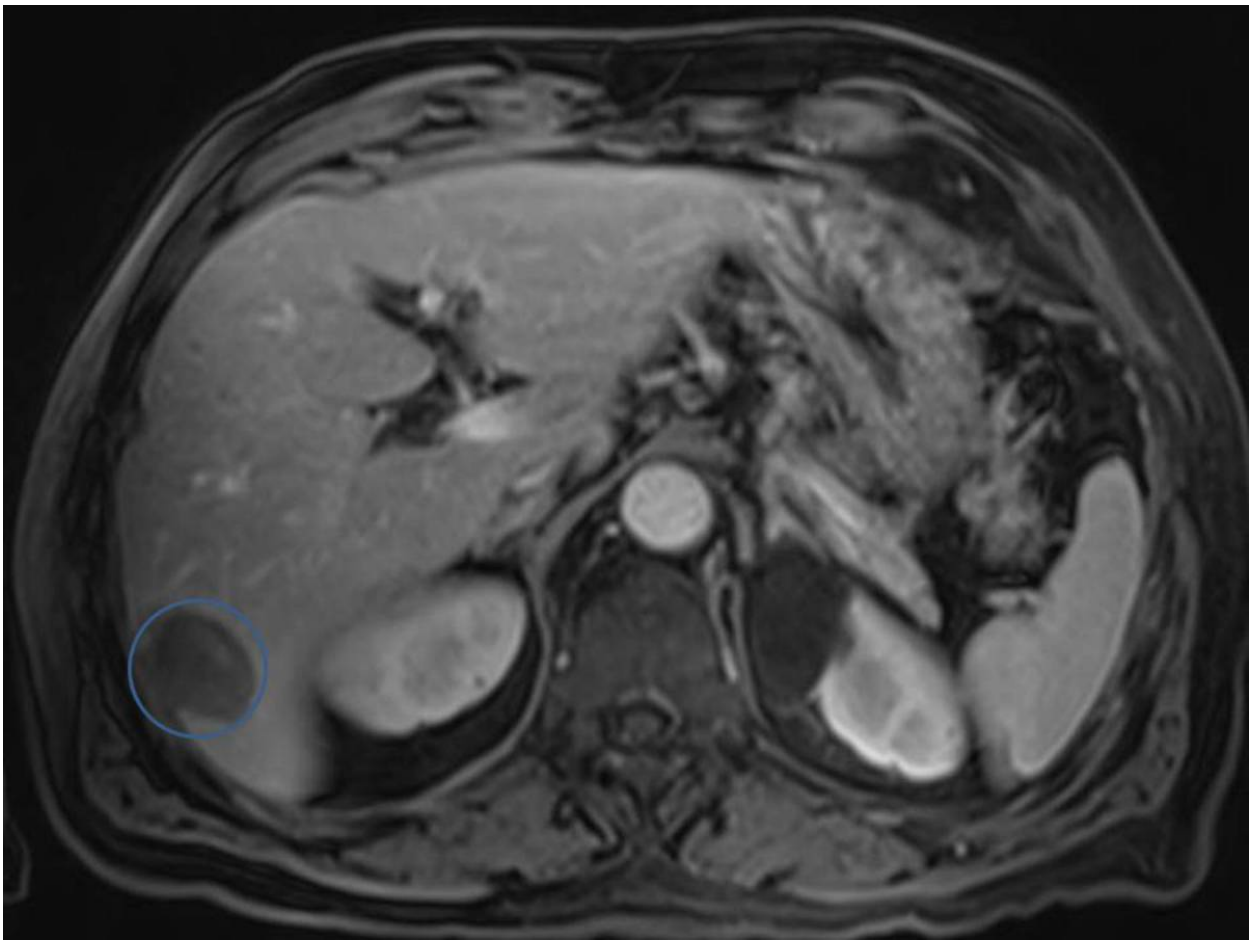

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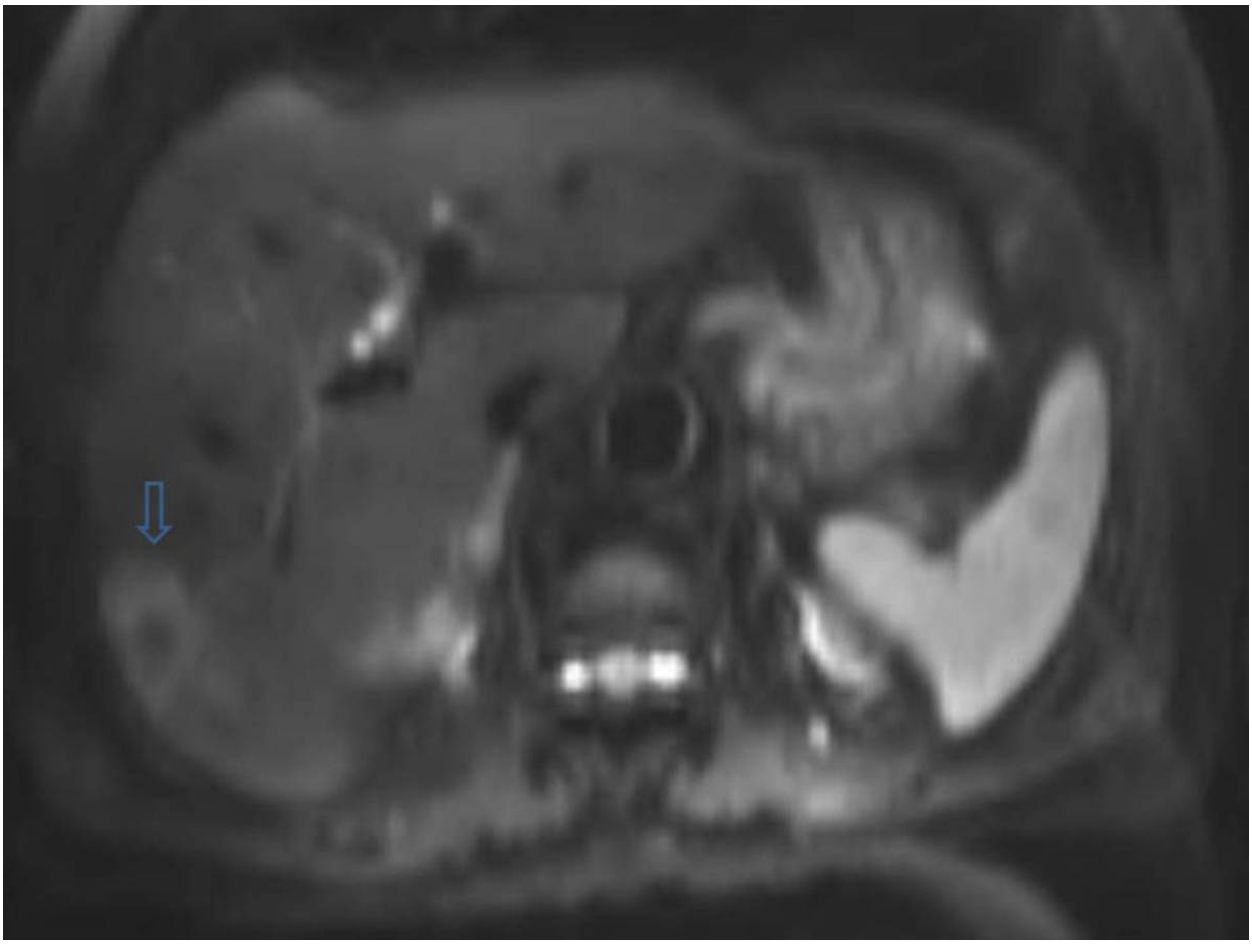

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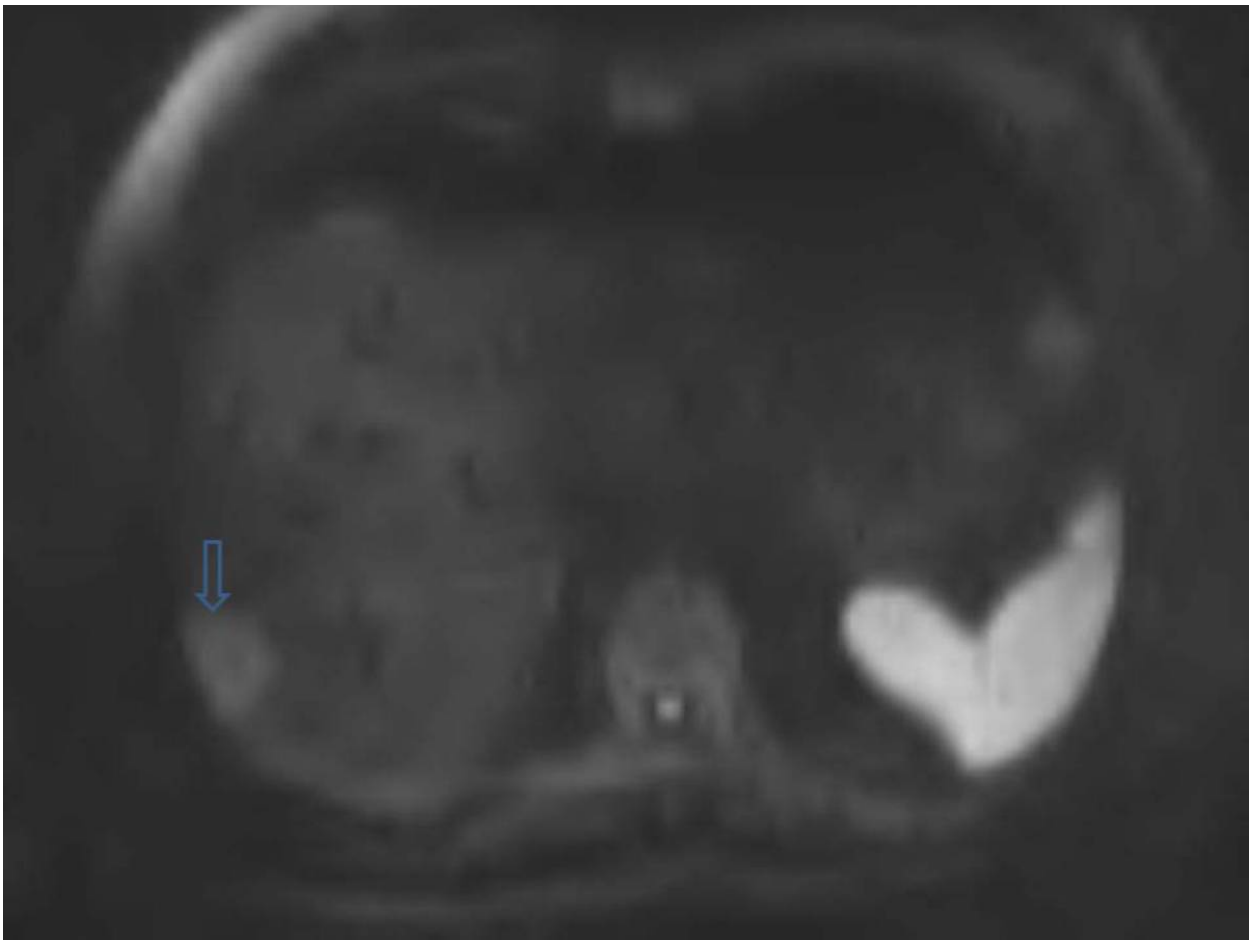

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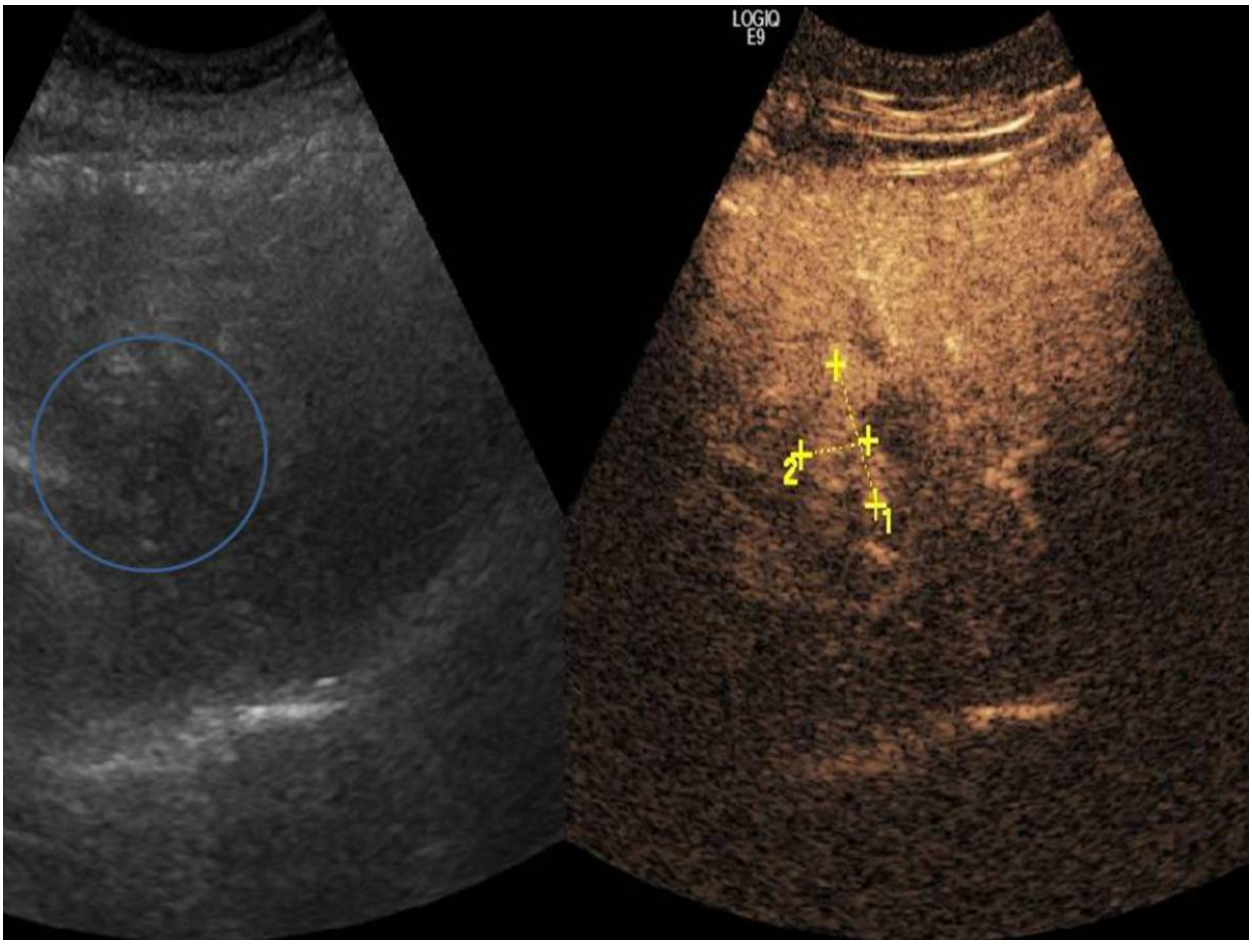

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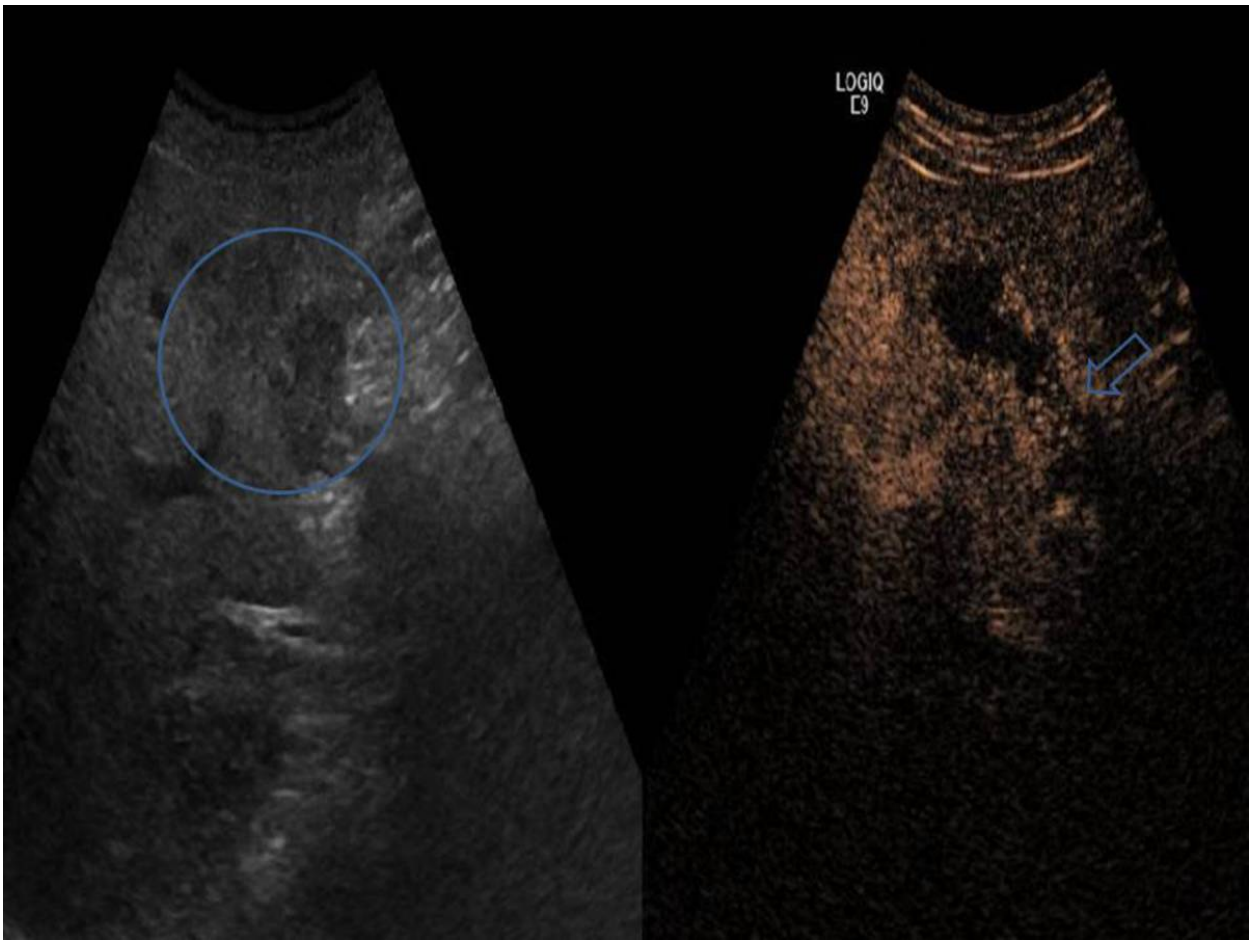

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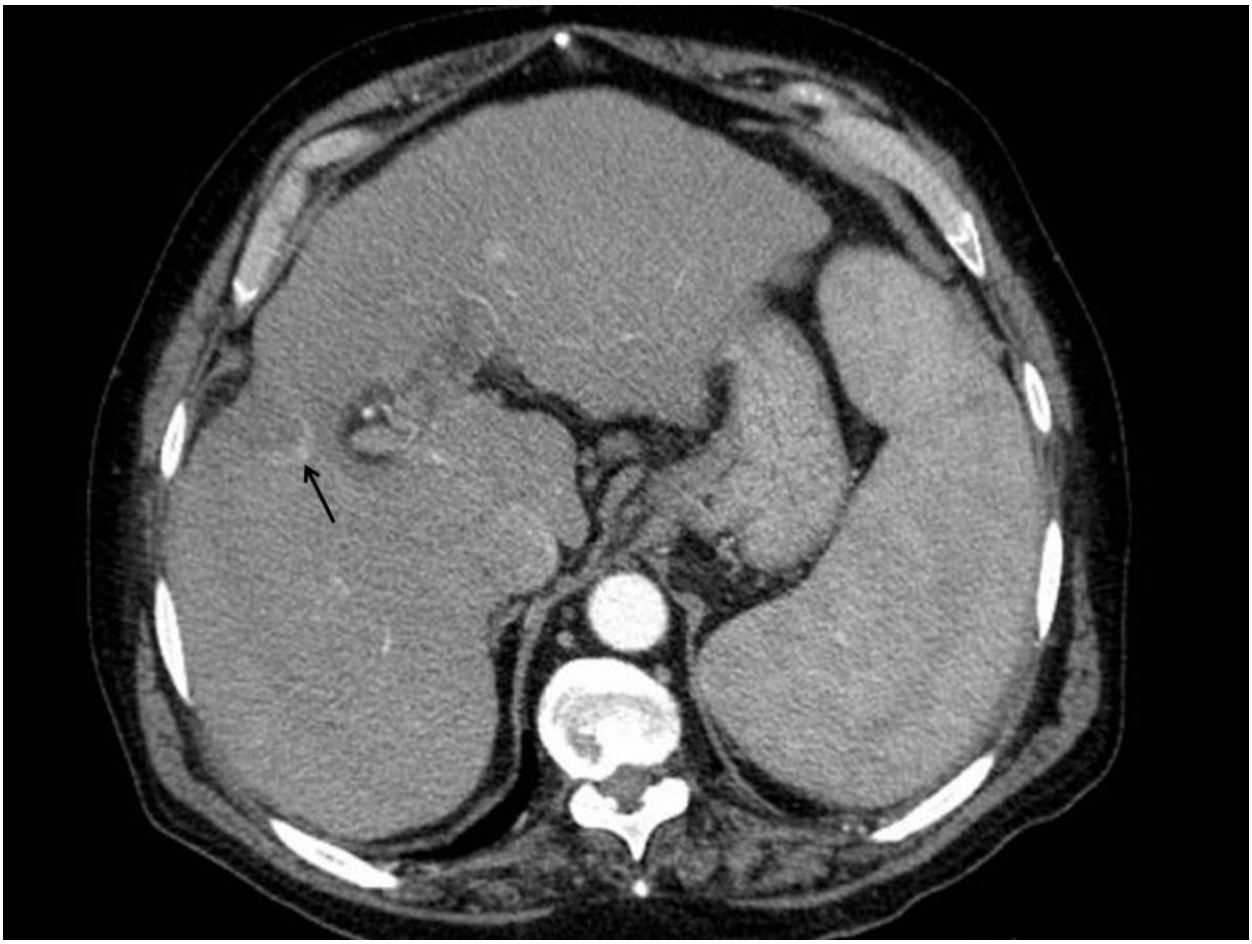

Fig. 10: Post contrast axial CT image, showing eccentric marginal thickening (black arrow), in keeping with recurrent tumour.

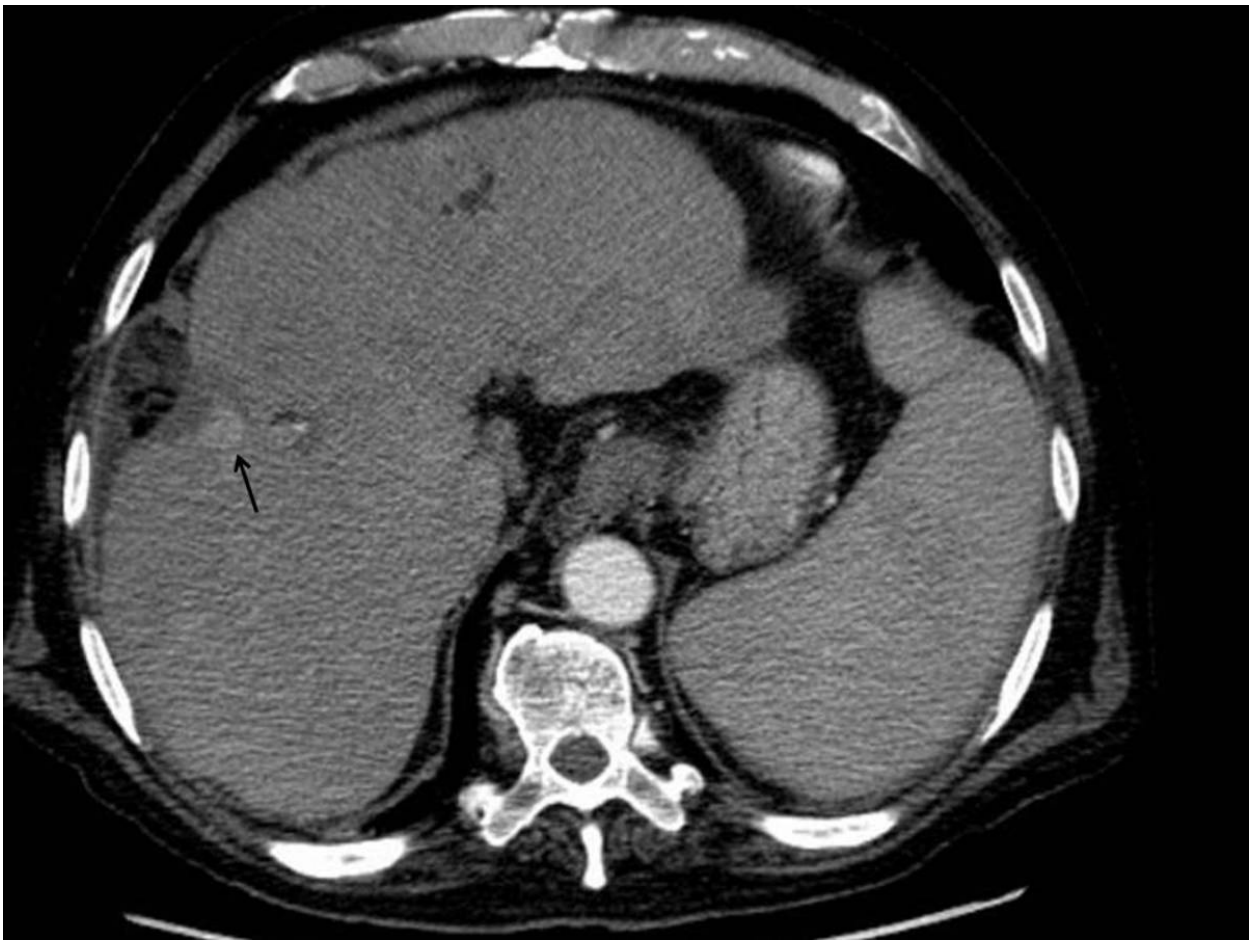

Fig. 11: Post-contrast axial CT image showing nodular thickening of the margin of a treated lesion (black arrow), in keeping with recurrence

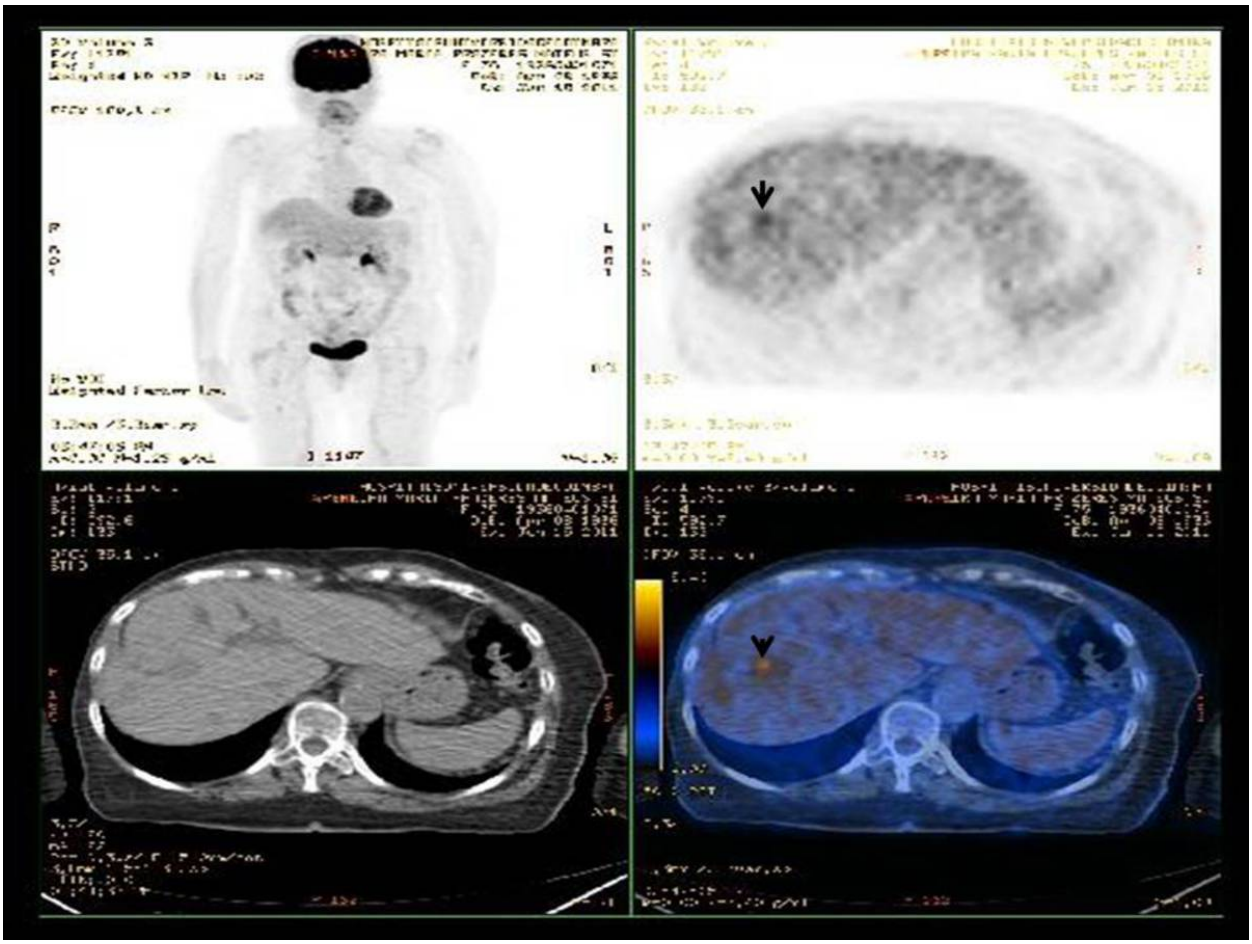

Fig. 12: FDG PET CT showing avid nodular lesion (black arrow) in the periphery of a previously treated lesion, in keeping with recurrence.

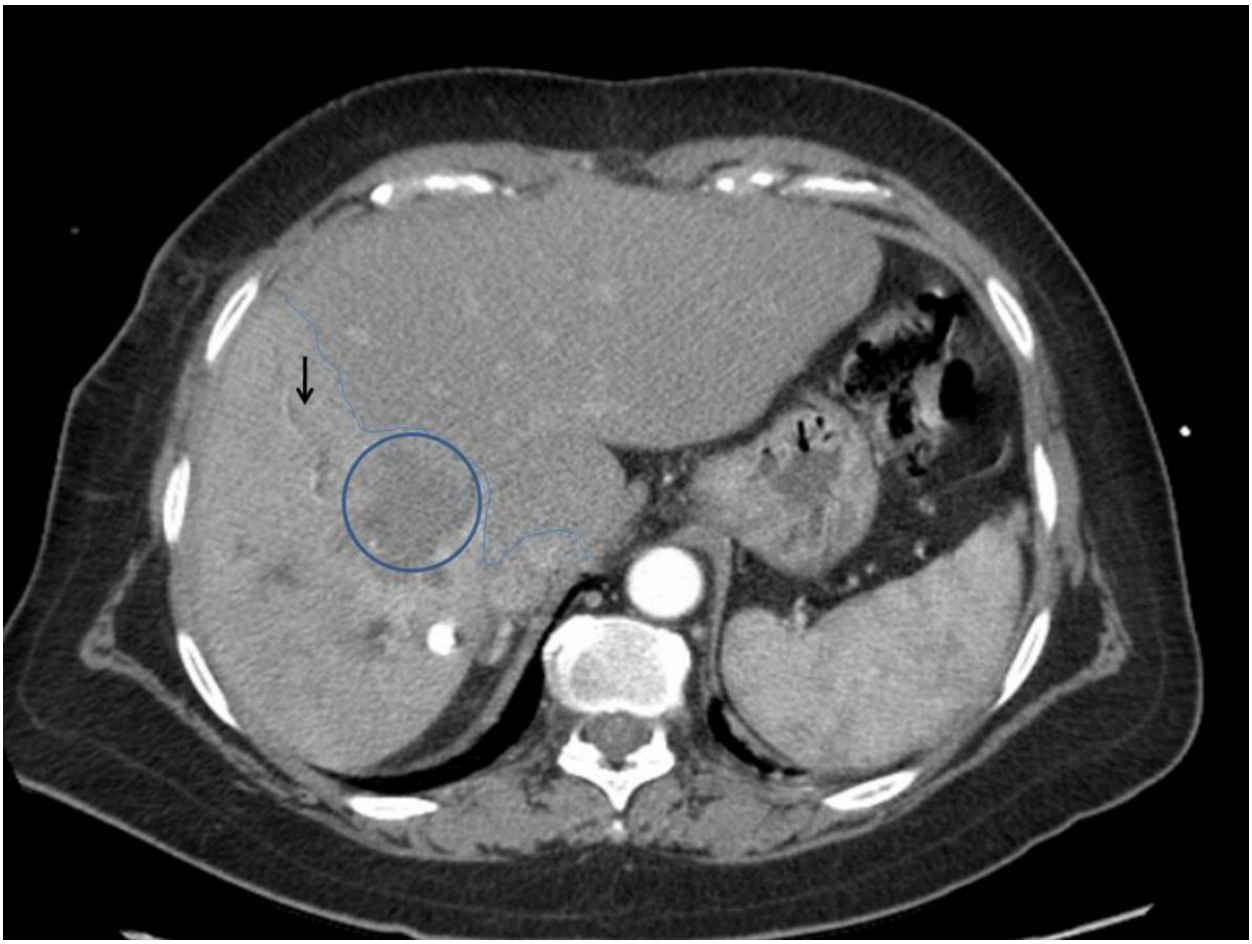

Fig. 13: Axial post-contrast CT image, in arterial phase, a showing hypodense nodular lesion without significant enhancement, in keeping with a treated lesion. Associated with it there is clear attenuation difference (blue line) as well as biliary dilatation (black arrow)

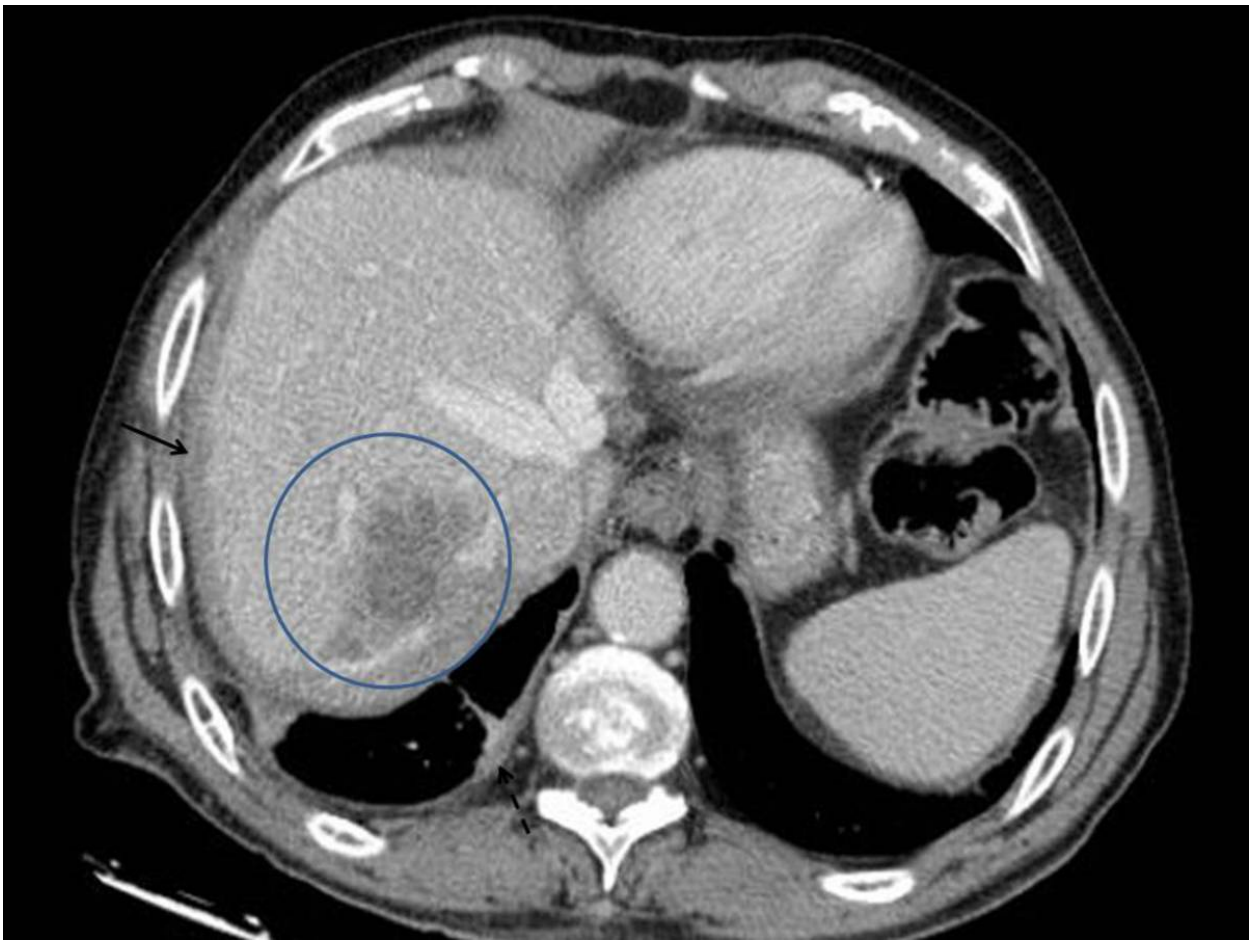

Fig. 14: Post-contrast axial CT image, showing post RFA changes, with a hypodense non-enhancing lesion, in keeping complete lesion ablation (blue circle). Notice slight pleural effusion (black interrupted arrow), probably related to diaphragmatic irritation.

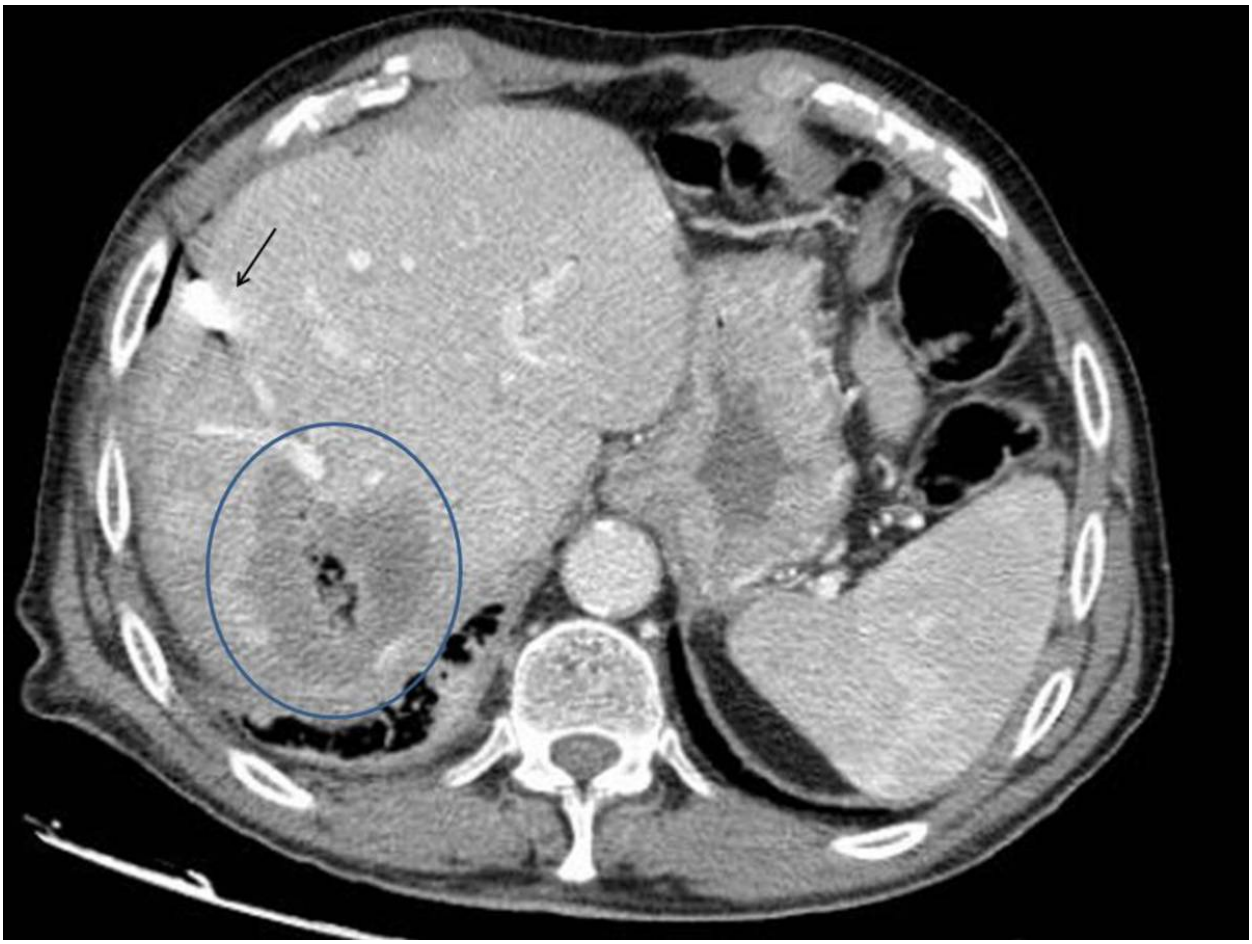

Fig. 15: Post contrast axial CT image, of the same patient depicted in Fig. 14, but 2 weeks later. This shows an increase in the size of the lesion as well as gas within the lesion, changes in keeping with an abscess. Note drain being positioned (black arrow)

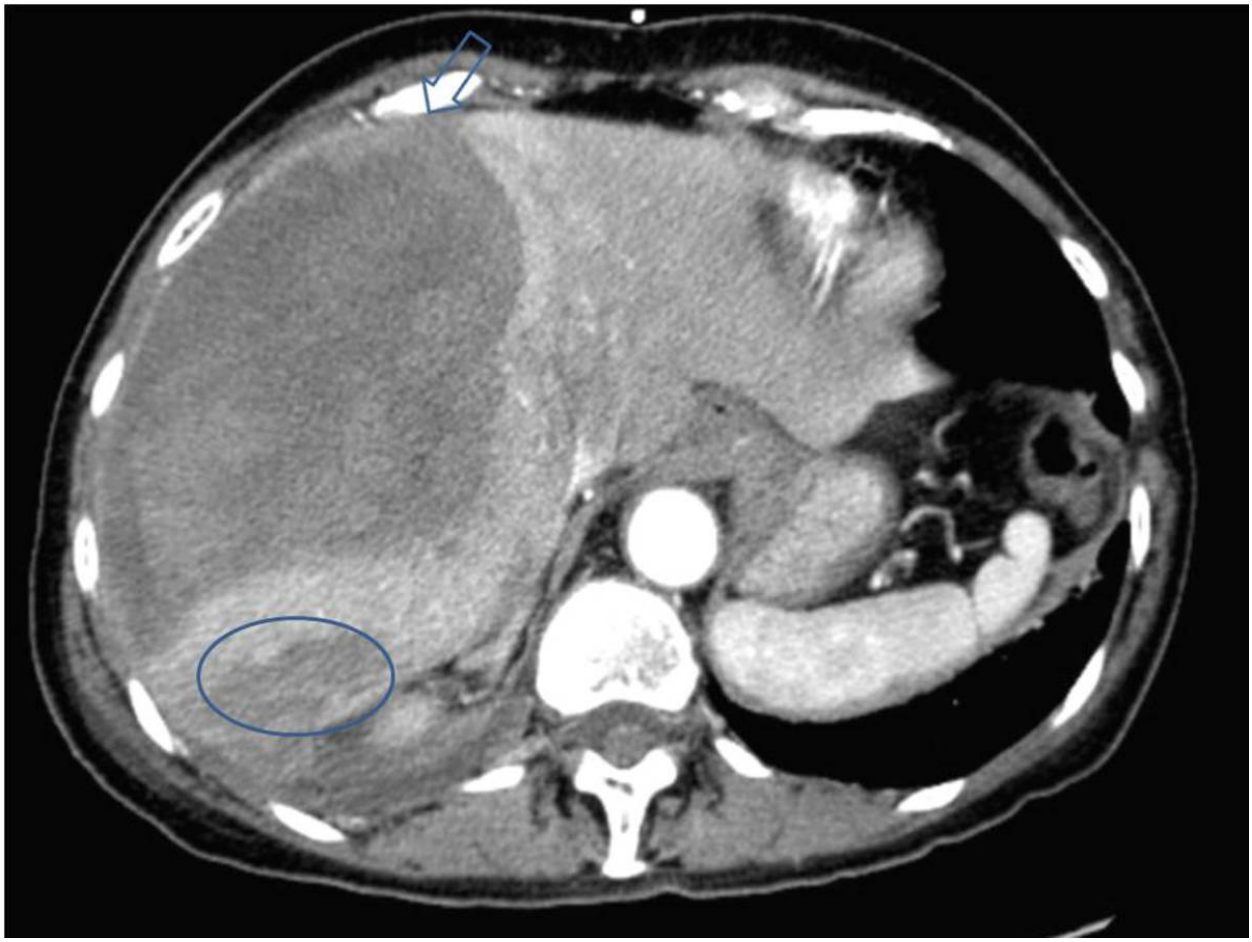

Fig. 16: Post-contrast axial CT image depicting a subcapsular heterogeneous collection, in keeping with a large sub-capsular hematoma (blue arrow). Notice also intra-parenchymal heterogenous collection in keeping with a intra-hepatic haematoma (blue circle).Compare with Fig. 17.

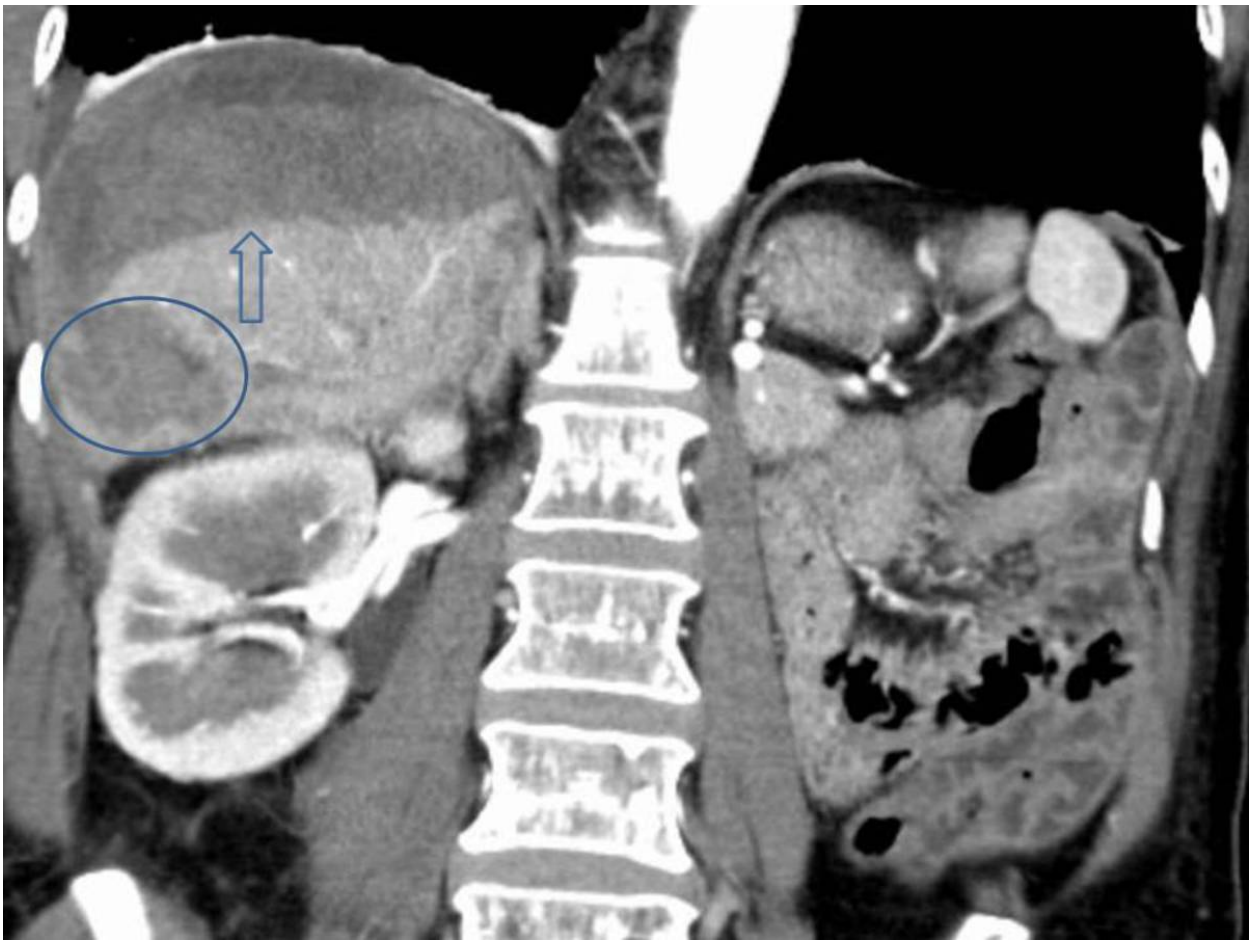

Fig. 17: Post-contrast coronal CT reconstruction depicting a subcapsular heterogeneous collection, in keeping with a large sub-capsular hematoma (blue arrow). Notice also intra-parenchymal heterogenous collection in keeping with a intra-hepatic haematoma (blue circle).Compare with Fig. 16.

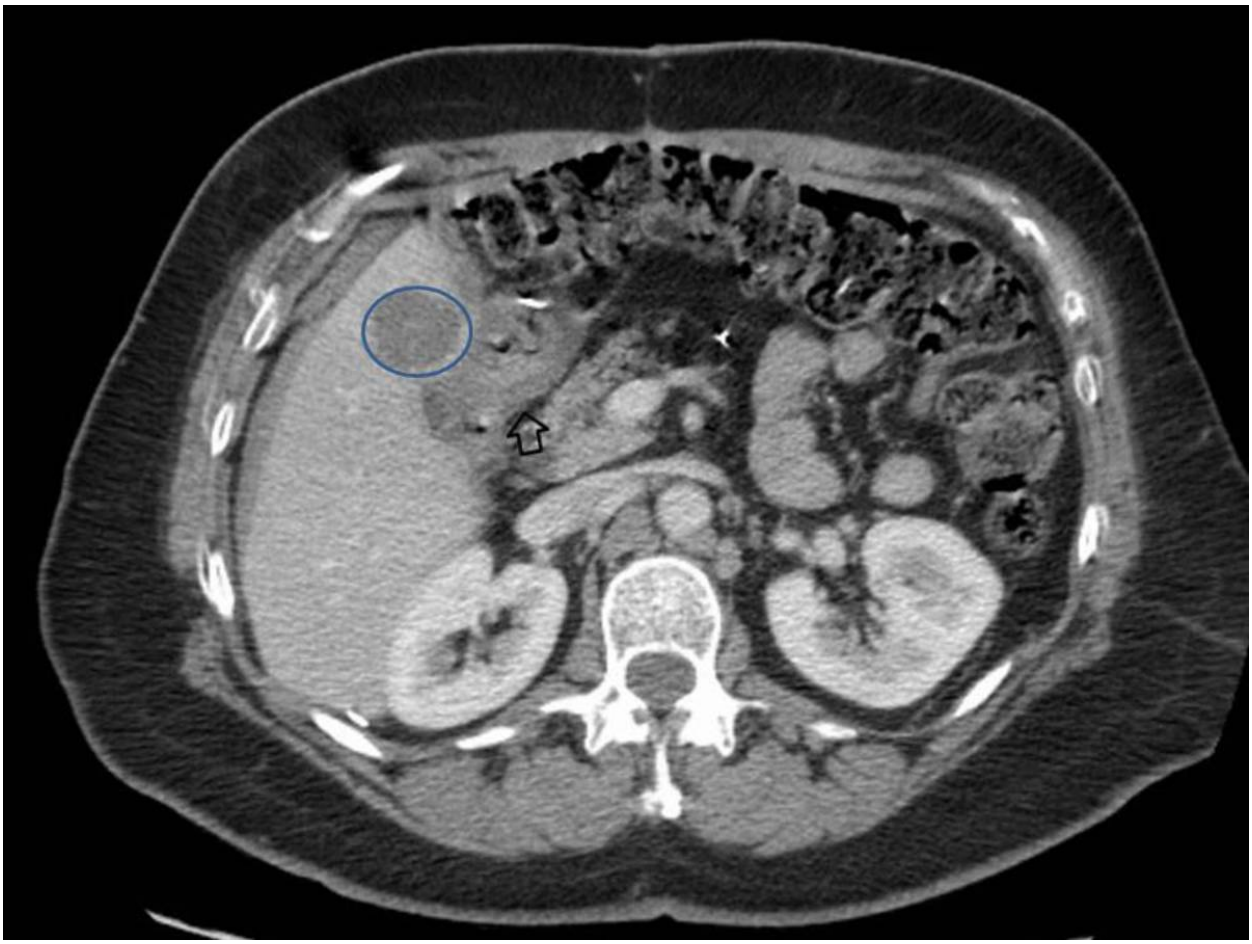

Fig. 18: Post-contrast axial CT image, showing hypodense unhencing lesion in the liver (blue circle). Adjacent to it is a thickened duodenum, secondary to thermal injury.

Conclusion

Radiologists need to be aware of the expected and unexpected changes that occur post-RFA. Expected changes are benign and resolve with time. Unexpected changes, recurrence/persistence and post-procedural complications, are especially important to recognise.

Personal information

References

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