review of post RFA CT appearance of lung tumors

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Authors: M. F. S. SHAUKAT, H. E. Wijesinghe, S. Hussain, M. Djearaman; BIRMINGHAM/UK
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Learning objectives

This poster aims to provide over-view of common CT appearances of post RFA (radio-frequency ablation) of lung malignancies, so that radiologists can become more aware and are more confident in reporting thoracic CT scans of post RFA lung malignancy follow up.
Background

Pulmonary nodules and metastases is a common occurrence in current practice. Thermal ablation is now an accepted technique in management of primary lung cancer and pulmonary metastases. This non surgical technique is particularly valuable in patients with poor pulmonary function and in situations where we want to preserve as much lung tissue as possible. \(^{(1)}\) As thermal ablation for lung tumors is not widely available, clinicians and general radiologists are not aware of post ablation imaging features of lung tumors. Thermal ablation includes radiofrequency ablation\(^{(2)}\), microwave ablation and cryoablation, depending upon the technique available at the specialist centre.

In our institution we primarily use Radio Frequency Ablation (Boston Scientific) to treat metastases and primary lung cancers. In this technique, the radiofrequency electrode is placed in/adjoining the tumor under CT guidance. Radio frequency electrode is then coupled to a radio frequency generator and is earthed by means of a grounding pad or pads applied to the patient's thighs. Radio-frequency generator produces a rapidly changing alternating current at the tips of the electrode which induces tissue heating \(^{(3)}\). Tissue heating to high temperatures leads to immediate cell necrosis. \(^{(4)}\)

In the lung, radio-frequency energy is very effectively deposited because the surrounding air acts as an insulator (concentrating the radiofrequency energy within the tumor). However if the nodule is close to major blood vessel, the generated thermal energy is lost as "heat sink" from the target tissue. \(^{(5,6)}\) In order to reduce the risk of incomplete ablation, 1 cm margin of healthy tissue at the tumor periphery, referred as " safety zone" must also be ablated. \(^{(7,8)}\)
Findings and procedure details

Post RFA CT imaging appearances can be divided into three phases\(^{(2)}\):

-- early phase (immediately post procedure to 1 week post RFA),

-- intermediate phase (> 1 week to 2 months post RFA)

-- late phase (> 2 months after RFA)

**EARLY PHASE** (immediately post procedure to 1 week post RFA)

Most common CT finding immediately post RFA is ground glass opacification surrounding the treated tumor and intra-lesional bubbles. Track of the RFA electrode shows increased attenuation. \(^{(9)}\)

On CT scan, immediately post RFA, multiple concentric rings of variable attenuation sometimes may be seen surrounding the ablated tumor. These concentric rings are termed as cockade phenomenon. \(^{(10)}\) This phenomenon is caused by sudden tissue coagulative necrosis and destruction of micro-circulation caused by high temperatures. \(^{(11)}\)

Immediately post RFA and up to a month after the procedure, the ablation zone appears larger than original tumor because the ablated zone comprises of both tumor and perilesional ground glass opacification corresponding to the safety zone. CT of the thorax is performed in 2 phases, an unenhanced CT of the chest followed by a scan of the chest 70 seconds after administration of intravenous contrast. CT thorax with contrast post RFA shows central hypo-attenuation with marked reduction in contrast uptake due to RFA induced micro-circulation damage. \(^{(12)}\)

Thin <5 mm thick, smooth concentric rim of enhancement called benign peri-ablation enhancement can also be seen peripheral to ablation zone. \(^{(13)}\)

**Intermediate phase (> 1 week to 2 months post RFA)**
After 1 month, perilesional surrounding ground glass opacities have mostly involuted with cavitation being common in treated tumor between 1 to 3 months especially if lesion is close to chest wall or large airways. \(^{(14)}\)

In the intermediate phase, pleural thickening is also a common finding especially in the region of pleura traversed by radiofrequency electrode(s). \(^{(15)}\)

Compared with the original tumor, the ablation zone will continue to be larger, in the intermediate phase, but should be smaller relative to early phase appearances. Ablation zone shows marked reduction in contrast enhancement compared to with pre-RFA tumor enhancement in the intermediate phase. \(^{(16)}\)

**Late phase (>2months post RFA)**

During this phase, the ablation zone undergoes further involution. Cavitation in the ablation zone eventually disappears. Sequential CT scans show resolution of early and intermediate findings including pleural thickening. With passage of time, scarring also develops in the ablation zone. \(^{(16)}\)

At 6 months, post RFA, the size of ablation zone should be same or smaller than the tumor before ablation. \(^{(17)}\)

All neoplasms that show continued growth beyond 6 months on follow-up scans are concerning for recurrent/ residual disease. \(^{(16)}\)

Tissue sampling, FDG PET CT should be considered at this stage to help decide further management. It would be invaluable to discuss the imaging with the team that carried out the ablation in the first instance.

**Complications seen post Lung RFA**

There are number of complications may be seen post lung RFA for example, pneumothorax, pleural effusion, haemothorax, air embolism. Incomplete ablation from obscuration of tumour by pulmonary haemorrhage, large pneumothorax are potential intraprocedure complications.
Fig. 2: Pre-procedure image - Colorectal Pulmonary metastasis in right lower lobe.

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Fig. 3: Immediately post-procedure - ground-glass attenuation surrounding the lesion

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Fig. 4: 1 month post-procedure - Satisfactory margin of ground glass attenuation with adjacent pleural thickening.

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**Fig. 5:** After 6 months post RFA, lesion has become solid with internal high attenuation areas.

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**Fig. 6**: After 12 months, post ablated lesion shows reduction in size than original tumor. Pleural thickening has regressed.

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**Fig. 7:** In some cases, cavitation can be seen post ablation.

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Fig. 8: Sagittal CT image shows ground-glass attenuation in post-ablation lesion that was metastatic lesion from melanoma in right lung.

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Fig. 9: Right sided pneumothorax identified as a complication after Lung RFA procedure

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Conclusion

Thermal ablation is currently an accepted treatment for lung malignancies. Availability of this technique will grow and general radiologists will encounter more patients that have undergone lung RFA. Distinguishing post RFA changes from complications/ residual/ recurrent disease is vital for follow up.
Personal information

Contact Details:

Dr MUHAMMAD FAHAD SHAHZAD SHAUKAT
International Training Fellow (RADIOLOGY)
Birmingham Heartlands Hospital
Birmingham
United Kingdom (UK)
Post Code: B9 5SS

e-mail: fahadshaukat2001@mail.com

Dr HAREN WIJESINGHE
Radiology Registrar in Training
Birmingham Heartlands Hospital
Birmingham
United Kingdom (UK)
Post Code: B9 5SS

e-mail: haren_wijesinghe@hotmail.com

Dr MADAVA DJEARAMAN
Consultant Cardiothoracic Radiologist (RFA Lead)
Birmingham Heartlands Hospital
Birmingham
United Kingdom (UK)
Post Code: B9 5SS

e-mail: madava.djearaman@heartofangland.nhs.uk

Dr SHAHID HUSSAIN

Consultant Cardiothoracic Radiologist
CT Clinical Lead Radiology Directorate
Simulation Lead Birmingham Radiology Scheme
Birmingham Heartlands Hospital
Birmingham
United Kingdom (UK)
Post Code: B9 5SS

e-mail: shahid.hussain@heartofengland.nhs.uk
References


