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Role of percutaneous radiofrequency ablation in treatment of liver malignancies

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Abstract
Background: Hepatocellular carcinoma (HCC) and metastases from colorectal carcinoma are the two most common malignant tumors to affect the liver. When these tumors are left untreated, the prognosis for both is dismal, with essentially 100% mortality at 5 years. Conventional therapies such as systemic chemotherapy or radiation have proven ineffective.
Objective: Evaluation of the safety, efficacy of radiofrequency ablation in treatment of liver malignancies that fulfill its established parameters.
Patients and Methods: This experimental non-randomized study was carried between (January 2019 and October 2019) in collaboration with Medical and trpoical medicine Department. Twenty patients with hepatic malignancies were treated by ultrasound-guided percutaneous radiofrequency ablation.
Results: In our study, Boston RF 3000 system was used for treatment of liver tumors. Energy is delivered from the generator to the target tissue by a 14-gauge needle that has twelve hook shaped electrodes inside and the system offers the advantage of an electrical measurement of tissue impedance. Twenty patients with Twenty four focal lesions were treated by twenty seven RFA sessions are divided the size of the focal lesion into two groups, group A (patients with focal lesions less than 3cm) fourteen patients with eighteen focal lesions were treated by eighteen RFA sessions; complete ablation was (88.9%) , recurrence was (11.1%) and no residual detected , Group B (patients with focal lesions (3-5cm)) six patients had six focal lesions were treated by nine RFA sessions, complete ablation was (50%) , residual was (33.3%) , recurrence (16.6%).
Conclusion: There are several guidelines to assess treatment response in patients with HCC, including the World Health Organization (WHO), Response Evaluation Criteria in Solid Tumors (RECIST), and European Association for the Study of the Liver (EASL), or modified RECIST (mRECIST) criteria.
The Liver Imaging Reporting and Data Systems (LI-RADS), is an extensive approach to categorize and assess residual or recurrent malignancy, including after loco regional therapies. Specifying response criteria with definitions, examples and a precise algorithm, LIRADS guidelines are designed to standardize the response assessment and improve communication within HCC multidisciplinary teams, both for clinical practice and clinical trials.

Keywords: hepatocellular carcinoma, barcelona clinic liver cancer

Introduction

Primary liver cancer is the sixth most commonly occurring cancer in the world and the second largest contributor to cancer mortality. Globally, the most common histology (approximately 80%) is hepatocellular carcinoma (HCC), a tumor of the parenchymal cells of the liver. The second most common histology (approximately 15%) is intrahepatic cholangio carcinoma, which arises in the cholangiocytes of the intrahepatic bile ducts. Large geographic disparities in incidence and mortality of all types of liver cancer exist [1].

Hepatocellular carcinoma (HCC) is a major health problem worldwide, with an estimated incidence ranging between 500,000 and 1,000,000 new cases annually -related deaths [2].

The geographic distribution of this disease accompanies its principal risk factors: Chronic hepatitis B virus and hepatitis C virus infection, alcoholism, aflatoxin B1 intoxication, liver cirrhosis, and some genetic attributes. Recently, type II diabetes has been shown to be a risk factor for HCC together with obesity and metabolic syndrome. Although the risk factors are quite well known and it is possible to diagnose HCC when the tumor is less than 1 cm diameter, it remains elusive at the beginning and treatment is often unsuccessful [3].

Hepatic resection can be safely done in cirrhotic HCC patients aging 70 years, but the prognosis of these patients is less favorable than < 70 years patients, even when curative resection is achieved [4].

Liver transplantation is thus far considered the best treatment for HCC as it cures HCC and the underlying liver disease. Using the Milan criteria, overall survival after liver transplantation for HCC is about 70% after 5 years In addition to liver transplantation other therapies have been proposed such as resection, tumor ablation by different means, embolization and chemotherapy. An important step in the treatment of advanced HCC has been the introduction of sora fenib, the first oral, systemic drug that has provided significant improvement in survival [3].

Liver is the primary site of metastatic malignancies of the gastrointestinal tract. Hepatic metastases cause significant morbidity and mortality in patients with colorectal cancer. About 30% of these patients will present with metastatic disease confined to the liver [5].

Surgical resection is the gold standard for treatment of primary or metastatic liver cancer [6].

Although old age may increase the risk of hospital mortality for patients with HCC after hepatic resection, elderly patients can obtain acceptable long-term prognoses from hepatic resection. Hepatic resection is an effective treatment and can be used for selected elderly patients with well-preserved liver function [7].

The 5-year survival rate for patients undergoing resection of HCC or hepatic metastases is only 20-40%. Most patients die from recurrent hepatic tumors. Although in some instances surgery may be repeated to resect recurrent tumor, at most institutions hepatic resection is a "one-shot" therapy. In light of these shortcomings, an effective, minimally invasive technique is needed for treating these tumors-one that can be repeated as necessary to treat recurring tumor [8].

However, most patients are not candidates for hepatic resection because of anatomic limitations, multifocal nature of the disease, insufficient functional liver reserve, extra hepatic metastases, or comorbidities. The most commonly used thermal ablation modalities are RFA and MWA. RFA has become a recognized treatment approach because of its efficacy [6].

However, the percentage of patients who are suitable for this invasive procedure, with its associated morbidity and mortality, is widely quoted as being between 20% and 35% [9].

Several ablation modalities have developed and have been refined over time. These technologies include in clude chemo embolization, direct injection of alcohol into HCC tumors, Thermal ablation techniques for the treatment of malignant hepatic tumors include both freezing (cryoablation) and heating (radiofrequency, microwave, laser, and high-intensity focused sono graphy) techniques [10].

Radiofrequency Developed in 1990 for the percutaneous treatment of HCC, RFA utilizes radiofrequency alternating current to induce heat between the percutaneously placed probe and the surrounding tissues ultimately leading to tissue coagulation necrosis and death. Target tissue temperatures between 60 and 100 °C must be maintained for several minutes to ensure complete necrosis of the tumor and immediate surrounding tissue [10].

I n last decade, there has been a rapid advancement in the utilization of percutaneous, image-guided tumor ablation methods, and RF ablation has been the method of choice because of its availability, safety, efficacy, and cost. In the clinical setting.

RF ablation has been shown to be an effective treatment option for patients with primary and metastatic liver tumors.

Image-guided RF ablation is minimally invasive and usually appropriate for inoperable patients with other comorbidities.

It requires a minimal hospital stay or can be performed on an outpatient basis. It preserves more normal organ tissue and is less expensive than surgery.

For patients with cirrhosis and HCC ≤3 cm, who are not surgical candidates based on impairment of liver function, the number and distribution of tumors, or cardiopulmonary dysfunction, RF ablation can be used as a first-line treatment method [11].

In patients with HCC awaiting liver transplantation, loco regional treatment is recommended when wait times are predicted to exceed 6 months Because RFA can provide higher rate of complete necrosis of target tumor than other loco regional therapies.**(12)** RFA results in a higher rate of complete necrosis and requires few treatment sessions. Long term survival rates are also better with RFA [13].

RF ablation of hepatic tumors is a relatively safe modality with a reported overall complication rate of 7.1% and a very low mortality (0.3%). Immediate major complications include hemorrhage, biliary leakage or obstruction, infection, pneumothorax, and injury to adjacent organs (18, 19). Careful selection of appropriate patients and RF ablation tools, as well as utilization of adjunctive maneuvers are important to prevent complications. In order to decrease the risk of post procedural bleeding and tumor seeding, exophytic tumors should be avoided, and a trans hepatic route rather than a direct route should be selected to approach peripheral tumors [11]**.** According to Barcelona Clinic Liver Cancer (BCLC) guidelines, interventional radiology procedures are valuable treatment options for many hepatocellular carcinomas (HCCs) that are not amenable to resection or transplantation. Accurate assessment of the efficacy of therapies at earlier stages enables completion of treatment, optimal follow-up and to prevent potentially unnecessary treatments, side effects and costly failure [14]. There are several guidelines to assess treatment response in patients with HCC, including the World Health Organization (WHO), Response Evaluation Criteria in Solid Tumors (RECIST), and European Association for the Study of the Liver (EASL), or modified RECIST (mRECIST) criteria [15].

The Liver Imaging Reporting and Data Systems (LI-RADS) is an extensive approach to categorize and assess residual or recurrent malignancy, including after locoregional therapies. Specifying response criteria with definitions, examples and a precise algorithm, LIRADS guidelines are designed to standardize the response assessment and improve communication within HCC multidisciplinary teams, both for clinical practice and clinical trials [16].

Aim of the work

Evaluation of the safety, efficacy of radiofrequency ablation in treatment of liver malignancies that fulfill its established parameters.

Patients and Methods

This exprimental non-randomized study was carried between (January 2019 and october 2019) in collaboration with Medical and trpoical medicine Department. Twenty patients with hepatic malignancies were treated by ultrasound-guided percutaneous radiofrequency ablation.

Eligibility Criteria

All patients were included in this study to receive RFA treatment according to the following criteria:

Inclusion criteria

Patients with confirmed unresectable hepatic malignancies. No evidence of extra hepatic disease. Absence of vascular or biliary invasion. Good liver functions with serum albumin more than 3.0 gm/dL, serum total bilirubin less than 3.0 mg/dL, and Child-Pugh class A and B. Absence of ascites or controllable mild ascites. Absence of marked bleeding tendency with prothrombin concentration more than 50% and a platelet count more than 50.000/$mm^{3.}$ Tumor less than 5 cm in size and less than 3 tumors in number. No history of hepatic encephalopathy. Tumors in

position where the electrode can be inserted and held safely. A detailed verbal and written description of the procedure was provided to all patients, and informed written consent was obtained before treatment.

Exclusion criteria

Extra hepatic metastasis. Tumors more than 5 cm in size or more than 3 in number. Tumors near large vessels or peripheral tumors. Portal vein or IVC thrombosis, or biliary duct invasion. Severe liver cirrhosis with Child-Pugh class C. Severe coagulation disorders (pro thrombin concentration less than 50%, and platelet count less than 50.000/mm$^{3)}$. Presence of uncontrollable ascites.

Child: pugh scoring system

Table 1: Child-Pugh scoring system of cirrhotic patients.

Measure	1 point	2 points	3 points
Total bilirubin (mg/dl)	<2	2-3	>3
Serum albumin, gm/l	>3.5	2.8-3.5	<2.8
INR	<1.7	1.71-2.30	> 2.30
Ascites	None	Mild	Moderate to Severe
Hepatic encephalopathy	None	Grade I-II (or suppressed with medication)	Grade III-IV (or refractory)

Interpretation of scoring: 5-6>>>> groups A. 7-9>>>> groups B. 10-15>>>> groups C.

Pretreatment assessment

All patients in this study were subjected to the following:

Detailed history and clinical examination for all patients

Laboratory evaluation: Complete blood picture, serum blood glucose, and renal function tests. Liver functions including alanine aminotransferase, aspartate amino transferase, gamma-glutamyl transferase, alkaline phosphatase, and serum albumin, total and differential bilirubin. Coagulation profile including platelet count, prothrombin time and concentration, and partial prothrombin time. Hepatitis markers including viral serology for HCV and HBV. Tumor markers including AFP for HCC patients and CA 19.9 for metastatic colorectal patients.

Radiological evaluation: The following radiological examinations were done to exclude extra hepatic metastasis and to evaluate the intrahepatic disease:

Chest X-ray: As a pre-anaesthetic assessment and exclude extra hepatic metastasis.

Abdomino-pelvic ultrasound: All patients were subjected to ultrasound with a 3.5 MHz curved linear transducer, simens acqsion x300 to.

Triphasic CT OR MRI abdomen and pelvis examination

All patients in this study were subjected to the following: CT scan or MRI scan. Routine dynamic liver CT were performed after insertion of 18 gaugue cannula and using automatic injector (Medrad, Vistron injector system, USA). Triphasic CT of the liver was performed to all patients. Contiguous 5 mm- thick axial CT scans were obtained with Siemens Soma tom Emotion 16-slice CT (Siemens Medical Solutions; GE Healthcare) CT scanners. Routine dynamic liver CT includes the pre contrast, late arterial, portal venous, and delayed phases. After pre contrast scanning, 2.0 mL/kg of iodinated contrast medium was injected intravenously (60-100 mL of ultravist 350 mg I ⁄ ml), (amoun pharmaceutical - co, guerbert, france) at a rate of 3-4 mL/sec, followed by 20-mL saline bolus injected during 30 s (fixed duration). Using the bolus-tracking method, The entire liver was scanned three time following the initiation of contrast material injection as following the late arterial phase was scanned at 18–20 s after100-HU attenuation of the abdominal aorta. The portal venous and delayed phases were obtained with a delay time of 30 s and 150 s after the scanning of late arterial and portal venous phases, respectively. The CT parameters were as follows: 120 kV; 240 mAs; rotation time, 0.5 s; beam pitch, 2; and slice thickness, 3–5 mm.

Dynamic liver MRI scan was performed using 1.5T machine (Intera Achieva, Philips Medical Systems). Routine liver MRI included the following sequences: dual-echo spoiled gradient-echoT1-weighted in-phase and opposed-phase images, multi-shot and single-shot turbo T2-weighted spin-echo images, and diffusion-weighted imaging with single-shot echo-planar images. Dynamic fat-suppressed spoiled gradient-echo T1-weighted images were acquired before and after contrast medium injection (late arterial, portal venous, 3-min and 5-min delayed phases). Using the bolus-tracking method, the late arterial and portal venous phases were usually obtained at 20–30 s and 60–70 s after contrast injection. In all patients gadodiamide (Omniscan) (Nycomed Amersham, Princeton, NJ, USA) was used as a contrast agent, and 0.1 m mol/kg body weight. Was administrated at a rate of 1 or 2 mL/s. The Hepato biliary phase was obtained at 15 or 20 min after contrast injection.

Pre-anesthetic assessment

Including: Cardiac and chest examination. ECG. blood pressure. Blood glucose level.

Radiofrequency ablation system: Patients were treated by RF 3000 mono polar system produced by Boston Scientific Corp. (Natick, MA, USA; formerly Radio therapeutics)

The RF 3000 system consists of

Monopolar radiofrequency generator: The generator delivers an isolated RF output of up to 200 watts to the electrode full power is available in the impedance range of 25 to 100 Ω at a constant RF voltage, the generator has a front panel for the power, time, and impedance.

LeVeen RFA expandable electrode (15cm): Le Veen electrode is a 14 gauge, 15 cm long insulated cannula with 1 cm shaft markers and echogenic tip that help to guide insertion under ultrasound guidance. It contains 12 solid, retractable, curved hook electrodes that are deployed in situ perpendicular to the axis of the probe. When these are fully extended, their diameter is 5 cm and the device assumes an umbrella-shaped array design to help create a complete, predictable, spherical thermal lesion. It relies on electrical measurement of tissue impedance as feedback monitoring.

Indifferent dispersive electrode pads: To be applied to the patient's thighs and connected to the generator to close the electric circuit.
Main cable for device: The cable connects and delivers RF energy from the generator to electrode.

Advantages of the Boston RF system
Impedance-based feedback system: is designed to: Accurately monitor extent of tissue desiccation. Permit continued delivery of RF energy until achievement of complete ablation. Accommodate lesion and patient variability. Provide predictable, consistent clinical endpoints. It can preserve the uniformity of sphere shape of ablated lesion.

Disadvantages of Boston RF 3000 system: Difficult visualization of the multiple hooks during real-time deployment. Damage to adjacent organs. Injury to adjacent stracture within the liver parenchyma as GB, PV.

Radiofrequency ablation technique
Pre- ablation assessment
The patients: Radiofrequency ablation was performed on inpatients after 12 hours fasting with hospital stay 1 day after the procedure.
General assessment: On the morning of the procedure, an anaesthesiologist evaluates the patient for suitability of anaesthesia. The medical history was revised and the laboratory test results were checked, and the ECG was interpreted. A peripheral IV line was started, and the patient was monitored for blood pressure, pulse, respiratory rate, and the peripheral oxygenation.
Ultrasound approach assessment: Percutaneous RFA was performed with real- time US guidance by using 3.5 MHz convex probe. Pre-ablation US assessment was performed to determine the number and size of the tumours, their relationship to surrounding structures as blood vessels, bile ducts, gall bladder, diaphragm, and bowel, and to determine if a safe and adequate approach exists. Six patients were done by inter costal apporach with patient in the left lateral decubitus for lesions in the right lobe. eight patients were done by inter costal apporach with patient in the supine position for lesions in the right lobe. six patients were done by epigastric apporach with the patients in supine position for lesions in the left lobe.
System preparation: The procedure was done in a special sterilized unit containing the ultrasound machine (Toshiba, Xario, Japan), the services of general anaesthesia, the radiofrequency system, and a mobile sterile table (for sterile patients' and doctors' gowns, antiseptics, syringes, IV fluid, medications, and gauze). The grounding pads, representing the dispersive electrode, are placed on the patient's thighs and properly connected to the generator. The system was tested to be sure working. The patient was prepared and draped in the usual sterile manner, the right upper abdominal region is adequately sterilized, and the patient is placed in either the supine or the left lateral decubitus position depending on the site of the tumour and the planned needle track.
Anesthesia and Medications: All patients undergone RFA were treated under general intravenous anesthesia consisted of a propofol infusion (deprivane, 3-6 mg/kg/h) and fentanyl citrate IV injection (fentanyl, 1-2.5µg/kg). The advantages of the propofol are the deep level of anaesthesia that can be obtained and the short duration of action.
Needle electrode placement: Skin is pricked with a small sterile lancet. The LeVeen needle electrode was introduced into the liver through the skin incision and advanced to the target area of the tumour under US guidance. The free hand technique was used with the needle electrode parallel to the plane of the US probe. After verifying the positioning of the needle electrode, the multiple arrays were deployed and the needle electrode was connected to the RF 3000 generator.
Treatment strategy: Treatment strategy was established before placement of the needle electrode within the tumour according to the size of the tumour. The objective in treating the tumours was to ablate the entire tumour as well as at least 1 cm- tumour- free margin of normal liver. For tumours less than 2 cm, the 3 cm array diameter was used. The needle electrode tip was placed through the center of the tumour and advanced to the deepest margin between the tumour and the normal liver. The arrays then were extended and verified by US. For tumours of 3 cm in the maximum diameter, the 4 cm array diameter was used. For tumors between3-5 cm multiple ablations were needed to be overlapped to build a composite thermal lesion with sufficient size to kill the entire tumour and to provide 1 cm tumour-free margin. Strict geometric analysis and planned order of ablations were designed. the lesion was divided to superficial and deep equal parts. The arrays were extended and were confirmed by the US to be placed correctly first in the deep part. This positioning permitted ablation of the deep part of the tumour and a rim of non-malignant liver. Following completion of RF ablation of the deep part, the arrays were fully retracted and the needle electrode was pulled back (withdrawn) to 2-2.5 cm. The arrays were redeployed and the second, more superficial part of the tumour with anterior tumour-free margin was ablated.
Application of the RF energy: For nodules up to 1.5 cm in diameter an initial power of 30 W is applied and increased at a rate of 10 W/min to 60 W. RF energy is applied until either marked increases in impedance are achieved or 15 minutes had elapsed. The second treatment is then applied at the same position until either marked increases in impedance are achieved or 10 minutes had elapsed at the 75% of the maximum output of the first treatment. If the marked increases in impedance are not obtained after the second treatment within 10 minutes the third treatment is initiated at the same power of the second treatment and increased at a rate of 10 W/min to 90 W maximum until marked increases in impedance are obtained.(Shibata, Shibata, Maetani, Isoda, & Hiraoka, 2006) For nodules 1.5–2.5 cm in diameter , An initial power of 30 W is applied and increased at a rate of 10 W/min to 80 W. RF energy is applied until either marked increases in impedance achieved or 15 minutes elapsed. The second treatment is then applied at the same position until either marked increases in impedance are achieved or 10 minutes elapsed at the maximum output of the first treatment. If the marked increases in impedance are not obtained after the second treatment during 10 minutes the third treatment is initiated at the same power of the second treatment and increased at a rate of 10 W/min to 90 W maximum until marked increases in impedance are obtained For nodules larger than 2.5 cm in diameter An initial power of (40-50W) is applied and increased at a rate of 10 W/30sec to 90 W. RF energy is applied until either marked increases in impedance achieved or 15 minutes elapsed. The second treatment is then applied

at the same position until either marked increases in impedance are achieved or 10 minutes elapsed at the maximum output of the first treatment. If the marked increases in impedance are not obtained after the second treatment during 10 minutes the third treatment is initiated at the same power of the second treatment and increased at a rate of 10 W/min to 90 W maximum until marked increases in impedance are obtained. Use forward pressure to avoid outer needle "pull-back" during deployment.

Ending RFA treatment: After the suggested complete ablation of the tumour was achieved, the arrays were completely retracted. The needle track was ablated as the needle electrode was withdrawn, and then the needle electrode was removed.

Post: ablation care

The anesthesia was stopped and the patients were allowed to recover. All patients experienced post-ablation pain and nausea with the decrease of the anaesthesia. IV antiemetic was given. Strong IV analgesics were given to control pain as pethidine hydrochloride 50mg (pethidine) or tramadol hydrochloride 50mg (tramadol).

All patients were observed clinically for 2-3 hours to detect any acute complications and to start IV fluid. Prophylactic IV antibiotic were started, amoxicillin-clavulanic acid (augmentin) or ceftazidine (fortum), and metronidazole (flagyl), and continued for 3 days.

Before leaving the hospital, US examination was performed to the patients to detect any collection. The skin incision was sterilized and dressed. The patient was allowed to eat after 6-8 hours.

Post treatment assessment.

After Percutaneous Radio Frequency Ablation All Patients in This Study Were Subjected To The Following

Detailed history and Clinical examination for all patients

Radiological evaluation: The following radiological examinations were done to evaluate treatment response of RFA and exclude extrahepatic metastasis and to evaluate the intrahepatic disease:-

Chest X-ray: After RFA seesion to assessment and exclude thoracic complication as pneumothorax.

Abdomino-pelvic ultrasound: All patients were subjected to ultrasound with a 3.5 MHz curved linear transducer, simens acqsion x300.

Triphasic CT OR MRI abdomen and pelvis examination

Radio frequency ablation act by induction of tumor necrosis which is not necessarily accompanied by tumor shrinkage in spite of response. Hence, to assess viable tumor contrast uptake in arterial phase has to be assessed using dynamic CT or MRI studies. All patients in this study were subjected to the following: CT scan or dynamic liver mri scan 1 month after completion of the RFA therapy to detect any residual enhancing tumour tissue. If any area suspicious for viable tissue was detected, the patient was retreated by RFA of that area. If there was no evidence of residual the patient were followed up (up to six months). Triphasic CT scan or dynamic liver MRI scan was performed every 3 months to detect any residual or recurrence in the ablated tumour and to monitor for the development of new hepatic or extra hepatic disease.

Laboratory evaluation: we obtain level of AFP in HCC patients and CA 19.9 in colorectal metastasis patients (at the same intervals of triphasic CT or dynamic liver MRI scan follow up). Their values were helpful in assessing subtle changes on the scan and in determining if additional evaluation was warranted. The patients were followed-up for three months after RFA.

Appearance after radiofrequency ablation

Immediately after ablation technique, success is defined as a non-enhancing ablation zone encompassing the entire tumor and an ablative safety margin of at least 5 mm of the non-tumor hepatic parenchyma Moreover, tiny air bubbles that result from the boiling of tissue can be seen immediately after RFA and will typically have resolved by 1 month follow up The air bubbles should be differentiated from the mottled persistent air densities seen with a hepatic abscess or within a peripheral wedge shaped defect of a hepatic infarct. Follow-up evaluation after ablation technique a central area of coagulative necrosis is often seen within the tumor or the ablation site. This coagulative necrosis will result in a hyper density within the treated HCC on CT and hyper intense signal on T1- weighted imaging, thus limiting assessment for residual tumor enhancement. However, these findings frequently will have resolved on subsequent imaging. Subtraction images can be a helpful adjunct for differentiating hemorrhage from enhancing tumor on MRI. Transient hyperemia manifested by thin, uniform enhancement of the treated zone is an expected finding after RFA, and represents a transient physiologic response to thermal injury and embolization to the hepatic parenchyma. This finding should be differentiated from residual malignancy. Typically transient enhancement resolves within several months on follow-up imaging. However, small foci of residual tumor may be obscured by transient hyperemia, so cases showing persistent arterial enhancement with washout on delayed phase images at short-term follow-up should be evaluated further to determine whether additional directed therapy is needed

Nodular or thick areas of arterial enhancement along the margin of a treated HCC are consistent with residual tumor, especially when there is associated washout, and require additional treatment.

After ablation, residual viable tumor or tumor regrowth tends to be detected at the periphery of the treated cavity either as irregular thickening at the margin or as a new tumor nodule. Hyper intense appearance on T2-weighted imaging or DWI with associated nodular enhancement is characteristic of tumor or incompletely treated tumor. Care should be taken not to diagnose peripheral regrowth when a thin, regular rim of progressive enhancement is present because this finding is a sign of simple vascularized inflammation or fibrosis. In addition, after RFA, arterioportal shunts can be seen due to thermal injury to small vessels in the hepatic parenchyma but will resolve on follow-up evaluation.

Evaluation of treatment response after radio frequency

Accurate assessment of the efficacy of therapies at earlier stages enables completion of treatment, optimal follow-up and to prevent potentially unnecessary treatments, side effects and costly failure.

Evaluation of treatment response after radiofrequency ablation According to the European Association for the Study of the Liver (EASL) and American Association for the Study of Liver Diseases (AASLD) introduced the

concept of including bi-dimensional measure(as described by the WHO criteria) of tumor enhancement in arterial phase of contrast-enhanced imaging studies to assess only viable target tumors.

According to the EASL criteria, local response to treatment is determined as follows: complete response (CR): complete disappearance of enhancing tissue in target lesion(s); partial response (PR): ≥50% decrease in sum of arterial enhancing area; stable disease (ST): does not qualify for CR/PR or progressive disease (PD); PD: ≥25% increase in sum of arterial enhancing area or appearance of new lesion(s).

Evaluation of treatment response after radiofrequency ablation According to modified RECIST includes the measurement of only the longest diameter of the Enhancing tumors.

In the mRECIST system, CR is achieved when any intra tumoral arterial enhancement in all target lesions disappears. The PR is at least a 30% decrease in the sum of diameters of viable target lesions, taking as reference the baseline sum of the diameters of target lesions. The PD is an increase of at least 20% in the sum of the diameters of viable target lesions, taking as reference the smallest sum of the diameters of viable target lesions recorded since the treatment started. The SD includes any cases that do not qualify for either partial response or PD. Since their introduction, m RECIST criteria have become the gold standard in the evaluation of HCC response.

Evaluation of treatment response after radiofrequency ablation according to The Liver Imaging Reporting and Data Systems (LI-RADS) algorithm should first assess whether a treatment-related observation is evaluable or not. If evaluation is not possible due to image degradation or lack of multiphasic imaging, should categorize it as LR-TR non-evaluable.

If the treated observation is evaluable, one of three available treatment responses categories: When treated lesion shows complete lack of enhancement or expected treatment-specific enhancement patterns ,such as a thin rim of hyper enhancement around the treated Nonviable tumor which is occasionally seen after ablation , denoting LI-RADS treatment response (LR-TR) nonviable. When the treated lesion shows features of viability as a nodular, mass like or thick irregular tissue in or along lesion margins, with any of the following features: arterial phase hyper enhancement or washout appearance or enhancement similar to pretreatment denoting LI-RADS treatment response LR-TR viable. When the radiologist is unsure about the assessment of tumor viability after treatment and the observation do not clearly belong to LR-TR viable or LR-TR nonviable category. This category is LI-RADS treatment response LR-TR equivocal. Whenever available, pretreatment LI-RADS category or biopsy result should be included in radiologist report in order to estimate the percent response. However, LI-RADS specifies that radiologic viability is not necessarily coherent with pathologic viability, as imaging is not sensitive to microscopic or small foci of residual tumor ,Therefore, the combination of the assigned LI-RADS category and clinical assessment findings (such as AFP changes) is recommended to define optimal management of patient.

It is suggested to repeat imaging with the same modality every 3 months for treated observations assigned to category LR-TR none valuable, LR-TR nonviable or LR-TR equivocal, whereas the decision to retreat or to perform alternative treatments in case of LR-TR viable category should be made on the basis of a tumor board or multidisciplinary discussion.

Results

Table 2: Age distribution among the studied patients.

Age	Male		Female		Total %
	number	Percent %	Number	Percent %	
40-49 years	3	(15%)	2	10%	5(25 %)
50-59 years	10	(50%)	3	(15%)	13 (65 %)
60-69 years	2	(10%)	-	-	2 (10 %)
Total %	15	(75 %)	5	(25 %)	20 (100 %)

Table 3: Histopathological criteria among the study patients.

Patients	HCC	Metastasis
Number	17	3
Percent	(85%)	(15%)

Table 4: Size of the focal lesions

Size	< 3cm	3-5cm
	18 (75%)	6 (25%)

Table 4: Response and follow up of study patients.

	With focal lesions <3cm	With focal (3-5cm)
Well ablated	12 (85.7%)	3 (50%)
Residual	-	2 (33.3%)
Local recurrence	-	1 (16.6%)
New lesions	2 (14.2%)	-

Table 5: Relation Between Tumors Size and Ablation

Tumor	< 3 cm	3 - 5 cm
Number	18	6
Well ablated	16 (88.9%)	3 (50%)
Residual	-	2 (33.3%)
Local Recurrence	-	1 (16.6%)
New lesions	2 (11.1%)	-

Table 6: Relation Between number of focal lesions and residual and recurrence.

Tumor	Single	Multiple
Residual	2 (11.7%)	-
Local recurrence	1(5.88%)	-
New lesions	-	2 (66.6%)

Table 7: major complications post RFA

Complication	Number of patients	%	Controlled by
Sub capsular hematoma	-	-	
Pleural effusion	-	-	
Ascites	2	10%	salt restriction and diuretics
Jaundice (due to anesthesia)	1	5%	Medical treatment

Table 8: Minor complications post RFA

Complication	Number of patients	%	Controlled by
Pyrexia	6	30%	antipyretics
Epigastric pain	7	35%	analgesics
Right hypochondrial pain	6	30%	analgesics

Table 9: Relation of complications to number of focal lesions

Complications	Single	Multiple
Jaundice	-	1(33.3%)
Ascites	-	2(66.6%)
Pyrexia	5	1
Epigastric pain	7	-
Right hypochondrial pain	4	2

Table 10: Comparison between LI-RADS treatment response algorithm and Mrecist, CI, confidence interval; LI-RADS, Liver Imaging Reporting and Data System; m RECIST, modified Response Evaluation Criteria in Solid Tumors; RFA, Radio frequency ablation. p values are obtained from comparison of between LI-RADS and m RECIST The optimal cut-off value of LI-RADS was considered as equivocal category CI, confidence interval; LI-RADS, Liver Imaging Reporting and Data System; m RECIST, modified Response Evaluation Criteria in Solid Tumors; RFA, radiofrequency ablation;

	Sensitivity (95% CI)	Specificity (95% CI)	Accuracy (95% CI)	AUC (95% CI)	p value
CT					
RFA					0.288
LI-Rads	29.4 (12.5, 54.8)	87.5 (71.0, 100.0)	57.6 (39.3, 74.0)	0.602 (0.488, 0.716)	
M Recist	17.7 (5.716, 43.1)	93.8 (81.8, 100.0)	54.6 (36.3, 71.5)	0.558 (0.470, 0.646)	
MRI					
RFA					0.507
LI-Rads	75.0 (23.8, 96.7)	100.0 (100.0, 100.0)	91.7 (58.3, 98.9)	0.836 (0.566, 1.000)	
M Recist	75.0 (23.8, 96.7)	100.0 (100.0, 100.0)	91.7 (58.3, 98.9)	0.844 (0.566, 1.000)	

Discussion

Hepatocellular carcinoma (HCC) is a major cause of cancer death. Hepatocellular carcinoma (HCC) is the most common type of primary liver cancer. It is the fifth most common cancer worldwide and the third most common cause of cancer mortality, the most prominent risk factors for this cancer are hepatitis B virus (HBV) and hepatitis C virus (HCV). Some other factors are participating in a high incidence of HCC such as cirrhosis, cigarette smoking, alcohol drinking, obesity, aflatoxin exposure, familial/genetic factors, and metabolic disorders [17].

The liver is the most common site of metastasis in patients with colorectal cancer due to its anatomical situation regarding its portal circulation. About 14 to 18% of patients with colorectal cancer present metastasis at the first medical consultation, and 10 to 25% at the time of the resection of the primary colorectal cancer [3].

Liver transplantation is thus far considered the best treatment for HCC as it cures HCC and the underlying liver disease. Using the Milan criteria, overall survival after liver transplantation for HCC is about 70% after 5 years In addition to liver transplantation other therapies have been proposed such as resection, tumor ablation by different means, embolization and chemo therapy [3].

Surgical resection is the gold standard for treatment of primary or metastatic liver cancer. However, most patients are not candidates for hepatic resection because of anatomic limitations, multifocal nature of the disease, insufficient functional liver reserve, extra hepatic metastases, or comorbidities. The most commonly used thermal ablation modalities are RFA and MWA. RFA has become a recognized treatment approach because of its efficacy [6].

Several ablation modalities have developed and have been refined over time. These technologies include in clude chemoembolization, direct injection of alcohol into HCC tumors, Thermal ablation techniques for the treatment of malignant hepatic tumors include both freezing (cryoablation) and heating (radiofrequency, microwave, laser, and high-intensity focused sono graphy) techniques [10].

In last decade, there has been a rapid advancement in the utilization of percutaneous, image-guided tumor ablation methods, and RF ablation has been the method of choice because of its availability, safety, efficacy, and cost In the clinical setting.

RF ablation has been shown to be an effective treatment option for patients with primary and metastatic liver tumors. Among loco regional treatments for hepatocellular carcinoma (HCC), radiofrequency ablation (RFA) has been accepted as the most popular alternative to curative transplantation or resection, and it shows an excellent local tumor control rate and acceptable morbidity. The benefits of RFA have been universally validated by the practice guidelines of international societies of Hepato logy. The main advantages of RFA include 1) it is minimally invasive with acceptable morbidity, 2) it enables excellent local tumor control, 3) it has promising long-term survival, and 4) it is a multimodal approach. Based on these pros, RFA will play an important role in managing the patient with early HCC (smaller than 3 cm with fewer than four tumors.

In our study, Boston RF 3000 system was used for treatment of liver tumors. Energy is delivered from the generator to the target tissue by a 14-gauge Le Veen needle that has twelve hook shaped electrodes inside and the system offers the advantage of electrical measurement of tissue impedance as feedback monitoring, Follow-up evaluations were done with CT at first month and then every three months after treatment.

In our study, RFA was used to treat twenty patients with pathologically proved hepatic malignancies 17 patient

(85%) with HCC and 3 patient (15%) with metastasis, It is noted that 17 of 20 (85%) had single focal lesion and 2 of 20 (10%) had two focal lesions (each one (5%) has two focal lesions) while 1 of 20 (5%) had three lesions.

These 20 patients had 24 focal lesions distributed at both liver lobes, 14 of 24 (58.33%) focal lesions in the right lobe and 10 of 24 (41.66%) in the left lobe.

As regard the results of our study twenty patients are divided into two groups, (group A) 14 patients had tumors less than 3 cm and (group B) 6 patients had tumors 3-5 cm. In group A, 12 patients of 14 (85.7%) with sixteen focal lesions with diameter less than 3cm showing no residual or new lesions appeared at three months follow up, 2 patients of 14 (14.2%) with four focal lesions (each one had two focal lesion) with diameter less than 3cm developed multiple newly lesions at three months follow up and were of metastatic nature

In group B, 3 patients of 6 (50%) with three focal lesions with diameter (3-5cm) of mean diameter (4cm) showing no residual or new lesions appeared at three months follow up, 2 patients of 6 (33.3%) with Two lesions with diameter 5cm showing residual at one month follow up while One patient of 6 (16.6%) with single lesion with diameter (3-5cm) showing newly appearing lesion at three months follow up.

Rossi *et al*. [18] treated 37 patients with liver tumors with an expandable RF electrode needle (cool tip), the patients were divided into two groups according to the size of the tumors; (group A) 23 patients had tumors less than 3 cm and (group B) 14 patients had tumors 3-5 cm. In group A, no residual active lesion was detected after one month on follow up and recurrence was evident in two (8.6%) patients 2/23, in group B residual was evident in one (7.1%) patient 1/14 and recurrence was evident in two (14.2%) patients 2/14 , Rossi *et al*. [18] had less residual and recurrence than in our study as they used different RF system (cool tip) which has the advantage of decreased charring and desiccation of the underlying tissues and promotes more ablation area.

Livraghi *et al*.[19] treated two groups, (group A) 52 patients with HCC lesions smaller than or equal to 3 cm in diameter and (group B) 80 patients with HCC lesions ranged from 3.1 to 5.0 cm in diameters, with cooled-tip system. In group A, complete ablation was seen in 47 (90.4%) patients 47/52. In group B, complete ablation was seen in 56 (71%) patients 56/80

Shirato *et al*.[20] treated 30 HCC patients with HCC lesions smaller than 3 cm with Le Veen system, no residual was detected, recurrence was evident in two (6.6%) patients 2/30 and complete ablation was evident in 28 (93.4%) patients 28/30 during follow up period of 3–15 months (mean, 8.4 months).

Buscarini *et al*. [21] treated 88 patients had HCCs ≤ 3.5 cm in diameter by percutaneous RFA. The patients were divided into two groups, group A were treated by conventional electrode and group B were treated by expandable electrode. In group (A) residual was (20%) and recurrence was (29%), while in group (B) residual was (4.5%) and recurrence was (15.9%). Buscarini *et al*. [21] had high residual and recurrence rate in group A as they used conventional electrodes which had higher residual and recurrence rate than expandable electrodes. Laeseke *et al*. [22] treated 23 patients with HCC (mean diameter, 2.7 cm; range, 0.7–10.0 cm) with an impedance-based multiple electrode system (cool tip system). One, two, or three 17-gauge electrodes were placed, and tumors were ablated using combination of CT and sono graphy for guidance and monitoring. Electrodes were placed in close proximity (mean spacing: two electrodes, 1.0 cm; three electrodes, 1.4 cm) to treat large tumors. Laeseke *et al*. [22] had residual in 1 (4.3%) patient 1/23 and recurrence in 3 (13%) patients 3/23 Laeseke *et al*. [22] had residual and recurrence rates less than our study due to using of multiple electrodes (cool tip system).

Another study was done by Lee *et al*. [23]**,** treated 30 patients with single medium-sized HCCs (mean, 3.5 cm; range, 3.1-4.4 cm) were enrolled. The patients were treated under ultra sono graphic guidance by percutaneous switching mono polar RFA with a multichannel RF generator and two or three internally cooled electrodes. Three cluster electrodes (cool tip RFA system) were used. Lee *et al*. [23] had residual active lesion in 1 (3.3%) patient 1/30 and recurrence in three (10%) patients 3/30. The lower rates of residual and recurrence by Lee *et al*. [23] were due to using different RFA system (cool tip switching system with three cluster electrodes) and small tumor size.

Adam *et al*. [24] treated 18 patients with HCC (ranged from 3 to 8 cm in diameter) by percutaneous RFA using (RITA medical system). Adam *et al*. [24] reported residual in 3 (16.7%) patients 3/18 and recurrence was detected in 4 (22.2%) patients 4/18.

In our study, there were no fatal complications related to RFA treatment. 6 (30%) patients experienced post ablation right hypochondrial pain that was controlled by analgesics Also 6 (30%) experienced post-ablation pyrexia for 1–3 days and 7 (35%) patients experienced post ablation epigastric pain and controlled by analgesics

In considiration to major complications due to RFA, Geyik *et al*. [25]**,** treated 9 HCC and 20 metastatic patients. in HCC group, the major complications aroused in three (33.3%) patients 3/9, one patient died due to myocardial infarction immediately after procedure, one patient developed empyema and was treated by drainage and medical treatment, the third patient developed skin burns and was treated medically. While in our study no mortality was detected, the major complications arouse in Two patients (10%) developed post ablation ascites they were controlled by salt restriction and diuretics and One patient (5%) developed post ablation (hepatocellular) jaundice and received medical treatment

Buscarini *et al*. [21] trated two groups of HCC patients, each group consisted of 44 HCC patients, group A were treated by conventional electrode and group B were treated by expandable electrodes. No major complications were reported in patients were treated by conventional method (group A). While major complications were presented in (27.2%) of patients were treated by expandable electrodes (group B). In our study, major complications were (15%). In spite of safty and minimal complications caused by use of conventional electrode, but its higher residual and recurrence rate than expandable electrodes make it the second choice.

Lee *et al*. [23] treated 30 HCC patients, major complications arouse in one (3.3%) patient 1/30 who developed obstructive jaundice due to common bile duct stricture and no death was detected during the follow-up period. While in our study we had major complications arouse in five (15%) patients. Lee *et al*. [23] had lower complications than our study due to their using to cool tip cluster electrodes which are safer than our Expandable Le Veen needle electrodes.

Adam *et al*. [24] treated 34 patients with heaptic malignancies (18 HCC and 16 metastatic patients) in HCC patients major complications were detected in 6 (33.3%) patients 6/18. While in our study we had (15%) complications. We had lower complications rate than Adam *et al*. [24] as regard our smaller tumors size.

Laeseke *et al*. [22] treated 23 HCC patients, major complications were detected in four (17.4%) patients 4/23, one patient developed post procedure lower limbs deep venous thrombosis and died from pulmonary embolus, one patient developed pneumothorax, and two patients developed perihepatic hemorrhage, while in our study, the major complications arouse in three (15%) patients. Laeseke *et al*. [22] had one death, while we hadn't.

Follow-up of patients who had been treated with surgical RFA ablation should consist of the clinical evaluation of liver function and the tumor response to the therapy, by CT or MRI studies every 3 months the first 2 years and lance every 6 months later on by US, enhanced CT and MRI scans.

CT and MRI have been used to depict hepatic lesions, to guide the intervention process, and to evaluate the response of malignant liver lesions after minimally invasive local the rapies. MRI has been described as superior to CT in detecting and following up ablated lesions because of its known higher sensitivity and specificity. Recent advances in the development of functional imaging techniques have provided the ability to detect microscopic changes in tumor microenvironment and microstructure, thus allowing the assessment of tumor response after loco regional treatment by observing alterations in tumor viability, perfusion or vascularity. Diffusion weighted MR imaging is useful in the follow-up imaging after RF ablation. ADC-based evaluation of signal alterations adjacent to the ablation zone may contribute to the identification of local tumor progression and non tumoral post-treatment tissue changes**.** [26]. The standard conventional method to define radiological responses of solid tumors consists of tumor size changes over time, based on the assumption that imaged and measured shrinkage is associated with a better response to therapy versus tumor increase in size (morphometry or morphology) [27]. The promise of quantitative imaging approaches is that such a measurement may provide an objective, reproducible and reliable end point for the assessment of overall response. The first proposed quantitative methodology was WHO bidimensional criteria published in 1979, which was then followed by unidimensional measurements, Response Evaluation Criteria in Solid Tumors (RECIST), created in 2000 and updated in 2009, In both cases, the imaging response biomarker is the size of the tumor, which is estimated on the basis of the longest diameter (RECIST) or the two longest diameters (WHO) on single slice 2D images, usually axial**.** [28]. Nevertheless, these simple anatomic criteria are hampered by some limitations. First, they assume that neoplastic nodules have a spherical shape and thus, they exhibit homogeneous size changes; however, malignant nodules are known to have irregular burden and morphology, whose maximum dimensions may not respect predominantly axial growth and whose margins may be challenging to define. Further more, these simple dimension-based criteria lack of sensitivity when applied to newer treatment paradigms whose mechanisms differ from traditional cytotoxic agents, and may not result in an immediate decrease of tumor size, despite efficacy on a molecular or cellular scale. This efficacy may not be translated into immediate lesions shrinkage [29].

Many HCC treatments act by induction of tumor necrosis or reduction in vascularity, which is not necessarily accompanied by tumor shrinkage in spite of response. Hence, to assess viable tumor contrast uptake in arterial phase has to be assessed using dynamic CT or MRI studies. Therefore expert groups convened by the European Association for the Study of the Liver (EASL) and American Association for the Study of Liver Diseases (AASLD) introduced the concept of including bi-dimensional measure(as described by the WHO criteria) of tumor enhancement in arterial phase of contrast-enhanced imaging studies to assess only viable target tumors. The tumor viability measurement guidelines have recently been amended to include the measurement of only the longest diameter of the Enhancing tumors to formally amend RECIST to modified RECIST (mRECIST) [15].

Seo *et al*. [30] In this study, the mRECIST and recently introduced LI-RADS v2017 treatment response algorithm was compared. The mRECIST defines viable tumor solely based on APHE, whereas the treatment response algorithm in LI-RADS v2017 includes washout and enhancement similar to that at pretreatment imaging, in addition to APHE, According to our results, with CT, the diagnostic performance of

LI-RADS considering three categories (viable, equivocal, non-viable) was superior to mRECIST, and the performance of CT to predict viable tumor was improved to similar level as that of MRI, using LI-RADS. However, the sensitivity and specificity of LR-TR viable were not significantly different from APHE alone. Therefore, superior performance of LI-RADS to mRECIST on CT seems to be due to the application of equivocal category rather than the addition of washout and enhancement similar to pretreatment imaging as viable criteria. On the other hand, incorporation of the equivocal viable category in LI-RADS treatment response algorithm seems to increase CT to detect viable tumor. Equivocal category reflects the real-world challenge of difficulty in determining viability in some treated nodules. Equivocal category more frequently on CT than on MRI. In addition, lesions assigned as equivocal category on CT were mostly viable tumor (93.8–100%), while those on MRI were with lower likelihood of viable tumor (50.0–60.0%) than CT Therefore, the equivocal category in LI-RADS algorithm should be interpreted carefully considering the imaging modality. LI-RADS have strengths; it can improve the accuracy of CT to detect viable tumor and provide standardized reports, although the application of LIRADS is more complicated and the inter observer agreement is lower than that of mRECIST. As there is no difference in the treatment response algorithm between LI-RADS v2017 and recently released LI-RADS v2018, our results may be valid also for the LI-RADS v2018. CT and MRI have different characteristics for assessment of treated HCCs.

Several previous studies have reported conflicting results regarding optimal imaging modality to assess the viability of HCC after LRT. In our study, the overall diagnostic performance of both CT and MRI was similar using LI-RADS. Therefore, our results suggest that either CT or MRI could be used to assess the treatment response of HCC after LRT using LI-RADS. In contrast, with using mRECIST,

MRI was better than CT in predicting the viable tumor. [31]
Further studies including per-patient analysis are warranted.
In conclusion, LI-RADS v2017 treatment response algorithm had better diagnostic performance than mRECIST using CT. With the LI-RADS, CT and MRI showed comparable performance to diagnose tumor viability of HCC after LRT.
However, LI-RADS specifies that radiologic viability is not necessarily coherent with pathologic viability, as imaging is not sensitive to microscopic or small foci of residual tumor ,Therefore, the combination of the assigned LI-RADS category and clinical assessment findings (such as AFP changes) is recommended to define optimal management of patient. It is suggested to repeat imaging with the same modality every 3 months for treated observations assigned to category LR-TR none valuable, LR-TR nonviable or LR-TR equivocal, whereas the decision to retreat or to perform alternative treatments in case of LR-TR viable category should be made on the basis of a tumor board or multidisciplinary discussion [16].
Moving from mRECIST, LI-RADS criteria reflect atypical HCC enhancement patterns, increasing the sensitivity for the detection of residual disease. Moreover, it assigns guidelines for follow-up in equivocal cases to ensure the optimum management of the patient. Nevertheless, it should be noted that LI-RADS provides guidelines only to identify the viable tissue and not to classify its changes over time. An integration of LI-RADS with mRECIST could be thus necessary for the best response evaluation over time [16].
There has been a growing interest to monitor the therapeutic response, at an early phase of treatment, by measuring tumor viability and/or perfusion. Therefore the importance of tumor viability assessment is increasingly being recognized. Other advances in MR imaging such as diffusion weighted imaging (DWI) are also emerging as biomarkers of Cellular integrity. In addition, positron emission tomography (PET) can also be used to investigate tumor metabolism. With the availability of so many imaging techniques, it is challenging to determine the most appropriate image criteria to serve as a surrogate end point of treatment response [15].

Conclusion

Surgical resection remains the gold standard for treating primary and secondary liver tumors; however, most patients are not candidates for hepatic resections because of tumor size, number, location, or severely ill patients to permit liver resection.
Minimally invasive thermal ablation techniques including RFA are a simple, effective and less expensive technique with a low morbidity compared with surgical treatment. Radiofrequency thermal ablation can produce significant long-term survival rates and excellent local control for cirrhotic patients with early stage, unresectable hepatic tumors.
Accurate assessment of the efficacy of therapies at earlier stages enables completion of treatment, optimal follow-up and to prevent potentially unnecessary treatments, side effects and costly failure.
To assess viable tumor contrast uptake in arterial phase has to be assessed using dynamic CT or MRI studies. Therefore the tumor viability measurement guidelines have recently been amended to include the measurement of only the longest diameter of the Enhancing tumors therefore complete response in the mRECIST system, is achieved when any intra tumoral arterial enhancement in all target lesions disappears.

References

1. Mc Glynn KA, Petrick JL, London WTJCild. Global epidemiology of hepatocellular carcinoma: an emphasis on demographic and regional variability. 2015; 19(2):223-238.
2. Lu DS, Raman SS, Limanond P, Aziz D, Economou J, Busuttil R, *et al*. Influence of large peritumoral vessels on outcome of radiofrequency ablation of liver tumors. 2003; 14(10):1267-1274.
3. Mazzanti R, Arena U, Tassi RJWjoem. Hepatocellular carcinoma: Where are we. 2016; 6(1):21.
4. Cho YK, Kim JK, Kim WT, Chung JWJH. Hepatic resection versus radiofrequency ablation for very early stage hepatocellular carcinoma: a Markov model analysis. 2010; 51(4):1284-1290.
5. Machi JJCJ. Radiofrequency thermal ablation of synchronous metastatic liver tumors can be performed safely in conjunction with colorectal cancer resection. 2000; 6(4):S344-S350.
6. Izzo F, Granata V, Grassi R, Fusco R, Palaia R, Delrio P, *et al*. Radiofrequency Ablation and Microwave Ablation in Liver Tumors: An Update, 2019.
7. Zhao LY, Huo RR, Xiang X, Torzilli G, Zheng MH, Yang T, *et al*. Hepato logy Hepatic resection for elderly patients with hepatocellular carcinoma: a systematic review of more than 17,000 patients. 2018; 12(10):1059-1068.
8. Mc Gahan JP, Dodd III GDJAJoR. Radiofrequency ablation of the liver: current status. 2001; 176(1):3-16.
9. Cha C, De Matteo RP, Blumgart LHJJocg. Surgery and ablative therapy for hepatocellular carcinoma. 2002; 35(5):S130-S137.
10. Bailey CW, Sydnor MKJDd. sciences. Current state of tumor ablation therapies. 2019; 64(4):951-958.
11. Tatli S, Tapan Ü, Morrison PR, Silverman SGJD, Radiology I. Radiofrequency ablation: technique and clinical applications. 2012; 18(5):508.
12. Lee MW, Raman SS, Asvadi NH, Siripongsakun S, Hicks RM, Chen J, *et al*. Radiofrequency ablation of hepatocellular carcinoma as bridge therapy to liver transplantation: A 10-year intention-to-treat analysis. 2017; 65(6):1979-1990.
13. Yamagiwa K, Shiraki K, Yamakado K, Mizuno S, Hori T, Yagi S, *et al*. Survival rates according to the Cancer of the Liver Italian Program scores of 345 hepatocellular carcinoma patients after multimodality treatments during a 10-year period in a retrospective study. 2008; 23(3):482-490.
14. Patella F, Pesapane F, Fumarola E, Zannoni S, Brambillasca P, Emili I, *et al*. Assessment of the response of hepatocellular carcinoma to interventional radiology treatments. Future Oncology. 2019; 15(15):1791-1804.
15. Arora A, Kumar A. Treatment response evaluation and follow-up in hepatocellular carcinoma. Journal of clinical and experimental Hepato logy. 2014; 4:S126-S129.
16. Elsayes KM, Kielar AZ, Chernyak V, Morshid A, Furlan A, Masch WR, *et al*. LI-RADS: a conceptual and historical review from its beginning to its recent

integration into AASLD clinical practice guidance. Journal of hepatocellular carcinoma. 2019; 6:49.
17. Siddiqui MA, Siddiqui HH, Mishra A, Usmani AJ. V. (2018). Epidemiology of hepatocellular carcinoma, 2018; 18:19.
18. Rossi S, Di Stasi M, Buscarini E, Quaretti P, Garbagnati F, Squassante L, *et al*. Percutaneous RF interstitial thermal ablation in the treatment of hepatic cancer. 1996; 167(3):759-768.
19. `Livraghi T, Goldberg SN, Lazzaroni S, Meloni F, Ierace T, Solbiati L, *et al*. Hepatocellular carcinoma: radio-frequency ablation of medium and large lesions. 2000; 214(3):761-768.
20. Shirato K, Morimoto M, Tomita N, Kokawa A, Sugimori K, Saito T, *et al*. Small hepatocellular carcinoma: therapeutic effectiveness of percutaneous radio frequency ablation therapy with a LeVeen needle electrode. 2002; 21(1):67-76.
21. Buscarini E, Buscarini LJEr. Radiofrequency thermal ablation with expandable needle of focal liver malignancies: complication report. 2004; 14(1):31-37.
22. Laeseke PF, Sampson LA, Brace CL, Winter III TC, Fine JP, Lee Jr, *et al*. Unintended thermal injuries from radiofrequency ablation: protection with 5% dextrose in water. 2006; 186(5):S249-S254.
23. Lee J, Lee JM, Yoon JH, Lee JY, Kim SH, Lee JE, *et al*. Percutaneous radiofrequency ablation with multiple electrodes for medium-sized hepatocellular carcinomas. 2012; 13(1):34-43.
24. Adam R, Hagopian EJ, Linhares M, Krissat J, Savier E, Azoulay D, *et al*. A comparison of percutaneous cryosurgery and percutaneous radiofrequency for unresectable hepatic malignancies. 2002; 137(12):1332-1339.
25. Geyik Serdar Geyik, Okan Akhan, Osman Abbasoğlu, Devrim Akıncı, Orhan Şeref Özkan, Erhan Hamaloğlu, *et al*. Radiofrequency ablation of unresectable hepatic tumors, 12, Diagn Interv Radiol, 2006, 195-200.
26. Mahmoud BEMH, Elkholy SF, Nabeel MM, Abdelaziz AO, Elbaz T, Shousha HI, *et al*. Role of MRI in the assessment of treatment response after radio frequency and microwave ablation therapy for hepatocellular carcinoma. 2016; 47(2):377-385.
27. Gonzalez-Guindalini FD, Botelho MP, Harmath CB, Sandra segaran K, Miller FH, Salem R, *et al*. Assessment of liver tumor response to therapy: role of quantitative imaging. Radiographics. 2013; 33(6):1781-1800.
28. Nishino M, Jagannathan JP, Ramaiya NH, Van den Abbeele AD. Revised RECIST guideline version 1.1: what oncologists want to know and what radiologists need to know. American Journal of Ro entgenology. 2010; 195(2):281-289.
29. Kuhl CK, Alparslan Y, Schmoee J, Sequeira B, Keulers A, Brümmendorf TH, *et al*. Validity of RECIST version 1.1 for response assessment in metastatic cancer: a prospective, multi reader study. Radiology. 2018; 290(2):349-356.
30. Seo N, Kim MS, Park MS, Choi JY, Do RK, Han K, *et al*. Evaluation of treatment response in hepatocellular carcinoma in the explanted liver with Liver Imaging Reporting and Data System version 2017. European radiology, 2019, 1-11.
31. Gervais DA. LI-RADS Treatment Response Algorithm: Performance and Diagnostic Accuracy, 2019.