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Contrast enhanced ultrasound: Roles in immediate post-procedural and 24-h evaluation of the effectiveness of thermal ablation of liver tumors☆

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KEYWORDS
Contrast-enhanced ultrasound;
Ultrasonography;
Interventional;
Ablation techniques;
Sensitivity and specificity.

Abstract *Purpose:* To retrospectively assess the diagnostic accuracy of immediate post-procedural CEUS, 24-h CEUS, and 24-h CT in verifying the effectiveness of thermal ablation of liver tumors ablation, using the combined results of 3-month post-procedure CEUS and MDCT as the reference standard.

Materials and methods: From our database, we selected patients who had immediate post-procedural CEUS and 24-h CEUS and MDCT examinations after undergoing thermal ablation of a liver tumor between January 2009 and March 2010. The study population consisted of 53 subjects and 55 tumors (44 HCC and 11 metastasis) were evaluated. Thirty-seven tumors were treated with radiofrequency and 18 with microwave ablation.

Post-procedural CEUS, 24-h CEUS and MDCT, and 3-month follow-up CEUS and MDCT images were blindly reviewed by two radiologists, who measured the size of the ablation area on the post-procedural and 24-h studies. They also evaluated the ability of each of these three index tests to predict the outcome (residual tumor vs. no residual tumor) using imaging studies done at the 3-month follow-up as the reference standard.

Results: Mean tumor diameter on preablation CEUS (the day before treatment) was 20 ± 9 mm. Mean diameter of the necrotic area was 29 ± 9 mm on post-procedural CEUS, 34 ± 11 mm on 24-h CEUS, and 36 ± 11 mm on 24-h MDCT. Diameters of the necrotic area (mean and maximum) on post-procedural CEUS were significantly smaller than those measured on 24-h CEUS or 24-h MDCT, which were not significantly different. For predicting the presence of residual tumor at the 3-month follow-up, post-procedural CEUS, 24-h CEUS, and 24-h MDCT displayed sensitivity of 33%, 33%, and 42%; specificity of 92%, 97%, and 97%; negative predictive value of 84%, 85%, and 83%. The accuracy parameters of these three imaging modalities were

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not significantly different from one another.
Conclusions: In patients undergoing thermal ablation for liver tumors, the immediate post-procedural CEUS seems comparable to 24-h CEUS and MDCT in terms of detecting residual disease.

Sommario *Scopo:* Determinare retrospettivamente l'accuratezza diagnostica nella valutazione di efficacia delle ablazioni di tumori epatici della CEUS eseguita al termine della procedura ablativa, della CEUS e della la tomografia computerizzata multi-detettore (TCMD) eseguite a 24 ore, utilizzando la CEUS e TCMD a 3 mesi di follow-up come standard di riferimento.
Materiali e metodi: Abbiamo selezionato dal nostro data base i pazienti sottoposti a CEUS subito dopo una procedura di ablazione e a CEUS e TCMD dopo 24 ore tra gennaio 2009 e marzo 2010. Il campione era composto da 53 soggetti in cui abbiamo valutato 55 lesioni (44 HCC e 11 metastasi). Trentasette lesioni sono state trattate con ablazione a radiofrequenza, 18 mediante microonde. La CEUS post-trattamento, la CEUS e la TCMD eseguite a 24 ore, e la CEUS e la TCMD eseguite a tre mesi di follow-up sono state rivalutate in cieco da due radiologi. Abbiamo confrontato tra loro le dimensioni della termoablazione misurate alla CEUS post-procedura, alla CEUS e alla TCMD eseguite a 24 ore. Abbiamo calcolato l'accuratezza diagnostica della CEUS post-procedura, della CEUS e della TCMD a 24 ore valutando la capacità di ogni metodica nel rilevare il tessuto vitale residuo utilizzando come standard di riferimento il follow-up a 3 mesi (TCMD e CEUS combinate).
Risultati: Il diametro medio del tumore alla CEUS il giorno prima del trattamento era di 20 $\pm$ 9 mm. Il diametro medio della necrosi ottenuta è di: 29 $\pm$ 9 mm alla CEUS post-trattamento, 34 $\pm$ 11 mm alla CEUS a 24 ore e 36 $\pm$ 11 mm alla TCMD a 24 ore. Il diametro medio ed il diametro massimo dell'area di necrosi misurati alla CEUS post-trattamento rispetto alla CEUS o alla TCMD eseguite a 24 ore sono risultati significativamente inferiori. La differenza tra le dimensioni dell'area di necrosi misurate alla CEUS e alla TCMD a 24 ore non è significativa. La CEUS post-trattamento, la CEUS a 24 ore e la TCMD a 24 ore hanno dimostrato i seguenti parametri di accuratezza diagnostica nell'individuare il tumore residuo rispetto al follow-up: sensibilità, 33%, 33%, 42%; specificità, 92%, 97%, 97%; valore predittivo negativo 84%, 85% and 83%. La differenza tra i parametri di accuratezza diagnostica delle tre metodiche non è risultata significativa.
Conclusioni: L'accuratezza diagnostica della CEUS post-trattamento nell'individuare tessuto tumorale residuo dopo ablazione di tumori epatici è comparabile a quella della CEUS e della TCMD a 24 ore.

Introduction

The past decade has witnessed a rapid increase in the popularity of thermal ablation as a nonsurgical option for the management of localized primary and secondary liver tumors. It is considered a curative treatment for Barcelona Clinic Liver Cancer Stage I hepatocellular carcinomas (HCC), and reported rates of local tumor control in this setting exceed 80% [1,2]. In addition, local tumor control and survival rates comparable with those obtained with surgical resection have recently been reported in selected patients with liver metastases from colorectal and breast cancers [3,4].

The aim of thermal ablation is to destroy by heat the entire tumor mass together with a safety margin consisting of a 5—10 mm rim of normal tissue. An applicator is inserted directly into the tumor under imaging guidance, and the local temperature is increased until it exceeds a threshold of about 50 °C, thereby inducing coagulation necrosis [5]. Different types of energy (e.g., radiofrequency, microwave, laser) can be used to generate locally the heat necessary to obtain thermal ablation of the tumor tissues [6—8].

To ensure good local tumor control, the completeness of the ablation must be verified immediately after treatment so that any residual viable tissue can be retreated during the same session. All currently available imaging modalities used for this purpose have limitations related to the reactive, hyperemic halo that develops around the ablated tissue and remains visible for several days. This halo impairs detection of viable residual tissue and is a possible source of both false positive and false negative findings [9,10].

In institutions where ablation is performed under multidetectorCT (MDCT) guidance, this imaging modality is also used frequently to assess the completeness of the ablation at the end of the procedure [11]. Promising preclinical experience has also been reported with magnetic resonance imaging for early post-ablation evaluation [12]. However, throughout the world, ablations are usually performed under ultrasound (US) guidance and monitoring, so it would be ideal to have an ultrasound-based modality for the immediate post-procedure assessment. Unfortunately, gray-scale US is not a very precise tool for assessing the completeness of an ablation. During the procedure,