Liver Cancer Microwave Ablation Guided by Imaging Fusion and Needle Tracking Based on Electromagnetic Volume Navigation

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Abstract: Not every liver cancer is visible on ultrasound. We report a case that the liver cancer was invisible on gray-scale ultrasound but was very distinct on MRI. The microwave ablation was guided by imaging fusion and needle tracking, based on electromagnetic volume navigation. We took advantages both the visibility of MRI and the flexibility of ultrasound and made the needle tip always seen.

Key Word: Electromagnetic volume navigation; Needle tracking; Microwave ablation

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Case Report

A 58-year-old male patient with a history of HBV for more than 10 years and liver cirrhosis for 4 years. He has undergone a transcatheter arterial chemoembolization a month ago because of liver cancer in left lobe of liver. He also had a history of smoking and alcohol for 30 years. His physical examination is normal, except for fist percussion over the liver (+). Laboratory examination: Blood routine: WBC $1.90 \times 10^9/L$, RBC $3.05 \times 10^{12}/L$, HGB 103 g/L, PLT $94 \times 10^9/L$; liver function: ChE 2494 U/L, ALP 157.8 U/L, γ -GT 136.1 U/L, albumin 33.0 g/L, and AFP 17.57 ng/ml. Child-pugh classification: A (6 score). Radiology: contrast-enhanced MRI, a lesion in right lobe was mildly low tension on T1WI and mildly high tension on T2WI, it was rim-enhanced in arterial phase and low-enhanced in lag phase; contrast-enhanced ultrasound: the lesion did not wash-in in arterial phase and wash-out in portal and vein phase (Fig. 1). It's considered a cirrhosis nodule transforming to a cancer. According to European Association for the Study of the Liver and AASLD guidelines for the treatment of hepatocellular carcinoma, the patient accepted to undergo a microwave ablation.

Instruments: ultrasound machine: GE LOGIQ E9 XD CLEAR with C1-6 probe; microwave machine: Nanjing Kangyou microwave ablation machine 2 450 Hz with type B microwave electrodes.

Figure. 1 A, the lesion doesn't show washing-in in arterial phase (at 31s). B, the lesion shows wash-out in portal and lateral phase (at 1min 2s).

Patient was in the horizontal position and the magnetism generator (Fig. 2A*) was placed over the right shoulder of patient. The DICOM data was uploaded to ultrasound machine and the sensor (H4913NK, CIVCO Medical) was assembled on the C1-6 probe (Fig. 2A→). The ultrasonography was fused with MRI by Plane. The needle-tracking device (eTRAXTM, CIVCO Medical) was

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fixed on the needle bar with 170 mm distant from tip (Fig. 2B). The center of the lesion was set as the target on both MRI and ultrasound. The target was punctured guided by ultrasound. Signal $\diamond$ marks the position of the needle tip, the signal appear as + when the needle tip punctured the center of lesion set before (Fig. 3). The needle tip was visible in the whole operation (Fig. 4). No enhancement was found in and around the ablation area on CEUS after the operation. AFP was normal 3 month later.

Figure 2 A, “*” was a magnetism generator and the red arrow was pointing the magnetic sensor on the transducer. B, the red arrow was pointing the needle-tracking device.

Figure 3 The screen was showing the same plane both ultrasound image (left) and MRI (right) in real time synchronously. “T” represented the lesion which has been marked as the target and the green “□” was marking the needle tip.

Figure 4 The brown “□” was marking the needle tip, which was out of probe plane.

Discussion

Image fusion technology has become increasingly mature and the multi-modal image fusion is able to capture all kinds of images. Image fusion has been used in many clinical areas, such as prostate biopsy in urology [1], radiotherapy in oncology [2]. In addition to the ultrasonic-CT/MRI image fusion, PET can be fused with ultrasonography by uploading the DICOM data of PET-CT into the system, and it has been done on prostate now.

Imaging registration is one of the critical steps in the image fusion. The accuracy of manual and semiautomatic co-registration is better than that of automatic co-registration [3]. At present, the commonly used image registration method is three-point method point-plane method, while we usually prefer the latter. The essence of imaging registration is to match the volume of MRI to the magnetic field, where the generator as a Cartesian coordinate system anatomically correspondingly [4]. For point-plane method, the selected plane must be parallel to the axial view and perpendicular to coronal view so that the directions of the X and Y axis can be determined. The Z axis is equal to the head-feet direction of patients. And we set an anatomical landmark to adjust two spaces. Liver imaging fusion is different from bone or head because it is obstructed by respiration movement notably, thus the position of patient should be controlled [5]. We’ve been thinking if we could fix this issue with a respiratory gating which could be affiliated to electromagnetic volume navigation.

Needle tracking technology has not been used widely even it’s been commercially available for some time. There are different methods of needle tracking, such as electromagnetic tracking, mechanical position encoders, image-based software tracking [6]. This study applied the electromagnetic tracking supported by GE LogiQ E9. Our challenge to solve needle visualization and deflection, determining enter point and avoiding critical anatomy. Most of early research were about vascular intervention [7] and nerve block anesthesia [8] performed by non-interventional ultrasound professors, however, there has been research on bone biopsy currently [9]. Due to operators’ experience or tissue character it’s difficult to identify the target or the needle tip, thus this is the area where needle tracking technology needs to be developed. Researches has shown that this technology has superiority in liver tumor biopsies compared with ultrasound guiding freehand [10]. And research had also confirmed the feasibility and safety of this technique on guiding the liver cancer radiofrequency ablation [11]. No large sample study has reported that using the microwave ablation guided by image fusion. In this case the operator could see the needle tip in the whole procession

even it was covered by the heated gas and no serious complications were observed after the operation.

Ethical statements

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions. Informed consent was obtained from patient for being included in the study. Additional informed consent was obtained from patient for which identifying information is included in this article.

Conflicts of Interest

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