International Journal of Advanced Technology in Engineering and Science
Vol. No.3, Special Issue No. 01, November 2015
www.ijates.com
ijates
ISSN 2348 - 7550

RECENT ADVANCES IN IMAGE PROCESSING TECHNIQUES USING USG AND MRI OF LIVER

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ABSTRACT

Magnetic resonance imaging (MRI) is playing an increasing role in the assessment of patients with liver disease due to its high soft tissue resolution, lack of ionizing radiation and ability to provide functional data. There are various types of diseases in the liver. So, to identify these diseases and to get a clear image of the damaged part various imaging techniques are used mainly Sonography and MR based techniques. These techniques are easy to implement across different MRI platforms, and results in enhanced disease detection and characterization. Diffusion Weighted Imaging (DWI) is used to identify the lesion in the liver, Perfusion Weighted Imaging (PWI) is used to identify the volume and functioning of the cirrhotic liver.

Keywords: ANOVA, Chronic Liver Disease (CLD), Dynamic hepatocyte-specific contrast-enhanced MRI (DHCE-MRI), Diffusion Weighted Magnetic Resonance Imaging (DWMRI), Kruskal-Wallis test, RLE (Relative Liver enhancement)

I. INTRODUCTION

There are various imaging techniques which are prevailing now a day in the assessment of patients with liver diseases. One of the widely used techniques is Diffusion Weighted Magnetic Resonance Imaging (DWMRI).It is a functional imaging technique.DW imaging is increasingly used in the abdomen, particularly in the liver with promising results for liver lesion detection and characterization [7]. We calculate Apparent Diffusion Coefficient (ADC) values in it and the calculated ADC values can be displayed as an image and quantitative analysis can be performed by placing measuring the mean value within a Region of Interest (ROI). Earlier, Mono-exponentially fitted ADC values were calculated which was contaminated by micro-perfusion so Bi-exponential model was required and data was compared using ANOVA and Kruskal-Wallis test. DW Imaging can be easily implemented in clinical protocols, as it can be performed relatively quickly and does not require contrast agent injection [1].

Several, studies have reported that ADC can contribute to the differential diagnosis of benign and malignant focal lesion in the liver. In particular, the combination of DWI and PWI of the liver may supply additional tools to assess liver function, providing information concerning both the soft-tissue characteristics and the vascularity of the lesions. By diagnosing both MR perfusion can improve the sensitivity and specificity of diagnostic liver imaging [2].

Gd-EOB-DTPA is a contrast agent developed for MRI. We use dynamic hepatocyte-specific contrast-enhanced MRI (DHCE-MRI) to evaluate liver volume and function in the liver cirrhosis, correlate the results with standard scoring models and explore the inhomogeneous distribution of liver function in cirrhotic livers [3].

Then gadoxetic acid-enhanced 3T MR Imaging was performed and RLE (Relative Liver enhancement) was calculated. Liver failure was defined according to 50-50 criteria and ISGLS classification. RLE was inversely related to the probability of liver failure according to 50-50 and ISGLS criteria. RLE was independently associated with a higher probability of liver failure according to ISGLS classification [4].

In all above techniques, we described about liver cirhossis.Now, Grey Relational Analysis (GRA) is proposed to recognize fatty livers in B-scan ultrasonic images. Main diagnostic methods for fatty liver are B-mode ultrasound, followed by a CT-scan and MRI. Ultrasonography was based on brightness of the image where an echo is created that is, returning signal [6].

II. IMAGING TECHNIQUES

Since morphologic alterations and features of portal hypertension are present only in advanced Chronic Liver Disease (CLD), routine examinations by ultrasound (US), computed tomography (CT) and magnetic resonance imaging (MRI) could produce specific findings, but with very limited sensitivity. CT offers improved resolution of early morphological changes with cirrhosis but has low accuracy in fibrosis detection. MRI identify specific features of cirrhosis such as hepatic vein narrowing, caudate to right lobe ratio, and expanded gallbladder fossa, but remains lacking in earlier stages of fibrosis. Hence, assiduous efforts have been made to search for technological developments [9].

2.1 Sonography Based Techniques for Assessment of Liver Fibrosis

Recently, diverse Sonography–based techniques have been used in assessment of liver fibrosis, including Transient Elastography, Real-Time Elastography, and Acoustic Radiation Force Imaging sonoelastography.

2.1.1 Transient Elastography

Transient Elastography (TE) (Fibro Scan®, Echosens, and Paris, France) is a new imaging modality for detecting hepatic fibrosis. The measuring instrument comprises a computer driven control unit and a probe with an ultrasound transducer, which is located at the end of a vibrating piston. TE measures liver stiffness in a volume that approximates a cylinder 1 cm wide and 4 cm long, between 2.5 cm and 6.5 cm below the skin surface [10].

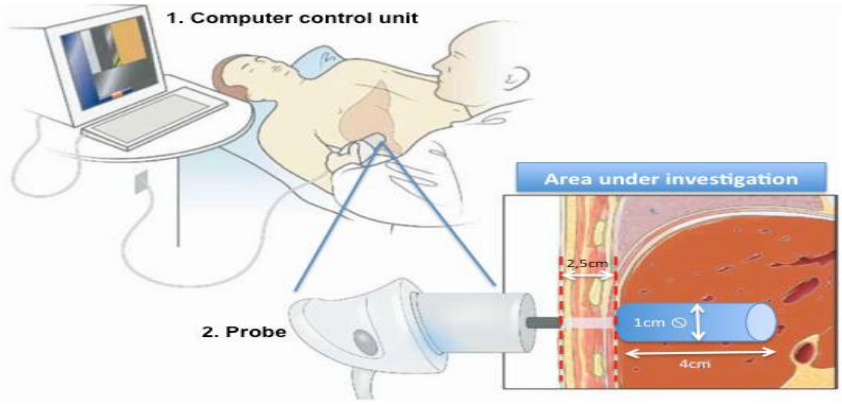

Figure 1 Illustration of the two different constituent of the measuring instrument and the positioning of the probe in relation to the area of liver under investigation.

The advantages of TE are that the results are immediately available, and the procedure is painless, rapid (~3 minutes per patient), and easy to perform. One of the important aspects of liver stiffness measurements is the cut-off values that are adopted for different stages of fibrosis, with higher cut-off levels corresponding to higher fibrosis stages [11-13]. There are some physical limitations of TE, such as obesity (particularly the fatness of the chest wall), narrow intercostals space and ascites [11].

2.1.2 Real-Time Elastography

Real-Time Elastography (RTE) is an alternative method for measurement of tissue elasticity integrated in a Sonography machine developed by Hitachi Medical Systems. Ophir et al. [14] first described the principle of this technique in 1991. To reduce the time-consuming calculations, Pesavento etal.developed a fast cross-correlation technique that is the basis for RTE. The difference in hardness between diseased and surrounding tissue can be detected by RTE based on the physical properties of the tissue. The calculation of tissue elasticity distribution is assessed in real-time ultrasound imaging and depicted as color-coded images with the conventional B-mode image in the background [15, 16]. The color scale includes the following colors: red (soft tissue), green (intermediate, normal tissue), and blue (anelastic, hard tissue).

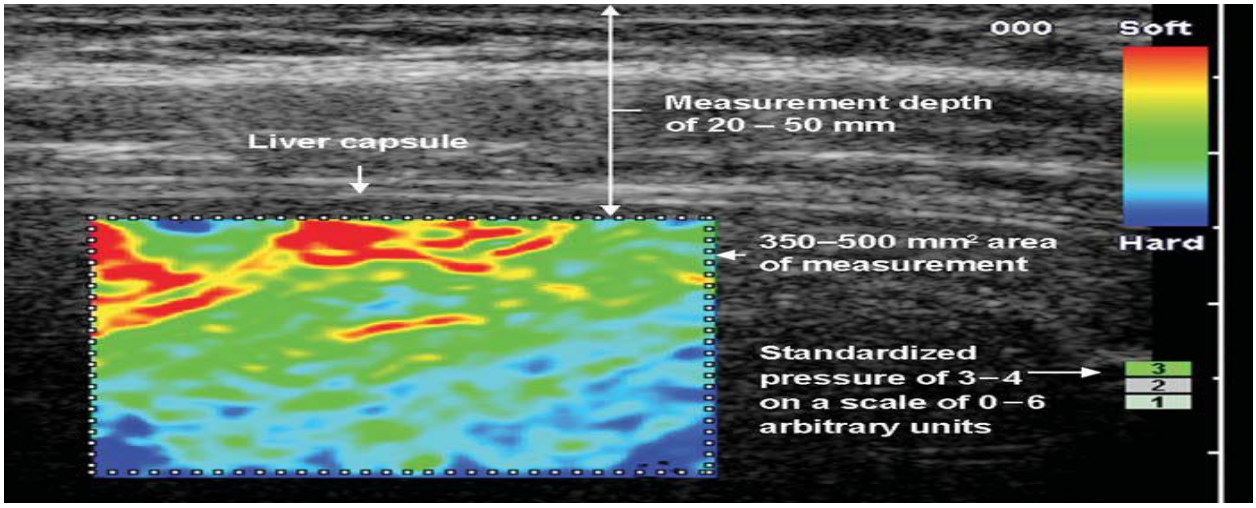

Figure 2 Example of tissue elasticity distribution in a healthy subject represented as color-coded images over conventional B-mode image [17].

As for TE even for RTE obesity, narrow intercostals space and ascites are potential physical limitations. More number of samples about chronic hepatitis with assessment by RTE is needed to perform to certify its advantages.

2.1.3 Acoustic Radiation Force Impulse Elastography

Acoustic Radiation Force Impulse (ARFI) imaging is a novel ultrasound-based Elastography method that is integrated in a conventional Ultrasound machine enabling the exact localization of measurement site. Unlike conventional B-mode Sonography, which provides anatomical details based on differences in 3–4 on a scale of 0–6 arbitrary units [9].

2.2 MR Imaging Based Techniques for Assessment of Liver Fibrosis

In the last decade, the development of MRI scanner with high-performance magnetic field gradients made the introduction of three-dimensional sequences for liver imaging possible. Volumetric image acquisitions with

near-isotropic voxels (1–3 mm in all three-dimensions) through the entire liver can be achieved in a single breath-hold or using respiratory triggering. In detail, several technological advances have been made for assessment of fibrosis, including Conventional MRI, Double contrast-material enhanced MRI, Diffusion-weighted MRI, and MR Elastography, perfusion MRI, and MR spectroscopy [9].

2.2.1 Unenhanced MRI

In patients with precirrhotic stages of liver fibrosis as well as patients with early cirrhosis, the liver parenchyma usually has a normal appearance or may reveal only subtle, generic heterogeneity on unenhanced MRI [18].

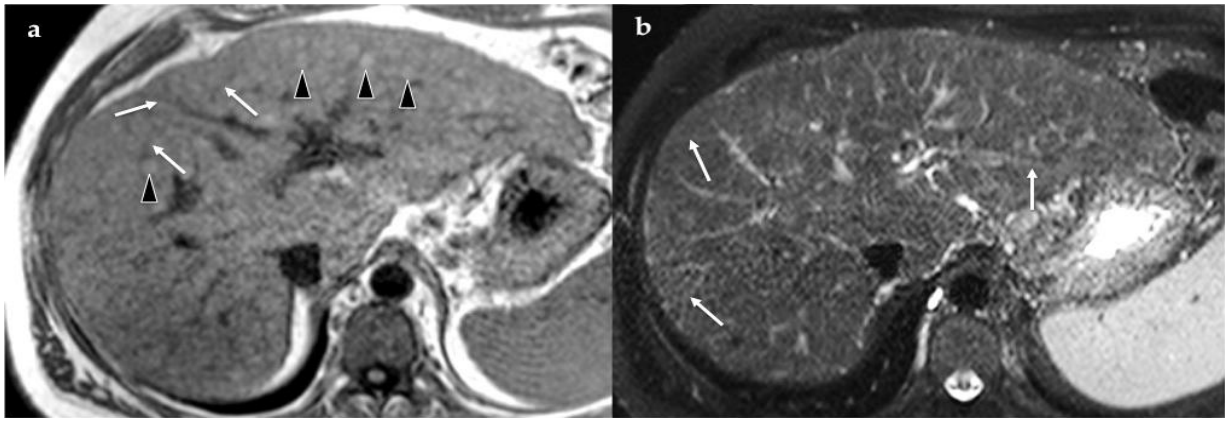

Figure 3 Unenhanced MR imaging in a in a 61-year-old man with alcohol-related cirrhosis. Unenhanced T1-weighted image (a) shows hypo intense reticulations (arrows) and numerous regenerative nodules (arrowheads), which are isotohyperintense. Unenhanced T2-weighted fat-saturated image (b) allows a clearer visualization of the reticulations throughout the liver parenchyma visible as hyper intense septa (arrows)[19].

2.2.2 Contrast-enhanced MRI

The detection of liver fibrosis is improved by the administration of contrast agents. Three contrast agents are currently commercially available: gadolinium-based contrast agents; super paramagnetic iron oxide particles; Gd-EOB-DTPA. Gadolinium-based contrast agents cause T1 shortening and signal enhancement on T1-weighted images [20]. Most gadolinium-based contrast agent formulations freely equilibrate with the extracellular compartment and accumulate in tissues with large extracellular volumes such as liver fibrosis. Super paramagnetic iron oxide particles (SPIO) are reticulo-endothelial-specific particulate MRI contrast agents which are cleared from the blood through phagocytosis and accumulate in the cells of the reticule-endothelial system of the liver, spleen, and bone marrow, with approximately 80% taken up by the liver [9].

2.2.3 Double-contrast enhanced MRI

Double-contrast MRI (DC-MRI) using extracellular contrast agents in combination with SPIO particles was shown to sensitively detect liver fibrosis and depict HCC in cirrhotic livers [21]. The consequence is high image contrast between the low-signal-intensity liver parenchyma and high-signal-intensity fibrotic reticulations (Fig 4[4].

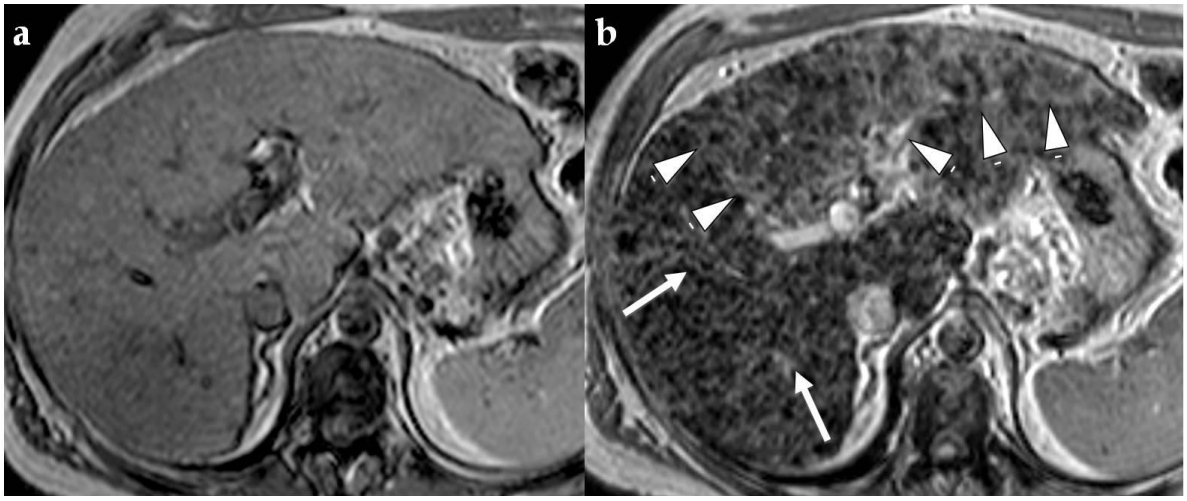

Figure 4 Advanced fibrosis and infiltrative HCC in a 46-year-old man with HCV-related cirrhosis. T2*-weighted gradient-echo images obtained before (a) and after (b) intravenous SPIO injection. After injection, fibrotic reticulations in the right lobe have diminished Kupffer cell density, do not accumulate iron oxides, - hence appear relatively hyper intense (arrows in b). The left lobe is expanded and shows a wedge-shaped mass with heterogeneous hyper intensity (arrowheads in b) in the hepatocellular phase, suggestive for infiltrative HCC Aguirre et al. [23] examined 101 CLD patients who underwent DC-MRI to detect hyper intense reticulations, which are postulated to represent septal fibrosis, and hypo intense nodules.

2.2.4 MR Elastography

A new option for assessing shear stiffness in various tissue types, including liver fibrosis, is MR Elastography (MRE) [24]. MRE uses a modified phase contrast technique to sensitively image the propagation characteristics of acoustic shear waves that are generated with the organ of interest [25]. A specialized phase-contrast MRI sequence is then used to image the propagating waves in the liver [9].

2.2.5 MR Spectroscopy

MR spectroscopy (MRS) enables the non-invasive measurement of concentrations of different chemical components within tissues, which are displayed as a spectrum with peaks consistent with the various chemicals detected [9].

III. CONCLUSION AND FUTURE SCOPE

A fast, safe and reliable technique to assess fibrosis of CLD and to follow up progression or regression of fibrosis during treatment is required. Ultrasound is still a widespread, low cost, user-friendly, and accurate technique [9]. An advantage of DC-MRI is that it works on routine imaging units and does not require specialized equipment. Computer-based texture analysis techniques may assess texture abnormalities qualitatively or quantitatively [9]. The primary advantage of the GRA method is that it is based on an algorithm which precisely compares with own liver image [6]. Gadoxetic acid–enhanced MR imaging can help with the assessment of the risk for liver failure after major liver resection[4]. In conclusion, to date, the most promising techniques appear to be Transient Elastography [26] and MRE [27, 28] since they provide reliable results in

detecting severe fibrosis and future developments promise to increase the reliability and accuracy of staging of hepatic fibrosis. In the future, MRI technical development and new contrast agents could permit imaging of fibro genesis.

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