Medical Applications

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Investigation of hepatic fibrosis in rats with X-ray diffraction enhanced imaging

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Introduction

X-ray diffraction enhanced imaging (DEI) is a kind of phase contrast imaging[1]. It can provide much more information on soft tissue morphology than conventional absorption radiography. We evaluate the potential of DEI for imaging hepatic fibrosis. Hepatic fibrosis refers to the accumulation of fibrillar extracellular matrix proteins with abnormal distribution, and the diffuse process may ultimately progress to cirrhosis. To date, the invasive liver biopsy is still the "gold standard" for diagnosing hepatic fibrosis. Here we demonstrate that the refraction contrast images obtained from the DEI method show great visibility of fibrous liver architectures. Moreover, different stages of hepatic fibrosis can be clearly distinguished.

Materials and methods

The samples of hepatic fibrosis were prepared in Liver Research Center, Beijing Friendship Hospital. Hepatic fibrosis in rats was induced by human albumin[2]. The liver specimens were fixed in 10% formalin solution. Sections with thickness approximately 2.5mm were cut for DEI imaging.

The imaging was performed at Photon Factory in beam line BL-14B. During the experiment, the X-ray energy was set at 15 keV. Images were taken on each side of the full width at half maximum position of the RC, and then refraction images were obtained by the algorithm proposed by Chapman et al[1].

After imaging, samples were processed and embedded in paraffin, and then 4μm thick sections were cut and stained with picrosirius red. The slides were observed by optical microscope and reviewed by an experienced pathologist. Those proceedings were accomplished in department of pathology, China-Japan Friendship Hospital. The stage of fibrosis was assessed according to the scoring system proposed by Zhao et al[3].

Results

We compared refraction images of hepatic fibrosis of rat liver sections with those corresponding histological pictures, and morphological features of DEI images of different stages of fibrous samples were obtained.

The refraction image of normal sample shows that liver textures appear ordered and regularly; vessel walls are quite smooth; and vessel trees down to small branches of tens of micrometers in diameter can be clearly distinguished. Compared to normal structures, there are obviously changes in morphological levels in different stages of hepatic fibrosis, including vessel structures and liver textures. At the initial stage, small vessel branches are destroyed first; with fibrosis further developed, deformations on large vessels become apparent; and it appears that the greater degree of fibrosis, the severer distortion of vessels. However, the roughness of liver textures may not increase as the fibrosis stage increases.

In order to further investigate the texture features, image textures were quantified using gray level co-occurrence matrix method[4]. The texture measures of inverse difference moment, entropy, difference average and sum entropy were obtained respectively. It demonstrates that normal and different stages of fibrosis can be clearly differentiated by these texture features, and there is a correlation between the results of numeric values of texture features and image appearances discussed above. The results indicate that DEI provides a potential way of non-invasive diagnosis of hepatic fibrosis. However, the results also show limitations associated with the DEI method.

References

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