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Evaluation of Liver Fibrosis Diagnosing Method by Scatterer Distribution Estimation

散乱体分布を指標とした肝線維化判定法の評価

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1. Introduction

The probability density function (PDF) of echo envelop is an important factor for the tissue characterization (TC) by ultrasound. The PDF of the normal liver which has homogeneous scatterer distribution can be approximated to Rayleigh distribution. On the other hand, the PDF of the liver fibrosis which has heterogeneous scatterer distribution can't obey Rayleigh distribution [1,2]. The liver fibrosis has a fiber tissue where scatterer density is high. In order to detect the fiber tissue quantitatively, we have examined relationship between the scatterer distribution and the PDF of echo envelopes of medium which the part of high scatterer density was intermingled with computer simulation. Parameters to estimate scatterer density of fiber tissue was calculated by Q-Q plot.

In this research, we applied these parameters to *in vivo* echo data examination, and compared between the result of examination and the fibers score measured from the liver biopsy to fix estimation parameters. We examined possibility of a quantitative diagnosis method of liver fibrosis by the estimating of the scatterer distribution.

2. Relationship between parameters and scatterer distribution

By estimation of various condition of computer simulation model of heterogeneous medium, Q-Q plot shows the line of various curves as the mixture rate and the density of a high-density part which are intermingled change. We approximated the result of the Q-Q plot in two different straight lines, and proposed slope and intersection coordinates as indexes of the mixture rate and the density of a high scatterer density part. The slope was calculated by a $\tan^{-1}\theta$ in high amplitude part (**Fig.1**). **Figure 2** shows the relationship between parameters($\tan^{-1}\theta$ and intersection coordinates) and scatterer distribution. These parameters can detect the density and the mixture rate of a high density part.

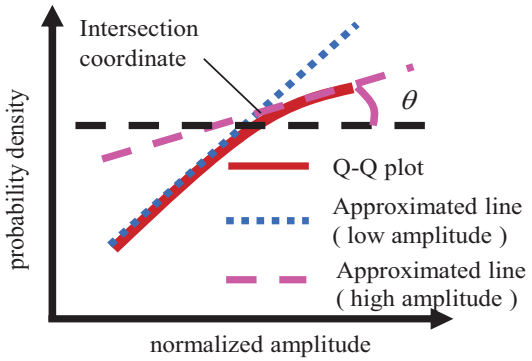

Fig.1 Parameters which evaluate the scatterer distribution.

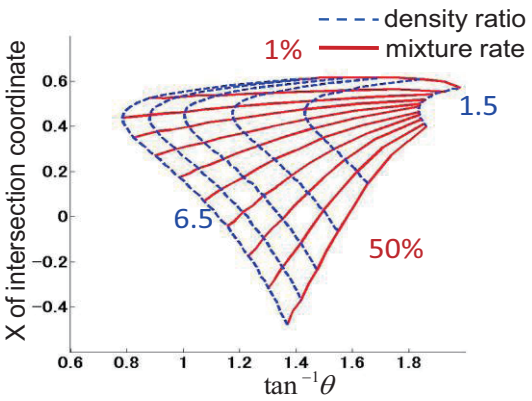

Fig.2 Relationship between parameters and scatterer distribution

3. Application to *in vivo* data of liver fibrosis

In this study, *in vivo* data were classified into F1 to F4 according to the shin-Inuyama classification based on the result of the liver biopsy (**Table 1**). **Figure 3** shows the difference in the parameters of the *in vivo* data of F1 and F4. F4 has more parts of scatterer density higher than F1. Each value of $\tan^{-1}\theta$ and X in F4 was assumed to be

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Table 1. Classification of acquired data.

Stage	Liver condition	Number
F0	no fibrosis	4
F1	portal fibrosis widening	5
F2	portal fibrosis widening with bridging fibrosis	6
F3	bridging fibrosis plus lobular distribution	6
F4	liver cirrhosis	2

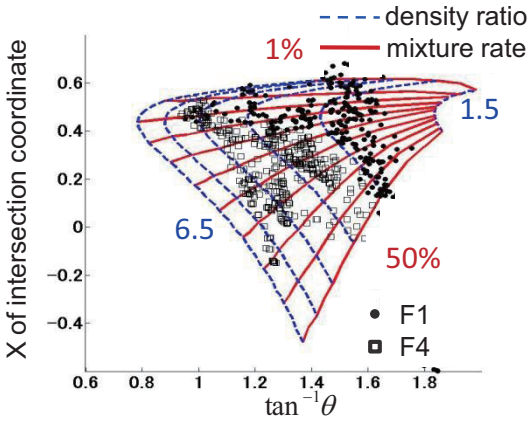

Fig.3 Difference between parameters of F1and F4

the combination of the suitable parameter for fiber extraction. By this presumed technique, region of the combination of these parameters is equal to the high density part of 3 to 5 times being intermingled 10 to 30%.

4. Comparison of this method and biopsy

Figure 4 shows the original echo data sets and results of applying our estimation method with these parameters. The part presumed to be the high density part of 3 to 5 times being intermingled 10 to 30% was dyed red. In F0 which is normal liver, the dyed part is only portal veins or a vein. In F1 in early stages of a pathological change, a small number of dyeing part is observed in the edge of liver. The quantity of the dyeing part increased and diffused with advance of a pathological change as same as the feature of liver fibrosis.

Figure 5 shows the relationship between the stage of a pathological change, and the rate of red parts in a liver area. The stage and the rate of red parts have correlation. But since variance is large, it is difficult to detect pathological change at an early stage. This is considered to be because for a portal vein or a vein to have dyed.

5. Conclusion

Our proposed method can detect a high scatterer density part sensitively in the medium by

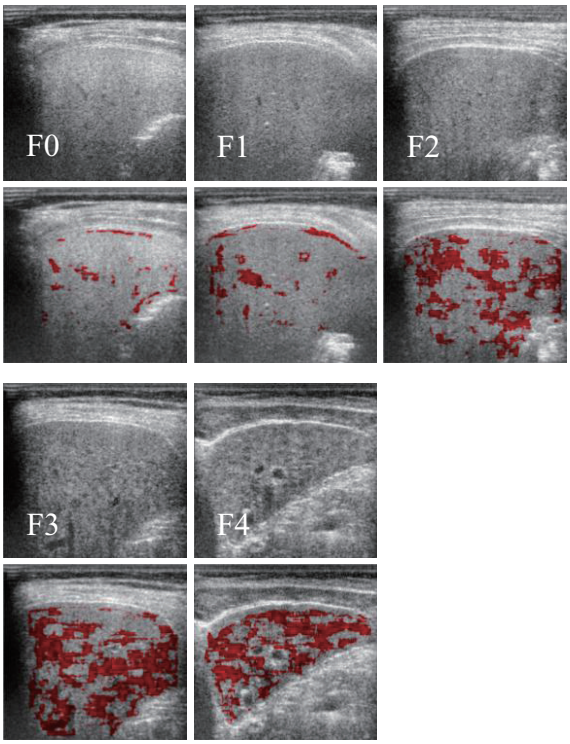

Fig.4 Detection of high scatterer density part.

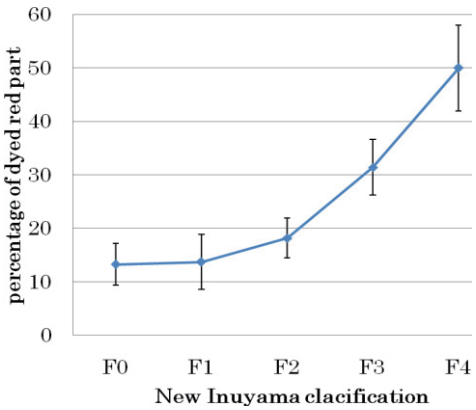

Fig.5 Relationship between stage of fibrosis and dyed red part

which two different tissues are intermingled, and is useful in quantitative diagnosis of liver fibrosis. In order to apply to actual diagnosis, it is necessary to also enable detection of a low density part, such as a portal vein or a vein, simultaneously.

Acknowledgment

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