International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Grading of Liver Cirrhosis in Ultrasound Images Using Texture Analysis

Safaa Abdoelrahman Mohamed[1], Mohamed izeldin[2], Abdoelrahman Hassan A. B.[3]

[1, 2, 3] Sudan University of Science and Technology, Collage of Medical Radiologic Science, Khartoum 3199, Sudan

Abstract: ***The process of liver cirrhosis may vary according to its courses and its severity, this study was aimed to characterize and to classify the liver cirrhosis into different liver grades using ultrasound scanning techniques in which the images treated as IDL variables for purpose of tissue texture extraction and the variable was including the First Order Statistics measures (FOS). And liver cirrhosis firstly classified using US scanning and the assessment was carried out so four grads was estimated here from grade (0) up to grade (3) then using SW-LDA the classification reveals that 94.7% of the original classes were correctly predicted by the classification function. Where the sensitivity was equal to 96.1% and specificity of 90.6%. A linear equation was extracted in order to calculate the liver grades simply using ultrasound machine.***

Keywords: ultrasound, cirrhosis, texture analysis, grading.

1. Introduction

The World Health Organization (WHO) defines cirrhosis as a diffuse process characterized by fibrosis and the conversion of normal liver architecture into structurally abnormal nodules. [1] Three major pathologic mechanisms combine to create cirrhosis: cell death, fibrosis, and regeneration. Cirrhosis has been classified as micronodular, in which nodules are 0.1 to 1 cm in diameter, and macronodular, characterized by nodules of varying size, up to 5 cm in diameter. Alcohol consumption is the most common cause of micronodular cirrhosis, and chronic viral hepatitis is the most frequent cause of the macronodular form. [2] Patients who continue to drink may go on to end-stage liver disease, which is indistinguishable from cirrhosis of other causes. Other etiologies are biliary cirrhosis (primary and secondary), Wilson's disease, primary sclerosing cholangitis, and hemochromatosis. The classic clinical presentation of cirrhosis is hepatomegaly, jaundice, and ascites. However, serious liver injury may be present without any clinical clues. In fact, only 60% of patients with cirrhosis have signs and symptoms of liver disease.

Because liver biopsy is invasive, the ability to detect cirrhosis by noninvasive means, such as sonographic, holds great clinical interest. The sonographic patterns associated with cirrhosis include the following (Fig. 1.):

Volume redistribution: In the early stages of cirrhosis the liver may be enlarged, whereas in advanced stages the liver is often small, with relative enlargement of the caudate lobe, left lobe, or both, compared with the right lobe. Several studies have evaluated the ratio of the caudate lobe width to the right lobe width (C/RL) as an indicator of cirrhosis. [3]. A C/RL value of 0.65 is considered indicative of cirrhosis. The specificity is high (100%), but the sensitivity is low (43%-84%), indicating that the C/RL ratio is a useful measurement if it is abnormal. [4]. However, no patients in these studies had Budd-Chiari syndrome, which may also cause caudate lobe enlargement.

Coarse echotexture: Increased echogenicity and coarse echotexture are frequent observations in diffuse liver disease. These are subjective findings, however, and may be confounded by inappropriate time gain compensation (TGC) settings and overall gain. Liver attenuation is correlated with the presence of fat, not fibrosis. [5] Cirrhotic livers without fatty infiltration had attenuation values similar to those of controls. This accounts for the relatively low accuracy in distinguishing diffuse liver disease [5] and the conflicting reports regarding attenuation values in cirrhosis.

Nodular surface: Irregularity of the liver surface during routine scanning has been appreciated as a sign of cirrhosis when the appearance is gross or when ascites is present. [6] The nodularity corresponds to the presence of regenerating nodules and fibrosis.

Regenerating nodules (RNs): These regenerating hepatocytes are surrounded by fibrotic septae. Because RNs have a similar architecture to the normal liver, ultrasound and CT have limited ability in their detection. RNs tend to be isoechoic or hypoechoic with a thin, echogenic border that corresponds to fibrofatty connective tissue. [7] MRI has a greater sensitivity than both CT and ultrasound in RN detection. Because some RNs contain iron, gradient echo sequences demonstrate these nodules as hypointense. [8]

Dysplastic nodules: Dysplastic nodules or adenomatous hyperplastic nodules are larger than RNs (diameter of 10 mm) and are considered premalignant. [9] They contain well-differentiated hepatocytes, a portal venous blood supply, and atypical or frankly malignant cells. The portal venous blood supply can be detected with color Doppler flow imaging and distinguished from the hepatic artery–supplied HCC. [10] In a patient with cirrhosis and a liver mass, percutaneous biopsy is often performed to exclude or diagnose HCC.

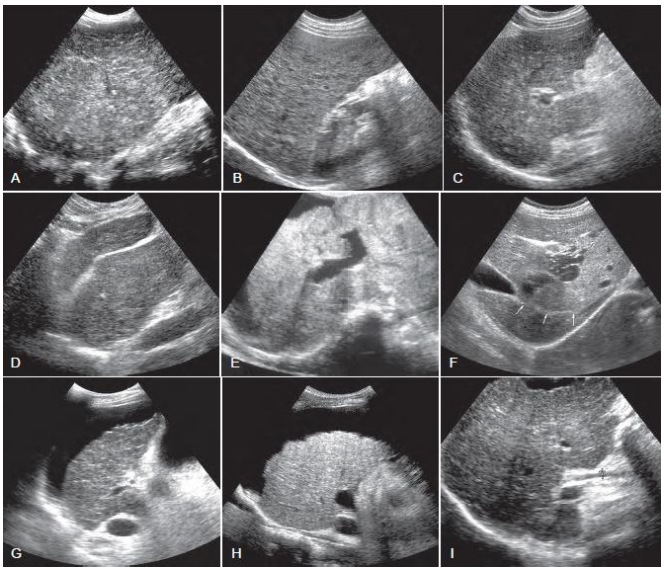


Figure 1: Cirrhosis: spectrum of appearances. *Top row,* **Parenchymal changes. A,** Coarse parenchyma and innumerable tiny, hyperechoic nodules. **B,** Coarse parenchyma and innumerable tiny, hypoechoic nodules. **C,** Coarse parenchyma and surface nodularity. *Middle row,* **Lobar redistribution. D,** Sagittal image showing an enormous caudate lobe. **E,** Transverse sonogram shows the right lobe is small, with enlargement of the left lateral segment. **F,** Subcostal oblique view showing a tiny right lobe of the liver, which is separated from the large left lobe by the main lobar fissure *(arrows). Bottom row,* **Contour abnormality**. **G** and **H,** Small, end-stage livers with surface nodularity, best appreciated in patients with ascites, as shown here. **I,** Liver contour varies greatly, as shown here, where a large nodule protrudes from the deep liver border.

2. Methods of Analysis

The study was done in 53 patients were exposed to bilharziasis using 2D conventional ultrasound to diagnosis the changes in the liver. All patients scanning by ultrasound using curvilinear low frequency probe (3.5 – 5 MHZ) for more penetration sonyscape machine by using an international scan guidelines protocols to scanning liver using ultrasonography. After that ultrasound image were stored in computer disk were uploaded into the computer based software; Interactive Data Language (IDL) where the DICOM image were read by IDL where the author clicks on several images that represents liver cirrhosis as grade 0, grade 1, grade 2 and grade 3. In these areas a window of 3×3 pixel were set and the first order statistics were calculated, which include mean, variance, skewness, kurtosis, energy and entropy. The data concerning the liver cirrhosis as grade 0, grade 1, grade 2 and grade 3 were processed by SPSS software with its classes to generate a classification score using stepwise linear discriminant analysis; to select the most discriminant features that can be used in the classification (grading) of liver cirrhosis in one of its four grades. Where scatter plot using discriminant function were generated as well as classification accuracy and linear discriminant function equations to grade unseen images for its grade objectively.

3. Results and Discussion

The results of this study showed that liver cirrhosis in ultrasound images can be graded into (0, 1, 2 and 3) using first order statistics which extracted from images represents these grades by applying linear discriminant analysis as classification tools, where it minimizes the between class variance and increase the between class variance; Figure 1. Classification scatter plot generated by linear discriminant analysis that matches between the original grade and the predicted one through the multiple regression linear equation as a function for classification.

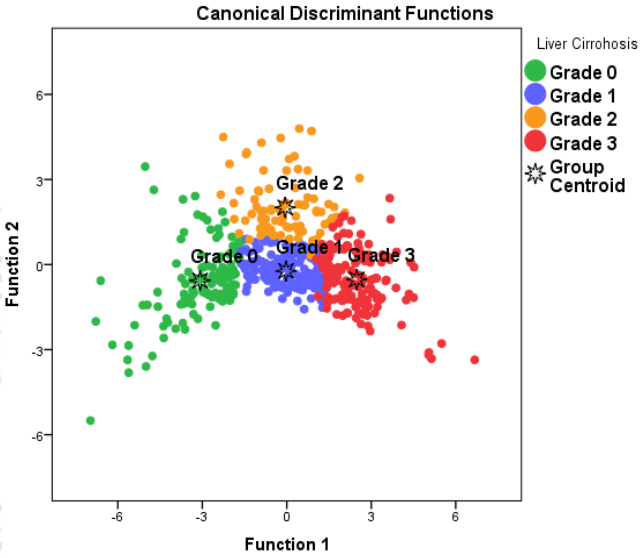


Figure 2: Scatter plot show the centroid for each class and the distribution of each class around the classification center in respect to the classification function.

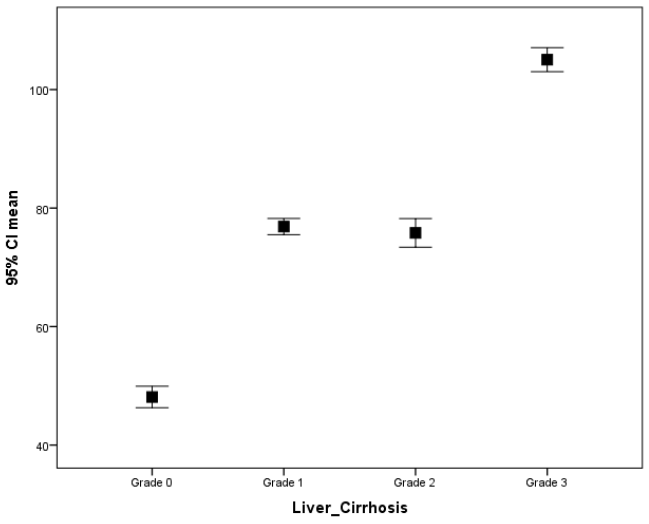
The results of the classification showed that 94.7% of the original classes were correctly predicted by the classification function. Where the sensitivity was equal to 96.1% and specificity of 90.6%

Table 1: Confusion matrix showed a correct percentage of cross match results in the diagonal line with the off diagonal matrix gives the miss classification percentage.

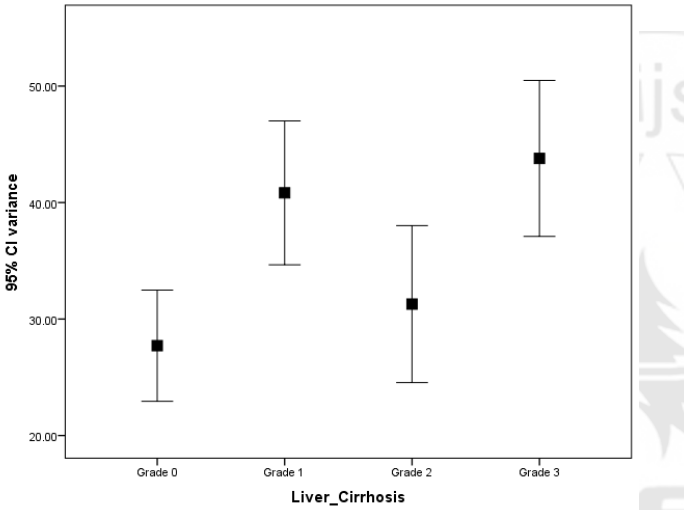
		Predicted Group Membership				Total
Liver Cirrhosis		Grade 0	Grade 1	Grade 2	Grade 3	
%	Grade 0	**90.6%**	7.7%	1.7%	0.0%	100.0%
	Grade 1	0.0%	**100.0%**	0.0%	0.0%	100.0%
	Grade 2	0.0%	2.2%	**97.8%**	0.0%	100.0%
	Grade 3	0.0%	6.7%	2.7%	**90.6%**	100.0%

94.7% of original grouped cases correctly classified.

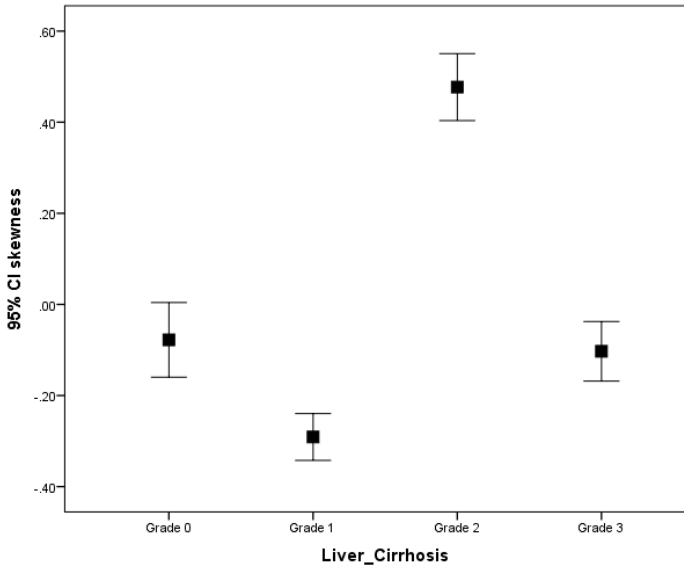
Stepwise linear discriminant analysis choses all the entered features as the most discriminant one i.e. none of the features were rejected for redundancy or for correlation problem between them as independent features. The feature mean (mean intensity or signal) gives a good separation between the normal liver tissues Grade 0 and the rest of the grade, but grade 1 and 2 were inseparable (Figure 2).



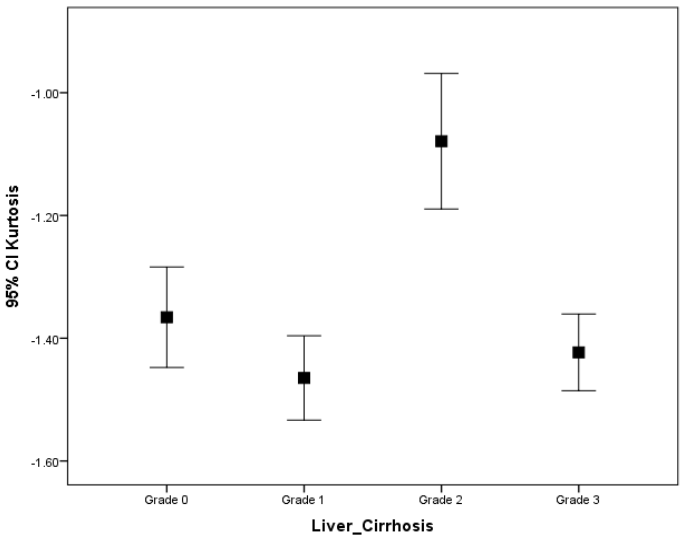
(A)



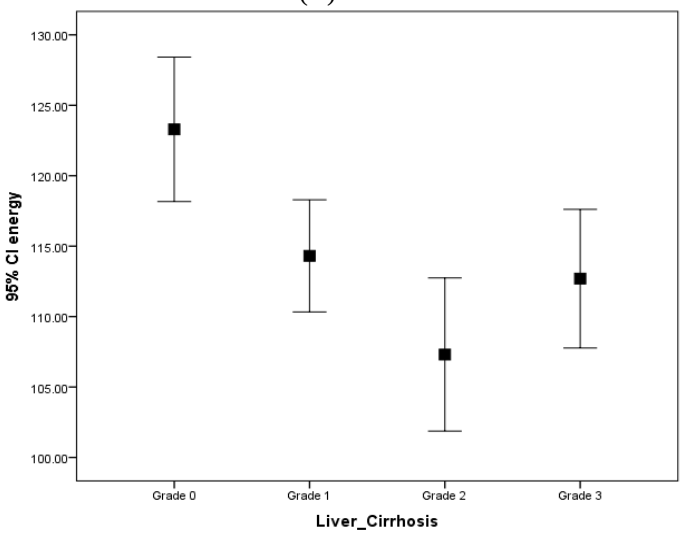
(B)



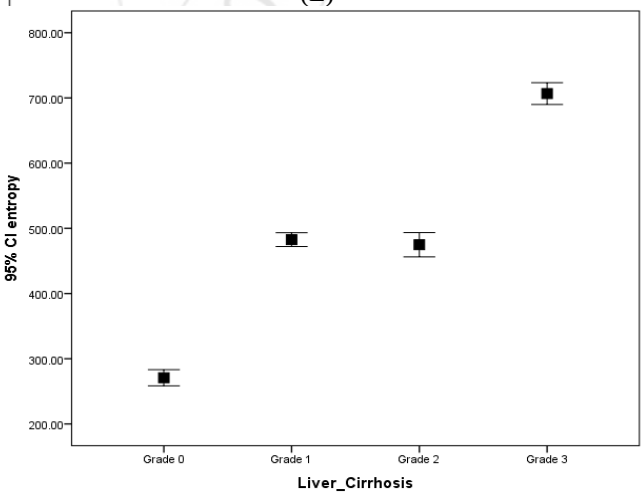
(C)



(D)



(E)



(F)

Figure 3: Error bar plot for the textural features (A) mean, (B) variance, (C) skewness, (D) Kurtosis, (E) energy and (F) entropy for liver cirrhosis grade 0, 1, 2 and 3.

These graphs reveals that the liver grades of cirrhosis can be totally differentiated using texture feature extracted from ultrasound images so that its consider as one of new method of classification and tissue cirrhosis estimation.

4. Conclusion

Grade 0 = (mean×23.5) + (skeness×3.99) + (kurtosis×-7.29) + (energy×0.08) + (entropy×-2.97)-175.1
Grade 1 = (mean×26.4) + (skeness×3.8) + (kurtosis×-8.8) + (energy×0.07) + (entropy×-3.349)-228.6
Grade 2= (mean×26.8) + (skeness×10.2) + (kurtosis×-5.3) + (energy×0.05) + (entropy×-3.349)-228.3
Grade 3 = (mean×25.4) + (skeness×5.7) + (kurtosis×-9.3) + (energy×0.076) + (entropy×-3.15)-237.1

References

[1] Anthony PP, Ishak KG, Nayak NC, et al. The morphology of cirrhosis: definition, nomenclature, and classification. Bull WHO 1977; 55: 521-540.
[2] Millward-Sadler GH. Cirrhosis. In: MacSween RNM, Anthony PP, Scheuer PJ, editors. Pathology of the liver. 2nd ed. New York: Churchill Livingstone; 1987. p. 342-363.
[3] Giorgio A, Amoroso P, Lettieri G, et al. Cirrhosis: value of caudate to right lobe ratio in diagnosis with ultrasound. Radiology 1986; 161:443-445.
[4] Taylor KJ, Riely CA, Hammers L, et al. Quantitative ultrasound attenuation in normal liver and in patients with diffuse liver disease: importance of fat. Radiology 1986; 160: 65-71.
[5] Sanford NL, Walsh P, Matis C, Baddeley H, Powell LW. Is ultrasonography useful in the assessment of diffuse parenchymal liver disease? Gastroenterology 1985; 89: 186-191.
[6] Freeman MP, Vick CW, Taylor KJ, Carithers RL, Brewer WH. Regenerating nodules in cirrhosis: sonographic appearance with anatomic correlation. AJR Am J Roentgenol 1986; 146: 533-536.
[7] Murakami T, Kuroda C, Marukawa T, et al. Regenerating nodules in hepatic cirrhosis: MR findings with pathologic correlation. AJR Am J Roentgenol 1990; 155: 1227-1231.
[8] Theise ND. Macroregenerative (dysplastic) nodules and hepatocarcinogenesis: theoretical and clinical considerations. Semin Liver Dis 1995; 15: 360-371.
[9] Tanaka S, Kitamra T, Fujita M, et al. Small hepatocellular carcinoma: differentiation from adenomatous hyperplastic nodule with color Doppler flow imaging. Radiology 1992; 182: 161-165.
[10] Bolondi L, Li Bassi S, Gaiani S, et al. Liver cirrhosis: changes of Doppler waveform of hepatic veins. Radiology 1991; 178: 513-516.
[11] Colli A, Cocciolo M, Riva C, et al. Abnormalities of Doppler waveform of the hepatic veins in patients with chronic liver disease: correlation with histologic findings. AJR Am J Roentgenol 1994; 162: 833-837.