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Quantitative Analysis and Characterization of Liver Diseases using Ultrasound Scans

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Abstract: ***This is a retrospective study done to evaluate the role of ultrasound in classification of diffuse liver diseases mainly Hepatitis(B) and Cirrhosis with normal liver, in which there were 179 cases (60 were normal cases, 59 had Cirrhosis and 60 had Hepatitis (B))) were subjected to be examined by a trans abdominal U/S scanning using 'Honda' Aloka and General Electric scanners with 3.5 MHz probe to collect data about liver echo texture, shape, caudate and right lobe sizes, portal vein caliber, spleen size, shape of left edge of liver and presence of ascites. Any patient had liver tumor or fatty liver was excluded from this study. The collected data were analyzed using linear discrimination to identify ultrasound finding for each disease. The results of the study using linear discriminant analysis and measurable quantities for the livers; reveals that the normal liver can be identified by an accuracy of (100%) while the sensitivity of the diagnosing liver cirrhosis was 98.3% and for hepatitis type B the sensitivity was 90% where 10% of the cases showed measures similar to the normal liver; this occurs specially in early stage of disease.***

Keywords: liver cirrhosis, Hepatitis, portal vein, edge of the liver, caudate lobe.

1. Introduction

The liver is the largest organ in the body weighing 1400-1600 gm in the males and 1200-1400 gm in the females (Mohan 2010) occupying a substantial portion of the upper abdominal cavity. It occupies most of the right hypochondrium and epigastrium, and frequently extends into the left hypochondrium as far as the left lateral line. As the body grows from infancy to adulthood the liver rapidly increases in size. This period of growth reaches a plateau around 18 years and is followed by a gradual decrease in the liver weight from middle age. The ratio of liver to body weight decreases with growth from infancy to adulthood. The liver weighs approximately 5% of the body weight in infancy and it decreases to approximately 2% in adulthood. The size of the liver size is measures less than 15 cm (Harald 2011) and varies according to sex, age and body size.

Hepatitis is inflammation of the liver, which can ultimately lead to cirrhosis, portal hypertension, and hepatocellular carcinoma (HCC) in its chronic stages. Hepatitis can be acute or chronic, and come in many forms, including hepatitis A, B, C, D, E, and G. The two most common forms are hepatitis A and B. Hepatitis A is spread by fecal–oral route in contaminated water or food. Hepatitis B is spread by contact with contaminated body fluids, mother-to-infant transmission, or inadvertent blood contact, as seen in the case of intravenous drug abuse or occupational exposure. An additional concern for healthcare workers is work-related exposure to hepatitis C. The World Health Organization (WHO) defies cirrhosis as a diffuse process characterized by fibrosis and the conversion of normal liver architecture into structurally abnormal nodules. 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.

Sonographic examination is often requested to assess hepatic abnormality. It is of a homogeneous, mid-grey organ on ultrasound. It has the same, or slightly increased echogenicity when compared to the cortex of the right kidney. Its outline is smooth. Criteria for analyzing diffuse liver disease include evaluation of liver parenchyma (echo texture, shape, caudate and right lobe size, ultrasound attenuation, vascular architecture) as well as its surface.

2. Materials and Method

Firstly the Patient was prepared by a period of fasting prior to upper abdominal imaging to maximize the distension of the gall bladder and to reduce food residue and gas in the upper GI tract which may reduce image quality or precluded liver imaging. This is essential for full imaging of the liver and related biliary tree but may not be required in an acute situation such as trauma where imaging of the gall bladder is not immediately essential. A patient may take small amounts of still water by mouth prior to scan, particularly for taking any medications. Because there is some evidence that smoking can reduce image quality when scanning upper abdominal structures so it is good practice to encourage a patient not to smoke for 6-8 hours prior to US scan. Smoking

increases gas intake into upper GI tract and may reduce image quality. Also, some chemicals in tobacco are known to cause contraction of the smooth muscle of the GI tract and this can cause contraction of the gall bladder, even when fasting has occurred, and the gall bladder cannot be scanned. A trans-abdominal scanning was performed and liver scanned by sagittal and transverse scans were done to evaluate liver shape, texture, outlines, liver span, Right lobe size, caudate lobe size, portal vein caliber, spleen size, shape of left edge of liver and presence of ascites. All these collected data were analyzed using SPSS program using linear discriminant analysis after successful quantitative measurement.

3. Result

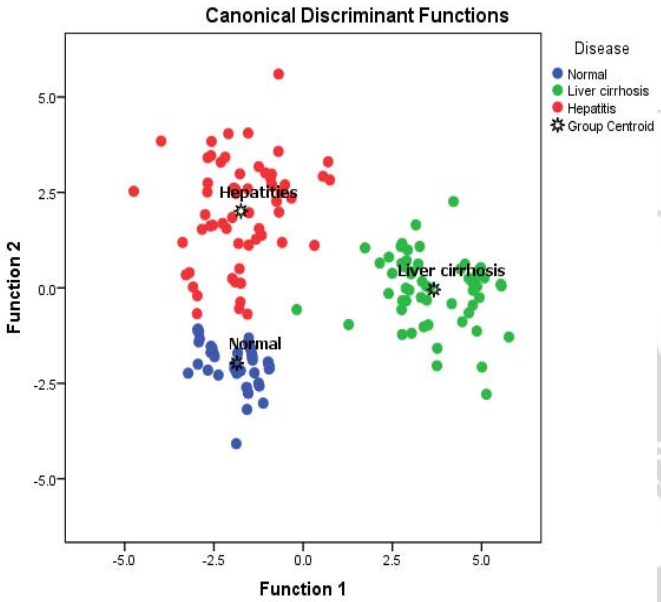

Figure 1: Scatter plot demonstrate the distribution of the normal and abnormal liver characteristics in respect to their associated class centers.

Table 1: Classification matrix show the matching of the predicted groups with the original groups using linear discriminant function:

Classification Results					
Disease		Predicted Group Membership			Total
		Normal	Liver cirrhosis	Hepatitis	
Count	Normal	60	0	0	60
	Liver cirrhosis	1	58	0	59
	Hepatitis	6	0	54	60
%	Normal	100.0	0.0	0.0	100.0
	Liver cirrhosis	1.7	98.3	0.0	100.0
	Hepatitis	10.0	0.0	90.0	100.0
96.1% of original grouped cases correctly classified.					

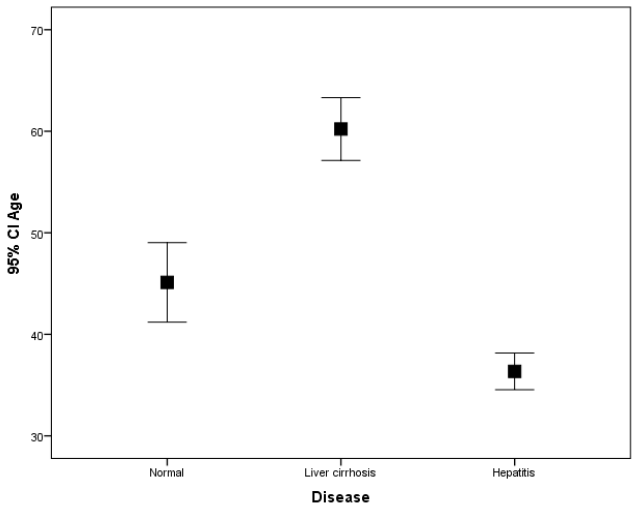

Figure 2 (A)

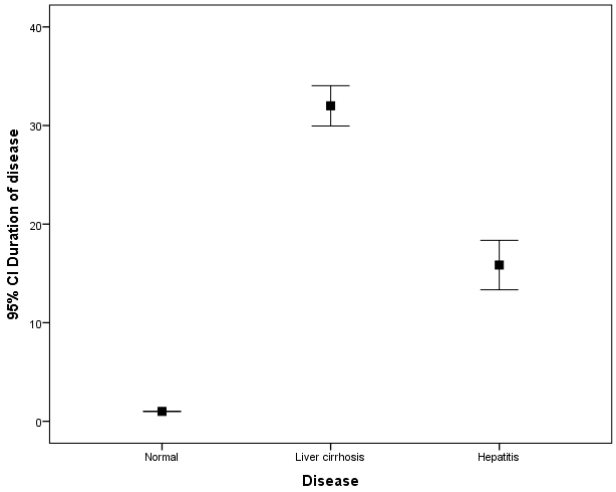

Figure 2 (B)

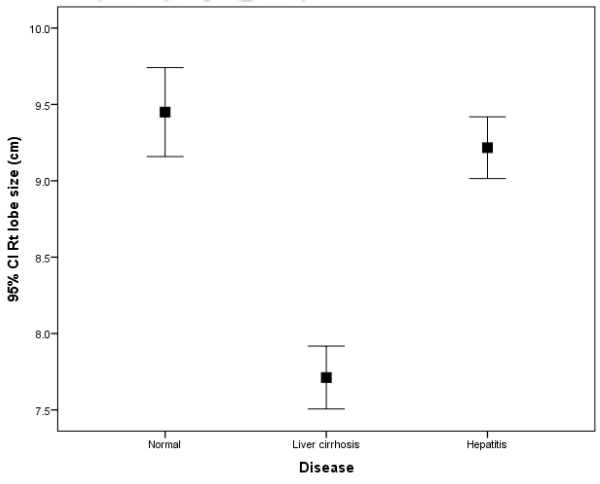

Figure 2 (C)

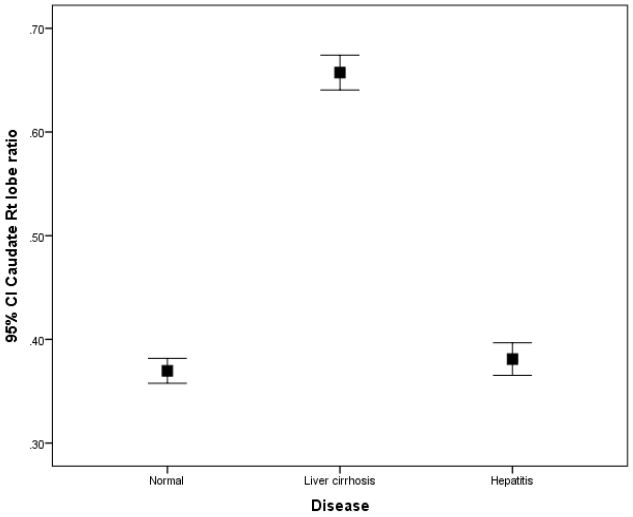

Figure 2 (D)

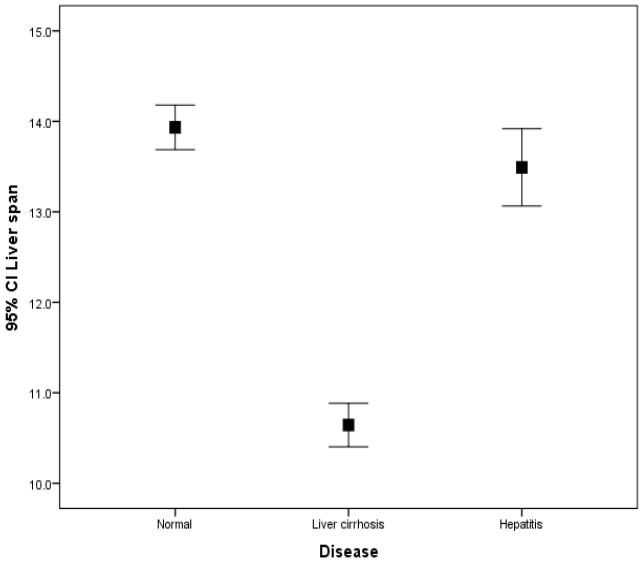

Figure 2 (E)

Table 2: ANOVA test for normal liver, cirrhosis and hepatitis B

ANOVA			
Variables		Sum of Squares	Sig.
Age	Between Groups	17325.7	0.000
	Within Groups	24609.9	
	Total	41935.6	
Duration of disease	Between Groups	28598.5	0.000
	Within Groups	91317	
	Total	37730.2	
Rt lobe size	Between Groups	105.6	0.000
	Within Groups	147.1	
	Total	252.8	
Caudate Rt lobe ratio	Between Groups	3.1	0.000
	Within Groups	0.58	
	Total	3.7	
Liver span	Between Groups	378.3	0.000
	Within Groups	265.0	
	Total	643.3	

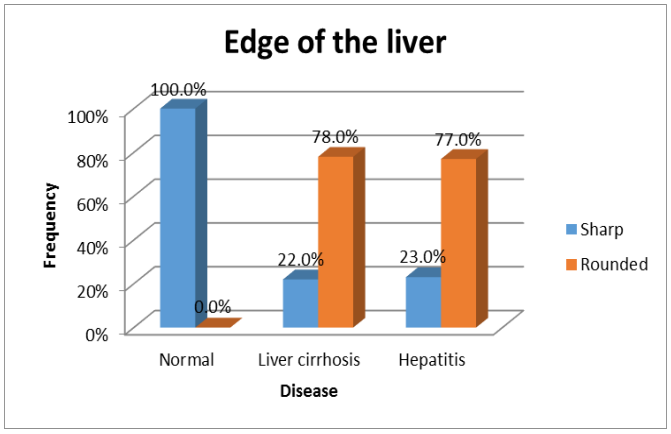

Figure 3: Bar graph shows the percentage distribution of liver edge status in case of normal, cirrhosis and hepatitis.

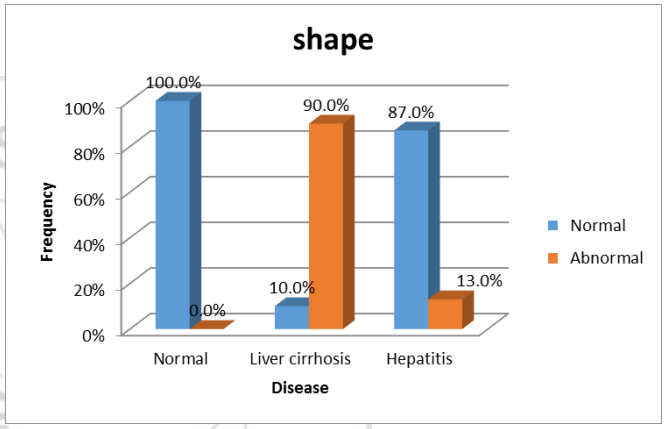

Figure 4: Bar graph shows the percentage distribution of liver shape in case of normal, cirrhosis and hepatitis.

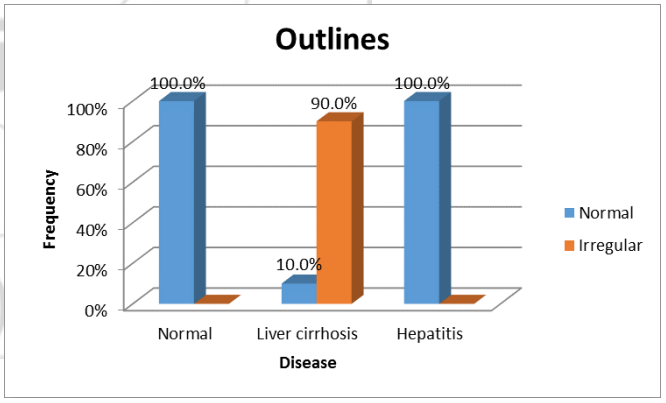

Figure 5: Bar graph shows the percentage distribution of liver outline status in case of normal, cirrhosis and hepatitis.

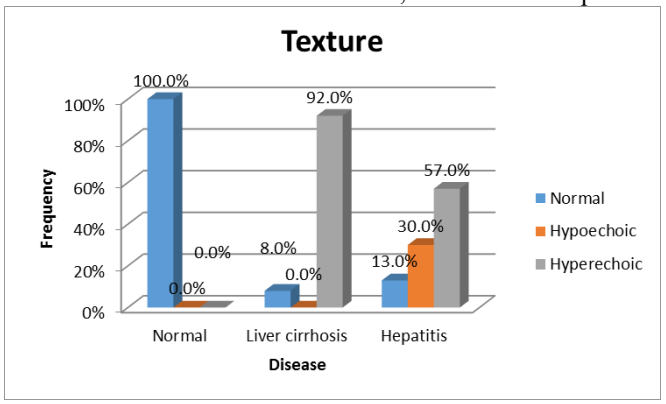

Figure 6: Bar graph shows the percentage distribution of liver echo texture in case of normal, cirrhosis and hepatitis.

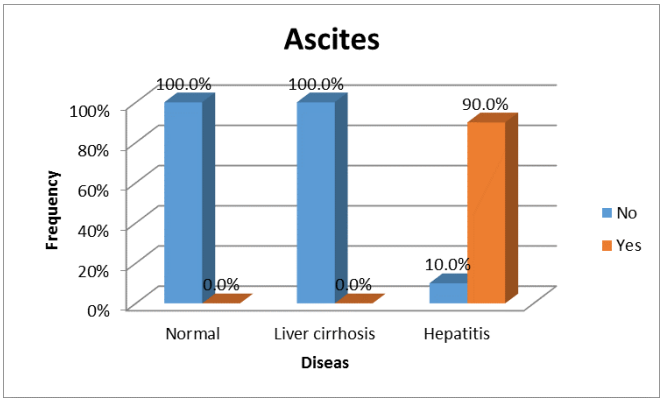

Figure 7: Bar graph shows the percentage distribution of liver ascites status in case of normal, cirrhosis and hepatitis.

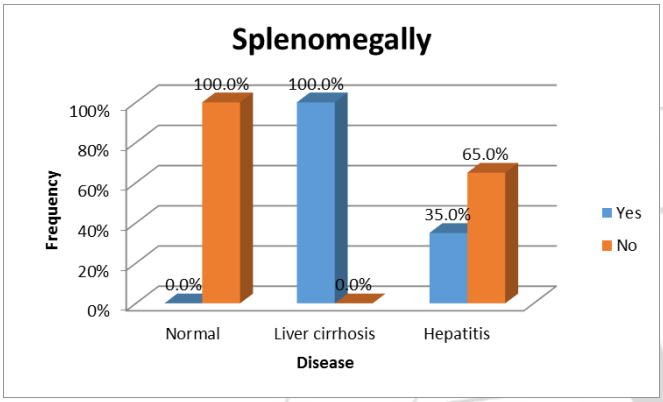

Figure 8: Bar graph shows the percentage distribution of splenomegaly status in case of normal, cirrhosis and hepatitis

4. Discussion

In this study we measured the Right lobe of the liver including the caudate lobe and then having the caudate Right lobe ratio as well as the portal vein size, duration of disease and age of the patient whom diagnosed as having liver cirrhosis or hepatitis type B including patient with normal liver measures. All these data were classified using linear discriminant analysis using stepwise method to choose the well correlated variable with the specified disease (classes) portal vein diameter and caudate lobe size were excluded by the stepwise method from the analysis due to their insignificant correlation with classes. The classification scatter plot shows well separation of the liver characteristics according to their class (disease) i.e. remarkable concentration around the class center; with an overall accuracy of 96.1% as in (Table 1).

The results of the study using linear discriminant analysis and measurable quantities for the livers; reveals that the normal liver can be identified by and accuracy of (100%) while the sensitivity of the diagnosing liver cirrhosis was 98.3% and for hepatitis type B the sensitivity was 90% where 10% of the cases showed measures similar to the normal liver; this occurs specially in early stage. The variable used to discriminate between the different classes showed different resolving power; where the age of the patient differentiate between the livers cirrhosis measures and the normal and hepatitis (Figure2 (A)) which associated with older patient. While duration of disease in average can differentiate between the three classes where livers cirrhosis also got the higher duration in respect to hepatitis type B (Figure 2 (B)), the Rt liver lobe showed a shrunken size in average for patient with livers cirrhosis relative to the other classes (Figure 2 (D)) this situation lead to a larger ratio (caudate lobe Right lobe). Arbitrary liver span depicted similar essence as the Right lobe of the liver (Figure 2(E)).

These measure showed a significant difference between the normal and abnormal groups (cirrhosis and hepatitis) using ANOVA analysis at p = 0.05 (Table 2).

Also the study using B-mode qualitative data showed that the edge of the liver has around edge in more than 75% of case in liver cirrhosis and hepatitis B versus sharp edge in case of normal liver.

The shape of the liver showed normal shape in hepatitis patients relatively similar to normal (87%) while in cirrhosis 90% of the cases gives an abnormal outline due to the nodularity and fibrotic tissues that replaces the normal (Figure 4), but in case of outline only liver cirrhosis also showed 90% of abnormal outline attributed to the same cause abnormal shape. As in (Figure 5).

The liver texture in liver cirrhosis showed hyperechoic texture appearance in 92% of the patients while 57% of the patient with hepatitis showed hypoechoic, while ascites mainly associated with hepatitis in 90% of the cases (Figure 7), splenomegaly mainly associated with liver cirrhosis.

5. Conclusion

U/S scanning is a good diagnostic tool for classification between normal liver, Hepatitis B and liver cirrhosis. The U/S features of liver cirrhosis include decreased liver size, increased it is echogenicity, increased the caudate/ right lobe ratio (above, 65 %), portal hypertension, splenomegaly and ascites. The U/S features of hepatitis include increased liver size, decreased it is echogenicity in acute stage, and decreased size and increased echogenicity in chronic stage and changed the left lobe edge shape (Bounded). Diagnosis of liver cirrhosis, hepatitis type B can be carried out using ultrasound measures quantitatively using a set of linear discriminant analysis as follows:

Normal liver = (age *-0.630) + (D-of-D*2.538) + (right lobe size*13.442) + (ratio*144.985) + (liver span*15.183) - 184.244

Liver cirrhosis = (age*-0.660) + (D-of-D*3.058) + (right lobe size*14.563) + (ratio*217.057) + (liver span*15.183) – (238.887).

Hepatitis = (age*-0.909) + (D-of-D*3.350) + (right lobe size*15.411) + (ratio*138.636) + (liver span*17.373) – (225.755).

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