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Scientific Research

Evaluation of Venous Ammonia Level, Splenic Longitudinal Diameter, Portal Vein and Splenic Vein Diameters as Non-Invasive Indicators for the Presence of Portosystemic Collaterals in Egyptian Cirrhotic Patients

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Abstract

Introduction and Aim of the Work: The identification of cirrhotic patients with esophageal varices or other portosystemic collateral by non-invasive means is appealing in that it could decrease the necessity of endoscopic screening. This study was to evaluate the diagnostic utility of venous ammonia level with other ultrasonographic parameters as non-invasive markers for the presence of portosystemic shunts. Patients and methods: The study included 3 groups of Child Pugh class A and early B patients. Group (A): 25 patients with evidence of both esophageal varices and portosystemic collaterals; group (B) 25 patients with neither evidence of varices nor portosystemic collaterals and group (C): 25 patients with evidence of varices but no collaterals. Measurement of venous ammonia level was done for all patients. Results: serum ammonia level was significantly higher in group A (222.8 ± 54 µg/dL) than that in group B (85 ± 21.1 µg/dL) and group C (148.2 ± 19.6 µg/dL). The cut-off value of serum ammonia level 113 µg/dL was a good predictor for the presence of esophageal varices, while the cut-off value of serum ammonia level at 133 µg/dL was a good predictor for the presence of both esophageal varices and abdominal collaterals. Combination of portal vein diameter > 13mm + splenic vein diameter > 8.9mm + ammonia level > 133 µg/dL gives 100% of sensitivity and 96% of specificity for the prediction of the presence of portosystemic shunts. Conclusion: Determination of serum ammonia level, splenic, portal vein and

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splenic vein diameters are considered as good predictors for the presence of portosystemic shunts in patients with liver cirrhosis.

Keywords

Serum Ammonia, Potosystemic Collaterals, Portal Hypertension, Esophageal Varices, Splenic Vein Diameter, Portal Vein Diameter, Splenic Longitudinal Diameter

1. Introduction

Portal hypertension leads to the formation of portosystemic collateral veins, of which esophageal varices have the greatest clinical impact and the most severe complications. Specifically, they are discovered on endoscopy in up to two thirds of decompensated cirrhotics. The possibility of identifying cirrhotic patients with esophageal varices or presence of other collateral by non-invasive means is appealing, in that it could decrease the necessity of endoscopic screening with reduced healthcare costs. Increased spleen volume is an independent predictor of large esophageal varices in liver cirrhosis [1].

So far, several studies addressing this issue have been performed with varying success. They have either been based on laboratory parameters, *i.e*. platelets count or ultrasono-graphic features [2], of which the spleen longitudinal diameter seems to be the most interesting one. Other manifestations of portal hypertension include portal hypertensive gastropathy [3] and large spontaneous shunts. Large spontaneous shunts have been shown to be responsible for recurrent or persistent portal-systemic encephalopathy [4]. Actually, ammonia (NH4) levels cannot serve as a laboratory marker for portal-systemic encephalopathy, being neither specific nor highly sensitive [5], although there may be a correlation with severity [6].

1.1. Aim of the Work

The aim of the work was to evaluate the diagnostic utility of venous ammonia level, splenic longitudinal diameter, portal vein and splenic vein diameters as indicators for the presence of portosystemic collaterals in Egyptian cirrhotic patients.

1.2. Patients and Methods

This study was conducted on seventy five patients with liver cirrhosis selected from Tropical medicine department and hepatology outpatient clinic. Diagnosis of liver cirrhosis was done by clinical, laboratory and ultrasonographic data of cirrhosis. Liver function was assessed by Child Pugh classification [7]. The selected patients were of Child Pugh class A and early B. They were divided into three groups:

Group (A): included 25 patients with evidence of both varices (oesophageal or gastric) by upper gastrointestinal endoscopy and portosystemic collaterals by abdominal ultrasound.

Group (B): included 25 patients with neither evidence of varices (oesophageal or gastric) by upper gastrointestinal endoscopy nor portosystemic collaterals by abdominal ultrasound.

Group (C): included 25 patients with evidence of varices (oesophageal or gastric) by upper gastrointestinal endoscopy but no portosystemic collaterals by abdominal ultrasound.

Exclusion criteria: Patients who had undergone previous interventions for oesophageal varices, patients who receive beta-blockers, patients with hepatocellular carcinoma or recent upper gastrointestinal tract bleeding and patients of Child Pugh class C.

All patients of the three groups were subjected to the following.

1) Full history taking;

2) General examination including: manifestations of chronic liver disease and liver cell failure.

3) Abdominal examination for: Liver size, consistency, splenomegaly, ascites and dilated veins on the abdominal wall.

4) Laboratory investigations including: Complete blood count with manual count for platelet. Liver profile including:

ALT, AST and Alkaline phosphatase, total and direct bilirubin, serum albumin, prothrombin time and INR,

renal function tests (serum creatinine and blood urea nitrogen), viral markers (HBsAg and HCVAb) and Alpha fetoprotein.

5) Imaging techniques.

Abdominal ultrasound for:

a) Liver: size, echogenicity, presence of focal lesions and portal vein diameter and patency.

b) Spleen: size, echogenicity, presence of focal lesions and splenic vein diameter and patency.

c) Presence of ascites and abdominal vascular collaterals including lienorenal collaterals, patent paraumblical vein and gall bladder collaterals.

6) Upper gastrointestinal endoscopy: This was done by the most advanced video-endoscope for use in the upper gastrointestinal tract (GF-Q240Z: Olympus Optical Co. Ltd, Tokyo, Japan). Comment was done for the following finding:

a) Esophageal varices.

b) Gastric varices: which appear as dilated tortous veins pulge from the fundus of stomach.

c) Portal hypertensive gastropathy.

7) Measurement of venous ammonia level: Preparation of the patients before measurement:

a) Patients were given standard protein diet.

b) Factors that may increase blood ammonia as muscular exercise, alcohol, barbiturates, narcotics, diuretics were avoided.

c) Factors that may decrease blood ammonia as broad spectrum antibiotics, levodopa, lactobacillus and potassium salts were avoided.

1.3. Sample Collection and Preservation

Blood samples were collected in tubes containing ethylenediaminetetraacetic acid (EDETA).

1.4. Statistical Methods

All data were analyzed by SPSS (V.15) software. Continuous values were expressed by mean +/− standard deviation and compared using the Student's t-test.

Categorical values were expressed by count and proportions and compared by the X^2 test. Univariate analysis for determining the association of various cinical, laboratories variables with the presence or absence of esophageal varices were performed, and P-values below 0.05 were considered significant.

All variables that were found to be different between patients with and without esophageal varices on univariate analysis were included as candidate variables in a logistic regression analysis to identify independent predictors for the presence of such varices.

The receiver operating characteristic curves (ROC curves) were applied to calculate and compare various predictors for the diagnosis of esophageal varices.

The validity of the model was measured by means of the area under receiver operating characteristic curve (AUROC). A model with an AUROC above 0.7 was considered useful, while an AUROC between 0.8 and 0.9 indicated excellent diagnostic accuracy the optimum cut-off value was chosen as the value corresponding with the highest accuracy (minimal false sensitivity and false positive results) for single variables, and various cut-off values were investigated to determine the optimal cut off values for predicting or excluding EV.

The sensitivity (Se), specificity (Sp), negative predictor value (NPV), positive likelihood ratio (+LR) and diagnostic accuracy (DA) were calculated for various corresponding cut-off values.

2. Results

This study was conducted including 3 groups: group (A) contains 23 males (92%) and 2 females (8%) while group (B) contains 13 males (52%) and 12 females (48%), also group (C) contains 20 males (80%) and 5 females (20%). As regard the age, the M ± S.D. of age was 53.9 ± 8.3 years in group A, 51.4 ± 8.1 years in group B and 52.5 ± 6.6 years in group C (**Table 1**).

The level of serum ammonia was significantly higher in group A (222.8 ± 54 μg/dL) than group B (85 ± 21.1 μg/dL) and group C (148.2 ± 19.6 μg/dL). On the other hand group C showed statistically significant higher level of serum ammonia (148.2 ± 19.6 μg/dL) than group B (85 ± 21.1 μg/dL) with $P < 0.001$, in other word, level of serum ammonia was significantly lower in group B than both group A & C (**Table 2**).

Table 1. sociodemographic data of studied patients.

		Group (A) (n = 25)	Group (B) (n = 25)	Group (C) (n = 25)
Age (years)	Mean ± S.D.	53.9 ± 8.3	51.4 ± 8.1	52.5 ± 6.6
Sex	Male (n = 56)	23 (92%)	13 (52%)	20 (80%)
	Female (n = 19)	2 (8%)	12 (48%)	5 (20%)

Table 2. Comparison between the studied patients' groups as regard serum ammonia level.

	Group A	Group B	Group C	P value
Ammonia level(µg/dL) (mean ± S.D.)	222.8 ± 54	85 ± 21.1	148.2 ± 19.6	<0.001

Group B showed statistically significant lower mean of spleen longitudinal diameter (13.6 ± 2.5 cm) when compared to group A (16 ± 1.3 cm) and group C (16 ± 1.4 cm) ($P < 0.05$), but no statistically significant difference was found between group A and C ($P > 0.05$). Group B showed statistically significant lower mean of splenic vein diameter (8.1 ± 0.6 mm) when compared to group A (11.6 ± 1.1 mm) and group C (9.6 ± 0.7 mm) ($P < 0.05$), and group C showed significantly lower mean than group A ($P < 0.05$). Group B showed significantly lower mean of portal vein diameter (10.4 ± 1.2 mm) when compared to group A (15.5 ± 1.3 mm) and C (15.4 ± 1.3 mm) ($P < 0.05$), with no statistiacally significant difference between group A and C ($P > 0.05$) **(Table 3)**.

Portal hypertensive gastropathy was found in 88% of patients in group A (22 patients) and 76% of patients in group C (19 patients).

Patients with portosystemic shunts (group A & C) showed statistically significant higher mean INR (1.4 ± 0.1) and total bilirubin (2.1 ± 0.3) when compared to patients without portosystemic shunts (group B) ($P < 0.05$). They also have statistically significant higher mean of serum ammonia level (185 ± 55.1 µg/dL) compared to those without portosystemic shunts (85 ± 21.1 µg/dL). There was no statistical significant difference between the two groups as regard the mean of other parameters $P > 0.05$. Patients with portosystemic shunts had higher spleen longitudinal diameter (16.1 ± 1.4 cm) compared to patients without portosystemic shunts (13.6 ± 2.5 cm).

Also patients with portosystemic shunts showed higher mean of portal vein diameter (15.5 ± 1.3 mm) in comparison to patients without portosystemic shunts (10.4 ± 1.2 mm).

Patients with portosystemic shunts showed higher mean of splenic vein diameter (10.6 ± 1.4 mm) in comparison to patients without portosystemic shunts (8.1 ± 0.7 mm) (**Table 4**).

The receiver operating characteristic (ROC) curve was done for ammonia level, portal vein diameter, spleen longitudinal diameter, for the prediction of portosystemic shunts where it revealed that the portal vein diameter (**Figure 1**, **Table 5**). It yielded the highest AUROC (100%) followed by the ammonia level (99%), splenic vein diameter (96%), splenic longitudinal diameter (77%), $P < 0.05$, so all these variables are considered statistically significant.

The optimum cut-off values of the previously mentioned parameters to predict the presence of portosystemic shunts were:

Portal vein diameter =13 mm;

Spleen longitudinal diameter =13.2 cm;

Splenic vein diameter =8.9 mm;

Serum ammonia level =133 µg/dL.

Our data showed that the positive likelihood ratios of the different cut-off values are good. However, the specificity for the cut-off ratio 0.90 is low but had a good diagnostic accuracy (71%), PVD and ammonia level showed the highest diagnostic indices followed by splenic longitudinal diameter and splenic vein diameter and all showed acceptable sensitivity (100% for all except 98% for splenic vein diameter) and acceptable diagnostic accuracies (100%, 99%, 88%, 83%), Ammonia showed higher LR+ so it is ideal predictor for portosystemic shunts. While on combining factors we found that PV diameter + ammonia level + splenic vein diameter at their cut-off values mentioned before gave 100% sensitivity and 96% specificity, also the same result found on combining PV diameter + ammonia level, also when combining splenic vein diameter + ammonia level **(Table 6)**.

On the other hand to assess the value of serum ammonia to predict presence of abdominal collaterals in addition to esophageal varices or presence of varices alone, one roc curve was designed to compare between group A

Table 3. Comparison between the studied groups as regard the abdominal ultrasonographic finding in the studied groups.

		Group A (N = 25)	Group B (N = 25)	Group C (N = 25)	P value
liver chogenicity	Coarse	25 (100%)	25 (100%)	25 (100%)	
	Homogenous	-	-	-	
	heterogenous	-	-	-	
Ascites		-	-	-	
Abdominal collaterals		25 (100%)	-	-	<0.05
Spleen longitudinal diameter (cm)	(mean ± S.D.)	16 ± 1.3	13.6 ± 2.5	16 ± 1.4	<0.001
Liver size (cm)		17.4 ± 1.2	15.6 ± 1.6	17.5 ± 1.4	<0.001
Splenic vein diameter (mm)		11.6 ± 1.1	8.1 ± 0.6	9.6 ± 0.7	<0.001
Portal vein diameter (mm)		15.5 ± 1.3	10.4 ± 1.2	15.4 ± 1.3	<0.001

Table 4. Comparison between cases with portosystemic shunts (both varices and abdominal collaterals) and without, as regard liver profile and ultrasound findings.

	Cases with portosystemic shunts (Group A & C) N = 50	Cases without portosystemic shunts (Group B) N = 25	P value
INR	1.4 ± 0.1	1.3 ± 0.1	<0.05
AST (IU/L)	72.4 ± 25.1	77.1 ± 36	>0.05
ALT (IU/L)	77.8 ± 22.2	72.9 ± 18.1	>0.05
Albumin (gm/dl)	2.9 ± 0.2	3 ± 0.3	>0.05
T.bil (mg/dl)	2.1 ± 0.3	1.7 ± 0.3	<0.001
Ammonia (µg/dL)	185.5 ± 55.1	85 ± 21.1	<0.001
Spleen longitudinal diameter (cm)	16.1 ± 1.4	13.6 ± 2.5	<0.001
Liver size by US (cm)	17.5 ± 1.3	15.6 ± 1.6	<0.001
Portal vein diameter by US (mm)	15.5 ±1.3	10.4 ± 1.2	<0.001
Splenic vein diameter by US (mm)	10.6 ± 1.4	8.1 ± 0.7	<0.001

INR: International normalization ratio; AST: Aspartate aminotransferase; ALT: alanine aminotransferase T.bil.: Total bilirubin.

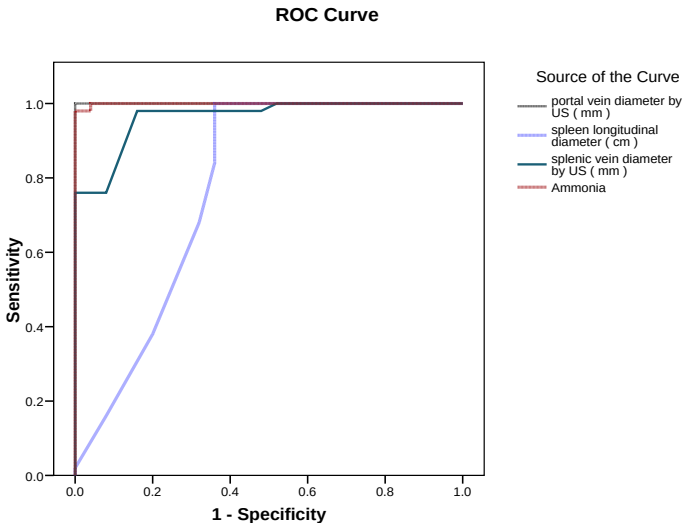

Figure 1. Receiver Operating Characteristic (ROC) curve to define the best cut-off value for spleen longitudinal diameter, ammonia level, splenic vein diameter and Portal vein diameter to detect portosystemic shunts.

Table 5. Receiver Operating Characteristic (ROC) curve to define the best cut-off value for spleen longitudinal diameter, ammonia level, splenic vein diameter and Portal vein diameter to detect portosystemic shunts.

	AUC	Std. Error	P	95% Confidence Interval	
Spleen longitudinal diameter (cm)	0.774	0.068	<0.001	0.64	0.91
Portal vein diameter by US (mm)	1.00	0.001	<0.001	1.00	1
splenic vein diameter by US (mm)	0.96	0.01	<0.001	0.936	1
Ammonia	0.99	0.001	0.0001	0.99	1

Table 6. The diagnostic performances for different cut-off values.

	Sensitivity	Specificity	PPV	NPV		LR+	DOR 95% CI		
PVD13 mm	100	100	100	100	100				
Ammonia 133	100	96	98	100	99	25	51	7.32	355.13
Spleen long diameter 132 mm	100	64	84.7	100	88	2.8	6.56	3.59	11.96
Splenic vein diameter 8.9	98	84	92.5	95.5	93.3	6.13	257.25	27.11	2441.07
Combined factors (PV + ammonia + splenic vein)	100	96	98.0	100.0	98.7	25	51.00	7.32	355.13
Combined factors (ammonia + splenic vein)	100.0	96.0	98.0	100.0	98.7	25	51.00	7.32	355.13
Combined factors (PV + ammonia)	100.0	96.0	98.0	100.0	98.7	25	51.00	7.32	355.13

(patients with varices and abdominal collaterals) and group B (patients with neither varices nor abdominal collaterals) & another roc curve to compare between group B and group C (patients with varices only) all as regards the serum ammonia level.

Receiver Operating Characteristic (ROC) curve to define the best cutoff to serum ammonia level to detect portosystemic collaterals (both varices and abdominal collaterals) (**Figure 2**, **Table 7**) yielded high AUROC (100%) P < 0.0001 the optimum cut-off value of ammonia was 133 μg/dL.

Receiver Operating Characteristic (ROC) curve to define the best cutoff to ammonia to detect only esophageal varices (**Figure 3**, **Table 8**) yielded high AUROC (98%), P < 0.0001. The optimum cut-off value of ammonia was 113 μg/dL.

3. Discussion

The portal system has numerous collaterals that interconnect with the systemic circulation. When portal pressure rises above 10 mmHg, potential portosystemic collaterals may develop. Formation of collaterals is a complex process involving the opening, dilation and hypertrophy of pre-existing vascular channels. It is possible that active neoangiogenesis is involved in the formation of collateral vessels [8].

Portosystemic shunts have been shown to be responsible for recurrent or persistent portosystemic encephalopathy [4]. Ammonia plays a major role in the pathogenesis of hepatic encephalopathy in cirrhotic patients [9].

The generated ammonia, which reaches the liver through the portal vein, is converted to urea by means of the urea cycle and excreted from the kidneys. In patients with decreased hepatic functional reserve or those with portosystemic shunt, ammonia level in the blood rises.

This study was conducted to evaluate the role of some non-invasive marker for the presence of portosystemic shunts. To achieve this aim this study was conducted on seventy five patients with compensated liver cirrhosis divided into 3 groups: group (A): includes 25 patients with evidence of both varices (esophageal or gastric) and abdominal portosystemic collaterals, group (B): includes 25 patients with neither evidence of varices nor abdominal portosystemic collaterals and group (C): includes 25 patients with evidence of varices but no abdominal portosystemic collaterals.

Results of the present work showed that serum ammonia level was significantly higher in group A [both types of shunts] (222.8 ± 54 μg/dL) than group B [no shunts] (85 ± 21.1 μg/dL) and group C [varices only, no abdo-

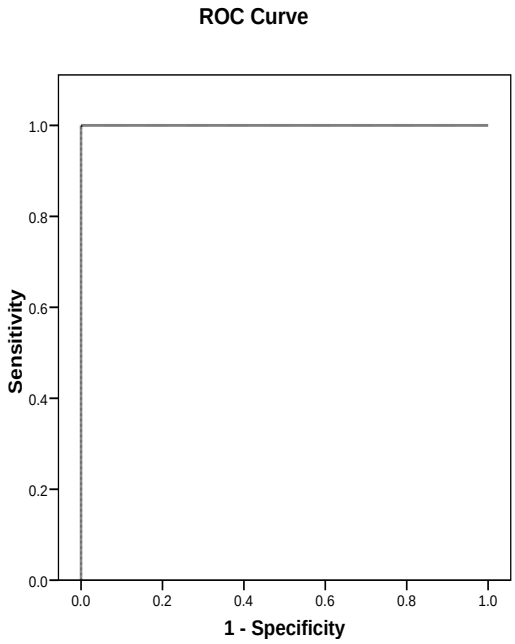

Figure 2. Comparison between group A and B as regard serum ammonia level, Receiver Operating Characteristic (ROC) curve to define the best cutoff to serum ammonia level to detect portosystemic collaterals (both varices and abdominal collaterals).

Table 7. Comparison between group A and B as regard serum ammonia level.

	AUC	Std. Error	P	95% Confidence Interval	
Ammonia	1.00	0.0001	<0.001	1.00	1.00

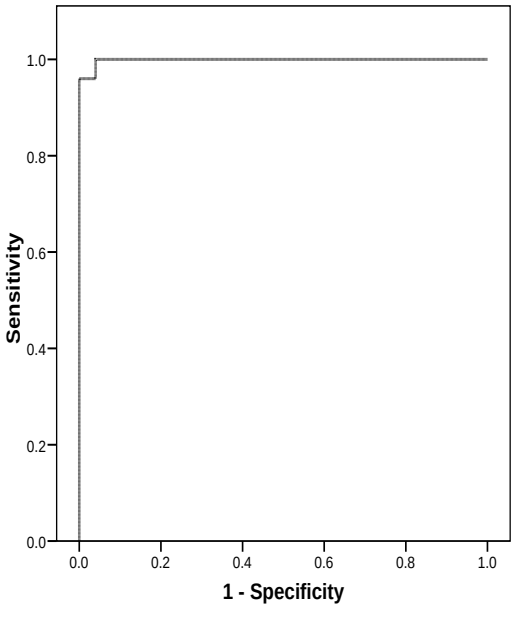

Figure 3. Comparison between group B and C as regard serum ammonia level, Receiver Operating Characteristic (ROC) curve to define the best cutoff to ammonia to detect only esophageal varices.

Table 8. Comparison between group B and C as regard serum ammonia level.

	AUC	Std. Error	P	95% Confidence Interval	
Ammonia	0.98	0.003	<0.001	0.99	1.00

minal portosystemic collaterals] (148.2 ± 19.6 µg/dL).

In the literature, no much study is published on this issue. However, these results agreed with the results of *Tarantino et al.*, 2009 [10], found that ammonia level above 71 µg/dL had 97% sensitivity and 73% specificity for prediction of presence of portosystemic shunts.

Here in the current work, it was also crucial to determine a cut off value for serum ammonia to identify patients with and without portosystemic shunts. It was found that serum ammonia level > 133 µg/dL can predict the presence of portosystemic shunts (both esophageal varices and abdominal portosystemic collaterals).It has a sensitivity of 100% and specificity of 96% with a positive predictive value of 98%.

Gastroesophageal varices are the most relevant portosystemic collaterals because their rupture results in variceal hemorrhage, the most common lethal complication of cirrhosis. Varices and variceal hemorrhage are the complications of cirrhosis that result most directly from portal hypertension. Patients with cirrhosis and gastroesophageal varices have an HVPG of at least 10 - 12 mm Hg [11].

Gastroesophageal varices are present in approximately 50% of patients with cirrhosis. Their presence correlates with the severity of liver disease,

The gold standard in the diagnosis of varices is esophagogastroduodenoscopy (EGD). Since the point that prevalence of medium/large varices is approximately 15% - 25% [12], The majority of subjects undergoing screening EGD either do not have varices or have varices that do not require prophylactic therapy. There is, therefore, considerable interest in developing models to predict the presence of high risk varices by non-endoscopic methods. Several studies have evaluated possible noninvasive markers of esophageal varices in patients with cirrhosis [13].

In the current study, specifically serum ammonia level was determined in patients with esophageal varices only (group C) in comparison to patients with no portosystemic shunts (group B). It was found that group C [varices only] showed statistically significant higher level of serum ammonia (148.2 ± 19.6 µg/dL) than group B [no shunts] (85 ± 21.1 µg/dL) with P < 0.001. Again, a cut off value of >113 µg/dL for serum ammonia level can predict the presence of esophageal varices alone in comparison to absence of any portosystemic shunts. These results give a hope that serum ammonia level can be used as a noninvasive indicator to the presence of portosystemic shunts in cirrhotic patients.

As regards the ultrasound data, the results of the present work revealed that portal vein diameter is considered as an independent factor for prediction of the presence of portosystemic shunts, as patients with portosystemic shunts (group A and C) showed statistically significant higher mean of portal vein diameter in comparison to patients without portosystemic shunts (group B). Also, results of the present work showed that portal vein diameter equal or above 13 mm has 100% sensitivity in predication of esophageal varices.

This is in agreement with *Sarangapani et al.* (2010) [14], found that portal vein diameter above 13 mm has 76.5% sensitivity and 80% specificity in prediction of the presence of large esophageal varices.

Schepis et al. (2001) [15] also found that portal vein diameter above 13 mm has 96% sensitivity and 62% specificity in prediction of the presence of esophageal varices.

Cottone et al. (1986) [16] found that a cut-off point of the portal vein at 13 mm indicate the need for endoscopy in 47% of their studied patients with 95% sensitivity and 55% specificity in prediction of the presence of varices. *Prihatini et al.* (2005) [17] set portal vein diameter of 11.5 mm as a cut-off value for the prediction of the presence of esophageal varices with 75% sensitivity and 54.5% specificity in a cross sectional study conducted on forty seven cirrhotic patients.

Sarwar et al. (2005) [18] found that cirrhotic patients with portal vein >11 mm are more likely to develop esophageal varices.

Results of the present study revealed that spleen longitudinal diameter has statistically significant higher mean in patients with esophageal varices *i.e.* group A (16 ± 1.3 cm) & group C (16 ± 1.4 cm) in comparison with patients without varices group B (13.6 ± 2.5 cm) so it can be considered as a good predictor for the presence of esophageal varices. Spleen longitudinal diameter equal or more than 13.2 cm has 100% sensitivity and 64% specificity for the prediction of the presence of esophageal varices. This was near to data of *Thomopoulos et al.*

2003 [19] who proved that spleen longitudinal diameter of 13.5 cm or more has 95% sensitivity and 37% specificity in prediction of the presence of esophageal varices in a study done on 184 patients. Different values were set by other studies, in a study done by *Prihatini et al.* (2005) [17] they found that spleen longitudinal diameter of 10.3 cm or more is 83% sensitive and 63.6% specific as a predictive factor for esophageal varices in patients with liver cirrhosis. *Sarangapani et al.* (2010) [14] set a cut-off value of 13.8 cm for the spleen longitudinal diameter for prediction of the presence of esophageal varices in their study. Chang *et al*. (2007) [20] found that spleen longitudinal diameter equal or above 12 cm is statistically associated with the presence of esophageal varices.

Tarzamni et al. (2008) [21] found that there are 2 independent factors to predict the presence of esophageal varices in patients with compensated liver cirrhosis: portal hypertensive index >2.08 and spleen longitudinal diameter >15.05 cm.

The current study results revealed that splenic vein diameter is significantly wider in patients with esophageal varices (group A & C) than those without varices (group B). The splenic vein diameter of 8.9 mm or more is a good predictor for the presence of esophageal varices with 98% sensitivity and 84% specificity.

This was near to findings of *Sarangapani et al.* (2010) [14] who found that splenic vein diameter equal or above 11.5 mm can predict the presence of esophageal varices in patients with chronic liver disease.

4. Conclusion

So finally it can be concluded that the determination of serum ammonia level is considered as a good predictor for the presence of portosystemic shunts in patients with liver cirrhosis, also its combination with portal vein diameter and splenic vein diameter increases its sensitivity and specificity for prediction.

Conflict of Interests

The study was approved by the medical ethical committee in Ain Shams University.

All Authors have no conflicts of interests and no financial disclosure.

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