Characterization of portosystemic collateral vessels: multislice computed tomography-based study

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Background
Portosy stemic collateral veins (PSCVs) are a consequence of the portal hypertension that occurs in chronic liver diseases and are responsible for numerous complications, including bleeding esophageal and gastric varices and hepatic encephalopathy. Few studies have evaluated the rare types of PSCVs. Our study characterized rare type of portosystemic collaterals by the use of multislice computed tomography (MSCT) and developed a novel classification of splenic collaterals: Assiut classification of splenic collaterals. This is considered a unique study in Egypt for rare type of PSCVs, which has been ignored for a long time.

Patients and methods
This case–control study was performed in Assiut University and Al-Rajhi Hospitals. We recruited 100 patients, comprising 50 patients with cirrhosis with collaterals and 50 patients without as detected by using MSCT.

Results
A total of 94% of the cirrhotic patients with collaterals (n = 50) had splenic collaterals. Splenic collaterals were classified according to their site (in relation to the splenic hilum), shape, and in accordance of their existence. Hepatocellular carcinomas were associated with development of collaterals in 88.2%. There was no statistically significant difference in the splenic size between patients with and those without collaterals.

Conclusions
Splenic collaterals are the most common types of collaterals. The clinical significance of the site and shape of splenic collaterals (The Assiut classification of splenic collaterals) needs to be investigated. MSCT provides accurate delineation of the distribution and extent of PSCVs.

Keywords:
multislice computed tomography, portosystemic collateral vessels, splenic collaterals

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Introduction

Portosystemic collateral veins (PSCVs) are a consequence of the portal hypertension that occurs in chronic liver diseases and are responsible for numerous complications, including bleeding esophageal and gastric varices and hepatic encephalopathy [1–3].

As a consequence of liver cirrhosis, the blood flow in the portal veins becomes blocked, or stenosis leads to blood stasis, which induces markedly higher pressure within the portal veins, and subsequently results in an extrahepatic portosystemic shunt [4]. Once portal hypertension develops, it leads to arterial vasodilation and collateral circulation formation, which diverts a greater proportion of the blood flow into the portal vein. Portal hypertension is exacerbated by the increased portal blood flow [5].

Portosystemic collateral circulation can be classified into two groups, that is, varices (the gastroesophageal varices and ectopic varices) and shunts, which can be anatomically divided into intrahepatic, transhepatic, and extrahepatic shunts [6].

Endoscopy is the gold standard in the diagnosis of gastroesophageal varices and rectal varices; however, the use of endoscopy as a method of screening all portosystemic collaterals is limited, owing to the presence of other collateral, which cannot be diagnosed by endoscopy [7–9].

Ultrasound imaging also was noninvasive, nonexpensive and well tolerated but it has limited specificity as compared with multislice computed tomography (MSCT), which has sensitivity of 94.8% and specificity of 98.5% for detection of collaterals [10].

MSCT imaging is noninvasive, does not necessitate sedation, and allows accurate assessment of variceal site and size in addition to other rare types of portosystemic collaterals, and also better tolerated by most of the patients than endoscopy. The aim of this study was to characterize rare type of portosystemic collateral by the use of MSCT, and this is considered a unique study in Egypt for rare type of portosystemic collaterals, which had been ignored for a long time. We aimed also to develop a classification for the splenic collaterals, that is, Assiut classification of the splenic collaterals. This could be a base for many future studies such as the clinical significance of the site and shape of splenic collaterals and the effect of various types of splenic collaterals on patients' survival, variceal bleeding occurrence, and recurrence. This is considered a unique study in Egypt for rare type of PSCVS, which has been ignored for a long time.

Patients and methods

In this case–control study, 100 patients from the outpatient clinic and inpatient ward and Gastroenterology at Assiut University and Al-Rajhi Hospitals were enrolled according to the inclusion criteria. A total of 50 cases were assigned to the group of cirrhotic patients with collaterals and 50 cases were assigned to the group cirrhotic without collateral according to MSCT findings. We included patients with liver cirrhosis, portal hypertension, and splenomegaly with or without previous attacks of hepatic encephalopathy and excluded patients with previous attack of upper gastrointestinal tract bleeding and band ligation or sclerotherapy, patients on current or past treatment with beta-adrenergic receptor blockers, patients with raised renal chemistry, and patients who refused to participate.

All patients were subjected to detailed medical history and complete clinical examination, and blood samples were tested for complete blood count, liver function tests, renal profile, and international normalization ratio. Abdominal ultrasound was performed for screening for collaterals. The patients were classified according to their Child–Pugh grading and model of end-stage liver disease (MELD) score [11,12] according to the following formula:

$$\mathrm{MELD} = 3.78 \times \ln\left[\text{serum bilirubin}\left(\text{mg}/\text{dl}\right)\right] + 11.2 \times \ln\left[\text{INR}\right] + 9.57 \times \ln\left[\text{serum creatinine}\left(\text{mg}/\text{dl}\right)\right] + 6.43.$$

Abdominal helical CT scans were carried out on 100 patients by a General Electric 16-slice CT. Scanning protocol consisted of an initial noncontrast study to identify the liver location and volume of interest. Subsequently, 120 ml of nonionic water-soluble contrast material (Ultravist 300, Bayer, German) was injected through a pressure injector at the rate of 3 ml/s. Arterial phase images were initiated 30 s after initiation of contrast material injection. Portovenous phase images were acquired 70 s after initiation of contrast injection, and finally, equilibrium phase was acquired 180 s after initiation of contrast injection. Source images were transferred to the vendor workstation for reconstruction of three-dimenaional images using maximum intensity projection and volume-rendering algorithms.

We did not use Doppler ultrasound as our aims were mainly to characterize portosystemic collaterals by MSCT owing to its high sensitivity and specificity, and it allows also to obtain three-dimensional reconstruction images.

The study was approved by the Ethical Committee of Faculty of Medicine, and confidentiality was maintained and ethical principles was followed. The targeted population was encouraged to participate without any undue pressure, and written informed consent was obtained.

Statistical analysis

Qualitative data were examined using the χ^2 test, whereas quantitative data were examined using Student's t test or Mann–Whitney U test. P value less than 0.05 was considered to indicate a statistically significant difference. Statistical package for social Sciences (SPSS) software (SPSS Inc., Chicago, Illinois, USA), version 20 for Windows 7 was used for analysis.

Results

Baseline characteristics of the studied patient (n = 100)

A total of 50 cases with liver cirrhosis had PSCVs and 50 were without. There was no significant difference in studied patients regarding the age, sex, or etiology. There was no significant difference in Child–Pugh grading between the two studied groups (P = 0.119). Although 34% of the patients with collaterals were classified as Child A, 24% of patients without collaterals were Child A. Similarly, Child B grade was found in 28% of patients with collaterals and in 48% of patients without collaterals. Child C score were in 38% of patients with collaterals and in 28% of patients without collaterals. There was

a significant difference in the MELD score between both group (P = 0.05) (Table 1).

Laboratory investigation of the studied patients (with and without collaterals)

Laboratory investigations of the studied patients (with and without collaterals) are shown in Table 2. There was no statistically significant difference in the complete blood count, liver function, renal function, or international normalized ratio between patients with and without collaterals.

Various types of portosystemic collaterals in the studied patients

This study showed that 47 (94%) of the cirrhotic patients with collaterals (n = 50) had splenic collaterals, where 82% of them were isolated splenic collaterals and 12% of them were in association with other collaterals. Such collaterals included ovarian, periportal, retropubic, recanalized paraumbilical vein, gastrorenal, or urinary bladder varices. Moreover, isolated lienogastric and periportal collaterals, as well as recanalized paraumbilical vein were found in about 6% of cases (Table 3).

A novel classification of splenic collaterals (Assiut classification of splenic collaterals)

After the screening with abdominal ultrasound, and with the use of MDCT angiography, the splenic collaterals found in 47 patients were evaluated and classified according to their site (in relation to the splenic hilum), shape, and in accordance of their existence either isolated or in association with other intra-abdominal collaterals. This classification is NOVEL and its significance is beyond the scope of this study and requires further investigation (Table 4).

Hepatocellular carcinoma and portosystemic collateral veins

As shown in Table 5, HCC was associated with development of collaterals in 88.2%, and only 11.8% of patients with HCC had no collaterals, with highly significant difference (P = 0.001). All patients with HCC had no portal vein thrombosis.

Relation between splenic size and portosystemic collateral veins

The mean splenic diameter in the studied patients was 14.74 ± 2.06 cm, with no statistically significant difference between patients with and those without collaterals (P = 0.788), as shown in Table 6.

Table 1 Baseline characteristics, Child and model of end-stage liver disease score of patients with and without collaterals (n=100)

	With collateral (n=50) [n (%)]	No collateral (n=50) [n (%)]	P
Age	54.62±14.1	50.4±9.99	0.087
Sex			
Male	32 (64.0)	33 (66.0)	0.834
Female	18 (36.0)	17 (34.0)	
Etiology			
HCV	42 (84.0)	42 (84.0)	0.621
HBV	2 (4.0)	4 (8.0)	
Wilson	1 (2.0)	0	
Unknown	5 (10.0)	4 (8.0)	
Child score			
Class A	17 (34.0)	12 (24.0)	0.119
Class B	14 (28.0)	24 (48.0)	
Class C	19 (38.0)	14 (28.0)	
MELD	28.37±3.42	24.94±4.33	0.05*

HBV, hepatitis B virus; HCV, hepatitis C virus; MELD, model of end-stage liver disease; *,Significant.

Table 2 Laboratory investigations of the studied patients (with and without collaterals) (n=100)

	Unit	With collateral (n=50)	No collateral (n=50)	P
WBC	10^9/l	7.54±6.38	7.06±5.06	0.675
RBC	cells/mcl	3.59±0.66	3.65±0.66	0.616
HB	g/dl	10.45±1.91	9.67±2.33	0.071
MCV	f/l	86.76±13.99	84.01±15.99	0.361
PLT	10^3/µl	124.96±106.26	119.12±66.79	0.743
Total BIL	mg/dl	5.46±8.22	2.78±4.1	0.061
Direct BIL	mg/dl	3.51±6.12	1.66±3.53	0.067
Total protein	g/l	67.21±13.36	55.1±10.53	0.061
Albumin	g/l	26.02±8.06	24.8±5.85	0.389
SGOT	IU/l	76.02±111.9	99.62±183.19	0.439
SGPT	IU/l	99.25±115.39	52.3±31.09	0.4
ALP	IU/l	159.94±98.31	141.54±136.52	0.441
Prothrombin time	s	18.65±5.1	16.71±4.96	0.06
INR		1.57±0.42	1.47±0.37	0.07
Urea	mg/dl	6.34±5.75	8.45±6.47	0.089
Creatinine	µmol/l	80.23±30.27	83.38±48.88	0.699

Data expressed as mean±SD. ALP, alkaline phosphatase; BIL, bilirubin; HB, hemoglobin; INR, international normalized ratio; PLT, platelet; MCV, mean corpuscular volume; RBC, red blood cell; WBC, white blood cell.

Table 3 Characterization of collaterals in the studied cirrhotic patients (n=50)

Collaterals	Incidence [n (%)]
Splenic	47 (94.0)
Isolated splenic	41 (82.0)
Splenic with other collaterals	6 (12.0)
Ovarian varices	1 (1.0)
Periportal	1 (1.0)
Retropubic, recanalized paraumblical vein	2 (2.0)
Gatrorenal	1 (1.0)
UB varices, recanalized paraumblical vein	1 (1.0)
Lienogastric	1 (2.0)
Recanalized paraumblical vein	1 (2.0)
Periportal	1 (2.0)

UB, urinary bladder.

Table 4 Splenic collaterals classification (Assiut classification of splenic collaterals) (*n*=47)

Existence	*n* (%)
Isolated splenic	41 (82)
Splenic associated with other PSCVs	6 (12)
Pattern of collaterals	
a-Isolated hilar	14 (29.8)
b-Isolated polar	15 (31.9)
Lower pole	12 (25.5)
Upper pole	3 (6.4)
c-Combined hilar and polar	
a-Hilar and lower	9 (19.1)
b-Hilar and upper	6 (12.8)
c-Hilar, upper and lower	3 (6.4)
Shape of collaterals	
Grape-like	21 (44.7)
Serpiginous	19 (40.4)
Worm-like	7 (14.9)

PSCV, portosystemic collateral vein.

Table 5 Association between hepatocellular carcinoma and portosystemic collateral veins

	HCC present [*n* (%)]	HCC absent [*n* (%)]	*P*
With collaterals	15 (88.2)	35 (42.2)	0.001*
Without collaterals	2 (11.8)	48 (57.8)	

HCC, hepatocellular carcinoma.

Table 6 Splenic collaterals classification (*n*=47)

Existence	*n* (%)
Isolated splenic	41 (82)
Splenic associated with other PSCVs	6 (12)
Pattern of collaterals	
a-Isolated hilar	14 (29.8)
b-Isolated polar	15 (31.9)
Lower pole	12 (25.5)
Upper pole	3 (6.4)
c-Combined Hilar and polar	
a-Hilar and lower	9 (19.1)
b-Hilar and upper	6 (12.8)
c-Hilar, upper and lower	3 (6.4)
Shape of collaterals	
Grape-like	21 (44.7)
Serpiginous	19 (40.4)
Worm-like	7 (14.9)

Data expressed as *n* (%). PSCV, portosystemic collateral vein.

Discussion

PSCV formation in cirrhosis plays an important part in events that define the natural history in affected patients. A detailed understanding and description of collaterals anatomy in cirrhotics is essential to envisage diagnosis, management, and outcomes of portal hypertension.

Few studies are reported on uncommon collateral circulation, including splenorenal, gastric, renal, and retroperitoneal shunts, but there is no previous study up till now describe and classify splenic collateral by using MSCT. In the present study, the features of uncommon collateral circulation in patients with hepatic cirrhosis were characterized by using MSCT, with special emphasis on the splenic one.

Our study showed that the development of PSCVs was closely associated with the Child–Pugh classification of liver function. As shown in Table 1, the percentage of Child–Pugh grades in patients with PSCVs was 34.0% for Child A, 28% for Child B, and 38.0% for Child C. This is concordant with a study by Qin *et al.* [13], which concluded that the incidence of PSCVs is associated with the Child–Pugh grades of hepatic function.

Our study showed that there was a statistically significant difference in the mean MELD score between patient with and without PSCVs (P = 0.50), and this was concordant with a study by Ramanathan *et al.* [14], which demonstrated that MELD score was a strong independent predictor of higher portal pressure and PSCV formation.

In our study, 94% of the cirrhotic patients with PSCVs had splenorenal collaterals, and this is concordant with a study by Vilgrain, which showed that splenorenal or gastrorenal veins were seen most frequently, and collaterals other than splenorenal veins, gastroesophageal veins, left gastric vein, and paraumbilical vein were not found except for presumed dilated cystic veins in one patient [15].

Our study classified the splenic collaterals according to the site in (relation to the hilum, upper, and lower pole) and according to the shape (grape, worm like, and serpiginous) by using MSCT.

A study by Maruyama *et al.*[16] classified the splenic collaterals by the use of ultrasound into SS1 encompassed vessels running toward the upper pole of the spleen, and SS2 encompassed vessel running toward the lower pole, both along the spleen. A pattern showing both SS1 and SS2 was defined as SS3.

Our study showed that HCC was associated with development of PSCVs, and this is compatible with a study by Tarantino *et al.* [17], which concluded that patients with splenorenal shunts are burdened by an increased incidence of HCC.

Our study showed that the mean splenic size in the studied patients was 14.74 ± 2.06, with no statistically significant difference between patient with and without PSCVs (*P* = 0.788). This is compatible with a study of Irom *et al.* [18], which reported that there was no correlation between the splenomegaly and the portal pressure, strengthening the earlier postulates of other complex interplay in between the

different hemodynamic parameters rather than simple congestive splenomegaly.

The main limitations of our study were relatively small number of the patient in each type of PSCVs that prevent proper correlation with many parameters such as liver function and Child score. Moreover, some patient refused to participate in the study. Finally, high cost needed for MSCT and contrast material was a limitation.

We conclude from this study that MSCT provides accurate delineation of the distribution and extent of PSCVs. Splenorenal shunt is the most common type of shunt. We recommend careful screening for the presence of spontaneous portosystemic shunt in every patient with liver cirrhosis and portal hypertension. The clinical significance of the site and shape of splenic collaterals (The Assiut classification of splenic collaterals) needs to be investigated. Awareness and correct diagnosis of unusual portosystemic shunts are essential for transplant surgeons to decide the adequate route for the surgical approach.

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Conflicts of interest
There are no conflicts of interest.

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