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A comparative study of multi-detector CT portography versus endoscopy in evaluation of gastro-esophageal varices in portal hypertension patients

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Abstract

Background: Portal hypertension is a major complication resulting from obstruction of portal blood flow, like cirrhosis or portal vein thrombosis, that leads to portal hypertension. MDCT angiography has become an important tool for investigation of the liver as well as potentially challenging varices by detailing the course of these tortuous vessels. This information is decisive for liver transplantation as well as for common procedures in which an unexpected varix can cause significant bleeding.

Results: This study included an assessment of 60 cases of portal hypertension (28 males and 32 females), their age ranged from 42 to 69 years (mean age = 57.2 ± 6.63). All patients were diagnosed with portal hypertension, underwent upper GI endoscopy followed by a triphasic CT scan with CT angiographic assessment for the screening of gastro-esophageal varices.
CT is highly sensitive as compared to upper GI endoscopy (sensitivity 93%) in detecting esophageal varices. Gastric varices detected by CT in 22 patients (37%) compared to 14 patients (23%) detected by endoscopy. While paraesophageal varices were detected in 63% of patients and retro-gastric varices in 80% of patients that were not visualized by endoscopy. Our study reported that the commonest type of collaterals were the splenic collaterals, and we also found there is a significant correlation between the portal vein diameter and the number of collaterals as well as between the portal vein diameter and splenic vein diameter.

Conclusions: Multi-slice CT serves as an important non-invasive imaging modality in the diagnosis of collaterals in cases of portal hypertension. CT portography can replace endoscopy in the detection of high-risk varices. It also proved that there is a correlation between portal vein diameter, splenic vein diameter, and number of collaterals.

Keywords: Portal hypertension, Cirrhosis, CT portography, Endoscopy, Varices

Background

Portal hypertension is a prejudicial complication resulting from obstruction of portal blood flow as in liver cirrhosis leading to portal hypertension [1].

Gastric fundic and/or esophageal varices are severe complications of portal hypertension with the possibility of massive hemorrhage from the upper gastro-intestinal tract. Management of gastric varices (GV) is related to their hemodynamics and locations. GV were classified into three types according to Sarin's classification that is based on the location of varices detected by endoscopy [2, 3].

Variceal bleeding is life-threatening with a 6-week mortality rate of approximately 20%. Patients with medium- or large-sized varices and patients with cirrhosis undergo screening for esophageal varices by upper gastro-intestinal endoscopy [4, 5]. Up to 30% of patients screened by upper gastro-intestinal endoscopy were found to have moderate to large varices (> or = 5 mm diameter) that are at high risk of hemorrhage [6].

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CT imaging optimally describes extra-vascular anatomy [7]. The development of multidetector-row computed tomography (MDCT) has resulted in better spatial resolution and elimination of motion artifacts due to its ability to acquire images continuously and rapidly during a single breath-hold [8].

The capacity for post-processing of imaging data with a variety of three-dimensional (3D) reformatting techniques can enhance the identification of the origin of the veins and the distribution of porto-systemic collateral vessels in patients with the cirrhotic liver; therefore, MDCT is considered as the optimal imaging technique in this setting [9].

MDCT angiography with thee-dimensional vascular reconstructions can enhance the surgeon's perception of potentially problematic varices by detailing the course of these tortuous vessels. This information is crucial, not only for liver transplantation, but also for other common procedures in which unexpected varix can cause significant bleeding [10].

The aim of our work is to discuss the role of multi-slice CT angiography over upper GI diagnostic endoscopy in the evaluation of the gastro-esophageal varices in cases with portal hypertension.

Methods

Patients

The study was approved by the hospital's ethical committee, and an informed consent was obtained assuring respect of the confidentiality of the medical records. The study design is a prospective study. This study included assessment of 60 cases (28 males and 32 females), and their age ranged from 42–69 years (mean age = 57.2 ± 6.63) over a period of 3 years (from September 2014 till April 2017) who were prospectively recruited for this study. They were referred from inpatients of the hepatology department.

Inclusion criteria were as follows:

- Patietnts diagnosed to have liver cirrhosis.
- Patients diagnosed to have portal hypertension.
- Clinical condition appropriate for upper GI endoscopy.

Exclusion criteria were as follows:

- Patients with impaired renal functions.

All patients were subjected to the following

Full clinical assessment including; recording of age, sex, family history, and clinical presentation (patients diagnosed to have portal hypertension after complaining of portal hypertension symptoms like hematemesis, melena, and ascites).

Clinical examination.

Laboratory investigation:

- Liver function tests:
  - SGOT (serum glutamate oxaloacetate transaminase).
  - SGPT (serum glutamate pyruvate transaminase).
- Hepatitis markers:
  - Hepatitis B surface antigen (HBs-Ag) by ELISA.
  - Hepatitis C virus antibody (HCV-Ab) by ELISA third
  - Generation by Inurex anti-HCV version III.
- Renal function tests: creatinine level (accepted up to 1.5 mg/dL).

Upper GIT endoscopy.

Triphasic multislice CT scanning.

Technique of MDCT

All patients underwent a triphasic CT scan with CT angiographic assessment for the screening of gastro-esophageal varices.

CT studies were performed by Toshiba Aquilion 8-Slice CT scanner and Toshiba Aquilion 64-Slice CT scanner (both made in Japan).

Patients' laboratory data was initially revised with a particular interest in the results of the renal function tests (creatinine level).

Patients were instructed to do the following:

1- Fast for food for 6 to 8 h prior to the examination and asked to continue adequate simple water intake up to 3 h prior to the examination to ensure adequate hydration.
2- Patients were told how to hold breath during examination when requested, to ensure their cooperation.
3- Patients were positioned supine on the CT table in the "head first" position with their arms resting comfortably above the head.
4- An 18–20 gauge cannula was placed into a superficial vein within the antecubital fossa or dorsum of the hand.
5- After successful cannulation of the vein, the contrast material was administrated by the injector at a high rate of flow with the patients' arms in the scanning position.

Multidetector CT scanner is applied to perform, pre-contrast, arterial, porto-venous, and delayed phases on all patients. All patients received non-ionic contrast material (Ultravist 300) (a dose of 0.7

g iodine per kilogram of patient's total body weight with an average dose of 120 ml) is introduced with an infusion rate of 4.0 ml/s IV using power injector.

The scan parameters of the 8 channel CT [arterial and portal venous phase scan: voltage, 120 kV; tube current, 200–300 mA; rotation time, 0.5 s; detector collimation, 4 × 1 mm; table feed, 6–8 mm/gantry rotation; image reconstruction, 1 mm (increment, 0.5 mm) and 3 mm (increment, 3 mm) slice thickness; unenhanced and venous phase scan: 120 kV; 200–300 mA; 0.5 s; 4 × 5 mm; 20–30 mm/rotation; 5 mm slice thickness (5 mm)] resulted in an average scan duration of 12.5–16.7 s for 20 cm scan length in the early contrast phases.

The scan duration of the 64-channel CT [120 kV; 100–350 mA with automatic dose modulation was 14.9 s per 20 cm for the arterial scan [0.7 s; 16 × 0.625 mm; 9.37 mm/rotation; 0.625 mm (increment, 0.625 mm) and 3.75 mm (3.75 mm) slice thickness] and 5.1 s per 20 cm for the portal venous scan [0.7 s; 16 × 1.25 mm; 27.5 mm/rotation; 1.25 mm (1.25 mm) and 3.75 mm (3.75 mm) slice thickness]. [Unenhanced and venous scan: 0.7 s; 16 × 1.25 mm; 35 mm/rotation; 1.25 mm (1.25 mm) and 5 mm (5 mm) slice thickness.]

Image processing

All further data were reconstructed with a standard algorithm, and post-processing was performed on a commercially available workstation (Syngo work station) equipped with a software tool that allows the generation of 3D images.

Two experienced radiologists (with more than 5 years post-MD degree experience) used MIP technique for 2D image reconstruction in the detection of details and orientation of vessels (after studying the patients' clinical history) during the same setting and the final diagnosis was reached by their agreement (in consensus).

The images were reconstructed at 1.5 collimation and 0.7 position increment.

Image interpretation:

The following features were recorded:

1. The portography images and portal phase images were analyzed for portal vein patency and diameter.
2. Splenic vein diameter
3. Signs of portal hypertension as liver cirrhosis, splenomegaly, ascites
4. Presence of collaterals, its sites, and detection of its grading.
5. Presence of HCC and if it was managed or not.

Types of varices

The dilated varices are classified into varices draining into the SVC as esophageal, paraesophageal, and gastric varices as well as varices draining into the IVC as splenic, perisplenic, linorenal, and recanalized paraumbilical vein (Fig. 1). The dilated veins present within and outside the walls of the lower esophagus are termed esophageal and paraesophageal respectively.

The dilated veins within the submucosal layer of the stomach are the gastric sub-mucosal varices whereas that within the adventitial layer at the exterior wall of the stomach are termed the gastric adventitial varices. The dilated veins along the splenic hilum are termed the splenic varices whereas veins surrounding the spleen are termed the peri-splenic. The recanalized paraumbilical vein is the dilated vein at the site of the ligmantum teres and falciform ligaments. On cross-section, they appear as circular or tubular structures (Fig 2).

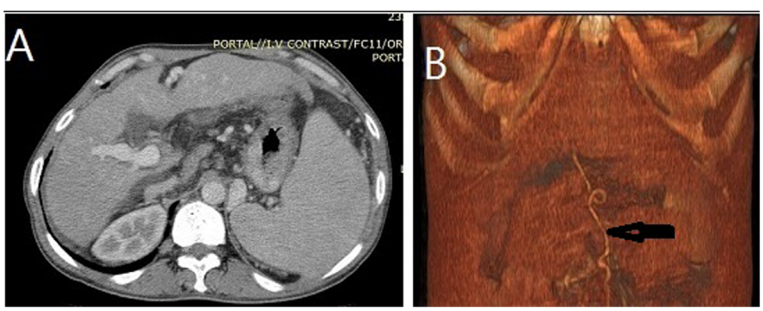

Fig. 1 **a**, **b** A 55-year-old male patient. **a** Triphasic CT study of the liver with CT portography axial image showing recanalized paraumblical vein. **b** Triphasic CT study of the liver with CT portography 3D image showing recanlized paraumblical vein with abdominal wall collaterals (black arrow)

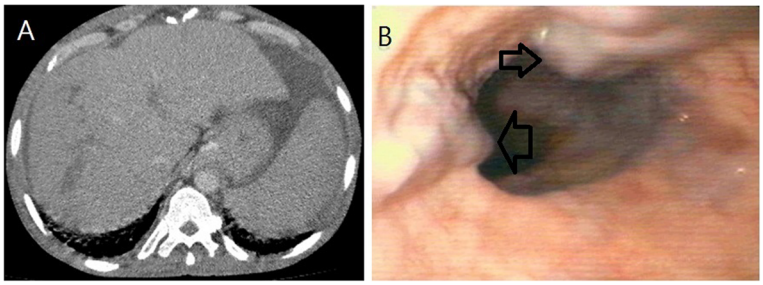

Fig. 2 **a**, **b** A 63-year-old male patient. **a** Triphasic CT study of the liver with CT portography axial image showing submucosal gastric varex. **b** Endoscopy of the patient showing esophgeal varices (arrows)

Varices involving the splenic, lieno-renal, and recanalized paraumbilical vein were defined as vascular structures if diameter > 3 mm, while for the esophageal, paraesophageal, and gastric collaterals, the size criteria was 2 mm in diameter. Detecting grading of varices by measuring the largest visible varix, according to the diameter of the largest varix, and the number of varices on cross-section images varices are graded on 5-point scale. If there were more than four dilated vessels on 2D cross-section, the varices were graded one step higher. The criteria for grading are presented in Table 1 [9].

Image display

All images, including 3D reconstructed models, were sent to work station which permits interactive analysis and were copied on hard copies.

Statistical analysis

Our data were collected, coded, and processed by statistical software (SPSS) and then the results were collected, tabulated, and statistically analyzed by IBM personal computer and statistical package SPSS version 20. Two types of statistics were done:

Table 1 Esophageal varices are graded by CT according to the following (Kim et al. 2008) [11]

Varices	Largest Diameter of Varices (mm)
Esophageal, paraesophageal, and gastric submucosal varices	
Grade	
0	< 2
1	2–2.9
2	3–6.9
3	≥ 7
4[a]	≥ 7
Gastric adventitial, splenic, mesenteric, retroperitoneal varices	
Grade	
0	< 3
1	3–4.9
2	5–9.9
3	≥ 10
4[a]	≥ 10

Note—If the number of dilated vessels on transverse images is more than 4, the grade of varices increases one step higher.
[a]Grade 4 was assigned when the number of grade 3 varices exceeded 4.

Descriptive: e.g., percentage (%), mean, and standard deviation SD

Analytical:

- Mann-Whitney test: it is a non-parametric test of Student's t test used to collectively indicate the presence of any significant difference between two groups for a not normally distributed quantitative variable.
- Pearson's correlation analysis: it is used to show the strength and direction of the association between two quantitative variables.
- p value: it is of significant difference if $p < 0.05$, non-significant difference if $p > 0.05$, and highly significant difference if $p < 0.001$.

Results

This study included the assessment of 60 patients of portal hypertension (28 males and 32 females), their age ranged from 42 to 69 years (mean age = 57.2 ± 6.63).

According to the rate of hematemesis, 20 out of 60 cases (33%) experienced it once, 24 out of 60 cases (40%) had recurrent hematemesis, and 16 out of 60 cases (27%) never had hematemesis before. All cases were diagnosed to have portal hypertension based on their clinical data and Doppler findings.

According to portal vein diameter and patency, the patients of this study were found to have a patent portal vein in 50 out of 60 cases (83%) and thrombosed portal vein in 10 out of 60 cases (17%). Portal vein was found of normal diameter in 34 out of 60 cases (57%) and dilated in 26 out of 60 cases (43%) (Fig. 3).

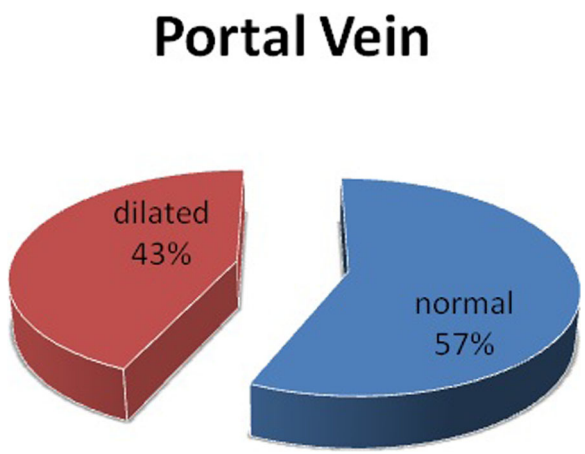

Fig. 3 A pie chart showing distribution of the studied patients regarding their portal vein diameter

During esophageal varices' assessment, based on CT study findings, 54 out of 60 cases (90%) had eseophageal varices while bases on endoscopic findings 58 out of 60 cases (97%) had eseophageal varices. CT sensitivity in detecting esophgeal varices compared to endoscopy is 93% (Fig. 4).

CT grading revealed that oesophageal varices were grade I in 22, grade II in 22, grade III in 10, and grade IV in 0 cases out of 54 cases. On the other hand, endoscopy grading revealed that oesophageal varices were grade I in 24, grade II in 16, grade III in 6, and grade IV in 0 cases out of 58 cases while 12 cases were previously banded in an old endoscopic intervention (Fig. 5).

There is a high significant correlation between the CT esophageal varices grade and hematemesis attacks as $p = 0.001$. The increase in the esophageal varices grade is associated with the increase in the number of hematemesis attacks.

CT grading revealed that gastric varices were grade I in 2, grade II in 6, grade III in 6, and grade IV in 8 cases out of 22 cases, while by endoscopy, they were grade I in 10, grade II in 2, grade III in 2, and grade IV in 0 cases out of 14 cases. CT was found to be more sensitive than endoscopy in detecting gastric varices (Fig. 6).

Studying the patients with paraesophageal and retro-gastric varices according to CT findings proved high CT efficiency in their detection as these varices are extra-luminal and cannot be detected by endoscopy (Figs. 4 and 5).

Studying the patient's classification according to portosystemic collaterals proved that splenic hilum and peri-splenic collateral group is the commonest type of collaterals present in 87% of cases (Table 2) (Fig. 7).

There is a significant correlation between the PV diameter and the number of collaterals as $p = 0.02$. The increase in collateral number is associated with the decrease in PV diameter.

There is a high significant correlation between the PV diameter and splenic vein diameter $p > 0.002$. the increase in PV diameter is associated with an increase in splenic vein diameter.

There is no significant correlation between PV thrombosis and the number of collaterals as $p > 0.05$.

The specificity of CT in identifying gastro-esophageal varices is 83% for esophageal varices and 90% for gastric varices.

Discussion

The portal system consists of all veins that carry blood from the abdominal part of the gastrointestinal tract except the lower rectum and anal

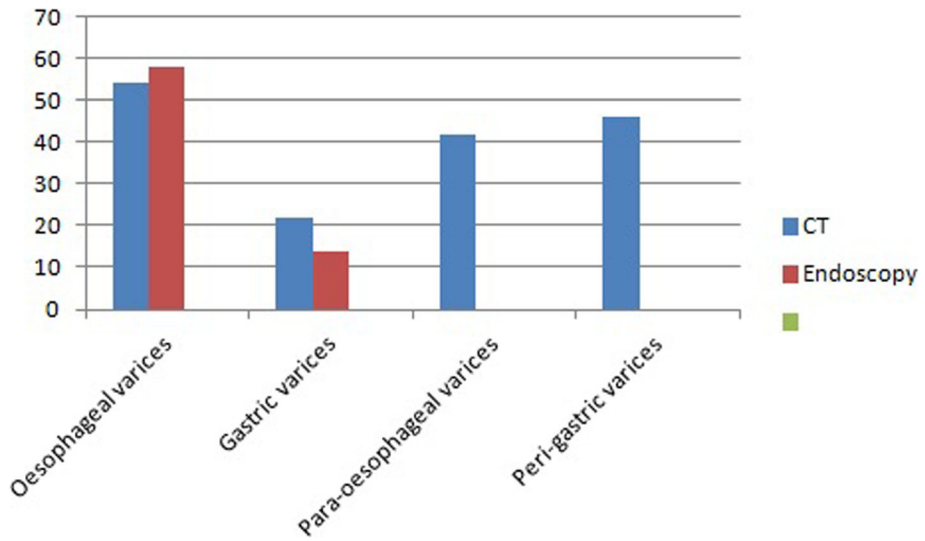

Fig. 4 A 3D column chart showing sensitinity of CT versus endoscopy in oesophageal and gastric varices

canal. It also receives venous drainage from the spleen, pancreas, and gall bladder. MDCT portography can determine the extent and the location of portosystemic collaterals in cases with portal hypertension [12].

In portal hypertension, some blood in the portal venous system may reverse direction and pass through the portosystemic anastomoses in the systemic venous system resulting in major hepato-fugal collateral pathway development [13].

The advantages of computed tomographic (CT) angiography and three-dimensional (3D) rendered images allowed a relatively non-invasive detailed investigation of the abdominal vasculature. The combination of intravenously administered non-ionic contrast material, multi-detector array CT assemblies, X-ray tubes, higher heat capacity, faster helical rotation times, more powerful computers, and advanced reformation algorithm made CT angiography considered as an alternative to conventional angiography [14, 15].

Multislice CT is a very important method for the detection of collateral sites, draining routes, grading, and also

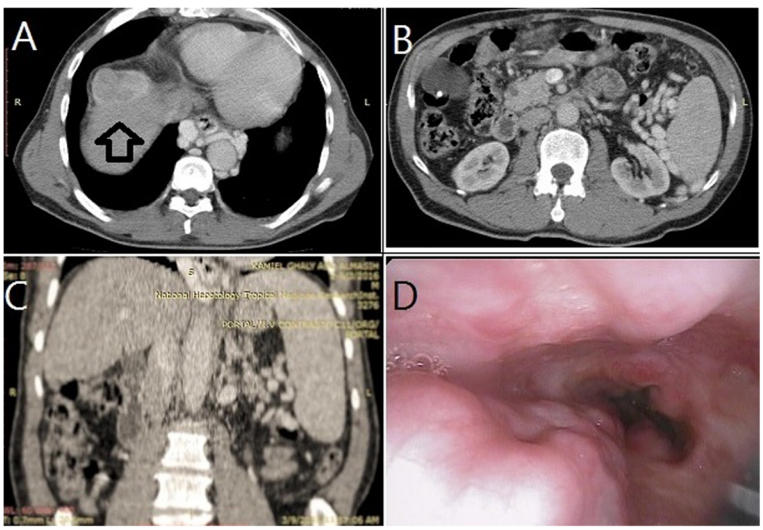

Fig. 5 a–**d** A 60-year-old male patient. **a** CT axial image of a triphasic CT study of the liver with CT portography showing esophgeal varices , paraesophgeal varices , right lobe HCC (arrow). **b** CT axial image of a triphasic CT study of the liver with CT portography showing perisplenic collaterals. **c** CT coronal image showing dilated collaterals. **d** Endoscopy of the patient showing esophgeal varices

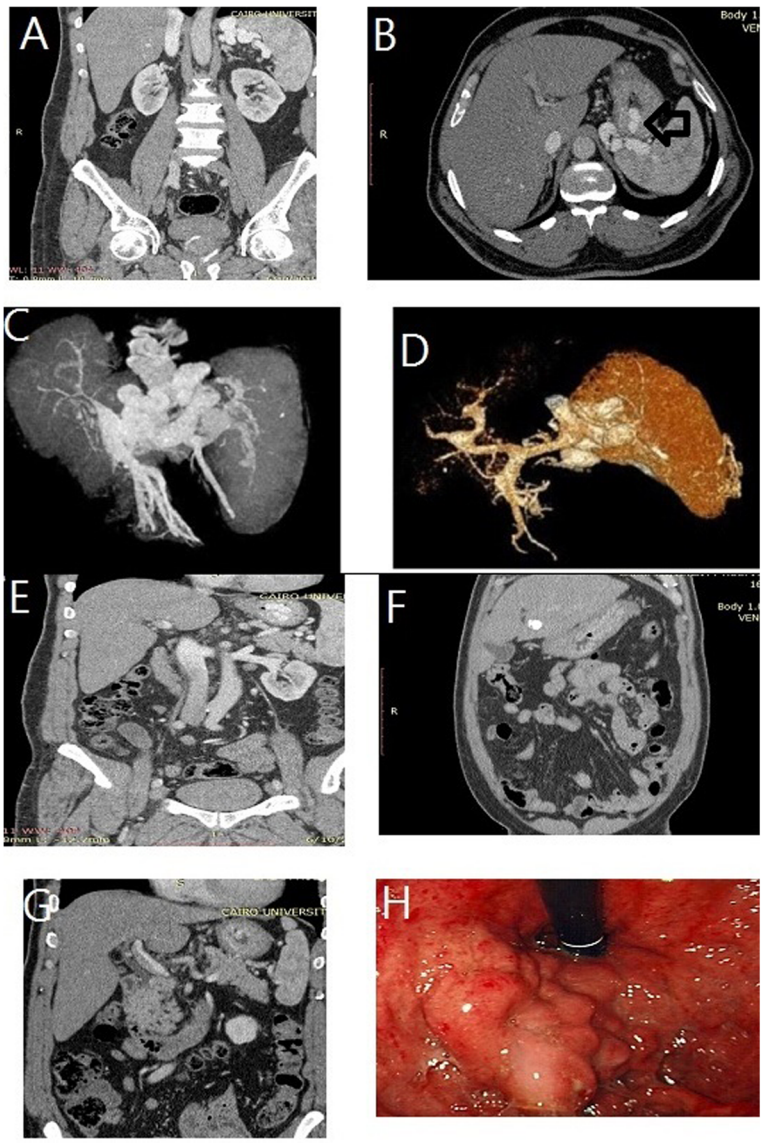

Fig. 6 a–**h** A 69-year-old male patient. **a** A triphasic CT study of the liver with CT portography coronal reconstructed image showing perisplenic and splenic hilum collaterals. **b** Triphasic CT study of the liver with CT portography axial image showing gastric fundal varices (arrow). **c** Triphasic CT study of the liver with CT portography MIP image showing dilated collaterals axial image show perisplenic varices. **d** Triphasic CT study of the liver with CT portography 3D reconstructed image showing dilated perisplenic collaterals coronal image. **e** Triphasic CT study of the liver with CT portography coronal reconstructed image showing gastric varices and gastrorenal shunt. **f** Triphasic CT study of the liver with CT portography coronal reconstructed image showing HCC chemoembolization. **g** Triphasic CT study of the liver with CT portography coronal reconstructed image showing portal vein thrombosis. **h** Upper GI endoscopy showing gastric fundal varices

the presence of portal vein thrombosis and hepatocellular carcinoma. For this purpose, 60 patients diagnosed to have portal hypertension and suffering from liver cirrhosis were evaluated by triphasic CT study.

In agreement with this study, Wang et al. [16] reported that CT MIP portography is an effective and non-invasive method for detecting the compensatory circulation resulting from decompensated portal hypertension.

With disagreement with this study, computed tomography is a second line to ultrasonography with color Doppler in a patient with known portal hypertension, not a primary one [17]. However, in this, CT was considered as the first line for the demonstration of all types of collateral.

Based on the radiological imaging according to Agrawal SK et al. (17), splenomegaly was seen in 85% of cases and portal vein thrombosis was recorded in 5% of cases.

Table 2 Distribution of the studied patients regarding their other portosystemic collaterals

Other portosystemic collaterals	Patients No. 60 (%)
Splenorenal	
Present	16 (27%)
Splenic hilum-peri splenic	
Present	52 (87%)
Paraumbilical vein	
Present	6 (10%)
Abdominal wall	
Present	2 (3%)
Coronary	
Present	30 (50%)
Retroperitoneal	
Present	8 (13%)
Mesenteric	
Present	4 (7%)
Gastrorenal	
Present	4 (7%)
Intrahepatic	
Present	2 (3%)
Duodenal	
Present	2 (3%)

In this study, based on the radiological images, splenomegaly was reported in 97.5% of cases and portal vein thrombosis in 17% of cases.

The commonest type of collaterals draining into superior vena cava is the perigastric type as we detected esophageal and paraesophageal collaterals in 70% of cases, perigastric in 76.7% was found in this study. These results are in agreement with Hesenler et al. [14].

CT MIP portography demonstrates the gastric fundic varices in 32 cases (97.0%) and esophageal varices in 27 (81.8%) and similarly to Wang et al. [16]. Gastric varices were shown in 97% of cases and esophageal varices were shown in 83% and according to Agarwal et al. [17] esophageal collaterals were shown in 6% of cases, collaterals along the left gastric vein in 13%, collaterals along the short gastric vein 5%. This is due to the similarity in the diseases leading to portal hypertension.

These results are with disagreement with Hesenler et al. [14] who detected esophageal collaterals in 90% of cases and gastric in 34% of cases. This is due to variation in the causes of portal hypertension

According to collaterals draining into the inferior vena cava, this study reported that the commonest type of collaterals was the splenic collaterals which shown in 56.7%; however, the recanalized paraumbilical vein in 10%. These results are in agreement with El Wakeel et al. [3] who reported that the collaterals originated from the splenic vein shown in 56% and the paraumbilical vein shown in 10%. This is due to the similarity in the diseases leading to portal hypertension

In this study, according to CT findings regarding variceal grading, it was found that the esophageal varices in 40.7% of cases are G1, 40.7% are G2, 18.6% are G3, and 0% are G4.

According to CT findings, gastric group showed that 9% of cases are G1, 27.3% are G2, 27.3% are G3, and 36.4% are G4.

According to CT findings, splenic hilum collaterals showed that 17.6% of cases are G2, 41.2% are G3, and 41.2% are G4.

With comparison of the upper GI endoscope and abdominal triphasic CT to detect esophageal varices grading it was found that there was an upgrading of collaterals by CT. This is in agreement with Yu et al. [18] and El Wakeel et al. [3] who reported that endoscopic undergrading of high-risk esophageal group will lead to overestimation of CT sensitivity for low-risk esophageal varices and also in agreement to Kim et al. [19] who reported that careful evaluation of high-risk esophageal varices on a liver MDCT examination may be useful to avoid performing endoscopy. CT can be used as a single non-invasive surveillance tool for both esophageal varices and recurrent HCC.

Similarly, Perri et al. [20] reported that CT demonstrated high sensitivity for assessment of high-risk gastric varices and in addition detected gastric varices in many patients in whom gastric varices not reported in endoscope and similarly according to Boregowda U et al. [5] reported that in correlation to endoscope, MDCT is useful for prediction of high-risk esophageal varices.

In this study, there was a significant correlation between the portal vein diameter and the number of collaterals as (p = 0.001). The increase in the number of collaterals is associated with the decrease in portal vein diameter due to the conversion of blood from portal vein to the collaterals.

Also, a significant correlation between the portal vein diameter and splenic vein diameter as $p <$ 0.001 was found as the increase in portal vein diameter is associated with the increase in splenic vein diameter.

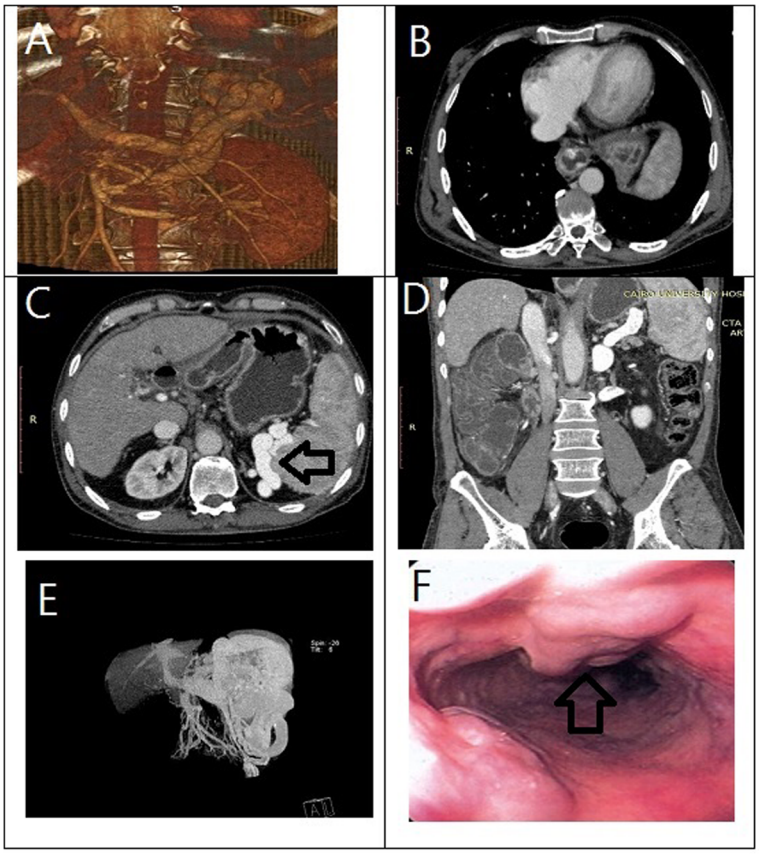

Fig. 7 a–**f** A 50-year-old male patient. **a**–**e** Triphasic CT study of the liver with CT portography. **a** CT VRT images shows the dilated collaterals. **b** CT axial image shows esophgeal varex. **c** CT axial image show perisplenic varices. **d** CT coronal image shows splenorenal shunt (arrow). **e** CT portography image shows dilated splenorenal collaterals. **f** Upper GI endoscopy showing esophgeal varices (arrow)

Conclusion

Multi-slice CT serves as an important non-invasive imaging modality in the diagnosis of collaterals in cases of portal hypertension. CT portography can replace diagnostic endoscopy in the detection of high-risk varices. It can also help in the detection of associated abnormalities as hepatocellular carcinoma and portal vein thrombosis. It also proved that there is a correlation between portal vein diameter, splenic vein diameter, and the number of collaterals.

Abbreviations

2D: Two dimensional; 3D: Three dimensionsal; CT: Computed tomography; ELISA: Enzyme-linked immunosorbent assay; GI: Gastro-intestinal; GIT: Gastro-intestinal tract; GV: Gastric varices; HCC: Hepato-cellular carcinoma; IVC: Inferior vena cava; MDCT: Multi-detector computed tomography; Mm: Milli-meter; SGOT: Serum glutamate oxaloacetate transaminase; SGPT: Serum glutamate pyruvate transaminase; SVC: Superior vena cava

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Authors' contributions

HE, LM, HA, and MI contributed equally to this work. HE and MI designed the research. HE and LM performed the research. HA and MI analyzed the data. HE and LM wrote the paper. All authors have read and approved the manuscript.

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Availability of data and materials

All the datasets used and analyzed during this study are available with the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the research ethics committee of the Radiology department of the Faculty of Medicine, Cairo University, on 3/9/2014, Reference number of approval: 769-2014. All patients included in this study gave a written informed consent to participate in the research. If the patient was less than 16 years old, or unconscious at the time of study, written informed consent was given by their parent or legal guardian.

Consent for publication

All patients included in this study gave written informed consent to publish the data contained in this study. If the patient was less than 16 years old, or unconscious at the time of study, written informed consent was given by their parent or legal guardian.

Competing interests

The authors declare that they have no competing interests.

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