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ORIGINAL ARTICLE

Diagnostic performance of multidetector computed tomography in the evaluation of esophageal varices

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KEYWORDS

Esophageal varices;
Multidetector CT (MDCT);
Portosystemic collaterals;
Red color sign

Abstract *Objective:* Our purpose was to evaluate the role of multidetector computed tomography (MDCT) in evaluation of esophageal varices (EV).
Patients and methods: 112 patients with liver cirrhosis were included, EV was evaluated for grades, presence of collateral, palisade vein dilatation and also patient acceptability.
Results: The sensitivity of MDCT for radiologist A was 94.8%, specificity 98.5%, Accuracy 97.8%, PPV 94.8%, NPV 98.5% and for radiologist B, 99.4%, 99.6%, 99.6%, 99.3% and 99.7% respectively. MDCT detected para esophageal varices in 38 cases, gastric fundus varices in 47 cases and splenorenal collaterals were seen in 14 cases, palisade vein dilatation was +ve in 58 cases, −ve in 47 cases and (±) in 7 cases. 3 cases of HCC and 1 liver cyst were incidentally found during examination. There was a highly significant correlation between degree of palisade vein dilatation, increasing grade of esophageal varices and Red color sign with p value <0.01. MDCT was more accepted than endoscopy in 83%. The preference of CT was statistically significant $p < 0.01$.
Conclusion: MDCT is a fast, well tolerable, non-invasive procedure and accepted from most of the examined patients for evaluation and grading of EV, detection of other portosystemic collaterals and hepatobiliary pathologies.

Introduction

Portal hypertension is a serious complication of cirrhosis. It is defined as a hepatic venous pressure gradient (HVPG) above 5 mmHg. Development of significant complication for portal hypertension as ascites and/or esophageal and gastric varices generally develops when HVPG increases above 10 mmHg (1,2).

Gastroesophageal varices were the most recognized portosystemic collaterals because their rupture results in danger-

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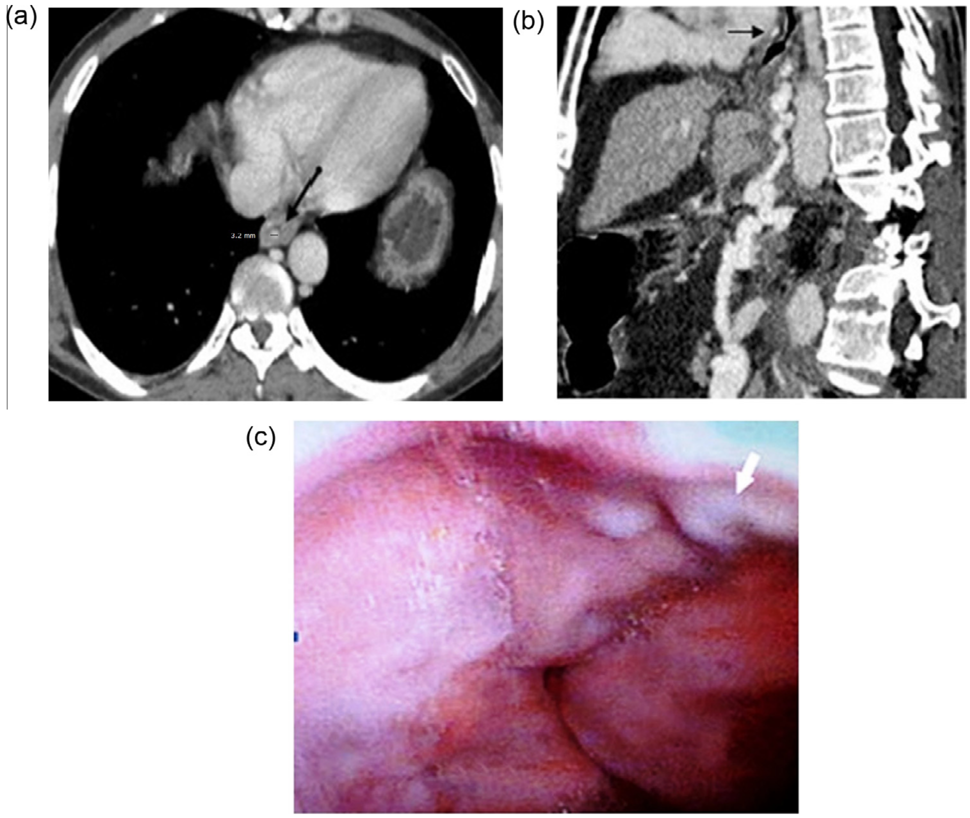


Case 1 50 years old male presented with posthepatitis cirrhosis; (a) CT post-contrast portal venous phase axial image shows single enhanced vascular structure in the esophageal wall projecting inside the lumen measuring 3.2 mm in diameter representing single esophageal varix (black arrow) (Score I); (b) CT multiplannar reformatted image shows the enhanced esophageal varix (black arrow); (c) upper GI endoscopy shows single intraluminal tubular shaped esophageal varix not risky (grade 1) (white arrow) (CT Score 1, endoscopy grade 1, RC 0).

ous variceal bleeding, which is considered as the commonest lethal complication of portal hypertension (3).

Reports from the 1940s to the 1980s demonstrate mortality rates 30–60% from variceal bleeding. Although mortality from a variceal bleeding has been reduced to be 20–30% with progression of endoscopic and radiological techniques simultaneously with new pharmacologic therapies, it remains of clinical significance (4,5).

Early diagnosis of gastroesophageal varices before the onset of first bleed is highly recommended as many studies showed that the risk of variceal bleeding can be reduced from 50% to 15% for large esophageal varices (6).

Esophagogastroduodenoscopy (EGD) is the gold standard in the diagnosis of gastroesophageal varices; however, the use of endoscopy as a method of screening is limited, due to its invasive, expensive, need sedation, and patients poor acceptance of the procedure (7–9).

To limit the number of patients who should undergo endoscopic screening, a noninvasive, less expensive and well tolerated test for diagnosis of varices with high sensitivity and specificity has been studied, such as platelet count and prothrombin time; as well as radiological criteria such as spleen size, but found to be not highly accurate predictors of high-risk varices (10). Ultrasound imaging also was noninvasive, nonexpensive and well tolerated but it has limited specificity and cannot substitute endoscopy as a screening tool for large esophageal varices (11,12).

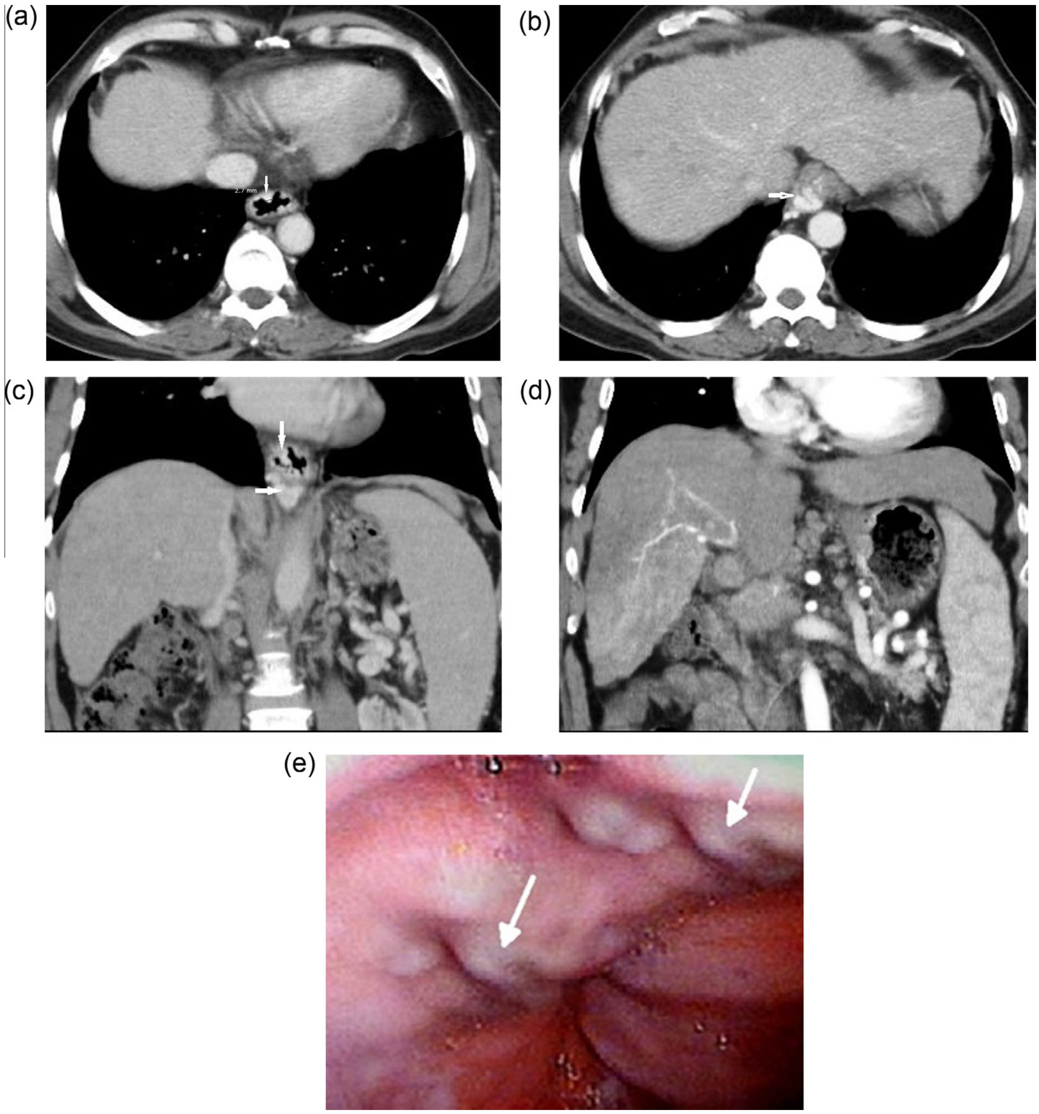
Computed tomography (CT) imaging is noninvasive, does not necessitate sedation, and allows accurate assessment of variceal site and size, and it is also better tolerated by most of the patients than endoscopy. With rapid evolution of CT technology especially the introduction of multi-detector computed tomography (MDCT) imaging with its multiplanar capabilities, esophageal, paraesophageal and gastric varices as well as other portosystemic shunts was progressively recognized in patients with liver cirrhosis (13–15).

Magnetic resonance (MR) imaging is probably as accurate as CT but is more expensive and less accessible; in addition, some of the rarest pathways (eg, pleuropericardial or thoracic wall varices) may be missed at MR imaging (16).

The purpose of this study was to prospectively evaluate the effectiveness of MDCT in evaluation of esophageal varices in cirrhotic patients compared with finding of the gold standard Esophagogastroscopy.

Patients and methods

112 patients with liver cirrhosis were included in this study. Patients were examined at the period between 2011 and 2014 in Suez Canal and Zagazig University hospitals in radiology



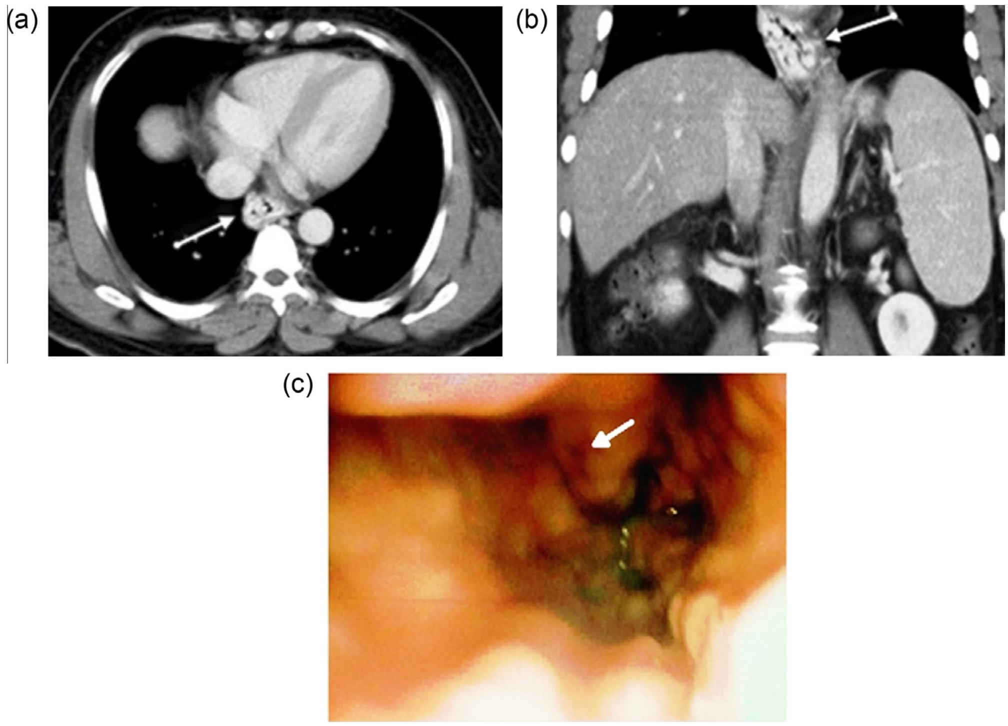
Case 2 A 47 years old male with posthepatitis liver cirrhosis. (a) CT axial post-contrast portal venous phase image shows multiple small enhanced esophageal varices on the inner surface of the esophagus projecting inside the lumen measuring in between 1 and 2.7 mm in diameter {white arrow}(Score 2), and there are associated enhanced para-esophageal varices. (b) Axial CT at different level shows the enhanced paraesophageal varices (white arrow). (c) CT Coronal reformatted image shows the esophageal and paraesophageal (two white arrows) with splenomegaly and splenic hilar varices. (d) CT Coronal reformatted image of the arterial phase of triphasic examination shows ill defined rapidly enhancing hepatic focal mass involving segment VI with related neovascularity representing HCC. (e) Upper GIT endoscopy shows multiple lobulated intraluminal esophageal varices not risky (white arrows) (grade 2) (CT Score 2, endoscopy grade 2, RC 0).

departments and endoscopy units. 77 patients were male and 45 patients were females, and their ages ranged between 38 and 72 years with mean age 51.4 years. Approval from committee board was obtained for the study and written consent was taken from all patients after explanation of the procedure and any possible complications for the patients. All patients had CT study with IV. Contrast injection followed by upper GIT endoscopy within 2 weeks from CT study.

Exclusion criteria were Patients with active gastrointestinal hemorrhage, those with a history of endoscopic variceal ligation, those with a history of adverse reactions to iodinated contrast agent, patients with known congenital anomalies of the portal vein, and those who refused to do endoscopy after CT angiography were excluded.

CT examination for the abdomen

Plain CT examination including the lower chest and the upper abdomen was done first to demonstrate calcification and compare pattern of enhancement, followed by triphasic examination after injection of contrast media; 100 ml of iopamidol 300, was injected using automatic injector (Medrad Stellant injector, Indianola PA, USA), at a rate of 4.0 ml/s through a 18-gauge IV catheter inserted into an antecubital vein.



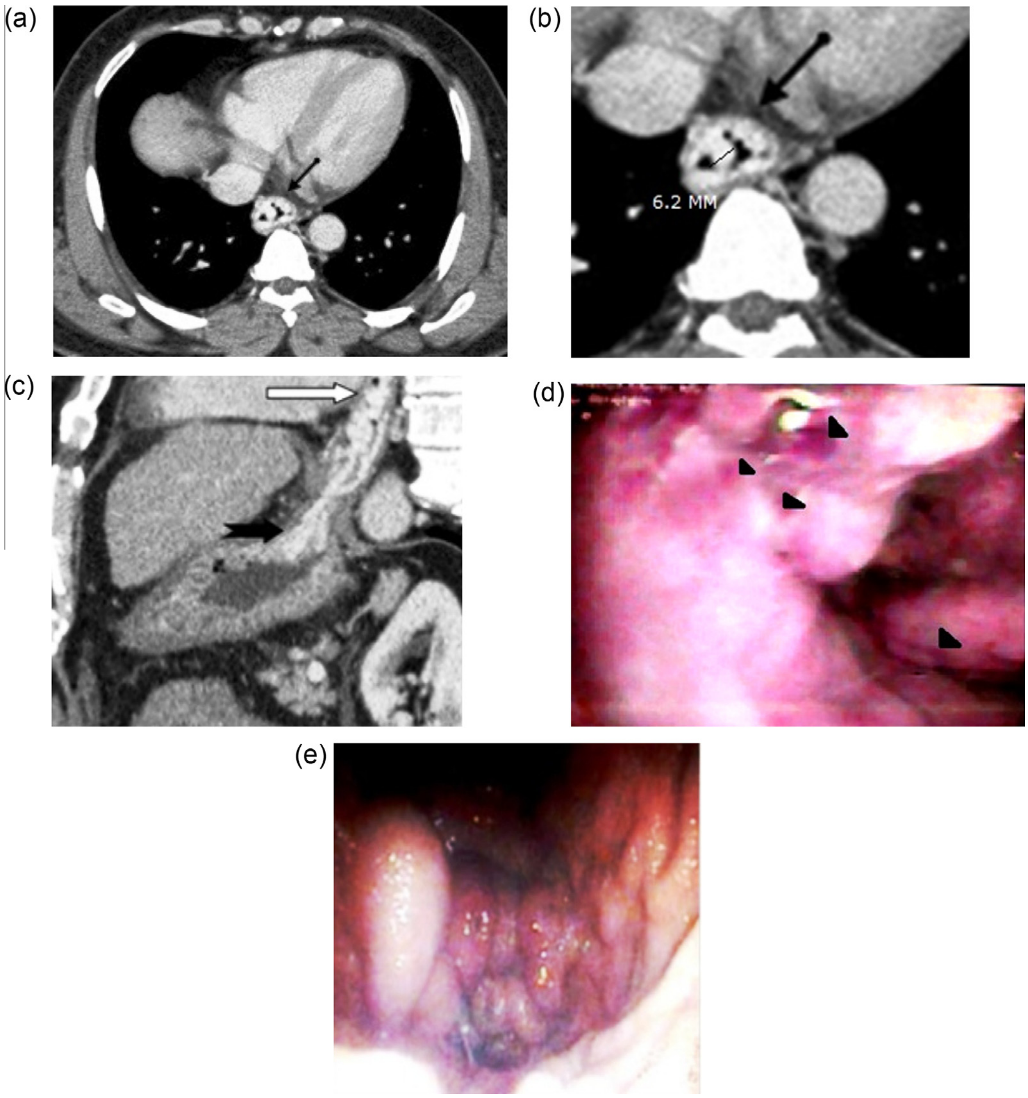
Case 3 A 38-years-old male with history of hepatitis. (a) CT axial post-contrast portal venous phase image shows multiple enhanced vascular structures involving the whole circumference of the inner surface of lower esophagus measuring between 1.2 and 2.3 mm (white arrow) (Score 3). (b) CT coronal reformatted image shows the multiple enhanced esophageal varices affecting lower esophagus (white arrow). (c) Upper GIT endoscopy shows multiple tortuous tubular intraluminal esophageal varices (grade 3) with mucosal red spot seen (white arrow) representing (RC 1) (CT Score 3, endoscopy grade 3, RC 1).

Three sets of images were acquired in a craniocaudal directional at 25, 65, and 180 s after injection of the contrast medium. The first acquisition was used for hepatic arterial phase imaging; the second acquisition for portal venous phase imaging, and the 3rd acquisition to image the hepatic venous phase. Images were obtained during single breath holding. All scans were performed utilizing a 64-slice CT scanner (Somatom Definition AS, Siemens Medical, Forchheim, Germany) and utilizing the high-quality scan mode, at 1.25-mm slice thickness, and reconstruction Intervals of 0.625 mm for portal venous phase imaging. Images were transferred to a workstation and multiplanar reformation (MPR) images were obtained in coronal and sagittal sections at 0.5- or 1-mm thickness, and a 5-mm interval in the region where varices were detected. The second set of triphasic enhanced CT images was used for evaluation of the entire esophageal varices in detail. All CT images were interpreted by two independent radiologists (A and B). Utilizing the information obtained from MDCT, images were analyzed for the following:

I. Size of the varices; CT-Visualized esophageal varices were classified into 4 groups by MDCT according to classification proposed by Shimizu et al. (17) whereas Score 0: no varices visualization on the inner surface of the esophagus, Score 1: one varix less than 5 mm in diameter detected on inner surface from the esophagus, Score 2: several varices less than 5 mm detected on the inner surface from the esophagus, and Score 3: one varix 5 mm or greater or several varices occupy more than half of the circumference of the esophagus.
II. The presence or absence of palisade vein dilatation. Palisade vein was defined as visualization of vessels that traversed between the lower esophagus and the cardiac region according to the criteria proposed by Japan society of portal hypertension (18).
III. Visualized porto-systemic collaterals. The prevalence of the various routes of Porto systemic shunts seen by MDCT was recorded.
IV. Acceptance and tolerability of the patients for either MDCT or upper GIT endoscopy were assessed by patient questionnaire after doing both techniques.

Upper GIT endoscopy was performed within 2 weeks following CT study; esophageal varices were evaluated for location and form, and presence or absence of RC sign. Classification system of the Japanese Society for Portal Hypertension and esophageal varices (18) was used such as Score 1 (small straight), Score 2 (enlarged tortuous) and Score 3 (large coiled shaped).

Red color sign (RC), defined as endoscope-detected dark red spots on the mucosa of the lower esophagus, was used to evaluate the risk of hemorrhage and provide a rough estimate of intravascular pressure within the esophageal varices (EV), and RC was classified into four grades: RC 0: no mucosal coloring; RC 1: a few localized red spots; RC 2: between RC 1 and RC 3; and RC 3: several mucosal red spots throughout the circumference of the lower esophagus. Upper GI endoscopy was done by experienced doctor of 11 years of experience in performing upper GI endoscopy. Results were recorded, tabulated and statistically analyzed.



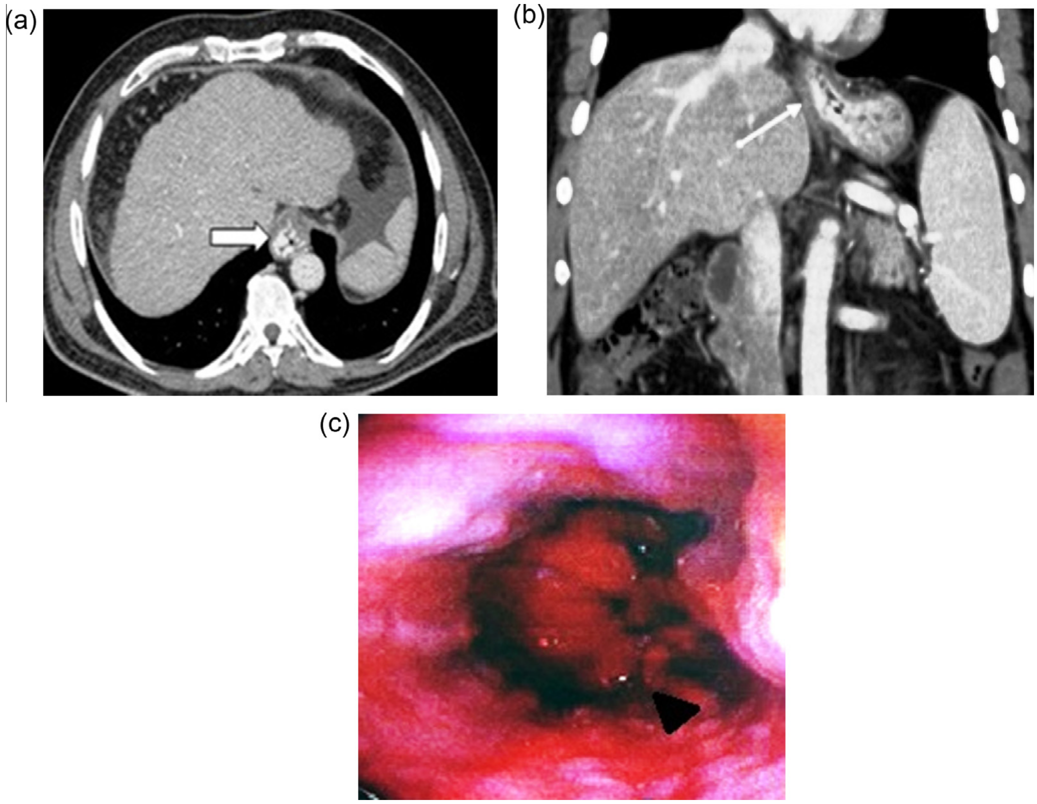
Case 4 A 40-years-old male with esophageal and gastric fundal varices. (a) and (b) CT axial post-contrast portal venous phase image shows enhanced intraluminal esophageal varices involving the whole circumference of the inner surface of lower esophagus with large varix measuring 6.2 mm in diameter (white arrow) (Score 3). (c) CT coronal reformat shows enhanced vascular structures at the gastric fundus (white arrow). (d) Upper GIT endoscopy shows multiple lobulated submucosal esophageal varices (grade 3) and mucosal red spots (black arrow heads) representing (RC 2). (e) associated gastric endoscopy shows fundal multiple lobulated submucosal gastric varices (CT Score 3, endoscopy grade 3, RC 2).

Statistical analysis

The categorical variables were expressed as a number (percentage). Comparison between percent of paired categorical variables was done by McNemar (χ^2) test with exact correction if number of discordant pairs was fewer than 20, while Pearson's Chi-square (χ^2) test was used for unpaired categorical variables. Inter-rater agreement in detection and grading of esophageal varices between MDCT and endoscopy was analyzed using McNemar, and Kappa (K) statistic. Agreement was obtained if the McNemar was not significant and the Kappa statistic was significant, and criteria to qualify for strength of agreement were as follows: $K < 0.2$: poor; K 0.21–0.40: fair; K 0.41–0.60: moderate; K 0.61–0.80: good; K 0.81–1.00: very good. All tests were two sided, and p-value < 0.05 was considered significant. All statistics were performed using SPSS 22.0 for windows (SPSS Inc., Chicago, IL, USA) and MedCalc 13 for windows (MedCalc Software bvba, Ostend, Belgium).

Results

One hundred and twelve patients with liver cirrhosis were investigated in this study (77 males, 45 females, age 38–72 years; mean 51.4. with SD 8.4). There were no significant differences in age and sex distribution regarding detection and grading of esophageal varices ($p > 0.05$). The cause of cirrhosis was Hepatitis B in 52 (46%) patients, Hepatitis C in 49 (44%) patients and Bilharziasis in 11 (10%) patients. The diagnosis of cirrhosis for the involved patients was based on



Case 5 A 44-years old male with liver cirrhosis, esophageal and gastric fundal varices. (a) CT axial post-contrast portal venous phase image shows multiple enhanced intraluminal esophageal varices involving the whole circumference of the inner surface of lower esophagus (white arrow) (Score 3), and there is associated liver cirrhosis and ascites. (b) CT coronal reformatted image shows the enhanced lower esophageal varices (white arrow) and gastric fundal varices (black arrow). (c) Upper GIT endoscopy shows multiple tubular elongated submucosal esophageal varices (grade 3), and there is multiple mucosal red spots with active bleeding (black arrow heads) representing (RC 3) (CT Score 3, endoscopy grade 3, RC 3).

liver histologic findings (22 cases) or the combination of typical clinical features (symptoms and signs of cirrhosis and its complications), laboratory results (viral marker, hyperbilirubinemia, hypoalbuminemia, coagulopathy, and cytopenia testing), and imaging findings (liver configuration, border irregularity, splenomegaly, ascites, and collateral vessels) (90 cases). Hepatocellular carcinoma was diagnosed in 3 cases from the involved patients with liver cirrhosis and one case of hepatic cyst was differentiated from HCC as well utilizing MDCT.

Table 1 Performance of both radiologists in grading of esophageal varices compared to upper GIT endoscopy.

Esophageal varices grades	Radiologist (A)	Radiologist (B)	Upper GIT Endoscopy	
Grade 0	15 (13%)	13 (12%)	Score 0	13 (12%)
Grade I	44 (39%)	46 (41%)	Score I	47 (42%)
Grade II	41 (37%)	39 (35%)	Score II	38 (34%)
Grade III	12 (11%)	14 (12%)	Score III	14 (12%)

According to MDCT finding the esophageal varices were graded into Score 0, Grade I (Case 1), Grade II (Case 2) and Grade III (Cases 3–5). The detection and scoring of esophageal varices by MDCT as obtained from each radiologist (A and B) were compared with the endoscopy results which were used as gold slandered (Table 1), and the sensitivity, specificity, accuracy, positive and negative predictive value of radiologist A and radiologists B for each grade from EV were recorded and tabulated as well (Table 2).

No statistically significant difference was detected between radiologists A and B in detecting and grading esophageal varices with p-value = 0.563, 0.503, 0.563, 0.250 for grade 0, I, II and III respectively (Table 3).

Good agreement was detected between radiologists A, B and upper GIT endoscopy regarding detection and grading of esophageal varices (Table 4) with Kappa coefficient equal to 0.953, 0.987 and 0.895 for Radiologist A vs. Upper GIT endoscopy, Radiologist B vs. Upper GIT endoscopy and Radiologist A vs. Radiologist B respectively which was highly significant with p value < 0.001 for all.

Other portosystemic collaterals; among the examined cases were detected by MDCT as para esophageal varices were seen in 38 cases, gastric fundus varices in 47 cases and splenorenal collaterals were seen in 14 cases. Yet the direction of blood flow within the vasculature could not be determined utilizing multidetector CT.

Table 2 Sensitivity, specificity, accuracy, +VE and −VE predictive values of radiologists A and B in detection of different grades of esophageal varices.

Variable	Grade							
	0		I		II		III	
	A	B	A	B	A	B	A	B
Sensitivity	100%	100%	93.6%	97.8%	100%	100%	85.7%	100%
Specificity	98%	100%	100%	100%	96.1%	98.6%	100%	100%
Accuracy	98.2%	100%	97.5%	99.2%	97.4%	99.1%	98.2%	100%
+VE PV	86.6%	100%	100%	100%	92.7%	97.4%	100%	100%
−VE PV	100%	100%	96.1%	98.7%	100%	100%	98%	100%

Table 3 Comparison between radiologists A and B as regards detection and grading of esophageal varices.

Esophageal varices grades	Radiologist A (n = 112)		Radiologist B (n = 112)		Test[a]	p-value
	No.	%	No.	%		
Grade 0	15	13.4	13	11.6	0.333	0.563
Grade I	44	39.3	46	41.1	0.363	0.503
Grade II	41	36.6	39	34.8	0.333	0.563
Grade III	12	10.7	14	12.5	0.250	0.250

Qualitative data are expressed as number and percent (%); $p < 0.05$ is significant.
[a] McNemar test.

Incidental finding was detected during MDCT examination of our patients as hepatocellular carcinoma (HCC) in three cases and hepatic cyst in one case.

Red color sign also was assessed by endoscopy as an indicator for variceal bleeding. RC 0: no mucosal coloring was seen in 20 cases; RC 1: a few localized red spots were seen in 42 cases; RC 2: between RC 1 and RC 3 were seen in 37 cases and RC 3: several mucosal red spots throughout the circumference of the lower esophagus were seen in 13 cases. Correlation of red color sign with CT grades of esophageal varices shows statistically significant correlation between grade of red color sign and that of CT ($p < 0.05$) (Table 5).

In MDCT detection of palisade vein dilatation, we found 58 cases were negative (−), 47 cases were positive (+), and 7 cases were defined as equivocal (±) with poor contrast enhancement. During analyzing these cases, those who judged to be (−) or (±) are seen to have lower variceal grading, lower degree or no RC sign, whereas cases judged to be (+) are seen having the tendency for high variceal grades, positive and stronger RC signs. There was a highly significant correlation between degree of palisade vein dilatation, increasing grade of esophageal varices and Red color sign. These findings of palisade vein dilatation also correlated with variceal grades ($p < 0.01$), presence and severity of RC sign ($p < 0.01$).

93 patients (83%) out of 112 found that MDCT is more preferable and accepted than endoscopy, only 8 (7.1%) patients found endoscopy more preferable and 11 patients

Table 5 Endoscopic findings of red color signs and its correlation with EV grades by MDCT.

Red color sign	Number of cases seen by endoscopy	Correlation with No. of cases of similar CT grades of EV
RC 0	20 (18%)	Grade (0) 14 (12%)
RC I	42 (38%)	Grade (I) 45 (40%)
RC II	37 (33%)	Grade (II) 40 (36%)
RC III	13 (11%)	Grade (III) 13 (11%)

Table 6 Comparison between MDCT and endoscopy as regards patient preference.

Patient preference	MDCT (n = 112)		Endoscopy (n = 112)		Test[a]	p-value
	No.	%	No.	%		
Prefer[b]	104	92.9	19	17	130.274	<0.001
Not prefer	8	7.1	93	83		

Qualitative data are expressed as number and percent (%); $p < 0.05$ is significant.
[a] Chi square test.
[b] 11 patients show no preference.

Table 4 The agreement between radiologists and endoscopy regarding detection and grading of esophageal varices.

Observers	Inter-rater agreement				
	p-value[a]	Kappa	Standard error	95% CI	p-value[*]
Radiologist A vs Upper GIT endoscopy	0.375	0.953	0.028	0.879–0.990	<0.001
Radiologist B vs Upper GIT endoscopy	1.000	0.987	0.013	0.961–1.000	<0.001
Radiologist A vs Radiologist B	0.289	0.895	0.035	0.826–0.964	<0.001

95% CI: 95% confidence interval; $p < 0.05$ is significant.
[a] McNemar test.
[*] p value of kappa statistics.

(0.8%) show no preference between both techniques. The preference of CT as imaging modality from the patient side was statistically significant $p < 0.01$ (Table 6).

Illustrative cases represent MDCT scoring of esophageal varices.

Discussion

Variceal bleeding is a serious adverse event in patients with liver cirrhosis. Patients survive the 1st episodes of variceal bleeding have a greater than 60% risk of recurrent hemorrhage within 1st year of recurrent episode (19). We tried in this study to detect the value of MDCT in diagnosis of esophageal varices as a newly evolving, non-invasive procedure and its acceptance to the patients.

112 patients with liver cirrhosis were involved in this study (77 males, 45 females, age 38–72 years; mean 51.4. SD 8.4.

In this study, utilizing MDCT, the scanning series take very short time and most of the patients can withstand single breath hold which makes the procedures and diagnostic quality much better. This was mentioned by Rydberg et al. (20) who clarified that the rapid scanning capability of MDCT allows increased craniocaudal scanning range and thinner slice acquisition in a single breath hold. This results in high spatial resolution and better depictions of fine vasculature. We found also the availability of precise MIP in sagittal and coronal planes raise the diagnostic performance in visualization of esophageal varices, differentiating it from paraesophageal varices as well as visualization of other portosystemic collaterals and this was reported by Nakayama et al. (21) and Ishikawa et al. (22).

Using multidetector CT in detection of esophageal varices shows high sensitivity, specificity, accuracy, positive and negative predictive values. Our recorded sensitivity, specificity, accuracy, +ve and −ve predictive value of CT in detection of EV for radiologist A were 94.8%, 98.5%, 97.8%, 94.8% and 98.5% and for radiologist B were 99.4%, 99.6%, 99.6%, 99.3% and 99.7% respectively. In our study, the difference between radiologists A and B in detecting different grades of esophageal varices was insignificant. Also there is a good agreement between radiologists A, B and upper GIT endoscopy regarding detection and grading of esophageal varices. This statistically proved high performance of multidetector CT in our study was in agreement with Perri et al. (23) who reported sensitivity and specificity of 75%, 62% and 85%, 75% for radiologist 1 and radiologist 2 respectively. Also Kim et al. (24) recorded 90–93.3% for sensitivity, and 81.7–96.7% for specificity for radiologists 1 and 2 respectively. The higher sensitivity and specificity in our study may be due to the fact that we use 64 slice CT while in study of Perri et al. (23) they used 4 detectors and in Also Kim et al. (24) they used 16 detectors in their studies.

In endoscopic findings, particularly cases with erythrogenic findings (red color sign), we try to see whether there is relation between the degree of red color sign and the grades of EV detected by CT and we found that there was a significant correlation between grades of esophageal varices seen by multidetector CT and grades of red color sign ($p < 0.05$). This result was similar to that mentioned by Dessouky and Abdel Aal (25).

In examining presence or absence of palisade vein dilatation, we found 58 negative cases and 47 positive cases and 7 cases were recognized as equivocal (±) showing poor contrast opacification. When we correlate negative and equivocal cases with the degree of RC sign, we found these cases either do not get or have low grade RC sign. In contrary we found cases which were evaluated as positive tended to have positive and stronger RC signs ($p < 0.01$). Also we observed that there is increase in the degree of vein dilatation with increasing grades of EV ($p < 0.01$). These highly significant correlation results were in agreement with those Dessouky and Abdel Aal (25).

In the incidental detection of other portosystemic collaterals, we have 38 cases of para esophageal varices and 47 cases of gastric fundus varices whereas splenorenal collaterals were seen in 14 cases utilizing high speed multidetector CT which was able to identify them and differentiates it from esophageal varices, having the advantage more than endoscopy which shows EV only and this was in agreement with Kodama et al. (13) and Mifune et al. (15) who clarified the important advantage of multi-detector row CT over single-detector row helical CT and conventional portography is the increased speed of scanning, which permits routine use of very thin collimation for imaging the portosystemic collateral vessels whereas collateral vessels can now be demonstrated without the risk, discomfort and invasiveness of catheterization.

In our study, multidetector CT was able to detect the feeding and draining variceal vessels, yet it could not detect the direction of blood flow within the portosystemic collaterals which is considered a drawback compared to the conventional portography. This limitation of multidetector CT was mentioned also by Chen et al. (26).

Also MDCT was able to diagnose 3 cases of HCC within cirrhotic liver patients and differentiate those from another case of simple hepatic cyst during its routine protocol scanning for esophageal varices and this gives other advantage of MDCT over endoscopy and other invasive procedures. And this was in agreement with Kim et al. (27), who stated that considering the high cost of performing multiple tests and the relative invasiveness of endoscopy, a single noninvasive surveillance tool for both varices and HCC may be important.

When we compare the acceptance of both techniques (CT and endoscopy) from the patient side, 93 patients (83%) out of 112 found that MDCT is more preferable and accepted than endoscopy, only 8 (7.1%) patients found endoscopy more preferable and 11 patients (0.8%) show no preference between both techniques. The preference of CT as imaging modality from the patient side was statistically significant $p < 0.01$. This was in agreement with Perri et al. (23), Kim et al. (24) and also Dessouky and Abdel Aal (25), who found multidetector CT more tolerable and cost-effective compared to upper GIT endoscopy and patients are more willing to utilize it for followup.

Conclusion

Multidetector CT with MIP facilities is a reliable noninvasive, highly tolerable examination in evaluation of esophageal varices with ability to detect other portosystemic collaterals; in addition, evaluation of the whole MDCT examination allows the detection of other associated pathologies.

Conflict of interest

The authors declare that there are no conflict of interests.

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