



## Radiodiagnosis

## DETECTION AND GRADING OF ESOPHAGEAL VARICES ON MULTIDETECTOR COMPUTED TOMOGRAPHY (MDCT) IN PATIENTS WITH CHRONIC LIVER DISEASE AND CORRELATION WITH ENDOSCOPIC GRADING

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**ABSTRACT** • **Aim:** This prospective study was undertaken to evaluate the role of multidetector computed tomography (MDCT) in detection and grading of oesophageal varices in patients with chronic liver disease and to correlate the MDCT findings with endoscopic grading of oesophageal varices.

- **Material and Methods:** A total of 31 patients above 18 years of age were included in the study. Upper gastrointestinal endoscopy was performed within 4 weeks of (before/after) of MDCT. MDCT was done in unenhanced, arterial and portal venous phase. The CT images were reviewed for the presence and size of esophageal varices at 3mm sections. Multiplanar reformation images of axial, coronal and sagittal sections were made at 0.9 mm thickness region where varices were visualized.
- **Results:** Sensitivity, specificity, positive and negative predictive values of CT in determining characteristics of varices were taken out, with endoscopy regarded as the reference standard. The results of CT were correlated with the presence and grade of esophageal varices documented on endoscopy. Our study revealed a good correlation between the MDCT size of esophageal varices and endoscopic form and the presence of red color sign. The overall sensitivity, specificity, PPV and NPV of MDCT was 88.4%, 80%, 95.8% and 57.1% respectively in detection of esophageal varices.
- **Conclusion:** MDCT is an excellent modality for the detection of collaterals including oesophageal varices. The use of CT oesophagography allows grading of oesophageal varices, as well as differentiation between low and high-risk varices. A criterion of a 3-mm diameter on CT for large varices could be useful in identifying high-risk esophageal varices, which is most important given the high morbidity and mortality associated if they bleed.

**KEYWORDS :** Multi detector computed tomography; Oesophageal varices; Grading; Chronic liver disease; Red sign

### INTRODUCTION

Cirrhosis is the end stage of chronic liver disease, resulting in formation of fibrous tissue, disorganization of liver architecture, and nodule formation, which interferes with liver function and results in portal hypertension. Portal hypertension is associated with development of a hyperdynamic circulation and complications such as ascites, hepatic encephalopathy and oesophago-gastric varices [1]. Variceal bleeding is the most serious complication of portal hypertension, because of the risk of bleeding and related high mortality [2]. Therefore, in cirrhotic patients, detection and prevention of the oesophageal variceal haemorrhage is crucial to minimize complications.

Patients without varices or with small varices, need to undergo endoscopic surveillance to monitor for the development of large varices. The presence of large varices is considered an indication for prophylaxis against variceal bleeding with either nonselective beta-blockers or endoscopic variceal ligation. Upper GI endoscopy is deemed to be the gold standard against which all other tests are compared, but is not without its limitations.

However, with the availability of cross-sectional imaging techniques, collateral vessels can now be demonstrated in all parts of the abdomen and thorax without the risk, discomfort, and intrusiveness of catheterization [3].

Multi-detector row computed tomography (MDCT) is the latest advancement in CT technology and is now more readily available than in the past. MDCT scanners are faster and allow thinner collimation. Images are rapidly and continuously acquired during a single breath hold, resulting in improved spatial resolution and the elimination of motion artefacts. The use of MDCT combined with post processing of the imaging data with a variety of three-dimensional reformatting techniques (e.g., maximum intensity projection, shaded surface display, volume rendering) allows creation of vascular maps whose quality equals or exceeds that of maps created at classic angiography.

Peri-oesophageal varices which cannot be detected by endoscopy may be an important bed of collateral vessels to evaluate in patients with portal hypertension [4]. With advancement in MDCT imaging, spontaneous portosystemic shunts, oesophageal, gastric varices, and peri-luminal varices are increasingly recognized in patients with cirrhosis. Since, patients with cirrhosis undergo CT examinations for the evaluation of other complications of cirrhosis, CT could provide an opportunity to evaluate oesophageal varices without any added cost.

MDCT is simple, quick, reproducible, less invasive, better tolerated and less expensive diagnostic test with high sensitivity and specificity for detection of large varices. CT is better tolerated than endoscopy by most patients. Furthermore, the accuracy of CT in detecting oesophageal varices is significant.

### MATERIALS AND METHODS

This descriptive observational (Cross-sectional) study was done from November 2012 to March 2014 in the department of Radio Diagnosis. The study group comprised of all patients of chronic liver disease with portal hypertension above eighteen years of age with clinical suspicion of oesophageal varices. Out of 42 patients with cirrhosis a total of 31 patients were included in the study after applying the exclusion criteria of a recent episode (within 15 days) of upper gastrointestinal bleeding (n=5), patients who underwent band ligation or sclerotherapy (n=3) and patients with renal insufficiency defined as a serum creatinine of 1.7 mg/dL in nondiabetics or 1.5 mg/dL in diabetics (n=3).

The diagnosis of cirrhosis was made on the basis of combination of typical clinical features (symptoms and stigmata of cirrhosis and its complications), laboratory results (Hb, TLC, platelet count, liver function tests, renal function tests, HBsAg, and antiHCVAbs) and imaging findings of abdominal ultrasound and Doppler (liver configuration, blood flow, splenomegaly, ascites, and collateral vessels). Child Pugh class was assigned to each patient. Informed consent was obtained from all patients.

Ultrasound and Doppler examination was done in every case with the

patient fasting using 3.5 – 5 MHz curvilinear and 7 – 14 MHz linear transducer (ATL-HD15000 and Philips IU-22).Detailed examination of whole abdomen was performed with special emphasis on spleno-portal axis. We prospectively evaluated all patients with both MDCT and endoscopy On endoscopy, all patients were called empty stomach and were administered local anaesthetic oral spray.Upper gastrointestinal endoscopy was done using Olympus CLK 4 GIF type IT 30 endoscope within four weeks (before/after) of MDCT after obtaining informed consent. A single endoscopist with many years of experience interpreted the endoscopy results which ensured uniformity of the reports.

Detection and grading of varices was noted. For the purpose of this study, the grading system was used according to criteria proposed by the General Rules for Study of Portal Hypertension (The Japan Society for Portal Hypertension, 2nd Edition, 2004) [5].The presence of oesophageal varices was graded as[6]:

- F0 - varices absent
- F1 – linear relatively faint varices
- F2 – bead shaped moderate varices
- F3 – nodule or mass shaped varices

The presence of red signs on the oesophageal varices was noted and they were classified subjectively into four categories of severity as follows:

- RC0 – no erythrogenic findings
- RC1 – a few localised erythrogenic findings
- RC2 – between RC1 and Rc3
- RC3 – many erythrogenic findings through 360 degrees.

Further, the patients were divided into two groups (low and high risk) on the basis of their probability for developing an oesophageal variceal hemorrhage. A grade of F2 or higher was chosen as the cut-off point to define high risk varices[7].

**MDCT (TECHNIQUE)**

MDCT was done on Philips Brilliance 190 P 40 slice multidetector scanner in the unenhanced, arterial and portal venous phase.Each patient was received in fasting state on the day of examination and was given 1200 ml of water and 300 ml of 20% w/v mannitol to drink for 40 – 60 minutes before the scan. Plain scan was obtained from tracheal bifurcation to L1 vertebral level. For CECT 80 – 100 ml of iohexol contrast (iodine component 300 mg/ml, Omnipaque 300 Syringe) was administered intravenously by power injector(medrad). The injection rate of was between 4 ml per second and was followed by saline chase 30 ml at the rate of 30 ml/sec.

Contrast enhanced CT images were obtained during the arterial phase with fixed delay of 25 seconds from start of the contrast injection and carried out from above the diaphragm through the liver and pancreas. Portovenous phase scanning was initiated with delay of 65 seconds and was carried out from the level of the tracheal bifurcation to pubis symphysis.All CT images were acquired at end inspiration.

MDCT parameters during portovenous phase were as follows: collimation = 40x0.625, pitch = 0.929, rotation time = 0.5 second, FOV = 350, matrix size = 512, section thickness = 3mm, increment = 1.5 mm, kV = 120 and mAs = 200

**IMAGE ANALYSIS**

The CT images were reviewed for the presence and size of esophageal varices. Combined interpretation of unenhanced, hepatic arterial dominant phase, and portal dominant phase images was performed. Bones were clipped out by use of differences of CT value. Window levels and widths were set for easy observation of the portal system, and three-dimensional images (maximum intensity projection, volume rendering) were made. Multiplanar reformation images of axial, coronal and sagittal sections were made at 3 and 0.9mm thick sections in the region where varices were visualized. We also reviewed the source images.

In our study we used both standard and thinner sections with multiplanar reconstructions and MIP images to achieve as accurate measurement as possible.

Axial images were evaluated to determine the presence and size of esophageal varices. For positive CT interpretations the maximal short-

axis diameter (MSAD) of the largest perceived variceal column on axial images, rounded to the nearest millimeter, using electronic callipers under liberal image magnification was used.Readings were classified as:

No varices detected, Small varices < 5mm (low risk),Large varices ≥ 5mm (high risk).For negative CT cases a size of 0 mm was assigned. Large oesophageal varices on CT scan were defined as those that were measured as greater than or equal to 5 mm in diameter, with small varices being those that measured less than 5 mm in diameter.A finding of circumferential oesophageal wall thickening alone without any nodular enhancing lesion was not considered to indicate the presence of esophageal varices. A luminal protruding lesion without enhancement was also not deemed an esophageal varix. A temporal enhancement pattern reflecting that of the portal vein—for example, progressive opacification spanning the arterial and portal phases or enhancement in the portal phase alone—was considered to reflect esophageal varices that constitute portal venous collaterals via the left gastric vein.

**STATISTICAL EVALUATION**

For statistical evaluation results were analysed using SPSS (version12) software.The results of CT were correlated with the presence and grade of oesophageal varices documented on endoscopy. Correlations between size measurements of perceived oesophageal varices on CT and endoscopic grading were performed using Spearman rank correlation test.

**OBSERVATION AND RESULTS**

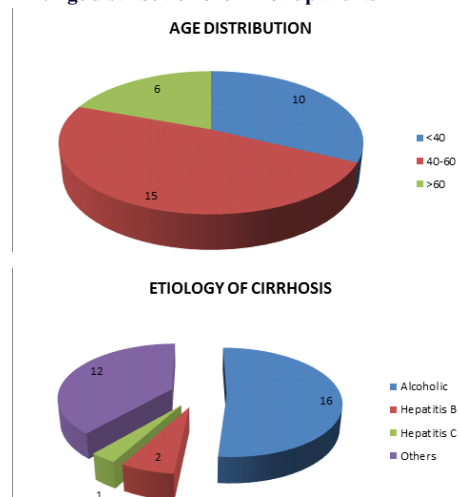
Of the 31 patients with cirrhosis included in the study, 17 (55%) were men and 14 (45%) were women . Varices were present in 16 (94%) males and 10 (71%) femalesThe majority of patients (48%) as shown in table 1 in this study were between 40 and 60 years old. The next largest group of patients (32%) were below 40 years old and in the prime of their lives. Elderly patients > 60 years constituted 19% of the study population.The mean age of cirrhotic patients in this study was 47.26 ± 11.86 years with a range of 25-68 years. (fig.1)

**TABLE 1: Distribution of cirrhotic patients across age groups**

Age (years)	Frequency	High risk group	Low risk group
<40	10 (32%)	1(3.3%)	9(29%)
40-60	15 (48%)	1(3.3%)	14(45%)
>60	6 (19%)	1(3.3)	5(16%)
TOTAL	31 (100%)	3 (10%)	28 (90%)

High risk varices were found in 3 (10%), while 28 (90%) of study group had low risk varices on MDCT.High risk varices on MDCT were seen in 3.3 % (n=1), 3.3% (n=1) and 3.3% (n=1) of patients in >60, 40-60 and < 40 years age group respectively.

**FIGURE 1: Age distribution of cirrhotic patients**



**FIGURE 2: Distribution of cirrhotic patients according to etiology**

Alcoholic liver disease (n=16) was found to be the most common cause of cirrhosis and accounted for 52% of the patients in the present study group (fig.2). This was followed by other causes (n=12) (including Wilson's disease, autoimmune hepatitis and cryptogenic cirrhosis)and

Chronic hepatitis B (n=2) and hepatitis C (n=1) (Fig. 2).

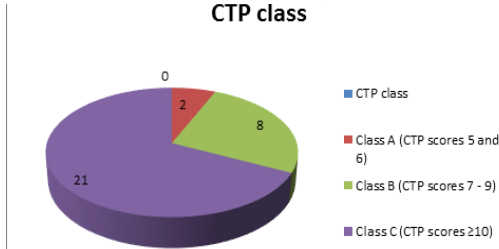
Most patients included in this study had relatively advanced cirrhosis on admission (figure 3). The distribution across Child-Turcotte-Pugh (CTP) classes A, B and C was uneven; with CTP class C emerging as the largest group with almost 52% of patients (table 2). CTP class A and class B included 10% and (39%) of the total patients respectively.

**TABLE 2: Distribution of cirrhotic patients across CTP classes**

CTP class	Number and percent
Class A (CTP scores 5 and 6)	2 (6%)
Class B (CTP scores 7 - 9)	8 (26%)
Class C (CTP scores ≥10)	21 (68%)
Total	31 (100%)

Most of the patients 68% (n=21) belonged to class C and B 26% (n=8) with only 6% (n=2) in class A. Fifty percent (n=1), 63% (n=5) and 38% (n=8) of the patients had high risk varix in class A, B and C respectively on endoscopy. The average score was 10 ±2 and a range of 6 to 17. (Table 2,fig3)

**FIGURE 3: CTP class distribution (n=31)**

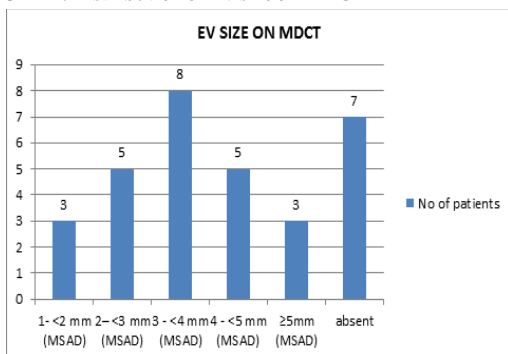


**TABLE 3: Distribution of EV size on MDCT measured in maximum short axis diameter (MSAD)**

EV size on MDCT	No of patients
1- <2 mm (MSAD)	3 (10%)
2- <3 mm (MSAD)	5 (16%)
3 - <4 mm (MSAD)	8 (26%)
4 - <5 mm (MSAD)	5 (16%)
>5mm (MSAD)	3 (10)
absent	7 (23%)
total	31 (100%)

On MDCT esophageal varices was detected in 24(77%) patients. No varices could be seen in 7 (23%) patients. The average maximum short axis diameter of the detected varices was 3.4 ±1.4 (SD) mm with a range of 1.2-6.9 mm. Ten percent (n=3) had variceal size between 1- <2 mm, 16% (n=5) between 2- <3 mm, 26% (n=8) between 3- <4 mm, 16% (n=5) between 4- <5 mm and 10% (n=3) above 5mm. (table 3, fig. 4)

**FIGURE 4: Distribution of EV size on MDCT**



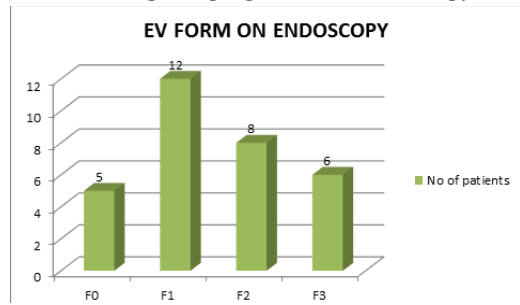
**ENDOSCOPIC FINDINGS: VARICEAL FORM**

**TABLE 4: Distribution of EV form on endoscopy**

EV form	F0	F1	F2	F3	total
No of patients	5 (16%)	12 (39%)	8 (26%)	6 (19%)	31 (100%)

A total of 26 (84%) patient was diagnosed with esophageal varices on endoscopy. In 5 (16%) varices were absent and graded as F0. Of the diagnosed patient 39% (n=12), 26% (n=8) and 19% (n=6) were graded as F1, F2 and F3 respectively. 17 (55%) patients had low risk varices and 14 (45%) had high risk varices. (Table 4, fig. 5)

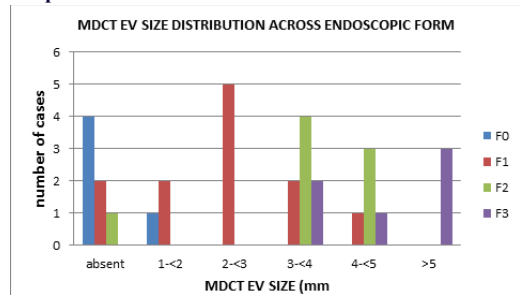
**FIGURE 5: Grading of esophageal varices on endoscopy**



**TABLE 5: Distribution of MDCT EV size across endoscopic variceal forms**

EV size on MDCT (mm) (MSAD)	F0	F1	F2	F3	Total
absent	4	2	1	0	7
1-<2	1	2	0	0	3
2-<3	0	5	0	0	5
3-<4	0	2	4	2	8
4-<5	0	1	3	1	5
>5	0	0	0	3	3
total	5	12	8	6	31

**FIGURE 6: Distribution pattern of MDCT EV size across endoscopic variceal forms**



Spearman coefficient of EV size on CT with forms on endoscopy =0.798, significant at 0.01. (p<0.01) (Table 5, fig.6)

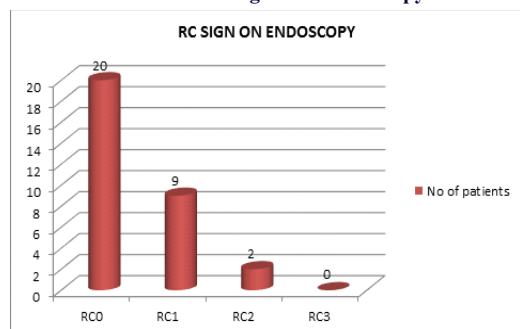
**RED COLOR SIGN**

**TABLE 6: Frequency of RC sign on endoscopy**

RC sign	Rc0	RC1	RC2	Rc3	total
No of patients	20 (65%)	9 (29%)	2 (6%)	0 (0%)	31 (100%)

Red color sign was present in 11 (35%) patients with 29% (n=9) graded as RC1 and 6% (n=2) under RC2. None of the subjects had RC3 grade of red signs (table 6, fig.7)

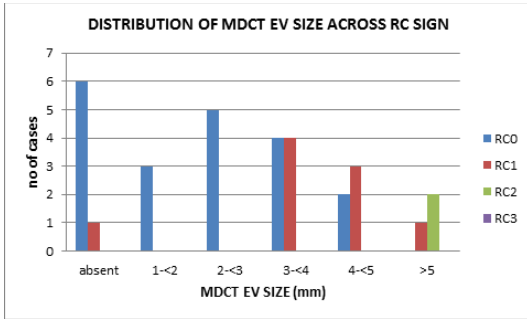
**FIGURE 7: Distribution of RC grade on endoscopy**



**TABLE 7: Distribution of MDCT EV size across endoscopic Red color signs**

EV size on MDCT (mm) (MSAD)	RC0	RC1	RC2	RC3	Total
absent	6	1	0	0	7
1-<2	3	0	0	0	3
2-<3	5	0	0	0	5
3-<4	4	4	0	0	8
4-<5	2	3	0	0	5
>5	0	1	2	0	3
total	20	9	2	0	31

**FIGURE 8: Distribution pattern of MDCT EV size across endoscopic Red color signs**



RC sign and MDCT EV size were positively correlated with Spearman coefficient ( $r = 0.609$ ) and this was statistically significant at  $p < 0.01$ . (Table 7, fig.8)

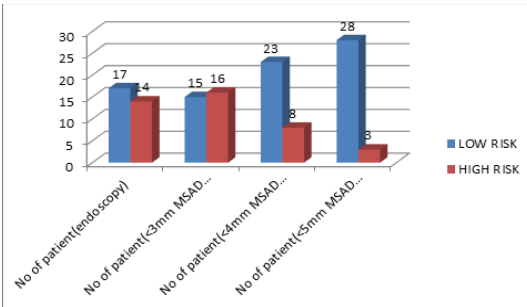
**RISK OF BLEEDING**

**TABLE 8: High risk EV identification at different MDCT EV sizes**

Risk of hemorrhage	LOW RISK	High Risk
No of patient(endoscopy)	17 (55%)	14 (45%)
No of patient(<3mm MSAD on CT)	15 (48%)	16 (52%)
No of patient(<4mm MSAD on CT)	23 (74%)	8 (26%)
No of patient(<5mm MSAD on CT)	28 (90%)	3 (10%)

On endoscopy, no varices or those with low risk of bleeding (F0 and F1) were seen in 55% (n=17) and with high risk (F2 and F3) were present in 45% (14) of the patients. On MDCT, using a 5 mm criteria to identify high risk varices, 10% (n=3) were categorized as high risk. Similarly at 4 mm and 3mm cut offs 26% (n=8) and 52% (n=16) patients were identified to have varices with increased risk of bleeding. (table 8, fig. 9)

**FIGURE 9: Identification of high risk EV on endoscopy and MDCT**



**SENSITIVITY, SPECIFICITY, PPV AND NPV MDCT VARICEAL DETECTION**

**TABLE 9: EV seen on endoscopy and MDCT**

Esophageal varices	present	absent	total
Endoscopy	26 (84%)	5 (16%)	31 (100%)
MDCT	24 (77%)	7 (23%)	31 (100%)

Esophageal varices were seen in 26 (84%) patients on endoscopy and 77% (n=7) of patients on MDCT. (Table 9)

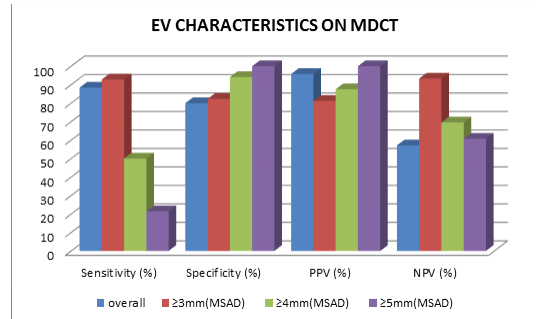
**TABLE 10: EV detection at different MDCT sizes**

MDCT EV parameters	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
overall	88.4	80	95.8	57.1
≥3mm(MSAD)	92.8	82.3	81.2	93.3
≥4mm(MSAD)	50	94.1	87.5	69.5
≥5mm(MSAD)	21.4	100	100	60.7

Overall sensitivity, specificity, PPV and NPV in detection of EV on MDCT as compared to endoscopy which is the gold standard was 88.4%, 80%, 95.8% and 57.1% respectively.

The sensitivity, specificity, PPV and NPV in identifying varices at high risk of bleeding using 5 mm, 4 mm and 3 mm criterion was 21.4%, 100%, 100% and 60.7%; 50%, 94.1%, 87.5% and 69.5%; and 92.8%, 82.3%, 81.2% and 93.3%. respectively (table 10, fig.10)

**FIGURE 10: Ability of MDCT in detecting and grading EV compared with endoscopy**



Imaging plates(1-5) of few cases on MDCT have been supplemented.

**DISCUSSION**

MDCT now using several detector rows provides near-isotropic or isotropic data sets, allowing multiplanar anatomic representations. Using such high-resolution techniques, excellent results were obtained in a prospective study by Perri et al comparing CT and endoscopy for the detection of esophageal varices [8]. A more specialized CT esophagography examination incorporating luminal distention with air insufflation and scan coverage of the esophagus through the entire thorax has also been shown to be promising in another prospective study by Kim et al [9]. Such a protocol, however, at least partially negates the advantages of non-invasiveness (catheter intubation and insufflation of the esophagus and IV administration of antispasmodic agent) and technical concision (addition of chest scanning) that recommend imaging over endoscopy in this setting. We aimed to study the accuracy of a standard triple-phase liver CT protocol using 3 mm slices in the portal phase without cumbersome patient manipulation for the detection of high-risk varices.

CT findings of esophageal wall thickening, intraluminal protrusions or irregularities, and nodular enhancement within the wall suggest the presence of esophageal varices [10]. However, wall thickening and intraluminal protrusions are not specific for esophageal varices because the normal esophagus could show such findings owing to peristalsis or redundant mucosal folds [11]. Also, such findings may be present in other esophageal diseases, including esophageal carcinoma or esophagitis [12]. Paraesophageal varices may be seen as dilated veins closely juxtaposed to the outer wall of the esophagus. It is not always easy to distinguish paraesophageal varices from esophageal varices, especially if the esophageal wall is collapsed, given their intimate anatomic relationship [13]. It is sometimes difficult to visualize small enhancing varices almost embedded in the wall of esophagus [14] because the wall itself enhances to variable degrees. Finally, variceal enhancement may have been suboptimal because we used a fixed time delay rather than a bolus-tracking technique, which would allow more accurate timing of arterial and portal venous phases [15].

In our study esophageal varices were detected in 24(77%) patients on MDCT. Varices were absent in 7 (23%) patients. The average maximum short axis diameter of the detected varices was 3.4 ±1.4 (SD) mm with a range of 1.2-6.9 mm. We used 5 mm criteria in our study to differentiate high risk EV from low risk which yielded high Specificity and PPV however sensitivity was very poor alongwith low NPV. Also the association with red color sign seen at endoscopy was poor. Perri et al (2008) conducted a study in which they used similar criteria of 5 mm to define high risk cases and showed 56% and 66% sensitivity for two different radiologists[8]. Specificity was 55% and 45%. The reason for this discrepancy is unclear but is likely multifactorial. First, the measurement technique that was detailed in their methods may have favoured more liberal sizes. For instance, they did not measure the short-axis on the axial images, as shown by the included figures that routinely show callipers in the transverse axis. They used coronal or sagittal maximum-intensity projection reconstructions, also suggested in the figures, which are well known to exaggerate luminal diameter.

Our results suggest 3 mm is a useful CT threshold size for defining large esophageal varices. Although a 4-mm cut off yielded improved specificity and positive predictive value, the more conservative criterion of 3 mm may be prudent for screening applications in which sensitivity and negative predictive value should receive priority (92.8% and 93.3%, respectively, in our series).It showed better



correlation with the red color sign. In study done by Kim et al (2007) 3 mm cut off yielded 92% and 98% of specificity and NPV [9].Likewise, a recent preliminary report byChiorean et al., presented at the 2004 annual meeting of the ARRS), of a study in which 41 patients were included, also suggested a 3-mm criterion for CT differentiation of large esophageal varices from small varices[16].

We analysed the MDCT images on standard 3mm sections and thin section reconstruction of 0.9mm with multiplanar reformations. We also created MIP (maximal intensity projection) and volume rendered images. We found very little difference between the standard 3mm and 0.9 mm reconstructed images. In a study by Nam et al (2011) standard 5mm slice thickness was compared with thin section multiplanar reconstruction at 1 to 3 mm and they found that sensitivity and NPV were same for both the settings however specificity improved due to decrease in the partial volume effect [17].In our institution, we routinely perform portovenous phase scanning at 3 mm interval and in our study we did not find thinner sections reconstruction very beneficial. Because varices course craniocaudally the increase in z-axis resolution afforded by modern scanners and with thinner axial reconstructions may be of marginal benefit. Also, these thicker-slice images appear easier to read because of lower noise. The MIP images were very useful in the demonstration of collaterals; however the other 3D rendering techniques which we created for image interpretation (volume rendering, surface shading) had little advantage and was time consuming so we did not use such images in our result interpretations. Willmann et al. (2003) compared the visualization ability of MDCT with endoscopic ultrasound (EUS) for varices of the cardiac region and reported that MDCT had visualization ability equal to that of EUS and was able to distinguish submucous from perigastric varices [18]. Matsumoto et al. (2001) compared the visualization ability of MDCT-portography with that of conventional angiography in patients with varices in the gastric fundus and peripheral vessels, and described the utility of MDCT [19]. During CT the esophagus is in its normal, nondistended state which permits variceal channels to be unaffected accounting for some of the discrepancy between the two techniques in assessing variceal size. Because bleeding from varices occurs while the esophagus is in its normal nondistended state, the measurement of varices in a nondistended state may provide a more accurate measure of which varices are at risk of bleeding.

A correlation was studied between the diameters of esophageal mural veins as observed on routine magnetic resonance angiography and the endoscopic grades of esophageal varices in patients with portal hypertension by Erden et al[20]. A correlation was found between the diameters of the esophageal mural veins and the endoscopic grades of the esophageal varices. Magnetic resonance angiography may give information about the status of esophageal varices in portal hypertension in future..

**Limitation of study**

In our study we used fixed time delay both during arterial and portovenous phase. A bolus tracking technique should further improve the accuracy of such studies.

Breath holding during CT may result in increased intrathoracic and intraabdominal pressure from the Valsalva effect to partly decompress the varices.

Red color signs cannot be evaluated directly on CT and few small varices with such stigmata may occasionally be missed. We did not collect accurate data about the bleeding episodes or therapeutic interventions (that may lead to reduction in the size of the varices) from patients beyond the exclusion period of two weeks in our study which may also explain the occurrence of red color signs in low risk (F0 and F1) cases.

Another limitation is that endoscopy is not a perfectly ideal reference standard given a grading system that relies on subjective visual assessment. Indeed, significant interobserver variability and intraobserver variability have been reported in endoscopic grading .Certainly a bleeding event on prospective lengthy follow-up would provide the best reference standard for distinguishing low from high-risk disease but would be difficult to incorporate into a practical study design and also was not possible because patients were appropriately treated based on concurrent endoscopic findings.

**CONCLUSION**

- MDCT is an excellent modality for the detection of collaterals including esophageal varices. It is non-invasive and allows accurate localization and grading of esophageal varices, as well as differentiation between low and high risk varices with regard to propensity for bleeding.
- Our study revealed a good correlation between the MDCT size of esophageal varices and endoscopic form and the presence of red color sign. The overall sensitivity, specificity, PPV and NPV was 88.4%, 80%, 95.8% and 57.1% respectively in detection of esophageal varices.
- A 5mm criterion for stratification of varices in high and low risk was poor in identifying high risk varices with sensitivity, specificity, PPV and NPV of 21.4%, 100%, 100% and 60.7% respectively.
- A criterion of a 3-mm diameter on CT for large varices could be useful in identifying high-risk esophageal varices. In our study, the sensitivity and specificity for predicting high-risk esophageal varices were approximately 92.8% and 82.3%, respectively for 3 mm criteria. Because this conservative cut off will inevitably capture a proportion of low-risk patients without large varices (specificity of 82.3% and positive predictive value of 81.2%, in our series), endoscopy may be used for definitive diagnosis in the identified group before initiation of prophylactic therapy. In this way, CT, rather than obviating endoscopy, may play an adjunctive role by allowing a more targeted, cost-effective application of diagnostic and therapeutic endoscopy.

**Recommendations**

- The use of 80 KV scanning will further improve the visualization of esophageal varices as the iodine signal is 1.5-2.0 times greater when scanning at this low energy, but may require new two-tube CT systems to reduce imaging noise in heavy patients.

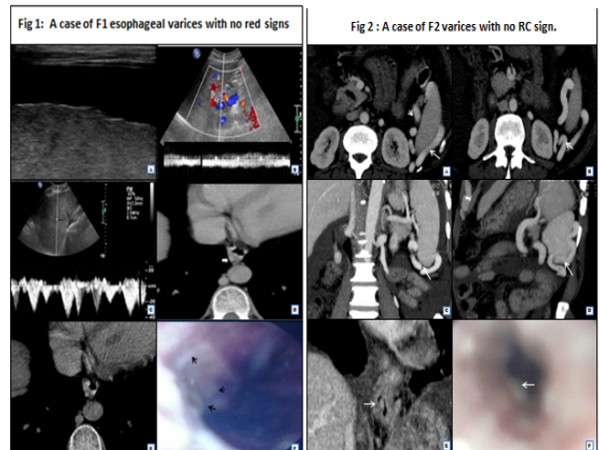


Fig 1: 25 yr old patient with cirrhosis with F1 varices (RC0) showing (A) sagittal nodular liver surface , coarse nodules and ascites (B) Portal vein maximum velocity is decreased (C) Hepatic veins shows triphasic wave pattern. (D) scalloped esophageal lumen with enhancing submucosal esophageal veins (black arrow), paraesophageal veins (white arrow). (E) Thin section axial reconstruction at 0.9 mm showing similar findings. (F) Endoscopic image showing faint linear varices with no RC signs (black arrows).

Fig 2: A case of F2 varices with no RC sign. 63-yr old male with alcoholic cirrhosis (A - D) Axial MIP MDCT images show dilated and tortuous perigastric (short arrow) and splenoportal (long arrow) collaterals, coronal and sagittal images show splenoportal collaterals. (E) Coronal sections portovenous phase shows nodular enhancement of submucosal veins with protrusion in the esophageal lumen. (F) Endoscopic image showing F2 nodular esophageal varices.

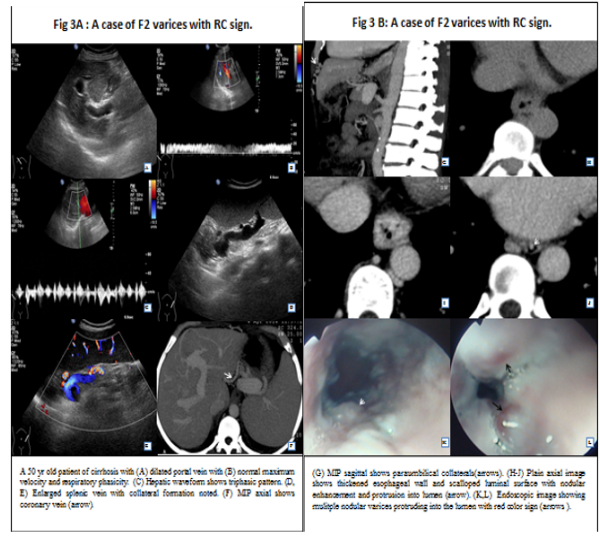
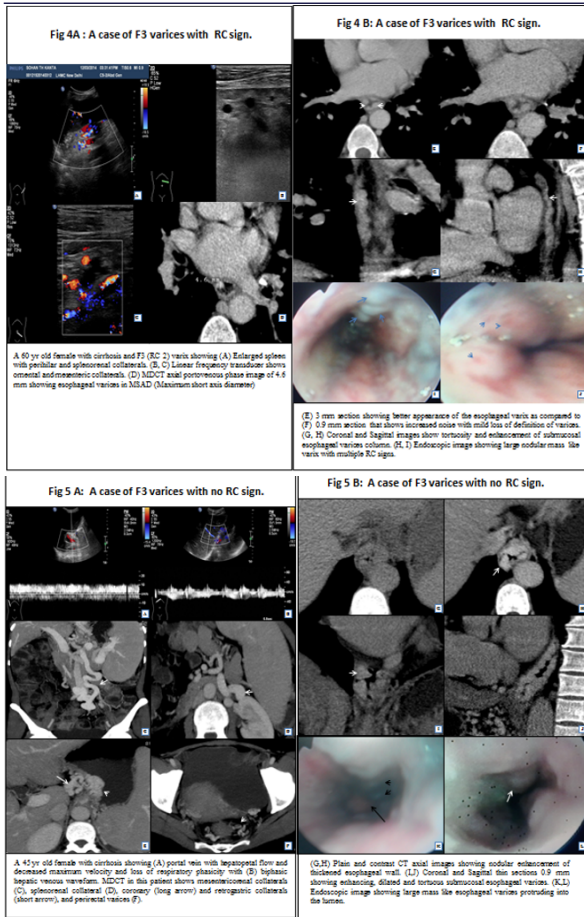


Fig 3A: A case of F2 varices with RC sign. A 30-yr old patient of cirrhosis with (A) dilated portal vein with (B) normal maximum velocity and respiratory phasicity (C) Hepatic variforms shows triphasic pattern. (D, E) Enlarged splenic vein with collateral formation noted. (F) MIP axial shows coronary vein (arrow).

Fig 3B: A case of F2 varices with RC sign. (A) 50-yr old patient of cirrhosis with (A) dilated portal vein with (B) normal maximum velocity and respiratory phasicity (C) Hepatic variforms shows triphasic pattern. (D, E) Enlarged splenic vein with collateral formation noted. (F) MIP axial shows coronary vein (arrow).



**REFERENCES**

- RyeK,Scott R, Mortimore G, Lawson A, Austin A, Freeman J. Towards Noninvasive Detection of Oesophageal Varices. International journal of Hepatology.2012;343591
- Bosch J, Abraldes JG, Berzigotti A, Garcia-Pagan JC, Portal Hypertension and Gastrointestinal Bleeding. Seminars in Liver Disease.2008;28(1):3-25.
- Arora A,Rajesh S, Yamini S, Binit S, Kalpana B, Sarin SK. Spectrum of hepatofugal collateral pathways in portal hypertension: an illustrated radiological review. Insights into Imaging.2015;5(6): 559-572
- Ajayi AO, Ajayi EA, RaimTHi, FadareJO,Soloman OA, Adeoti AO. Oesophageal varices in patients with liver cirrhosis. Scientific Journal of Medical Science.2013;2(11):212-
- Tajiri T, Yoshida H, Obara K, OnjiM,Kage M et al.General rules for endoscopic findings of esophagogastric varices(2nd edition).2010;22(1):1-9
- Mifune H,Akaki S, Ida K, Sei T, Kanazawa S, Okada H et al. Evaluation of esophageal varices by Multidetector- row CT: Correlation with Endoscopic 'Red Color Sign'.ActaMedica Okayama. 2007;61(5):247
- Kim SH, Kim YJ, Lee JM, Choi KD, Chung YJ, Han JK et al. Esophageal varices in patients with cirrhosis: Multidetector CT Esophagography- Comparison with Endoscopy. Radiology.2007;242(3):759-68
- PerriRE,Chiorean MV, Fidler JL, Fletcher JG,Talwalkar JA, Stadheim L et al. A prospective evaluation of computerized tomography (CT) scanning as a screening modality for esophageal varices. Hepatology.2008;47(5):1587-94
- Kim YJ, Raman SS, Nam CY, To'o KJ, Jutabha R, Lu DSK. Esophageal varices in cirrhotic patients: evaluation with liver CT. American Journal of Roentgenology.2007;188(1):139-44
- Burton JR, Liangpunsakul S, Lapidus J, Giannini E, Chalasani N, Zaman A. Validation of a multivariate model predicting presence and size of varices. Journal of Clinical Gastroenterology.2007;41(6)609-1514.
- Paquet KJ, Causes and pathomechanisms of oesophageal Varices Development. Medical Science Monitor: International Medical Journal of Experimental and Clinical Research.1999.6(5):915-2819.
- Popper H, Zak FG. Pathological aspects of cirrhosis. Am J Med.1958;24:593-625
- Baldus WP, Hoffbauer FW. Vascular changes in the cirrhotic liver as studied by injection technique. Am J Digest Dis.1993;8:689-92
- Genecin P, Groszman RJ. Portal Hypertension. In: Schiff E, Schiff L (eds): Diseases of the Liver. JB Lippincott Company, Philadelphia. 1993;935-73
- Columbato LA, AlbillosA,Groszman RJ. Temporal relationship of peripheral vasodilation, plasma volume expansion and the hyperdynamic circulatory state in portal hypertensive rats.Hepatology. 1992;15:323-28.
- Ma Somsouk,Katherine To'o, Mujtaba Ali, Eric Vittinghoff, BenzaminM,et al.Esophageal varices on computed tomography and subsequent variceal hemorrhage.Abdom Imaging.2014;39(2):251-256
- Nam C, Yu, Daniel Margolis,Margret Hsu, Steven S Raman, et al. Detection and Grading of Esophageal Varices on Liver CT: Comparison of Standard and Thin-Section Multiplanar Reconstructions in Diagnostic Accuracy. American journal of Roentgenology2011;197(3):643-649
- J K Willman, D Weishaupt, T Bohm, T Pfammatter,et al. Detection of submucosal gastric fundal varices with multi-detector row CT angiography. Gut.2003;52(6):886-892
- Matsumoto A, Kitamoto M, Imamura M,Nakanishi T, Ono C, Ito K,et al. Three-dimensional portography using multislice helical CT is clinically useful for management of gastric fundic varices. Am J Roentgenology.2001;176:899-905
- Erden A, Idilman R, Erden I, Bektas M, Ozden A. MR angiography of esophageal mural