

Evaluation of Esophageal Varices by Multidetector-row CT: Correlation with Endoscopic 'Red Color Sign'

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To evaluate the ability of multidetector-row CT (MDCT) to predict a risk of hemorrhage in patients with esophageal varices, a total of 40 MDCT scans were performed in 29 patients who had been diagnosed with esophageal varices by conventional upper gastrointestinal tract endoscopy. In 11 patients, MDCT was performed both before and after endoscopic injection sclerotherapy (EIS). Endoscopically, the red color sign (RC sign) was present in 28 scans. Of the 11 patients who underwent EIS, the RC sign disappeared after EIS in 9. The MDCT scans were obtained in the arterial, portal, and equilibril phases, and the portal phase images were used in this study. Subsequently, the extent of esophageal varices was categorized into four MDCT scores. The variceal score, the maximum short axis of the varices, and the presence of palisade vein dilatation obtained from MDCT had significant correlation with endoscopic variceal forms, and the presence and severity of RC sign, respectively ($p < 0.01$). All cases with a maximum minor axis of more than 4 mm showed positive RC sign. MDCT was useful in the evaluation of esophageal varices for predicting a risk of hemorrhage.

Key words: esophageal varices, red color sign, MDCT

In patients with esophageal varices, rupture and hemorrhage are major factors aggravating prognosis, so it is important to be able to predict these complications [1, 2]. In endoscopic findings, particularly, cases with erythrogenic findings (the red color (RC) sign) are known to be liable to bleeding [3-5].

Recently, the utility of hemodynamics evaluation by use of computed tomography (CT) or multidetector-row CT (MDCT) before esophagogastric varices treatment has been reported [6-8]. However, we can

find no known reports comparing MDCT findings with endoscopic findings. Thus, the purpose of our study was to evaluate the ability of MDCT in comparison with endoscopic findings to predict the risk of hemorrhage in patients with esophageal varices.

Subjects and Methods

At Okayama University Hospital, a total of 40 MDCT scans were performed in 29 patients (22 men, 7 women; age range 36-79 years; mean age 65 years) who had been diagnosed with esophageal varices by upper gastrointestinal tract endoscopy. Informed consent for CT scans and the use of contrast media was

obtained from all patients. In 11 patients, MDCT was performed both before and after endoscopic injection sclerotherapy (EIS). Intervals between MDCT scan and endoscopy ranged from 0 to 46 days. There were no symptomatic changes or additional therapy given between these examinations.

Endoscopic findings. Endoscopically, esophageal varices were evaluated as to location and form, and presence or absence of RC sign. These findings were evaluated following The General Rules for Study of Portal Hypertension (The Japan Society for Portal Hypertension, 2nd Edition, 2004) [9]. Lesion location was categorized as follows: Li: found only in the lower part of the esophagus, Lm: found from the lower to the middle part, Ls: found anywhere from the lower to the superior part. Form was classified as follows: F₁: linear relatively faint varices. F₂: bead-shaped moderate varices. F₃: nodule or mass-shaped varices. When varices were not found after EIS treatment, the form was defined as F₀.

The RC sign was defined as existing when erythrocytic findings were seen on the varices endoscopically. To evaluate the risk of hemorrhage and degree of pressure, we classified the RC sign subjectively into 4 categories of severity as follows: RC₀: there were no erythrocytic findings. RC₁: a few localized erythrocytic findings. RC₂: between RC₁ and RC₃. RC₃: many erythrocytic findings through 360°.

MDCT technique. The MDCT examinations were performed with a 4-detector scanner (Aquilion, Toshiba Medical Systems, Tokyo, Japan). The contrast media used was 100 ml of iohexol (iodine component 300 mg/ml, Omnipaque 300 Syringe, DAIICHI SANKYO CO., LTD., Tokyo, Japan). The infusion rate of contrast media was 4 ml per second. In patients weighing more than 60 kg, a higher quantity of contrast media (150 ml) was used.

The region of interest was set to the aorta at the epigastric level, and MDCT scanning was performed consecutively in real time immediately after injection of the contrast media. The portal venous phase was set to begin 45 sec after the arrival of contrast media in the aorta. In the portal venous phase, the scan range was from the level of the tracheal bifurcation to the caudate margin of the liver. Other phase scans (non-enhanced, arterial, and equilibrium phase) were also performed in 21 of 29 patients. In these cases, scans were performed at 2-mm collimation at a table

speed of 11 mm per rotation, reconstitution was done at 1-mm thickness and the scan range included the whole liver. The arterial phase and equilibrium phase were set to begin 18 sec and 3 min after the arrival of contrast media in the aorta, respectively. In the remaining 8 patients, scans were performed only in the portal venous phase because variceal visualization was the sole purpose of the examination. In these cases, scans were performed at 1-mm collimation at a table speed of 5.5 mm per rotation, and reconstitution was done at 0.5-mm thickness.

An Aquarius workstation (TeraRecon, Inc., San Mateo, CA, USA) was used for image postprocessing. 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 (volume rendering, maximum intensity projection; MIP) were made. These images were anteriorly observed from right to left through 90 degrees with 15-degree increments. Multiplanar reformation images of axial and coronal sections were made at 0.5- or 1-mm thickness, and a 5-mm interval in the region where varices were visualized. We also reviewed the source images. We referred mainly to the source images and multiplanar reformation in drawing our conclusions.

From data obtained in MDCT, depicted variceal findings were categorized into 4 groups as follows: Score 0: no varices visualization on the inner surface of the esophagus; Score 1: 1 varix less than 5 mm in diameter detected on the inner surface of the esophagus; Score 2: several varices less than 5 mm in diameter detected on the inner surface of the esophagus; Score 3: 1 varix 5 mm or greater in diameter, or varices occupying more than half the circumference of the esophagus [6].

The maximum minor axis of the varices (mm) and presence or absence of palisade vein dilatation ((+) or (-)) were also recorded. Palisade vein dilatation was defined as visualization of vessels that traversed between the lower esophagus and the cardiac region [9]. When palisade veins dilatation did exist, but contrast enhancement of the veins was relatively poorer than before EIS treatment, the degree was defined as (±).

The evaluations were made with agreement of 2 radiologists who were not aware of the endoscopy results, and consensus was obtained whenever their

opinions differed.

The statistical analysis was performed by use of Dr. SPSS II for Windows Version 11.0.1J (SPSS Japan Inc., Tokyo, Japan). Mann-Whitney's U test was used for comparison between the presence of RC sign and MDCT score, the maximum minor axis of varices. Fisher's exact probability test was used for comparison between presence of the RC sign and palisade vein dilatation. In the comparisons between the severity of the RC sign and MDCT score, the maximum minor axis of varices, and degree of palisade vein dilatation, severity of RC sign and degree of palisade vein dilatation were expressed numerically, respectively, and then evaluated by Spearman's rank correlation. Furthermore, endoscopic variceal forms were also compared using the MDCT score, the maximum minor axis of varices, and degree of palisade vein dilatation. $p < 0.05$ was considered to be a statistically significant difference.

Results

Endoscopic findings

1. Form. In a total of 40 scans, F₁ varices were seen in 13, F₂ varices were seen in 17, and F₃ varices were seen in 5. F₀ varices were seen in 5 patients who underwent EIS therapy.

2. RC sign. In a total of 40 scans, the RC sign was present in 28. RC₁ was seen in 16, RC₂ in 11, and RC₃ in 1. RC₀ was seen in 12 cases. Of 11 patients who had EIS treatment, RC signs disappeared in 9.

MDCT findings

The data obtained from MDCT was analyzed and compared with endoscopic variceal forms (Table 1) and RC signs (Table 2).

1. MDCT score. Of the MDCT scores, 5 were judged to be "0", 7 were judged to be "1", 11 were judged to be "2", and 17 were judged to be "3". Of these, patients with small MDCT scores tended to have a lower degree of variceal forms and no or lower degree of RC sign, and, on the other hand, patients with large scores tended to have a stronger degree of variceal forms and a positive or stronger degree of RC sign. These MDCT findings were well correlated with variceal forms (Spearman's rank correlation, $p < 0.01$) and with the presence and severity of RC sign (Mann-Whitney's U test and Spearman's rank correlation, $p < 0.01$).

2. Maximum minor axis. The maximum minor axis of the varices on MDCT ranged from 0 to 3 mm (mean 1.6 mm) in cases without RC signs, from 0 to 8 mm (mean 4 mm) in cases with RC₁, from 2 to 9 mm (mean 5.2 mm) in cases with RC₂, and was 2 mm in 1 case with RC₃. The maximum minor axis of the varices was correlated with variceal forms (Spearman's rank correlation, $p < 0.01$) and presence and severity of RC sign (Mann-Whitney's U test and Spearman's rank correlation, $p < 0.01$).

In cases with a maximum minor axis of the varices of more than 4 mm, sensitivity for presence of the RC sign was 67%, specificity was 100%, and accuracy was 40%. In other words, they all showed positive

Table 1 MDCT score, maximum minor axis and presence of palisade vein dilatation compared with endoscopic variceal forms

Form	F ₀ 5	F ₁ 13	F ₂ 17	F ₃ 5	Total	
MDCT score						$p < 0.01$
0	1	4	0	0	5	
1	2	4	1	0	7	
2	1	4	5	1	11	
3	1	1	11	4	17	
maximum minor axis (mm)						$p < 0.01$
	0-3 [1.6] [†]	0-5 [1.9]	2-9 [4.4]	2-8 [6.2]		
palisade vein dilatation						$p < 0.01$
(-)	2	8	0	0	10	
(±)	2	1	0	1	4	
(+)	1	4	17	4	26	

[†]Numbers in brackets indicate the mean.

Table 2 MDCT score, maximum minor axis, and presence of palisade vein dilatation compared with endoscopic RC sign

RC sign	RC ₀ 12	RC ₁ 16	RC ₂ 11	RC ₃ 1	Total	
MDCT score						$p < 0.01$
0	4	1	0	0	5	
1	4	1	2	0	7	
2	3	6	1	1	11	
3	1	8	8	0	17	
maximum minor axis (mm)	0-3 [1.6] [†]	0-8 [4]	2-9 [5.2]	2 [2]		$p < 0.01$
palisade vein dilatation						$p < 0.01$
(-)	7	2	1	0	10	
(±)	3	1	0	0	4	
(+)	2	13	10	1	26	

[†]Numbers in brackets indicate the mean.

RC signs.

3. Palisade vein dilatation. In examining palisade vein dilatation, we judged 10 to be (-) and 26 to be (+). Four were defined as (±) because contrast enhancement of the dilated palisade vein became poorer after EIS treatment. Of these, cases judged to be (-) or (±) tended to have no RC sign or lower degree RC sign, whereas cases judged to be (+) tended to have positive and stronger RC signs. These findings of palisade vein dilatation also correlated with variceal forms (Spearman's rank correlation, $p < 0.01$) and presence and severity of RC sign (Fisher's exact probability test and Spearman's rank correlation, $p < 0.01$).

Fig. 1 shows the results of examination of a 57-year-old man with esophageal varices (EV) (Lm, F₂, RC₂, MDCT score 3, maximum minor axis 9 mm, palisade vein dilatation (+)). The axial MDCT image shows submucosal varices in the posterior wall of the lower esophagus (Fig. 1A). In a coronal section, consecutive palisade vein dilatation is clearly depicted (Fig. 1B). The endoscopic image shows bead-shaped moderate varices (Fig. 1C). These findings were significantly correlated with MDCT. A maximum intensity projection image shows consecutive flow in the left gastric vein from the portal trunk reaches gastric varices, and continues on to esophageal varices via a dilated palisade vein (Fig. 1D).

Fig. 2 shows the results of examination of a 79-year-old man with EV (Lm, F₂, RC₂, MDCT score 3, maximum minor axis 6 mm, palisade vein

dilatation (+)). The axial MDCT image before EIS shows submucosal varices in the right wall of the lower esophagus (Fig. 2A). After EIS, varices are not observed (Fig. 2B). Submucosal varices in the lower esophagus are also depicted in the coronal image taken before EIS (Fig. 2C). After EIS, varices were endoscopically improved to Lm, F₁, and RC₀ and to score 0, maximum minor axis 0, and palisade vein dilatation (-) in MDCT (Fig. 2D). An endoscopic image shows bead-shaped moderate varices and RC sign before EIS (Fig. 2E). After EIS, RC sign had disappeared (Fig. 2F). Each endoscopic finding correlated significantly with MDCT. Coronal images of the cardiac region show palisade vein dilatation before EIS (Fig. 2G), and the dilatation has disappeared after EIS (Fig. 2H). These findings are also significantly correlated with endoscopic findings.

Fig. 3 shows the results of examination of a 62-year-old man with EV (Lm, F₁, RC₂, MDCT score 1, maximum minor axis 3 mm, palisade vein dilatation (-)). The axial MDCT image (Fig. 3A) and coronal image (Fig. 3B) of the lower esophagus are shown. Submucosal varices can be seen in the posterior wall of the lower esophagus. No palisade vein dilatation was seen in a coronal MDCT image of the cardiac region (Fig. 3C), but the endoscopic finding is RC₂ (Fig. 3D). It was difficult to predict the RC sign in this case.

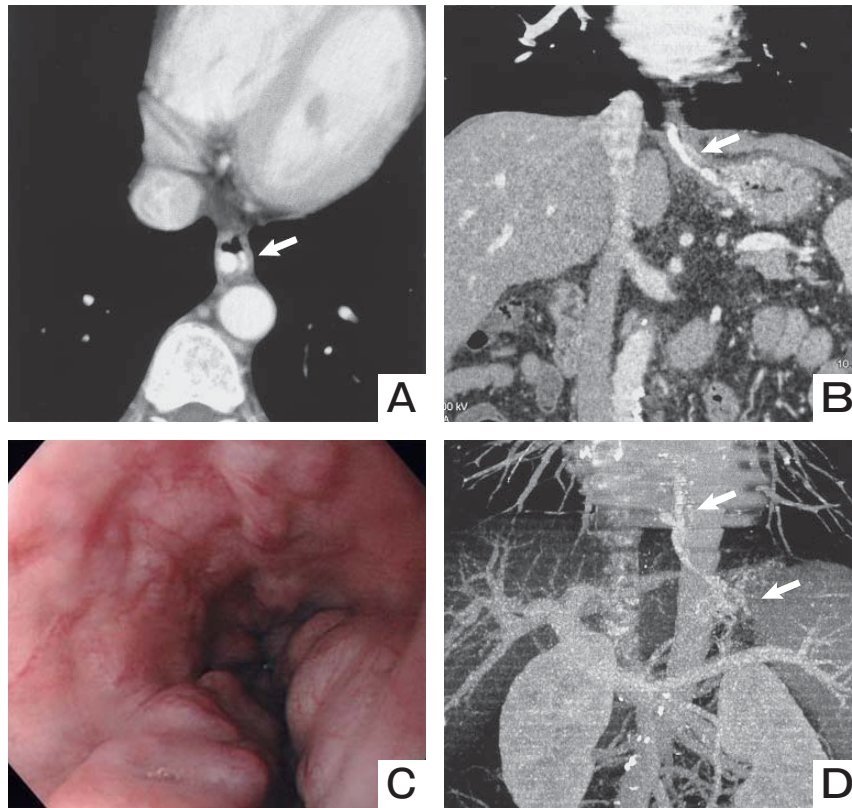


Fig. 1 A 57-year-old man with EV (Lm, F₂, RC₂). (MDCT score 3, maximum minor axis 9 mm, palisade vein dilatation (+)) **A**, Axial MDCT image (1-mm reconstructed) shows submucosal varices in the posterior wall of the lower esophagus (arrow); **B**, In coronal section, consecutive palisade vein dilatation is clearly depicted (arrow). Endoscopic findings were significantly correlated with MDCT; **C**, Endoscopic image shows bead-shaped moderate varices; **D**, Maximum intensity projection image. Consecutive flow in the left gastric vein from the portal trunk reaches gastric varices and continues on to esophageal varices via a dilated palisade vein (arrow).

Discussion

In patients who have esophageal varices, rupture and hemorrhage are major factors aggravating prognosis [1, 2]. When RC signs are found endoscopically, it is an indication that the varices are likely to bleed, and such patients can become good candidates for treatment such as EIS [3–5]. It was difficult to predict varices, however, in patients who did not undergo endoscopic examination.

Willmann *et al.* compared the visualization ability of MDCT with endoscopic ultrasound (EUS) for varices of the cardiac region and reported that MDCT had a visualization ability equal to that of EUS and was able to distinguish submucous from perigastric varices [7]. Matsumoto *et al.* 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 [8]. There are some reports evaluating esophageal and other varices using single helical CT [6, 10–13] and magnetic resonance imaging [14]. However, to our knowledge there have been no reports about esophageal varices that compared MDCT findings with endoscopic findings.

When the inner pressure or the diameter of varices increases, they bleed more easily. Tsai *et al.* reviewed CT portography for esophageal varices [15] and, according to their report, the frequency of esophageal varices bleeding was significantly higher in patients in whom contrast enhancement of the collateral circulation reached the inner wall of the esophagus, compared to patients who only showed contrast enhancement of the portal vein and other collateral

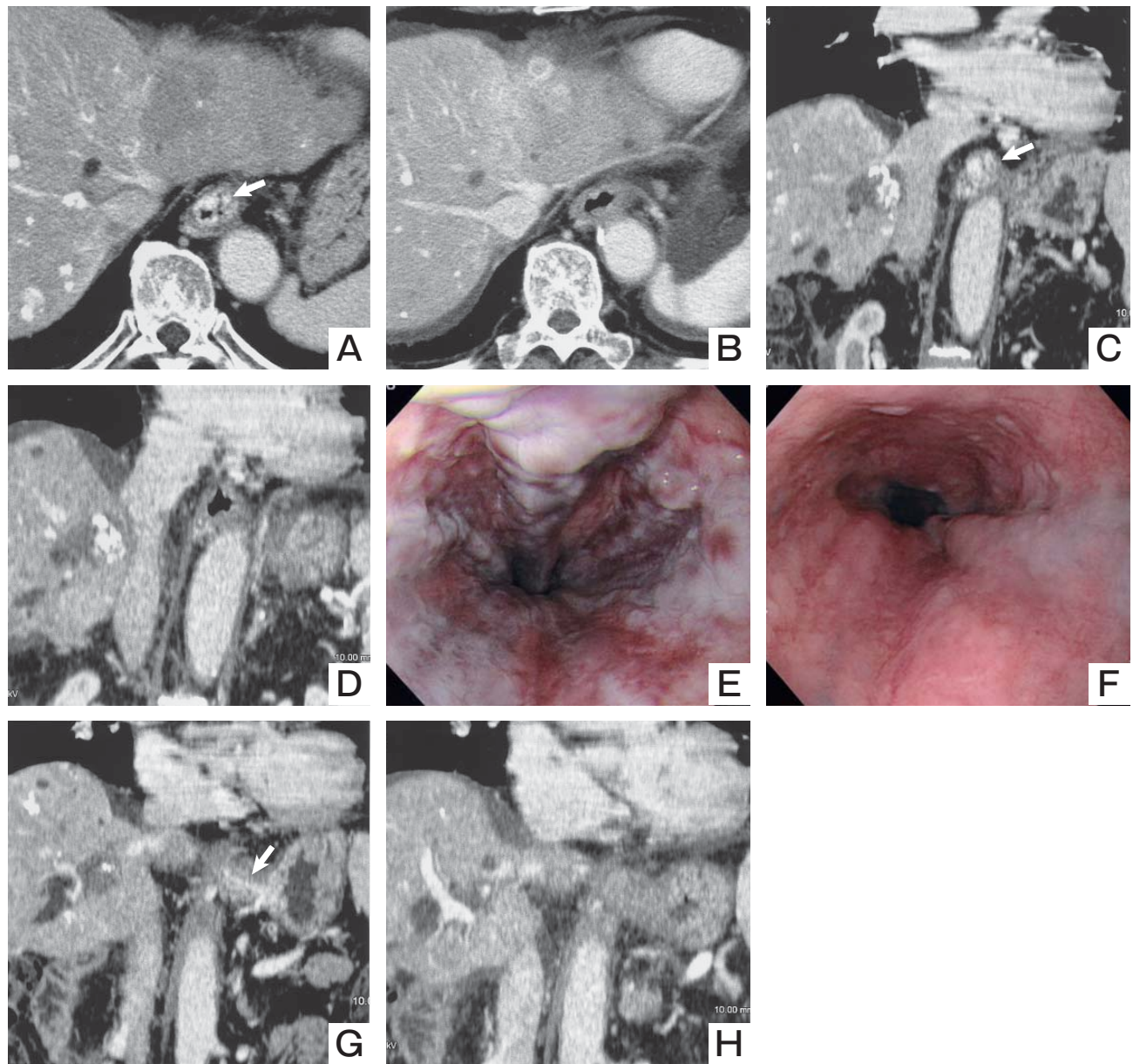


Fig. 2 A 79-year-old man with EV (Lm, F₂, RC₂). (MDCT score 3, maximum minor axis 6 mm, palisade vein dilatation (+)) **A**, Axial MDCT image (1-mm reconstructed) before EIS shows submucosal varices in the right wall of the lower esophagus (arrow); **B**, After EIS, varices are not observed; **C**, Submucosal varices in the lower esophagus (arrow) are also depicted in a coronal image before EIS; **D**, After EIS. Varices were endoscopically improved to Lm, F₁, and RC₀ and to score 0, maximum minor axis 0, and palisade vein dilatation (-) in MDCT. Each endoscopic finding correlated significantly with MDCT; **E**, Endoscopic image shows bead-shaped moderate varices and red color sign before EIS; **F**, After EIS, red color sign has disappeared; **G**, **H**, Coronal images (1-mm reconstructed) of cardiac region. **G**, Palisade vein dilatation is seen before EIS (arrow), and **H**, this has disappeared after EIS. These findings are also significantly correlated with endoscopic findings.

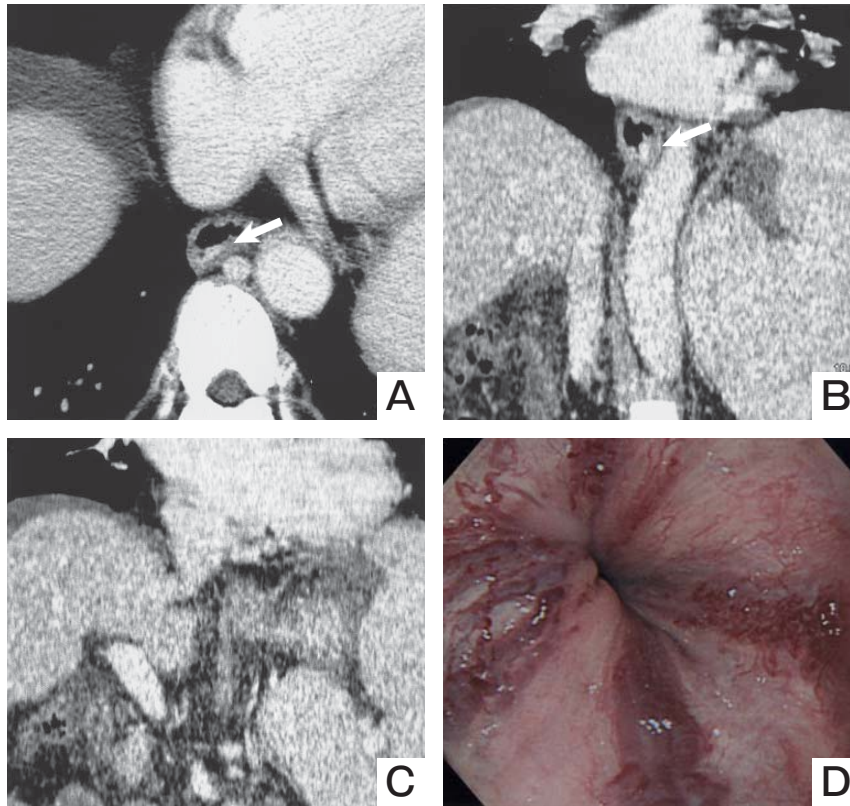


Fig. 3 A 62-year-old man with EV (Lm, F₁, RC₂). (MDCT score 1, maximum minor axis 3 mm, palisade vein dilatation (-)) **A**, Axial MDCT image (1-mm reconstructed) and **B**, coronal image of the lower esophagus. Submucosal varices can be seen in the posterior wall of the lower esophagus (arrow); **C**, No palisade vein dilatation was seen in a coronal MDCT image of the cardiac region; **D**, Endoscopic finding is RC₂. It was difficult to predict RC sign in this case.

circulation. Because such blood flow reaching the esophageal lumen tended to flow in from the gastric veins via palisade veins, dilatation of those veins was added to the list of findings of MDCT that could be used to predict rupture.

With a minimal magnification of scanning area only to the level of tracheal bifurcation in the portal phase, esophageal varices evaluation by MDCT could be performed, and could be compared with endoscopic findings. As mentioned above, each variceal score, maximum minor axis, and palisade vein dilatation obtained from MDCT was significantly correlated with variceal forms, and presence and severity of the RC sign. Therefore, the MDCT data were useful for predicting variceal form, and presence and severity of RC sign. Moreover, in cases with a maximum minor axis of more than 4 mm, all patients showed a positive RC sign, so this seems to be an important index for the

diagnosis and treatment of esophageal varices.

We conclude that some MDCT findings are strong enough to predict endoscopic RC sign with a high hemorrhagic risk. Whenever these findings are seen, endoscopic examination and subsequent treatment must be actively considered. An advantage of this method is that MDCT technique is routinely available.

There were some limitations to our study. One is that our study was limited to patients who were confirmed to have esophageal varices endoscopically. Moreover, an endoscopist might tend to order MDCT examination for patients with RC signs needing future treatment, but not in cases with slight varices. This fact alone might promote a significant bias. Another possible limitation is the fact that patients after EIS therapy were included in this study, which is problematic because there may be some difference in RC sign frequency in patients before treatment and those after

treatment even though varix form or size is the same. This also might create a bias.

In the future, serious consideration will have to be given to including more patients with portal hypertension in this type of study, and to dividing patients into 'before' and 'after' treatment when considering the results.

In conclusion, MDCT was useful in evaluation of esophageal varices for predicting a risk of hemorrhage. With a minimal magnification of scanning area to the level of tracheal bifurcation in the portal phase, distinct esophageal varices evaluation could be routinely done by MDCT.

References

1. Park DK, Um SH, Lee JW, Lee JB, Kim YS, Park CH, Jin YT, Chun HJ, Lee HS, Lee SW, Choi JH, Kim CD, Ryu HS and Hyun JH: Clinical significance of variceal hemorrhage in recent years in patients with liver cirrhosis and esophageal varices. *J Gastroenterol Hepatol* (2004) 19: 1042-1051.
2. Graham DY and Smith JL: The course of patients after variceal hemorrhage. *Gastroenterology* (1981) 80: 800-809.
3. Merli M, Nicolini G, Angeloni S, Rinaldi V, De Santis A, Merkel C, Attili AF and Riggio O: Incidence and natural history of small esophageal varices in cirrhotic patients. *J Hepatol* (2003) 38: 266-272. Comment in: (2003) 38: 361-363.
4. Sarin SK, Lahoti D, Saxena SP, Murthy NS and Makwana UK: Prevalence, classification and natural history of gastric varices: a long-term follow-up study in 568 portal hypertension patients. *Hepatology* (1992) 16: 1343-1349.
5. de Franchis R and Primignani M: Why do varices bleed? *Gastroenterol Clin North Am* (1992) 21: 85-101.
6. Shimizu T, Namba R, Matsuoka T, Tabuchi K, Yamamoto K, Uesugi Y, Matsui R, Sueyoshi K and Narabayashi I: Esophageal varices before and after endoscopic variceal ligation: evaluation using helical CT. *Eur Radiol* (1999) 9: 1546-1549.
7. Willmann JK, Weishaupt D, Bohm T, Pfammatter T, Seifert B, Marincek B and Bauerfeind P: Detection of submucosal gastric fundal varices with multi-detector row CT angiography. *Gut* (2003) 52: 886-892.
8. Matsumoto A, Kitamoto M, Imamura M, Nakanishi T, Ono C, Ito K and Kajiyama G: Three-dimensional portography using multislice helical CT is clinically useful for management of gastric fundic varices. *Am J Roentgenol* (2001) 176: 899-905.
9. The Japan Society for Portal Hypertension: The General Rules for Study of Portal Hypertension, 2nd Ed, Kinbara, Tokyo (2004) pp 37-38 (in Japanese).
10. Cho KC, Patel YD, Wachsberg RH and Seeff J: Varices in portal hypertension: evaluation with CT: *Radiographics* (1995) 15: 609-622.
11. Gulati MS, Paul SB, Arora NK, Mathur P and Berry M: Esophageal and gastric vasculature in children with extrahepatic portal hypertension: evaluation by intravenous CT portography. *Clin Imaging* (2000) 24: 351-356.
12. Ibukuro K, Tsukiyama T, Mori K and Inoue Y: Preaortic esophageal veins: CT appearance. *Am J Roentgenol* (1998) 170: 1535-1538.
13. Levine CD, Gonzales RN and Wachsberg RH: CT evaluation of pararectal varices. *J comput assist Tomogr* (1997) 21: 992-995.
14. Imazu H, Matsui T, Noguchi R, Asada K, Miyamoto Y, Kawata M, Nakayama M, Matsuo N, Matsumura M and Fukui H: Magnetic resonance angiography for monitoring prophylactic endoscopic treatment of high risk esophageal varices. *Endoscopy* (2000) 32: 766-772.
15. Tsai HM, Lin XZ, Chang YC, Lin PW and Hsieh CC: Hepatofugal flow on computed tomography of arterial portography: its correlation with esophageal varices bleeding. *Hepatogastroenterology* (2000) 47: 1615-1618.