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ORIGINAL ARTICLE

Clinical Trials Study

Endoscopic measurement of variceal diameter

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Abstract

AIM: To measure *in vitro* diameter of imitational varices using a self-made endoscopic scale and confirm its accuracy and clinical feasibility.

METHODS: A catheter was introduced into the endoscope accessory channel and attached to a zebra wire guide that was used as a stylet. The wire guide was fixed onto the tip of the catheter by a soft and thin string. By gently advancing the stylet into the catheter, the width of the opening loop at the tip of the endoscope approximated the diameter of the imitational varices. Measurements performed *in vitro* using this self-made endoscopic ruler were compared to measurements of simulative varices.

RESULTS: At the handle, the sleeve moving distance ranged from 5 to 14 mm. There was no obvious proportional relationship between the sleeve movement distance and endoscopic measurement ruler. The results indicated that the gap between the endoscopic measurement and actual measurement of the object size tended to close. The *in vitro* measurement of the diameter of the simulative varices showed that the two kinds of measuring methods were not significantly different with respect to their accuracy (P = 0.8499).

CONCLUSION: *In vitro* experiments confirmed that using a self-designed endoscopic ruler to measure the diameter of simulative varices was objective, accurate and feasible.

Key words: Endoscopic measuring ruler; Variceal diameter; Visual method

Core tip: There are no specific criteria for variceal size assessment. There are different conventions for grading variceal size but little is known about their relative value. Subjective bias and inter-observer variation in the endoscopic evaluation of these predictors cannot be excluded. In this study, we compared the accuracy of *in vitro* measurement of the diameter of simulative varices by ruler with a self-made endoscopic scale. The results showed that the difference between the two methods was not statistically significant.

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INTRODUCTION

At present, endoscopic measurement of the variceal diameter of the gastrointestinal tract is mainly performed visually (providing a visual estimate) utilizing the clamp method (open biopsy forceps), an instrument rule, biopsy forceps and other physical standards[1-6] (substantial internal standards), of which the credibility is not high[7-9]. Although some recent articles have reported the successful use of the virtual internal standard endoscopic measuring method, these investigators did not conduct clinical evaluations of its efficacy[10,11] or investigate the reason for its use. The main factors that influence the use of virtual internal standard endoscopy are associated with the special requirements of the endoscopic equipment itself. In this study, we showed that the use of a self-made endoscopic measuring scale was easier to use and resulted in greater measuring accuracy. Moreover, the production of this endoscopic measuring ruler was simple.

MATERIALS AND METHODS

Equipment

Olympus GIF-H260 or Q260J electronic endoscopy system. Wilson-Cook one contrast catheter or pushing catheter (as outer cannula). Zebra guide wire 0.035 inches one diameter (as stylet); several columnar objects of varying diameter, mimicking varices; one red cylindrical container mimicking the shape of the human stomach.

Principle and set-up

One contrast catheter or pushing catheter was inserted as the loading catheter in the endoscope accessory channel and attached to the zebra wire guide into the catheter as a stylet. The stylet was fixed onto the tip of the catheter using a soft and thin string as described previously[12]. (1) the catheter was inserted into the endoscopic accessory channel, the wire guide was gently advanced into the catheter, and the width of the opening loop was made to approximate the diameter of the simulative varices. The width of the opening loop was measured and a mark on the handle at the junction of stylet and the loading catheter was made; (2) the stylet was pulled back to close the loop, and another mark was made on the handle at the junction of the stylet and the loading catheter; and (3) the distance between the two marks on the handle (the wire guide sliding distance on the handle) was measured. Thus, each time the diameter of the mimicking varix was made, which corresponded to the diameter of the opening loop, it corresponded to the distance between two marks on the handle. A diagram describing the principle of this endoscopic measuring scale is shown in Figure 1.

Operation

The procedure for measuring the diameter of the mimicking varix *in vitro* was as follows. (1) the wire guide in the catheter was slid ahead 0.5 cm on the handle, measuring the width of the opening loop at the tip of the endoscope, which was 0.1 cm. The sliding distance of the wire guide forward was 1.0 cm, and the width of the opening loop was 0.2 cm. When the wire guide slid forward 1.4 cm, the width of the opening loop was 0.3 cm; (2) when the wire guide slid forward to a maximum distance of 14.0 cm, the maximum width of the opening loop was 3.3 cm, which was the largest diameter of the opening loop at the tip of the endoscope; (3) this procedure was used to create a control table showing the width measurements of the opening loop at the tip of the endoscope corresponding to the wire guide moving length on the handle; and (4) selected *in vitro* measurement of the diameter of the mimicking varix with a self-designed endoscopic measuring scale in comparison with direct ruler measurement.

LDRf classification

Location (L): The location of the varices. Le represented the esophageal varices. The esophageal varices were divided into superior (s), middle (m) and inferior (i), and recorded as Les, Lem and Lei. If more than one part was included, the record combined all the relevant letters (Table 1).

Lg represented the gastric varices. The gastric varices were divided into founder (f), body (b) and antrum (a), and recorded as Lgf, Lgb and Lga, respectively. If gastric varices included more than one part, the record combined all the relevant letters.

Ld represented the duodenal varices. The duodenal varices included the first segment (duodenal bulb) and second segment (duodenal descending part), and recorded as Ld_1 and Ld_2. If duodenal varices included both segments, the two numbers were included. $Ld_{1,2}$ meant the varices located in the junction of the above two segments.

Lr represented the rectal varices. If the esophageal and gastric varices were extended from each other, the varices were recorded as Leg. If the esophageal and gastric varices were co-existing and independent, the varices were recorded as Le and Lg.

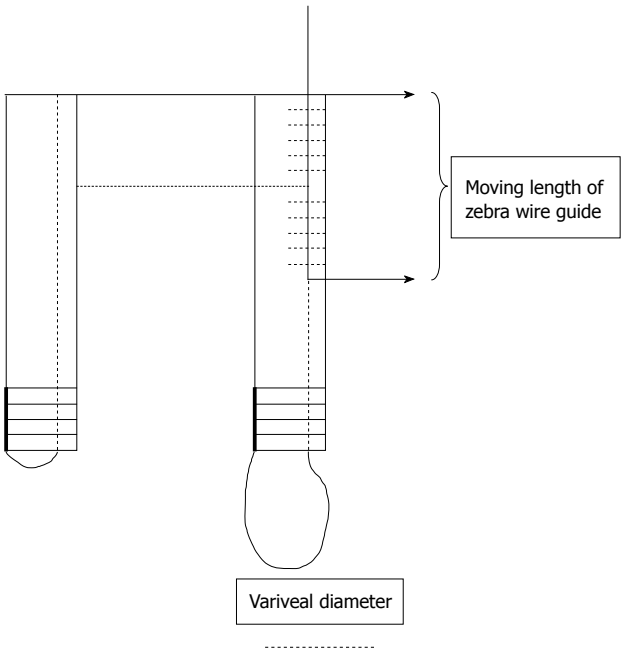

Figure 1 Diagram describing the principle of this endoscopic measuring scale. A: Closing loop of stylet; B: Opening loop of stylet.

Diameter (D): The diameter referred to the maximum diameter of the varices. The variceal diameter was divided into the following gradients: D_0: no varices; $D_{0.3}$: variceal diameter ⩽ 0.3 cm; D_1: variceal diameter 0.4-1.0 cm; $D_{1.5}$: variceal diameter 1.1-1.5 cm; D_2: variceal diameter 1.6-2.0 cm; D_3: variceal diameter from 2.1-3.0 cm; D_4: variceal diameter 3.1-4.0 cm; D_5: variceal diameter 4.1-5.0 cm; If the maximum diameter was > 5 cm, it was recorded as D_5^+.

Risk factor (Rf): The risk factor represented the risk index for variceal bleeding, and included the following. (1) eed color signs (RC): if blood vesicle, streak or cherry red signs were present, the varices were recorded as RC+, if not, RC-; (2) hepatic venous pressure gradient (HVPG) was used to evaluate the variceal bleeding caused by portal hypertension. Some studies have shown that there is a high risk of variceal bleeding if HVPG is > 12 mmHg; (3) erosion indicated that the mucosa of the varices was injured. Varices with erosion are most likely to bleed soon and should undergo endoscopic treatment; (4) red or white thrombi are both signs of recent bleeding, and varices with thrombus need immediate treatment; and (5) active bleeding: the varices observed under endoscopy are spurting or oozing blood and also should be treated immediately.

All the above factors were not present, but a lot of fresh blood was found under endoscopy and non-variceal bleeding could be excluded, which is also considered as a risk factor.

The risk factors were recorded as follows: Rf_0: the above risk factors were not present, and there were no signs of recent bleeding; Rf_1: RC+ or HVPG > 12 mmHg, so recent bleeding was possible and endoscopic treatment should be performed in due time; Rf_2: varices with erosion, thrombus, active bleeding, or a lot of fresh blood excluded from the non-variceal bleeding, should be treated immediately.

Table 1 LDRf classification for gastrointestinal varices

Factors	Classification
Location(L)	Le: Esophageal varices
	Le_s: Varices in superior esophagus
	Le_m: Varices in middle esophagus
	Le_i: Varices in inferior esophagus
	Lg: Gastric varices
	Lg_f: Varices in gastric fundus
	Lg_b: Varices in gastric body
	Lga: Varices in gastric antrum
	Ld: Duodenal varices
	Ld_1: Varices in the first part of duodenum
	Ld_2: Varices in the second part of duodenum
	$Ld_{1,2}$: Varices in the junction of the above two parts
	Lj: Jejunal varices.
	Li: Ileac varices.
	Lb:Biliary duct varices.
	Lc: Colonic varices.
	Lc_a: Varices in ascending colon
	Lc_t: Varices in transverse colon
	Lc_d: Varices in descending colon
	Lc_s: Varices in Sigmoid colon
	Lr: Rectal varices
Diameter (D)	D_0: No varices.
	$D_{0.3}$: The variceal diameter ≤ 0.3 cm.
	D_1: The variceal diameter is from 0.4 cm to 1.0 cm;
	$D_{1.5}$: The variceal diameter is from 1.1 cm to 1.5 cm;
	D_2: The variceal diameter is from 1.6 cm to 2.0 cm;
	D_3: The variceal diameter is from 2.1 cm to 3.0 cm;
Risk factors (Rf)	Rf_0: RC-; no erosion, thrombus and active bleeding
	Rf_1: RC+/HVPG > 12 mmHg; no erosion, thrombus and active bleeding
	Rf_2: Erosion/thrombus/active bleeding, or lots of fresh blood excluded non-variceal bleeding

Significance of LDRf classification

The common therapies used for gastroesophageal varices include endoscopic variceal ligation (EVL), endoscopic variceal sclerotherapy (EVS), injection of tissue adhesives, and combination therapy. The use of argon plasma coagulation (APC), laser and hemostatic clips for varices are still under research. LDRf classification can help with selection and timing of treatment. (1) The location is helpful in choosing the method to treat the varices; (2) the diameter also helps with treatment decision making (Table 2); and (3) the risk factors can give some clues about the time of treatment.

Statistical analysis

SPSS version 13.0 software was used for statistical analysis. Quantitative data are expressed as mean ± SD. matched data with *t*-test, $P < 0.05$ was considered a significant difference.

Table 2 Diameter and method chosen for treating varices

Maximum diameter (cm)	Appropriate treatment	Inappropriate treatment
No varices	Presentation after treatment	
≤ 0.3	APC, laser, hemostatic clips	EVL, EVS and injection of tissue adhesives
0.4-1.0	EVL, EVS	APC, laser, hemostatic clips
1.1-1.5	EVL, EVS	APC, laser, hemostatic clips
1.6-2.0	EVS for esophageal varices, and injection of tissue adhesives for non-esophageal varices	EVL,APC, laser, hemostatic clips
2.1-3.0	EVS for esophageal varices, and injection of tissue adhesives for varices outside the cardia and esophagus	EVL, APC, laser, hemostatic clips

EVL: Endoscopic variceal ligation; EVS: Endoscopic variceal sclerotherapy; APC: Argon plasma coagulation.

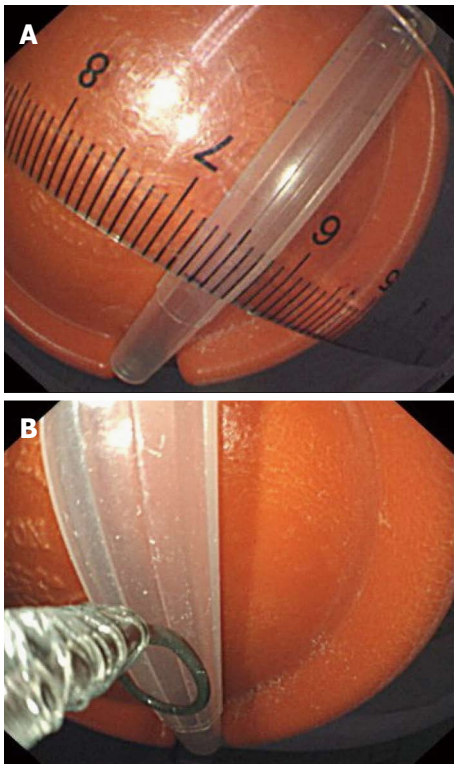

Figure 2 Two different methods of measurement; the diameter of the simulative varices was 0.6 and 0.5 cm, respectively. A: Ruler measuring diameter 0.6 cm; B: Endoscopic measuring scale diameter 0.5 cm.

RESULTS

The diameter of the mimicking varix was measured with a self-designed endoscopic measuring scale, and with a direct ruler measurement, and the results were divided into two groups accordingly. After applying these two different methods of measurement, the diameter of the simulative varices were 0.6, 0.5, 0.45 and 0.5 cm, respectively (Figures 2 and 3). The mean values were 1.850 ± 0.829 and 1.800 ± 0.830, respectively. There was no significant difference between these two methods ($P > 0.05$) (Table 3).

We compared the diameter of simulative varices *in vitro* using a self-designed endoscopic measuring scale *vs* a direct ruler measurement, and showed that the difference in accuracy was not significantly different with these two methods ($P > 0.05$).

DISCUSSION

Timely and effective endoscopic treatment is vital for patients with variceal bleeding. Three more international consensus conferences have helped further define clinical endpoints and practice recommendations[13-16]. Different conventions for grading variceal size are used but little is known about their relative value. There are no specific criteria for variceal size assessment in the Japanese Research Society for Portal Hypertension grading system. Evaluation of variceal form is closest to assessing variceal size. Although variceal form did correlate with variceal bleeding, assessed individually, it was of little help because it could explain only 30% variability[17]. The validity of these endoscopic signs studied individually or collectively remains to be assessed. Subjective bias and inter-observer variation in the endoscopic evaluation of these predictors cannot be excluded[1]. For this purpose, Linghu proposed a new standard of LDRf typing[18], which addresses some of the confusion surrounding when treatment should begin and which method of endoscopic therapy is most appropriate. The LDRf criteria and their significance to varices have been validated in clinical studies. LDRf classification is different from the previous grading system in that it is suitable for recording endoscopic varices in the whole gastrointestinal tract, and this classification has been validated in our clinical applications[19-25].

Elimination of varices usually involves a series of treatments. Endoscopic management should be seen as only part of a patient's overall care. Available techniques include banding, injection sclerosis, and combination techniques. Clips and loops have also been used recently[26-28]. EVL has a hemostasis rate up to 80%, which is the first choice for the prevention and treatment of liver cirrhosis with esophageal variceal bleeding[29]. The procedure of EVL has been described in detail elsewhere[30-35]. An analysis of the rate of bleeding in relation to the form of varices showed that larger varices bleed more often than smaller varices. Variceal form

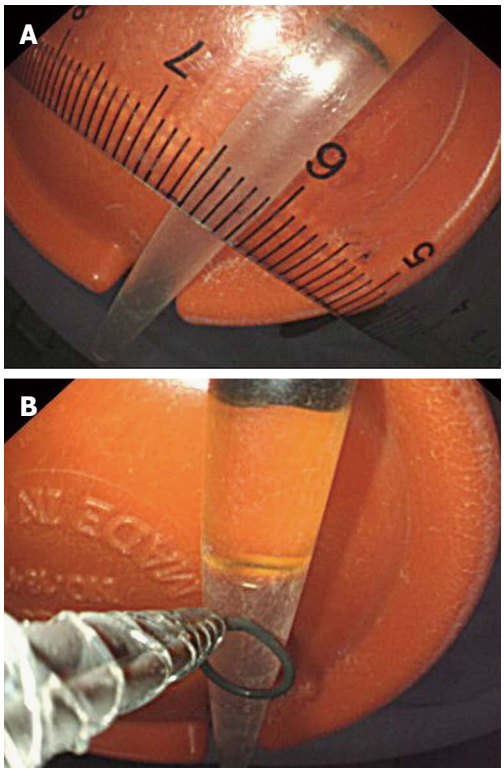

Figure 3 Two different methods of measurement; the diameter of the simulative varices was 0.45 and 0.5 cm, respectively. A: Ruler measuring diameter 0.45 cm; B: Endoscopic measuring scale diameter 0.5 cm.

explained only 3% variability for predicting variceal bleeding. There is, however, some confusion and subjectivity in the literature in assessing variceal size[36-39].

Our previous animal experiments showed that the larger the variceal diameter, the higher the pressure, the variceal diameter was 0.4-1.0 cm, 100% degree of ligation was higher, and the effect of band ligation was sturdy and complete.

Therefore, safety considerations and accurately measuring the diameter of varices are paramount[40,41]. Formerly, the rules for form of esophageal varices were classified into four groups according to their shape. A precise system for the systematic evaluation and recording of esophagogastric varices is essential for the management of portal hypertension[42].

At present, there are few relevant reports that have discussed the measurement of endoscopic lesion size, thus the endoscopist assesses the diameter of esophagogastric varices with the naked eye. This visual method is prone to error, is often not credible, and is influenced by the therapeutic effect of variceal bleeding. Therefore, the size of the lesion should be measured by endoscopic ruler that is accurate and reliable. The use of an endoscopic ruler not only avoids subjective visual errors by the endoscopist, but also makes the best use of the venous diameter as part of LDRf typing for endoscopic treatment.

The present study compared the accuracy of *in vitro* measurement of the diameter of mimicking varices by ruler with a self-made endoscopic scale. Our results showed that the difference between the two methods was not significant ($P > 0.05$). This result suggests that the self-made endoscopic diameter ruler is accurate and feasible and that it can be used for measuring the diameter of a varix, as well as measuring the size of gastrointestinal ulcers, polyps and tumors. The manufacture of this measuring scale is simple and the operation is convenient, making it the ideal tool for the endoscopist.

Table 3 *t*-test for matched data

Variable	mean ± SD
Ruler measuring	1.85 ± 0.829
endoscopic measuring	1.80 ± 0.830
P value	0.8499

However, the endoscopic diameter ruler also has some disadvantages, because its mechanical design is mainly based upon pulling a zebra wire guide. When this wire guide was pulled, the maximum length was at 14 cm on the handle, corresponding to the maximum curvature of the opening loop, which was 33 mm at the tip of the endoscope. When exceeding this limit, the instrument becomes less accurate, thus requiring further study to improve its use in the clinic.

This endoscopic measurement ruler is probably the first device to measure variceal diameter correctly. Although endoscopic parameters are expected to be helpful in correctly predicting variceal bleeding, the search for the unknown variables influencing variceal bleeding should continue.

COMMENTS

Background

There are no specific criteria for variceal size assessment in the Japanese Research Society for Portal Hypertension grading system. There are different conventions for grading variceal size but little is known about their relative value. Moreover, subjective bias and inter-observer variation in the endoscopic evaluation of these predictors cannot be excluded.

Research frontiers

Unfortunately, at present there is no known technique to measure the diameter of the varices accurately. Although variceal form did correlate with variceal bleeding, it was of little help. In this study, using a self-made endoscopic measuring scale measured the *in vitro* diameter of imitational varices, and the method was objective, accurate and feasible.

Innovations and breakthroughs

The diameter of the mimicking varix was measured with a self-designed endoscopic measuring scale, and with a direct ruler measurement, and the difference with these two methods was not significant ($P > 0.05$). This measuring scale is accurate and it manufacture is feasible. Moreover, its operation is simple and convenient, and it may be the ideal tool for an endoscopist.

Peer-review

This is a very interesting study. In this study, the authors measured the *in vitro* diameter of imitational varices using a self-made endoscopic measuring scale and confirmed that it was accurate and clinically feasible. They confirmed that

using a self-designed endoscopic ruler to measure the diameter of simulative varices *in vitro* is objective, accurate and feasible. The manuscript is very well written.

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