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Research Article

Basal Indentation Due to a Function of Geometry on CT Air-Contrast Enema for Sessile Colorectal Polyps: Quantitative Evaluation using Cross-Sectional Multiplanar Reconstruction

Mitsutoshi Miyasaka[1]*, Masanobu Ueda[2], Toshio Muraki[2], Michio Yoshida[2], Daisuke Tsurumaru[1], Yusuke Nishimuta[1], Masahiro Komori[1], Yoshiki Asayama[1] and Hiroshi Honda[1]

[1]*Department of Clinical Radiology, Kyushu University, Japan*
[2]*Department of Radiology, Munakata Medical Association Hospital, Japan*

***Corresponding author**
Mitsutoshi Miyasaka, Department of Clinical Radiology, Graduate School of Medical Sciences, Kyushu University, 3-1-1 Maidashi, Higashi-ku Fukuoka City 812-8582, Japan, Tel: +81-92-642-5695; Fax: +81-92-642-5708; Email: mmiya@radiol.med.kyushu-u.ac.jp

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Keywords

- Colorectal polyp
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- Cross-sectional multiplanar reconstruction
- CT- Colonography

Abstract

Objective: Basal Indentation (BI) on CT air-contrast enema (CT enema) for colorectal cancer consists essentially of the both factors of a function of geometry and a tumor invasion. This study was conducted to investigate the feasibility of quantitative evaluation of the basal indentation due to a function of geometry (BI-G) on CT enema for colorectal polyps using Cross-Sectional Multiplanar Reconstruction (CS-MPR) images.

Materials and Methods: The study group consisted of 21patients with 37 sessile colorectal polyps that were pathologically confirmed as restricted to the mucosa. We calculated the maximal depth of BI-G (max BI-G) on CT enema for colorectal polyps, and compared the max BI-G with the estimated max BI-G (e-max BI-G), which was calculated using the CS-MPR images.

Results: A strong positive correlation was found between e-max BI-G and max BI-G (R^2= 0.91, P <0.0001), although there was a significant difference in the mean values between e-max BI-G and max BI-G (0.64 ± 0.52 mm and 0.51 ± 0.73 mm, respectively; P < 0.05).

Conclusion: CS-MPR is effective for quantitative evaluation of BI-G on CT enema for sessile colorectal polyps. Such evaluation may lead to improvement of the diagnostic accuracy of the invasion depth of colorectal cancers.

INTRODUCTION

Basal Indentation (BI), an intestinal deformity in the profile view of a barium enema for colorectal cancer, consists essentially of the both factors of a function of geometry and a tumor invasion [1-6]. Maruyama et al. demonstrated that BI is one of the most important indicators for the diagnosis of Colorectal Cancer (CRC) by barium enema [3]. On the other hand, Ament et al. demonstrated that BI due to a Geometric function (BI-G) was seen for all polyps by barium enema in both patients and colon phantoms [1]. According to the theorem of Pythagoras, the max depth of BI-G(max BI-G) depends on both the diameter of the intestine and the size of the colorectal polyp at the cross-sectional view of the intestine [1].

CT Colonography (CTC) is generally useful as a preoperative or screening examination for CRC [7-10]. CT air-contrast enema (CT enema), also known as “virtualbarium enema,” is a three-

dimensional image display method in CTC, and has also been reported to be useful in the depth diagnosis of CRC, with the overall diagnostic accuracy of T staging ranging from 79%–82.5% [11-15]. However, the depth diagnosis of early CRC using BI on CT enema is not high, with the sensitivities for T is and T1 staging being 71% and 47%, respectively [11,15]. As to the cause of the low diagnostic accuracy in the depth diagnosis of early CRC using BI on CT enema, it has been suggested that a failure to account for BI-G is primarily responsible. Thus it would be desirable to quantitatively evaluate BI-G in distinction from BI due to tumor invasion to improve the accuracy of the depth diagnosis of early CRC.

However, to our knowledge, there have been no reports that quantitatively evaluated the BI-G of colorectal tumors on CT enema. The purpose of the present study was to investigate the feasibility of using cross-sectional multiplanar reconstruction (CS-MPR) to quantitatively evaluate the BI-G of colorectal tumorson CT enema.

MATERIALS AND METHODS

Subjects

The initial patient pool consisted of 32 patients with 54 sessile colorectal polyps who underwent CTC as pretherapeutic examination at Kyushu University Hospital between January 2009 and November 2011 or at Munakata Medical Association Hospital between April 2012 and November 2012. Fifty polyps were resected by Endoscopic Mucosal Resection (EMR).The other 4 polyps were resected by surgery. All polyps were pathologically diagnosed as lesions that were restricted to the mucosa. Ten patients with 15 polyps that were located on a haustral fold were excluded from this study because a geometric bowel deformity due to haustral fold is difficult to distinguish from BI-G of colorectal polyps. One patient with 2 polyps that were undetected on CTC images was also excluded from the study.

The final study population consisted of 21 patients (15 male and 6 female) with 37 polyps. The mean age of the patients was 65.4 years (range 47–84 years). This retrospective study was approved by the institutional review board of each hospital. The requirement for informed consent was waived. The mean interval between CTC and EMR or surgery was 27 days (range 3–157 days).

CTC procedure

For each patient, CTC was performed on the same day and within 1hr after a colonoscopy, using the method of bowel preparation with PEG. Before the CTC, a double balloon tube was inserted into the rectum by the transanal route, and room air was injected for dilatation of the large intestine. Room air was manually injected until the patient exhibited abdominal distension. If the dilatation of the large intestine on a scout image was inadequate, additional room air was injected. CTCs were performed using either a 16-slice multi-detector-row computed tomography (MDCT) scanner (Aquilion 16; Toshiba Medical Systems Corporation, Tokyo) or a 64-slice MDCT (Aquilion64; Toshiba Medical Systems Corporation) with the following parameters: 120 kV, 200-300 mA, beam collimation 1 mm, slice thickness 1 mm, reconstruction interval 1 mm. Intravenous (IV) contrast media was used for 15 of the 21 patients. The IV contrast media could not be used in the remaining 6 patients due to contraindications.

All patients underwent both supine and prone scans. In patients for whom IV contrast media were used, CT images were obtained 40 s, 70 s and 240 s after the IV administration of 100 mL nonionic iodine contrast media (Iopamiron 300: Bayer Health Care, Osaka, Japan) at a rate of 3 mL/s in the supine position (40 s and 70 s) and in the prone position (240 s).The MDCT data sets were loaded onto a workstation (Synapse Vincent, Fujifilm Medical, Tokyo). After all image data sets were transferred to the workstation, they were converted into 2D images of Multiplanar Reformation (MPR) and 3D images (i.e., CT enema images and virtual endoscopic images) using onboard software.

Image analysis

First, the colorectal polyps were identified using MPR images, virtual endoscopic images and CT enema images. Subsequently, CT enema images in the location of the colorectal polyps were extracted using the best distended series in the supine or prone position, and the max BI-G on the CT enema in the colorectal polyps was calculated based on the consensus of two gastrointestinal radiologists who had 13 years and 14 years of experience. Additionally, CS-MPR images that were equivalent to the short-axis view of the intestine were obtained at the level of the polyps, and the estimated max BI-G (e-max BI-G) was calculated based on the consensus of the two gastrointestinal radiologists using the CS-MPR images with the theorem of Pythagoras as follows: e-max BI-G = $D/2\sqrt{(D/2)^2 - (L/2)^2}$; D, the diameter of the intestine; L, the size of the lesion (Figure 1). Finally, we compared the max BI-G with the e-max BI-G.

Statistical Analysis

All data are presented as the mean ± SD. Differences between the mean values of the max BI-G and e-max BI-G were assessed using the paired t-test. We also examined the correlation between the max BI-G and e-max BI-G with a Pearson correlation analysis. All statistical analyses were performed using JMP software (JMP version 9.0.2; SAS Institute Inc., Cary, NC). P-values <0.05 were considered significant.

RESULTS

The characteristics of colorectal polyps are summarized in Table 1. The average size of the polyps was 9.8 ± 4.1 mm (range 5–22 mm). BI-G was detected in 21 (57%) of the 37 polyps, and was not detected in the other16 (43%) polyps. There was a significant difference in the mean values between e-max BI-G in the polyps in which BI-G was detected and those in which BI-G was not detected (0.97 ± 0.85 mm and 0.24 ± 0.09 mm, respectively; $P < 0.05$). Moreover, a strong positive correlation was found between max BI-G and e-max BI-G ($R^2 = 0.91$, $P< 0.0001$) (Figure 2), although there was a significant difference in the mean values between e-max BI-G and max BI-G (0.64 ± 0.52 mm and 0.51 ± 0.73 mm, respectively; $P <0.05$).

DISCUSSION

When using the profile view of a barium enema or CT enema to diagnosis the depth of CRC, BI-G is of the same importance as

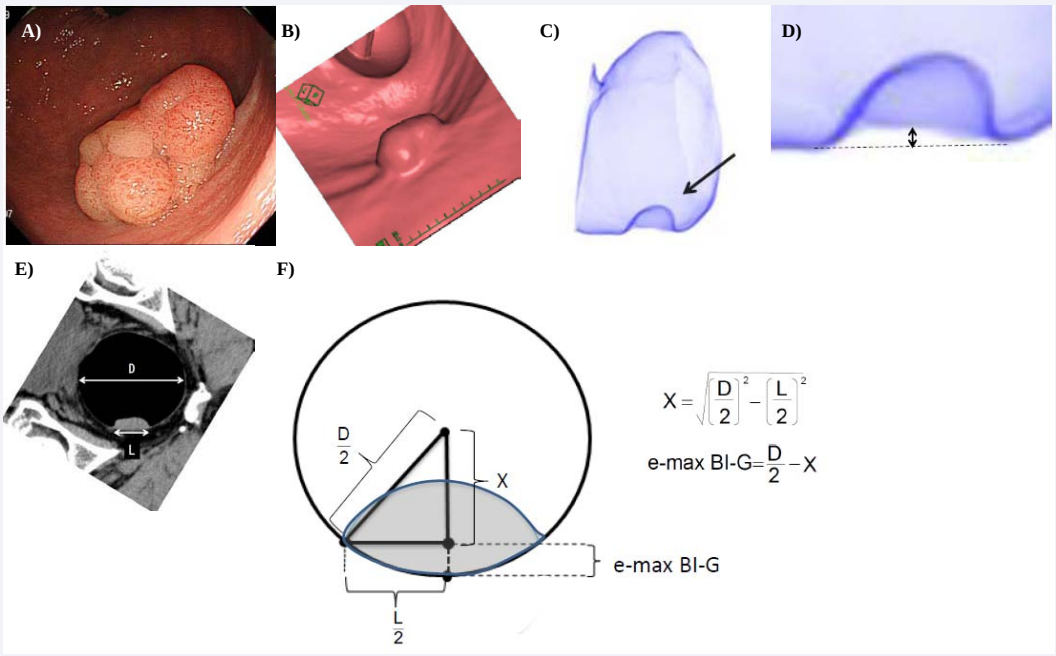

Figure 1 Methods to calculatemax BI and e-max BI (52-year-old man with rectal polyp).
Optical (a) and virtual (b) endoscopic images show sessile rectal polyp. The max BI-G (double-headed arrow, d; d is the magnification of panel c) was defined as length from the line joining both sides of the bottom of the polyp (arrow, c) to the top of the BI at the profile view on a CT enema image (c). The diameter of the intestine and the size of the lesion needed to calculate the e-max BI-G were measured with a CS-MPR image in the short-axis view of the intestine in which the polyps existed (e). D, diameter of intestine; L, size of lesion.
Diagram and calculating formula (f) show the method used to calculate the e-max BI-G using the theorem of Pythagoras in panel e.

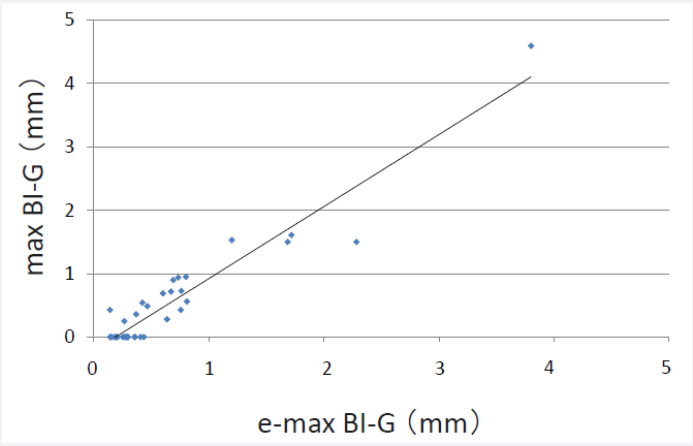

Figure 2 Correlation between e-max BI-G and max BI-G.A strong positive correlation was found between e-max BI-G and max BI-G (R2 = 0.91, P <0.0001).

BI due to tumor invasion. Ament et al. and Kayashima et al. have shown that BI-G was detectable for all elevated lesions on barium enema and CT enema images using colon phantoms [2,13]. According to the theorem of Pythagoras, the max BI-G depends on both the diameter of the intestine at the polyp's location and the diameter of polyps at the basement on a cross-sectional view. Namely, the larger the diameter of the polyp in the basement on the cross-sectional view, the larger the max BI-G. In contrast, the smaller the diameter of the intestine, the larger the max BI-G. Although BI due to a tumor invasion is considered to occur in colorectal cancers of the submucosa or deeper, it is difficult to differentiate BI-G from BI due to a tumor invasion on CT enema for invasive CRC.

One of the biggest advantages of CTC is that it permits the evaluation of not only BI on CT enema but also e-max BI-G, which is theoretically equivalent to max BI-G, using CS-MPR. In the present study, a strong positive correlation was found between max BI-G and e-max BI-G for the colorectal intramucosal tumor lacking BI due to tumor invasion.Our results suggested that it was possible to quantitatively evaluate BI-G on CT enema using CS-MPR for colorectal tumors. The quantitative evaluation of BI-G on CT enema may lead to improvement of the depth diagnostic

Table 1: Characteristics of the colorectal polyps examined.

	Number of lesions (n=37)
Polyp Location	
Cecum	0 (0%)
Ascending colon	4 (10.8%)
Transverse colon	3 (8.1%)
Descending colon	4 (10.8%)
Sigmoid colon	20 (54.1%)
Rectum	6 (16.2%)
Polyp size	
≤ 9mm	21 (56.8%)
10–19mm	14 (37.8%)
≥ 20mm	2 (5.4%)
Histological classification	
Adenoma (tubular)	31 (83.8%)
Adenocarcinoma	4(10.8%)
inflammatory polyp	2 (5.4%)

accuracy for early CRC.

Regarding the possible reasons for the significant difference in the mean values between e-max BI-G and max BI-G in colorectal intramucosal tumors, we considered the following factors. First, the shape and circularity of the colon in CS-MPR images are not regular due to the complex anatomy of the colon. It is thus possible that the e-max BI-G is not consistent with the max BI-G for colorectal intramucosal tumors. Secondly, we were not able to detect max BI-G on CT enema for the polyps with lower e-max BI-G values. Thus it may be difficult to accurately measure a minute max BI-G on CT enema. On the other hand, it may not be very important to calculate the minute max BI-G, because it is not considered to be a main factor in the depth diagnosis of CRC.

Our study had several limitations. Selection bias was a possible limitation because we excluded polyps that were located on a haustral fold. The small number of subjects was also a limitation. Moreover, we did not evaluate interobserver variability in the calculation of max BI-G and e-max BI-G.

CONCLUSION

CS-MPR is effective for the quantitative evaluation of BI-G on CT enema for sessile colorectal polyps. Such evaluation may be useful in the depth diagnosis by BI on CT enema in patients with early CRC.

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