

Is a Double Contrast Barium Enema Necessary in Patients who Undergo a CT Colonography as a Preoperative Work-up?¹

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Purpose: To determine the efficiency of CT colonography (CTC), as compared with the double contrast barium enema (DCBE) for the preoperative work-up of colorectal neoplasms.

Materials and Methods: A total of 39 patients underwent both a CTC and DCBE before surgery. Three abdominal radiologists and three colorectal surgeons retrospectively reviewed virtual double contrast (VDC) and DCBE images, regarding each examination for localization, conspicuity, extent and morphology of neoplasms. We reviewed the radiological reports of the CTC and DCBE for the polyps.

Results: In the case of both VDC and DCBE, 40 cancers were detected in 39 patients. According to abdominal radiologists, VDC showed the same ability to identify DCBE for localization of neoplasms ($p < 0.001$). However, DCBE was significantly superior or equal to the VDC ($p < 0.05$) in conspicuity, extent, and morphology of the main mass. According to colorectal surgeons, VDC was significantly superior or equal to DCBE for all parameters (each $p < 0.05$). The ability to detect polyps was not significantly different between the CTC and DCBE ($p > 0.05$).

Conclusion: The performance of the CTC is comparable to the DCBE for the localization of main mass and polyps in patients with colorectal neoplasm. Barium enema don't seem to be necessary for patients who undergo a CTC as preoperative work-up.

Index words : Colorectal neoplasms

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Malignant tumors of the large bowel are a major health concern worldwide, and constitute a significant cause of cancer-related death. Most colorectal cancers are believed to arise from preexisting adenomatous polyps that remain clinically silent until presentation. Therefore, early detection is very important (1, 2). The conventional colonoscopy is unique among the diagnostic tests in that it can be a diagnostic procedure to examine the entire colon, as well as allow for a biopsy of a lesion in the colon and facilitating therapeutic procedures such as a polypectomy (3–5).

However, definite localization of the tumor is difficult with a colonoscopy, especially in the tortuous redundant colon. Furthermore, it is impossible to evaluate the proximal portion of an obstructive lesion because of the difficulty in getting the colonoscope to traverse the lesion (6, 7). Between 1.5% and 9.0% of patients with colorectal carcinomas have synchronous cancer; and, between 27% and 55% of them have multiple coexistent adenomatous polyps (8–10). The preoperative evaluation of the entire colon for patients suffering with colorectal cancer is widely recommended in order to improve the disease-free survival rate following surgery (11, 12).

In the cases of obstructive colon cancer and the exact localization of the tumor, a double contrast barium enema (DCBE) is generally employed for the preoperative examination of colorectal cancer.

The computed tomographic colonography (CTC) has recently been investigated in many countries as a potential method of performing colon cancer screening (13–17).

The CTC is used to complete the examination of the entire colon before surgery, when a conventional colonoscopy is incomplete. Virtual double contrast (VDC) also has the ability to evaluate the luminal surface, in the same manner as DCBE, by using the volume rendering method. The aim of this study was to compare the efficacy of CTC and DCBE to evaluate the main tumor mass and the synchronous lesions and to determine whether CTC can replace DCBE in the preoperative work-up of colorectal neoplasm.

Materials and Methods

Patients

A total of 258 patients underwent a CTC at our institution during 1 year. Of these, the study included 39 patients who underwent a DCBE, CTC, complete conven-

tional colonoscopy and colorectal neoplasms which were confirmed by surgery at our institution. Of the 39 patients, 26 were men and 13 were women and ranged in age from 39 to 73 years (mean: 57 years).

Of the remaining 219 patients that were excluded from the study, 73 had colorectal neoplasms that underwent conventional colonoscopy and 65 patients underwent a DCBE at an outside institution. We excluded these cases because the colonoscopic reports and radiological imaging were inadequate. We also excluded 54 patients who only underwent a sigmoidoscopy ($n = 29$) and incomplete colonoscopy ($n = 25$) due to luminal narrowing by a mass, colonic redundancy or diverticulosis. The 20 patients who underwent a CTC to a screen for a colorectal lesion or CTC after performing polypectomy, were also excluded. The 7 remaining patients were excluded due to nontumorous conditions such as appendiceal disease ($n = 2$), familial adenomatous polyposis ($n = 2$), extrinsic compression from a lymphoma of the small bowel, tuberculosis and pneumatosis coli ($n = 1$, respectively).

This study was performed with the approval and under the guidelines of our institutional review board.

Computed Tomographic Colonography

A CTC was performed within 1–28 days (mean: 6 days, $n = 35$) before and within 7–49 days (mean: 28 days, $n = 4$) after performing a DCBE. The bowel preparation method was the same as that used for a conventional colonoscopy at our hospital, which consisted of a low-residue diet for one day and fasting after the evening meal, followed by a 4 L colonic lavage (Colonlyte®, Meditech Korea Pharm, Seoul, Korea). The CT scan was performed on multidetector-row computed tomography (MDCT) scanners (Light Speed Ultra 8 or 16, GE Medical Systems, Milwaukee, WI). With the patient placed in the left lateral decubitus position, a rectal tube was inserted and the colon was gently insufflated with room air by means of an auto injector (Enema Teleflator®, Kaigen, Japan) up to the patient's maximum tolerance (about 1.5–2.0L). The patient was then turned in the prone position and a standard CT scout film of the abdomen and pelvis was acquired to assess the adequacy of colonic distension. Additional air insufflation was performed, if necessary. The MDCT scanning of the abdomen and pelvis was acquired during a single breath-hold with the patient in the prone position, and then was repeated in the supine position after confirming adequate distension of the colon. The intravenous contrast

media (Ultravist® 300, Shering, Germany) was administered before scanning in the supine position for the work-up of tumor staging. The images were acquired with a 10-mm collimation beam, a table speed of 13.5 mm/rotation (pitch 1.35), a slice thickness of 1.25 mm, an interval of 1.25 mm, a 512 × 512 matrix, 350 mA, 120 kV and a tube rotation of 0.6 sec. The breath-hold time ranged from 22 to 25 seconds. None of the patients received any antiperistaltic drugs or sedation.

Once acquired, the images were automatically transferred to a dedicated workstation (Advantage Workstation 4.0, GE Medical Systems, Milwaukee, WI) equipped with Navigator software. The two-dimensional and three-dimensional CTC were then performed on this station. Two abdominal radiologists (LJ and LSJ), who both had over 7 years of experience in the gastroin-

testinal department, evaluated the multi-reformatted two-dimensional axial, coronal and sagittal images to detect the colorectal lesions. We also obtained a raysum image of the colon after removal of the air-filled small intestine. Next, we performed the VDC, which consisted of overhead and multiple magnified images at various rotational angles (Figs.1A-F). The virtual colonoscopy (VC) images were simultaneously evaluated by threshold rendering.

Double Contrast Barium Enema

A DCBE was performed by a second level resident who was under the supervision of an abdominal radiologist staff member (LSJ). Moreover, the DCBE was performed by the usual method and room air was infused using an automatic inflator (Enema Teleflator®, Kaigen,

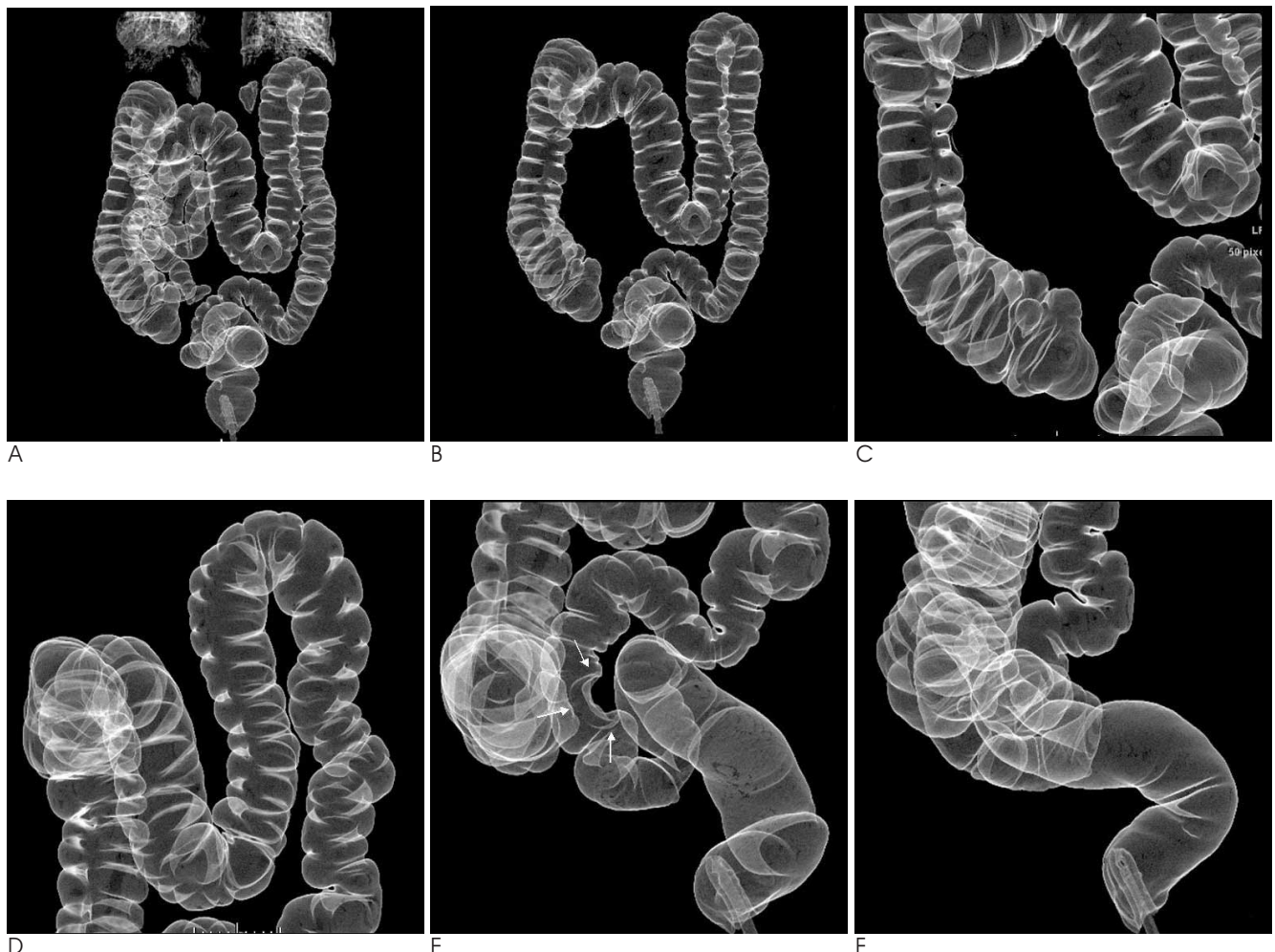


Fig. 1. Virtual double contrast (VDC) imaging of sigmoid colon cancer.

A. The initial volume rendering image shows gas-filled structures, including the colon, small intestine, stomach and lungs.

B. The virtual double contrast image after removal of the small intestines, stomach and lungs appears like the over-head view of DCBE.

C-F. The VDC images of each segment of the colo-rectum showed spots with an "apple-core" appearance in the sigmoid colon (arrows), as did the images by DCBE, indicating colon cancer.

Japan). An overhead image and ten or more spot images were obtained. Colon preparation for the barium enema was standardized for all the patients and included a 24-hr liquid diet, oral hydration and 296 ml of magnesium citrate the day before the examination. Next, two Bisacodyl 10-mg suppositories were inserted in the rectum at 6 a.m. on the morning of the examination. The diagnosis of cancer was recorded if the report described a lesion as "probable or suggestive of carcinoma". In the case of polyps, a "filling defect consistent with a polyp or suspicious of a polyp" was regarded as a positive diagnosis.

Conventional Colonoscopy and Pathology

A conventional colonoscopy was performed within 4–5 hours after a CT scan in 13 patients, within 4–30 days after CT scan in 2 patients, and within 1–32 days before a CT scan in 24 patients. Two skilled endoscopists, who were "blinded" to the results of the CTC examination, performed the colonoscopies. Electronic video endoscopes (CF-2401, Olympus, Tokyo, Japan) were used for the observation of the lower gastrointestinal tract during the study. An antiperistaltic drug (Buscopan®, Seoul, Korea, 1 cc intramuscularly) and sedation (Midazolam®, Seoul, Korea, 0.035 mg / kg intravenously) were routinely administered prior to an endoscopy unless the patient had a contraindication. Immediately after performing the colonoscopy, the endoscopist reported the presence, location and size of all identified colon lesions.

The conventional colonoscopy detected 40 colorectal neoplasms in the 39 patients. The colorectal neoplasms were located in the rectum ($n = 27$), sigmoid colon ($n = 11$), ascending colon ($n = 1$) and cecum ($n = 1$). The pathological examination that followed the colectomy revealed 36 adenocarcinomas, 2 adenocarcinomas with underlying tubulovillous adenomas and 2 villous adenomas. For one patient with rectal cancer, a villous adenoma was identified in the cecum. The mean size of the neoplasms was 3.7 cm (range: 2.0–6.7 cm).

An additional 53 polyps were detected in 27 of the 39 patients. Thirteen (24.5%) were 10.0 mm in diameter or larger, 18 (34%) were between 5.0 and 9.0 mm in diameter, and 22 (41.5%) were 4.0 mm in diameter or smaller. The mean size of the polyps was 6.0 mm (range: 2–15 mm). The polyps were located in the descending colon ($n = 14$), sigmoid colon ($n = 12$), transverse colon ($n = 12$), rectum ($n = 8$), ascending colon ($n = 6$) and cecum ($n = 1$). Of these 53 polyps, 50 (94%) were resected endoscopically, and of these, 32 were tubular adenomas, 12 were hyperplastic polyps, 4 were tubulovillous

adenomas, 1 was villous adenoma and 1 was an inflammatory polyp. The remaining 3 polyps were removed at surgery along with a coexisting colorectal carcinoma. Of these 3 polyps, 2 were tubular adenomas and 1 was a carcinoid.

Image Analysis

For the first step of imaging analysis, three abdominal radiologists (LJ, CD and KMJ) working in consensus retrospectively reviewed the VDC and DCBE images with respect to their aptitude for determining the localization (defined as 5 segments as the ascending, transverse, descending and sigmoid colon and rectum), conspicuity (defined as the ability to clearly distinguishing the margin between the lesion and the normal area), the extent (defined as the length of the involved segment), and the morphology (defined as the configuration of the lesion) of the main mass. We defined the main mass as being greater than 2.0 cm. Three colorectal surgeons then reviewed these images using the same methods. We categorized the images into three levels based on their consensus reading: the same, higher or at a lower level between the two studies. We sorted them into large two groups. One group, defined as VDC, showed an equal or greater ability; whereas, the other group, defined as DCBE, showed only lower level compared with VDC for variables. We used the Chi-square test for evaluating the superior, equal or inferior ability to determine the localization, the conspicuity, the extent and the morphology of the masses on the basis of two resorted groups between VDC and DCBE.

In the second step, an abdominal radiologist (LJ) retrospectively reviewed the radiologic reports of the CTC (including the multi reformatted two-dimensional axial, coronal and sagittal images and the virtual colonoscopy) as well as the DCBE with regards to the evaluation of the polyps and compared it to the conventional colonoscopy as the gold standard. The general estimating equation test was used to investigate the relationship between the abilities of the two modalities for detecting polyps.

All statistical analyses were performed using SPSS 10.0 (SPSS, Inc., Chicago, IL). A p value < 0.05 is considered to be significant.

Results

Colorectal Neoplasms

All of the radiologists and surgeons detected 40 col-

orectal neoplasms in the 39 patients for both the VDC and DCBE. For the results reviewed by the abdominal radiologists on the basis of having an equal or superior ability of VDC to DCBE (Table 1), the VDC was significantly equal or superior to DCBE concerning the localization of the main mass (39/40, $p < 0.001$, Chi-square test) (Fig. 2). According to the extent, conspicuity, and

morphology of the main mass, VDC was not significantly equal or superior to the DCBE (Fig. 3) (22/40, 22/40, 14/40, each $p > 0.05$, Chi-square test). Conversely, the DCBE showed an equal or superior ability to VDC for the localization, extent, conspicuity, and morphology of the main mass (39/40, 35/40, 30/40, 35/40 each $p < 0.001$, Chi-square test).

Table 1. The Ability of CTC (VDC) and DCBE to Depict Main Mass by Abdominal Radiologist Interpretation ($n = 40$ tumors/39 patients)

| | DCBE > VDC | DCBE = VDC | DCBE < VDC | p value* |
|--------------|------------|------------|------------|------------|
| Localization | 1 | 38 | 1 | < 0.001 |
| Extent | 18 | 17 | 5 | > 0.05 |
| Conspicuity | 18 | 12 | 10 | > 0.05 |
| Morphology | 26 | 9 | 5 | > 0.05 |

* For superiority or equality of CTC, each p value was calculated using the Chi-square test. CTC = computed tomography colonography; VDC = virtual double contrast; DCBE = double contrast barium enema.

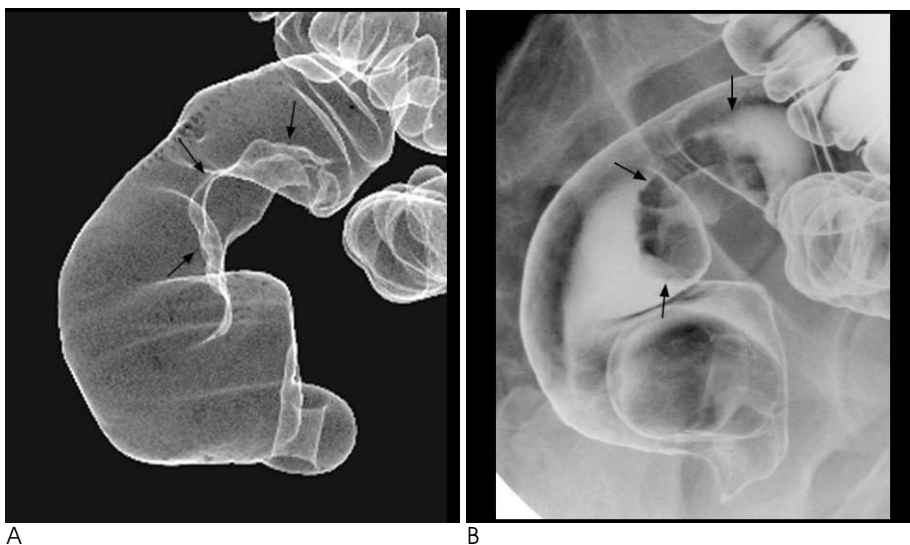


Fig. 2. A 56-year-old man with rectosigmoid colon cancer. The VDC (A) and DCBE (B) reveal a similar morphology, extent and localization for the adenocarcinoma (arrows) in the rectosigmoid colon.

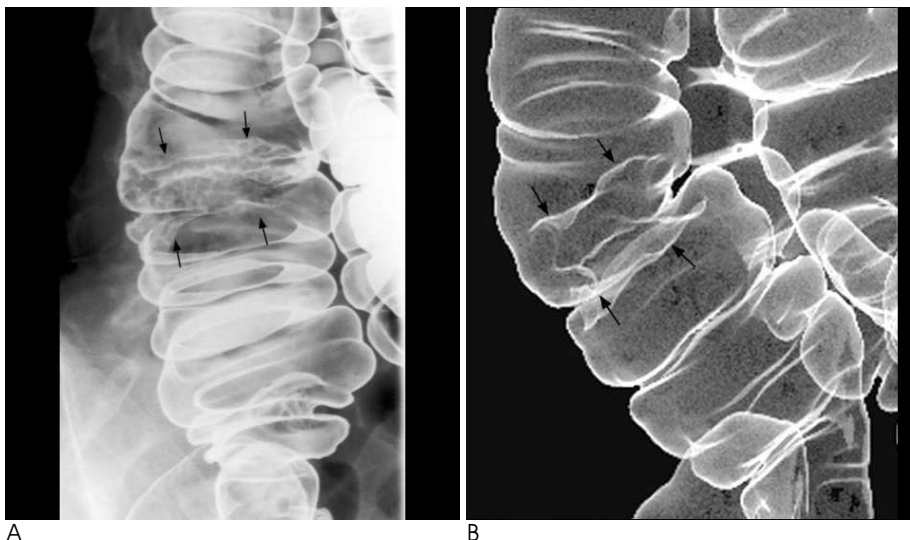


Fig. 3. A 68-year-old woman with villous adenoma located in the proximal ascending colon. DCBE (A) shows the velvety surface of the villous adenoma (arrows), but VDC (B) does not allow visualization of the surface detail.

For the results reviewed by the colorectal surgeons (Table 2), the VDC was significantly superior or equal ability to the DCBE in terms of the localization, extent, conspicuity, and morphology of the main mass in 39/40, 33/40, 30/40 and 30/40 cases, respectively (each $p < 0.05$, Chi-square test) (Fig. 4).

Polyps

The conventional colonoscopy diagnosed 53 polyps in the 39 patients, but the CTC achieved the diagnosis of 54 polyps. The overall sensitivity of the CTC for polyp detection, as compared to conventional colonoscopy (as the gold standard) was 37% (20/53). On the basis of the size of the polyp, the sensitivities of CTC were 18% (≤ 4 mm), 39% (5–9 mm), and 69% (≥ 10 mm). Thirty-three

of the 53 polyps were missed by the CTC and 34 polyps were diagnosed only with the CTC, which probably indicated false positive diagnoses.

Twenty-one polyps were diagnosed on the DCBE. The overall sensitivity of DCBE for the polyp detection, compared to conventional colonoscopy, was 23% (12/53). On the basis of the size of the polyp, the sensitivities of the DCBE were 5% (≤ 4 mm), 33% (5–9 mm) and 38% (≥ 10 mm). On DCBE, 41 of the 53 polyps were missed and nine polyps were only diagnosed by DCBE.

According to the results of the generalized estimating equation analysis, the detectability of the polyps was not significantly different between CTC and DCBE ($p > 0.05$), regardless of their size (Table 3).

Table 2. The Ability of CTC (VDC) and DCBE to Depict the Main Mass by Surgeon Interpretation ($n = 40$ tumors/39 patients)

| | DCBE > VDC | DCBE = VDC | DCBE < VDC | p value* |
|--------------|------------|------------|------------|------------|
| Localization | 1 | 33 | 6 | < 0.001 |
| Extent | 7 | 18 | 15 | 0.004 |
| Conspicuity | 10 | 13 | 17 | 0.039 |
| Morphology | 10 | 16 | 14 | 0.039 |

* For superiority or equality of CTC, each p value was calculated using the Chi-square test. CTC = computed tomography colonography; VDC = virtual double contrast; DCBE = double contrast barium enema.

Table 3. The Detectability of Polyps on CTC and DCBE

| | All | ≤ 4 mm | 5–9 mm | ≥ 10 mm |
|-------------|---------|-------------|--------|--------------|
| Colonoscopy | 53 | 22 | 18 | 13 |
| DCBE | 12 (23) | 1 (5) | 6 (33) | 5 (38) |
| CTC | 20 (37) | 4 (18) | 7 (39) | 9 (69) |
| p value* | > 0.05 | > 0.05 | > 0.05 | > 0.05 |

Note. To determine the degree of detection of polyps on CTC and DCBE, the $*p$ value was calculated using the generalized estimating equation. The numbers in parentheses are percentages. CTC = computed tomography colonography, DCBE = double contrast barium enema.

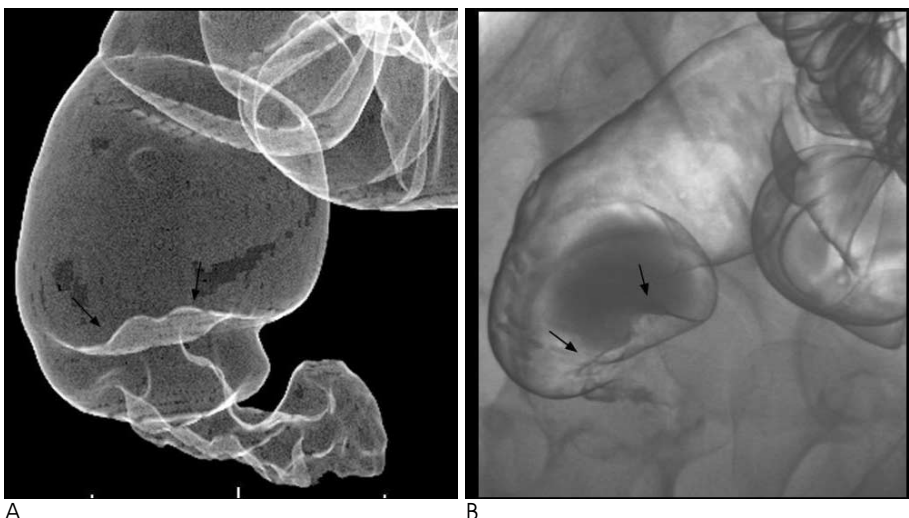


Fig. 4. A 70-year-old man with distal rectal cancer. VDC (A) shows an overhanging edge and the exact extent of the mass and narrowing of the lumen (arrows). The DCBE (B) does not allow for the evaluation of the lower margin of the mass due to a collapsed segment (arrows).

Discussion

The preoperative evaluation of the entire colon is generally recommended for patients suffering with colorectal cancer (9, 10). Failure to identify a synchronous cancer or a precancerous lesion before surgery may not only result in failed curative resection, but this also exposes the patient to the additional risk of morbidity and mortality associated with a second surgical procedure. Those patients with colorectal cancer who undergo a preoperative total colon examination have a longer disease-free survival rate (11, 12).

Although a conventional colonoscopy is regarded as a good method for evaluating the colon before surgery, prospective studies have shown that colonoscopy allows the entire colon to be visualized in only 42–60% of the patients with colorectal cancer (12, 18, 19). In other reports, it was stated that failure to visualize the entire colonic surface occurs in 5–30% of colonoscopic examinations (7, 20). Those lesions that were overlooked via a colonoscopy showed a tendency to be situated behind flexures and folds, in the rectum and in the angulated areas of the colon, as well as the cecum and the ileocecal valve (21, 22). Furthermore, the ability to localize tumors by conventional colonoscopy is not perfect. Vignati et al. reported that the endoscopic localization was incorrect for 14% of colorectal cancers (6).

Until recently, the DCBE has usually been used to pinpoint the exact localization of the colorectal mass before radical surgery and for evaluation of the entire colon in the case of an incomplete colonoscopy. We performed a barium enema before surgery in all the patients with colorectal cancer to evaluate the exact localization and configuration of the entire colon and to detect any synchronous colorectal lesion. Yet, this type of examination requires one day or more before surgery to adequately cleanse the colon and; in addition, is associated with an increased risk of barium inspissation.

The CTC is a minimally invasive diagnostic method of screening for colorectal cancer, and; it is also used for a post-polypectomy follow-up as well as a first diagnostic test for patients suffering from colorectal disorders (13, 14, 23). The CTC usually emphasizes the luminal images, similar to a colonoscopy to detect polyps in the colon. For the evaluation of the size and morphology of colorectal tumors, a raysum image was shown to be more accurate than a virtual colonoscopy or multiplanar reformatted images (24). A raysum image is similar to

the image of the mucosal phase in double contrast barium enema. Particularly, this technique has an established role in the preoperative evaluation of patients with occlusive colorectal cancers (15, 25).

We obtained raysum images in all patients for the exact tumor localization and to examine colorectal tumors. We could detect and evaluate all of the colorectal tumors on VDC, including one synchronous lesion. Our abdominal radiologists reported that VDCs, as a whole, have a similar ability for DCBEs for the localization of main mass, but VDCs showed an overall low ability to DCBEs for the extent, conspicuity, and morphology of the main mass. Colorectal surgeons prefer to examine VDCs rather than DCBEs for the pre-operative work-up of colorectal cancer. The DCBE has segments of the small intestine overlapped with the colon. However, on VDC, all the small intestines were erased with only the colo-rectum remaining; therefore, the surgeons could easily interpret the VDC. We placed a lot of emphasis on determining exact localization of main mass as a role of VDCs or DCBEs for the preoperative work up of colorectal tumors. Hence, DCBEs could be replaced by VDCs for the localization of the main mass.

The CTC detected 8 (15%) more polyps than did the DCBE, when comparing the conventional colonoscopy as a gold standard. Johnson et al. reported the sensitivity of polyp detection on CTC was 29–79% for polyps of 5–9 mm in diameter and 56–79% for polyps larger than 10 mm in diameter (26). In comparison, the sensitivity of the DCBE varied from 29–58% for the polyps 5–9 mm in diameter and from 39–56% for the polyps larger than 10 mm in diameter. All the readers of the study detected more polyps on the CTC than on the DCBE, which is consistent with our study. We found no statistical significance between the two methods when testing polyp detection. The overall ability to detect polyps via a CTC, in our study, was inferior to the other reported series (16, 23, 26). Hara et al. (23) and Laghi et al. (16) detected 92.8–100.0% of all polyps larger than 10.0 mm, 71.0–84.6% of polyps 5–9 mm, and 24.0–28.0% of polyps smaller than 5 mm. This discrepancy may be attributable to poor bowel preparation in some cases or due to poor distension due to occlusive colorectal cancer.

Additionally, the CTC has several advantages over the DCBE. It requires little additional air insufflation for optimal images to be obtained after an incomplete colonoscopy, and it is more comfortable for the patient than is the DCBE. The CTC can be performed on the same day as a conventional colonoscopy. Hence, it re-

duces the time from diagnosis to surgery. It allows barium inspissation to be avoided in patients with severe obstructive cancers. It is also possible to simultaneously evaluate the extraluminal pathology, including the presence of local tumor spread, distant metastasis and other organ abnormalities. Unlike a barium enema and conventional colonoscopy, the CTC has the ability to evaluate the colon wall thickness and to visualize lymph nodes and liver involvement; thus, it is possible to assess the preoperative stage of colorectal cancer.

Our study had several limitations. First, we had a bias for the analysis of our results of the CTC (VDC) and DCBE, to depict the main mass according to localization, extent, conspicuity, and morphology. If the CTC had a superior or equal ability for the detection of the main mass compared with DCBE, we considered that DCBE was replaced by CTC for the preoperative work up in colorectal tumors. Even if DCBE was better at identifying the CTC for the extent, conspicuity, and morphology of main mass (18 vs. 5, 18 vs. 10, 26 vs. 5, DCBE vs. CTC, respectively, Table 1), we laid less emphasis on the results. We thought that the localization of main mass was more important than the extent, conspicuity, or morphology of main mass on the role of the VDCs or DCBEs for the preoperative work up of colorectal tumors. Second, we could not evaluate the effect of radiation on the patient during acquisition of both the CTC and DCBE. Hara *et al.* (27) reported that the calculated effective radiation dose in a patient when scanning both in the prone and supine positions at a tube current of 70 mA (374 mrad for men, 570 mrad for women) is 50% lower than the dose used for a standard abdominal and pelvic CT scan and this is comparable with the dose used for a barium enema examination (343 mrad for men, 638 mrad for women). Third, the total times required for the entire CTC and DCBE were not formally investigated. The total times required were estimated to be about 20–60 minutes for image acquirement, reconstruction and image post processing in the case of CTC and 10–15 minutes for image acquirement, verification and interpretation in the case of DCBE. It is most important to save time during the image post-processing step so that an experienced radiologist will have approximately 20 minutes for the entire CTC interpretation. Finally, conventional colonoscopy was used as the gold standard for the detection of polyps. Rex *et al.* (28) demonstrated that conventional colonoscopy has an overall 24% miss rate for adenomas.

In conclusion, CTC can compare favorably with

DCBE for the preoperative work-up for localizing and examining the main mass and also for the detection of polyps in those patients harboring colorectal neoplasms. Barium enema does not seem to be necessary for patients who undergo CTC as a preoperative work-up.

References

1. Winawer SJ, Zauber AG, Ho MN, O'Brien MJ, Gottlieb LS, Sternberg SS, *et al.* Prevention of colorectal cancer by colonoscopic polypectomy. The national polyp study workgroup. *N Engl J Med* 1993;329:1977-1981
2. Stryker SJ, Wolff BG, Culp CE, Libbe SD, Ilstrup DM, MacCarty RL. Natural history of untreated colonic polyps. *Gastroenterology* 1987;93:1009-1013
3. Smith GA, O'Dwyer PJ. Sensitivity of double contrast barium enema and colonoscopy for the detection of colorectal neoplasms. *Surg Endosc* 2001;15:649-652
4. Irvine EJ, O'Connor J, Frost RA, Shorvon P, Somers S, Steneson GW, *et al.* Prospective comparison of double contrast barium enema plus flexible sigmoidoscopy v colonoscopy in rectal bleeding: barium enema v colonoscopy in rectal bleeding. *Gut* 1988;29:1188-1193
5. Rex DK, Rahmani EY, Haseman JH, Lemmel GT, Kaster S, Buckley JS. Relative sensitivity of colonoscopy and barium enema for detection of colorectal cancer in clinical practice. *Gastroenterology* 1997;112:17-23
6. Vignati P, Welch JP, Cohen JL. Endoscopic localization of colon cancers. *Surg Endosc* 1994;8:1085-1087
7. Anderson ML, Heigh RI, McCoy GA, Parent K, Muhm JR, McKee GS, *et al.* Accuracy of assessment of the extent of examination by experienced colonoscopists. *Gastrointestinal Endoscopy* 1992;38:560-563
8. Langevin JM, Nivatvongs S. The true incidence of synchronous cancer of the large bowel, A prospective study. *Am J Surg* 1984;147:330-333
9. Adloff M, Arnaud JP, Bergamaschi R, Schloegel M. Synchronous carcinoma of the colon and rectum: prognostic and therapeutic implications. *Am J Surg* 1989;157:299-302
10. Tate JJ, Rawlinson J, Royle GT, Brunton FJ, Taylor I. Preoperative or postoperative colonic examination for synchronous lesions in colorectal cancer. *Br J Surg* 1988;75:1016-1018
11. Thorson AG, Christensen MA, Davis SJ. The role of colonoscopy in the assessment of patients with colorectal cancer. *Dis Colon Rectum* 1986;29:306-311
12. Howard ML, Greene FL. The effect of preoperative endoscopy on recurrence and survival following surgery for colorectal carcinoma. *Am J Surg* 1990;56:124-127
13. Pichkardt PJ, Kim DH. CT colonography (virtual colonoscopy): a practical approach for population screening. *Radiol Clin North Am* 2007;45:361-375
14. Rockey DC. Colon cancer screening, polyp size, and CT colonography: making sense of it all? *Gastroenterology* 2006;131:2006-2009
15. Lee SJ. Virtual CT colonoscopy and virtual CT barium enema using multidetector-row CT. *Korean J Gastroenterol* 2006;48:233-240
16. Laghi A, Iannaccone R, Carbone I, Catalano C, Panebianco V, Di Giulio E, *et al.* Computed tomographic colonography (virtual colonoscopy): blinded prospective comparison with conventional colonoscopy for the detection of colorectal neoplasia. *Endoscopy* 2002;34:441-446

17. Pickhardt PJ, Choi JR, Hwang I, Butler JA, Puckett ML, Hildebrandt HA, et al. Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults. *N Engl J Med* 2003;349:2191-2200
18. Pagana TJ, Ledesma EJ, Mittelman A, Nava HR. The use of colonoscopy in the study of synchronous colorectal neoplasms. *Cancer* 1984;53:356-359
19. Askew A, Ward M, Cowen A. The influence of colonoscopy on the operative management of colorectal cancer. *Med J Aust* 1986;145:254-255
20. Glick SN, Teplick SK, Balfe DM, Levine MS, Gasparaitis AE, Maglinte DD, et al. Large colonic neoplasms missed by endoscopy. *AJR Am J Roentgenol* 1989;152:513-517
21. Laufer I, Smith NC, Mullens JE. The radiologic demonstration of colorectal polyps undetected by endoscopy. *Gastroenterology* 1976;70:167-170
22. Thoeni RF, Petras A. Double-contrast barium-enema examination and endoscopy in the detection of polypoid lesions in the cecum and ascending colon. *Radiology* 1982;144:257-260
23. Hara AK, Johnson CD, Reed JE, Ehman RL, Ilstrup DM. Colorectal polyp detection with CT colography: two- versus three-dimensional techniques. Work in progress. *Radiology* 1996;200:49-54
24. Luo MY, Shan H, Yao LQ, Zhou KR, Liang WW. Postprocessing techniques of CT colonography in detection of colorectal carcinoma. *World J Gastroenterol* 2004;10:1574-1577
25. Kay CL, Kulling D, Hawes RH, Young JW, Cotton PB. Virtual endoscopy-comparison with colonoscopy in the detection of space-occupying lesions of the colon. *Endoscopy* 2000;32:226-232
26. Johnson CD, MacCarty RL, Welch TJ, Wilson LA, Harmsen WS, Ilstrup DM, et al. Comparison of the relative sensitivity of CT colonography and double-contrast barium enema for screen detection of colorectal polyps. *Clin Gastroenterol Hepatol* 2004;2:314-321
27. Hara AK, Johnson CD, Reed JE, Ahlquist DA, Nelson H, Ehman RL, et al. Reducing data size and radiation dose for CT colonography. *AJR Am J Roentgenol* 1997;168:1181-1184
28. Rex DK, Cutler CS, Lemmel GT, Rahmani EY, Clark DW, Helper DJ, et al. Colonoscopic miss rates of adenomas determined by back-to-back colonoscopies. *Gastroenterology* 1997;112:24-28

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대장 직장암의 수술 전 검사로 CT 대장조영술(CT colonography)을 시행한 환자에서 이중조영 바륨 관장술(Double contrast barium enema)이 필요한가?¹

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목적: 대장암의 수술 전 검사에 있어서 이중 조영 바륨 관장술(Double contrast barium enema)과 비교하여 CT 대장조영술 (CT colonography)의 효과를 알아보고자 하였다.

대상과 방법: 본 연구 기관에서 수술 전 CT 대장조영술과 바륨 관장술을 동시에 시행한 39명의 대장 직장암을 갖는 환자를 대상으로 하였다. 세 명의 영상의학과 의사와 세 명의 대장 항문 외과 의사가 대장 직장암의 모양, 위치, 범위, 두각 정도(암과 주변 정상 조직과의 구별 정도)를 CT 대장조영술에서 얻어진 가상 이중 조영영상과 바륨 관장술에서 얻은 영상을 각각 후향적으로 분석하였다. 또한, 검사별 용종의 발견율도 후향적으로 평가하였다.

결과: 가상 이중 조영술과 바륨 관장술 모두에서 40개의 암을 발견하였다. 영상의학과 의사에 의하면, 대장암의 위치 결정에는 가상 이중 조영술과 바륨 관장술에 차이가 없었으며, 범위, 두각, 모양에는 오히려 바륨관장술이 의미 있게 같거나 높은 점수를 얻었다. 대장 항문 외과 의사에 의하면 가상 이중 조영술이 바륨 관장술에 비해 모든 변수에서 의미 있게 같거나 높은 점수를 얻었다. 용종의 발견율에 있어서는 두 검사간에 의미 있는 차이는 없었다.

결론: 대장암과 용종의 발견에서 CT 대장조영술은 바륨 관장술을 대체할 수 있어, 수술 전 검사로 CT 대장조영을 시행한 경우 바륨관장술은 필요하지 않을 것으로 보인다.