

A comparative study of degree of colorectal distention with manual air insufflation or automated CO₂ insufflation at CT colonography as a preoperative examination

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Abstract

Objectives The purpose of this study was to compare the degree of colorectal distention between manual insufflation using room air and automatic insufflation using carbon dioxide for computed tomography colonography performed as a preoperative examination for patients with colon cancer.

Materials and methods Participants comprised 200 patients who underwent computed tomography colonography immediately after colonoscopy from October 2011–2012. The first 100 patients were examined using

manual insufflation, and the remaining 100 patients were examined using automated insufflation. Two radiologists independently assessed colorectal distention using a 4-point scale in six segments: cecum, ascending colon, transverse colon, descending colon, sigmoid colon, and rectum. Mean scores of the two radiologists were used to analyze whether any differences existed between techniques in terms of the degree of distention per segment.

Results Mean distention values for the colonic lumen were better using the automated technique than with the manual technique in both positions ($p < 0.05$). In segments, distention was significantly better using the automated technique than using the manual technique in the sigmoid and descending colon for prone patients, and in all segments for supine patients.

Conclusions Automated carbon dioxide insufflation offered significantly improved colorectal distention scores compared to manual room air insufflation.

Keywords CT · Virtual colonoscopy · CT colonography · Colon cancer

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Introduction

The incidence of colorectal cancer in western countries and Japan has risen significantly for both sexes [1, 2]. Colorectal cancer was the third most commonly diagnosed cancer in Japan in 2010 [3]. Among all cancer deaths in Japan in 2010, colorectal cancer was the cause of death in 11 % of men and 14 % of women [3]. Computed tomography (CT) and optical colonoscopy (OC) have been established as preoperative examinations for colorectal cancer [4]. Computed tomographic colonography (CTC) is a relatively new colonic imaging technique that can be used to screen for

colorectal cancer, polyps and preoperative colorectal tumors [5–8]. Previous reports have revealed that the sensitivity of CTC compares favorably with that of optical colonoscopy for detecting colorectal lesions [9]. In addition, a small number of reports have examined the usefulness of CTC for preoperative evaluation [10, 11].

Laparoscopic surgery is currently popular as a method of colon surgery [12]. However, locating lesions during laparoscopic surgery is difficult for surgeons. Preoperative colonoscopy is sometimes inaccurate for determining tumor location [13]. Furthermore, evaluation of the whole colon is important because one-third of colon cancers are located in a different segment as synchronous colon cancer [14]. For that reason, accurate preoperative location of colon tumors is needed. We think that CTC has the potential to gain favor as a useful technique for preoperative detection of colorectal cancer [15]. Several studies have compared manual and automated insufflation techniques [16–18], but preoperative evaluation with CTC requires adequate distention for accurate diagnosis.

The purpose of this study was to compare the degree of colorectal distention between manual insufflation using room air and automatic insufflation using carbon dioxide for CTC performed as a preoperative examination for patients with colon cancer.

Materials and methods

Study population

We analyzed 200 subjects among the 257 patients who underwent preoperative CTC between October 2011–2012. A total of 57 patients were excluded (21 from the manual group; 36 from the automated group) due to either severe luminal narrowing from cancer that prevented evaluation of the degree of distention or history of colorectal surgery. We also analyzed the anatomical location of colorectal cancers and distention at each sub-site. In our institute, OC and CTC are performed on the same day as a standard procedure. Patients were excluded if they showed severe luminal narrowing of an entire sub-site of the colon by cancer that prevented evaluation of the degree of distention or a history of colorectal operation. Written informed consent for contrast-enhanced CT and CTC was obtained from all patients prior to enrollment. In our institution, this retrospective study did not require institutional review board approval.

Bowel preparation

Colonic cleansing was performed using 2 l of polyethylene glycol lavage solution (Niflec; Ajinomoto Pharma, Tokyo,

Japan) and 10 ml of sodium picosulfate (Laxoberon; Teijin Pharma, Tokyo, Japan) prior to optical colonoscopy [19]. All patients maintained a low-fiber diet for 24 h before colonoscopy, and were not allowed to eat anything after midnight other than a small amount of water.

Colonoscopy

Colonoscopy was performed the same day by an experienced endoscopist according to the standard of practice at our institution. Administration of 20 mg of scopolamine butyl bromide (Buscopan; Boehringer Ingerheim, Berkshire, England) was infused before colonoscopy for all patients, and CTC was subsequently performed on the same day immediately after colonoscopy if there were no signs or symptoms of complications. We did not use scopolamine butyl bromide for patients with a history of side-effects or prostatomegaly. The number of patients who had scopolamine butyl bromide was 73 in the manual group and 76 in the automated group. No sedation was used. We defined classification of the flat lesion according to Paris endoscopic classification [20].

Insufflation technique: manual room air technique

Manual insufflation was performed by four radiologists using a standard barium enema bag (Horii Pharm, Tokyo, Japan) filled with ~2 l of room air. The barium enema bag was attached to a thin rectal tube via a connecting tube that could be sealed with a plastic clip. All patients were placed in the left-lateral decubitus position, and an enema tube was inserted into the anus. The operator compressed the barium enema bag gently over ~3 min. The patient was gradually shifted to a supine position after the bag was approximately empty [16]. A standard scout image was obtained to assess colonic distention. Additional room air was insufflated if inadequate colorectal distention was suggested on scout view.

Insufflation technique: automated insufflation technique

Automated carbon dioxide insufflation was also performed by the same four radiologists. Before CTC was performed, a thin rectal tube with a retention cuff was inserted into the rectum by an experienced radiologist and inflated with 30 ml of room air. Placement and insufflation were started with all patients in a left-lateral decubitus position. Colonic insufflation was achieved with carbon dioxide using an automated device (PROTOCO₂L; E-Z-EM, Monroe Township, NJ). The patient was gradually moved into a supine position after rectal pressure reached 18–20 mmHg, and the upper limit of pressure was set to 25 mmHg [17, 21]. A standard scout view was obtained with the patient in

the supine position, and more gas was introduced by an experienced radiologist if findings on scout images suggested areas of collapse.

CTC procedure

Following air insufflation, contrast-enhanced CT was performed in both supine and prone positions used 1.8 mg/kg of non-ionic iodine contrast material (Iomeron; Eisai, Tokyo, Japan) administered over a period of 30 s. CTC examination was obtained using a 128-detector row multi-detector row CT scanner (Somatom Definition Flash or Somatom Definition AS; Siemens Medical Solutions, Forchheim, Germany) with these parameters: beam collimation, 0.6 mm; reconstruction interval, 1 mm; automated exposure control, 200 mAs; and 120 kV. The balloon of the rectal tube was deflated for prone position imaging to obtain adequate visualization if the tumor was located in the rectum.

Image analysis

CT data sets were assessed by two radiologists using a CTC workstation (AZE Virtual Place; AZE, Tokyo, Japan). Two-dimensional transverse images were evaluated using a viewer program (AZE Virtual Place; AZE). Each radiologist independently assessed images obtained in the supine and prone positions. The colon was divided into six segments: rectum, sigmoid colon, descending colon, transverse colon, ascending colon, and cecum (Fig. 1) [22]. According to previous reports [22], the degree of colorectal distention in each segment was assessed in the least distended portion of the segment using a 4-point scale: 4 optimally distended, 3 adequately but not optimally distended, 2 partially collapsed, 1 completely collapsed (Table 1) (Fig. 2a–d). Lumens showing severe narrowing and obstruction of an entire sub-site of colon caused by the tumor itself were excluded.

Statistical analysis

All statistical analyses were calculated using SPSS version 21.0 software (IBM, Armonk, NY). The Mann–Whitney *U* test was used for categorical data to compare proportions and for comparisons of colonic distention scores for the least distended portion in supine and prone positions. Values of $p < 0.05$ were considered statistically significant. Interobserver agreement between distention scores was assessed using the weighted kappa statistic, defined as follows: poor <0.2 , fair $>0.2–\leq 0.4$, moderate $>0.4–\leq 0.6$, good $>0.6–\leq 0.8$, and excellent, $>0.8–\leq 1$.

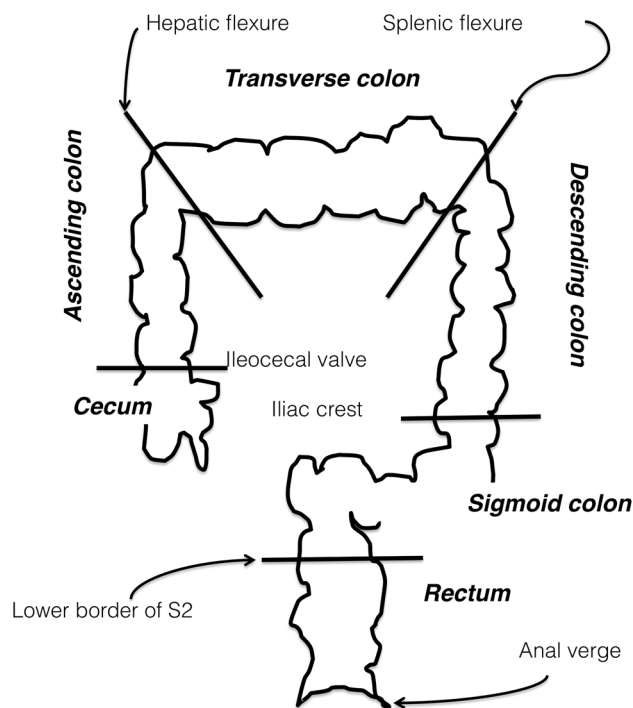


Fig. 1 Sub-sites of the colon and rectum

Table 1 Colorectal distention according to the 4-point scale

Score	4	3	2	1
Degree of distention	Optimally distended	Adequately but not optimally distended	Partially collapsed	Completely collapsed

Results

We identified 200 subjects among the 257 patients who underwent CTC during the study period. The 200 patients analyzed comprised a manual group [62 men, 38 women; mean (\pm SD) age 64.9 ± 10.4 years] and an automated carbon dioxide group (59 men, 41 women; mean age 64.5 ± 12.1 years) (Table 2). The reason for the change in CTC method is that the Ministry of Health, Labour and Welfare in Japan approved only CTC using automated carbon dioxide insufflation for coverage by medical insurance in April 2012. No complications associated with CTC or colonoscopy performed before CTC were encountered.

We also analyzed sub-sites of colorectal cancer in both groups. A total of 1,200 segments were evaluated in each position. The sigmoid colon and rectum were the most common tumor sites in both groups (manual group, 36 and 35 %, respectively; automated carbon dioxide group, 31 and 37 %, respectively). The descending colon was the least common site overall (manual group, 3 %; automated carbon dioxide group, 1 %) (Table 2).

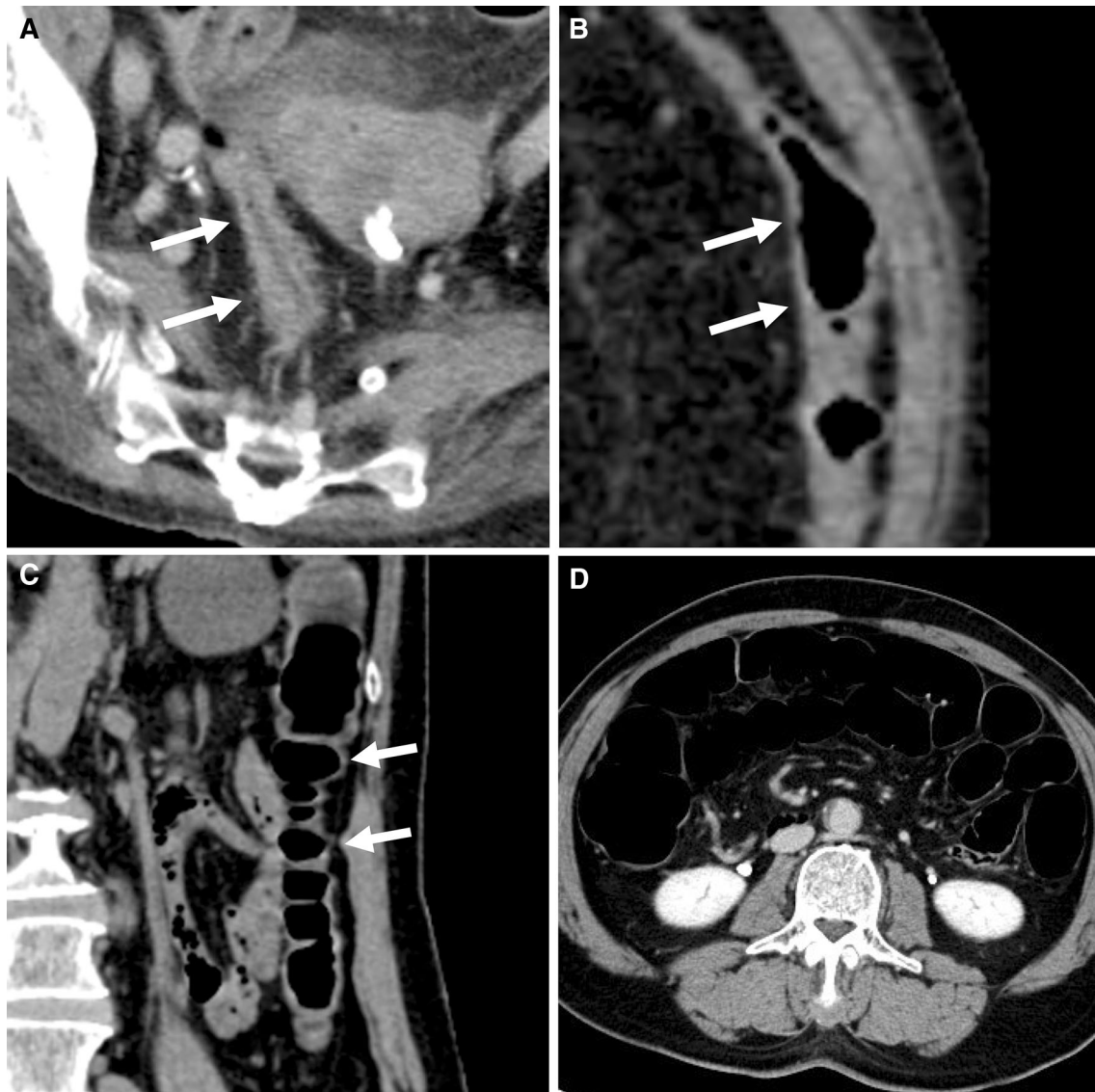


Fig. 2 Grade of colorectal distention on 2D transverse image of CT colonography. **a** Grade 1 distention in a 75-year-old woman. Complete collapse is seen in the sigmoid colon (white arrows). **b** Grade 2 distention in a 62-year-old man. Partial collapse is seen in

the descending colon (white arrows). **c** Grade 3 distention in a 61-year-old woman. Adequate but not optimal distention is seen in the descending colon (white arrows). **d** Grade 4 distention in a 77-year-old man. Optimal distention is seen in the transverse colon

Mean distention of the overall colonic lumen using the automated technique was better than that with the manual technique in both positions ($p < 0.05$) (Fig. 3). In individual segments, distention was significantly better with the automated technique than with the manual technique in the sigmoid and descending colon when patients were prone, and in all segments when patients were supine (Fig. 4a, b).

Comparison of distention scores between the two independent radiologists yielded a weighted kappa of 0.932, indicating excellent agreement.

We analyzed the visibility of colorectal tumors related to the degree of colorectal distention, but found no significant differences between groups in the prone position

($p = 0.175$). However, the automated technique was better than the manual technique when the patient was supine ($p < 0.05$). In addition, we compared the visibility of colorectal tumors classified morphologically as listed in Table 3. No differences in the visibility of flat lesions or total tumors were seen between the manual and automated insufflation groups.

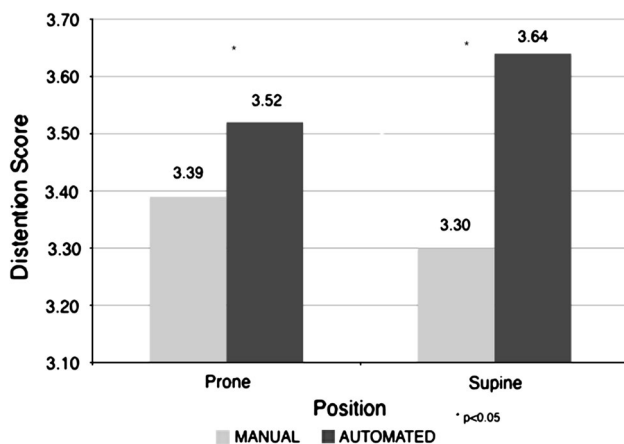
Discussion

CTC is a noninvasive examination technique that has the benefit of less patient discomfort, no need for sedation, and

Table 2 Participant characteristics and distribution of colorectal tumors

	Manual (<i>n</i> = 100)	Automated (<i>n</i> = 100)	<i>p</i>
Sex			
Male	62	59	0.772
Female	38	41	
Age (mean ± SD)	64.9 ± 10.4	64.5 ± 12.1	0.926
Tumor location			
Rectum	36	31 ^a	
Sigmoid colon	35	37	
Descending colon	3	1	
Transverse colon	9	6	
Ascending colon	12	18 ^a	
Cecum	5	8	
Early stage	14	17	
Advanced stage	67	67 ^a	

^a One patient had cancer at the rectum and the ascending colon

**Fig. 3** Mean distention scores for the entire colon using different positions

rapid data acquisition [23, 24]. The sensitivity of CTC compares favorably with that of optical colonoscopy in terms of the detection of colorectal lesions [9]. In April 2012, the Ministry of Health, Labour and Welfare in Japan approved CTC for coverage by medical insurance. Although comparisons of automated and manual insufflation using carbon dioxide or room air have been reported previously [15, 16], no studies to date appear to have compared manual room-air insufflation with automated carbon dioxide insufflation in terms of preoperative examinations.

Although OC is regarded as the gold standard for detecting colorectal lesions prior to surgery, preoperative

evaluation of the entire colon in patients with colorectal cancer is recommended [7]. Laparoscopic surgery has gained widespread use in the treatment of colorectal tumor [12], but OC is sometimes inaccurate in terms of detecting tumor location [13]. CTC with good distention facilitates accurate location of colorectal cancer and accurate T-staging before surgery [10]. CTC is also useful for evaluating the colon before surgery in patients with distal occlusive colon cancer [25].

CTC requires adequate intraluminal distention that separates the colorectal walls and allows clear visualization of the lumen and detection of lesions. Manual insufflation depends on operator technique, because maintaining adequate pressure during examination can be difficult. In addition, previous work has shown that the left colon tends to collapse under manual insufflation techniques [26], and automated carbon dioxide insufflation offers improved distention of the left colon [16].

The present study revealed good distention in the sigmoid, descending, and transverse colon in prone patients, and in all segments in supine patients. However, no significant differences were observed between techniques in the cecum and ascending colon in the prone position. Furthermore, previous work has shown that distention was better in the prone position than in the supine position [16]. The lack of significant improvement in the right colon in the prone position may be because the cecum is a dead end, so intra-luminal pressure is easily increased using either method of insufflation. In contrast, distention of the left colon was considered difficult [27]. Improvement of distention in the rectum and sigmoid colon using the automated method may be beneficial for the detection of colon cancer because distal colon cancer is much more prevalent than proximal colon cancer [28]. We revealed that the most common sub-site of colorectal tumors in the present study was the sigmoid colon. Proportions of colon cancer by sub-site have been reported previously, with the sigmoid colon reported as the most common sub-site in Europe, the United States and Asia [28, 29]. In addition, the incidence of left colon cancer has increased [30].

What we emphasize is that improvement of distention using the automated method at the sigmoid colon, one of the most frequent sub-sites of colorectal cancer, in the prone and supine positions may increase the detection of colorectal cancer. In addition, this approach will contribute to accurate laparoscopic surgery for colorectal cancer in terms of tumor location.

Various potential limitations must be considered when interpreting the present results. First, patient recruitment in this study was not randomized, and most of our controls were historical. We have not used a manual insufflation method since starting to use the automated carbon dioxide insufflation method due to medical insurance reasons.

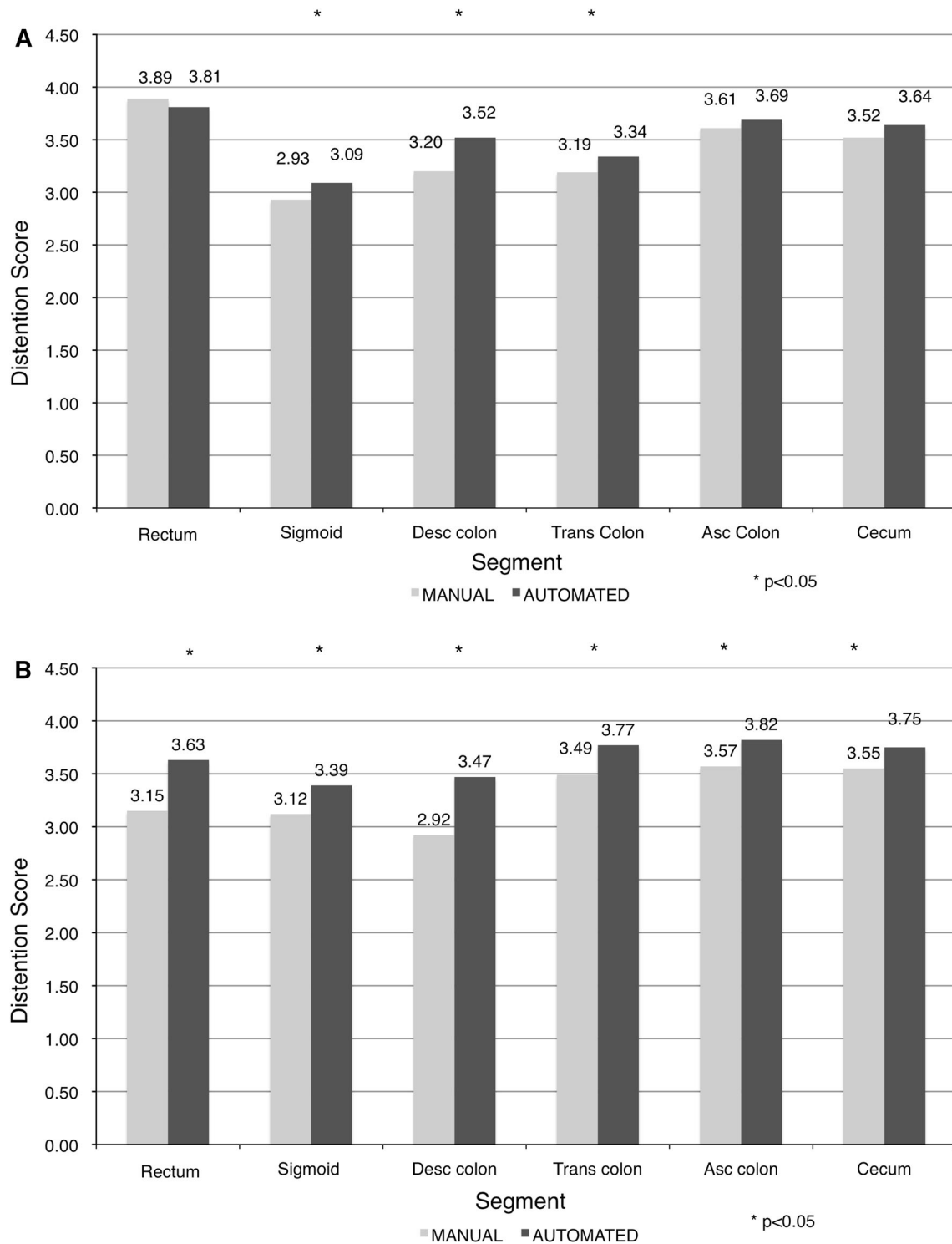


Fig. 4 Mean distention scores using different positions. **a** Mean distention scores for each segment in prone patients. **b** Mean distention scores for each segment in supine patients

However, no significant differences in age or sex were seen between the manual and automated groups.

Second, in our study, patient preferences were not assessed in either group. In a comparison of CTC and

optical colonoscopy, patients reportedly preferred CTC over OC [31]. Previous studies have found no significant difference in patient preference between manual and automated insufflation groups [16, 32]. On the other hand,

Table 3 Visibility of lesions according to morphology (Paris classification)

Classification of tumor	Manual	Automated
Polypoid (0–I s+0–I p) total No.	7	4
True-positive, No.	4	3
Visibility (95 % CI)	0.57 (0.18–0.90)	0.75 (0.19–0.99)
Flat (0–II a+0–II c) total No.	3	10
True-positive, No.	1	6
Visibility (95 % CI)	0.33 (0.01–0.91)	0.60 (0.26–0.88)
0–II a+II c (flat depressed) total No.	4	3
True-positive, No.	2	0
Visibility (95 % CI)	0.50 (0.07–0.93)	0.00 (0.00–0.71)
Type1 total No.	2	8 ^a
True-positive, No.	2	8
Visibility (95 % CI)	1.00 (0.16–1.00)	1.00 (0.63–1.00)
Type2 total No.	62	53
True-positive, No.	60	51
Visibility (95 % CI)	0.97 (0.89–1.00)	0.96 (0.87–1.00)
Type3 total No.	3	3
True-positive, No.	2	3
Visibility (95 % CI)	0.67 (0.09–0.99)	1.00 (0.29–1.00)
Type4 total No.	0	2
True-positive, No.	N/A	2
Visibility (95 % CI)	N/A	1.00 (0.16–1.00)
Type5 total No.	0	1
True-positive No.	N/A	1
Visibility (95 % CI)	N/A	1.00 (0.03–1.00)
Post endoscopic excision No.	15	12
Others No.	4	5
Total tumor No	81	84
True-positive, No.	71	74
Visibility (95 % CI)	0.88 (0.78–0.94)	0.88 (0.79–0.94)

^a One patient had cancer at the rectum and the ascending colon

carbon dioxide is rapidly resorbed compared to room air and is associated with improved patient comfort after examination [33].

However, previous studies have not investigated the situation in Japan. Incidence of colorectal cancer appears to differ between geographical regions and ethnic groups [1, 2, 28], and patient comfort must take various factors into consideration. Further clinical research in Japan is warranted.

Conclusion

In conclusion, automated carbon dioxide insufflation improved colorectal distention compared to manual insufflation during preoperative CTC. In particular, improved distention at the sigmoid colon, one of the most frequent sub-sites of colorectal cancer, may be useful to achieve

accurate location of colorectal tumors and diagnosis of colorectal tumors on preoperative CTC.

Conflict of interest The authors declare that they have no conflict of interest.

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