Received:
13 June 2018

Revised:
14 August 2018

Accepted:
05 September 2018

<https://doi.org/10.1259/bjr.20180538>

Cite this article as:

Takahashi N, Nagata K, Iyama A, Mikami T, Kanazawa H, Saito H. Colonic distention and patient acceptance of CT colonography: supine/prone vs left/right lateral scanning. *Br J Radiol* 2019; **92**: 20180538.

FULL PAPER

Colonic distention and patient acceptance of CT colonography: supine/prone vs left/right lateral scanning

^{1,2}NORIAKI TAKAHASHI, BS, ^{1,3,4}KOICHI NAGATA, MD, PhD, ⁵ATSUSHI IYAMA, RT, ⁵TEPPEI MIKAMI, RT, ^{4,6}HIDENORI KANAZAWA, MD, PhD and ^{7,8}HIROSHI SAITO, MD, PhD

¹Division of Screening Assessment and Management, Center for Public Health Science, National Cancer Center, Tsukiji, Japan

²Division of Screening Technology, Center for Public Health Science, National Cancer Center, Tsukiji, Japan

³Cancer Screening Center, National Cancer Center Hospital, Tsukiji, Japan

⁴Department of Radiology, Jichi Medical University, Shimotsuke, Japan

⁵Department of Radiology, Sakakibara Sapia-tower Clinic, Marunouchi, Japan

⁶Department of Radiology, Haga Red-cross Hospital, Tochigi, Japan

⁷Aomori Prefectural Central Hospital, Aomori, Japan

⁸Division of Medical Support and Partnership, Center for Cancer Control and Information Services, National Cancer Center, Tsukiji, Japan

Address correspondence to: Dr Koichi Nagata

E-mail: Nagata7@aol.com

Objective: To prospectively evaluate and complete the colonic distention and patient acceptance of CT colonography (CTC) in the supine/prone and left/right lateral positions.

Methods: A total of 220 consecutive patients were alternately allocated to the supine/prone positioning or left/right lateral positioning group. Two readers scored the degree of colonic distention by segment using a 4-point Likert scale (4 = optimal, 3 = adequate, 2 = inadequate, 1 = collapsed). In addition, patients were asked to rate the discomfort due to positioning during each scan using a 3-point animated face scale (3 = difficult, 2 = somewhat unacceptable, 1 = easy).

Results: The overall mean colonic distention scores for supine, prone, left lateral, and right lateral positions were

3.16, 3.29, 3.22, and 3.42, respectively. Of all, the right lateral position provided the best colonic distention ($p < 0.01$). Combined left lateral and right lateral positions provided more adequately distended segments compared with combined supine and prone positions (95.6% vs 90.7 %, respectively, $p < 0.01$). Patient acceptance was significantly lower in the prone position compared to other positions; however there was no difference in patient acceptance between the supine and left/right lateral positions.

Conclusion: Right lateral positioning provided the best colonic distention and good patient acceptance.

Advances in knowledge: The left/right lateral position should be considered for routine CTC positioning protocols.

INTRODUCTION

CT colonography (CTC) is a less invasive colon examination compared with optical colonoscopy.^{1–6} An additional advantage of CTC over optical colonoscopy is its lower complication rate.^{7–9} Although CTC is a patient-friendly examination, further improvement in patient acceptance of the procedure is important because not all patients are willing to undergo CTC.¹⁰

Dual-position scanning is required for CTC and a standard combination is supine and prone positioning.¹¹ However, prone positioning can cause discomfort or pain during intestinal insufflation especially in fragile or obese patients.^{11,12} In addition, the prone position increases the possibility of inadequate colon distension and breathing

artefacts.¹³ In contrast, the right lateral position has been reported to improve colonic distention and the use of right lateral positioning has been proposed for standard protocols.¹² Alternatively, others have recommended the left lateral position as an alternative to the prone position because it reduced breathing artefacts.¹³ However, neither study evaluated colonic distention in left/right lateral positioning. Inadequate colon distention and breathing artefacts can result in false positive and false negative findings for colonic neoplasms, which may lead unnecessary additional colonoscopies. It is important to determine which position provides the best colon distention and patient acceptance of CTC. To the best of our knowledge, no previous study has compared colonic distention and patient acceptance of

the four scanning positions (supine, prone, left lateral, and right lateral) during CTC.

Therefore, we conducted a prospective study comparing distention and patient acceptance of the supine/prone and left/right lateral positions during CTC.

METHODS AND MATERIALS

This study was approved by the local ethics committee prior to starting. Average risk patients who were scheduled to undergo CTC for colorectal cancer screening between June 2012 and December 2012 at a single outpatient-screening centre were recruited for the study. Ultimately 230 consecutive asymptomatic patients were alternately assigned to either the supine/prone or left/right lateral position group. Patients were excluded from the study if they had a serious medical condition associated with an increased risk of complications from bowel preparation or CTC, an existing colorectal mass, or a history of prior colorectal surgery. Of the 230 potentially eligible patients, 10 (4%) were excluded because they did not meet inclusion criteria (had a history of colorectal mass or prior colorectal surgery). Of the remaining consecutive 220 patients, 107 (mean age, 57.8 years; interquartile range, 49–66 years) were in the supine/prone position group and 113 (mean age, 59.1 years; interquartile range, 50–66 years) were in the left/right lateral position group. All patients were informed about the nature of the study, and those who agreed to participate provided written informed consent before enrolment. The study was financially supported in part by a Health, Labour and Welfare Policy Research Grant (H27-006) in Research for Promotion of Cancer Programs and was registered in the UMIN Clinical Trials Registry (number UMIN000026162).

CTC bowel preparation and scanning protocol

Bowel preparation included reduced laxative purgation and sodium diatrizoate (Gastrografin®; Bayer Yakuhin, Ltd, Osaka, Japan) for tagging.⁶ Diet was unrestricted until the day before the procedure, and participants were instructed not to eat after midnight the night before the examination.¹⁴ Spasmolytic agents, such as butylscopolamine bromide or glucagon hydrochloride, and sedatives were not used during the CTC procedure.¹⁵ Colon insufflation was achieved by manual administration of carbon dioxide with a manual carbon dioxide (CO₂) insufflation system (5 Lgasbag; Horii Pharmaceutical Ind., Ltd, Osaka, Japan) which consisted of a bag filled with approximately 5 L of CO₂ connected to a thin flexible rectal tube.¹⁶ Gas insufflation was performed until reasonable patient tolerance had been reached. A scout CT image was examined for colonic distention. If the subjective opinion of trained radiologic technicians determined the scout image revealed inadequate colonic distention, additional CO₂ was introduced while moving the extension tube to confirm the absence of blockage, repositioning the rectal tube tip to avoid possible occlusion of the tip against the rectal wall, or changing the patient's position. After completion of the first positioning (supine or left lateral) scan, patients were scanned in the second positioning (prone or right lateral) with a 64-slice CT scanner (Aquilion 64; Toshiba Medical Systems Corporation, Otawara, Japan). The scanning protocol was as follows: 120 kV, rotation time 0.5 s, pitch 0.828, section thickness 1.0 mm, and

reconstruction interval 0.8 mm, and automatic tube current modulation system (Volume EC, SD20; Toshiba Medical Systems Corporation, Otawara, Japan). During the procedure, one of two trained radiologic technicians (AI, TM) was responsible for the insufflation of CO₂. Prior to this study, both radiologic technicians had performed over 500 scans using manual CO₂ insufflation for CTC procedures.

Outcome measures

The primary outcome was comparison of the colon distention in each position, and the secondary outcome was patient acceptance of each position.

The degree of colon distention in each position was assessed by two independent readers (AI, TM) who had previously evaluated over 500 CTC examinations. In addition, the two readers previewed 10 test cases and, after some discussion, agreed on how the ratings would be determined before starting the study. Each reader assessed the colon distention independently from another reader. A radiological technician assessed the image quality for use in the study but not to establish a clinical diagnosis. For the purposes of data recording and analysis, the colon was divided into six segments: the caecum, ascending colon, transverse colon, descending colon, sigmoid colon, and rectum. The distention of each segment in each position was graded on axial 2-dimensional images using a 4-point Likert scale (4 = optimal, 3 = adequate, 2 = inadequate, 1 = collapsed).¹⁵ Score 1 colonic distention was defined as complete luminal collapse. Score 2 colonic distention was defined as partial luminal collapse. Colonic haustra were bulbous and attach at centerline, so-called “kissing folds.” Score 3 colonic distention was defined as reasonable but suboptimal luminal distention. Colonic haustra seemed to be slightly bulbous. Score 4 colonic distention was defined as optimal luminal distention. Colonic haustra were sharply defined. Scores of 3 and 4 were considered to be clinically adequate distention. The least distended portion of any individual segment was used to assign the overall distention grade for that segment. Assessment of adequate distention for the combined supine/prone datasets and the combined left/right lateral datasets was counting up the number of segments with score 3 or 4 in at least one position.

All patients were given a written questionnaire by the reception staff after the CTC examination that assessed their acceptance of each position during scanning using a 3-point animated face scale (3 = difficult, 2 = somewhat unacceptable, 1 = easy).

Statistical analysis

Statistical analysis was performed using EZR (v. 1.32),¹⁷ which is a graphical user interface for R (The R Foundation, Vienna, Austria, v. 3.2.2). The Fisher's exact test and Mann–Whitney U test were used to assess statistical significance of differences in patient characteristics for both groups. The Fisher's exact test was used to evaluate differences in the proportion of adequate colon distention between the supine/prone and left/right lateral positions. We assessed whether the presence of sigmoid colon diverticula is associated with the sigmoid colon distention or the overall distention for both groups (Fisher's exact test). The

Table 1. Patient Characteristics

Group	Supine/prone	Left/right lateral	<i>p</i> value
Number of patients	107	113	
Female/male ratio ^a	36/71	37/76	1.00
Age (years) ^b			
Mean	57.8	59.1	0.626
Interquartile range	49–66	50–66	
Mean body mass index (kg m ⁻²) ^b	23.4	23.1	0.380
Number of diverticula ^a			
0	47 (43.9%)	62 (54.9%)	0.277
1–3	33 (30.9%)	28 (24.8%)	
≥4	27 (25.2%)	23 (20.3%)	
Additional scan after two position ^a	30 (28.0%)	11 (9.7%)	<0.01
Supine	0	10	
Prone	0	1	
Left lateral	6	0	
Right lateral	24	0	
Additional optical colonoscopy after CTC	0	0	

Data represent numbers of patients, unless otherwise indicated.

^aFisher's exact test.

^bMann-Whitney *U* test.

Steel-Dwass post-hoc test was used to compare each pair of positions. Differences in responses to the patient acceptance questionnaire for each position were tested using the Fisher's exact test and the Steel-Dwass test. We set the significance level at 0.05 for two-sided hypothesis tests. Inter reader reliability was examined using kappa values for the two independent readers. Agreement in the degree of colon distention for each position between the two readers was considered fair to good if kappa values were 0.4–0.75 and excellent if greater than 0.75. A kappa value of zero indicated absence of agreement and a negative kappa value indicated disagreement.¹⁸

RESULTS

All 220 patients tolerated bowel preparation and the entire CTC procedure well. No serious adverse events were observed. In each position group, all segments were free of breathing artefact. Patient characteristics did not differ significantly between the groups except for additional scan examination as shown in Table 1. In cases of necessitating a third scan examination because of collapsing a same colonic segment, the frequency for performing an additional scan was much higher in supine/prone group than in left/right lateral group (28.0% vs 9.7%, *p* < 0.01). Repeat CTC or additional colonoscopy were not performed.

Colon distention

The overall mean pooled colon distention scores for supine, prone, left lateral, and right lateral positions were 3.16, 3.29, 3.22, and 3.42, respectively (Figure 1). Of all the positions, the right lateral provided the best colonic distention (*p* < 0.01). Pooled colon distention scores by segment for each position are shown

in Figure 2. Only the right lateral position provided clinically adequate distention (scores over 3.0) in all colonic segments. In the caecum, ascending colon, and rectum, all positions had clinically adequate distention. In contrast, mean pooled colonic segmental scores were below 3.0 in the sigmoid colon for the supine (mean score, 2.66), prone (mean score, 2.96), and left lateral positions (mean score, 2.92), while the mean score for the right lateral position was 3.30. The adequately distended segments for each position are shown in Table 2. The right lateral position provided adequate distension in 89.5% of all segments, and provided the best colonic distention of all the positions. The combined left lateral and right lateral positions has more

Figure 1. The overall mean pooled colon distention scores for each position.

Figure 2. Pooled colon distention scores by segment for each position.

adequately distended segments than that of the combined supine and prone positions (95.6% vs 90.7%, respectively, $p < 0.01$). Figure 3 shows the percentage of adequately distended segments by colon segment for each position. The combined left and right lateral position had better adequate distension than the combined supine and prone position in the sigmoid colon (92.9% vs 78.5%, respectively, $p < 0.01$) and the descending colon (91.2% vs 77.6%, respectively, $p < 0.01$). In the caecum, ascending colon, transverse colon, and rectum, the percentages of adequately distended segments were not significantly different between the groups. The presence of sigmoid colon diverticula was not significantly associated with the sigmoid colon distention in both groups: Adequately distended colon with and without diverticula in supine/prone group was 76.9 and 79.0%, respectively (not significant), and those in left/right lateral group was 94.1 and 92.7%, respectively (not significant). Regarding the presence of sigmoid colon diverticula, we have not observed any association with the overall colon distention: Adequately distended colon with and without diverticula in supine/prone group was 92.0 and 90.2%,

respectively (not significant), and those in left/right lateral group was 96.3 and 95.4%, respectively (not significant).

There was good inter reader agreement between the two readers for the assessment of the degree of colon distention for each position, having a kappa value of 0.724 (95% CI, 0.685–0.762).

Patient acceptance

Tables 3 and 4 show the responses to the patient acceptance questionnaire for each position. Although no patients in either group gave a difficult rating, nine patients (8.4%) in supine/prone group rated the prone positioning as somewhat unacceptable. Patient acceptance was significantly lower in the prone position than other positions ($p < 0.05$). There was no difference in acceptance between the supine and left/right lateral positions.

DISCUSSION

Our study showed that the right lateral position was best for adequate colonic distention and good patient acceptance. The left/right lateral position should be considered for routine CTC positioning protocols. Previous studies have evaluated colon distention for CTC in the left/right lateral position.^{12,13} Similar to our study, Pickhardt *et al* found that the right lateral position provided the best overall colonic distention and significantly improved the distention of the sigmoid colon.¹² A limitation pointed out in that study was its single-arm design, which might cause selection bias because the distention in the supine and prone positions were already determined to be suboptimal. Gryspeerdt *et al* found the left lateral position reduced breathing artefacts and improved distension of the transverse colon compared to the prone position although there were no significant differences in colon distention in the combined supine/prone and combined supine/left lateral positions.¹³ Because the study was performed

Table 2. Adequately distended segments in each position

		Segments	<i>p</i> value
Supine/prone position	Supine	76.8 (493/642)	<0.01 ^a
	Prone	84.3 (541/642)	
	Combined	90.7 (582/642)	
Left / right lateral position	Left lateral	77.6 (526/678)	
	Right lateral	89.5 (607/678)	
	Combined	95.6 (648/678)	

Data represent percentages with number of segments in parentheses.

^aFisher's exact test for combined positions in both groups.

Figure 3. Percentage of adequately distended segments by colon segment

with single-slice CT scanner, breathing artefacts were observed in some patients. It was recently recommended that CTC should be performed with a multi detector CT (≥ 16 slice) scanners, which might resolve the problem of breathing artefacts.¹⁹ No breathing artefacts were observed in any of the four positions in our study, which was performed using 64-detector CT scanners.

The two studies mentioned above and our study found that the prone position was not suitable for CTC due to poor colonic distention and patient discomfort. Therefore, the prone position should be replaced with another position. Although we recommend the left/right lateral position over the combined supine/prone position, the left/right lateral position might be unfavourable for extracolonic reading. The deformity of extracolonic organs in the left/right lateral position might affect the extracolonic reading. However, the US Preventive Services Task Force has found there is insufficient evidence regarding the potential harm of associated extracolonic findings, which are common.²⁰ The significance and verification of the extracolonic reading in the left/right lateral position should be assessed in future studies. Pickhardt et al recommended routine supine and right lateral positions as the standard CTC protocol.¹² Although

this combination of positions is good for extracolonic reading, it might make it difficult to distinguish between pedunculated lesions and residual faeces with only a 90-degree turn. However, the left/right lateral position with a 180-degree turn may be suitable for detecting colorectal polyps. To answer this clinical question, assessment of the detection rate of pedunculated lesion might be needed in a future study.

De Cecco et al reported that the overall prevalence of diverticula was 47.3% in 1091 patients (mean age 68 ± 12 years) who underwent CTC.²¹ Although the population of our study was a young screening cohort (mean age 59 ± 12 years), the prevalence rate of diverticula was 50.5% and its value was similar compared with above study.²¹ Our results found the presence of diverticula did not impair the colonic distention. Flor et al also reported distention at CTC examinations were not influenced by the presence of diverticular disease, even in case of severe diverticular disease.²²

From our results, it is worth to highlight that the left/right lateral position works well for CTC in a younger patient cohort of normal BMI as well as its advantages in the older and/or obese patient.^{11,12} At the best of our knowledge, no studies have

Table 3. Patient acceptance responses for each position

Answers	Supine	Prone	Left lateral	Right lateral	p value
1: easy	100 (107/107)	91.6 (98/107)	99.1 (112/113)	100 (113/113)	<0.01 ^a
2: somewhat unacceptable	0 (0/107)	8.4 (9/107)	0.9 (1/113)	0 (0/113)	
3: difficult	0 (0/107)	0 (0/107)	0 (0/113)	0 (0/113)	

Data represent percentages with numbers of segments in parentheses.

^aFisher's exact test.

Table 4. Comparison of patient perception for each position (multiple comparison)

Comparison	<i>p</i> value
Supine vs prone	0.012
Supine vs left lateral	0.765
Supine vs Right lateral	1.000
Prone vs Left lateral	0.038
Prone vs Right lateral	0.009
Left lateral vs Right lateral	0.749

Steel-Dwass test

reported this issue. Because CTC is a patient-friendly examination, this result should be considered as a good new approach especially in screening programs.

This study has several limitations. First, colonic distension was performed using manual insufflation of carbon dioxide, although automated insufflators are preferred. Since the trained radiologic technicians who performed the gas insufflation had significant experience using manual CO₂ insufflation for CTC procedures (>500 scans), this study can be valuable despite this limitation. However, the combined supine and prone position in the sigmoid colon and the descending colon were lower than previous report.¹³ Although the true reason was unknown, manual CO₂ insufflation might impair the colon distension. Second, although we included all four positions (supine, prone, left lateral, and right lateral) for CTC examinations, we could not compare the four positions directly because supine/prone positioning was performed in a supine-prone order and left/right lateral positioning was performed in a left-right order. The second

positioning (prone or right lateral) had better colonic distension than the first positioning (supine or left lateral) as shown in Table 2. This could introduce temporal bias and might affect the results. Third, the differences in body mass index (BMI) were not compared in this study. Patients with a high BMI were not included in this study population. However, it has been shown in a previous study that BMI was found to negatively correlate with colonic distension.¹² Fourth, we evaluated the combined datasets as adequate by counting up the number of segments with score 3 or 4 (Figure 3). This evaluation might be insufficient. A segment could score less than 3 on both positions but actually be a 3 or 4 when the positions were combined as the areas of collapse were different between the two positions such that when they were compared side by side, the distension overall was adequate. However, it was difficult to judge if the areas of collapse were same or different between the two positions precisely. In both combined datasets, the result of adequately distended segments could have been better.

CONCLUSION

Our study shows that the right lateral position provides the best colonic distension and good patient acceptance. Our findings show that the left/right lateral position can be used routinely in CTC positioning protocols.

ACKNOWLEDGMENT

We thank all the patients who agreed to participate in this study.

FUNDING

This study received funding from a Health, Labour and Welfare Policy Research Grant (H27-006) in Research for Promotion of Cancer Programs.

REFERENCES

1. Taylor SA, Halligan S, Saunders BP, Bassett P, Vance M, Bartram CI. Acceptance by patients of multidetector CT colonography compared with barium enema examinations, flexible sigmoidoscopy, and colonoscopy. *AJR Am J Roentgenol* 2003; **181**: 913–21. doi: <https://doi.org/10.2214/ajr.181.4.1810913>
2. Nagata K, Endo S, Honda T, Yasuda T, Hirayama M, Takahashi S, et al. Accuracy of CT colonography for detection of polypoid and nonpolypoid neoplasia by gastroenterologists and radiologists: a nationwide multicenter study in Japan. *Am J Gastroenterol* 2017; **112**: 163–71. doi: <https://doi.org/10.1038/ajg.2016.478>
3. Jensch S, Bipat S, Peringa J, de Vries AH, Heutinck A, Dekker E, et al. CT colonography with limited bowel preparation: prospective assessment of patient experience and preference in comparison to optical colonoscopy with cathartic bowel preparation. *Eur Radiol* 2010; **20**: 146–56. doi: <https://doi.org/10.1007/s00330-009-1517-0>
4. von Wagner C, Ghanouni A, Halligan S, Smith S, Dadswell E, Lilford RJ, et al. Patient acceptability and psychologic consequences of CT colonography compared with those of colonoscopy: results from a multicenter randomized controlled trial of symptomatic patients. *Radiology* 2012; **263**: 723–31. doi: <https://doi.org/10.1148/radiol.12111523>
5. Nagata K, Iida N, Kanazawa H, Fujiwara M, Mogi T, Mitsushima T, et al. Effect of listening to music and essential oil inhalation on patients undergoing screening CT colonography: a randomized controlled trial. *Eur J Radiol* 2014; **83**: 2172–6. doi: <https://doi.org/10.1016/j.ejrad.2014.09.016>
6. Utano K, Nagata K, Honda T, Mitsushima T, Yasuda T, Kato T, et al. Performance and patient acceptance of reduced-laxative CT colonography for the detection of polypoid and non-polypoid neoplasms: a multicenter prospective trial. *Radiology* 2017; **282**: 399–407. doi: <https://doi.org/10.1148/radiol.2016160320>
7. Sosna J, Blachar A, Amitai M, Barmeir E, Peled N, Goldberg SN, et al. Colonic perforation at CT colonography: assessment of risk in a multicenter large cohort. *Radiology* 2006; **239**: 457–63. doi: <https://doi.org/10.1148/radiol.2392050287>
8. Pendsé DA, Taylor SA. Complications of CT colonography: a review. *Eur J Radiol* 2013; **82**: 1159–65. doi: <https://doi.org/10.1016/j.ejrad.2012.04.011>
9. Nagata K, Takabayashi K, Yasuda T, Hirayama M, Endo S, Nozaki R, et al. Adverse events during CT colonography for screening, diagnosis and preoperative staging of colorectal cancer: a Japanese national

- survey. *Eur Radiol* 2017; **27**: 4970–8. doi: <https://doi.org/10.1007/s00330-017-4920-y>
10. de Wijkerslooth TR, de Haan MC, Stoop EM, Bossuyt PM, Thomeer M, van Leerdam ME, et al. Reasons for participation and nonparticipation in colorectal cancer screening: a randomized trial of colonoscopy and CT colonography. *Am J Gastroenterol* 2012; **107**: 1777–83. doi: <https://doi.org/10.1038/ajg.2012.140>
 11. Neri E, Halligan S, Hellström M, Lefere P, Mang T, Regge D. ESGAR CT Colonography Working Group. The second ESGAR consensus statement on CT colonography. *Eur Radiol* 2013; **23**: 720–9.
 12. Pickhardt PJ, Bakke J, Kuo J, Robbins JB, Lubner MG, del Rio AM, et al. Volumetric analysis of colonic distention according to patient position at CT colonography: diagnostic value of the right lateral decubitus series. *AJR Am J Roentgenol* 2014; **203**: W623–W628. doi: <https://doi.org/10.2214/AJR.13.12369>
 13. Gryspeerdt SS, Herman MJ, Baekelandt MA, van Holsbeeck BG, Lefere PA. Supine/left decubitus scanning: a valuable alternative to supine/prone scanning in CT colonography. *Eur Radiol* 2004; **14**: 768–77. doi: <https://doi.org/10.1007/s00330-004-2264-x>
 14. Bellini D, De Santis D, Caruso D, Rengo M, Ferrari R, Biondi T, et al. Bowel preparation in CT colonography: is diet restriction necessary? A randomised trial (DIETSAN). *Eur Radiol* 2018; **28**: 382–9. doi: <https://doi.org/10.1007/s00330-017-4997-3>
 15. Nagata K, Fujiwara M, Shimamoto T, Iida N, Mogi T, Mitsushima T. Colonic distention at CT colonography: randomized evaluation of both IV hyoscine butylbromide and automated carbon dioxide insufflation. *AJR Am J Roentgenol* 2015; **204**: 76–82. doi: <https://doi.org/10.2214/AJR.14.12772>
 16. Nagata K, Iyama A, Hanatsuka B, Endo S, Kudo S-ei. Carbon dioxide insufflation system for CT colonography. *Nippon Daicho Komonbyo Gakkai Zasshi* 2009; **62**: 129–31. doi: <https://doi.org/10.3862/jcoloproctology.62.129>
 17. Kanda Y. Investigation of the freely available easy-to-use software 'EZ' for medical statistics. *Bone Marrow Transplant* 2013; **48**: 452–8. doi: <https://doi.org/10.1038/bmt.2012.244>
 18. Ross B. *Fundamentals of biostatistics*. New York: Duxbury Press; 1995. pp. 518–9.
 19. The American College of Radiology. ACR–SAR–SCBT–MR Practice Parameter for the Performance of Computed Tomography (CT) Colonography in Adults Revised 2014 (Resolution 2). 2014. Available from: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/ct-colonog.pdf> [June 13 2018].
 20. , Bibbins-Domingo K, Grossman DC, Curry SJ, Davidson KW, Epling JW, et al. Screening for Colorectal Cancer: US Preventive Services Task Force Recommendation Statement. *JAMA* 2016; **315**: 2564–75. doi: <https://doi.org/10.1001/jama.2016.5989>
 21. De Cecco CN, Ciolina M, Annibale B, Rengo M, Bellini D, Muscogiuri G, et al. Prevalence and distribution of colonic diverticula assessed with CT colonography (CTC). *Eur Radiol* 2016; **26**: 639–45. doi: <https://doi.org/10.1007/s00330-015-3866-1>
 22. Flor N, Rigamonti P, Di Leo G, Ceretti AP, Opocher E, Sardanelli F, et al. Technical quality of CT colonography in relation with diverticular disease. *Eur J Radiol* 2012; **81**: e250–e254. doi: <https://doi.org/10.1016/j.ejrad.2011.02.006>