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Patient Acceptance of CT Colonography and Conventional Colonoscopy: Prospective Comparative Study in Patients with or Suspected of Having Colorectal Disease¹

PURPOSE: To prospectively evaluate, by means of self-assessed questionnaires, patient acceptance of computed tomographic (CT) colonography compared with that of conventional colonoscopy, when performed in patients with or suspected of having colorectal disease.

MATERIALS AND METHODS: One hundred eleven patients underwent CT colonography followed immediately by conventional colonoscopy. Patient acceptance was evaluated with questionnaires, and the proportions of patients who favored one examination were compared. The main variables were overall impression, discomfort during air filling or instrumentation, and perceived pain, evaluated by using ordered verbal descriptor scales after each examination. The preference for either examination was evaluated after completion of both examinations.

RESULTS: Of the 68 patients who favored one examination, 56 (82%) preferred CT colonography ($P < .00001$). Concerning overall impression of problems or discomfort in connection with the examination, 49 (69%) of 71 with a preference considered colonoscopy to be more difficult ($P = .002$). CT colonography was regarded as "not painful" by 62 (57%) of 108 patients compared with 28 (26%) for colonoscopy, and a larger proportion of patients rated pain as higher during colonoscopy than during CT colonography (95% CI: 30%, 56%). Discomfort from air filling of the colon was the major complaint about CT colonography.

CONCLUSION: CT colonography was considered less painful and less difficult overall than colonoscopy and was the preferred examination.

The most common methods for diagnosing colorectal polyps and cancer are fecal occult blood testing, flexible sigmoidoscopy, barium enema examination, and conventional colonoscopy. For total colon examination, a barium enema or colonoscopy is performed. Colonoscopy is more effective than barium enema examination for polyp detection (1-3) and also offers the opportunity to perform biopsy and remove polyps. However, being an invasive examination, colonoscopy has some important disadvantages, such as patient pain and discomfort and the frequent need for sedative and/or analgesic medication. Furthermore, colonoscopy is associated with a risk, although small, of perforation (4,5), and in 5%-15% of patients, colonoscopy fails to depict the entire colon (6,7).

Computed tomographic (CT) colonography, or "virtual colonoscopy," is a radiologic examination technique based on thin-section spiral CT to generate cross-sectional transverse and reformatted two- and three-dimensional images, including endoluminal perspective images of the colon, resembling those obtained during conventional colonoscopy. To our knowledge, the diagnostic accuracy of CT colonography has not been fully investigated, although findings of recent studies (8-11) suggest that CT colonography is potentially an alternative or complement to current methods in clinical practice. Import-

tant advantages of CT colonography are that the examination is minimally invasive and that sedatives or analgesics are not required. CT colonography is therefore likely to be more acceptable to the patient than colonoscopy, which is an important advantage (10,12,13). However, to our knowledge, this has not been confirmed in controlled studies.

The clinical indications for CT colonography have not yet been determined, but authors of several studies (11,13) have suggested that CT colonography is useful as a complementary colonic examination in symptomatic patients who have undergone incomplete or failed colonoscopy.

Patient acceptance is important in clinical practice and is also a key feature of a diagnostic method used for screening (14). Colorectal cancer is one of the leading causes of cancer-related death in the Western world (15) and has many features of a disease suitable for screening (16). Guidelines for colorectal cancer screening based on fecal occult blood testing, sigmoidoscopy, colonoscopy, and barium enema examination have been published (14,17), but compliance with current recommendations is low (18,19), possibly because of poor acceptance of the diagnostic techniques used.

If CT colonography were better tolerated than colonoscopy, it might be attractive as an alternative to currently used methods in clinical practice and as a possible alternative to other methods in future screening programs.

The purpose of this study was to prospectively evaluate, by means of self-assessed questionnaires, patient acceptance of CT colonography compared with that of conventional colonoscopy in patients with or suspected of having colorectal disease.

MATERIALS AND METHODS

Patients with or suspected of having colorectal disease were prospectively examined between May 1998 and September 1999. All patients were referred for colonoscopy to a specialized endoscopy unit at a university hospital, and patients with anemia and/or rectal bleeding had priority in the random recruitment of consecutive study patients. If such patients were not available at the predetermined study occasions, patients were consecutively recruited from the clinical colonoscopy waiting list. The indication for examination was unknown to the radiologist. Patients with acute colitis or enterostomy and women younger than

50 years of age were excluded. The study protocol was approved by the ethics committee at Göteborg University, and all patients gave their informed consent.

The study group of 111 individuals consisted of 66 men (59%) and 45 (41%) women. The median age was 66.0 years (range, 19–86 years; interquartile range, 55.0–76.0 years).

All patients underwent CT colonography immediately before conventional colonoscopy. The patients were given written information about the examinations, and verbal information was given immediately before each examination.

Outpatients were also given written instructions about bowel preparation and food restrictions before the examinations. The bowel preparation routines of the colonoscopy department were followed. Most of the patients ($n = 106$) underwent preparation that included fasting from 1400 hours and ingesting 4 L of a polyethylene glycol solution (Laxabon; Tika, Lund, Sweden), one glass every 10 minutes from 1700 to 2100 hours, 1 day before the examinations. Three patients instead received a phosphate solution (Phosphoral; Ferring, Oslo, Norway), 45 mL at 1500 hours and 45 mL at 1900 hours 1 day before the examinations. One inpatient received a solution containing 5 mg sodium picosulphate (Pico-salax; Ferring) at 0800 hours and 1600 hours 1 day before the examinations, and for another inpatient, the bowel preparation used was not specified. Because this study concerns the comparison of acceptance of CT colonography and colonoscopy for each patient, the choice of bowel preparation did not affect the study outcome.

Overall acceptance of the bowel preparation was assessed separately by the patient before the examinations by using a four-level scale with the response alternatives "not difficult," "slightly difficult," "fairly difficult," or "very difficult."

CT Colonography

CT colonography was performed during suspended respiration, with spiral CT of the abdomen and pelvis after air insufflation of the colon.

The patient's maximal breath-holding ability was tested before air filling. With the patient in the lateral decubitus position, a lubricated short-tip rectal enema tube was inserted into the distal part of the rectum. A rectal balloon was used in two cases to prevent leakage of air. Through a simple balloon pump attached to the rectal tube, room air was gently pumped in manually, until the patient requested that air

filling be discontinued or distention was thought to be adequate. To relieve spasm, reduce bowel motion, and optimize distention, a spasmolytic agent was administered intravenously at the end of air insufflation. Hyoscine-N-butylbromide (40 mg Buscopan; Boehringer Ingelheim, Ingelheim, Germany) was routinely prescribed ($n = 87$), and if contraindicated (eg, for prostate hyperplasia, gastrointestinal obstruction, or tachycardia), glucagon (1 mg, Novo Nordisk, Bagsvaerd, Denmark) was intravenously administered ($n = 24$). The intravenous catheter applied was also used for administration of medication during colonoscopy. The patient was then turned to the supine position, and air distribution was assessed by obtaining a standard pilot CT scan. Additional air was insufflated if necessary and if allowed by the patient.

Spiral CT (PQ 5000; Picker International, Cleveland, Ohio) of the abdomen and pelvis was performed, with a section thickness of 5 mm, a pitch of 1.25, 125 mAs, and 110 kV, first with the patient in the supine position and then repeated with the patient in the prone position. According to the ability of each patient to hold his or her breath, each examination was usually divided into two or more consecutive spiral scan acquisitions. After scanning, the enema tip was removed, and the patient left the department for subsequent colonoscopy.

All CT colonography was performed by a specially trained radiologist (M.H.S. or M.H.). Maximal breath-holding time, number of spiral scan acquisitions, total examination time, and drug side effects were recorded by the radiologist according to a standardized protocol. Total examination time was defined as the time the patient spent in the examination room, including undressing; testing maximal breath-holding capacity; patient preparation; and scanning.

After the examination, the patient assessed the breath-holding experience on a four-level scale by using the response alternatives "not difficult," "slightly difficult," "fairly difficult," or "very difficult to hold my breath." Similarly, the patient assessed a preference for body position during scanning ("supine," "prone," or "no difference").

The number of colonic segments that were nonassessable in both the supine and prone position was recorded.

Colonoscopy

Colonoscopy was performed as a routine clinical diagnostic and, when needed, therapeutic examination. Eight experienced

endoscopists (including A.L.), who all were part of a highly specialized team in the endoscopy department, performed the colonoscopic examinations. Medication routines varied slightly between endoscopists, but when medication was administered, 20–50 mg pethidine (Petidin; Pharmacia & Upjohn, Stockholm, Sweden) and/or 1–2 mg midazolam (Dormicum; Roche, Germany) were administered intravenously before the examination, either routinely or after agreement between the patient and the endoscopist. Supplemental pethidine and/or midazolam were administered during the procedure if needed.

The indication for examination, the extent of colonic visualization, the reason for incomplete examination, and the medication administered were recorded by the endoscopist in accordance with a specially designed protocol. The examination time, defined as the time from introduction to removal of the instrument, was recorded. The patient preparation time and the observation time (about 60 minutes after the examination) were not included in the examination time. The intubation time from rectum to cecum also was recorded.

Any invasive procedure or therapeutic action during colonoscopy was recorded, and three subgroups were defined. Subgroup 1 included patients who received no interventions; in subgroup 2, biopsy and/or “hot” biopsy (removal of a small polyp with diathermia) but no other interventions were performed; in subgroup 3, other interventions (eg, polypectomy) were performed.

Questionnaires

Three self-administered questionnaires were used in the assessment of patient acceptance. One questionnaire concerned acceptance of CT colonography and was completed by the patient directly after CT and before colonoscopy. Another similar questionnaire concerned acceptance of the colonoscopic examination and was completed twice. It was first completed by the patient before leaving the ward after colonoscopy and a subsequent observation time of about 1 hour. The patient then received an exact copy of this questionnaire and was instructed to complete it 1 day after the examination and return it by mail. This procedure was used to control for possible effects of sedation, and the responses on the two colonoscopy questionnaires were compared. The responses on the second colonoscopy questionnaire were intended primarily for comparison with the CT evaluation.

The variables of patient acceptance of examinations were overall impression of problems or discomfort associated with the examinations (“not difficult,” “slightly difficult,” “fairly difficult,” or “very difficult”), pain (“not painful,” “slightly painful,” “fairly painful,” or “very painful”), perceived discomfort during air filling and instrumentation of the bowel (“not unpleasant or uncomfortable,” “slightly unpleasant or uncomfortable,” “fairly unpleasant or uncomfortable,” or “very unpleasant or uncomfortable”), and the degree of embarrassment (“not embarrassing,” “slightly embarrassing,” “fairly embarrassing,” or “very embarrassing”). Hence, the responses consisted of four ordered verbally described alternatives. When two response alternatives to the same question were marked, the worst alternative was chosen as the response if they were adjacent (eg, “fairly painful” was chosen if both “slightly painful” and “fairly painful” were marked), which was the case for 14 answers (six patients); otherwise, the response was regarded as missing. If the response to a question was lacking or three or more alternatives were marked, the response was considered as missing.

Further questions concerned the sufficiency of written and verbal information given before the examination (“perfectly sufficient,” “fairly sufficient,” “not enough” or “no information received”), the degree of concern before the examination (“not concerned,” “slightly concerned,” “fairly concerned,” or “very concerned”) and the reasons for concern according to predefined alternatives. Furthermore, the quality of personal reception (“very good,” “fairly good,” “not very good,” or “poor”) and willingness to undergo the same examination on another occasion (“yes,” “no,” or “don’t know”) were evaluated.

The patient’s own comparison and preference for the two examinations was evaluated by means of a third questionnaire completed at the same time as the second copy of the questionnaire concerning colonoscopy. The variables concerned the more difficult examination in overall terms, the more unpleasant examination, the more embarrassing examination, and the preferred examination (“CT colonography,” “colonoscopy,” “no difference,” or “don’t know”). There were also open-ended questions regarding advantages and disadvantages of the two examinations.

Statistical Methods

The mean value and SD were calculated for quantitative variables when ap-

propriate. Otherwise, the median, range, and interquartile range were given.

The subjective assessments on the scales of the questionnaires produced ordered categorical data. The main property of such data is that the ordered categorical responses represent only a rank order and not a mathematical value. These nonmetric properties imply that statistical methods based on ranks are appropriate for analysis.

Comparisons of the subjective assessments of acceptance between CT colonography and colonoscopy were analyzed by evaluating the joint distribution of paired assessments in contingency tables. In the present approach, the main diagonal of consistent assessments was oriented from the lower left to the upper right corner. The percentage agreement in opinion concerning the two examinations was calculated. Different ordered categorical (marginal) distributions are a sign of systematic difference in opinion in common for the group (20).

The 95% CI for proportions and for the difference between paired proportions were calculated. The hypothesis of no difference in experience between the methods was analyzed by means of the sign test, with correction for continuity. The hypothesis of no difference between the ordered categorical distributions in subgroups was analyzed with the Kruskal-Wallis test. The relationship between qualitative variables was evaluated with the Spearman rank-order correlation coefficient (r_s) and between quantitative variables with the Pearson correlation coefficient (r) (21).

A P value less than .05 was regarded as indicating a statistically significant result. To adjust for multiple tests and to obtain an overall significance level of at least .05, the individual P values were corrected according to Holm stepwise adjustment for multiple tests (22).

RESULTS

The indications for examination in the 111 patients were anemia and/or rectal bleeding and/or positive fecal occult blood test results ($n = 48$), suspected malignancy ($n = 5$), previous findings at barium enema examination ($n = 11$), diarrhea ($n = 16$), abdominal pain and/or diverticulitis ($n = 16$), colitis control ($n = 6$), or polyp control ($n = 9$).

Bowel preparation was considered “not difficult” by 15 (14%) patients, “slightly difficult” by 47 (42%), “fairly difficult” by 34 (31%), and “very difficult” by 14 (13%) patients ($n = 110$, no response in one case).

CT Colonography

The maximal ability for breath holding, as tested before scanning, was 10–60 seconds. Therefore, each examination was divided into one to four separate spiral scan acquisitions with the patient in the supine (mean, 2.3 acquisitions \pm 0.5) and prone position (mean, 2.4 acquisitions \pm 0.6). One examination was discontinued before prone scanning at the request of the patient because of abdominal pain. The maximal breath-holding capacity averaged 30.8 seconds \pm 10.7 and was negatively correlated with age ($r = -0.47$). Breath holding was reported to be “not difficult” by 54 (49%) patients, “slightly difficult” by 47 (42%), “fairly difficult” by six (5%), and “very difficult” by four (4%) of the 111 patients.

Of the 80 patients with a preference for either the supine or prone position during scanning, 64 (80%) preferred the supine position (95% CI: 71%, 89%; $P < .00001$).

Of all colonic segments (eight per patient) in all patients, 10 segments among seven patients were nonassessable in both the supine and prone positions. The affected segments were the rectum ($n = 2$), sigmoid colon ($n = 1$), right flexure ($n = 2$), ascending colon ($n = 2$), and cecum ($n = 3$). They were nonassessable because of poor air filling ($n = 3$), insufficient bowel preparation ($n = 1$), tumor ($n = 1$), or a combination of insufficient bowel preparation and poor air filling ($n = 5$).

Thirty-nine of the 87 patients who received hyoscine-N-butylbromide reported anticholinergic side effects. These were dry mouth ($n = 30$), blurred vision due to impaired accommodation of the eyes ($n = 8$), or both ($n = 1$). One of the 24 patients who received glucagon reported nausea. Side effects from medication administered at CT colonography did not seem to affect the opinion regarding the preferred examination. Of the patients who chose CT colonography, colonoscopy, or answered “no difference,” 25 (76%) of those with side effects at CT colonography ($n = 33$) and 31 (52%) of those without ($n = 59$) preferred CT colonography.

The patients spent 26–52 minutes in the examination room (median, 37.0 minutes; interquartile range, 34.0–42.0 minutes), with the time increasing with age ($r = 0.44$).

Colonoscopy

Routine medication, that is, 25–50 mg pethidine and 1–2 mg midazolam, was given to 91 (82%) patients. Seven pa-

TABLE 1
Frequency Distribution of Comparative Assessment of Problems Associated with the Two Examinations

Examination	“More Difficult Overall” ($n = 111$)	“More Unpleasant” ($n = 111$)	“More Embarrassing” ($n = 111$)
CT colonography	22	22	5
No difference	30	23	88
Colonoscopy	49	54	7
Don’t know	2	3	2
Missing	8	9	9

Note.—Responses to the questions “Which of the investigations, the CT colonography or the colonoscopy, was more difficult in overall terms?”; “Which of the investigations was more unpleasant (in the form of pain, for example)?”; and “Which of the investigations was more embarrassing?” Data are the numbers of responses.

tients received only midazolam (1–2 mg), six patients received no medication, and six patients received combinations exceeding routine doses (50–75 mg pethidine and 2–4 mg midazolam). In one case, medication was not specified.

The time for the endoscopic procedure was 4–145 minutes (median, 31.0 minutes; interquartile range, 22.0–43.0 minutes). In 101 (91%) patients, the entire colon was examined, and in 47 of these, the terminal part of the ileum also was examined. The remaining examinations were completed to the rectum ($n = 1$), sigmoid colon ($n = 4$), transverse colon ($n = 1$), right flexure ($n = 1$), or ascending colon ($n = 3$). Three of these examinations were discontinued because of technical difficulties; three, because of stricture; two, because of insufficient bowel preparation; one, because of patient pain; and one, because of a combination of technical difficulties and insufficient bowel preparation. The median intubation time from rectum to cecum was 13.0 minutes (range, 1–75 minutes; $n = 100$).

Thirty-six of the colonoscopic examinations included no interventions (subgroup 1). Biopsy and/or hot biopsy but no other interventions were performed in 61 cases (subgroup 2), and 14 of the examinations included other interventions (eg, polypectomy in subgroup 3). No difference was found between the median ages (71.0, 62.0, and 64.5 years) in the three subgroups.

Examination Preference

One hundred four patients completed the third questionnaire concerning preferences for either examination. Table 1 shows the frequency distribution of comparative assessment of problems associated with the two examinations. Of the 71 patients who favored one examination, a majority, 49 (69%; 95% CI: 58%,

TABLE 2
Frequency Distribution of Examination Preference

Preferred Examination	Patients Preferring Examination ($n = 111$)
CT colonography	56
No difference	25
Colonoscopy	12
Don’t know	3
Missing	15

Note.—Response to the question “If you were able to choose between a colonoscopy and a CT colonography, which would you prefer if they both produced the corresponding results?”

80%), rated colonoscopy as more difficult in overall terms ($P = .002$). Thirty patients reported “no difference.” Colonoscopy was considered the more unpleasant examination by 54 (71%; 95% CI: 61%, 81%) of the 76 patients who expressed an opinion in favor of one examination ($P = .0008$). Twenty-three patients reported no difference between examinations with regard to which was more unpleasant.

A majority (88 patients) indicated that there was no difference between examinations in terms of embarrassment, as shown in Table 1. CT colonography and colonoscopy were regarded as “not embarrassing” by 92 (85%, $n = 108$) and 93 (87%, $n = 107$) patients, respectively.

Table 2 shows the frequency distribution for examination preference. Among the 68 individuals with a distinct preference for one examination, 56 (82%; 95% CI: 73%, 91%) would have chosen CT colonography ($P < .00001$), and 12 (18%) would have chosen colonoscopy. No difference in median age was found between those who preferred CT colonography (median age, 66.0 years) or colonoscopy (median age,

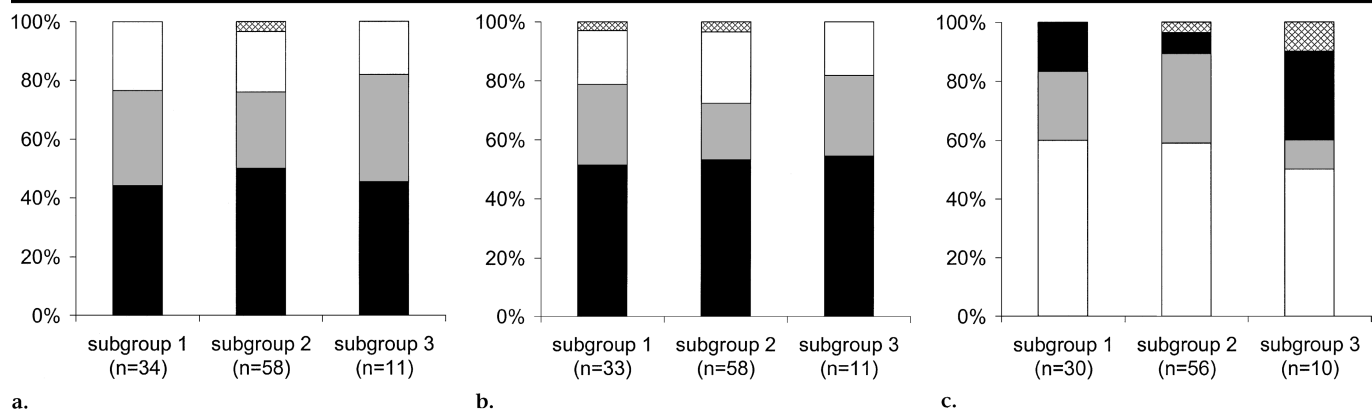


Figure 1. Graphs show response, divided by subgroups, to the following questions: (a) “Which of the investigations, the CT colonography or the colonoscopy, was more difficult in overall terms?” (b) “Which of the investigations was more unpleasant (in the form of pain, for example)?” and (c) “If you were able to choose between a colonoscopy and a CT colonography, which would you prefer if they both produced the corresponding results?” Response alternatives were “CT colonography” (white bars), “colonoscopy” (black bars), “no difference” (gray bars) and “don’t know” (crosshatched bars). In subgroup 1, no interventions were performed during colonoscopy. Biopsy and/or hot biopsy but no other interventions were performed in subgroup 2, and in subgroup 3, other interventions (eg, polypectomy) were performed.

		CT colonography				
		Overall impression				
		not difficult	slightly difficult	fairly difficult	very difficult	total
Colonoscopy	Overall impression					
	very difficult	2	1			3
	fairly difficult	7	12	2		21
	slightly difficult	23	28	3	1	55
	not difficult	16	12		1	29
	total	48	53	5	2	108

		CT colonography				
		Air filling				
		not unpleasant	slightly unpleasant	fairly unpleasant	very unpleasant	total
Colonoscopy	Instrumentation					
	very unpleasant	1	2	2		5
	fairly unpleasant	4	8	4	2	18
	slightly unpleasant	6	34	14	4	58
	not unpleasant	4	16	6	1	27
	total	15	60	26	7	108

c.

70.0 years) or answered “no difference” (median age, 69.0 years).

As shown in Figure 1, the preference for CT colonography and the opinion regarding which examination was more difficult overall and which was more un-

		CT colonography				
		Pain				
		not painful	slightly painful	fairly painful	very painful	total
Colonoscopy	Pain					
	very painful	4	1			5
	fairly painful	11	13	2		26
	slightly painful	29	18	1	1	49
	not painful	18	8	1	1	28
	total	62	40	4	2	108

Figure 2. (a) Contingency table shows the overall impression of CT colonography versus colonoscopy in response to the question, “What was your overall impression of the problems or discomfort in connection with the investigation?” (b) Contingency table shows pain during CT colonography versus that during colonoscopy in response to the question, “Was the investigation painful?” (c) Contingency table shows discomfort associated with air filling during CT colonography versus discomfort associated with instrumentation at colonoscopy in response to the questions, “Was having your intestine filled with air unpleasant or uncomfortable?” and “Was it unpleasant to have an instrument inserted in your intestine?”

pleasant were not associated with the interventions performed at colonoscopy.

Comparison of Assessments of CT Colonography and Colonoscopy

All patients completed the CT colonographic questionnaire. One hundred four

patients completed the first colonoscopy questionnaire, and 106 completed the second. Both colonoscopy questionnaires were missing in two cases. Since the opinion on the colonoscopic examination was found to not change between the first and second questionnaire, missing responses on items in the second questionnaire were replaced with the corresponding responses from the first colonoscopy questionnaire (11 patients).

As shown in Figure 2a, concerning the patient’s overall impression of problems or discomfort in connection with the examination, CT colonography was systematically rated as less difficult than colonoscopy. CT colonography was regarded as “not difficult” by 48 (44%) of the patients with an opinion on both examinations ($n = 108$), compared with 29 (27%) for colonoscopy. Forty-six (43%) patients, of whom 44 reported “no” or “slight” difficulties with both examinations, gave identical difficulty ratings (shaded diagonal in Fig 2a). In 45 (42%; above shaded diagonal), the degree of difficulty was higher at colonoscopy than at CT colonography; the opposite was true for the remaining 17 (16%) patients. The 95% CI for the difference in these proportions (above and below the diagonal, respectively) was 13% to 39% ($P = .001$).

Figure 2b shows that colonoscopy was regarded as more painful than CT colonography. Among the patients with an opinion on both examinations ($n = 108$), 62 (57%) regarded CT colonography as “not painful” compared with 28 (26%) for colonoscopy. The examination was “fairly painful” or “very painful” ac-

ording to 31 patients at colonoscopy and six at CT colonography. The percentage agreement in the perceived pain assessments was 35%, and in 58 (54%) patients, the degree of pain was higher at colonoscopy than at CT colonography. The 95% CI for the difference between the proportion who gave a higher pain rating at colonoscopy and those who gave a higher pain rating at CT colonography was 30% to 56% ($P < .00001$).

Figure 2c shows that 42 (39%, $n = 108$) patients rated the level of discomfort associated with air filling at CT colonography as the same as that during instrumentation at colonoscopy. A higher degree of discomfort was associated with air filling than with instrumentation according to 43 (40%) patients, and 23 (21%) patients had the opposite opinion. The 95% CI for the difference in these proportions was 4% to 33% ($P = .02$).

Eighteen of the 22 patients who, in the comparative questions, regarded CT colonography as the more unpleasant examination also rated the discomfort associated with air filling as greater than that associated with instrumentation. None of the 23 patients who had rated discomfort at CT colonography as less than that at colonoscopy found CT colonography to be more unpleasant, and 16 found colonoscopy to be more unpleasant.

Evaluation of the possible relationship between the overall impression of the method and the variables of pain and discomfort showed that the overall impression of CT colonography was related to discomfort during air filling ($r_s = 0.50$, $P < .0001$) and to the perceived pain during CT colonography ($r_s = 0.63$, $P < .0001$). There was also a relationship between pain and discomfort during air filling ($r_s = 0.41$, $P < .0001$). No relationship ($r_s = 0.07$) was found between the difficulty of breath holding and the overall impression of the examination.

The overall impression of colonoscopy was related to discomfort associated with instrumentation ($r_s = 0.60$, $P < .0001$) and to perceived pain ($r_s = 0.79$, $P < .0001$). Pain was also associated with discomfort from instrumentation ($r_s = 0.51$, $P < .0001$).

The written information provided to the patients was regarded as "perfectly sufficient" by 96 (86%, $n = 111$) patients at CT colonography and by 92 (89%, $n = 103$) patients at colonoscopy. A majority, 110 (99%, $n = 111$) patients at CT colonography and 88 (85%, $n = 103$) patients at colonoscopy, also considered the verbal information "perfectly sufficient." Five patients had not received any

TABLE 3
Response to the Question "If You Were Concerned, What Were You Concerned About?"

Response	CT Colonography	Colonoscopy
"That it would be painful"	28	52
"What the examination would reveal; the result of the examination"	29	33
"That I would be given medicine and its effects (effects and side effects)"	10	7
"That I would not be able to hold my breath"	8	*
"That it would be embarrassing (such as having to take off my clothes)"	4	2
"That I would have an injection"	4	*
"The risk of complications during the investigation; that the investigation might be dangerous"	*	4
"That I would be irradiated during the x-ray exposure"	3	*

Note.—The response alternatives were predefined, and every appropriate response alternative could be chosen. At least one alternative was chosen by 50 patients at CT colonography and by 66 patients at colonoscopy. Data are the numbers of patients choosing each alternative.

* Nonavailable response alternative.

written information about CT colonography. With regard to colonoscopy, one patient received no written information, and three received no verbal information. At colonoscopy, one patient considered the written information and another considered the verbal information as "not enough." The remaining patients found the written or verbal information "fairly sufficient."

Slightly more patients, 73 (70%, $n = 104$), were concerned about colonoscopy than about CT colonography, 57 (52%, $n = 110$). Sixteen patients were "fairly concerned" or "very concerned" about CT colonography. The corresponding number for colonoscopy was 23 patients.

Evaluation of possible relationships between the degree of concern and the variables of overall impression, pain, and discomfort showed a weak relationship between concern and discomfort during instrumentation at colonoscopy ($r_s = 0.31$, $P = .003$) and between concern and overall impression of colonoscopy ($r_s = 0.21$, $P = .03$). No relationship was found between concern and perceived pain ($r_s = 0.081$). In the CT evaluation, a weak relationship was found between concern and discomfort associated with air filling ($r_s = 0.35$, $P = .0004$) but not between concern and overall impression ($r_s = 0.13$) or between concern and perceived pain ($r_s = 0.059$).

Table 3 shows that pain was the most frequently reported cause of concern, and many patients were also concerned about what the examination would reveal. Medication effects and side effects were the third most frequent cause of concern.

A majority of the patients, 108 (97%, $n = 111$) at CT colonography and 92 (85%, $n = 108$) at colonoscopy, perceived a "very good" personal reception. One patient considered the personal reception at colonoscopy "not very good," and the remaining patients rated the personal reception at CT colonography or colonoscopy "fairly good."

Most patients, 87 (79%, $n = 110$), would have considered undergoing CT colonography on another occasion; eight answered "no"; and the remaining 15 were uncertain. Correspondingly, a majority, 74 (70%, $n = 106$), would have considered undergoing another colonoscopic examination; 10 patients were negative; and 22 were uncertain. Eighty-three patients had identical opinions on both examinations (percentage agreement, 79%; $n = 105$), and 10 patients who would have considered undergoing another CT colonographic examination were uncertain about colonoscopy.

Open-ended Questions

The main open-ended questions concerned advantages and disadvantages of the two methods. The patients' responses are summarized in Table 4.

Among the advantages claimed for colonoscopy were the possibility of watching the examination on a television monitor, the direct availability of information about the findings, and the possibility of obtaining biopsy samples and removing polyps. The lack of these possibilities was mentioned as a disadvantage of CT colonography. Medication

TABLE 4
Response to Open-ended Questions Regarding Advantages and Disadvantages of CT Colonography and Colonoscopy

Examination	Advantages	Disadvantages
CT colonography*	Less painful ($n = 14$) Fast ($n = 11$) No instrumentation needed ($n = 10$) Gives information about other organs, as well ($n = 10$) Less difficult ($n = 8$) No sedatives required ($n = 1$) No advantages ($n = 4$)	Air distention of colon causes discomfort and inconvenience ($n = 10$) Painful ($n = 9$) Breath holding is difficult ($n = 7$) Uncomfortable ($n = 7$) Side effects from medication ($n = 3$) Biopsy and therapeutic actions cannot be performed ($n = 3$) Not possible to watch examination on television monitor ($n = 2$) No information about findings is given in direct association with investigation ($n = 2$) Irradiation ($n = 2$) None ($n = 18$) Painful ($n = 23$)
Colonoscopy†	Possible to watch examination on television monitor ($n = 16$) Biopsy and therapeutic actions can be performed ($n = 8$) Information about findings given in direct association with investigation ($n = 6$) Analgesic medication given ($n = 5$) Not painful ($n = 1$) Fast ($n = 1$) No irradiation ($n = 1$) None ($n = 8$)	Sedatives required ($n = 7$) Instrumentation of colon needed ($n = 3$) Takes a long time ($n = 3$) Unpleasant ($n = 3$) Difficult ($n = 1$) None ($n = 8$)

Note.—Data in parentheses are numbers of patients with similar responses. Some patients gave several suggestions.

* Responses for advantages suggested by 49 patients; responses for disadvantages suggested by 54 patients.

† Responses for advantages suggested by 37 patients; responses for disadvantages suggested by 44 patients.

was considered both an advantage and a disadvantage of colonoscopy, and side effects from medication were also mentioned as a disadvantage of CT colonography.

DISCUSSION

In this study, we chose to compare patient acceptance of CT colonography with that of conventional colonoscopy, because the latter is the primary diagnostic technique at our hospital. We constructed questionnaires to measure physical (ie, pain, discomfort) as well as psychological (ie, embarrassment, concern) aspects of the examinations and also attempted to control possible confounding influences, such as differences in the quality of information provided to the patient and the reception given the patients.

We were concerned that the response to the questions concerning patient acceptance of colonoscopy would be influenced by the sedative and analgesic drugs given at colonoscopy. The questionnaire concerning colonoscopy was therefore administered twice, which revealed an agreement in opinions between occasions.

According to the comparative questionnaire, CT colonography was regarded as less difficult in overall terms, as well as less unpleasant than colonoscopy. A ma-

majority of the patients would have preferred CT colonography if they had been able to choose between examinations. The individual ratings after the respective examination were in agreement with the results from the comparative questions. The overall impression was systematically rated as better for CT colonography than for colonoscopy. In general, CT colonography appeared to be an acceptable examination, since only a few patients considered it more than slightly difficult overall.

Pain ratings were lower for CT colonography than for colonoscopy. Despite the fact that almost all patients received analgesic and/or sedative medication at colonoscopy, pain seemed to be an important problem with colonoscopy. It was also the most common subject of concern before the examination. Pain was often mentioned as a disadvantage of colonoscopy in the open-ended comments, and, correspondingly, less pain was a common motivation for the choice of CT colonography as the preferred examination. Although pain was also the most frequent cause of concern about CT colonography, only six patients considered CT colonography "fairly" or "very" painful.

A more common problem with CT colonography was discomfort associated with air filling of the intestine; most patients found it at least slightly unpleasant

to have the intestine filled with air. Instrumentation at colonoscopy was not unpleasant to the same degree as air filling during CT colonography. Despite the relatively high rating of discomfort associated with air filling during CT colonography, a majority considered colonoscopy to be worse overall and CT colonography to be preferable. Pain thus seemed to have a more decisive influence on examination preference than did discomfort. This was also made evident by the fact that the rating of overall impression of each of the examinations showed a stronger relationship to the rating of pain than to the rating of discomfort during instrumentation and air filling, respectively.

In this study group, irradiation at CT colonography did not seem to be a major concern. Only three patients reported concern about irradiation, and two mentioned it as a disadvantage of CT colonography. Embarrassment associated with the procedure was expected to be an important factor in patient acceptance. However, it was not considered a problem for any of the examinations.

Whereas CT colonography is a purely diagnostic examination, colonoscopy also provides therapeutic possibilities, which could affect the overall impression, as well as the rated discomfort and pain, since some therapeutic actions (eg, polypectomy) are potentially painful. In this study,

we found no difference in opinion between patients who underwent purely diagnostic colonoscopy without intervention and those who underwent biopsy or other invasive procedures. Therefore, interventions did not seem to worsen the patient's opinion of the examination. Instead, the therapeutic possibilities and the possibility of direct information were mentioned as advantages of colonoscopy, as was the possibility of watching the examination on a television monitor. Similar participation and instant information were not possible during CT colonography because image processing and interpretation were performed after the patient left the department.

Approximately one-third of patients experienced side effects from medication administered in association with CT colonography. All but one patient with side effects had received Buscopan. However, most of these patients experienced only dry mouth, and side effects did not appear to affect the preference for either examination.

Colonoscopy was always performed after CT colonography, since a randomized order of examinations is not appropriate when one examination changes the conditions for evaluation. Randomization of the order of examinations is appropriate only if there is substantial evidence that the examination has no carryover effects (23). Because of the preceding CT colonographic examination, the colonoscopic examinations in this study may have been more technically complicated than were regular colonoscopic examinations because of residual air in the colon. However, this was not reported by the endoscopists to be a major problem. It may also be speculated that patient tolerance was affected because of the preceding CT colonographic examination. Although some carryover effect from CT colonography to colonoscopy might be expected, this effect is likely to be less pronounced than in the reverse case.

The study situation might also have affected assessment of the two examinations. Although selected experienced endoscopists performed all examinations, the colonoscopic examinations were performed for clinical indications according to routine clinical practice, whereas patients were asked to undergo CT colonography as an extra examination for a research project. The fact that some patients had undergone colonoscopy on previous occasions and were familiar with this examination, whereas CT colonography was new to all patients, might also have af-

ected the psychological reaction of the patients.

Another possible cause of bias might be the information provided to the patient about the examinations and the personal reception received by the patients. In this study, the opinions concerning personal reception and the information provided were generally positive and similar concerning both examinations, and the differences in rating of overall impression are unlikely to be explained by these factors.

The assessments were subjective, and comparisons were made within each individual (paired assessments). Furthermore, to reduce the risk of bias due to design, we included transitional questions, that is, comparative questions to be answered 1 day after the examinations. The benefit of such an approach has been proposed by Feinstein et al (24).

The study population was selected and all examinations were performed on the basis of clinical indications. The study situation also provided a controlled examination situation at both colonoscopy and CT colonography, with only a few investigators, who were all experienced and highly motivated. Therefore, the results could not be directly translated to an unselected and possibly asymptomatic population (eg, a screening population). Further studies are required to confirm the validity of these results in an ordinary clinical setting, as well as in a screening population.

CT colonographic technique is continually developing. This study was performed with a standard spiral CT technique. Faster scanning with a subsecond multidetector technique will markedly reduce the time from the start of air insufflation of the colon to examination completion. This will markedly reduce the breath-holding requirements and could improve the overall impression of CT colonography and further reduce discomfort and pain. Another possible improvement in CT colonography is the use of carbon dioxide instead of room air. Study findings (25) suggest that there is less discomfort during double-contrast barium enema examination when carbon dioxide is used. Fecal tagging instead of bowel preparation is another possible future development in CT colonography that might improve the overall acceptability of the examination. In this study, acceptance of bowel preparation was assessed separately, and the diagnostic techniques were evaluated on the condition that bowel preparation was equally

necessary. Nearly half the patients rated the bowel preparation as "fairly" or "very" difficult.

If the examination could have been limited to scanning in only one body position, it was evident from our findings that the supine position was preferred.

In conclusion, CT colonography was less painful and better tolerated than colonoscopy and was the preferred examination in this selected symptomatic study group. Pain seemed to play an important role in the choice of preferred examination, whereas discomfort from air filling was the major problem associated with CT colonography. CT colonography seems to be a well-accepted examination when performed in symptomatic patients. Although the results are not directly applicable to a screening situation, they should be taken into account in the discussion of future screening for colorectal neoplasms.

STATISTICAL CONSULTANT COMMENTARY

The authors are commended for their use of the Holm stepwise adjustment for multiple tests (Holm S. A simple sequentially rejective multiple test procedure. *Scand J Stat* 1979; 6:65-70). It is well known that multiple testing results in an inflation of the probability of incorrectly rejecting a hypothesis, that is, erroneously concluding statistical significance. The Bonferroni correction is commonly employed to decrease the likelihood of making such an error. This adjustment reduces the significance level (probability of making a type-I error) associated with each of the tests in such a manner that the overall level of significance is approximately equal to the desired level. The problem with the use of the Bonferroni adjustment is that it is conservative, especially when the number of comparisons made is large. Practically, this has the effect of missing real differences, which suggests that the statistical power of the test has been decreased. Procedures such as the one used by the authors have been developed to improve the Bonferroni correction. Through their use, the desired overall level of significance is preserved, with improved statistical power. Hochberg has developed another stepwise adjustment procedure with desirable statistical properties that is easily implemented (Hochberg Y. A sharper Bonferroni procedure for multiple tests of significance. *Biometrika* 1988; 75:800-802).

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