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Computed tomography colonography compared with conventional colonoscopy for the detection of colorectal polyps

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ABSTRACT

OBJECTIVE: To determine the diagnostic accuracy of computed tomography colonography (CTC) compared with conventional colonoscopy (CC).

METHODS: Patients with an indication of CC were included. Fifty patients underwent CTC using multidetector CT before diagnostic colonoscopy was performed by an expert colonoscopist. Diagnostic accuracy was assessed individually both for each polyp and for each patient.

RESULTS: Fifty patients were included and 40 polyps were analyzed. The by-polyp sensitivity of CTC was 15% for polyps 5 mm or less, 75% for polyps 5- 10 mm and 75% for polyps 10 mm or larger. By-patient specificity was 6% for polyps 5 mm or less, 75% for polyps 5-10 mm and 80% for polyps 10 mm or larger. The specificity of CTC was 94%. CTC was preferred over CC by 90% of the patients. The mean colonoscopy examination time was 30 minutes for CC and 35 minutes for CTC ($p < 0.05$).

CONCLUSIONS: The sensitivity of CTC is moderate in detecting polyps larger than 10 mm, low in detecting 5-10 mm polyps and very low in detecting those less than 5 mm. The overall specificity of the procedure was 94%. Procedure time was lower with CC than with CTC but the latter was better tolerated by most patients.

VALIDACIÓN DE LA COLONOSCOPIA VIRTUAL FRENTE A LA COLONOSCOPIA CONVENCIONAL PARA EL DIAGNÓSTICO DE PÓLIPOS Y TUMORES COLORRECTALES

OBJETIVO: Determinar la exactitud diagnóstica de la colonoscopia virtual (CV) comparada con la colonoscopia convencional (CC).

MÉTODOS: Se incluyeron pacientes con indicación de CC. Se les realizó una CV y, posteriormente, se llevó a cabo la CC sin sedación por parte de un colonoscopista experto. El análisis del rendimiento diagnóstico se efectuó tanto individualmente para cada pólipo como por paciente.

RESULTADOS: Se han incluido 50 pacientes, y se contabilizó un total de 40 pólipos. La CV tuvo una sensibilidad del 15% para pólipos menores de 5 mm, aumentó hasta el 75% para pólipos de entre 5 y 10 mm, y fue del 75% para los mayores de 10 mm. La sensibilidad respecto al diagnóstico de pacientes con lesiones fue del 6% para pólipos menores de 5 mm, del 75% para pólipos de 5-10 mm y del 80% para los mayores de 10 mm. La especificidad de la colonoscopia virtual fue del 94%. La CV fue la exploración preferida por el 90% de los pacientes. La duración media de la CC fue de 30 min, mientras que la de la CV fue de 35 min ($p < 0,05$).

CONCLUSIONES: La CV es una técnica moderadamente sensible para la detección de pólipos mayores de 10 mm; dicha sensibilidad desciende considerablemente en los pólipos de 5-10 mm y es muy baja para los menores 5 mm. La especificidad global de la prueba ha sido del 94%. La duración de la CC fue menor que la de la CV, y esta última fue mejor tolerada por la mayoría de los pacientes.

INTRODUCTION

Colorectal cancer represents the second cause of cancer-related mortality in the world, irrespective of gender, after lung cancer in males and breast cancer in females[1]. In Western countries its incidence is around 40-50 per 10^5

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per year. Colonic carcinogenesis is a multistage process involving a number of morphologic, molecular and genetic steps. Substantial evidence exists that most colorectal carcinomas arise from preexisting adenomas. The adenoma-carcinoma sequence takes many years to develop. The time interval from normal colon to invasive cancer has been estimated to be 10 years, and from normal colon to adenoma 5 years[2]. This long interval implies that colorectal carcinoma is a potentially preventable disease, as long as polyps are discovered and removed before they become malignant. Thus, the screening for colorectal polyps may be one of the most effective currently available cancer-preventive strategies[3,4].

Conventional colonoscopy (CC) is widely accepted as the best available method for the diagnosis and prevention of colorectal cancer. CC allows the operator to have a direct vision of any visible lesion, to perform biopsies and, finally, to efficiently remove polyps risk. The disadvantages of colonoscopy are the attendant discomfort, a reason that is frequently mentioned to decline screening, and the small but definite risk for complications. There is a need for simpler screening methods that would allow colonoscopy to be used more selectively and efficiently[5]. In this respect, computed tomographic colonography (CTC), also called virtual colonoscopy, is a promising candidate.

CTC has been developed as a minimally invasive alternative to conventional colonoscopy[6]. This technique utilizes computer processing of two and three-dimentional image data-set, such as those acquired by computed tomography scan, to provide simulated imaging, equivalent to those produced by standard endoscopy procedures[3]. The technique requires bowel preparation and colonic insufflation, but sedation and the risk of bleeding and perforation are generally avoided, so it is an attractive modality that allows total colonic evaluation and may perhaps decrease unnecessary colonoscopies. It does not, however, permit polyp removal[6]. Although detection (or exclusion) of all lesions is the ultimate goal, the key screening parameter is the ability to detect participants with lesions because the detection of any lesion would lead, logically, to colonoscopy[7].

The aim of our study was to conduct a blinded direct comparative study assessing the diagnostic accuracy of CTC compared with the criterion standard CC.

METHODS

The study was conducted between Febrery 2005 and January 2006 in the Gastroenterology Unit and Radiology Department at La Princesa University Hospital in Madrid, Spain. Patients sent for CC consecutively selected, who agreed to the CTC examination, were enrolled. Written informed consent was obtained. Exclusion criteria were as follows: age < 18 years, inability to give written consent, refusal to participate, prior colorectal surgery, diagnosis of inflammatory bowel disease, contraindications for a CC, and pregnancy. Patients underwent CTC and, approximately one hour later, CC.

Bowel preparation

Colon cleaning was done with a standard bowel preparation consisting of dietary restriction without fiber 3 days before the examination and cathartic preparation 24 hours before the examination, with a polyethylene glycol solution (Solución evacuante Bohm, Laboratorios Bohm S. A., Madrid, Spain).

Computed tomographic colonography

Patient was placed in the lateral decubitus position. A balon-tipped rectal enema was inserted. To distent the colon, approximately 2L of room air was administered by insufflation (until the patient verbally indicated had reached maximal tolerance). The catheter was clamped and left in the rectum, and a supine scout CT image was obtained to verify adequate bowel distension. If bowel distension was inadequate, additional air was insufflated into the rectum. Once bowel distension was adequate, CTC was performed. No bowel relaxant was used.

The scan was performed with a multislice CT scanner × 4 (Toshiba-Asteión, Japón) with the following scan parameters: collimation, 4 × 2 mm; 120 kV; reconstruction interval 1.25 mm; rotation time < 1 second and 50 mAs.

Both prone and supine acquisition were obtained, each in a single breath hold. The reconstructed supine and prone data sets were transferred to a workstation (Vitrea 2. Vital Images Plymouth, Minn). Study data were read from 2-dimensional slices in transverse, coronal and sagital CT images, and 3-dimensional endoluminal reconstructions were evaluated to confirm findings. The presence, location, and size of the colorectal lesions were assessed in eight colonic segments, ie, rectum, sigmoid, descending colon, splenic flexure, transverse colon, hepatic flexure, ascending colon and cecum. The evaluation time was recordered.

Conventional colonoscopy

Patients underwent colonoscopy with a standard colonoscope (Olympus CF- EC-200 MR, Fujimon, Japan) at the Endoscopy Department. During this procedure, patients did not receive sedatives or analgesics. CC was performed by an experienced staff member. CC was performed without prior knowledge of the CTC findings. Segmental unblinding was performed: after a colonic segment was examined, the instrument was sequentially withdrawn into the more distal segments. Unblinding to the results of CTC was done after the instrument had been withdrawn. One segment. Following unblinding, if any lesion had been suspected on CTC but not detected by CC, the instrument was reinserted into the segment for a second look. After the segment was reexamined, the instrument continued to be withdrawn until the examination was complete. If CTC was negative, a second look was not performed. Endoscopist recordered location and size of the lesions. Lesion measurement was performed by comparing the lesion with a closely held forceps of known size. All lesions identified with CC were biopsied or resected.

Duration of the CC was reported. An assessment of the patient's preparation was made, rating as inadequate when residual stool permitted proper assessment of the mucosa, as adequate when the faeces could be partly aspirated, and as good when the colon contained no stool or water.

Questionnaires were filled in after CC to evaluate the use of bowel preparation, pain and discomfort with CTC and pain and discomfort with CC (table I). In addition, patients were asked to indicate whether they would prefer CTC or CC if a future colon examination was indicated.

Data comparison

The findings of CTC were compared with those of CC. Results of CC for location and size were considered the gold standard in all cases. When CTC detected a lesion missed on initial CC, results of the second-look CC after unblinding were considered the reference standard. When CTC and CC results were discordant, two negative looks on CC were considered a true-negative finding for CC and false positive finding for CTC. When initial CC was negative, but second-look CC confirmed the positive CTC finding, the result was considered a true-positive for CTC. When CTC and CC finding were discordant in the setting of a positive CC, the CC finding was considered a true-positive finding, with a false-negative finding for CTC.

For each lesion detected, the location and size determined by CC were considered the standard criterion. A lesion was concordant with the criterion standard if both location and size criteria matched. A lesion detected on CTC was considered concordant with one found on CC with respect to location if it was located in the same or adjacent colonic segment. Lesion size measurement during CC is associated with significant error; measurement error during CTC is unknown. In light of these factors, provisions for error associated with matching by size were made a

TABLE I. **Questionnaire of tolerance**

1. Indicate the degree of disturbances that you have experienced with the bowel preparation (1 to 5)
2. Indicate the degree of disturbances that you have experienced during the CTC (1 to 5)
3. Indicate the degree of disturbances that you have experienced during the CC (1 to 5)
4. If you could choose, which exploration (CTC or CC) would you prefer to undergo?

priori. For a lesion to match by size criteria, the size determined by CTC had to be within fifty percent margin of error from the size determined by CC (criterion standard).
Results are expressed in two ways: individual lesion detection (per lesion) and patient detection (per patient).

Statistical analysis

The overall (i.e., any lesion size) sensitivity and specificity of CTC for identifying patients with colorectal polyps or masses relative to CC were calculated and 95% confidence intervals computed for these parameters. By grouping patients according to lesion size as measured by CC (e.g., > 5 mm, > 10 mm and so on), a range of relative sensitivities and specificities (i.e. at least 1 true lesion of size > cutoff value) were computed with respective 95% confidence intervals. Similarly, the sensitivity of CTC for identifying individual colorectal lesions was calculated with confidence intervals. Because a total number of true-negative lesions cannot reasonably be ascertained without assumptions, specificity for individual lesions cannot be calculated (i.e., no unit of measure).

RESULTS

Baseline characteristics of the subjects

Of 50 recruitment patients, all CC were complete to the cecum. Demographic characteristics of the study population are shown in table II. The 50 patients consisted of 24 women (48%) and 26 men (52%), with a mean age of 62 years and a range of 25-83 years. The main indications of colonoscopies were a history of colorectal polyps in 24% of the patients and the study of hematochezia in 26% of the patients.

Conventional colonoscopy

The mean colonoscopy examination time, consisting of insertion and inspection, biopsies and polypectomies was 30 minutes.
A negative CC was observed in 26 patients (52%). A total of 40 lesions were identified in the remaining patients. The majority of the lesions found were smaller than 5 mm. Mean size of the polyps was 6.3 mm (table III).
Thirty-seven percent of colorectal lesions smaller than 5 mm were adenomas. Lesions >10 mm were carcinomas in all cases reported (table III).
Most of the lesions were located in rectum and sigmoid.

CT colonography

CTC was technically successful in all patients and identified a total of 16 suspected lesions in 11 subjects. When compared with CC, 7 (44%) lesions were classified as false-positive lesions, and 9 (56%) were classified as true-positive lesions.

TABLE II. **Baseline characteristics of the subjects and indication for colonoscopy**

Characteristics	Results
Males, n (%)	26 (52)
Women, n (%)	24 (48)
Age (yr)	
Range	25-83
Mean	62
Indication for colonoscopy, n (%)	
Gastrointestinal symptoms	2 (4)
Hematochezia	13 (26)
Iron-deficiency anemia	4 (8)
Screening	4 (8)
History of colorectal polyps	12 (24)
Altered bowel habits	5 (10)
Family history of colorectal mass	4 (8)
Others	6 (12)

TABLE III. **Characteristics of colorectal lesions confirmed by conventional colonoscopy**

Characteristics	Number	Percent
Number of lesions	40	
Patients with any lesion	24	48
Lesion characteristics		
No by size category		
< 5 mm	32	80
5-10 mm	4	8
> 10 mm	4	8
Histology by size category		
< 5 mm		
Adenoma	12	37.5
Hyperplastic	3	9.37
Tubulovillous	1	3.12
None reported	16	50
5-10 mm		
Adenoma	3	75
None reported	1	25
> 10 mm		
Carcinoma	3	75
None reported	1	25
Location		
Rectum	7	17.5
Sigmoid	11	27.5
Descending	2	5
Splenic flexure	3	7.5
Transverse	6	15
Hepatic flexure	5	12.5
Ascending	5	12.5
Cecum	1	2.5

The mean duration for CTC was 35 minutes, including examination room time and evaluation time.

Patient detection

Table IV shows the ability of CTC to identify patients with colorectal lesions by size category. The sensitivity of CTC in detecting individuals with at least 1 lesion of any size was 31%; specificity was 94%.

Individual lesion detection

Table V shows the ability of CTC to detect individual lesions correlating by size and location criteria as previously described. CTC correctly identified 11 of the

TABLE IV. **Accurancy of virtual colonoscopy to identify patients with colorectal polyps or masses according to lesion size**

Size (mm)	TP (n)	TN (n)	FP (n)	FN (n)	Sensitivity (%)	Specificity (%)
< 5	1	32	2	16	6	94
5-10	3	41	5	1	75	89
> 10	4	45	0	1	80	100

FN: false negative; FP: false positive; TN: true negative; TP: true positive.

TABLE V. **Sensitivity of virtual colonoscopy to detect individual colorectal lesions**

Size (mm)	TP (n)	FN (n)	FP (n)	Sensitivity (%)
< 5	5	29	1	15
5-10	3	1	6	75
> 10	3	1	0	75

FN: false negative; FP: false positive; TP: true positive.

40 lesions identified on CTC for an overall sensitivity of 26%.

CTC failed to detect 31 lesions, which were classified as false negatives. The majority of missed lesions were < 5 mm in size (96%).

Participants' preferences

Participants mostly preferred virtual colonoscopy (90%), over conventional colonoscopy. The tolerance of patients was goood in all patients.

DISCUSSION

Colorectal cancer is a curable disease if detected and treated early. Screening may decrease the morbidity and mortality rates associated with colorectal cancer by enabling detection and removal of premalignant adenomatous polyps before they become invasive cancers. Despite the consensus on the need for colon cancer screening and the multiple options currently available, there are many new cases of colorectal cancer diagnosed every year.

Optical colonoscopy allows complete examination of the large bowel whilst simultaneously providing a method of biopsying or removing suspicious lesions. Although colonoscopy is highly effective in the diagnosis and treatment of colorectal poplyps, it is associated with small but definite risk for complication due to its invasive nature[7] and patients frequently refuse to undergo screening programs[8]. Since its first report in the literature, CTC has attracted progressively increasing interest as possible future alternative to CC in the diagnostic of colorectal polyps and cancer.

Our study showed a sensitivity of 75% for the ability of CTC to detect individual colorectal lesions measuring 10 mm or more, similar to other study results[9,10]. Moreover, our sensitivity of 75% for lesions 5-9 mm are in keeping with published series reporting a sensitivity of 43 to 82%[9,10].

Although individual polyps detection is extremely important to assess the performance of CTC, the identification of patients with colorectal polyps is, from a clinical point of view, far more important. In our study, the performance of CT colonography in identifying patients with colorectal lesions correlated positively with the cutoff size used. CTC had a high sensitivity (80%) and specificity (90%) in detecting individuals with lesions 1 cm or greater, and poorer results with a cutoff size of 5 mm (sensitivity 75%, specificity 89%). Published studies report sensitivities of 85%[9,10] and specificities of 97%[9,10] in identifying patients with lesions 1 cm or greater. These investigators similarly found lower accuracy in identifying patients with polyps 5-10 mm, with sensitivity of 75% and specificity of 93%[9,10].

In our study population prevalence of lesions of any size was 48%, suggesting a higher prevalence than the average population. When interest focuses on individuals with lesions 5 mm or greater, examination of our study group reveals that close to 85% of colonoscopies could have been avoided at a cost of 2 false negative examinations. With a cutoff size of 1 cm, over 90% of colonoscopies would have been found to be negative at the expense of 1 false-negative examination.

As seen in other studies[11-14], our results showed that CTC faired poorly in detecting individual lesions and patients with lesions 5 mm or less. In our study, only 5 (14%) of 34 lesions in this range size were detected at CTC. However the probability of malignancy of diminute polyps is extremely small, approximating 0.25%[15]. Therefore, future studies should be performed that would provide patient follow-up with CTC overtime[15].

CTC specificity is very homogeneous, but the reported sensitivities for CTC vary widely, even for larger polyps. There are some factors that may account for the wide range of sensitivities. First, scanners that used thinner collimation has higher sensitivity. Secondly, the mode of the imaging also appears to be important. However this latter finding must be interpreted with caution as it is based on only two studies and considerable heterogenity was found for the other types of image used[9]. The use of intravenous contrast medium may therefore enable an increase in the specificity of this technique, but the added risks and cost of administrating intravenous contrast medium probably preclude its use as part of screening CTC protocols for large populations[16]. We did not use intravenous medium contrast in our study. Dietary faecal tagging combined with a low residue diet and cathartic colon cleaning has been found to be a valuable alternative to other preparations before CTC because it reduces cathartic cleaning and results in improved patient compliance. Further research is needed to optimize fluid tagging to enable faecal substraction and primary 3D read[17].

In our study, the majority of the polyps lower than 5 mm were adenomas. Small adenomas (< 5 mm) are transformed into large adenomas (> 10 mm), then into noninvasive carcinomas and finally into invasive carcinomas. As a result of our study, we can recommend that all diminutive

polyps must be removed, since the majority are adenomas. Authors of other studies in which the relevance of small colorectal polyps was evaluated have reached different conclusions. Waye et al found that most polyps smaller than 5 mm were adenomas, while other authors have reported that most small polyps are not adenomas and that cancer in small adenomas is extremely rare.

Patient preference is an important issue, with discrepant results in the literature. Our participants did indicate a strong preference for CTC over CC, but the lack of sedation for colonoscopy in our study may be relevant. However, the preference question is complex and the answer may depend on how it is framed. The results of a 5-week follow-up study demonstrated that increased-risk patients preferred CTC to CC; however, this preference decreased in time, while outcome considerations gradually replaced temporary experiences of inconvenience[18]. Many participants may opt to go directly to CC if they know there is approximately a 20% chance that CC will also be needed for treatment, with second bowel preparation[5].

Our study has some limitations. The first limitation is that we used CC as the gold standard, but it cannot claim complete accuracy, even in the hands of experts. However, this design, including segmental unblinding, has been used in other major studies and it is difficult to conceive of a realistic alternative[19-23]. Secondly, another limitation of our study is that it was not designed to evaluate a true screening population (that is, persons who are at average risk for colorectal cancer).A final limitation is that our study did not evaluate the cost-effectiveness of CTC. Cost-effectiveness is an important consideration because CTC is not an inexpensive examination and would be performed more frequently than CC for screening. The current cost of a screening strategy involving CTC exceeds what most would considerer good value for health care money[4,6,24-26].

Over the last decade, CTC has been used to investigate the colon for colorectal neoplasia. Numerous clinical and technical advances have allowed CTC to advance from a research tool to a viable option for colorectal cancer screening, but results for several recent studies show the sensitivity of CTC may not be as high as we would like. Currently, CTC may have application in patients with obstructing tumors[27], and in patients where colonoscopy is incomplete for other reasons[28-30].

In conclusion, our results indicate that CTC using these techniques is not ready for routine use as a tool at this time, as many others have concluded[25,31-33]. There is an obvious need for continuing collaboration between radiologists and gastroenterologists in further evaluation of this exciting new technology. For the time being, CTC should be used in research protocols or when other accepted diagnostic methods, such as CC, are not appropriate[9].

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