Diagnostic accuracy and interobserver agreement of CT colonography (virtual colonoscopy)

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Abstract

Background and aims—Computed tomographic (CT) colonography or virtual colonoscopy (VC) is a non-invasive imaging method proposed for screening patients with colorectal neoplasias. Our aims were to study the diagnostic accuracy and interobserver agreement of VC for correct patient identification compared with conventional colonoscopy (CC).

Methods—This was a prospective study of 50 patients successively undergoing VC and CC. Multiplanar two dimensional CT images and three dimensional VC were constructed using surface rendering software and interpreted by two independent investigator teams. VC findings were compared with those of CC. Interobserver agreement was determined using kappa statistics.

Results—VC found 65 polyps in 24 patients. For identification of patients with polyps \( \geq 10 \text{ mm} \), the sensitivity of VC was 38% and 63%, and specificity was 74% and 74% for teams 1 and team 2. Interobserver agreement was good (kappa 0.72). For patients with polyps of any size, the sensitivity of VC was 75% and 71%, and specificity was 62% and 69% for teams 1 and 2. Interobserver agreement was fair (kappa 0.56). Accuracy improved when comparing the results of the first 24 with the last 26 patients.

Conclusions—In our experience, VC had a low diagnostic value for identification of patients with colorectal neoplasias. Interobserver agreement for VC interpretation was fair. These results may be explained by software imperfections and a learning curve effect.

(Keywords: computed tomographic; colonography; colonoscopy; diagnostic accuracy; interobserver agreement)

Screening for colorectal cancer is now widely recommended but raises important economic problems as the prevalence of precursor adenomas is about 25% after the age of 50 years. The goal of screening should be detection of patients with these precursor lesions. Unfortunately, current screening methods are either poorly specific and sensitive (faecal occult blood testing, sigmoidoscopy) or too expensive and invasive (total colonoscopy).\(^1\)\(^-\)\(^3\) Computed tomographic (CT) three dimensional colonography or virtual colonoscopy (VC) was introduced in 1994 as a non-invasive rapid imaging method of the colon and rectum.\(^1\) On the basis of initial studies, VC appears to be an excellent diagnostic procedure compared with conventional colonoscopy for detection of polyps and carcinomas.\(^4\)\(^-\)\(^8\) However, an adequate and prospective evaluation of VC as a screening procedure has not been performed. Therefore, the aims of our study were to test the sensitivity and specificity of VC as well as interobserver variability, using commercially available software in a prospective series of 50 consecutive patients referred for diagnostic colonoscopy without recent prior morphological study of the colorectum.

Methods

This prospective study was conducted from March 1997 to March 1998 and was preceded by a series of VC test examinations to adjust the technical parameters. The study included 50 consecutive patients (31 men and 19 women) aged 50–85 years (mean 68 (8) years). The study design was approved by the local ethics committee and all patients gave informed written consent. All patients were aged >50 years and were referred for conventional colonoscopy (CC). Exclusion criteria were inflammatory bowel disease and refusal of consent. Indications for colonoscopy included: abdominal pain (n=11), iron deficiency anaemia of unknown origin (n=10), surveillance because of a personal history of colon polyps (n=10), haematochezia or positive occult faecal blood test (n=7), tumour search (n=7), or personal history of colorectal cancer (n=5). A partial colectomy had been performed in all patients with colorectal cancers.

After standard oral colonoscopy preparation (3 litres of polyethylene glycol; Fordtran, Streuli, Switzerland) patients underwent helical CT scanning (Advantage General Electrics, Switzerland). All patients received an intravenous injection of a musculotropic spasmylytic (N-butyl-Hyoscine 20 mg; Buscopan, Boehringer Ingelheim, Germany). Patients were placed in the supine position and colon insufflation was performed with room air to maximal tolerance. A standard CT scout view was used to assess the degree of colonic distension. CT images were obtained during one or two breath-holds of 25–40 seconds, using 5 mm collimation with a table speed of 7.5 mm/s.

Abbreviations used in this paper: CT, computed tomography; VC, virtual colonoscopy; CC, conventional colonoscopy.
Axial CT images were reconstructed at 2.5 mm intervals. Scanning parameters were 200 mA and 110 kVp. We used a $512 \times 512$ matrix for image reconstruction. Scanning was in the craniocaudal direction. The two dimensional and three dimensional CT colonoscopy calculations were performed by downloading the data to a Sun Spark 20 computer workstation (Microsystems Mountain View, California, USA) equipped with commercially available software (Advantage Windows, Navigator, version 24/7/97, General Electrics, Switzerland). Using surface rendering techniques, multiplanar two dimensional views and a virtual fly-through (in retrograde and antegrade directions) of the colon were constructed and stored on optical CD for further viewing. The threshold value chosen for CT attenuation was $-800 \text{HU}$.

Conventional colonoscopy (CC) with either polypectomy of all resectable polyps or biopsy of all non-removable polyps and masses was performed immediately after helical CT by an independent experienced operator, unaware of the results of CT. Polyp size was determined by open biopsy forceps and verified immediately after polypectomy. VC interpretation was performed by two independent investigator teams each consisting of one radiologist and one gastroenterologist of similar seniority. In case of an incomplete CC, interpretation of VC concerned only the segments explored by CC. Both teams were blinded to the results of CC and the interpretation of the other team. However, intermediate data analysis with unveiling of the results of CC was performed after completion of VC interpretation for the first 24 patients; all participants had access to these results. The study protocol was not modified subsequently. A second analysis was performed after completion of VC interpretation for the remaining 26 patients. Thus the learning process was not studied on a case by case basis.

To compare VC with the reference method CC, the following prospective definitions were used: determination of sensitivity and specificity of VC for correct patient classification (with or without polyps). Polyps were grouped according to size: $<10 \text{ mm}$ or $\geq 10 \text{ mm}$ in diameter. VC findings were considered to correlate with CC findings when polyp size was identical $\pm 3 \text{ mm}$, when polyp morphology was similar (sessile or pedunculated), and when VC located the polyp in the same colon segment as CC (rectum, sigmoid, descending colon, transverse colon, ascending colon, or caecum, respectively). A subset analysis according to polyp location in the six colon segments was performed. Statistical comparison of percentages was performed by Fisher's exact test. We evaluated interobserver agreement using the kappa coefficients (±standard error). Agreement is considered fair to good if kappa values are $0.4–0.75$ and excellent if greater than $0.75$. A kappa value of zero indicates absence of agreement; negative kappa values indicate disagreement.

Analysis for individual polyp description has been reported elsewhere.

**Results**

CC detected 65 polyps in 24 patients; 46 polyps were $1–5 \text{ mm}$ in diameter, eight polyps measured $6–9 \text{ mm}$ in diameter, and 11 polyps $\geq 10 \text{ mm}$ in diameter. The distribution of polyps according to histology was: 35 adenomas and 11 hyperplastic polyps $<5 \text{ mm}$; eight adenomas of $6–9 \text{ mm}$ in diameter; seven adenomas $\geq 10 \text{ mm}$ in diameter; and four carcinomas $\geq 10 \text{ mm}$ (two of which were stenosing). Two colonoscopies were incomplete due to stenosing masses.

For identification of any particular patient with polyps of any size, VC had the following diagnostic values: sensitivity of $75\%$ (95\% confidence interval (CI) $\pm 18\%$) and $71\%$ ($\pm 18 \%$) for teams 1 and 2, respectively; specificity of $62\%$ and $69\%$ (95\% CI $\pm 19 \%$), respectively. Positive predictive values were $72\%$ for both teams; negative predictive values were $64\%$ and $68\%$ for teams 1 and 2, respectively. When the analysis was restricted to patients carrying at least one or more polyps $\geq 10 \text{ mm}$ in diameter, sensitivity was $37\%$ (95\% CI $\pm 33\%$) and $62\%$ (95\% CI $\pm 33\%$) for teams 1 and 2, respectively, and specificity was $74\%$ (95\% CI $\pm 13\%$) for both teams. Positive predictive values were $21\%$ and $31\%$ for both teams; negative predictive values were $78\%$ and $89\%$ for both teams.
values were 86% and 91% for teams 1 and 2, respectively. For patients with polyps <10 mm, values were: sensitivity 71% (95% CI ±19%) for both teams and specificity 59% (95% CI ±18%) and 69% (95% CI ±17%) for teams 1 and 2, respectively. Positive predictive values were 55% and 62% for both teams; negative predictive values were 74% and 77%, respectively.

False negative findings for patients with polyps ≥10 mm occurred in six and three cases, respectively, according to teams 1 and 2. In an attempt to explain the low sensitivity values, we analysed all false negative results for polyps ≥10 mm for a total of six patients with 11 lesions. Team 1 had missed seven, including three of four carcinomas. The reasons for failure to detect these seven lesions were mostly perceptive errors (four cases), explained by inadequate analysis of the two dimensional CT images (three cases) and polyp masked by fluid (one case). The three remaining polyps could not be found on review of the whole data set (one case). The three remaining polyps could not be found on review of the whole data set (one case).

Specificity and sensitivity values for identification of patients with polyps of any size were analysed separately according to the study periods. For patients 1–24, sensitivity was 100% and 92%, and specificity was 42% and 58% for teams 1 and 2, respectively. For patients 25–50, sensitivity was 50% and specificity was 43%, respectively. For patients 51–60, sensitivity was 75% and 43%, respectively. These values are insufficient for screening purposes. A high rate of false positive findings has also been reported by some investigators, which in a screening programme would eventually result in performance of unnecessary complementary CC.

Our study was unique in that it involved data interpretation by two independent observer teams with ratings for interobserver agreement, and assessment of a learning process. We assumed that the most important goal of VC was correct patient selection for performance of CC. The results of our study do not agree with most published series. For patients with polyps ≥10 mm, our two observer teams found low sensitivities of 38% and 63%; specificity was only 74% for both teams. The low sensitivity might be explained by three factors: firstly,
preparation quality was often suboptimal. This becomes especially obvious after analysis of miss rates according to anatomical location. Thus all lesions in the rectum were missed, mostly as a result of fluid persistence in the rectum. Secondly, the resolution capacity of the software may have been insufficient. Indeed surface rendering software (as used in this study) appears to be less reliable than more complex, time consuming, expensive volume rendering software. Problems in image reconstruction have been reported by another group who were also unable to find lesions after a second analysis of the data set. In this series, however, mostly flat adenomas and not stenosing masses were missed. Finally, as our study reflected early experience with the method, there was a lack of expertise, in particular in the first part of the study.

The low specificity reported was due to a learning process reflected by the fact that the false positive findings decreased after analysis of the first 24 patients. Accordingly, VC specificity was very modest for patients 1–24 but considerably improved for patients 25–50. However, sensitivity decreased as specificity improved, not only because better experience led to underdiagnosis of the clinically less relevant small polyps but also due to a lack of diagnosis of large lesions. This finding also explains the paradoxical better sensitivity for detection of patients with small adenomas (<10 mm). The explanation lies in the high rate of false positive findings—that is, the overall low specificity of the method. We prospectively divided our data into two groups to assess a possible learning effect. Although this method does not reflect a true learning process on a possible learning effect. 

In conclusion, in our experience VC does not yet appear to be suitable for colorectal cancer or polyp screening. Presented in part at the Annual Meeting of the American Gastroenterological Association, New Orleans, May 18–22, 1998 (Gastroenterology 1998;114:A662).