Screening for Colorectal Neoplasia with CT Colonography: Initial Experience from the 1st Year of Coverage by Third-Party Payers[1]

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Purpose: To evaluate our experience in the 1st year of computed tomographic (CT) colonography screening since the initiation of local third-party payer coverage.

Materials and Methods: This HIPAA-compliant study was approved by the institutional review board, and informed consent was waived. Over a 1-year period that ended on April 27, 2005, 1110 consecutive adults (585 women, 525 men; mean age, 58.1 years) underwent primary CT colonography screening. More than 99% were covered by managed care agreements. CT colonographic interpretation was performed with primary three-dimensional polyp detection, and the final results were issued within 2 hours. Patients with large (≥10-mm) polyps were referred for same-day optical colonoscopy, and patients with medium-sized (6–9-mm) lesions had the option of immediate optical colonoscopy or short-term CT colonography surveillance.

Results: Large colorectal polyps were identified at CT colonography in 43 (3.9%) of 1110 patients. Medium-sized lesions were identified in 77 (6.9%) patients, 31 (40%) of whom chose optical colonoscopy and 46 (60%) of whom chose CT colonography surveillance. Concordant lesions were identified in 65 of 71 patients who underwent subsequent optical colonoscopy (positive predictive value, 91.5%). Sixty-one (86%) of 71 optical colonoscopic procedures were performed on the same day as CT colonography, thereby avoiding the need for repeat bowel preparation. The actual endoscopic referral rate for positive findings at CT colonography was 6.4% (71 of 1110 patients). The demand for CT colonography screening from primary care physicians and their patients increased throughout the study period.

Conclusion: As a primary colorectal screening tool, CT colonography covered by third-party payers has an acceptably low endoscopic referral rate and a high concordance of positive findings at optical colonoscopy.

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Computed tomographic (CT) colonography, also referred to as virtual colonoscopy, is a minimally invasive examination of the entire colon and rectum that does not require sedation or pain control. Although CT colonography represents a promising colorectal screening tool, it has yet to achieve widespread acceptance or implementation, largely due to mixed results from multicenter clinical trials and a lack of third-party reimbursement (1–4). Managed care organizations at the national level continue to view CT colonography screening as largely investigational (4). However, the need for additional effective screening options in the United States is reflected by the fact that an estimated 60% of the intended population has not been screened (5). As such, colorectal cancer, despite being a largely preventable condition, remains the second leading cause of cancer-related mortality in the United States (6).

In February 2004, gastrointestinal radiologists and gastroenterologists at the University of Wisconsin Hospital and Clinics met with the major third-party payers who covered our practice to discuss the prospects of CT colonography screening through the use of a clinically validated method (1). As a result, in April 2004 our program became the first in the country to receive standard third-party coverage for CT colonography screening (4,7). The purpose of our study was to evaluate our experience in the 1st year of CT colonography screening since the initiation of local third-party payer coverage.

Advances in Knowledge

- When covered by third-party payers, patient demand for screening CT colonography rapidly increases.
- With current CT colonography techniques, the positive predictive value for polyps 6 mm and larger is about 90%.
- As a result of decreased false-positive results, the overall CT colonography test-positive rate at the 6-mm threshold is nearly one-third of that predicted from the earlier screening trial data.

Materials and Methods

Study Group

The protocol for primary CT colonography screening was approved by our institutional review board, which also approved our retrospective study with waiver of informed consent. All aspects of our study were compliant with the Health Insurance Portability and Accountability Act. One author (P.J.P.) is a medical consultant for Viatronix, Stony Brook, New York.

In late April 2004, local third-party coverage was initiated for CT colonography screening by the major managed care providers in our area (Physicians Plus Insurance, Unity Health Insurance, and Group Health Cooperative) (4,7). All patients who underwent primary evaluation with CT colonography were referred by their primary physician for colorectal screening; we do not accept self-referred patients for CT colonography given the potential implications of both colonic and extracolonic CT findings (8).

Over a 1-year period that ended April 27, 2005, 1192 patients underwent evaluation with CT colonography at our institution. The 82 patients who were referred from gastroenterology for secondary CT colonography for completion of an incomplete optical colonoscopic examination were excluded from further analysis. The remaining 1110 patients who underwent primary evaluation with CT colonography composed the study group. Ten (0.9%) patients were private payers because their health insurance plan denied coverage for the procedure. However, a number of third-party payer plans (in addition to the three listed above) preauthorized coverage for CT colonography screening on an individual basis for at least one patient in this series. Focused medical, surgical, and family histories were obtained from all patients at the time of enrollment and scheduling for CT colonography. Demographic data from the study group are shown in the Table.

Study Design

Bowel preparation for CT colonography entailed a clear-liquid diet the day before examination, including oral administration of a single dose each of sodium phosphate (45 mL), 2% barium suspension (250 mL), and diatrizoate (60 mL). Magnesium citrate (two doses of 296 mL each) was substituted for sodium phosphate in patients who were known to have or who were suspected of having renal or cardiac insufficiency. The CT colonography program coordinator, who was a registered nurse, screened all enrollment forms for patients who had a potential need for renal and/or cardiac preparation. Patients were instructed to discontinue use of aspirin and other nonsteroidal antiinflammatory drugs 5 days prior to CT colonography unless potential same-day optical colonoscopy was not feasible or not desired by the patient. Patients taking warfarin and clopidogrel were instructed to continue these medications unless advised otherwise by their doctor. The individual components for the bowel preparation were assembled into a single convenient kit by our pharmacy; the kit was then made available at all satellite locations.

CT colonography screening was scheduled between 7:00 AM and 10:00 AM each week, Monday through Thursday. CT colonography began with the insertion of a small flexible rectal catheter, with pneumocolon achieved by using either automated CO_2 delivery (n = 691) (PROTOCO$_2$L; E-Z-Em, Westbury, NY) or patient-controlled insuffla-

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Abbreviations:
CI = confidence interval
3D = three-dimensional
2D = two-dimensional

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Guarantors of integrity of entire study, P.J.P., A.J.T.; study concepts/study design or data acquisition or data analysis/interpretation, all authors; manuscript drafting or manuscript revision for important intellectual content, all authors; manuscript final version approval, all authors; literature research, P.J.P., M.R., D.V.G.; clinical studies, P.J.P., A.J.T., M.R., D.V.G., P.R.P.; statistical analysis, P.J.P.; and manuscript editing, all authors

See Materials and Methods for pertinent disclosures.

tion of room air (n = 419) immediately before CT scanning. Part way through the year, automated CO_2 delivery became our standard front-line method for colonic distention (9). No spasmolytics were given to any patient. Single-breath-hold supine and prone acquisitions were obtained by using an eight-section or 16-section CT scanner (LightSpeed Series; GE Medical Systems, Milwaukee, Wis). The CT technique consisted of 1.25-mm collimation, 1-mm reconstruction interval, 120 kVp, and 50–75 mAs.

CT data postprocessing and the interpretation of results from CT colonography were performed by using a commercial CT colonography system that was capable of primary three-dimensional (3D) evaluation (V3D Colon; Viatronix). The results of all examinations with CT colonography were prospectively interpreted online by one of two radiologists (P.J.P. or A.J.T.), each with prior experience in CT colonography (interpretation of at least 50 cases). Final results with regard to colorectal polyps were issued to patients within 2 hours of the completion of CT colonography. With few exceptions, patients remained fasting to allow for same-day optical colonoscopy if necessary, thus avoiding the need for repeat bowel preparation.

Recent advances in CT colonography software allowed for a more rapid and effective 3D endoluminal fly through, which resulted in typical reading times of 10 minutes or less (10). We employed a biphasic interpretive approach whereby primary 3D polyp detection (bidirectional fly through for supine and prone endoluminal data sets) is combined with secondary two-dimensional (2D) review for polyp detection and for confirmation of suspicious 3D findings (10,11). We do not employ electronic subtraction of opacified luminal fluid because we have found that our current bowel preparation generally leaves relatively little residual fluid, which is well tagged and shifts location between supine and prone positioning, and that increased flight speed is possible without the artifacts introduced by the digital fluid subtraction (11).

Characteristics of 1110 Patients Who Underwent Primary Evaluation with CT Colonography

Characteristic	Data*
Age (y)	
Mean	58.1
Median	56
Sex	
Female	585 (52.7)
Male	525 (47.3)
Asymptomatic	1071 (96.5)
Symptomatic†	39 (3.5)
Family history of colorectal cancer‡	75 (6.8)
Medical history	
Risk factor for optical colonoscopy§	35 (3.2)
Cancer (not colorectal)‖	162 (14.6)
Abdominal surgery#	394 (35.5)

* Unless otherwise indicated, data are the number of patients, with percentages in parentheses.

† Symptoms included gastrointestinal bleeding, unexplained weight loss, and abdominal pain.

‡ First-degree relative with a history of colorectal cancer.

§ Risk factors included anticoagulation, history of difficult and/or incomplete endoscopy, known stricture, and sedation risk.

‖ Limited to skin cancer in 80 (49.4%) of 162 patients.

Not including herniorrhaphy.

For patients with positive results at CT colonography, all polyps measuring 6 mm or larger were recorded prospectively according to segment location, and multiple digital images displaying lesion appearance and location were stored. Management subsequent to a positive result at CT colonography was determined primarily by the size of the largest detected polyp, which was obtained by using a combined 2D and 3D assessment for optimizing maximal polyp dimension (12). The approach is similar to the recent CT Colonography Reporting and Data System recommendations put forth by the Working Group on Virtual Colonoscopy (13).

For large (≥10-mm) polyps or masses, immediate optical colonoscopy was recommended unless contraindicated by a confounding patient factor. For medium-sized (6–9-mm) lesions, we used an institutional review board–approved follow-up plan (including informed consent) whereby patients were offered either immediate optical colonoscopy for polypectomy or CT colonography surveillance, which was set as a compromise between the involved radiologists and gastroenterologists at 2 years for patients with 6–7-mm lesions and 1 year for patients with 8–9-mm lesions. Potential diminutive (≤5-mm) lesions were not reported because the accuracy of CT colonography at this polyp size is low, matching at optical colonoscopy is problematic, the risk of diminutive lesions does not clearly outweigh the risk of optical colonoscopy, and the presence or absence of such lesions does not ultimately affect our management decisions (1,14,15).

For patients without polyps measuring 6 mm or larger (ie, a negative CT colonographic study), the recommended routine screening interval was set at 5 years, which is the lower limit suggested by the CT Colonography Reporting and Data System and is well within reason according to the accepted tenets of the adenoma-carcinoma sequence (13,14).

Information pertaining to the above follow-up plan according to CT colonographic results was provided to patients prior to the study and was reiterated at the time of the examination. In addition, our referring physicians were aware of and in agreement with this diagnostic algorithm. Patients with medium-sized lesions detected at CT colonography

were immediately counseled by the interpreting radiologist and/or nurse coordinator, with further consultation with their referring physician as needed before an informed decision was made. Full written informed consent was obtained from patients who elected to undergo CT colonography surveillance for medium-sized lesions. The institutional review board waived the need for signed consent for all other patients because the existing standard of care regarding colorectal polyps was followed (ie, endoscopic removal of all polyps 6 mm or larger). Optical colonoscopy was generally recommended for patients with three or more medium-sized polyps (13).

When indicated, optical colonoscopy was typically performed within several hours of the CT colonographic interpretation by one of nine experienced gastroenterologists (range of experience, 3–25 years; mean experience, 14.2 years) who used standard techniques and endoscopes (EC-3430L and EC-3830/31L Series; Pentax, Montvale, NJ). Gastroenterologists were fully informed of the results of CT colonography and were sent digital images that demonstrated the findings prior to optical colonoscopy. The standard endoscopic technique included cecal intubation and sequential withdrawal of the scope for polyp detection. Polyp size and location were visually estimated per routine. Whenever possible, all polyps that were detected at optical colonoscopy and that were deemed to be of clinical importance were retrieved or biopsy was performed for histologic evaluation.

Statistical Analysis

To determine concordance between the results of optical colonoscopy and those of CT colonography, an established matching algorithm was used that allowed for some degree of uncertainty in localization and size estimation at optical colonoscopy (1). To be considered a positive match, a polyp must be located within either the same segment or an adjacent segment and the polyp size measurements must be within a 50% margin of error. The concordance of findings at optical colonoscopy with lesions detected at CT colonography was used to determine the positive predictive value of findings at CT colonography. Because optical colonoscopy is not an infallible reference standard, the positive predictive value may be slightly underestimated (16–19). The positive predictive value of findings at CT colonography was evaluated according to both the individual polyps and the patient. The latter assessment is more relevant to the overall care of the patient and will therefore be emphasized. All study data were entered into a customized CT colonography database (Access; Microsoft, Redmond, Wash). The χ^2 test was used to evaluate the difference between positive CT colonography test rates in men and those in women. The two-sided 95% confidence interval (CI) is reported for relevant results. Stata (version 8.2; Stata, College Station, Tex) was used to perform statistical analysis.

Figure 1

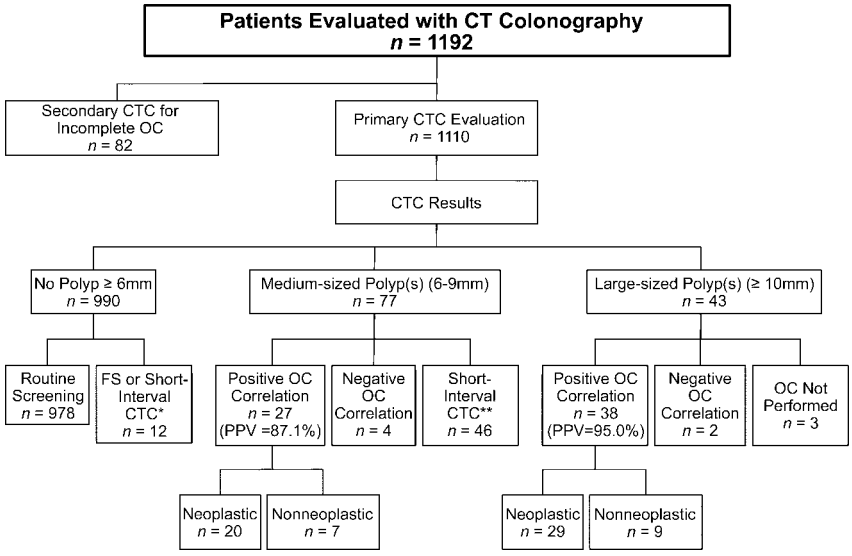

Figure 1: Flowchart of relevant findings for patients undergoing primary CT colonography at our institution over a 1-year period. Flexible sigmoidoscopy or short-interval virtual colonoscopy was performed for nondiagnostic segmental evaluation of the sigmoid or descending colon in all cases (*). Short-interval virtual colonoscopy group includes one patient who underwent incomplete optical colonoscopy (**). *CTC* = CT colonography, *FS* = flexible sigmoidoscopy, *OC* = optical colonoscopy, *PPV* = positive predictive value.

Results

The main findings and disposition for the 1110 consecutive patients who underwent primary CT colonography within our screening program over this 1-year period are shown in Figure 1. Large (≥10-mm) colorectal lesions were identified at CT colonography in 43 (3.9%; 95% CI: 2.8%, 5.2%) patients (Fig 2), 40 of whom underwent subsequent optical colonoscopy. In three patients with large polyps, optical colonoscopy was not performed because of various patient-related issues. Medium-sized (6–9-mm) colorectal polyps were identified at CT colonography in 77 (6.9%; 95% CI: 5.5%, 8.6%) patients (Fig 3), 31 (40%) of whom chose optical colonoscopy and 46 (60%) of whom chose short-interval CT colonography surveillance.

The overall CT colonography test-positive rate for 6-mm polyps was 10.8% (120 of 1110 patients). Because most patients with medium-sized lesions chose to undergo follow-up with CT colonography, the actual endoscopic referral rate for patients with positive findings at CT colonography was 6.4% (95% CI: 5.0%, 8.0%; 71 of 1110 patients). If all patients with either a polyp

measuring 6 mm or larger (n = 120) or a nondiagnostic segment (n = 12) had undergone subsequent endoscopy, the maximum referral rate would have been 11.9% (95% CI: 10.0%, 13.9%; 132 of 1110 patients).

Concordant Lesions

Concordant findings for polyps that were detected at CT colonography were identified at subsequent optical colonoscopy in 65 of 71 patients, yielding a per-patient positive predictive value of 91.5% (95% CI: 82.5%, 96.8%). At least one matching lesion was neoplastic in 49 (75%; 95% CI: 63.1%, 85.2%) of 65 patients. The positive predictive value for individual polyps measuring 6 mm or larger that were detected at CT colonography was 88.5% (95% CI: 80.7%, 93.9%; 92 of 104 lesions).

Histologic diagnoses for matched neoplasms included tubular adenoma (n = 50), tubulovillous adenoma (n = 12), villous adenoma (n = 2), adenocarcinoma (n = 1), malignant carcinoid tumor (n = 1), and mucinous adenoma of the appendix (n = 1). Hyperplastic polyps were the most common cause of nonneoplastic matched lesions; other entities included lymphoid, mucosal (ie, normal mucosa), and hamartomatous polyps. Individual adenomas that were 6 mm or larger were identified at optical colonoscopy but not at prospective CT colonography in five (7%) of 71 patients. However, additional adenomas that were detected at CT colonography and were of similar or larger size were found in each of these patients such that the prevalence and size categories of detected neoplasms were unchanged. No additional cancers or adenomas with high-grade dysplasia were detected at optical colonoscopy.

Thirty-six (54%) of the 67 neoplasms measuring 6 mm or larger that were detected at CT colonography and confirmed at pathologic examination were located proximal to the splenic flexure. Six patients were referred to undergo surgery for definitive resection. The mean age of patients with positive findings at CT colonography was 59.4 years compared with a mean age of 56.8 years for those with negative results.

Figure 2

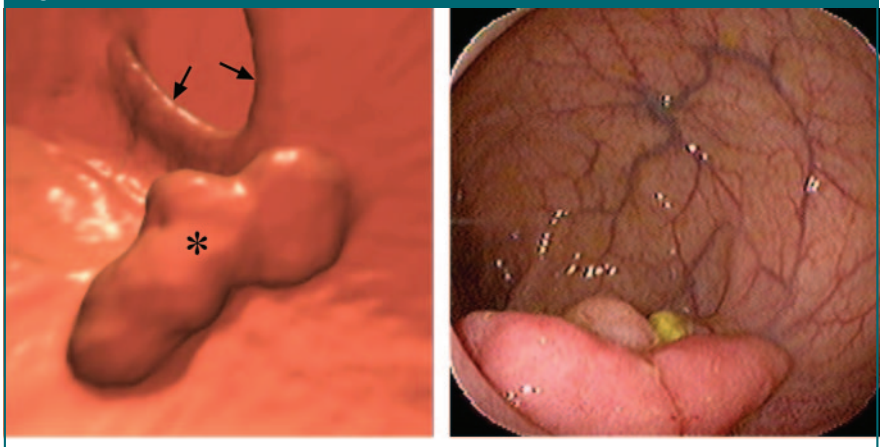

Figure 2: Large colorectal polyp in asymptomatic 53-year-old man at average risk for colorectal neoplasia. **(a)** Still image obtained at 3D endoluminal CT colonography fly through shows a lobulated 3.5-cm mass (*) located behind a rectal fold (arrows). **(b)** Digital photograph obtained at optical colonoscopy performed on the same day shows the same lesion, which proved to be tubulovillous adenoma with high-grade dysplasia at histologic examination.

The results of CT colonography were more frequently positive in men (71 [13.5%] of 525 patients) than in women (49 [8.4%] 585 patients) ($P < .01$). The results of CT colonography were positive in 11% of patients with a first-degree relative who had a history of colorectal cancer (eight of 75 patients) and in 10.8% of patients with no family history of colorectal cancer (112 of 1035 patients).

Complications

There were no clinically notable complications following bowel preparation or CT colonography in the 1110 patients. Two (3%) of the 71 patients who underwent subsequent evaluation with optical colonoscopy for positive CT colonographic findings were hospitalized for minor complications (postpolypectomy syndrome and abdominal pain). Both patients had multiple large polyps that were removed at optical colonoscopy, and both patients fully recovered with only conservative measures. In three patients (5%), optical colonoscopy that was performed after CT colonography was incomplete and did not reach the location of the lesions that were detected at CT colonography; one patient who had a 7-mm polyp did not undergo repeat optical colonoscopy and will be followed up with CT colonography. The other two patients underwent successful repeat optical colonoscopy.

Overall, 61 (86%) of the 71 initial optical colonoscopic examinations were performed on the same day as screening CT colonography. The reasons for optical colonoscopy being delayed or not pursued include anticoagulation or other coexisting health problem, medical coverage issues, patient not remaining in fasting state, or no available driver.

In 12 patients (1.1%) with otherwise negative findings at CT colonography, at least one colonic segment was considered nondiagnostic because of luminal collapse from advanced diverticular disease of the sigmoid and/or descending colon. Flexible sigmoidoscopy without sedation was performed on the same day as CT colonography in four of these patients, and negative results were obtained in all four cases. In the remaining eight patients, follow-up flexible sigmoidoscopy or evaluation with shorter-interval CT colonography was recommended. Completion of colorectal screening with unsedated same-day flexible sigmoidoscopy after nondiagnostic CT colonography is analogous to

performing CT colonography for incomplete optical colonoscopy. Repeat screening at 5 years was recommended for the remaining patients in whom no nondiminutive polyps were detected at CT colonography. The choice of a 5-year interval versus a 10-year interval reflects (in part) the fact that diminutive polyps are not assessed with CT colonography screening.

Quarterly Volume

Of note, the total number of patients who underwent optical colonoscopy did not decrease with the increasing number of patients who underwent CT colonography (Fig 4). The reasons for the modest increase in patients who underwent optical colonoscopy were multifactorial and included the increased availability of faculty gastroenterologists and the improved efficiency of endoscopy units. Overall, there was a significant increase in the overall screening of our population, with a doubling of patients from the 1st quarter of 2004 to the 1st quarter of 2005.

Figure 3

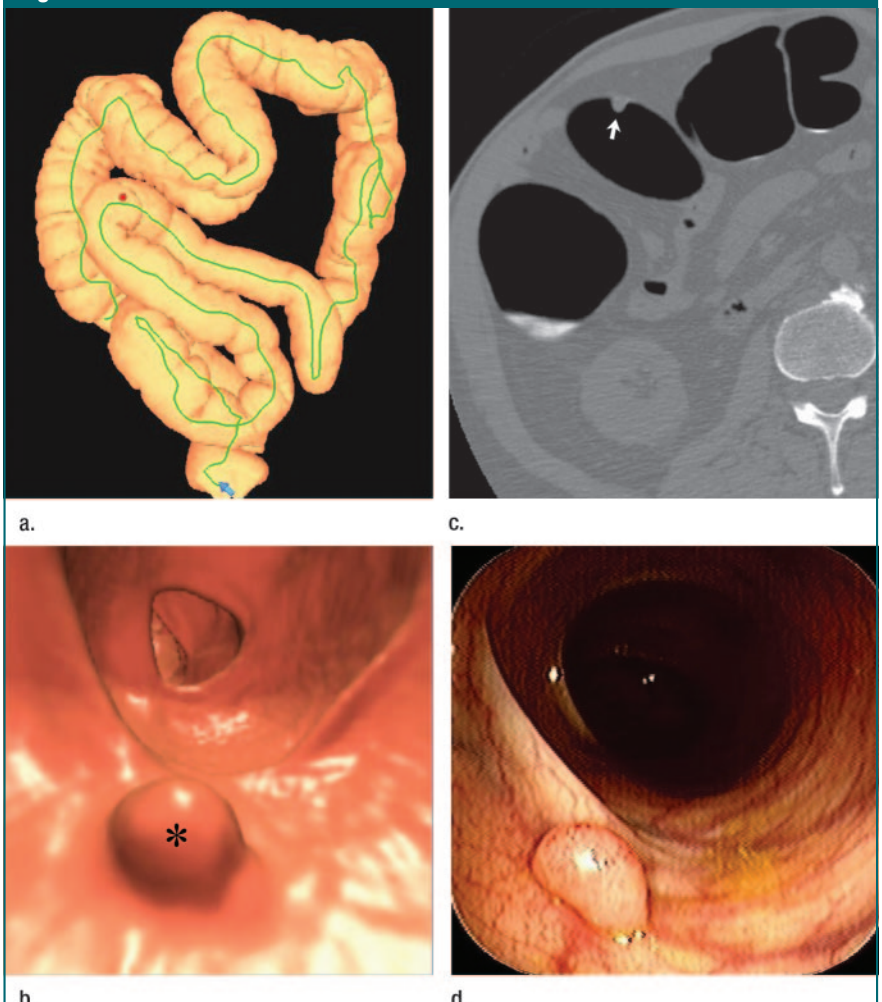

Figure 3: Medium-sized colorectal polyp in asymptomatic 60-year-old man at average risk for colorectal neoplasia. **(a)** Schematic map of gas-filled colon automatically generated from CT scan data. The red dot indicates the location of a polyp detected at CT colonography. The green line represents the centerline for automated endoluminal navigation. Note the tortuous and elongated sigmoid colon in this case. **(b)** Still image obtained at 3D endoluminal CT colonography fly through shows 7-mm sessile polyp (*) located in sigmoid colon, as indicated in **a**. **(c)** Transverse 2D view confirms that the polyp identified in **b** is a soft tissue lesion (arrow). Correlation of positive 3D finding on 2D view is essential in all cases for avoiding false-positive diagnosis. Patient chose immediate polypectomy. **(d)** Digital photograph obtained at optical colonoscopy on the same day shows the same polyp, which proved to be a tubular adenoma at histologic examination. Colonoscopist believed the polyp was located in the descending colon, likely related to sigmoid tortuosity.

Discussion

The results of our program suggest that combining 3D CT colonography with an existing optical colonoscopy practice can be a viable and generalizable means of achieving the goal of detection and removal of large polyps in the majority of the screening population (11,15,20,21).

At the national level, it is understandable that the role of CT colonography for colorectal screening currently remains uncertain given the mixed performance results in the published literature. It is important, however, to critically analyze the differences among the three large multicenter CT colonography trials to date (ie, Pickhardt et al [1], Cotton et al [2], and Rockey et al [3]). The fact that these studies actually transpired in reverse order of their publication (with the trial by Pickhardt et al beginning more than 2 years after the other two) may give the false impression that the performance of this rapidly evolving tool is declining. To the contrary, these collective results provide further evidence that certain technical improvements, particularly CT colonography software that is capable of effective primary 3D polyp detection and colonic preparation with oral contrast agents for fluid and stool tagging, are essential to success (4,10,11,22–26).

Reliable colonic cleansing and adequate colonic distention are also critical. Reader inexperience or the steeper learning curve for primary 2D polyp detection may also have had a detrimental effect on the earlier studies because each site averaged only 40–70 cases in the earlier trials compared with over 400 cases per site in the trial by Pickhardt et al (1). In addition, the perfor-

mance of CT colonography in this larger trial that used primary 3D interpretation did not vary significantly according to site or over the course of the trial, which suggests a much simpler learning curve for this approach. Furthermore, primary 3D polyp detection still allows for complementary 2D detection (an approach we refer to as biphasic examination), whereas primary 2D evaluation with 3D problem solving lacks the benefit of 3D polyp detection.

Since the multicenter validation trial (1), continued advances in the specific CT colonography technique, including improvements in software, colonic preparation, and colonic distention, have led to examinations that are of consistently higher quality and better tolerated by patients. Recent improvements in the V3D Colon software (Viatronix) have greatly reduced interpretation times, with most reading times of 10 minutes or less (10). From a workforce perspective, our CT colonography program currently uses only four half-day readouts per week by a single radiologist, further demonstrating the potential efficiency of this process. Patient-friendly modifications have reduced the total volume of the bowel preparation by half (now less than 400 mL) while improving the overall quality of CT colonography. Instituting an automated CO_2 delivery system has resulted in both improved colonic distention and decreased postprocedural discomfort (9).

The combined effect of these improvements may help explain the significantly higher positive predictive value seen with our current technique. For example, our positive predictive value per patient for lesions measuring 6 mm or larger that were detected at CT colonography was 93.8% compared with 58.5% in the previous validation trial by Pickhardt (27). When only neoplasms are considered as a positive result, our positive predictive value was 72.3% compared with 40.7% in the previous screening trial (1,27). Although we cannot assess the negative predictive value of CT colonography in the current study, it was previously shown to approach 100% for nondiminutive adenomas by using this CT colonography method (1).

Figure 4

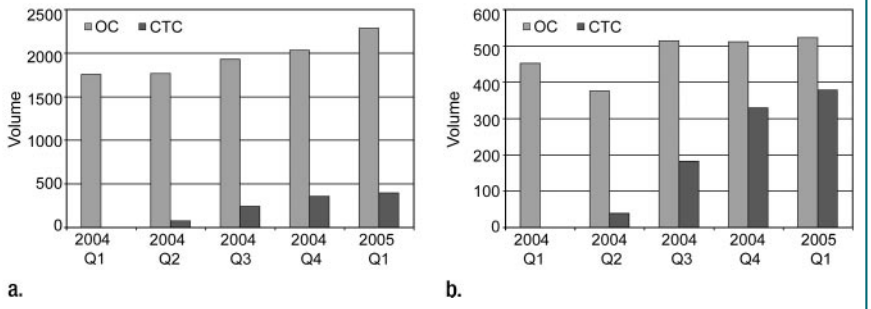

Figure 4: Volume of patients who underwent colonoscopy at our institution over five quarters. Bar graphs demonstrate **(a)** total and **(b)** screening volumes for both CT colonography *(CTC)* and optical colonoscopy *(OC)*. Note that the total number of patients who underwent optical colonoscopy has not decreased with the increasing number of patients who underwent CT colonography. The overall number of patients screened doubled between the 1st quarters of 2004 and 2005.

We believe that these clinical results are generalizable to other practices if our approach to CT colonography is adhered to. The current results improve on the methods employed in the multicenter screening trial by Pickhardt et al (1) and further validate this screening tool, regardless of the future results of ongoing validation trials that may employ a variety of different methods (28). To become a truly successful screening tool, however, CT colonography must be embraced by patients, referring physicians, national third-party payers, and gastroenterologists. Within our practice, patient demand for CT colonography screening has remained strong, primarily fueled by word-of-mouth advertising because no dedicated marketing campaign has been needed. Available CT colonography slots are quickly filled, pressing the program to further increase capacity. Our patients value the provision for same-day polypectomy, because this avoids the needs for a second bowel preparation. The active female participation in our program has been encouraging; this factor may account for the relatively low prevalence of adenomas in our population.

The local physician referral base for CT colonography screening has been primarily composed of a relatively small group of primary care providers who are knowledgeable about the University of Wisconsin program and the relevant issues related to colorectal screening. Further expansion of this referral base may require additional education, in addition to publication of our program results. Expansion of third-party coverage for CT colonography screening beyond our program alone should be inevitable, assuming that proved methods are employed. However, it is unclear if managed care organizations would approve coverage for groups that use other CT colonography software systems that have not yet been proved effective for screening. It should be noted that reimbursement for CT colonography screening at University of Wisconsin was closely tied to use of the previously validated technique (10).

Gastroenterologists should not feel threatened by the implementation of CT colonography, as we have found it to be a useful complement to optical colonoscopy rather than a potential replacement. The complementary nature becomes readily apparent because optical colonoscopy may occasionally demonstrate synchronous lesions that are not prospectively identified at CT colonography, just as some polyps that were detected at CT colonography would have gone undetected at primary optical colonoscopy (16,17).

Variability in patient preferences and physician referral patterns will undoubtedly translate into a continued demand for primary optical colonoscopy screening. In fact, the success of CT colonography may ultimately benefit gastroenterology practices the most. The theoretic concerns that the imple-

mentation of CT colonography might decrease the overall volume of patients who undergo optical colonoscopy (29) are trumped by the vast untapped supply of patients who are in need of screening and by the continued need for therapy (ie, polypectomy). Furthermore, an increased percentage of truly therapeutic optical colonoscopic examinations would represent better use of a limited resource that is more costly and more invasive than CT colonography. Ultimately, the real issue may be whether there are enough gastroenterologists and radiologists combined to adequately handle a considerable increase in screening compliance (30,31).

CT colonography represents a paradigm shift for colorectal screening, as it provides for effective and relatively noninvasive risk stratification. Because CT colonography can exclude the presence of large polyps with a high level of confidence (1), an important related question is whether the low inherent neoplastic risk of a medium-sized (6–9-mm) polyp that is detected at CT colonography is outweighed by the procedural risk of removing the polyp at optical colonoscopy (32). To fully answer this, more insight into the long-term natural history of these lesions is needed (33–36). Other aspects of CT colonography screening that require further investigation include the effect of extracolonic CT findings, an analysis of cost-effectiveness, patient compliance data, the prospects for noncathartic preparation, and computer-aided polyp detection (8,24,37).

There are limitations to our study. It is important to reiterate that our screening results only apply to the specific CT colonography methods that we employed and that have been previously validated in a large multicenter screening trial (1). To date, the CT colonography software system that we used (V3D Colon; Viatronix) remains the only U.S. Food and Drug Administration–approved system for the purpose of screening. It is our hope that other CT colonography systems will continue to develop their own 3D detection tools to allow for similar time-efficient performance results with a biphasic interpretive approach.

Another potential limitation is that the sensitivity of CT colonography relative to optical colonoscopy cannot be directly assessed because not all patients were evaluated with optical colonoscopy. However, the negative predictive value was previously shown to be in the 99% range (1). In addition, we also have new data that show that the number of advanced adenomas (the primary target of screening) that are detected at CT colonography and subsequently removed at optical colonoscopy in this patient series equals the number of advanced adenomas that are detected and removed during primary optical colonoscopy at our institution in matched populations of more than 2000 patients (D.H.K. and P.J.P., unpublished data, August 2006). This reinforces the efficiency of CT colonography screening because the same primary goal of screening is achieved, even though fewer than 10% of patients underwent optical colonoscopy (vs 100% in the comparison group).

A final limitation is that we do not yet know the clinical outcome of CT colonography surveillance for unresected medium-sized lesions. The natural history of these lesions will be the focus of future investigation.

In conclusion, combining our CT colonography methods with an existing optical colonoscopy practice has resulted in a synergistic approach to colorectal screening in our population. With our current protocol, more than 90% of patients who underwent primary CT colonography were not referred for subsequent optical colonoscopy. For those patients who underwent optical colonoscopy, the likelihood of confirming a lesion that was detected at CT colonography was more than 90% and, in the majority of cases, did not require additional bowel preparation. The low endoscopic referral rate and high positive predictive value not only demonstrate the clinical effectiveness of this approach but also provide encouraging data for cost-effectiveness analyses. The present results may help to remove misconceptions surrounding CT colonography that relate to clinical results obtained from now less-current methods.

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