CT Colonography of a Medicare-Aged Population: Outcomes Observed in an Analysis of More Than 1400 Patients

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OBJECTIVE. We evaluated outcomes of patients 65 years old and older who underwent CT colonography (CTC) between 2004 and 2009.

CONCLUSION. The frequency of referral to colonoscopy based on a polyp size threshold of 6 mm was 14.5%. Colorectal neoplasia was found in 9.3% of patients, with advanced neoplasia in 3.3%. Potentially important extracolonic findings were observed in 2.9% of patients. The low rates of referral to colonoscopy, prevalence of advanced neoplasia, and prevalence of extracolonic findings make CTC a viable option for Medicare-aged patients.

Keywords: colon cancer, colorectal cancer screening, CT colonography, Medicare, screening

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to date had evaluated outcomes associated with CTC in a solely Medicare-aged population. They also indicated that uncertainty regarding the prevalence and impact, both clinically and economically, of extracolonic findings identified with CTC, and uncertainty regarding the effects of additional ionizing radiation in this population were important considerations for the noncoverage of screening CTC. Additionally, because CTC does not reliably detect polyps smaller than 6 mm, the uncertain impact of these polyps on the testing intervals of CTC was another consideration in the decision.

In this article, we address several of these data deficiencies and report the clinical findings arising from CRC screening and polyp surveillance with CTC in 1410 consecutive Medicare-aged patients who underwent screening or surveillance CTC as part of the Colon Health Initiative (CHI) at the National Naval Medical Center (NNMC) in Bethesda, MD. We measured the colonoscopy referral rate and compliance with colonoscopy referral after a positive CTC examination, and we describe the prevalence and nature of colonic neoplasia and extracolonic findings detected with CTC to address several of the uncertainties cited by the USPSTF and CMS with regard to CTC of this patient population.

Materials and Methods

Study Population

Patients were included in the analysis if they were 65 years old or older at the time they underwent CTC for the indication of CRC screening or polyp surveillance. The total number of CTC procedures performed from 2004 to 2009 was 8317, of which 1612 (19.4%) were examinations of patients 65 years old or older. Patients who underwent diagnostic CTC (e.g., for failed colonoscopy or for symptoms or signs suggestive of colorectal disease) and patients who had undergone CTC within the previous 5 years were excluded. Patients with a personal history of CRC, advanced colonic neoplasia, inflammatory bowel disease, or familial history of colon cancer syndromes were also excluded. If an individual patient underwent more than one CTC examination during the study period, only the first adequate CTC examination was included in the analysis. Finally, patients who met the inclusion criteria but who also participated in another clinical trial of CTC at our institution, which includes random selection to undergo colonoscopy after normal CTC, were excluded for the specific endpoint of progression to colonoscopy but were included for other endpoints such as intracolonic neoplasia and extracolonic findings.

All patients were Department of Defense medical beneficiaries who underwent CTC as part of the CHI at NNMC in Bethesda, MD.

CT Colonography Protocol

Preparation for CTC has been described elsewhere [10]. Briefly, after cathartic preparation of the colon with the addition of radiopaque contrast material for fluid and stool labeling, colonic insufflation was performed using carbon dioxide delivered via automated insufflators with preset ramped flow rates and automatic venting at predetermined intracolonic pressures. Images were obtained with patients in the prone and supine positions with an MDCT scanner utilizing the following imaging parameters: 120 kVp, 30–60 mAs, 1.5-mm slice thickness, 1.25-mm reconstruction interval, and 40 × 0.625 collimation.

CT source images were sent to a dedicated workstation for interpretation and archived as part of the medical record. The CTC workstations at our institution allow synchronized prone and supine 2D and 3D endoluminal navigation and interrogation, standard multiplanar reformation, window and level setting adjustments, and FOV manipulation of the CT source images. The colon was evaluated with a primary read of the 3D images coupled with utilization of the 2D images for problem solving. Extracolonic findings were evaluated on the 2D CT source images in the coronal, sagittal, and axial planes. All studies were interpreted by experienced radiologists who have individually reviewed more than 8000 CTC examinations. IV contrast material was not used in any of the CTC procedures.

Possible complications of CTC were assessed during and immediately after the procedure and included colonic perforation; vasovagal reactions; nausea or vomiting; and severe abdominal pain, defined as a score of 7 or greater on a scale of from 1 to 10, lasting more than 1 hour after insufflation. Traditional measures of colonoscopy complications (perforation, cardiovascular collapse, immediate or delayed procedural bleeding, postpolypectomy syndrome or infection) were used.

Results were reported in accordance with the CT Colonography Reporting and Data System (CRADS) reporting system [11]. This system consists of two components: intracolonic findings and extracolonic findings (Table 1). Intracolonic findings are denoted C0–C4 and range from nondiagnostic CTC (C0) to the likely presence of colorectal malignancy (C4). The extracolonic findings are similarly denoted E0–E4 and range from non-diagnostic images of the extracolonic tissues (E0) to potentially important extracolonic findings (E4).

Patients in the current analysis followed the standard operating procedure at our institution: They were referred for colonoscopy if any polyps ≥ 6 mm in diameter were detected on CTC (categories C2, C3, or C4). Studies with findings suggestive of malignancy of the digestive system were referred immediately to a staff gastroenterologist. Extracolonic findings outside the digestive system that were of concern were communicated to the patients’ primary care provider for further action.

We maintain a database consisting of basic demographic data and results of CRC screening procedures for use in our CRC screening program. The data in this database were sorted by patient age at the time of CTC, and results of both CTC and colonoscopy (when available) for patients 65 years old or older were abstracted to a separate database for analysis. Data migrated for the current analysis included age, race, intra- and extracolonic results, colonoscopy results, polyp histology, and participation status in other clinical trials. Additional information such as medication use and medical history was not retrieved on the basis of the parameters of the study approved by the NNMC institutional review board. For the purposes of this analysis, advanced colonic neoplasia was defined by the presence of any number of adenomas ≥ 10 mm in maximal diameter, any villous histology, high-grade dysplasia, or overt malignancy.

Statistical Analysis

Descriptive statistics were used to denote basic patient demographics and the frequency of intracolonic and extracolonic findings found on CTC in patients included in this analysis. The percentage of patients who received a recommendation for colonoscopy was calculated as the sum of all patients with category C2, C3, or C4 classifications divided by the total number of patients who underwent CTC. The prevalence of advanced neoplasia was reported on the basis of the most advanced intracolonic abnormality detected by colonoscopy in any patient. Comparisons of differential rates of proceeding to colonoscopy among different demographic strata were calculated using the chi-square test or Fisher exact test for categoric variables and Student t test or Kruskal-Wallis test as appropriate. Evaluations of differential rates of colonic findings (e.g., any neoplasia, advanced neoplasia) were analyzed by univariate logistic regression to calculate the odds of exposure to given demographic categories among those with and without the colonoscopy outcomes of interest. Statistical significance was set at p < 0.05. Statistics software (Stata, version 11.0, StataCorp) was used for all analyses.

Role of the Funding Source

Funding of this study was intramural from the Responsible Conduct of Research Department (RCRD) at NNMC. The institutional review board of the RCRD approved the protocol and the RCRD ensured protocol adherence and compliance.
CTC of Medicare Patients

Results

Between 2004 and 2009, 1410 Medicare-eligible patients 65 years old or older underwent screening or surveillance CTC and met the eligibility criteria for this analysis. The mean age was 75.0 years and most patients were white (83.5%). Medicare-aged men (58.3%) were slightly more likely to undergo screening CTC than women during this time period. After exclusion of 46 patients with normal CTC examination findings who proceeded to immediate colonoscopy because of participation in another research trial, the overall frequency of referral to colonoscopy for C2–C4 lesions noted on CTC was 14.5% (198/1364). At our institution, patients with CTC results interpreted as C0 are referred for colonoscopy as long as the indication for CTC was not a failed colonoscopy. Among the 1410 Medicare-aged patients in the cohort who underwent CTC screening or surveillance, 46 (3.3%) had CTC examinations that were graded C0 and these patients were referred to colonoscopy. This practice is not universal; some practices recommend a second CTC attempt within 6 months after a C0 examination depending on the clinical situation. For a variety of reasons, 53 patients referred to colonoscopy for C0 or C2–C4 interpretations did not elect to undergo colonoscopy, so the actual frequency of colonoscopy performed after CTC was 14.0% (191/1364). No short- or long-term complications were noted.

### TABLE 1: CT Colonography Reporting and Data System (C-RADS) Reporting Scheme

<table>
<thead>
<tr>
<th>C-RADS Classification</th>
<th>Definition</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Colonic classification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category C0</td>
<td>Inadequate study</td>
<td>Inadequate preparation; cannot exclude lesions ≥ 10 mm due to fluid, feces, or both; inadequate insufflation (i.e., one or more collapsed segments on prone and supine images)</td>
</tr>
<tr>
<td>Category C1</td>
<td>Normal colon or benign lesion</td>
<td>No visible abnormalities of the colon and no polyp ≥ 6 mm</td>
</tr>
<tr>
<td>Category C2</td>
<td>Intermediate polyp or indeterminate finding</td>
<td>Largest polyp is 6–9 mm; fewer than 3 polyps in number; indeterminate findings; cannot exclude polyp ≥ 6 mm in technically adequate examination</td>
</tr>
<tr>
<td>Category C3</td>
<td>Polyp, possibly advanced adenoma</td>
<td>Polyp ≥ 10 mm; ≥ 3 polyps, each 6–9 mm</td>
</tr>
<tr>
<td>Category C4</td>
<td>Colonic mass, likely malignant; surgical consultation recommended</td>
<td>Lesion compromises bowel lumen, shows extracolonic invasion</td>
</tr>
<tr>
<td><strong>Extracolonic classification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category E0</td>
<td>Limited examination</td>
<td>Evaluation of extracolonic soft tissues is severely limited; compromised by artifact</td>
</tr>
<tr>
<td>Category E1</td>
<td>Normal findings or anatomic variant</td>
<td>No extracolonic abnormalities</td>
</tr>
<tr>
<td>Category E2</td>
<td>Clinically unimportant finding</td>
<td>No workup indicated</td>
</tr>
<tr>
<td>Category E3</td>
<td>Unimportant finding, incompletely characterized</td>
<td>Workup may be indicated</td>
</tr>
<tr>
<td>Category E4</td>
<td>Potentially important finding</td>
<td>Communicate with referring physician per accepted practice guidelines</td>
</tr>
</tbody>
</table>

*a* Examples: lipoma, inverted diverticulum, or nonneoplastic findings such as colonic diverticula.

*b* Examples: simple cysts of the liver or kidney, cholelithiasis without cholecystitis, vertebral hemangioma.

*Examples: solid renal mass, lymphadenopathy, aortic aneurysm, nonuniformly calcified parenchymal nodule ≥ 1 cm.

### TABLE 2: Demographic Characteristics of Patients Undergoing CT Colonography by CT Colonography Reporting and Data System (C-RADS) Category

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>C0 (n = 46)</th>
<th>C1 (n = 1166)</th>
<th>C2 (n = 130)</th>
<th>C3 (n = 66)</th>
<th>C4 (n = 2)</th>
<th>Total (n = 1410)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>Mean (SD)</td>
<td>76.2 (6.4)</td>
<td>74.9 (6.1)</td>
<td>74.7 (5.8)</td>
<td>76.8 (6.0)</td>
<td>74.5 (2.1)</td>
</tr>
<tr>
<td>Sex, no. (%) of patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>22 (47.8)</td>
<td>498 (42.7)</td>
<td>41 (31.5)</td>
<td>26 (39.4)</td>
<td>1 (50.0)</td>
<td>588 (41.7)</td>
</tr>
<tr>
<td>Male</td>
<td>24 (52.2)</td>
<td>668 (57.3)</td>
<td>89 (68.5)</td>
<td>40 (60.6)</td>
<td>1 (50.0)</td>
<td>822 (58.3)</td>
</tr>
<tr>
<td>Race, no. (%) of patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>40 (87.0)</td>
<td>971 (83.3)</td>
<td>106 (81.5)</td>
<td>58 (87.9)</td>
<td>2 (100)</td>
<td>1177 (83.5)</td>
</tr>
<tr>
<td>African-American</td>
<td>4 (8.7)</td>
<td>155 (13.3)</td>
<td>19 (14.6)</td>
<td>7 (10.6)</td>
<td>0</td>
<td>185 (13.1)</td>
</tr>
<tr>
<td>Asian or Pacific Islander</td>
<td>2 (4.3)</td>
<td>34 (2.9)</td>
<td>5 (3.9)</td>
<td>1 (1.5)</td>
<td>0</td>
<td>41 (2.9)</td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
<td>6 (0.5)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6 (0.4)</td>
</tr>
<tr>
<td>Underwent colonoscopy</td>
<td>19 (41.3)</td>
<td>46 a</td>
<td>105 (80.8)</td>
<td>65 (98.5)</td>
<td>2 (100)</td>
<td>191 (14.0)</td>
</tr>
</tbody>
</table>

Note—NA = not applicable.

aProceeded to colonoscopy due to participation in another clinical study protocol.
tions occurred as a result of CTC or colonoscopy in any patient included in this analysis.

Most patients (82.7%, 1166/1410) had normal CTC (C1) examination findings. Most C0 examinations were nondiagnostic because of incomplete distention of the same colonic segment on both prone and supine CTC images or because of inadequate colonic preparation (n = 32). Among the patients who had findings suggestive of colorectal disease, 65.2% (129/198) were classified as C2, 33.8% (67/198) were C3, and 1.0% (2/198) were C4. At the time of analysis, 78.3% of patients (191/244) with C0 or C2–C4 studies had undergone colonoscopy as recommended (Table 2). Patients who complied with the recommendation to proceed to colonoscopy after CTC were younger than those who did not (mean age, 75.1 vs 77.0 years, respectively; p = 0.048) but were not different with regard to race or sex.

Colorectal neoplasia was found in 9.3% of the overall cohort (131/1410). Among the patients with colorectal neoplasia, 96.2% (126/131) underwent colonoscopy because of a C2, C3, or C4 CTC interpretation. Advanced colorectal neoplasia was found in 3.3% of the cohort (46/1410), and 97.8% of patients with advanced colonic neoplasia had evidence of intracolonic abnormalities on CTC. There were 62 lesions that fulfilled the criteria for advanced neoplasia that were identified and removed during colonoscopy. The average size of the advanced neoplastic lesions was 16.5 mm. When the variables of age, race, and sex were examined with respect to the presence of colonic neoplasia and advanced colonic neoplasia, men were significantly more likely to have colonic neoplasia than women (odds ratio [OR], 1.85; p > 0.002; 95% CI, 1.24–2.74). The results from the intracolonic portion of the CTC examinations are shown in Table 2, and several representative depictions of colonic neoplasia found with CTC and their endoscopic correlates are shown in Figures 1–3.

Among the 191 patients who completed colonoscopy after CTC, 10% (19/191) had a C0 CTC interpretation; 55.0% (105/191), C2; 34.0% (65/191), C3; and 1.0% (2/191), C4. There were 476 polyps or mass lesions seen in the 14% of patients who proceeded to colonoscopy. Polyps < 6 mm accounted for 60.7% (289/476) of polyps found on colonoscopy, 6–9 mm for 25% (119/476), and ≥ 10 mm for 14.3% (68/476). Table 3 delineates the frequency of all polyps or mass lesions identified during colonoscopy according to size and histology. Approximately 54% (156/289) of polyps ≤ 5 mm were adenomas. No advanced neoplasia was identified in these diminutive polyps. Among the 119 small polyps (6–9 mm) identified by CTC and removed during colonoscopy, 70.6% were adenomas and 5.8% contained advanced neoplastic features. One cancer was found in this group of polyps and six contained villous histology. Among polyps ≥ 10 mm, 67.9% fulfilled the criteria for advanced neoplasia, with carcinoma identified in 4.4% (3/68) and high-grade dysplasia in 7.3% (5/68). There were 110 hyperplastic polyps found in 60 individuals. Twenty percent (12/60) had three or more hyperplastic polyps and 76.4% (84/110) of hyperplastic polyps were < 6 mm, of which 83 were sessile and one was pedunculated. Among 19 hyperplastic polyps between 6 and 9 mm, 14 (74%) were sessile, four (21%) were pedunculated, and one was flat. Of the five hyperplastic polyps > 9 mm, three were sessile, one was pedunculated, and one had a mixed sessile-pedunculated morphology. Because not all patients who underwent CTC proceeded to colonoscopy and because endoscopists were not blinded to the CTC results, sensitivity and specificity of CTC were not calculated for the entire study population.

The frequency and characterization of extracolonic findings included findings that were unlikely to be clinically significant (E3) in 196 patients (13.9%) and were most commonly attributed to the pulmonary (34.7%), retroperitoneal or genitourinary (34.7%), gas-
trointestinal (23.5%), and vascular (16.3%) organ systems. Forty-one patients (2.9%) had potentially important (E4) extracolonic findings. These findings were observed in the retroperitoneal or genitourinary (43.9%), pulmonary (25%), vascular (25%), and gastrointestinal (10%) organ systems. Specific extracolonic findings are shown in Table 4.

Discussion

As the practice of CTC has evolved, multiple studies have shown improving detection sensitivity that approaches or exceeds the sensitivity of colonoscopy for colorectal neoplasia ≥ 10 mm [8, 13–15]. It is widely acknowledged that polyp size ≥ 10 mm is the most important predictor of clinically important colonic neoplasia [16]. Despite the evidence supporting the diagnostic accuracy of CTC relative to currently accepted and reimbursed CRC screening tests, CMS issued a noncoverage decision for screening CTC [7] citing a lack of outcomes data (neoplasia prevalence, referral rates to colonoscopy, complications), the unknown significance of extracolonic findings, and the unknown risks of radiation exposure in patients 65 years old or older [9].

The results of the current study involving a Medicare-aged population undergoing CRC screening and polyp surveillance with CTC show that colorectal neoplasia was found in 9.3% of the cohort and advanced colonic neoplasia was found in 3.3%. Detection of colonic polyps ≥ 6 mm with CTC led to colonoscopy in 14% of the Medicare-aged cohort, similar to rates observed in other CTC screening trials involving younger patients [13–15, 17]. Additionally, studies of colonoscopy screening have described similar prevalence values as the current report for polyps of this size [18–20].

Kim and colleagues [21] described the findings associated with CTC screening in 577 Medicare-aged patients in Wisconsin. In that study, the colonoscopy referral rate was 15.3% and advanced neoplasia was identified in 7.6% (mean size, 21 mm). Macari et al. [22] recently reported CTC findings in 250 seniors (age range, 65–92 years) compared with CTC findings in 204 nonseniors (age range, 44–64 years). They found that 8.4% of seniors had at least one 6- to 9-mm polyp compared with 9.3% of nonseniors ($p = 0.733$). The prevalence of a polyp ≥ 10 mm was 4.8% in seniors and 4.9% in nonseniors ($p = 0.96$), implying a colonoscopy referral rate of 14.1% in seniors.

TABLE 3: Histologic Findings of All Polyps Removed at Colonoscopy Performed After Abnormal Findings on CT Colonography (CTC)

<table>
<thead>
<tr>
<th>Histology</th>
<th>No.</th>
<th>%</th>
<th>No.</th>
<th>%</th>
<th>No.</th>
<th>%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benign colonic mucosa</td>
<td>46</td>
<td>15.9</td>
<td>8</td>
<td>6.7</td>
<td>6</td>
<td>8.8</td>
<td>60</td>
</tr>
<tr>
<td>Hyperplastic polyp</td>
<td>84</td>
<td>29.1</td>
<td>20</td>
<td>16.8</td>
<td>6</td>
<td>8.8</td>
<td>110</td>
</tr>
<tr>
<td>Inflammatory polyp</td>
<td>1</td>
<td>0.3</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>Lipoma</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>Carcinoid</td>
<td>1</td>
<td>0.3</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>Serrated adenoma</td>
<td>1</td>
<td>0.3</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>Tubular adenoma</td>
<td>156</td>
<td>54.0</td>
<td>84</td>
<td>70.6</td>
<td>30</td>
<td>44.1</td>
<td>270</td>
</tr>
<tr>
<td>Tubulovillous adenoma</td>
<td>0</td>
<td>0.0</td>
<td>6</td>
<td>5.0</td>
<td>15</td>
<td>22.1</td>
<td>21</td>
</tr>
<tr>
<td>Carcinoma</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
<td>0.8</td>
<td>3</td>
<td>4.4</td>
<td>4</td>
</tr>
<tr>
<td>Tubular adenoma with high-grade dysplasia</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>2</td>
<td>2.9</td>
<td>2</td>
</tr>
<tr>
<td>Tubulovillous adenoma with high-grade dysplasia</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>3</td>
<td>4.4</td>
<td>3</td>
</tr>
</tbody>
</table>

Total 289 119 68 476

Note—Only polyps ≥ 6 mm were reported at CTC. Polyps removed at colonoscopy may or may not have matched those found at CTC.
There are some potentially important differences between these studies [21, 22] and our study. Kim and colleagues [21] excluded patients from their analysis who were under surveillance for previous colonic adenomas, something we were unable to do. Approximately two thirds of the seniors in the study by Macari and colleagues [22] underwent CTC because of incomplete colonoscopy and approximately one third of those were being evaluated for a positive fecal occult blood test; thus, those CTC examinations could be considered diagnostic examinations rather than screening. As in our study, there were no complications resulting from CTC or colonoscopy reported in either of these other studies [21, 22]. Thus, the similarity of results across these different practice settings and investigators supports the reliability of our observations in Medicare-aged patients, another previously cited concern for policy makers [7].

Although potentially important extracolonic findings were identified in 2.9% of our cohort, any subsequent evaluations and their associated costs were not quantified. In the report by Kim et al. [21] potentially important extracolonic findings were seen in 15.4% and 7.8% of their cohort underwent additional evaluation. Macari et al. [22] reported at least one extracolonic finding in 74.0% of seniors and in 55.4% of nonseniors (p < 0.0001). The highest rating of extracolonic finding in seniors was E1 or E2 in 91.9% and there was no difference in the percentage of seniors who received a recommendation for additional evaluation of extracolonic findings compared with nonseniors (6.0% vs 4.4%, respectively; p = 0.45). Multiple other reports have quantified the costs associated with extracolonic findings and have consistently found that they add from $30 to $50 to the cost of each CTC examination [23, 24], and a previous analysis of extracolonic cancers identified by CTC determined that these cancers were detected at earlier stages than would be predicted based on Surveillance Epidemiology and End Results data [25]. Moreover, because coverage of abdominal aortic aneurysm (AAA) screening is approved in Medicare-aged patients, it is conceivable that CTC could have avoided the costs of sonography in the eight patients found to have AAA ≥ 3 cm.

The effective radiation dose for a CTC examination is typically 5 mSv or less and has been reported as low as 0.7 mSv [26, 27]. The average effective radiation dose with CTC at our institution during the period of time encompassed by this analysis was calculated to be 4.24 mSv per CTC examination. To place this dose in clinical context, the average yearly radiation exposure of American adults is approximately 6.2 mSv [28, 29]. According to the Health Physics Society [30], the risks of health effects for radiation exposures below 50–100 mSv (which includes occupational and environmental exposures) are either too small to be observed or are nonexistent. A risk-benefit analysis of CTC-induced radiation-related cancers compared with the prevention of CRC used estimated mean radiation doses of 7–8 mSv [30]. Therefore, the more important, and an-
ity to evaluate possible confounders or other outcomes. Specifically, we cannot compare the accuracy of CTC relative to colonoscopy with this analysis. The fact that there are now multiple published direct comparisons showing the two modalities to have similar accuracies for CRC, albeit mostly in younger populations, mitigates this concern. We also do not know what percentage of patients in this analysis had undergone previous CRC screening or polypectomy, but a conservative estimate would be that at least 50%, based on Healthcare Effectiveness Data and Information Set compliance rates of our enrolled patient population. Thus, the prevalence of colorectal neoplasia observed in this cohort may underestimate what would be observed in a cohort of older patients without prior screening experience. As with any radiologic examination, interobserver variation exists for CTC [32]. However, it should be remembered that similar variation has been shown for colonoscopy [33]. Because our institution has a long history as a leading site of CTC, our observations may not represent those from community practice.

Our results provide additional indirect evidence regarding the rarity of advanced colonic neoplasia in diminutive polyps (≤ 5 mm). CTC interpreters do not typically report lesions ≤ 5 mm and this practice has been another stated area of concern for policy makers. In the current study, none of the diminutive polyps identified and removed during colonoscopy harbored advanced neoplastic features, a reassuring observation in this group of older patients. Conversely, advanced colorectal neoplasia was identified in almost 6% of patients with small (6–9 mm) polyps, supporting current recommendations for referral of these patients to colonoscopy for polypectomy. It could be argued, however, that the identification of small (< 10 mm) advanced lesions in older patients is less ominous than in younger patients because of the shorter life expectancy of older patients and thus shorter polyp dwell time. Until the natural history of small and diminutive polyps is better understood, however, the conservative approach of polypectomy for lesions ≥ 6 mm remains prudent.

In summary, we performed a retrospective analysis of the findings associated with screening and surveillance CTC in Medicare-aged patients and found that approximately one of eight patients who underwent CTC for CRC screening or polyp surveillance progressed to colonoscopy. CTC identified advanced colorectal neoplasia in 3.3% of Medicare-aged patients. Both of these outcomes are similar to other CTC trials involving younger patients as well as the two other reports of CTC in older patients. Extranodular findings in this population are common, but most of these findings are not clinically important and do not require additional diagnostic testing when CTC interpreters adhere to the C-RADS reporting schema.

These results provide previously unavailable information regarding outcomes associated with CTC in older patients and should be considered carefully by policy makers when making coverage and public health implementation decisions regarding CTC screening for the Medicare-eligible population. Given the wide acceptance of the value of CTC as a CRC screening test and the increasing amount of data supporting the practice in older patients, we believe that CTC screening and surveillance for CRC in Medicare-aged patients is a viable alternative to other tests and should be reconsidered for endorsement by both the USPSTF and CMS.

**CTC of Medicare Patients**

**References**