Amy K. Hara, MD
C. Daniel Johnson, MD
Robert L. MacCarty, MD
Timothy J. Welch, MD

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[1] From the Department of Radiology, Mayo Clinic, 200 First St SW, Rochester, MN 55905. From the 1998 RSNA scientific assembly. Received January 28, 1999; revision requested, April 1; final revision received, July 13; accepted July 30. **Address correspondence to** A.K.H. (e-mail: *haraa2@yahoo.com*).

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Incidental Extracolonic Findings at CT Colonography[1]

PURPOSE: To determine the frequency of extracolonic findings at computed tomographic (CT) colonography and the effect of these findings on subsequent patient treatment and cost.

MATERIALS AND METHODS: Conventional transverse CT colonographic scans in 264 consecutive patients were evaluated independently by two radiologists. Extracolonic findings were classified as having high, moderate, or low clinical importance. The effect of CT findings on patient treatment was assessed with chart review. The cost of additional examinations was calculated by using 1999 Medicare reimbursements.

RESULTS: Thirty (11%) patients had highly important extracolonic findings, which resulted in further examinations in 18 (7%) patients, including ultrasonography in 10, CT in 13, and intravenous pyelography in one. Six patients underwent surgery because of incidentally discovered CT colonographic findings. Two patients with findings of moderate or low importance underwent additional imaging. A total of $7,324 was required for work-up for extracolonic findings (mean of an additional $28 per examination). Three extracolonic malignancies were overlooked at CT colonography.

CONCLUSION: Additional work-up of extracolonic CT colonographic findings was relatively infrequent but was often worthwhile when performed for lesions classified as highly important. The evaluation of extracolonic structures at CT colonography has definite limitations with regard to solid organs but can help detect serious disease without substantially increasing the cost per patient.

Computed tomographic (CT) colonography is a promising method for detecting colorectal polyps with use of nonenhanced, low-radiation-dose CT performed at a 5-mm section thickness through the abdomen and pelvis. Results of previous studies (1,2) have shown a sensitivity and specificity for polyp detection of up to 96% each for patients with polyps at least 1 cm in diameter. This promising performance, coupled with a lack of alternative full-structural colon screening options other than colonoscopy and barium enema study, has catapulted CT colonography to the forefront of future colorectal screening possibilities.

So far, a standard method for assessing CT colonographic images has not been universally established. Techniques in which endoluminal, reformatted two-dimensional, and transverse CT scans are used are all currently under study (3–5). One approach, in which optimized transverse CT scans are used as a preliminary evaluation step, not only provides images of the colon but also includes solid abdominal and pelvic organs and vascular and bone structures. Further evaluation of any extracolonic abnormalities could induce substantial additional costs. To our knowledge, the number, types, and clinical importance of incidental extracolonic findings at nonenhanced low-radiation-dose CT colonography have not been previously reported. The purpose of this study was to determine the frequency of extracolonic CT colonographic findings and their subsequent effect on patient treatment and cost.

MATERIALS AND METHODS

From December 1996 through March 1998, 264 consecutive patients were recruited to undergo CT colonography. Informed consent was obtained from all patients. All patients were at high risk for colorectal carcinoma (ie, they had previous polyp or cancer, positive

family history, known colorectal lesion). Of the 264 patients, 162 had previously diagnosed colonic lesions, and 102 were recruited for screening. There were 146 men and 118 women aged 33–88 years (mean age, 64 years). This study was performed with the approval of our institutional review board.

All CT scans were obtained by using a helical scanner (HiSpeed Advantage; GE Medical Systems, Milwaukee, Wis) with 5-mm collimation, a 3-mm reconstruction interval, a pitch of 1.3, 120 kVp, and 70 mA. No intravenous or oral contrast material was administered. CT colonography was performed as previously described (1) in a fully cleansed colon after subcutaneous administration of 0.5-mL glucagon. The colon was insufflated with carbon dioxide gas by a registered nurse. Imaging was performed in both the prone and supine positions, and adequate colonic distention was assessed by the nurse. An entire examination consisted of three or four overlapping breath-hold acquisitions with a 3-cm overlap between acquisitions.

Each CT colonographic study was evaluated by using customized software to display enlarged standard transverse CT scans (3). The observer could scroll through images by using a mouse. Preset window and level settings were available (bone, soft tissue, lung) and could also be interactively adjusted by the observer. Intracolonic evaluation was not an aspect of this study but can be performed with this software. Any suspicious intracolonic region can be indicated with a cursor by using the mouse, and fully interactive reformatted two-dimensional and endoluminal three-dimensional images are immediately available.

Three board-certified radiologists (C.D.J., R.L.M., T.J.W.) participated in the evaluation of the CT colonographic images. Each study was assessed by two of the three radiologists. Each observer worked independently while blinded to any patient medical history such as known malignancies or colonoscopic results. One radiologist per study was responsible for dictating an official CT colonographic report, which included both intra-and extracolonic findings. All extracolonic findings, whether reported by one or both radiologists, were included.

Findings were classified as being of high, moderate, or low clinical importance. Highly important findings included indeterminate adrenal or pulmonary lesions of any size, indeterminate masses at least 1 cm in diameter in a solid organ (kidney, liver, spleen), likely malignant masses, or lesions that would require relatively prompt medical or surgical treatment (eg, abdominal aortic aneurysm, inguinal hernia containing bowel, pneumothorax). Moderately important lesions included benign findings that may eventually require medical or surgical intervention (eg, renal stones, gallstones). Lesions of low importance were unlikely to require any future treatment (eg, renal cysts, calcified granulomas, tiny [<1 cm] indeterminate lesions in solid organs). In addition to inclusion of all extracolonic findings in the CT report, letters were sent to notify the primary physician when a highly important lesion was found.

Clinical and radiologic follow-up was assessed through October 1998 on the basis of chart review and a computerized radiology information system. The number and results of radiologic or surgical procedures performed or recommended on the basis of the CT colonographic findings were tabulated.

In an effort to discover any false-negative extracolonic CT colonographic findings, all patient records were reviewed to determine whether any abdominal radiologic examination (eg, contrast material–enhanced CT or ultrasonography [US]) was performed within a year of CT colonography. These included examinations performed because of extracolonic CT colonographic findings, as well those performed for other reasons (eg, hematuria or cancer staging).

The economic effect of follow-up imaging performed because of extracolonic CT colonographic findings was estimated by using 1999 Medicare reimbursements (Table 1). Both recommended and performed follow-up examinations were included in the total cost. An evaluation of cost based on estimated work-up for all highly important findings also was assessed.

TABLE 1
1999 Medicare Reimbursement for Follow-up Procedures

Procedure	Reimbursement ($)*
Abdominal CT without and with intravenous contrast material	405
Abdominal CT without intravenous contrast material	284
Chest CT without intravenous contrast material	292
Complete abdominal US	120
Renal US	119
Intravenous pyelography	108

* Includes professional and technical fees.

RESULTS

The minimum follow-up after CT colonography was 7 months; the maximum was 22 months. The mean time between CT colonography and an additional imaging examination was 86 days (approximately 3 months) and ranged from 1 day to 16 months. There were 151 incidental extracolonic findings in 109 (41%) of the 264 patients (Tables 2, 3). Forty-two patients had more than one finding. Thirty-four (23%) of the 151 findings were considered to be of high importance; 49 (32%), of moderate importance; and 68 (45%), of low importance.

The 34 highly important lesions were found in 30 (11%) of the 264 patients. These lesions included an indeterminate mass at least 1 cm in diameter in a solid organ, abdominal aortic aneurysms, indeterminate pulmonary and adrenal nodules, an inguinal hernia containing bowel, and a pneumothorax. Four patients had more than one highly important finding. Two abdominal aortic aneurysms had been diagnosed before CT colonography, and no additional work-up was performed. In three cases (two abdominal aortic aneurysms, one indeterminate pulmonary nodule), 6–12-month follow-up was recommended. In four cases (two indeterminate adrenal masses, two indeterminate pulmonary nodules), continued follow-up was recommended. To date, no further work-up has been performed in 10 cases (one abdominal aortic aneurysm and three indeterminate renal, three adrenal, and three pulmonary lesions).

Eighteen patients with lesions classified as highly important underwent 22 additional imaging examinations, including CT in 13, US in eight, and intravenous pyelography in one. Two patients had a malignant lesion (renal cell carcinoma) that necessitated surgery (Fig 1), three had a nonmalignant lesion (abdominal aortic aneurysm in two [Fig 2], pneumothorax in one) that necessitated surgery, four had indeterminate lesions (pulmonary nodules in two, probable adrenal adenoma in two), and nine had benign lesions (renal cysts in four, calcified pulmonary granuloma in one, liver with focal fat in one, 4.2-cm abdominal aortic aneurysm in one, hepatic cyst in one, and splenic cyst in one). The most common lesion was an indeterminate renal mass, which was present in nine patients; the lesions in two of these pa-

TABLE 2
Findings That Resulted in Additional Work-up

Finding	No. of Findings*	Work-up	Future Work-up†	Results	No. of Patients Who Underwent Surgery
High importance					
Renal mass	6/9	CT (n = 3), US (n = 3), intravenous pyelography (n = 1)	None	Renal cell cancer (n = 2), cyst (n = 4)	2
Lung nodule	3/8	CT (n = 4)	CT (n = 3)	Granuloma (n = 1), indeterminate (n = 2)	0
Abdominal aortic aneurysm > 4 cm	3/7	US (n = 3)	US (n = 2)	Abdominal aortic aneurysm > 4 cm (n = 3)	2
Adrenal mass	2/5	CT (n = 3)	CT (n = 2)	Probable adenoma (n = 2)	0
Hepatic mass	2/2	CT (n = 2), US (n = 1)	None	Focal fat (n = 1), cyst (n = 1)	0
Splenic mass	1/1	US	None	Cyst	0
Pneumothorax	1/1	CT	None	50% Pneumothorax and large bulla	1
Inguinal hernia with bowel	0/1	None	None	Not applicable	1
Low importance					
Renal cyst	2/25	US (n = 2)	None	Renal cyst (n = 2)	0

* Data are number of findings resulting in work-up/total number of findings.
† Future work-up included follow-up (6–12 months) imaging.

TABLE 3
Findings That Did Not Result in Further Work-up

Finding	No. of Patients
Moderate importance	
Gallstones	20
Renal stones	14
Coronary arterial calcification	5
Uterine fibroleiomyoma	5
Inguinal hernia without bowel	2
Situs inversus	1
Horseshoe kidney	1
Cirrhosis	1
Low importance	
Hepatic cyst	8
Pulmonary granuloma	8
Hiatal hernia	8
Splenic granuloma	7
Fatty liver	3
Renal scar	3
Hepatic granuloma	3
Renal angiomyolipoma	2
Splenic cyst	1

Figure 1. Nonenhanced transverse CT scan obtained at 70 mA for CT colonography demonstrates an 8-cm-diameter left renal mass (arrow). Renal cell carcinoma (stage 1, grade 2) was diagnosed at nephrectomy.

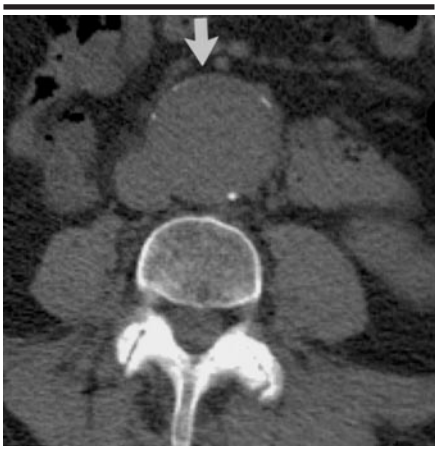

Figure 2. Nonenhanced transverse CT scan obtained at 70 mA for CT colonography demonstrates a 4.9-cm-diameter infrarenal abdominal aortic aneurysm (arrow), which was previously unknown. The patient underwent successful aneurysm repair 8 days later.

tients were malignant. These two patients had a renal cell carcinoma that measured 5.0 cm and 8.0 cm in diameter, were asymptomatic, and underwent nephrectomy; no metastases were found. One patient with a known inguinal hernia underwent surgery because of the CT colonographic finding that the hernia contained nonstrangulated bowel.

Forty-nine lesions classified as moderately important were found in 46 (17%) of 264 patients. None of these patients underwent further radiologic imaging on the basis of CT colonographic findings. These 49 lesions included renal and gallbladder stones, coronary arterial calcification (all in patients older than 59 years), uterine fibroleiomyoma, situs inversus, horseshoe kidney, cirrhotic liver, and inguinal hernia without bowel. Fourteen of these findings had been diagnosed previously (five renal stones, six gallstones, one coronary arterial calcification, one situs inversus, and one horseshoe kidney).

Sixty-eight lesions classified as being of low importance were found in 55 (21%) of 264 patients. Only two of the 68 findings prompted limited renal US to help confirm the presence of a simple and a hemorrhagic renal cyst. Other lesions included cysts or granuloma in the liver and spleen, pulmonary granuloma, renal angiomyolipoma, fatty infiltration of the liver, hiatal hernia, and renal scar. For five of the findings, a diagnosis had been previously established (two renal cysts, two renal scars, one hepatic cyst).

A separate evaluation of the patients included a review of all abdominal radiologic examinations performed within a year of CT colonography. These examinations, therefore, included those performed for reasons other than the CT colonographic findings (eg, hematuria, to rule out metastases, abdominal pain), as well as for work-up of indeterminate extracolonic CT colonographic findings. Additional abdominal radiologic examinations were performed in 24 patients within a year of CT colonography, including contrast-enhanced complete abdominal CT (n = 11), abdominal US (n = 9),

and intravenous pyelography (n = 6). Ten patients underwent the additional imaging because of CT colonographic findings; the remaining 14 underwent the examinations for other reasons. In three patients, contrast-enhanced CT demonstrated extracolonic findings not seen at CT colonography, including a gastric adenocarcinoma (proved at endoscopic biopsy), a psoas muscle metastasis (proved at biopsy), and a simple renal cyst. In two patients, US demonstrated ovarian cysts and cholelithiasis not seen at CT colonography. In one patient, intravenous pyelography demonstrated an invasive transitional cell carcinoma of the bladder not identified at CT colonography. CT colonography, however, demonstrated many findings not seen at US, including renal cyst, renal stone, adrenal mass, and liver cyst. CT colonography also depicted a renal cyst in one patient with negative intravenous pyelographic findings.

On the basis of Medicare reimbursements, the cost of follow-up studies performed or recommended for evaluation of abnormal extracolonic CT colonographic findings was $7,324. On the basis of the results of follow-up imaging, $1,702 (23%) of the $7,324 was for surgical or malignant disease, $3,196 (44%) was for indeterminate lesions (pulmonary or adrenal nodules), and $2,450 (33%) was for benign findings. If additional studies were performed for all highly important findings (US for renal masses, nonenhanced CT for adrenal masses and lung nodules), the estimated cost would be $9,409.

DISCUSSION

CT colonography has the potential to be a powerful new radiologic instrument for colorectal cancer screening. Unlike currently available colorectal screening tools such as colonoscopy, flexible sigmoidoscopy, and barium enema study, CT colonography allows visualization of organs outside the colon. The capacity to evaluate the extracolonic structures, however, can present a clinical dilemma. On the positive side, CT colonography may demonstrate asymptomatic malignant disease or conditions requiring surgery, thus reducing morbidity and mortality. On the negative side, CT colonography may reveal multiple unimportant findings, which could result in costly additional diagnostic examinations and an increase in morbidity.

Most (117 of 151) of the extracolonic findings in our study were considered to be of low (68 of 151) or moderate (49 of 151) clinical importance, because they were clearly benign and were judged by the referring physician as unlikely to become symptomatic or necessitate surgery. Despite the low radiation dose (70 mA) and nonenhanced technique, CT colonography did not prompt unnecessary and costly additional examinations for these findings of doubtful clinical importance. Only two of the 79 patients with low- or moderate-importance findings underwent additional imaging to help confirm the presence of renal cysts; the remaining 77 patients underwent no further work-up. It is possible that at other institutions, a more aggressive approach may be used in the work-up for these small incidental findings, which would consequently increase costs. The treatment in one patient with a moderately important finding was changed owing to the CT colonographic findings. This patient had known viral hepatitis, and previously unsuspected cirrhosis was found at CT colonography, which allowed the decision to monitor the disease with liver enzyme assays.

A minority of patients (30 [11%] of 264) had extracolonic findings classified as highly important. Of those patients, 18 underwent additional imaging, which demonstrated similar numbers of patients with malignant findings or who required surgery ($n = 5$), benign findings ($n = 9$), or indeterminate findings ($n = 4$). The remaining 12 patients had findings of a previously diagnosed condition ($n = 2$), were recommended to undergo follow-up imaging at a later time ($n = 3$), and/or did not undergo any documented additional work-up ($n = 10$). Therefore, it appears that the work-up for highly suggestive lesions seen at nonenhanced CT colonography is relatively infrequent, but such imaging, when performed, is usually beneficial. Most important, only a small number of patients (11 [4%] of 264) with lesions of high, moderate, or low importance underwent additional imaging owing to benign disease.

CT is being used with increased frequency as an initial examination in the setting of possible urolithiasis (6) and trauma (7) and in patients at high risk for lung cancer (8). With the escalating use and wide availability of CT, the frequency of incidental findings undoubtedly will increase. In fact, many asymptomatic conditions that were commonly detected in late stages are being detected earlier with growing regularity. For example, in one study (9), the number of renal cell carcinomas discovered incidentally comprised only 13% of all renal cell carcinomas detected in 1985, as compared with 73% in 1993. In a study (10) with 243 patients who were undergoing elective repair of an abdominal aortic aneurysm, aneurysms were discovered incidentally in 62%. In addition, adrenal ''incidentalomas'' are found at CT performed for reasons other than the suspicion of adrenal disease in up to 5% of patients (11). These results are supported in this study, where these three asymptomatic entities comprised nearly half (15 of 34) of the highly important findings.

There are many advantages to the detection of extracolonic incidental findings. The most beneficial situation would be the discovery of an asymptomatic early process that could be cured with early treatment. For example, the mortality rate associated with abdominal aortic aneurysms is much lower for elective early surgery (5%) than for surgery after rupture (85%–95%) (12). Even if an untreatable condition is serendipitously found, patients may appreciate the advanced warning, so that they may organize their lives (13). Finally, early treatment may decrease costs owing to less complicated surgical procedures and reduced hospital courses for patients with minimally advanced disease. The final judgment concerning incidental findings likely will ultimately depend on the results of long-term studies of patient outcome.

Potential disadvantages are of equal magnitude. At the worst extreme, patient mortality or morbidity could increase due to invasive diagnostic evaluation or nonessential surgery. Other disadvantages include unnecessary patient anxiety, as well as higher costs and extra patient radiation exposure from superfluous additional examinations. Online physician monitoring could help minimize patient inconvenience by immediately identifying patients who need intravenous contrast material instead of having patients return at a later date for a diagnostic examination. In a busy clinical practice, however, this may not be feasible because of logistic reasons. For example, the examinations in this study were not actively monitored by a radiologist, and several patients subsequently returned to undergo contrast-enhanced CT for assessment of incidental findings.

Using the same approach as that for a previous study (14), we performed a cost-identification analysis by calculating the Medicare reimbursements for follow-up studies performed or recommended for evaluation of abnormal extracolonic CT colonographic findings. The Medicare reimbursements for extra examinations

prompted by extracolonic findings totaled $7,324, which averaged to an additional $28 per examination. Twenty-three percent ($1,702 of $7,324) of the costs of these additional examinations benefitted patients by enabling the diagnosis of a previously unsuspected malignancy or an important disease that necessitated surgery. Forty-four percent ($3,196 of $7,324) of the additional costs were for examinations to evaluate for potentially important disease that would require further follow-up. The remaining $2,450 was spent on additional examinations for benign extracolonic findings. Unfortunately, no further work-up has been performed to date for 10 of the 34 highly important findings. Even if all highly important findings were evaluated with another imaging study (US for renal masses, nonenhanced CT for adrenal masses and lung nodules), the estimated additional cost per examination would still be only $36. These results suggest that the added cost per patient for the work-up of abnormal extracolonic findings is relatively small.

A study comparing nonenhanced, low-radiation-dose CT colonography with a radiologic standard of reference may eventually be needed to determine whether (*a*) the classification of lesions as having low or moderate importance is accurate, and (*b*) all extracolonic findings are reported at CT colonography. In our small subset of 24 patients who underwent contrast-enhanced abdominal CT, US, or intravenous pyelography within 1 year of CT colonography, the same extracolonic findings were reported in 15 patients. Highly important extracolonic findings, however, were overlooked in three patients; these included a gastric carcinoma, a 2.5-cm psoas muscle metastasis, and an invasive transitional cell carcinoma of the bladder. Even in retrospect, these lesions could not be identified at nonenhanced CT colonography. It appears from this small subset that important low-attenuating lesions in solid organs can be overlooked by using this low-radiation-dose technique without the use of intravenous or oral contrast material. Conversely, high-attenuating lesions such as calcifications or cysts in solid organs are commonly and accurately differentiated with CT colonography. Other issues that remain to be further addressed include the cost of CT colonography, reimbursement issues, long-term patient outcome, and cost-effectiveness.

Because it appears that CT colonography can enable extracolonic findings to be adequately classified as having high or low clinical importance, the evaluation of these extracolonic structures may eventually become a valuable part of this examination. Although nonenhanced CT colonography at one-fourth the standard milliampere setting is not adequate for screening of solid abdominal and pelvic organs, important and common asymptomatic disease such as renal cell carcinoma and abdominal aortic aneurysm can be detected. CT colonography can, therefore, be beneficial for some types of asymptomatic extracolonic disease.

In conclusion, the majority of extracolonic CT colonographic findings were of low clinical importance and did not lead to further work-up. All but two of the follow-up examinations were performed in patients with findings classified as highly important. The additional and recommended work-up added little to the examination cost per patient ($28) and revealed malignant disease, disease requiring surgery, or potentially important but as yet indeterminate disease in 10 (4%) of 264 patients. Therefore, the evaluation of extracolonic structures with CT colonography can help detect clinically important disease without substantially increasing the cost per patient. The ability to visualize the entire abdominal and pelvic contents in the course of a routine screening examination holds the promise for earlier detection of selected diseases, at a more curable stage.

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