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CT colonography: perforation rates and potential radiation risks

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Abstract

CT colonography has emerged as a potential screening tool for colorectal cancer that could provide good efficacy combined with greater acceptability than optical colonoscopy and fecal occult blood testing. Some organizations have raised concerns about potential harms, including perforation rates, radiation dose and the risk of radiation-related cancer, and have not recommended that it be currently used as a screening tool in the general population. In this paper we review the current evidence for these potential harms for CT colonography, and compare them to potential harms from the alternatives including colonoscopy and double-contrast barium enema.

Keywords

Computed tomography; colorectal cancer; screening; radiation; risk; perforation; colonography

Colorectal cancer is a common cancer that can be prevented by screening (1). Unfortunately screening uptake is relatively low, partly because the acceptability of the available screening tools, such as optical colonoscopy and fecal occult blood testing, is low (2). CT colonography has emerged as a potential screening tool that may provide good efficacy combined with greater acceptability (1). Despite the evidence that it can be as sensitive as optical colonoscopy for large polyp and cancer detection it is not yet recommended as a routine screening tool by all organizations in the US. The American Cancer Society recently added CT colonography to its list of recommended screening tools for colorectal cancer (1). However, concerns were raised by the US Preventive Services Task Force (USPSTF) (3) and Medicare (4) about the potential harms including perforation rates, radiation dose and the risk of radiation-related cancer. In this paper we review the current evidence for these potential harms for CT colonography, and compare them to potential harms from the alternatives including colonoscopy and double-contrast barium enema. The related issue of the consequences of identifying extracolonic findings including anxiety and additional testing is covered in a related article in this journal (5).

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Colonic perforation

Perforation of the colon is an exceedingly uncommon complication of CT colonography. An advantage of CT colonography is that unlike colonoscopy it does not require the insertion and maneuvering of an endoscope to the cecum. Instead the patient undergoes gas insufflation of the colon using a small rectal tube, which is considered to be safer than colonoscopy. Additionally whereas patients are sedated for their colonoscopy procedure, patients are able to avoid the cardiopulmonary risks of sedation for CT colonography since they remain awake during the scanning and are also able to be immediately assessed for any signs and symptoms of over distention of the colon or possible perforation.

The first reports of colonic perforation related to CT colonography were published in 2004, about ten years after the first introduction of the technique. Initial reports of perforation occurred in patients who had known colonic pathology. Kamar et al. reported a case of rectal perforation in a patient with a large obstructive rectosigmoid carcinoma (6). An intrarectal balloon had been inflated in the patient and the perforation was thought to be related to manual over-inflation of the rectum with room air in the presence of an obstructing mass. Two other reports of perforation related to CT Colonography occurred in patients with active inflammatory bowel disease. Coady-Fariborzian reported a patient with long-standing steroid-dependent ulcerative colitis who developed cecal perforation during CT colonography (7). Triester et al. reported colonic perforation during CT colonography in a patient with active fibrostenosing Crohn's disease (8). The patient had multiple strictures in the rectum, sigmoid and at an ileo-ascending colon anastomosis, placing her at high risk for possible perforation.

A national survey in the United Kingdom evaluated adverse events at CT colonography in 17,067 patients who had symptoms of possible colorectal cancer carried out at 50 sites (9). There were nine perforations reported occurring at 6 centers for an overall perforation rate of 0.05%. However, for 5 of the 9 patients, perforations had identifiable causes such as insufflation of a rectal stump, forced placement of a rectal catheter, ulcerative colitis, obstructive sigmoid carcinoma, and perforation prior to CTC which was thought related to the bowel preparation. Four of 9 patients were entirely asymptomatic and extraluminal gas was noted on the CT scan between 6 hours and 4 hours after the procedure. All four patients had already returned home, did not have any clinical symptoms of perforation when contacted and were treated conservatively. Thus, the symptomatic perforation rate from this study was 0.03%. The authors specify that the symptomatic perforation rate is the clinically relevant perforation rate that should be used for comparison with other types of colon studies since CT colonography inherently depicts even tiny amounts of free air that would otherwise not be detected by other examinations like colonoscopy, sigmoidoscopy, or barium enema.

A retrospective study assessed the risk of perforation at CT colonography in 11,870 patients at 11 centers in Israel (10). There were seven cases of colon perforation occurring at 5 sites yielding a total perforation rate of 0.06%. Four cases of perforation occurred in patients referred for CT colonography after incomplete colonoscopy. The mean age of patients in this study was high at 78 years. All studies were performed after room air insufflation and an intrarectal balloon was inflated in 6/7 cases of perforation. Surgery was performed in 4/7 patients with colon perforation and three patients were treated conservatively for a symptomatic perforation rate of 0.03%. Risk factors for perforation that were determined in this study included severe diverticulosis in 3 patients, obstructive carcinoma in 1 patient, and left inguinal hernia trapping sigmoid colon in 4 patients with some diseases occurring concomitantly.

In the largest study to date, a survey of 16 medical centers across 5 countries (Working Group on Virtual Colonoscopy) was conducted to evaluate the symptomatic perforation rate and the overall significant complication rate of CT colonography (11). A total of 21,923 CT

colonography examinations were included with about half of the cases performed for screening and the other half were diagnostic cases. Two perforations were reported in patients undergoing diagnostic CT colonography. Manual room air insufflation was employed in the two patients. One patient had a known annular sigmoid carcinoma and was already symptomatic prior to the CT colonography. One patient was asymptomatic and did not require hospitalization or any treatment for the perforation. The overall perforation rate was 0.009% (2/21,923) and the symptomatic perforation rate was determined to be 0.005% (1/21,923). It was concluded that the safety profile for CT colonography is very favorable, particularly for asymptomatic screening type patients.

In comparing the published series of perforations occurring during CT colonography, the symptomatic perforation rate of CT colonography has been found to range from 0.005% to 0.03% (9-11). These rates impart a significantly more favorable safety profile for CT colonography compared to colonoscopy. Most patients who have perforated during CT colonography have had conditions that likely contributed to or exacerbated baro-trauma to the bowel wall during insufflation of the colon. Obstructive or occlusive lesions such as due to carcinoma, diverticulosis, benign inflammatory stricture, and left inguinal hernia containing sigmoid colon have been found to be associated with perforation. Specific attention is recommended to the left groin in patients with known pre-existing left inguinal hernia during the insufflation process of CT colonography (12,13). Insufflation is discontinued if there is increase in size of the hernia sac. Active inflammatory bowel disease such as ulcerative colitis with weakening of the bowel wall can increase the risk for perforation. Other causes of weakening of the colon wall such as following colonoscopic biopsy or polypectomy may increase the likelihood of perforation during CT colonography. Some sites will postpone performing CT colonography in this situation until one to two weeks after the biopsy (12,14). The inflation of a balloon-tipped catheter may increase the likelihood of rectal perforations and its use is recommended with caution by appropriately trained personnel. There are also reports of colonic perforation during CT colonography in patients without known colonic disease (15,16). These occurred in elderly patients who were managed conservatively with antibiotic treatment.

Colonic perforation is a known risk of conventional colonoscopy screening and ranges between 0.06% - 0.19% of cases. The perforation rate is approximately 0.1% for diagnostic colonoscopy and 0.2% for therapeutic colonoscopy in larger series (17-23). Therefore, perforation rates for diagnostic colonoscopy are significantly higher than for CT colonography. Although positive findings from CT colonography screening will typically require a subsequent colonoscopy and therefore the total perforation rate for the combination of procedures will be somewhat higher than the rate for just the CT colonography alone. Mechanical trauma due to the colonoscope is thought to be the primary cause of perforation. The sigmoid colon is a common site for perforation during colonoscopy. Diverticulosis typically occurs in the sigmoid which is also often redundant, tortuous and may be more fixed if pelvic adhesions are present. High pneumatic pressure during insufflation of the colon can contribute to an increased risk for perforation during colonoscopy. The risk of perforation also increases during a therapeutic colonoscopy when polypectomy is performed. Colonoscopic biopsy, particularly when deep, also is a risk factor for perforation of the colon. The reported mortality rate for colonoscopy ranges from 0 - 0.07% (17-23). To date there have been no deaths associated with the performance of CT colonography.

The double-contrast barium enema has been reported to have a risk of perforation ranging between 0.004% - 0.2% (24,25). The complications related to colon perforation due to barium enema are thought to be more clinically significant than those that occur during CT colonography. In one study, 10% of patients who suffered colon perforation due to barium enema died from barium peritonitis (25). Perforations occurring as a result of barium enema

are typically due to trauma from insertion of the rectal tube or overinflation of the intrarectal retention balloon (26,27). Perforation during barium enema may also occur if the procedure is performed in patients with a weakened colon wall such as caused by ischemia, steroid use or following a deep colonic biopsy. Similar to CT colonography, to decrease the likelihood of perforation during barium enema, it is recommended to wait at least one week following biopsy (16).

Radiation dose and cancer risk

Several recent studies have raised concerns about the cancer risks from CT scans (28,29). The typical radiation doses from CT colonography, the sensitivity and specificity of low-dose CT colonography, the potential radiation-related cancer risks from the screening and the follow-up examinations for extra-colonic findings are discussed.

Radiation dose

Most medical examinations that involve ionizing radiation only expose certain parts of the body to radiation. This is referred to as partial body exposure. Absorbed organ doses and effective dose are the key quantities used to summarize dose from such partial body exposures. Here we briefly describe these quantities, estimation methods and sample dose estimates for CT colonography screening.

The amount of radiation energy that is absorbed per gram of tissue is called the absorbed dose (30). It is measured in grays (Gy) where one gray corresponds to one joule of energy absorbed per Kg. The biological effect per unit of absorbed dose depends on the particular tissue that is exposed as some tissues have been shown to be more sensitive to radiation than others. For example, a given dose to the breast is more likely to cause cancer than the same dose given to the rectum (30). To compare doses from different tests involving partial body exposure the effective dose is typically used. The effective dose is a weighted average of the absorbed doses to each exposed organ with weights that reflect the relative radio-sensitivity of each organ (31).

Radiation dose from CT scanning depends on patient size, CT scanner model, and protocol. For the same CT scanner and the same protocol, patients with smaller body size (e.g., pediatric patients) receive higher radiation doses because there is less tissue to attenuate the radiation before it reaches a particular organ. Even for the same CT scanner model the protocol used may vary between hospitals or technicians. The operational factors specified in the protocol include number of scans, scan length, image thickness, degree of overlap between adjacent x-ray beams (pitch or table feed), tube current-time product (mAs) and tube potential (kVp) (32).

There are a number of operational factors that typically result in higher doses. Repeated CT scanning such as multiphase examinations increases the radiation dose. For example for CT colonography two sets of images are performed with the patient in the supine and then the prone position and so the radiation dose is typically doubled. Radiation dose also increases very rapidly with the beam potential (kVp); as a rule of thumb by a power of 2.5 (33). Longer scan length results in radiation exposure to a greater anatomic region and hence higher radiation dose. Thinner images provide better image resolution and improved visibility of small objects. However, beam intensity needs to be increased to reduce the noise in these thinner images, which concurrently increases the radiation dose. CT scan images can be obtained in contiguity, as well as with an overlap, or a gap between x-ray beams. The degree of the overlap or the gap between the beams is expressed by pitch. Pitch of less than one indicates overlapped beam exposure. Therefore, radiation dose is inversely proportional to pitch. Tube current-time product (mAs) is the product of tube current (mA) and gantry rotation time (sec) and radiation

dose is linearly proportional to mAs. In general the key factors that are modified in order to reduce the radiation exposure from a CT scan are the tube current and the beam potential.

Because there are multiple factors in the CT protocol that influence radiation exposure in different directions special software programs have been developed to estimate organ-specific and effective doses from CT scans for a user-defined input involving CT scan parameters and scanner type (eg CT expo (34) and Impact (35)). These use pre-established organ dose databases generated by radiation transport computer simulations, which simulate radiation interactions in the human body (36-39). These programs assume that the patient is a 'standard man', which is defined as 170cm in height and 70kg in weight. They are useful for comparing doses across protocols or scanners but cannot be used to estimate the dose to a specific individual.

Since the first introduction of CT colonography using single-detector CT scanners, there has been the development of multi-detector CT scanners with incorporation of low-dose CT techniques. The 2009 American College of Radiology practice guideline for the performance of CT colonography in adults specifies that screening studies which are performed in individuals without signs or symptoms of colorectal cancer should be performed using a low-dose, non-enhanced multi-detector CT technique (40). The use of technique charts or automatic exposure control is suggested so that patient size may be accounted for. The CT protocol employed also varies depending upon the clinical indication for the test. If the patient is undergoing CT colonography as a screening examination then intravenous contrast is not routinely used. Although there are parameters that may be specific to particular CT scanners, in general for a tube potential of 120 kVp, an effective mAs of between 50 and 80 is recommended when performing screening CT colonography (low-dose CT colonography). If diagnostic CT colonography is being performed in a patient with symptoms of possible colorectal carcinoma, intravenous contrast may be necessary and CT acquisition parameters will typically require higher mAs.

Sensitivity and specificity of low-dose CT colonography

Early studies have shown that tube current may be decreased in order to reduce radiation exposure without compromising polyp detection on CT colonography. This is due to the inherent large difference in density between the air-filled lumen and the soft tissue attenuation of colonic polyps (41). CT colonography was performed using single detector CT in two patient groups. One group of 8 patients with 31 polyps were scanned using 140 mA, 5 mm collimation, pitch of 1.3 and 3 mm reconstruction interval. The second group of 10 patients with 30 polyps were scanned using the same parameters except for 70 mA, pitch of 1 and 1 mm reconstruction interval. There was 100% sensitivity for detection of polyps 5mm and larger for both groups. The radiation dose for dual position CT colonography at 70 mA was determined to be 50% lower than the dose for a standard CT scan of the abdomen and pelvis and similar to the radiation dose for a barium enema.

A study evaluating multi-detector CT colonography at various radiation dose levels was performed in 50 patients at high risk for the development of colorectal carcinoma and showed no compromise in polyp detection ability with lower dose protocols (42). Patients were scanned using 120 kVp and 100 mAs. Two low-dose CT scans were then obtained by simulating 50 mAs and 30 mAs. Although there was overall decreased image quality at 30 mAs, the per patient sensitivity for the detection of polyps measuring 5mm and larger was 90% at all dose levels. Similarly, the per polyp sensitivity for detecting polyps measuring 5 mm and larger ranged between 85% - 92% for all doses.

Low-dose thin-section multi-detector CT colonography was performed in 105 patients who had symptoms of possible colorectal cancer followed by conventional colonoscopy (43). CT

scan parameters included 120 kVp, 50 mAs and thin sections with 1.25 mm reconstructions at a 1.0 mm interval. The per lesion sensitivities for detection of polyps 6 – 9 mm and 10 mm and larger were 70% and 93% respectively. Overall specificity was excellent at 98%. The effective doses for dual position CT colonography were 5.0 mSv for men and 7.8 mSv for women. This study demonstrated that low-dose MDCT colonography has excellent sensitivity and specificity for the detection of large polyps.

Most recently, low-dose CT colonography technique has also been evaluated successfully in average risk patients without symptoms of colorectal disease. A performance trial using the newest 64-slice multi-detector CT was conducted in 307 subjects who underwent CT colonography for screening (44). Patients were scanned using a tube voltage of 120 kVp, and a tube current of 70 mAs in the supine position and decreased to 30 mAs in the prone position. A new dose modulation technique was employed to adapt the tube current automatically to patient anatomy. The calculated mean radiation dose to patients was 4.5 mSv for the entire examination which is significantly reduced from earlier studies. The sensitivity and specificity of CT colonography for the detection of adenomatous polyps larger than 5 mm were 91% and 93%, respectively and for adenomatous polyps larger than 10 mm were 92% and 98% respectively.

Several studies have evaluated the potential for decreasing the radiation dose for CT colonography even further. A pilot study reported excellent results with even lower dose CT colonography in 27 patients with symptoms of possible colorectal cancer (45). Multi-detector CT was performed with 140 kVp, and 10 mAs. All nine cancers were identified and there was 100% sensitivity for polyps 10 mm and larger (3/3) as well as for polyps between 6 and 9 mm (3/3). Total radiation dose for dual position CT colonography was 1.7 mSv for men and 2.3 mSv for women which was a 40 - 70% decrease in radiation dose compared with prior studies. A follow-up study using the same lower dose CT colonography protocol was performed in 158 patients and revealed similar excellent results (46). CT colonography performed with 10 mAs resulted in 100% sensitivity for carcinomas (22/22), 100% sensitivity for large polyps (13/13), and 83% sensitivity for small polyps (20/24). There was 97% specificity and the positive predictive value and negative predictive value were 94% and 98% respectively. The simulated effective doses for combined supine and prone acquisitions were 1.8 mSv in men and 2.4 mSv in women. CT colonography using effective mAs of 10 was performed in 88 patients who underwent two sequential colonoscopies with results of the second colonoscopy serving as the reference standard for determination of the performance of the CT colonography and the first colonoscopy (47). The per polyp sensitivities for lesions 6 mm and larger for CT colonography and the initial colonoscopy were 86% and 84% respectively. The initial colonoscopy missed 16 polyps, six of which were identified by low-dose CT. The per patient sensitivities for polyps 6 mm and larger for CT colonography and the first colonoscopy were 84% and 90% respectively with specificities of 82% and 100% respectively.

A different concept is to help reduce radiation dose by scanning patients in only one position. However, it is not clear that scanning in one position will provide adequate colonic cleansing and distention given that dual position scanning typically allows for shifting of residual material in the colon and improved distention (48). In a study evaluating low-dose CT colonography, 137 patients were scanned in the supine position only (49). CT scan parameters included 120 kVp, and effective mAs of 10. The effective dose using this type of protocol was 0.7 mSv for men and 1 mSv for women. The sensitivities for detection of > 10 mm, 5- 9.9 mm and <5 mm polyps were 78.6%, 85.7%, and 57% respectively with the specificity for each size group at 100%, 92.8%, and 85.9% respectively. It was concluded that low-dose CT colonography is feasible with substantial radiation dose reduction but additional studies are required to evaluate whether there is a compromise in polyp detection ability when scanning in one position. Current standard practice consists of scanning patients in supine and prone positions (40).

There have been other efforts to determine whether radiation dose could be lowered even more. A pilot study was performed in 15 patients who were scanned using different mAs levels ranging between 0.4 mAs to 100 mAs correlating with doses ranging from 0.05 mSv to 12 mSv (50). Sensitivity was 80 -100% for the detection of large polyps (> 10 mm) for all mAs and dose levels. The mean sensitivity for identifying polyps 5 mm and larger was 74% across all mAs and dose levels except for the lowest level of 0.4 mAs. The number of false positive results decreased as the mAs decreased for 5 mm and larger lesions which was thought to be due to increased noise and smoothing algorithms applied to the lowest dose images. Continued investigation is needed to explore the clinical value of very low-dose CT colonography.

A recent international survey of 34 institutions aimed to evaluate what protocols were actually being used in practice currently (51). Based on the institutions protocols the estimated effective dose for CT colonography screening ranged from 2.6mSv to 14.7mSv per examination and the median dose was 5.6mSv. The largest source of variation in the protocols was the mAs, which varied from 25 to 100 mAs for the supine scan. These survey results suggest that low-dose protocols are being used in many different countries, but there is still wide variation in practice. The effective dose from a double-contrast barium enema is of a similar magnitude to CT colonography, but also highly variable. A recent literature review found that the average dose per procedure was 8mSv but with a range of 2-18mSv (52).

Radiation-related cancer risk

Despite the fact that low-dose protocols are being used routinely and have shown excellent sensitivity and specificity for lesion detection, there are still concerns about the potential cancer risks. A large number of epidemiological studies have established that radiation can cause most types of cancer and that there is unlikely to be a threshold below which there is no risk (30). The study of the Japanese atomic bomb survivors in Nagasaki and Hiroshima, known as the Life Span Study, is the most important study of the long-term effects of radiation exposure. The key strengths are its large size ($n \approx 120,000$), long term follow-up (>50 years) and the fact that the population was not selected because of a specific disease or an occupation and therefore includes a wide range of ages of healthy men and women who were exposed to a broad range of radiation doses (0-4 Gy). A common misconception about the Life Span Study is that it is a study of high-dose radiation exposures. The median dose in the exposed population is 250 mGy and about 25% of the population had exposures in the range of 5-100 mGy (53). For solid cancers the risk is approximately linear in dose, whereas for leukemia the dose-response is curvilinear so that the risk per unit doses is lower at lower dose levels. There is also evidence of a significantly increased cancer risk in the 0-150mGy dose range, and the magnitude of the risk per unit dose is similar to the risk across the whole dose range. Risks are generally found to be higher if exposure occurs at younger ages, and after exposure there appears to be a life-long elevation in cancer risk.

Other populations that have been studied for the long-term effects of radiation include those exposed for medical reasons (both therapeutic and diagnostic), and occupational groups such as radiologists and nuclear power workers (30). These studies also contribute important information on the risks from repeated low-dose radiation exposures, as opposed to the acute single exposure that was received in the Japanese atomic bombing. Although there is evidence of significantly elevated cancer risks for low doses of radiation (<100mGy), most studies do not have adequate power to enable precise risk estimates at these low dose levels, especially taking into account factors such as age at exposure and cancer site (54). Therefore, risks from low doses are generally estimated by extrapolating models based on the results from the whole range of exposures received in the Life Span study. Such risk projection methods based on existing data can provide a much more timely estimate of the long-term risk of radiation-related cancer.

A recent committee for the National Research Council (the BEIR VII committee) developed detailed models for estimating the lifetime risk of radiation-related cancer for the US population (30). These risk models are based primarily on the most recent follow-up of the Japanese atomic bomb survivors since for most cancer sites they remain the most detailed models available for estimating the risks by sex, age and time since exposure (53). These risk models, with minor modifications (mainly the addition of several cancer sites: pancreas, rectal, kidney, esophagus, oral and brain cancer) combined with the organ-specific dose estimates (described below) have been used to estimate the lifetime risk of radiation-related cancer after CT colonography screening.

Whereas effective dose estimates are useful for comparing doses from different protocols, cancer risk estimation is best performed with organ dose estimates. As there are no recent published estimates of organ-specific doses from CT colonography in the US we used CT expo (34) and a CT colonography screening protocol from the recent ACRIN trial for the GE lightspeed 64 scanner (120 kVp, 50 mAs, pitch of 1 and image thickness of 1.25 mm (55)) to estimate organ doses for a typical screening examination in the US. Organ dose estimates varied from 14mGy to the stomach to 2mGy to the lung for males and from 15mGy to the kidney to 1mGy to the breast for females. The effective dose per screening examination was 8mSv for a male and 9mSv for a female. The scanner that we used for these calculations is one that is commonly used in the US and the protocol is in line with the recommendations for CT colonography screening from the American College of Radiology (40).

We estimated that a single CT colonography screen at age 60 would result in a lifetime risk of radiation-related cancer of approximately 0.05% (ie 5 cancers per 10,000 individuals screened). The risks were similar for males and females. For a single screen at age 50 the risks were slightly higher (0.06%) and at age 70 were lower (0.03%), primarily because of longer versus shorter life-expectancy, respectively. If an individual undergoes multiple screens, for example, screening every five years from age 60-75 then the total risk would be approximately 0.016% ($2 \times 0.05\% + 2 \times 0.03\%$). As the effective dose estimates for barium enema are broadly similar to those for CT colonography the radiation-related cancer risks will also be similar.

Previous estimates of the radiation-related cancer risk from CT colonography screening were approximately twice as high, even though they were based on similar organ doses (0.14% for a single screen at age 50 compared to 0.06%) (56). The difference between these risk estimates was mostly due to the assumptions underlying the radiation risk models. The previous study used the BEIR V committee's risk models from a report published in 1990 (57). The main change between the two reports was the assumption of how risks are transported from the Japanese to the US population. The BEIR VII report provides in depth description of the new data and justification for these alternative assumptions (30). Most other national and international committees that provide risk projection estimates currently use similar methods to those used in the BEIR VII report (eg UNSCEAR (58)). There are a number of uncertainties and assumptions that go into the estimation and it is not unreasonable to assume that the risks may vary by a factor of two (30). Therefore, the previous estimates of 0.14% for a screen at age 50 could be taken as approximate upper bounds for the potential risk.

Unlike colonoscopy the whole abdomen is visible during CT colonography screening. Potential abnormalities outside of the colon can therefore be picked up. A number of US screening studies have collected data on the number of patients that had clinically significant extracolonic findings that required further imaging. The proportion of patients that had follow-up CT scans to investigate these findings was generally in the range of 5-10% (59-61); in one small study it was 24% (62). The most common follow-up scan was an abdomen CT scan. Abdomen/pelvis and chest CT scans were also performed. The dose from an abdomen/pelvis CT scan performed with and without contrast is about 20 mSv (52), which will result in a radiation risk that is

about twice as high as the risk from CT colonography. However, as only a small proportion (eg 10%) of the screening population will receive these additional scans it is unlikely that they will increase the average risk to the whole screening population by more than 20%.

Summary

Although a number of organizations have raised concerns about the safety of CT colonography the current evidence suggests that the risks are likely to be small. The data on colonic perforation suggests that the rate is low (0.005%-0.03%), especially compared to colonoscopy (0.06%-0.19%). Also because no sedation is required the cardiopulmonary risks are avoided. Current CT colonography technique uses low-dose parameters. The 2009 ACR practice guidelines specifically recommend the use of low-dose technique for screening CT colonography. Studies have been performed showing that with the use of multi-detector CT scanners the ability to detect 6 mm and larger polyps is maintained with low-dose techniques. New dose modulation techniques which are now available may be employed to help reduce radiation dose further. For a typical low-dose US protocol the effective dose estimate was 8mSv for males and 9mSv for females. Based on these doses the risk of radiation-related cancer is about 0.05% from a single screen at age 60. Risks from follow-up scans are unlikely to increase the total risk to the population undergoing screening by more than 20%. Radiation doses and hence risks from double-contrast barium enema are likely to be similar in magnitude.

The potential benefits from CT colonography screening are likely to be high because of the ability to both prevent colon cancer cases as well as deaths (1). When further quantitative data become available on the magnitude of these benefits a full-risk benefit analysis can be conducted. Given that the risks are relatively small it seems likely that the benefit from CT colonography screening will exceed these risks for most individuals.

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