Incidence of Colonic Perforation at CT Colonography: Review of Existing Data and Implications for Screening of Asymptomatic Adults[1]

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In this issue of *Radiology*, investigators from two countries in two separate studies report the colonic perforation rate at computed tomographic (CT) colonography on the basis of their experience (1,2). Although the investigators in both studies conclude that CT colonography appears to be safer than optical colonoscopy, they nonetheless report a perforation rate at CT colonography that is substantially higher than that recently reported by the international Working Group on Virtual Colonoscopy (3). Thus, it is essential to review these studies so that their findings are not considered to represent the actual risk for screening of healthy asymptomatic adults with CT colonography. There are several common features between these two studies that provide the necessary insight to place them in their proper context. Before discussing these specific studies, I would first like to share the findings of an even larger survey encompassing more than 20 000 studies with CT colonography that uncovered very different results.

Experience of the Working Group on Virtual Colonoscopy

A formal survey of the members of the Working Group on Virtual Colonoscopy was conducted in September 2005, and the results were recently presented (3). The Working Group on Virtual Colonoscopy consists of an informal international collective of radiologists bound by common academic and clinical interests in CT colonography. A questionnaire was electronically mailed and a survey response was received from all active members, with respondents representing 16 medical centers from around the United States and four other countries (Belgium, Ireland, Italy, and the Netherlands). Collected data included the total CT colonography caseload (including diagnostic vs screening examinations), methods for colonic distention (manual insufflation with staff control, manual insufflation with patient control, or automated delivery and room air vs CO_2), and frequency of direct physician monitoring of studies. A more detailed history was obtained for all instances of colonic perforation or any other clinically important complication, which was defined as any CT colonography–related event that led to hospitalization.

The combined Working Group on Virtual Colonoscopy experience consisted of 21 923 studies with CT colonography performed between 1997 and 2005. At 11 of 16 medical centers involved, more than 1000 examinations with CT colonography had been performed. The indication for CT colonography was screening in 53.4% of cases, and that in the remaining 46.6% of cases was diagnostic in nature. Colonic distention was achieved via staff-controlled room air insufflation in 46.9% of cases, patient-controlled room air insufflation in 12.7%, and automated CO_2 delivery in 40.4%; however, automated CO_2 delivery was clearly the predominant method in current use by the group. A minority (45.8%) of the studies with CT colonography were directly performed or monitored by a physician, with this practice widely varying at individual centers from essentially never to always.

There were no cases of colonic perforation at CT colonography among the 11 707 patients being screened, and there were two cases of perforation among patients who underwent 10 216 diagnostic studies. In both cases with perforation, studies were performed with staff-controlled manual insufflation of room air. In one patient with known annular carcinoma of the sigmoid colon who was already symptomatic prior to evaluation with CT colonography, massive pneumoperitoneum was found after only a few puffs of air were delivered manually. Cecal perforation, likely present before manual insufflation, was confirmed

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See also the articles by Burling et al and Sosna et al and the editorial by Dachman in this issue.

at surgery. Rectal bleeding was the indication for diagnostic CT colonography in the other patient in whom small bubbles of extraluminal gas, presumably related to the procedure, were identified in the extraperitoneal pelvis. This patient remained entirely asymptomatic and did not require hospitalization or any treatment. Overall, there were four patients with clinically important CT colonography–related complications: one patient with symptomatic perforation (already discussed), two patients with acute renal failure likely exacerbated by the bowel preparation, and one patient who developed chest pains (myocardial infarction was subsequently ruled out). Therefore, the overall complication rate at CT colonography was 0.02% (one of 5481 patients), the total perforation rate (including asymptomatic patients who did not require treatment) was 0.009% (one of 10 962 patients), and the symptomatic perforation rate (the relevant rate that can be directly compared with the rate of optical colonoscopy) was 0.005% (one of 21 923 patients). CT colonography–related complications other than perforation will not be discussed further since they are beyond the scope of this editorial.

Experience in the United Kingdom

With the results of the Working Group on Virtual Colonoscopy survey in mind, let us now take a closer look at the national survey of the United Kingdom conducted by Burling and colleagues (1). Nearly all studies with CT colonography in the United Kingdom are performed in symptomatic high-risk patients and are not performed for the purpose of screening asymptomatic patients. There were nine cases of perforation reported among the 17 067 diagnostic examinations with CT colonography. Most important, unsuspected extraluminal gas without an obvious cause was incidentally noted in four patients who remained completely asymptomatic. From the description of the extraluminal gas as "surrounding" the involved colon in these patients, it is not entirely clear whether these patients had actual transmural perforation or simply pneumatosis (particularly for the patients with "intraperitoneal" gas, since gas would be expected to migrate and not simply surround the involved segment). The distinction is quite important, since gas contained within the colonic wall (pneumatosis) does not represent true perforation and is generally a self-limited process that rarely occurs at both CT colonography and optical colonoscopy (4). Even if actual perforation is assumed for these four asymptomatic patients, these cases must be handled separately since they do not appear to be clinically important. Because these events in asymptomatic patients would generally not be recognized at optical colonoscopy, their inclusion in the calculation for determination of perforation rates at CT colonography results in what I believe is an unfair comparison. The authors correctly point out that the symptomatic perforation rate (0.03%) is the relevant comparator with the rate in patients who have undergone optical colonoscopy, but inclusion of these asymptomatic patients nonetheless adds to their total number of potentially serious adverse events.

Attributable causes, which can serve as valuable lessons for preventing future incidents, could be identified in the five cases of symptomatic perforation. The intake process during scheduling of an examination with CT colonography should generally include a focused medical history that elicits instances of previous abdominal surgery, active symptoms, or a history of colitis or cancer, and so forth, which would be pertinent for the patient with the rectal stump and the patient with active ulcerative colitis. Use of a smaller-caliber flexible rectal catheter in lieu of the large rigid retention balloon catheter typically used for barium enema examination could possibly have prevented rectal perforation in two of the patients. I believe that staff-controlled manual insufflation may have caused or contributed to nearly all of the cases of symptomatic perforation. Patient control of manual insufflation or low-pressure automated distention techniques have more built-in safeguards to protect against excessive force. Inclusion of the patient with pneumoperitoneum who never actually underwent colonic distention at CT colonography represents an obvious reporting dilemma. Although bowel preparation could have conceivably exacerbated an underlying bowel condition in this complex case, the inclusion of this case can lead to an accounting error if it is mixed with the cases of perforation related to active colonic distention at CT colonography. I believe that, of these nine cases of perforation, only the illustrated case with obstructive carcinoma of the sigmoid colon remains as a clinically relevant CT colonography–related complication that may have been difficult to prevent (although alternative catheter selection and distention technique could have possibly made a difference).

It is important to note that only one of nine patients with CT colonography–related colonic perforation in the series of patients discussed by Burling et al (1) required surgical treatment. As discussed later, laparotomy is required much more frequently with cases of optical colonoscopy–related perforation. This finding provides further evidence that perforation at CT colonography often is less ominous and implies that similar cases of subclinical perforation at optical colonoscopy may in fact occur but are not diagnosed, since there would be no clinical indication for radiologic imaging.

Experience in Israel

Sosna and colleagues (2) present the Israeli experience with CT colonography in this issue of *Radiology*. In their article, they reported seven cases of colorectal perforation in 11 870 total studies. All studies were performed with manual insufflation of room air, presumably controlled by the staff and not the patient. Other common themes among the group with perforation included advanced patient age (mean, 77.8 years) compared with the age of the total population of patients who underwent CT colonography (mean age, 59.9 years), use of a rigid retention balloon catheter that is typically employed in a barium enema examination for all but one patient, and a site of perforation in the rectum or sigmoid colon in all patients. In addition, all patients had a potentially obstructive process (carci-

noma, diverticular disease, or inguinal hernia) in the sigmoid colon.

One wonders how many of these cases of perforation could have possibly been prevented if the patient had controlled the rate and degree of insufflation or if low-pressure automated CO_2 delivery were applied. The fact that four of seven patients had an incarcerated inguinal hernia, which caused obstruction of the sigmoid colon, seems unusually high, although this rare event has also caused problems at optical colonoscopy (5). Of note, one of the cases of perforation, which was associated with a large incarcerated hernia, involved a patient who underwent screening, and, to my knowledge, this is the only known example of perforation in this cohort to date. Finally, most of their cases involved patients who had recently undergone incomplete optical colonoscopy, including two cases in which both studies were performed the same day. Inclusion of such complicated cases may cause an overestimation of the true risk for screening with CT colonography, not to mention that these cases of perforation actually may have occurred at optical colonoscopy.

It remains unclear how many of the seven cases of perforation reported by Sosna et al (2) represent asymptomatic perforations, as was seen in the survey of the Working Group on Virtual Colonoscopy and the national survey of the United Kingdom. This is an important consideration because the symptomatic perforation rate is emerging as the clinically relevant statistic and as the one that should be compared with the perforation rate at optical colonoscopy. At the very least, it would be useful to know if the three cases of perforation that did not require surgical treatment represented incidental imaging findings or symptomatic disease. Despite that all of their patients who were undergoing CT colonography were monitored by a physician, the perforation rate was greater than that at centers from the Working Group on Virtual Colonoscopy (including my own), where physician monitoring of patients who were undergoing CT colonography was not routinely employed.

Sosna et al (2) posit that their results will help "facilitate an evidence-based choice for population screening recommendations," but I believe that their findings lead to overestimation of the actual risk for screening of asymptomatic adults, particularly when safer distention techniques are used.

Combined Data

By combining the results from the three surveys outlined previously, the total number of studies with CT colonography exceeds 50 000. There are some common threads that should be emphasized, some of which may serve as important lessons. Of note, none of the cases of CT colonography–related perforation from these three groups resulted in patient death, which is further evidence that they may represent a milder variation compared with cases of optical colonoscopy–related perforation. Many cases of CT colonography–related perforation have involved high-risk symptomatic patients for whom optical colonoscopy was either incomplete or contraindicated. It is also telling that no cases of symptomatic perforation resulted from colonic distention via patient-controlled room air insufflation or from automated CO_2 delivery and that only one case of perforation occurred among the entire screening cohort. By learning from these previous cases of perforation, perhaps future events can be prevented through increased awareness of which patients are at risk and use of the distention techniques that appear to be safer.

Adequate colonic distention is critical for effective performance of CT colonography. Optimal colonic distention (which is distinct from maximal distention) is achieved when diagnostic quality is properly balanced against patient comfort and safety. With regard to the risk of perforation, the cumulative evidence now suggests that there is an increased risk of perforation when staff-controlled manual insufflation is used in symptomatic patients compared with the risk when either patient-controlled manual insufflation or automated low-pressure CO_2 delivery is used. The actual risk with staff-controlled manual insufflation probably is very small when a normal colon is distended. By allowing substantial transient involuntary increases in intraluminal pressure (6), however, staff-controlled manual insufflation lacks the inherent safeguards of the other two distention methods (7). Not surprisingly, manual insufflation has accounted for virtually all known cases of symptomatic perforation. In our experience, we have found that automated CO_2 delivery is not only safe but also results in improved colonic distention compared with manual techniques and also that use of CO_2 compared with room air results in less postprocedural discomfort (8). As for spasmolytic agents such as glucagon, I believe that the preponderance of the available evidence does not justify its routine use in patients undergoing CT colonography (8).

Retention balloon catheters designed for barium enema examinations are relatively large and rigid and, in my opinion, should only be used sparingly (and with appropriate caution) for CT colonography in patients in whom the smaller flexible catheters are inadequate. Although the larger balloon associated with catheters for barium enema examination could have potentially played a role in previous cases of perforation, this finding should not be misinterpreted as a condemnation of all balloon catheters. In fact, small flexible low-pressure balloon catheters specifically designed for CT colonography are now available and appear to be very safe.

Beyond the three large multicenter surveys reviewed previously, I am aware of only two additional case reports of colonic perforation at CT colonography (9,10) (note that one other case report [11] was already accounted for in the series of patients reported by Sosna et al). The additional cases reinforce the same risk factors elicited in the combined survey data. In one case in a high-risk symptomatic elderly patient with active ulcerative colitis, distention was achieved by using a manual technique, presumably with a rigid large-caliber retention balloon catheter, with the control by staff personnel (9). In the other case in a high-risk elderly patient who was suspected of having a malignancy, distention also was achieved by using a manual technique

controlled by staff personnel (10). Given the lack of symptoms of concern in this second patient, this case may represent another that would go undetected and unaccounted for at optical colonoscopy.

The exquisite sensitivity of CT for detection of extraluminal gas has effectively created a new subclinical complication: the asymptomatic (presumed) perforation. The incidental and unsuspected discovery of a small amount of extraluminal gas at CT colonography in a patient who is completely asymptomatic is a special case clinical scenario. Expedited correlation with the patient's clinical status and close follow-up are of course warranted, but intervention or treatment does not appear to be necessary. Because patients undergoing optical colonoscopy are obviously not routinely evaluated with CT, it is unknown how often extraluminal gas is present after conventional endoscopy in asymptomatic patients. It is also important to distinguish pneumatosis (gas confined to the bowel wall) from transmural extension into peritoneal or extraperitoneal spaces. Pneumatosis may be related to increased mucosal permeability or perhaps a small mucosal defect but is generally a minor and self-limited complication.

Neither Burling et al (1) nor Sosna et al (2) found a significant difference in the perforation rate with CT colonography between academic and nonacademic practices. In addition, direct physician performance or physician monitoring of studies with CT colonography does not appear to be a major deterrent with regard to perforation rates. Overall, I believe that the results of the survey of the Working Group on Virtual Colonoscopy reflect what is achievable in community and nontertiary care practices, assuming a reasonable level of basic training and proper distention technique. Going forward, there is no reason to believe that the actual complication rate with CT colonography would be any greater than that with the barium enema examination (12), since CT colonography is a similar but less involved procedure from the patient's standpoint.

Optical colonoscopy is a wonderful diagnostic tool for the nonsurgical removal of clinically relevant colorectal polyps. Its therapeutic capability ensures its continued role in cancer prevention. As a screening test applied to asymptomatic adults, however, optical colonoscopy is a relatively invasive procedure, with reported perforation rates typically in the range of 0.1%–0.2% (13–17). More important, reported cases of perforation at optical colonoscopy more often result in surgery and even death compared with those at CT colonography (13,14,18–20). Given that a relatively small minority of screening patients actually harbor a clinically relevant lesion, the high rate of negative screening studies may come into question now that a less invasive alternative for effective total colonic examination, CT colonography, is becoming more widely available.

In conclusion, the specific results from the two studies published in this issue of *Radiology* provide valuable lessons for the clinical practice of CT colonography but should not be taken out of context and applied to the screening setting. Rather, analysis of these studies, in conjunction with the larger Working Group on Virtual Colonoscopy experience, shows that the safety profile for CT colonography is extremely favorable. The actual risk of colonic perforation at CT colonography is exceedingly low and may likely approach zero in asymptomatic patients who are undergoing screening when specific techniques are employed.

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