Advice for Optimizing Colonic Distention and Minimizing Risk of Perforation during CT Colonography

Computed tomographic (CT) colonography is an attractive alternate to optical colonoscopy in some patients because of its less invasive nature and the fact that sedation is not required. In this issue of *Radiology*, two articles report the findings of retrospective studies on the incidence of colonic perforation during CT colonography (1,2). These reports emphasize the fact that although CT colonography is less invasive and has fewer complications than optical colonoscopy, it is not free of potential risks. To my knowledge, the actual complication rate for CT colonography has not been well studied prospectively; this is mostly because no complications were initially reported and partly because no single clinical trial can be large enough to include rare complications and some colonic perforations are asymptomatic and might be visible only after conclusion of the examination. Complications include (a) prolonged cramping related to gaseous distention of the colon; (b) nausea, vomiting, or vasovagal reactions that can be caused by either colonic distention or administration of a spasmolytic (glucagon in the United States and hyoscine butyl bromide in Canada and Europe); and, rarely, (c) colonic perforations (1–4).

Successful colonic distention with CT colonography is multifactorial and requires knowledge and experience on the part of the technologist or radiologist monitoring the insufflation. The desire to maximize patient comfort and minimize the risk of perforation might lead to a conservative approach during colonic insufflation and result in somewhat suboptimal colonic distention. This approach might decrease reader confidence in the interpretation and lead to decreased sensitivity for detection of polyps or decreased specificity because of false-positive findings in suboptimally distended segments. Since optimal colonic distention is a critical requirement for obtaining an optimal study, these recent reports could adversely affect the diagnostic performance of CT colonography.

The data on colonic distention in prior CT colonography reports can be a source of confusion because changing one variable can dramatically change the findings. One cannot mix and match recommendations regarding (a) the use of glucagon, air versus carbon dioxide, and mechanical insufflation versus manual insufflation versus self-insufflation; (b) the rate or volume of inflation; and (c) the end point for obtaining CT images. Each variable must be evaluated separately to understand its effect on distention and patient comfort. The purpose of this editorial is to describe strategies for optimizing colonic distention and patient comfort while minimizing the risk of perforation.

Preparation

Ideal preparation will leave the colon free of particulate stool. Before starting CT colonography, patients should be advised to empty their rectum within 30 minutes of the examination, and they should be queried as to the results of the colon cleansing regimen. Patients should report no formed stool or solid particulate matter; however, the stool need not be clear unless one plans to offer same-day optical colonoscopy in patients with polyps found at CT colonography. Nonviscous liquid will not interfere with interpretation of the findings, and—after placing the rectal tube—fluid entering the tube can easily be manipulated into a bag designed to catch fluid. If the preparation leaves a residue of semiliquid stool with retrograde flow into the CT colonography tubing, the semiliquid stool could clog the tubing and block the flow of gas, particularly when mechanical insuffla-
Optimizing Colonic Distention

I recommend performing a radiographic phary after same-day optical colonoscopy. If a patient is referred for CT colonography, radiologists can obtain either a left-side-down decubitus radiograph before the patient undergoes CT or a limited low-radiation-dose CT image of the abdomen and pelvis with a wide intersection gap. The scout image obtained with CT colonography may be helpful, but it is unlikely to be sensitive enough to depict small amounts of extraluminal gas. Same-day CT colonography performed after colonoscopy is contraindicated if the patient underwent snare biopsy (since CT colonography might draw the colon wall into the snare) or well biopsy (in which multiple samples are taken from the same site). In a routine biopsy, only superficial mucosal tissue is obtained; therefore, this examination is not a contraindication to CT colonography. If one chooses to wait for tissue to heal after colonoscopic biopsy, it is best to allow sufficient time for the wall to heal. Although the literature suggests that a 1-week period is sufficient (6), I prefer to wait longer than 1 week to be safe. Waiting 1 week is not a rational approach, since the amount of granulation tissue is maximal in most surgical wounds and the wall is paradoxically weakest and most susceptible to perforation at this time.

Use of Spasmolytics

The use of spasmolytics remains controversial. If one chooses to use glucagon, it is best administered subcutaneously about 10 minutes before insufflation. At my institution, we often obtain patient consent and inject 1 mg of glucagon just before the patient changes into a gown, assuming the CT suite is open and ready for commencement of the examination. Intramuscular injection is acceptable; however, it is also more painful. Intravenous injection is also acceptable and effective at a dose of 0.5 mg, but glucagon should be administered with a very slow push about 1–2 minutes before insufflation is started. The lower 0.5-mg dose may also help minimize the side effects of nausea and vomiting. The effect of glucagon on distention and the diagnostic quality of the images is controversial (5). It is generally agreed that glucagon makes the examination more comfortable. The drawbacks of glucagon are its expense and the fact that it relaxes the ileocecal valve, thus resulting in more reflux of gas into the small bowel and potentially resulting in less colonic distention unless there is a constant flow of gas into the colon (which might occur if a mechanical insufflator is used during the examination). The reflux of gas into the small bowel may contribute to prolonged retention of gas and cramping, particularly if room air is used.

Insufflation of the Colon

I prefer mechanical insufflation of carbon dioxide gas because it is the most effective at a dose of 0.5 mg, but glucagon makes the examination more comfortable. The drawbacks of glucagon are its expense and the fact that it relaxes the ileocecal valve, thus resulting in more reflux of gas into the small bowel and potentially resulting in less colonic distention unless there is a constant flow of gas into the colon (which might occur if a mechanical insufflator is used during the examination). The reflux of gas into the small bowel may contribute to prolonged retention of gas and cramping, particularly if room air is used.

CT Colonography after Optical Colonoscopy

If a patient is referred for CT colonography after same-day optical colonoscopy, I recommend performing a radiographic examination to check for free intraperitoneal gas due to an asymptomatic rupture during optical colonoscopy. If this search is not performed before the rectal tube is placed, any subsequent demonstration of perforation will be attributed to CT colonography. To search for perforation due to optical colonoscopy, radiologists can obtain either a left-side-down decubitus radiograph before the patient undergoes CT or a limited low-radiation-dose CT image of the abdomen and pelvis with a wide intersection gap. The scout image obtained with CT colonography may be helpful, but it is unlikely to be sensitive enough to depict small amounts of extraluminal gas. Same-day CT colonography performed after colonoscopy is contraindicated if the patient underwent snare biopsy (since CT colonography might draw the colon wall into the snare) or well biopsy (in which multiple samples are taken from the same site). In a routine biopsy, only superficial mucosal tissue is obtained; therefore, this examination is not a contraindication to CT colonography. If one chooses to wait for tissue to heal after colonoscopic biopsy, it is best to allow sufficient time for the wall to heal. Although the literature suggests that a 1-week period is sufficient (6), I prefer to wait longer than 1 week to be safe. Waiting 1 week is not a rational approach, since the amount of granulation tissue is maximal in most surgical wounds and the wall is paradoxically weakest and most susceptible to perforation at this time.

Insertion of the Rectal Tube

To minimize patient discomfort and risk of perforation due to traumatic insertion of the rectal tube, the external anus, anal canal, and catheter tip should be sufficiently lubricated with jelly. If the patient has an extremely tender anus due to the preparation, external hemorrhoids, or both, lidocaine jelly can be substituted, although it is more costly. If there is good visualization of the anus, it may be unnecessary to perform digital rectal application of lubricant jelly. If the anatomy of the buttocks prevents good visualization, however, it is important to perform a limited rectal examination to learn the optimal direction of catheter insertion and to lubricate the anal canal. Improper direction of the catheter tip and excessive force are likely the main causes of traumatic insertion of the rectal tube.

Another way to minimize the risk of perforation of the rectum when the rectal tube is inserted is to use a thin soft catheter. While any catheter designed for rectal use is acceptable, my choice is always a catheter with a thin soft tip, such as a thin catheter with a small balloon (E-Z-Em, Westbury, NY). A small-gauge Foley catheter is similar. I prefer to use a catheter with a small inflatable balloon rather than a red rubber Robinson catheter with no balloon. Although overdistention of the balloon is implicated in some cases of rectal perforation at barium enema and CT colonography, this should not occur if the balloon is properly positioned and inflated. The deflated balloon should be advanced well into the capacious rectal vault. Then, it should be inflated with about 30 mL of air to achieve a diameter of 1.34 inches (compared with a standard double-contrast barium enema balloon tip inflated with 100 mL of air to a diameter of 2.7 inches). If a Foley catheter is used, 5–10 mL of air is typically used to inflate the balloon. Tugging gently on the catheter will seat the balloon against the anal verge. This will help prevent the catheter from dislodging during the examination, particularly when the patient moves from the supine to the prone position. Inserting the catheter too far could also contribute to obscuring a rectal lesion, even if no balloon is used (7). The alternative to not inflating the balloon requires that a 10-inch strip of perforated plastic tape be placed in a butterfly fashion around the tube at the anus to secure the catheter to the buttocks. If the tape is not placed as close as possible to the anus, it may serve as a fulcrum and actually cause the tube to dislodge as the patient turns.
time-efficient method for a technologist working alone; however, manual insufflation and even patient self-insufflation have been successful (8). The tube is placed with the patient in the right-side-down decubitus position, and insufflation of gas should commence with the patient in the same position. At my institution, we administer the first liter of gas with the patient in the right-side-down decubitus position. We then instruct the patient to move to the prone position for 15 seconds, then to the left-side-down position for 15 seconds, and finally to the supine position, where the patient is positioned by the technologist to obtain the scout view. An initial pressure setting of 20–25 mm Hg is recommended.

Nearly all of the perforations reported to date (1–4) have been associated with manual insufflation, although two of 16 reported cases (1,2) occurred with mechanical insufflation of carbon dioxide. A causal relationship between manual insufflation and perforation cannot be inferred because it is unknown how many subjects underwent mechanical versus manual insufflation.

Carbon dioxide is more rapidly resorbed than room air and may improve patient comfort after completion of the examination, particularly if there is abundant reflux of gas into the small bowel. Mechanical insufflation also is more feasible for a single CT technologist working alone because insufflation can commence mechanically while other tasks, such as entering the examination protocol into the CT scanner, are completed. The technologist should monitor the patient closely during insufflation and always remain in communication with the patient either in the CT suite or from the console. The insufflator was designed with patient comfort in mind. Insufflation begins with a flow rate of 1.0 L/min for the first half liter of carbon dioxide before increasing to a rate of 2.0 L/min for the second half liter of carbon dioxide and reaching a maximum flow rate of 3.0 L/min. The insufflator will inflate the colon to a pressure of 25 mm Hg and then stop. If pressure exceeds 50 mm Hg for more than 5 seconds, an alarm sounds and gas is vented into the room until the pressure drops below 50 mm Hg. A backup mechanical release valve is activated if pressure reaches 75 mm Hg. The insufflator also turns off automatically after delivering 4 L of carbon dioxide and after insufflation of every 2 L of carbon dioxide thereafter. Insufflation must be restarted by the person performing the examination. These safety features help minimize but do not eliminate the risk of perforation.

It is unknown if any perforations occur because of high pressure; however, it is possible to monitor pressure with the insufflation pump and use a strategy to avoid high pressure, achieve optimal insufflation, and maintain patient comfort. In my experience, the highest pressures (40–50 mm Hg) are generated when the patient turns from the supine to the prone position. To avoid these high pressures, the pump should be turned off after completing the supine series, and the rectum should be deflated by disconnecting the tube from the pump for 3 seconds. This will not deflate the entire colon, but it will allow sufficient collapse of the rectum to make the patient comfortable and prevent the generation of high pressure in the rectum. At my institution, we use the same decompression technique during any part of the examination if the patient is in extreme pain (which is rare) and states that he or she cannot continue the examination. In every case in which we used this technique, there was sufficient gas for a diagnostic examination.

When to Obtain a Scout View

The decision of when to obtain a scout view is based on three factors: the patient’s discomfort level, the pressure level, and the volume of gas administered. If little or no gas is being pumped because the pressure is nearly always more than 25 mm Hg, a scout view is obtained regardless of the volume of gas administered. If this happens within the first 30 seconds of insufflation, check that the tube is not clamped. Otherwise, we generally wait to obtain a scout view until at least 2 L of gas has been pumped. If room air is used, the rate of inflation can be modified on the basis of patient discomfort, and a scout view can be obtained after about 50 puffs of air or when the patient experiences constant moderate pain.

Patients are asked to rate their pain on a three-point scale as mild, moderate, or severe. If a patient does not report pain, look for signs that indicate pain, such as grimacing or toe wiggling. If there is no pain and the pressure varies such that gas is slowly entering the colon, wait for an additional 0.5–1.0 L of gas to flow into the colon before obtaining a scout view. Conversely, if little or no gas is entering the patient but the pain level is severe, obtain a scout view immediately.

Sometimes patients have undergone same-day optical colonoscopy and have moderately distended colons because of the carbon dioxide or room air administered during colonoscopy. If patients did not undergo same-day colonoscopy, they may be at risk for perforation due to a distal mechanical obstruction to retrograde flow of gas. Several patients with reported perforations had obstructing masses (1,2). Masses may produce obstruction to retrograde flow of gas (or barium in a barium enema) even though they do not produce obstruction to antegrade flow of gas. Thus, the patients do not have clinical signs of colonic obstruction. At my institution, we encountered one such case, in which pain was immediate after insufflation of 0.2 L of gas. We applied the rule: “When in doubt, scout”. A scout view is a low-radiation view, and it can be helpful when assessing the status of colonic distention. The same can be accomplished with CT units equipped with CT fluoroscopy (biopsy mode). In this case, a distal obstruction resulting from an incisional hernia containing colon was found in a patient with a penile prosthesis. Caution should also be exercised in men known to have or suspected of having inguinal hernia. If there is an obvious increase in the size of a hernia during insufflation, one should consider performing CT scanning at that point to assess the anatomy without obtaining optimal insufflation. Several of the men in whom perforation was reported also
had a left-sided inguinal hernia (1). Extra caution should also be exercised in elderly or frail patients.

**When to Scan**

The decision to proceed with CT scanning depends on the same factors described previously for obtaining the scout view and the appearance of the colon on the scout view. If the colon is not well distended on the scout view but the patient is in pain and gas continues to flow, encourage the patient to tolerate the discomfort. If the pain is severe and the colonic distention is adequate but not optimal, proceed with the examination. If the pain is severe and gas is not flowing because the pressure is nearly always more than 25 mm Hg and the colonic distention is not optimal (this is rare but occurs more commonly in obese patients, particularly in the prone position), I switch to supplemental manual insufflation. This can be performed with carbon dioxide by rigging a pump with a one-way valve into the tube or by simply clamping the tube to prevent the escape of gas, disconnecting the tube from the machine (shut off the machine), cutting off the tip that clips to the machine with scissors, and forcing a manual insufflation bulb known as a “blue puffer” into the end of the tubing. Thereafter, unclamp the tube and proceed with slow manual insufflation of room air. Query the patient about the pain level and slow down or stop pumping if the patient experiences cramping. If pain is constant and moderate (not severe), stop pumping and obtain a scout view. Do not try to achieve maximal inflation. If distention is optimal, proceed with the examination. If distention is adequate, proceed with the examination but pump additional air (usually about 10 puffs) immediately before scanning (after the table has been positioned for the examination). In this manner, optimal insufflation will be achieved and the patient will need to tolerate moderate to severe pain for a few seconds. At my institution, scanning is performed with a 40-section scanner in less than 10 seconds with a breath hold in expiration to help straighten out the splenic flexure. Immediately after the examination, disconnect the blue puffer for 3 seconds to partially deflate the rectum and diminish the pain level.

After moving the patient into the prone position, use one to three pillows in a wedge-like fashion under the chest and pelvis (more pillows should be used with obese patients) to minimize pressure of the abdomen against the table. This will improve distention of the transverse colon, and it may slightly diminish colonic intraluminal pressure. Some investigators suggest deflating the rectal balloon or removing the tube just before scanning patients in the prone position to prevent obscuring rectal lesions. I believe that the small air-filled balloon is unlikely to obscure lesions and that deflation of the balloon is optional; thus, I leave the catheter in place.

A determination can be made as to the need for additional views on the basis of a cursory viewing of the images reconstructed with the scanner while the patient’s colon is still insufflated. If the right colon is not sufficiently distended, the study can be supplemented with a left-side-down decubitus view (9). Likewise, if there is a large amount of retained fluid, the study can be supplemented with either a right- or a left-side-down decubitus view to maximize visualization of the colonic mucosa (8). I obtain this extra view if 50% or more of the diameter of a well-distended segment contains fluid.

**Perforation during CT Colonography**

If a patient is suspected of having a perforation during CT colonography, decompress the colon, deflate the rectal balloon, gently remove the rectal tube, and obtain a CT image to document the extent and location of gas. Intravenous fluid access should be established, and surgery consultation should be performed immediately.

**Completing the Examination**

When the examination is completed, do not rush to remove the catheter. Rather, disconnect the tubing from the pump or blue puffer and remove the pillows from under the patient’s chest. Allow the tubing to remain in place for 30–60 seconds. At this point, most of the gas will evacuate via the tubing into the room and the patient will feel comfortable. Thereafter, collapse the balloon (if it has not been collapsed prior to scanning), remove the tube, and wipe the jelly from the rectum with a soft tissue. Be sure the patient has no diziness or vasovagal symptoms before he or she sits up and is allowed to stand.

**Summary**

Radiologists should take precautions to minimize the risk of perforation, and they should be particularly mindful in situations that may increase the risk of perforation, such as signs or symptoms of a possible partially obstructing colonic lesion, known hernia that might involve the colon, recent colonic polypectomy or biopsy, known underlying colon disease, difficulty in inserting the rectal tube, and elderly or frail patient status.

These recommendations reflect personal experience from about 400 examinations performed since 1997, particularly from examinations performed in the past 2 years since the mechanical insufflator was modified to its current form. At my institution, we have not had any perforations attributable to CT colonography, and only minor cramping and minor vasovagal reactions have been seen—neither of which has been severe enough to require treatment. Certainly, other approaches are acceptable. I encourage readers to share their experience and offer advice on performing CT colonography. I also suggest that patients be informed of the risks and diagnostic limitations of CT colonography (at my institution, this is done when patients provide written informed consent) and of the small risk of perforation.

**References**


