CT Colonography: Improving Interpretive Skill by Avoiding Pitfalls

Zina J. Ricci, MD
Fernanda S. Mazzariol, MD
Mariya Kobi, MD
Milana Flusberg, MD
Melanie Moses, MD
Judy Yee, MD

Abbreviations: OC = optical colonoscopy, 3D = three dimensional, 2D = two dimensional

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From the Department of Diagnostic Radiology, Montefiore Medical Center/Albert Einstein College of Medicine, 111 E 210th St, Bronx, New York 10467 (Z.J.R., M.K,. M.M., J.Y.); Department of Diagnostic Radiology, New York Presbyterian Hospital/Weill Cornell Medicine, New York, NY (F.S.M.); and Department of Diagnostic Radiology, Westchester County Medical Center/New York Medical College, Valhalla, NY (M.F.). Presented as an education exhibit at the 2018 RSNA Annual Meeting. Received March 24, 2019; revision requested May 6 and received June 2; accepted June 25. For this journal-based SA-CME activity, the authors, editor, and reviewers have disclosed no relevant relationships. **Address correspondence to** Z.J.R. (e-mail: *zricci@montefiore.org*).

SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- Recognize the causes and appearances of artifacts and pseudolesions on CT colonography 3D and 2D images.
- Apply interpretative skills that combine complementary assessment of both 2D and 3D datasets to unmask artifacts and pseudolesions and prevent erroneous diagnoses.
- Implement imaging strategies to eliminate or diminish artifacts and pseudolesions on CT colonography images.

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CT colonography image interpretation requires simultaneous detection of colonic pathologic disease and recognition of pitfalls that can simulate or obscure real findings. Artifacts and pseudolesions are commonly encountered at CT colonography and far exceed the frequency of true colonic pathologic disease. They pose a real challenge to the interpreting radiologist, who must be knowledgeable about their many appearances. Some are intrinsic to either two-dimensional (2D) or three-dimensional (3D) CT colonography images and others are unavoidable on both. Nearly all artifacts are equally visualized on 2D and 3D images, whereas most pseudolesions are visualized solely on 3D images. Artifacts are often unavoidable at CT colonography and can degrade image quality on both 2D and 3D images, whereas pseudolesions almost always plague 3D images and can usually be rapidly disregarded, as they are unsubstantiated on corresponding 2D images. Mastery of interpretative skills and careful correlation of findings on 2D and 3D images allow the radiologist to unmask artifacts and pseudolesions and avoid diagnostic errors. Misinterpretation of a pseudolesion as colonic pathologic disease can lead to subsequent optical colonoscopy and unnecessary risk to the patient. Some artifacts and pseudolesions can be circumvented with optimal colonic cleansing, adequate fecal and fluid tagging, ideal colonic distention, and optimization of examination technique. The authors discuss the causes and appearances of artifacts and pseudolesions at CT colonography, provide an interpretative approach for their recognition, and review strategies to decrease or prevent them.

Online supplemental material and the slide presentation from the RSNA Annual Meeting are available for this article.

Introduction

Colorectal cancer is the third most commonly diagnosed cancer in both men and women in the United States and is the overall second leading cause of cancer death. The American Cancer Society recommends colorectal screening beginning at age 45 for average-risk patients and supports the use of both optical colonoscopy (OC) and CT colonography as visual screening methods (1).

An earlier incorrect version of this article appeared online. This article was corrected on December 20, 2019.

TEACHING POINTS

- Artifacts from cardiac pulsatility mirror motion artifact at CT colonography, with 2D images depicting a unilateral blurred defect on the colonic wall that immediately abuts the left ventricle and 3D images depicting a focal jagged edge or mottled defect.
- In patients with obesity, it is necessary to increase the tube current (mA) to improve 2D resolution, and interpretation may rely on 2D images alone when 3D images are degraded. Raising the radiation dose to maintain diagnostic image quality in a patient with morbid obesity is acceptable.
- Suspected underdistention or spasm occurring in two positions may necessitate a third focused image of the affected area in another position after further insufflation to achieve better distention and exclude pathologic stricture.
- Tagged stool plaques have homogeneous high attenuation with a concave smooth border extending to the mucosal surface, whereas coated flat polyps have a slightly irregular soft-tissue border between the outer colonic wall and contrast material coat. Beam-hardening artifact from overlying contrast material and low-dose technique can cause the diminutive underlying soft tissue of a flat lesion to falsely appear to have lower attenuation, or even fat attenuation, and to be erroneously discarded as stool or lipoma.
- Prolapsing mucosal polyps are nonneoplastic lesions most often associated with diverticular disease, usually located in the sigmoid colon. They can cause abdominal pain or bleeding. As the affected colonic segment foreshortens owing to muscular hypertrophy, remaining redundant mucosa can prolapse into the colonic lumen, mimicking broad-based polyps on both 2D and 3D images.

OC is the traditional standard screening test for colorectal cancer, simultaneously enabling tissue sampling. However, OC requires sedation but carries a low risk of perforation and bleeding. CT colonography is the alternative minimally invasive screening imaging test, does not require anesthesia administration, and has a much lower complication rate than that of OC (2). CT colonography is particularly well suited to screening patients with serious medical problems who are at higher risk for anesthesia complications or increased risk of procedural bleeding or perforation, and it has been readily and successfully used to complete colonic screening after incomplete OC. As OC and CT colonography have equivalent sensitivity for colorectal cancer detection (96% for CT colonography; 95% for OC) (3), the utility of CT colonography will likely continue to rise, and the need for experienced CT colonography readers will expand.

Artifacts and pseudolesions are commonly encountered at CT colonography and can simulate or obscure true pathologic disease (Table; Table E1). Accurate CT colonography image interpretation is twofold and requires both knowledge of colonic pathologic diseases for the detection of precancerous and cancerous lesions and proficient identification of common artifacts and pseudolesions to avoid misdiagnosis and unnecessary workup. In fact, the prevalence of artifacts and pseudolesions encountered at CT colonography far exceeds that of true colonic pathologic diseases detected at CT colonography. Artifacts and pseudolesions occur on both two-dimensional (2D) and three-dimensional (3D) endoluminal CT colonography images (referred to as *2D images* and *3D images*, respectively, in this article), but careful and complementary correlation of each dataset will almost always allow the radiologist to unmask them. Some artifacts and pseudolesions can be circumvented with optimal colonic cleansing, adequate fecal and fluid tagging, ideal colonic distention, and optimization of examination technique.

In this article, we review CT colonography artifacts and pseudolesions and provide strategies to recognize and prevent them.

Artifacts at CT Colonography

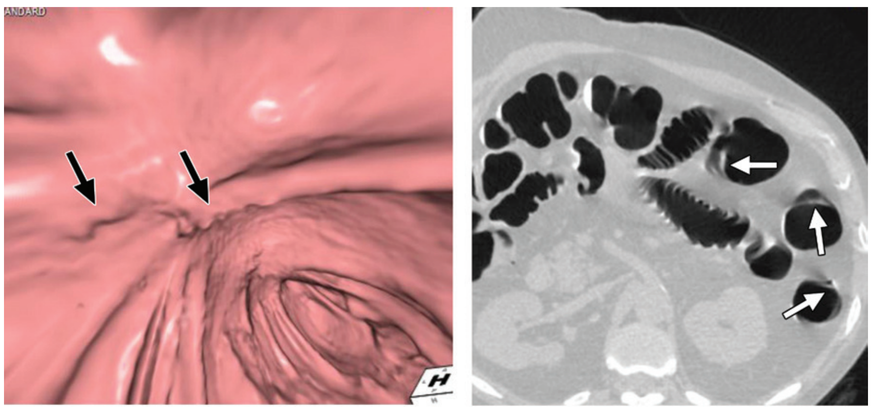
Motion Artifact

Motion is one of the most common causes of artifact at CT colonography. Prominent respiratory excursions, inadvertent patient movement, bowel peristalsis, and cardiac pulsatility cause motion artifact, which degrades colonic evaluation, either focally or diffusely. Respiratory motion is particularly prominent at CT colonography in patients with chronic lung disease and in patients who require oxygen supplementation. Respiratory motion will provide a significant challenge to interpretation as CT colonography rises as the preferred visual colorectal cancer screening examination in lung transplant candidates, who have a higher complication risk with sedation.

Motion causes misregistration artifact, which has a shaded or streaked appearance on reconstructed images (4). On 2D images, motion manifests as faint linear blurred areas of attenuation that typically have lower attenuation than normal colonic folds and are most conspicuous with colonic window settings (width ranging from 1400 to 1500 HU; level ranging from –200 to –400 HU) than with soft-tissue window settings (width, 400 HU; level ranging from 10 to 40 HU). When motion artifact is oriented parallel to an adjacent fold, a twin-fold appearance occurs (5). Correlative stair-step defects disrupting the smooth outer margin of the abdominal wall can be visualized on sagittal or coronal reformatted images (5,6). On 3D images, motion manifests as linear areas of attenuation with a jagged sawtooth margin, which can be variably oriented in the colonic lumen (Fig

CT Colonography Artifacts

Artifact	Appearance	Diagnostic Tips
Motion	2D images: faint linear blurred areas of attenuation; may cause “twin-fold” appearance 3D images: linear areas of attenuation with a jagged sawtooth margin, variably oriented in the colonic lumen; uncommonly creates a pseudopolypoid structure	Correlative stair-step defects disrupting the smooth outer margin of the abdominal wall can be visualized on sagittal or coronal reformatted images obtained at the same level Artifact from cardiac pulsatility occurs in the colonic wall abutting the left ventricle
Obesity	Increased image noise; most prominent in the pelvis 2D images: increased graininess of images worse with soft-tissue window settings than with wider colonic window settings 3D images: surface mottling, which obscures colonic mucosa	Raising the tube current is critical to improve 2D image resolution When 3D images are degraded, primary 2D image interpretation is necessary
Metal or dense contrast interface	Beam-hardening artifact 2D images: radiating linear white streaks emanating from a dense structure 3D images: mottled parallel linear streaking granular areas of attenuation that obscure the mucosa	Using bone window settings to review 2D images may be helpful Dual-energy CT technology may be useful to reduce streak artifact from metallic objects
Dense waterfall sign	Gravitational flow of tagged luminal fluid 2D images: hyperattenuating arciform starburst streaks 3D images: mottled focal distortion	Inspect the image obtained in the other position for resolution of the artifact
Digital subtraction artifact	3D images: *(a)* multiple bizarre pseudopolypoid lesions at the fluid surface owing to poor fluid tagging; *(b)* pseudopolypoid lesions in the periphery of a fluid level abutting the colonic wall or haustral fold owing to partial volume averaging; *(c)* pseudopolypoid lesions owing to untagged or poorly tagged submerged stool or air bubbles	Pseudolesions depicted on 3D images are not depicted on the unsubtracted 2D dataset

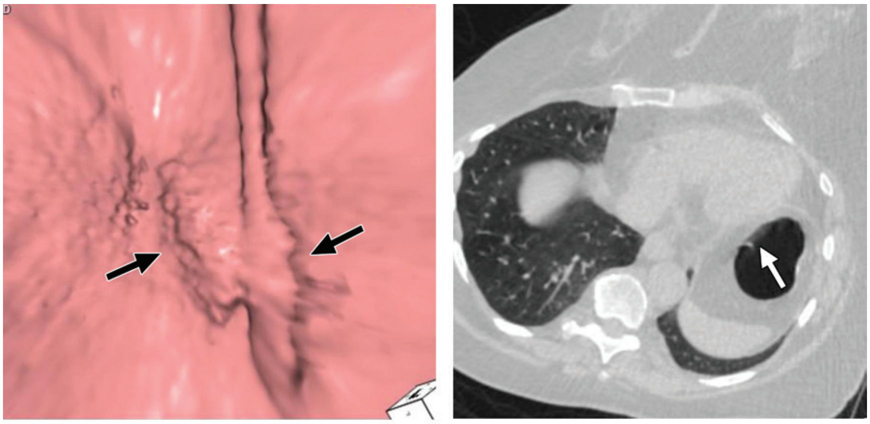


a. **b.**

Figure 1. Artifact from patient motion. Endoluminal 3D CT colonography image **(a)** shows a saw-tooth mucosal defect (arrows in **a**) corresponding to faint blurred crescentic luminal areas of attenuation (arrows in **b**) on the axial 2D CT colonography image **(b)**.

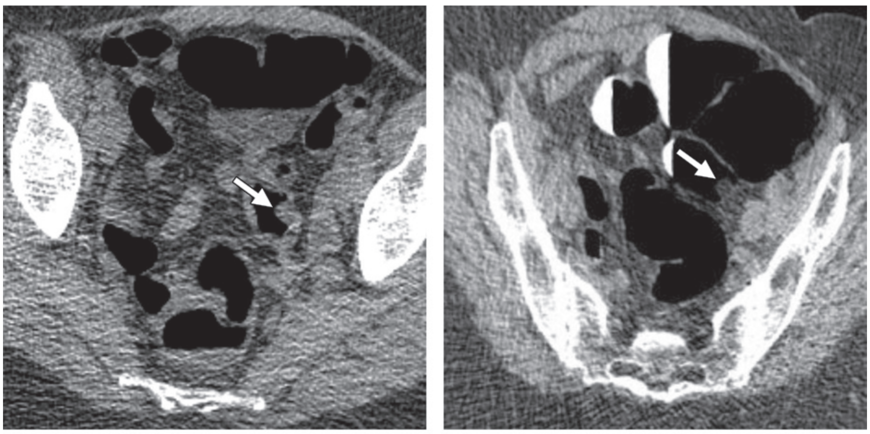
1). Least commonly, motion artifact can create a pseudopolypoid structure (5) that has an irregular unnatural polyp contour on 3D images and a corresponding faint blurred area of attenuation on 2D images.

Motion artifact may be unavoidable in some patients. Coaching the patient to lie still and follow the breathing instructions is essential to prevent motion. It is recommended to acquire images at end-expiration, which will help minimize respiratory motion–related artifacts. Scrutinizing the 2D datasets for motion artifact before examination termination can help determine if a colonic segment is degraded on both views, allowing the opportunity to plan a third focused view of the segment.



a. b.

Figure 2. Artifact from cardiac pulsatility in the splenic flexure abutting the left ventricle. Endoluminal 3D CT colonography image **(a)** shows a mottled jagged mucosal defect (arrows in **a**) corresponding to a hazy faint blurred luminal area of attenuation (arrow in **b**) adjacent to the left ventricle on the axial 2D CT colonography image **(b)**.



a. b.

Figure 3. Noise artifact in a patient with obesity who underwent imaging with 160 mA. **(a)** Axial 2D CT colonography image (soft-tissue window) shows an apparent sigmoid polyp (arrow) with soft-tissue attenuation. **(b)** Follow-up axial 2D CT colonography image (soft-tissue window) obtained 9 years later with 200 mA shows the sigmoid lesion (arrow) with gross fat attenuation, a finding consistent with lipoma.

Artifacts from cardiac pulsatility are uncommon and occur in the splenic flexure or colonic segment that abuts the diaphragm below the left ventricle. An elevated heart rate is the most common cause of cardiac motion artifacts reported at CT coronary angiography. Arrhythmias are a reported cause of stair-step artifacts (7). Artifacts from cardiac pulsatility mirror motion artifact at CT colonography, with 2D images depicting a unilateral blurred defect on the colonic wall that immediately abuts the left ventricle and 3D images depicting a focal jagged edge or mottled defect (Fig 2).

Image Noise in Patients with Obesity

Image noise dramatically increases at CT colonography in patients with obesity. The pelvis is more affected than the remainder of the abdomen because the pelvic bones and wider soft-tissue girth of the pelvis cause greater x-ray attenuation and image noise. Evaluation of the rectosigmoid or other colonic segments included in the areas of greater noise may be compromised. Resultant artifacts in the colonic lumen are more prominent on 3D images than on 2D images. On 2D images, artifact is worse with soft-tissue window settings than with wider colonic window settings and is characterized as image graininess. The overall heterogeneity of the soft tissues renders the distinction of polyps from stool or lipoma subject to error. Polyps can appear erroneously low in attenuation on 2D images with soft-tissue window settings, mimicking stool or lipoma. Conversely, lipoma can appear erroneously high in attenuation on 2D images with soft-tissue window settings, mimicking a polyp (Fig 3).

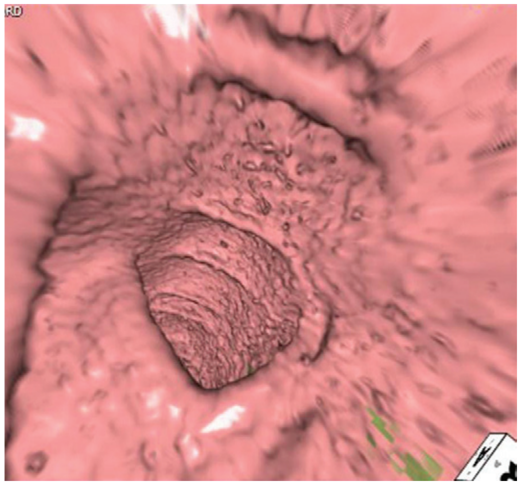
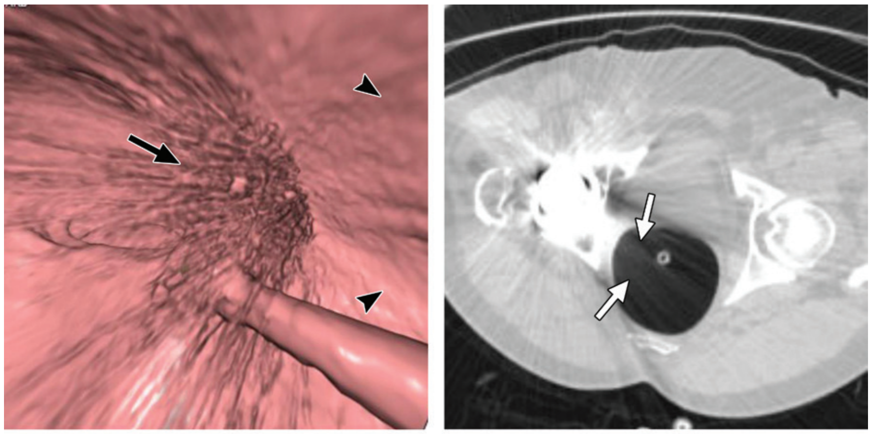


Figure 4. Noise artifact in a patient with morbid obesity who underwent imaging with 160 mA. Endoluminal 3D CT colonography image of the transverse colon shows innumerable stippled granular mucosal defects, with no correlate lesions on 2D CT colonography images (not shown).



a. b.

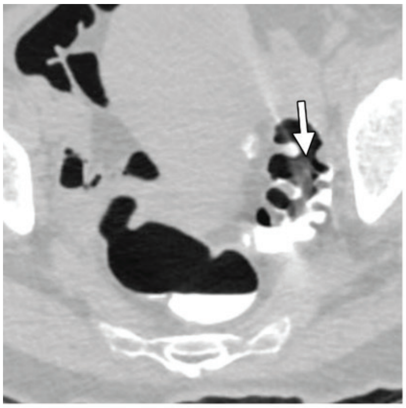
Figure 5. Streak artifact from a right hip prosthesis. **(a)** Endoluminal 3D CT colonography image shows linearly oriented mottled luminal defects (arrow) that obscure the mucosa. Note that the contralateral colonic wall (arrowheads) lacks the artifact. **(b)** Axial 2D CT colonography image shows fine hazy linear streaks (arrows) radiating from the right hip prosthesis.

On 3D views, image noise manifests as surface mottling (8,9), characterized by innumerable stippled irregular nodular defects that can severely or totally obscure the underlying mucosal surface (Fig 4). Three-dimensional images may be nondiagnostic in patients with morbid obesity. In patients with obesity, it is necessary to increase the tube current (mA) to improve 2D resolution, and interpretation may rely on 2D images alone when 3D images are degraded. Raising the radiation dose to maintain diagnostic image quality in a patient with morbid obesity is acceptable (10).

Metallic Objects or Dense Contrast Interface

Any type of metallic device will cause streak artifact at CT colonography. Hip prostheses are the most commonly encountered culprit. Other devices that can cause streak artifact include penile prostheses, pacemaker leads, surgical clips (especially when multiple in a cluster configuration), and spinal or other orthopedic hardware.

Streak artifact is a type of beam-hardening artifact that occurs as the x-ray beam passes through an object that causes its mean energy to increase, because lower-energy photons are more rapidly absorbed by the object, rendering the beam harder (4). On 2D images, this appears as radiating linear white streaks emanating from a dense structure. On 3D images, this appears as mottled parallel linear granular streaks that obscure the mucosa (6) (Fig 5). This artifact is always worse on the side of the colonic lumen that is adjacent to the metallic object. Evaluation of the rectosigmoid is often limited in patients with hip prostheses (6). Occasionally, dense tagged fluid is vulnerable to streak artifact from beam hardening at the air-fluid interface. Viewing 2D images with bone window settings may be helpful to examine areas obscured by the artifact. Dual-



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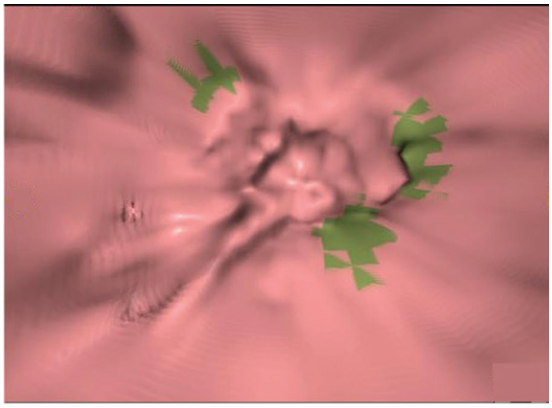


b.

Figure 6. Dense waterfall sign in the sigmoid colon. **(a)** Axial 2D CT colonography image shows hyperattenuating arciform streaky areas (arrow) owing to the dependent flow of tagged fluid. **(b)** Endoluminal 3D CT colonography image shows mottled defects of motion artifact. Green areas = tagged fluid.

energy CT technology can be used to decrease streak artifact of metallic objects.

Gravitational Flow of Tagged Luminal Fluid

Coined the *dense waterfall sign* by Boyce et al (11), the gravitational flow of tagged luminal fluid from a higher to a lower level during the examination creates a hyperattenuating artifact at CT colonography that mimics beam-hardening artifact. On 2D images, it causes hyperattenuating arciform starburst streaks (Fig 6). On 3D images, it causes mottled focal distortion. Once the artifact has been recognized on an image obtained in one position, the images obtained in the subsequent position can be scrutinized for resolution of the artifact and exclusion of an underlying pathologic condition.

In a study of 179 patients who underwent CT colonography in supine and prone positions, the artifact was found in 23.5% of patients (11). The artifact was more frequent in patients who already had the artifact in another colonic segment, and it was more common on images obtained in the supine position in well-distended colonic segments and in the sigmoid colon.

Digital Subtraction Artifact

Digital subtraction artifact is unique to CT colonography that uses electronic cleansing technology, in which tagged fluid is digitally subtracted. There are several scenarios that cause pseudolesions on 3D subtracted images. First, if there is poor fluid tagging, cleansed 3D images will show multiple bizarre pseudopolypoid lesions at the fluid surface. Second, as partial volume averaging occurs at the interface of luminal air and tagged fluid where voxels overlap with those of soft tissues, pseudopolypoid lesions occur in the periphery of a level where a meniscus effect is depicted adjacent to the colonic wall or haustral fold. Third, untagged or poorly tagged submerged stool or air bubbles can cause pseudopolypoid defects. However, these pseudolesions are not substantiated on unsubtracted 2D images. Since they are often depicted on corresponding subtracted 2D images, only the unsubtracted 2D dataset should be relied on for diagnostic viewing (12, 13).

Pseudolesions and Pitfalls

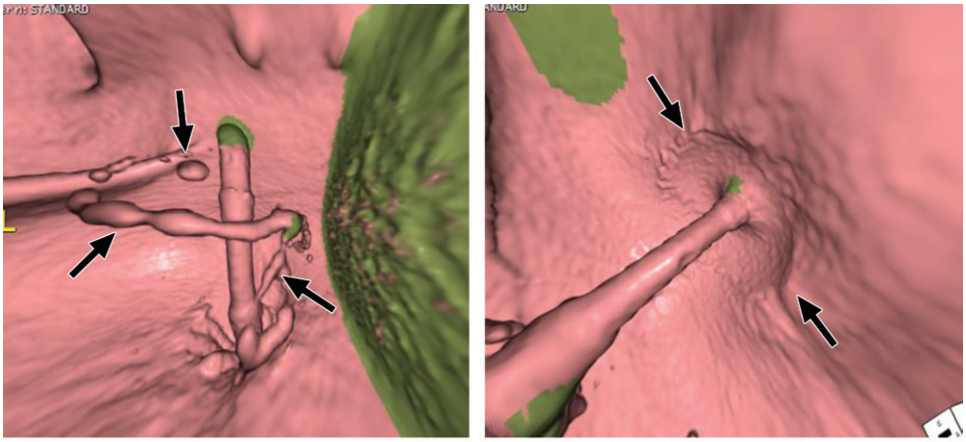
Rectal Catheter and Balloon

The rectal catheter tip commonly causes pseudolesions on 3D images, which are easily unmasked on corresponding 2D images. Two common pseudolesions can occur when *(a)* the catheter simulates a polyp when only the tip is in the field of view, projecting above a rectal fold; and *(b)* the catheter leans against the inferior surface of a rectal fold and appears as an extrinsic impression on the superior surface of the fold (14).

The distended rectal balloon also commonly causes pseudolesions on 3D images, which are easily unmasked on corresponding 2D images. Spotty adherent secretions or tagged fluid on the surface of the balloon causes curved elongated or nodular floating structures that are easily pinpointed on the balloon surface on corresponding 2D images. The distended balloon may also cause a meniscus-like defect in which it indents the lower rectum (14) (Fig 7).

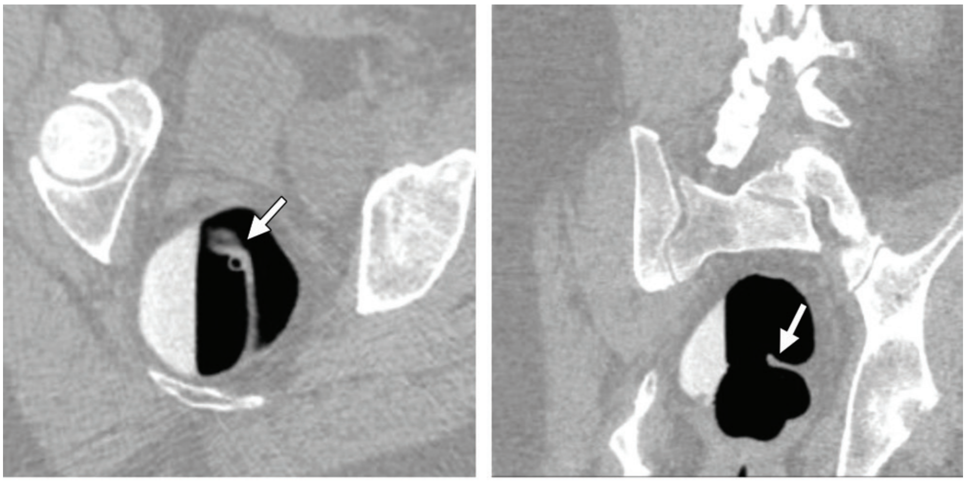
Rectal Folds

The inferior, middle, and superior rectal folds, or valves of Houston, encircle one-third to one-half of the rectal circumference (14) and can simulate a pedunculated polyp on axial 2D



a. b.

Figure 7. Artifacts from a rectal balloon. Green areas = tagged fluid. **(a)** Endoluminal 3D CT colonography image shows several nodular and curved floating defects (arrows) surrounding the rectal tube, which corresponded to small clumpy areas of adherent contrast material on the balloon surface on 2D CT colonography images (not shown). **(b)** Endoluminal 3D CT colonography image in another patient shows a symmetric meniscus-like impression surrounding the anorectal junction (the space between the arrows) owing to the impression of the inflated balloon (not shown).



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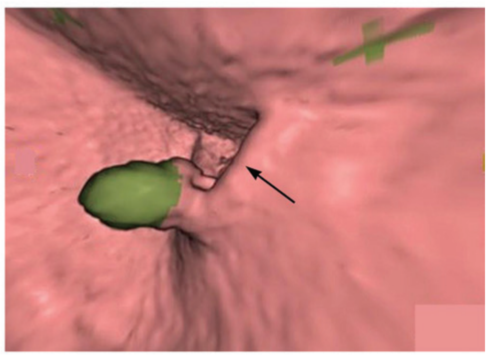


c.

Figure 8. **(a)** Axial 2D CT colonography image shows an inferior rectal fold simulating a pedunculated polyp owing to a contour indentation (arrow) by the rectal tube. **(b)** Coronal 2D CT colonography image shows a normal inferior rectal fold (arrow) located on the left. **(c)** Endoluminal 3D CT colonography image shows a smooth fold draped against the rectal tube (arrow). Green areas = tagged fluid.

images, often abutting the rectal tube (Fig 8). Correlation with findings on coronal 2D images easily confirms the appearance of the indenting rectal valve and its typical location. Three-dimensional images easily show the smooth curved shape of a rectal fold.

Underdistended Bowel and Colonic Spasm

Underdistended bowel and less commonly colonic spasm can be confused with benign or malignant strictures. Three-dimensional images depict smooth or irregular luminal narrowing, and 2D images depict a variably thick-walled narrowed segment (Fig 9). Underdistention tends to affect longer segments of bowel compared with malignancy and most commonly occurs in the

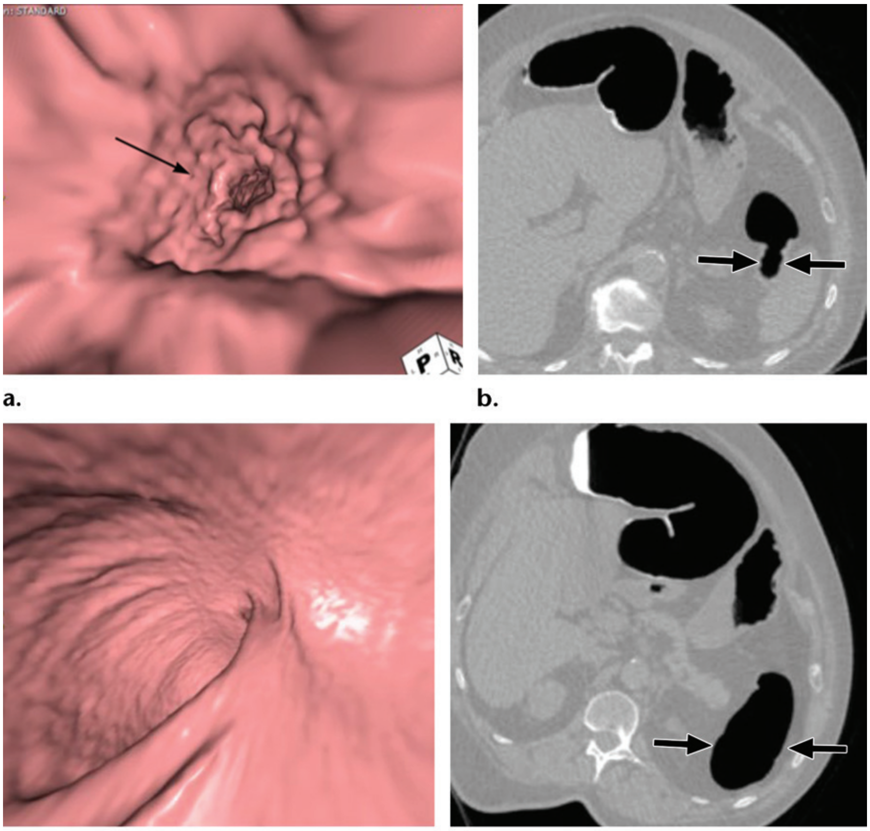


Figure 9. Colonic spasm mimicking a malignant stricture. **(a)** Endoluminal 3D CT colonography image shows an area of splenic flexure narrowing with mucosal irregularity (arrow). **(b)** Axial 2D CT colonography image shows a collapsed segment with minimal mural thickening (between arrows). **(c, d)** Endoluminal 3D CT colonography **(c)** and axial 2D CT colonography **(d)** images obtained in the right decubitus position show resolution of the collapsed segment (between arrows in **d**).

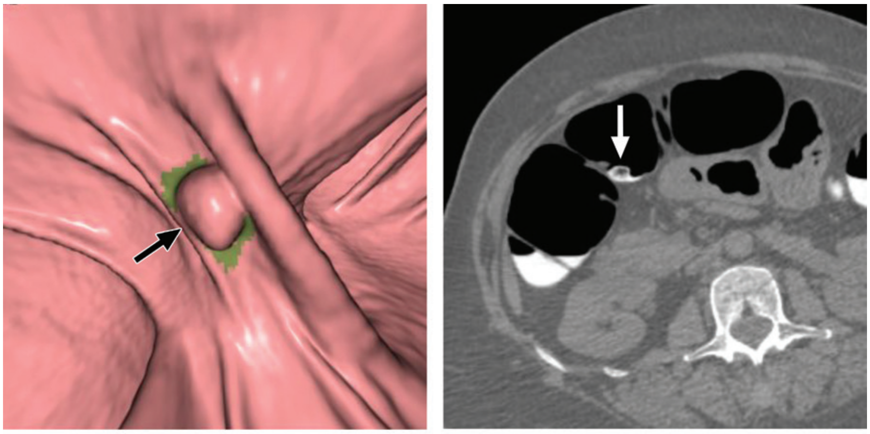
rectum, sigmoid colon, and descending colon in the supine position. It is confirmed by the absence of adjacent lymphadenopathy, infiltrated pericolonic fat, and soft-tissue nodules or mass projecting beyond the bowel wall on 2D images. Underdistention is easily confirmed when there is improved distention of the affected segment in the subsequent position. Spasm tends to involve short focal bowel segments and almost always resolves on images in the subsequent position. Spasm occurs sporadically owing to peristaltic muscular colonic contraction (6).

Bowel distention is best achieved with carbon dioxide (CO_2) automated insufflation (6,15). Spasmolytics are not mandatory for CT colonography and are variably used. Glucagon and more recently intravenous hyoscine butylbromide (Buscopan; Boehringer, Ingelheim, Germany) (15) have not been shown to significantly improve colonic distention. Suspected underdistention or spasm occurring in two positions may necessitate a third focused image of the affected area in another position after further insufflation to achieve better distention and exclude pathologic stricture.

Before performing each examination, a scout view is inspected to determine adequate colonic distention, evidenced by a prominent gas-filled colon with decreased conspicuity of the interhaustral folds. Gas incontinence occurs in some patients despite the presence of the inflated rectal balloon, preventing adequate colonic distention. Wide silk tape can be used to tightly approximate the buttocks around the rectal tube to help minimize CO_2 leak.

Successful colonic insufflation may be challenging in patients with morbid obesity. Owing to the larger abdominal girth in this population, low-pressure colonic CO_2 insufflation often is not strong enough to overcome weight-related intra-abdominal pressure. We use the right lateral decubitus position to start insufflation and often wait for about 1.5 L of CO_2 to be delivered before slowly turning the patient to the supine position to complete the insufflation for the first supine examination, often achieved at 3.5–4 L of CO_2.

We have also observed that patients find it difficult to maintain colonic distention in the prone position owing to greater pressure placed on the



a. b.

Figure 10. Retained stool mimicking a polyp. **(a)** Endoluminal 3D CT colonography image shows a polypoid lesion (arrow) surrounded by tagged fluid (green areas). **(b)** Axial 2D CT colonography image (soft-tissue window) with the patient in the supine position shows the structure with internal heterogeneous low attenuation (arrow). The stool pellet moves into a dependent location in the right lateral decubitus position (not shown).

anterior abdominal wall. The transverse colon is most often compressed in the prone position, limiting its evaluation. In our practice, if adequate tagging has occurred, an initial supine image is routinely followed by a right lateral decubitus position image, which optimizes left-sided distention and allows optimal right colonic distention (16). A third view in the left lateral decubitus position is rarely necessary.

For cases of recent incomplete OC reaching the hepatic flexure of the colon and for the purpose of clearing the right colon, the image in the second position could be obtained in the left lateral decubitus position to strive for maximum distention of the right colon. Uncommonly, a third-position image or a focused image of a colonic segment is obtained if better distention is needed. For rare cases without tagging, we use the traditional supine and prone positions to ensure maximal mucosal exposure by moving the untagged fluid to the opposite wall.

Last, a patent ileocecal valve may allow reflux of gas into the small bowel, and colonic distention may never be optimal. If marked filling of the small bowel is observed on the scout view, we image when colonic distention is fair rather than optimal to prevent extreme patient discomfort and avoid failed CT colonography due to patient intolerance.

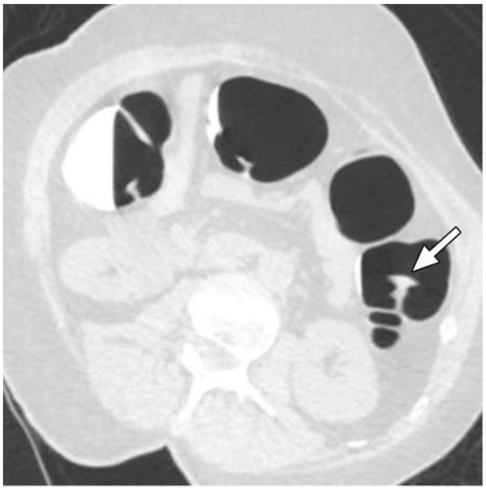
Stool

Residual stool mimicking a polyp on 3D images is one of the most common causes of pseudolesions at CT colonography. On 2D images, stool is usually identified by its mobility into a dependent location and/or its heterogeneous attenuation owing to internal pockets of gas (Fig 10). However, not all stool has characteristic heterogeneous attenuation, and stool may be adherent to the colonic wall. A nontagged homogeneously attenuating adherent stool pellet is indistinguishable from a polyp even with careful evaluation of 2D images. Fecal tagging with dilute 2% barium sulfate is a critical step of CT colonography preparation before colonic cleansing. Stool, unlike polyps, becomes impregnated with dense barium contrast material, allowing its recognition regardless of mobility. Tagged stool will appear either homogeneously or heterogeneously hyperattenuating on 2D images and is best recognized when using soft-tissue window settings.

Translucency rendering is a 3D technique that combines attenuation-dependent transparency with color mapping to allow differentiation of tagged stool from true polyps by color assignments on 3D images. This reduces the need for 2D image correlation and decreases interpretation time. However, the reader must be cautioned as a polyp etched with fluid tagging may be erroneously labeled as stool on translucency-rendered images (8,17). In such cases, 2D image correlation is important because the suface of a polyp can have a coated surface, sometimes irregularly if villous anatomy is present, rendering it similar in appearance to tagged stool. Flat sessile serrated polyps may also be highlighted by contrast material coatings and mistaken for adherent stool (18).

Thickened Folds

Thickened folds, or bulbous folds, often related to suboptimal colonic distention, are a common cause of pseudopolypoid lesions at CT colonography. Kissing folds are thickened folds that extend from opposite sides of the bowel wall and meet in the mid-lumen, most often visualized in a poorly distended sigmoid colon. Other



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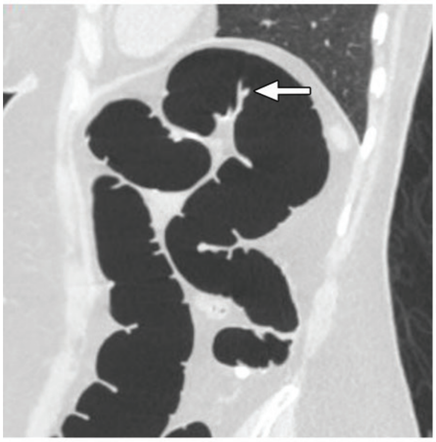

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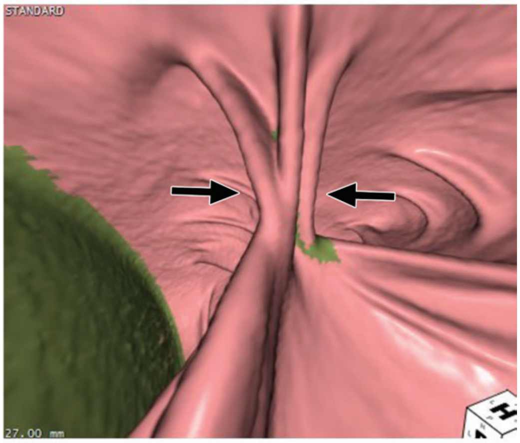


c.

Figure 11. Splenic flexural pseudotumor mimicking a flat polypoid structure. **(a, b)** Axial 2D CT colonography image **(a)** shows a thick polypoid flat structure (arrow in **a**), which corresponds to clustered folds (arrow in **b**) that can be tracked by scrolling through serial coronal (not shown) and sagittal CT colonography 2D **(b)** images. **(c)** Endoluminal 3D CT colonography image shows three smooth folds converging at the colonic flexure (between arrows). Green areas = tagged fluid.

causes of thickened folds include normal folds that are slightly thicker than usual, folds buckled at areas of colonic bending (complex folds), folds overlapping normal folds (crossing folds), the confluence of folds (folds converging at the same point), and areas of myochosis associated with diverticulosis (19).

Pseudopolypoid lesions due to thickened folds depicted on 2D images require correlation with findings on multiplanar views to demonstrate the course of an elongated fold or cluster of folds and to confirm the absence of a pathologic lesion. Three-dimensional images readily confirm the elongated smooth linear nature of a fold. The exception is malignancy that focally infiltrates a fold and manifests as an isolated irregular thickened fold. In these cases, it is important to recognize that a fold infiltrated with tumor stands out from neighboring folds because of its size and surface irregularity (20).

Flexural Pseudotumor

When the colon has a sharp bend in its course, the inner colonic wall is more collapsed, causing pseudothickening that can mimic a colonic mass or polyp on 2D or 3D images (Fig 11). The pseudothickening is due to crowded colonic folds and may be accentuated by pericolic fat and its vascular structures (5). Careful scrolling through multiplanar 2D images is necessary to resolve an underlying smooth collapsed fold or converging folds at the bend. Rotating the 3D endoluminal view along the centerline is also helpful to resolve the pseudolesion. Reviewing the images obtained in the other position may better depict the bend, helping to exclude pathologic lesions. Occasionally, 2D images show pericolonic fat within a compressed fold. Flexural pseudotumor most commonly occurs in the flexures but can occur anywhere the colon folds over itself, particularly in the sigmoid

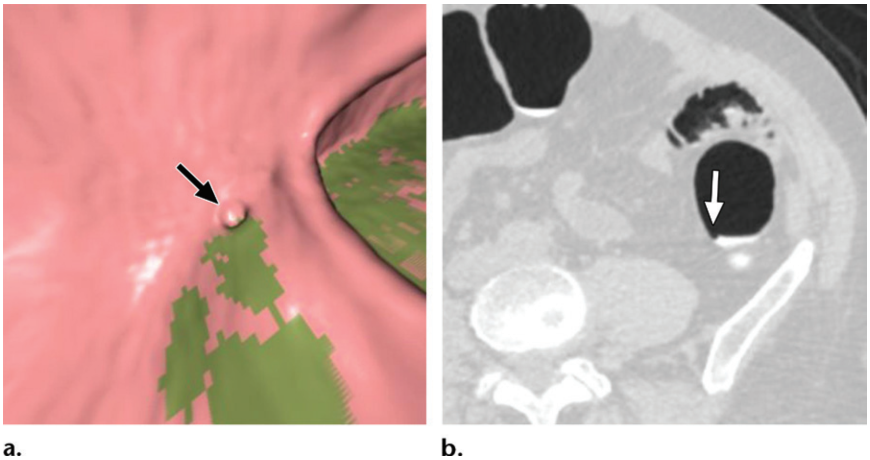


Figure 12. Air bubble in the descending colon mimicking a diverticulum. Green areas = tagged fluid. **(a)** Endoluminal 3D CT colonography image shows a polypoid lesion (arrow) with a partially dark ringlike defect. **(b)** Axial 2D CT colonography image shows the round depressed defect (arrow) on the surface of the tagged fluid in a corner.

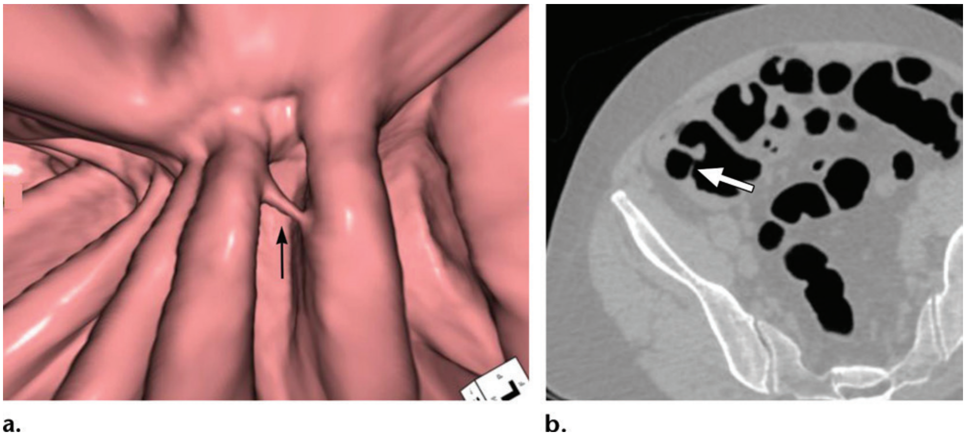


Figure 13. Mucus strand mimicking a pedunculated polyp stalk. **(a)** Endoluminal 3D CT colonography image shows a tubular structure (arrow) spanning two folds in the ascending colon. **(b)** Axial 2D CT colonography image shows a barely visible faint elongated area of attenuation (arrow).

colon. Optimal colonic distention helps avoid these pseudotumors.

Gas Bubble

Gas bubbles are relatively common and mimic a polypoid lesion or occasionally a diverticulum. Most often appearing on top of a fluid level or near folds or corners, bubbles may be solitary or multiple and clustered. They are most conspicuous when floating on a tagged fluid level. On 3D images, they appear as round polypoid structures. Multiple clustered bubbles can mimic a villous polypoid lesion on 3D images. On 2D images, they are resolved as a scalloped indentation of the top of a fluid level, as the bubble wall itself is not readily visible on 2D images (6) (Fig 12). When bubbles are present without surrounding fluid, they can be better resolved on 2D images with wider colonic or bone window settings.

Mucus Strand

A mucus strand is an occasional mimic of a pedunculated polyp. Mucus strands can be solitary or multiple and have no specific cause. On 3D images, they mimic a pedunculated polyp but lack a nodular tip. They appear as a thin tubular or linear structure that extends from one colonic surface to another; they may be mobile and change in thickness and length in different positions based on the degree of colonic distention and their span of stretch. On 2D images, a mucus strand can be distinguished from a polyp by its faint visibility, typically best or only visualized with wide colonic or bone window settings (6) (Fig 13).

Contrast Material Etching of Polyps

A contrast material–coated polyp can be confused with adherent tagged stool fragment. Contrast material adheres to polyps that secrete a surface mucin film, creating a contrast material cap. On 2D images, coated polyps can mimic stool if the central soft-tissue attenuation is not appreciated. Careful inspection of 2D images shows surface coating without internal impregnation with contrast material. Three-dimensional images demonstrate the tagged polyp that if measured on the 3D image will include the surface coating (Fig 14).

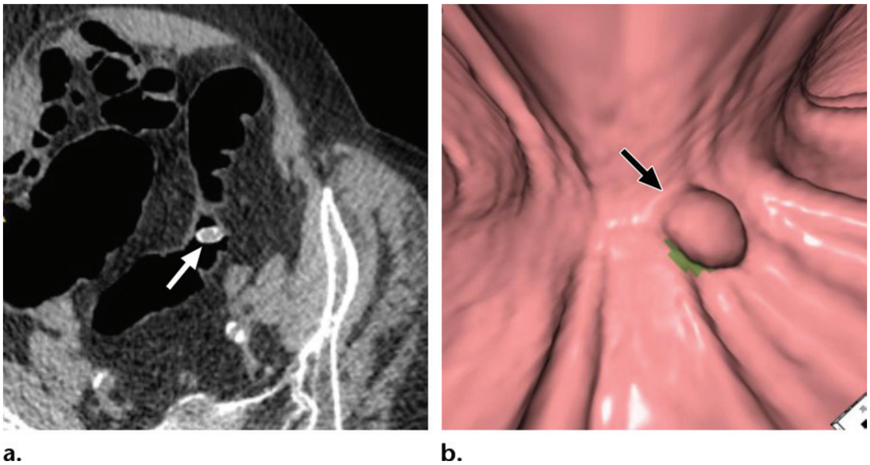


Figure 14. Coated polyp in the sigmoid colon mimicking tagged stool. (a) Axial 2D CT colonography image (soft-tissue window) with the patient in the supine position shows a pedunculated polypoid structure (arrow) with soft-tissue attenuation etched in contrast material. (b) Endoluminal 3D CT colonography image shows a 1-cm polyp (arrow). The results of pathologic examination confirmed tubular adenoma. Green area = tagged fluid.

Flat polyps coated with contrast material can be mistaken for tagged stool plaques because of their morphology. On 2D images, the soft-tissue component of a flat polyp underlying the adherent contrast material coating is much less conspicuous than that in a sessile or pedunculated polyp and can easily go unnoticed. Tagged stool plaques have homogeneous high attenuation with a concave smooth border extending to the mucosal surface, whereas coated flat polyps have a slightly irregular soft-tissue border between the outer colonic wall and contrast material coat. Beam-hardening artifact from overlying contrast material and low-dose technique can cause the diminutive underlying soft tissue of a flat lesion to falsely appear to have lower attenuation, or even fat attenuation (18), and to be erroneously discarded as stool or lipoma.

Foreign Bodies and Ingested Pills

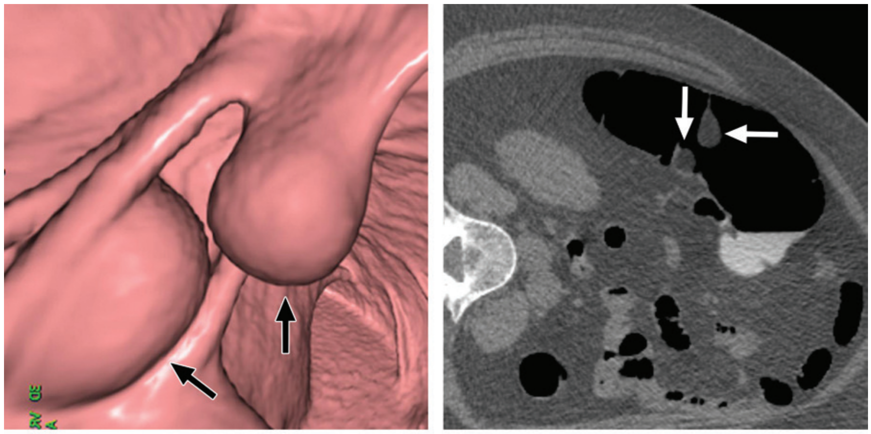
Retained foreign matter is not commonly encountered at CT colonography after successful bowel preparation. However, pill fragments, capsules, and undigested food, including corn and seeds, have been reported. These can mimic single or multiple polypoid lesions on 3D images. A pill or capsule is suspected if the polypoid structure is strikingly uniform or geometrically or unnaturally shaped. On 2D images, a polyp may not be distinguishable from a foreign body if it is adherent and nonmobile. A polyp can be excluded if the structure is hyperdense (21). Radiopaque medications include iron and potassium preparations, calcium carbonate, acetazolamide, and busulfan (22). Radiopaque ingested bones can be depicted on 2D images with a nonspecific elongated tubular appearance on 3D images (23). Adherence to the bowel preparation instructions, including a low-residue diet with restriction of beans, nuts, seeds, and whole grains beginning 2 days before CT colonography, can help avoid retained colonic foreign matter.

Lipoma

Colonic lipomas are common benign submucosal masses that mimic broad-based polypoid lesions or pedunculated polyps on 3D images. With a reported incidence of up to 4.4% (24), they are more common in women and most commonly manifest in the right colon (25); 60% are reported in the cecum and/or ascending colon, 20% in the descending colon, 16% in the transverse colon, and 3%–4% in the rectum (26). Lipomas can be multiple in 10% of patients. Colonic lipomas are easily diagnosed on 2D images owing to their gross fat content. When sessile, they are smooth and broad based. Three-dimensional images are helpful for depicting the stalk when it is pedunculated (Fig 15). Colonic lipomas should not be confused with a lipomatous ileocecal valve (27).

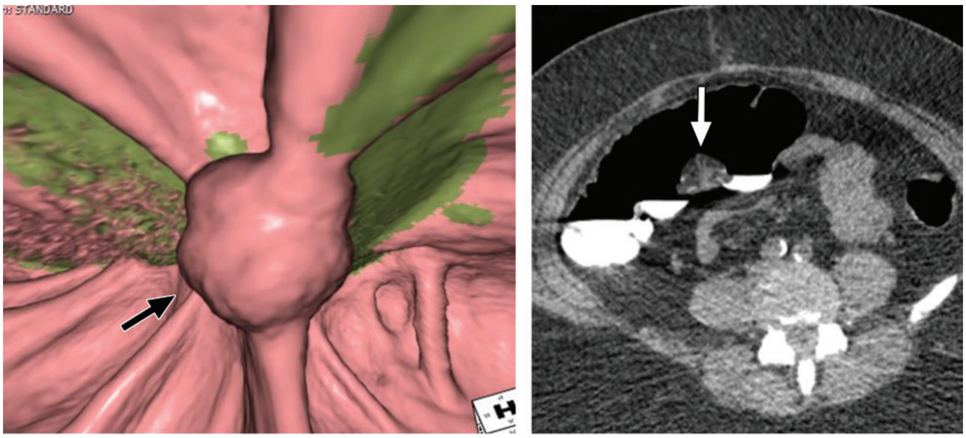
Ileocecal Valve

The ileocecal valve has a variable appearance and occasionally mimics a polypoid mass on 3D images. Identification of the contiguous terminal ileum on 2D images serves as a landmark for the ileocecal valve, resolving the issue. Three endoscopic ileocecal valve configurations have been classified: labial (slitlike opening), papillary (dome-shaped protruberance), and lipomatous (containing prominent fat). The labial configuration is easily recognized at CT colonography. On 3D images, the papillary configuration can be confused with a broad-based polyp with a small dimple in its center, providing a clue to its identity. The lipomatous valve can be variably enlarged and confused with a lobular polypoid lesion on 3D images; its fat attenuation is unmasked on 2D images (6) (Fig 16). It is important to routinely inspect the ileocecal valve on CT colonography images to avoid dismissing a cecal lesion for a prominent ileocecal valve and overlooking mucosal lesions that can occur on the ileocecal valve.



a. b.

Figure 15. Colonic lipomas mimicking polyps in the ascending colon. **(a)** Endoluminal 3D CT colonography image shows sessile polyps (arrows). **(b)** Axial 2D CT colonography image (wide bone window) shows lesions with gross fat attenuation (arrows).



a. b.

Figure 16. Ileocecal valve mimicking a lobular polypoid mass in the ascending colon. **(a)** Endoluminal 3D CT colonography image shows a polypoid lesion with an irregular surface in the cecum (arrow). Green areas = tagged fluid. **(b)** Axial 2D CT colonography image (soft-tissue window) shows lipomatous hypertrophy of the ileocecal valve (arrow), with the terminal ileum inserting on it (not shown).

Poor Fluid Tagging

Fluid tagging with ionic water-soluble contrast material (eg, diatrizoate meglumine and diatrizoate sodium solution; Gastrografin; Bracco Diagnostics, Monroe Township, N.J.) or nonionic contrast material (eg, iohexol; Omnipaque; GE Healthcare, Princeton, N.J.) (28) is a crucial component of CT colonography preparation because untagged residual luminal fluid can obscure a submerged colonic pathologic finding. When fluid levels are tagged, 2D images are inspected with a wider bone window setting because submerged lesions are obscured by fluid levels on 3D images. Submerged colonic lesions are more conspicuous in this setting than on soft-tissue or colonic window settings.

Fluid tagging can be compromised if the patient does not ingest the full amount of the tagging agent, dilutes the contrast material with too much water, or drinks an excessive amount of water before or after ingesting the fluid-tagging agent. Poorly tagged fluid on 2D images is not hyperdense but rather has variable intermediate attenuation and may have a mottled inhomogeneous appearance, including variable hyperdense mottled foci due to retained barium or tagged stool and hypoattenuating mottled foci due to mucus, frothy secretions, or foci of untagged particulate matter (Fig 17).

An easy-to-follow instruction guide for CT colonography bowel preparation, in addition to in-person review of these instructions with patients, can help avoid inadequate bowel preparation. Although various CT colonography preparatory bowel regimens are available, optimal colonic preparation on the day before CT colonography should include a strict liquid diet and fecal tagging with 2% barium sulfate followed by colonic cleansing and ending with undiluted or minimally diluted ionic water-soluble contrast material ingestion late at night, before the patient retires to sleep. The patient should be instructed to avoid liquid ingestion after the last step and remain fasting on the day of CT colonography to prevent dilution of fluid tagging.

RadioGraphics

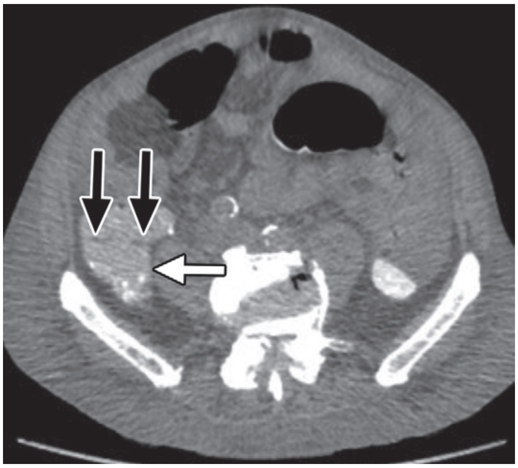


Figure 17. Poor fluid tagging causing pseudolesions in the ascending colon. Axial 2D CT colonography image shows dilute inhomogeneous fluid tagging with dependent mottled hyperdense contrast (white arrow) and short tubular hypoattenuated structures (black arrows).

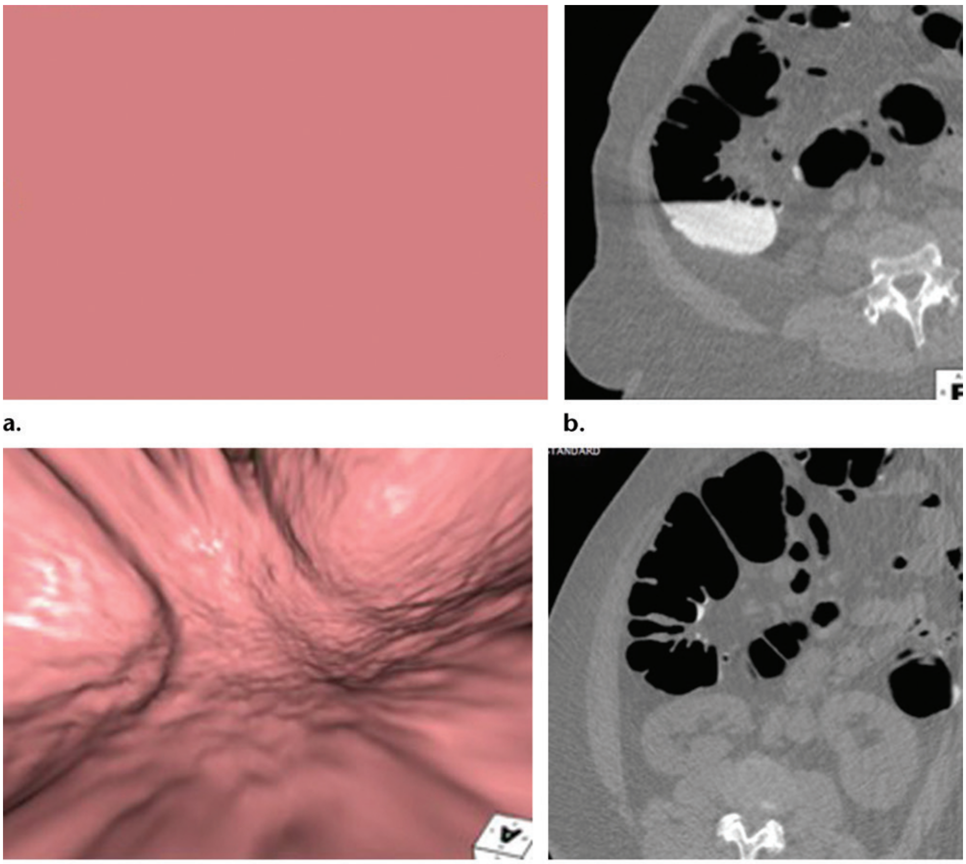
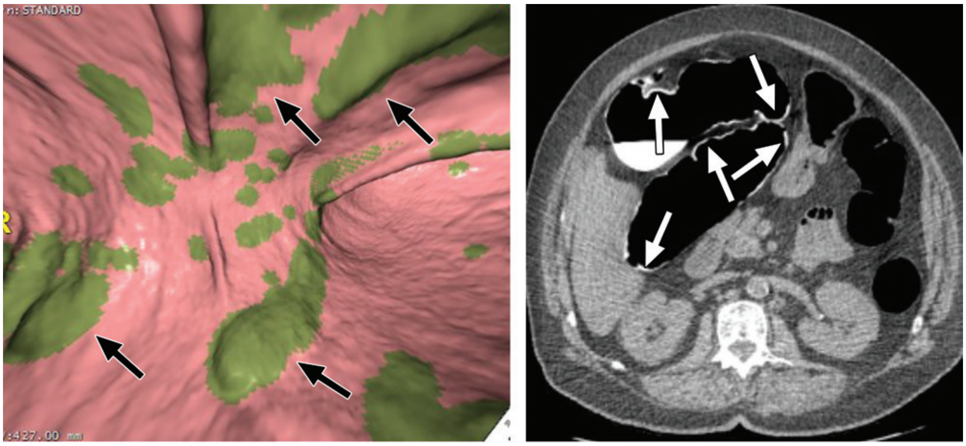


Figure 18. Fluid-filled lumen mimicking an obstructing stricture in the ascending colon. **(a)** Endoluminal 3D CT image has a blank appearance. **(b)** Axial 2D CT colonography image in the supine position shows the segment completely filled with tagged fluid. **(c, d)** Corresponding endoluminal 3D **(c)** and axial 2D **(d)** CT colonography images in the left decubitus position show a normal distended colon after the fluid has shifted.

Fluid-filled Lumen

Although a small amount of residual tagged fluid causing air-tagged fluid levels is expected at CT colonography, occasionally a large amount of fluid completely fills a colonic segment. When a portion of colon is completely opacified, 3D images will have a blank appearance, mimicking a tight stricture or obstructing mass. This can be disregarded when corresponding 2D images depict a fluid-filled colonic segment (Fig 18).

Changing the patient's position to shift the fluid out of the opacified segment allows successful visualization of the obscured segment. Having the patient evacuate immediately before performing CT colonography may help eliminate



a. b.

Figure 19. Sticky coat in the ascending colon. **(a)** Endoluminal 3D CT colonography image shows extensive spotty contrast material coating in green (arrows). **(b)** Axial 2D CT colonography image (soft-tissue window) shows nondependent diffuse prominent thin mucosal coating (arrows), which is most conspicuous with soft-tissue window settings.

some excess colonic fluid. If too much fluid refluxes into the rectal tube on insertion, the rectal tube can be used to drain some of the fluid and exchanged to avoid difficulty with CO_2 colonic insufflation caused by the water siphon phenomenon. The reason for the presence of a large amount of residual colonic fluid is unclear, but it may be related to the type of colonic preparation used for cleansing or excessive water intake late on the evening before CT colonography.

In cases of failed OC owing to a nearly obstructing colonic malignancy or benign stricture, there may be copious retained fluid proximal to the narrowed segment, which provides a challenge to CT colonography performed to clear the proximal colon. Although in some cases the fluid precludes successful colonic insufflation owing to the water siphon phenomenon and leads to a failed CT colonography, in most cases CT colonography is successful for confirming pathologic disease in the proximal colon and is useful before surgery.

Sticky Coat

Prominent coating of barium on the mucosal surface, referred to as *sticky coat*, blocks visualization of the colonic mucosa. On 2D images, it appears as a thin (<2 mm) mucosal coating of barium that is distinguished from contrast material etching by its larger area of distribution. On 3D images, it appears with a heavily spotted or patchy appearance with areas highlighted in green, reflecting mucosal areas obscured by the tagging agent. It is necessary to scrutinize 2D data with soft-tissue windows to optimize the detection of any focal soft-tissue thickening deep relative to the sticky coat (Fig 19).

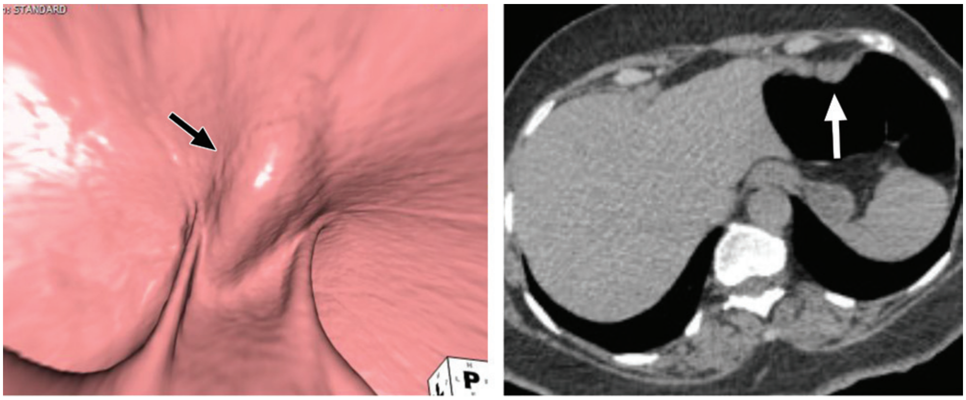
Sticky coat can occur when the patient erroneously reverses the order of ingestion of the tagging agents, taking the fluid tagging agent (eg, diatrizoate meglumine and diatrizoate sodium solution; Gastrografin, Bracco) before the fecal tagging agent (barium sulfate 2%) (9). Sticky coat has been shown to decrease when a lower quantity of barium is administered earlier in the day before the examination (29). Sticky coat can also occur in patients with dehydration in whom magnesium citrate bowel preparation fails to draw enough fluid into the colonic lumen, causing the barium to adhere to the bowel wall. The detection of contrast material–coated flat lesions is in particular precluded in these patients (18).

Extrinsic Mass Effect from Extracolonic Structures

Extracolonic structures can indent the colon, mimicking broad-based colonic lesions on 3D images. This can be caused by normal or pathologic structures, including muscles, gynecologic organs, liver, spleen, vessels, and other bowel loops. Extrinsic mass effect on the colon is reportedly more prominent in patients who are thin and in those with better colonic distention. Three-dimensional images reveal a smooth broad-based bumplike convexity. Similar to OC images, 3D CT colonography images cannot differentiate extrinsic mass effect from pathologic lesions arising in the bowel wall. However, 2D images easily resolve the origin of the bump depicted on 3D images by depicting the adjacent extrinsic structure and a broad smooth indentation of the outer colonic contour (6) (Fig 20).

Extrinsic Mass Effect from Submucosal Lesions

Submucosal colonic lesions include both intramural and extramural lesions that protrude into the lumen, mimicking mucosal polypoid lesions on



a. b.

Figure 20. Extrinsic mass effect from a prominent diaphragmatic muscle slip mimicking a sessile polyp in the transverse colon. Endoluminal 3D CT colonography image **(a)** shows a broad-based structure (arrow in **a**) suggestive of a submucosal lesion, which correlates with an extrinsic luminal bulge (arrow in **b**) owing to a diaphragmatic muscle slip on the axial 2D CT colonography image (soft-tissue window) **(b)**.

3D images. Lipoma is the most common intramural neoplasm visualized on CT colonography images, easily recognized on 2D images by its gross fat attenuation. Other intramural lesions include carcinoid tumor, lymphoma, metastases, and gastrointestinal stromal tumor. Extramural neoplasms that may invade the colon include peritoneal carcinomatosis, appendiceal tumors, and adjacent extracolonic malignancies. Although submucosal lesions mimic broad-based polypoid colonic lesions on 3D images, inspection of 2D images may help differentiate them from mucosal masses, particularly if the mass has an obvious extracolonic origin, such as in cases of peritoneal carcinomatosis. However, submucosal soft-tissue masses that project primarily into the colonic lumen may be indistinguishable from polyps at CT colonography and require OC and biopsy for diagnosis (27).

Pneumatosis Cystoides Coli

Pneumatosis cystoides coli is a relatively rare cause of a submucosal mass at CT colonography. It is characterized by multiple round gas-filled cysts in the colonic submucosa and/or subserosa, typically in the left colon (30). Pneumatosis cystoides can be idiopathic or associated with inflammatory bowel disease, lung diseases such as chronic obstructive pulmonary disease and cystic fibrosis, autoimmune diseases, and postinfectious or posttraumatic causes. Patients are usually asymptomatic.

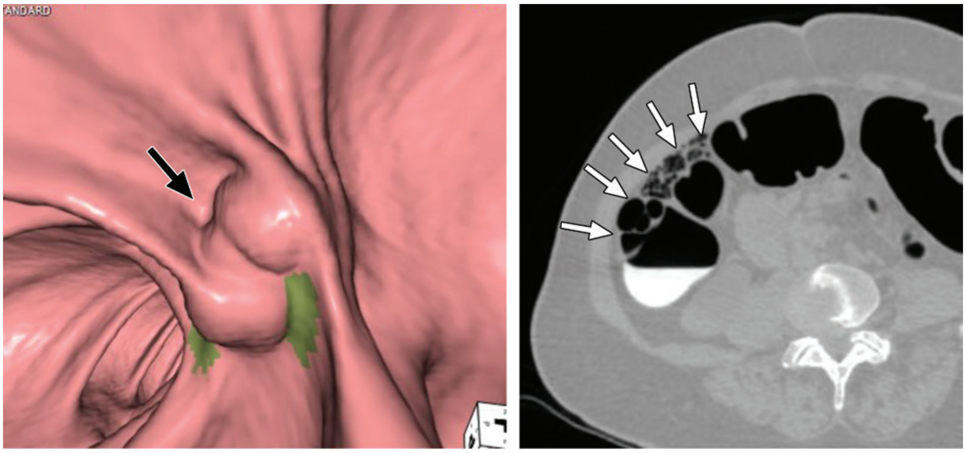
On 3D images, pneumatosis cystoides coli mimics multiple adjacent polyps (31). Visualization of gas within the polypoid structures allows the diagnosis to be made on corresponding 2D images. A wider colonic window may be needed to clearly demonstrate the gas as separate from the lumen (Fig 21). Pneumatosis cystoides coli should be differentiated from linear pneumatosis, which is associated with intestinal ischemia but has also been found to be a self-limited phenomenon in the right colon in up to 0.17% of CT colonography examinations performed by using automated CO_2 insufflation (32).

Colonic Diverticula

Impacted or inverted colonic diverticula can cause pseudolesions on 3D images, simulating polyps. Impacted diverticula are extremely common and usually multiple. They contain trapped stool that hardens into a fecalith and variably bulges into the colonic lumen. On 2D images, an impacted diverticulum has internal heterogeneous attenuation like that of stool, is usually hyperattenuating, and is often tagged with barium. The impacted stool will have a portion projecting beyond the outer colonic wall and a portion bowing into the colonic lumen. Oftentimes the part protruding in the colonic lumen has a sharp peaklike appearance on the 3D images rather than the rounded appearance of a polyp (Fig 22). An inverted diverticulum is rare. On 2D images, an inverted diverticulum will abut the inner colonic lumen and will not project beyond the outer colonic wall. Pericolic fat will often be visualized within its center (18).

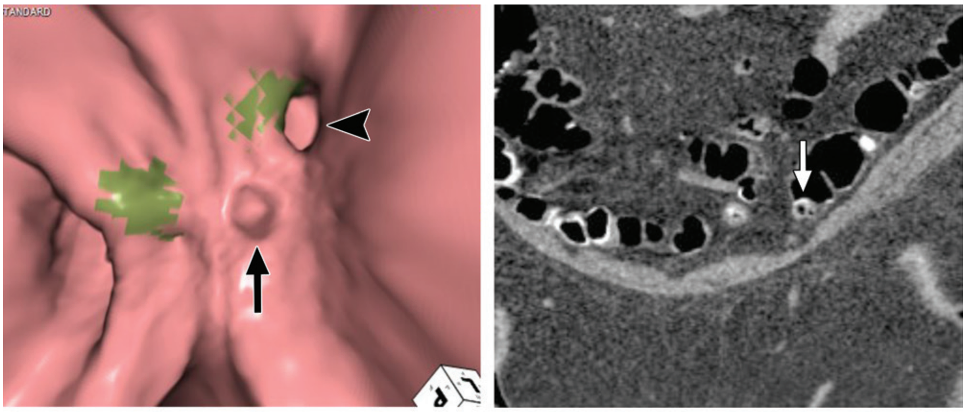
Prolapsing Mucosal Polyps

Prolapsing mucosal polyps are nonneoplastic lesions most often associated with diverticular disease, usually located in the sigmoid colon. They can cause abdominal pain or bleeding. As the affected colonic segment foreshortens owing to muscular hypertrophy, remaining redundant mucosa can prolapse into the colonic lumen, mimicking broad-based polyps on both 2D and 3D images (33). These lesions may be multiple or solitary and are variable in size, measuring up to



a. b.

Figure 21. Pneumatosis cystoides coli mimicking a polyp in the ascending colon. **(a)** Endoluminal 3D CT colonography image shows a bilobed polypoid structure (arrow). Green area = tagged fluid. **(b)** Axial 2D CT colonography image shows multiple round clustered gas-filled structures (arrows) within the colonic wall, which were visualized in retrospect at routine CT of the abdomen and pelvis 6 years earlier (not shown).



a. b.

Figure 22. Impacted diverticulum mimicking a polyp in the sigmoid. **(a)** Endoluminal 3D CT colonography image shows a peaklike broad-based polypoid structure (arrow) with a typical nearby diverticulum (arrowhead). Green areas = tagged fluid. **(b)** Coronal 2D CT colonography image shows a coated stool pellet (arow) partially bulging into the lumen and outside the colonic wall in the impacted diverticulum.

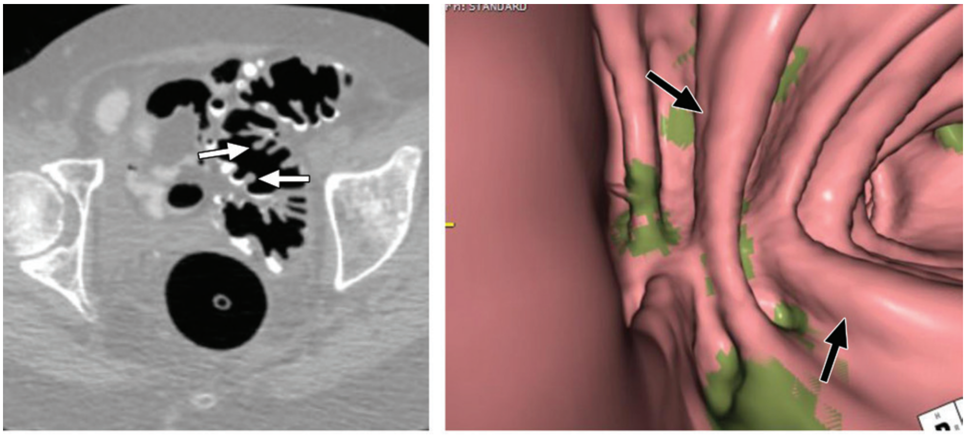
4 cm. Their appearance ranges from small well-circumscribed mucosal elevations, to asymmetrically swollen folds, and finally to frankly polypoid masses with broad bases. At OC, their surfaces are erythematous, in contrast to the surrounding mucosa (34).

Muscular Hypertrophy

Muscular hypertrophy, also known as myochosis, is a common cause of pseudolesions in patients with diverticulosis. Histologically, there is hypertrophy of myocytes in the circular and longitudinal muscle layers of the colon, with deposition of connective tissue (35). Muscular hypertrophy most commonly involves the sigmoid colon and causes regular segmental mural thickening and poor distensibility, along with diverticulosis. The semicircular folds become thickened and the interhaustral segments shortened, creating a zigzag or sawtooth appearance of the involved segment on 2D images where the folds may indent or nearly indent each other (33). These thickened folds mimic short tubular polypoid projections on 2D images. Correlation with findings on 3D images is necessary to confirm that these represent smooth enlarged semicircular folds (Fig 23). Evaluation of the involved segment can be improved with maximal distention, which is best achieved by placing the affected segment in the nondependent position and adding a few manual insufflations of the CO_2 bag attached to the insufflator.

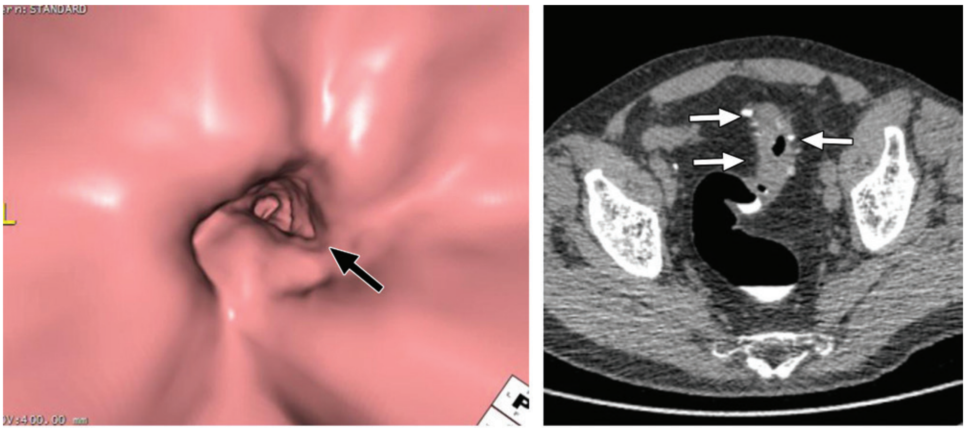
Diverticular Stricture

Diverticular strictures provide a technical and interpretative challenge at CT colonography and may simulate malignancy. In patients who can-



a. b.

Figure 23. Sigmoid muscular hypertrophy mimicking tubular polyps in the sigmoid colon. **(a)** Axial 2D CT colonography image shows a poorly distended colon with diverticula and multiple short tubular polypoid projections (sawtooth pattern) (arrows). **(b)** Endoluminal 3D CT colonography image shows that these projections correlate with smooth thickened folds (arrows), a finding consistent with muscular hypertrophy. Green areas = tagged fluid.



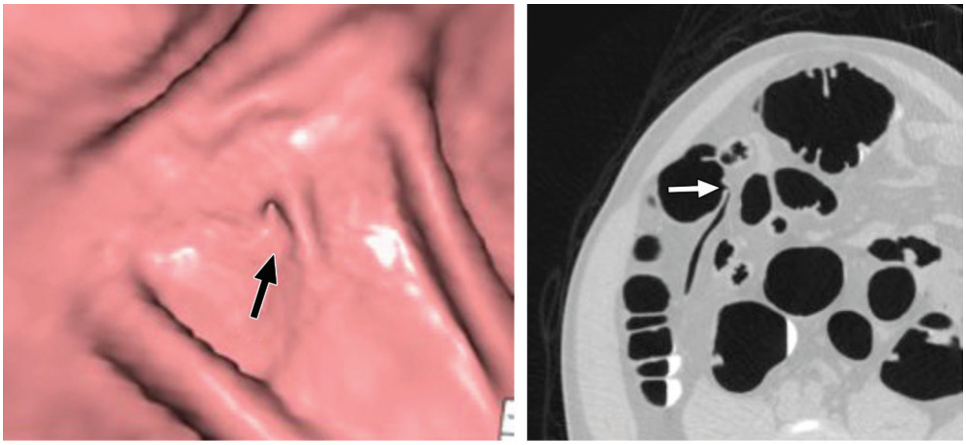
a. b.

Figure 24. Chronic diverticular stricture mimicking malignancy in a 79-year-old man who previously underwent a failed colonoscopy because the scope could not pass the sigmoid stricture. **(a)** Endoluminal 3D CT colonography image shows a smooth-bordered segment of sigmoidal narrowing (arrow) that precludes visualization of the mucosa. **(b)** Axial 2D CT colonography image (soft-tissue window) best shows the preservation of diverticula along the thick-walled segment, in which the curvature is preserved (between arrows). Note the absence of shouldering or lymphadenopathy.The sigmoid stricture was unchanged from its appearance at CT of the abdomen and pelvis performed 4 years earlier.

not undergo colonoscopy or in cases in which colonoscopy failed because of tight stricture, CT colonography is the nonoperative diagnostic option. Three-dimensional images are nearly always of no value when the stricture is severe because adequate mucosal visualization is precluded.

Findings on 2D images can mimic circumferential malignancy, but paying attention to imaging details can aid in the prediction of a diverticular stricture. Well-established 2D CT colonography findings that indicate a diverticular stricture are as follows: *(a)* the presence of diverticula in the affected segment, *(b)* involved segment length greater than 10 cm, *(c)* preserved mucosal folds, and *(d)* preserved sigmoid curvature. Two features strongly predicting malignancy are absence of diverticula in the affected segment and shouldering. Other imaging features favoring malignancy are as follows: *(a)* eccentric growth pattern, *(b)* straightened colonic growth pattern, *(c)* regional lymphadenopathy, *(d)* distorted mucosal folds, *(e)* shorter length, and *(f)* absence of fascial thickening (36) (Fig 24).

Maximal effort to distend the narrowed segment, including imaging in a third position, may be necessary to distinguish stricture from spasm. Inspection of the scout view before the examiniation and evaluation of the 3D transparency view of the colon can help identify the typical long-segment involvement of poorly distended sigmoid



a. b.

Figure 25. Appendiceal orifice mimicking a diverticulum in the cecum. **(a)** Endoluminal 3D CT colonography image shows a partial ringlike defect (arrow). **(b)** Axial 2D CT colonography image shows a V-shaped outpouching (arrow) that is continuous with the appendix.

colon with distorted and crowded folds depicted in a diverticular stricture. Comparison with prior CT or MRI examinations can help determine the stability of a masslike stricture and add confidence to the diagnosis of a diverticular stricture. Subsequent CT colonography with intravenous contrast material can be considered to demonstrate hyperenhancement or heterogeneous enhancement of colonic malignancy.

Appendiceal Orifice

The appendiceal orifice mimics a cecal diverticulum on 3D images, appearing as a well-defined complete or partial round dark ring, a V-shaped dark ring, or sometimes a slitlike incomplete dark ring at the cecal base. Two-dimensional images show the appendix or appendiceal stump tracking into it (Fig 25). Visualization of the appendiceal orifice can be anticipated on 3D fly-through views owing to its typical location in the cecum, a few centimeters distal to the ileocecal valve.

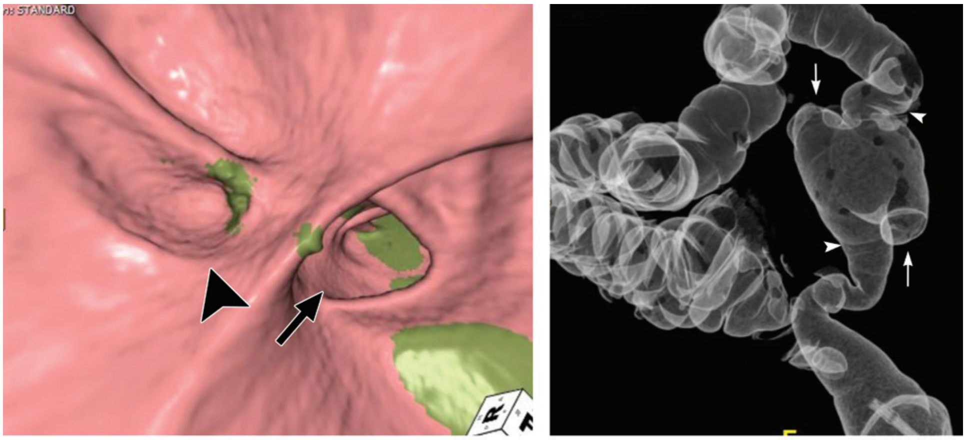
Appendiceal Stump Inversion and Appendiceal Intussusception

Appendiceal stump inversion can rarely occur after any type of appendectomy and is an expected finding after inversion-ligation appendectomy, a surgical procedure not commonly performed. An inverted appendiceal orifice or stump can mimic a cecal polyp on both 2D and 3D images. Stump inversion can be suggested by the typical location in the cecum, history of appendectomy or absence of the appendix after scrutiny of 2D multiplanar images, and internal fat attenuation in the polypoid defect on 2D images (36). Confirmation with OC and biopsy test results may be necessary, especially if the polypoid defect has homogeneous soft-tissue attenuation on 2D images. Obtaining prior surgical history as a standard practice before performing CT colonography can help the radiologist suggest this diagnosis (6,37).

Appendiceal intussusception, or spontaneous inversion, is extremely rare, with a reported incidence of 0.01%. It is more common in adults than in children and twice as common in women than in men. In adults, the most common cause is a pathologic lead point instead of an inflammatory lead point. Endometriosis is a commonly found lead point. Chronic abdominal symptoms that wax and wane over weeks to months is the most common presentation. Acute abdominal pain, nausea, and vomiting may occur, with some cases spontaneously reducing. The McSwain classification system describes five types of appendiceal intussusception, with variable starting points in the appendix. Appendiceal intussusception can extend for a variable length further into the colon (38), and the CT colonography appearance will vary according to the amount of appendix invaginating into the cecum. It can simulate a polyp on both 2D and 3D images. Fat within the bump of an inverted appendix on 2D images has been reported (39,40) and may be helpful in excluding a soft-tissue polyp.

Anastomosis

End-to-side or side-to-side anastomoses can cause pseudolesions on 3D images that appear as two large adjacent diverticula-like structures, which correspond to the orifices of each limb of the anastomosis. Stapled anastomoses can be identified on 2D images, providing a clue for diagnosis. In end-to-side anastomosis, this artifact often appears on the forward 3D fly-through view because there is often a "dog ear"



a. b.

Figure 26. Side-to-side anastomosis mimicking two adjacent diverticula-like structures after sigmoid colon resection. **(a)** Endoluminal CT colonography 3D image shows two adjacent large orifices, one representing the origin of an overhanging limb (dog ear sign) (arrowhead) and the other representing the orifice to the main colonic lumen (arrow). Green areas = tagged fluid. **(b)** CT colonography colon overlay image shows the pouchlike area of widening of an anastomosis, with a proximal and distal set of paired dog-ear signs (arrows). The colonic lumen proximal and distal to the anastomosis are indicated by the arrowheads.

sign of the sewn-off segment of distal colon to which the proximal colon attaches. In a side-to-side anastomosis, if prominent dog-ear signs are present, these paired pseudolesions will be depicted twice, once on the proximal anastomotic segment on the forward fly-through view and once on the distal anastomotic segment in the backward fly-through view. A 3D transparency colonic view and 2D multiplanar images are helpful and show the aberrant configuration of a colonic anastomosis (Fig 26). End-to-end anastomoses are not visible on 3D images and may only be identified on 2D images if a radiopaque staple line is present.

Hernia

A colon containing a hernia can cause pseudolesions and problems with insufflation at CT colonography. Hernias with large defects may not affect the colon if the CO_2-distended colonic segment in the hernia is not constricted. In hernias in which the dilated colonic segment contained in the hernia compresses the more proximal loop entering the hernia sac after initial insufflation, CO_2 may not be able to pass into the most proximal colon, preventing its distention. In such situations, it is helpful to manually reduce the hernia before CO_2 insufflation and maintain manual pressure during insufflation to achieve complete colonic distention before imaging.

When the hernia wall defect constricts the colon, pseudolesions depicted on 3D images are easily rectified with correlative 2D images. A Richter hernia with partial herniation of the ventral aspect of a colonic loop can appear as a rounded meniscus-shaped defect. In a narrow-necked hernia, two adjacent diverticula-like structures will be depicted that correspond to the bowel loops entering and exiting the hernia sac. In some hernias, the indentation of the colonic loop traveling through the abdominal wall defect may be unilateral and not concentric.

Segmental Mobility

Segmental colonic mobility can lead to false characterization of a polyp as mobile nontagged stool. The cecum, transverse colon, and sigmoid long mesentery allow them to rotate between different CT colonography positions (41). Cecal rotation is complex and occurs in multiple planes (42). Laks et al (43) found that 27% of polyps in a series of 41 patients moved from a ventral to a dorsal location between supine and prone positions (43). At opposite CT colonography positions, a polyp in the cecum, transverse colon, or sigmoid colon that appears to change position should not be hastily discounted as mobile stool because colonic mobility may be responsible for apparent position change. Awareness of colonic rotation and inspection of neighboring colonic landmarks such as diverticula, folds, the appendiceal orifice, and the ileocecal valve may help confirm the fixed position of a polyp (5). Inspection of 3D colon overview images in the subsequent position may help the radiologist appreciate the overall change in position of mobile or tortuous segments (Fig 27). Scrolling through multiplanar 2D images can help detect mobility; coronal plane 2D images are particularly useful in the identification of ascending colon mobility (42).

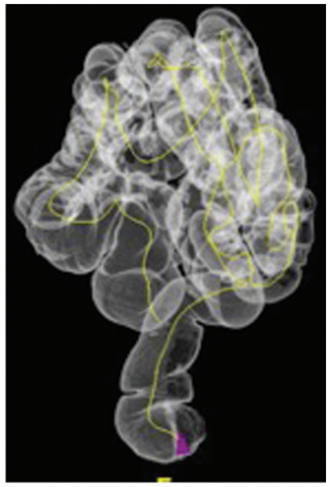
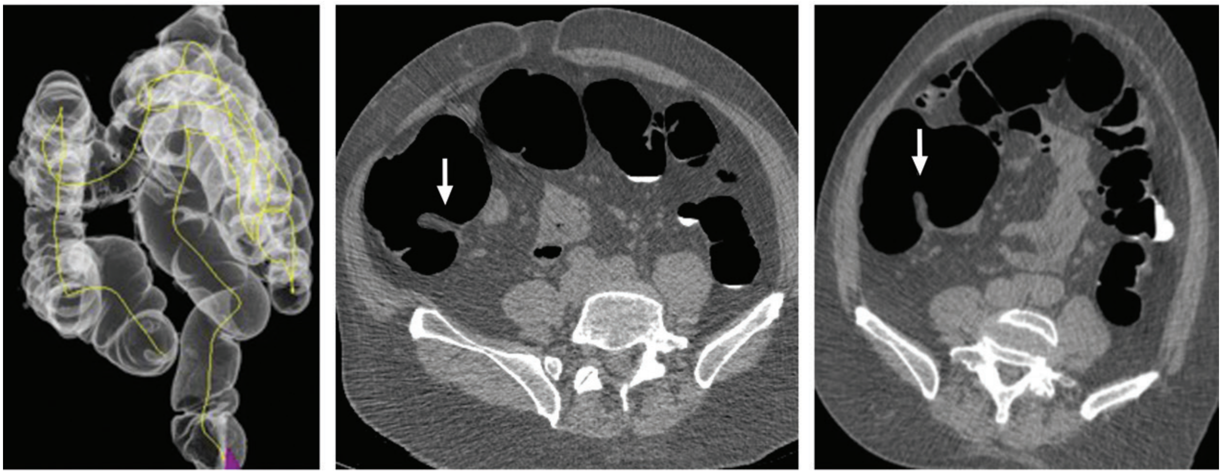

a.

Figure 27. Cecal mobility. **(a, b)** CT colonography colon overlay images show a subtle change in position of the cecum between the supine **(a)** and left lateral decubitus **(b)** positions, despite the apex being relatively unchanged. **(c, d)** Axial 2D CT colonography images show that the ileocecal valve (arrow) has undergone a shift in position from a more horizontal axis in the supine position **(c)** to a more vertical position in the decubitus position **(d)**.


b. c. d.

Occasionally, a polyp falsely appears to move in relation to a respective haustral fold in the following position, which is attributed to redundant mucosa sliding over the fold (18). Attention to this detail may help the radiologist avoid mistaking a polyp for nontagged stool.

Conclusion

CT colonography utilization as a screening and diagnostic imaging modality for colorectal cancer is likely to increase in the near future. Proficiency in CT colonography image interpretation requires prompt identification of artifacts and pseudolesions simulating or obscuring true pathologic diseases to avoid misdiagnosis and unnecessary subsequent workup. As CT colonography readers improve their pattern-recognition skills to identify these commonly visualized entities, they can more promptly and easily disregard them as nonpathologic findings. The Table and Table E1 summarize the artifacts, pseudolesions, and pitfalls discussed in this article and highlight the diagnostic clues to avoid and recognize them. A suggested reading list is provided in Appendix E1. It is important to understand the polyp and cancer impostors at CT colonography, examination pitfalls that can obscure pathologic conditions, and strategies for recognition and prevention.

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Errata

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CT Colonography: Improving Interpretive Skill by Avoiding Pitfalls
Zina J. Ricci, Fernanda S. Mazzariol, Mariya Kobi, Milana Flusberg, Melanie Moses, Judy Yee

Erratum in:
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Page 106, Figure 10b: The arrow in Figure 10b was positioned incorrectly. Figure 10b is reprinted correctly here.

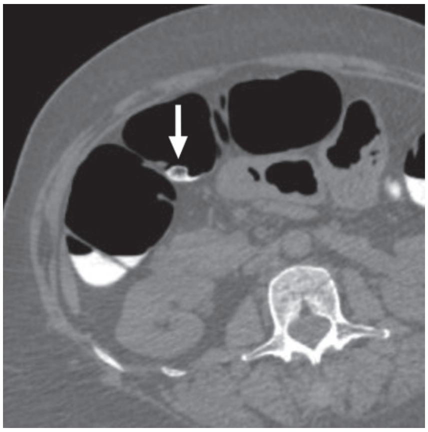

Figure 10. Retained stool mimicking a polyp. **(b)** Axial 2D CT colonography image (soft-tissue window) with the patient in the supine position shows the structure with internal heterogeneous low attenuation (arrow). The stool pellet moves into a dependent location in the right lateral decubitus position (not shown).

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Myra K. Feldman, Sara A. Hunter, Uma C. Perni, Peter Liu, Cristiano Quintini, Andreas G. Tzakis, Rebecca Flyckt

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Page 294, third paragraph: The first sentence should read as follows: "The first UT in the United States was performed at the Cleveland Clinic in February **2016**."