CT colonography: Why? When? How?

C. Ridereau-Zins\textsuperscript{a,}\textsuperscript{*}, F. Pilleul\textsuperscript{b}, Y. Gandon\textsuperscript{c}, V. Laurent\textsuperscript{d,e}, la Société d’imagerie abdominale et digestive (SIAD)\textsuperscript{1}

\textsuperscript{a} Department of Radiology, CHU, 4, rue Larrey, 49933 Angers cedex 9, France
\textsuperscript{b} Gastrointestinal Radiology Unit, CHU Édouard-Herriot, hospices civils de Lyon, 69003 Lyon, France
\textsuperscript{c} Department of Radiology, hôpital Ponchaillou, CHU de Rennes, 2, rue Henri-Le-Guilloux, 35033 Rennes cedex 9, France
\textsuperscript{d} Adult Radiology Unit, hôpitaux de Brabois, CHU de Nancy, 54500 Vandœuvre-lès-Nancy, France
\textsuperscript{e} Inserm U947, Adaptive, Diagnostic and Interventional Imaging Laboratory, université de Lorraine, hôpitaux de Brabois, 54500 Vandœuvre-lès-Nancy, France

KEYWORDS
Colon polyps; Colon cancer; Water enema colonography; Virtual colonoscopy

Abstract Although optical colonoscopy is still the gold standard for diseases of the colon, radiologic examination of the colon is now being performed by CT scan. Evaluation of the colon is enhanced by distension, which “de-folds” the intestinal wall, thus facilitating its examination for abnormalities of the mucosa, the wall as a whole, and the diameter of the bowel lumen. Water or gas (CO\textsubscript{2}) may be used for the distension, depending on the suspected lesions. The water enema method of colonography combines filling the bowel lumen with water and intravenous injection of a contrast medium. It is indicated when there is a clinical suspicion of colon cancer, for initial discovery of liver metastases, and for staging of colon tumors. This technique, which requires little or no colon cleansing preparation, can be performed with no special equipment and has a short learning curve. The gas enema method of colonography, or virtual colonoscopy, is performed by distending the colon with CO\textsubscript{2}, without any intravenous injection of contrast medium. Its purpose is to detect polyps as part of a screening for pre-cancerous growths. This technique, which does require bowel cleansing preparation, uses a dedicated console for reading and requires specific training.

© 2011 Éditions françaises de radiologie. Published by Elsevier Masson SAS. All rights reserved.

* Corresponding author.
\textit{E-mail address: caridereauzins@chu-angers.fr} (C. Ridereau-Zins).

\textsuperscript{1} Société d’imagerie abdominale et digestive : siad@sfradiologie.org.
**Introduction**

The term "colonography" encompasses two CT techniques for examining the colon. While both are based on distension of the colon for examination of the lumen and wall of the bowel, each has a different technique and indications (Table 1).

The first technique is the water enema method of colonography; this combines filling the bowel lumen with water and intravenous injection of a contrast medium. This is an oncological tool, indicated when there is a clinical suspicion of colon cancer, or for initial CT discovery of liver metastases, or for staging of colon tumors.

The second technique is the gas enema method of colonography, also called virtual colonoscopy. It is performed by expanding the colon with air or CO₂ and is done without injection of intravenous contrast medium. Its purpose is to detect polyps as part of a screening for precancerous growths.

As a colorectal cancer screening program is now being implemented at the national level, it is important to be aware of these specific colon examination techniques and to understand their respective issues.

We have deliberately excluded emergency situations and perioperative periods, which have an entirely different set of problems. The colon can be examined with no particular preparation, or an iodinated contrast medium can be swallowed in order to reveal a fistula.

**Water enema colonography**

**Objective**

The purpose of this technique is to diagnose and assess colon cancer. This makes it possible to clarify its topography within the bowel, to determine its size and extent, and to find secondary tumors (hepatic, lymph node, mesenteric, and pulmonary).

**Patient preparation**

The preparation of the bowel consists only of a distal cleansing enema (such as Microlax®) 1 hour before the procedure, for greater patient comfort. Since the presence of residual fecal matter does not interfere with interpretation of the study, it can perfectly well be performed on a non-prepared patient.

**Technique**

The study begins by inserting a balloon enema nozzle, inflated based on the patient’s anal continence (usually with 20 to 50 mL of water). For incontinent elderly patients, using a flexible plastic basin can prevent leaks on the CT scanner table. The nozzle is connected with a tube to an enema bag containing 2 liters of warm water, and placed in an elevated position (Fig. 1).

Debridat® (two ampoules in 50 mL of normal saline infused a few minutes before distension of the colon) or Spasfon Lyoc® (1–2 sublingual tablets) can be used to prevent bowel spasms during the procedure.

Acquisition in spontaneous contrast and low dose mode is usually done to verify the absence of extensive fecal obstruction and to examine the liver prior to injection. The enema flows rapidly (3 minutes), while the patient lies still in a supine position. A second acquisition is performed after intravenous injection of iodinated contrast medium (120 mL at a flow rate of 3 mL/sec) during the portal phase (70–80 seconds after the start of the injection).

The enema is then immediately evacuated by lowering the enema bag.

The total duration of the procedure is 10 minutes. When a tumor is found, a chest examination must be done during the same procedure.

**Contraindications**

The major contraindication is intestinal obstruction syndrome. A history of severe allergy to iodinated contrast

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Indications, preparations, and techniques for the two types of colonography.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>CO₂</td>
</tr>
</tbody>
</table>
| Clinical indications | Symptomatic patients  
Suspicion of colon cancer (anemia; rectorrhagia; impaired motility; deterioration of general condition; initial liver metastases)  
Asymptomatic patients  
Screening for polyps  
(failure of colonoscopy, incomplete colonoscopy, or refusal of optical colonoscopy) |
| Patient preparation | No  
Or Microlax®  
Yes  
Colon cleansing and fecal tagging |
| Antiperistaltic agents | Yes  
On demand |
| IV injection of contrast medium | Yes  
Possible without IV  
No |
| Patient mobilization | No  
Yes |
| Number of acquisitions | 2  
2 |
| Post-treatment | Standard CT console  
2D, MPR  
Dedicated console  
2D MPR, 3D, CAD |
media and renal failure are limiting factors. However, examination by filling the colon with water, without any intravenous injection of contrast medium may be sufficient, since the bowel wall is spontaneously hyperdense relative to the water content. However, the performance of this technique has not been evaluated.

Bowel incontinence can complicate the procedure, but that is offset by good inflation of the rectal nozzle balloon and fast performance of the procedure.

Results

The results are read on a “standard” CT console with no need for specific software. The learning curve is short for reading and semiology.

In its normal state, the colon wall appears in the form of a fine line measuring less than 3 mm in thickness, homogeneously enhanced in the portal phase. The haustra and folds are quite distinct, easily followed on the axial slices and in multiplanar reconstruction (Fig. 2).

A bowel lesion causes local parietal thickening that is clearly and heterogeneously enhanced after intravenous injection of contrast medium. The lesion may be budding, projecting into the bowel lumen, or infiltrative, and more or less circumferential. It may or may not be associated with stenosis of the bowel lumen and infiltration of the adjacent fat [1–3]. Its size and location in the colon can be determined, as well as any involvement of an organ in the abdominal cavity (Figs. 3 and 4).
Performance and indications

The performance of this diagnostic procedure for colon cancer was validated by two studies, including a prospective study that reported a 98.6% sensitivity and a 99.1% negative predictive value [4,5]. Good patient tolerance and a short learning curve for reading the test were also reported.

The current indications are: diagnosis of colon cancer when bowel symptoms are present (recent impaired motility, abdominal cramps, rectorrhagia), after an incomplete colonoscopy, or where colonoscopy is contraindicated; initial discovery of liver metastases on the CT scan (during an abdominal study performed for another reason); elderly or vulnerable patients with bowel symptoms.

The gas enema colonography or virtual colonoscopy

Objective

The purpose of this procedure is to detect polyps and precancerous growths requiring subsequent resection by optical colonoscopy.

Patient preparation

Good colon cleansing preparation is crucial and is as taxing as for an optical colonoscopy. It includes a low-residue diet.

Figure 3. Example of a colon tumor during water enema colonography. The growth (white arrow) is budding and projects into the bowel lumen. Its location in the left colon is seen on the axial slice (a) and coronal reconstruction (b). The adjacent fat is not infiltrated. This is a case of adenocarcinoma (pT3). Note the presence of fecal matter (white arrow), easily recognized by its air content.

Figure 4. Example of a colon tumor during water enema colonography. The tumor growth (white arrow) causes heterogeneous thickening of the colon wall; its circumferential nature is well visualized on the axial slice (a). Its cecal location is seen on the coronal reconstruction (b). Its stenosing nature is clear on the sagittal reconstruction (c). There is infiltration of the adjacent fat. Note the existence of a liver metastasis (black arrow).
(started 2 days before the test) and a laxative purge the day before (Phosphosoda, or PEG for heart or kidney failure patients) followed by a Dulcolax® suppository the morning of the procedure.

Residue tagging is combined with this bowel preparation the day before the procedure: by swallowing a barium contrast medium (Micropaque®) for fecal tagging and an iodated contrast medium (Telebrix Gastro®) for tagging of liquid residue.

**Technique**

Distension of the colon, initially recommended to be performed with air, is currently being done with a CO₂ insufflator, which makes it possible to fully control the insufflation pressure, practically eliminating the risk of perforation. Quickly absorbed by the mucosa of the bowel, CO₂ provides painless distension and rapid “deflation” of the colon at the end of the procedure. The distension should reach the cecum; it is verified in CT scout mode (Fig. 5a, b).

Two acquisitions are performed, one in prone position and one in supine position, to mobilize the residues. If it is impossible to place the patient in prone position, these series should be replaced by examination in left and right lateral decubitus position [6].

The acquisitions are performed at low dose without intravenous injection of contrast medium.

Antispasmodics (Spasfon Lyoc® or Debridat®) are not routinely administered, but given on demand.

**Contraindications**

Contraindications are intestinal obstruction syndrome, acute abdomen syndrome, recent abdominal surgery, and pregnancy.

Difficulties insufflating the colon or positioning the patient may be encountered with obese patients.

**Results**

Interpretation is done using specific dedicated software. The use of this software and semilogic interpretation require a relatively long learning curve. The images are analyzed in 2D, in supine and prone position, with two appropriate windows: abdominal (Fig. 6a) and pulmonary (Fig. 6b), and in 3D. This 3D analysis can be done in endoluminal or fly-through navigation in the lumen after the central path of the colon is defined (Fig. 7) or by colon “stretching” (Fig. 8).

Each detected abnormality is thus examined in different views and described by its shape (sessile, pedunculated, flat with or without depression of the surface, irregular, stenosing), size, density, and location (colon segment and distance from the anal margin). A search for extracolonic growths (bladder, kidneys, aorta, etc.) is routinely done, but is limited when there is no intravenous injection of contrast medium.

**Performance and indications**

The metaanalysis by Steve Halligan et al. [7] reviewed all studies involving virtual colonoscopy from 1996 to 2003, and retained only those studies that met strict criteria: same bowel preparation as for colonoscopy, double acquisition in prone and supine position, and use of spiral CT scanners, taking into account the experience of the surgeon. One thousand three hundred and ninety-eight references were found, but only 24 studies had the required essential criteria. For polyps larger than 1 cm in size, the results show high sensitivity (93%) and specificity (97%). For polyps measuring 6 mm to 1 cm, there was good sensitivity (86%), but variable specificity with a mean of 86% and range of 55–100%. For polyps smaller than 6 mm in size, the results are very variable for sensitivity (45–97%) and specificity (26–97%).

After in-depth training, this technique may be considered to have a performance level for screening of polyps compa-
Virtual colonoscopy: Why? When? How?

CT colonography: Why? When? How?

**Figure 6.** Virtual colonoscopy: analysis of native slices. Analysis of colon in abdominal window (a) and pulmonary window (b).

**Figure 7.** Virtual colonoscopy, 3D analysis: endoluminal fly-through mode: virtual CT.

Virtual colonoscopy is recommended in the United States for first-line screening in high- and medium-risk patients. Only patients with one or more polyps measuring more than 9 mm detected by that procedure are referred for optical colonoscopy. In this strategy, polyps measuring less than 6 mm are deliberately disregarded, while for polyps measuring 6—9 mm, the patient has the choice between monitoring with future colonography procedures or undergoing colonoscopy to remove the polyps [9—14].

These data have been confirmed by a French multicenter study (STIC-2005), sponsored by the Institut national du cancer (INCa), the Société française d’endoscopie digestive (SFED), and the Société française de radiologie (SFR), which included 845 patients at 26 centers, and found that performance for the detection of polyps measuring more than 6 mm depended primarily on the experience of the radiologist. This was 72% for the most experienced radiologists and only 51% for the radiologists least seasoned in this technique [8].

Virtual colonoscopy is recommended in the United States for first-line screening in high- and medium-risk patients. Only patients with one or more polyps measuring more than 9 mm detected by that procedure are referred for optical colonoscopy. In this strategy, polyps measuring less than 6 mm are deliberately disregarded, while for polyps measuring 6—9 mm, the patient has the choice between monitoring with future colonography procedures or undergoing colonoscopy to remove the polyps [9—14].

Virtual colonoscopy is recommended in the United States for first-line screening in high- and medium-risk patients. Only patients with one or more polyps measuring more than 9 mm detected by that procedure are referred for optical colonoscopy. In this strategy, polyps measuring less than 6 mm are deliberately disregarded, while for polyps measuring 6—9 mm, the patient has the choice between monitoring with future colonography procedures or undergoing colonoscopy to remove the polyps [9—14].

Virtual colonoscopy is recommended in the United States for first-line screening in high- and medium-risk patients. Only patients with one or more polyps measuring more than 9 mm detected by that procedure are referred for optical colonoscopy. In this strategy, polyps measuring less than 6 mm are deliberately disregarded, while for polyps measuring 6—9 mm, the patient has the choice between monitoring with future colonography procedures or undergoing colonoscopy to remove the polyps [9—14].
In France, this screening strategy has not been validated and, while awaiting an update of the Haute Autorité de Santé (HAS) recommendations, the attitude advocated by the learned societies is as follows: The Hemocult® is still used for (medium risk) population screening. Optical or virtual colonoscopy is not justified as an alternative. In high-risk patients, colonoscopy remains the first-line gold standard technique. However, after being fully informed, if a person at high risk or with a positive stool refuses colonoscopy, it is important that he/she be offered an effective alternative such as virtual colonoscopy, as recommended by the HAS. In addition, virtual colonoscopy is indicated in case optical colonoscopy fails or is contraindicated (HAS metaanalysis, January 2010) [14].

In daily practice

What should the radiologist do when asked to examine a colon (other than in emergency or perioperative situations)?

The first part of the answer is to choose the CT scan as the examination method, since it analyzes the colon as a whole (wall, lumen, paracolic space) and in all spatial planes. In addition, the entire peritoneal cavity can be examined.

The second part of the answer concerns what CT technique to use: water enema colonography or virtual colonoscopy? It depends on the suspected lesion – cancer or polyp?

In two common clinical situations, the choice is simple:

- when there are clinical gastrointestinal signs (recent change in motility, rectorrhagia), possibly associated with a change in general health or with hepatic metastases leading to a suspicion of colon cancer: water enema colonography should be performed;
- when the test is requested for screening and a colonoscopy performed for that purpose was incomplete or refused by the patient: virtual colonoscopy should be performed.

Other circumstances are less straightforward, such as those involving:

- patients over 75 years of age, with no clear gastrointestinal signs, possibly with unexplained iron-deficiency anemia, for whom the clinician requests a colon study “on principle” to rule out cancer; the procedure to perform is water enema colonography. In case of renal failure, the procedure can be performed without intravenous injection of iodinated contrast medium, with rectal water filling;
- patients with rectal cancer after an incomplete colonoscopy: water enema colonoscopy should be performed for thoracoabdominal staging, in order to find any colon metastases that could affect the subsequent surgical procedure. Any associated polyps are screened and resected during postoperative follow-up colonoscopies;
- patients with colon cancer diagnosed by colonoscopy: water enema colonoscopy could be systematically performed for routine CT staging in order to determine the location of the cancer (potentially imperfect localization with colonoscopy);
- “moderately elderly” patients (age 65–75) with no gastrointestinal signs but with a family or personal history of polyps or cancer, who do not or no longer want to undergo a screening colonoscopy: virtual colonoscopy can be suggested;
- patients scheduled for an organ transplant: these usually undergo a complete CT examination for tumors prior to immunosuppressant therapy. The CT examination could include a (simultaneous) virtual colonoscopy to look for polyps.

Conclusion

Colonography is a specific CT scan of the colon. It is recommended in either of two different modes depending on the clinical context: the water method in an oncological context and the gas method in a screening context. The choice of which of the two techniques to use depends on the indication for the study, i.e., the type of suspected lesion. The procedure is performed by a radiologist, but the clinician must understand it. In fact, clinician awareness of the diagnostic possibilities of these two colonography techniques is the best guarantee of sound management.

Although the patient preparation, the practical techniques, and the reading learning curve are different for the two procedures, they have in common that they have definitively replaced the barium enema for investigation of colon tumor disease.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


