Virtual CT Colonography: Technique and findings: Single Institute experience.

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Background

Colorectal cancer is the second leading cause of death due to malignancy in industrialized counties. It is argued that most large bowel malignancies arise from preexisting adenormas. Computed tomographic (CT) colonography is a noninvasive, rapidly evolving technique that has been shown in some studies to be comparable with conventional colonoscopy for the screening of colorectal cancer. However, widespread colorectal screening and preventive efforts aimed at detecting disease in this early stage are opposed by several practical obstacles, including limited resources, and poor patient acceptance and therefore poor compliance (1-2).
Patients and methods

Introduction

tomographic colonography (CTC) is an efficient technique for the evaluation of the entire colon. It has an upper hand over conventional colonoscopy because of its minimally invasive nature and no need for sedation and recovery time. The examination is based on a helical, thin-section CT of the cleansed and distended colon. Data evaluation is performed with commercially available CT colonography post-processing software with simultaneously available multiplanar 2D and virtual endoscopic 3D image displays (3). CTC has high sensitivity in high risk populations, with a sensitivity greater than 90% for polyps ≥10 mm. Results in the Computed low prevalence population were more heterogeneous and less impressive (34–93.8%). This wide range of results is likely caused by differences in patient selection, examination and evaluation techniques, and reader experience (3).

Aim of the work:

To express our experience in performing CT colonography to increase accuracy of results and to avoid pitfalls as much as possible.

TECHNIQUE OF CT COLONOGRAPHY

Indications

Currently, there are several indications where CT colonography may play an important role in patient care. These include:

1-Clinical indications:

A- Patients with positive symptoms and signs of colorectal cancer (4);

- Change in bowel habits such as persistent diarrhea, constipation, melena, or mucous in stools, that lasts for more than a few days.
- Feeling that the bowel has not completely emptied.
- Rectal bleeding, dark stools, or blood in the stool.
- Cramping or abdominal (belly) pain.
- Weakness and fatigue.
- Unintended weight loss.
- Abdominal mass.

The authors suggested that CTC may be a valuable tool for the rapid evaluation of symptomatic patients.

B- Local staging of tumors (T3, T4 stages) because of its high spatial resolution and excellent depiction of the colonic wall, as well as adjacent pericolonic fat.

C- The most widely accepted clinical indication is incomplete or failed colonoscopy.

The CTC examination can be performed on the same day directly after conventional colonoscopy, and thus, no additional bowel preparation is needed. It can also analyze the cause of incomplete endoscopy as those with a history of incomplete colonoscopy are at a higher risk for failure of a second attempt. (5).

D- Patients at increased risk for endoscopy or sedation (generally elderly, immobile patients who are symptomatic), or patients who refuse endoscopy because of fears or prior negative experiences.

E- The search for a primary neoplasm in patients with widespread metastatic disease. For these purposes, it should be recognized that CT colonography is a superior test for colorectal polyp and cancer detection, when compared with colonoscopy. **(6).**

F- Post-surgical conditions in the colon, Contrast-enhanced CT colonography is used for routine surveillance to detect local recurrence, metachronous disease, and distant metastases in patients with a history of invasive colorectal cancer **(6).**

G- CTC may also be used to evaluate known diseased patients as evaluation of a colonic mass size, extent and invasion. Diverticular disease is a common colonic disorder and often leads to diverticulitis. CTC is not only helpful in the assessment of the lumen and the extent of diverticulosis, but also for any extramural changes in cases with the chronic stenotic stages of diverticulits **(7).**

1-Colorectal cancer screening

In contrast to symptomatic patients, CTC is also considered a potential screening tool for colorectal neoplasia in asymptomatic high- and average-risk patients. The goal of colorectal cancer screening is a reduction in the morbidity and the mortality associated with colorectal cancer through early detection and resection of adenomas and cancer.

Contraindications:

Contraindications to CTC include acute abdominal pain, recent abdominal or pelvic surgery, abdominal wall hernia with entrapment of colonic loops, and acute inflammatory conditions, such as acute diverticulitis, acute active stage of ulcerative colitis or Crohn's disease, and toxic megacolon. In these conditions, insufflation of the colon can lead to perforation and widespread peritonitis. In addition, there are also general CT contraindications that matter in CTC as well, such as weight and girth limitations of the scanner, artifacts from metal prosthesis, pregnancy, and patients with claustrophobia **(8).**

CTC is not a preferred test in younger people, particularly less than 40 years of age, because of the radiation used in the procedure

Pitfalls:

Artifacts may be present in the technique and results in false positive or false negative results. The artifacts are caused by reconstruction errors if patient moved during the scan resulting in artifacts that mistaken as polyps. In addition virtual dissection images may misses small lesions as small polyps. **(9)**.

As for conventional colonoscopy, CT virtual colonography needs good patient preparation as small hard fecal residue may resemble small polyps. Also fecal fluid content will prevents 3D reconstruction of the entire colon and as a results it affects the sensitivity of the technique and obscures small polyps and diverticulae.

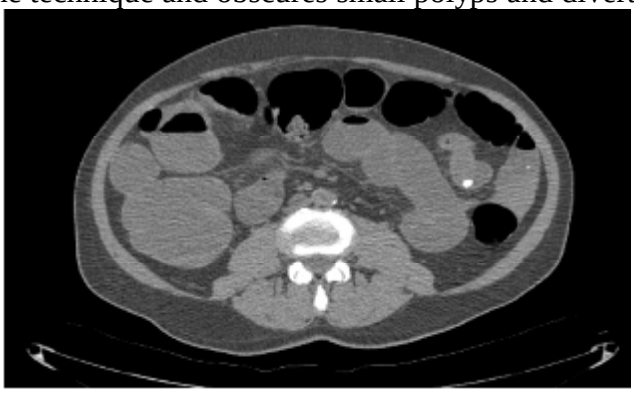


Fig 1. Inadequate patient preparation prevents good analysis of the ascending colon.

Difficulties

1- One of the greatest difficulties that challenges the CT virtual colonography assessment is unprepared patient. As the fecal matter prevents visualization of small lesions and increases the possibilities of false positive results (Fig. 1).

2- Using combined supine and prone technique during virtual colonography improves the sensitivity of polyp detection, yet it doubles the radiation dose to the patient which is already high as we use a small slice thickness. **Rogalla et al.,** suggests that axial supine CT images of the patient to be reviewed while the patient is still on the table and then applying the decision on additional prone position scans if needed.

3- Performing the examination without sedation and colonic inflation with room air prior to CT scanning causes transient abdominal discomfort, which is usually relieved soon after the procedure. Colon inflation with CO2, which is more rapidly absorbed than air, might improve the discomfort associated with inflation.

4- Sensitivity of CT colonography decreases considerably in diagnosis of flat lesions and ulcers. **Pickhardt et al.,** demonstrated that VC detected 83% of flat adenomas and 80% of all flat lesions 6 mm or greater. However flat lesions less than 6mm are highly difficult to detect.

Steps of CT colonography technique:

CT colonography is based on a helical, thin-section CT of the cleansed and distended colon. The examination consists of three major steps: patient preparation, including cathartic cleansing and distention of the bowel; data acquisition with MDCT; and data evaluation.

1- Bowel preparation:

The key factor of excellent CT colonography examination outcome is a well prepared clean, and well-distended colon. Residual stool and fluid may lead to a false-negative or false-positive diagnosis. Patients usually follow a clear liquid diet starting about 24 h prior to the examination. Cathartic cleansing is usually performed by oral administration of laxatives. Various commercially offered bowel preparations are

options, including cathartics, such as magnesium citrate (LoSo Preparation, EZ-Em Inc, Westbury, USA) and phosphosoda (Fleet Pharmaceuticals, Lynchburg, VA), and colonic lavage solutions, such as polyethylene glycol (PEG). Radiologists generally need a dry colon because of the inability to aspirate residual fluid during the examination.

It has been noticed that laxatives (as magnesium citrate) result in an adequately prepared and dry colon for most of patients whereas rectal enema preparations frequently leave significant amounts of residual fluid in the colon. Therefore, though rectal enema is commonly prescribed for lower endoscopy, it should be avoided while preparing for CT cholonography.

Although many institutions apply fecal tagging with oral contrast agents, our trials have revealed that oral contrast gave unsatisfactory results as the non-concentrated contrast added to the obscurity of the residual fecal matter and prevented the required virtual reconstruction. Thus, we gained better results without oral contrast intake.

2- Bowel distention:

Optimal colonic distention is a fundamental prerequisite for CTC data evaluation that allows intraluminal evaluation of the large bowel. Under-distended or collapsed segments may hide intraluminal lesions.

Before beginning bowel distention, patients should be advised to empty their rectum. Bowel distention is performed in the left decubitus or supine position with a thin, flexible rubber catheter placed in the rectum (e.g., thin plastic or rubber 14F rectal tube, small gauge Foley catheter). For bowel distention, either room air or carbon dioxide (CO2) can be used. Some authors argue that CO2 is superior to air, largely based on colonoscopy and the barium enema literature, which suggests that it causes less discomfort because of its rapid mucosal absorption. The amount of gas required to distend the colon is usually about 1 L of room air (15-20 50cc syringe). However, fixed gas amounts may be impractical because of different colonic volumes, so gentle insufflation is continuous until the patient feels uncomfortable or bloated. After distention is completed, a CT scout view of the abdomen is obtained to ensure optimal colonic distention and to add additional gas if collapsed segments are identified. Following the supine axial image acquisition, the patient is turned to the prone position. Before prone image acquisition, another scout scan is obtained with additional gaseous insufflations if needed.

The intravenous administration of antispasmodic agents may improve colonic distention and reduce spasms. However, IV spasmolytics should not be administered routinely, but can be used if patients experience pain, discomfort, or spasm.

Bowel distention may lead to perforation of the bowel in rare cases. In most of the reported cases, perforation occurred in symptomatic patients with acute inflammatory or stenotic colons, the bowel distention was performed manually, and rectal balloon catheters were used (8).

3- CT scanning:

CT scanning is ideally performed on an MDCT scanner in both the supine and then the prone positions with a thin collimation. MDCT has several technical advantages over single-detector-row CT, including faster imaging times and acquisition of multiple thin sections with nearly isotropic voxels. The higher speed and spatial resolution of MDCT should offer improved sensitivity and specificity for CTC compared to single-detector CT. As mentioned before, acquisition of an initial scout view before each scan helps to ensure adequate distention of the colonic segments with additional CO2 or room air being insufflated, if required. The use of both the supine and prone CT datasets helps to differentiate mobile stool from fixed pathology,

such as polyps or cancers, allows more even distention of the colon because of gas redistribution, and improves visualization of segments of the colon that may be obscured by intraluminal fluid. To avoid breathing artifacts, which are more prominent in the upper abdomen, scanning is performed in the cephalo-caudal direction (12).

Thin sections are a prerequisite for high-quality multi-planar reformations (MPR) and 3D reconstructions. As recommended by a recently published consensus statement, collimation should not exceed 3mm when using MDCT. However, with 16-row and 64-row MDCT, thinner, sub-millimeter, collimations are preferable (13).

One of the major limitations of CTC is the relatively high radiation exposure, and therefore, increasing attention has been focused on low-dose protocols. Because a thin collimation is necessary for CTC, dose reduction is widely achieved by reducing the milliampere-seconds level. A recent MDCTC study showed excellent results for the detection of polyps >10 mm, with thin beam collimation and an effective 50 mAs. Generally useful exposure settings are 120 kVp and 50–100 mAs in the prone and in the supine positions. (14).

Contrast media:

Intrinsic colonic lesions and extra-colonic pathology can be enhanced by IV injection of iodine contrast media (IV CM) in the second scan. Previous studies have shown contrast media to be of benefit in cases with clinical indications, such as in patients with symptoms of colorectal cancer, or to detect local recurrence, metachronous disease, or distant metastasis in patients with prior colorectal cancer. However, because of the increased cost, the need for intravenous access, and the risk of allergic anaphylactic reactions the application of IV contrast media might be contraindicated in a screening population and limited to clinical indications (15).

Data analysis

Image processing and interpretation is performed on a commercially available computer workstation equipped with dedicated CT colonography software. In addition to 2D axial and multiplanar reformations in a cine mode, such systems provide an interactive, manual, mouse-driven, automated or semi-automated, virtual "fly-through" of the surface- or volumerendered 3D intraluminal images (16).

Primary 2D evaluation is based on "lumen tracking," by interactively tracing through the 2D dataset, focusing on only the air-distended colonic lumen from one end to the other, with special focus on the cross-section of one colonic segment at a time. Primary 2D evaluation provides information about the attenuation of findings during the search process and is more time-efficient. Additional 3D views are often used for problem solving. Primary 3D evaluation is based on 3D virtual endoscopy in an antegrade and retrograde fashion. Primary 3D evaluation was shown to be sensitive for polyp detection because both, the conspicuity, especially of small and mediumsized polyps, and the duration of visualization, are increased. Additional 2D views are necessary for characterization of findings. However, the primary 3D evaluation is time-consuming because it must be performed in an antegrade and retrograde fashion for the perception of lesions behind haustral folds. Collapsed segments must be evaluated alternatively, by 2D planar images (14).

At present, the most commonly used platform for data interpretation of CTC is a primary 2D interpretation, with 3D used for problem solving, while primary 3D interpretation is preferred by an increasing minority (13).

Findings

Findings of the colon are characterized by their morphology, by their attenuation characteristics, and by their mobility.

1- Diverticula

It is one of the most common findings detected with CTC. On 2D CTC images, diverticulae appear as air-filled outpouchings of the colonic wall. However, on the 3D virtual endoscopic images, the diverticular orifice can be recognized as a complete dark ring (Fig. 2). Due to the increased risk of perforation CTC has no role in the diagnosis of acute diverticulitis. However, in chronic stages of diverticulitis, CTC may show cone-shaped stenosis with mild wall thickening with involvement of a long segment (>10 cm) with pericolic fat stranding, and fluid at the root of the mesentery **(17).**

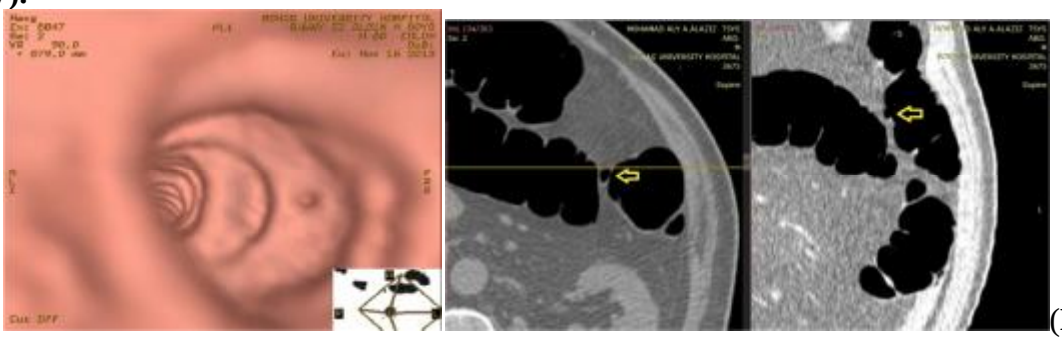
(A)  **(B)**

Fig. 2. Diverticula in the descending colon. (a) 3D virtual endoscopic CT image shows a complete dark ring at the diverticula. (b) Supine 2D axial CT image shows multiple gas-filled outpouchings of the colon wall.

2- Polyps:

They are the most common benign lesions of the colon. The risk of malignant transformation increases with the size of the polyp. Most polyps are sessile although some have a stalk. On 3D virtual endoscopic images, polypoid lesions present as a sessile or stalked, round, oval, or lobulated intraluminal filling defect. On 2D plane images, polyps have homogenous, soft tissue attenuation (Fig. 3). CTC is not able to reliably distinguish between hyperplastic and adenomatous polyps using morphological features alone, although 50% of polyps below 5mm are hyperplastic (18).

3- Lipomas:

Lipomas are the most common submucosal lesions in the colon (especially common on the ileocecal valve). CT colonography allows confident diagnosis of lipomas based on their characteristic fatty attenuation. A lipoma, in general, is 1–3 cm in size and rarely exceeds 4 cm. On 2D plane images, lipomas show a homogenous fatty attenuation. Because lipomas are soft lesions, their shape may change when moving from the prone to the supine position. In general, small lipomas need no further treatment; only large lipomas require endoscopic resection because they can lead to intussusception (13).

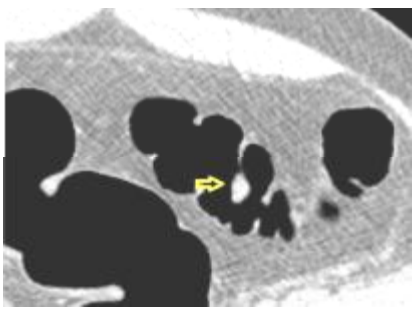
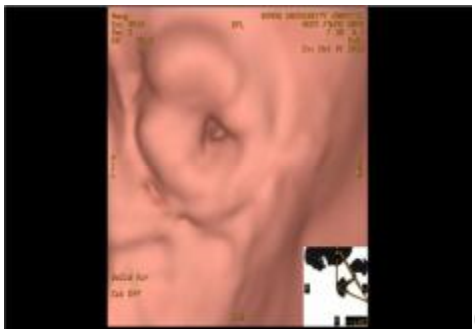


Fig. 3. Large, 1.6 cm stalked polyp in the sigmoid colon. Supine 2D coronal CT image shows a homogenous soft tissue attenuation of the intraluminal lesion (arrow). Histology revealed two adenomas of the sigmoid colon.

4- Colorectal cancer

Colorectal cancer is the most common colonic primary tumour. Most carcinomas show an exophytic, polypous type of growth with frequent central degeneration. Adenocarcinomas tend to infiltrate the bowel wall circumferentially and 50% are found in the rectum, and 25% in the sigmoid. Colorectal cancer typically shows extensive focal polypoid, asymmetric, or circular wall thickening with short extension (<5 cm), especially with shoulder formation (Fig. 4). CT differentiation between stages T1 (invasion of mucosa and/or submucosa) and T2 (invasion of the muscularis propria) is not feasible, but tumor extension beyond the colon wall (T3), characterized by fat stranding, an indistinct boundary, and nodular protrusions into pericolic fat tissue, is readily appreciated by CT. Tumor infiltration to adjacent organs (T4) is most likely if the carcinoma shows a broad-based contact, no intervening fat planes, and indistinct boundaries to other organs. Pericolonic lymph nodes and distant metastases are signs of progression of the disease and can be evaluated using 2D axial source images and MPR views (4).

Since the whole abdomen and pelvis is scanned, extra-colonic structures can be evaluated. The incidence of extra-colonic findings has been reported to be high (69%), but only about 10% are of high clinical importance, such as large aneurysms, masses, lung nodules, and large lymph nodes (Fig. 4b). Elderly and symptomatic patients are more likely to have significant extra-colonic findings compared to a younger screening population. It has been noted that the lack of IV contrast, and the low-dose technique used for VC, limit the evaluation of extra-colonic findings (19).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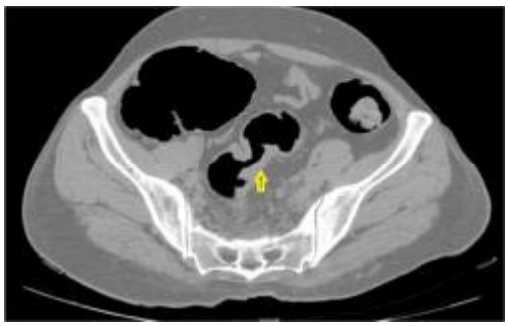
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Fig. 4. Stenotic cancer of the sigmoid colon. (a) 3D endoluminal image shows an irregular, circular, stenotic filling defect (arrow). (b) Supine sagittal contrast-enhanced CT image shows circular wall thickening (arrow).

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