CT colonography: Techniques, indications, findings

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Abstract

Computed tomographic colonography (CTC) is a minimally invasive technique for imaging the entire colon. Based on a helical thin-section CT of the cleansed and air-distended colon, two-dimensional and three-dimensional projections are used for image interpretation. Several clinical improvements in patient preparation, technical advances in CT, and new developments in evaluation software have allowed CTC to develop into a powerful diagnostic tool. It is already well established as a reliable diagnostic tool in symptomatic patients.

Many experts currently consider CTC a comparable alternative to conventional colonoscopy, although there is still debate about its sensitivity for the detection of colonic polyps in a screening population. This article summarizes the main indications, the current techniques in patient preparation, data acquisition and data analysis as well as imaging features for common benign and malignant colorectal lesions.

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1. Introduction

Computed tomographic colonography (CTC), also known as virtual colonoscopy (VC), is a powerful technique for the evaluation of the entire colon. It has potential advantages 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.

The ability of CTC to detect colorectal polyps has been tested in a multitude of studies. CTC appeared to be promising in high-risk populations, with a reported sensitivity greater than 90% for polyps ≥ 10 mm. Recent results in the low prevalence population were more heterogeneous and less impressive (34–93.8%) [1–4]. This wide range of results is likely caused by differences in patient selection, examination and evaluation techniques, and reader experience [5,6].

Currently, there are several clinical indications for CT colonography. They include evaluation of the colon after an incomplete or unsuccessful conventional colonoscopic examination and evaluation of the colon proximal to an obstructing neoplasm [7–11]. Another potential indication for CT colonography is in the evaluation of frail and elderly patients or patients who would have an increased risk with conventional colonoscopy. The use of CTC to monitor patients after surgery for colorectal cancer is currently under investigation [12,13]. In addition, CT colonography may contribute to colorectal screening by providing a safe, effective, and rapid examination that can be used to evaluate the entire colon for clinically relevant lesions.

This article summarizes the main indications, the current technique in patient preparation, data acquisition and data analysis, and the imaging features of common benign and malignant colorectal lesions.

2. Indications

Currently, there are several indications where CT colonography may play an important role in patient care. These include clinical indications, such as the evaluation of patient symptoms, evaluation after an incomplete colonoscopy, and screening in asymptomatic high- and average-risk patients.
2.1. Clinical indications

The most widely accepted clinical indication is incomplete or failed colonoscopy. An incomplete colonoscopic examination is defined as a failure to intubate the caecum. Incomplete colonoscopy may be the result of poor bowel preparation, redundant colon, and patient intolerance to the procedure, spasm, or colonic obstruction caused by a neoplastic or non-neoplastic stenosis. The CTC examination can be performed on the same day directly after conventional colonoscopy, and thus, no additional bowel preparation is needed [14]. CTC can complete the colonic evaluation in the majority of patients, which can also analyze the cause of incomplete endoscopy [7,8]. Patients with a history of incomplete colonoscopy are at higher risk for failure of a second attempt. Therefore, CTC, rather than a second attempt at conventional colonoscopy, may be recommended.

Double-contrast barium enema (DCBE), traditionally being used to evaluate the proximal colon in incomplete colonoscopy, has been outperformed by CTC in some institutions [15]. The residual colonic air distention after a failed colonoscopy may be an impediment to a successful, immediate, follow-up DCBE on the same day, but an immediate follow-up CTC is beneficial because the requisite colonic distention is already present. Two recent large prospective clinical trials show a sensitivity for DCBE of only 50% for “significant” polyps, measuring at least 10 mm in diameter [4,16]. At the same time, CTC has shown a better performance in several studies in patients with polyps 10 mm or larger [17]. In addition, patient preference studies are also discouraging for DCBE. In two recent questionnaire studies, patients ranked DCBE a distant last among three alternative colon cancer screening tests CTC, optical colonoscopy, and DCBE [4,18]. Last, but not least, in the future, radiologic experience in performing DCBE studies will fade because of the decreasing volume of investigations and fewer knowledgeable teachers.

In cases of an obstructing cancer, CTC offers information about the pre-stenotic colon, local tumor invasion, lymph nodes, and distant metastases [19–21]. CTC reportedly allowed detection of synchronous carcinomas, which occur in approximately 5% of cases, as well as synchronous adenomas, with a reported incidence of 27–55% proximal to the stenosis [7,9,11] (Fig. 1). In this setting, IV contrast is helpful to enable a complete staging of the patient [11].

Another potential indication for CTC is in the evaluation of patients with contraindications to colonoscopy or who refuse other screening options [22]. This includes patients in need of anticoagulation, a history of difficult or incomplete colonoscopy in the past, and patients who cannot be sedated due to medical conditions. In addition, in cases of advanced patient age, and in frail or immobile patients and patients with severe comorbidities, CTC can be safely performed to exclude neoplastic or stenotic conditions [22].

Taylor et al. reported on the use of diagnostic CTC in patients with positive symptoms of colorectal cancer, such as a change in bowel habits, lower gastrointestinal bleeding, iron deficiency anemia, or abdominal mass and abdominal pain [23]. The authors suggested that CTC may be a valuable tool for the rapid evaluation of symptomatic patients. In addition, CTC could have an extra benefit for the 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.

With regard to post-surgical conditions in the colon, there is no general agreement about the use of CT colonography. Contrast-enhanced CT colonography has the potential to detect local recurrence, metachronous disease, and distant metastases in patients with a history of invasive colorectal cancer [12,13]. Currently, endoscopy or barium enemas are performed in many
cases after colonic surgery for routine surveillance, to detect tumour recurrence, or to discover a metachronous cancer. After partial colonic resection, some of these follow-up examinations could be replaced by contrast-enhanced CT colonography. In most cases, CT colonography allows visualization of the entire colon, which is important for the demonstration of post-surgical anatomic conditions. Two-dimensional views offer information about the wall morphology of the anastomosis [4,16].

In addition to these main indications, there are other conditions where the role of CT colonography is not yet clearly defined. Some of these conditions may lead to colonic obstruction, where CTC may be performed after incomplete colonoscopy. However, CTC may also be used for surveillance of these conditions, as an alternative to colonoscopy or barium enema. Diverticular disease is the most common colonic disorder in the Western world 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 diverticulitis [24]. At chronic stages of inflammatory bowel diseases, CT colonography can provide information on the extent of the disease and about stenosis and stricture regions, as well as the extracolonic extent and complications of the diseases [25–27].

At the very last, patients who are unwilling to undergo conventional colonoscopy because of anxiety, fear, or embarrassment may profit from a relatively painless and safe CTC examination [22].

2.2. 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. CTC as a screening tool has the potential for a wider public acceptance compared to conventional colonoscopy. Several studies have shown that patients prefer CTC over conventional colonoscopy [18,28,29].

Although a recent study by Pickhardt et al. showed an excellent performance for CTC in an average-risk population, with a reported sensitivity of 93.8% for polyps ≥10 mm [3], other authors achieved less impressive results ranging from 34 to 53% [1,2,4]. This wide scatter in sensitivity was attributed to technical differences with regard to the examinations, evaluations, and reader experience.

Therefore, the current use of VC generally does not include screening of asymptomatic individuals, as suggested by the American Cancer Society [30] and the American Gastroenterological Association [31]. Both of these organizations decided that CTC should not yet be used for colorectal cancer screening, because data on true screening populations are missing. However, further attempts to validate this rapidly evolving technique are ongoing. Currently, CTC is the second best imaging modality for complete colonic evaluation, being superior to DCBE for detection of colorectal polyps and cancer [79]. Therefore, a practical approach is to consider CTC a reasonable alternative to the other colorectal cancer screening tests when a patient is unable or unwilling to undergo conventional colonoscopy [32].

2.3. 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 [33–35]. 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.

3. CT colonography technique

CT colonography is based on a helical, thin-section CT of the cleaned 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.

3.1. Bowel preparation

The key element of a high quality CTC examination is a well-prepared clean, and well-distended colon. Residual stool and fluid may lead to a false-negative or false-positive diagnosis. Therefore, CTC, at present, requires full bowel preparation, just like colonoscopy and DCBE.

Patients usually follow a clear liquid diet starting about 24 h prior to the CTC examination. Cathartic cleansing is usually performed by oral administration of laxatives. Different commercially available bowel preparations have been described for CTC, 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 reported that phosphosoda and magnesium citrate result in an adequately prepared and dry colon for the majority of patients, whereas PEG preparations frequently leave large amounts of residual fluid in the colon and, therefore, are not optimal for CTC [36]. However, it should be mentioned that phosphosoda is contraindicated in patients with known renal failure, preexisting electrolyte abnormalities, congestive heart failure, ascites, or ileus [37]. Therefore, because PEG is not contraindicated in patients with renal or cardiac insufficiency, it can be used alternatively in these cases [22]. In addition, some European centers have reported the use of other laxatives, such as Picolax [38].

As opposed to a standard bowel preparation, the addition of oral contrast agents (small amounts of barium or iodine
contrast) will tag residual stool or fluid (Fig. 2). The resulting higher attenuation of fecal and fluid residues simplifies their distinction from colonic abnormality. Although commercial tagging agents (Tagitol, EZ-Em Inc., Westbury, USA) are not yet available in the EU, there is no general consensus about the agent or the amount preferable for use in fecal tagging. Whereas some authors prefer tagging with barium only [39], others have reported good results with iodine [40] or a combination of both to achieve fecal and fluid tagging [3]. In brief, Pickard et al. achieved excellent results with a combination of 500 ml of 2.1% barium contrast material for solid stool tagging and 120 ml of an ionic water-soluble contrast agent (Gastrografin, Schering AG, Berlin, Germany) for fluid opacification [3]. Fecal tagging is now advocated by an increasing number of investigators as the method of choice to prepare the colon for CT colonography.

Compared to cathartic preparations, so called prepless bowel preparation is a laxative-free regimen where patients may eat and drink normally or are asked to maintain a low residue or low fiber diet while fecal tagging is achieved by multiple doses of oral contrast (barium or iodinated contrast) over a 24–72 h period prior to CTC. With computer-generated electronic cleansing techniques, either by using thresholding or using specific subtraction computer software, the high attenuation tagged fecal material can be subtracted from the data, leaving only the colonic wall and colonic lesions [41,42]. Although initial results are promising for detection of lesions of 1 cm or larger [40,41], this method is still at the research stage and must be validated in a screening population. In the future, prepless CTC may increase overall patient compliance by replacing the cumbersome bowel preparation.

3.2. Bowel distention

Optimal colonic distention is a fundamental prerequisite for CTC data evaluation that allows intraluminal evaluation of the large bowel. Underdistended 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) [43]. Larger catheters, such as those used in DCBE, are not required to successfully distend the colon in CTC [44]. For bowel distention, either room air or carbon dioxide (CO2) can be used. The easiest and cheapest method is manual room air distention via a handheld plastic bulb insufflator, an effective technique that can even be performed by patients themselves. 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. CO2 can be administered either manually, over a standard enema bag filled with approximately 31 of gas (via a gas cylinder) attached to a rectal catheter over a connecting tube, or automatically, using a dedicated insufflation device (Protocol colon insufflation system, EZ-Em Inc., Westbury, USA). This device electronically controls the flow rate of CO2, the total administered gas volume, and the intracolonic pressure (which is limited up to a maximum of 25 mmHg). Advocates of automated insufflation suggest that introducing CO2 at controlled flow rates and pressures improves patient compliance and overall distention [45,46]. During the gas insufflation, the patient is placed in the supine position and gentle insufflation is continuous until the patient feels uncomfortable or bloated. This generally will take 2–4 l of gas, depending on the patient’s individual colonic anatomy. Fixed gas amounts may be impractical because of different colonic volumes. 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 insufflation if needed.

The i.v. administration of antispasmodic agents (hyoscin-N-butylbromide, buscopan, or glucagon) may improve colonic distention and reduce spasms. However, the use of spasmyotics is controversial; i.v. hyoscin-N-butylbromide likely improves distention, but is not licensed in the United States [44], whereas glucagon hydrochloride, its licensed alternative, does not appear to be as beneficial [47,48]. In addition, some authors argue that administration of an IV drug adds to patient discomfort, creates an opportunity for possible new side effects, and increases examination time and cost. The general opinion, provided by a recently published, consensus statement is that IV spasmyotics should not be administered routinely, but can be used if patients experience pain, discomfort, or spasm [32].

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 [33–35].
3.3. CT scanning

CT scanning is ideally performed on an MDCT scanner in both the supine and prone positions with a thin collimation. MDCT has several technical advantages over single-detector-row CT, including faster imaging times and acquisition of multiple [4–64] 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 [49,50]. To avoid breathing artifacts, which are more prominent in the upper abdomen, scanning is performed in the cephalo-caudal direction.

Thin sections are a prerequisite for high-quality multiplanar reformations (MPR) and 3D reconstructions. As recommended by a recently published consensus statement, collimation should not exceed 3 mm when using MDCT [32]. However, with 16-row and 64-row MDCT, thinner, sub-millimeter, collimations are preferable. Near-isotropic imaging is already provided on a 4-row MDCT scanner with a detector configuration of 4 mm × 1 mm (minimal slice thickness of 1.25 mm), which allows scanning of the abdomen during a 30-s breath-hold. With a 16-row or 64-row MDCT scanner, and a detector configuration of 16 mm × 0.75 mm or 64 mm × 0.6 mm, scanning is completed in 11–12 s or 6–7 s. Such datasets can be reconstructed as 1 mm sections overlapped every 0.7 mm.

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 [51]. However, lower mAs values (10 mAs, ultra low-dose) have also been reported to be feasible for polyp detection [52]. However, such “ultra low-dose” protocols may not be feasible for the evaluation of extracolonic structures (because of the increased image noise,) or for obese patient, but further research is needed. Generally useful exposure settings are 120 kVp and 50–100 mAs in the prone and in the supine positions. A recent analysis of different CTC research institutions showed a median mAs value of 67 at a median collimation of 2.5 mm [53]. Use of automated dose modulation techniques that adapt mAs values to patient anatomy should always be used, if these techniques are available on the CT scanner [80].

3.3.1. Contrast media

Intrinsic colonic lesions and extracolonic pathology can be enhanced by IV injection of iodine contrast media (IV CM) in the second scan [54,55]. 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 [11,12,20,54]. 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. As reported by a recently published consensus statement most of CTC investigators do not routinely administer i.v. contrast media for screening purposes [32].

4. 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 volume-rendered 3D intraluminal images.

CTC datasets can be evaluated by a primary 2D or a primary 3D approach. In either case, the alternative viewing technique must be available for rapid correlation and characterization of any suspicious findings. The combined use of both, 2D and 3D visualization techniques has been shown to be superior to the evaluation of 3D or 2D views only, with regard to sensitivity and specificity [56,57].

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 [57]. Primary 2D evaluation provides information about the attenuation of findings during the search process and is more time-efficient [56,58]. 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 medium-sized polyps, and the duration of visualization, are increased [3]. 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.

There is no general consensus on whether a primary 2D or 3D approach should be employed. It depends primarily on the radiologist’s preferences and the capabilities of the workstation. 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 [32].

In 2005, the working group on virtual colonoscopy proposed a reporting scheme, “C-RADS—CT Colonography Reporting and Data System,” that includes recommendations for the follow-up of colonic polyps [59]. In brief, this scheme is based on
lesion size, morphology, location, attenuation, and preliminary recommendations for lesion surveillance. Although this effort needs to be refined with a multi-disciplinary consensus, it represents an important step toward more consistent and reproducible reporting in CTC.

4.1. Improvements in 3D visualization

Current developments in 3D visualization include virtual dissection, or panoramic, as well as unfolded, cube projections and translucency rendering. These views differ from conventional 3D simulation of endoscopic examinations, a technique that has limitations with regard to blind spots, as well as time-consuming, bi-directional evaluation. These new projections have been created to overcome this limitation by increasing surface visibility.

With “virtual dissection,” the colon is fully dissected longitudinally and unfolded, similar to a pathological preparation [60] (Fig. 3). The “unfolded cube” projection renders six planar projections at 90° viewing angles from points on the central path. The unfolding of such a cube shows the complete field of view at a path position [61]. The panoramic view is a variation of the unfolded cubic view, which renders five faces of a cubic view in the plane in a continuous fashion. To minimize distortions, the front view is mapped into a square while the other four faces are mapped around it into a disk [62] (Fig. 4).

Initial results for some algorithms tested in small series of patients showed a reduced reading time without a significant difference in sensitivity [60,61,63]. However, increasing surface visibility, by flattening a 3D structure in a 2D image or by changing viewing angles, is likely to suffer from the fact that luminal anatomy is distorted, especially in areas of flexures or in suboptimal distended segments. Therefore, further studies are needed to evaluate the feasibility of such tools.

“Translucency rendering” is a 3D tool that has been developed to provide information on lesion attenuation beneath the rendered surface by an attenuation-dependent color scale superimposed on a 3D endoluminal view [64] (Fig. 5). These views assign different colors (e.g., blue, green, red, and white) to areas of increasing attenuation, and therefore, provide a rapid and effective differentiation between soft-tissue lesions and pseudo-lesions, such as stool. True colorectal polyps will show a uniform concentric ring pattern with a homogenous red core, while stool, if tagged, will have a white core. If stool is not tagged, because of small gas bubbles, it will display an inhomogeneous translucent pattern.
3.9. Role of CAD

Computer-aided detection (CAD) systems are software programs that automatically highlight polyp “candidates” and therefore support the radiologist by pointing out possible abnormalities that may otherwise have been missed. Based on morphologic and attenuation characteristics, the reader then decides whether the “candidate lesion” is a true- or a false-positive finding. Recent CAD algorithms showed a promising performance, with a reported a CAD sensitivity of 89.3% for adenomas ≥1 cm [65]. Some of these systems have recently become available on CTC workstations.

CAD algorithms can be used as a “first reader,” as a “concurrent reader,” or as a “second reader.” In a first-reader paradigm, the observer only ever reads with CAD-assistance and confines his/her attention to CAD marks alone, ignoring unprompted areas of the colon. However, aside from ethical issues, such a separation is likely to come with an increased number of missed abnormalities [66]. If CAD is used as a concurrent reader, pre-calculated CAD results are displayed in the image data while performing the primary data evaluation. In the second reader scheme, a reader reviews the case, first blinded to the CAD results, and then evaluates the CAD findings to integrate them with his/her own findings. There are relatively little data about the potential benefit of CAD on reader performance. The “potential” contribution of a CAD algorithm to the sensitivity of different readers without CAD was reportedly between 10% and 38% [67,68].

5. Findings

Findings of the colon are characterized by their morphology, by their attenuation characteristics, and by their mobility [69,70].

One of the most common findings detected with CTC is diverticular disease. On 2D CTC images diverticula appear as air-filled outpouchings of the colonic wall. On the 3D virtual endoscopic images, the diverticular orifice can be recognized as a complete dark ring [71] (Fig. 6). 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.

Polyps 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. Typically, the margin to the normal mucosa is displayed as an incomplete ring shadow. On 2D plane images, polyps have homogenous, soft tissue attenuation (Fig. 7) [69]. Generally, polyps maintain their position with respect to the bowel surface, with the exception of stalked polyps or polyps in mobile colon segments [72]. CTC is not able to reliably distinguish between hyperplastic and adenomatous polyps using morphological features alone, although 50% of polyps below 5 mm are hyperplastic [73].

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 3D virtual endoscopic images, lipomas are present as a sessile or pedunculated polypoid intraluminal filling defect, most often with a smooth surface. On
Fig. 6. Diverticula in the sigmoid colon. (a) 3D virtual endoscopic CT image shows a complete dark rings at the diverticula (arrows). (b) Prone 2D axial CT image shows multiple gas-filled outpichings of the colon wall.

2D plane images, lipomas show a homogenous fatty attenuation (Fig. 8). 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 [69].

Whereas truly flat adenomas, not arising over the mucosal level, are almost impossible to detect at CTC, flat lesions can be depicted if they are slightly raised over the colonic mucosa level. Flat polyps are defined as lesions with a height less than 50% of the lesion width [74]. Their clinical importance has been a topic of controversy, and recent data from the National Polyp Study indicate that the flat lesions that were found are not more aggressive than sessile or stalked polyps [81]. In CTC, flat polyps appear as a fairly circumscribed area of mild wall thickening with homogenous soft tissue attenuation. Sometimes a mild nodularity is found on the surface by 3D endoluminal images (Fig. 9).

Colorectal cancer is the most common colonic primary tumour. Most carcinomas show an exophytic, polyposus type of
Fig. 8. Large flat adenoma of the transverse colon. (a) 3D virtual endoscopic CT image shows a flat filling defect of the colon adjacent to a haustral fold (arrow) (b) Prone 2D axial CT image shows a slight focal wall thickening with homogenous soft tissue attenuation. Histology revealed a villous adenoma of the transverse colon.

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. 10) [71,75]. 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.

Since the whole abdomen and pelvis is scanned, extracolonic structures can be evaluated. The incidence of extracolonic 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. 10b) [76,77]. Elderly
and symptomatic patients are more likely to have significant extracolonic 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 extracolonic findings [78].

6. Conclusion

In summary, CTC is a valuable diagnostic tool for evaluation of the entire colon. Accurate diagnosis relies on high quality studies, which require adequate bowel cleansing and distention, thin-section MDCT scans performed in the prone and supine positions, and a combined evaluation of 2D and 3D images. CTC is widely accepted as a powerful tool for evaluation of the colon after incomplete colonoscopy, or in patients with known or suspected colorectal cancer. The role of CTC in a screening population remains to be determined, with encouraging results published in the last two years. Ongoing research in CAD and improved software products have the potential to increase the accuracy and ease of interpretation of CTC, which would accelerate its acceptance as a colorectal screening tool.

References


