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CT colonography in the detection of polyps

White Paper

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*Using images to reconstruct the inner wall of the colon mimics the view though an endoscope**

CT colonography has become an accepted primary method for detecting polyps, some of which may be cancerous. Multidetector CT provides increased coverage and faster rotation speeds, enabling CT colonography to be applied in routine clinical practice.

Colorectal cancer is the number two cause of cancer death in the United States. The disease develops from small polyps. Most are benign, but some may develop into malignant tumors. If the polyps or tumors are detected early enough, they can generally be removed by endoscopic intervention or surgery. Unfortunately, many colorectal cancers are detected only when the cancer has already metastasized, mostly to the liver. At this stage, treatment is difficult and the prognosis is poor.

For this reason, the American Cancer Society recommends regular screening for all men and women aged 50 and over, with earlier and more frequent screening for people at risk. Screening methods include an annual fecal occult blood test (FOBT), a fecal immunochemical test (FIT), and every five years an internal examination such as flexible sigmoidoscopy[1].

The colorectal cancer care cycle

Philips Healthcare addresses the visualization and treatment of polyps with a care cycle approach, covering all stages patients experience on their way through the healthcare system.

The care cycle approach is applicable to any medical condition - in principle. It allows valuable insights in the current status of the current care model and provides a framework for understanding the clinical needs from both the patient's and caregiver's perspective. This makes it possible to select the most appropriate methods of diagnosis and treatment, and to improve cost-effectiveness, access, and quality of care[2].

Within the context of the colorectal care cycle, CT colonography is indicated where optical colonoscopy is incomplete or contraindicated. It has now been accepted as a primary, minimally invasive visualization tool.

* This article is based on interviews with Philips staff members Roel Truyen and Peter Martin.

Fig. 1 The colorectal cancer care cycle. (In graphic, "CEA" = Carcino-embryonic antigen; "DCBE" = Double-contrast barium enema; "FOBT" = Fecal occult blood test)

CT colonography

CT colonography reconstructs an image of the inner wall of the colon from CT image data, and presents the results as "virtual colonoscopy," mimicking the view through a conventional endoscope, but with the possibility of providing additional views that could not be obtained in any other way. The CT colonography procedure begins with bowel preparation on the day before the examination, followed by insufflation and image acquisition.

Preparation

Adequate bowel preparation is important, in order to prevent feces and fluids from affecting the images. It consists of a low-residue diet, cathartic cleansing, and fecal tagging[3].

Residual feces and fluid that might simulate polyps are tagged to differentiate them from real polyps. Tagged fluid that might otherwise obscure visualization of polyps can be removed using electronic cleansing software.

Insufflation

Adequate colonic distension is essential for achieving full visualization of all bowel segments. This is done by inflating the colon with air or CO_2. Mechanical injection of carbon dioxide is preferred because it results in slightly less post-procedure patient discomfort (mostly because the body absorbs the CO2 more easily than room air) and better colonic distension.

Acquisition

The images are acquired with the patient in both the supine and the prone positions. A scout view is performed before each of the scans to confirm optimal colonic distension. Imaging in the supine position promotes optimal distension in the anterior colon, while distension in the posterior colon is best when patient lies prone.

Using two patient positions also increases polyp conspicuity, improving overall diagnostic performance, and differentiating between polyps and feces. Gravity causes residual fluid and feces to move to the lower side, while polyps remain attached to the wall.

The advent of multidetector CT has made it practical to apply CT colonography in routine clinical practice. The increased coverage and faster rotation speeds offer shorter breath-hold times for patients, thinner slices, and minimal motion artifacts due to peristalsis. A 64-slice multi-detector CT (MDCT) scanner configuration provides a single breath-hold of around 5-10 seconds, thinner slices, and minimal motion artifacts.

Visualization

After the acquisition, the volumetric dataset has to be visualized and inspected. Traditionally the primary reading is done using large, axial two-dimensional (2D) images to detect abnormal polypoid shapes on the colon wall. This is a tedious procedure and requires both training and concentration.

Three-dimensional (3D) visualizations may be used for problem solving and to better discriminate polyps from (complex) folds, while an overview image of the colon can serve as a navigation aid.

Over the past decade or so there has been a swing towards using the 3D "virtual colonoscopy" images for the primary reading, while the original CT slices are used for problem solving. The virtual colonoscopy images mimic the images seen on a conventional endoscope by providing internal perspective views of the colon wall, allowing easier and more intuitive reading. However, it must be stressed that the 2D and 3D visualizations are complementary and should always be combined, whatever the primary reading method may be.

In order to reduce the read times still further, and expose more colonic surface, new visualization techniques have been developed. Two of these, the unfolded view and the perspective-filet view, are described below.

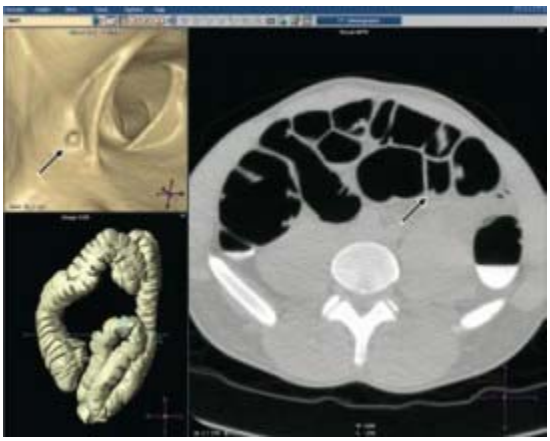

Fig 2: Primary 2D viewing mode with large axial images together with 3D endoluminal images and an overview image of the colon. The

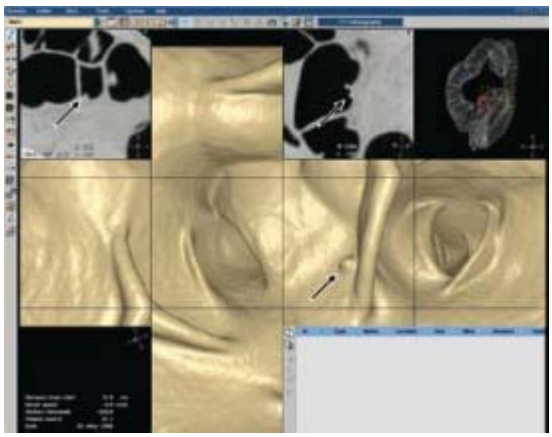

Fig. 3: Primary 3D viewing mode displayed using the unfolded view. A small polyp is visible (arrow), demonstrating the ability of the

primary 2D image shows a small polyp in the sigmoid colon (arrow) that is confirmed on the 3D endoluminal image.

unfolded view to look behind the haustral folds. The image at top left is a zoomed axial view of the polyp (arrow), while the view on the right shows a multiplanar reformat view through the same polyp but perpendicular to the colon centerline.

Unfolded view

In the unfolded view proposed by Vos et al.[4], the endoluminal viewing is not limited to ante- and retrograde viewing directions, but also contains up, down, left, and right views, providing a complete omnidirectional view of the colon wall. With the viewpoint at the center, images of the surroundings are projected on the faces of a cube. The six images are then unfolded into one image so that the six faces can be examined simultaneously.

The unfolded view allows the user to immediately see polyps on and behind haustral folds. Moreover, it provides an intuitive view, which leads to significantly less inspection time (19 to 20 minutes) compared with using bi-directional fly-through (approximately 36 minutes[4]. The colon surface is more clearly visualized than in a conventional endoscope-type display, and with a known degree of distortion[6].

Perspective-Filet view

A different visualization technique is the virtual dissection view, as proposed by Hoppe[5] and Rottgen[6]. In this view, the entire colonic lumen is laid out like an anatomical specimen.

The perspective-filet view is a variation on the virtual dissection view, designed to overcome the "blind spots" sometimes created when all of the resampling is performed perpendicular to the centerline. By tilting the projection rays as a function of the distance from the center line, the perspective-filet view adds perspective to the previously flat view. This view allows the user to move through the colon and see inside traditional blind spots, while reducing geometrical distortion, helping to maintain and confirm the conspicuity of the polyp.

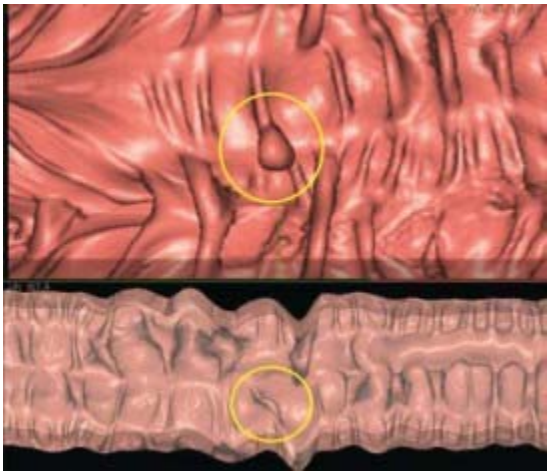

Fig. 4: The Philips perspective-filet view (top) makes the polyp very conspicuous compared with a conventional virtual dissection view (below). The latter distorts the morphology of the same polyp to make it appear like a fold, which might result in a significant oversight.

Size measurement

The size of a polyp can be directly measured in the CT colonography image. The size is important because it is a predicting factor for malignancy. The probability that a polyp larger than 2 cm is malignant is greater than 50%. For polyps between 1 and 2 cm in size, the probability decreases to 9.5%. Polyps smaller than 1 cm have only a 1% probability of being malignant[7].

The estimated potential for malignancy is used to decide whether a polyp should be removed to prevent the patient from developing colorectal cancer. If a polyp is small, it may take several years before it develops into a cancer-if ever. Thus, it is safe to leave it in situ and to let the patient return in a few years for another colon examination.

Fig. 5: Measurement of a 13.8 mm polyp.

Conclusion

During the past decade, CT colonography has matured from research to clinical practice as a valuable tool in the detection of polyps, which may be cancerous. New developments in both data acquisition and image post processing have improved results and reduced costs.

Fast, multidetector CT scanners allow acquisition of high-resolution isotropic abdominal data within seconds. Advanced visualization and navigation tools are expected to increase the detection performance of human readers - and will eventually reduce reading time.

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