Virtual endoscopy was first described by Vining et al. in 1994 [1]. The virtual colonoscopy procedure that he introduced has since become a basic examination technique. It is a non-invasive procedure that simulates conventional colonoscopy using a combination of computer tomography (CT), three-dimensional computerized reconstruction and virtual reality. A number of different terms are nowadays used in medical literature to describe the same technique: virtual colonoscopy, virtual endoscopy, 3D colonoscopy etc. Johnson et al. [2] proposed a term in 1998 that is still in use today, and perhaps best describes the examination; this expression is composed correctly of the term “colonography” prefixed by the sectional imaging method used, giving us “CT colonography”. At this point it should also be mentioned that colonography can also be performed, in theory, using MRI, but with the disadvantage that one has to accept poorer spatial resolution and motion artifacts.

**CT colonography today**

In recent years CT colonography has benefited greatly from developments in CT scanner technology and new methods of 3D image processing.

Since its invention by Hounsfield and Cormack in the early 1970s, the use of computer tomography in clinical practice has spread rapidly. The introduction of spiral CT by Kalender in the early 1990s represented a quantum leap in the technology, culminating in the development of multidetector CT systems (also known as multislice CT). The advantage of this equipment lies in its ability to scan greater volumes in thinner slices in less time. It is thus possible, for example, to examine an abdomen within a single breath hold and without disturbing respiration artifacts – an advantage that is particularly beneficial for CT colonography [3,4]. The thinner slices have made it possible to produce virtually artifact-free three-dimensional representations of the colon.

When evaluating CT data (up to 1,000 images per examination) both 2D and 3D procedures are used. The most important 2D procedures are the evaluation of the axial output images and the preparation of multiplanar reconstructions (MPR) that can be used to reconstruct any required scan orientation (e.g. coronary or sagittal). 3D image processing offers great potential for CT colonography. For example, in conventional colonoscopy it is not always possible to see behind intestinal folds, while there are now reconstruction algorithms for CT colonography that enable this to be done. The principal technique in this respect is the dissected representation of the colon (Philips “Filet View”). The colon is no longer shown in an endoluminal view as in conventional colonoscopy, but in a plan view similar to a pathological specimen (Figure 1). This enables the reader to see behind intestinal folds and, in addition, it provides a faster overview of the data set – a major advantage in the daily routine [5].
CT colonography procedures not only differ in the hardware (CT system and workstation) and software used, but also in patient preparation and the examination technique. An examination in the prone and supine positions leads to a significant improvement in the sensitivity of polyp detection [6]. Fractionated oral administration of contrast agent (“fecal tagging”) can improve discrimination between stool residues and genuine polyps, and thus potentially improve the specificity of CT colonography [7-8]. Adequate inflation of the intestine with ambient air or CO2 is also essential.

Previously published studies on CT colonography report widely differing results for the detection rate of colorectal lesions. Some publications report excellent results. The work of Pickhardt et al. published in the “New England Journal of Medicine” in late 2003 [9] is outstanding. For the first time it was possible to demonstrate in a large group that CT colonography has the required sensitivity and specificity to be used for examination purposes in a low-risk population. The authors examined 1,233 patients on the same day in a multi-center study using CT colonography and optical colonoscopy. The sensitivity of CT for adenomatous polyps over 10 mm in size was 93.8%; for polyps over 8 mm it was 93.3%, and for polyps over 6 mm it was 88.7%. Macari [10] and Chung [11] have published similarly good results (at least for polyps >10mm). Both demonstrated a sensitivity of 100% for polyps >10 mm in diameter.

However, there are published studies, some of earlier date, that report much poorer results. A large retrospective multi-center-population study (341 patients) was published in 2003 by Johnson et al. in Gastroenterology [12]. Here, using collimation of up to 5 mm, the authors reported a mean sensitivity of 75% and a mean specificity of 73% for polyps >10 mm. In their study of 614 patients Rockey et al. achieved a sensitivity of 59 % for polyps >10 mm, and 51% for lesions of 6-9 mm. Collimation of up to 5 mm was also used in this study.

From the above studies it can be seen that the method of examination depends, to a large extent, on the image quality. Moreover, the physician’s experience in evaluating CT colonography data is an essential requirement.

**The future of CT colonography**

In the near future standards should be set defining the minimum requirements for CT colonography. This will need an appropriate CT system and a physician with the appropriate training to perform and evaluate the examination.

If the examination is performed with these aspects in mind, high sensitivity and specificity can already be achieved in the detection of colorectal polyps. Nevertheless, the technique still has great potential for development, particularly in the post-processing procedures. One example of this is automatic bowel cleansing. In this procedure, an oral contrast medium is administered to patients during the preparation for the examination in order to label residues of stool or liquid (see “fecal tagging” above). Based on the differences in density between the labeled residues and the intestinal wall or the air...
CT colonography is the method of choice for incomplete exams and high-risk patients.

Many current studies [17-20] deal with automatic polyp detection (Computer-Aided Detection - CAD). In this, suspect lesions are detected and marked by the computer. The physician can then decide whether these suspected lesions are actually polyps or, for example, stool residues (Figure 3). This algorithm could lead to a further reduction in examination time.

Nevertheless, its use in routine examinations should be subject to the introduction of quality controls with prescribed examination standards (preparation for examination, CT parameters, subsequent processing, qualified physician). Computer-assisted evaluation has the potential to further shorten the examination time.

References:


