West of England Medical Journal

Formerly Bristol Medico-Chirurgical Journal

The e-journal of the Bristol Medico-Chirurgical Soc

Virtual Colonoscopy – Current and Future Practice

West of England Medical Journal Volume 110, Number 3, Article 2 September 2011

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Abstract

In the search for an accurate and safe, less invasive and cost-effective method for examining the large bowel, computed tomography (CT) of the colon or virtual colonoscopy is a rapidly evolving diagnostic method for the detection of colorectal polyps and cancer with similar accuracy to conventional colonoscopy in high-risk groups and for screening in low-prevalence populations.

Introduction

In the UK, an estimated 38,000 new cases of bowel cancer are diagnosed each year. Colorectal cancer is now the third most common cancer with a lifetime prevalence of 1 in 20 [1, 2, 3, 4, 5]. In Avon, Somerset and Wiltshire in 2007, 1224 new cases were diagnosed and 465 people died from it [6]. The occurrence of large bowel cancer is strongly related to age, with most cases arising in people who over 60 years old and being rare in those age under 40 [7]. (Figure 1)

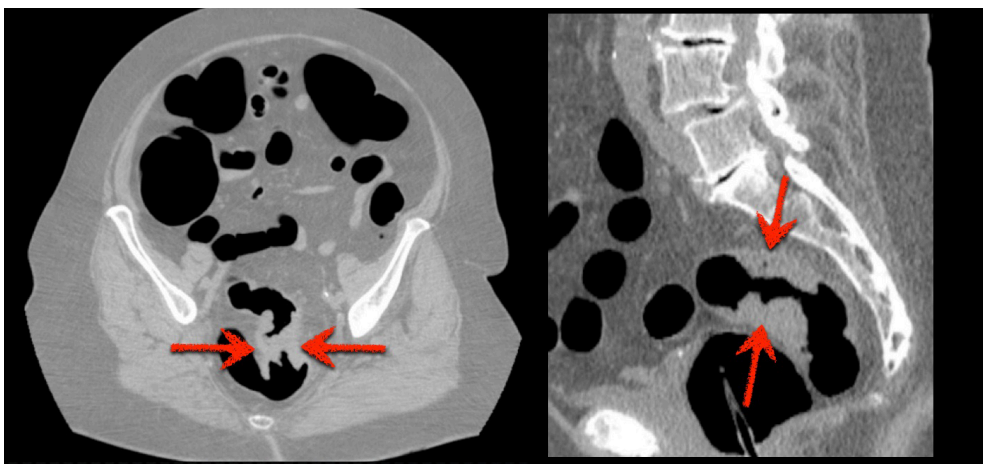

Figure 1 – An annular rectosigmoid tumour (arrowed) is demonstrated in both the sagittal (left) and axial plane (right)

Although survival has improved in the last 20 years, overall mortality from colorectal cancer is still around 40% [8]. One of the main hurdles to improved survival is late presentation of disease, with around 20% of cases having metastases at presentation. As most tumours arise from benign adenomatous polyps that develop slowly over years, there is considerable evidence that screening for and removal of polyps and early cancers can reduce the incidence of cancer and cancer-related mortality [9]. Screening of some sort is necessary as the clinical features of colonic malignancy are notoriously unreliable and vague. Even the symptom of rectal bleeding has only an 8% positive predictive value for the presence of a tumour [10].

A persistent stumbling block for screening is uptake, cost and feasibility of all diagnostic tests. Flexible sigmoidoscopy and faecal occult blood (FOB) testing are probably the most feasible screening tests.

Flexible sigmoidoscopy has been shown to reduce mortality [11]. However, flexible sigmoidoscopy examines only the distal 60 cm of the colon and therefore misses more proximal lesions in more than half of patients with advanced colonic adenomas [12]. Commentators have noted that screening for bowel cancer with flexible sigmoidoscopy is as clinically logical as performing "mammography of one breast" to detect breast cancer [13].

FOB testing is probably the most feasible. It detects as little as 10ng/ml of haemoglobin in stool and up to 50% of those with a positive test subsequently being shown to have a polyp or tumour [9, 14]. Four randomised controlled trials have shown that population screening with FOB test can reduce colorectal cancer mortality by around 15% [9, 15, 16, 17]. FOB testing has false negatives; it fails to detect 25-50% of cancers and up to 75% of polyps, hence it relies on multiple tests in the same individual to detect tumours reliably.

Despite these limitations, in 2006 the NHS launched the Bowel Cancer Screening Programme. In England this currently recommends that all those who reach 55 are offered a flexible sigmoidoscopy and those between the ages of 60 and 69 are screened every 2 years via an FOB test.

Examination of the whole colon

Large-scale population screening with whole colon examinations is not fiscally realistic [18]. On the other hand, an examination of the whole colon is necessary in those with a positive FOB or in those with symptoms suggestive of colorectal cancer. Those with a strong family or personal history of colorectal cancer should also be screened.

For many years, examination of the entire colon was reliant on double-contrast barium enemas. It is a reliable way of visualising the whole length of the colon and it is reasonably accurate in detecting cancers, with a sensitivity of 85% for polyps over 10mm [19]. On the other hand, there is no doubt that barium enemas have lost importance due to its relative inability to accurately detect subcentimetre polyps [19] [Figure 2]. Prospective studies report sensitivities as low as 50-75% in asymptomatic patients with positive FOB tests [14]. Furthermore, the barium enema is disliked by patients, more so than any other bowel investigations [20].

Fibre-optic colonoscopy has been widely available since the 1970s and allows examination of the whole colon with the benefit of simultaneous lesion biopsy and resection. Although acknowledged as the gold standard for detecting colonic neoplasms,

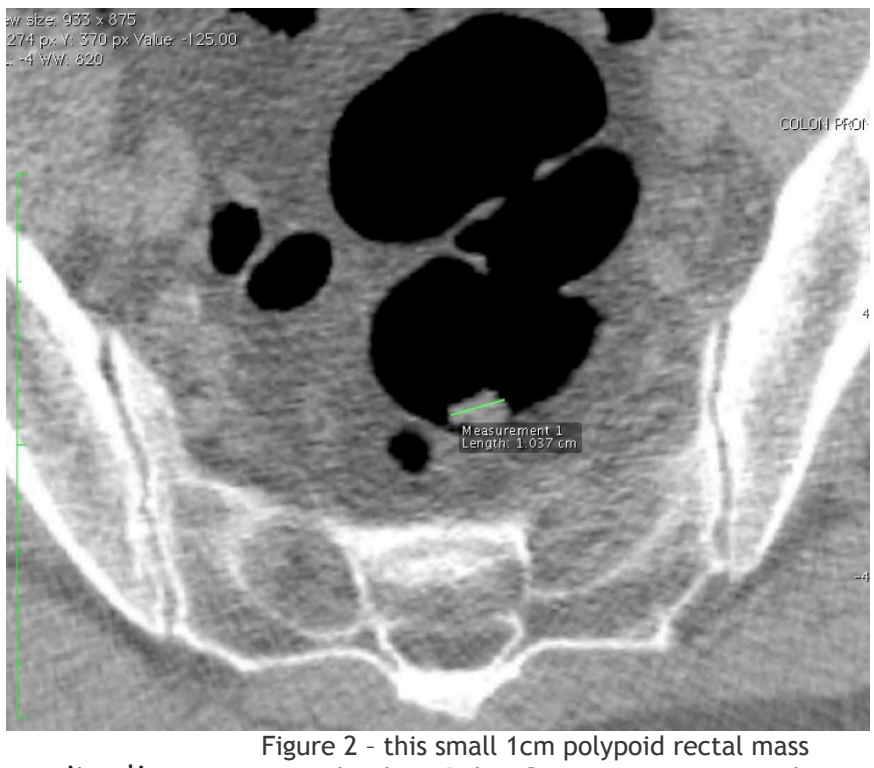

Figure 2 – this small 1cm polypoid rectal mass proved to be a Dukes C carcinoma at surgical resection. The patient is alive and well 7 years later.

it is not perfect [18]. It fails to demonstrate the entire colon in up to 5% of cases even in experienced hands [21, 22] and up to 20% of all adenomas can be missed [23]. The need for sedation in the majority of patients speaks volumes about how unpleasant the experience is. Furthermore, there are the risks of complications associated with diagnostic and therapeutic colonoscopy, including perforation (1 in 1,000), major haemorrhage (3 in 1,000) and death (1 in 30,000) [24].

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Virtual Colonoscopy – Current and Future Practice (continued)

CT Colonography

Computed tomography (CT) Colonography is seen by many to be the answer to many of these woes. This basically entails fully insufflating a prepared colon, therefore also called CT Pneumocolon, CT Colonoscopy or Virtual Colonoscopy. It is safe and well accepted by patients and is considered a less invasive test that reliably visualises the whole bowel. Multiple trials over the last decade have shown a similar accuracy to conventional colonoscopy in detecting polyps and cancers [25, 26, 27, 28].

Virtual colonoscopy refers primarily to the method of using 3D computer-generated images to examine the colon. Modern multi-slice CT generates a 3D data set. Rather than just axial images, this data can then be reconstructed in any plane. Three-dimensional images can be generated, simulating those obtained during conventional colonoscopy [figure 3].

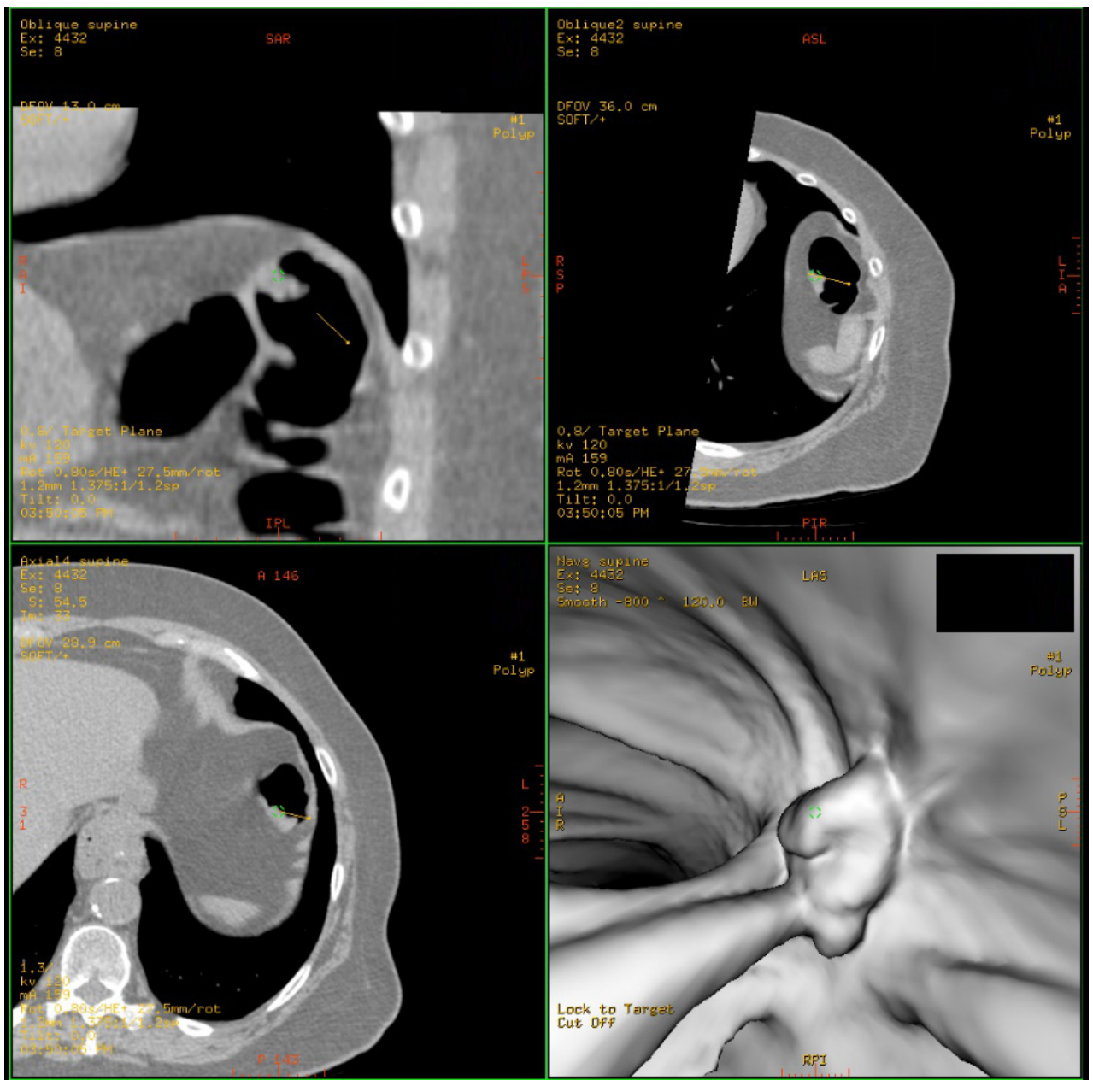

Figure 3 – A small ulcerating tumour at the splenic flexure is shown in coronal (top left), oblique (top right), axial (bottom left) but easiest to appreciate on a 3d "endoluminal" volume rendered view

When it was first described in 1994 by Vining et al. [29], the scan took 50 seconds, acquiring on 5mm sections and the resulting images required 8 hours of computing time. The very first Virtual Colonoscopy was demonstrated at the US Society of Gastrointestinal Radiologists in Feb 1994. During the presentation, Vining used a computer mouse to navigate a "fly-through" of a volunteer's colon, to the accompaniment of Wagner's "Ride of the Valkyries".

Since then, the technology has evolved considerably. Scan times are less than 10 seconds, acquiring 0.6mm sections with reconstruction times of less than 20 seconds.

Much has also been done to optimise the scan technique. Patient discomfort has been improved by several methods and radiation dose has been reduced considerably. Also better understanding of the interpretation of such scans has significantly improved diagnostic accuracy. These factors will be discussed below.

Lessening Patient Discomfort

Bowel Preparation

The success of this method relies on a pre-examination bowel preparation to empty the bowel and 'tag' solid food and liquid residues with oral contrast media. Typical regimes use both Barium and iodinated but non-absorbed water-soluble media, such as Gastrografin [30, 31, 32, 33, 34, 35, 36]. Barium predominately tags the more solid elements of the retained colonic residue [37]. Hyperosmolar iodine-based contrast agents promote stool softening by inducing colonic fluid secretion. This allows homogenous tagging of both solid and fluid residue but can induce significant diarrhoea when administered in large volumes.

These high-density contrast agents intermingle with faecal matter rendering them high-density, appearing bright white on the CT image [Figure 4]. This difference in contrast allows easy discrimination between faeces and mucosal pathology. This process also circumvents the problem of

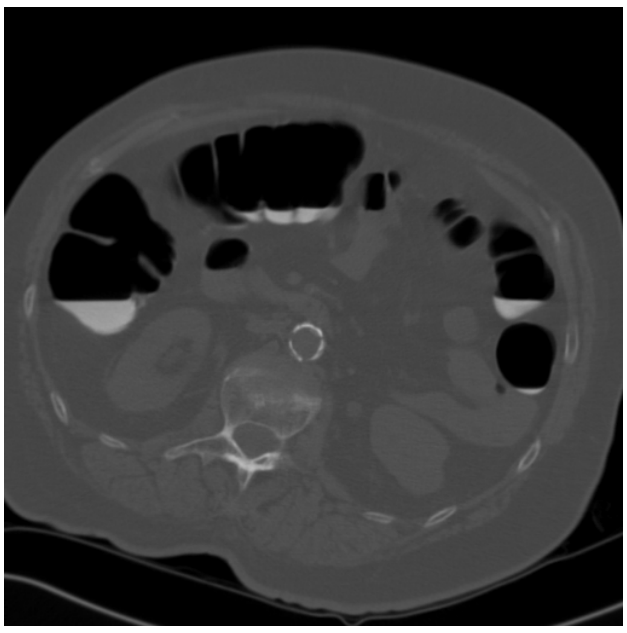

Figure 4 – Residual liquid faecal material "tagged" with dense barium and iodine contrast media is rendered bright white on the CT image

non-visualisation of bowel due to faecal residue and also eradicates false positive diagnoses, where polyps can be mimicked by stool.

This process is known as "faecal tagging" and allows a less vigorous bowel preparation. As a consequence, such regimes are much better tolerated by patients in comparison to the full cathartic bowel preparation used in barium enemas and conventional colonoscopy. Full bowel prep regimes are unpopular with patients [38, 39], and carry a significant morbidity and even mortality [40].

Many bowel preparation regimes employ a low residue diet in the days leading up to the examination. The use of a low residue diet is a simple and effective way of reducing the volume of residual faecal material [41] with no difference in patient acceptance [42].

The key to any CT colonoscopy bowel prep regime, particularly in the context of screening, when the patient is often asymptomatic, is obtaining the optimum balance between a well prepared colon, allowing the radiologist to confidently diagnose or exclude colorectal pathology and a well tolerated regime with few side effects for the patient.

In our institution patients undergo a simple regime consisting of a combination of low fibre diet, mild stimulant laxative and small volumes of barium and iodine. This is now tried and trusted; audits of its efficacy have shown that it produces a reliably well-prepared bowel with fewer side-effects than Picolax used for barium enema.

CT Colon Procedure

The key to an accurate study is a good quality study. It is entirely possible to perform a good quality study yet make it comfortable for the patient.

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Several procedural aspects improve patient comfort: a slick and speedy procedure, the routine use of an antispasmodic, fine-bore rectal catheters and automated carbon dioxide (CO_2) insufflation are all of benefit.

The examination itself is quick. With experienced staff and a mobile patient a "table time" of 15 minutes is usual with a further 15 minutes for interpretation and reporting. This contrasts favourably with barium enema and markedly shorter than optical colonoscopy [28, 43].

The patient receives an intravenous injection of an antispasmodic, 20mg butylscopalamine bromide (Buscopan) whilst on the CT table to paralyse the bowel. This reduces colic for the patient by preventing bowel spasm. This lack of spasm also enables better visualisation of mucosal pathology.

A soft fine-bore flexible rectal tube is inserted and secured in position and the patient is positioned supine. This slim tube is much better tolerated than semi-rigid large bore enema tubes or endoscopes.

CO_2 gas is instilled via the rectal catheter via an automated insufflator until adequate colonic distension has been achieved. Automated insufflation has the advantage of preventing high intra-luminal pressures, which can cause discomfort and even bowel perforation. CO_2 has the advantage of being absorbed very rapidly and post-procedural discomfort is minimized [44]. The patient's abdomen and pelvis are subsequently scanned. The patient is then turned prone and the scan is repeated. This increases the chance that any areas of colon not completely distended on the supine scan (particularly the sigmoid) will be adequately visualised.

Once the scans are completed the rectal catheter is removed and the patient is escorted to a nearby toilet to expel residual colonic gas to prevent colicky abdominal pain as the effect of the antispasmodic wears off.

In our centre no intravenous contrast is used during the scan. Some centres use contrast in all symptomatic patients. The rationale being that any extra-colonic lesions, including potential liver metastases are better visualised and characterised with contrast and the patient effectively undergoes a staging scan at the same visit. The downside of this approach is the increased time and resources, longer scan times as well as the associated risks of intravenous iodinated contrast administration.

The images are reviewed on a CT workstation. The whole colon is interrogated on in the axial plane but also reformatted images in the sagittal and coronal planes. Such workstations allow construction of 3-D surface-rendered images, allowing an endoluminal 'fly through'. Some radiologists use this as a primary interpretation and others use it as an adjunct for equivocal cases.

Radiation Dose

Modern CT scanners feature very powerful x-ray tubes, allowing very good quality images in even very obese patients. However, the x-ray dose in such patients can be very high. As with other radiological scans involving ionising radiation, such as CT, it is important to keep radiation dose to a minimum without compromising the quality of the images obtained.

Although very low dose studies can be done and polyps and cancers can be adequately visualised, soft tissue visualisation will be compromised due to image noise. Some radiologists will tolerate very noisy images and accept that the abdominal and pelvic viscera are not seen in detail. In our institution, we believe it is important to see the extra-colonic soft tissues in some detail. Hence, we perform the supine scan at a moderate dose setting and the prone scan at a lower dose setting. By doing this, we have reduced dose down to around 8mSv, which is just less than twice that of a barium enema.

Improving accuracy

The major features of an accurate CT colonoscopy are a good quality study interpreted by trained experts. Training and experience is important: early studies of accuracy of CT colonography such as that by Rockey et al [43] were hampered by relative inexperience of many of the radiologists involved.

Extra-colonic findings

An important advantage of CT colonoscopy is the possibility of diagnosing unsuspected extra-colonic pathologies as the cross-sectional imaging yields relatively detailed information regarding the imaged organs in the abdomen. Extra-colonic lesions are commonly found and their incidence increases with age, being characterised as of high, medium and low clinical importance. Gluecker et al. [45] reported incident rates of 10% of high clinical importance findings in asymptomatic patients, 27% of medium and 50% of low clinical importance. The potential to diagnose high and moderate clinical importance lesions, such as renal cell carcinoma, abdominal metastatic disease, non-Hodgkin lymphoma and aortic aneurysm adds benefit to the study. It does carry the drawback of an economic impact due to supplement costs of the further workup and treatment of the incidentally found lesions [46] [Figure 5].

Conversely, the main disadvantage of CT colonography is that any lesion detected will ultimately require endoscopic biopsy and / or removal. On the other hand, it can guide and direct the optical colonoscopy procedure when a lesion is detected and biopsy is necessary by determining its location and characteristics.

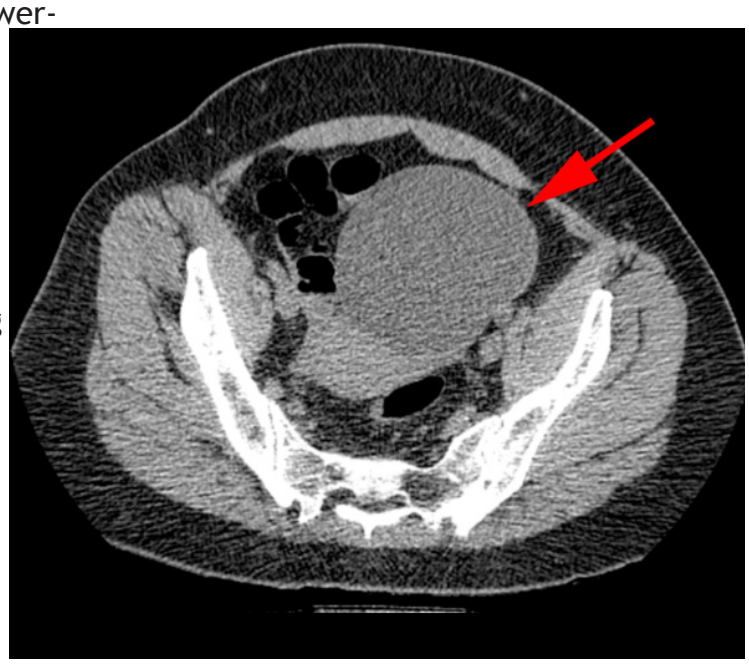

Figure 5 – This entirely asymptomatic 10cm ovarian cyst was fortunately of benign histology upon subsequent resection

Summary

In summary, CT colonography is accurate, safe and quick to perform. Patients prefer it as it is minimally invasive and requires less vigorous bowel preparation and hence is well tolerated, even by the more elderly patients.

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