Afro Carribeans and white Caucasians with type 2 diabetes. Diabetes Care 2005; 28(2): 496.
27. Chaturvedi N, Bulpitt CJ, Leggetter S *et al.* Ethnic differences in vascular stiffness and relations to hypertensive target organ damage. J Hypertens 2004; 22(9): 1731–7.
28. Brancati FL, Whittle JC, Whelton PK, Seidler AJ, Klag MJ. The excess incidence of diabetic end-stage renal disease among blacks. A population-based study of potential explanatory factors. JAMA 1992; 268: 3079–84.
29. Cameron JD, Bulpitt CJ, Pinto ES, Rajkumar C. The aging of elastic and muscular arteries: a comparison of diabetic and nondiabetic subjects. Diabetes Care 2003; 26(7): 2133–8.

Received 1 December 2005; accepted in revised form 13 July 2006

Age and Ageing 2007; **36:** 48–52
doi:10.1093/ageing/afl116
Published electronically 17 November 2006

Minimal-preparation CT colon in detection of colonic cancer, the Oxford experience

Arul Ganeshan, Sara Upponi, Raman Uberoi, Horace D'Costa, Carol Picking, Helen Bungay

John Radcliffe Hospital, Radiology Department, Headley Way, Headington, Oxford OX3 9DU, UK

Address correspondence to: A. Ganeshan. Tel: (+44) 1865220813. Fax: (+44) 1865 220801.
Email: aganeshan@hotmail.com

Abstract

Background: the main colonic imaging modalities, including barium enema, colonoscopy and computed tomography colonography, require bowel preparation. Performing these imaging procedures in the elderly can difficult due to immobility, incontinence and poor tolerance of bowel cleansing. Minimal preparation CT (MPCT) colon was introduced in the early 1990s in the UK. Much of the published literature on MPCT colon is limited by small patient numbers and short duration of follow-up.
Objective: the aim of this study is to review our experience with the MPCT technique involving a large consecutive cohort of patients with long follow-up.
Methods: all studies of MPCT performed in a 1-year period between July 2000 and July 2001 at our institution were reviewed retrospectively. MPCT reports were cross-referenced with the cancer registry to allow for an average period of 30 months follow-up. A definite diagnosis of cancer was only given following the appearance on the cancer registry. Those patients who had negative MPCT colon were assumed to be true negatives if no corresponding name was identified on the cancer registry. In the event of data mismatch, patient notes were reviewed to ascertain a diagnosis.
Results: 391 MPCT examinations were performed during the period of the study (209 males, median age 82: age range 56–91 years). Thirty-four patients who had MPCT colon during the study period appeared on the cancer registry. A further three patients with disseminated colorectal malignancy identified on MPCT colon died without histological confirmation (tumour prevalence = 9.5%). Thirty-two of the registry confirmed 34 cases were detected on MPCT colon, giving a sensitivity of 0.94 (95% confidence interval 0.86–1.00). Including the three cases without histological confirmation gives a slightly higher sensitivity of 0.95. There were seven patients with definitely abnormal MPCT colons, who did not appear on the registry, resulting in specificity for definite abnormality of 0.98 (confidence interval 0.97–1.0). However, three of these seven are those who died of disseminated colorectal malignancy as above, raising the specificity to 0.99. Fourteen cases (3.5%) of extra-colonic malignancies were observed in this study.
Conclusion: even with the longer follow-up of this large cohort of patients the sensitivity and specificity in our study for the diagnosis of colorectal cancer with MPCT remains comparable with that of other studies and this technique competes well with other common colonic imaging modalities.

Keywords: *colonic cancer, elderly patients, MPCT*

Colonoscopy, barium enema, and computerised tomography colonography (CTC) are recognised forms of investigation for suspected large bowel pathology. However, all these require full bowel preparation, which can be uncomfortable and distressing, particularly in the elderly. It may also be associated with fluid and electrolyte imbalances in elderly patients and those with comorbidities. Poor mobility and incontinence make it problematic to administer the requisite medications in a domiciliary setting, and the process of bowel preparation may necessitate hospital admission [1]. Poor mobility and incontinence also hinder investigations such as barium enema and reduce its successful completion rate [2]. Even with great perseverance, nearly a third of barium enemas or colonoscopies in the elderly or mentally disabled patients result in incomplete demonstration of the large bowel [3]. In addition, colonoscopy requires sedation, which is poorly tolerated by this group of patients.

There are a number of published studies regarding the use of computed tomography (CT) of the colon without complete bowel preparation as an alternative tool for investigating elderly patients with suspected bowel cancer [4–8]. Minimal-preparation computed tomography (MPCT) colon was first described by Day *et al.* in the early 1990s as an alternative technique for imaging the large bowel in frail elderly patients with suspected colorectal pathology who are referred for barium enema [9]. The basic premise is that it is the detection of colonic cancer that is important in this elderly cohort and it is presumed that the presence of polyps is of less clinical relevance. Comparative studies of MPCT with barium enema demonstrate the former to be reasonably sensitive (75–96%) and specific (82–94%) for detecting colonic malignancy [4, 9]. Published data have shown that MPCT is well tolerated by the elderly population who are intolerant of bowel preparation [9]. The effective radiation dose to the patient is also shown to be similar for barium enema and abdomino-pelvic CT [10].

MPCT colon in the elderly remains underutilised, which is partly because of limited documentation in the literature regarding the technique and its generality of application. All the published studies using MPCT come from a few UK-based institutions [4–9]. All but one of these studies are small (30–118 patients), and the average duration of follow-up is short (0–18 months) [6]. The true incidence of cancer in the studied populations is difficult to assess, as most of the published studies found difficulties in correlating imaging findings with clinical data or cancer databases. The main aim of the present study is to review our experience with the MPCT technique involving a large consecutive cohort of patients who have been traced in the cancer registry for a longer period.

Methods

In this study, MPCT reports of all patients between 1 July 2000 and 30 June 2001 were reviewed retrospectively and cross-referenced with the Oxford Cancer Registry up to 1 July 2004 for an average period of 30 months (range 26–39 months). The cancer registry is a comprehensive database that contains details of all patients who have a diagnosis of colonic tumour confirmed histologically. The MPCT findings were categorised as definite colonic malignancy, possible malignancy, or no malignancy. A confirmed diagnosis of cancer was given only when patients with MPCT finding of colonic malignancy matched those in the cancer registry. For those who had a normal MPCT, the findings were deemed to be true negatives if no corresponding names were found on the cancer registry. In the event of a mismatch between the registry and MPCT findings, the patient's notes were reviewed to ascertain the final outcome.

MPCT was introduced in our institution in 1999 to investigate patients with suspected large bowel tumours. All frail elderly patients or patients who are physically or mentally incapacitated, are routinely imaged using MPCT rather than barium enema. Our protocol is a modified version of the published technique by Day *et al.* [9]. Patients receive six doses of 5-ml gastrografin (Schering, Berlin, Germany) diluted with 300-ml water over a 48-h period (evening dose 2 days prior to the study, morning and evening doses the day before the study, morning dose the day of the study, a dose 30 min before the study, and the last dose just before the study). No additional bowel preparation is given. Axial 7.5/22.5-mm high-speed helical consecutive CT images of the abdomen and pelvis are obtained. This differs from the technique of Day *et al.* in that we administer no laxative for the preparation.

Results

There were 391 MPCT examinations performed during the period of the study (209 males, median age 82, age range 56–91 years) (Figure 1). MPCT reports were categorised as definite colonic malignancy (Figure 2) in 39 cases, possible malignancy in 38 cases, and normal in the remaining 314 cases. Thirty-four patients in the studied group appeared on the Cancer Registry. An additional three patients with abnormal MPCT and evidence of large bowel obstruction died within eight days of disseminated malignancy consistent with colorectal origin without histological confirmation and were not found in the cancer registry. This leaves a total of 37 patients with colorectal cancer in this study, resulting in a tumour prevalence of 9.5%. Thirty-two of the 34 registry-confirmed cancer cases were identified using the MPCT, giving a sensitivity of 0.94 (95% CI = 0.86–1.0) (Table 1). Inclusion of the three additional cases that did not appear on the cancer registry, but died of disseminated malignancy, increases the sensitivity to 0.95.

Two cases of colonic malignancy were not detected by MPCT. One of these occurred at the anorectal junction. Even in retrospect, this was not visible radiologically. The tumour, however, should have been palpable on digital rectal examination. In the second case, the presence of neoplasm was difficult to assess because of coexisting extensive diverticular disease, and further evaluation of this region by endoscopic examination was recommended in the report.

Table 1. Comparison of our result with the currently available literature on MPCT colon studies

Studies	Number of patients	Average period of follow-up in months	Sensitivity (%)	Specificity (%)	Extracolonic tumour (%)
Ng [6]	1,031	15	85	95	2
Robinson [5]	195	16	100	87	5.6
Kealey [7]	72	12	75	87	1.4
Domjan [4]	118	0	75	96	2.5
Day [9]	37	3	100	87	3.3
Oxford Experience	391	30	94/95[a]	99/88[a]	4

[a]Range is dependent on the inclusion of 'possible malignancy'.

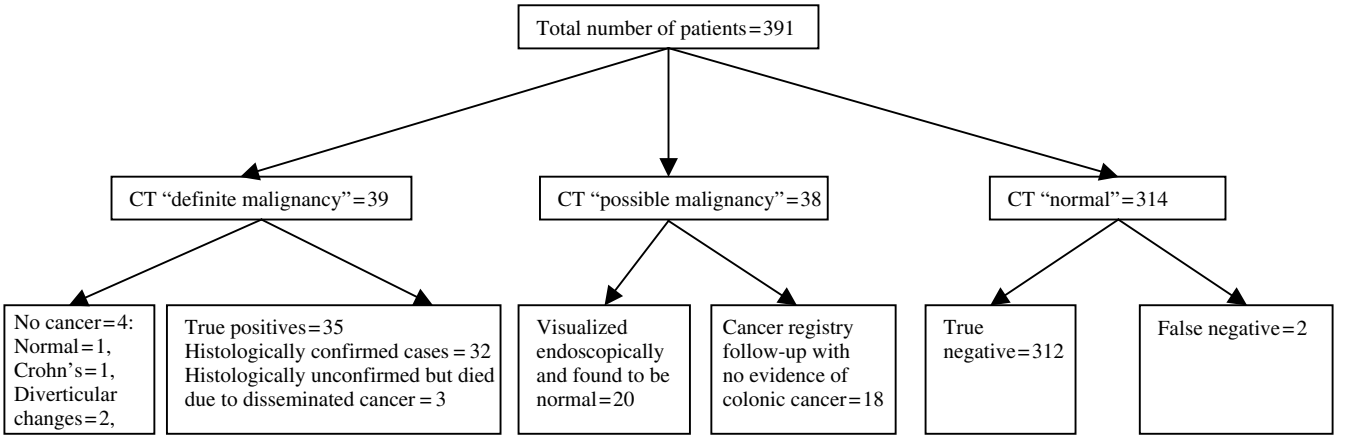
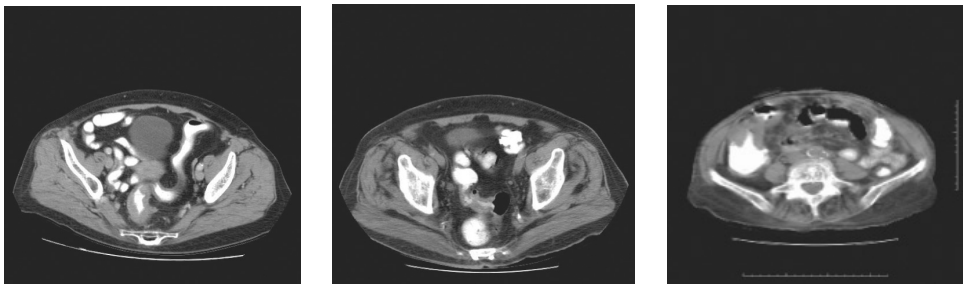


Figure 1. Flow diagram depicting various categories of MPCT reports.

Of the 39 definite cancers on MPCT, there were 32 histologically confirmed cancers. Three cases were the histologically unconfirmed but clinically consistent cases as described above. This results in a positive predictive value of 0.90. There were another four patients with definite cancer on MPCT, whose names were not found on the cancer registry, resulting in a specificity of 0.99 (95% CI 0.98–1.0). The four patients with false positive diagnoses subsequently underwent direct visualisation of the large bowel endoscopically. Findings were normal in one case, showed Crohn's disease in one case, and diverticular changes in the remaining two cases.

None of the 38 cases that were reported as 'possible malignancy' was found in the cancer registry. Twenty of these 38 cases subsequently underwent colonoscopy, which was normal in 11 cases, showed diverticular disease in five cases, and tubulovillous adenomas in four patients. The remaining 18 patients either refused further investigation or were not clinically fit for the same. When the 38 cases in which MPCT was reported as 'possible malignancy' are considered as false positives, specificity for this technique is reduced to 0.88 (95% CI 0.85–0.92).

Extracolonic findings suggestive of spread of the primary colorectal tumour were identified in six cases. In addition,



(a) (b) (c)

Figure 2. Examples of 'CT definite (histologically confirmed)' colonic cancer malignancies showing concentric wall thickening with evidence of shouldering: sigmoid [2(a) and (b)] and ascending colon (2c).

MPCT identified 14 cases of extracolonic malignancies, with a tumour prevalence of 3.6%.

Discussion

This study, from a single institution in the UK, is the largest series to date analysing the MPCT technique in patients in whom standard modalities of colonic investigation are likely to have a poor outcome. We acknowledge the potential limitations of utilising a cancer registry for corroboration, but migration in this elderly population should be low [11]. The disease prevalence for our population was similar to those in other studies in the literature [4–8]. We report a high sensitivity (0.95) and specificity (0.88–0.99) in diagnosing colonic malignancy using MPCT in elderly or incapacitated patients with suspected colonic pathology. Accepting that the 'gold standard' of appearance on the colorectal cancer registry has limitations, our study does suggest that MPCT performs favourably in comparison with barium enema or colonoscopy in the elderly. Furthermore, none of the consecutive examinations in the 391 cases was technically inadequate. This is in comparison with an expected failure rate of 33% in the elderly cohort with barium enema and colonoscopy examinations [3].

MPCT colon is not sensitive enough to detect small colonic lesions or polyps less than 1–2 cm in size [12]. Such findings are frequently benign and though polyps may have malignant potential and may warrant identification and removal in a younger patient cohort, they are not of the same clinical significance in the elderly [9]. Studies of the adenoma–carcinoma sequence suggest that progression of an adenoma to an invasive carcinoma is estimated to take 5–8 years [13]. MPCT, therefore, may be considered an acceptable alternative imaging modality for investigating elderly patients with suspected bowel cancer. Furthermore, in this series, no cases of the 'possible colonic abnormalities' were confirmed to be malignant in nature. Therefore, this study confirms that subtle abnormal colonic findings are unlikely to represent malignancy and can safely be ignored unless clinical suspicion is high [5–7].

MPCT also competes well with other major forms of colorectal examination in terms of cost, level of complications, and radiation safety. The cost of an MPCT in our centre is £ 123, compared with £ 109 for barium enema and £ 425 for colonoscopy. The radiation dose in this elderly population is of less significance than in a young cohort, but the dose from MPCT is of a similar order to that of barium enema (5 mSv vs 3.8 mSv). Major complications of MPCT are negligible, compared with a 0.3% complication rate for colonoscopy and 0.01% for barium enema [14, 15]. Anecdotally, only a few patients complained of diarrhoea induced by the three days of oral contrast, but this does not render the examination a failure.

A further benefit of MPCT is its ability to identify additional extracolonic pathology that may contribute to the patient's symptoms. Abdominal malignancies in the elderly tend to have protean manifestations and may be more difficult to diagnose. In our study, 14 (3.6%) previously unknown extracolonic tumours were identified from 391 examinations. This prevalence is comparable to other published data: Ng and colleagues identified such tumours in 2% of their cases [16]. Our patient cohort has a higher incidence of other cancers than has been reported from other series of patients undergoing MPCT, and this probably reflects our elderly population. The use of MPCT as a first-line investigation is also useful in the staging of any colonic tumours identified and provides additional information in a third of such patients [5]. This information has the potential to alter patient management and to avoid unnecessary interventions in the setting of disseminated cancer.

Conclusion

MPCT is a non-invasive technique that is well tolerated by patients. It avoids the need for bowel cleansing agents and is more likely to be tolerated in a domiciliary environment. The present study confirms that MPCT can be recommended for investigating the elderly with suspected colorectal pathology and is both sensitive and specific for diagnosing colorectal cancer in this population.

Key points

- Minimal-preparation CT colon is a minimally invasive, well tolerated, and economical investigation for colorectal cancer in the frail, elderly population.
- It is very sensitive in the detection of colorectal malignancy.
- If MPCT colon findings are equivocal, then the likelihood of colorectal cancer is very low.

Conflicts on interest

We declare no commercial interests, such as directorships, share-holdings, consultancies, honoraria, grants, fees, gifts, or travel expenses received from organisations whose product is used in the study or referred to in our article.

References

1. Coni N, Davidson W, Webster S. Lecture notes on geriatrics. Oxford: Blackwell Scientific Publications, 1988; 203.
2. Stewart ET, Dodds WJ. Predictability of rectal incontinence on barium enema examination. AJR Am J Roentgenol 1979; 132(2): 197–200.
3. Tinetti ME, Stone L, Cooney L, Kapp MC. Inadequate barium enemas in hospitalized elderly patients. Incidence and risk factors. Arch Intern Med 1989; 149(9): 2014–6.
4. Domjan J, Blaquiere R, Odurny A. Is minimal preparation computed tomography comparable with barium enema in elderly patients with colonic symptoms? Clin Radiol 1998; 53(12): 894–8.

5. Robinson P, Burnett H, Nicholson DA. The use of minimal preparation computed tomography for the primary investigation of colon cancer in frail or elderly patients. Clin Radiol 2002; 57(5): 389–92.
6. Ng CS, Doyle TC, Pinto EM *et al.* Evaluation of CT in identifying colorectal carcinoma in the frail and disabled patient. Eur Radiol 2002; 12(12): 2988–97.
7. Kealey SM, Dodd JD, MacEneaney PM, Gibney RG, Malone DE. Minimal preparation computed tomography instead of barium enema/colonoscopy for suspected colon cancer in frail elderly patients: an outcome analysis study. Clin Radiol 2004; 59(1): 44–52.
8. Koo BC, Ng CS, U-King-Im J, Prevost AT, Freeman AH. Minimal preparation CT for the diagnosis of suspected colorectal cancer in the frail and elderly patient. Clin Radiol 2006; 61(2): 127–39.
9. Day JJ, Freeman AH, Coni NK, Dixon AK. Barium enema or computed tomography for the frail elderly patient? Clin Radiol 1993; 48(1): 48–51.
10. National Radiological Protection Board (NRPB). 1979; **10**(1) (www.nrpb.org).
11. Rogerson PA. Geographic perspectives on elderly population growth. Growth Change 1996; 27(1): 75–95.
12. Painter NS. The cause of diverticular disease of the colon, its symptoms and its complications. Review and hypothesis. J R Coll Surg Edinb 1985; 30(2): 118–22.
13. Muto T, Bussey HJR, Morson BC. The evolution of cancer of the colon and rectum. Cancer 1975; 36: 2251–70.
14. Habr-Gama A, Waye JD. Complications and hazards of gastrointestinalendoscopy. World J Surg 1989; 13: 193–201.
15. Eddy DM. Screening for colorectal cancer. Ann Intern Med 1990; 113: 373–84.
16. Ng CS, Doyle TC, Courtney HM, Campbell GA, Freeman AH, Dixon AK. Extracolonic findings in patients undergoing abdomino-pelvic CT for suspected colorectal carcinoma in the frail and disabled patient. Clin Radiol 2004; 59(5): 421–30.

Received 21 March 2006; accepted in revised form 14 August 2006