NATIONAL INSTITUTE FOR CLINICAL EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedures overview of computed tomography colonography (virtual colonoscopy)

Introduction

This overview has been prepared to assist members of the Interventional Procedures Advisory Committee (IPAC) in making recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in August 2004.

Procedure name

- Computed tomography (CT) colonography (or CTC).
- Virtual colonoscopy.

Specialty societies

- Royal College of Radiologists.
- Society of Radiographers.
- British Society of Gastroenterology.
- Special Interest Group in Gastrointestinal and Abdominal Radiology (SIGGAR).
- Association of Coloproctology of Great Britain and Ireland

Description

Indications

CT colonography is used to examine the colon and rectum, and detect abnormalities such as polyps and cancer. Polyps are growths in the lining of the colon or rectum that protrude into the intestinal canal. They may be adenomatous (precancerous) or benign. It is generally agreed that polyps smaller than 6 mm should be regarded as clinically insignificant.[1]

Colorectal cancer is the third most common cancer in men, and the second most common cancer in women in the UK.[2] Symptoms include blood in the stool, change in bowel habit, abdominal pain and unexplained weight loss. Risk factors include increasing age, a previous polyp or colorectal cancer, personal history of chronic bowel inflammation, and a family history of colorectal cancer.

As well as its use in symptomatic patients, CT colonography may be used in asymptomatic patients with a high risk of developing colorectal cancer, and to screen asymptomatic patients with an average risk of developing colorectal cancer.

Current alternatives

Conventional colonoscopy and double contrast barium enema are the main methods currently used for examining the entire colon. The bowel must be empty before either of these procedures is performed.

A colonoscopy is normally done under conscious sedation. It involves inserting a long, flexible endoscope into the rectum and advancing it along the colon to visualise the lining. The aim is to reach as far as the caecum, but this is not always possible. A biopsy can be taken or a polyp removed during the procedure.

A double contrast barium enema is an X-ray of the colon. A small tube is inserted into the rectum and barium liquid is passed through into the colon. When the barium has spread throughout the colon, the surplus is removed, air is insufflated and several X-ray pictures are taken with the patient placed in different positions.

What the procedure involves

CT colonography is less invasive than a conventional colonoscopy. It involves using a CT scanner to produce 2- and 3-dimensional images of the entire colon and rectum.

CT colonography is performed on an empty bowel. Sedation is not usually required. The colon is distended by insufflation with air or carbon dioxide, via a small rectal tube. Antispasmodic agents and/or contrast agents may be administered intravenously before the scan. The CT scan is done with the patient holding his or her breath for approximately 20 seconds in both the supine and prone positions.

The images are then manipulated and interpreted by a radiologist.

Efficacy

A meta-analysis of data in 14 studies reported the sensitivity and specificity for the detection of polyps, using conventional colonoscopy as the reference standard. The pooled per-patient sensitivity for polyps 10 mm or larger was 88% (95% confidence interval [CI]: 84–93%), for polyps 6–9 mm it was 84 (95% CI 80–89%) and for polyps 5 mm or smaller it was 65% (95% CI 57–73%). The pooled per-polyp sensitivity for polyps 10 mm or larger was 81% (95% CI 76–85%), for polyps 6–9 mm it was 62% (95% CI 58–67%) and for polyps 5 mm or smaller it was 43% (95% CI 39–47%). The overall specificity for detection of polyps 10 mm or larger was 95% (95% CI 94–97%).

A recent study including 1233 asymptomatic adults reported that the per-patient sensitivity of CTC for polyps 6 mm or larger was 89% (95% CI 83–93%) compared with 92% (95% CI 87–96%) for optical colonoscopy. The per-patient sensitivity for polyps 10 mm or larger was 94% (95% CI 83–99%) for CTC and 88% (95% CI 75–95%) for optical colonoscopy. A second study of 703 asymptomatic patients reported per-patient sensitivities of 64% (95% CI 48–77%) for polyps 10 mm or larger and 65% (95% CI 53–76%) for polyps 5–9 mm.

Two studies reported that 68% (686/1005) and 72% (357/494) of patients found CTC to be more acceptable then optical colonoscopy. One study also reported that 97% (518/534) of patients preferred CTC to double contrast barium enema.

The main concern expressed by the Specialist Advisors was the risk of missing flat or small lesions. One Specialist Advisor stated that up to 30% of the bowel may be inadequately visualised.

Safety

No significant complications were reported in the studies. Two studies reported on the level of discomfort felt by the patients during the procedure. One study reported that 1% (6/696) of patients experienced “extreme” or “severe” discomfort during CTC, compared with 4% (25/696) for colonoscopy ($p = 0.63$). Of the 617 patients given CTC and double contrast barium enema, 0.7% (4/617) of patients had “severe” or “extreme” discomfort during CTC compared with 29% (181/617) for the barium enema ($p < 0.001$). A second study reported that 54% (546/1005) of patients found CTC to be more uncomfortable than optical colonoscopy, but this was probably affected by the fact that patients were sedated for the optical colonoscopy and not for the CTC.

The Specialist Advisors did not express any major safety concerns. Bowel perforation is a potential adverse effect but this would be rare. Patients are exposed to ionising radiation with a similar dose to barium enema examinations (equivalent to a few years of natural background radiation). There is a potential risk of a reaction to a contrast agent if one is administered.

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to virtual colonoscopy. Searches were conducted via the following databases, covering the period from their commencement to June 2004: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and Science Citation Index. Trial registries and the Internet were also searched. No language restriction was applied to the searches.

The following selection criteria (Table 1) were applied to the abstracts identified by the literature search. Where these criteria could not be determined from the abstracts the full paper was retrieved.

Table 1 Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising methodology.
Patient	Patients with symptoms of bowel disease, asymptomatic patients at high risk of colorectal polyps or cancer, asymptomatic patients at average risk of colorectal cancer.
Intervention/test	Computed tomographic colonography.
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the overview

This overview is based on seven studies, including a systematic review with a meta-analysis of 14 studies published between 1994 and 2002.[3] Three studies report the sensitivity and specificity of CTC, using colonoscopy as the standard, including one which was also in the systematic review. [1,4,5] One study reports the results of a community-based screening project.[6] One study reports the sensitivity and specificity of CTC compared with double contrast barium enema.[7] The final study presented in Table 2 reports the experiences of patients given either CTC and colonoscopy or CTC and a double contrast barium enema.[8]

Existing reviews on this procedure

A systematic review, including literature published between 1994 and July 2002 was published in 2003.[3] This review has been summarised in Table 2.

An assessment by the Minnesota Department of Health, published in 2002, concluded that CTC is a safe procedure but further research is needed before it can be recommended as a screening tool.[9] The report stated that the sensitivity and specificity of CTC needs to improve to be comparable to that of colonoscopy. The Medical Services Advisory Committee, Australia, published a horizon scanning briefing reviewing the literature between 1998 and July 2001.[10] The review concluded that CTC appears to be safe when used for diagnosing colorectal cancer in individual patients but that its safety as a population-based screening tool has yet to be evaluated.

Table 2 Summary of key efficacy and safety findings on computed tomography colonography (CTC)

Study Details	Key efficacy findings	Key safety findings	Comments
Sosna, J (2003)[3] USA Systematic review. Literature published between 1994 and July 2002 146 articles on CTC were identified, of which 14 fulfilled the inclusion criteria: • Royster et al. (1997)[11], n = 20 • Dachman et al. (1998)[12], n = 44 • Hara et al. (1998)[13], n = 70 • Fenlon et al. (1999)[14], n = 100 • Rex et al. (1999)[15], n = 46 • Morrin et al. (2000)[16], n = 33 • Mendelson et al. (2000)[17], n = 53 • Pescatore et al. (2000)[18], n = 50 • Fletcher et al. (2000)[19], n = 180 • Macari et al. (2000)[20], n = 42 • Hara et al. (2001)[21], n = 237 • Yee et al. (2001)[4], n = 300 • Spinzi et al. (2001)[22], n = 99 • Gluecker et al. (2002)[23], n = 50	Pooled per-patient sensitivity: Polyps 10 mm or larger = 0.88 (95% CI: 0.84 to 0.93) Polyps 6–9 mm = 0.84 (95% CI: 0.80 to 0.89) Polyps ≤ 5 mm = 0.65 (95% CI: 0.57 to 0.73). Pooled per-patient sensitivity (outlier studies removed): Polyps 10 mm or larger = 0.85 (95% CI 0.79 to 0.91) Polyps 6–9 mm = 0.89 (95% CI 0.85 to 0.94) Polyps ≤ 5 mm = 0.80 (95% CI 0.72 to 0.89). Pooled per-polyp sensitivity: Polyps 10 mm or larger = 0.81 (95% CI 0.76 to 0.85) Polyps 6–9 mm = 0.62 (95% CI 0.58 to 0.67) Polyps ≤ 5 mm = 0.43 (95% CI 0.39 to 0.47). Pooled per-polyp sensitivity (outlier studies removed): Polyps 10 mm or larger = 0.81 (95% CI 0.68 to 0.94) Polyps 6–9 mm = 0.45 (95% CI 0.39 to 0.52) Polyps ≤ 5 mm = 0.17 (95% CI 0.12 to 0.23). Pooled specificity for polyps 10 mm or larger = 0.95 (95% CI 0.94 to 0.97).	**No safety data were reported.**	Review only included prospective, peer-reviewed English language studies in which the reference standard was conventional colonoscopy. The studies analysed differed regarding technical factors such as pitch and reconstruction interval. Studies included mostly high-risk patients.

Study Details	Key efficacy findings	Key safety findings	Comments
Pickhardt, PJ (2003)[1] USA 2002–2003 Comparative study 1233 asymptomatic adults given CTC followed by optical colonoscopy Mean age = 58 years Inclusion criteria: age between 50 and 79 years old with an average risk of colorectal cancer, age between 40 and 79 years old with a family history of colorectal cancer Exclusion criteria: positive guaiac-based test of stool within 6 months before referral, iron-deficiency anaemia within previous 6 months, rectal bleeding within previous 12 months, unintentional weight loss of more than 4.5 kg within previous 12 months, optical colonoscopy within previous 10 years, barium enema within previous 5 years, history of adenomatous polyps, colorectal cancer, or inflammatory bowel disease, history of familial adenomatous polyposis or hereditary nonpolyposis cancer syndromes, rejection for optical colonoscopy for any reason, medical condition that precludes the use of sodium phosphate preparation, pregnancy	Prevalence of adenomatous polyps ≥ 6 mm in diameter = 13.6% **Analysis according to patient (detection of adenomatous polyps)** no. / total no. (% [95% CI]) Sensitivity / Specificity CTC Polyp ≥ 6 mm: 149/168 (88.7 [82.9–93.1]); 848/1065 (79.6 [77.0 - 82.0]) Polyp ≥ 10 mm: 45/48 (93.8 [82.8 - 98.7]); 1138/1185 (96.0 [94.8 - 97.1]) Optical colonoscopy Polyp ≥ 6 mm: 155/168 (92.3 [87.1–95.8]) Polyp ≥ 10 mm: 42/48 (87.5 [74.8–95.3]) **Analysis according to polyp (detection of adenomatous polyps)** no. / total no. (% [95% CI]) Sensitivity CTC Polyp ≥ 6 mm: 180/210 (85.7 [80.2–90.1]) Polyp ≥ 10 mm: 47/51 (92.2 [81.1–97.8]) Optical colonoscopy Polyp ≥ 6 mm: 189/210 (90.0 [85.1–93.7]) Polyp ≥ 10 mm: 45/51 (88.2 [76.1–95.6]) Extracolonic findings on CT of potentially high clinical importance = 4.5% (56/1233) 0.4% (2/554) adenomatous polyps were malignant; both were detected on CTC. More acceptable: CTC = 68% (686/1005), optical colonoscopy = 24% (242/1005), $p < 0.001$	**Complications** There were no clinically significant complications after CTC One patient was hospitalised for delayed bleeding after a polyp was removed during optical colonoscopy Greater discomfort: CTC = 54% (546/1005), optical colonoscopy = 38% (383/1005), $p < 0.001$	Patients were recruited primarily through referrals for screening colonoscopy. CTC and optical colonoscopy were both performed on each patient on the same day. Eight patients were excluded because of an incomplete optical colonoscopy. Six patients were excluded because of inadequate preparation and six patients were excluded because of failure of the CT colonographic system. CTC results were interpreted by radiologists immediately before the optical examination. Optical colonoscopy was performed by colonoscopists initially unaware of the results of the CTC. The final results included findings after re-examinations informed by the results of CTC. two- and three-dimensional views used. 3% (32/1233) patients had a higher than average risk of colorectal cancer. 81.5% (1005/1233) patients returned post-study questionnaires. Rates of discomfort were probably affected by sedation, which was only used for optical colonoscopy.

Study Details	Key efficacy findings	Key safety findings	Comments
Yee, J (2001)[4] USA 1998–1999 Comparative study 300 adults given CTC followed by optical colonoscopy. • 32% (96/300) for cancer screening • 68% (204/300) for evaluation of symptoms Mean age = 63 years Inclusion criteria: patients referred for colorectal cancer screening or for evaluation of symptoms, including stools with blood or positive haemoccult test results, and iron deficiency anaemia Exclusion criteria: pregnancy	**Analysis according to patient** Sensitivity of CTC Polyps / Adenomas Overall: 90% (164/182) / 94% (124/132) < 5 mm: 82% (65/79) / 86% (37/43) 5.0–9.9 mm: 93% (50/54) / 95% (40/42) ≥ 10 mm: 100% (49/49) / 100% (47/47) 100% (8/8) sensitivity for the detection of carcinomas Specificity of CTC Polyps / Adenomas Overall: 72% (85/118) / 57% (95/168) **Analysis according to polyp** Sensitivity of CTC Polyps / Adenomas Overall: 70% (365/524) / 78% (231/298) < 5 mm: 59% (178/301) / 67% (95/142) 5.0–9.9 mm: 80% (113/141) / 82% (72/88) ≥ 10 mm: 90% (74/82) / 94% (64/68) 100% (8/8) sensitivity for the detection of carcinomas By-polyp analysis showed 185 false-positive lesions, 87% (161) of which were smaller than 10 mm There was no statistically significant difference in the sensitivity between asymptomatic and symptomatic patients for the detection of cancer	**Complications** There were no complications after either CTC or standard colonoscopy	This study was also included in the systematic review (Sosna et al, 2003). CTC and optical colonoscopy were both performed on each patient on the same day. A subset of 115 patients received glucagon (antispasmodic) prior to CTC. Radiologists were blinded to the patient's history. two- and three-dimensional views used.

Study Details	Key efficacy findings	Key safety findings	Comments
Johnson, CD (2003)[5] USA Comparative study 703 asymptomatic patients with higher-than-average risk of colorectal cancer given CTC followed by colonoscopy Mean age: 64 years Inclusion criteria: a prior history of colorectal neoplasia, a strong family history of colorectal cancer, or new onset of asymptomatic iron deficiency anaemia Exclusion criteria: blood in the stools, inflammatory bowel disease, and known familial polyposis	3.3% (23/703) of patients had a nondiagnostic CTC, due to residual stool, excessive fluid, or suboptimal distention Overall lesion prevalence for adenomas ≥ 1 cm in diameter = 5% **Analysis according to patient (detection of polyp)** no. / total no. (% [95% CI]) Sensitivity / Specificity Polyp 5–9 mm: 45/69 (65 [52.8–76.3]) / 542/634 (86 [82.5–88.1]) Polyp ≥ 10 mm: 30/47 (64 [48.5–77.3]) / 625/656 (95 [93.4–96.8]) **Analysis according to polyp** no. / total no. (% [95% CI]) Sensitivity Any polyp 5–9 mm: 51/94 (54.3 [43.7–64.6]) Any polyp ≥ 10 mm: 37/59 (62.7 [49.2–75.0]) Adenomatous polyp 5–9 mm: 31/51 (60.8 [46.1–74.2]) Adenomatous polyp ≥ 10 mm: 26/41 (63.4 [46.9–77.9]) The risk of missed detection was greater for both sessile polyps (RR = 1.9, 95% CI: 1.2 to 2.2) and for flat polyps (RR = 1.9, 95% CI: 1.1 to 2.2) relative to the pedunculated polyps.	No safety data reported.	CTC and optical colonoscopy were both performed on each patient on the same day. 90% (635/703) patients received glucagon prior to CTC. Diagnostic review of CT scans was performed by 2 of 3 experienced radiologists in a blinded fashion. Reviewers were instructed to ignore polyps < 5 mm in diameter. two- and three-dimensional views used. Colonoscopists were blinded to the results of CTC. The paper presents results from each of the three reviewers and the combined reports of the two individual reviewers. The double reading results have been presented here. High interobserver variability. Low lesion prevalence population. Same study centre as Gluecker et al, 2003.[7]

Study Details	Key efficacy findings	Key safety findings	Comments
Edwards, JT (2004)[6] Australia Community-based screening study 2000 asymptomatic adults were offered CT colonography, 1452 were eligible and 23.6% (343/1452) participated Exclusion criteria: personal history of colonic polyps or cancer or history of first-degree relative with colorectal cancer, colonoscopy or barium enema within the past 5 years, history of rectal bleeding, change in bowel habit, weight loss within the previous 12 months, severe medical illness precluding bowel preparation	27.4% (93/340) of CT colonographies had positive findings. 73% (67/92) patients with positive CTC also had a positive colonoscopy 7.4% (25/339) of CTC findings were false-positive for any polyp 12.1% (41/339) of CTC findings were false-positive for adenomatous polyps 100% (9/9) of polyps > 9 mm detected at colonoscopy were also detected by CTC 70% (30/43) of polyps 6–9 mm detected at colonoscopy were also detected by CTC 37% (31/84) of polyps < 6 mm detected at colonoscopy were also detected by CTC	**Complications** Mild nausea with gas insufflation = 0.9% (3/340) Postprocedural abdominal pain requiring short bed rest = 0.6% (2/340) Flushing and sweating during CTC = 0.6% (2/340) 4.9% (4/82) patients who received the magnesium citrate / sodium picosulphate bowel preparation had syncopal or presyncopal episodes during the bowel preparation, which were judged to be caused by relative dehydration. This bowel preparation was subsequently abandoned	Major reasons for non participation were insufficient time and perceived good health. Participation was higher in younger subjects and in those from a high socioeconomic region. Patients were only referred for colonoscopy if findings at CTC were abnormal. Colonoscopists were aware of the CTC results. two- and three-dimensional views used. The percentages of polyps detected by CTC as well as colonoscopy do not represent true sensitivities, as negative findings at CTC did not proceed to the performance of colonoscopy.

Study Details	Key efficacy findings	Key safety findings	Comments
Johnson CD (2004)[7] USA 1998–2001 Comparative study 837 asymptomatic patients with an increased risk of developing colorectal cancer given CTC followed by same-day double contrast barium enema (DCBE) Mean age = 63.4 years Inclusion criteria: age ≥ 50 years, prior history of colorectal neoplasia or first-degree family member with a history of colorectal cancer or new onset of asymptomatic iron-deficiency anaemia Exclusion criteria: blood in the stools, inflammatory bowel disease, familial polyposis	4% (31/837) of CTC examinations were nondiagnostic because of the presence of fluid, stool, or colonic distention. **Analysis according to patient (patients having 1 or more polyps 5–9 mm)** no. / total no. (%) Sensitivity / Specificity CTC: 25/30 (83%) / 566/661 (86%) DCBE: 18/30 (60%) / 643/661 (97%) p = 0.04 / p < 0.001 **Analysis according to polyp (detection of adenomatous polyps)** no. / total no. (%) Sensitivity Polyps 5–9 mm CTC: 28/39 (72%) DCBE: 17/39 (44%) p < 0.01 Polyp ≥ 10 mm CTC: 25/31 (81%) DCBE: 14/31 (45%) p = 0.01	No safety data reported.	Patients were prescheduled for DCBE. 89% (742/837) patients received glucagon before CTC. Diagnostic review of each CTC was performed by two of three experienced radiologists, blinded to the results at DCBE. DCBE was read only once, CTC was read twice. Colonoscopy was recommended for any patient with a lesion ≥ 5 mm in diameter. Not all positive CTC tests were followed up with colonoscopy. The radiologists performing DCBE were blinded to the results at CTC. Reviewers were instructed to ignore polyps < 5 mm in diameter. The paper presents results from each of the 3 reviewers and the combined reports of the 2 individual reviewers for CTC. The double reading results have been presented here. There was wide variation in polyp detection rates at CTC between observers.

Study Details	Key efficacy findings	Key safety findings	Comments
Gluecker, TM (2003)[8] USA Comparative study 1313 asymptomatic patients with higher-than-average risk of colorectal cancer: • 53% (696/1313) CTC and colonoscopy, median age = 65 years • 47% (617/1313) CTC and double contrast barium enema, median age = 64 years	Patients with CTC and colonoscopy: 72.3% (357/494) of patients preferred CTC, 5.0% (25/494) preferred colonoscopy, $p < 0.001$ Patients with CTC and barium enema: 97.0% (518/534) of patients preferred CTC, 0.4% (2/534) preferred barium enema, $p < 0.001$	Perception of “extreme” or “severe” discomfort: CTC = 1.3% (9/696) Colonoscopy = 3.6% (25/696), $p = 0.63$ CTC = 0.7% (4/617) Barium enema = 29.3% (181/617), $p < 0.001$	No randomisation. All patients received glucagon prior to CTC. 74% (515/696) patients with CTC and colonoscopy returned the questionnaire. 87% (538/617) patients with CTC and barium enema returned the questionnaire. To avoid the effects of sedation, patients were asked to complete the questionnaire not sooner than 12 hours after the colonoscopy. Study design mandated that CTC was performed first – this may have introduced a technical or response bias. Same study centre as Johnson et al, 2003.[5]

Abbreviations used: CTC = computed tomography colonography, CI = confidence interval

Validity and generalisability of the studies

- Most of the studies use colonoscopy as the reference standard to calculate the sensitivity and specificity of CTC, although colonoscopy has been reported to miss 24% of all adenomas.[23]

- One study reports on the use of CTC as a diagnostic tool for symptomatic patients.[4] The other studies presented in this overview consider the use of CTC as a screening tool in asymptomatic patients. In three studies, the patients were at a higher risk than average for colorectal cancer. [5,7,8]

- Technical factors such as slice thickness, tube current, pitch, method of interpretation and the software used vary between studies. Some of these factors may affect the reported performance of CTC.

- All of the studies (including those in the systematic review) scanned patients in both the supine and prone positions.

- Verification bias may have occurred in studies that evaluated high-risk patients with CTC and verified the results with conventional colonoscopy.[3]

- Some studies administered glucagon to all patients prior to CTC. One study used glucagon in a subset of patients, stating that available information in the literature showed no difference in the polyp detection in patients undergoing CTC with glucagon versus those without glucagon.[4]

- There may be high interobserver variability of the CT readings.[5]

- One study did not include polyps less than 5 mm in diameter. [5]

Specialist Advisors' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College.

- Most of the Specialist Advisors regard this to be established practice and no longer new.
- The main efficacy concern is the risk of missing flat or small lesions.
- CTC also examines organs other than the colon.
- Intravenous contrast is useful for patients with endoscopically proven lesions or if there is a high suspicion of colorectal cancer.
- Elderly or frail patients tolerate CTC better than barium enema.
- CTC is useful for evaluating patients after an incomplete colonoscopy. It can be used to see bowel beyond an obstructing lesion.
- Computer-aided detection software is being developed.
- There is a marked learning curve and training is important.

Issues for consideration by IPAC

Two parallel, prospective multicentre randomised controlled trials are underway, one comparing CTC with colonoscopy and the other comparing CTC with barium enema (CT colonography, colonoscopy or barium enema for diagnosis of colorectal cancer in older symptomatic patients [SIGGAR1]). The trials are expected to be published in April 2008.

References

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5 Johnson CD, Harmsen WS, Wilson LA, et al. Prospective blinded evaluation of computed tomographic colonography for screen detection of colorectal polyps. *Gastroenterology* 2003; 125: 311–9.

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Appendix A: Additional papers on CT colonography not included in the summary tables

The following table outlines studies that are considered potentially relevant to the overview but were not included in the main data extraction table and is by no means an exhaustive list of potentially relevant studies.

Article title	Number of patients	Comments	Direction of conclusions
Hellström M, Svensson MH, Lasson A. Extracolonic and incidental findings on CT colonography (virtual colonoscopy). *American Journal of Roentgenology* 2004; 182: 631–8.	111 patients.	All patients had symptoms of colorectal disease.	23% (26/11) patients had important incidental CT findings including lymphadenopathy, aortic aneurysm, hepatic masses, and renal masses.
Iannoccone R, Laghi A, Catalano C, et al. Detection of colorectal lesions: lower-dose multi-detector row helical CT colonography compared with conventional colonoscopy. *Radiology* 2003; 229: 775–81.	158 patients.	Screening and symptom evaluation.	CTC per-patient analysis: Sensitivity = 96% Specificity = 98%
Laghi A, Iannaccone R, Carbone I, et al. Detection of colorectal lesions with virtual computed tomographic colonography. *The American Journal of Surgery* 2002; 183: 124–31.	165 patients.	Population at high risk of colorectal cancer.	Per-patient sensitivity = 92%, specificity = 97%.
Lefere P, Gryspeerdt S, Baekelandt M, et al. Diverticular disease in CT colonography. *European Radiology* 2003; 13: L62–74.	160 patients.	CTC images retrieved for patients with divert-icular disease.	Some equivocal findings. Study recommends use of colonoscopy when clinically significant lesion is suspected.
Macari M, Bini EJ, Xue X, et al. Colorectal neoplasms: prospective comparison of thin-section low-dose multi-detector row CT colonography and conventional colonoscopy for detection. *Radiology* 2002; 224: 383–92.	105 patients.	Patients with symptoms or history of polyps.	Sensitivity: < 5 mm = 12% 6–9 mm = 70% ≥ 10 mm = 93%. Overall specificity = 98%.
Pederson BG, Christiansen TEM, Bjerregaard NC, et al. Colonoscopy and multidetector-array computed-tomographic colonography: detection rates and feasibility. *Endoscopy* 2003; 35: 736–42.	148 patients.	Screening and symptom evaluation.	Complete colonoscopy = 91% Satisfactory CTC = 76%. Equal overall sensitivity for polyps ≥ 6 mm.
Pineau BC, Paskett ED, Chen GJ, et al. Virtual colonoscopy using oral contrast compared with colonoscopy for the detection of patients with colorectal polyps. *Gastroenterology* 2003; 125: 304–10.	205 patients.	Contrast agent used With CTC. 46% patients had symptoms.	Overall sensitivity = 62%. Overall specificity = 71%. Lesions ≥ 6 mm: 84% sensitivity, 83% specificity. Lesions ≥ 10 mm: 90% sensitivity 95% specificity.

Article title	Number of patients	Comments	Direction of conclusions
Ristvedt SL, McFarland EG, Weinstock LB, et al. Patient preferences for CT colonography, conventional colonoscopy, and bowel preparation. *The American Journal of Gastroenterology* 2003; 98: 578–85.	120 patients.	Patients at increased risk of colorectal cancer.	Overall appraisals similar for both CTC and colonoscopy. 58% patients preferred CTC, 14% preferred colonoscopy.
Taylor SA, Halligan S, O'Donnell C, et al. Cardiovascular effects at multi-detector row CT colonography compared with those at conventional endoscopy of the colon. *Radiology* 2003; 229: 782–90.	144 patients.	Pulse, blood pressure, and oxygen saturation measured.	CTC had no significant cardiovascular effect. CTC is less painful than colonoscopy.
Taylor SA, Halligan S, Saunders BP, et al. Acceptance by patients of multidetector CT colonography compared with barium enema examinations, flexible sigmoidoscopy, and colonoscopy. *American Journal of Roentgenology* 2003; 181: 913–21.	168 patients.	Mainly symptom-atic patients.	Overall satisfaction greater with colonoscopy. CTC caused less discomfort and was better tolerated.
Thomeer M, Bielen D, Vanbeckevoort D, et al. Patient acceptance for CT colonography: what is the real issue? *European Radiology* 2002; 12: 1410–5.	124 patients.	Screening and symptom evaluation.	71% patients preferred CTC, 24% preferred colonoscopy.
Yee J, Kumar NN, Hung RK, et al. Comparison of supine and prone scanning separately and in combination at CT colonography. Radiology 2003; 226: 653–61.	182 patients.	Screening and symptom evaluation.	Using both positions yielded significantly higher sensitivity.

Appendix B: Literature search for CT colonography

The following search strategy was used to identify papers in Medline. A similar strategy was used to identify papers in EMBASE, Current Contents, PreMedline and all EMB databases.

For all other databases a simple search strategy using the key words in the title was employed.

#	Search History
1	virtual colonoscopy.mp. or exp Colonography, Computed Tomographic/
2	exp COLONOSCOPY/
3	exp Tomography, X-Ray Computed/ or CT.mp.
4	2 and 3
5	1 or 4
6	limit 5 to (human and english language)