CT-colonography in population-based colorectal cancer screening

de Haan, M.C.

Citation for published version (APA):
de Haan, M. C. (2012). CT-colonography in population-based colorectal cancer screening
Does CT-colonography have a role for population-based colorectal cancer screening?

Margriet C. de Haan
Steve Halligan
Jaap Stoker

European Radiology (accepted for publication)
Abstract

Colorectal cancer (CRC) is the second most common cancer and second most common cause of cancer-related deaths in Europe. CRC screening has been proven to reduce disease-specific mortality and several European countries employ national screening programmes. These almost exclusively rely on stool tests, with endoscopy used as an adjunct in some countries. CT-colonography is a potential screening test, with an estimated sensitivity of 88% for advanced neoplasia ≥10 mm. Recent randomised studies have shown that CT-colonography and colonoscopy have similar yields of advanced neoplasia per screened invitee, indicating that CT-colonography is potentially viable as a primary screening test. However, the evidence is not fully elaborated. It is unclear whether CT-colonography screening is cost-effective and the impact of extracolonic findings, both medical and economic, remains unknown. Furthermore, the effect of CT-colonography screening on CRC-related mortality is unknown, as it is also unknown for colonoscopy. It is plausibly that both techniques will lead to a decrease in mortality, as for sigmoidoscopy and gFOBT. Although radiation exposure is a drawback, this disadvantage may be over emphasised. Concluding, the detection characteristics and acceptability of CT-colonography suggest it is a viable screening modality. Implementation will turn on detection of extracolonic pathology and health-economic impact.
**Introduction**

In Europe, colorectal cancer (CRC) is the second most common cancer as well as the second most common cause of death from cancer. In 2008, approximately 432,414 European citizens received a new diagnosis of CRC. The majority of cancers develop from adenomatous polyps, benign precursors with a relatively long premalignant phase. Adenomas can vary in size but those ≥10 mm and/or with ≥25% of villous histology and/or high-grade dysplasia have the strongest association with malignancy and are named advanced adenomas. It is estimated that the adenoma to carcinoma transition takes at least 10 years. Several studies have shown that removal of adenomas (e.g. via a CRC screening programme), results in reduced CRC incidence and CRC-related mortality subsequently, by interruption of the adenoma-carcinoma pathway. Screening programmes can also reduce CRC-related mortality (but have no effect on incidence) by detecting asymptomatic cancers, which tend to be earlier-stage and thus associated with improved prognosis and survival. The impact of CRC screening is maximised in population-based programmes, which is more efficient and less costly than opportunistic screening.

Potential CRC screening tests can be generally divided into two categories; direct and indirect. Stool-based tests (guaiac Faecal Occult Blood Test, gFOBT; Faecal Immunochemical Test, FIT; Faecal DNA tests) indirectly diagnose cancers and large adenomas by detecting their by-products (blood, DNA) in the stool. Such tests are non-invasive, and in the case of FBOT/FIT simple to perform and relatively cheap. However, because cancers may not bleed or only bleed intermittently, they need to be repeated frequently (e.g. every two years). Also, approximately 50% may be false positives, leading to unnecessary referrals for subsequent colonoscopy. Perhaps most importantly, indirect tests favour cancer detection rather than adenomas, and so provide less opportunity to impact on cancer incidence.

Direct tests such as flexible sigmoidoscopy, colonoscopy, CT-colonigraphy directly visualize the target lesion, be it cancers or adenomas. Such tests can impact on both cancer mortality and incidence, and so need repeating only once per five to ten years. Compared to indirect tests, direct tests are more invasive (making them more burdensome), and costlier.

Newer potential tests include capsule endoscopy, serum-based markers including serum proteomics, nuclear matrix proteins, and serum DNA testing. None of these have been sufficiently tested in representative populations.
Effect of screening on CRC specific mortality

Both gFOBT and flexible sigmoidoscopy screening have been shown to decrease CRC-related mortality. Several randomised-controlled trials have shown that biennial gFOBT screening leads to a subsequent mortality reduction of 11% to 21%, after a median follow-up of 10 to 13 years (five to six rounds); overall CRC mortality reduction is approximately 14% after ten years of screening \(^6,14-17\). One large randomised-controlled trial showed that a single flexible sigmoidoscopy performed between 55 and 64 years of age led to an overall CRC mortality reduction of 31% amongst invitees, rising to 42% in those who attended \(^7\). These data prove that removal of benign adenomas reduces the incidence of subsequent CRC. It is therefore plausible that other screening techniques that reliably identify significant adenomas, namely colonoscopy and CT-colonography, will also impact on CRC-related mortality. The magnitude of benefit can only be determined precisely via large randomised-controlled trials with long-term follow-up. The NordICC-trial (Nordic Initiative on Colorectal Cancer) is such a trial that evaluates the effect of colonoscopy screening on CRC-related mortality with its end-point at ten years \(^18\). At the time of writing, we are aware of no current or planned studies that aim to evaluate the effect of CT-colonography on CRC-related mortality.

Accuracy

The diagnostic performance of various screening tests is summarised in Table 1. gFOBT and FIT have a per patient sensitivity of 11% to 20% and 27% to 48% respectively for advanced neoplasia and of 13 to 38% and 56% to 88% for CRC \(^19-23\). Sigmoidoscopy has a sensitivity of approximately 83% for advanced neoplasia and 58% to 75% for CRC \(^21,24\). Colonoscopy has a sensitivity of 88% for all advanced neoplasia, of 98% for advanced neoplasia ≥10 mm, and of 95% to 97% for CRC \(^21,25,26\).

CT-colonography might be a viable alternative since it has an estimated per patient sensitivity of 88% for advanced neoplasia ≥10 mm in screening populations \(^27\). These estimates are based on the aggregated results of five studies (n=4,086 participants) that each evaluated the sensitivity of CT-colonography relative to colonoscopy in an average risk population \(^21,26,28-31\). Three of these studies reported per patient sensitivity for advanced neoplasia ≥6 mm, ranging from 84% to 93% \(^21,28,29\). No CRC was missed by CT-colonography. A recently published meta-analysis (including both average and highrisk subjects), found that CT-colonography has a sensitivity of 96% for CRC \(^32\), which is comparable to colonoscopy.
Attendance and diagnostic yield

The efficacy of a screening programme is not only determined by diagnostic test accuracy but also by the proportion of invitees who ultimately attend. For example, the diagnostic yield of CRC screening can be defined as the number of invitees ultimately found to have advanced neoplasia, per 100 invitees.

Several trials have determined the attendance and subsequent diagnostic yield of gFOBT and FIT screening. In most studies, invitees were asked to undergo more than one test, a procedure that may underestimate attendance compared with the offer of a single test. In one of these studies, 23% of kits that were distributed by the community drug stores (containing three different stool tests) were completed and returned. An unrandomised invitational-based Australian study, in which invitees were offered the choice of gFOBT, FIT, or both, found that 36% of invitees participated overall, but relatively more participants participated in FIT screening than gFOBT (OR 1.9, 95%CI: 1.6 to 2.2). gFOBT and FIT had different diagnostic yields for advanced neoplasia of approximately 1.4 vs 3.3 per 100 participants respectively (0.4 vs 1.3 per 100 invitees), but this difference disappeared after adjustment for differences in baseline characteristics.

In the Netherlands, several population-based screening trials have been performed over the last decade, comparing attendance and subsequent yield of a first screening round for gFOBT, FIT and/or flexible sigmoidoscopy. gFOBT and FIT had participation rates of 47% and 59% to 60%, figures that are relatively high compared to those from other studies. Contrasting with data from previous studies, FIT screening resulted in higher attendance rates than gFOBT. Thirty percent of invitees for flexible sigmoidoscopy participated. However, despite higher participation rates for gFOBT and FIT over flexible sigmoidoscopy, first round diagnostic yield was only 0.6 and 1.4 to 1.5 per 100 invitees, compared with 2.2 for sigmoidoscopy.

Previous studies of flexible sigmoidoscopy screening, performed in Italy and the UK, randomised invitees after they had indicated that they were interested in participation or after preselection of average risk subjects by the general practitioner (in order to increase power) preventing precise evaluation of attendance rates. In the UK study, 38% of citizens that were contacted participated, while initially 55% of subjects responded positively to a mailed questionnaire that they would like to attend if invited.

As far as we are aware, two randomised controlled trials have
been performed previously, in which the attendance and diagnostic yield of population-based CT-colonography screening was compared with colonoscopy\textsuperscript{43,44}. An Australian trial reported participation rates of 18\% and 16\% for CT-colonography and colonoscopy respectively, and a subsequent diagnostic yield (defined as number of participants with advanced neoplasia) of 9.0 and 8.4 per 100 participants\textsuperscript{43}. A Dutch trial reported participation rates for CT-colonography and colonoscopy of 34\% and 22\% respectively, and a subsequent diagnostic yield of 6.1 and 8.7 per 100 participants\textsuperscript{44}. Ultimately, enhanced participation for CT-colonography was countered by the greater sensitivity of colonoscopy, with the result that the two tests had similar diagnostic yields for advanced neoplasia of 2.2 and 1.9 per 100 invitees respectively. The Dutch trial differed in that participants undergoing CT-colonography were only referred for subsequent colonoscopy if lesions ≥10 mm were detected (thus increasing positive predictive value); participants with lesions of 6-9 mm were offered surveillance with CT-colonography \textsuperscript{44}. Surveillance data are not yet available.

Table 1 CRC screening techniques: overview of sensitivity, (Dutch) attendance and diagnostic yield of a first round of population-based screening, and CRC-related mortality reduction

<table>
<thead>
<tr>
<th></th>
<th>gFOBT</th>
<th>FIT</th>
<th>Sigmoidoscopy</th>
<th>Colonoscopy</th>
<th>CT-colonography</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensitivity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- advanced neoplasia</td>
<td>11%-20%\textsuperscript{19,25}</td>
<td>27%-48%\textsuperscript{19,25}</td>
<td>83%\textsuperscript{21,24}</td>
<td>88%\textsuperscript{21,25,26}</td>
<td>84%-93%\textsuperscript{21,26-32, b}</td>
</tr>
<tr>
<td>- CRC</td>
<td>13%-38%</td>
<td>56%-88%</td>
<td>58%-75%</td>
<td>95%-97%</td>
<td>96%-100%</td>
</tr>
<tr>
<td><strong>Attendance (%)\textsuperscript{a}</strong></td>
<td></td>
<td></td>
<td>47%\textsuperscript{36,37}</td>
<td>59%-60%\textsuperscript{36,37}</td>
<td>30%\textsuperscript{16}</td>
</tr>
<tr>
<td><strong>Yield advanced neoplasia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- per 100 exams</td>
<td>1.2\textsuperscript{36,37}</td>
<td>2.4-2.5\textsuperscript{16,37}</td>
<td>7.3\textsuperscript{16}</td>
<td>8.7\textsuperscript{44}</td>
<td>6.1\textsuperscript{44}</td>
</tr>
<tr>
<td>- per 100 invitees</td>
<td>0.6</td>
<td>1.4-1.5</td>
<td>2.2</td>
<td>1.9</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Mortality reduction</strong></td>
<td>14%\textsuperscript{b}</td>
<td>unknown</td>
<td>32%\textsuperscript{7}</td>
<td>unknown</td>
<td>unknown</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Attendance defined as number of invitees that completed the screening procedure.

\textsuperscript{b} Advanced neoplasia ≥6mm.

Table 1 compares attendance and yield for differing screening modalities when used in comparable settings and populations. Whether the differences in compliance and yield observed in the Dutch trials can be sustained and extrapolated into future screening rounds is currently unknown. Two studies reporting the attendance and yield of subsequent gFOBT screening rounds found that CRC detection rate decreased\textsuperscript{45,46}. The first study found that attendance decreased significantly from 59\% in the first round to 52\% in the second\textsuperscript{45}. Although detection rates for advanced
neoplasia were similar, cancer detection rates decreased significantly in the second round (from 1.35 to 0.94 per 1,000 screened)\textsuperscript{45}. The second study found that the attendance rate was similar in the first, second and third rounds of gFOBT screening (55\%, 53\% and 55\%, respectively), but cancer detection decreased from 2.1 per 1,000 participants to 0.7 (first vs. third round)\textsuperscript{46}.

**CRC screening guidelines**

Recently, the European Union (EU) recommended CRC screening for men and women aged 50 to 74 years\textsuperscript{8}. Outside the EU, several organisations also recommend CRC screening, including the American Society for Gastrointestinal Endoscopy\textsuperscript{47}, the American Cancer Society, the U.S. Multi Society Task Force on Colorectal Cancer, the American College of Radiology\textsuperscript{48,49}, the American College of Gastroenterology\textsuperscript{50}, and the Asia Pacific Working Group on Colorectal Cancer\textsuperscript{51}. The societal benefits of CRC screening are clearly widely accepted. However, at this point in time there is no consensus regarding the preferred screening modality or combination of modalities: the EU only specifies FOBT (gFOBT or FIT) as recommended screening tests since, at the time the guideline was drafted, gFOBT was the only test for which a significant decrease in disease-specific mortality had been demonstrated. Most of the US guidelines recommend colonoscopy as the first choice strategy based on superior sensitivity and specificity for adenomas and cancer (and ignore the fact that a reduction in disease-specific mortality has not been demonstrated directly); flexible sigmoidoscopy and/or CT-colonography are alternative options for those patients who refuse colonoscopy or whose colonoscopy is incomplete. In Asia, either gFOBT, FIT, flexible sigmoidoscopy, or colonoscopy screening are recommended. According to EU and Asian guidelines CT-colonography is not recommended as a screening modality due to insufficient evidence of efficacy.

At the time of writing, national CRC screening programmes for CRC have been implemented in several European countries. For example, in Finland, France, and the United Kingdom gFOBT is used as the primary modality. In Italy both FIT and flexible sigmoidoscopy are used as primary modalities, while in Poland only colonoscopy is used\textsuperscript{8,52}. The UK is currently implementing flexible sigmoidoscopy alongside the gFOBT programme, with a once-once examination offered at the ages of 55 years\textsuperscript{53}. CT-colonography has supplanted barium enema as the preferred whole-colon examination in gFOBT positive patients who cannot undergo colonoscopy or whose colonoscopy
is incomplete, as a consequence of results from a randomised-controlled-trial of 5,427 symptomatic patients that found CT-colonography significantly more sensitive than barium enema, with a lesser false negative rate.

**Is there a role for CT-colonography in population-based CRC screening?**

*Advantages of CT-colonography screening*

As for colonoscopy, one of the major advantages postulated for CT-colonography is that it enables visualisation of the entire colorectum. Secondly, CT-colonography has the advantage that it detects advanced neoplasia in an early phase. CT-colonography screening results in a higher diagnostic yield per 100 invitees than primary gFOBT and FIT screening, and in a similar yield as sigmoidoscopy and colonoscopy screening\(^{41,42,44}\). Because of enhanced detection characteristics for adenomas and cancers the inter-test interval for CT-colonography is much longer than for stool-based tests; e.g. once per 5 to 10 years versus once per two years\(^{13}\). Kim et al recently showed that in an audit of 1,011 screening participants with a negative baseline CT-colonography, a single carcinoma occurred during an average follow-up period of 4.73±1.15 years. Follow-up was primarily performed by reviewing the electronic medical records of all participants.

Several comparative unrandomised studies have shown that CT-colonography is less burdensome than colonoscopy\(^{54,55}\). A single randomised study of 547 patients found that CT-colonography was more acceptable than colonoscopy and associated with less physical side effects, but this was performed in a symptomatic setting\(^{56}\). Although most CT-colonography studies have utilised full cathartic bowel cleansing, non-cathartic preparations are increasingly popular and are expected to enhance compliance. Iodine is already used to tag residual stool with the aim of facilitating radiological interpretation, and this approach can be extrapolated into a non-cathartic preparation, decreasing the volume ingested orally. A disadvantage of most iodinated contrast agents is that they induce diarrhoea because most agents are hyperosmotic. This non-cathartic bowel preparation has recently been shown in a randomised-controlled design to be less burdensome than the alternative of two litres of laxatives and two litres of clear fluids required for colonoscopy\(^{57}\). However, the same investigators also found that increased diarrhoea was perceived as more burdensome by CT-colonography participants\(^{57}\). Invitees were also asked – before they
underwent the allocated screening procedure—whether they anticipated the procedure would be burdensome: 36% of colonoscopy invitees anticipated a “rather” or “extremely” burdensome experience compared to only 9% of CT-colonography invitees. Ultimately, 21% of CT-colonography participants indicated that the experience was “worse” than expected, compared to 12% of colonoscopy participants. These findings suggest that CT-colonography invitees underestimate the burden of CT-colonography (e.g. diarrhoea and abdominal pain) relative to colonoscopy. The differences in perceived burden of the entire screening procedure were small (mean score on 5-point Likert scale 1.8 in colonoscopy vs 2.0 in CT-colonography; p<0.001), and did not result in a significantly different proportion of participants that indicated they would be willing to participate in a future screening round. Other bowel preparation schemes with less iodine may result in a less burdensome procedure.

The relatively low risk of serious adverse events associated with CT-colonography is frequently cited as an advantage compared to colonoscopy screening, which has a complication risk of 0.1-0.3%58-60. However, while this holds true for the examinations in isolation, the correct approach is to consider the diagnostic pathway as a whole. Colonoscopic complications precipitated by a positive CT-colonography result must be included and accounted for as part of the diagnostic trajectory for screening CT-colonography. In the Dutch trial, the prevalence of post-polypectomy bleeding was non-significantly different for CT-colonography (0.3% of participants) and colonoscopy (0.2% of participants)44.

Whether the visualisation of extracolonic structures and consequent detection of potential pathology is an advantage or disadvantage is frequently debated and remains unclear. It is clear however that potential screenees regard this aspect of CT-colonography as attractive, intriguing, and a distinct advantage over all other competing tests61. In a screening population, the prevalence of (potentially) important findings that precipitate additional diagnostic follow-up testing ranges from 4.5% to 11%30,43,62,63. One audit of 10,286 participants undergoing CT-colonography screening found extracolonic (non-colorectal) cancer in 36 (0.35%) participants; renal cell carcinoma, lung adenocarcinoma and non-Hodgkin lymphoma were most common64. However, the majority of potentially important findings ultimately emerge as clinically unimportant after follow-up testing, and therefore have the potential to cause anxiety, morbidity (and even mortality) for no clinical benefit. Furthermore, the incremental costs of diagnostic follow-up
tests including surgery, and additional clinic visits etc, may be substantial, averaging from €20 to €25 per participant overall\cite{62,63}. It is possible that early detection of important extracolonic findings might ultimately lead to lower costs and decreased mortality in the long run but these data are currently unavailable and would require randomised trials with tens of thousands of participants. Currently, the only data available arise from modelling the costs and consequences of extracolonic detections using currently available research. For example, one approach is to screen only for intracolonic lesions, aortic aneurysms and extracolonic cancers\cite{65,66}. At the time of writing, it is uncertain whether this is feasible; in some countries, it is hard to imagine that radiologists will be allowed legally to “close their eyes” to certain categories of findings potentially revealed by CT-colonography.

**Disadvantages of CT-colonography screening**

When CT-colonography is used for screening - as for positive stool tests and flexible sigmoidoscopy - there is a need for subsequent testing in positive patients who have a potential lesion large enough to trigger subsequent colonoscopy. In an unrandomised USA study that evaluated the diagnostic yield per 100 participants for colonoscopy and CT-colonography, 7.9% of participants having CT-colonography were referred for subsequent colonoscopy\cite{58}. Participants with lesions of 6-9 mm were offered the choice of colonoscopy or surveillance CT-colonography. Within the Dutch screening trial, 8.6% of CT-colonography participants were referred for colonoscopy as a consequence of lesions ≥10 mm. However, if a referral threshold of ≥6 mm were used, 16.7% of participants having CT-colonography would have been referred for subsequent colonoscopy.

Exposure to ionizing radiation may provoke radiation-induced cancers, but this potential disadvantage needs to be balanced against potential gains. Gonzales and colleagues estimated that a five-yearly CT-colonography screening program would prevent the development of 24 CRCs for every radiation-induced cancer, based on an estimated mean effective dose of 8mSv for women and 7mSv for men\cite{67}. In fact, the dose conveyed by screening CT-colonography averages 4mSv\cite{68}.

Most previous cost-effectiveness models of population-based CT-colonography screening programmes estimate that CT-colonography is less cost-effective than alternative methods\cite{65,69-74}. According to some of these models, CT-colonography screening could be more cost-effective than colonoscopy if the unit cost per CT-colonography falls to less than 60-72%
of the unit costs for colonoscopy\textsuperscript{65,69}, if attendance for CT-colonography is \(\geq 25\%\) higher than colonoscopy\textsuperscript{70} or a combination of both that offers a net-benefit\textsuperscript{71}. However, the precise unit cost of CT-colonography when employed within population-based CRC screening programmes is largely unknown, and will vary depending on the healthcare system in question. Existing estimates are based on unit costs ranging from €346 to €594 for abdominal and/or pelvic computed tomography or colonoscopy, or on unspecified assumptions related to costs. Increased efficiencies that are likely to accompany the deployment of CT-colonography in a screening programme would probably diminish the unit cost for CT-colonography when used in this setting, compared to unit costs in symptomatic patients. Ultimately, the key-metric required by health policy makers will be the cost-per-cancer detected and the cost-per-significant-adenoma detected per 100 subjects invited for screening, which allows direct cost-comparisons between competing screening modalities. The costs, diagnoses, and consequences of screening should be collected prospectively as part of a randomised controlled trial (or established screening programme) so that the cost-effectiveness model is populated with reliable data rather than test characteristics and costs estimated from the literature, which may be inaccurate or derived from healthcare settings that are not generalizable to the setting in question.

\textbf{Logistics}

Before CT-colonography is implemented as primary screening modality, sufficient CT scanner capacity should be available. Assuming that there is limited time available on hospital scanners currently, this would likely require large-scale investment to increase available screening capacity. One potential approach might utilize mobile CT-colonography units similar to those that are used currently for breast cancer screening in several countries including the UK and the Netherlands; such dedicated units are likely efficient and may increase attendance due to the convenience of proximity. It is clear that sufficient, adequately trained CT-colonography readers are needed; on average inexperienced readers need training with at least 175 individual cases before they reach an acceptable sensitivity and specificity for lesions of 6 mm and larger\textsuperscript{75}. One alternative possibility is to train radiographic technicians to interpret CT-colonography since they are less expensive than radiologists. Such an approach would also lower the unit cost of CT-colonography. Another alternative could be to use computer-aided detection (CAD) as second reader, subsequent to the radiologist’s interpretation. This strategy
has shown to result in significantly higher sensitivity for lesions of ≥6 mm and although specificity inevitable decreases, it does not do so significantly\textsuperscript{76,77}. Additionally, CAD might be used as the primary CT-colonography reader (i.e. in advance of any radiologist interpretation), followed by a radiologist evaluation restricted to the CAD marks. An Italian study of FOBT positives recently showed that such a reading detected 11 of 13 colorectal carcinomas. If the evaluation of CAD findings was followed by evaluation of the 2D images, this resulted in a sensitivity of 89% for advanced adenomas, which was comparable to double primary 2D read followed by secondary CAD read\textsuperscript{78}.

**CT-colonography as a triage test following positive FOBT?**

As positive stool tests have a relatively limited positive predictive value for CRC, it has been suggested that CT-colonography could be used as an intermediate test, triaging FOBT positives for colonoscopy. CT-colonography has a per patient sensitivity of 93% for adenomas ≥6 mm and of 95% for advanced neoplasia ≥10 mm and CRC, in FOBT positives (using FIT or gFOBT)\textsuperscript{79}. A previous study performed in 302 FOBT positive individuals found that CT-colonography would prevent a subsequent colonoscopy in only 28% of cases, while lesions ≥10 mm would have been missed in 2%\textsuperscript{80}. Given the relatively high prevalence of abnormality in patients who are FOBT positive, it is unlikely that CT-colonography is a clinically- or cost-effective triage method in first round FOBT screening. CT-colonography may have a role in subsequent rounds when the prevalence of abnormality may be expected to decrease, or where newer stool tests are employed that have greater sensitivity but proportionally less specificity when compared to gFOBT.

**Conclusion**

Screening for colorectal cancer using CT-colonography as a primary modality is feasible – the detection characteristics of CT-colonography in this context are increasingly well-established and compliance seems to be increased. These factors lead to a similar yield of advanced neoplasia for CT-colonography compared to colonoscopy and flexible sigmoidoscopy, and higher yields than gFOBT and FIT. Therefore, the viability of CT-colonography as a primary screening modality is likely to turn on other factors, such as cost-effectiveness and whether the ability to detect extracolonic disease (impossible with alternative modalities) is ultimately beneficial or not. Whether there is a need to demonstrate a direct reduction in disease-specific mortality is debatable given that detection characteristics of CT-colonography for cancers
and adenomas are well-defined. However, the CT-colonography community should be aware that the lack of large scale implementation pilots, including an evaluation of effect on disease specific mortality, remains an obstacle for health policy makers shaping population-based CT-colonography screening in Europe in the future.
References


Chapter 11

Review: role for CTC in screening?


