VIRTUELLE KOLOSKOPIE

Soweit in diesem Kontext personenbezogene Bezeichnungen nur in weiblicher oder nur in männlicher Form angeführt sind, beziehen sie sich generell auf Frauen und Männer in gleicher Weise.

1 Inhaltsverzeichnis

2 Kurzbericht

Die Methoden der virtuellen Koloskopie wurden erstmals 1996[1] und 1997[2] beschrieben. Die «virtuelle Koloskopie» basiert auf Abdomenaufnahmen, die mit einem der beiden herkömmlichen Schnittbildverfahren, Computertomographie (CT) und Magnetresonanztomographie (MR), gewonnen werden. Aus den Daten der Schnittbilder wird mit Computerprogrammen eine Innenansicht des Kolons konstruiert (MR- Kolonographie, CT- Kolonographie).

Für eine CT- und MR-Kolonographie muss der Patient genau wie bei der Koloskopie vollständig abgeführt werden. Stuhlreste können Raumforderungen vortäuschen. Für die MR-Kolonographie wird der Darm mit 2–3 Litern Wasser gefüllt, welches Gadolinium enthält. Danach werden MR-Aufnahmen in Bauch- und Rückenlage gemacht. Für die CT-Kolonographie wird der Darm mit Luft gefüllt.

Die CT-Kolonographie kann als etablierte Methode angesehen werden.[3]

Die konventionelle Koloskopie wird als „Gold Standard“ in der Detektion kolorektaler Polypen und des kolorektalen Karzinoms angesehen,[4] ist aber kein perfekter Screeningtest; in einer Studie[5] war die Fehlerrate der übersehenen 10mm und größeren Adenome 6%, für 6-9mm große Adenome 13% und für 5mm und kleinere Adenome 17%. Die Effektivität der Koloskopie in Bezug auf die Senkung der kolorektalen Karzinommortalität wurde bisher weder in Fall - Kontrollstudien noch in randomisiert kontrollierten klinischen Studien nachgewiesen.

In mehr als 20 Studien wurde die diagnostische Treffgenauigkeit der CT-Kolonographie mit der konventionellen Koloskopie verglichen, allerdings in nur 5 Studien wurden asymptomatische Patienten mit einem durchschnittlichen Risiko für ein kolorektales Karzinom[6] im Rahmen eines Routinescreenings untersucht.

Die in den Studien berichteten Sensitivitäten der CT-Kolonographie variieren sehr stark, von 35% bis 100% für Patienten mit 10mm und größeren Adenomen, größere Studien berichten Sensitivitäten in einer Bandbreite von 55% bis 94%. Die in den meisten Studien berichtete Spezifität beträgt mehr als 90%. In der Detektion kleinerer Adenome nimmt die Sensitivität und Spezifität ab.

Positive Ergebnisse in einer CT-Kolonographie erfordern eine Überweisung zur Koloskopie um den Befund zu bestätigen und/oder zur Polypenentfernung.[7] Eine CT-Kolonographie führt zu einer relevanten Bestrahlung,[8] dies ist vor allem bei Patienten, die sich freiwillig einem Screening unterziehen zu bedenken.

Es gibt bisher keine Evidenz, ob und dass die CT-Kolonographie das Gesundheitsergebnis verbessert, nämlich die karzinomspezifische Mortalität senkt, keine Studie zeigte eine Senkung der Mortalität wie für die Sigmoidoskopie oder den Test auf

okkultes Blut im Stuhl,[9] die Evidenz für die konventionelle Koloskopie ist allerdings auch nur eine indirekte.[10]

Die CT-Kolonographie hat eine relativ hohe Spezifität, aber die berichteten Sensitivitäten sind sehr breit gestreut. Die meisten Studien über CT-Kolonographie konnten keine mit der konventionellen Koloskopie vergleichbare Sensitivität zeigen.[11] Unterschiedliche Patienten- und Scannercharakteristika können diese Variabilitäten nicht vollständig erklären, und um die CT-Kolonographie für ein generelles Screening zu empfehlen, müssen die Ursachen für die sehr heterogenen Ergebnisse geklärt werden.[12]

Als „first line" Screening Methode bei asymptomatischen Personen wird die CT-Kolonographie in der recherchierten Literatur nicht empfohlen.[13,14,15,16]

Nur eine Studie[17] kommt zu dem Ergebnis, dass die CT-Kolonographie bei asymptomatischen Patienten mit einem durchschnittlichen Risiko für ein kolorektales Karzinom eine geeignete Screeningmethode in der Detektion von kolorektalen Polypen im Vergleich zur konventionellen Koloskopie darstellt. Die Studie wurde unter „idealen" Bedingungen erstellt, sowohl von Seiten der Software als auch von Seiten speziell geschulter Befunder. Andere Studien mit deutlich schlechteren Ergebnissen hinsichtlich der Sensitivität sind unter „normalen" Bedingungen entstanden, die der Situation entsprechen dürfte, in der auch die meisten Patienten untersucht werden.

Die CT-Kolonographie wird ebenfalls nicht als „first line" Untersuchungsmethode für Patienten mit einer hohen Wahrscheinlichkeit für ein kolorektales Karzinom empfohlen.[18, 19,20]

Als Indikation wird die CT-Kolonographie nach inkompletter Koloskopie als Ersatz der Irrigoskopie angesehen, sowie bei älteren Patienten und bei Patienten, bei denen eine Anästhesiebereitschaft im Rahmen einer Koloskopie erforderlich ist. Argumente dafür sind die Risiken und die Kosten, die mit einer Koloskopie in Narkose verbunden sind. Bei älteren Patienten kann die Polypengröße von 10mm als cut off für einen „signifikanten Polypen" angenommen werden, da eine geringe Wahrscheinlichkeit besteht, dass sich Polypen mit einer Größe unter 10 mm in der verbleibenden Lebenszeit zu einem Karzinom entwickeln.[21]

Die CT-Kolonographie sollte als Erstuntersuchung bei Patienten in Erwägung gezogen werden, die bei früheren konventionellen Koloskopien nicht oder schwierig zu untersuchen waren, bei Vorliegen von Stenosen[22] und bei Perforationen oder Blutungen in vorangegangenen Koloskopien.

Die virtuelle Kolonographie sollte die Irrigoskopie nach inkompletter Koloskopie ersetzen.[23]

In England im Rahmen des NHS Health Technology Assessment Programm läuft seit Februar 2004 eine randomisierte kontrollierte Studie zur Evaluierung der virtuellen Koloskopie im Vergleich zur konventionellen Koloskopie und Irrigoskopie in der Diagnostik des kolorektalen Karzinoms bei symptomatischen Patienten, älter als 55 Jahre.[24] Ergebnisse sind Mitte 2009 zu erwarten. Der Stellenwert der CT-Kolonographie[25] als Screeningmethode bei asymptomatischen Personen wird in England kontroversiell gesehen, die Studie soll die Hypothese verifizieren, dass die CT-Kolonographie eine sichere und kosteneffektive Untersuchungsmethode ist bei symptomatischen Patienten, die älter sind und eine Koloskopie schlechter tolerieren.

Der medizinische Zusatznutzen der CT-Kolonographie besteht darin, dass auch andere Organe als das Kolon beurteilt werden können, dass ältere oder gebrechliche Patienten die CT-Kolonographie besser als die Irrigoskopie[26] tolerieren, allerdings muss der Patient für die Aufnahmen zum Teil relativ lange die Luft anhalten (40 Sekunden), was bei älteren Patienten schwierig sein kann.

Basierend auf einer Evaluation der Qualität und der ökonomischen Aspekte schätzt der dänische HTA Report[27] die Mindestfrequenz für die CT-Kolonographie an einer radiologischen Abteilung auf 100 pro Jahr (2 pro Woche), um die Untersuchung mit guten Ergebnissen durchführen zu können.

Autorin: Dr. Irmgard Schiller-Frühwirth, MPH

3 Fragestellung

Derzeitige Wertigkeit der virtuellen Koloskopie (CT- Colonography)

1) Handelt es sich bei der Methode um eine wissenschaftlich anerkannte Form der Diagnostik im Rahmen einer Krankenbehandlung?
2) Wenn ja, bei welchen Indikationen?
3) Welchen medizinischen Zusatznutzen hat diese Methode im Vergleich zur konventionellen Koloskopie/Sigmoidoskopie?
4) Ist eine qualitativ ausreichende Erbringung auch im niedergelassenen Bereich möglich?

4 Suchstrategie

Keywords:Colon, CT; Colon neoplasms, CT; intestinal neoplasms, diagnosis; Cancerscreening; CT colonoscopy; CT Kolonographie; Computed Tomographic Colonography
Medline MesH Term: Colonography, Computed Tomographic
A non-invasive imaging method that uses computed tomographic data combined with specialized imaging software to examine the colon.
Medline:

Result:

0

Translations:

Humans[Mesh]	„humans“[MeSH Terms]

Database:

PubMed

User query:

“Colonography, Computed Tomographic”[MeSH] NOT “Colonoscopy”[MeSH] AND (□as abstract[text]) AND Meta-Analysis[ptyp] AND Humans[Mesh] AND (“2000”[Pdat]:”2005”[Pdat])

Result:

4

Translations:

Humans[Mesh]	„humans“[MeSH Terms]

Database:

PubMed

User query:

“Colonography, Computed Tomographic”[MeSH] NOT “Colonoscopy”[MeSH] AND (□as abstract[text]) AND Randomized Controlled Trial[ptyp] AND Humans[Mesh] AND (“2000”[Pdat]:”2005”[Pdat])

Result:

62

Translations:

Humans[Mesh]	„humans“[MeSH Terms]

Database:

PubMed

User query:

“Colonography, Computed Tomographic”[MeSH] NOT “Colonoscopy”[MeSH] AND (as abstract[text]) AND Review[ptyp] AND Humans[Mesh] AND (“2000”[Pdat]:”2005”[Pdat])

Suche in Trip Database: keyword: Colonography, personalised: oncology
Evidence Based Results: 16
Suche in EBM/HTA Datenbanken: California Technology Assessment Forum,[28] NICE, EBM Online, Centre for Reviews and Dissemination, University York, Health Technology Assessment (HTA) Database, Swedish Council on Technology Assessment, Blue Cross Blue Shield Association, CCOHTA, Effective Health Care Bulletin, Ontario Ministry of Health and Long Term Care, Minnesota Department of Health, ICSI, Medical Service Advisory Committee (Australia), NHS Economic Evaluation Database, NHS Health Technology Assessment Programme.
Suche in Guideline International: Finnish Medical Society Duodecim, National Guideline Clearinghouse, NICE-Clinical Guidelines, New Zealand Guideline Group, CMA Infobase (Canada), American Cancer Society

Suche in ACP Journal Club

#	Search History	Results	Display
1	colonography.mp. [mp=title, abstract, full text, keywords, caption text]	4	DISPLAY

Suche in Cochrane Database of Systematic Reviews

#	Search History	Results	Display
1	colonography.mp. [mp=title, abstract, full text, keywords, caption text]	0	-

2	colon neoplasma.mp. [mp=title, short title, abstract, full text, keywords, caption text]	0	-
3	computed tomographic colonography.mp. [mp=title, short title, abstract, full text, keywords, caption text]	0	-

Cochrane Library, Health Technology Assessment Database

Record #1 of 11
ID: HTA-20030541
AU: Institute for Clinical Systems Improvement
TI: Computed tomographic colongraphy for detection of colorectal polyps and neoplasms
YR: 2001
US: http://www.mrw.interscience.wiley.com/cochrane/clhta/articles/HTA-20030541/frame.html
KY: Colorectal Neoplasms [diagnosis]; Colonic Polyps [diagnosis]; Colonography, Computed Tomographic

Record #2 of 11
ID: HTA-20040764
AU: Institute for Clinical Systems Improvement
TI: Computed tomographic colonography for detection of colorectal polyps and neoplasms
YR: 2004
US: http://www.mrw.interscience.wiley.com/cochrane/clhta/articles/HTA-20040764/frame.html
KY: Colorectal Neoplasms [diagnosis]; Colonic Polyps [diagnosis]; Colonography, Computed Tomographic; Tomography Scanners X-Ray Computed

Record #3 of 11
ID: HTA-20040743
AU: Ontario Ministry of Health, Long-Term Care
TI: Computed tomographic colonography (virtual colonoscopy)
YR: 2003
US: http://www.mrw.interscience.wiley.com/cochrane/clhta/articles/HTA-20040743/frame.html
KY: Colorectal Neoplasms [diagnosis]; Colonography, Computed Tomographic; Mass Screening

Record #4 of 11
ID: HTA-20030448
AU: Health Technology Advisory Committee
TI: Computed tomographic colonography (virtual colonoscopy)
YR: 2002

US: http://www.mrw.interscience.wiley.com/cochrane/clhta/articles/HTA-20030448/frame.html
KY: Colorectal Neoplasms [diagnosis]; Colonography, Computed Tomographic; Colonoscopy; Costs and Cost Analysis

Record #5 of 11
ID: HTA-20010519
AU: Danish Centre for Evaluation and Health Technology Assessment (DACEHTA) (formerly DIHTA)
TI: CT colonography - a comparison with colonoscopy (funded by DIHTA) - primary research (project)
US: http://www.mrw.interscience.wiley.com/cochrane/clhta/articles/HTA-20010519/frame.html
KY: Colonoscopy; Diagnostic Imaging

Record #6 of 11
ID: HTA-20050003
AU: Swedish Council on Technology Assessment in Health Care
TI: CT colonography (virtual colonoscopy) (Alert)
YR: 2004
US: http://www.mrw.interscience.wiley.com/cochrane/clhta/articles/HTA-20050003/frame.html
KY: Colonoscopy; Diagnostic Techniques, Digestive System; Tomography Scanners X-Ray Computed

Record #7 of 11
ID: HTA-20040668
AU: Blue Cross Blue Shield Association
TI: CT colonography ('virtual colonoscopy') for colon cancer screening
YR: 2004
US: http://www.mrw.interscience.wiley.com/cochrane/clhta/articles/HTA-20040668/frame.html
KY: Colonic Neoplasms [diagnosis]; Colonoscopy; Colonography, Computed Tomographic; Mass Screening

Record #8 of 11
ID: HTA-20040858
AU: Canadian Coordinating Office for Health Technology Assessment
TI: Virtual colonoscopy
YR: 2004
US: http://www.mrw.interscience.wiley.com/cochrane/clhta/articles/HTA-20040858/frame.html
KY: Colonoscopy; Colonography, Computed Tomographic; Magnetic Resonance Imaging
Record #9 of 11
ID: HTA-20020833

AU: Medical Services Advisory Committee
TI: Virtual colonoscopy
YR: 2002
US: http://www.mrw.interscience.wiley.com/cochrane/clhta/articles/HTA-20020833/frame.html
KY: Colonography, Computed Tomographic; Colonoscopy; Colorectal Neoplasms [diagnosis]

Record #10 of 11
ID: HTA-20040634
AU: HAYES, Inc
TI: Virtual colonoscopy (computed tomography colonography)
YR: 2003
US: http://www.mrw.interscience.wiley.com/cochrane/clhta/articles/HTA-20040634/frame.html
KY: Colonography, Computed Tomographic; Colorectal Neoplasms [diagnosis]

Record #11 of 11
ID: HTA-20030057
AU: Canadian Coordinating Office for Health Technology Assessment
TI: Virtual colonoscopy (computed tomography colonography)
YR: 2002
US: http://www.mrw.interscience.wiley.com/cochrane/clhta/articles/HTA-20030057/frame.html
KY: Human [checkword]; Colonoscopy [methods]; Colonography, Computed Tomographic

NHS Health Technology Assessment Programme[29]
Registrierte randomisiert klinische Studie ISRCTN95152621 (*International Standard Randomised Controlled Trial Number)
URL of this project on the Controlled Trials Website:http://www.controlled-trials.com/isrctn/trial/|/0/95152621.html
Computed tomography (CT) colonography, colonoscopy, or barium enema for diagnosis of colorectal cancer in older symptomatic patients[30]
Start date: February 2004, Publication date: Mid 2009

5 Koloskopie – „Gold Standard“

Alle CT-Kolonographie Studien vergleichen ihre Ergebnisse mit der konventionellen Koloskopie. Überraschenderweise wurde die Effektivität der Koloskopie in Bezug auf die Senkung der kolorektalen Karzinommortalität bisher weder in Fall - Kontrollstudien noch in randomisiert kontrollierten klinischen Studien nachgewiesen. Indirekte Evidenz unterstützt den Einsatz als Screeningmethode und viele Experten sehen die konventionelle Koloskopie als “Gold Standard” in der Detektion kolorektaler Polypen und Karzinome (Walsh, Terdiman 2003).

Die Koloskopie ist kein perfekter Screeningtest, Rex et al (1997)[31] fand in unmittelbar aufeinander folgenden Koloskopien, von Experten durchgeführt, eine Fehlerrate von 6% für 10mm und größere Adenome, von 13% für 6-9mm große Adenome und von 17% für 5mm und kleinere Adenome.

Die Koloskopie ist im Allgemeinen eine sichere Methode, aber nicht so sicher wie die Sigmoidoskopie oder die CT-Kolonographie. In einer Studie (Zubarik et al 1999) hatten 1 bis 2% der Patienten Komplikationen, die einen Besuch in einer Notfallaufnahme zur Folge hatte und das Risiko einer Perforation wird mit ungefähren 0,1 % angegeben (Nelson et al 2002).

Für die konventionelle Koloskopie muss ebenso wie für die CT- und MR-Kolonographie der Patient am Tag vor der Untersuchung vollständig abgeführt werden. Die Untersuchung dauert ca. 30 Minuten, sobald eine Sedierung erfolgt, ist ein längerer Aufenthalt in der Endoskopie Einheit notwendig.

6 Virtuelle Koloskopie

Unter dem Begriff der virtuellen Koloskopie werden zwei unterschiedliche radiologische Verfahren verstanden, die CT-Kolonographie (CTC) und die MR-Kolonographie, die beide zwei und dreidimensionale Bilder des Kolon liefern, die in rascher Abfolge einen „Flug“ durch das Kolon ermöglichen.

Während die meiste Erfahrung mit virtueller Koloskopie von Spiral Computertomographen stammt, kommt eine größer werdende Anzahl von Literatur aus Europa, die sich mit MR Kolonographie in der Detektion von kolorektalen Polypen beschäftigt (Geenen et al. 2003, Pappalardo et al 2000, Morin et al 2001, Luboldt et al 2001).[32]

Die «virtuelle Koloskopie» basiert auf Abdomenaufnahmen, die mit einem der beiden herkömmlichen Schnittbildverfahren, Computertomographie (CT) und Magnet-resonanztomographie (MR), gewonnen werden. Aus den Daten der Schnittbilder wird dabei mit Computerprogrammen eine Innenansicht des Kolons konstruiert. Die Methoden wurden erstmals 1996[33] und 1997[34] beschrieben. Das Verfahren kann mit jedem gängigen MR- oder CT-Gerät gemacht werden. Neu ist die Methode, das Kolon zu kontrastieren und die Software. Für die CT- und MR- Kolonographie muss der Patient genau wie bei der Koloskopie vollständig abgeführt werden. Stuhlreste können Raumforderungen vortäuschen. Für die MR- Kolonographie wird der Darm mit 2–3 Litern Wasser gefüllt, welches Gadolinium enthält. Danach werden MR-Aufnahmen in Bauch- und Rückenlage gemacht. Für die CT-Kolonographie wird der Darm mit Luft gefüllt. Für die Aufnahmen muss der Patient zum Teil relativ lange die Luft anhalten (40 Sekunden), was bei alten Patienten manchmal schwierig ist. Die Gabe von i.v.-Kontrastmittel ist nicht unbedingt notwendig. Kontraindikationen für die Durchführung der MR- Kolonographie sind dieselben wie bei allen anderen MR-Aufnahmen (Schrittmacher, Metallteile im Körper). Die Auswertung der Daten erfolgt mit Hilfe der bereits erwähnten Software nach Abschluss der Aufnahmen.[35]

Eine CT-Kolonographie führt zu einer relevanten Bestrahlung,[36] dies ist vor allem zu bedenken bei Patienten, die sich freiwillig einem Screening unterziehen.

Die meisten Studien über CT-Kolonographie konnten keine mit der konventionellen Koloskopie vergleichbare Sensitivität zeigen. Es gibt bisher keine Evidenz, ob und dass die CT-Kolonographie das Gesundheitsergebnis verbessert, nämlich die karzinomspezifische Mortalität senkt, keine Studie zeigte eine Senkung der Mortalität wie für die Sigmoidoskopie oder den Test auf okkultes Blut im Stuhl,[37] die Evidenz für die konventionelle Koloskopie ist allerdings auch nur eine indirekte.[38]

Wenige CT-Kolonographie Studien wurden in der Population durchgeführt, die mit einem durchschnittlichen Risiko für ein kolorektales Karzinom zum Screening zugewiesen werden.

7 Health Technology Assessments

7.1 Computed Tomographic Colonography (Virtual Colonoscopy) for Screening of Colorectal Cancer[39]

The scientific evidence must permit conclusions concerning the effectiveness of the technology regarding health outcomes.
Since colorectal screening is clearly effective on the basis of results from randomized controlled trials of FOBT (Mandel *et al* 1993 and 1999) and case-control studies of sigmoidoscopy (Selby *et al* 1992), it has been recommended that new tests such as CTC only need to demonstrate that they have equal or superior performance characteristics to be recommended for colorectal cancer screening (Winawer *et al* 1997). As a result, there is a growing body of literature comparing the sensitivity and specificity of CTC with conventional colonoscopy. Many of these studies were undertaken in populations with a high risk of colorectal polyps or cancer. More well designed studies comparing CTC to other accepted screening methods in average risk populations are needed before we can fully assess the effectiveness of this technology on health outcomes.

In the first published study to examine CTC to detect colorectal polyps, Hara *et al* (1996) concluded that this “novel technique” was feasible for detecting polyps ≥0.5cm in diameter. Since that time, there have been at least 14 additional studies published in peer-reviewed journals that have examined the sensitivity and specificity of CTC in detecting colorectal polyps. In all of these studies, the sensitivity and specificity of CTC is significantly better for polyps ≥1.0cm. For screening purposes, some authorities recommend that 1 cm or larger should be the target lesion size (Winawer *et al* 1997), although some experts assert that flat adenomas, which are usually smaller, are more likely to have high grade dysplasia for a given size. Conventional colonoscopy is used as the standard of reference (the "gold standard") for detected polyps in all studies to date. Many studies distinguish in their analyses between “per-polyp” and “per-patient” sensitivity and specificity. For example, in Yee *et al.* (2001), a polyp noted at CTC was considered to have matched with a polyp identified at colonoscopy if it was in the same or in an adjacent segment of the colon and had a difference in size less than 4mm in diameter. In the per-patient analysis, the findings at CTC and conventional colonoscopy were considered to match if both studies showed at least one polyp or if neither test showed a polyp. The size, number or location of polyps was not considered. Although this type of analysis (i.e. per-patient) is a less rigorous standard by which to evaluate CTC, it may be more clinically relevant since any finding of a polyp on CTC should lead to a referral for a complete colonoscopy for the patient in question.

The technology must improve the net health outcomes. For diagnostic tests, there is evidence that use of the test would result in improved medical management in a way that will benefit the patient.

There have been more than 20 studies in which the accuracy of CT colonography has been compared with conventional colonoscopy. However, in only five studies to date are at least some of the patients drawn from an average-risk population who present for routine screening (Pickhardt *et al*. 2003; Edwards *et al*. 2003; Yee *et al* 2001; Rex *et al* 1999; Macari *et al* 2000).

Effectiveness in Average-risk Screening Population

Pickhardt *et al*. (2003) evaluated the performance of CTC for the detection of colorectal neoplasia in an average-risk screening population. A total of 1233 adults underwent same day CTC and conventional colonoscopy. The final results on colonoscopy, including findings on repeat colonoscopy after unblinding to the results of CTC, served as the reference standard by which initial colonoscopy and CTC were compared. Of the 1233 patients, 97.4% were considered to be of average risk. The prevalence of adenomatous polyps 6 mm or more in diameter was 13.6%. In an analysis according to the patient, sensitivity of CTC for adenomatous polyps was 93.8% for polyps at least 10 mm, 93.9% for polyps at least 8 mm and 88.7% for polyps at least 6 mm. The corresponding specificity was 96%, 92.2% and 79% respectively. The sensitivity of conventional colonoscopy (prior to unblinding to results of CTC) was 87.5%, 91.5% and 92.3% for ≤ 10 mm, ≤ 8 mm and ≤ 6 mm polyps. If a threshold polyp size of 10 mm had been used, 7.5% of patients who underwent CTC would have required referral for polypectomy; at a threshold of 6 mm 29.7% of patients would have required referral.

In a study conducted in Australia, **Edwards** *et al*. (2003) evaluated CTC as a screening tool for average risk asymptomatic subjects in a community with regard to participation, acceptability and safety. This study was not able to accurately assess the sensitivity of CTC as only patients with positive CTC went on for colonoscopy
In the first blinded prospective study, **Hara** *et al* (1997) examined the sensitivity and specificity of CTC in 70 consecutive patients, half with known colorectal polyps and half from a surveillance population of individuals who were being followed up after removal of polyps 1-5 years earlier. All patients underwent colonoscopy, which served as the standard of reference and supine position only CTC. The sensitivity and specificity for the two observers with CTC was 75% and 90% in patients ≥1.0 cm, 66% and 63% in patients with adenomas ≥5 mm and 45% and 80% for patients with adenomas less than 5 mm in diameter.

In a blind trial, **Rex** *et al* (1999) performed helical CT followed by same day colonoscopy on 46 asymptomatic patients, 60 years of age or older with no history of colonic neoplasia. The CT scans reported in the study were performed in 1995 and 1996, in an early phase of the technology. They found that CTC failed to identify a significant number of large polyps and most small adenomas (sensitivity = 50% for polyps ≥10 mm, sensitivity = 43% for polyps ≥5 and ≤10 mm, and 11% for those ≤5 mm).

Macari *et al* (2000) compared the findings of 2D, 3D and time-efficient CTC with conventional colonoscopy for detecting colorectal polyps in 42 asymptomatic

patients. Twelve patients had a family history of colon cancer. Colonoscopy detected 16 polyps in 13 patients. Of these, 6 were prospectively visible on CTC and 10 polyps were overlooked. Sensitivity for polyps measuring 7 mm or more was 100% (4/4), 6 mm or more 67% (4/6). Overall sensitivity for polyp detection was 38%.

In the largest prospective, blind study to date, **Yee** *et al* (2001) evaluated the sensitivity and specificity of CTC in 300 asymptomatic (n=96) and symptomatic (n=204) patients recruited from a Veterans Affairs hospital. Patients were predominantly male with a mean age of 62.6 years (a population with an expected higher prevalence of colorectal polyps and cancer). The overall sensitivity and specificity of CTC for polyp detection were 90.1% and 72% respectively. By direct polyp matching, the overall sensitivity was 69.7%. The sensitivity was 94% for the detection of adenomas 10 mm or larger, 82% for adenomas 5 - 9 mm and 66.9% for adenomas smaller than 5 mm. As the authors point out, however, specificity was not optimal. Thirty-three patients with normal colonoscopies had polyps on CTC and would most likely be referred for colonoscopy in clinical practice. Overall specificity for adenoma detection was 57%. No statistically significant differences were found between symptomatic and asymptomatic patients in the sensitivity of CTC.

Recommendation
It is recommended that CT Colonography does not meet California Technology Assessment Forum TA criteria as a first-line screening test for colorectal cancer in persons at average risk.

7.2 CT Colonography ("Virtual Colonoscopy") for Colon Cancer Screening[40]

The scientific evidence must permit conclusions concerning the effect of the technology on health outcomes.
The current evidence consists of studies evaluating the sensitivity and specificity of CT Colonography compared to either colonoscopy alone or a colonoscopy aided by CT colonography results. In this assessment, 11 studies evaluating diagnostic performance at a per-patient level of analysis at specific minimum size thresholds met study selection criteria for this review. Included studies were prospective studies that compared CT colonography and optical colonoscopy to a valid reference standard (usually colonoscopy), provided per-patient analysis allowing calculation of sensitivity and specificity of CT colonography, and reported on at least 50 patients. Overall, sensitivities were quite variable between studies, from as low as 35% to as high as 100% for detecting patients with 10 mm or larger lesions. The larger studies with more stable estimates of sensitivity ranged from 55% to 94%. Specificities were less variable, and most studies reported sensitivities greater than 90%. At a smaller size threshold of detection CT colonography was both less sensitive and less specific. Variable performance of CT colonography may be associated with interpreter experience or other technical factors. Such evidence does not allow conclusions on the effect of CT colonography in improving health outcomes,

however. Positive findings on CT colonography require referral for colonoscopy to confirm findings and remove polyps. The appropriate minimum size of polyp that should be referred and the appropriate screening interval are unknown. It would defeat the purpose of initial non-invasive screening to refer patients with any polyp for colonoscopy, because the prevalence of polyps is so high that a large proportion of patients would need to undergo both procedures. Because known polyps are left behind, and sensitivity for small polyps is known to be less than colonoscopy, CT colonography is meant to be used more frequently than colonoscopy in a screening program.

The technology must improve the net health outcome.
There is no direct evidence as to whether CT colonography improves health outcomes. However, the evidence evaluating colonoscopy, its principal comparator, is also indirect. Colonoscopy has become an accepted mode of colon cancer screening through understanding of the natural history of colon cancer and its role in other proven methods of colon cancer screening.

The technology must be as beneficial as any established alternatives.
The current evidence does not allow conclusions as to the comparative efficacy of CT Colonography and colonoscopy. Comparison of sensitivity and specificity with colonoscopy is incomplete evidence, because the 2 techniques are intended to be used differently. The bowel preparation currently required for CT colonography is the same as conventional colonoscopy and depending on the criteria for referral, a variable proportion of patients require colonoscopy, which necessitates another bowel preparation. CT colonography only identifies for removal polyps of a certain minimum size threshold, and is meant to be used more frequently. It is uncertain what the appropriate size threshold for referral and frequency of screening is appropriate. Actual longitudinal studies or modelling studies are needed to assess comparative efficacy in preventing colon cancer mortality. Improvements in the technical aspects of CT colonography include developments in stool tagging and digital subtraction, which may obviate the need for bowel preparation. In such a case it might then be appropriate to compare CT colonography to one of the less-invasive colon cancer screening techniques.

The improvement must be attainable outside the investigational settings.
Diagnostic performance of CT colonography is variable in the studies, possibly due to differences in interpreter experience and variability in other technical aspects of performing the test. Standards of performance are yet to be developed. It is likely that diagnostic performance in the community may also vary. While there is no direct evidence of improvement of health outcomes with use of CT colonography, poor diagnostic performance virtually precludes any possible positive effects of the technology. Based on the above, CT colonography as an alternative to colonoscopy for the purpose of colon cancer screening does not meet the TEC criteria.

7.3 Colon Examination with CT Colonography - A Health Technology Assessment Summary[41]

The technology
In the study at Aarhus University Hospital the sensitivity of CT colonography for lesions 6 mm was 81% as compared to 87% with colonoscopy. This difference was not significant. In the study at Hillerød Hospital, in contrast, the sensitivity of CT colonography was significantly lower for lesions of 5 mm (66%) than that of colonoscopy (93%). In the study at Aarhus University Hospital the sensitivity of CT colonography differed significantly between two observers. This was not the case in the study at Hillerød Hospital. That the quality of the investigation differed considerably depending on the observer highlights the need for training and testing of radiologists who perform CT colonography. The S-shaped part of the bowel (sigmoid colon) can be difficult to examine with CT colonography. In just under 20% of the patients in the study at Aarhus University Hospital, the investigation of the sigmoid colon was technically deficient. This, together with perceptual errors and flat polyp morphology, was the main reason for lesions remaining undetected. The problem with the sigmoid colon, where approx. 30-40% of the polyps are located, can be solved by a supplementary endoscopy of that part of the bowel.

The patient
Compared with colonoscopy, CT colonography was considered to be significantly less painful, less uncomfortable, less humiliating and less stressful. The bowel cleansing was considered to be a significant nuisance, and it would be to CT colonography's advantage if it eventually becomes possible to perform the procedure without prior conventional cleansing. In cases where renewed colon investigation is required, 81-94% of the patients would prefer CT colonography to colonoscopy.

Organisation
Surprisingly, it was not possible to identify major changes/improvements in the sensitivity and specificity during the course of evaluation of the first 100 investigations by two independent observers. The variations in the learning curve seem more to be attributable to variations in »difficult« and »easy« colons than an effect of learning. Alternatively, it could be attributable to the learning curve being very long and extending beyond the first 100 investigations. In contrast, time expenditure for evaluation of an investigation reduces considerably after completion of the first approx. 30 investigations, which reflects the fact that the observers become conversant with the software and the workstation after that number of investigations. Both learning and the maximum level is individual, which necessitates that the individual radiologist should know his/her ability before the investigation is used clinically.

The Project Group's overall conclusion and recommendations

- CT colonography should not generally replace colonoscopy as the primary investigation in Danish colorectal cancer (CRC) patients.
- CT colonography should replace barium enema in incomplete colonoscopy.
- CT colonography should be considered as the primary investigation in:
- Patients requiring examination for polyps/CRC in cases where it is known from previous investigations that their bowel is difficult to investigate, for example due to a long and tortuous bowel, stenoses, etc.
- Patients with earlier traumatic experiences in connection with colonoscopy, either mentally or physically in the form of severe pain or bowel perforation/bleeding.
- CT colonography has a place in:
- Elderly, weak and other patients, where the assistance of an anaesthetist is required in connection with colonoscopy. The arguments are the risks and the costs associated with both colonoscopy and anaesthesia. In elderly patients, 10 mm can be considered as the cut-off value for a »significant polyp« as polyps smaller than 10 mm are unlikely to develop into cancer during the patient's lifetime. The risk of the development of cancer is therefore hardly likely to be commensurate with the disadvantages associated with removal of the polyp.
- The prerequisites for CT colonography are:
- The necessary technology
- A radiologist trained and experienced in CT colonography
- Quality assurance through double investigation with both CT colonography and colonoscopy of selected patients locally and via long-term follow-up through the Danish Cancer Register.
- Despite the potential economic benefits, CT colonography should not replace colonoscopy as the primary diagnostic method in a Danish outpatient colonoscopy population. Such a strategy requires further research at a few centres before widespread use in routine clinical practice.
- The prospective studies in this report have been performed in high-risk populations and hence do not allow conclusions to be drawn as to the diagnostic reliability of CT colonography in low-risk populations, for example in a screening context. Consideration could be given to a scientific evaluation of the technique in patients with a positive Haemoccult test.
- Based on an overall evaluation of quality and the economic aspects, the Project Group estimates that a department needs to carry out at least 100 CT colographies per year (2 investigations per week) in order to be able to perform the investigation satisfactorily.
- CT colonography's place in the Danish health service should be evaluated regularly. Technological improvements continue to take place that could change the status of CT colonography in the long term.

8 Empfehlungen für Screening des kolorektalen Karzinoms

8.1 Blue Cross Blue Shield Association (BCBSA)

The Blue Cross Blue Shield Association Technology Evaluation Center reviewed CT Colonography in June, 2004, and has indicated that it does not meet TEC criteria.

8.2 Centers for Medicare and Medicaid Services

Colorectal Cancer: As of January 1, 1998, Medicare will cover colorectal cancer screening. This coverage includes fecal-occult blood tests, flexible sigmoidoscopy, colonoscopy (for people at high risk for colorectal cancer), and in certain cases, barium enemas. Each of these tests are covered under different circumstances, so patients should check with their physician to determine what is best for them. In the past, these tests were covered only when a physician already suspected the patient had cancer or other disease, and was using them for diagnostic, rather than screening, purposes. ”A policy specific to CT Colonography was not found on either the national or local level.

8.3 American Cancer Society Guidelines

The American Cancer Society does not endorse CT Colonography as a method of screening for colorectal neoplasms. (Last update: Levin *et al*. 2003)

8.4 California Radiological Society

The California Radiological Society provided representation at the meeting and testimony in support of the use of virtual colonoscopy.

8.5 American Gastroenterological Association

The American Gastroenterological Society recently concluded that “virtual colonoscopy” is not yet ready for widespread screening outside the research setting (Winawer *et al*. 2003). An AGA representative attended the meeting and provided testimony.

8.6 U.S. Preventive Services Task Force

The USPSTF 2002 Recommendations and Rationale – The USPSTF found insufficient evidence that newer screening technologies (for example, computed tomographic colonography) are effective in improving health outcomes (Am Family Phys).

8.7 California Technology Assessment Forum

It is recommended that CT Colonography does not meet California Technology Assessment Forum TA criteria as a first-line screening test for colorectal cancer in persons at average risk.

9 Systematischer Review und Metaanalysen

9.1 Interventional procedures overview of computed tomography colonography (virtual colonoscopy)[42]

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.[43]

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. 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.

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.

Inclusion criteria for identification of relevant studies

Characteristic Criteria	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 metaanalysis of 14 studies published between 1994 and 2002.[44] Three studies report the sensitivity and specificity of CTC, using colonoscopy as the standard, including one which was also in the systematic review.[45,46,47] One study reports the results of a community-based screening project.[48] One study reports the sensitivity and specificity of CTC compared with double contrast barium enema.[49] The final study reports the experiences of patients given either CTC and colonoscopy or CTC and a double contrast barium enema.[50]

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.[51]
- One study reports on the use of CTC as a diagnostic tool for symptomatic patients.[52]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.[53,54,55]
- 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.[56]
- 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.[57]
- There may be high interobserver variability of the CT readings.[58]
- One study did not include polyps less than 5 mm in diameter.[59]

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.

9.2 Meta-Analysis: Computed Tomographic Colonography[60]

Purpose:
To systematically review the test performance of CT colonography compared to colonoscopy or surgery and to assess variables that may affect test performance.

Data Sources:
The PubMed, MEDLINE, and EMBASE databases and the Cochrane Controlled Trials Register were searched for English-language articles published between January 1975 and February 2005.

Study Selection:
Prospective studies of adults undergoing CT colonography after full bowel preparation, with colonoscopy or surgery as the gold standard, were selected. Studies had to have used state-of-the-art technology, including at least a single-detector CT scanner with supine and prone positioning, insufflation of the colon with air or carbon dioxide, collimation smaller than 5 mm, and both 2-dimensional and 3-dimensional views during scan interpretation. The evaluators of the colonogram had to be unaware of the findings from use of the gold standard test.

Data Synthesis:
33 studies provided data on 6393 patients. The sensitivity of CT colonography was heterogeneous but improved as polyp size increased (48% [95% CI, 25% to 70%] for detection of polyps <6 mm, 70% [CI, 55% to 84%] for polyps 6 to 9 mm, and 85% [CI, 79% to 91%] for polyps >9 mm). Characteristics of the CT colonography scanner, including width of collimation, type of detector, and mode of imaging, explained some of this heterogeneity. In contrast, specificity was homogenous (92% [CI, 89% to 96%] for detection of polyps <6 mm, 93% [CI, 91% to 95%] for polyps 6 to 9 mm, and 97% [CI, 96% to 97%] for polyps >9 mm).

Limitations:
The studies differed widely, and the extractable variables explained only a small amount of the heterogeneity. In addition, only a few studies examined the newest CT colonography technology.

Conclusions:
Computed tomographic colonography is highly specific, but the range of reported sensitivities is wide. Patient or scanner characteristics do not fully account for this variability, but collimation, type of scanner, and mode of imaging explain some of the discrepancy. This heterogeneity raises concerns about consistency of performance and about technical variability. These issues must be resolved before CT colonography can be advocated for generalized screening for colorectal cancer.

Sensitivity of CT Colonography
Per-patient sensitivity for CT colonography varied from 21% to 96%.The overall pooled sensitivity for CT colonography was 70% (95% CI, 53% to 87%). Sensitivity increased progressively as polyp size increased: it was 48% (CI, 25% to 70%) (range, 14% to 86%) for detection of polyps smaller than 6 mm, 70% (CI, 55% to 84%) (range, 30% to 95%) for polyps 6 to 9 mm, and 85% (CI, 79% to 91%) (range, 48% to 100%) for polyps larger than 9 mm. Each of these analyses was statistically heterogeneous, and most of the variance was attributable to between-study heterogeneity. We found several potential sources for this heterogeneity. First, studies that used thinner slices for collimation appeared to have better sensitivity, and meta-regression of data from 19 studies suggested that every 1-mm increase in collimation width decreases sensitivity by 4.9% (CI, 0.8% to 7.1%). Second, the 7 studies that used multidetector scanners and that reported overall sensitivity had homogenously high sensitivity (95% [CI, 92% to 99%]). This sensitivity was higher than that in the 9 studies reporting overall sensitivity in which a scanner with a single-detector was used (82% [CI, 76% to 92%]), although the latter results were heterogeneous. The 10 studies that used 2-dimensional imaging, with confirmation by 3-dimensional imaging only when considered necessary, yielded a sensitivity of 81.9% (CI, 71% to 91%) whereas the 6 studies that used standard 2-dimensional imaging and concomitant 3-dimensional imaging had a pooled sensitivity of 91% (CI, 83% to 99%) and the 2 studies that used fly-through technology had a pooled sensitivity of 99% (CI, 95% to 100%).

Specifity of CT Colonography
In contrast to the broad range of sensitivities reported, per-patient specificity was more consistent across polyp sizes. Overall, CT colonography was 86% specific (CI, 84% to 88%) on the basis of data from 14 studies. Specificity improved as polyp size increased, and the results were homogenous within each strata. Only 4 studies reported specificity for detection of polyps smaller than 6 mm, and the pooled specificity from these studies was 91% (CI, 89% to 95%). For polyps 6 to 9 mm in size (6 studies), specificity was 93% (CI, 91% to 95%) and increased to 97% (CI, 96% to 97%) for polyps larger than 9 mm (15 studies).

9.3 CT Colonography of Colorectal Polyps: A Metaanalysis[61]

The purpose of this study is to use metaanalysis to assess the reported accuracy of CT colonography compared with conventional colonoscopy for detecting colorectal polyps.

Fourteen studies fulfilled all the study inclusion criteria and gave a total of 1,324 patients and 1,411 polyps. The pooled per-patient sensitivity for polyps 10 mm or larger was (sensitivity [95% CI]) 0.88 (0.84–0.93), for polyps 6–9 mm it was 0.84 (0.80–0.89), and for polyps 5 mm or smaller it was 0.65 (0.57–0.73). The pooled per-polyp sensitivity for polyps 10 mm or larger was 0.81 (0.76–0.85), for polyps 6–9 mm it was 0.62 (0.58–0.67), and for polyps 5 mm or smaller it was 0.43 (0.39–0.47).

Sensitivity for detection of polyps increased as the polyp size increased. The pooled overall specificity for detection of polyps larger than 10 mm was 0.95 (0.94–0.97).

The studies analyzed differ regarding technical factors such as pitch and reconstruction interval. To the best of knowledge, these factors have not been proven to alter the performance of CT colonography in clinical settings.[62] Tube current was also variable (50–260 mA), but even lower tube currents were recently shown to have good diagnostic yield.[63] The effect of using different oral bowel-cleansing solution preparations has never been proven to affect diagnostic yield directly.[64]

Although the results on CT colonography are compared with the traditional gold standard of conventional colonoscopy, the latter is not perfect. Six percent of polyps were missed in a back-to-back conventional colonoscopy study.[65] Therefore, the comparison of CT colonography is not with another perfect technique but rather with one that is approximately 95% sensitive for polyps 10 mm or larger.

10 Procedure Guidance

10.1 Computed tomographic Colonography (virtual colonoscopy)[66]

Interventional Procedure Guidance 129

Guidance
Current evidence on the safety and efficacy of computed tomographic colonography (virtual colonoscopy) appears adequate to support the use of this procedure provided that the normal arrangements are in place for consent, audit and clinical governance.

Indications
Computed tomographic (CT) colonography is used to examine the colon and rectum to detect abnormalities such as polyps and cancer. Polyps may be adenomatous (which have the potential to become malignant) or completely benign.

In addition to its use as a diagnostic test in symptomatic patients, CT colonography may be used in asymptomatic patients with a high risk of developing colorectal cancer. Conventional colonoscopy and double-contrast barium enema are the main methods currently used for examining the colon.

Outline of the procedure
CT colonography involves using a CT scanner to produce two- and three-dimensional images of the entire colon and rectum. CT colonography is less invasive than conventional colonoscopy.

CT colonography is usually performed on an empty bowel although ‘faecal tagging’ may be used, which eliminates the need for a cathartic bowel preparation. Faecal tagging requires the patient to ingest an iodinated contrast agent with meals approximately 48 hours before the scan. Sedation is not usually required for CT colonography. 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 images are manipulated and interpreted by a radiologist.

Efficacy
A meta-analysis of data from 14 studies with a total of 1324 patients reported the sensitivity and specificity of CT colonography 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 the detection of polyps 10 mm or larger was 95% (95% CI, 94–97%).

A study involving 1233 asymptomatic adults reported that the per-patient sensitivity for polyps 10 mm or larger was 94% (95% CI, 83–99%) for CT colonography and 88% (95% CI, 75–95%) for conventional colonoscopy. The per-patient sensitivity for polyps 6 mm or larger was 89% (95% CI, 83–93%) for CT colonography and 92% (95% CI, 87–96%) for conventional colonoscopy. A study of 615 patients reported per-patient sensitivities of 55% (95% CI, 40–70%) for polyps 10 mm or larger and 39% (95% CI, 30–48%) for polyps 6 mm or larger. Another study of 614 patients reported that CT colonography was significantly more sensitive than barium enema but less sensitive than colonoscopy. A study of 203 patients that used faecal tagging reported an overall per-patient sensitivity of 90% (95% CI, 86–94%).

The Specialist Advisors noted that the procedure may fail to detect small or flat lesions, but commented that this was also the case with other diagnostic techniques.

Safety

No significant complications were reported in the studies. Two studies reported on the level of discomfort felt by patients during the procedure.

One study reported that 1% (9/696) of patients experienced ‘extreme’ or ‘severe’ discomfort during CT colonography, compared with 4% (25/696) for colonoscopy. In the same study, less than 1% (4/617) of patients had ‘extreme’ or ‘severe’ discomfort during CT Colonography compared with 29% (181/617) during a barium enema ($p < 0.001$). A second study reported that 54% (546/1005) of patients found CT colonography to be more uncomfortable than conventional colonoscopy, but this may have been affected by the fact that patients were sedated for the conventional colonoscopy but not for the CT colonography. In the same study, CT colonography was reported to be more acceptable in terms of convenience than conventional colonoscopy in 68% (686/1005) of patients.

In one study, 72% (357/494) of patients were reported to prefer CT colonography to conventional colonoscopy, and 97% (518/534) preferred CT colonography to double-contrast barium enema.

The Specialist Advisors noted that the potential complications are similar to those associated with other techniques, and include bowel perforation and reaction to the intravenous contrast medium.

Other comments

It was noted that this is a rapidly evolving technology, dependent on the type of equipment used and the training and experience of the operator.

It was noted that patient selection was important; this is an alternative procedure to barium enema, and is particularly useful in frail and elderly patients as a diagnostic tool to detect tumours.

11 Literatur

ACP Journal Club

11.1 Colonoscopy detected colon polyps better than air-contrast barium enema or computed tomographic colonography[67]

Question:
In patients at high risk for colonic neoplasia, what is the comparative accuracy of air-contrast barium enema (ACBE), computed tomographic colonography (CTC), and colonoscopy for detecting large colonic polyps?
Methods:
Design: Blinded comparison of ACBE, CTC, and colonoscopy.
Setting: 14 centers in the United States.
Patients: 614 patients (mean age 57 y, 70% men) with >= 1 positive test result for fecal occult blood, >= 1 episode of bright-red blood per rectum in the previous 3 months, iron-deficiency anemia, or a family history of colon cancer or adenoma. Exclusion criteria included active gastrointestinal hemorrhage and serious medical illness.
Description of tests: ACBE was done according to standard protocols. Before ACBE, patients were given bisacodyl tablets and a suppository. After infusion of high-density barium and distension of the colon with room air, spot films were taken of all specific colon segments and overhead radiographs were obtained in various positions. 7 to 14 days after ACBE, CTC and colonoscopy were done on the same day. Patients were prepared for CTC with a phosphate-based cathartic. After placement of a rectal tube, the colon was insufflated with either room air or carbon dioxide with patients in the prone and supine positions. 4-slice or 8-slice multidetector CT scanners were used; nominal slice thickness was 2.5 mm with 1-mm reconstruction intervals. Interpretation of CTC was done before colonoscopy. Colonoscopy was done in a standard manner. Lesions were measured in comparison with open biopsy forceps, photographed, and assessed by a colonoscopist. All tests were interpreted by observers blinded to other test results.
Outcomes
Sensitivity, specificity, and likelihood ratios for the detection of large colonic polyps.
Main results:
63 patients had 76 lesions >= 10 mm in size, 55 of which were adenomas or cancer. 116 patients had 158 lesions 6 to 9 mm in size, 97 of which were adenomas. 155 patients had 234 lesions >= 6 mm in size, 152 of which were adenomas or cancer.
Conclusion:
In patients at high risk for colonic neoplasia, colonoscopy was more sensitive and specific than air-contrast barium enema or computed tomographic colonography for detecting large colonic polyps.

Commentary:
The study by Rockey and colleagues prospectively evaluated ACBE, CTC, and colonoscopy for the diagnosis of colonic neoplasia in high-risk patients. The study showed the accuracy of colonoscopy to be higher than that of ACBE or CTC. Overall, the study was well designed and well done. All investigators were adequately trained to do the tests being evaluated. Each test was interpreted blind, with segmental unblinding during the colonoscopy and independent blinded review of discordant results on any of the 3 tests. All tests were repeated in the event of continued disagreement. This rigorous method minimizes bias in favor of colonoscopy.
The study has 2 limitations. First, no barium stool tagging was used for CTC. Because colonic lesions can be obscured by untagged fluid and stool, this lowers the accuracy of CTC. Second, the Vitrea software used in the study has limited 3-dimensional reconstruction, with lower resolution for polyp conspicuity and less similarity to optical colonoscopy than the Viatronix software in a study by Pickhardt.[68]
CTC was better than ACBE for detection of 6- to 9-mm lesions. However, both CTC and ACBE had lower accuracy than colonoscopy, which also allows tissue biopsy and excision. Even with the anticipated technologic advances, CTC will not be cost-effective for diagnosing colonic neoplasia in high-risk populations because of the frequent need for follow-up colonoscopy. In this study, if CTC were fully accurate, 29% of patients would still have needed colonoscopy to remove or to facilitate biopsy on lesions > 6 mm. Consequently, within its current operational parameters, CTC cannot be advocated as the first-line investigation for patients with a high likelihood of colonic neoplasia. For such populations, CTC should be reserved for patients unwilling or unable to have colonoscopy. However, CTC may have a role in low-risk screening populations where most patients will not have colonic neoplasia and will not need a subsequent colonoscopy.

11.2 Computed tomographic colonography without cathartic preparation performed well in detecting colorectal polyps[69]

Question:
What is the diagnostic performance of low-dose multidetector computed tomographic colonography (CTC) without bowel cathartic preparation compared with optical colonoscopy for detection of colonic polyps?
Methods:
Design: Blinded comparison of CTC with optical colonoscopy.
Setting :A university hospital in Rome, Italy.
Patients: 203 patients >= 35 years of age (mean age 61 y, 69% men) who were scheduled to have optical colonoscopy because of average-risk colorectal cancer screening, personal or family history of colorectal polyps, family history of colorectal cancer, abnormal screening test result, iron deficiency anemia, hematochezia, change in bowel habits, abdominal pain, or weight loss. Exclusion criteria were history of familial adenomatous polyposis or hereditary nonpolyposis cancer syndromes; previous colorectal surgery; suspected inflammatory bowel disease, bowel obstruction, or acute diverticulitis; contraindications to bowel preparation or

iodine-containing contrast agents; or pregnancy.
Description of test
Fecal tagging was done using an oral iodinated contrast agent, which patients ingested during the 5 principal meals 48 hours before CTC. CTC was done using a multidetector helical CT scanner. The colon was insufflated with room air with patients in the prone and supine positions. CT images were acquired using a low-dose protocol for the scanner (slice collimation 2.5 mm, slice thickness 3.0 mm, and reconstruction interval 1.0 mm). The images were read separately and independently by 3 gastrointestinal radiologists who were blinded to the indications and results of optical colonoscopy.
Diagnostic standard
Optical colonoscopy was done 3 to 7 days after CTC. A single colonoscopist, blinded to CTC results, inserted a standard video colonoscope into the cecum and sequentially withdrew it segment by segment. After each segment was examined, the results of CTC were revealed for the previously examined segment allowing the endoscopist to reexamine that segment.
Outcomes
Sensitivity and specificity of CTC averaged across the 3 readers for detection of colorectal polyps.

Main results:

Agreement among the 3 readers for detection of colorectal polyps was high to excellent ([kappa] range 0.79 to 0.91). In a per-polyp analysis, the mean sensitivity for detecting polyps (<= 5 to >= 10 mm) was 64% (95% CI 60 to 69). The mean sensitivity for polyps >= 6 mm was 86% (CI 82 to 91) and for polyps >= 8 mm was 96% (CI 92 to 99).
Conclusion:
Low-dose multidetector computed tomographic colonography without bowel cathartic preparation compared favorably with optical colonoscopy for detection of colonic polyps.

Commentary:

Virtual colonoscopy, considered promising technology for colon cancer screening for over 10 years, has recently begun to live up to its promise. In virtual colonoscopy, an abdominal CT scan is rendered into a 3-dimensional image that looks like the image (minus mucosal coloration and other detail) from conventional colonoscopy. High sensitivity (94%) and specificity (96%) have recently been shown, although it is unclear whether such results can be routinely obtained in other settings A laxative preparation, understandably unpopular with patients, has been needed for conventional colonoscopy and, until now, for virtual colonoscopy. The study by Iannaccone and colleagues shows that satisfactory images may be obtained using a noncathartic tagging technique and is an important advance
Before virtual colonoscopy becomes well accepted as a colorectal cancer screening test, other challenges will need to be addressed. Because > 30% of Americans > 50 years of age have >= 1 polyp, decisions must be made about what size polyp is a target for screening, requiring further workup with conventional colonoscopy. Can some small polyps be ignored or simply followed with watchful waiting? Radiation dose, expense, and inconvenience may be important factors inhibiting the adoption

of virtual colonoscopy screening. Currently recommended screening programs include fecal occult blood testing and sigmoidoscopy as well as colonoscopy. Based on the progress reported recently, however, virtual colonoscopy is likely to become a contender in the near future.

11.3 Virtual colonoscopy performed poorly in detecting colorectal neoplasia.[70]

Question:
In patients presenting for colonoscopy, what is the accuracy of computed tomographic (CT) colonoscopy (virtual colonoscopy [VC]) in detecting colororectal neoplasia?
Methods:
Design: Blinded, noninferiority comparison of VC with conventional colonoscopy.
Setting: 8 clinical centers in the United States and 1 center in England.
Patients: 615 patients (mean age 61 y, 55% women) presenting for colonoscopy because of overt and occult rectal bleeding, change in stool habit, abdominal pain, or surveillance after polypectomy. Patients who had had colonoscopy within the past 3 years were excluded.
Description of tests: The colon was insufflated with room air or carbon dioxide. VC was done using 2- and 4-section CT scanners with nominal slice thicknesses of 2.5 or 5 mm and reconstruction increments of 1.5 or 1 mm, depending on equipment. Scans were read in 2-dimensional slices and 3-dimensional snapshot reconstructions when necessary. Radiologist interpretations were recorded in a sealed envelope for each colon segment. Conventional colonoscopy was done within 2 hours of VC. Endoscopists were blinded to VC results during insertion of the colonoscope. After each segment was examined and results recorded, the VC results for that segment were revealed, allowing the endoscopist to reexamine any discrepancy. The diagnostic standard comprised the initial VC results, additional findings on conventional colonoscopy after segmental unblinding to the VC results, and the results of additional diagnostic tests done later when clinically indicated.
Outcomes:
Sensitivity and specificity of VC and conventional colonoscopy in detecting lesions >= 6 mm.
Main results: 827 lesions were detected in 308 patients. The prevalence of lesions 1 to 5 mm, 6 to 9 mm, and >= 10 mm was 79%, 14%, and 6.5%, respectively. The sensitivity of VC for detecting lesions of any size was much less than that of conventional colonoscopy.
Conclusion:
In patients presenting for colonoscopy, virtual colonoscopy was inferior to conventional colonoscopy in detecting colorectal neoplasia.

11.4 Virtual colonoscopy detected colorectal polyps in asymptomatic patients with average risk for colorectal neoplasia.[71]

Question:
In asymptomatic patients with average risk for colorectal neoplasia, what is the accuracy of virtual colonoscopy for detecting colorectal polyps?
Methods:
Design:
Blinded comparison of virtual colonoscopy (VC) with optical colonoscopy (OC).
Setting: 3 medical centers in the United States.
Patients: 1233 patients (mean age 58 y, 59% men) with average risk for colorectal cancer. Exclusion criteria included positive result on guaiac-based test of stool <= 6 months before referral; iron-deficiency anemia in the previous 6 months; rectal bleeding or hematochezia or unintentional weight loss > 4.5 kg in the previous 12 months; OC in the previous 10 years; barium enema in the previous 5 years; a history of adenomatous polyps, colorectal cancer, or inflammatory bowel disease; and pregnancy.
Description of test and diagnostic standard:
VC was done before OC using a computed tomography (CT) protocol wherein pneumocolon was produced by insufflating room air through a rectal catheter immediately before scanning. A 4- or 8-channel CT scanner (GE LightSpeed or LightSpeed Ultra, General Electric Medical Systems) generated 2- and 3-dimensional (3-D) endoluminal displays of the colon and rectum while the patient held his or her breath in the supine and prone positions. The 3-D display was used for the initial detection of polyps. OC used a standard commercial video colonoscope inserted to the cecum. After each segment was inspected, results of VC for that segment were revealed. If a polyp >= 5 mm in diameter was seen on VC but not on OC, the endoscopist reexamined the segment to create the diagnostic standard (enhanced OC) and to capture false-negative results on OC that would otherwise be recorded as false-positive results on VC.
Main outcome measures:
Sensitivity, specificity, and likelihood ratios.
Main results:
554 adenomatous polyps were detected. The prevalence of polyps of diameters >= 6 mm, >= 8 mm, or >= 10 mm, was 13.6%, 6.7%, and 3.9%, respectively. Sensitivity for initial OC was slightly less than that of VC at polyp sizes >= 8 mm. Of 55 polyps (>=5 mm in diameter) detected by VC but missed by initial OC, 21 (38%) were adenomatous and measured >= 6 mm in diameter. OC was not as sensitive as VC for detecting advanced neoplasms (measuring >= 10 mm) (sensitivity according to the polyp 88.1% vs 91.5%). Of the 2 adenocarcinomas identified, VC detected both and initial OC missed 1 (an 11-mm polyp).
Conclusion:
In asymptomatic patients with average risk for colorectal neoplasia, virtual colonoscopy was sensitive and specific for detecting colorectal polyps.

Commentary:
All currently accepted tests for colorectal cancer screening-fecal occult blood tests, sigmoidoscopy, double-contrast barium enema, and colonoscopy-are effective, but none is ideal. There is always room for another test with a different combination of such characteristics as accuracy, safety, convenience, comfort, cost, and availability. VC has been a promising option, but no rigorous evaluations of polyp detection have been done in persons at average risk for colorectal neoplasia.
Now there is good information on how well VC detects clinically important polyps in average-risk persons.
2 strong studies, published within 4 months of each other, come to different conclusions. The study by Pickhardt and colleagues says "CT virtual colonoscopy ... is an accurate screening method ... and compares favorably with optical colonoscopy..." The study by Cotton and colleagues says "computed tomographic colonoscopy ... is not ready for widespread clinical application." I believe both are right. They ask different questions and get different answers. Pickhardt and colleagues ask whether state-of-the-art VC under ideal circumstances can detect polyps in average-risk persons as well as conventional colonoscopy, the current gold standard. The test they studied had technologic features, such as "electronic cleansing" (computer-based removal of residual fluid), that are not generally available. Interpretation relied primarily on a 3-dimensional, rather than a 2-dimensional, approach to the detection of polyps, which is not generally used. Also, the 6 radiologists were specially trained, having done >= 25 (and in some cases > 100) such studies. Cotton and colleagues, on the other hand, studied the performance of VC under more ordinary circumstances, the kinds of settings where most patients would have the procedure.
Is it time for VC to be included among the screening options? If I had had only the Pickhardt study to guide me, I might have been tempted. But the Cotton study reminds us that the test is not yet ready for general use. Sensitivity and specificity in ordinary circumstances are not high enough. Also, cost and the consequences to patients with abnormal results have not yet been vigorously examined. Abnormal VC results must be followed up with another procedure (conventional colonoscopy), with its own demanding preparation and costs. As for the strength of the evidence of effectiveness, there are no studies of whether screening VC prevents colorectal cancer deaths. However, the medical community seems willing to accept that polyp detection by any means, followed by removal, leads to fewer cases of colorectal cancers-by generalizing from studies in which both polyp or cancer detection rates and colorectal cancer deaths have been reported.
VC is already available in some centers and marketed to the general public. But it is not yet included in guidelines. As the technology continues to improve and if more studies of recent-generation technology are as persuasive as the Pickhardt study, it may be just a matter of time before VC is added to the list of accepted screening options. The Pickhardt study suggests that the time might not be far away, and the Cotton study reminds us that the time has not yet arrived.

12 Übersichtsarbeiten

12.1 CT Kolonographie: Diagnostik kolorektaler Polypen und Tumoren[72]

Überblick über die Durchführung einer CT-Kolonographie, es wird der Stellenwert, die Indikation, Vorteile und Nachteile dieser Methode beleuchtet.

12.2 Emerging Technologies in Screening for Colorectal Cancer: CT Colonography, Immunochemical Fecal Occult Blood Tests, and Stool Screening Using Molecular Markers[73]

Current Evidence

Results from major centers in the United States show accuracy of CT colonography to be comparable to conventional colonoscopy for the detection of polyps greater than 10 mm with few false positives.[74] In the hands of highly experienced radiologists, polyps greater than 10 mm are detected with sensitivity and specificity approaching 90 percent, with sensitivity falling to 50 percent for polyps 5 mm in size. Some published studies have also found CT colonography to be effective in detecting frank colon cancers with a sensitivity of 100 percent and no false positives.[75,76,77] Results from three recent clinical trials[78,79,80] from academic centers studying the sensitivity of CT colonography show that the sensitivity of CT colonography for detecting individual polyps of various sizes (No. Per Polyp) is substantially greater for individual polyps > 10 mm compared with individual polyps less than 10 mm in size. For patients with at least one polyp larger than 6 mm (number per patient), CT colonography had nearly equivalent sensitivity for polyps 6 to 9 mm compared with polyps > 10 mm. Insofar as these trials represent a small series of patients examined by experts investigating CT colonography, the generalisability of these findings to the screening setting requires further study. It is important to note that most published studies of virtual colonoscopy involve individuals undergoing diagnostic studies or high-risk patient groups, as is common in studies of new screening tests, in order to have a higher prevalence of occult disease. These studies also emanate from radiologists who are highly experienced in the relevant techniques. Large clinical trials are underway comparing colonoscopy with CT colonography in average-risk and high-risk screening populations.[81]

Advantages/Indications of CT Colonography

CT colonography offers the advantage of potentially identifying cancers in the colon that may not be adequately assessed or identified by conventional endoscopy, e.g., those located near complex haustral folds. Additionally, it has the ability to image the colon proximal to occlusions and redundant loops; and in many settings it is becoming the technique of choice for completing examination of the colon after failed or incomplete colonoscopy. CT- colonography also offers the patient a choice regarding polypectomy. Since small and likely hyperplastic polyps are not likely to

progress to cancer in the near term, there may be little therapeutic benefit in removing them. However, leaving small polyps behind means reassessment on a regular basis to monitor them, and CT colonography may be determined to be an appropriate way to follow such patients. In the future, if CT colonography proves to be a useful screening test, it may offer a 'roadmap' for endoscopists performing therapeutic colonoscopies showing the number and location of polyps to be removed.

Limitations of CT Colonography

A number of limitations of CT colonography have been identified, including challenges that are common to other visual inspection tests of the colon as well as those unique to CT colonography:

- False-positive readings occur in about 15 percent of cases, and may result in unnecessary follow-up colonoscopy. The main causes of false-positive results have been:
    - Retained stool.
    - Diverticular disease which results in areas of the colon those are poorly distensible.
    - Thick or complex haustral folds misinterpreted as polyps or masses.
    - Metal and motion artefacts: metal artefacts (i.e., image streak artefact) result from x-rays passing through metallic hip prostheses, Herrington rod implants, etc. (motion artefacts are due to respiratory excursions or other body motion).
- An unknown ability to detect flat adenomas. While relatively rare, flat adenomas are thought to be more aggressive than typical adenomatous polyps; therefore, their detection is critical. No data are available on the ability of CT colonoscopy to detect these lesions. However, hyperplastic polyps, which are softer than adenomatous polyps and therefore flatten against the surface of the air-distended colon, are not as easily detected with CT colonoscopy. This has led to speculation that perhaps the technology would not be as sensitive for the detection of flat adenomas.
- Lack of standards for performance, training, and reading of scans.
- CT colonography is not therapeutic, i.e., polyps cannot be removed during the procedure. In a recent study of over 3,000 US Army veterans (with mean age of 64 years) undergoing colonoscopy, 38 percent had one or more neoplastic lesions, and 8 percent had advanced lesions (i.e., polyps ≥ 10 mm). If a polyp is found that needs to be removed, the patient will need to undergo conventional colonoscopic polypectomy. It is important to note, however, that there are differing opinions about whether or not this is a shortcoming, since most individuals undergoing screening do not require diagnostic evaluation or intervention.
- The cost of CT colonography may be higher than conventional colonoscopy. The cost analysis of this procedure should include the time required to perform the procedure and the time required for a radiologist to interpret the resulting images. Additionally, all positive tests must be followed up with conventional colonoscopy.

Discussion:

A growing body of research suggests that many small polyps, i.e., those less than 10 mm, may not progress to cancer in the patient's lifetime, and may be of little clinical significance to the average adult.[82,83] Therefore, the fact that CT colonography may not be as accurate in detecting these smaller polyps may ultimately prove to be of little significance. Indeed, CT colonography may be best at detecting the polyps that should be removed, and thus the real potential benefit of CT colonography may be to segregate the population into those who need colonoscopy from those who don't. However, more research is needed to answer these questions. Studies are also needed on the ability of CT colonography to detect flat adenomas. As the technology currently exists, CT colonography requires bowel preparation. Most investigators have found that patients find the preparation more unpleasant than the procedure, both for conventional and virtual colonoscopy. New protocols exploring stool tagging with pre-exam consumption of a radio opaque material or through the use of "electronic cleansing" (computerized or digital elimination of stool based on density measurement) hold the potential to reduce or even eliminate the amount of preparation involved, creating an advantage of CT colonography over colonoscopy.[84] Another practical issue is the fact that there is a learning curve for radiologists to master the technology. Even though the technology is becoming widespread, it lacks the oversight of national standards, which should include the training of radiologists, standardization of protocols, and certification of the technology. These issues are currently being addressed by leading practitioners in the field. Another concern is the presence of radiologic detection of extra colonic abnormalities, many of which may require evaluation.[85] A medical consensus needs to emerge on the management of these incidental findings. Further computing advances, including computer-assisted diagnosis, will likely make CT colonography easier and more accurate to use. However, there is a concern that the newer generation of CT colonography technology uses higher doses of radiation. This concern is alleviated somewhat by the fact that if screening begins at age 50 and occurs every five to seven years, the cumulative radiation doses result in only small, theoretical increases in the risk of developing cancer, which are measurably offset by the benefit of early detection of colorectal cancer. Nevertheless, as with other screening procedures, potential harms must be recognized and obviated where possible.

Conclusion:

The advisory group concluded that CT colonography is a compelling, emerging technology that shows considerable promise, but it has not yet been studied in a typical screening population; therefore, whether or not it has comparable or superior performance compared with conventional tests is unknown.

13 Zusammenfassung

Die Methoden der virtuellen Koloskopie wurden erstmals 1996[86] und 1997[87] beschrieben. Die «virtuelle Koloskopie» basiert auf Abdomenaufnahmen, die mit einem der beiden herkömmlichen Schnittbildverfahren, Computertomographie (CT) und Magnetresonanztomographie (MR), gewonnen werden. Aus den Daten der Schnittbilder wird mit Computerprogrammen eine Innenansicht des Kolons konstruiert (MR- Kolonographie, CT-Kolonographie). Für die CT- und MR-Kolonographie muss der Patient genau wie bei der konventionellen Koloskopie vollständig abgeführt werden. Stuhlreste können Raumforderungen vortäuschen. Für die MR- Kolonographie wird der Darm mit 2–3 Litern Wasser gefüllt, welches Gadolinium enthält. Danach werden MR- Aufnahmen in Bauch- und Rückenlage gemacht. Für die CT-Kolonographie wird der Darm mit Luft gefüllt.

13.1 Sensitivität

Die Sensitivität gibt die Wahrscheinlichkeit eines positiven Testbefundes bei erkrankten Personen an. Die Sensitivität ist eine Maßzahl für den Anteil Patienten mit einer gewissen Erkrankung die durch Anwendung des Tests erkannt werden, also ein positives Testresultat haben. Ein Test mit einer hohen Sensitivität erfasst nahezu alle Erkrankten. Ein negatives Testresultat kann bei hoher Sensitivität die gesuchte Erkrankung mit hoher Wahrscheinlichkeit ausschließen, weil die Anzahl der Probanden, die trotz negativem Test die gesuchte Erkrankung haben (falsch negatives Testresultat) klein ist.

In der Metaanalyse Computed Tomographic Colonography[88] wird die patientenbasierte Sensitivität der virtuellen Kolographie mit 21% bis 96% angegeben. Die Sensitivität insgesamt beträgt 70%. Die polypenbasierte Sensitivität nimmt mit der Polypengröße zu, für Polypen kleiner als 6 mm 48%, für Polypen 6 bis 9 mm 70%, und für Polypen größer als 9 mm 85%. Es besteht eine große Heterogenität zwischen den Studien, abhängig von der Detektorkollimation, der rekonstruierten Schichtdicke und von Einschicht- oder Mehrschicht- Computertomographen.[89]

In der Metaanalyse von Sosna ist die patientenbasierte Sensitivität bei dem cut off von 10 mm Größe (des Adenoms) 88% und die polypenbasierte Sensitivität 81%. Bei einem cut off von 5-9.9 mm Größe beträgt die patientenbasierte Sensitivität 84% und die polypenbasierte Sensitivität 62%.[90] Die besten Resultate erzielte Pickhardt et al. mit einer polypenbasierte Sensitivität von 92% für Adenome 8mm und größer.

13.2 Spezifität

Die Spezifität gibt die Wahrscheinlichkeit eines negativen Testbefundes bei nicht erkrankten Personen an. Die Spezifität ist eine Maßzahl für den Anteil Personen

ohne Erkrankung, die einen (richtig) negativen Test haben. Im Gegensatz zu der großen Bandbreite der berichteten Sensitivität ist die patientenbasierte Spezifität konstanter bei unterschiedlichen Polypengrößen, die Spezifität wird mit 86% anhand der Ergebnisse von 14 Studien angegeben (CI, 84% to 88%).[91] Die Spezifität nimmt mit zunehmender Polypengröße ebenfalls zu. Nur in 4 Studien wird die Spezifität von Polypen kleiner als 6 mm berichtet, die gepoolte Spezifität aus diesen Studien beträgt 91% (CI, 89% bis 95%), für Polypen 6 bis 9 mm (6 Studien) 93% (CI, 91% bis 95%) und für Polypen größer als 9 mm 8 15 Studien) 97% (CI, 96% bis 97%).

Der wichtigste Faktor bei der Detektion von Polypen, außer bei der Koloskopie, ist die Rate der richtig negativen Befunde. Wenn die CT-Kolonographie mit sehr hoher Konfidenz richtig negative Resultate zeigt, kann dem Patienten die andernfalls erforderliche nachfolgende Koloskopie erspart werden. Patienten mit einem positiven Resultat in der CT-Kolonographie haben keinen Vorteil, weil sie zu einer weiteren nachfolgenden Koloskopie überwiesen werden müssen.

13.3 Patientensicht

Verglichen mit der Koloskopie wird aus Patientensicht die CT-Kolonographie in mehreren Untersuchungen als weniger schmerzvoll, weniger unangenehm und weniger erniedrigend erachtet. Die Darmentleerung ist eine bedeutsame Beeinträchtigung und Belästigung.[92] 1% (9/696) der Patienten gibt sehr starke oder starke Beschwerden während der CT-Kolonographie an, verglichen mit 4% (25/696) während der Koloskopie. In der gleichen Studie geben weniger als 1% (4/617) sehr starke oder starke Beschwerden während der CT-Kolonographie an, verglichen mit 29% (181/617) während der Irrigoskopie. In einer zweiten Studie beurteilen 54% (546/1005) der Patienten die CT-Kolonographie unangenehmer als die Koloskopie, möglicherweise bedingt durch die Sedierung, die sie während der Koloskopie, aber nicht während der CT-Kolonographie erhielten. In einer anderen Studie geben 72% (357/494) an, dass sie die CT-Kolonographie der konventionellen Koloskopie und 97% (518/534) die CT-Kolonographie der Irrigoskopie vorziehen.[93]

13.4 Screening bei asymptomatischen Patienten

Unter Screening ist in diesem Kontext die Untersuchung von asymptomatischen Personen mit einem durchschnittlichen Risiko für ein kolorektales Karzinom zu verstehen. Die konventionelle Koloskopie wird als „Gold Standard“ in der Detektion kolorektaler Polypen und des kolorektalen Karzinoms angesehen,[94] ist aber auch kein perfekter Screeningtest, in einer Studie[95] war die Rate der übersehenen 10mm und größeren Adenome 6%, für 6-9mm große Adenome 13% und für 5mm und kleinere Adenome 17%. Die Effektivität der konventionellen Koloskopie in Bezug auf die Senkung der karzinomspezifischen Mortalität wurde bisher weder in Fall-Kontrollstudien noch in randomisiert kontrollierten klinischen Studien nachgewiesen.

In mehr als 20 Studien wurde die diagnostische Treffgenauigkeit der CT-Kolonographie mit der konventionellen Koloskopie verglichen, allerdings in nur 5 Studien (Pickhardt et al. 2003; Edwards et al. 2003; Yee et al 2001; Rex et al 1999; Macari et al 2000) wurden auch asymptomatische Patienten mit einem durchschnittlichen Risiko für ein kolorektales Karzinom[96] im Rahmen eines Routine-screenings untersucht. Die in den Studien berichteten Sensitivitäten der CT-Kolonographie variieren von 35% bis 100% für Patienten mit Adenomen 10mm und größer, größere Studien berichten Sensitivitäten in einer Bandbreite von 55% bis 94%. Die in den meisten Studien berichtete Spezifität beträgt mehr als 90%. In der Detektion kleinerer Adenome nimmt die Sensitivität und Spezifität ab.

Positive Ergebnisse in einer CT-Kolonographie erfordern eine Überweisung zur Koloskopie um den Befund zu bestätigen und/oder zur Polypenentfernung.[97]

Die CT-Kolonographie hat eine hohe Spezifität, aber die berichteten Sensitivitäten sind sehr breit gestreut. Unterschiedliche Patienten- und Scannercharakteristika können diese Variabilitäten nicht vollständig erklären; um die CT-Kolonographie für ein generelles Screening zu empfehlen, müssen die Gründe für die sehr heterogenen Ergebnisse geklärt werden.[98]

Eine Studie[99] kommt zu dem Ergebnis, dass die CT-Kolonographie bei asymptomatischen Patienten mit einem durchschnittlichen Risiko für ein kolorektales Karzinom eine geeignete Screeningmethode in der Detektion von kolorektalen Polypen im Vergleich zur konventionellen Koloskopie darstellt. Die Studie wurde unter „idealen“ Bedingungen erstellt, sowohl von Seiten der Software als auch von Seiten speziell geschulter Befunder. Andere Studien mit deutlich schlechteren Ergebnissen hinsichtlich der Sensitivität sind unter „normalen“ Bedingungen entstanden, die der Situation entsprechen dürfte, in der auch die meisten Patienten untersucht werden.

Als „first line“ Screening Methode bei asymptomatischen Personen wird die CT-Kolonographie in der recherchierten Literatur nicht empfohlen.[100,101,102,103]

Die American Cancer Society empfiehlt die CT-Kolonographie nicht als Methode für das Screening des kolorektalen Karzinoms. (Last update: Levin et al. 2003)
Die American Gastroenterological Society kommt zu dem Schluss, dass die virtuelle Koloskopie noch nicht als Screening außerhalb des Forschungsbereiches angewendet werden sollte. (Winawer et al. 2003).

13.5 CT-Kolonographie bei erhöhtem Risiko für kolorektales Karzinom

Die größten Bedenken bestehen bezüglich des Risikos kleine Adenome und sogenannte “flat adenomas“ zu übersehen.[104]

Bei Patienten mit einem höheren Risiko für ein kolorektales Karzinom ist die konventionelle Koloskopie sensitiver und spezifischer in der Detektion großer Kolonpolypen als die Irrigoskopie oder die CT-Kolonographie.[105] Diese Studie hat zwei Limitationen, erstens wurde keine Stuhlmarkierung mit Barium durchgeführt, zweitens hat die verwendete Software eine schlechtere 3-dimensionale Rekonstruktion und geringeres Auflösungsvermögen als die in der Studie von Pickhardt.[106] CT-Kolonographie ist besser als die Irrigoskopie in der Detektion von 6 bis 9mm großen Adenomen, allerdings haben sowohl die CT-Kolonographie als auch die Irrigoskopie eine geringere Treffsicherheit als die konventionelle Koloskopie, die darüber hinaus auch Gewebeproben und Adenomentfernungen erlaubt.

In der Studie von Rockey[107] würden unter der Annahme, dass die CT-Kolonographie fehlerfrei ist, noch immer 29% der Patienten zur Biopsie oder Entfernung von Adenomen eine Koloskopie benötigen. In einem Hochrisiko Patientenkollektiv für ein kolorektales Karzinom wird daher aufgrund der Notwendigkeit für eine nachfolgende Koloskopie die CT-Kolonographie als nicht effizient angesehen.

Die CT-Kolonographie wird nicht als „first line“ Untersuchungsmethode für Patienten mit einer hohen Wahrscheinlichkeit für ein kolorektales Karzinom empfohlen.[108, 109] Nach der Empfehlung des dänischen HTA Report sollte die CT-Kolonographie die Koloskopie nicht generell als Erstuntersuchung bei Patienten mit einem erhöhten Risiko für das kolorektale Karzinom ersetzen.[110]

13.6 Indikation für CT-Kolonographie

Als Indikation wird die CT-Kolonographie nach inkompletter Koloskopie als Ersatz der Irrigoskopie angesehen, sowie bei älteren Patienten und bei Patienten, bei denen eine Anästhesiebereitschaft im Rahmen einer Koloskopie erforderlich ist. Argumente dafür sind die Risiken und die Kosten, die mit einer Koloskopie in Narkose verbunden sind. Bei älteren Patienten kann die Polypengröße von 10mm als cut off für einen „signifikanten Polypen“ angenommen werden, da eine geringe Wahrscheinlichkeit besteht, dass sich Polypen mit einer Größe unter 10 mm in der verbleibenden Lebenszeit zu einem Karzinom entwickeln werden.

Die CT-Kolonographie sollte als Erstuntersuchung bei Patienten in Erwägung gezogen werden, die bei früheren Untersuchungen nicht oder schwierig zu untersuchen waren, bei Vorliegen von Stenosen, bei Perforationen oder Blutungen in vorangegangenen Koloskopien. Die virtuelle Kolonographie sollte die Irrigoskopie bei inkompletter Koloskopie ersetzen.[111]

14 Referenzen

[1] Hara AK, Johnson CD, Reed JE, Ahlquist DA, Nelson H, Ehman RL, et al. Detection of colorectal polyps by computed tomographic colography: feasibility of a novel technique. Gastroenterology 1996;110:284–90.

[2] Luboldt W, Bauerfeind P, Steiner P, Fried M, Krestin GP, Debatin JF. Preliminary assessment of three-dimensional magnetic resonance imaging for various colonic disorders. Lancet 1997;349:1288–91

[3] NATIONAL INSTITUTE FOR CLINICAL EXCELLENCE INTERVENTIONAL PROCEDURES PROGRAMME, August 2004.

[4] Walsh J,Terdiman J. Colorectal cancer screening JAMA 2003; 289:1297-1302

[5] DOUGLAS K. REX, CHRISTOPHER S. CUTLER, GREGORY T. LEMMEL, EMAD Y. RAHMANI, DAVID W. CLARK, DEBRA J. HELPER, GLEN A. LEHMAN, and DAVID G. MARK. Colonoscopic Miss Rates of Adenomas Determined by Back-to-Back Colonoscopies.GASTROENTEROLOGY 1997;112:24–28

[6] Mitchell D. Feldman, MD, M.Phil.Professor of Medicine Division of General Internal Medicine Department of Medicine University of CA, San Francisco. Computed Tomographic Colonography (Virtual Colonoscopy) for Screening of Colorectal Cancer. California Technology Assessment Forum June 9, 2004 San Francisco, CA

[7] CT Colonography (“Virtual Colonoscopy”) for Colon Cancer Screening Assessment Program Volume 19, No. 6 July 2004 BlueCross BlueShield Association

[8] Dixon AK, Dendy P. Spiral CT: how much does radiation dose matter? Lancet 1998;352:1082–3.

[9] Mitchell D. Feldman, MD, M.Phil.Professor of Medicine Division of General Internal Medicine Department of Medicine University of CA, San Francisco. Computed Tomographic Colonography (Virtual Colonoscopy) for Screening of Colorectal Cancer. California Technology Assessment Forum June 9, 2004 San Francisco, CA

[10] CT Colonography (“Virtual Colonoscopy”) for Colon Cancer Screening Assessment Program Volume 19, No. 6 July 2004 BlueCross BlueShield Association

[11] Mitchell D. Feldman, MD, M.Phil.Professor of Medicine Division of General Internal Medicine Department of Medicine University of CA, San Francisco. Computed Tomographic Colonography (Virtual Colonoscopy) for Screening of Colorectal Cancer. California Technology Assessment Forum June 9, 2004 San Francisco, CA

[12] Brian P. Mulhall, Ganesh R. Veerappan, Jeffrey L. Jackson, Ann Intern Med. 2005;142:635-650.

[13] Mitchell D. Feldman, MD, M.Phil.Professor of Medicine Division of General Internal Medicine Department of Medicine University of CA, San Francisco. Computed Tomographic Colonography (Virtual Colonoscopy) for Screening of Colorectal Cancer. California Technology Assessment Forum June 9, 2004 San Francisco, CA

[14] CT Colonography (“Virtual Colonoscopy”) for Colon Cancer Screening Assessment Program Volume 19, No. 6 July 2004 BlueCross BlueShield Association

[15] Ginnerup Pedersen B, Arnesen RB, Poulsen PB, Adamsen S, Hansen OH, Laurberg S. Colon examination with CT Colonography – a health technology assessment. Danish Health Technology Assessment – grant funded projects 2005; 5(3) Copenhagen: National Board of Health, DACEHTA, 2005. p. 9-11. In Danish. Full length pdf at www.dacehta.dk

[16] Brian P. Mulhall, Ganesh R. Veerappan, Jeffrey L. Jackson, Ann Intern Med. 2005;142:635-650.

[17] ACP Journal Club. Volume 141(1):p.22, July/August, 2004. Pickhardt PJ, Choi JR, Hwang I, et al. Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults. N Engl J Med. 2003;349:2191-200.

[18] ACP Journal Club. Volume 143(1), July/August 2005, p 22.Rockey DC, Paulson E, Niedzwiecki D, et al. Analysis of air contrast barium enema, computed tomographic colonography, and colonoscopy: prospective comparison. Lancet. 2005;365:305-11.

[19] ACP Journal Club. Volume141(1):p.23, July/August, 2004. Cotton PB, Durkalski VL, Pineau BC, et al. Computed tomographic colonography (virtual colonoscopy): a multicenter comparison with

standard colonoscopy for detection of colorectal neoplasia. JAMA. 2004;291:1713-9.
[20] Ginnerup Pedersen B, Arnesen RB, Poulsen PB, Adamsen S, Hansen OH, Laurberg S. Colon examination with CT Colonography – a health technology assessment. Danish Health Technology Assessment – grant funded projects 2005; 5(3) Copenhagen: National Board of Health, DACEHTA, 2005. p. 9-11.
[21] Ginnerup Pedersen B, Arnesen RB, Poulsen PB, Adamsen S, Hansen OH, Laurberg S. Colon examination with CT Colonography – a health technology assessment. Danish Health Technology Assessment – grant funded projects 2005; 5(3) Copenhagen: National Board of Health, DACEHTA, 2005. p. 9-11. In Danish. Full length pdf at www.dacehta.dk
[22] NATIONAL INSTITUTE FOR CLINICAL EXCELLENCE INTERVENTIONAL PROCEDURES PROGRAMME, August 2004.
[23] Ginnerup Pedersen B, Arnesen RB, Poulsen PB, Adamsen S, Hansen OH, Laurberg S. Colon examination with CT Colonography – a health technology assessment. Danish Health Technology Assessment – grant funded projects 2005; 5(3) Copenhagen: National Board of Health, DACEHTA, 2005. p. 9-11. In Danish. Full length pdf at www.dacehta.dk
[24] Computed tomography (CT) colonography, colonoscopy, or barium enema for diagnosis of colorectal cancer in older symptomatic patients, ISRCTN95152621, NHS R&D National Coordinating Centre for Health Technology Assessmemt (NCCHTA). HTA 02/02/01, http://www.controlled-trials.com/isrctn/trial/|/0/95152621.html, aufgesucht am 7.2.2006
[25] http://www.ncchta.org/projectdata/1_project_record_notpublished.asp?PjtId=1366&SearchText=You+selected+cancer+AND+all+AND+allTitle%3DClick+here+for+details+of+this+project
[26] NATIONAL INSTITUTE FOR CLINICAL EXCELLENCE INTERVENTIONAL PROCEDURES PROGRAMME, August 2004.
[27] Ginnerup Pedersen B, Arnesen RB, Poulsen PB, Adamsen S, Hansen OH, Laurberg S. Colon examination with CT Colonography – a health technology assessment. Danish Health Technology Assessment – grant funded projects 2005; 5(3) Copenhagen: National Board of Health, DACEHTA, 2005. p. 9-11. In Danish. Full length pdf at www.dacehta.dk
[28] http://www.ctaf.org/ass/viewfull.ctaf?id=32362336390
[29] NHS Health Technology Assessment Programme, HTA project details: CT colonography, colonoscopy or barium enema for diagnosis of colorectal cancer in older symptomatic patients (SIGGAR1). Start date: February 2004, Publication date: Mid 2009
[30] Computed tomography (CT) colonography, colonoscopy, or barium enema for diagnosis of colorectal cancer in older symptomatic patients, ISRCTN95152621, NHS R&D National Coordinating Centre for Health Technology Assessmemt (NCCHTA). HTA 02/02/01, http://www.controlled-trials.com/isrctn/trial/|/0/95152621.html, aufgesucht am 7.2.2006
[31] DOUGLAS K. REX, CHRISTOPHER S. CUTLER, GREGORY T. LEMMEL, EMAD Y. RAHMANI, DAVID W. CLARK, DEBRA J. HELPER, GLEN A. LEHMAN, and DAVID G. MARK. Colonoscopic Miss Rates of Adenomas Determined by Back-to-Back Colonoscopies.GASTROENTEROLOGY 1997;112:24–28
[32] Mitchell D. Feldman, MD, M.Phil.Professor of Medicine Division of General Internal Medicine Department of Medicine University of CA, San Francisco. Computed Tomographic Colonography (Virtual Colonoscopy) for Screening of Colorectal Cancer. California Technology Assessment Forum June 9, 2004 San Francisco, CA
[33] Hara AK, Johnson CD, Reed JE, Ahlquist DA, Nelson H, Ehman RL, et al. Detection of colorectal polyps by computed tomographic colography: feasibility of a novel technique. Gastroenterology 1996;110:284–90.
[34] Luboldt W, Bauerfeind P, Steiner P, Fried M, Krestin GP, Debatin JF. Preliminary assessment of three-dimensional magnetic resonance imaging for various colonic disorders. Lancet 1997;349:1288–91
[35] P. Bauerfeind. Die «virtuelle» Koloskopie: Back to the future? Schweiz Med Wochenschr 2000;130:1782–7
[36] Dixon AK, Dendy P. Spiral CT: how much does radiation dose matter? Lancet 1998;352:1082–3.
[37] Mitchell D. Feldman, MD, M.Phil.Professor of Medicine Division of General Internal Medicine

Department of Medicine University of CA, San Francisco. Computed Tomographic Colonography (Virtual Colonoscopy) for Screening of Colorectal Cancer. California Technology Assessment Forum June 9, 2004 San Francisco, CA
[38] CT Colonography ("Virtual Colonoscopy") for Colon Cancer Screening Assessment Program Volume 19, No. 6 July 2004 BlueCross BlueShield Association
[39] Mitchell D. Feldman, MD, M.Phil.Professor of Medicine Division of General Internal Medicine Department of Medicine University of CA, San Francisco. Computed Tomographic Colonography (Virtual Colonoscopy) for Screening of Colorectal Cancer. California Technology Assessment Forum June 9, 2004 San Francisco, CA
[40] CT Colonography ("Virtual Colonoscopy") for Colon Cancer Screening Assessment Program Volume 19, No. 6 July 2004 BlueCross BlueShield Association
[41] Ginnerup Pedersen B, Arnesen RB, Poulsen PB, Adamsen S, Hansen OH, Laurberg S. Colon examination with CT Colonography – a health technology assessment. Danish Health Technology Assessment – grant funded projects 2005; 5(3) Copenhagen: National Board of Health, DACEHTA, 2005. p. 9-11.
[42] NATIONAL INSTITUTE FOR CLINICAL EXCELLENCE INTERVENTIONAL PROCEDURES PROGRAMME, August 2004.
[43] Pickhardt PJ, Choi JR, Hwang I, et al. Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults. The New England Journal of Medicine 2003; 349: 2191–9.
[44] Sosna J, Morrin MM, Kruskal JB, et al. CT colonography of colorectal polyps: a metaanalysis. *American Journal of Roentgenology* 2003; 181: 1593–8.
[45] Pickhardt PJ, Choi JR, Hwang I, et al. Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults. *NEJM* 2003; 349: 2191–9.
[46] Yee J, Akerkar GA, Hung RK, et al. Colorectal neoplasia: performance characteristics of CT colonography for detection in 300 patients. *Gastrointestinal Imaging* 2001; 219: 685–92.
[47] 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.
[48] Edwards JT, Mendelson RM, Fritschi L, et al. Colorectal neoplasia screening with CT colonography in average-risk asymptomatic subjects: community-based study. *Gastrointestinal Imaging* 2004; 230: 459–64.
[49] Johnson CD, MacCarty RL, Welch TJ, et al. Comparison of the relative sensitivity of CT colonography and double-contrast barium enema for screen detection of colorectal polyps. *Clinical Gastroenterology and Hepatology* 2004; 2: 314–21.
[50] Gluecker TM, Johnson CD, Harmsen WS, et al. Colorectal cancer screening with CT colonography, colonoscopy, and double-contrast barium enema examination: prospective assessment of patient perceptions and preferences. *Radiology* 2003; 227: 378–84.
[51] Gluecker T, Dorta G, Keller W, et al. Performance of multidetector computed tomography colonography compared with conventional colonoscopy. *Gut* 2002; 51: 207–11.
[52] Yee J, Akerkar GA, Hung RK, et al. Colorectal neoplasia: performance characteristics of CT colonography for detection in 300 patients. *Gastrointestinal Imaging* 2001; 219: 685–92.
[53] 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.
[54] Johnson CD, MacCarty RL, Welch TJ, et al. Comparison of the relative sensitivity of CT colonography and double-contrast barium enema for screen detection of colorectal polyps. *Clinical Gastroenterology and Hepatology* 2004; 2: 314–21.
[55] Gluecker TM, Johnson CD, Harmsen WS, et al. Colorectal cancer screening with CT colonography, colonoscopy, and double-contrast barium enema examination: prospective assessment of patient perceptions and preferences. *Radiology* 2003; 227:378–84.
[56] Sosna J, Morrin MM, Kruskal JB, et al. CT colonography of colorectal polyps: a metaanalysis. *American Journal of Roentgenology* 2003; 181: 1593–8.

[57] Yee J, Akerkar GA, Hung RK, et al. Colorectal neoplasia: performance characteristics of CT colonography for detection in 300 patients. *Gastrointestinal Imaging* 2001; 219: 685–92
[58] 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.
[59] 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.
[60] Brian P. Mulhall, Ganesh R. Veerappan, Jeffrey L. Jackson, Ann Intern Med. 2005;142:635-650.
[61] Jacob Sosna, Martina M. Morrin, Jonathan B. Kruskal, Philip T. Lavin,Max P. Rosen, Vassilios Raptopoulos. CT Colonography of Colorectal Polyps:A Metaanalysis *AJR* 2003;181:1593–1598
[62] Whiting BR, McFarland EG, Brink JA. Influence of image acquisition parameters on CT artefacts and polyp depiction in spiral CT colonography: in vitro evaluation. *Radiology* 2000;217:165–172
[63] Van Gelder RE, Venema HW, Serlie IWO, et al. CT colonography at different radiation dose levels: feasibility of dose reduction. *Radiology* 2002;224:25–33
[64] Fletcher JG, Johnson CD, Welch TJ, et al. Optimization of CT colonography technique: prospective trial in 180 patients. *Radiology* 2000;216:704–711
[65] Rex DK, Cutler CS, Lemmel GT, et al. Colonoscopic miss rates of adenomas determined by back-to-back colonoscopies.*Gastroenterology* 1997;112:24–28
[66] Published by the National Institute for Health and Clinical Excellence, June 2005; ISBN 1-84629-042-2 www.nice.org.uk/ip208overview
[67] ACP Journal Club. Volume 143(1), July/August 2005, p 22.Rockey DC, Paulson E, Niedzwiecki D, et al. Analysis of air contrast barium enema, computed tomographic colonography, and colonoscopy: prospective comparison. Lancet. 2005;365:305-11.
[68] Pickhardt PJ. Three-dimensional endoluminal CT Colonography (virtual colonoscopy): comparison of three commercially available systems. AJR Am J Roentgenol. 2003;181:1599-606.
[69] ACP Journal Club. Volume 142(2):p.49, March/April, 2005. Iannaccone R, Laghi A, Catalano C, et al. Computed tomographic colonography without cathartic preparation for the detection of colorectal polyps. Gastroenterology. 2004;127:1300-11.
[70] ACP Journal Club. Volume141(1):p.23, July/August, 2004. Cotton PB, Durkalski VL, Pineau BC, et al. Computed tomographic colonography (virtual colonoscopy): a multicenter comparison with standard colonoscopy for detection of colorectal neoplasia. JAMA. 2004;291:1713-9.
[71] ACP Journal Club. Volume 141(1):p.22, July/August, 2004. Pickhardt PJ, Choi JR, Hwang I, et al. Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults. N Engl J Med. 2003;349:2191-200.
[72] Radiologie up2date 4/2003 http://www.thieme-connect.com/ejournals/pdf/rad-u2d/doi/10.1055/s-2003-45363.pdf

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)[8] 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.

[73] Bernard Levin, MD; Durado Brooks, MD, MPH; Robert A. Smith, PhD;Amy Stone, MCo Emerging Technologies in Screening for Colorectal Cancer:CT Colonography, Immunochemical Fecal Occult Blood Tests, and Stool Screening Using Molecular Markers *CA Cancer J Clin* 2003;53;44-55
[74] Ferrucci JT. Colon cancer screening with virtual colonoscopy: Promise, polyps, politics. AJR Am J Roentgenol 2001;177:975-988.
[75] Hara AK, Johnson CD, Reed JE, et al. Colorectal polyp detection with CT colography: Two- versus three- dimensional techniques.Work in progress. [see comments]. Radiology 1996;200:49-54.
[76] Hara AK, Johnson CD, Reed JE, et al. Detection of colorectal polyps with CT colography: Initial assessment of sensitivity and specificity. Radiology 1997;205:59-65
[77] Royster AP, Fenlon HM, Clarke PD, et al. CT colonoscopy of colorectal neoplasms:Two-dimensional and three-dimensional virtual-reality techniques with colonoscopic correlation. AJR Am J Roentgenol 1997; 169:1237-1242.
[78] Fenlon HM, Clarke PD, Ferrucci JT. Virtual colonoscopy: Imaging features with colonoscopic correlation. AJR Am J Roentgenol 1998;170: 1303-1309.
[79] Fletcher JG, Johnson CD, Welch TJ, et al. Optimization of CT colonography technique: Prospective trial in 180 patients. Radiology 2000;216:704-711.
[80] Yee J,Akerkar GA, Hung RK, et al. Colorectal neoplasia: Performance characteristics of CT colonography for detection in 300 patients. Radiology 2001;219:685-692.
[81] American College of Radiology Imaging Network. Evaluating the accuracy of computerized tomographic colonography compared with pathology and colonoscopy for detecting clinically important colorectal neoplasia in a screening population (ACRIN Protocol A6664 – In Development.). Vol. 2002: American College of Radiology, 2002. http://www.acrin.org/6664_protocol.html
[82] Eide TJ. Natural history of adenomas.World J Surg 1991;15:3-6.
[83] Ferrucci JT. Colon cancer screening with virtual colonoscopy: Promise, polyps, politics. AJR Am J Roentgenol 2001;177:975-988
[84] Vining DJ, Pineau BC. Improved bowel preparation for virtual colonoscopy examinations [abstract]. Gastroenterology 1999;116:524A.
[85] Hara AK, Johnson CD, MacCarty RL, et al. Incidental extracolonic findings at CT colonography. Radiology 2000;215:353-357
[86] Hara AK, Johnson CD, Reed JE, Ahlquist DA, Nelson H, Ehman RL, et al. Detection of colorectal polyps by computed tomographic colography: feasibility of a novel technique. Gastroenterology 1996;110:284–90.
[87] Luboldt W, Bauerfeind P, Steiner P, Fried M, Krestin GP, Debatin JF. Preliminary assessment of three-dimensional magnetic resonance imaging for various colonic disorders. Lancet 1997;349:1288–91
[88] Brian P. Mulhall, Ganesh R. Veerappan, Jeffrey L. Jackson, Meta-Analysis: Computed Tomographic Colonography. Ann Intern Med. 2005;142:635-650.

[89] Jacob Sosna, Martina M. Morrin, Jonathan B. Kruskal, Philip T. Lavin,Max P. Rosen, Vassilios Raptopoulos. CT Colonography of Colorectal Polyps:A Metaanalysis *AJR* 2003;181:1593–1598
[90] http://www.emedicine.com/radio/topic185.htm
[91] Brian P. Mulhall, Ganesh R. Veerappan, Jeffrey L. Jackson, Meta-Analysis: Computed Tomographic Colonography.Ann Intern Med. 2005;142:635-650
[92] Ginnerup Pedersen B, Arnesen RB, Poulsen PB, Adamsen S, Hansen OH, Laurberg S. Colon examination with CT Colonography – a health technology assessment. Danish Health Technology Assessment – grant funded projects 2005; 5(3) Copenhagen: National Board of Health, DACEHTA, 2005. p. 9-11.
[93] Published by the National Institute for Health and Clinical Excellence, June 2005; ISBN 1-84629-042-2 www.nice.org.uk/ip208overview
[94] Walsh J,Terdiman J. Colorectal cancer screening JAMA 2003; 289:1297-1302
[95] DOUGLAS K. REX, CHRISTOPHER S. CUTLER, GREGORY T. LEMMEL, EMAD Y. RAHMANI, DAVID W. CLARK, DEBRA J. HELPER, GLEN A. LEHMAN, and DAVID G. MARK. Colonoscopic Miss Rates of Adenomas Determined by Back-to-Back Colonoscopies.GASTROENTEROLOGY 1997;112:24–28
[96] Mitchell D. Feldman, MD, M.Phil.Professor of Medicine Division of General Internal Medicine Department of Medicine University of CA, San Francisco. Computed Tomographic Colonography (Virtual Colonoscopy) for Screening of Colorectal Cancer. California Technology Assessment Forum June 9, 2004 San Francisco, CA
[97] CT Colonography ("Virtual Colonoscopy") for Colon Cancer Screening Assessment Program Volume 19, No. 6 July 2004 BlueCross BlueShield Association
[98] Brian P. Mulhall, Ganesh R. Veerappan, Jeffrey L. Jackson, Ann Intern Med. 2005;142:635-650.
[99] ACP Journal Club. Volume 141(1):p.22, July/August, 2004. Pickhardt PJ, Choi JR, Hwang I, et al. Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults. N Engl J Med. 2003;349:2191-200.
[100] Mitchell D. Feldman, MD, M.Phil.Professor of Medicine Division of General Internal Medicine Department of Medicine University of CA, San Francisco. Computed Tomographic Colonography (Virtual Colonoscopy) for Screening of Colorectal Cancer. California Technology Assessment Forum June 9, 2004 San Francisco, CA
[101] CT Colonography ("Virtual Colonoscopy") for Colon Cancer Screening Assessment Program Volume 19, No. 6 July 2004 BlueCross BlueShield Association
[102] Ginnerup Pedersen B, Arnesen RB, Poulsen PB, Adamsen S, Hansen OH, Laurberg S. Colon examination with CT Colonography – a health technology assessment. Danish Health Technology Assessment – grant funded projects 2005; 5(3) Copenhagen: National Board of Health, DACEHTA, 2005. p. 9-11.
[103] Brian P. Mulhall, Ganesh R. Veerappan, Jeffrey L. Jackson, Ann Intern Med. 2005;142:635-650.
[104] NATIONAL INSTITUTE FOR CLINICAL EXCELLENCE INTERVENTIONAL PROCEDURES PROGRAMME, August 2004.
[105] ACP Journal Club. Volume 143(1), July/August 2005, p 22.Rockey DC, Paulson E, Niedzwiecki D, et al. Analysis of air contrast barium enema, computed tomographic colonography, and colonoscopy: prospective comparison. Lancet. 2005;365:305-11.
[106] Pickhardt PJ. Three-dimensional endoluminal CT Colonography (virtual colonoscopy): comparison of three commercially available systems. AJR Am J Roentgenol. 2003;181:1599-606.
[107] ACP Journal Club. Volume 143(1), July/August 2005, p 22.Rockey DC, Paulson E, Niedzwiecki D, et al. Analysis of air contrast barium enema, computed tomographic colonography, and colonoscopy: prospective comparison. Lancet. 2005;365:305-11.
[108] ACP Journal Club. Volume 143(1), July/August 2005, p 22.Rockey DC, Paulson E, Niedzwiecki D, et al. Analysis of air contrast barium enema, computed tomographic colonography, and colonoscopy: prospective comparison. Lancet. 2005;365:305-11.
[109] ACP Journal Club. Volume141(1):p.23, July/August, 2004. Cotton PB, Durkalski VL, Pineau BC, et al. Computed tomographic colonography (virtual colonoscopy): a multicenter comparison with

standard colonoscopy for detection of colorectal neoplasia. JAMA. 2004;291:1713-9.
[110] Ginnerup Pedersen B, Arnesen RB, Poulsen PB, Adamsen S, Hansen OH, Laurberg S. Colon examination with CT Colonography – a health technology assessment. Danish Health Technology Assessment – grant funded projects 2005; 5(3) Copenhagen: National Board of Health, DACEHTA, 2005. p. 9-11.
[111] Ginnerup Pedersen B, Arnesen RB, Poulsen PB, Adamsen S, Hansen OH, Laurberg S. Colon examination with CT Colonography – a health technology assessment. Danish Health Technology Assessment – grant funded projects 2005; 5(3) Copenhagen: National Board of Health, DACEHTA, 2005. p. 9-11.