



Original Paper

CT colonography standards

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Computed tomography (CT) colonography is the established successor to the barium enema for the detection of colonic neoplasia due to superior performance and patient experience. Consequently, CT colonography is widely disseminated across Western populations and increasingly provided by both subspecialist and general radiologists alike. As a result, CT colonography is now part of the core training curriculum for radiology in the UK. However, study data shows wide performance gaps between centres and between individuals of differing experience, which is perhaps unsurprising given the complexity of the CT colonography technique and interpretation. This article summarizes the background, evolution and recommendations of the CT colonography standards document ([Appendix](#)) developed by the International CT Colonography Standards Collaboration, which included highly experienced radiologists, radiographers, gastroenterologists, and screening experts. These standards are intended to guide and support radiology teams across the world by promoting methods for improving the quality of CT colonography technique and the patient experience.

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Introduction

Computed tomography colonography (CTC, virtual colonoscopy) has been approved by several national groups permitting reimbursement for both diagnostic and screening applications in colorectal cancer.^{1,2} As a result, CTC is widely available across the world in both public and private practice. However, performance is variable. In one UK study, the accuracy of subspecialist radiologists offering a CTC service in routine National Health Service (NHS)

clinical practice, ranged from 53 to 93% for the detection of significant colonic pathology, mirroring results from other major European and US studies.^{3–7} Even where deficiencies in training and experience have been addressed, CTC can be associated with low positive predictive values, thereby leading to excessive rates of referral for unnecessary conventional colonoscopy.⁷ Causes of variable interpretation accuracy are multifactorial, occurring at different stages along the diagnostic pathway. However, most experienced practitioners acknowledge that highest quality CTC is provided by centres that focus their effort towards optimizing technique, patient outcomes.

Patients have a right to knowledge and understanding of CTC prior to examination, which should enhance both compliance with bowel preparation regimens and co-operation with the subsequent examination. Patients must consent to undergo CTC and should be provided with appropriate, high-quality information.⁸ The choice of whether to undergo CTC will require information about what the examination involves, its potential benefits, and risks. The recommendations summarized in this article address how information

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should be provided to patients, with an example patient information booklet provided online ([Appendix](#)).

CTC technique, including colonic preparation, distension, and use of intravenous contrast media, fundamentally influences subsequent interpretation.^{9–14} There is an extensive peer-reviewed body of literature providing evidence-based strategies for optimizing the technique. CTC examinations generally utilize multidetector row CT platforms, but protocols vary, potentially resulting in excessive radiation dose^{15,16} or inappropriate use of intravenous contrast media.¹² In addition, suboptimal workflow patterns can be inefficient and result in longer examination times with detrimental effects on patient experience. Standards for imaging protocols and technique are provided in the standards document ([Appendix](#)).

An excellent patient safety profile is a critical determinant of CTC success, but there are documented risks of colonic perforation and other complications.^{17–19} Survey data suggests complications are associated with potentially avoidable causes, for example, colonic perforation related to poor catheter insertion technique and manual insufflation of gas.¹⁷ Although perforations are rare (approximately 1 in 3000 diagnostic CTC examinations in the UK) we recommend in the standards document that practitioners are aware of the range of complications and of ways to avoid them.

In the past, methods of data interpretation have been the subject of considerable debate, but authorities now agree CTC software must provide both two (2D) and three-dimensional (3D) displays complementary for accurate detection and characterisation of polyp and cancer candidates.²⁰ In addition, new developments, such as computer-aided detection (CAD) systems are increasingly available and may be of value, but there is limited information regarding its implementation in routine clinical practice.²¹

This article describes the evolution of the CTC standards document and summarizes key recommendations (derived from the main standards document available online – [Appendix](#)), which help determine a positive outcome for patients. The aim is to encourage public and independent imaging providers to adopt minimum standards of CTC practice so as to enhance the quality of their service by creating the clinical environment in which standards of best practice are achieved.

Materials and methods

Initially a steering group was convened by the lead author of this document in December 2007 to address the issue of variability in CTC performance and interpretation with a plan to discuss strategies for reducing performance gaps between centres in the UK NHS and possibly beyond. This group comprised experienced representatives of all major UK stakeholder groups.

At this initial meeting, it was concluded that a standards committee should be formed to jointly author a standards document for the reasons outlined above ([Table 1](#)). The committee members were selected by the steering group and comprised four consultant radiologists and four senior

Table 1
CT Colonography Standards Steering Group

Standards Committee	
• Dr David Burling	Consultant Radiologist
• Dr Andrew Lowe	Consultant Radiologist
• Dr Stuart Taylor	Consultant Radiologist
• Dr Damian Tolan	Consultant Radiologist
• Mrs Christine Bloor	Radiographic technologist
• Mrs Janice Muckian	Radiographic technologist
• Mrs Julie Nightingale	Radiographic technologist
• Prof. Audrey Paterson	Radiographic technologist
Standards Steering Group	
• Dr David Burling	Corresponding Author and Consultant Radiologist
• Dr Erika Denton	National Clinical Lead for Diagnostic Imaging, DH
• Prof. Steve Halligan	Principal Investigator for SIGGAR 1 Trial
• Dr Clive Kay	Chairman of BSGAR & Consultant Radiologist
• Dr Giles Maskell	Registrar, Royal College of Radiologists
• Prof. Julietta Patnick	Director, Bowel Cancer Screening Program
• Prof. Audrey Paterson	Society and College of Radiographers
• Dr Roland Valori	National Clinical Lead for Endoscopy, DH
• Mr Chris Wiltsher	Patient representative, Royal College Radiology

radiographers with a combined wealth of expertise, including delivery of high-quality CTC in the NHS (>5000 examinations performed/interpreted), supervising and conducting CTC research (>100 peer-reviewed articles), organizing and delivering CTC training in the UK, Europe, Asia and Australia; co-authoring guidelines for the UK's National Institute for Health and Clinical Excellence (NICE) and developing a European Consensus Statement for CTC.¹²

Relevant evidence ([Table 2](#)) was appraised by the standards committee and discussed at a 1 day meeting held July 2008.

A draft document was subsequently produced and this was refined via email correspondence prior to review by the Steering Group between October and December 2008.

The Steering group met for a second time in December 2008 to review all aspects of the document and develop a strategy for wider consultation and subsequent publication. A consultation document was then produced ([Appendix](#)). The recommendations cover 12 topics relating to the procedures involved in CTC from referral and patient information through to follow-up and surveillance. Recommendations on CTC implementation and service delivery are also provided.

Table 2
Evidence appraised by CT colonography standards committee

- Currently published peer-reviewed literature available via Medline
- Articles in press including preliminary results from SIGGAR 1 study (personal communication from Professor Halligan)
- Expert consensus including ESGAR (European Society of Gastrointestinal and Abdominal Radiology) consensus statement
- Expert opinion (standards committee and steering group)
- Standards from Radiology Accreditation Programme
- Standards used for Endoscopy particularly recommendations of Joint Advisory Group (JAG) and Bowel Cancer Screening Program (BCSP)

Table 3
Organisations involved in consultation process

<p>UK</p> <ul style="list-style-type: none"> • Independent sector via Independent Healthcare Advisory Services • British Society Gastroenterology • Association of Coloproctology Great Britain & Ireland • The Canadian Association of Radiologists CTC working group. Drs. L. Stein, M Fraser-Hill, N Jaffer, P O'Brien, G Stevenson. <p>Australia and New Zealand</p> <ul style="list-style-type: none"> • Abdominal Radiology Group Australia and New Zealand (ARGANZ) • Dr Helen Moore, Dr Adrian Balasingam, Prof. Richard Mendelson <p>Europe</p> <ul style="list-style-type: none"> • Asst. Professor E. Neri, Prof. Andrea Laghi on behalf of European Society of Gastrointestinal and Abdominal Radiology (ESGAR) CTC committee
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Each topic heading is followed by a brief rationale for standards in that particular area, followed by a list of “minimum standards” and “standards of best practice” when appropriate. Each topic has up to five key references to assist further reading in each area. The information provided has been kept necessarily brief in order to produce a document that can be read easily and rapidly accessed. The references provide an introduction to further reading for those team members keen to glean more detailed information about the topics.

The resulting document was then disseminated in January 2009 to interested groups, nominated by the steering committee and listed in [Table 3](#). The consultation period lasted until June 2009.

Constructive feedback was incorporated into the main document where appropriate. In addition, the lead author presented the consultation document to the Royal College of Radiology Standards Committee May 2009 who, following subsequent revision, accepted these standards for CTC on behalf of the Royal College of Radiologists.

The standards are presented below in their summary form, but readers are encouraged to review these in conjunction with the main document (providing rationale and references for each topic) and available at [Appendix](#).

Standards

A. Patient information and consent

[Appendix 1](#) of main document provides appropriate example text for written information.

Minimum

- National guidance for development of patient information is adopted
 - For example, in the UK, the “NHS brand guidelines website” is a helpful resource for developing information based on several guiding principles relating to communication with different patient groups. It also provides templates for written information in booklet or poster format
- Prior to distribution of information to patients, the centre’s local patient information group should be

consulted about its quality and appropriateness for the local population

- Written information should be provided in clear, easily understandable language (appropriate for a reading age of 12 years) and where necessary depending on local population, available in translation for those “minority” languages encountered most frequently
- It is advisable that a record of consent is obtained that should include the name and designation of the individual to whom the consent was given
- A telephone number and email address providing access to an experienced member of the team should be available to deal with additional questions prior to the day of examination

Best practice

- Audiovisual formats should be considered particularly for those patients who have difficulty with reading — for example, see video from the Canadian Association of Radiologists <http://www.carj.ca/video/#>
- Further resources should be made available to “expert” patients, including web-based information and peer-reviewed articles. However, patients should be made aware that web resources may provide incomplete or conflicting information, but in qualified centres (University, Hospitals) web resources are available to simplify the patient’s understanding of the technique
- Patient information sheets are reviewed annually and amended as necessary
- Patients’ frequently asked questions are incorporated into the published patient information
- Centres should consider obtaining formal written consent to help ensure that sufficient information has been provided to patients, to provide evidence that patients understand the information and give patients a further opportunity to discuss questions with experienced staff members

B. Bowel preparation

Minimum

- Full laxation (using “dry” purgatives”) without faecal tagging is current standard practice in many centres, particularly outside Europe
- However, increasingly, faecal tagging (barium or iodine-based compounds or a combination of both) is favoured by many experts across the world
- Consideration should be given to potential allergy when prescribing iodinated oral contrast media for outpatient use

Best practice

- Use of faecal tagging (barium or iodinated contrast media, e.g., gastrografin or a mixture) may be the preferred choice, but requires:
 - additional interpretative experience of validated tagged examinations,
 - additional resource by adding to cost and complexity of patient preparation.

C. Imaging parameters and protocols

Minimum

- Multidetector CT (MDCT) should be used:
 - when older scanners are used, pitch/table feed per rotation should be adjusted to achieve anatomical coverage within a single breath-hold to minimize movement artefact
 - there are no published data supporting use of electron beam CT scanners for CT colonography.
- An initial “scout” view is essential to assess bowel distension
- Dose should be kept as low as reasonably practicable (ALARP):
 - 120 kVp is generally recommended,
 - mA according to scan indication, use of intravenous contrast media,
 - should reduce dose to minimum parameters (tailored to colon only) for at least one of scan acquisitions, irrespective of clinical indication
- The patient should be imaged in the cranio-caudal direction
- Collimation/section thickness should be ≤ 3 and ≥ 1 mm
- Effective doses should be monitored locally and dose reference levels set

Best practice

- Where available, dose modulation should be used:
 - caution should be taken with obese patients, as it may in some instances increase their dose.

D. On the scanner table

Minimum

- Dual-position scanning is a requirement for CTC:
 - supine and prone positions should be routine, but in some cases, for example, immobility or obesity, lateral decubitus imaging should be considered as an alternative
- Patient history of prior colonic surgery must be sought routinely
- Thin rectal catheters with or without small inflated balloons (which help reduce anal incontinence of gas) should be utilized
 - Staff performing rectal catheterization and colonic insufflation require appropriate knowledge of anatomy and risks and must have appropriate technical skills
 - Disposable catheters and tubing to insufflation apparatus should be used once only and not reused for subsequent patients
- Adequate patient information about risks of the procedure provided before entering examination room
- Hyoscine butylbromide improves colonic distension during CTC and should be actively considered unless contra-indicated
 - Patients should be advised to seek medical attention if they develop painful blurred vision following injection
 - Glucagon is not recommended as an alternative

- A scout image should be performed prior to full scan acquisition and sooner if difficulty arises with insufflation
- All CT images should be reviewed before the end of the examination to decide whether additional scans should be undertaken for example, where distension is sub optimal. This initial review must be undertaken by an experienced practitioner and could be performed by an experienced radiographer with adequate training

Best practice

- Colonic distension should be undertaken with carbon dioxide, preferably using an automated insufflator
 - Manual insufflation of carbon dioxide or air via thin flexible catheters is an alternative when insufflators are not available

E. Use of intravenous contrast

Minimum

- Intravenous contrast media should generally not be administered to asymptomatic individuals undergoing CTC
- Currently local policy should dictate whether intravenous contrast is administered routinely to patients with symptoms that are potentially attributable to colorectal cancer
- Where no contrast medium has been administered, reports should make this explicit and indicate that the ability to exclude potentially significant extra-colonic pathology is diminished

F. Additional post ctc “one-stop” tests

Minimum

- Completion (contrast enhanced), staging CT should be performed in the majority of patients where a probable colonic or extra-colonic cancer is detected at the time of examination
 - Staff making this decision require appropriate knowledge, skills and experience to avoid unnecessary ‘over-staging’
- Local agreement should be sought and clearly documented on whether flexible sigmoidoscopy alone (versus full colonoscopy) is deemed appropriate for left-sided cancer detected by CTC
 - This agreement is influenced by radiologist and endoscopist experience and also individual examination findings

Best practice

- CTC review is performed by suitably trained and audited readers
- Same-day endoscopy for cancer is usually desirable, but may be contraindicated or inappropriate/inconvenient for some patients
- Local agreement should be sought and clearly documented on whether flexible sigmoidoscopy alone (versus full colonoscopy) is deemed appropriate for left-sided cancer detected by CTC

- This agreement is influenced by radiologist and endoscopist experience and also individual examination findings
- Same-day CTC for incomplete colonoscopy is desirable unless inappropriate for the patient or their bowel is inadequately prepared
- Where CTC review is performed by radiographic technologists they should be suitably trained and audited (to optimize service efficiency and patient experience)

NB: Same day rectal MRI may be appropriate but unlikely to be implemented routinely due to limited availability in many centres.

G. Patient experience and safety

Minimum Patient experience

- Patients should have easy access to toilet and changing facilities

Patient safety

- All members of the CTC team should be trained to recognize peri- and post-procedure complications
- CTC team should follow clearly documented and visible protocols for management of complications including
 - Cardiovascular complications including angina, hypotension, and bradycardia (frequently combined as vaso-vagal attacks and may be secondary to use of Buscopan or colonic insufflation)
 - Anaphylaxis
 - Contrast extravasation or haematoma at cannula site
 - Severe abdominal pain
 - Colonic perforation
- Facilities should be available to manage immediate complications, including:
 - Resuscitation and monitoring equipment
 - Access to both appropriately qualified medical and nursing staff
- Local protocol for management of diabetic patients taking Metformin
- Patients who have had intravenous contrast media should remain in the CT department for at least 15 min after the injection and 30 min if they are at increased risk of anaphylaxis. If inserted, a cannula should remain in situ until the patient is ready to leave the department if there is any suspicion of an adverse event
- Colonic perforation is a recognized complication of CTC. A radiologist or suitably qualified radiographic technologist should review the 2D images before the patient leaves the scanning suite. Where perforation is demonstrated the radiologist should contact the appropriate surgical team to request a timely clinical assessment. Whilst most perforations caused by CTC are asymptomatic, further management should be at the discretion of the local surgical team

Best practice

Patient experience

- There should be a comfortable quiet area for patients to relax and “recover”

- Patients should be offered patients light refreshments, e.g., tea and biscuits (after a 15 min observation period where intravenous contrast medium is administered), although it may be appropriate to restrict this to water only until a decision on whether to proceed to same-day endoscopy is made.
- Patient information should be available after an examination explaining common post-procedure symptoms of minor discomfort with advice on how to seek additional help if symptoms are more severe or persist for more than a few hours
- Following CTC some patients may require further imaging for staging, onward referral or same day colonoscopy. In order to carry this out, staff will require additional skills and competencies (interpretation skills, communication skills, including “breaking bad news”) and should work within local protocols and procedures. An appropriate, private area should be available if it is necessary to communicate scan results to patients.

H. Interpretation methods and CAD

Minimum

- CTC interpretation requires access to software, providing axial 2D display, multiplanar reformats and a 3D endoluminal reconstruction
 - There is insufficient evidence to recommend one primary reading paradigm over another
- Readers should be competent in both 2D and 3D reading techniques
 - Choice of primary reading method will vary within and between CTC datasets depending on technical quality and target lesion but both techniques are required for the majority of patients

Best practice

- Consideration should be given to double reading CTC datasets particularly amongst less experienced readers
- CAD is likely to have a positive effect on reader sensitivity but its effect on specificity is less certain
- Novel 3D displays such as virtual dissection may increase efficiency but should be used only by readers with experience of the associated distortions

I. Patient management and interval surveillance

Minimum

- CTC teams should agree and document polyp management strategies with clinical colleagues (including gastroenterologists and colorectal surgeons)
- Reporting radiologists must have sufficient knowledge of the colorectal cancer pathways and biological significance of polyps with differing size and morphology

Best practice

- Radiologists report likely biological significance of colonic findings to referrer and propose an appropriate management strategy

- Radiologists provide an indication of reader confidence for the presence of true pathology to help guide appropriate patient management and to provide a likelihood estimate of a positive finding at subsequent endoscopic review
- For asymptomatic “screening” patients, guidance on polyp management is summarized by the US working group
 - large polyps ≥ 10 mm referred for polypectomy
 - medium polyps 6–9 mm either referred for polypectomy, or if fewer than three in number, surveyed by CTC after an interval of up to 3 years
 - diminutive polyps (< 6 mm) routine surveillance (5–10 years)
 - Subsequent surveillance guidance can be informed by consensus guidance for colonoscopy
- For symptomatic patients, guidance should be individualized according to clinical scenario including comorbidity and risk benefit analysis for polypectomy

J. Planning CTC lists and teams

Minimum

- A radiologist with appropriate CTC expertise should provide leadership and primary responsibility for the CTC service
- CTC should not be offered routinely to patients suspected of having inflammatory bowel disease
- A team approach is critical to the success of CTC. Local organization of teams will depend upon the range of skills and competencies of team members. These skills and competencies should be clearly defined within protocols

Best practice

- Robust governance and risk management strategies should be documented and team members should be aware of these to facilitate appropriate delegation of responsibility
- Reporting times for radiologists decrease with experience. As a guide, for experienced readers in an uninterrupted environment, cases can be reviewed in approximately 20 min (on average) for colonic and extra-colonic findings

K. Measuring and monitoring CTC activity/outcomes

Best practice

- All departments offering a CTC service should audit and monitor their activity and outcomes in relation to patient safety, patient outcomes and patient experience. Please see [Appendix 3](#) of main document for suggestions

L. Training and assessment

Minimum

- All individuals performing and interpreting CTC examinations should undergo training, appropriate to the

standard recommended by the national radiological organization in their country of practice

- For UK, Europe, Canada, Australia and New Zealand, basic training should include:
 - individual hands on training with 50+ endoscopically validated CTC cases,
 - training on anatomy, pitfalls of interpretation (including accurate polyp size estimation), complications, and pathogenesis and epidemiology of colorectal cancer,
 - this requisite training is conveniently offered as part of “Hands on” CTC workshops, now widely available in several countries, although such training does not guarantee competency.
- Only individuals with a national board certificate in radiology should report CTC, which should include both colonic and extra-colonic findings
- All team members undergo training appropriate to their role and responsibility
- Training on examination technique including (bowel preparation, patient information/consent, colonic insufflation, CT scan parameters, patient/radiation safety) is required for all radiologists and radiographers responsible for these.
- Regular audit processes are in place to compare CTC findings with endoscopy, pathology and cancer registries

Best practice

- A list of competencies for all team members, aligned to national recommendations and agreed locally are clearly displayed and easily available for team members to review.
- Every member of the CTC team including radiology assistants undergo training appropriate to their role and responsibility. Opportunities for role extension are supported
- A list of competencies for all team members are clearly displayed with provision for team members to extend their role by acquiring new skills commensurate with their post

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Appendix. Supplementary data

Supplementary data associated with this article can be found in the online version, at [doi:10.1016/j.crad.2009.12.003](https://doi.org/10.1016/j.crad.2009.12.003).

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