



Standards of practice for computed tomography colonography (CTC)

Joint guidance from
the **British Society of
Gastrointestinal and
Abdominal Radiology** and **The
Royal College of Radiologists**

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Foreword

It gives me real pleasure to introduce this joint publication between the British Society of Gastrointestinal Radiologists (BSGAR) and The Royal College of Radiologists (RCR) on the standards of practice for computed tomography colonography (CTC). This publication is the culmination of a significant amount of work by all of the listed authors, who are experts in this field and I would like to say a huge thanks. I would also like to thank Andrew Plumb for leading the collaboration between BSGAR and the RCR in producing these standards

Colorectal cancer is the fourth most common cancer in the UK with over 42,300 cases a year and CTC provides a well-tolerated test which, when performed well, has a high sensitivity for the diagnosis of carcinoma.¹ However, we know there is huge variability in the way this examination is performed; this document sets out the standards which ensure delivery of the highest quality of examination and sensitivity for disease detection. This maximises patient safety while optimising the study. It uses all available evidence to define optimum examination technique and standards of reporting including both minimum numbers of examinations to be reported by an individual and the time taken to report studies. These are the performance indicators which allow us to evaluate our own departments and individual performance.

There is an entire section dedicated to how to conduct local audits which allows us to turn the standards and recommendations into local service improvement

This collaboration, I hope you will agree, has achieved a comprehensive set of standards which are patient focused and will allow the development a consistent and high-quality CTC service across the UK.

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Summary points

1. This guidance is divided into three parts:
 - Technical and process standards ('what to do')
 - Quality indicators and performance indicators ('what to measure')
 - Audit guidance ('how to measure it').
2. There is a greater emphasis on audit and measurable metrics than in previous editions.
3. Completing such audits will be time-consuming unless units adopt efficient ways to gather the data; structured reports (as are already required for the Bowel Cancer Screening Programme [BCSP] in England) will make this much easier, as the large majority of data points can be captured at the time of scan reporting. Structured report templates are therefore strongly encouraged; in particular the BCSP have recommended structured reporting templates that would be suitable.²
4. It is anticipated that computed tomography colonography (CTC) services will be asked to expand rapidly over the next 3–5 years. Considerable investment will be required if quality is to be maintained. These standards may be useful in supporting business cases for additional staff recruitment.

Introduction

CT colonography (CTC) is a highly sensitive, well-tolerated test for the diagnosis of colorectal cancer and polyps.³ Currently, over 100,000 CTC examinations are conducted each year in England alone; this figure is increasing each year.⁴ When performed to the highest quality, CTC has excellent diagnostic accuracy for clinically significant neoplasia (that is, colorectal cancer and advanced neoplasia) in both symptomatic and screening populations.^{5–10} However, analogous to colonoscopy, substantial variation in practice has been observed in the UK and internationally.^{7,11}

This document defines:

- a. Technical and process standards for CTC ('what to do')
- b. Evidence-based quality measures and performance indicators for monitoring services and individuals ('what to measure')
- c. Practical advice, audit definitions and templates to assist services in auditing and documenting adherence to the relevant standards ('how to measure it').

All standards are based on published literature where such evidence exists. Where there is no clear evidence, the agreed standards are derived from the opinion of the standards development group.

For each indicator, a minimum standard has been identified. Where such standards are not met, services or individuals (as appropriate) must take action to improve performance. Where higher standards are judged desirable and have been shown to be achievable, these have been set as aspirational targets. These targets represent the highest quality practice and as a suitable goal for all services. This approach mirrors the model that has been deployed to great success for colonoscopy in the UK.^{12,13}

Guidance for the use of imaging in the NHS Bowel Cancer Screening Programme (BCSP) was revised in 2019, and deals with specific applications of CTC within the BCSP.² Services providing CTC to the BCSP should read these two documents in conjunction.

Standards overview

Table 1. Technical and process standards

	Element	Minimum requirement	Page
Before the test	Referrals for CTC	Sufficient information provided to permit safe bowel preparation	10
	Information giving and consent	Patient information leaflet provided in advance	10
	Bowel preparation	Faecal tagging to be used	10
	Same-day CTC after incomplete colonoscopy	Faecal tagging to be given	12
	CTC after recent colonic endoscopic intervention	Discussion between CTC and endoscopy teams	13
During the test	CT scanning parameters and radiation dose	MDCT at <2 mm with dose as low as reasonably practicably (ALARP)	13
	Spasmolytics	Buscopan to be considered in all cases	14
	Gas insufflation	CO ² via an automated insufflator	14
	Patient positioning	At least two scan positions	15
	Intravenous contrast	Always used for cancer staging Not routinely used for BCSP patients	15
	On-table review	Trained staff to recognise under-distension and correct it	15
	Safety	Trained staff to recognise perforation and other CTC-related complications	16
After the test	Patient recovery	Explanation of expected post-procedure symptoms	16
	Reporting facilities	Access to CTC software with endoluminal reconstruction	17
	Reporting methods	Adherence to the NHS BCSP minimum dataset for all screening patients	17
	Diminutive (<6 mm) polyps	Diminutive (<6 mm) polyps should not be reported routinely	17
	Communication of results	All CTC-diagnosed colorectal cancers to be notified to the cancer multidisciplinary team meeting (MDTM)	18

Table 2. Quality standards and performance indicators

Quality Standard	Minimum standard	Aspirational target	Level of audit	Comment and evidence	Page
Percentage of scans rated diagnostic quality of adequate or better (unadjusted)	95%	98%	Service	Using a global assessment of cleansing, tagging and distension. Scan quality should be recorded prospectively by the radiologist interpreting each CTC and documented in the report, ideally using a structured template such as the BCSP minimum dataset.	19
6 mm+ polyp identification rate (PIR) that is, polyps identified at CTC	13%	16%	Service and individual	In a screening population (Pooler <i>et al</i> , 2014), the rate of 6 mm+ polyps (that is, C-RADS C2 or greater) was 14.3%. ¹⁴ Lung <i>et al</i> (2014) and Obaro <i>et al</i> (2019) found a rate of 17% in UK symptomatic patients. ^{15,16} Sammutt <i>et al</i> (2019) reported 18.3% in a similar symptomatic cohort. ¹⁷	20
Positive predictive value (PPV)	80%	90%	Service and individual	On a per-patient basis, without polyp matching, for individuals undergoing endoscopic confirmation or follow-up CTC.	21
Subsequent endoscopy rate	<25%	n/a	Service	CTC is not cost-effective if colonoscopy is over-used subsequently; the tipping point in one economic analysis was ~30% (Halligan <i>et al</i> , 2015), therefore below this CTC is likely cost-effective compared to optical colonoscopy (OC). ¹⁸	21
Radiation dose length product (DLP)	Median of <950 mGy.cm	Median of <600 mGy.cm	Service	Linked to national diagnostic reference level (DRL) (currently 950 mGy.cm).	22
Proportion of CTCs showing cancer in which same-day staging chest CT is performed	50%	80%	Service	Lung <i>et al</i> (2014) showed 79% was possible as an aspirational target. ¹⁵	22

Quality Standard	Minimum standard	Aspirational target	Level of audit	Comment and evidence	Page
Interpretation time	Mean of ≥ 20 mins	Mean of ≥ 25 minutes	Service and individual	Average time in the Department of Defence (DoD) study (Pickhardt <i>et al</i> , 2003) was 19 mins and in ACRIN-6664 (Johnson <i>et al</i> , 2008) was 19 mins (2D), 25 mins (3D). ^{5,7} Faster = lower detection in real world (Obaro <i>et al</i> , 2019). ¹⁶ Either audited using the radiology information system (RIS) or via inspection of job plans/time allocated for CTC interpretation.	23
Number of CTCs interpreted by new radiologists before independent practice	175	300	Individual	Liedenbaum <i>et al</i> (2011) showed 175 was the minimum for acceptable performance; but in 1/3 of readers, 175 was insufficient. ¹⁹ Plumb <i>et al</i> (2014) showed superior detection after >300 cases. ¹¹	24
Number of CTCs per radiologist per annum on an ongoing basis	100	175	Individual	Plumb <i>et al</i> (2014) showed higher detection rates at sites with a throughput of >175 cases/radiologist/year. ¹¹	24
Additional (third or fourth imaging position) acquisition rate	Auditable outcome	n/a	Service	Target as yet unclear but rates <5% should provoke further local investigation of scan quality and staff training.	25
Patient experience	Auditable outcome	n/a	Service		25
Post-imaging colorectal cancer (PICRC) at three years	Auditable outcome	n/a	Service	Units must have a policy for capturing PICRCs (usually involving the colorectal MDTMs) and identify them as adverse events and via the radiology events and learning meetings. Root cause analysis should be performed for each case using the minimum data set for post-test colorectal cancers.	25
Perforation rate	Auditable outcome	n/a	Service		26

Table 3. Audit requirements and frequency

Quality standard being audited	Minimum number of scans to include	Frequency of audit	Page
Adequate scans	400	Every two years	27
6 mm+ polyp identification rate (PIR)	500 for service-level data; 200 for radiologist-level data	Every two years	28
Positive predictive value (PPV)	200 for service-level data; 100 for radiologist-level data	Every two years	28
Subsequent endoscopy rate	200	Every two years AND after changes to CTC referral pathways	29
Radiation dose	100	Every 2 years AND after changes to CTC hardware or scanning parameters	30
Same-day staging	Varies	Every two years	31
Interpretation time	Varies	Every two years AND if job plan changes will impact CTC reporting	32
Number of CTCs reported prior to independent practice	n/a	One-off event for new reporters within a CTC service	32
Number of CTCs reported per annum	100	Annual	33
Additional acquisition rate	200	Every two years	32
Patient experience	100	Every two years	34
Post-imaging colorectal cancers at three years	n/a	Continuous via weekly MDTM; or via linkage to registry every three years	34
Perforation rate	n/a	Continuous	36

Also see section **4. Workflow to combine audits.**

1. Technical and process standards

Introduction and definitions

These standards relate specifically to CT colonography; defined hereafter as thin-section scanning of the prepared (not necessarily fully cleansed), gas-distended colon, obtained in at least two patient positions. They are an update of the previous standards document published in 2014 by BSGAR and draw on previous international consensus recommendations as well as the recently published literature.^{20–23}

A. Before the test

1. Referrals for CTC

Key minimum requirements: sufficient referral information to permit safe prescription of bowel preparation.

All referrals for CTC must meet requirements to enable the CTC team to justify the radiation exposure under the Ionising Radiation (Medical Exposure) Regulations 2017.²⁴ Note must be made of the patient's fitness for bowel preparation, particularly if purgative bowel preparation is being used. Centres should be aware of previous safety advice from the National Patient Safety Agency (NPSA), which still remains relevant despite reconfiguration of patient safety reporting in the NHS. Decisions on bowel preparation should ensure that the dose of laxative is consistent with the vulnerability of the patient and the nature of the target lesion. For example, a reduced laxative dose may suit a frail patient in who the target lesion is cancer. Ideally, departmental referral guidelines should be drawn up to permit rapid selection of patients for CTC or colonoscopy based on presenting symptoms and patient factors. These referral guidelines may be agreed at wider (for example regional) level depending on local clinical and commissioning arrangements.

2. Information giving and consent

Key minimum requirements: patient information leaflet provided in advance.

All patients undergoing a CTC examination should be provided with appropriate verbal and written information in the form of a patient information leaflet (PIL) in advance of the examination. This should include contact details for an experienced CTC team member so that patients can resolve any specific queries in advance. Written consent is required for BCSP patients and is considered beneficial for all patients. Written consent can be collected by a suitably trained member of the CTC team prior to the scan, at a similar time to completing a safety checklist. This should be documented on the radiology information system (RIS) and/or the patient notes/ electronic healthcare record.

3. Bowel preparation

Key minimum requirements: faecal tagging.

Bowel preparation can be divided into two major components:

- Cleansing of residue
- Faecal tagging.

There is now universal agreement that faecal tagging is a pre-requisite for adequate imaging but the ideal agent and dose are not yet agreed. There is growing consensus that full cathartic bowel preparation is not required for all patients as orally ingested hyperosmolar iodinated agents – such as Gastrografin® (sodium diatrizoate/meglumine diatrizoate, Bayer plc, Newbury, UK) – that are used for tagging often also give adequate cleansing.

Moreover, there is no consensus regarding the need for dietary restriction; some practitioners advocate it as a means to reduce residue, whereas a European randomised trial showed no benefit in image quality.²⁵ If dietary restriction is implemented, patients should be given advice in the PIL regarding what can and cannot be eaten; ideally this will be tailored to the demographics of the local population with input from the local dietetic team as required.

Specific advice must be provided for patients with diabetes to allow control of glucose levels during periods of dietary restriction.

Given the lack of consensus regarding bowel preparation, there is no stipulation or recommendation for a particular technique other than to mandate the use of faecal tagging. Sites should audit the quality of their examinations and, where these fail to meet the standards outlined in **Part 2. Quality standards and performance indicators**, adjust their bowel preparation regime accordingly.

The possibility of adverse reactions should be considered when prescribing iodinated oral contrast to outpatients. This should be assessed at the time of CTC requesting and information about these possible reactions should be included in the patient information literature. It is extremely rare for orally ingested iodinated contrast to provoke a significant reaction even in patients who have had previous reactions to intravenous contrast medium, not least because only 1–2% of contrast crosses the intact gastrointestinal (GI) tract.²⁶ Moreover, most patients with a history of prior contrast reaction to intravenous contrast do not have a repeat reaction on subsequent administration, although their risk is elevated compared to an unselected population receiving intravenous contrast.²⁶ Nonetheless, given that anaphylaxis to doses of <1 ml of intravenous contrast medium have been reported and patients undergoing CTC may have bowel disease which permits greater quantities of iodinated contrast to cross the GI tract, there is a theoretical risk of severe reaction to oral iodinated contrast, albeit small. Accordingly, local protocols that clearly define an approach to handling patients with a history of prior contrast reaction must be in place. These should include alternative means of bowel preparation in the very rare situations in which the risk is deemed to be high.

One approach is to risk-stratify according to the severity of the previous contrast reaction as follows:

Table 4

Severity of prior reaction*	Method of preparation for CTC
Mild, moderate or unknown/ undocumented	As per normal practice
Severe or life-threatening	Consider one of the following: Cathartic preparation with barium tagging** Cathartic preparation with iodinated contrast given in the department 3–4 hours prior to CTC (ideally a different agent to that provoking the reaction) Iodinated contrast given in the department 3–4 hours prior to CTC Exceptionally; cathartic preparation alone

Table 5. Summary of definitions of severe and moderate contrast reactions

Severe	Moderate
Diffuse oedema, or facial oedema with dyspnoea	Diffuse urticaria/pruritus
Diffuse erythema with hypotension	Diffuse erythema but normal vital signs
Laryngeal oedema with stridor and/or hypoxia	Facial oedema without dyspnoea
Wheezing/bronchospasm with hypoxia	Throat tightness or hoarseness without dyspnoea
Anaphylactic shock (hypotension + tachycardia)	Wheezing/bronchospasm without hypoxia

4. Same-day CTC after incomplete colonoscopy

Key minimum requirements: faecal tagging.

Same-day CTC for incomplete colonoscopy is usually desirable if practical and appropriate for that patient. Oral administration of a small volume of iodinated faecal tagging agent (for example, 20–50 mls dilute Gastrograffin at least three hours prior to the scan) should be performed in all cases. If this is impossible due to time constraints, either the patient should be re-booked for a second procedure (repeat colonoscopy or CTC) or oral contrast can be administered overnight, ensuring the patient adheres to a low residue or liquid diet and the patient invited to re-attend the following morning.

*Defined according to the ACR manual on contrast media also see summary table²⁶

**Suggested protocol: commercially available 4.9% weight / volume barium suspension (eg E-Z-CAT), diluted 50:50 with water; total of 150mls taken in three divided doses the day prior to the CTC study.

5. CTC after recent colonic endoscopic intervention (biopsy and/or polyp resection)

Key minimum requirements: discussion between the CTC and endoscopy teams OR review of relevant endoscopy reports to determine the precise nature of the colonic intervention.

CTC is commonly requested following previous colonic investigation, including flexible sigmoidoscopy with biopsies or polypectomy. In general terms, there is no requirement for specific delay or precautions immediately after simple mucosal biopsies or straightforward polypectomies. Although there is little published data, in one report of 34 patients who had same-day CTC after polypectomy (75% of which were <5 mm), no adverse incidents were observed.²⁷ This is consistent with older data derived from in vitro studies and barium enema examinations.²⁸ Similarly, tattooing downstream of an obstructing colonic tumour is not a contraindication to same-day CTC (to complete colonic imaging). An initial low-dose CT scan prior to insufflation should be considered to document the absence of extraluminal gas, particularly if the patient has any abdominal pain.

There is no direct evidence to guide the precise timing of CTC following colonoscopic polypectomy or deep biopsy. Published recommendations for a safe interval following deep biopsy/polypectomy vary from 1–4 weeks.²⁹ Discussion between the endoscopy and radiology teams is the crucial step prior to undertaking CTC in these situations since decisions are largely based on clinical judgement. Caution should be taken after a large endoscopic mucosal resection (EMR) or endoscopic submucosal dissection (ESD), especially on the right side of the colon, where a 3–4 week delay should be considered. Smaller, left-sided polypectomies are lower risk and a delay of 1–2 weeks may be appropriate; undertaking same-day CTC (if required) is also an option in such cases.²⁷

B. During the test

1. CT scanning parameters and radiation dose

Key minimum requirements: multidetector computed tomography (MDCT) using slices ≤ 2 mm at a dose that is as low as is reasonably practicable (ALARP).

MDCT is now universal and must be used. Pitch/table feed per rotation should be adjusted to achieve full anatomical coverage within a single breath hold and to minimise movement artefact. The dose should be kept as low as is reasonably practicable (the ALARP principle) and reduced to the minimum needed to evaluate the colon for at least one of the scan acquisitions – typically, the second scan can be acquired at significantly lower doses. Parameters will vary according to patient body mass index, use of intravenous contrast medium and CT platform. Iterative reconstruction and dose modulation should be used where available. Caution should be exercised with obese patients, however, as dose modulation may sometimes inadvertently increase radiation dose. CT teams are advised to seek local medical physics advice when devising CTC protocols. Reconstructed slice thickness should be ≤ 2 mm as a minimum, typically 1 mm or less, using a softer (for example soft tissue) CT reconstruction algorithm.

Effective doses should be monitored locally and dose reference levels should be set and recorded (see **Part 2. Quality standards and performance indicators**).

2. Spasmolytics

Key minimum requirements: Buscopan® use to be considered in all patients.

Spasmolytics are recommended for CTC but not considered mandatory. Hyoscine butylbromide (Buscopan®) is often prescribed in CTC examinations to optimise image quality by reducing bowel peristalsis. A Medicines and Healthcare Products Regulatory Agency (MHRA) alert in response to a coroner's inquest following a death related to the use of Buscopan® at colonoscopy highlighted its potential for rare cardiac side-effects. The RCR and BSGAR have previously released a joint position statement related the use of Buscopan® in radiology examinations.³⁰ Regarding the use of Buscopan® for CTC examinations the following must be considered.

- It is important for radiologists to balance the benefits of improved image quality when Buscopan® is used against the real but rare serious cardiovascular complications. This risk calculation must consider the danger of suboptimal imaging which could lead to a missed cancer diagnosis and potential for subsequent unnecessary investigations. As such, in patients with heart disease a risk calculation should be made by an experienced radiologist, where necessary with colleagues from other specialties.
- Buscopan® should typically be withheld in patients with recent acute coronary syndrome, uncontrolled cardiac failure and a cardiac tachyarrhythmia.
- Buscopan® is also contraindicated in myasthenia gravis.
- Close observation of patients is required during and immediately after procedures where Buscopan® is used.

Departments should have processes in place to assess risk from Buscopan® either on the referral form completed by the referrer and/or by completion of a questionnaire by all patients.

Alternative spasmolytics (for example glucagon) are not recommended.

3. Gas insufflation

Key minimum requirements: carbon dioxide via automated insufflator for all patients.

Automatic carbon dioxide insufflation is the preferred method for colonic distension. Continuous low-pressure carbon dioxide provides greater overall colonic distention and is more comfortable for the patient than the manual room air insufflation technique. Staff performing rectal catheterisation and colonic insufflation should have appropriate levels of anatomical knowledge and technical competence and must be alert to the risks associated with these procedures. They should be aware of potential difficulties in larger patients, those with perianal disease (including haemorrhoids) and where the perineum is atrophic. Adequate lighting and clear communication with the patient reduces the risk of incorrect catheter placement (for example, intravaginal).

Disposable catheters and tubing connecting to the insufflation apparatus should be used once and discarded. The use of an inflatable rectal balloon catheter has not been shown to improve colonic distension compared to a thin rectal tube. If a balloon catheter is used, the balloon should be deflated for one acquisition to avoid obscuring the low rectum; however, if insufflation is inadequate due to anal incontinence of gas, it can be reinflated.

If insufflation proves difficult, then an exploratory scout scan should be performed to exclude a distal obstructing lesion (including hernias).

Although rarely necessary, CTC can be performed via a colostomy. A small hole can be cut in the existing stoma bag to access the stomal orifice, while still catching small leaks of faecal residue. The patient should be advised to bring a spare stoma bag with them to change after the procedure. The catheter should be inserted into the stoma and then the balloon carefully inflated to achieve a seal with the abdominal wall to create continence for bowel insufflation. Limited axial scans through the catheter tip may be performed prior to carbon dioxide insufflation if there is doubt about positioning of the catheter. The volume of gas and pressure required for insufflation will be lower than usual and it is recommended that supervising staff remain in the room to observe the catheter during insufflation in case it is expelled. Initial slow filling at a reduced pressure can be accelerated to patient tolerance.

Gas insufflation of closed-off rectal stumps is not recommended due to both the reported risk of perforation and also the difficulty in cleansing the stump of residue (or tagging its contents). CTC is also not recommended when the patient has a defunctioning ileostomy, as it is not possible to administer oral bowel cleansing and/or tagging, and the defunctioned colon is typically challenging to distend adequately.

4. Patient positioning

Key minimum requirements: dual patient positioning for all patients.

Positioning is important for adequate colonic distension. Scanning in two positions is a requirement and needed to allow redistribution of gas and dependent movement of fluid residue. In addition to scanning in a supine position, the right lateral decubitus has been shown to be consistently superior to a prone position, particularly in obese patients.³¹ A randomised trial has demonstrated superior distension for right lateral decubitus and left lateral decubitus compared to prone and supine series.³² Therefore, sites may consider adopting 'double decubitus' positioning as routine. Insufflated scanning but in a single position is by definition not CTC and is therefore beyond the scope of this document.

5. Intravenous (IV) contrast

Key minimum requirements: IV contrast should not be given to NHS BCSP patients and should be used for cancer staging in all patients (unless contraindicated).

NHS BCSP patients should not receive IV contrast routinely. If cancer is detected then contrast should be administered unless contraindicated.

In the symptomatic population, non-colonic cancers and significant extra-colonic findings are more prevalent than in the screening population. Services should consider routine use of intravenous contrast in this patient cohort; this may be tailored to patient symptoms and other investigations.

Intravenous contrast should be routinely used, unless contraindicated, when CTC is performed to stage a neoplasm and assess the proximal colon following incomplete colonoscopy or when a cancer is detected during a CTC examination.

6. On-table review and further testing

Key minimum requirements: trained staff must be available to recognise (and rectify) colonic under-distension at the time of scanning.

Staff performing CTC should have the skills to recognise colonic under-distension and perform additional series and technique modifications when necessary. They must be able to interpret the scout image for adequate distension and should not start scanning

unless there is good distension on the scout. However, it is common for the scout to appear adequate but for the axial images to reveal one (or more) collapsed segments – therefore, performing staff must also be able to interrogate the first axial scan series for collapsed segments and modify the examination accordingly to optimise the complete imaging dataset for subsequent interpretation.

Specific attention should be paid to the identification of perforation which, although rare (1 in 3,000) and almost invariably managed conservatively, often requires a period of close clinical observation by an appropriate team. It is optimal for the team performing CTC to identify cancers at the time of examination and perform completion CT staging at the same attendance (see **Part 2. Quality standards and performance indicators**).

7. Safety

Key minimum requirements: trained staff with adequate resources to identify and provide initial treatment for common CTC-related complications.

All members of the CTC team must be able to recognise complications arising before, during and immediately after procedures. The CTC team must follow local protocols for managing complications such as:

- Cardiovascular symptoms (including angina, hypotension and bradycardia). These may accompany vasovagal attacks and can result from the use of Buscopan®
- Anaphylaxis
- Contrast extravasation or haematoma at the cannula site if intravenous contrast medium has been given
- Severe abdominal pain
- Colonic perforation.

Resuscitation and monitoring equipment and appropriately qualified and trained medical and nursing staff must be available to manage immediate complications in all departments performing CTC, including those remote from acute hospital services. There must be a local protocol in place for managing diabetic patients with renal impairment taking metformin hydrochloride if intravenous contrast medium is to be administered; typically, patients with an estimated glomerular filtration rate (eGFR) of >30 ml/min/1.73m² and no evidence of acute kidney injury do not require any adjustment to metformin dosing.³² Radiographers who administer IV contrast medium or Buscopan® must do so in accordance with a patient group direction.

C. After the test

1. Patient recovery and advice

Key minimum requirements: explanation of expected post-procedure symptoms and recovery.

Patients should remain in the CTC department for at least 15 minutes after an injection of IV contrast medium or Buscopan® and for at least 30 minutes if they are judged at increased risk of anaphylaxis (for example if they have had a previous contrast reaction). If a cannula has been inserted and an adverse event is anticipated, the cannula should remain in place until the patient is ready to leave the department.

Patients should have easy access to lavatory and changing facilities and a suitable area should be available for them to recover after a procedure. Patients should ideally be given

(or advised to bring with them) light refreshments (such as tea and biscuits) to have once the initial observation period of 15 minutes following administration of intravenous contrast medium has elapsed. If same day endoscopy is planned, it may be appropriate to restrict oral intake to clear fluids (see Same-day endoscopy).

Patients should be provided with information explaining the minor symptoms that commonly follow the procedure and giving advice on what to do in the event of more severe or persistent symptoms (that is, those lasting more than a few hours). Symptoms and adverse effects are not always due to the CTC procedure but may be related to the medications used. Information should also cover delayed reactions to contrast media, as well as the rare but important acute angle closure glaucoma that can be precipitated by Buscopan®.

2. Same-day endoscopy

Key minimum requirements: none.

Same-day endoscopy for cancer may be desirable for some patients but may be contraindicated, impractical, inappropriate or inconvenient for others. Relatively few CTC services have the capacity to perform the immediate reporting needed and arrange a same-day endoscopy. If same-day endoscopy is being considered, a clear pathway for referral to endoscopy (either sigmoidoscopy or complete colonoscopy) should be developed in conjunction with the endoscopy unit.

3. Reporting facilities

Key minimum requirements: access to CTC interpretation software with endoluminal reconstruction.

CTC reading can be performed using 2-D, 3-D or both. Reporting radiologists should be competent in these and have access to the requisite software. 2-D reading requires the use of multi-planar reformats (typically axial and coronal) in each patient position. 3-D reading uses endoluminal reconstructions to create a virtual colonoscopy. The choice of reading method may vary within and between CTC datasets, depending on the technical quality and the nature of the target lesion. Computer-aided detection (CAD) software is incorporated into many reading platforms and may increase the sensitivity of the interpretation, particularly when deployed in a 'second-read' paradigm (that is after initial unaided interpretation).^{34,35}

4. Reporting methods and size thresholds

Key minimum requirements: adherence to the NHS BCSP minimum dataset for screening patients which states that small polyps (<6 mm) should not be reported routinely.

CTC interpreted for the NHS BCSP must adhere to their minimum dataset requirements. To assist report communication and for audit purposes, we also strongly recommend that services adopt these for all CTC reporting although this is not mandatory.

Radiologists should provide clear guidance regarding the presence or absence of polyps and/or colorectal cancer. Equivocal reports should be avoided where possible. If a finding is genuinely equivocal, this should be accompanied by a clear recommendation for either endoscopy, repeat CTC (and at what time interval) or no action.

There are varying views regarding the appropriateness of reporting polyps of under 6 mm. Under almost all circumstances, they should not be reported. The risk of advanced

neoplasia in small (that is <6 mm) polyps is less than that in the general, asymptomatic, 50-year-old population making it illogical to refer these for colonoscopy. Non-reporting of small polyps is safe; the risk of cancer in the subsequent 3–5 years after a colonoscopy showing no 6 mm+ polyps is very small – comparable to that of a colonoscopy finding no polyps.³⁶ Moreover, reporting of small lesions at CTC has extremely poor cost-effectiveness (over \$460,000 per life-year gained in one US analysis), well over commonly-applied thresholds for UK health care.³⁷

In rare circumstances (for example younger, asymptomatic patients) it may be appropriate to report small polyps if ALL of the following criteria are met.

- The polyp/s can be seen with high confidence on a high-quality CTC examination.
- Three or more polyps can be seen.
- The reporting radiologist meets all key performance indicators (KPIs) as outlined in **Part 2. Quality standards and performance indicators.**

5. Communication of results

Key minimum requirements: all CTC-diagnosed colorectal cancers should be notified directly to the cancer MDTM.

For both NHS BSCP cases and symptomatic cases, results should be communicated in a timely fashion. In cases of possible or definite colonic carcinoma this will require referral to the colorectal cancer MDTM for discussion and review. Critical, urgent or unexpected abnormal results should be highlighted through a suitable notification system that complies with current RCR guidelines.³⁸

If symptomatic cases are referred from primary care via a straight-to-test pathway, the reporting radiologist must be mindful of who will read and act on the report (for example general practitioners and/or specialist nurses), and be explicit about colonic and extra-colonic findings and advice on further investigation. Patients may also have direct access to radiology reports and this should be considered when reporting.

2. Quality standards and performance indicators

Introduction

The preceding section outlines the 'how' of CTC; this section deals with 'what to measure'. This will provide referrers, commissioners and patients with the reassurance that their service meets or exceeds quality standards. The final section will consider 'how to measure it' by providing standard definitions for audit purposes.

Summary list of quality standards

See **Table 2. Quality standards and Performance indicators**

1. Image quality

Minimum standard: colonic cleansing, tagging and distension of at least adequate quality in 95% of patients.

Aspirational: Cleansing, tagging and distension of at least adequate quality in 98% of patients.

Accurate interpretation of CTC fundamentally depends on high-quality image acquisition. This relies on many factors, including appropriate patient selection, information, preparation (including both cleansing and tagging, either using separate cathartics and tagging agent or a single agent), positioning and insufflation. There is little evidence of superiority of one mode of bowel preparation over others. In an Italian randomised controlled trial (RCT) of a screening population, a reduced-laxative regime was better tolerated by patients than an intensive preparation regime, with no significant difference in diagnostic yield.^{39,40} However, this may not be true for older symptomatic patients. Units should select their preferred agent based on local experience and audit.

Research studies evaluating bowel cleansing and tagging typically use relatively complex scoring systems evaluating the colon segment by segment for each of cleansing, tagging and distension.^{32,41,42} While inter-observer reliability of these scales is good, they are too cumbersome for clinical practice.⁴¹ The BCSP recommends a simple three-point scale; good, adequate or inadequate. There is inherent subjectivity regarding what constitutes an 'adequate' examination, which may differ depending on patient co-morbidities and the goals of the examination (that is, exclusion of protuberant cancer versus identification of smaller polyps). Despite this, we recommend use of this three-point scale for all CTC examinations. Guidance regarding how to apply these categories is provided in **Part 3. Definitions and audit guidance.**

The minimum standard of 95% is based on data from two paired pragmatic UK randomised trials, in which the rate of onward referral for further testing due to uncertainty after CTC was 5.2%.^{8,43} The same rate has been observed in the English BCSP (albeit with moderate missing data; C Nickerson, personal communication). Therefore, 95% is regarded as an achievable minimum standard for all units. However, several individual sites have published superior adequacy rates, for example 98% in a UK symptomatic cohort and 99% in a US screening cohort.^{14,15} Accordingly, it is likely that rates approaching 98% are highly achievable in routine practice and should be targeted by most services.

2. Polyp identification rate (PIR)

Minimum standard: Identification rate of 6 mm+ polyps (that is, identified at CTC) in >13% of patients.

Aspirational: Identification rate of 6 mm+ polyps in >16% of patients.

There are several possible metrics that capture the goal of 'finding polyps'. Hereafter, we refer to the following:

- a. Polyp identification rate (PIR) – the rate at which polyps are identified as being present at CTC
- b. Polyp detection rate (PDR) – the rate of endoscopically confirmed polyps, regardless of histological subtype,
- c. Adenoma detection rate (ADR) – the rate of histologically confirmed adenomas.

Unlike colonoscopy, for various reasons, polyps identified at CTC may not always be removed. In many cases, the aim of the examination is to identify cancer rather than polyps. However, identification of polyps is a proxy marker for the quality of interrogation of the colonic mucosa – colonoscopists who find more adenomatous polyps have lower interval cancer rates.^{44,45} The average age of patients having CTC in England is approximately 70 years;³ the mean life expectancy at this point is approximately 16 years for women and 15 years for men.⁴⁶ Removal of polyps prevents future cancers, meaning their identification assumes considerable importance for most patients.^{47–51}

Endoscopically confirmed polyp detection rate (PDR) and the adenoma detection rate (ADR) were considered as quality standards; however, while these may be desirable in situations where all patients can readily undergo subsequent colonoscopy to remove polyps, this is frequently not the case when imaging frail symptomatic patients. Moreover, monitoring ADR requires interrogation of histopathology databases and excludes serrated lesions. At CTC, ADR is therefore frequently as much a function of the imaged population, their comorbidity and endoscopic decision-making as it is of CTC quality. Accordingly, PIR is preferred, but must be viewed in conjunction with positive predictive value.

The prevalence of 6 mm+ polyps at CTC varies according to the group being studied. It is greater in men than women, increasing with age and is generally greater in symptomatic compared to screening cohorts. Arguably, asymptomatic screening cohorts represent the lower limit of expected polyp detection since this is the baseline risk in the general population. One US study of 6,769 patients reported an overall PIR at a 6mm+ threshold of 14.3%.¹⁴ A single UK centre reported a rate of 17% in (mainly) symptomatic patients and the average rate across two UK centres, again dominated by symptomatic work, was also 17%.^{15,16} Similarly, a separate UK centre reported a PIR of 18.3% in a cohort of largely symptomatic patients.¹⁷ Based on these data, a pragmatic minimum standard of 13% has been set, with a higher target of 16% judged achievable.

4. Positive predictive value (PPV)

Minimum standard: the per-patient positive predictive value (PPV) should be >80%. This is defined as the proportion of patients with polyps identified at CTC who undergo endoscopy, surgery or imaging follow-up AND have a polyp of 4 mm or greater confirmed by the second procedure, regardless of its segmental location.

Aspirational: per-patient PPV of >90%.

Many patients with polyps identified at CTC will not have subsequent endoscopic removal – for example, due to co-morbidity or inaccessible segments. However, for those who do, it is critical that endoscopy is being performed for a genuine abnormality, both for patient experience and to reduce healthcare costs. Moreover, an emphasis on PPV is critical to make the PIR meaningful – without close attention to PPV, there may be a tendency to ‘overcall’ equivocal cases as positive to increase PIR.

Research studies typically require a degree of ‘polyp matching’ to ensure that the abnormality identified at CTC legitimately corresponds to that identified at colonoscopy – often using a combination of polyp segmental location (in the same or adjacent segment) and size (within 50%).^{5,7} Although important for establishing test characteristics, this is often impractical for radiology services to monitor and requires more detailed scrutiny of both CTC and colonoscopy reports. It is far simpler to adopt a ‘per-patient unmatched’ analysis and regard a true positive CTC examination as one in which a polyp (or cancer) was identified and subsequently confirmed, regardless of whether or not this is genuinely the same lesion. We accept this has limitations but it has the advantages of reproducibility and simplicity, meaning it is far more likely to be achievable in most centres. We permit a 4 mm size for the confirmatory test, to allow for minor size mis-measurement at either CTC, endoscopy or histopathology.

Regarding suitable minimum standards, in primary screening populations it is possible to achieve PPV in excess of 90% (94% in one Spanish series and 92% in a US cohort).^{52,53} Similarly, a large UK series reported a per-patient PPV of 92% and a more recent UK series for two centres found 90% per-patient unmatched PPV.^{15,16} However, in the BCSP which includes many more scanning services, PPV was only 72.1%. Accordingly, a pragmatic minimum standard of 80% has been drawn between these two figures with 90% viewed as an aspirational target for both services and individuals.

5. Subsequent endoscopy rate

Minimum standard: the proportion of patients undergoing endoscopy after CTC should be <25%.

Although it may seem potentially counter intuitive, there are two reasons for advocating a lower rate of endoscopy after CTC. First, cost-effectiveness modelling suggests that CTC is not cost-effective in a UK setting if subsequent use of colonoscopy significantly exceeds 30%.¹⁸ Second, CTC is commonly used to avoid colonoscopy; a high referral rate for colonoscopy subjects patients to additional inconvenience, risk and discomfort. Services with high downstream colonoscopy rates should use their PIR and PPV data to determine the cause; high PIR with low PPV should be addressed by attention to examination technique and radiologist training, whereas services with high PIR and PPV (thus with high colonoscopy use) should consider restructuring referral pathways to triage higher-risk patients directly to colonoscopy, thereby reducing costs and patient inconvenience.

6. Radiation dose

Minimum standard: median radiation dose for patients undergoing CTC should correspond to a dose-length product (DLP) of <950 mGy.cm

Aspirational target: median radiation dose for patients undergoing CTC should correspond to a dose-length product (DLP) of <600 mGy.cm.

CTC dose varies between scanners but in two international surveys from 2008 and 2012 the average effective radiation dose was estimated at 9.1 mSv for symptomatic scans and 5.7 mSv for screening scans in 2008 and 7.6 mSv (symptomatic) and 4.4 mSv (screening) in 2012.^{54,55} A 2012 single-centre report, using modern CT technology which is now widely used in the UK estimated doses to be around 2.5–3 mSv.⁵⁶ This compares to average annual background radiation exposure of 2–3 mSv per annum in the UK.⁵⁷

Radiation doses are more commonly and easily quantified using DLP since this is routinely generated at the time of CT scanning and often entered into the RIS and/or stored onto the picture archiving and communication system (PACS). Although DLP does not directly correspond to effective dose, there is a relationship between the two parameters and, for simplicity and practicality, we have chosen DLP as the relevant metric.⁵⁸ This aligns with the national DRL, which currently is 950 mGy.cm for CT colonography.⁵⁹ These data derive from a 2011 review, at which time lower radiation dose CT scanners incorporating iterative reconstruction and other technologies were not widely available. A more recent regional UK audit of scans performed on 27 scanning units found an average DLP of 650 mGy.cm for contrast-enhanced CTC (Tolan D *et al*, personal communication). Therefore 950 mGy.cm is suggested as an acceptable minimum standard, with 600 mGy.cm as an achievable target for many sites with modern CT scanners and optimised imaging protocols.

7. Same-day cancer staging

Minimum standard: the proportion of examinations showing colorectal cancer in which same-day staging (including chest CT) is performed should be >50%.

Aspirational target: the proportion of examinations showing colorectal cancer in which same-day staging (including chest CT) is performed should be >80%.

Where CTC diagnoses a mass suspicious for colorectal cancer (CRC), same-day staging should be performed to facilitate further management and reduce patient inconvenience. This will entail contrast-enhanced imaging of the abdomen and pelvis and thoracic imaging, and thus requires rapid recognition of the presence of a mass on the initial CTC acquisition. For most services, the radiographers acquiring the images will be checking scans for quality and completeness and so are ideally placed to identify such tumours rapidly. This may require additional training in basic CTC interpretation which has many benefits for CTC services.

Few real-world observational studies of CTC in clinical practice (as opposed to prospective studies of diagnostic accuracy) report the proportion of examinations in which CRC was recognised immediately at the time of the CTC examination. In one expert UK centre, 79% of such CRCs were successfully identified, which we therefore regard as a suitable aspirational target.¹⁵

In practical terms, when considering same-day staging, departments need to consider the possibility of inadvertently revealing a likely CRC diagnosis to an unprepared and unaccompanied patient. Almost no department will have staff trained in delivering

such information nor facilities in place to deal with breaking bad news. Therefore, when instituting same-day staging, departments should liaise with referring clinical teams to ensure patients are not left unsupported. Additionally, there must be a process by which the team performing the CTC (usually a trained radiographer) can expedite urgent reporting and rapid liaison with referrers and the MDTM. Virtually all patients diagnosed with CRC will require endoscopic biopsy so if complete staging has not been performed at the time of CTC, services should aim to co-ordinate colonoscopic confirmation with completion staging.

8. Interpretation time

Minimum standard: average interpretation time (including reporting) should be >20 minutes.

Aspirational target: average interpretation time should be >25 minutes.

Radiologists are increasingly pressured to report greater volumes of cross-sectional imaging. Yet greater speed may increase error rates; eye-tracking data shows that more rapid endoluminal navigation reduces both the amount of colonic surface viewed by radiologists and polyp detection.⁶⁰ Endoscopists have long recognised the importance of withdrawal time at colonoscopy, since slower withdrawal permits superior inspection of the mucosa. Colonoscopists with longer withdrawal times have higher adenoma detection rates and lower interval cancer rates.^{61–63} In a laboratory setting, faster CTC interpretation leads to lower detection rates.⁶⁴ This translates to real-world practice; radiologists who reported faster than their colleagues had lower polyp identification rates in one recent UK study.¹⁶ Therefore, we recommend that CTC services protect their radiologists from requirements to report too fast by implementing a minimum average interpretation time. We considered using only the interpretation time for cases ultimately called normal (that is, the 'negative interpretation time') since this most closely reflects time spent interrogating the colonic mucosa (whereas the length of time interpreting a positive case is skewed by the need for polyp measurement and characterisation); however, for CTC this difference is small, and we judged the benefits of this 'cleaner' metric to be outweighed by the relative difficulty in measuring it. For practical advice regarding how to estimate this, see **Section 3. Definitions and audit guidance.**

Average interpretation times in the landmark DoD and ACRIN-6664 studies of CT colonography were 19–25 minutes depending on the precise mode of interpretation.^{5,7} In the real-world study described above, of over 5,000 CTC examinations reported by seven different radiologists, the average time taken was 30 minutes (including report dictation, checking and extracolonic evaluation).¹⁶ In a survey of over 100 UK centres, median estimated time for reporting a single CTC examination was 18 minutes;⁶⁵ a repeat survey in 2018 of 141 UK radiologists found a median time of 23 minutes (A Obaro, personal communication). We therefore regard 20 minutes as an average reporting time to be a suitable minimum standard, with 25 minutes as an aspirational target that has been shown to be achievable in UK practice. We accept that some individual radiologists, particularly those with significant experience, may naturally report more quickly than others and may successfully meet or exceed all other relevant quality standards even with more rapid interpretation. Accordingly, our emphasis is on service-level estimation of this metric rather than focusing primarily on individual practice.

Although radiologists may be pressured by external factors to report as many CTC studies in as short a period as possible, this risks missed neoplasia. Although we are (to a degree) sympathetic to the argument that unreported scans may be an even greater risk than a suboptimal but timely report, patients will rightly not accept missed lesions due to interrupted reporting and time pressures. Specifying reporting environment and time standards is in line with colonoscopic practice in the UK; it is inappropriate for patients undergoing CTC to be subject to lower levels of safeguarding. CTC readers require adequate, uninterrupted reporting time and NHS trusts should use this standard to aid departmental job planning and recruitment.

9. Radiologist training prior to independent reporting

Minimum standard: supervised interpretation of >175 validated cases.

Aspirational target: supervised interpretation of >300 validated cases.

The learning curve for CTC varies between individuals, but it is clear that specific training in CTC is needed and that experience cannot substitute for training.^{19,43,66,67} Early unpublished data from a UK cluster RCT of radiologist training and feedback to improve polyp detection show poor correlation between lifetime experience of reporting radiologists and diagnostic accuracy when tested on previously unseen cases.

In one early prospective study, training on 50 validated cases was insufficient for the majority of inexperienced radiologists and radiographers to achieve diagnostic accuracy comparable to more experienced and expert practitioners.⁶⁷ In support, a prospective Dutch trial found that the average number of cases for novice readers to achieve acceptable diagnostic accuracy (defined as >90% of 6 mm+ polyps in a high imaging quality test dataset) was 164.¹⁹ Even so, some readers failed to reach this level of performance even after 200 cases, meaning a higher target of 300 cases is suggested as an aspirational target. Notably, radiologists with an experience of over 300 cases had significantly higher detection rates than less experienced colleagues in the UK BCSP.¹¹ We strongly recommend that radiologists who wish to report for the NHS BCSP should meet the aspirational target before commencing.

10. Ongoing experience of reporting radiologists

Minimum standard: >100 cases interpreted per annum (rolling average over previous three years).

Aspirational target: >175 cases interpreted per annum (rolling average over previous three years).

Maintenance of competence for radiologists interpreting CTC is clearly fundamental to delivery of a high-quality service. The UK BCSP has, until recently, recommended a minimum number of 100 cases per year for screening radiologists – a figure that has been almost universally achievable in quality assurance visits (D Tolan; D Blunt, personal communications). Ensuring that this is possible for all radiologists may necessitate double reporting of some cases or restricting the pool of CTC reporters to those with particular expertise. In the UK BCSP, screening sites with higher throughput (>175 cases per radiologist per annum) had significantly higher detection rates and superior PPV than lower throughput sites, suggesting this is a desirable (and achievable) target.¹¹

In some services, radiologists may be required to report large numbers of cases (>800 per annum) as demand for CTC increases. CTC services should be configured and staffed to protect individual readers from unsustainable workloads. Services must allow adequate reporting time in job plans for each case.

11. Additional (third or fourth imaging position) acquisition rate

Auditable outcome: if the rate is <5%, attention is required.

Despite best efforts, optimum distension is not always achieved with only two imaging positions; an additional acquisition frequently resolves this. Increasing age, body mass index (BMI) and a history of incomplete colonoscopy all make the need for a third series more likely.⁶⁸ However, there is considerable variation between different scanning sites regarding their use of a third acquisition, often due to patient factors. Patients cannot be imaged adequately with only two scans in all cases – therefore, if the rate of acquiring a third scan is zero, this implies that at least some inadequate scans are being accepted and used for clinical reporting. Presently, there are no robust data to determine the expected range in which additional acquisition rates would lie (BCSP data suggest a median rate of 6.2%, with inter-quartile range (IQR) 2.4–12%, although frequently this field is left blank on the national database; C. Nickerson, personal communication). Accordingly, we suggest that sites monitor their rate; if it is <5% then further radiographer training regarding insufflation and technique may be required.

12. Patient experience

Auditable outcome

Patient experience is a crucial facet of quality and patients should have as dignified and comfortable a procedure as possible. Analysis of patient experience data from the BCSP showed over 95% of patients agreed they were treated with privacy and respect during their test, although over 25% found the test more uncomfortable than they had expected.⁶⁹ We recommend units audit patient experience, including the pre-test experience (preparation, booking, communication and bowel preparation), the test procedure itself (pain/discomfort, privacy and dignity) and the post-test experience (recovery, pain and receiving results). This is a powerful means by which units can identify and highlight areas for improvement that matter to patients. The NHS BCSP performs post-test patient experience questionnaires and this is being revised to include and be applicable to CTC cases.

13. Assessment of post-imaging colorectal cancers (PICRC) at 36 months post-procedure

Auditable outcome

The most common indication for CTC is to search for CRC and pre-malignant polyps. Since adenomas and serrated lesions take many years (or even decades) to transition from pre-malignant to invasive cancer, if a cancer is not identified at a particular CTC examination but subsequently diagnosed in the following few years, it is highly likely that neoplasia was already present at the time of the original scan.^{70,71} Such cancers are termed 'interval cancers' in the context of a call-recall screening programme or post-imaging colorectal cancers (PICRCs) where there is no such routine screening interval.⁷² These are directly analogous to PCCRCs (post-colonoscopy colorectal cancers) in the endoscopy literature. Most such cancers are genuine 'misses' (both at CTC and colonoscopy), and most are visible in retrospect.³⁶ It is therefore estimated that up to 75% of PCCRCs and PICRCs are potentially preventable with optimised technique and interpretation.

Typically, PCCRCs and PICRCs are defined using the time at which cancer is diagnosed relative to the original test (colonoscopy or CTC). By convention, in epidemiological studies (in which imaging and endoscopy reports may not be available), CRCs diagnosed between zero and six months after a given test are assumed to have been identified by that test, whereas CRCs diagnosed at 6–36 months are assumed to have been missed (and diagnosed by alternative means – for example, a repeat test). Although this will inevitably misclassify some cases, it is a reasonable pragmatic assumption and avoids scrutinising every patient record. The simplest way to present such data is as a percentage of ‘missed cancers’ at 36 months (that is, PICRCs) relative to the total number of cancers that are diagnosed (that is, cancers found by CTC plus those that it missed) as follows:

$$\text{PICRC-36m \%age} = \frac{\text{PICRCs i.e. CRCs diagnosed 6 – 36 months after CTC}}{\text{total cancers i.e. all CRCs found 0 – 36 months after CTC}} * 100$$

The threshold of 36 months is arbitrary but standard in the colonoscopy literature and endorsed by expert bodies.⁷² Therefore the same nomenclature and timelines have been adopted in this guidance.

The expected PICRC rate is, as yet, unknown but one systematic review estimated it to be 4.4% in the published CTC literature (which may not be representative of routine clinical practice).³⁶ Since PICRCs are rare, it is implausible that they can be used meaningfully to compare between individual CTC services (much less individual radiologists) due to low numbers and correspondingly wide confidence intervals. Instead, sites should have a means to identify PICRCs and conduct root-cause analysis (RCA) when identified (see **Section 3. Definitions and audit guidance** for suggestions on how to achieve this) which can be collated at a regional or national level so that common themes can be identified. A template for PICRC RCA has been provided by the World Endoscopy Organization (WEO) – use of this is recommended.⁷²

14. Perforation rate

Auditable outcome

Perforation at CTC is rare; it is estimated to occur in approximately 1 in 3,000 examinations, with symptomatic perforation requiring surgery occurring at roughly 1 in 12,500 studies.⁷³ Predisposing factors are not known with certainty, but use of older, large bore insufflation devices (rather than flexible catheters), excessive inflation volumes or pressures and pre-existent bowel herniation, inflammation or recent biopsy have been suggested.^{73,74} Given the rarity of perforation and in particular symptomatic perforation requiring surgery, it will not be possible to compare rates between institutions reliably for PICRCs. However, units should audit their perforation rate and conduct RCA where these occur to assist learning at a regional or national level.

3. Definitions and audit guidance

Introduction

The standards outlined in the previous sections should permit CTC services to ensure they are providing a high-quality service to their patients. Improvement nationally is likely to require comparison and shared learning between different services. For the quantitative metrics defined as quality indicators in **Section 2. Quality standards and performance indicators**, this is only meaningful if definitions and methodology are used consistently. The goal of this section is to provide detail regarding each specific quality indicator and recommendations regarding how it should be measured in practice. Anecdotally, that there is considerable confusion and variation regarding how best to audit CTC services; this guidance aims to clarify this. Feedback from services and readers on how these recommendations can be refined and improved in the future is welcomed.

Many of the quality indicators can be efficiently recorded at the time of scan reporting; we strongly encourage services to use a proforma reporting template similar to that advocated by the BCSP to facilitate this. It cannot be over-emphasised how much easier this makes the audit process. Services making a transition to structured reports are advised to adjust carefully the formatting of the proforma to ensure subsequent RIS data extracts are easy to manipulate (for example, making the text of reports easy to search in spreadsheet programmes). A test extract from the RIS after a handful of cases has been reported is advisable.

For all metrics, it is acceptable to use rolling data from multiple years at re-audit if this is necessary to achieve sufficient patient numbers. For example, a quality standard may require data for 100 CTC-diagnosed polyps and audit in 2020 may have used data from the years 2015–2019 to achieve this number. It is acceptable for re-audit in 2022 to use data from the years 2017–2021 (that is, overlapping with prior audit) if required to ensure the number of cases included is meaningful.

1. Image quality

Minimum standard: colonic cleansing, tagging and distension of at least adequate quality in 95% of patients.

Aspirational: cleansing, tagging and distension of at least adequate quality in 98% of patients.

Definition of adequate quality

- Overall global judgment combining a subjective assessment of cleansing, tagging and distension.
- 'Adequate' implies the reporting radiologist has sufficient confidence to reliably (>90% certainty) exclude the target lesion for that patient; typically a polyp of over 1 cm, but for some patients this will be a stenosing mass.

Recommendation for how to measure and document

- Prospective recording at the time of CTC reporting by the reporting radiologist using a simple three-point scale for scan quality (good, adequate or poor).
- If using the BCSP minimum dataset, services should extract BOTH the rate at which studies are described as 'poor' AND the Cx rate (that is, the inadequate study code) and regard the worse of these two rates as the true rate of inadequate studies.
- A minimum of 400 cases should be included as inadequate studies are relatively rare.
- If prospective data recording has not been done a consecutive sample of at least 400 CTCs should be retrospectively assessed using the criteria for scan adequacy outlined above.

Minimum frequency of audit

- Every two years.

2. Polyp identification rate (PIR)

Minimum standard: identification rate of 6 mm+ polyps (that is, identified at CTC) in >13% of patients.

Aspirational: identification rate of 6 mm+ polyps in >16% of patients.

Definition of polyp identification

- Reporting of a polyp measured at CTC of 6 mm or more in the body or conclusion of a CTC report or in the summary code (preferred).
- Equivocal reports (for example, 'possible polyp') should not be included.

Recommendation for how to measure and document

- Prospective reporting by the radiologist at the time of CTC interpretation.
- Use of a reporting proforma and a summary 'C' code is strongly recommended.
- A RIS search extracting summary codes for all CTC reports will permit straightforward measurement of this metric; summation of all codes of C2 or greater, with the exception of C3c ('indeterminate stricture') should be regarded as polyp identification.
- Do not include C1 codes or diminutive polyps (that is, 5 mm or less).
- Data should be measured at service level (all radiologists) and for each individual radiologist.
- A minimum of 500 cases, or one year's worth of data (whichever is greater) should be included at service level; and 200 cases or one year's worth of data (whichever is greater) at radiologist level.

Minimum frequency of audit

- Every two years.

3. Positive predictive value (PPV)

Minimum standard: the per-patient positive predictive value (PPV) should be >80%. This is defined as the proportion of patients with polyps identified at CTC who undergo endoscopy, surgery or imaging follow-up AND have a polyp of 4 mm or greater confirmed by the second procedure, regardless of its segmental location.

Aspirational: per-patient PPV of >90%.

Definition of PPV

- A polyp must have been identified at CTC (defined as per the preceding section).
- The patient must have undergone a follow-up test within six calendar months; either endoscopy, surgery or repeat imaging – ignore patients with no follow-up test.
- If the follow-up test confirms the patient to have a genuine polyp of 4 mm or greater, this counts as a true positive CTC, regardless of its segmental location or the size of the abnormality reported on the index CTC; there is no need for 'polyp matching' by exhaustive scrutiny of endoscopy reports or images.
- The polyp may be of any histological subtype; it does not need to be an adenoma or sessile serrated lesion.
- If no polyp is confirmed at this confirmatory test, regard this as a CTC false positive.
- If a patient has undergone more than one follow-up test (for example, two separate endoscopy procedures), combine these two tests when judging the overall PPV of the CTC study (for example, if initial flexible sigmoidoscopy fails to show a polyp diagnosed on CTC, but colonoscopy does, count this as a true positive CTC finding).

Recommendation for how to measure and document

- Prospective reporting by the radiologist at the time of CTC interpretation.
- Extract from the RIS a list of all patients with CTC-identified polyps (either by word search of all CTC reports or using summary codes).
- Cross-reference this list against the endoscopy database and (electronic) patient record.
- A minimum of 100 CTCs showing polyps should be included for this metric; preferably 200 for service-level data.
- The result should be presented both at service level (all radiologists) and individual level (that is, PPV for each radiologist) – this may require several years' of data to be aggregated for an individual radiologist to accumulate 100 patients with polyps who have undergone a confirmatory test.

$$\text{PPV (per-patient)} = \frac{\text{True positives (patients with a polyp at CTC and later confirmed)}}{\text{False positives (patients with a polyp at CTC and then refuted)}} \times 100$$

Minimum frequency of audit

- Every two years.

4. Subsequent endoscopy rate

Minimum standard: the proportion of patients undergoing endoscopy after CTC should be <25%.

Definitions

- Include any endoscopic examination regardless of the clinical indication (for example, polypectomy, confirmatory biopsy, resolving diagnostic uncertainty and so on).
- Include flexible sigmoidoscopy and colonoscopy (including in theatre) but not anoscopy, proctoscopy or rigid sigmoidoscopy in clinic.
- Only include examinations occurring within six calendar months of the date of the original CTC.

- Measure on a per-patient basis rather than per-scan or per-endoscopy; for example, if a patient has two CTC examinations at months one and two, and an endoscopy at month three, this counts as a single 'subsequent endoscopy' rather than two such events.
- Similarly, if a patient has more than one endoscopy within three months of a single CTC (for example, initial sigmoidoscopy followed by colonoscopy; or polypectomy followed by a site check), count this as a single 'subsequent endoscopy' for audit purposes.

Recommendation for how to measure and document

- Extract a list of all patients who have had CTC within a given time period.
- Cross-reference against the endoscopy database and/or electronic patient record (EPR) for studies occurring within three months.
- A minimum of 200 CTC studies should be included.
- This should be measured at service level.

Minimum frequency of audit

- Every two years; AND after changes to CTC referral pathways or requesting criteria.

5. Radiation dose

Minimum standard: median radiation dose for patients undergoing CTC should correspond to a dose-length product (DLP) of <950 mGy.cm.

Aspirational target: median radiation dose for patients undergoing CTC should correspond to a dose-length product (DLP) of <600 mGy.cm.

Definitions

- The preferred metric for radiation dose comparisons will be mGy.cm; although this has limitations it is simple to collect and a straightforward means to compare over time and between institutions.
- All CTC examinations, both screening (BCSP) and symptomatic should undergo dose audit.

Recommendation for how to measure and document

- Prospective dose monitoring from commercial or in-house software is ideal if available; this may be integrated into the EPR or have been provided with equipment purchase.
- For most sites, these facilities are not available and instead retrospective sampling of consecutive CTC studies should be conducted; for BCSP sites this should be split into screening and symptomatic studies.
- A minimum of 100 studies should be included, including all BCSP cases during the audit period for BCSP sites.
- Non-BCSP sites should simply collate a list of 100 (or more) consecutive CTC studies for dose monitoring; BCSP sites should first collate a list of all BCSP cases over the audit period and record the dose of these; thereafter, further symptomatic cases should be identified to make up the total of 100 cases (that is, there is no mandate for BCSP sites to audit more patients in total than non-BCSP sites).
- The mean (plus standard deviation), median (plus interquartile range) and absolute range of CTC doses should be documented.

- BCSP sites should present data for both symptomatic and BCSP cases separately (since the latter will usually be lower dose examinations).
- Individual services or regions may wish to conduct more detailed CTC dose audits (for example, estimating effective doses using simulation software); although this is encouraged it is not a requirement.

Minimum frequency of audit

- Every two years AND after changes to CTC scanning parameters (including installation of a new CT scanner).

6. Same-day cancer staging

Minimum standard: the proportion of examinations showing colorectal cancer in which same-day staging (including chest CT) is performed should be >50%.

Aspirational target: the proportion of examinations showing colorectal cancer in which same-day staging (including chest CT) is performed should be >80%.

Definitions

- Same-day staging is defined as CT of the chest AND contrast-enhanced imaging of the abdomen and pelvis on the same day as the CTC examination.
- For most patients who will be receiving intravenous contrast as part of the CTC study, this simply entails extended coverage of the entire torso in the second scan position (rather than just the colon).
- If intravenous contrast has not been administered for the first scan position, and it is not contraindicated, it must be given for the second scan to qualify as 'same-day staging'.
- If a mass is only identified on the second scan position, completion imaging of the chest (+/- contrast-enhanced abdominopelvic imaging, if needed in addition to the CTC images) should be performed after the CTC.
- If intravenous contrast is contraindicated, unenhanced imaging is acceptable but must be of normal diagnostic quality (that is, at full radiation dose for visceral evaluation, not the reduced-dose protocol that may be used for screening patients).

Recommendation for how to measure and document

- Identify all CTC studies showing a mass requiring urgent referral to the colorectal cancer MDT or highly suspicious of cancer (that is, C5a or C5b using the recommended minimum dataset; although code C5b is for patients already known to have cancer, such individuals should still have single-visit staging).
- Do not include polyps that subsequently transpired to be malignant on histological assessment.
- Record the percentage of patients in who same-day staging (defined as above) was completed.
- Although the quality standard is for aggregated data, services should ideally present the data separately for newly diagnosed cancer patients identified at CTC (code C5a) and those with incomplete colonoscopy and known cancer attending for completion colonic imaging (code C5b).

Minimum frequency of audit

- Every two years.

7. Interpretation time

Minimum standard: average interpretation time (including reporting) should be >20 minutes.

Aspirational target: average interpretation time should be >25 minutes.

Definitions and recommendations for how to document

- It may be possible to record directly from the RIS or PACS the average time that a particular procedure code (that is, CT colonography) has taken to interpret. However, generally this is not possible due to technical factors.
- If this approach is taken, all time between opening a case for interpretation and issuing the final report should be included.
- All cases should be included (normal and abnormal).
- Only cases interpreted by a single reader should be included (for example, review of a scan initially reported by another reader should be disregarded).
- Direct estimation is frequently not possible; therefore services should estimate the number of CTC studies conducted per annum and ensure their radiologists are provided with sufficient job-planned time to report this number of CTC examinations while adhering to the recommendations above.
- For example, a service performing 1200 CTC examinations per annum requires, as a minimum, 400 hours of CTC reporting to be job-planned for radiologist reporting (500 hours to meet the aspirational requirement). This does not include any additional allowance for covering leave, or SPA activity, which are also requirements for a safe CTC service.
- Individual radiologists may wish to record the number of CTC studies they report in any given year and consider if their existing job plans provide sufficient protected time to enable them to meet this target; if not, these recommendations should be brought to the attention of NHS trusts to ensure appropriate job plans are implemented (aided by radiologist recruitment where necessary).

Minimum frequency of audit

- Every two years AND if job plan changes will impact CTC reporting.

8. Radiologist training prior to independent reporting

Minimum standard: supervised interpretation of >175 validated cases.

Aspirational target: supervised interpretation of >300 validated cases.

Definitions

- 'Interpretation' is defined as image scrutiny with documentation of an opinion regarding what the image shows; this need not be a formal report and may simply be a verbal opinion conveyed to a trainer.
- 'Supervised interpretation' is defined as an interpretation (see above) that is subject to feedback from a trainer. This is typically, but does not have to be, face to face. Indirect supervision (for example, using electronic messaging services integrated into the PACS/RIS) is acceptable. However, at least 50% of cases should be subject to direct supervision.

- A 'validated case' is defined as a CTC study that has the final diagnosis confirmed by either endoscopy, surgery or CTC follow-up. Cases can be normal or abnormal, although during training it is appropriate to provide a large number of abnormal cases so that learners are exposed to a wide variety of different findings.
- Attendance at CTC courses is an efficient way to review a large number of cases with endoscopic validation but cannot, in isolation, provide sufficient training for independent practice.

Recommendations for how to measure and document

- Individuals training in CTC should record the number of supervised validated case interpretations they have conducted.
- Services should review such documentation prior to permitting individual radiologists to independently report CTC studies.
- Where new appointees are yet to reach this standard, a period of double-reporting of CTC studies is appropriate.
- Radiologists interpreting for the BCSP should meet the higher (aspirational) standard.

Minimum frequency of audit

- One off event for new CTC reporters within a service.

9. Ongoing experience of reporting radiologists

Minimum standard: >100 cases interpreted per annum (rolling average over previous three years).

Aspirational target: >175 cases interpreted per annum (rolling average over previous three years).

Definitions

- Case interpretation is defined as issuing a report for a CTC examination.
- Review at MDTM or sign-off of a report issued by a different reporter does not qualify for this standard.

Recommendations for how to measure and document

- The RIS should be used to extract the number of CTC examinations reported over a three-year period for each radiologist.
- The average number of studies reported per annum should be used for this standard (to allow for temporary reductions in activity, for example due to job plan changes).
- Do not include periods of absence from work (for example, maternity leave, sickness absence, sabbaticals).

Minimum frequency of audit

- Annual.

10. Additional (third or fourth imaging position) acquisition rate

Auditable outcome: if the rate is <5%, attention is required.

Definitions

- Inclusion of a third (or fourth) acquisition at CTC; typically an additional left or right lateral decubitus series.
- The acquisition does not need to encompass the entire abdomen and pelvis to qualify as a third acquisition (for example, it may be limited to the pelvis only).

Recommendations for how to measure and document

- This should be recorded prospectively at the time of CTC reporting by the relevant radiologist; it is a component of the BCSP minimum dataset.
- If not recorded prospectively, retrospective scrutiny of CTC studies on PACS will be required.
- A minimum of 200 cases should be included for such retrospective audits.
- It may be convenient to combine this audit with estimation of scan quality, although prospective documentation remains much superior.

Minimum frequency of audit

- Every two years.

11. Patient experience

Auditable outcome

Recommendations for how to measure and document

- The BCSP provides a patient experience questionnaire for those undergoing CTC; departments may wish to adapt this for their entire CTC service.
- A minimum of 100 questionnaires should be analysed.

Minimum frequency of audit

- Every two years.

12. Assessment of post-imaging colorectal cancers (PICRC) at 36 months post-procedure

Auditable outcome

Definitions

- Post-imaging colorectal cancers (PICRC) are defined as colorectal cancers that are not identified at CTC but are then diagnosed within a number of months or years after that initial CTC. The most commonly applied time period is 36 months, sometimes termed PICRC-36m.
- The assumption is that most of these cancers will have been potentially preventable by CTC (since, within three years, the cancer would have either already have been present or have been a detectable polyp at that stage).
- A small proportion of such cancers may be genuinely new (presumed rapid carcinogenesis) but this is rare.

- Cancers occurring after CTC may be diagnosed by a different service from that performing the original CTC, meaning it is difficult to calculate a true local PICRC-36m rate without accessing national cancer registry data.
- This is often challenging due to data security and information governance barriers.
- Therefore, although services are encouraged to determine their own PICRC-36m rates by linkage to cancer registry data, this is not a requirement of these standards.
- Instead, we suggest that sites collate PICRCs locally via their colorectal cancer MDTM for reflection and learning.

Recommendations for how to measure and document

- All patients with a new diagnosis of cancer being discussed at the colorectal cancer MDTM should have their imaging record reviewed for previous CTC examinations.
- It is only a requirement to include CTCs occurring in the 36 months immediately preceding the cancer diagnosis; however, older scans may still provide useful learning and can be included at the discretion of each individual service.
- This initial scrutiny of the imaging record is generally best conducted by the MDTM co-ordinator, for escalation to the imaging team only if required.
- If CTC has been conducted in these preceding years, the images and report should be retrieved for case categorisation as follows (adapted from Rutter M *et al* 2018):⁷²
 - Technical (the PICRC occurred in a segment of colon subject to image artefact, poor distension or retained untagged stool).
 - Perceptual (the PICRC arose from a lesion that was, in retrospect, visible).
 - Management (the PICRC arose from a lesion that was identified by CTC but, for whatever reason, was not removed; this includes patients lost to follow-up, declining endoscopy and lesions intentionally left in situ).
 - Non-diagnosable lesion (the PICRC arose in a segment of colon that is, even in retrospect, radiologically normal).
- Services should record PICRCs and, ideally, share lessons learned from such cases both internally and more widely.
- It will not be possible to use such data to compare the rates of PICRC-36m between services or radiologists, since (a) the number of cases identified is dependent on the rigour of the initial search, (b) the denominator that is, how many CRCs were found by CTC (as opposed to missed) will not be known and (c) as noted above many PICRC-36m may present to institutions other than that conducting the original CTC.
- However, sites may be able to collate and identify common factors underpinning PICRCs, helping avoid them in the future.
- This process should be independent of, but may be parallel to, the internal Radiology Events And Learning Meetings (REALMs, formerly Learning from Discrepancy Meetings) and the Duty of Candour legislation.

Minimum frequency of audit:

- Continuous via weekly colorectal cancer MDTM.

- **Perforation rate**

Auditable outcome

Definitions

- Perforation is defined as extraluminal gas introduced at the time of CTC.
- Extraluminal gas is common after colonoscopic tattooing so cases in which there is localised extraluminal gas following placement of a colonoscopic tattoo should not be included unless the patient has relevant symptoms; generalised free intraperitoneal gas should still be considered a perforation.

Recommendations for how to measure and document

- Perforations should be recorded on a case-by-case basis as they occur.
- Cases should be subdivided into symptomatic and asymptomatic perforation.
- Any subsequent management (for example, nil, admission, antibiotics, surgery and so on) should be documented.

Minimum frequency of audit

- Continuous.

4. Workflow to combine audits

The number of metrics may seem initially overwhelming but in practice many of these can be combined into a small number of data extracts from the RIS. These are made much simpler by prospective use of proforma reports, which is strongly recommend.

One simple workflow to combine these audits (assuming use of structured reports) is as follows:

1. Extract data from the RIS for CTC examinations for a two-year period, spanning the period from 30 to six months prior to the audit date. The six month 'window' permits follow-up endoscopy and so on to have occurred. Key fields for the PACS office to include are:
 - i. Date of CTC study
 - ii. Accession number
 - iii. Hospital number
 - iv. Reporting radiologist
 - v. Report text
2. Filter the report text for scan quality; identify the number of studies described as 'poor' or with a Cx study code and calculate the percentage of each relative to the total number of CTCs performed. Simple spreadsheet search filters make this straightforward. Present the higher of these percentages as Q11 (scan quality).
3. Filter the report text for polyp identification; calculate the number of studies with study codes C2, C3a, C3b, C4a, C4b, C5a or C5b (that is, all categories except C1 and C3a). Again this is most efficiently done using spreadsheet text filters. Present this percentage as Q12 (6 mm+ PIR).
4. Cross-reference the list of all CTCs against the endoscopy database for endoscopic procedures occurring within six months of CTC. Present this percentage as Q13 (subsequent endoscopy rate).
5. For the list of patients with polyps, found from number 3 in this list, determine which of these patients had subsequent endoscopy, found in 4 of this list. Examine the endoscopy reports for these patients for the presence/absence of a 4 mm+ polyp or cancer. Present this percentage as Q14 (PPV).
6. From a consecutive sample of 100 CTC studies from the list generated for point 1 of this list, return to the RIS and extract the radiation dose (DLP) for each of these 100 studies. Calculate the mean and median. Present the mean as Q16 (radiation dose).
7. From the list generated in point 1 of this list, calculate the number of CTC studies interpreted by each radiologist in the service. Present this as Q18 (ongoing experience of radiologists).
8. From the CTC structured reports extracted in point 1 of this list, filter for cases reported as C5a or C5b (cancer diagnosed). Determine from the PACS what percentage of these patients had same-day staging. Present this as Q19 (same-day staging).
9. From the CTC structured reports, determine the number of CTC studies with a third acquisition. Present this percentage as Q110 (additional acquisition rate).

The remaining quality indicators (Q15: Interpretation time; Q17: Radiologist training; Q111: PICRC-36 monitoring; Q112: Patient experience; Q113: Perforation rate) should be

accumulated separately and, with the exception of patient experience, are monitored continuously rather than via periodic audit.

The principles are the same if a reporting template is not used; however, it is considerably more time-consuming and requires significant effort to manually trawl through report text and determine (for example) whether or not a polyp was found.

An example summary 'report card' of how these metrics might be presented to internal governance committees or service commissioners is provided on the following pages.

Table 6.

	Quality indicator	Minimum standard	Aspirational target	This service	Data period	Changes implemented	Next audit due
1	Percentage of scans rated with diagnostic quality of adequate or better (unadjusted)	95%	98%	94%	2017–2019	Increased dose of faecal tagging	2021
2	6 mm+ polyp identification rate (PIR) – that is polyps identified at CTC	13%	16%	15% (service) R1 = 17% R2 = 13% R3 = 13% R4 = 14% R5 = 16%	2017–2019	None	2021
3	Positive predictive value (PPV)	80%	90%	78% (service) R1 = 75% R2 = 88% R3 = 82% R4 = 79% R5 = 76%	2017–2019	Increased dose of faecal tagging	2021
4	Subsequent endoscopy rate	<25%	n/a	16%	2017–2019	None	2021
5	Radiation dose (DLP)	Median of <950 mGy.cm	Median of <600 mGy.cm	BCSP: 661 (mean) and 612 (median) Non-BCSP: 787 (mean) and 753 (median)	2019	None	2021
6	Proportion of CTCs showing cancer in which same-day staging chest CT is performed	50%	80%	23%	2017–2019	Radiographer training Named consultant supervisor per list	2021

	Quality indicator	Minimum standard	Aspirational target	This service	Data period	Changes implemented	Next audit due
7	Interpretation time (for negative examinations)	Mean of ≥20 mins	Mean of ≥25 minutes	Job planned vs unit activity	2018 to date	None	2020
8	Number of CTCs interpreted by new radiologists before independent practice	175	300	All >300	2018 to date	None	When new consultant starts
9	Number of CTCs per radiologist per annum on an ongoing basis	100	175	R1 = 221 R2 = 200 R3 = 101 R4 = 78 R5 = 212	2017–2019	R4 due to increase reporting time next year	2021
10	Additional (third or fourth imaging position) acquisition rate	Auditable outcome	n/a	11%	2017–2019	None	2021
11	Post-imaging colorectal cancer (PICRC) at three years	Auditable outcome	n/a	Two documented since 2016 (perceptual x2)	2016–2019	3D available on all workstations	Ongoing
12	Patient experience	Auditable outcome	n/a	See separate summary data	2019	None	2021
13	Perforation rate	Auditable outcome	n/a	Last in 2015	2015 to date	None	Ongoing

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