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Expert opinions and scientific evidence for colonoscopy key performance indicators

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ABSTRACT

Colonoscopy is a widely performed procedure with procedural volumes increasing annually throughout the world. Many procedures are now performed as part of colorectal cancer screening programmes. Colonoscopy should be of high quality and measures of this quality should be evidence based. New UK key performance indicators and quality assurance standards have been developed by a working group with consensus agreement on each standard reached. This paper reviews the scientific basis for each of the quality measures published in the UK standards.

INTRODUCTION

Colonoscopy is a widely performed procedure for patients with lower GI symptoms and is an integral part of all colorectal cancer (CRC) screening programmes, either primarily or secondarily following positive stool tests or other colonic imaging. There is evidence from randomised trials that faecal occult blood tests (guaiac faecal occult blood testing (FOBT)) and sigmoidoscopy[1–4] reduce CRC mortality in screening, but there is currently no evidence from randomised trials for screening colonoscopy.[5–7] Results from trials are expected in the 2020s.

It is fundamentally important that colonoscopy procedures are of the highest possible quality and that measures of quality are based upon evidence. Widely used quality measures include caecal intubation and adenoma detection rates (ADR) and these should be evaluated alongside other measures of quality. New UK key performance indicators (KPI) and quality assurance (QA) standards for colonoscopy have been developed by the British Society of Gastroenterology (BSG), the Joint Advisory Group for GI Endoscopy and the Association of Coloproctology of Great Britain and Ireland and are published in this edition of *Gut*.[8] The evidence presented in this review paper is taken from the development of these guidelines and from data review performed for the recently published German guidelines on quality standards in GI endoscopy.[9] While colonoscopy is crucial in the detection and prevention of CRC, this will only be the case if procedures are performed to high standards. In the UK, a 2012 national audit[10] demonstrated a significant improvement in colonoscopy completion rates when compared with a previous 1999 audit, it also showed that wide variation still existed between centres and endoscopists.[10 11] While colonoscopy can detect CRC and prevent it by removal of adenomas,[12] it can also lead to serious complications and quality measures should ensure that these are minimised.[13–16] Additionally, poor quality colonoscopy is associated with increased rates of interval cancers.[17 18] A major challenge is to deliver high quality colonoscopy in the setting of ever-increasing demand and activity. England has seen a 20% increase in colonoscopy activity over the last 5 years with 360 000 procedures performed annually.[19] In the USA, 14 million colonoscopies are performed per year,[20] with a significant percentage being primary screening colonoscopies as opposed to colonoscopies performed after positive FOBT screening in countries such as in the UK. Added pressures of new screening programmes have involved a significant increase in workload in the UK and throughout the world.[1 21 22]

A major variable for assessing quality of all colonoscopy is the rate of interval cancers. For screening colonoscopy this is the most important marker of quality. Interval cancers may occur in individuals screened by another modality such as FOBT, therefore in order to differentiate interval cancers in patients who have undergone colonoscopy and those screened by another means, the term postcolonoscopy colorectal cancer (PCCRC) has been developed.[23] PCCRC rates will become the gold standard in studies assessing surrogate quality variables such as ADR (the rate of procedures where at least one adenoma was detected). The term PCCRC has been used in this review where that is the measure reported in a study but the term interval cancer has been used where the data do not specifically report postprocedural cancers.

METHODS

In this paper, we review the importance of each of the UK KPI and QA standards and the evidence behind them. The aim of this paper is to provide supporting evidence for these new indicators and standards, and to demonstrate the value and importance of each of the measures. Each measure is addressed in turn including caecal intubation rate (CIR), ADR, bowel preparation, rectal retroflexion, withdrawal time, sedation practice and comfort levels, annual procedure volumes, polyp retrieval rate (PRR), management of suspected malignant lesions including tattooing of lesions, follow-up recommendations and adherence, diagnostic biopsy rate, PCCRC rate and adverse event rates.

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It should be borne in mind that much of the data on colonoscopy quality have been derived from the screening setting, and may not be automatically transferrable to diagnostic colonoscopy. The UK standards[8] were developed by a working group where individuals were tasked with reviewing evidence in each area and then standards agreed by consensus of all working group stakeholders. The balance was often struck between available evidence and expert opinion and pragmatism. The German standards[9] were also developed by a working group forming a consensus on the standards.

It is important that a systematic approach is developed regarding the implementation and monitoring of standards. Endoscopy programmes and units have the responsibility for QA and they should develop QA strategies for investigating and monitoring potential underperformance. Graphical representation, for example in the form of funnel plots,[24] allows evaluation of performance around a mean and helps measure performance where the numbers of procedures vary and where some individuals may be performing low numbers of procedures. Where performance appears to fall below agreed standards then investigation should ensure that confounders such as case mix, age and gender of patients are taken into consideration. In addition, the nature of procedures should be considered, for example, complications maybe higher where advanced therapy is undertaken. Monitoring of quality should be a continuous process and early identification of deteriorating performance prior to individuals falling below lower confidence limits is preferable. Where true underperformance is identified, however, strategies to address this should be put in place.

THE STANDARDS

Caecal intubation rate

CIR is the most frequently used indicator of colonoscopy quality.[25–28] It is self-evident that complete examination of the large bowel is essential to detect abnormalities,[29 30] however, CIR varies as demonstrated in a number of studies.[11 31 32] Although CRCs are more commonly found in the distal colon (61.5%), 32.7% were found proximal to the splenic flexure, with 15% identified in the caecum or appendix, highlighting the need for complete examination of the colon.[33] Previous work has demonstrated higher PCCRC rates in endoscopists with a lower CIR,[34] and in colonoscopies which were incomplete.[35] PCCRCs were more commonly identified in the right side of the colon.[35] A Canadian database analysis of 1260 PCCRCs showed that endoscopists with high caecal intubation rates and those with higher polypectomy rates had significantly lower rates of PCCRC during follow-up.[34] On the other hand, there is limited evidence with respect to the correlation of caecal intubation and ADR with conflicting results reported.[36 37] However, it can be speculated that lower caecal intubation rates and/or insufficient caecal visualisation may be some of the major reasons for the higher rate of proximal PCCRCs demonstrated in several studies (see online supplementary table S1).

A 2011 UK audit of all colonoscopies performed in a 2 week period demonstrated an unadjusted CIR of 92.3%, rising to 95.8% following adjustment for impassable strictures and poor bowel preparation.[10] This was a significant improvement from a previous audit in 1999, which demonstrated a CIR of 76.9%.[11] This improvement was achieved following introduction of a national training programme and a national emphasis on improving quality. These improvements are also demonstrated elsewhere in the UK in both general endoscopy units and within the Bowel Cancer Screening Programme (BCSP), with unadjusted CIR of 92.5%[38] and 95.2%,[36] respectively. These large series demonstrate that caecal intubation rates >90% can be readily achieved. The American Society for GI Endoscopy (ASGE)/American College of Gastroenterology (ACG) taskforce for colonoscopy sets a similar standard for diagnostic procedures.[28] A CIR of 95% is recommended by the European Society of GI Endoscopy (ESGE) and the ASGE/ACG for screening colonoscopies.[28 39] Reporting of caecal intubation rates may be presented in a non-adjusted form based upon CIR in all patients where the intention was to reach the caecum, or be adjusted for factors such as impassable strictures and poor bowel preparation. Different studies adjust for different factors and this must be borne in mind when comparing different studies (see online supplementary table S2).[31 32 40–46] It may be assumed that in the screening setting (as opposed to the symptomatic service), a lower rate of poorly prepared colons and strictures will be found, therefore the recommended higher rate for screening versus diagnostic colonoscopy (95% vs 90%) seems to be justified. The European Union (EU) guidelines on the quality of colonoscopy as part of CRC screening demand a minimum CIR of at least 90%, and suggest a rate of 95% is desirable.[23]

Regarding documentation of caecal intubation, the EU guidelines[47] recommend 'auditable photodocumentation of completion', as do American guidelines,[26] but reported practice varies from 50% in the UK[10] to 70%–99% in other parts of Europe.[48 49] The reliability of photodocumentation of the caecum in demonstrating completion has been questioned with ileal photodocumentation advocated as more accurate.[50] Biopsy of the ileum may additionally be useful in confirming completion but can be technically difficult, comes with extra costs and has some associated risks, so it is not recommended as a standard of practice.[51–53]

Adenoma detection rate

Most CRCs develop through the adenoma-carcinoma sequence.[54] Detection and removal of these adenomas therefore reduces CRC risk. Screening flexible sigmoidoscopy has been repeatedly demonstrated to reduce CRC incidence and mortality,[5] so it is likely that results can be extrapolated to colonoscopy.

The ADR is currently considered the most reliable surrogate marker of PCCRC and is therefore widely used as a marker of colonoscopy quality.[37] A lower ADR is associated with higher rates of PCCRC,[17] as demonstrated by data from the Polish bowel cancer screening programme and a US study. In the Polish study, colonoscopists with an ADR <20% had a hazard ration (HR) for PCCRC that was 10 times higher than colonoscopists with an ADR ≥20% (absolute risk 0.011% when ADR ≥20% vs 0.115% when ADR <20%).[17] An inverse relationship between ADR and PCCRC rate (and for advanced stage cancer and cancer mortality) has also been demonstrated in a study of over 300 000 screening, surveillance or diagnostic colonoscopies, performed by 136 colonoscopists in the USA.[18] Each 1% increase in ADR was associated with a 3% decrease in the risk of PCCRC. The latter study suggested that there may be no upper cut-off limit for ADR, but elements of that study should be considered. The study was based on a medical insurance database (Kaiser Permanente) and included both screening and diagnostic colonoscopies. Follow-up information from the insurance database was available in only 2/3 of cases and the range of average number of annual colonoscopies per examiner included was wide (27–461), with those undertaking low numbers included. This raises the question as to whether all colonoscopies per examiner were available for the analysis, or whether some endoscopists had also performed examinations for other

insurance providers. It is therefore possible that the ADR in the Kaiser-Permanente database may not completely reflect endoscopists' true ADR.

Both the Polish and US paper are based upon ADR. Other measures of adenoma detection may also be important, for example, the rate of advanced adenoma detection (AADR, those adenomas ≥10 mm in size, or with villous components or high-grade dysplasia),[55] as advanced adenomas may be more relevant for cancer prevention if detected and removed. The correlation of ADR with AADR seems to yield variable results; a US study including 1933 colonoscopies from 14 colonoscopists showed substantial variations in both ADR and AADR, but no correlation between them.[55] It may well be that a high ADR mainly reflects a high detection rate of mainly small and potentially innocuous adenomas, as recently shown by an analysis of a continuing ADR rise over the years within the German screening programme.[56] The role of sessile serrated polyps (SSP) as precursors for CRC is an area of growing knowledge and importance and as evidence for their incidence becomes more robust.[57] In the future, it may be important to consider the detection of SSPs as a marker of quality.

While ADR is clearly important, variations on this measure of number of adenomas detected may also be developed to gain further insight into colonoscopy quality. ADR reflects the findings of at least one adenoma in an individual but it does not measure the number of adenomas detected in a given individual and it is important that all the adenomas within that individual are found. Mean adenomas per procedure (MAP, the total number of adenomas detected divided by the total number of procedures) and mean adenomas per positive procedures (MAP +, the total number of adenomas detected divided by the number of procedures with at least one adenoma detected) were calculated for 36 000 colonoscopies performed by 177 colonoscopists within the BCSP[36] and demonstrated that some endoscopists detect more adenomas on average per procedure. These quality measures may be a better representation of the performance of an individual in detecting adenomas and may be valuable if used as a feedback measure to allow endoscopists to evaluate their own practice, however, clear correlation with PCCRC rates are not yet available.

One drawback of measuring ADR is that it is dependent on obtaining histology results following the procedure. This requires interrogation of pathology databases to obtain polyp histology, which can be time consuming. The polyp detection rate (PDR) is often simpler to obtain as most electronic endoscopy reporting software calculates it automatically. The relationship between the ADR and PDR has been studied both in the UK and the USA, in screening and symptomatic populations,[58–60] and PDR has been demonstrated to reliably estimate the ADR. ADR is the key performance measure but where it can be demonstrated that a ratio between an endoscopist's PDR and ADR has been developed and validated, then PDR may be an acceptable marker, with ongoing review of the validity of PDR to represent ADR required. However, it should be noted that PDR can be manipulated by endoscopists more easily than ADR. Polypectomy rate may be more reliable than PDR and less susceptible to gaming, and higher polypectomy rates have been shown to correlate with lower proximal PCCRC rates.[34]

ADR varies between observers, centres, cohorts of patients and even within procedures on the same person. One systematic review looked at six studies in which participants underwent tandem (same day) colonoscopies.[61] Miss rates for all polyps and adenomas were 21% and 22%, respectively. A recent UK study demonstrated wide variation in ADR with a global ADR of 15.9%,[24] although this study included patients of all ages and only those colonoscoped for symptoms (most commonly diarrhoea, iron deficiency anaemia and rectal bleeding). An overview of studies focusing on the factors influencing ADR is shown in online supplementary table S3.[40 43 62–68]

ADR measurements and comparisons are most relevant in screening populations, where the reason for the procedure is consistent and allows for the age of the screening population and the screening modality used. It should be remembered that expected ADR will differ between primary colonoscopy screening, colonoscopy after positive FOBT or faecal immunochemical test (FIT) and colonoscopy within the symptomatic population. ADR may vary for other indications with an overview given in online supplementary table S4.[69–81] It is important that these are considered when setting a standard.

Many methods to attempt to improve ADR have been developed. These include training, endoscopic devices, medication, position change and non-procedural aspects such as scheduling. Detailed discussion of these measures is beyond the scope of this review paper, however, we have provided a brief summary of these methods.

Training: A randomised controlled trial (RCT) in Poland revealed that dedicated training of screening centre leaders has led to a sustained effect on colonoscopy performance among leaders themselves and members of the unit as measured by ADR, proximal ADR and non-polypoid lesion detection rate.[82]

Colonoscope factors (high definition colonoscopes, image processing): The use of high definition colonoscopes does not seem to result in increased ADR.[83–89] One cohort study demonstrated an increase in the number of non-flat polyps >6 mm in size when high definition colonoscopes were used.[84] Another study suggested a 4.5% increase in ADR, but this retrospective review did not adjust for confounding factors.[90] Image processing ('virtual chromoendoscopy', where narrow spectra of light are isolated to enhance mucosal visualisation, or postcapture treatment of the image) is incorporated in modern endoscopes such as narrow band imaging (NBI)[91–96] or Fujinon intelligent chromoendoscopy,[94] or both,[97] or autofluorescence imaging (AFI). Some smaller studies have reported positive results,[98 99] but these findings were not confirmed by others,[100] and a Cochrane review of NBI found no evidence for an improvement in ADR over standard endoscopy.[93] For AFI, no large RCTs are yet available. Widening and altering the angle of view has been studied. No improvement was seen with moderate increases from 140° to 170°, but may be demonstrated with colonoscopes with forward plus side viewing optics. Retroflexion of the scope in the colonic lumen, mostly in the proximal colon, increased ADR or decreased adenoma miss rate by 2%–4.5% in most,[101–103] but not all, studies.[104] It is not superior to tandem examination of the right colon,[105 106] which may be an alternative to be discussed.

Chromoendoscopy: Whether, as stated in the most recent and largest meta-analysis,[94] conventional chromoendoscopy really has a positive effect on ADR remains doubtful, since this mostly refers to small adenomas, and two of the nine studies analysed were in the setting of IBD. Adding stains to colon preparation fluids, or the administration of oral methylene blue tablets is currently under investigation.[107]

Antispasmodics: Antispasmodic medications such as hyoscine butylbromide and glucagon have been used to improve mucosal views during colonoscopy by reducing the spasm of the colon. They have been shown to improve ease of insertion[108] and ileal intubation rates.[109 110] However, in terms of ADR, a consistent increase when antispasmodics are used has not been demonstrated in three meta-analyses.[111–113]

Position change: Changing patient position seems to slightly increase ADR,[114] especially if colonoscopy is difficult[115 116]; however again, results vary, with one recent randomised trial suggesting no improvement,[117] one suggesting an improvement in ADR distal to the hepatic flexure[118] and another suggesting that examining the right side of the colon in the left lateral position significantly improved ADR in the right colon.[119]

Mechanical methods: Methods such as the use of transparent caps or a balloon around the endoscope tip have been tested in numerous trials. Simple short (3–4 mm) caps at the colonoscope tip were not shown to increase ADR as demonstrated in all but one of six meta-analyses.[94 120–123] A Cochrane review concluded that while PDRs were increased with cap usage, there was not enough evidence for an increase in ADR.[121] Newer and longer caps with side flanges (such as the Endocuff, ARC Medical) increased ADR in two subsequent studies from the same group[124 125]; however, an RCT has shown an increase in the number of adenomas detected, but not in the overall ADR or MAP.[126] A transparent balloon around the colonoscope tip (NaviAid G-EYE) reduced adenoma miss rate in a small tandem study (n=126).[127 128] The so-called third eye endoscope (retrograde view via a small 'baby' endoscope introduced through the working channel) also increased ADR in a back-to-back study,[129–131] but is not in common usage.

Scheduling: Some studies suggest ADR is higher in morning procedures than in afternoon colonoscopies,[132–134] but this is not backed up by other studies.[135–137] No variation between weekdays is demonstrated.[138] In part, this is likely partially related to the bowel preparation quality.[139]

Bowel preparation

Good quality bowel preparation is required in order to perform high quality colonoscopy. Poor preparation has been associated with incomplete tests,[140] prolonged procedure time[141] and with reduced yield.[142] Evidence in the UK from the national colonoscopy audit[10] showed that 22% of failed colonoscopies were due to poor bowel preparation. While no significant difference in large polyps (those >9 mm in size) and cancer detection has been demonstrated related to bowel preparation, a significant difference in detection of smaller polyps and flat lesions has been demonstrated.[143] PCCRC rates have been suggested to be higher in those with inadequate bowel preparation,[144] although this may be multifactorial.

A number of different scoring systems for bowel preparation are used making comparison difficult. At least five validated bowel preparation scales exist[128 145–148]; all involve relatively complex scoring systems and not all are in common usage. The UK BCSP uses a 4-point scale: excellent, adequate, complete despite poor preparation or failed due to poor preparation.[149] The ASGE guidelines do not suggest a preferred system for grading bowel preparation, and the ESGE guidance for screening colonoscopy does not recommend a specific system, but suggests that one system should be used across all providers in order to standardise reporting.[39] It is also important to be clear at what point a score is given. Ideally, it should be given following attempts to clean the colon with washing and suction via the colonoscope.

Although scales have a number of levels, the only consistent differences found in diagnostic rates were between preparation rated as good or poor. Little additional benefit of multiple point scales were found with no additional ADR differences between excellent, good and moderate bowel preparation scores.[62 66 141 150 151] The most widely used scale, the Boston Bowel Preparation Scale,[147 152] demonstrated a correlation with ADR where preparation was rated as perfect,[153] although this was not confirmed in another recent study.[154] No studies directly correlating preparation with PCCRC are available.

Despite the above limitations of scoring systems, it is self-evident that optimal bowel preparation contributes to the success of colonoscopy. Repeat procedures involve the waste of clinical resources as well as increasing risk and inconvenience to patients. The optimum bowel cleansing preparation should be effective, tolerable for the patient and be safe, without causing excessive shifts in electrolytes or water, and not affecting patient concomitant medication. It should also be safe for people with comorbidities. Multiple different regimens exist, with varying timings, volumes and preparation constituents. The lowest volume (and therefore often better tolerated) preparations contain sodium phosphate, but can cause electrolyte disturbances and as such are not suitable for patients with comorbidities. Fewer side effects are caused by polyethylene glycol (PEG) preparations, but large volumes (up to 4 L) are required, making the preparation less tolerable for patients. Different bowel preparation methods are reviewed in a recent American consensus document.[155] Furthermore, the type and timing the of the bowel cleansing agent is an important contributor to the quality of the bowel preparation; however, given the lack of evidence of one superior agent,[39] units should select their preferred agent based on local experience and any existing guidance from gastroenterology bodies (such as the BSG guidance on bowel preparation).[156]

An overview of the studies examining the correlation of bowel cleanliness and colonoscopy quality parameters is given in online supplementary table S5.[11 31 62 66 73 141 147 150 151 153 157 158]

Rectal examination and rectal retroflexion

Digital rectal examination (DRE) is recommended as a standard part of endoscopic examination of the lower GI tract. It allows examination of the anal canal and lower rectum for pathology, as well as preparing the anal canal for the insertion of the scope.[159] Anal pain or sphincter spasm may occasionally mean that it is difficult to perform a DRE; this may lead to consideration of the use of topical anaesthesia and a narrow scope. A comparison of DRE and rectal retroflexion showed that DRE was sensitive for detection of abnormalities in the lower rectum and upper anal canal that were subsequently demonstrated on retroflexion of the endoscope,[160] therefore, it should be routinely undertaken.

Retroflexion of the colonoscope in the rectum has long been recommended as a technique to allow adequate visualisation of the lower rectum and upper anal canal.[159] A number of studies have demonstrated increased detection of pathology by using retroflexion after standard views of the rectum have been obtained. Older studies of variable size (from n=75 to 1502, total 3600 patients), showed an increased detection rate of between 0.3% and 2% for adenomas.[161–164] Serious rectal injuries related to retroflexion leading to haemorrhage and perforation have infrequently been reported in the literature, mostly as case reports.[89 165–169] One large study of nearly 40 000 colonoscopies addressed this issue.[168] With four rectal perforations in the study group they estimate the risk to be 0.01%. Of these, three were successfully managed conservatively and one required surgical intervention. The risks and benefits of rectal retroflexion should be carefully considered. While the technique leads to an increased yield, it is not without risk. Therefore, it is essential that careful attention is paid to good technique and if resistance is encountered then the endoscopist should carefully consider the reasons for this and have a low threshold for discontinuing the retroflexion. If retroflexion is aborted then

careful antegrade inspection should be performed down to the dentate line.

Withdrawal time

Most mucosal inspection takes place during withdrawal of the endoscope from the caecum to the rectum and there is an association between ADR and colonoscopy withdrawal time (CWT)—that is, the length of time taken to remove the colonoscope once the caecum or terminal ileum has been reached. The CWT is calculated for each colonoscopist using cases where the investigation was normal (in order to remove the time taken to undertake therapy) then comparing it with ADR in all cases. Initial work demonstrated that a CWT of >6 min was associated with higher ADR,[170] and more recently longer times of 7 or 8 min have been advocated.[171 172] In a review of over 30 000 colonoscopies performed in an FOBT-positive screening population in the UK, a CWT of up to 11 min was associated with a higher ADR with no additional benefit beyond 11 min (ADR 43% with withdrawal 6 min or less, and 46.5% if >10 min).[173]

The relationship between CWT and ADR is likely to be complex, as not all studies support the increasing ADR with lengthening CWT.[174 175] Multiple factors are likely to be responsible for the superior ADR seen with longer CWT, such as time being taken to fully clean and inspect all folds and flexures,[176] suction pools of liquid and employ position changes[144] in order to optimise mucosal views. It should be noted that in at least some of the publications the analysis was retrospective. Prospective studies may allow for calculation of withdrawal time in all cases by stopping the clock for polypectomy, biopsy and other therapy.[177] Increasing CWT has led to conflicting results with regard to an increase in ADR.[171 175] A study in Berlin showed no relation between withdrawal time and ADR, but the range of CWT (6–11 min) was already above the 6 min proposed.[62] Other analyses from Norway and England showed that, using different cut-offs, longer withdrawal times led to higher ADR.[67 173 174] To recommend a specific cut-off such as 6 min is therefore only partially based on good scientific evidence. It may be for this reason that the recent EU guidelines have not published a specific withdrawal time recommendation.[23] The important issue remains that adequate time is taken for mucosal visualisation. It is unlikely that this can be achieved in <6 min, and will sometimes take considerably longer particularly if adequate mucosal views are difficult to achieve for example, with residual colonic fluid. CWT is a surrogate marker for ADR which, as has been outlined, is a surrogate marker for PCCRC; therefore, it is the effect of CWT on ADR that is more important than the CWT itself. An overview of the relevant studies is given in online supplementary table S6.[62 67 170–182]

Sedation practice and comfort levels

Sedation practice varies across centres and countries. The US and Australian practice tends towards deeper sedation (often using propofol), whereas across Europe, Asia and Africa sedation practice varies widely.[183] In the UK, the majority of colonoscopies are performed under conscious sedation (89%), with 10% unsedated, and <1% under propofol or general anaesthesia.[10] In the UK, propofol sedation may only be administered by an anaesthetist[184] and these logistics may limit its use. Elsewhere, propofol may be administered by the endoscopist, or by an anaesthetic technician. In Germany, a large study of almost 10 000 cases demonstrated low complication rates of propofol-supported colonoscopy (0.03% mask ventilation due to apnoea, 0.39% minor hypoxaemia (oxygen saturation <90%), 0.07% bradycardia, 0.24% hypotension, 0.03% perforation and 0.12% bleeding) and as such was felt to be safe and cost-effective.[185] However, a US cohort study demonstrated overall increased risk of complications after colonoscopy when anaesthesia was used, specifically with increased risk of perforation, bleeding, abdominal pain and complications of anaesthesia.[186] Safety recommendations for sedation dosages exist in some countries,[184 187] and the ESGE have produced a guideline on the use of propofol.[188]

The approach to sedation may have a strong cultural basis and maybe related to both patients' expectation and clinicians' usual practice. In some countries including Norway, unsedated colonoscopy is the practice in selected centres for >50% of cases. This can be achieved by good training and is well accepted by clinicians and patients.[189]

Sedation practice should be considered alongside comfort, as reduced sedation levels should not be at the expense of patient experience. Comfort levels are affected by many factors including technique and some evidence suggests that endoscopists performing better on other KPI also provide a more comfortable patient experience with less sedation.[190] A national audit[10] demonstrated that moderate or severe discomfort was experienced by approximately 10% of 20 000 cases recorded. Factors known to influence patient comfort include[191] diverticular disease; prior hysterectomy; when colonoscopy was preceded by gastroscopy; female sex; anxiety; irritable bowel and where discomfort was anticipated.

Several systems for scoring patient comfort exist, such as the Gloucester nurse-reported 5-point scale,[190] which combines features of pain, frequency of pain and distress. Patient-reported comfort scores use either 4-point Likert scales or 100 mm visual analogue scales in lightly or unsedated patients.[191] Validation of scores is variable. One well-validated score exists: the Nurse Assessed Patient Comfort Score, an international study[192] in which 300 patients undergoing colonoscopy and their endoscopy nurses rated comfort levels. Even in this validated scoring system, there was discrepancy between the patient-reported levels of comfort and the clinician-reported levels, with lower levels of comfort reported by patients. This has been demonstrated in other studies,[193] and as yet, no patient-derived, validated measures of patient experience of endoscopy exist. It is becoming increasingly recognised that patient experience needs to be optimised primarily to make the procedures tolerable for patients, but also to ensure that procedures are complete, and to optimise attendance for screening and surveillance procedures.[194–196] It should be mentioned that data on the influence of sedation on ADR are not homogeneous, but most to date do not show any correlation.[197–200]

The method used to distend the colon may influence patient comfort during and after colonoscopy. Use of CO_2 to insufflate the colon has been studied extensively and repeatedly demonstrated to improve patient comfort.[39] There are few subjects researched in endoscopy research where agreement is repeatedly reached in all randomised trials regardless of country and settings,[201 202] but the method used to distend the bowel is one such subject. The main effect is on abdominal pain experienced on the day of colonoscopy; this is summarised in three meta-analyses.[203–205] Possible restrictions of CO_2 use in patients with chronic obstructive pulmonary disease (COPD) are not well studied, and capnographic measurements in patients without COPD did not show significant CO_2 increases.[206–208] A Japanese study on colorectal endoscopic submucosal dissection (ESD) in 77 patients with COPD could not detect any differences versus controls.[209] Water-aided colonoscopy (either with water immersion or water exchange) has also been demonstrated

to significantly reduce pain levels when compared with air insufflation.[210]

Number of colonoscopies performed per year

Competency may be affected by the learning curve of colonoscopy, ongoing number of procedures and lifetime experience. There is considerably more literature on acquisition of competency and the learning curve than on minimal numbers for established practitioners. The most usually studied marker of trainee competency is CIR. In the UK, 200 colonoscopies are currently required before provisional competency can be assessed and 300 procedures for full competency,[211] compared with 140 for colorectal surgery and gastroenterology trainees in the USA.[212] A recent study[213] demonstrated that competency (based on a CIR of 90%) was reached by 233 procedures. Other studies suggest similar procedure numbers required to reach competency, with figures between 150 and 600 reported[214–222]; the data are summarised in a recent review.[221] A study from Harvard showed ADR increases between 50 and 100 colonoscopies, with no further rise thereafter.[180] Similarly, another study observing 11 fellows demonstrated increases in CIR and a decrease of examination times between years 1 and 3, but no change in ADR between years of training.[220] It could be speculated that endoscopists in training may be more attentive,[223] with possibly a shorter learning curve for adenoma detection. In a small study in the Netherlands, it was demonstrated that ADR during training varied widely and correlated to ADR when the individual became a consultant.[224]

Maintaining competence requires ongoing experience, but is much less well studied. It has been suggested that at least 100 procedures per year is the minimum required,[155 225] with some suggesting an even higher volume of 200–300 may be necessary.[225] Other markers of competence such as ADR do not appear to correlate well with procedural numbers.[62] In general, training studies mostly use CIR, however, studies on maintenance of competence have explored ADR.

It is likely that prior experience and annual case volume may be complementary at least with regard to ADR as a quality parameter. A US study showed that for endoscopists with experience of up to 5 years, case volume was correlated with ADR (92.5% for >200 vs 88.5% for <200 annual colonoscopies), while this effect could not be shown in endoscopists with longer colonoscopy practice and experience.[225] Another study showed the highest ADR in the middle groups of case number quintiles as compared with colleagues with very few or many colonoscopies.[226] A study from Berlin showed no influence of case volume on ADR.[62] With regard to colonoscopy completeness, online supplementary table S3 shows that results vary with case volume demonstrating no,[32] a positive,[46] or even a negative influence.[43] In one Canadian study, case volume was correlated with complication rates,[16] which were increased in physicians with very low case volumes.

The current EU guidelines on quality of CRC screening set the cut-off for annual colonoscopy volume at 300.[23] However, this number can be debated with differing programmes proposing different levels. The correlation of case numbers and complication rates stems from two Canadian studies[16 227]; one was a databank analysis of 97 091 outpatient colonoscopies from several Canadian provinces, which did not distinguish between diagnostic and therapeutic colonoscopy for which bleeding and perforation rates may be quite different.[16] The second study was a retrospective data analysis of 24 509 examinations including 13% undergoing sigmoidoscopy. Endoscopists with annual case volume <200 procedures had twice the complication rate. This study did not include a multivariate analysis.[227] Agreement on the exact minimal numbers per year can be debated and in the UK a minimum of 100 procedures per annum has been agreed.

Polyp removal, retrieval and histological analysis

After a polyp has been removed, it is currently necessary to retrieve it for histological assessment. Polyps ≥1 cm diameter have an increased probability of advanced features (high-grade dysplasia, villous components or cancer).[228] Polyps <1 cm less frequently (but still potentially)[54] contain these features, and do still require retrieval. Histology of polyps is used to calculate surveillance intervals based on adenoma numbers[229–231] and in some countries numbers of serrated polyps. Polyp retrieval is also considered a reflection of the technical skill and application of the colonoscopist. Studies have shown no difference in the success rates of methods of polyp retrieval (eg, suction,[232] Roth nets[233]) with some techniques limited by polyp size. The recommended PRRs are ≥90% in the UK and ≥95% in the USA.[26 234 235]

In the future, endoscopic visual assessment of polyps in vivo using enhanced imaging modalities may allow accurate optical identification of adenomatous polyps, which then will not require histological review, reducing histopathology workload.[236] This so-called Detect InSpect Characterise Resect And Discard (DISCARD) strategy—mainly for polyps ≤5 mm—has been summarised in multiple reviews and meta-analyses,[237–241] and in a recent ASGE recommendation update.[242] This review shows that almost all endoscopic techniques seem to reach high accuracy rates in endoscopic polyp differential diagnosis, mainly based on studies from expert centres.[86 243 244] The Preservation and Incorporation of Valuable Endoscopic Innovations (PIVI) statement issued by the ASGE has issued advice on acceptable performance thresholds for real-time endoscopic assessment of diminutive polyps required before optical diagnosis should be recommended for routine clinical practice.[245] The PIVI statement advises that optical diagnosis can be used for diminutive (1–5 mm) and histological diagnosis for small (6–9 mm) polyps and those summated results used to determine surveillance. Under routine conditions in non-expert centres, such a differential diagnosis does not seem to work,[204 244 246 247] as recently confirmed in a large multicentre UK trial, which indicated that a DISCARD policy was not yet generalisable to routine clinical settings.[248] A further difficulty for polyp differential diagnosis is the increasing focus on sessile serrated adenomas (SSA).[249–251] Their endoscopic detection and histopathological confirmation varies considerably, particularly with regard to the differential between SSA and hyperplastic polyps,[252 253] with substantial rates of reclassification of hyperplastic polyps as SSA on second opinion.[249 254–256] There is also substantial interobserver variability in the histological diagnosis.[249 257 258] New endoscopic assessments[259] and classifications are underway.[260] Given this evidence, further work is required to define the role of a DISCARD strategy in routine clinical practice.

Completeness of resection is another potential quality indicator that would require both endoscopic and histopathological data. Since several factors impede a reliable histological assessment (piecemeal resection by forceps or snare, damage from thermal therapy), this has not been introduced into routine quality parameters. Endoscopic visual assessment of completeness of resection is often said to need improvement.[261]

Management of suspected malignant lesions and those not suitable for endoscopic resection

As polyps increase in size the risk that they harbour cancer increases, with malignant change found in 2.2%, 18.7% and

42.7% of polyps of size 6–15 mm, 16–25 mm and 26–35 mm, respectively.[262] Submucosal invasion was found in 7.8% of polyps ≥2 cm in size on a large meta-analysis,[263] and higher rates of submucosal invasion are found in laterally spreading tumours, particularly the non-granular type.[264] Current UK and American guidelines suggest all polyps ≥2 cm in size should have a tattoo placed nearby to mark their location. Lesions <2 cm in diameter should be carefully inspected, and potentially have their site marked if they have high-risk features.[265] This also applies to small, subcentimetre polyps that, as described recently, may also have distinctive malignant features. In such instances, polyps should be resected with care, ensuring completeness using very careful injection technique.[266]

The decision as to whether a lesion is amenable to resection may be influenced by physician interpretation and experience.[267] Polyps may appear unresectable due to features suggesting malignancy or technical factors impeding polypectomy such as location, size and polyp characteristics. Different endoscopists with different skill levels may have different views. Assessment of malignancy is difficult with many endoscopic studies using different classification systems.[103 268–270] There are two major polyp classification systems. The Paris classification[268] is based upon polyp shape and relationship to the surrounding mucosa and reflects the morphology of lesions. The Kudo classification[269] based on the pit pattern on the surface of the polyp is very important in indication of malignancy. The Japanese literature mostly involves the combined assessment of 'mucosal' (high-grade dysplastic) and submucosally invasive cancers. There are limited Western data. A large Australian polyp study (n=479) identified the following univariate risk factors for invasive cancer: Paris classification 0–IIa+IIc, morphology (non-granular surface) and Kudo pit pattern type V.[271] In this study, 31.8% of the 22 Paris type IIc or IIa+IIc lesions, 15.3% of the 98 non-granular lesions and 56% of the 25 Kudo type V polyps had malignant histology equivalent to invasive cancer; and should serve as a reminder to consider invasive cancer within these lesions.[271] Although not done in this study, Kudo type V is ideally substratified to Vn (may be high-grade dysplasia only) and Vi which is more closely correlated to submucosal invasive disease. The recently developed National Institute for Health and Care Excellence classification, which uses enhanced optical imaging techniques to evaluate lesions, showed high levels of accuracy in predicting submucosal invasion.[272] Studies to date have involved image analysis and not yet in vivo endoscopic diagnosis. As such, making a prediction about the presence of invasive malignancy in polyps should be based on an assessment of both polyp morphology (such as the Paris classification) as well as microscopic features (such as pit pattern or NBI vascular pattern). The 'non-lifting sign' may indicate the possibility of malignancy and submucosal invasion,[273 274] but not reliably so. It is important to differentiate a true non-lifting sign in a polyp where removal has not been previously attempted as compared with non-lifting related to scaring from previous attempted polypectomy. There may be other technical reasons making benign polyps difficult to resect and the 'non-lifting sign'[273 275] may again be important,[273 274] indicating expected technical difficulties during resection.[271] The differentiation between technically and clinically meaningful endoscopic resectability of a given colonic polyp therefore rests on the combined macroscopic and possibly histological assessment but evidence varies. Assessment of resectability correlates with the experience of the examiner. It has been shown that some polyps deemed not to be resectable by one endoscopist may be resected when referred to expert centres,[276–281] so automatic referral of these patients to surgery does not seem to be justified. In these expert centres, around 10% of patients ultimately undergo surgery for different reasons.[282 283] Thus, patients with complex polyps should be assessed in centres with full surgical back up, where a minimally invasive endoscopic resection may still be possible. Use of complex polyp multidisciplinary team meetings for such polyps may be beneficial when deciding upon their management.[267]

A complex question relates to which resection technique should be applied to lesions where there is a suspicion of malignancy and this is also limited by difficulty in endoscopic diagnosis of malignancy. The techniques most widely used are endoscopic mucosal resection (EMR) or en bloc endscopic submucosal dissection (ESD). Detailed discussion is beyond the scope of this review; however, recent studies show an overall success rate of EMR of over 90%,[271 284] but at the cost of repeated colonoscopies for treating remnant or recurrent lesions. ESD on the other hand appears to be complex and associated with a higher complication rate, with excellent midterm results in studies from the Far East.[285–298] The main limitations of these data are that simple adenomas, adenomas with high-grade dysplasia (often referred to as mucosal cancers) and invasive cancers are mixed together. Separate results for submucosal cancers are only rarely shown in detail, and if so, at least in Western studies, a high rate of secondary surgery is reported.[289 290] Long-term outcomes of patients undergoing endoscopic management of submucosal invasive CRCs are now beginning to emerge. In those with low risk features (negative vertical resection margins, well or moderately differentiated adenocarcinoma, lack of lymphovascular invasion and an invasion depth of <1000 μm), the recurrence rate at 5 years was 0.8% vs 6.6% (p<0.05) in those who lacked these features.[299] It has also been shown that in those with high risk features, the risk of local recurrence was significantly higher in submucosal rectal cancers than in submucosal colon cancers.[300] It is also now known that the risk of lymph node metastasis of T1 cancers is around 10%,[301] and can be predicted by the presence of unfavourable histological findings (lymphatic invasion, budding, submucosal invasion ≥1 mm and poor histological differentiation).[302] Data such as these will inform decision-making at polyp multidisciplinary team meetings, particularly decisions regarding additional surgery.

Tattooing of the mucosa adjacent to all suspected malignant lesions and resection sites of polyps ≥2 cm (other than those in the lower rectum and those proximal to the ileocaecal valve where landmarks are clear) allows optimal localisation of lesions for further endoscopic assessment or surgical resection[303] and promotes accurate endoscopic surveillance postpolypectomy. This technique was first described in the 1970s.[304] To minimise the risk of injecting the marker through the mucosal wall into the peritoneum and causing a localised inflammatory reaction,[305 306] a two-step method where a bleb of saline is raised just below the mucosal layer and then indelible marker injected into this fluid should be used.[307] There is however a caveat; regular tattooing of all lesions deemed to be unresectable may make subsequent endoscopic resection (as already discussed in this section) more difficult because of scarring and fibrosis at the base of the lesion, so tattoos should not be placed too close to the lesion.

Follow-up recommendations and adherence

A number of detailed recommendations for follow-up colonoscopy after polypectomy of adenomas exist. These are based upon the number, size and histology of polyps.[229 230 308] From a QA standpoint, adherence to surveillance intervals should be

considered among important quality indicators; a high ADR can be neutralised by poor quality polypectomy and also by poor adherence to follow-up guidelines. This may be also the reason why some studies from Norway and France have not shown any positive effect of polypectomy on decreasing CRC rates. In Norway, follow-up recommendations were 10 years for advanced adenomas, and perhaps therefore, these patients had a higher CRC risk than the normal population; on the other hand, there was no follow-up recommended in smaller (non-advanced) adenomas, and paradoxically, these patients had a lower CRC risk.[309] A French follow-up study after polypectomy within the national screening programme (FOBT followed by colonoscopy if positive) also showed an increased mortality from CRC (standardised incidence ratio 1.26), but this correlated with adherence to follow-up examinations. Patients with follow-up compliance had a lower risk (1.10 vs 4.26).[310] Whether follow-up should be more strictly adhered to or intensified in certain patients with certain adenomas is a very important clinical question and several studies of the value and interval of surveillance are underway.[311–313]

Diagnostic biopsies for unexplained diarrhoea

A macroscopically normal examination does not exclude all causes of diarrhoea. A study of 809 cases found clinically relevant abnormalities in 15% of cases.[314] In this study, the most common diagnosis was microscopic colitis (80 cases, 10%), including lymphocytic and collagenous colitis.[315] The European Microscopic Colitis Group[316] reports the incidence as similar to that of classical IBD.

Some studies, however, suggest that the majority of causes of diarrhoea can be identified within the range of a flexible sigmoidoscopy.[314] As such, rectal biopsies alone may be sufficient to diagnose or exclude microscopic colitis, particularly in patients under 45 years, where the diagnostic yield of flexible sigmoidoscopy is not significantly different to that of colonoscopy.[317] Other data exist suggesting that changes in the large bowel mucosa may be patchy, and as such, left-sided and right-sided colonic biopsies should be taken for diagnosis.[318–321] However, the cost-effectiveness of this policy has been questioned.[322] Local policies on biopsy for unexplained diarrhoea should be developed.

Postcolonoscopy colorectal cancer rate

As previously stated, PCCRC, also called colonoscopy interval cancer, is a CRC diagnosed after a colorectal screening examination or test in which no cancer is detected, and before the date of the next recommended examination.[323] PCCRCs may represent a missed cancer, a cancer arising in a missed or incompletely treated adenoma, or a cancer that started to develop after the colonoscopy. PCCRCs are potentially the most important markers of colonoscopy quality but due to their relative rarity and the time delay to diagnosis, PCCRC rates are difficult to measure and interpret.[324]

Online supplementary table S1 provides an overview of studies looking into PCCRCs and explores influencing factors.[17 18 29 30 325–338] It should be noted that almost all these studies are based on retrospective analyses of large databases and the quality of these may vary. A recent study with careful investigation of each case showed that in an institutional database including 43 661 colonoscopies, 21 of 45 cancers reported as interval cancers database were found to be incorrectly recorded due to administrative errors.[339]

Several studies have described PCCRC rates, with wide variation from 0% to 9% (online supplementary table S1).[34] Study design and definition of PCCRC in terms of time intervals varies between studies, making comparison difficult.[340] One study demonstrated an overall PCCRC rate of 8.5% (in patients diagnosed with CRC who underwent colonoscopy within 3 years prior to cancer diagnosis), but also suggested that these rates have been declining with time, from 10.6% in 2001 to 6.8% in 2008.[324] More recently, it has been demonstrated that a higher FIT haemoglobin concentrations is an independent predictor of PCCRC,[341] and with increasing use of FIT may be an area for future study.

PCCRCs may be related to endoscopist performance, for example, with poor mucosal inspection or incomplete polypectomy, or related to biological factors of the patient, such as aggressive pathology of colorectal lesions. Morphology may be important with the detection of subtle, flat, depressed and serrated lesions highly variable among endoscopists, particularly in the proximal colon.[342 343] Clearly there is overlap, but quality of colonoscopy is strongly endoscopist dependent.[340] Back-to-back colonoscopy studies demonstrate that significant lesions may be missed[12 61] and colonoscopists with high ADR and high polypectomy rates provide increased protection for proximal cancers compared with those with lower polypectomy rates.[34]

Polypectomy technique also influences PCCRC, with incomplete polypectomy contributing to later cancers.[332] Pooled North American postpolypectomy studies[334] demonstrate missed cancer contributing 52% to the PCCRC rate, with 19% possibly due to incomplete polyp resection. A further study[329] found 27% of PCCRCs developed in the same segment as a previous polypectomy suggesting that incomplete treatment may have been a contributory factor.

PCCRCs are hugely important and reducing them is a crucial element of any colonoscopy programme. However, given their relative rarity, difficulties in data acquisition including data protection and the long intervals before they develop mean that their role as markers of quality is limited and currently surrogate markers will continue to be needed.

Adverse events

Colonoscopy is an invasive procedure, which carries a risk of bleeding, perforation and even death. Although the risk is small with diagnostic colonoscopy, it increases markedly when therapeutic procedures such as polypectomy are performed. There have been several reviews on colonoscopy complications, most recently by ASGE[344] as well as a review specifically focusing on complications of screening colonoscopy.[345] Online supplementary table S7 provides an overview of the most relevant large series.[11 16 48 151 227 345–353]

A very important issue regarding adverse event assessment within QA and/or benchmarking is who records which data with which methodology over which period of time following colonoscopy. Databases such as the German screening colonoscopy registry underreported complications when audited alongside a prospective study.[62] Ease of collection of data varies, depending on whether only acute complications during the procedure or on the day of the procedure, hospital stay (if any) or all complications within a 2-week or 4-week follow-up period are recorded. Whether and to what extent the simple linkage of databases of hospitals, registries and insurance companies is helpful[354] is still uncertain due to variable and often insufficient data quality.

The EU guidelines recommend three methods of QA with regard to complications (contact with all patients at a certain point in time after colonoscopy, review of 30-day mortality, and review of unplanned hospital admissions within 8 days); they

however also admit that not all national or regional databases allow for such analyses. Therefore, the EU guidelines name unplanned admission on the day of colonoscopy (including reason for admission) as a KPI.[23]

Perforation rates

The proportion of diagnostic to therapeutic procedures performed influences the overall colonoscopic perforation rate. In four large series of 97 000–277 000 colonoscopies, overall perforation rates ranged from 0.03% to 0.085%.[13–16 23] A recent review of studies calculated an overall perforation rate of 0.07% (1 in 1400).[355] Studies have quoted perforation rates ranging from 0% to 0.2% for diagnostic colonoscopy.[151 356] The English BCSP has reported a diagnostic perforation rate of 1 in 3253 (0.03%).[357] The two main risk factors for postpolypectomy perforation are the size and proximal (caecal) location of polyps.[357] Two small prospective polypectomy series reported perforation rates of 1 in 153 (0.65%) and 1 in 368 (0.27%), whereas two slightly larger retrospective series reported rates of 1 in 923 (0.11%) and 1 in 1583 (0.06%).[351 358–360] A recent review of studies calculated the perforation rate in therapeutic colonoscopy to be 0.1%.[355] The English BCSP has reported a perforation rate in polypectomy procedures of 0.09%.[357] It should be acknowledged that, particularly in the era of EMR and ESD techniques, polypectomy perforation rates will vary according to the size, location and complexity of polyps removed.

Bleeding

The risk of postprocedural bleeding is very small with diagnostic colonoscopy, but increases markedly when polypectomy is performed. Bleeding rates of 0.3%–6.1% for polypectomies are reported.[151 361] The two main risk factors are the size and proximal (caecal) location of polyps.[357 359] Other reported risk factors include comorbidity including cardiovascular or chronic renal disease,[362] age,[361–363] anticoagulant use[361 362] and endoscopist experience.[361] Studies assessing the effect of polyp morphology are inconclusive, with some studies demonstrating higher risks for pedunculated[363] or sessile/thick-stalked polyps,[361] but others showing no effect.[357 364] The recent UK audit reported an overall bleeding rate of 0.26%,[10] and a recent large series reported a colonoscopy bleeding rate of 0.164%.[16] The UK BCSP data illustrate the importance of stratifying bleeding severity: in one study, the overall bleeding rate (including many clinically insignificant bleeds) was calculated as 0.59%; limiting the analysis to intermediate or major severity bleeds (haemoglobin drop of 2 g, blood transfusion, admission to intensive care, unplanned hospital admission for four or more nights, interventional radiology or endoscopy or surgery), the rate was 0.13%[36]; and limiting only to bleeding requiring transfusion, the rate was 0.04%.[357]

Polypectomy adverse events and size of polyp

Overall, it is primarily polyp size that determines the risk of adverse events of bleeding and perforation.[357] On multivariate analysis, the Munich Polypectomy Study (MUPS) of 2257 patients showed polyp size was the main risk factor for significant adverse events (OR 31.01, 95% CI 7.53 to 128.1).[359] Other studies have reached similar conclusions.[357 361–363 365–368] Several studies have demonstrated that the risk of polypectomy relates to colonic location. The MUPS reported that proximal polyp location was a significant risk factor for major complications (OR 2.40, 95% CI 1.34 to 4.28).[359] A further study of 2106 polypectomies also showed that right-colon polypectomies had a higher tendency of developing postpolypectomy syndrome and bleeding (p=0.002).[369] A case control study of 39 cases demonstrated that polyps in the right colon had an OR of 4.67 for postpolypectomy delayed haemorrhage (1.88–11.61, p=0.001),[364] and also suggested that the caecum seemed to be especially at high risk in univariate analysis (OR 13.82, 95% CI 2.66 to 71.73), but this could not be confirmed in multivariate analysis due to small numbers.[357]

CONCLUSION

Delivery of high quality colonoscopy should be the aim of all colonoscopists and colonoscopy programmes. It is important that quality measures and KPI are developed for all programmes. These measures of quality should be robust[370] and evidence based and programmes should develop systems for data collection and monitoring.[371] High quality colonoscopy should ensure low complication rates, low PCCRC rates and should provide patients with an acceptable procedural experience.

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