We are IntechOpen, the world’s leading publisher of Open Access books
Built by scientists, for scientists

6,400
Open access books available

174,000
International authors and editors

190M
Downloads

154
Countries delivered to

TOP 1%
Our authors are among the most cited scientists

12.2%
Contributors from top 500 universities

WEB OF SCIENCE™
Selection of our books indexed in the Book Citation Index in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com
Maintaining Quality in Endoscopy

Anita Balakrishnan\textsuperscript{1}, Stephen Lewis\textsuperscript{2} and Kenneth B Hosie\textsuperscript{1}

\textsuperscript{1}Department of Surgery
\textsuperscript{2}Department of Gastroenterology, Derriford Hospital, Plymouth, United Kingdom

1. Introduction

If something is worth doing it is worth doing well. A colonoscopy is only of value if the procedure accurately assesses the whole of the mucosa with minimal morbidity and distress to the patient. Colonoscopic examination properly performed is safe, sensitive and well-tolerated by the majority of patients. The benefits of colonoscopy are within acceptable cost-benefit rates; screening colonoscopies carry a cost of $20,000 per year of life saved (Pignone, Saha et al. 2002; Smith, Cokkinides et al. 2002; Winawer, Fletcher et al. 2003). However complications, such as the need for repeat procedures, and the use of surgical intervention for endoscopically-removable polyps, will reduce this cost-benefit ratio thereby reducing patient acceptance of this examination.

The inconsistency in the degree of technical expertise of colonoscopists as documented in the literature suggests the need for standardization of the quality of colonoscopy service provision nationally and internationally (Marshall and Barthel 1993; Rex, Cutler et al. 1997; Rex 2000; Postic, Lewin et al. 2002; Gatto, Frucht et al. 2003; Rabeneck, Souchek et al. 2003; Schoenfeld, Cash et al. 2005; Barclay, Vicari et al. 2006; Rex, Petrini et al. 2006; Simmons, Harewood et al. 2006; Shah, Paszat et al. 2007; Rabeneck, Paszat et al. 2008; Imperiale, Glowinski et al. 2009). These studies have contributed to the identification of a number of parameters that can be analysed to determine the quality of the colonoscopic procedures performed by an individual endoscopist or within an endoscopy unit (Rex, Petrini et al. 2006; Lieberman, Nadel et al. 2007) (Table 1). This chapter examines these factors which contribute to quality outcomes by review of the published evidence and expert opinion.

2. Patient experience

Pre-procedural checks are essential to identify risk factors that may contribute to an adverse outcome from colonoscopy. Such risk factors include the use of anti-coagulants that may predispose to bleeding following a therapeutic component of colonoscopy such as biopsy or polyp removal, or the existence of comorbidities such as heart failure, respiratory problems or renal failure (Sharma, Nguyen et al. 2007; Ko, Riffle et al. 2010). Indeed the commonest complications following colonoscopy are respiratory depression due to oversedation and renal failure induced by dehydration due to the effects of bowel preparation (Sharma, Nguyen et al. 2007; Ko, Riffle et al. 2010). The American Society of Anesthesiologists (ASA) score is a crude but effective parameter in the risk assessment for sedation and correlates...
Colonoscopy

with sedation-related complications of endoscopy (Dominitz, Eisen et al. 2003; Sharma, Nguyen et al. 2007; Vargo 2007).

| Appropriate indication for procedure |
|--------------------------------------|
| Informed consent obtained, including discussion of risks of and alternatives to colonoscopy |
| Use of recommended post-polypectomy and post-resection surveillance intervals |
| Documentation of the adequacy of bowel preparation |
| Caecal intubation rates evidenced by photodocumentation |
| Adenoma detection rate in asymptomatic (screening) individuals |
| Withdrawal time (minimum ≥ 6 minutes in individuals with intact anatomy) |
| Biopsies taken in patients with chronic diarrhoea |
| Sufficient biopsies obtained in patients with inflammatory bowel disease |
| Endoscopic resection of polyps where possible or documentation of unresectability |
| Incidence of perforation or bleeding documented |
| Post polypectomy bleeding managed endoscopically (nonoperatively) |

Adapted from Rex et al, Gastrointestinal Endoscopy 2006; 63 (4):S16-S28

Table 1. Quality indicators for colonoscopy

3. Bowel preparation

Bowel preparation is another important factor in ensuring successful colonoscopic outcomes as poor bowel preparation has been shown to not only increase procedure time but also to decrease the adenoma detection rate (Harewood, Sharma et al. 2003; Froehlich, Wietlisbach et al. 2005; Chiu, Lin et al. 2006). Common bowel preparation regimens include split dose sodium picosulphate or polyethylene glycol-electrolyte solutions. Patient related factors such as prior constipation, comorbid status and mobility may affect the regime prescribed as well as compliance thereby determining the success of bowel preparation (Athreya, Owen et al. 2011). The quality of bowel preparation and mucosal views should be documented for every case and is considered adequate if it permits the detection of polyps of 5mm or greater (Rex, Bond et al. 2002). High rates of inadequate bowel preparation should highlight the need for investigation into the method of patient information and the sufficiency of the bowel preparation regimen in use.

4. Patient information

Patients are often anxious about the impending procedure and their reassurance and subsequent tolerance of the procedure is dependent on the manner and professionalism of the doctors and nurses as well as the physical environment (Ko, Zhang et al. 2009). The use of electronic media such as information videos has been found to positively supplement the written information contained in leaflets by improving patients knowledge of colonoscopy and decreasing anxiety levels compared to information leaflets alone (Luck, Pearson et al. 1999). A consultation with either a medical professional or a nurse specialist prior to the procedure is necessary to allow detailed explanation of the procedure prior to obtaining informed consent. During the consent process, specific risks of colonoscopy should be explained including bleeding, perforation, infection, sedation adverse events, missed diagnosis, missed lesions and intravenous site complications (Rex, Petrini et al. 2006).
5. Endoscopy facilities

Appropriate waiting facilities, bathrooms and endoscopy rooms are essential in ensuring a comfortable patient experience. In addition, endoscopy departments are obliged to adhere to the published guidelines for endoscope disinfection (Banerjee, Shen et al. 2008; Beilenhoff, Neumann et al. 2008) and to have full resuscitation facilities including a cardiac defibrillator and emergency drugs tray (Working Party of the Clinical Services Committee of the British Society of Gastroenterology 1991). Procedure rooms should be equipped with pulse oximetry, piped oxygen and suction, electronic blood pressure cuffs and facilities for ECG monitoring (Working Party of the Clinical Services Committee of the British Society of Gastroenterology 1991).

6. Ensuring appropriate indications and surveillance intervals

Colonoscopy should be performed in accordance with accepted guidelines (Terraz, Wietlisbach et al. 2005; Rex, Kahi et al. 2006; Winawer, Zauber et al. 2006; U.S. Preventive Services Task Force 2008; Cairns, Scholefield et al. 2010) as previous studies have shown a higher rate of detection of pathology when endoscopies are performed for appropriate indications (Vader, Pache et al. 2000; de Bosset, Froehlich et al. 2002; Balaguer, Llach et al. 2005). The indications for colonoscopy in symptomatic patients are well described, and include evaluation of gastrointestinal bleeding of unknown origin, investigation of unexplained iron deficiency anaemia, evaluation of an abnormality (such as a filling defect, stricture or wall thickening) on barium enema or CT, assessment of chronic inflammatory bowel disease of the colon and changes in bowel habit such as diarrhoea (American Society for Gastrointestinal Endoscopy 2000). In particular, endoscopists should adhere to the recommended surveillance guidelines post-resection or post-polypectomy as well as the guidelines for surveillance in patients with Crohn’s or ulcerative colitis, which make the assumption of caecal intubation, adequate bowel preparation and careful examination (Rex, Petrini et al. 2006). Overuse of surveillance colonoscopy is not cost-effective and unnecessarily exposes patients to the discomfort and risks of a colonoscopy.

7. Sedation and analgesia

Ensuring an adequate yet safe degree of sedation is of paramount importance for successful colonoscopy and increases the likelihood of the patients’ willingness to have a repeat procedure if necessary. Recent studies have suggested that “moderate” sedation, in which patients continue to respond purposefully to either verbal commands alone or with light tactile stimulation without requiring intervention to maintain a patent airway or spontaneous ventilation, is sufficient for colonoscopy and safer than deep sedation, in which ventilation may be inadequate and airway protection may be required (Triebwasser and Browning 2001; American Society of Anesthesiologists 2002; Faigel, Baron et al. 2002; Brifish Society of Gastroenterology 2003; Waring, Baron et al. 2003; Rex 2006). Agents used for sedation include benzodiazepines (midazolam, diazepam), narcotics (fentanyl, meperidine), propofol, neuroleptic tranquilizers (droperidol), antihistamines (diphenhydramine), and dopaminergic receptor antagonists (promethazine). A meta-analysis showed no difference in the incidence of hypoxemia, need for supplemental oxygen, physician satisfaction with the procedure, or rates of patient pain or discomfort when either midazolam or diazepam was co-administered with a narcotic for colonoscopy (McQuaid and Laine 2008).
The use of propofol as a sole sedative agent was associated with higher rates of patient satisfaction and less memory of the procedure compared to midazolam co-administered with a narcotic, however no significant difference was noted in the incidence of bradycardia, hypotension, hypoxemia, physician satisfaction, or the number of patients reporting pain or discomfort (McQuaid and Laine 2008). Rates of propofol use are increasing in the United States, with >20% of physicians using propofol routinely for endoscopy. The narrow therapeutic window of propofol and the lack of a reversal agent can contribute to rapid depression of consciousness and cardiovascular function, necessitating additional training and monitoring when using this agent (American Society of Anesthesiologists 2002; Faigel, Baron et al. 2002; Vargo, Cohen et al. 2009). Combining propofol with midazolam and narcotics is believed to allow lower doses to be used thus improving the safety profile (Cohen, Dubovsky et al. 2003; Cohen, Hightower et al. 2004). The use of patient controlled analgesia using narcotics such as alfentanil and fentanyl has also been associated with high patient satisfaction and willingness to undergo repeat procedure (Usta, Turkay et al. 2011).

The inhalational agent nitrous oxide is also used for sedation and analgesia in colonoscopy due to its rapid onset of action and short recovery time. Randomised trials comparing nitrous oxide to intravenous opiates with or without benzodiazepines failed to show a clear difference between the two groups in terms of pain relief, reaction times or complex psychomotor co-ordination (Lindblom, Jansson et al. 1994; Saunders, Fukumoto et al. 1994; Notini-Gudmarsson, Dolk et al. 1996; Trojan, Saunders et al. 1997; Forbes and Collins 2000; Maslekar, Gardiner et al. 2009; Welchman, Cochrane et al. 2010). Patients given intravenous sedation had worse recall of the procedure and reduced manual dexterity compared to those given nitrous oxide (Lindblom, Jansson et al. 1994; Saunders, Fukumoto et al. 1994; Notini-Gudmarsson, Dolk et al. 1996; Trojan, Saunders et al. 1997; Forbes and Collins 2000; Maslekar, Gardiner et al. 2009; Welchman, Cochrane et al. 2010). All studies showed reduced post-procedural stay in patients given nitrous oxide compared to intravenous sedation (Lindblom, Jansson et al. 1994; Saunders, Fukumoto et al. 1994; Notini-Gudmarsson, Dolk et al. 1996; Trojan, Saunders et al. 1997; Forbes and Collins 2000; Maslekar, Gardiner et al. 2009; Welchman, Cochrane et al. 2010).

Carbon dioxide insufflation has been recommended during colonoscopy as carbon dioxide is highly soluble and can thus be passively absorbed by the colon and excreted by the lungs, thereby minimizing intra-procedural and post-procedural discomfort (Williams 1986). In addition the rapid absorbance of carbon dioxide allows double contrast CT or barium enema to be performed on the same day if necessary, while the minimal interference of carbon dioxide with colonic blood flow reduces the risk of ischaemia (Williams 1986). Studies comparing the use of carbon dioxide insufflation to the more routinely used air insufflation in colonoscopy have demonstrated decreased levels of pain and shorter examination times in the carbon dioxide insufflations group (Brethauer, Thiis-Evensen et al. 2002; Sumanac, Zealley et al. 2002; Church and Delaney 2003; Uraoka, Kato et al. 2009; Yamano, Yoshikawa et al. 2010).

8. Measurements of technical expertise

8.1 Caecal intubation rates

Caecal intubation (passage of the colonoscope to a point proximal to the ileocaecal valve) is necessary to ensure adequate visualisation of the entire colon. A significant fraction of colonic neoplasms are located in the right colon (Imperiale, Wagner et al. 2000; Rabeneck, Soucek et al. 2003), hence successful caecal intubation should be specifically noted, ideally...
Maintaining Quality in Endoscopy

Intubation of the terminal ileum or visualization of the lips of the ileocaecal valve may be further necessary if there is any doubt as to whether the caecum has been entered. Failure to intubate the caecum is associated with decreased sensitivity of the examination as well as the need for further radiographic imaging or repeat colonoscopy, thereby reducing the cost-effectiveness of the procedure. Recommended caecal intubation rates are >90% for all cases (Marshall and Barthel 1993) and ≥95% of screening cases in healthy adults (Rex, Petrini et al. 2006; Rabeneck, Rumble et al. 2007; Levin, Lieberman et al. 2008; National Health Service Cancer Screening Programmes 2011). Procedures which have been aborted due to poor bowel preparation, severe colitis, equipment failure and those performed solely for the treatment of strictures or polyp removal (where complete colonic imaging has been previously performed) are not included in calculation of the caecal intubation rate (Rex, Bond et al. 2002; Rex, Petrini et al. 2006).

8.2 Adenoma detection rate in screening

The adenoma detection rate (ADR) in asymptomatic patients undergoing screening colonoscopy is an important quality indicator in colonoscopy. A recent study by Kaminski et al demonstrated that the ADR of the endoscopist was an independent risk factor for the subsequent development of interval cancers (cancers occurring during surveillance colonoscopy after a previous screening colonoscopy). The number of interval cancers was significantly higher in patients who had undergone colonoscopy by endoscopists with an ADR of <20% compared to those who had undergone colonoscopy by endoscopist with an ADR of ≥20% (Kaminski, Regula et al. 2010). Studies of different practice groups have shown large disparities in the rates of adenoma detection between endoscopists within the same practice for both screening and symptomatic indications (Barclay, Vicari et al. 2006; Chen and Rex 2007; Imperiale, Glowinski et al. 2009) highlighting the possibility that suboptimal colonoscopy rather than technological limitations may be a significant contributing factor to the miss rate of incident cancers (Rex, Hewett et al.; Rex, Petrini et al. 2006). The decrease in sensitivity of colonoscopy associated with missed adenomas also has implications on surveillance intervals, as guidelines for surveillance interval assume thorough examination of the colon and cannot compensate for disparities in technical expertise between colonoscopists. Tandem colonoscopy studies demonstrated adenoma miss rates ranging from 0-6% for adenomas more than 1cm in size, 12-13% for those between 6-9mm, and 15-27% for those under 5mm (Hixon, Fennerty et al. 1990; Rex, Cutler et al. 1997). CT-colonography in turn demonstrated miss rates between 12 and 17% for adenomas greater than 1cm in size, indicating that tandem colonoscopies may underestimate the true prevalence of missed lesions (Pickhardt, Nugent et al. 2004; Van Gelder, Nio et al. 2004). Colonoscopy screening studies have consistently demonstrated adenoma prevalence rates of >25% in men and >15% in women over 50 years old (Johnson, Gurney et al. 1990; Lieberman and Smith 1991; Lieberman, Weiss et al. 2000; Schoenfeld, Cash et al. 2005); hence these form the basis of the current recommended ADRs in the United States. In the United Kingdom a slightly higher ADR of 35% has been set for screening colonoscopy (performed following positive faecal occult blood tests) (National Health Service Cancer Screening Programmes 2011).

While the ADR is considered a good quality indicator for colonoscopy, this parameter cannot be determined at the time of endoscopy and requires histological confirmation before
an accurate ADR can be calculated. Polypectomy rates have therefore been postulated as a suitable surrogate, as this can be calculated at the time of colonoscopy and appear to correlate with the ADR (Williams, Le et al. 2011). A disadvantage of using polypectomy rates is the potential for “gaming” – endoscopists artificially increasing their polypectomy rates by removing benign hyperplastic polyps rather than true adenomas (Rex, Hewett et al. 2010).

A recent randomized study examining the effects of the antispasmodic buscopan on polyp detection demonstrated increased polyp detection rates in only a subgroup of patients with significant colonic spasm (Lee, Cheon et al. 2010). In addition, the majority of studies to date have focused on the use of buscopan for the alleviation of colonic spasm and attendant discomfort during colonoscopy with inconsistent results (Saunders and Williams 1996; Mui, Ng et al. 2004; Yoong, Perkin et al. 2004), suggesting that further studies are necessary before buscopan can be routinely recommended for the improvement of polyp detection.

9. Withdrawal time

Measurement of colonoscope withdrawal time (the time between reaching the caecum and withdrawing the scope from the anus) has been used as a further quality indicator in units or endoscopists with low adenoma detection rates. Endoscopists who took longer than 6 minutes to withdraw the colonoscope were found to have very low miss rates and more than 2-fold higher rates of detection of both small and large adenomas (Rex 2000; Barclay, Vicari et al. 2006; Simmons, Harewood et al. 2006). It has therefore been recommended that withdrawal of the colonoscope in patients without any prior colonic surgery should last at least 6 minutes on average (Rex, Petrini et al. 2006). Mean withdrawal times are used rather than individual times as this figure is influenced by the adequacy of colon preparation as well as the length of the colon and the prominence of haustral markings. In addition a recent study has shown that the withdrawal time can be reduced safely with the use of wide angle scopes (Deenadayalu, Chadalawada et al. 2004). Despite the positive correlation between withdrawal time and ADR, Gellad et al. showed that withdrawal times failed to correlate with 5-year interval neoplasia (Gellad, Weiss et al. 2010). In addition in their study withdrawal times beyond a threshold of 5.2 to 8.6 minutes no longer correlated with adenoma detection rates. This may be explained by the possibility that longer withdrawal times were representative of more difficult rather than more careful examinations. Additionally longer withdrawal times have been found to correlate with the detection of smaller polyps (Simmons, Harewood et al. 2006), not all of which might have been removed at colonoscopy.

10. Surrogate markers

Despite the emphasis placed on caecal intubation rates and withdrawal times as a marker of adequacy of examination, Beckly et al (2007) found no correlation between caecal intubation rate or withdrawal times and the detection of artificial bowel markers placed within the colon by a separate intubating colonoscopists (Beckly, Douie et al. 2007). The miss rates of these markers corroborated the findings of Postic et al identifying synchronous lesions in specimens of resected colon (Postic, Lewin et al. 2002) as well as the findings of tandem colonoscopy studies which used a second closely sequential colonoscopy to determine the miss rate of the first colonoscopy (Hixson, Fennerty et al. 1990; Rex, Cutler et al. 1997). The
higher miss rate for markers placed at the flexures highlights the fact due to the high degree of angulation required to navigate these corners lesions may be missed at these sites even with good technique. The use of surrogate markers for assessing lesion detection may therefore represent a useful addition to endoscopy training.

10.1 Colonic biopsy
The sensitivity of colonoscopy for neoplastic and other pathological processes increases when coupled with endoscopic biopsies. This is particularly relevant in patients undergoing colonoscopic surveillance for Crohn’s or ulcerative colitis. The sensitivity of the examination for detecting dysplasia in this patient group is improved by quadrantic biopsies every 10cm of colon as well as biopsy of any suspicious lesions (Rubin, Haggitt et al. 1992). Panchromoscopy (dye-spray) of the colon with targeted biopsies has also been shown to increase sensitivity for dysplasia (Kiesslich, Fritsch et al. 2003; Rutter, Saunders et al. 2004). In addition to surveillance in inflammatory bowel disease, recent guidelines also recommend the use of biopsies in patients with chronic diarrhoea (Rex, Petrini et al. 2006). Serial biopsies of macroscopically normal colon can identify microscopic (collagenous and lymphocytic) colitis in patients with normal mucosa at colonoscopy (Zins, Tremaine et al. 1995; Yusoff, Ormonde et al. 2002). Detection of collagenous colitis in particular is improved when the proximal colon is biopsied (Zins, Tremaine et al. 1995; Yusoff, Ormonde et al. 2002).

10.2 Colonoscopic polypectomy
Routine polypectomy should be performed at diagnostic colonoscopy to minimize the reduction in cost-effectiveness and increased risk associated with an additional unnecessary colonoscopy for removal of the polyp. The UK national guidelines recommend that 90% of screen-detected polyps are removed at the time of detection (National Health Service Cancer Screening Programmes 2011). Consistent referral of sessile polyps <2cm in size for surgical resection is discouraged as these polyps are frequently amenable to endoscopic removal. In cases of technically difficult polyps, referral to an endoscopist experienced in endoscopic resection may be appropriate. The need for surgical intervention, where unavoidable, should be substantiated by photo documentation of the polyp and subsequent review of images with a second endoscopist. Furthermore, correlation of the endoscopic and pathologic measurements of the polyp should be performed following surgical resection to confirm the necessity of surgical resection (Rex, Petrini et al. 2006).

11. Post-procedure quality indicators
11.1 Complication rates
All complications such as perforation or bleeding following the procedure should be monitored and documented to allow identification and correction of any systematic errors that may be contributing to the incidence of these events. Perforations can occur during diagnostic colonoscopies, either mechanical in nature (e.g. rupture of the rectosigmoid by the instrument or perforation through a stricture) or barotrauma-related due to an excess of pneumatic pressure causing rupture of the caecum (Woltjen 2005). Therapeutic colonoscopies often run a greater risk of perforation, which can occur following polypectomy. This is most often associated with electrocautery and most
Colonoscopy frequently occurs following attempts at removal of large polyps from the proximal colon. Submucosal saline injection prior to polypectomy has been suggested might reduce the risk, (Norton, Wang et al. 2002; Singh, Harrison et al. 2004) however randomized controlled trial evidence on this observation is lacking. Current guidelines suggest that perforation rates of greater than the rate of 1:500 overall or 1:1000 in screening patients as documented in previous studies should highlight the need for further investigation into any inappropriate practices that may be a contributory (Silvis, Nebel et al. 1976; Nivatvongs 1986; Gatto, Frucht et al. 2003; Rabeneck, Paszat et al. 2008; National Health Service Cancer Screening Programmes 2011).

Bleeding is the most common complication following colonoscopic polypectomy, and is more frequent in large polyps with a proximal colonic location. Bleeding rates of large polyps (>2cm) in the proximal colon may exceed 10% however the recommended overall acceptable rate of bleeding is 1% (National Health Service Cancer Screening Programmes 2011). The risk of bleeding (particularly immediate bleeding) may be reduced by the use of epinephrine injections (Hsieh, Lin et al. 2001; Di Giorgio, De Luca et al. 2004) or detachable snares(Ishi, Tatsuta et al. 1996; Di Giorgio, De Luca et al. 2004). Immediate bleeding can often be managed endoscopically by pressure on the stalk for up to 10-15 minutes or injection of adrenaline followed by electrocautery (Rex, Lewis et al. 1992). Delayed bleeding is rarely significant and often stops spontaneously. Exceptions are patients who continue to pass bright red blood who may be experiencing arterial bleeding; urgent repeat colonoscopy with clipping or injection and electrocautery of the bleeding site is then necessary (Rex, Lewis et al. 1992). By these means over 90% of post-polypectomy bleeding can be managed conservatively without resorting to surgical intervention(Rex, Petrini et al. 2006). Accurate assessment of the delayed complication rates of individual colonoscopists such as perforation or bleeding may be difficult as patients may present to different centres, hence regular feedback and audit systems should be in place to ensure delayed complications are recorded.

11.2 Standardised reporting

Although standardized reporting and data collection systems are currently in use for many other large scale tests such as Papanicolaou testing and mammography, these have not currently been adopted for colonoscopy. Standardization of reporting colonoscopic procedures would allow improved communication of test results to primary care providers and patients as well as standardized terms and measurement criteria. In addition this would allow the development of national databases to be interrogated for audit and research purposes. In 1997 the Quality Assurance Task Group in the United States developed a standardized colonoscopy reporting and data system (CO-RADS) in conjunction with the major national gastroenterological societies, outlining the key components of colonoscopy that should be closely monitored in every endoscopy unit(Lieberman, Nadel et al. 2007) (Table 2). The use of and adherence to this standardized reporting has not been audited and remains to be seen. No standardized national reporting system exists for symptomatic colonoscopies in many other countries including the United Kingdom. (these are however in place in the United Kingdom for screening colonoscopies). Most endoscopic units in the United Kingdom employ commonly used endoscopic data recording software such as Endosoft® or Endoscribe® which require the documentation of the major quality indicators.
Table 2. Key subject areas in a standardized colonoscopy report

| Patient demographics | History of complaint and indications for colonoscopy | Assessment of patient risk and comorbid status | Technical description of procedure | Findings on colonoscopy | Assessment | Any intervention / unplanned events | Follow-up plan | Pathology |

Adapted from Lieberman et al, Gastrointestinal Endoscopy 2007; 65(6): 757-766

12. Other factors

12.1 Training and accreditation

As indicated by the studies quoted above, technical competence is of paramount importance in ensuring the delivery of a high quality endoscopy service. To achieve this particular attention must be paid to the instruction of medical and surgical trainees in the necessary skills for competent colonoscopy, and in many countries including the United Kingdom endoscopists are required to be formally certified to perform independent procedures (British Society of Gastroenterology 2004). Several studies have attempted to better define the learning curve that unquestionably accompanies colonoscopic training. Lee et al demonstrated achievement of the basic competencies (in terms of caecal intubation rate and polyp detection rate) after 150 colonoscopies (Lee, Chung et al. 2008), however this was disputed by Spier et al, who showed that over 500 colonoscopies were necessary before their gastroenterological fellows could perform ≥ 90% of colonoscopies independently (Spier, Benson et al. 2010; Spier, Durkin et al. 2010). Simulator training has been suggested as an alternative or adjunct to colonoscopic experience on live patients; Haycock et al demonstrated no significant difference between the performance novice colonoscopists trained on a simulator or live patients when assessed on live cases (Haycock, Koch et al. 2010), suggesting that use of the simulator may shorten the learning curve to competency on live patients.

Once competencies are acquired continued regular colonoscopic experience is necessary to maintain the skill levels required for this procedure. A recent study from Canada revealed that patients were more likely to have an incomplete colonoscopy if the procedure was performed by a low volume endoscopist (<240 colonoscopies per year) compared to a high volume endoscopist (370 colonoscopies per year) (Shah, Paszat et al. 2007). This was corroborated by a study from the United States showing no difference in complications but significant differences in completion rates and time to completion between endoscopists that performed 100-200 colonoscopies per year and those that only performed less than 10 per year (Harewood 2005). In keeping with these findings the National Institute for Clinical Excellence (NICE) in the United Kingdom has recommended that on average colonoscopists should perform a minimum of 100 procedures per year (National Institute for Clinical Excellence 2004). While screening colonoscopists should perform at least 150 procedures per year (National Health Service Cancer Screening Programmes 2011).
12.2 Nurse endoscopists
In countries such as the United Kingdom the demand for endoscopists is rapidly outstripping the capacity for medical endoscopists to perform the service within a reasonable time-frame. This has led to the training of nurse endoscopists to meet this need. To avoid any compromise in quality, nurse endoscopists are required to train to achieve the same competencies as medical endoscopists. Two to three sessions a week are mandated to maintain competencies achieved by a closely supervised period of apprenticeship as well as attendance of national endoscopy courses (British Society of Gastroenterology 2001). A recent pilot study from the Netherlands identified no difference in the caecal intubation rate and caecal intubation time between nurse endoscopists and gastrointestinal fellows in training, with 150 examinations required before independent procedures could be performed (Koornstra, Corporaal et al. 2009).

12.3 Cost effectiveness
Provision of a quality colonoscopic service should not only encompass clinical performance but also cost-effectiveness, which relies on the efficient use of resources as well as successful team-working. Challand et al found that colonoscopists performing >150 cases per year were more likely to achieve the recommended workload of 4 colonoscopies per 4 hour session that would be required to meet session costs, however the volume of cases of each endoscopist per year had no effect on the caecal intubation rate. In addition, endoscopists who offered ≥15% of their sessions for training were more likely to achieve the work required to meet session costs, suggesting that the most clinically effective endoscopists also offered the greatest number of training opportunities (Challand, Bullen et al. 2010). Cost-effectiveness has also been an important factor in the development of screening and surveillance guidelines. The majority of gastroenterological societies recommend surveillance colonoscopy following adenoma detection at ten yearly frequency in low-risk groups or five yearly in groups where the miss rate for adenomas is suspected to be high (Saini, Schoenfeld et al. 2010). Three yearly surveillance is not cost-effective and the inherent risks of colonoscopy may make such frequent surveillance incrementally harmful (Saini, Schoenfeld et al. 2010). Cost-effectiveness analyses have shown that colonoscopy is not an appropriate first line screening tool but is instead often used as a further investigation in patients with positive faecal occult blood tests (Pignone 2005).

13. Conclusion/ summary
The effectiveness and safety of colonoscopy is dependent on the quality of the procedure performed. The identification of specific quality indicators for colonoscopy as described above (outlined in Table 3) has contributed to the development of recommendations for improving the quality of colonoscopy internationally. Adherence to these recommendations will ensure a thorough examination that achieves the expected sensitivity of the procedure while avoiding complications that would offset the cost-benefit ratio of the process. Ensuring quality in colonoscopy is therefore of paramount importance in ensuring the delivery of a safe, accurate, effective and acceptable service for the diagnosis and management of colonic pathology.

Disclosures: est.

Copyright licence statement:
The authors attest that this manuscript is not currently under consideration by any other journal or publisher.
Abbreviations:
ADR – adenoma detection rate
ASA – American Society of Anaesthesiologists

14. References
American Society for Gastrointestinal Endoscopy (2000). "Appropriate use of gastrointestinal endoscopy." Gastrointest Endosc 52(6): 831-7.
American Society of Anesthesiologists (2002). "Practice guidelines for sedation and analgesia by non-anesthesiologists." Anesthesiology 96(4): 1004-17.
Athreya, P. J., G. N. Owen, et al. (2011). "Achieving quality in colonoscopy: bowel preparation timing and colon cleanliness." ANZ J Surg 81(4): 261-5.
Balaguer, F., J. Llach, et al. (2005). "The European panel on the appropriateness of gastrointestinal endoscopy guidelines colonoscopy in an open-access endoscopy unit: a prospective study." Aliment Pharmacol Ther 21(5): 609-13.
Banerjee, S., B. Shen, et al. (2008). "Infection control during GI endoscopy." Gastrointest Endosc 67(6): 781-90.
Barclay, R. L., J. J. Vicari, et al. (2006). "Colonoscopic withdrawal times and adenoma detection during screening colonoscopy." N Engl J Med 355(24): 2533-41.
Beckley, J. B., W. J. Douie, et al. (2007). "Artificial bowel markers: a novel method for measuring the accuracy of colonoscopy." Dis Colon Rectum 50(7): 1047-52.
Beilenhoff, U., C. S. Neumann, et al. (2008). "ESGE-ESGENA Guideline: cleaning and disinfection in gastrointestinal endoscopy." Endoscopy 40(11): 939-57.
Brethauer, M., E. Thiis-Evensen, et al. (2002). "NORCCAP (Norwegian colorectal cancer prevention): a randomised trial to assess the safety and efficacy of carbon dioxide versus air insufflation in colonoscopy." Gut 50(5): 604-7.
Brisith Society of Gastroenterology. (2001). "Provision of Endoscopy Related Services in District General Hospitals." Retrieved 18/02/2011, from http://www.bsg.org.uk/images/stories/docs/clinical/guidelines/endoscopy/endoscopy_related_services.pdf.
Brisith Society of Gastroenterology. (2003). "BSG Guidelines on Safety and Sedation during Endoscopic Procedures." Retrieved 18/02/2011, from http://www.bsg.org.uk.
British Society of Gastroenterology. (2004). "Guidelines for training in GI endoscopy." Retrieved 18/02/2011, from http://www.bsg.org.uk/pdf_word_docs/jag_recommendations_2004.pdf.
Cairns, S. R., J. H. SchOLEFIELD, et al. (2010). "Guidelines for colorectal cancer screening and surveillance in moderate and high risk groups (update from 2002)." Gut 59(5): 666-89.
Challand, C. P., N. Bullen, et al. (2010). "How Do You Measure Performance as a Colonoscopist?" Colorectal Dis.
Chen, S. C. and D. K. Rex (2007). "Endoscopist can be more powerful than age and male gender in predicting adenoma detection at colonoscopy." Am J Gastroenterol 102(4): 856-61.
Chiu, H. M., J. T. Lin, et al. (2006). "The impact of colon preparation timing on colonoscopic detection of colorectal neoplasms—a prospective endoscopist-blinded randomized trial." Am J Gastroenterol 101(12): 2719-25.
Church, J. and C. Delaney (2003). "Randomized, controlled trial of carbon dioxide insufflation during colonoscopy." Dis Colon Rectum 46(3): 322-6.

Cohen, L. B., A. N. Dubovsky, et al. (2003). "Propofol for endoscopic sedation: A protocol for safe and effective administration by the gastroenterologist." Gastrointest Endosc 58(5): 725-32.

Cohen, L. B., C. D. Hightower, et al. (2004). "Moderate level sedation during endoscopy: a prospective study using low-dose propofol, meperidine/fentanyl, and midazolam." Gastrointest Endosc 59(7): 795-803.

de Bosset, V., F. Froehlich, et al. (2002). "Do explicit appropriateness criteria enhance the diagnostic yield of colonoscopy?" Endoscopy 34(5): 360-8.

Deenadayalu, V. P., V. Chadalawada, et al. (2004). "170 degrees wide-angle colonoscope: effect on efficiency and miss rates." Am J Gastroenterol 99(11): 2138-42.

Di Giorgio, P., L. De Luca, et al. (2004). "Detachable snare versus epinephrine injection in the prevention of postpolypectomy bleeding: a randomized and controlled study." Endoscopy 36(10): 860-3.

Dominitz, J. A., G. M. Eisen, et al. (2003). "Complications of colonoscopy." Gastrointest Endosc 57(4): 441-5.

Faigel, D. O., T. H. Baron, et al. (2002). "Guidelines for the use of deep sedation and anesthesia for GI endoscopy." Gastrointest Endosc 56(5): 613-7.

Forbes, G. M. and B. J. Collins (2000). "Nitrous oxide for colonoscopy: a randomized controlled study." Gastrointest Endosc 51(3): 271-7.

Froehlich, F., V. Wietlisbach, et al. (2005). "Impact of colonic cleansing on quality and diagnostic yield of colonoscopy: the European Panel of Appropriateness of Gastrointestinal Endoscopy European multicenter study." Gastrointest Endosc 61(3): 378-84.

Gatto, N. M., H. Frucht, et al. (2003). "Risk of perforation after colonoscopy and sigmoidoscopy: a population-based study." J Natl Cancer Inst 95(3): 230-6.

Gellad, Z. F., D. G. Weiss, et al. (2010). "Colonoscopy withdrawal time and risk of neoplasia at 5 years: results from VA Cooperative Studies Program 380." Am J Gastroenterol 105(8): 1746-52.

Harewood, G. C. (2005). "Relationship of colonoscopy completion rates and endoscopist features." Dig Dis Sci 50(1): 47-51.

Harewood, G. C., V. K. Sharma, et al. (2003). "Impact of colonoscopy preparation quality on detection of suspected colorectal neoplasia." Gastrointest Endosc 58(1): 76-9.

Haycock, A., A. D. Koch, et al. (2010). "Training and transfer of colonoscopy skills: a multinational, randomized, blinded, controlled trial of simulator versus bedside training." Gastrointest Endosc 71(2): 298-307.

Hixson, L. J., M. B. Fennerty, et al. (1990). "Prospective study of the frequency and size distribution of polyps missed by colonoscopy." J Natl Cancer Inst 82(22): 1769-72.

Hsieh, Y. H., H. J. Lin, et al. (2001). "Is submucosal epinephrine injection necessary before polypectomy? A prospective, comparative study." Hepatogastroenterology 48(41): 1379-82.

Iishi, H., M. Tatsuta, et al. (1996). "Endoscopic resection of large pedunculated colorectal polyps using a detachable snare." Gastrointest Endosc 44(5): 594-7.

Imperiale, T. F., E. A. Glowinski, et al. (2009). "Variation in polyp detection rates at screening colonoscopy." Gastrointest Endosc 69(7): 1288-95.
Imperiale, T. F., D. R. Wagner, et al. (2000). "Risk of advanced proximal neoplasms in asymptomatic adults according to the distal colorectal findings." N Engl J Med 343(3): 169-74.

Johnson, D. A., M. S. Gurney, et al. (1990). "A prospective study of the prevalence of colonic neoplasms in asymptomatic patients with an age-related risk." Am J Gastroenterol 85(8): 969-74.

Kaminski, M. F., J. Regula, et al. (2010). "Quality indicators for colonoscopy and the risk of interval cancer." N Engl J Med 362(19): 1795-803.

Kiesslich, R., J. Fritsch, et al. (2003). "Methylene blue-aided chromoendoscopy for the detection of intraepithelial neoplasia and colon cancer in ulcerative colitis." Gastroenterology 124(4): 880-8.

Ko, C. W., S. Riffle, et al. (2010). "Serious complications within 30 days of screening and surveillance colonoscopy are uncommon." Clin Gastroenterol Hepatol 8(2): 166-73.

Ko, H. H., H. Zhang, et al. (2009). "Factors influencing patient satisfaction when undergoing endoscopic procedures." Gastrointest Endosc 69(4): 883-91, quiz 891 e1.

Koornstra, J. J., S. Corporaal, et al. (2009). "Colonoscopy training for nurse endoscopists: a feasibility study." Gastrointest Endosc 69(3 Pt 2): 688-95.

Lee, J. M., J. H. Cheon, et al. (2010). "Effects of Hyosine N-butyl bromide on the detection of polyps during colonoscopy." Hepatogastroenterology 57(97): 90-4.

Lee, S. H., I. K. Chung, et al. (2008). "An adequate level of training for technical competence in screening and diagnostic colonoscopy: a prospective multicenter evaluation of the learning curve." Gastrointest Endosc 67(4): 683-9.

Levin, B., D. A. Lieberman, et al. (2008). "Screening and surveillance for the early detection of colorectal cancer and adenomatous polyps, 2008: a joint guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology." Gastroenterology 134(5): 1570-95.

Lieberman, D., M. Nadel, et al. (2007). "Standardized colonoscopy reporting and data system: report of the Quality Assurance Task Group of the National Colorectal Cancer Roundtable." Gastrointest Endosc 65(6): 757-66.

Lieberman, D. A. and F. W. Smith (1991). "Screening for colon malignancy with colonoscopy." Am J Gastroenterol 86(8): 946-51.

Lieberman, D. A., D. G. Weiss, et al. (2000). "Use of colonoscopy to screen asymptomatic adults for colorectal cancer. Veterans Affairs Cooperative Study Group 380." N Engl J Med 343(3): 162-8.

Lindblom, A., O. Jansson, et al. (1994). "Nitrous oxide for colonoscopy discomfort: a randomized double-blind study." Endoscopy 26(3): 283-6.

Luck, A., S. Pearson, et al. (1999). "Effects of video information on precolonoscopy anxiety and knowledge: a randomised trial." Lancet 354(9195): 2032-5.

Marshall, J. B. and J. S. Barthel (1993). "The frequency of total colonoscopy and terminal ileal intubation in the 1990s." Gastrointest Endosc 39(4): 518-20.

Maslekar, S., A. Gardiner, et al. (2009). "Randomized clinical trial of Entonox versus midazolam-fentanyl sedation for colonoscopy." Br J Surg 96(4): 361-8.

McQuaid, K. R. and L. Laine (2008). "A systematic review and meta-analysis of randomized, controlled trials of moderate sedation for routine endoscopic procedures." Gastrointest Endosc 67(6): 910-23.

Mui, L. M., E. K. Ng, et al. (2004). "Randomized, double-blinded, placebo-controlled trial of intravenously administered hyoscine N-butyl bromide in patients undergoing colonoscopy with patient-controlled sedation." Gastrointest Endosc 59(1): 22-7.
National Health Service Cancer Screening Programmes. (2011). "Quality assurance guidelines in colonoscopy." Retrieved 18/02/2011, from http://www.cancerscreening.nhs.uk/bowel/publications/nhsbcs06.pdf

National Institute for Clinical Excellence. (2004). "Improving outcomes in colorectal cancer." Retrieved 18/02/2011, from http://www.nice.org.uk/nicemedia/live/10895/28832/28832.pdf

Nivatvongs, S. (1986). "Complications in colonoscopic polypectomy. An experience with 1,555 polypectomies." Dis Colon Rectum 29(12): 825-30.

Norton, I. D., L. Wang, et al. (2002). "Efficacy of colonic submucosal saline solution injection for the reduction of iatrogenic thermal injury." Gastrointest Endosc 56(1): 95-9.

Notini-Gudmarsson, A. K., A. Dolk, et al. (1996). "Nitrous oxide: a valuable alternative for pain relief and sedation during routine colonoscopy." Endoscopy 28(3): 283-7.

Pickhardt, P. J., P. A. Nugent, et al. (2004). "Location of adenomas missed by optical colonoscopy." Ann Intern Med 141(5): 352-9.

Pignone, M. (2005). "Is population screening for colorectal cancer cost-effective?" Nat Clin Pract Gastroenterol Hepatol 2(7): 288-9.

Pignone, M., S. Saha, et al. (2002). "Cost-effectiveness analyses of colorectal cancer screening: a systematic review for the U.S. Preventive Services Task Force." Ann Intern Med 137(2): 96-104.

Postic, G., D. Lewin, et al. (2002). "Colonoscopic miss rates determined by direct comparison of colonoscopy with colon resection specimens." Am J Gastroenterol 97(12): 3182-5.

Rabeneck, L., L. F. Paszat, et al. (2008). "Bleeding and perforation after outpatient colonoscopy and their risk factors in usual clinical practice." Gastroenterology 135(6): 1899-1906, 1906 e1.

Rabeneck, L., R. B. Rumble, et al. (2007). "Cancer Care Ontario Colonoscopy Standards: standards and evidentiary base." Can J Gastroenterol 21 Suppl D: 5D-24D.

Rabeneck, L., J. Souchek, et al. (2003). "Survival of colorectal cancer patients hospitalized in the Veterans Affairs Health Care System." Am J Gastroenterol 98(5): 1186-92.

Rex, D. K. (2000). "Colonoscopic withdrawal technique is associated with adenoma miss rates." Gastrointest Endosc 51(1): 33-6.

Rex, D. K. (2006). "Review article: moderate sedation for endoscopy: sedation regimens for non-anaesthesiologists." Aliment Pharmacol Ther 24(2): 163-71.

Rex, D. K., J. H. Bond, et al. (2002). "Quality in the technical performance of colonoscopy and the continuous quality improvement process for colonoscopy: recommendations of the U.S. Multi-Society Task Force on Colorectal Cancer." Am J Gastroenterol 97(6): 1296-308.

Rex, D. K., C. S. Cutler, et al. (1997). "Colonoscopic miss rates of adenomas determined by back-to-back colonoscopies." Gastroenterology 112(1): 24-8.

Rex, D. K., D. G. Hewett, et al. (2010). "Editorial: Detection targets for colonoscopy: from variable detection to validation." Am J Gastroenterol 105(12): 2665-9.

Rex, D. K., D. G. Hewett, et al. (2010). "Editorial: Detection targets for colonoscopy: from variable detection to validation." Am J Gastroenterol 105(12): 2665-9.

Rex, D. K., C. J. Kahi, et al. (2006). "Guidelines for colonoscopy surveillance after cancer resection: a consensus update by the American Cancer Society and US Multi-Society Task Force on Colorectal Cancer." CA Cancer J Clin 56(3): 160-7; quiz 185-6.
Rex, D. K., B. S. Lewis, et al. (1992). "Colonoscopy and endoscopic therapy for delayed post-polypectomy hemorrhage." Gastrointest Endosc 38(2): 127-9.

Rex, D. K., J. L. Petrini, et al. (2006). "Quality indicators for colonoscopy." Am J Gastroenterol 101(4): 873-85.

Rubin, C. E., R. C. Haggitt, et al. (1992). "DNA aneuploidy in colonic biopsies predicts future development of dysplasia in ulcerative colitis." Gastroenterology 103(5): 1611-20.

Rutter, M. D., B. P. Saunders, et al. (2004). "Pancolonic indigo carmine dye spraying for the detection of dysplasia in ulcerative colitis." Gut 53(2): 256-60.

Saini, S. D., P. Schoenfeld, et al. (2010). "Surveillance colonoscopy is cost-effective for patients with adenomas who are at high risk of colorectal cancer." Gastroenterology 138(7): 2292-9, 2299 e1.

Saunders, B. P., M. Fukumoto, et al. (1994). "Patient-administered nitrous oxide/oxygen inhalation provides effective sedation and analgesia for colonoscopy." Gastrointest Endosc 40(4): 418-21.

Saunders, B. P. and C. B. Williams (1996). "Premedication with intravenous antispasmodic speeds colonoscope insertion." Gastrointest Endosc 43(3): 209-11.

Schoenfeld, P., B. Cash, et al. (2005). "Colonoscopic screening of average-risk women for colorectal neoplasia." N Engl J Med 352(20): 2061-8.

Shah, H. A., L. F. Paszat, et al. (2007). "Factors associated with incomplete colonoscopy: a population-based study." Gastroenterology 132(7): 2297-303.

Sharma, V. K., C. C. Nguyen, et al. (2007). "A national study of cardiopulmonary unplanned events after GI endoscopy." Gastrointest Endosc 66(1): 27-34.

Silvis, S. E., O. Nebel, et al. (1976). "Endoscopic complications. Results of the 1974 American Society for Gastrointestinal Endoscopy Survey." Jama 235(9): 928-30.

Simmons, D. T., G. C. Harewood, et al. (2006). "Impact of endoscopist withdrawal speed on polyp yield: implications for optimal colonoscopy withdrawal time." Aliment Pharmacol Ther 24(6): 965-71.

Singh, N., M. Harrison, et al. (2004). "A survey of colonoscopic polypectomy practices among clinical gastroenterologists." Gastrointest Endosc 60(3): 414-8.

Smith, R. A., V. Cockinides, et al. (2002). "American Cancer Society guidelines for the early detection of cancer." CA Cancer J Clin 52(1): 8-22.

Spier, B. J., M. Benson, et al. (2010). "Colonoscopy training in gastroenterology fellowships: determining competence." Gastrointest Endosc 71(2): 319-24.

Spier, B. J., E. T. Durkin, et al. (2010). "Surgical resident’s training in colonoscopy: numbers, competency, and perceptions." Surg Endosc 24(10): 2556-61.

Sumanac, K., I. Zealley, et al. (2002). "Minimizing postcolonoscopy abdominal pain by using CO(2) insufflation: a prospective, randomized, double blind, controlled trial evaluating a new commercially available CO(2) delivery system." Gastrointest Endosc 56(2): 190-4.

Terraz, O., V. Wietlisbach, et al. (2005). "The EPAGE internet guideline as a decision support tool for determining the appropriateness of colonoscopy." Digestion 71(2): 72-7.

Triebwasser, A. and R. A. Browning (2001). "Sedation and analgesia by non-anesthesiologists." Med Health R I 84(10): 317-20.

Trojan, J., B. P. Saunders, et al. (1997). "Immediate recovery of psychomotor function after patient-administered nitrous oxide/oxygen inhalation for colonoscopy." Endoscopy 29(1): 17-22.

U.S. Preventive Services Task Force (2008). "Screening for colorectal cancer: U.S. Preventive Services Task Force recommendation statement." Ann Intern Med 149(9): 627-37.
Uraoka, T., J. Kato, et al. (2009). "CO(2) insufflation for potentially difficult colonoscopies: efficacy when used by less experienced colonoscopists." World J Gastroenterol 15(41): 5186-92.

Usta, B., C. Turkay, et al. (2011). "Patient-controlled Analgesia and Sedation With Alfentanil Versus Fentanyl for Colonoscopy: A Randomized Double Blind Study." J Clin Gastroenterol.

Vader, J. P., I. Pache, et al. (2000). "Overuse and underuse of colonoscopy in a European primary care setting." Gastrointest Endosc 52(5): 593-99.

Van Gelder, R. E., C. Y. Nio, et al. (2004). "Computed tomographic colonography compared with colonoscopy in patients at increased risk for colorectal cancer." Gastroenterology 127(1): 41-8.

Vargo, J. J. (2007). "Minimizing complications: sedation and monitoring." Gastrointest Endosc Clin N Am 17(1): 11-28, v-vi.

Vargo, J. J., L. B. Cohen, et al. (2009). "Position statement: Nonanesthesiologist administration of propofol for GI endoscopy." Gastroenterology 137(6): 2161-7.

Waring, J. P., T. H. Baron, et al. (2003). "Guidelines for conscious sedation and monitoring during gastrointestinal endoscopy." Gastrointest Endosc 58(3): 317-22.

Welchman, S., S. Cochrane, et al. (2010). "Systematic review: the use of nitrous oxide gas for lower gastrointestinal endoscopy." Aliment Pharmacol Ther 32(3): 324-33.

Williams, C. B. (1986). "Who's for CO2?" Gastrointest Endosc 32(5): 365-7.

Williams, J. E., T. D. Le, et al. (2011). "Polypectomy rate as a quality measure for colonoscopy." Gastrointest Endosc.

Winawer, S., R. Fletcher, et al. (2003). "Colorectal cancer screening and surveillance: clinical guidelines and rationale-Update based on new evidence." Gastroenterology 124(2): 544-60.

Winawer, S. J., A. G. Zauber, et al. (2006). "Guidelines for colonoscopy surveillance after polypectomy: a consensus update by the US Multi-Society Task Force on Colorectal Cancer and the American Cancer Society." CA Cancer J Clin 56(3): 143-59; quiz 184-5.

Woltjen, J. A. (2005). "A retrospective analysis of cecal barotrauma caused by colonoscope air flow and pressure." Gastrointest Endosc 61(1): 37-45.

Working Party of the Clinical Services Committee of the British Society of Gastroenterology (1991). " Provision of gastrointestinal endoscopy and related services for a district general hospital." Gut 32(1): 95-105.

Yamano, H. O., K. Yoshikawa, et al. (2010). "Carbon dioxide insufflation for colonoscopy: evaluation of gas volume, abdominal pain, examination time and transcutaneous partial CO2 pressure." J Gastroenterol 45(12): 1235-40.

Yoong, K. Y., D. Perkin, et al. (2004). " Intravenous hyoscine as a premedication for colonoscopy: a randomized double-blind controlled trial." Endoscopy 36(8): 720-2.

Yusoff, I. F., D. G. Ormonde, et al. (2002). " Routine colonic mucosal biopsy and ileoscopy increases diagnostic yield in patients undergoing colonoscopy for diarrhea." J Gastroenterol Hepatol 17(1): 276-80.

Zins, B. J., W. J. Tremaine, et al. (1995). "Collagenous colitis: mucosal biopsies and association with fecal leukocytes." Mayo Clin Proc 70(5): 430-3.
To publish a book on colonoscopy suitable for an international medical audience, drawing upon the expertise and talents of many outstanding world-wide clinicians, is a daunting task. New developments in videocolonoscope instruments, procedural technique, patient selection and preparation, and moderate sedation and monitoring are being made and reported daily in both the medical and the lay press. Just as over the last several decades colonoscopy has largely supplanted the use of barium enema x-ray study of the colon, new developments in gastrointestinal imaging such as computerized tomographic colonography and video transmitted capsule study of the colonic lumen and new discoveries in cellular and molecular biology that may facilitate the early detection of colon cancer, colon polyps and other gastrointestinal pathology threaten to relegate the role of screening colonoscopy to the sidelines of medical practice. This book draws on the talents of renowned physicians who convey a sense of the history, the present state-of-the-art and ongoing confronting issues, and the predicted future of this discipline.

How to reference
In order to correctly reference this scholarly work, feel free to copy and paste the following:

Anita Balakrishnan, Stephen Lewis and Kenneth B Hosie (2011). Maintaining Quality in Endoscopy, Colonoscopy, Prof. Paul Miskovitz (Ed.), ISBN: 978-953-307-568-6, InTech, Available from: http://www.intechopen.com/books/colonoscopy/maintaining-quality-in-endoscopy
