THE AMERICAN JOURNAL OF GASTROENTEROLOGY
Vol. 97, No. 6, 2002

ISSN 0002-9270/02/$22.00
Published by Elsevier Science Inc.
PII S0002-9270(02)04168-0

CLINICAL REVIEWS

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

Douglas K. Rex, M.D., John H. Bond, M.D., Sidney Winawer, M.D., Theodore R. Levin, M.D., Randall W. Burt, M.D., David A. Johnson, M.D., Lynne M. Kirk, M.D., Scott Litlin, M.D., David A. Lieberman, M.D., Jerome D. Waye, M.D., James Church, M.D., John B. Marshall, M.D., and Robert H. Riddell, M.D.

Department of Medicine/Gastroenterology, Indiana University Medical Center, Indianapolis, Indiana; Department of Medicine/Gastroenterology, Minneapolis VA Medical Center, University of Minnesota, Minneapolis, Minnesota; Department of Medicine/Gastroenterology, Memorial Sloan-Kettering Cancer Center, New York, New York; Department of Medicine/Gastroenterology, Kaiser Permanente Medical Center, Walnut Creek, California; Department of Medicine/Gastroenterology, Huntsman Cancer Institute at the University of Utah, Salt Lake City, Utah; Department of Medicine/Gastroenterology, Eastern Virginia School of Medicine, Norfolk, Virginia; Department of Internal Medicine, University of Texas Southwestern Medical Center at Dallas, Dallas, Texas; Department of Internal Medicine, Mayo Clinic, Rochester, Minnesota; Department of Medicine/Gastroenterology, Oregon Health Sciences University, Portland, Oregon; Department of Medicine/Gastroenterology, Mount Sinai Medical Center, New York, New York; Department of Colorectal Surgery, Cleveland Clinic Foundation, Cleveland, Ohio; Department of Medicine/Gastroenterology, University of Missouri, Columbia, Missouri; and Department of Pathology, Mount Sinai Hospital, Toronto, Ontario, Canada

INTRODUCTION

Colorectal cancer is the second leading cause of cancer death in the United States. Colonoscopy and polypectomy have been effective in reducing the incidence of colorectal cancer in cohort studies (1–3), a case control study (4), a randomized controlled trial (5), and a trial of fecal occult blood testing (6). Colonoscopy and polypectomy are becoming increasingly prominent tools in both the diagnosis and the prevention of colorectal cancer.

Colonoscopy and polypectomy are complex technical procedures that require training and experience to maximize accuracy and safety (7). These recommendations for the technical performance of colonoscopy and for continuous quality improvement in colonoscopy were developed by the U.S. Multi-Society Task Force on Colorectal Cancer, comprised of representatives of the American College of Gastroenterology, The American College of Physicians–American Society of Internal Medicine (ACP-ASIM), The American Gastroenterological Association, and The American Society for Gastrointestinal Endoscopy. This task force was assembled in December, 2000 as a collaborative project of these four societies to address issues in colorectal cancer detection and prevention.

The general focus of these recommendations is on the interaction of the quality of colonoscopy with the impact of colonoscopy on the detection and prevention of colorectal neoplasia. Thus, the recommendations do not address every diagnostic or therapeutic use of colonoscopy. These recommendations address the appropriate indications and intervals for colonoscopy and polypectomy, the technical performance of colonoscopy, biopsy and polypectomy, complications of colonoscopy, and the interaction of colonoscopists with pathologists. For each of these areas, continuous quality improvement targets are recommended.

The purpose of this article is to provide evidence- and consensus-based standards for the performance of high quality colonoscopy, and to facilitate the development of constructive programs in continuous quality improvement. Continuous quality improvement is recommended as part of every colonoscopy program.

This document is comprehensive with regard to quality improvement in colonoscopy. Other discussions of quality are available (8). The continuous quality improvement pro-

cess can be expensive and time consuming for practitioners. Colonoscopy programs should prioritize which targets are most suitable for initial review based on their own perceived needs, and extend the review process of other targets over a time period that ensures feasibility.

The recommendations in the document are based on literature review and the consensus of the task force. Some of the targets presented require validation with regard to feasibility of achievement and whether they result in improved patient outcomes. Colonoscopists are encouraged to report their experience using these recommendations as a guide to quality, and whether feedback to colonoscopists resulted in improved adherence to the target goals.

The task force also has posed a series of key research questions in each of the above areas for consideration by endoscopists-investigators. In addition to promoting investigation to improve this important technology, the questions underscore the limited evidence base supporting certain of the recommended targets.

These recommendations were reviewed and endorsed by the American College of Gastroenterology, The American Gastroenterological Association, and The American Society for Gastrointestinal Endoscopy. Although the ACP-ASIM representatives to the task force contributed to and approved the final document, the ACP-ASIM did not review it at a society level.

THE RATIONALE FOR QUALITY RECOMMENDATIONS

Colonoscopy is one of the most commonly performed medical procedures in the United States, with an estimated 4.3 million procedures performed in 1999 (9). Several lines of evidence suggest that the quality of performance of colonoscopy in clinical practice varies.

The best documented area of variation between examiners is the sensitivity of colonoscopy for colorectal neoplasia. The sensitivity of colonoscopy for colorectal cancer differs between gastroenterologists and nongastroenterologists (10, 11), as well as among gastroenterologists (10, 11). Different sensitivities between gastroenterologists for adenoma detection also have been described (12). In a recent study of screening flexible sigmoidoscopy, prevalence rates of adenomas varied among screening centers and were shown to be higher where examiners spent more time performing the examination (13). The quality of colonoscopic withdrawal technique has been shown to be associated with adenoma miss rates (14).

A second area of variation is in complication rates—specifically, perforation. Perforation rates reported in the 1990s varied widely, from 1 in 500 to 1 in >4000 (15–18). Although the reasons for this variation are uncertain, variable performance is likely an important contributor.

Given that the large number of colonoscopies already performed in the United States is expected to increase with the availability of reimbursement for screening colonoscopies for Medicare beneficiaries as of July 1, 2001, the importance of colorectal cancer as a public health problem, the evidence for variable performance, and the obvious desirability of maximizing the impact of colonoscopy on colorectal cancer incidence and mortality, we anticipate that the quality of colonoscopy will be among the most important issues surrounding its use. Anticipation of this issue is the basis for this report.

INDICATIONS AND INTERVALS

Discussion

Colonoscopists should know the appropriate indications for colonoscopy, their relative predictive value, and the intervals at which colonoscopy should be repeated for given indications. These intervals as well as appropriate age of onset for screening average and high risk persons and indications for colonoscopic evaluation of other positive screening tests are covered in detail in a separate publication (19) and summarized in Table 1. For average risk screening, colonoscopy every 10 yr is one of several acceptable screening options (19–21). Screening in average risk persons should begin at 50 yr. Mixed strategies have been discussed, such as annual fecal occult blood testing plus flexible sigmoidoscopy every 5 yr beginning at age 50, followed by switching to colonoscopy at ages 60–65 (22). Although no guideline group has yet endorsed a mixed strategy, its use in practice by knowledgeable clinicians is acceptable. Regardless of whether screening colonoscopy is first performed at age 50 or later, the recommended screening interval is 10 yr. The rationale for 10-yr intervals is discussed elsewhere (19–21). A 10-yr interval is believed, based on available evidence, to represent the best balance between factors such as colorectal cancer risk reduction, costs, and procedure risks. This principle applies to all recommended intervals in Table 1. These recommended intervals are associated with very substantial colorectal cancer risk reduction but not with risk elimination. Because of technical limitations of current colonoscopes and the variable biological behavior of colorectal cancer, some incident cancers will develop after clearing colonoscopy regardless of indication (23).

In general, bleeding indications (red blood in the toilet, iron deficiency anemia, positive fecal occult blood test, melena with a negative upper endoscopy [esophagogastroduodenoscopy]) have a high positive predictive value for colorectal cancer and large adenomas (24). Persons who have undergone colonoscopies for positive fecal occult blood tests and in whom examinations with adequate bowel preparation were negative may generally stop screening fecal occult blood testing for 10 yr because of the high negative predictive value of colonoscopy.

Indications such as abdominal pain and altered bowel habit, with no evidence of bleeding, have a predictive value for neoplasia similar to that of screening indications (25, 26). Colonoscopy may be indicated in a patient with these symptoms for the purpose of screening, depending on his or her age and family history. If a colonoscopy to the cecum is

Table 1. Indications for Colonoscopy and Appropriate Intervals

Indication	Interval*
Bleeding	
Positive FOBT	NR
Hematochezia	NR
Iron deficiency anemia	NR
Melena with negative esophagogastroduodenoscopy	NR
Screening	
Average risk	10 yr (begin at age 50)
Single FDR with cancer (or adenomas) at age 60 or older	10 yr (begin at age 40)
≥2 FDRs with cancer (or adenomas) or 1 FDR diagnosed at younger than 60	5 yr (begin at age 40 or 10 yr younger, whichever is earlier)
Prior endometrial or ovarian cancer diagnosed at younger than 50	5 yr
HNPCC (begin ages 20–25)	1–2 yr
Abdominal pain, altered bowel habit	†
Positive sigmoidoscopy (large polyp or polyp of <1 cm shown to be an adenoma)	‡
Postadenoma resection	
1–2 tubular adenomas of <1 cm	5 yr
Normal follow-up exam or only hyperplastic polyps at follow-up	5 yr
≥3 adenomas or adenoma with villous features, ≥1 cm or with HGD	3 yr
Numerous adenomas or sessile adenoma of >2 cm, removed piecemeal§	Short interval based on clinical judgment
Postcancer resection	Clear colon, then in 3 yr, then as per adenoma recommendations
Ulcerative colitis, Crohn's colitis surveillance after 8 yr of pancolitis or 15 yr of left-sided colitis	2–3 yr until 20 yr after onset of symptoms, then 1 yr

FDR = first degree relative; FOBT = fecal occult blood test; HGD = high grade dysplasia; HNPCC = hereditary nonpolyposis colorectal cancer; NR = interval not recommended. The need for repeat examination depends on the findings of the initial colonoscopy and may depend on the persistence of the indication and the results of other evaluations. In general, patients should resume screening in 5–10 yr or when they reach an age when screening would otherwise be recommended.

* Interval recommendations assume adequate preparation and cecal intubation.

† If colonoscopy is negative and symptoms are stable, repeat examination should be done according to screening recommendations.

‡ See postadenoma resection recommendation.

§ The goal is to reexamine the site for residual polyp; repeating a flexible sigmoidoscopy is adequate for a distal polyp.

negative in such a patient, the procedure will generally not need to be repeated at less than the recommended screening interval (*i.e.,* 10 yr) if the symptoms remain stable and no bleeding develops.

There is a growing recognition that much of the cohort with resected adenomas (and probably the postcancer resection cohort) is observed with repeat colonoscopies at intervals that are too short (19, 27) (see Table 1 for recommended intervals). This practice decreases the availability of resources for screening colonoscopy and exposes patients to unnecessary risk. Indeed, postpolypectomy surveillance has the lowest yield of all indications for colonoscopy except ulcerative colitis surveillance (24).

Patients with only hyperplastic polyps in the colon should be considered to have had normal examinations. An exception may exist when there are multiple (usually more than 20) hyperplastic polyps distributed throughout the colon (28). The significance of that finding and the need for follow-up are currently under study.

The onset of symptoms is the onset of disease for the purpose of timing initiation of surveillance in ulcerative colitis or Crohn's colitis. Established risk modifiers, such as a family history of colorectal cancer (29) or a personal history of primary sclerosing cholangitis (30), may lead to shortening of the intervals recommended in Table 1. Persons with primary sclerosing cholangitis discovered to have asymptomatic ulcerative colitis should begin surveillance at the time ulcerative colitis is diagnosed. Patients with only ulcerative proctitis should undergo the same colorectal cancer screening as average risk persons.

Continuous Quality Improvement Targets

1. Use of recommended postpolypectomy and postcancer resection surveillance intervals (Table 1).
2. Use of recommended ulcerative colitis surveillance intervals and timing of onset of surveillance (Table 1).
3. Use of recommended screening intervals (Table 1).

Key Research Questions

1. How familiar are current colonoscopists in practice with recommendations for appropriate intervals for performance of screening and surveillance colonoscopy?
2. What is the degree of adherence to recommended intervals among both gastroenterologists and nongastroenterologists?
3. What portion of the adenoma-bearing cohort can have intervals between examinations extended safely beyond 5 yr?
4. What intervals for screening are best in persons with one or more first degree relatives with cancer or adenomas who do not meet criteria for hereditary nonpolyposis colorectal cancer?
5. Would a single colonoscopy at a defined age successfully stratify the population according to subsequent risk of colorectal cancer?

Table 2. Definition of ASA Status

Class 1:	Patient has no organic, physiological, biochemical, or psychiatric disturbance. The pathological process for which the operation is to be performed is localized and does not entail systemic disturbance.
Class 2:	Mild to moderate systemic disturbance caused either by the condition to be treated surgically or by other pathophysiological processes.
Class 3:	Severe, systemic disturbance or disease from whatever cause, even though it may not be possible to define the degree of disability with finality.
Class 4:	Severe systemic disorders that are already life threatening, not always correctable by operation.
Class 5:	The moribund patient who has little chance of survival but is submitted to operation in desperation.

PRECAUTIONS

Discussion

Certain preexisting conditions increase the risk of colonoscopy and polypectomy. These conditions should be systematically identified and recorded during the preprocedure evaluation. A preprocedure history and examination (which may be focused) that assess and identify risk factors for sedation and procedural complications should be recorded. The risk of cardiopulmonary complications is increased in patients with higher American Society of Anesthesiology (ASA) classes (Table 2). Cardiopulmonary conditions are particularly important.

Reduction of sedation doses, increased intensity of intraprocedural monitoring, and performance of procedures in the hospital setting are appropriate in patients with higher ASA classes.

Colonoscopy with or without biopsy or polypectomy is associated with a low risk of bacteremia. However, patients may be considered on a case-by-case basis for antibiotic proplylaxis if they have high risk conditions for endocarditis (Table 3). A single dose of proplylactic antibiotics can be considered on a case-by-case basis before colonoscopy in patients during the 1st yr after placement of a synthetic vascular graft. Rare cases of peritonitis in the absence of perforation have been reported in cirrhotics with ascites undergoing colonoscopy. Prophylactic administration of antibiotics can be considered on a case-by-case basis. Antibiotics are not recommended before colonoscopy to prevent infection of prosthetic joints or orthopedic prostheses. The issue of antibiotic prophylaxis is discussed in detail elsewhere (31).

Therapeutic anticoagulation with warfarin is associated with an increased risk of bleeding after polypectomy but not after mucosal biopsy (32). The management of anticoagulation in the periprocedural period depends on the risk of thromboembolism and is discussed in detail elsewhere (32).

Continuous Quality Improvement Targets

1. Identification of ASA class and appropriate action (goal: 100%).

Table 3. Antibiotic Prophylaxis Before Colonoscopy With or Without Biopsy or Polypectomy

Consider prophylaxis on a case-by-case basis for the following conditions:

- prosthetic heart valves
- history of endocarditis
- surgically constructed systemic-pulmonary shunts

There are no other valvular heart conditions for which prophylaxis should be considered.

2. Identification of anticoagulation and appropriate action (goal: 100%).
3. Appropriate action with regard to prophylactic antibiotics (goal: 100%).

Key Research Questions

1. For which high risk conditions for thromboembolism can low molecular weight heparin replace the need for *i.v.* heparin?
2. For which high risk conditions for thromboembolism can warfarin be safely stopped without heparin coverage?
3. For which cardiac and noncardiac conditions is antibiotic prophylaxis actually warranted?
4. What is the optimal management of antiplatelet agents such as clopidogrel before and after polypectomy?

INSERTION

Discussion

The goal of insertion is safe cecal intubation. By definition, cecal intubation is achieved when the tip of the colonoscope is passed beyond the ileocecal valve lip into the caput coli, allowing effective visualization of the medial wall of the cecum lying proximal to the ileocecal valve. The distribution of colon neoplasms is such that a substantial percentage of lesions are proximal to the splenic flexure, including in the cecum (10, 33). Cecal intubation removes the need for a second examination such as barium enema or a second colonoscopy to complete the study. Reports from the 1990s indicate that cecal intubation rates above 90% are consistently achieved by experienced colonoscopists (34), and rates above 90% are a goal of training programs in colonoscopy. For screening of asymptomatic persons, cecal intubation rates of 97–99% have been consistently achieved (35–42). Thus, although $\geq$90% is an overall appropriate target for cecal intubation, rates of $\geq$95% should be achievable for screening examinations. When calculating cecal intubation rates, examinations aborted because of inadequate preparation before reaching the cecum should be excluded. Similarly, examinations aborted because of severe colitis may be excluded. Photographic documentation of inadequately prepared bowel or severe colitis is useful in justifying a repeat examination. All other examinations (including obstructed colons) are generally included in the calculation of cecal intubation rates.

The endoscopic appearance of the cecum is unmistakable

to the experienced examiner (43). Cecal intubation can be verified with complete certainty by visualization of the lips of the ileocecal valve and the appendiceal orifice. Identification of the terminal ileum adds to certainty but is not required unless clinically indicated. Identification of the "crow's foot" appearance caused by the impression of the taeniae coli on the cecum is also useful; however, it is unreliable as a single measure of cecal intubation because the impression of taenia coli in flexures can mimic the crow's foot. Identification of light transmission through the abdominal wall is generally unnecessary and by itself is an unreliable indication of cecal intubation.

The procedure report should document whether cecal intubation occurred and should in all cases specify the landmarks used to verify intubation. One or more photographs of the cecum should be included in the report whenever the technology is available. Because of variations in cecal anatomy, still photography does not provide convincing documentation in all cases (43, 44), underscoring the need to document landmarks identified in the text of the procedure report. Although imperfect, cecal photography is considered advisable by the task force. In most cases convincing photographs can be obtained and, when considered over multiple cases, will facilitate verification of a colonoscopist's cecal intubation rate in the continuous quality improvement process. As a side issue, cecal photography is advisable from a medical-legal perspective (23). Videotaping provides excellent documentation but is not practical for routine use (43). Videotaping can be very reliably used to evaluate a colonoscopist whose claimed cecal intubation rates have been questioned.

Variations in standard insertion tubes for colonoscopy include pediatric colonoscopes (45, 46) and variable stiffness colonoscopes (47–50). Although each may have particular advantages in certain patients (upper endoscopes or even enteroscopes may be useful in occasional patients), no variation in insertion tubes has yet been shown to make a substantial difference in cecal intubation rates or speed of intubation for routine colonoscopy (45–50).

Technical maneuvers of colonoscope insertion are described elsewhere (51–55).

Continuous Quality Improvement Targets

1. Cecal intubation rates in all cases (≥90%) and in screening cases (≥95%).
2. Documentation in endoscopic reports of cecal intubation and visualized landmarks (100%) and with photography when available.

Key Research Questions

1. What are rates of cecal intubation and adequate documentation of intubation across a range of community practices and by gastroenterologists *versus* nongastroenterologists?
2. Does variable stiffness improve cecal intubation rates or speed of intubation during training or among less experienced examiners?
3. Would magnetic electronic imaging (56, 57) shorten the learning curve for colonoscopy and improve cecal intubation rates or insertion times in trainees or in less experienced examiners?
4. Can training on simulators shorten the learning curve for colonoscopy?
5. What technical improvements could improve the ease, speed, and safety of colonoscopy?

COLONOSCOPE WITHDRAWAL

Discussion

Because most colonoscopists examine the colon primarily during withdrawal, it is a very important phase of colonoscopy. Even with careful technique, miss rates for small adenomas are still substantial and occasionally polyps larger than 1 cm are missed (12, 58). Adenoma detection rates are variable, and higher detection rates are associated with systematic efforts to visualize the mucosa on the proximal sides of folds, flexures, rectal valves, and the ileocecal valve. Adequate colonic distention, adequate suctioning and cleaning, and adequate time spent examining also correlate with detection rates (13, 14). Reports from experts suggest that the withdrawal phase, exclusive of time for biopsy and polypectomy, should average *at least* 6–10 min (59). This time range also encompasses the mean withdrawal time of an examiner with the lowest measured miss rate among 26 colonoscopists participating in a tandem colonoscopy study (14). Longer intervals may ultimately be shown to be necessary for optimal examination. Documentation of the time of cecal intubation and scope withdrawal from the anus allows determination of examination times, at least for normal examinations. In the unusual instance of colonoscopists who examine primarily on insertion, it is advisable to note this practice in the colonoscopy report and to again note the times for colonoscope insertion into the rectum, cecal intubation, and colonoscope withdrawal from the anus. The report should also document the quality of preparation and impairment in the colonoscopist's confidence attributable to preparation.

There is no standardized system for describing bowel preparation. An adequate examination is one that allows confidence that mass lesions other than small (≤5 mm) polyps were generally not obscured by the preparation. Recommended intervals for screening and surveillance assume adequate preparation.

The adenoma prevalence rate in a colonoscopist's practice is a function of the quality of the colonoscopist's examination technique and the demographics of the patient population. Cross-sectional screening colonoscopy studies indicate that 25–40% of the asymptomatic population older than 50 in the United States harbor one or more adenomas (35–42). Male gender and older age are associated with a higher risk, as is a positive family history of colorectal

cancer (35–42). The most important neoplastic endpoints in the colon are cancer and advanced adenomas, usually defined as adenomas of ≥1cm in size, or with high grade dysplasia or villous elements (*i.e.*, a villous or tubulovillous adenoma). The prevalence of advanced adenomas in screening populations is 3–10% and, again, is a function of age, gender, and family history of colorectal cancer. An understanding of and emphasis on advanced adenomas is particularly important in planning screening strategies and surveillance intervals (see Indications and Intervals). However, for estimating quality of withdrawal, we recommend that programs focus on overall adenoma detection rates. The rationale for this focus is as follows: 1) complete clearing of neoplasms from the colon is still considered a desirable outcome; 2) it is easier to detect variation in endoscopists' performance by consideration of overall adenoma detection rates, because overall adenoma prevalence rates are considerably higher than advanced adenoma prevalence rates; and 3) it is reasonable to assume that adequate technique to detect small adenomas will also detect advanced adenomas, which tend to be larger.

Recent studies (60–62) have identified occasional small flat adenomas with a tendency to harbor high grade dysplasia and invasive cancer in several countries, including the United Kingdom and the United States. In these studies, chromoscopy and more extensive bowel preparation were used routinely to enhance inspection of subtle surface abnormalities. However, a properly controlled trial to prove that specialized techniques are essential for the detection of these lesions has not yet been performed.

Continuous Quality Improvement Targets

1. Mean examination times (during duration of withdrawal phase). Goal: withdrawal times should average *at least* 6–10 min.
2. Adenoma prevalence rates detected during colonoscopy in persons undergoing first-time examinations. Goal: (≥25% in men older than 50 and ≥15% in women 50 or older.
3. Documentation of quality of bowel preparation. Goal: 100%

Key Research Questions

1. What are the most important aspects of high quality withdrawal technique?
2. What is the optimal duration of colonoscopic examination?
3. Should chromoscopy for enhancement of detection of flat adenomas be routinely employed in Western populations? If so, what method of chromoscopy should be used?
4. What is the current use of chromoscopy by endoscopists in the United States? What training is needed for experienced endoscopists to effectively perform chromoscopy?
5. What technical advances would allow reliable and efficient detection of flat dysplastic tissue without chromoscopy or other practices that reduce efficiency?
6. What technical advances in colonoscopes could expand the endoscopic field of view and reduce or eliminate miss rates?

BIOPSY AND POLYPECTOMY

Discussion

A colonoscopist should be proficient in both biopsy and polypectomy. Systematic biopsy of the terminal ileum and of the colon by segment can assist in establishing the extent of inflammatory bowel disease (IBD) and, in some cases, the type of IBD or assist in the exclusion of inflammatory conditions that mimic IBD. Recent evidence indicates that many gastroenterologists in both the United States and Britain are not familiar with appropriate biopsy protocols for dysplasia in ulcerative colitis or with current management of dysplasia detected in ulcerative colitis (63, 64). There is evidence that a systematic biopsy protocol is required in ulcerative colitis to maximize the sensitivity for dysplasia (65). The recommended protocol includes biopsies in all four quadrants from each 10 cm of the colon. The procedure report in ulcerative colitis surveillance examinations should specify the number and locations of biopsies from flat mucosa and the location and endoscopic appearance of any mass or suspicious polypoid lesions that were biopsied or removed (obvious pseudopolyps and inflammatory polyps need not be biopsied or removed). Additional biopsies from flat mucosa surrounding mass lesions that are believed to be possibly dysplastic are useful for separating sporadic adenomas (dysplastic mass lesions not related to the cancer potential of the colitis) from dysplasia-associated lesions or masses (DALMs) (in essence, dysplastic mass lesions that are related to the cancer potential of the colitis) (66, 67).

Polypectomy should be performed on all polyps identified during colonoscopy, with the exception of multiple small (usually 1–5 mm) hyperplastic-appearing (pale, sessile, sometimes disappearing with air insufflation) polyps in the rectosigmoid. These polyps may be sampled with biopsy forceps and otherwise left *in situ.* Skilled colonoscopists successfully retrieve more than 95% of resected colon polyps for pathological examination.

Trained colonoscopists can generally remove any mucosally based pedunculated polyp regardless of size. Large sessile, benign-appearing polyps are also generally removable endoscopically by piecemeal resection. A useful guideline is to consider endoscopic resection for benign-appearing lesions that occupy (≤30% of the circumference and do not cross two haustral folds. However, a decision for endoscopic *versus* surgical resection in an individual case may be based on an endoscopic position that favors surgical resection because of poor endoscopic access (*e.g.*, a broad flat polyp proximal to the ileocecal valve or proximal to a bend in the sigmoid colon) or favors endoscopic resection of a

polyp larger than in the guideline above (*e.g.,* a sessile polyp in a straight colonic section with large luminal caliber such as the rectum or ascending or transverse colon). Making appropriate judgments regarding endoscopic resectability of large sessile polyps requires substantial experience. Experienced colonoscopists who remove sessile polyps of ≥2cm in size frequently find that small portions of the polyp, which are invariably very flat in shape, cannot be removed by snaring. Thus, colonoscopists removing very large (≥2 cm) sessile colon polyps should be trained and experienced in the effective and safe delivery of an ablative technique such as argon plasma coagulation (68) or Nd:YAG laser (69, 70). Multipolar cautery may be effective for this purpose, but there is less reported experience. In general, patients with large polyps that are endoscopically resectable should be offered the option of endoscopic resection, either by the original colonoscopist or by another more experienced colonoscopist. In cases where the endoscopic resectability of a large sessile polyp is uncertain, review by a more experienced colonoscopist is appropriate.

Continuous Quality Improvement Targets

1. Number and distribution of biopsy samples in ulcerative colitis and Crohn's colitis surveillance. Goal: four per 10-cm section of involved colon or approximately 30 biopsies in cases of panulcerative colitis.
2. Documentation of the size and shape distribution of benign polyps sent for surgical resection (as measured by the pathologist). Goal: mucosally based pedunculated polyps and sessile polyps of <2 cm in size should not be sent for surgical resection without an attempt at endoscopic resection or documentation of endoscopic inaccessibility.
3. Percentage of resected colon polyps recovered for pathological examination. Goal: ≥95%.

Key Research Questions

1. What is the effectiveness of surveillance colonoscopy in IBD for colorectal cancer prevention in community practice in the United States?
2. How are dysplasia in flat mucosa, DALM, and sporadic adenoma managed in community practice?
3. What is the degree of adherence to recommended biopsy protocols for IBD in community practice?
4. How are large (>2 cm) colon polyps managed in community practice, and does this management differ among colonoscopists in different specialties (*e.g.,* gastroenterologists *vs* surgeons)?
5. What is the success rate of endoscopic resection of large sessile polyps (>2 cm) in community practice?

COMPLICATIONS

Discussion

As the use of colonoscopy increases, reducing complication rates and maintaining them at a very low level will become an increasingly important goal.

Informed consent for colonoscopy should focus on four possible adverse outcomes: 1) perforation and the probable need for surgical repair if this occurs, 2) missing a significant neoplasm, 3) postpolypectomy hemorrhage, and 4) adverse cardiopulmonary reactions, usually related to sedation. Some colonoscopists include in the informed consent process a variety of other possible outcomes (*e.g.,* possible ostomy, blood transfusion, etc). Patterns of practice indicate that an informed consent can be obtained on the day of the procedure, even in open access practices. The current rate of perforation in clinical practice is uncertain. Reports in the 1990s vary from 1 in 500 to 1 in >4000 (15–18). Ambulating well patients who are undergoing screening are at lower risk of perforation. Among more than 6000 screening colonoscopies reported thus far in average risk persons, no perforations have been reported (35–42). The expected rate of major postpolypectomy bleeding is <1% (71–73). However, the risk is as high as 15% with removal of very large polyps (74). The risk of major bleeding from mucosal biopsy is near zero, even in patients who are therapeutically anticoagulated (32). Perforation may result from either mechanical rupture of the colon from instrument passage or air insufflation or from polypectomy or other therapeutic procedures. The most important rule to avoid mechanical perforation is not to push forcibly against the sensation of fixed resistance. Patients in whom luminal distention cannot be achieved should be checked for abdominal distention, as perforation may already have occurred. Air should be insufflated with caution after passing colonic strictures. Patients with mechanical narrowing who are markedly distended after the procedure and are unable to decompress spontaneously should be observed closely or endoscopically decompressed. Care should be taken in attempting passage of strictures. Colonoscope passage over a guidewire passed through the stricture may prevent slippage of the scope tip off the stricture and dissection of the normal wall abutting the stricture. Converting from a standard size insertion tube to a pediatric colonoscope or upper endoscope often facilitates passage through strictures or areas of marked angulation or distortion.

During polypectomy, perforation and most delayed bleeding are related to the cautery burn. Regardless of the polypectomy device used, complications are more likely with polyps in the proximal colon and with large polyps (75, 76). Anecdotal data suggest that perforations and bleeding are more likely with hot forceps, but definite proof of increased risk is lacking. Cold snaring is particularly attractive for polyps of <7–8 mm in size, as anecdotal data suggest no risk of perforation and a very low risk of postpolypectomy bleeding (77, 78). Snaring (either hot or cold) is more effective than forceps removal (hot or cold) for destroying polyps (79). Thus, cold snaring may be an effective way to remove small polyps and nearly eliminate associated complications. Large polyps have larger vessels and require cautery to seal vessels and allow mechanical transection of tissue. There is no clear evidence to favor

coagulation *versus* cutting current (80). In general, cutting current is associated with more immediate bleeding, and pure coagulation current with delayed bleeding (81). Despite the lack of clear evidence, most experienced colonoscopists use low power pure coagulation or blended current to perform polypectomy. Injection of submucosal saline before piecemeal polypectomy of large sessile polyps reduces injury to the deep wall layers in experimental models (82) but has not been convincingly shown to reduce perforation rates in clinical practice. Further, there is no evidence of reduced bleeding associated with submucosal saline injection. However, the technique facilitates removal of some sessile polyps and probably reduces perforation. All colonoscopists should be skilled in its use (78, 83, 84). Recent innovations in prevention of bleeding include the use of detachable snares for large pedunculated polyps (85) and metal clips for sessile or semipedunculated polyps (86). As these devices take time to apply and given that the risk of hemorrhage is low, their use is not mandated at this time. They may be particularly appropriate for patients at high risk, such as those who will be anticoagulated after polypectomy. Injection of dilute epinephrine probably helps prevent immediate bleeding after transection of pedunculated polyps with thick stalks (87). Bleeding is more common in patients who are anticoagulated after polypectomy, and use of anticoagulants should be systematically identified before colonoscopy (see Precautions).

Cardiopulmonary events account for half of all adverse events during colonoscopy, some of which are related to sedation. The risk of adverse events is associated with higher ASA class, and ASA class should be systematically identified before colonoscopy. Colonoscopists should be prepared to manage adverse cardiopulmonary events. Recommendations for monitoring during sedation are available elsewhere (88, 89). Some patients, particularly older males without abdominal pain, can undergo colonoscopy without sedation, with minimal loss of satisfaction (90). Most American patients, however, prefer to have sedation and will incur a substantial loss of satisfaction without it. The most commonly used sedation in the United States is a combination of benzodiazepines and narcotics. Propofol has been given safely by nurses (91) and using patient-controlled analgesia (92, 93). However, local rules and/or state laws in the United States usually prevent its independent administration by gastroenterologists at this time. The cost-effectiveness of administration of sedation by an anesthesia specialist for routine cases has not been evaluated, and this practice is not recommended.

Continuous Quality Improvement Targets

1. Percentage of cases with informed consent. Goal: 100%.
2. Percentage of cases with four principal adverse outcomes listed on the consent form or on an accompanying procedure or progress note. Goal: 100%.
3. Incidence of minor sedation reactions, such as unplanned reversal of sedation. Goal: $\leq$1 in 100.
4. Incidence of more serious adverse reactions, such as need for mask ventilation or endotracheal intubation. Goal: $<$1 in 300.
5. Incidence of perforation by type (mechanical, small polyp, large polyp). Goal: $<$1 per 1000; for screening exams, $<$1 per 2000.
6. Incidence of postpolypectomy bleeding (immediate and delayed) (goal, $<$1 per 100) cases involving polypectomy. The expected rate will vary, being higher in practices that remove large polyps and much lower in those practices that refer large polyps to others.

Key Research Questions

1. What are the complication rates of colonoscopy in the United States in population-based studies?
2. How are perforation and postpolypectomy bleeding managed in community practices?
3. Does cold resection definitely reduce small polypectomy complications?
4. Does submucosal injection definitely reduce large sessile polyp perforation rates?
5. Under what circumstances and by what delivery protocol could propofol be safely given for colonoscopy without anesthesia specialists present?
6. Under what circumstances is prophylactic looping, injection, or clipping to prevent postpolypectomy bleeding effective and cost-effective?

INTERACTING WITH PATHOLOGISTS

Discussion

Decisions regarding surgical resection of the colon and surveillance intervals after polypectomy are commonly based on pathology findings in colonoscopically obtained specimens. The following recommendations reflect current thinking about the types of information that are needed on pathology reports, in cases of colonic neoplasia, to make clinical management and follow-up decisions as well as what is appropriate reporting terminology that will minimize adverse patient outcomes. Colonoscopists should familiarize themselves with this information and terminology and clearly understand the clinical significance of each pathological finding. Colonoscopists are encouraged to share these recommendations with their clinical pathologists and develop a mutual understanding of the clinical importance of complete pathological description and appropriate terminology, and to agree on mechanisms to monitor the quality of pathology reporting.

All adenomas should be designated as *tubular, tubulovillous,* or *villous* (94). The World Health Organization recommends that polyps with $<$20% villous elements should be designated tubular and those with 20–80%, tubulovillous. Tubulovillous and villous adenomas are often said to

have "villous elements." There is a tendency to overread villous elements in community practice (95), which can lead to overuse of surveillance. Recent colonoscopy series indicate that expert pathologists identify villous elements in <10% of adenomas (41). The clinical importance of villous elements is that they are a criterion for an "advanced adenoma," which in turn has implications for postpolypectomy surveillance intervals (Table 1).

Adenomatous (neoplastic) polyps are dysplastic by definition. The current trend is to designate dysplasia as *low grade* or *high grade.* Essentially all recent major clinical colon polyp trials have used this two-grade system for adenoma dysplasia. The designations *mild, moderate,* or *severe* in the description of dysplasia in colon polyps should not be used, as there is greater interobserver variation with a three-grade system, and it is not clear whether "moderate" dysplasia should be considered equivalent to low grade or high grade when making clinical decisions. Pathological description of adenomas should never employ the terms *carcinoma in situ* or *intramucosal adenocarcinoma.* Both morphological findings should be described using the term *high grade dysplasia.* Incorrect terminology is used more often than not (95).

The clinical importance of "high grade" dysplasia is that it is a criterion for an advanced adenoma, which in turn affects postpolypectomy surveillance intervals. The clinical importance of discontinuing use of the terms *carcinoma in situ* and *intramucosal adenocarcinoma* in description of colon polyps in favor of the term *high grade dysplasia* is that the former terms often cause confusion among colonoscopists, surgeons, referring physicians, and patients because they suggest that cancer is present. In fact, neither carcinoma *in situ* nor intramucosal adenocarcinoma constitutes cancer in the colon, because the dysplastic changes are confined to the mucosa. Anecdotally, pathologists have been reluctant to abandon these terms because they emphasize the seriousness of a lesion that may not have been fully sampled and that might yet require complete resection. In this regard, communication from the colonoscopist to the pathologist can allay concerns and encourage use of appropriate terminology. Indeed, experienced colonoscopists can generally predict the presence of overt cancer based on an endoscopic appearance of an irregular, often erythematous, firm, and frequently ulcerated sessile mass. Colonoscopists should communicate to pathologists their clear understanding that such masses will require rebiopsy, or surgical resection without rebiopsy, even if the initial pinch biopsies demonstrate only high grade dysplasia. "Sessile colon mass, probably cancer" is an example of an appropriate communication from the colonoscopist to the pathologist regarding such a lesion. On the other hand, pedunculated polyps and large sessile polyps lacking surface ulceration are usually benign. The description "benign-appearing polyp, appears fully resected by endoscopy" is an example of an appropriate communication from colonoscopist to pathologist in this instance. Avoidance of the terms *carcinoma in situ* or *intramucosal adenocarcinoma* in favor of *high grade dysplasia* can help avert an unnecessary surgery, as these lesions have zero risk of metastasis, though appropriate endoscopic follow-up is still needed (Table 1). In the case of large sessile lesions removed by piecemeal technique, this includes follow-up within a few months to verify successful complete endoscopic resection (Table 1). If invasive cancer is identified on pathological evaluation of an endoscopically completely resected polyp, it is certainly appropriate for the pathologist to designate it as invasive adenocarcinoma, in which case additional descriptors will assist the clinician in deciding whether surgical resection is needed (see below).

Malignant polyps (those with invasive cancer—*i.e.,* cancer cells penetrating the muscularis mucosa) should be described in all cases with the distance between the cancer and the endoscopic resection line (96) or at least a statement as to whether the resection line was clear of cancer (97). In addition, the degree of tumor differentiation (well, moderate, or poor) and the presence or absence of vascular or lymphatic invasion should be noted (98). The clinical significance of these descriptors is that cancer at the endoscopic resection line or within a defined distance of the resection line, poor differentiation, or vascular (lymphatic) invasion is generally an indication for surgical resection if the patient is deemed an acceptable surgical candidate. Beyond these pathological factors, the endoscopists' assessment of the completeness of endoscopic resection is also important in a decision regarding surgical resection.

Colonoscopists should supply their clinical suspicion, based on endoscopic appearance, of atypical polyps. For example, juvenile polyps, inflammatory polyps, and mucosal prolapse syndrome are often interpreted as adenomas by community pathologists (95). Because these polyps often have a distinct endoscopic appearance, provision of the colonoscopist's suspicion based on endoscopic appearance might help to reduce incorrect pathological interpretations. Colonoscopists should have a low threshold for asking for additional review by experts in GI pathology when pathological readings do not correlate with their clinical impression. All readings of dysplasia in flat mucosa in chronic ulcerative colitis or Crohn's colitis should be reviewed by a second, expert pathologist. Confirmation of any degree of dysplasia in flat mucosa in chronic IBD is often considered to be an indication for colectomy (99), though in some centers patients with unifocal low grade dysplasia are observed using close endoscopic surveillance (100). In chronic ulcerative colitis, designation of a resected dysplastic polypoid lesion as a sporadic adenoma or a DALM involves consideration of both pathological and clinical factors (Table 4). The clinical significance of this decision is that a DALM is an indication for colectomy, whereas in most centers colitis patients with sporadic adenomas are allowed to continue in endoscopic surveillance (66, 67). *DALM* is an unfortunate (but widely used) term. Indeed, the distinction between a DALM and sporadic adenoma is inherently confusing because both lesions are, by definition, dysplastic

Table 4. Endoscopic, Clinical, and Pathological Features Used to Distinguish Sporadic Adenomas From DALMs in Chronic Ulcerative Colitis

Factors favoring sporadic adenoma:
● smooth, rounded endoscopic appearance or pedunculated
● no dysplasia in adjacent flat mucosa
● tubular histology
● shorter colitis duration
● age >40–50 yr
Factors favoring DALM:
● irregular sessile endoscopic appearance
● dysplasia in adjacent flat mucosa
● villous or tubulovillous histology or high grade dysplasia*
● longer colitis duration
● age < 40–50 yr

* Histological features of advanced adenomas favor DALM over sporadic adenoma when encountered in ulcerative colitis.

mass lesions. However, in most cases consideration of clinical and pathological features (Table 4) will allow the colonoscopist and pathologist to reach a confident decision regarding DALM *versus* sporadic adenoma. In cases where the decision is uncertain because the dysplastic mass lesion has features of both a DALM and sporadic adenoma (Table 4), frank discussion with an informed patient will guide the decision regarding colectomy *versus* close surveillance.

Continuous Quality Improvement Targets

1. Percentage of adenomas with villous elements. Goal: <10%.
2. Reports using the terms *carcinoma in situ* or *intramucosal adenocarcinoma.* Goal: none.
3. Designation of the degree of dysplasia in adenomas as *low grade* or *high grade.* Goal: 100%.
4. Use of the terms *mild, moderate,* or *severe* to describe dysplasia and adenomas. Goal: none.
5. Adequate characterization of malignant polyps (resection line "margin," degree of differentiation, presence or absence of vascular [or lymphatic] invasion). Goal: 100%.

Key Research Questions

1. Can pathological evaluation of small colon polyps (*e.g.*, <5 mm) be replaced in a safe and cost-effective fashion by endoscopic assessment alone (*e.g.*, high resolution plus chromoscopy or optical biopsy techniques or laser-induced spectroscopy) or by ablation or resection and tissue disposal, without submission to pathology?
2. What educational process could improve the performance of community pathologists in interpretation of colon polyps?
3. How do colonoscopists and surgeons in clinical practice interpret and act on pathological reports of high grade dysplasia, carcinoma *in situ,* and intramucosal adenocarcinoma in colon polyps?
4. How do colonoscopists and surgeons in clinical practice interpret and act on pathological readings of malignant colon polyps with specified margins between the tumor and resection line, varying degrees of differentiation, and lymphatic (vascular) invasion?

CONCLUSIONS AND FINAL RECOMMENDATIONS

Appropriate use of colonoscopy can reduce colorectal cancer mortality and prevent colorectal cancers. The effectiveness of colonoscopy depends on the quality of examination. Evidence for variable performance of colonoscopy indicates that patient outcomes could be improved by a constructive process of continuous quality improvement that educates endoscopists in optimal colonoscopic techniques, procedure documentation, interpretation of pathological findings, and scheduling of appropriate follow-up examinations, and pathologists in the appropriate reporting of pathological findings. Continuous quality improvement is an integral part of a colonoscopy program. The recommendations and rationale for continuous quality improvement made in this document are evidence and/or consensus based. The task force recommends that these targets be periodically reviewed in continuous quality improvement programs. Findings of deficient performance can be used to educate colonoscopists and pathologists, and additional monitoring can be undertaken to document improvement in performance. Further, we recommend that both academic and community-based colonoscopy programs report in the medical literature the results of their reviews of adherence to these continuous quality improvement measures in their programs. This information will help validate the appropriateness and feasibility of the performance goals recommended in this document. We expect these recommendations to be updated as new information appears regarding optimal technical performance of colonoscopy and pathological interpretation of colonic neoplasia.

Reprint requests and correspondence: Douglas K. Rex, M.D., University Hospital, Suite 2300, 550 North University Boulevard, Indianapolis, IN 46202.

Received Jan. 22, 2002; accepted Jan. 30, 2002.

REFERENCES

1. Winawer SJ, Zauber AG, Ho MN, et al. Prevention of colorectal cancer by colonoscopic polypectomy. The National Polyp Study Workgroup. N Engl J Med 1993;329:1977–81.
2. Jorgensen OD, Kronborg O, Fenger C. The Funen adenoma follow-up study: Incidence and death from colorectal carcinoma in an adenoma surveillance program. Scand J Gastroenterol 1993;28:869–74.
3. Citarda F, Tomaselli G, Capocaccia R, et al. Efficacy in standard clinical practice of colonoscopic polypectomy in reducing colorectal cancer incidence. Gut 2001;48:812–5.
4. Muller AD, Sonnenberg A. Prevention of colorectal cancer by flexible endoscopy and polypectomy. A case-control study of 32,702 veterans. Ann Intern Med 1995;123:904–10.
5. Thiss-Evensen E, Hoff GS, Sauar J, et al. Population-based surveillance by colonoscopy: Effect on the incidence of colo-

rectal cancer. Telemark Polyp Study I. Scand J Gastroenterol 1999;34:414–20.
6. Mandel JS, Church TR, Bond JH, et al. The effect of fecal occult-blood screening on the incidence of colorectal cancer. N Engl J Med 2000;343:1603–7.
7. ASGE. Principles of training in gastrointestinal endoscopy. Gastrointest Endosc 1999;49:845–50.
8. ASGE. Quality and outcomes assessment in gastrointestinal endoscopy. Gastrointest Endosc 2002;52:827–30.
9. Planning Solution Data Sources, CPT Procedure Estimates, 1999.
10. Rex DK, Rahmani EY, Haseman JH, et al. Relative sensitivity of colonoscopy and barium enema for detection of colorectal cancer in clinical practice. Gastroenterology 1997; 112:17–23.
11. Haseman JH, Lemmel GT, Rahmani EY, Rex DK. Failure of colonoscopy to detect colorectal cancer: Evaluation of 47 cases in 20 hospitals. Gastrointest Endosc 1997;45:451–5.
12. Rex DK, Cutler CS, Lemmel GT, et al. Colonoscopic miss rates of adenomas determined by back-to-back colonoscopies. Gastroenterology 1997;112:243–8.
13. Atkin WS, Cook CF, Patel R, et al. Variability in yield of neoplasms in average risk individuals undergoing flexible sigmoidoscopy (FS) screening. Gastroenterology 2001;120: A66.
14. Rex DK. Colonoscopic withdrawal technique is associated with adenoma miss rates. Gastrointest Endosc 2001;51:33–6.
15. Waye JD, Lewis BS, Yessayan S. Colonoscopy: A prospective report of complications. J Clin Gastroenterol 1992;15: 347–51.
16. Rex DK. Rates of colonoscopic perforation in current practice. Gastroenterology 1998;114:1115 (letter).
17. Mandel JS, Bond JH, Church TR, et al. Reducing mortality from colorectal cancer by screening for fecal occult blood. Minnesota colon cancer control study. N Engl J Med 1993; 328:1365–71.
18. Anderson ML, Pasha TM, Leighton JA. Endoscopic perforation of the colon: Lessons from a 10-year study. Am J Gastroenterol 2000;95:3418–22.
19. Winawer S, Fletcher R, Rex DK, et al. Colorectal cancer screening and surveillance guidelines and rationale. Update based on new evidence. Gastroenterology (in press).
20. Smith RA, VonEschenbach AC, Wender R, et al. American Cancer Society guidelines for early detection of cancer: Update of early detection guidelines for prostate, colorectal, and endometrial cancers. CA Cancer J Clin 2001;51:77–80.
21. Rex DK, Johnson DA, Lieberman DA, et al. Colorectal cancer prevention 2000: Screening recommendations of the American College of Gastroenterology. Am J Gastroenterol 2000;95:868–77.
22. Levin TR, Palitz A, Grossman S, et al. Predicting advanced proximal colonic neoplasia with screening sigmoidoscopy. JAMA 1999;281:1611–7.
23. Rex DK, Bond JH, Feld AD. Medical-legal risks of incident cancers after clearing colonoscopy. Am J Gastroenterol 2001;96:952–7.
24. Rex DK. Colonoscopy: A review of its yield for cancer and adenomas by indication. Am J Gastroenterol 1995;90:353–65.
25. Rex DK, Mark D, Clarke B, et al. Flexible sigmoidoscopy plus air-contrast barium enema versus colonoscopy for evaluation of symptomatic patients without evidence of bleeding. Gastrointest Endosc 1995;42:132–8.
26. Lieberman DA, de Garmo PL, Fleischer DE, et al. Colonic neoplasia in patients with nonspecific GI symptoms. Gastrointest Endosc 2000;51:647–51.
27. Bond JH. Polyp guideline: Diagnosis, treatment, and surveillance for patients with colorectal polyps. Practice Parameters Committee of the American College of Gastroenterology. Am J Gastroenterol 2000;95:3053–63.
28. Khvatyuk O, Winawer SJ, Klimstra D, Markowitz AJ. Hyperplastic polyposis syndrome confers an increased personal and familial risk of adenomas and colorectal cancer. Gastroenterology 2001;120:A-742.
29. Askling J, Dickman PW, Karlen P, et al. Family history as a risk factor for colorectal cancer in inflammatory bowel disease. Gastroenterology 2001;120:1356–62.
30. Marchesa P, Lashner BA, Lavery IC, et al. The risk of cancer and dysplasia among ulcerative colitis patients with primary sclerosing cholangitis. Am J Gastroenterol 1997;92:1285–8.
31. ASGE. Antibiotic prophylaxis for gastrointestinal endoscopy. Gastrointest Endosc 1995;42:630–5.
32. ASGE. Guideline on the management of anticoagulation and antiplatelet therapy for endoscopic procedures. Gastrointest Endosc 1998;48:672–5.
33. Lieberman DA, Weiss DG. Veterans Affairs Cooperative Study Group 380. One-time screening for colorectal cancer with combined fecal occult-blood testing and examination of the distal colon. N Engl J Med 2001;345:555–60.
34. Marshall JB, Barthel JS. The frequency of total colonoscopy and terminal ileal intubation in the 1990's. Gastrointest Endosc 1993;39:518–20.
35. Johnson DA, Gurney MS, Volpe RJ, et al. A prospective study of the prevalence of colonic neoplasms in asymptomatic patients with an age-related risk. Am J Gastroenterol 1990;85:969–74.
36. Foutch PG, Mai H, Pardy K, et al. Flexible sigmoidoscopy may be ineffective for secondary prevention of colorectal cancer in asymptomatic, average-risk men. Dig Dis Sci 1991; 36:924–8.
37. Lieberman DA, Smith FW. Screening for colon malignancy with colonoscopy. Am J Gastroenterol 1991;86:946–51.
38. Rogge JD, Elmore MF, Mahoney SJ, et al. Low cost, office-based, screening colonoscopy. Am J Gastroenterol 1994;89: 1775–80.
39. Rex DK, Lehman GA, Ulbright TM, et al. Colonic neoplasia in asymptomatic persons with negative fecal occult blood tests: Influence of age, gender, and family history. Am J Gastroenterol 1993;88:825–31.
40. Kadakia SC, Wrobleski CS, Kadakia AS, Meier NJ. Prevalence of proximal colonic polyps in average-risk asymptomatic patients with negative fecal occult blood tests and flexible sigmoidoscopy. Gastrointest Endosc 1996;44:112–7.
41. Lieberman DA, Weiss DG, Bond JH, et al. Use of colonoscopy to screen asymptomatic adults for colorectal cancer. N Engl J Med 2000;343:162–8.
42. Imperiale TF, Wagner DR, Lin CY, et al. Risk of advanced proximal neoplasms in asymptomatic adults according to the distal colorectal findings. N Engl J Med 2000;343:169–74.
43. Rex DK. Still photography versus videotaping for documentation of cecal intubation: A prospective study. Gastrointest Endosc 2000;51:451–9.
44. Marshall JB, Brown DN. Photo documentation of total colonoscopy: How successful are endoscopists? Do reviewers agree? Gastrointest Endosc 1996;44:243–8.
45. Saiffuddin T, Trivedi M, King PD, et al. Usefulness of a pediatric colonoscope for colonoscopy in adults. Gastrointest Endosc 2000;51:314–7.
46. Marshall JB. Use of a pediatric colonoscope improves the success of total colonoscopy in selected adult patients. Gastrointest Endosc 1999;44:675–8.
47. Brooker JC, Saunders BP, Shah SG, Williams CB. A new variable stiffness makes colonoscopy easier: A randomized controlled trial. Gut 2000;46:801–5.

48. Rex DK. Effect of variable stiffness colonoscopes on cecal intubation times for routine colonoscopy by an experienced examiner in sedated patients. Endoscopy 2001;33:60–4.
49. Howell DA, Ku PM, Desilets DJ, Campana JM. A comparative trial of variable stiffness colonoscopes. Gastrointest Endosc 2000;51:AB58.
50. Gostout CJ, Sorbi D, Knipscheild MA, et al. Variable rigidity colonoscopes: A prospective randomized controlled study. Gastrointest Endosc 2001;53:AB179.
51. Hunt RH. Colonoscopy intubation techniques with fluoroscopy. In: Hunt HR, Waye JD, eds. Colonoscopy: Techniques, clinical practice, and colour atlas. London: Chapman and Hall, 1981:109–46.
52. Waye JD. Colonoscopy intubation techniques without fluoroscopy. In: Hunt RH, Waye JD, eds. Colonoscopy: Techniques, clinical practice, and colour atlas. London: Chapman and Hall, 1981:147–78.
53. Williams CB, Saunders BP. Technique of colonoscopy. In: Raskin J, Juergen NH, eds. Colonoscopy principles & techniques. New York: Igaku-Shoin Medical Publishers, 1995: 121–42.
54. Baillie J. Gastrointestinal endoscopy: Basic principles and practice. Oxford, UK: Butterworth-Heinemann, 1992:63–92.
55. Cotton PB, Williams CB. Colonoscopy. In: Cotton PB, Williams CB, eds. Practical gastrointestinal endoscopy. Cambridge, MA: Blackwell Science, 1990:160–223.
56. Saunders BP, Bell GD, Williams CG, et al. First clinical results with a real-time electronic imager as an aid to colonoscopy. Gut 1995;36:913–7.
57. Shah SG, Saunders BP, Brooker JC, Williams CB. Magnetic imaging of colonoscopy: An audit of looping, accuracy and ancillary maneuvers. Gastrointest Endosc 2000;52:1–8.
58. Hixson LS, Fennerty MD, Sampliner RE, et al. Prospective study of the frequency and size distribution of polyps missed by colonoscopy. J Natl Cancer Inst 1990;82:1769–72.
59. Cutler CS, Rex DK, Hawes RH, Lehman GA. Does routine intravenous glucagon administration facilitate colonoscopy? A randomized trial. Gastrointest Endosc 1995;42:346–50.
60. Rembacken BJ, Caims A, Dixon MF, et al. Flat and depressed colonic neoplasms: A prospective study of 1,000 colonoscopies in the UK. Lancet 2000;255:1211–4.
61. Suzuki N, Saunders BP, Talbot IC, et al. Small flat colorectal cancer: Experience in 870 consecutive colonoscopies. Gastrointest Endosc 2000;51:AB149.
62. Saitoh Y, Waxman I, West AB, et al. Prevalence and distinctive biologic features of flat colorectal adenomas in a North American population. Gastroenterology 2001;120: 1657–65.
63. Bernstein CNB, Weinstein WM, Levine DS, et al. Physicians' perceptions of dysplasia and approaches to surveillance colonoscopy in ulcerative colitis. Am J Gastroenterol 1995;90:2106–14.
64. Eaden JA, Ward BA, Mayberry J. How gastroenterologists screen for colonic cancer in ulcerative colitis: An analysis of performance. Gastrointest Endosc 2000;51:123–8.
65. Rubin CE, Haggitt RC, Burmer GC, et al. DNA aneuploidy in colonic biopsies predicts future development of dysplasia in ulcerative colitis. Gastroenterology 1992;103:950–6.
66. Engelsgjerd M, Farraye FA, Odze RD. Polypectomy may be adequate treatment for adenoma-like dysplastic lesions in chronic ulcerative colitis. Gastroenterology 1999;117:1288–94.
67. Rubin PH, Friedman S, Harpaz N, et al. Colonoscopic polypectomy in chronic colitis: Conservative management after endoscopic resection of dysplastic polyps. Gastroenterology 1999;117:1295–300.
68. Zlatanic J, Waye JD, Kim PS, et al. Large sessile colonic adenomas: Use of argon plasma coagulator to supplement piecemeal snare polypectomy. Gastrointest Endosc 1999;49: 731–5.
69. Brunetaud JM, Maunaury V, Cochelard D, et al. Endoscopic laser treatment for rectosigmoid villous adenoma: Factors affecting the results. Gastroenterology 1989;97:272–7.
70. Mathus-Vliegen E, Tytgat G. The potential and limitations of laser photoablation of colorectal adenomas. Gastrointest Endosc 1991;37:9–17.
71. Fruhmorgen P, Demling L. Complications of diagnostic and therapeutic colonoscopy in the Federal Republic of Germany. Results of an inquiry. Endoscopy 1979;2:146–50.
72. Nivatvongs S. Complications in colonoscopic polypectomy: An experience with 1555 polypectomies. Dis Colon Rectum 1986;29:825–30.
73. Silvis SE, Nebel D, Rogers G, et al. Endoscopic complications: Results of the 1974 American Gastrointestinal Endoscopy survey. JAMA 1976;235:928.
74. Zubarik R, Fleischer D, Mastropietro C, et al. Prospective analysis of complications 30 days after outpatient colonoscopy. Gastrointest Endosc 1999;50:322–8.
75. Weston AP, Campbell DR. Diminutive colon polyps: Histopathology, spatial distribution, concomitant significant lesions, and treatment complications. Am J Gastroenterol 1995;90:24–8.
76. Sorbi D, Norton I, Conio M, et al. Postpolypectomy lower GI bleeding: Descriptive analysis. Gastrointest Endosc 2000;51: 690–6.
77. Tappero G, Gaia E, DeGiuli P, et al. Cold snare excision of small colorectal polyps. Gastrointest Endosc 1992;38:310–3.
78. Waye JD. New methods of polypectomy. Gastrointest Endosc Clin N Am 1997;7:413–65.
79. Peluso F, Goldner R. Follow-up of hot biopsy forceps treatment of diminutive colon polyps. Gastrointest Endosc 1991; 37:604–6.
80. Parra-Blanco A, Kaminaga N, Kojima T, et al. Colonoscopic polypectomy with cutting current: Is it safe? Gastrointest Endosc 2000;51:676–81.
81. Van Gossum A, Cozzoli A, Adler M, et al. Colonoscopic snare polypectomy: Analysis of 1,485 resections comparing two types of current. Gastrointest Endosc 1992;38:472–5.
82. Norton ID, Wang LN, Levine SA, et al. Efficacy of submucosal saline injection in the limitation of colonic thermal injury by electrosurgical devices. Gastrointest Endosc 2000; 51:AB131.
83. Shirai M, Nakamura T, Matsuura A, et al. Safer colonoscopic polypectomy with local submucosal injection of hypertonic saline-epinephrine solution. Am J Gastroenterol 1994;89: 334–8.
84. Iishi H, Tatsuta M, Iseki K, et al. Endoscopic piecemeal resection with submucosal saline injection of large sessile colorectal polyps. Gastrointest Endosc 2000;51:697–700.
85. Iishi H, Tatsuta M, Narahara H, et al. Endoscopic resection of large pedunculated colorectal polyps using a detachable snare. Gastrointest Endosc 1996;44:594–7.
86. Iida Y, Miura S, Munemoto Y, et al. Endoscopic resection of large colorectal polyps using a clipping method. Dis Colon Rectum 1994;37:179–80.
87. Folwaczny C, Heldwein W, Obermaier G, Schindlbeck N. Influence of prophylactic local administration of epinephrine on bleeding complications after polypectomy. Endoscopy 1996;28:31–3.
88. ASGE. Sedation and monitoring of patients undergoing gastrointestinal endoscopic procedures. Gastrointest Endosc 1995;42:626–9.
89. Practice guidelines for sedation and analgesia by non-anesthesiologists. Anesthesiology 1996;84:459–71.

90. Rex DK, Imperiale TF, Portish V. Patients willing to try colonoscopy without sedation: Associated clinical factors and results of a randomized controlled trial. Gastrointest Endosc 1999;49:554–9.
91. Walker JA, Schleinitz PF, Jacobson KN, et al. Propofol: Multiple advantages for endoscopy and colonoscopy in 1,424 consecutive patients. Gastrointest Endosc 2000;51: AB59.
92. Kulling D. Safer colonoscopy with patient-controlled analgesia and sedation with propofol and alfentanil. Gastrointest Endosc 2001;54:1–7.
93. Ng J. Patient-controlled sedation with propofol for colonoscopy. Gastrointest Endosc 2001;54:7–13.
94. Hamilton SR, Vogelstein B, Kudo S, et al. Carcinoma of the colon and rectum. In: Hamilton SR, Aaltonen LA, eds. Pathology and genetics of tumours of the digestive system. Lyon: IARC Press, 2000:104–19.
95. Rex DK, Alikhan M, Cummings O, Ulbright TM. Accuracy of pathologic interpretation of colorectal polyps by general pathologists in community practice. Gastrointest Endosc 1999;50:468–74.
96. Volk EE, Goldblum JR, Petras RE, et al. Management and outcome in patients with invasive carcinoma arising in colorectal polyps. Gastroenterology 1995;109:1801–7.
97. Morson BC, Whiteway JE, Jones EA, et al. Histopathology and prognosis of malignant colorectal polyps treated by endoscopic polypectomy. Gut 1984;25:437–44.
98. Volk EE, Petras RE. Colorectal adenomas and malignant polyps: A review of the pathologist's role in patient management. Pathol Case Rev 1997;2:71–7.
99. Eaden JA, Mayberry JF. Colorectal cancer complicating ulcerative colitis: A review. Am J Gastroenterol 2000;95: 2710–9.
100. Snapper SB, Syngal S, Freidman LS. Ulcerative colitis and colon cancer: More controversy than clarity. Dig Dis 1998; 16:81–7.