Repeat colonoscopy’s value in gastrointestinal bleeding

Parit Mekaroonkamol, Kimberly Jegel Chaput, Young Kwang Chae, Michael L Davis, Pojnicha Mekaroonkamol, Sherry Pomerantz, Philip O Katz

AIM: To assess the diagnostic yield and clinical value of early repeat colonoscopies for indications other than colorectal cancer (CRC) screening/surveillance.

METHODS: A retrospective review of patients who had more than one colonoscopy performed for the same indication within a three year time frame at our tertiary care referral hospital between January 1, 2000 and January 1, 2010 was conducted. Exclusion criteria included repeat colonoscopies performed for CRC screening/surveillance, poor bowel preparation, suspected complications from the index procedure, and incomplete initial procedure. Primary outcome was new endoscopic findings that led to an endoscopic therapeutic intervention or any change in clinical management. Clinical parameters including age, sex, race, interval between procedures, indication of the procedure, presenting symptoms, severity of symptoms, hemodynamic instability, duration between onset of symptoms and when the procedure was performed, change in endoscopist, withdrawal time, location of colonic lesions and improvement of quality of bowel preparation were analyzed using bivariate analysis and logistic regression analysis to examine correlation with this primary outcome.

RESULTS: Among 19 772 colonoscopies performed during the above mentioned period, 947 colonoscopies (4.79%) were repeat colonoscopies performed within 3 years from the index procedure. Out of these repeat colonoscopies, 139 patient pairs met the inclusion criteria. The majority of repeat colonoscopies were for lower gastrointestinal bleeding (88.4%), change in bowel habits (6.4%) and abdominal pain (5%). Among 139 eligible patient pairs of colonoscopies, only repeat colonoscopies that were done for lower gastrointestinal bleeding and abdominal pain produced endoscopic findings that led to a change in management [25 out of 123 (20.33%) and 2 out of 7 (28.57%), respectively]. When looking at only recurrent lower gastrointestinal bleeding cases, new endoscopic findings included 8 previously undetected hemorrhoid lesions (6.5%), 7 actively bleeding lesions requiring endoscopic intervention, which included 3 bleeding arterio-venous malformations (2.43%), 2 bleeding radiation colitis (1.6%), and 2 bleeding internal hemorrhoids (1.6%), 5 previously undetected tubular adenomas [4 were smaller than 1 cm (4.9%) and 1 was larger than 1 cm (0.8%)], 3 radiation colitis (2.43%), 1 rectal ulcer (0.8%), and 1 previously undetected right sided colon cancer (0.8%). Of the 25 new endoscopic findings, 18 (72%) were found when repeat colonoscopy was done within the first year after the index procedure. These findings were 1 rectal ulcer, 3 radiation colitis, 4 new hemorrhoid lesions, 3 previously undetected tubular adenomas, 3 hemorrhoid prolapse, 2 radiation enteritis, 2 cancerous lesions, 1 stenosis, and 1 non-bleeding arterio-venous malformation.
INTRODUCTION

Colonoscopy has emerged as the procedure of choice for evaluation of lower gastrointestinal bleeding, colorectal cancer (CRC) screening, and polyp surveillance due to its diagnostic yield as well as its ability for therapeutic intervention. However, even though colonoscopy is generally safe, it is an invasive procedure that can rarely be complicated by perforation, hemorrhage, infection, and even death\(^1\)\(^-\)\(^3\). Repeating a colonoscopy unnecessarily is therefore, not only time consuming and resource wasting, but can lead to undue harm.

While the intervals for repeating colonoscopy for CRC screening or for polyp surveillance are well described, the evidence for repeating colonoscopy for other indications such as recurrent lower gastrointestinal bleeding or abdominal pain is sparse and less clear\(^4\)-\(^7\). Previous studies have suggested early colonoscopy for acute lower gastrointestinal bleeding but management in recurrent episodes is not well standardized\(^8\)-\(^13\). Therefore, when patients who recently had a colonoscopy performed present with the same symptoms, the dilemma remains—should we or should we not repeat another colonoscopy?

The objective of this study is to retrospectively assess the diagnostic yield of repeat colonoscopy performed for the same indication within a three year time frame from the original procedure. An additional goal is to identify factors that may help predict when a repeat colonoscopy will produce a clinically significant change. We hypothesized that early repeat colonoscopy for recurrent lower gastrointestinal bleeding would yield little clinical information beyond the original procedure.

MATERIALS AND METHODS

A retrospective review of patients who had more than one colonoscopy performed within a three year time frame from the time period including January 1, 2001 through January 1, 2010 for the same indication was conducted at our tertiary care referral hospital.

The reason for this three year time frame is because it is the shortest interval recommended for a repeat colonoscopy in individuals without a personal history of CRC/adenomatous polyps, a personal history of inflammatory bowel disease, or a family history of rare genetic diseases such as familial adenomatous polyposis and hereditary non polyposis colon cancer. We believe that the majority of our study population is similar to individuals described, who are average-risk individuals and individuals with family history of CRC/adenomatous polyps.

Exclusion criteria included: patients, whose repeat colonoscopies were done for CRC surveillance, repeat colonoscopy performed due to suspected complications from the initial one such as postpolypectomy bleeding, poor bowel preparation or incomplete first colonoscopy, and patients with missing data.

For eligible patients, data on age, sex, race, intervals between procedures, settings of the procedures (inpatient vs outpatient), whether the same endoscopist performed both procedures, a fellow’s involvement in the procedure, indication for the procedures presenting symptoms, severity of symptoms, hemodynamic instability, duration between onset of symptoms and when the procedure was performed, findings of the procedures, completion of the procedure (whether cecal intubation was performed), pre-procedure diagnosis, post-procedure diagnosis, complications from the procedures, withdrawal time, location of colon lesions, quality of bowel preparation, endoscopic intervention performed, and clinical management of the patients after the colonoscopies were collected. After colonoscopies with poor bowel preparation were excluded, the quality of bowel preparation was categorized using arbitrary scale into fair, good and excellent as judged and documented by the endoscopist who performed the procedure. Improvement of the quality of bowel preparation in the repeat procedure was noted and analyzed as one of the clinical parameters. All data were collected by two independent data collectors using one simple data collection form to avoid any collection bias.

Each of these clinical parameters was analyzed to evaluate the possibility of correlation between these variables and clinically significant change. “Clinically significant change” was defined as any new endoscopic finding that altered diagnosis, prognosis, management, or any change that required endoscopic intervention; a change in physical finding only was not considered a “clinically significant change”.

This study has been approved by an institutional re-
view board for human research conduct.

Statistical analysis
The statistical analysis was performed using Statistics and Data, version 11.0 (College Station, Texas, United States). Odds ratios (ORs) were calculated by performing bivariate logistic regression analysis in order to evaluate the association between colonoscopy-related variables and clinically significant change. Statistical significance was set at P value of less than 0.05.

RESULTS
Among 19,772 colonoscopies performed during the above-mentioned period, 947 colonoscopies (4.79%) were repeat colonoscopies performed within 3 years from the index procedure. Out of these repeat colonoscopies, majority of exclusions were poor bowel preparation (32.52%), different indications (20.48%), and CRC surveillance (17.74%). A total of 139 patient pairs of colonoscopies (1.41%) met the inclusion criteria.

Demographic data of the eligible patients are shown in Table 1. Among 139 eligible pairs of colonoscopies, 27 cases (19.42%) produced a “clinically significant change” as defined above. Only repeat colonoscopies that were done for lower gastrointestinal bleeding and abdominal pain produced endoscopic findings that resulted in a change in management (25 out of 123 and 2 out of 7, respectively).

However, the number of colonoscopies performed for indications other than lower gastrointestinal bleeding was too small for statistical analysis (9 pairs of colonoscopies for change in bowel habits and 7 pairs of colonoscopies for abdominal pain). Therefore, we analyzed only those performed for recurrent lower gastrointestinal bleeding.

After excluding index procedures with poor bowel preparation, majority of the colonoscopies’ bowel preparation quality were documented using arbitrary scale. 22.0% were excellent, 22.8% were good, 19.9% were fair, and 2.8% were poor. 22.3% were documented as “adequate” and there was no comment on bowel preparation in 10.2% of the procedures.

Out of 123 pairs of colonoscopies done for recurrent lower gastrointestinal bleeding, 25 cases (20.33%) had new endoscopic findings on the repeat procedure that led to a change in management as shown in Table 2.

Of 25 new endoscopic findings, 18 (72%) were found from repeat colonoscopy within the first year after index procedure. These findings were 1 rectal ulcer, 3 radiation colitis, 4 new hemorrhoid lesions, 3 previously undetected tubular adenomas, and one cancer. This suggests that repeating colonoscopy for recurrent lower gastrointestinal bleeding appears to have clinical value.

Of all parameters analyzed, Only the interval between procedures less than one year was associated with higher likelihood of finding a clinically significant change in repeat colonoscopy (ORs of interval between procedures of 1-2 year and 2-3 year compared to 0-1 year were 0.09; 95%CI 0.01-0.74; P = 0.025 and 0.26; 95%CI 0.09-0.72, P = 0.010 respectively), as shown in Table 3. Analysis of correlation between clinical parameters and clinically significant change using either bivariate analysis or logistic regression analysis has shown the same result.

No complications were observed among all 139 repeat colonoscopies studied.

DISCUSSION
The results of this study showed that the diagnostic yield of repeat colonoscopies for recurrent lower gastrointestinal bleeding was 20.33%. Majority of the endoscopic findings were new hemorrhoid lesions, actively bleeding lesions that required endoscopic intervention, previously undetected tubular adenomas, and one cancer. This suggests that repeating colonoscopy for recurrent lower gastrointestinal bleeding appears to have clinical value.

We opted to include new hemorrhoid lesions in “clinically significant change” as they were potential source of bleeding and bear some differential diagnostic value. However, new hemorrhoid in endoscopic findings may be subject to reporting bias. Since documentation of retroflexion maneuver at the rectum was not available in all cases and hemorrhoids are not always of key interest during colonoscopy, it is possible that presence of small
Table 2  New endoscopic findings on the repeat colonoscopy that led to a clinically significant change (n = 25)

| Findings                                                                 | Description                                                                 | Location          |
|--------------------------------------------------------------------------|------------------------------------------------------------------------------|-------------------|
| 8 previously undetected hemorrhoid lesions (6.5%)                        | 2 small hemorrhoid lesions                                                   | Rectum            |
|                                                                           | 2 large hemorrhoid lesions                                                   | Rectum            |
|                                                                           | 4 hemorrhoid lesions with no comment on size                                 | Rectum            |
| 7 actively bleeding lesions requiring endoscopic interventions (5.7%)     | 3 arterio-venous malformations                                               | 2 in ascending colon|
|                                                                           | 2 bleeding radiation colitis                                                 | 1 in descending colon|
|                                                                           | 2 bleeding internal hemorrhoids                                              | Descending colon  |
| 5 previously undetected tubular adenomas (4.1%)                          | 4 smaller-than-1-cm tubular adenomas                                        | 1 in sigmoid colon, |
|                                                                           | 1 larger-than-1-cm tubular adenoma                                           | 2 in ascending colon|
|                                                                           |                                                                               | Ascending colon    |
| 3 radiation colitis (2.43%)                                               |                                                                               | 2 in descending colon|
| 1 rectal ulcer (0.8%)                                                    |                                                                               | 1 in rectum        |
| 1 previously undetected cancer (0.8%)                                    | 1 large ulcerated mass                                                       | Ascending colon    |

Table 3  Logistic regression analysis of correlation between clinical parameters and clinical significant change

| Clinical parameters          | Odds ratio | 95%CI    | P value |
|-----------------------------|------------|----------|---------|
| Gender (male as reference)  | 1.83       | 0.72-4.65| 0.205   |
| Age > 60 yr                 | 0.47       | 0.17-1.28| 0.138   |
| Race                        |            |          |         |
| Caucasian (reference)       | 1.00       |          |         |
| African-American            | 3.48       | 0.43-28.4| 0.245   |
| Asian                       | 3.48       | 0.43-28.4| 0.245   |
| Hispanic                    | 9.60       | 0.85-108.7| 0.068  |
| Interval between procedure   |            |          |         |
| < 365 d (reference)         | 1.00       |          |         |
| 365-630 d                   | 0.09       | 0.01-0.74| 0.025   |
| 630-1095 d                  | 0.26       | 0.09-0.72| 0.010   |
| Hospital setting            |            |          |         |
| Inpatient procedures (reference) | 1.00     |          |         |
| Outpatient procedures       | 1.08       | 0.36-3.23| 0.887   |
| Outpatient then inpatient setting | 1.26     | 0.36-4.34| 0.718   |
| Inpatient then outpatient setting | 1.25    | 0.34-4.53| 0.738   |
| Presenting sign/symptom     |            |          |         |
| Hematochezia                | 4.31       | 0.94-19.7| 0.059   |
| Occult heme positive stool  | 0.64       | 0.13-3.13| 0.583   |
| Anemic symptoms             | 0.86       | 0.32-2.30| 0.771   |
| Hemodynamic instability     | 1.40       | 0.4-4.89 | 0.599   |
| Location of diverticulosis  |            |          |         |
| Right-sided (reference)     | 1.00       |          |         |
| Left-sided                  | 1.78       | 0.29-11.13| 0.535  |
| Pseudodiverticulosis        | 0.29       | 0.36-2.29| 0.238   |
| Improved quality of bowel preparation | 0.84   | 0.33-2.17| 0.725   |
| Change in endoscopist       | 0.98       | 0.39-2.4 | 0.961   |
| Fellow involvement          | 2.19       | 0.87-5.59| 0.098   |
| Duration between onset of symptoms and procedure more than 2 d           | 0.91       | 0.25-3.25| 0.882   |
| Withdrawal time more than 7 min                                      | 0.59       | 0.31-1.14| 0.578   |

Even though it is unlikely that previously undetected tubular adenomas were the source of bleeding, but their detection have led to a change in the patients’ surveillance protocol, thus they were included in “clinically significant change” as well\(^1\)\(^6\)\(^7\). However, as previous studies have reported rates of missing adenomas and/or cancer within 3 years as high as 2%-12\(^\%\)\(^14\)-\(^19\), missing small polyps during repeat colonoscopy for lower gastrointestinal bleeding is even more likely and expected.

One case of new cancerous lesion within 3 year interval despite good bowel preparation in the index procedure is concerning, but is also not unexpected, especially in the right side colon\(^10\),\(^21\). As interval cancers and advance adenomas have been described after screening colonoscopy, missing such lesions at the time of urgent colonoscopy during a lower gastrointestinal bleeding episode is understandable. In this case, the interval between procedures was 498 d. Shorter interval cancer detection after screening colonoscopy has been reported\(^14\),\(^15\),\(^22\),\(^24\).

Logistic regression analysis of clinical parameters showed that the interval between procedures was the only predictive factor for a clinically significant change in repeat colonoscopies. An interval between procedures of less than one year was more likely to find any clinically significant change.

Actively bleeding lesions were of key interest as they can not only reveal the cause of lower gastrointestinal bleeding but also can be promptly treated by endoscopic interventions. Interestingly, all 7 actively bleeding lesions were found in repeat colonoscopy performed within the first year of the index procedure. The reasons for this are unclear. However, severity of bleeding on clinical presentation did not have any significant association with a clinically significant new endoscopic finding, as shown in Table 3.

The decision to repeat colonoscopy should be individualized by clinical judgment on a case-by-case basis. However, since the repeat colonoscopies within the first year after the index procedure have significantly higher yield than remote procedures, we propose that threshold to repeat colonoscopy when bleeding recurs within the first year should be lower than those who bled after the first year.

As previously undetected tubular adenomas and cancer were found in a small but potentially important number of patients (4.1% and 0.8%, respectively), we suggest that a colonoscopy performed for lower gastrointestinal hemorrhoids may not be reported at the index colonoscopy.
bleeding should not be a substitute for a screening colonoscopy.

Improvement in quality of bowel preparation did not have any statistically significant correlation with clinically significant change. However, this study is limited by small sample size and the grading of the bowel preparation quality was subjective using arbitrary scale, which could be endoscopist-dependent. Even though, index procedures with poor bowel preparation were excluded, it is possible that small lesions could have been missed in good or fair bowel preparation. We suggest that in cases when the bowel preparation was sub-optimal, the decision to repeat colonoscopy should be individualized.

Majority of population included in this study were African-American (76%), who have the highest incidence of sporadic colorectal cancer. This may contribute to the higher rate of previously undetected tubular adenoma and colon cancer than anticipated found in this study. Generalization of these results to other ethnic group should be made with caution.

The reasoning behind the increase in diagnostic yield in repeating colonoscopy within the first year after the index procedure is unclear. Our study was limited by a retrospective design, single-center study, and a small sample size. Also, the number of repeat colonoscopy performed for indications other than recurrent LGIB such as abdominal pain, change in bowel habit, or diarrhea were too small to do any statistical analysis. Clinical use of repeat colonoscopy for these indications remains unknown. Further prospective studies with larger sample size are warranted.

In summary, the diagnostic yield of 20.33% and a low complication rate among repeat colonoscopies performed for recurrent lower gastrointestinal bleeding in our study, the benefit clearly outweighs the risk. These results suggest that there is clinical value of repeating a colonoscopy for this indication. We conclude that the answer to our question, when bleeding recurs, should colonoscopy be repeated, is yes.

COMMENTS

Background
Colonoscopy is the procedure of choice for evaluation of lower gastrointestinal disorder. While the intervals for repeating colonoscopy for colorectal cancer screening are well described, it is not known if repeating colonoscopy for other indications such as lower gastrointestinal bleeding is clinically useful. Moreover, repeating the procedure unnecessarily not only time consuming and resource wasting, but can lead to undue harm.

Research frontiers
Lacking new evidence to support the use of repeat colonoscopy, when patients who recently had colonoscopy preformed present with recurrent lower gastrointestinal bleeding, the dilemma remains—should people or should people not repeat another colonoscopy?

Innovations and breakthroughs
To date, there is no guideline to suggest the proper interval of repeat colonoscopy for the same indication other than for colorectal cancer screening and surveillance. With 20.33% of new endoscopic finding that led to a change in management, authors have validated clinical value of repeat colonoscopy for lower gastrointestinal bleeding. Interestingly, they also found the significant increase in diagnostic yield of early repeat colonoscopy within the first year of the index procedure.

Applications
With high diagnostic yield of repeat colonoscopy for lower gastrointestinal bleeding, the authors proposed that when lower gastrointestinal bleeding recurs, colonoscopy should be repeated.

Terminology
Clinically significant change is defined as any new endoscopic finding that altered diagnosis, prognosis, management, or any change that required endoscopic intervention.

Peer review
This is an interesting single-center retrospective study in which authors evaluate the diagnostic yield of repeat colonoscopy. The results suggest that there is clinical value in repeat colonoscopy for lower gastrointestinal bleeding. High diagnostic yield in the first year of index procedure is intriguing and should warrant further prospective studies.

REFERENCES
1. Al-Shamali MA, Kaloua M, Hasan F, Khajah A, Siddique I, Al-Nakeeb B. Colonoscopy: evaluating indications and diagnostic yield. Ann Saudi Med 2001; 21: 304-307 [PMID: 17261934]
2. Dominitz JA, Eisen GM, Baron TH, Goldstein JL, Hirota WK, Jacobson BC, Johanson JF, Leighton JA, Mallery JS, Raddawi HM, Vargo JI, Waring JP, Fanelli RD, Wheeler-Harbough J, Faigel DO. Complications of colonoscopy. Gastrointest Endosc 2003; 57: 441-445 [PMID: 12665750 DOI: 10.1016/S0016-5107(03)00005-6]
3. Arora G, Mannalithara A, Singh G, Gerson LB, Triadafilopoulos G. Risk of perforation from a colonoscopy in adults: a large population-based study. Gastrointest Endosc 2009; 69: 654-664 [PMID: 19251066 DOI: 10.1016/j.gie.2008.09.008]
4. Rex DK, Johnson DA, Anderson JC, Schoenfeld PS, Burke CA, Inadomi JM. American College of Gastroenterology guidelines for colorectal cancer screening 2009 [corrected]. Am J Gastroenterol 2009; 104: 739-750 [PMID: 19240699 DOI: 10.1088/aig.2009.104]
5. Winawer SJ, Zauber AG, Fletcher RH, Stillman JS, O’Brien MJ, Levin B, Smith RA, Lieberman DA, Burt RW, Levin TR, Bond JH, Brooks D, Byers T, Hyman N, Kirk L, Thorton A, Simmang C, Johnson D, Rex DK. 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 2006; 56: 143-159; quiz 184-185 [PMID: 16737947 DOI: 10.3322/canjclin.56.3.143]
6. Davila RE, Rajan E, Baron TH, Adler DG, Egan JV, Faigel DO, Gan SI, Hirota WK, Leighton JA, Lichtenstein D, Qureshi WA, Shen B, Zuckerman MJ, VanGuilder T, Fanelli RD. ASGE guideline: colorectal cancer screening and surveillance. Gastrointest Endosc 2006; 63: 546-557 [PMID: 16564851 DOI: 10.1016/j.gie.2006.02.002]
7. Bond JH. Polypl guideline: diagnosis, treatment, and surveillance for patients with colorectal polyps. Practice Parameters Committee of the American College of Gastroenterology. Am J Gastroenterol 2000; 95: 3053-3063 [PMID: 11095318 DOI: 10.1111/j.1572-0241.2000.03434]
8. Terdiman JP. Colonoscopic management of lower gastrointestinal hemorrhage. Curr Gastroenterol Rep 2001; 3: 425-432 [PMID: 11506802 DOI: 10.1007/s11894-001-0086-4]
9. Schmulewitz N, Fisher DA, Rockey DC. Early colonoscopy for acute lower GI bleeding predicts shorter hospital stay: a retrospective study of experience in a single center. Gastrointest Endosc 2003; 58: 841-846 [PMID: 14652590 DOI: 10.1016/S0016-5107(03)02304-6]
10. Siddique I, Mohan K, Hasan F, Memon A, Patty I, Al-Nakib B. Appropriateness of indication and diagnostic yield of colonoscopy: first report based on the 2000 guidelines of the American Society for Gastrointestinal Endoscopy. World J
Mekaroonkamol P et al. When bleeding recurs, should colonoscopy be repeated?

Gastroenterology 2005; 11: 7007-7013 [PMID: 16437607]

11 Strate LL, Syngal S. Timing of colonoscopy: impact on length of hospital stay in patients with acute lower intestinal bleeding. Am J Gastroenterol 2003; 98: 317-322 [PMID: 12591048 DOI: 10.1016/s0002-9270(02)05900-2]

12 Zuckerman GR, Prakash C. Acute lower intestinal bleeding. part I: clinical presentation and diagnosis. Gastrointest Endosc 1998; 48: 606-617 [PMID: 9852451 DOI: 10.1016/s0016-5107(98)70043-4]

13 Davila RE, Rajan E, Adler DG, Egan J, Hirota WK, Leighton JA, Qureshi W, Zuckerman MJ, Fanelli R, Wheeler-Harbaugh J, Baron TH, Faigel DO. ASGE Guideline: the role of endoscopy in the patient with lower-GI bleeding. Gastrointest Endosc 2005; 62: 656-660 [PMID: 16246674 DOI: 10.1016/j.gie.2005.07.032]

14 Rex DK, Rahmani EY, Haseman JH, Lemmel GT, Kaster S, Buckley JS. Relative sensitivity of colonoscopy and barium enema for detection of colorectal cancer in clinical practice. Gastroenterology 1997; 112: 17-23 [PMID: 8978337 DOI: 10.1016/s0016-5085(97)70213-8]

15 Bressler B, Paszat LF, Chen Z, Rothwell DM, Vinden C, Rabeneck L. Rates of new or missed colorectal cancers after colonoscopy and their risk factors: a population-based analysis. Gastroenterology 2007; 132: 96-102 [PMID: 17241863 DOI: 10.1053/j.gastro.2006.10.027]

16 Pickhardt PJ, Nugent PA, Mysliwiec PA, Choi JR, Schindler WR. Location of adenomas missed by optical colonoscopy. Ann Intern Med 2004; 141: 352-359 [PMID: 15353426]

17 Waye JD, Braunfeld S. Surveillance intervals after colonoscopic polypectomy. Endoscopy 1982; 14: 79-81 [PMID: 7075564 DOI: 10.1055/s-2007-1021858]

18 Hixson LJ, Fennerty MB, Sampliner RE, Garewal HS. Prospective blinded trial of the colonoscopic miss-rate of large colorectal polyps. Gastrointest Endosc 1991; 37: 125-127 [PMID: 2632595 DOI: 10.1016/s0016-5107(91)0688-8]

19 Rex DK, Cutler CS, Lemmel GT, Rahmani EY, Clark DW, Helper DJ, Lehman GA, Mark DG. Colonoscopic miss rates of adenomas determined by back-to-back colonoscopies. Gastroenterology 1997; 112: 24-28 [PMID: 8978338 DOI: 10.1016/s0016-5085(97)70214-2]

20 Singh H, Turner D, Xue L, Targownik LE, Bernstein CN. Risk of developing colorectal cancer following a negative colonoscopy examination: evidence for a 10-year interval between colonoscopies. JAMA 2006; 295: 2366-2373 [PMID: 16720822 DOI: 10.1001/jama.295.20.2366]

21 Lakoff J, Paszat LF, Saksin R, Rabeneck L. Risk of developing proximal versus distal colorectal cancer after a negative colonoscopy: a population-based study. Clin Gastroenterol Hepatol 2008; 6: 1117-1121; quiz 1064 [PMID: 18691942 DOI: 10.1016/j.cgh.2008.05.016]

22 Martinez ME, Baron JA, Lieberman DA, Schatzkin A, Lanza E, Winawer SJ, Zauber AG, Jiang R, Ahnen DJ, Bond JH, Church TR, Robertson DJ, Smith-Warner SA, Jacobs ET, Alberts DS, Greenberg ER. A pooled analysis of advanced colorectal neoplasia diagnoses after colonoscopic polypectomy. Gastroenterology 2009; 136: 832-841 [PMID: 19171141 DOI: 10.1053/j.gastro.2008.12.007]

23 Loeve F, van Ballegooijen M, Boer R, Kuipers EJ, Habbema JD. Colorectal cancer risk in adenoma patients: a nation-wide study. Int J Cancer 2004; 111: 147-151 [PMID: 15185356 DOI: 10.1002/ijc.20241]

24 Rabeneck L, Paszat FL. Circumstances in which colonoscopy misses cancer. Frontline Gastroenterol 2010; 1: 52-58 [DOI: 10.1136/fag.2009.00257]

25 Center of Disease Control and Prevention. Colorectal cancer rate by race and ethnicity. Available from: URL: http://www.cdc.gov/cancer/colorectal/statistics/race.htm.

26 Siegel R, Naishadham D, Jemal A. Cancer statistics, 2012. CA Cancer J Clin 2012; 62: 10-29 [PMID: 22237781 DOI: 10.3322/caac.20138]

27 Loconte NK, Williamson A, Gayle A, Weiss J, Leal T, Cetnar J, Mohammed T, Tevaarwerk A, Jones N. Increasing Disparity in Colorectal Cancer Incidence and Mortality Among African Americans and Whites: A State’s Experience. J Gastrointest Oncol 2011; 2: 85-92 [PMID: 21712962 DOI: 10.3978/j.issn.2078-6891.2011.014]

P-Reviewer Ferguson CB  S-Editor Gou SX  L-Editor A  E-Editor Zhang DN