

Overview of diagnostic and treatment colonoscopy function in gastrointestinal diseases

Abstract

This review discusses on diagnostic and therapeutic function of colonoscopy. Colonoscopy is a diagnostic and therapeutic procedure that allows the physician to examine and treatment of the rectum, colon and portion of the terminal ileum. Also colonoscopy is considered the gold standard for colon cancer screening and surveillance. Colonoscopy is the best screening test for early detection and prevention of Colorectal Cancer (CRC). Colonoscopy with removal of detected polyps has been shown to reduce the incidence and mortality of subsequent CRC. The growing importance of colonoscopy function in diagnostic and treatment of colon disorders and also the prevention of CRC have stimulated an effort to identify and to optimize the potential of colonoscopy as well as its new role in public health. Therefore today is needed to expand and improve the quality of colonoscopy and strengthen systems to provide colonoscopy services continuously.

Keywords: colonoscopy, diagnostic, therapeutic, gastrointestinal diseases, polyps, tumors, ulcers

Volume 2 Issue 4 - 2016

Sara Ashtari,¹ Pourhoseingholi MA,² Reza Zali M³

¹Epidemiologist in Research Institute of Gastroenterology and Liver Diseases, Shahid Beheshti University of Medical Sciences, Iran

²Basic and Molecular Epidemiology of Gastrointestinal Disorders Research Center, Shahid Beheshti University of Medical Sciences, Iran

³Gastroenterology and Liver Diseases Research Center, Shahid Beheshti University of Medical Sciences, Iran

Correspondence: Sara Ashtari, M.Sc. of Epidemiologist in Research Institute of Gastroenterology and Liver Diseases, Research Center of Gastroenterology and Liver Diseases, Shahid Beheshti University of Medical Sciences, Taleghani Hospital, Tabnak St, Yaman Ave, Velenjak, Tehran, Iran, Tel +98212243 2515, Fax +98212243 2517, Email sara_ashtari@yahoo.com

Received: October 19, 2016 | **Published:** November 17, 2016

Abbreviations: CRC, colorectal cancer; GIB, gastrointestinal bleeding; IBD, inflammatory bowel diseases; IBS, irritable bowel syndrome; LGIB, lower gastrointestinal bleeding; IDA, iron deficiency anemia; GI, gastrointestinal

Introduction

Colonoscopy is an exam used to detect changes or abnormalities in the large intestine (colon) and rectum. A colonoscopy helps find ulcers, colon polyps, tumors and areas of inflammation or bleeding. During a colonoscopy, tissue samples can be collected (biopsy) and abnormal growths can be taken out.¹ Colonoscopy is indicated for the diagnostic evaluation of signs and symptoms of a wide variety of gastrointestinal disorders, for therapeutic interventions and also can be used as a screening test to check for cancer or precancerous polyps in the colon or rectum.² In terms of diagnostically and therapeutically, patient has (past or in present) abdominal, intestinal or rectal symptoms such as; Gastrointestinal Bleeding (GIB), abdominal pain, iron deficiency anemia, unexplained changes in bowel habits (e.g., chronic constipation and diarrhea), polyps, Inflammatory Bowel Diseases (IBD), irritable Bowel Syndrome (IBS) and unexplained weight loss. Therefore, the assessment of these symptoms and signs is known as diagnostic colonoscopy.³ Therapeutic indications include stricture dilation, stent placement, colonic decompression and foreign body removal. In addition, polyps and lesions found during diagnostic procedures may require therapeutic intervention for example polypectomy or treatment of a bleeding lesion. The use of colonoscopy has become accepted as the most effective method of screening the colon and rectum for cancer, precancerous polyps and tumors.⁴ In this review, we discussed the function of colonoscopy in gastrointestinal diseases as diagnostic and therapeutic. Besides, we investigated the colonoscopy as the gold standard for colorectal cancer screening.

Diagnostic colonoscopy

Diagnostic colonoscopy is indicated for evaluation and recognizes the signs and symptoms of gastrointestinal disorders. In this situation, patient has past or present history of gastrointestinal symptoms or disease, polyps, or cancer. Additionally, if the colonoscopy is performed due to physical symptoms such as rectal bleeding or pain, the procedure will be considered diagnostic. The common symptoms that need colonoscopy to evaluated and recognized are lower gastrointestinal bleeding, iron deficiency anemia, unexplained changes in bowel habits (e.g., chronic constipation and diarrhea), polyps and Inflammatory Bowel Diseases (IBD). Acute massive Lower Gastrointestinal Bleeding (LGIB) has an incidence of 20 to 27 episodes per 100,000 persons annually, with a mortality rate of 4 to 10percent.^{5,6} Colonoscopy and arteriography are diagnostic tools that used to evaluate acute LGIB.⁷⁻⁹ As an initial diagnostic test, colonoscopy is highly effective and has a lower complication rate than arteriography.^{10,11} Several studies have demonstrated that colonoscopy identifies definitive bleeding sites in more than 70percent of patients.^{12,13} Iron Deficiency Anemia (IDA) is a common type of anemia and can be a sign of blood loss from the intestines or colon cancer.¹⁴ IDA often arises from bleeding gastrointestinal lesions, many of which are malignant.¹⁵ Establishment a definitive diagnosis of IDA usually requires an endoscopic and colonoscopy evaluation.¹⁶ Colonoscopy is as an essential component of the anemia evaluation.¹⁷ IDA affects approximately 30% of the world's population.¹⁸ Occult bleeding from the Gastrointestinal (GI) tract is the leading cause for IDA in men and postmenopausal women.¹⁶ Patients with unexplained IDA have a greater prevalence of colon cancer and should be evaluated for a colonoscopy.^{19,20} The prevalence of colon cancer in patients with IDA has been reported in previous studies, between 6% and 21%.²¹

Colonoscopy is a diagnostic test for finding the cause of unexplained changes in bowel habits (e.g., chronic constipation and

diarrhea).^{22,23} Changes in bowel habits can be caused by a range of conditions from a temporary infection to an underlying medical disorder.²⁴ The main reasons of changes in bowel habits that related to the gastrointestinal diseases includes; Crohn's disease, ulcerative colitis and irritable Bowel Syndrome (IBS).²⁵ Colonoscopy should be performed in patients with chronic, clinically significant diarrhea without an explanation.²⁶ But colonoscopy is generally not indicated as part of the evaluation for chronic constipation unless warning signs are present such as anemia or weight loss.²⁷ One of the conventional investigations in patients with suspected or proven inflammatory bowel diseases (IBD) is colonoscopy.²⁸ This test allows gastroenterologists to view entire colon. During the procedure, he/she can also take small samples of tissue (biopsy) for laboratory analysis, which may help confirm a diagnosis. Clusters of inflammatory cells called granulomas, if present, help confirm a diagnosis of Crohn's disease.²⁹ Therefore colonoscopy with biopsy remains the method of first choice to diagnose IBD.^{29,30} In addition, patients with colitis require routine surveillance for colonic dysplasia.^{31,32} Chromo endoscopy is a diagnostic method and endoscopic technique that uses for early detection of malignancies within the gastrointestinal tract. Chromo endoscopy which has become the standard technique for colonoscopic surveillance for dysplasia in inflammatory bowel disease, increasing pathology detection and reducing unnecessary biopsies when compared to random biopsy protocols. Chromo endoscopy is used to increase the detection rates for various pathologic processes during endoscopy. Chromo endoscopy is often used in surveillance of the esophagus for Barrett's esophagus, evaluation of polyps in the colon, and surveillance of dysplasia in inflammatory bowel disease. Dye sprays colonoscopy which may also increase adenoma detection in routine colonoscopy.³³⁻³⁵

Therapeutic colonoscopy

Colonoscopy plays an important role in management and treatment of gastrointestinal disorders. Colonoscopy may be required to determine the cause of colonic obstruction, obtain tissue for diagnosis, and provide treatment. Approximately 15% to 20% of patients with colorectal cancer present with colonic obstruction.³⁶ Metastatic cancer and locally advanced pelvic tumors also may cause colonic obstruction. Benign causes of obstruction include volvulus, Crohn's disease, diverticulitis, anastomotic strictures, radiation injury, ischemia, foreign bodies, and intussusceptions.³⁷ Endoscopic balloon dilation^{38,39} and endoscopic colonic stent by colonoscopy^{40,41} are effective treatments for colonic obstruction. Endoscopic balloon dilation has been shown to be effective for the treatment of strictures resulting from both surgical anastomoses and Crohn's disease. Endoscopic dilation was clinically successful in all cases, with no complications.^{42,43} Endoscopic balloon dilation of strictures due to IBD especially Crohn's disease is technically successful in 73% to 97% of patients, although the majority of patients treated with dilation experience recurrence, requiring repeated balloon dilation or surgery.^{44,45} Endoscopic endoclip is an effective and safe method of therapeutic and is primary application in hemostasis during endoscopy of the upper or colonoscopy of the lower gastrointestinal tract with satisfactory outcomes.⁴⁶ And also it's useful for preventing bleeding after therapeutic procedures such as polypectomy and in closing gastrointestinal perforation.^{47,48}

In addition, polyps and lesions found during diagnostic procedures may require therapeutic intervention for example polypectomy and tissue sampling as biopsy. Visible lesions identified during colonoscopy

should be sampled or removed for pathology. Tissue sampling includes biopsies, brushings and polypectomy.^{49,50} Polypectomy is the most commonly performed therapeutic intervention and all colonoscopists should be able to perform the procedure safely and effectively. Some types of polyps can develop into cancer. Therefore, colonoscopy with detection and removal polyps strongly reduces the risk of colorectal cancer (CRC).^{51,52} However, some polyps, due to their size, location or configuration are considered more technically challenging or are associated with an increased risk of complications (such as bleeding or perforation) and hence are not routinely removed.⁵³

Screening colonoscopy

Colonoscopy is the best screening test for early detection of colorectal cancer (CRC). CRC is the third most prevalent cancer in men and the second in women; accounting for 8.5% (n=693,933) of all cancer deaths worldwide.⁵⁴ The highest increase in the incidence of CRC is in the Eastern Europe and Asia.⁵⁵⁻⁵⁷ Recent cancer statistics indicate a decreasing trend in CRC incidence in the United States because of the increase in timely detection and treatment of precancerous polyps and early stage CRC through colonoscopy.^{58,59} CRC is often found after symptoms appear but most people with early colon or rectal cancer don't have any symptoms of the disease. Symptoms usually only appear with more advanced disease. So, regular CRC screening or testing is one of the most powerful weapons for preventing colorectal cancer and colonoscopy is considered the gold standard for early detection of colon cancer and polyp surveillance.⁶⁰

Colorectal polyps may be histologically classified as neo plastic (adenomatous), hyperplastic, hamartomatous or inflammatory.⁶¹ The neo plastic polyps are very important because colon carcinomas mostly arise from it and the time span for the transition process is estimated to nearly 10 years on average.⁶² Given the slow progression of colorectal adenomas into invasive adenocarcinoma.⁶³ Early detection and colonoscopy removal of these precancerous lesions, have been claimed to be effective in decreasing both the incidence and mortality rate of CRC.^{49,60,64} In the era of mass population screening for colorectal cancer, it is being performed more frequently than ever before. Advances in patient preparation, technical components of the procedure and management of pathology will contribute to improvements in performance quality and safety.

Colonoscopy in terms of CRC screening can be divided in two groups;^{65,66} Surveillance Screening Colonoscopy for high risk population: in this procedure patient is asymptomatic in present (no gastrointestinal symptoms) but they have any of the following colorectal cancer risk factors such as a personal history of colorectal cancer or adenomatous polyps, a strong family history of colorectal cancer or polyps (cancer or polyps in a first-degree relative younger than 60 or in two first-degree relatives of any age). A first-degree relative is defined as a parent, sibling, or child, a personal history of chronic IBD and family history of any hereditary nonpolyposis colon cancer. Patients in this category are required to undergo colonoscopy surveillance at shortened intervals (e.g., every 2-5 years).^{67,68} Preventive screening Colonoscopy: regular screening beginning at age 50, in this procedure patient is asymptomatic (no gastrointestinal symptoms), either in past and present and also they don't have any personal or family history of colorectal cancer or adenomatous polyps. So, patients in this category are required to undergo colonoscopy surveillance at longer intervals (e.g., every 10 years).^{69,70}

Discussion

Colonoscopy is widely used for diagnosis and treatment of colon disorders. Properly performed, colonoscopy is generally safe, accurate and well-tolerated. Visualization of the mucosa of the entire large intestine and distal terminal ileum usually is possible during colonoscopy. Colonoscopy with removal of detected polyps has been shown to reduce the incidence and mortality of subsequent CRC. Colonoscopy is the preferred diagnostic method to evaluate the colon in most adult patients with gastrointestinal symptoms, iron deficiency anemia, abnormal results on radiographic studies of the colon, unexplained changes in bowel habits, identified polyps and diagnosis and surveillance in IBD. Determine and treatment of colonic obstruction by endoscopic balloon dilation or endoscopic colonic stent, hemostasis by endoscopic endoclip and polypectomy are therapeutics procedure of colonoscopy. In addition colonoscopy is considered to be the gold standard for early detection of colon adenomas and CRC. The incidence of CRC is uncommon before age 40 but rises progressively by the age of 70. The lifetime occurrence for patients at average risk is 5%, with 90% of cases occurring after age 50. Patients with one first-degree relative experience 2-fold higher risk of CRC and patients with two or more relatives, a 4-fold increased risk independent of age at diagnosis. Therefore based on current guidelines, screening procedures should be start at age 50, every 10years for patients without any personal or family history of CRC or neo-plastic polyps as preventive screening colonoscopy. And screening for patients with personal or family history of CRC or neo-plastic polyps should be doing every 2-5years at any age as surveillance screening colonoscopy for high risk population.

Acknowledgments

This project was completely supported and funded by Gastroenterology and Liver Diseases Research Center, Research Institute for Gastroenterology and Liver Diseases, Shahid Beheshti University of Medical Sciences.

Conflict of interest

The author declares that there is no conflict of interest.

References

- Waye JD. Difficult colonoscopy. *Gastroenterol Hepatol (NY)*. 2013;9(10):676–678.
- Rex DK, Schoenfeld PS, Cohen J, et al. Quality indicators for colonoscopy. *Gastrointest Endosc*. 2015;81(1):31–53.
- Pullens HJ, Siersema PD. Quality indicators for colonoscopy: Current insights and caveats. *World J Gastrointest Endosc*. 2014;6(12):571–583.
- Schoenfeld PS, Cohen J. Quality indicators for colorectal cancer screening for colonoscopy. *Tech Gastrointest Endosc*. 2013;15(2):59–68.
- Hussain H, Lapin S, Cappell MS. Clinical scoring systems for determining the prognosis of gastrointestinal bleeding. *Gastroenterol Clin North Am*. 2000;29(2):445–464.
- Zuccaro G. Management of the adult patient with acute lower gastrointestinal bleeding. American College of Gastroenterology. Practice Parameters Committee. *Am J Gastroenterol*. 1998;93(8):1202–1208.
- Eisen GM, Dominitz JA, Faigel DO, et al. An annotated algorithmic approach to acute lower gastrointestinal bleeding. *Gastrointest Endosc*. 2001;53(7):859–863.
- Green BT, Rockey DC, Portwood G, et al. Urgent colonoscopy for evaluation and management of acute lower gastrointestinal hemorrhage: a randomized controlled trial. *Am J Gastroenterol*. 2005;100(11):2395–2402.
- Kovacs TO, Jensen DM. Recent advances in the endoscopic diagnosis and therapy of upper gastrointestinal, small intestinal, and colonic bleeding. *Med Clin North Am*. 2002;86(6):1319–1356.
- Jensen DM, Machicado GA. Colonoscopy for diagnosis and treatment of severe lower gastrointestinal bleeding. Routine outcomes and cost analysis. *Gastrointest Endosc Clin N Am*. 1997;7(3):477–498.
- Dimmitt LLM, Dimmitt SG, Wilson GR. Diagnosis of gastrointestinal bleeding in adults. *Am Fam Physician*. 2005;71(7):1339–1346.
- Baumbach R, Faiss S, Cordruwisch W, et al. Acute gastrointestinal bleeding. *Dtsch Med Wochenschr*. 2016;141(8):561–568.
- Angtuaco TL, Reddy SK, Drapkin S, et al. The utility of urgent colonoscopy in the evaluation of acute lower gastrointestinal tract bleeding: a 2-year experience from a single center. *Am J Gastroenterol*. 2001;96(6):1782–1785.
- Stephens MR, Hopper AN, White SR, et al. Colonoscopy first for iron-deficiency anaemia: a Numbers Needed to Investigate approach. *QJM*. 2006;99(6):389–395.
- Rockey DC, Cello JP. Evaluation of the gastrointestinal tract in patients with iron-deficiency anemia. *N Engl J Med*. 1993;329(23):1691–1695.
- Zhu A, Kaneshiro M, Kaunitz JD. Evaluation and treatment of iron deficiency anemia: a gastroenterological perspective. *Dig Dis Sci*. 2010;55(3):548–559.
- Nakama H, Zhang B, Fattah AS, et al. Colorectal cancer in iron deficiency anemia with a positive result on immunochemical fecal occult blood. *Int J Colorectal Dis*. 2000;15(5–6):271–274.
- Gasche C, Lomer MC, Cavill I, et al. Iron, anaemia, and inflammatory bowel diseases. *Gut*. 2004;53(8):1190–1197.
- Sawhney MS, Lipato T, Nelson DB, et al. Should patients with anemia and low normal or normal serum ferritin undergo colonoscopy? *Am J Gastroenterol*. 2007;102(1):82–88.
- Goddard AF, James MW, McIntyre AS, et al. Guidelines for the management of iron deficiency anaemia. *Gut*. 2011;60(10):1309–1316.
- Gordon SR, Smith RE, Power GC. The role of endoscopy in the evaluation of iron deficiency anemia in patients over the age of 50. *Am J Gastroenterol*. 1994;89(11):1963–1967.
- Cai J, Yuan Z, Zhang S. Abdominal pain, diarrhea, constipation--which symptom is more indispensable to have a colonoscopy? *Int J Clin Exp Pathol*. 2015;8(1):938–942.
- Badiani S, Desai A, Chapman MA. Is whole colonic imaging necessary for symptoms of change in bowel habit and/or rectal bleeding? *Colorectal Dis*. 2012;14(10):1197–1200.
- Akhavein MA, Patel NR, Muniyappa PK, et al. Allergic mastocytic gastroenteritis and colitis: an unexplained etiology in chronic abdominal pain and gastrointestinal dysmotility. *Gastroenterol Res Pract*. 2012;2012:950582.
- Neugut AI, Garbowski GC, Waye JD, et al. Diagnostic yield of colorectal neoplasia with colonoscopy for abdominal pain, change in bowel habits, and rectal bleeding. *Am J Gastroenterol*. 1993;88(8):1179–1183.
- Phillips SF. Diarrhea: a current view of the pathophysiology. *Gastroenterology*. 1972;63(6):495–518.
- Devroede G. Constipation: mechanisms and management. In: Sleisenger MH, editor. *Gastrointestinal disease*. 2nd ed. Philadelphia, USA: W B Saunders; 1978. p. 368–386.
- Mackalski BA, Bernstein CN. New diagnostic imaging tools for inflammatory bowel disease. *Gut*. 2006;55(5):733–741.
- Gasche C, Turetschek K. Value of MR colonography for assessment of inflammatory bowel disease? Believe what you see-see what you believe. *Gut*. 2005;54(2):181–182.

30. Schreyer AG, Rath HC, Kikinis R, et al. Comparison of magnetic resonance imaging colonography with conventional colonoscopy for the assessment of intestinal inflammation in patients with inflammatory bowel disease: a feasibility study. *Gut*. 2005;54(2):250–256.
31. Ullman T, Odze R, Farraye FA. Diagnosis and management of dysplasia in patients with ulcerative colitis and Crohn's disease of the colon. *Inflamm Bowel Dis*. 2009;15(4):630–638.
32. Siegel CA, Schwartz LM, Woloshin S, et al. When should ulcerative colitis patients undergo colectomy for dysplasia? Mismatch between patient preferences and physician recommendations. *Inflamm Bowel Dis*. 2010;16(10):1658–1662.
33. Tholoor S, Bhattacharyya R, Tsagkournis O, et al. Acetic acid chromoendoscopy in Barrett's esophagus surveillance is superior to the standardized random biopsy protocol: results from a large cohort study (with video). *Gastrointest Endosc*. 2014;80(3):417–424.
34. Fujiwara S, Yao K, Nagahama T, et al. Can we accurately diagnose minute gastric cancers ($\leq 5\text{ mm}$)? Chromoendoscopy (CE) vs magnifying endoscopy with narrow band imaging (M-NBI). *Gastric Cancer*. 2015;18(3):590–596.
35. Trivedi PJ, Braden B. Indications, stains and techniques in chromoendoscopy. *QJM*. 2013;106(2):117–131.
36. Billingsley KG, Morris AM, Dominitz JA, et al. Surgeon and hospital characteristics as predictors of major adverse outcomes following colon cancer surgery: understanding the volume-outcome relationship. *Arch Surg*. 2007;142(1):23–31.
37. Ascanelli S, Navarra G, Tonini G, et al. Early and late outcome after surgery for colorectal cancer: elective versus emergency surgery. *Tumori*. 2003;89(1):36–41.
38. Kochhar R, Kochhar S. Endoscopic balloon dilation for benign gastric outlet obstruction in adults. *World J Gastrointest Endosc*. 2010;2(1):29–35.
39. Endo K, Takahashi S, Shiga H, et al. Short and long-term outcomes of endoscopic balloon dilatation for Crohn's disease strictures. *World J Gastroenterol*. 2013;19(1):86–91.
40. Beck DE. Endoscopic colonic stents and dilatation. *Clin Colon Rectal Surg*. 2010;23(1):37–41.
41. Rodrigues C, Oliveira A, Santos L, et al. Biodegradable stent for the treatment of a colonic stricture in Crohn's disease. *World J Gastrointest Endosc*. 2013;5(5):265–269.
42. Ambrosetti P, Francis K, De Peyer R, et al. Colorectal anastomotic stenosis after elective laparoscopic sigmoidectomy for diverticular disease: a prospective evaluation of 68 patients. *Dis Colon Rectum*. 2008;51(9):1345–1349.
43. Di Giorgio P, De Luca L, Rivellini G, et al. Endoscopic dilation of benign colorectal anastomotic stricture after low anterior resection: A prospective comparison study of two balloon types. *Gastrointest Endosc*. 2004;60(3):347–350.
44. Nomura E, Takagi S, Kikuchi T, et al. Efficacy and safety of endoscopic balloon dilation for Crohn's strictures. *Dis Colon Rectum*. 2006;49(10 Suppl):S59–S67.
45. Scimeca D, Mocciano F, Cottone M, et al. Efficacy and safety of endoscopic balloon dilation of symptomatic intestinal Crohn's disease strictures. *Dig Liver Dis*. 2011;43(2):121–125.
46. Kumar A, Artifon E, Chu A, et al. Effectiveness of endoclips for the treatment of stigmata of recent hemorrhage in the colon of patients with acute lower gastrointestinal tract bleeding. *Dig Dis Sci*. 2011;56(10):2978–2986.
47. Mirzaie AZ, Abolhasani M, Moghaddam RM, et al. The Frequency of gastrointestinal polyps in Iranian population. *Iranian Journal Of Pathology*. 2012;7(3):183–189.
48. Tang SJ, Rivas H, Tang L, et al. Endoscopic hemostasis using endoclip in early gastrointestinal hemorrhage after gastric bypass surgery. *Obes Surg*. 2007;17(9):1261–1267.
49. Zauber AG, Winawer SJ, O'Brien MJ, et al. Colonoscopic polypectomy and long-term prevention of colorectal-cancer deaths. *N Engl J Med*. 2012;366(8):687–696.
50. Ignjatovic A, East JE, Suzuki N, et al. Optical diagnosis of small colorectal polyps at routine colonoscopy (Detect InSpect Characterise Resect and Discard; DISCARD trial): a prospective cohort study. *Lancet Oncol*. 2009;12(12):1171–1178.
51. Saha M. Recto-sigmoid polypectomy by a handmade snare: experience of 24 children with bleeding per rectum. *Afr J Paediatr Surg*. 2014;11(1):91–92.
52. Brenner H, Claude JC, Jansen L, et al. Colorectal cancers occurring after colonoscopy with polyp detection: sites of polyps and sites of cancers. *Int J Cancer*. 2013;133(7):1672–1679.
53. Orozco JFG, Gurudu SR. Complex colon polypectomy. *Gastroenterol Hepatol (N Y)*. 2010;6(6):375–382.
54. Ferlay J, Soerjomataram I, Dikshit R, et al. Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN 2012. *Int J Cancer*. 2015;136(5):E359–E386.
55. Jemal A, Center MM, DeSantis C, et al. Global patterns of cancer incidence and mortality rates and trends. *Cancer Epidemiol Biomarkers Prev*. 2010;19(8):1893–1907.
56. Jemal A, Bray F, Center MM, et al. Global Cancer Statistics. *CA Cancer J Clin*. 2011;61(2):69–90.
57. Pourhoseingholi MA. Increased burden of colorectal cancer in Asia. *World J Gastrointest Oncol*. 2012;4(4):68–70.
58. Decker KM, Singh H. Reducing inequities in colorectal cancer screening in North America. *J Carcinog*. 2014;13:12.
59. Meester RG, Doubeni CA, Zauber AG, et al. Public health impact of achieving 80% colorectal cancer screening rates in the United States by 2018. *Cancer*. 2015;121(13):2281–2285.
60. Fatemi SR, Shivarani S, Malek FN, et al. Colonoscopy screening results in at risk Iranian population. *Asian Pac J Cancer Prev*. 2010;11(6):1801–1804.
61. Shussman N, Wexner SD. Colorectal polyps and polyposis syndromes. *Gastroenterol Rep (Oxf)*. 2014;2(1):1–15.
62. Hartman ANB, Newcomb PA, Mandelson MT, et al. Colorectal polyp type and the association with charred meat consumption, smoking, and microsomal epoxide hydrolase polymorphisms. *Nutr Cancer*. 2011;63(4):583–592.
63. Huang CS, Farraye FA, Yang S, et al. The clinical significance of serrated polyps. *Am J Gastroenterol*. 2011;106(2):229–240.
64. Shergill AK, Connors EE, McQuaid KR, et al. Protective association of colonoscopy against proximal and distal colon cancer and patterns in interval cancer. *Gastrointest Endosc*. 2015;82(3):529–537.
65. Telford JJ. Canadian guidelines for colorectal cancer screening. *Can J Gastroenterol*. 2011;25(9):479–481.
66. Kruse GR, Khan SM, Zaslavsky AM, et al. Overuse of colonoscopy for colorectal cancer screening and surveillance. *J Gen Intern Med*. 2015;30(3):277–283.

67. Geiger TM, Ricciardi R. Screening options and recommendations for colorectal cancer. *Clin Colon Rectal Surg.* 2009;22(4):209–217.
68. Levin B, Lieberman DA, McFarland B, et al. Screening and surveillance for the early detection of colorectal cancer and adenomatous polyps, 2008: a joint guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer and the American College of Radiology. *CA Cancer J Clin.* 2008;58(3):130–160.
69. Wilson JA. Colon cancer screening in the elderly: when do we stop? *Trans Am Clin Climatol Assoc.* 2010;121:94–103.
70. Winawer SJ, Krabshuis J, Lambert R, et al. Cascade colorectal cancer screening guidelines: a global conceptual model. *J Clin Gastroenterol.* 2011;45(4):297–300.