Colonoscopic screening in early detection of colorectal cancer in high-risk groups: a prospective study

Mostafa R. Elkeleny, Tamer N. Abdelbaki, Ahmed A. Sabry, Mohamed Sharaan

Department of General Surgery, Faculty of Medicine, Alexandria University, Alexandria, Egypt

Correspondence to Mostafa R. Elkeleny, MD, MRCS, Lecturer of General Surgery, Department of General Surgery, Faculty of Medicine, Alexandria University, Alexandria, 2113, Egypt. Tel: 01005814622;
E-mail: mostafa.refaie910@gmail.com

Introduction
Colorectal cancer (CRC) is the world's third most common malignant neoplasm. In Egypt, a small incidence of CRC and a high proportion of young-onset disease is observed. Colonoscopy is commonly used for neoplastic colorectal screening. The aim of this work was to assess colonoscopy in high-risk groups as a screening and diagnostic method for early detection of CRC.

Patients and methods
The study included 200 patients, with age varying from 20 to 83 (mean: 53.42 ±15.50) years. They were presented to GIT Surgery Unit, Alexandria University Hospital, complaining of lower gastrointestinal tract symptoms and/or high risk of CRC over 9 months. Two professional endoscopists have performed 200 colonoscopies over 9 months.

Results
Total colonoscopy was done in 94% of cases, and the biopsies were tested. Colorectal polyps were observed in 54 (27%) patients. Of these polyps, the most common were adenomatous polyps (81.5%). Colonic masses were typically seen in males in 22 (11%) cases. Adenocarcinomas were the most common of these masses, accounting for 9% of all cases. A total of 14 (7%) patients reported inflammatory conditions. 6.7% of all cases were diagnosed as colitis. Eight cases were diverticulosis, and 10 cases were hemorrhoid.

Conclusion
There is an increased rate of detection of adenoma by using screening colonoscopy among endoscopists. Colonoscopy is a valuable screening and diagnostic tool for early detection of CRC.

Introduction

Colorectal cancer (CRC) is the world's third most common malignancy and the fourth leading cause of cancer-related death. CRC affects both sexes, all ethnic and racial groups, and is most seen in those 50 years of age or older [1,2].

The data on CRC prevalence in Egypt is deficient, for one research CRC accounted for just 4.4% of newly diagnosed cancer compared with 13% for western countries [3]. Screening with colonoscopy decreases the frequency and mortality of CRCs [4].

Types of CRC:

(1) Hereditary CRC has a positive family history and earlier age of onset, with presence of specific tumors and deficiencies. For example, family adenomatous polyposis (FAP) and hereditary nonpolyposis colorectal cancer are the subjects of numerous studies that gave significant insights into CRC pathogenesis [5].

(2) Sporadic CRC occurs in patients without relevant family history, generally affects the older age groups (65–80 years of age), and is usually manifested as an isolated colonic or rectal lesion. Genetic mutations associated with cancer occur in the tumor itself, whereas in the hereditary disease, the mutations present in all cells of the affected individual [5].

(3) Familial CRC is caused by a combination of environmental and genetic risk factors. People with familial cancer may have one or more family members with the same type of cancer, although a specific pattern of inheritance does not appear to be present (e.g. the risk of cancer is not passed from parent to child). The familial CRC concept is relatively recent. The risk for CRC increases for members in families with

younger age affection (<50 years) and the relative is close. Furthermore, the risk increases as the number of family members with CRC increase [5].

Approximately 75% of CRC cases occur sporadically, whereas 25% cases occur secondary to family syndrome [1].

Observations that support for the hypothesis of adenoma-carcinoma sequence include the following [5]:

(1) Large adenomas are commonly found to have cancer focus than the smaller adenomas. Many polyp features – scale greater than 1 cm, tubulovillous or villous adenoma, and multiple occurrences – have a high risk of malignant transformation [6].
(2) Most invasive CRCs have residual benign adenomatous tissue.
(3) There were benign polyps found to turn into cancers.
(4) Colonic adenomas are more common in patients with CRC . Nearly one-third of all patients with CRC have colonic polyp.
(5) Patients with adenomas at a higher risk of developing CRC.

There is additionally a high occurrence of colorectal polyps in people at high hazard for CRC. Adenomas are the most distinguished neoplastic polyps in the colon (50–67%) and are believed to be the antecedent to most colorectal malignant growth [7,8].

CRC screening
Screening is described as applying tests to asymptomatic people for early detection of the disease [9]. The colorectal adenomas, flat neoplasms, and serrated adenomas cause CRC. The overall evolution time from small adenoma to cancer has not been determined, but indirect evidence indicates that, in fact, an adenomatous polyp takes around 10 years on average [9].

Recommendation Updated CRC screening recommendations for the Asia-Pacific Consensus and the United States Preventive Services Task Force (USPSTF) Recommendation, as it has been shown that screening of adults between 50 and 75 years of age decreases CRC death [9].

Screening colonoscopy
The use of colonoscopy as a screening tool has been widespread since its original undertaking by Wolf and Shinya in 1969. The primary method for CRC screening in the USA is colonoscopy [10].

In addition, researches assessing cancer incidence after initial full colonoscopic polypectomy often indicate significant CRC incidence declines, varying from 76 to 90% depending on the reference population. Recently, a follow-up to the National Polyp Study with average monitoring time of 15.8 years after colonoscopic polypectomy also revealed a decreased incidence of 53%. It is therefore obvious that colonoscopy can screen and remove adenomatous polyps effectively and thus reduce the risk of CRC development and mortality [11].

Adenoma detection rate (ADR) is defined as the number of screening colonoscopy where at least one adenoma has been detected. It is one of the most important quality assurance measure within colonoscopic screening. Independent research found a correlation between a higher ADR and a lower risk of CRC mortality [12].

Aim
The aim was to assess colonoscopy in high-risk groups as a screening and diagnostic tool for early detection of CRC.

Patients and methods
This study involved 200 patients, comprising 92 males and 108 females, with ages from 20 to 83 (mean 53.42 ±15.50) years. The study approved by ethical committee of research in Alexandria University consent for intervention was taken from all patients. They were presented to the outpatient clinic of the gastrointestinal tract (GIT) Surgery Unit, Alexandria University Hospital, complaining of lower GIT symptoms and/or high risk of CRC over 9 months. Cases with previous history of colonoscopy were excluded. The patients were divided into sporadic and hereditary cases. Colonoscopy was done under general anesthesia using Olympus colonoscope (Olympus Optical Co. Ltd, Tokyo, Japan).

Bowel preparation
Oral preparation (Fortrans; IPSEN Pharma Singapore PTE Ltd), Macrogol 4000 (polyethylene glycol), was done. We use Fortrans based on using 1 sachet for 15–20 kg weight. The sachet was dissolved in one liter of potable water of room temperature. On the night before the examination, the solution was taken slowly (~in 4–5 h) from 5 p.m. till 10 p.m. On the morning of

the procedure, enemas were administered. Simple cold snare excision was used for any pedunculated polyp and small sessile polyps, but piecemeal technique was used for larger sessile lesions. Large and sessile polyps were removed by endoscopic mucosal resection.

Results

A total of 200 patients with lower GIT symptoms and/or high CRC risk complaints were included in this study. This study was conducted in the period between March 2017 and January 2018 at the GIT Surgery Unit, Alexandria University Hospital. All patients underwent screening colonoscopic examination. The study included 108 (54%) females and 92 (46%) males. The patients' age ranged from 20 to 84 years, and the mean age was 53.4±15.5 years. Table 1 illustrates the distribution of the studied cases' complaints. Family history of CRC was reported in 32 (16%) patients, whereas 168 (84%) patients had no family history of CRC.

Complete colonoscopic examination was done in 188 (94%) patients. Incomplete colonoscopic examination occurred in 12 (6%) patients owing to bad bowel preparation or presence of constrictive lesions. Regarding the complication of colonoscopy, 192 (96%) patients passed with no complications, four (2%) patients had gastro-intestinal bleeding treated conservatively, and four (2%) patients had postpolypectomy syndrome. No reported cases of perforation were seen.

According to the findings, 96 (48%) patients had no finding, whereas 104 (52%) patients had a positive finding: 22 (11%) patients had one mass or more; 54 (27%) patients had one polyp or more; regarding the signs of colitis, 14 (7%) patients had mild to moderate inflammation and superficial ulceration; and eight (4%) patients and six (3%) patients had diverticulosis and internal piles, respectively. Most of the patients with positive findings were aged between 40 and 60 years. Polyps were either solitary or multiple: solitary in 42 (21%) patients and multiple in 12 (6%) patients. Moreover, eight (4%) patients had two to five polyps and four (2%) patients had more than 100 polyps (FAP cases). Distribution of the studied cases according to site of polyps and masses is illustrated in Table 2.

The size of the polyps in our patients ranged from 3 to 23 mmm, with a mean of 12.87±5.5 mm. Polyps were divided into three categories based on the size of polyps. First, polyps from 3–10 mm were found in 29 patients, 11–23 mm in 21 patients, and four patients with polyps ranged from 3 to 23 mm (FAP cases). Size of the masses ranged from 1.5–9 cm, with the mean of 4.57 ±2.16 cm, and divided into three groups based on the size of masses: the mass size of 1.5–3 cm in six patients, mass size of 3.1–5 cm in seven patients, and mass size of 5–9.2 cm in nine patients. Table 3 shows the descriptive analysis of the studied cases according to the size of polyps and masses. Of the 54 polyps in which Paris classification was documented, 42 were type 0-IP (72.7%) and 12 polyps were type 0-IS (27.3%). Table 4 illustrates the Paris classification.

Of 90 biopsies, we had 54 polyps available for histopathologic analysis: eight were hyperplastic, 44 were adenomatous polyp (16 were tubulovillous with adenoma size ≥10 mm and 28 were tubular adenoma), and two were inflammatory. Of 22 masses in which histopathologic analysis was documented, 18 were adenocarcinoma and four were inconclusive. We had 14 cases of colitis in which histopathology was documented: six were non-specific colitis, five were

Table 1 Distribution of the studied cases according to complaint and colonoscopic finding (*n*=200)

	N (%)
Complaint	
No	11 (5.5)
Change in bowel habits	104 (52.0)
Bleeding per-rectum	76 (38.0)
Abdominal pain	40 (20.0)
Anemia	16 (8.0)
Tenesmus	12 (6.0)
Weight loss	8 (4.0)
Colonoscopic finding	
Finding	
Negative	96 (48.0)
Positive	104 (52.0)
Masses	22 (11.0)
Polyps	54 (27.0)
Sign of colitis	14 (7.0)
Diverticulosis	8 (4.0)
Internal piles	6 (3.0)

Table 2 Distribution of the studied cases according to site of polyps and masses

	N (%)
Site of polyps	
Entire colon	4 (7.4)
Right colon	10 (18.5)
Transvers colon	5 (9.3)
Left colon	19 (35.2)
Rectosigmoid	16 (29.6)
Site of masses	
Left colon	8 (36.4)
Right colon	5 (22.7)
Transvers colon	3 (13.6)
Rectosigmoid	6 (27.3)

Table 3 Descriptive analysis of the studied cases according to size of polyps and masses

	Number of patients with polyps/masses	Minimum–maximum (mm)	Mean±SD	Median
Size of polyps/mm				13
	29	3–10 mm	12.87±5.5	
	21	11–23 mm		
	4	3–23 mm		
Size of masses/cm				
	6	1.5–3.0 cm	4.57±2.16	4.3
	7	3.1–5.0 cm		
	9	5.1–9.2 cm		

Table 4 The Paris classification of superficial neoplastic lesions [12]

Protruding	I
Pedunculated	Ip
Sessile	Is
Nonprotruding and nonexcavated	II
Slightly elevated	IIa
Completely flat	IIb
Slightly depressed	IIc
Elevated and depressed types	IIa+IIc, IIc+IIa
Excavated	IIIa
Ulcer	III
Excavated and depressed type	IIc+III, III+IIc

Table 5 Distribution of the studied cases according to histopathology (n=90)

Histopathology	N (%)
Masses	
Adenocarcinoma	18 (20.0)
Inconclusive	4 (4.4)
Polyps	
Adenomatous polyps:	44 (48.9)
Tubular adenoma	28 (31.1)
Tubulovillous adenoma	16 (17.8)
Hyperplastic	8 (8.9)
Inflammatory polyp	2 (2.2)
Colitis	
Nonspecific colitis	6 (6.7)
Ulcerative colitis	5 (5.6)
Crohn's disease	3 (3.3)

ulcerative colitis, and three were Crohn's disease. Table 5 illustrates the distribution of the studied cases according to histopathology.

Of 18 cases of CRC diagnosed histopathologically, 14 were sporadic and four were hereditary (FAP), with no cases of hereditary nonpolyposis colorectal cancer. Of 21 (10.5%) patients operated by open surgery, 16 of them had CRC, four patients with FAP, and one patient was operated for ulcerative colitis. Two patients were operated laparoscopically for colon cancer. Four patients with ulcerative colitis and three patients with Crohn's disease were medically treated. A total of 50 patients with polyps were treated by snare polypectomy or endoscopic mucosal resection. Overall, six patients with piles were treated by hemorrhoidectomy. In the case of four inconclusive histopathological results, patients were referred for another biopsy. The remaining 104 (52%) patients in this study were treated medically. Table 6 illustrates the summary of detected neoplastic lesions during screening colonoscopy. Some of our endoscopic images are illustrated in Figs 1–10.

Discussion
Our study included 200 patients, comprising 108 (54%) females and 92 (46%) males. The age extended from 20 to 84 years, with a mean patient age of 53.4±15.5 years.

A similar study was done by Grossman et al. [13], which included 154 participants, comprising 71 (46%) males and 83 (54%) females, and the age ranged from 30 to 85 years (mean: 54.2 years). The results are unlike the research studies by Chiu et al. [14], which included 5657 participants from 15 locations, and the mean age was 57.8 years and 2879 were males (50.9%); Hotta et al. [15], which included 704 individuals, and the age ranged from 40 to 79 years; Lieberman et al. [16], which included 3121 patients who underwent a complete colonic examination, and the mean age of the patients was 62.9 years; Lisi et al. [17], which included 414 participants aged 55–64 years who were screened by colonoscopy; Jover et al. [18], which included 4539 individuals screened by colonoscopy, and the age ranged from 50 to 69 years; and Adler et al. [19], which included 12 134 consecutive screening colonoscopy cases, comprising 47% men, and the mean age was 64.5 years. Unlike most of the previous studies, this study included a small sample size and was done in a single hospital within a short period.

In our study, we screened high-risk group for CRC with the following presentation: change in bowel habits (52%), per-rectal bleeding (38%), abdominal pain

Table 6 Summary of detected neoplastic lesions during screening colonoscopy

	Number of screened patients	Any adenoma	Adenoma (3–10 mm)	Adenoma (11–23 mm)	Adenoma in FAP cases	CRC cancer
Male (all ages) (years)	92	24 (26)	13 (14.1)	9 (7.8)	2 (2.2)	10 (10.9)
20–30	9	0	0	0	0	0
31–40	10	2 (20)	1 (10)	1 (10)	0	2 (20)
41–50	26	7 (26.9)	4 (15.4)	2 (7.7)	1 (3.8)	1 (3.8)
51–60	19	8 (42.1)	4 (21)	3 (15.8)	1 (5.3)	3 (15.8)
61–70	13	5 (38.4)	3 (23)	2 (15.4)	0	2 (15.4)
<70	15	2 (13.3)	1 (6.7)	1(6.7)	0	2 (13.3)
Female (all ages) (years)	108	20 (18.5)	12 (11.1)	6 (5.6)	2 (1.9)	8 (7.4)
20–30	7	0	0	0	0	0
31–40	10	4 (40)	3 (30)	1 (10)	0	1(10)
41–50	30	8 (26.7)	5 (16.7)	2 (6.7)	1 (3.3)	2 (6.7)
51–60	25	6 (24)	3 (12)	2 (8)	1 (4)	2 (8)
61–70	19	1 (5.3)	1 (5.3)	0	0	3 (15.8)
<70	17	1 (5.9)	0	1 (5.9)	0	0
Total	200	44 (22)	25 (12.5)	15 (7.5)	4 (2)	18 (9)

CRC, colorectal cancer; FAP, family adenomatous polyposis.

Figure 1

Sessile polyp.

Figure 2

Sessile and pedunculated polyp.

(20%), and anemia, tenesmus, and weight loss accounted for 8, 6, and 4%, respectively. This is in contrast to the studies by Grossman *et al.* [13], Lieberman *et al.* [16], Nelson *et al.* [20], and Chiu *et al.* [14], where screening colonoscopy was done for asymptomatic individuals.

The current study included 32 (16%) patients with family history for CRC. Regula *et al.* [21] reported 13.3% of patients with family history for CRC and Hotta *et al.* [15] study included 33.7% of cases with positive family history for CRC. This is unlike the

studies by Jover *et al.* [18] and Lisi *et al.* [17] which excluded individuals who had a positive family history of CRC.

In our study, cecal intubation was done in 94% of patients. Incomplete intubation was done in 6% of patients because of the presence of constrictive lesions or bad bowel preparation. Regarding the complications of colonoscopy, 2% of the patients had lower gastrointestinal bleeding after polypectomy who were treated conservatively, and 2% of the patients experienced postpolypectomy syndrome. No reported

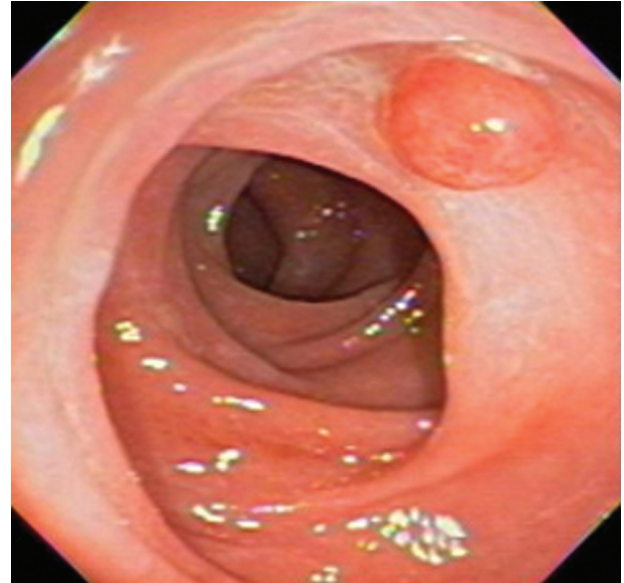**Figure 3**

Snare polypectomy.

Figure 4

Adenomatous polyp.

Figure 5

Inflammatory polyp.

Figure 6

Constricted tumor at sigmoid colon.

cases of perforation were seen. Similar result is seen in the study by Kubisch *et al.* [22] who reported that 94.4% of colonoscopies were complete and that incomplete colonoscopy cases were owing to the remaining stool in 0.42%, stenosis in 0.66%, pain in 0.29%, complications in 0.03%, and other reasons in 0.99%.

Other studies reported a high rate of cecal intubation, such as Adler *et al.* [19] The study rates of cecal intubation were 98%, and the complications were observed in 0.46% of cases. The study by Nelson *et al.* [20] recorded 97.2% successful cecal intubation

rate. The main complication was lower GI bleeding that needed either blood transfusion, hospitalization with fluid resuscitation, or surgery, which occurred in 0.22% of procedures, associated with polypectomy. The study by Hotta *et al.* [15] recorded a completion rate of 99.7% (702/704), and no significant complications occurred. Cecal intubation was not completed in the two patients who failed owing to a difficult situation.
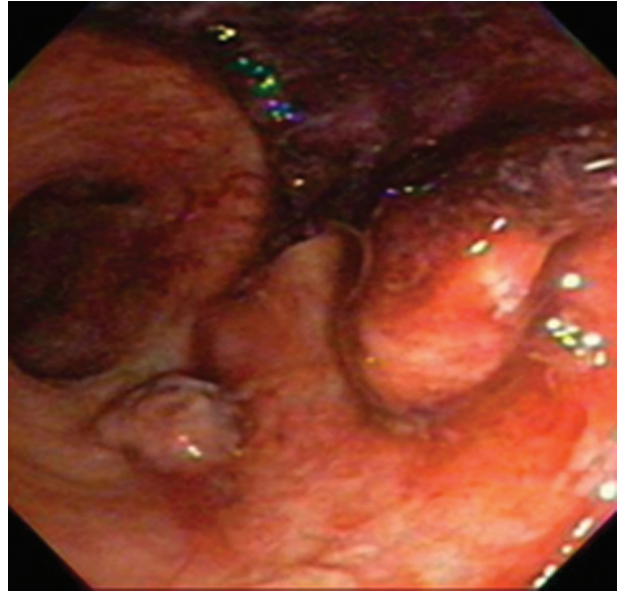
Colonoscopy detects adenomas with great accuracy. Polypectomy was shown to minimize the incidence of

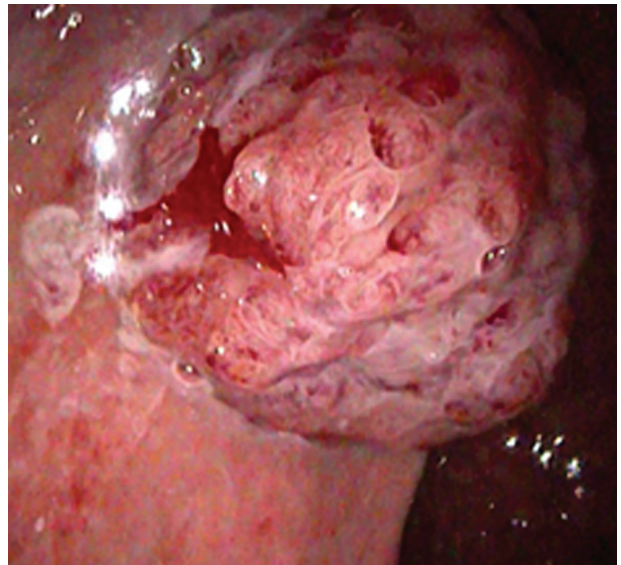**Figure 7**
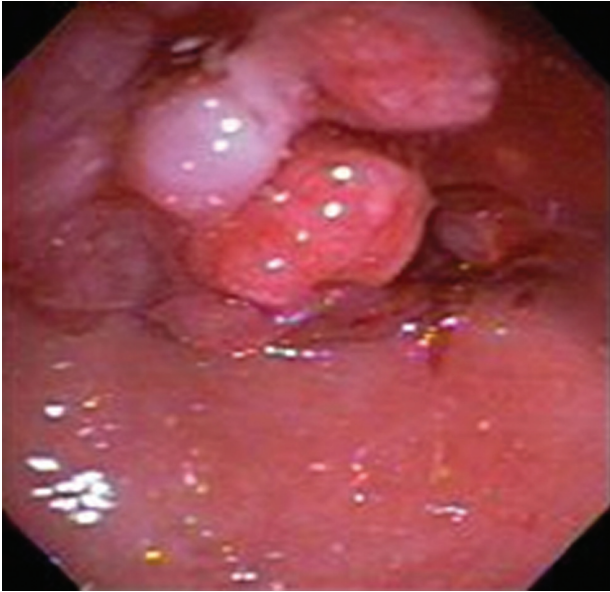
Rectosigmoid cancer.

Figure 8

Colon cancer (adenocarcinoma).

Figure 9

Ulcerative colitis with inflammatory polyp.

Figure 10

Large rectal polyp.

CRC afterward [20]. As Adenoma dedection rare (ADR) differs among endoscopists, work is needed to improve the low ADR. Corley *et al.* [23] found that a three percent decrease in risk of interval CRC was associated with each one percent increase in ADR. Therefore, the guidelines included minimal ADR nowadays [24].

The proposed focuses for ADR depended on colonoscopy screening tests and were set at levels somewhat underneath the normal ADR in those tests. In this way, it was recently suggested that individual endoscopists should distinguish at least one adenoma in at least 25% of men and 15% of women less than 50 years old undergoing colonoscopy screening [25].

This was a single-center prospective study that demonstrates ADR of 22%. Other studies demonstrate ADR of greater than or equal to 15%. Hotta *et al.* [15] reported the main ADR of 15.4%, whereas the study by Bond *et al.* [12] reported the main ADR of 46.5% because of using high-definition colonoscopy. Detection rates among studies are variable. The prevalence of ADR among

colonoscopists varied widely, ranging from 10 to 50%. The reasons for the variability were patient risk factors for neoplasia, colon preparation consistency, and technical factors associated with endoscopy [26].

Conclusion

Screening colonoscopy represents a vulnerable tool for diagnosis and management of colorectal lesions. The most common colonic lesions were colorectal carcinoma and polyps. Colonoscopy is a suitable first step in screening persons who are at high risk for CRC or present with lower GI symptoms. CRC and polyps were more common in males. In Egypt, a significant number of patients with cancer were aged greater than 50 years. The screening program for CRC should be introduced in Egypt.

Conflicts of interest
There are no conflicts of interest.

References

1 Abdel-Malak C, Darwish H, Elsaid A, El-Tarapely F, Elshazli R. Association of APC I1307K and E1317Q polymorphisms with colorectal cancer among Egyptian subjects. Fam Cancer 2016; 15:49–56.

2 Gado A, Ebeid B, Abdelmohsen A, Axon A. Colorectal cancer in Egypt is commoner in young people: is this cause for alarm? Alexandria J Med 2014; 50:197–201.

3 Elwassief A, Soliman AI, Mostafa BE-DH, Matar ER. Participation rate and results of screening colonoscopy in Egyptians with family history of colorectal cancer. Age Nat Sci 2014; 49:9.

4 von Karsa L, Patnick J, Segnan N, Atkin W, Halloran S, Lansdorp-Vogelaar I, et al. European guidelines for quality assurance in colorectal cancer screening and diagnosis: overview and introduction to the full supplement publication. Endoscopy 2013; 45:51–59.

5 Townsend CM, Beauchamp RD, Evers BM, Mattox KL. Sabiston Textbook of Surgery: The Biological Basis of Modern Surgical Practice 2017;1312–1392.

6 Mulholland MW. Greenfield 's Surgery: Scientific Principles and Practice. Wolters Kluwer Health 2016; 68:326–395.

7 Beck DE, Roberts PL, Saclarides TJ, Senagore AJ, Stamos MJ, Nasseri Y. The ASCRS textbook of colon and rectal surgery. Springer Sci Business Media 2011; 38:625–698.

8 Uraoka T, Hosoe N, Yahagi N. Colonoscopy is it as effective as an advanced diagnostic tool for colorectal cancer screening? Expert Rev Gastroenterol Hepatol 2015; 9:129–132.

9 Chan PW, Ngu JH, Poh Z, Soetikno R. Colorectal cancer screening. Singapore Med J 2017; 58:24–28.

10 Provenzale D, Jasperson K, Ahnen DJ, Aslanian H, Bray T, Cannon JA, et al. Colorectal cancer screening, version 1.2015. J Natl Comprehensive Cancer Network 2015; 13:959–968.

11 Steele SR, Hull TL, Read TE, Saclarides TJ, Senagore AJ, Whitlow CB. The ASCRS Textbook of Colon and Rectal Surgery. New York: Springer; 2016. 1:383-430.

12 Bond A, O'Toole P, Fisher G, Subramanian S, Haslam N, Probert C, et al. New-generation high-definition colonoscopes increase adenoma detection when screening a moderate-risk population for colorectal cancer. Clin Colorectal Cancer 2017; 16:44–50.

13 Grossman S, Milos ML. Colonoscopic screening of persons with suspected risk factors for colon cancer. Gastroenterology 1988; 94:395–400.

14 Chiu HM, Ching JY, Wu KC, Rerknimitr R, Li J, Wu DC, et al. A risk-scoring system combined with a fecal immunochemical test is effective in screening high-risk subjects for early colonoscopy to detect advanced colorectal neoplasms. Gastroenterology 2016;150:617-25e3.

15 Hotta K, Matsuda T, Kakugawa Y, Ikematsu H, Kobayashi N, Kushima R, et al. Regional colorectal cancer screening program using colonoscopy on an island: a prospective Nii-jima study. Jpn J Clin Oncol 2017; 47:118–122.

16 Lieberman DA, Weiss DG, Bond JH, Ahnen DJ, Garewal H, Harford WV, et al. Use of colonoscopy to screen asymptomatic adults for colorectal cancer. N Engl J Med 2000; 343:162–168.

17 Lisi D, Hassan C, Crespi M, Group AS. Participation in colorectal cancer screening with FOBT and colonoscopy: an Italian, multicentre, randomized population study. Dig Liver Dis 2010; 42:371–376.

18 Jover R, Zapater P, Polania E, Bujanda L, Lanas A, Hermo JA, et al. Modifiable endoscopic factors that influence the adenoma detection rate in colorectal cancer screening colonoscopies. Gastrointest Endosc 2013; 77:381–9e1.

19 Adler A, Wegscheider K, Lieberman D, Aminalai A, Aschenbeck J, Drossel R, et al. Factors determining the quality of screening colonoscopy: a prospective study on adenoma detection rates, from 12, 134 examinations (Berlin colonoscopy project 3, BECOP-3). Gut 2013; 62:236–241.

20 Nelson DB, McQuaid KR, Bond JH, Lieberman DA, Weiss DG, Johnston TK. Procedural success and complications of large-scale screening colonoscopy. Gastrointest Endosc 2002; 55:307–314.

21 Regula J, Rupinski M, Kraszewska E, Polkowski M, Pachlewski J, Orlowska J, et al. Colonoscopy in colorectal-cancer screening for detection of advanced neoplasia. N Engl J Med 2006; 355:1863–1872.

22 Kubisch CH, Crispin A, Mansmann U, Goke B, Kolligs FT. Screening for colorectal cancer is associated with lower disease stage: a population-based study. Clin Gastroenterol Hepatol 2016; 14:1612–8e3.

23 Corley DA, Jensen CD, Marks AR, Zhao WK, Lee JK, Doubeni CA, et al. Adenoma detection rate and risk of colorectal cancer and death. N Engl J Med 2014; 370:1298–1306.

24 Vleugels JL, van Lanschot MC, Dekker E. Colorectal cancer screening by colonoscopy: putting it into perspective. Dig Endosc 2016; 28:250–259.

25 Rex DK, Schoenfeld PS, Cohen J, Pike IM, Adler DG, Fennerty MB, et al. Quality indicators for colonoscopy. Gastrointest Endosc 2015; 81:31–53.

26 Imperiale TF, Glowinski EA, Juliar BE, Azzouz F, Ransohoff DF. Variation in polyp detection rates at screening colonoscopy. Gastrointest Endosc 2009; 69:1288–1295.