Systematic Review

Sensitivity and Specificity of Colorectal Cancer Mass Screening Methods: A Systematic Review of the Literature

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Abstract

Background: Colorectal cancer is the second cause of the cancer related mortalities in the world. Screening can effectively reduce the mortality and morbidity rate of this cancer. Sensitivity and specificity of screening methods play an important role in their efficacy. The aim of this study is to review sensitivity and specificity of selected colorectal cancer screening methods systematically.

Methods: This study conducted a systematic review of sensitivity and specificity of five common colorectal cancer screening methods. The sites Pubmed, Cochrane library and the center for review and dissemination (CRD database) were searched systematically in Jan 2009. Key questions for this search were focused on the sensitivity and specificity of the 5 screening methods.

Results: In these databases 2713 articles were matched well with our subject. Of these 130 articles were selected with specified inclusion-exclusion criteria. The mean ± standard deviation per patient sensitivities of colonoscopy, sigmoidoscopy, double contrast barium enema, CT colonography and fecal occult blood test for detecting colorectal cancer were respectively 94.7 ± 4.6 %, 82.0± 9.3%, 82.3 ± 8.7 % , 95.7 ±5.9% and 45.7 ± 26.5% . Specificities of these tests were respectively 99.8 ± 0.2%, 83.9%, 92.4 ± 14.7%, 98.5 ± 1.3% and 87.6 ± 11.4%.

Conclusions: Based on available evidences, colonoscopy has the highest sensitivity and specificity among the selected screening methods and fecal occult blood test has the lowest sensitivity. Almost all of the tests except stool exams have acceptable sensitivity and specificity for detecting colorectal cancer.

Key words: Sensitivity; Specificity; Colorectal neoplasm; Mass screening

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Introduction

Colorectal cancer has the greatest mortality rate after lung cancer among all malignancies and it has caused many problems in western countries [1]. Over 95% of colorectal cancers result from adenomatous polyps. These polyps are removable. This means that we can reduce the burden of this cancer by screening [2].Screening is considered as a second type prevention. It means that it can detect patients that have a silent problem (with no symptoms), so they would go under treatment and their disease have no time to develop.

Some diseases are more suitable for screening. Colorectal cancer is one of them. It can be diagnosed in early stages and it can be treated more effectively. Screening colorectal cancer will prevent it from becoming advanced [1, 3].

There are several methods for screening colorectal cancer. Each method has its own performance characteristics. Performance characteristics are the characteristics that can be used to describe the quality and usefulness of a test. Accuracy can be expressed through sensitivity and specificity, positive and negative predictive values, or positive and negative diagnostic likelihood ratios.

A proper test for screening should have four properties. It should be simple and not expensive [1]; should not have any danger to patients or healthy individuals [4]; should be acceptable for patients [1];

and it should be available [5].It is obvious that the disease to be screened must be also treatable [4].

Some of the characteristics of the screening methods for colorectal cancer are explained as follows:

Colonoscopy

Colonoscopy has become increasingly popular for screening. There is a strong biologic argument that colonoscopy, with direct visualization of the colonic mucosa and the ability to biopsy or excise polyps and localized cancers can prevent colorectal cancers and deaths. Furthermore, colonoscopy has the potential to detect proximal lesions that would be missed by screening sigmoidoscopy [1]. This procedure has a low (0.35%) risk of serious complications [6]. A recent study published in the Annals of Internal Medicine [7] implies that colonoscopy screening prevents approximately two thirds of the deaths due to colorectal cancers on the left side of the colon, and is not associated with a significant reduction in deaths from right-sided disease.

Sigmoidoscopy

The 60 cm flexible sigmoidoscope can reach to the splenic flexure. Primary care physicians, nurse practitioners and physicians assistants can become proficient in the technique of sigmoidoscopy with proper training. The patient preparation is less onerous than for colonoscopy or CT colonography, and the procedure may be performed without sedation in the office.

Computed Tomographic Colonography

"Virtual Colonoscopy" is performed via computed tomography (CT), sometimes called a CAT scan, or with magnetic resonance imaging (MRI) [8].about 1 in 10 patients will not have a complete right colon (cecum) evaluation completed with conventional colonoscopy [9]. It also takes less time than either a conventional colonoscopy or a lower GI series.VC provides a secondary benefit of revealing diseases or abnormalities outside the colon [10].Patients prepare for CTC with aggressive bowel preparation, the same as used for optical colonoscopy. Virtual Colonoscopy performed with CT exposes the patient to ionizing radiation; however some research has demonstrated that ultra-low dose VC can be just as effective in demonstrating colon and bowel disease due to the great difference in x-ray absorption between air and the tissue comprising the inner wall of the colon.

Fecal Occult Blood Test

Several guaiac reagents are marketed; Hemoccult-SENSA is more sensitive than Hemoccult, Hemoccult-II or Hemoccult-R. Newer, high-sensitivity modern tests look for globin, and are now recommended as best practice. Conventional guaiac-based fecal occult blood tests which look for heme are a less-preferred option. If colon cancer is suspected in an individual (such as in someone with an unexplained anemia) fecal occult blood tests are typically not warranted. If a doctor suspects colon cancer, more rigorous investigation is necessary, whether or not the test is positive.

The test is often false-positive . (This is often due to recent ingestion of under-cooked meats, and a patient is generally advised to keep a meat-free diet for several days before handing in the feces sample. False negatives may result if the patient has been taking vitamin C supplements. The test is more sensitive if the sample is hydrated before testing. However, the specificity is decreased in this method.

Fecal Immunological Test (FIT)

FIT tests detect the globin in feces rather than heme. By detecting globin the tests are both more sensitive and specific for lower gastrointestinal bleeding. The superior FIT tests are now recommended in place of the traditional annual standard guaiac FOBT, which is now identified as a "less-preferred option."

Fecal immunochemical tests (FIT or iFOBT) for hemoglobin are more specific than guaiac tests because they respond only to human globin, and do not detect upper gastrointestinal bleeding (since the globin is digested in transit) or foods with peroxidase activity.

Fecal DNA Tests

Colorectal neoplasm shed DNA in the stool where it can be isolated and tested for the presence of changes acquired during carcinogenesis. Not all genetic abnormalities associated with colorectal cancer can be included in the stool DNA test (sDNA), however, and false negative results occur. The test is expensive. Fecal DNA test (PreGen-Plus) is more sensitive than fecal occult blood in one study (51.6% vs. 12.9%) [11].

Double-contrast Barium Enema

Patients must undergo bowel preparation. Sedation is not ordinarily given. Patients experience some cramping during the procedure but can return to work after the examination. There is less radiation

exposure than an abdominal CT. Most experts feel that the risk is low compared with the benefits.

Optical colonoscopy is taken as the "gold standard" for colorectal cancer screening by the vast majority of the medical and research communities. Some radiologists recommend VC as a preferred approach to colorectal screening. However, optical colonoscopy is considered the gold standard by some professionals because it permits complete visualization of the entire colon, hence providing the opportunity to identify precancerous polyps and cancer, and then to do diagnostic biopsies or therapeutic removal of these lesions, as soon as possible.

The aims of this study is to undertaken a systematic review of sensitivity and specify of the five selected colorectal screening methods including colonoscopy, flexible sigmoidoscopy, CT colonography, double contrast barium enema and fecal occult blood test.

Materials and Methods

To review the sensitivity and specificity of each method of screening systematically 4 steps undertaken:

Step 1-Pubmed, Cochrane library and CRD database searched systematically in 24/1/2009.

Step 1-1: First the appropriate terms describe effectiveness and represent the accuracy of methods of screening were extracted from articles, books and especially from "MESH" database in the site "Pubmed". These terms were as follows:

Sensitivity, Specificity, Validity, Value, Accuracy, Efficacy, Effectiveness, Detection rate, Detectability, Positivity, Positive predictive value and Negative predictive value

Step 1-2: Then the terms were searched separately. The results then combined to each other by the logical operator "OR" to expand the research field appropriately.

We used the same strategy to search for "colon", "Cancer", and their synonyms separately. The terms used in this section were as follows:

Colon, Rectum, Colorectal, Bowel, Large intestine and Colonic

Step 1-3: The results then combined to each other by the logical operator "OR" to expand the research field appropriately.

Cancer, Carcinoma, Malignancy, Malignant, Tumor, Polyp, Adenoma, Neoplasia, Dysplasia, Hyperplasia and Neoplasm

Step 1-4: These results also were combined to each other by the logical operator "OR".

Then the name of each method of screening and their synonyms were searched systematically. The terms used in this section were as follows:

- Colonoscopy OR Colonoscopic
- Sigmoidoscopy OR Proctosigmoidoscopy
- FOBT OR "FOB test" OR "OB" OR Fecal occult blood test OR Guaiac OR "FOB"
- DCBE OR Double contrast barium enema OR Air contrast barium enema
- Virtual colonoscopy OR CT colonography OR Computed tomographic colongraphy

Step 1-5: The results of all these stages (steps 1-2, 1-3, 1-4 and the results for the names of each method of screening) put together with the operator "AND" for each method of screening separately to limit the search results reasonably.

Step 2-Reviewing the titles of the articles.

In this step the titles of articles were reviewed fully and proper ones were selected based on the inclusion and exclusion criteria.

Inclusion Criteria

All of the articles that directly measured sensitivity or specificity of each method of screening.

Exclusion Criteria

1-Studies that were not directly about measuring sensitivity or specificity of each method of screening and it is not the scope of their study.

2-Studies that were in the form of a review article, meta analysis or cost effectiveness analysis. The reason for putting these articles in exclusion criteria is that in this study we didn't use any "limit" and this study includes all of the studies that were used in review articles.

3-Becauseadenomatouse and large polyps increase the risk of colorectal cancer, studies that only measured sensitivity of screening methods for small benign polyps, were omitted.

Step 3-Reviewing the abstracts of selected articles.

In this step the abstracts of selected articles were reviewed carefully and, according to inclusion and exclusion criteria, appropriate papers were selected to be reviewed by researchers.

Step 4-Reviewing the full text of the selected articles

In this step the full texts of selected papers reviewed and all relevant information were extracted.

Sensitivities/specificities were reported for different polyp sizes. Most of the reported sensitivities were for polyps ≥ 10mm or cancer. In this study sensitivities that were reported for polyps ≤ 5 mm deleted; because these polyps do not indicate colorectal cancer [1].

The studies were conducted in different countries by different experts, equipments and in different times.

Results

In this study "the sensitivity for large polyps" means both the sensitivities reported for polyps ≥ 10mm and polyps ≥ 6mm and normally detecting the larger polyps is easier and the reported sensitivity/specificity is higher.

The results of studying articles and selecting proper ones using inclusion/exclusion criteria in the Pubmed, Cochrane library and CRD databases are presented in tables 1,2 and 3 respectively (Tables 1,2 , 3).

The summary of the sensitivity/specificity results extracted from the articles are presented in table 4.

Tables 5 and 6 summarized the results extracted from the publications based on the screening method and the criteria of the sensitivity.

Discussion

Diagnostic or screening tests should be valid, easy, with high compliance for patients and also cost-effective. The results show that colonoscopy has the highest sensitivity and specificity. In some methods of screening like sigmoidoscopy, there is actually some extent of lack of good evidences but in some of them like fecal occult blood test and CT colonography there are as many evidences as we can conclude a definite result from analyzing them. On the other hand increasing evidences is not so good in some aspects.For example the sensitivity of guaiac test varies widely among different articles, but in most of them, this test has a very low sensitivity. So for this test and the tests like it, doing a meta analysis on the results is encouraged.

Some reasons of this wide range of sensitivity are followed:

Sensitivities of screening tests are reported in different ways in articles. For example per-polyp sensitivity indicates the number of polyps detected with a method out of 100 polyps. Per patient sensitivity is the number of patients with polyps that are detected out of 100 patients with polyps. In the articles studied, per patient sensitivities in most of the cases were more than per polyp sensitivities. It could be because of the fact that the numbers of polyps that are missed during screening are more than the number of patients that are missed. But the difference between these sensitivities was not so much that affect the results.

Sensitivities/specificities were reported for different polyp sizes. Most of the reported sensitivities were for polyps ≥ 10mm or cancer. [In this study sensitivities that were reported for polyps≤ 5 modulated. Because these polyps does not indicate colorectal cancer [2]. In this study "the sensitivity for large polyps" means both the sensitivities reported for polyps ≥ 10mm and polyps ≥ 6mm and normally detecting the larger polyps is easier and the reported sensitivity/specificity is higher.

The studies were conducted in different countries by different experts, equipments and in different times. This study did not use any limit for publication date.

In FOBT method, the sensitivity depends on the number of tests performed. For example doing the test in 6 days gives more sensitivity than doing 3 times. In most of the articles it was done 3 times.

Although CT colonography is used widely in these days, still colonoscopy has a high sensitivity and still can be the gold standard.

Among all types of sensitivities, sensitivity for cancer in all methods is the highest. It is because of the fact that when the lesion is in cancerous state it's much easier to detect.

Table1. The search results of the Pubmed database

Method of screening	The initial number of articles	Number of articles after reviewing the titles	Number of articles after reviewing the abstracts	Final number of articles
Colonoscopy	1239	56	24	20
Sigmoidoscopy	377	83	15	12
FoBt	539	101	47	38
BE	135	42	27	26
CT colonography	323	113	67	64

Table2. The search results of the Cochrane library

Method of screening	The initial number	Number of articles after reviewing the titles	Number of articles after reviewing the abstracts
Colonoscopy	123	8	1
Sigmoidoscopy	56	2	0
FoBt	31	4	1
CT colonography	24	6	0

Table3. The results of studying articles of CRD site

Method of screening	The initial number of articles	Number of articles after reviewing the titles	Number of articles after reviewing the abstracts
Colonoscopy	135	2	0
Sigmoidoscopy	65	0	0
FoBt	74	1	0
CT colonography	29	1	0

Table 4. The initial results of studying articles about sensitivity/specificity of colorectal cancer [12-139]

Colonoscopy

	Authors and year	Sample size	Gold standard	Sensitivity (percent)			specificity	Ref. Number
				For large polyps	For cancer/ carcinoma	over all		
1	Heresbach D, Barrioz T(2008)	294	Same-day back-to-back video colonoscopy	74-91	100			12
2	Hosokawa O, Hattori M(2007)	59162	Cancer registry			88.9		13
3	Bressler B, Paszat LF(2007)	12487	Cancer Registry	94.1-97.7				14
4	Menardo G.(2004)			94				9
5	Rockey DC, Paulson	614	Air contrast barium enema,	98-99			99.6	15

	E(2005)		CTcolonography,Colonoscopy					
6	HoppeH, Netzer P(2004)	100	CT colonography,Colonoscopy	94				16
7	Rex DK, Cutler CS(1997)	183	Back-to-back colonoscopies	87-94		76		17
8	Warneke J, Petrelli N(1992)	235	Pathologic findings of the surgical specimen	96				18
9	Gelfand DW, Chen MY(1992)	77	Barium enema examination			85		19
10	Byrd RL, Boggs HW Jr(1989)	429	Postoperative pathologic specimen reports			97		20
11	Kalra L, Hamlyn AN(1988)	154	Known cases		88-100			21
12	Walleser S, Griffiths A(2007)	-	-	95	96		99.7-99.8	22
13	Cotton PB, Durkalski VL(2004)	615	CT colonography,colonoscopy	99-100			100	23
14	Iannaccone R, Catalano C(2005)	88	Colonoscopy	84-90			100	24
15	Pickhardt PJ, Choi JR(2003)	1233	CT colonography	87.5-92.3				25
16	Smith GA, O'Dwyer PJ(2001)	1081	Follow up after 1-2 years	91.4	97.5			26
17	Rex DK, Rahmani EY(1997)	2193	Medical records		95			27
18	Reiertsen O, Bakka A(1988)	303	Known cases		90			28
19	Thoeni RF, Petras A(1982)	53	Known cases			78		29
20	Fork FT(1981)	250	Known cases		91			30

Sigmoidoscopy

	Authors and year	Sample size	Gold standard	Sensitivity (percent)			Specificity	Ref. Number
				for cancer	for large polyps/adenomas	over ally		
1	Soon MS, Kozarek RA(2005)	4859	Colonoscopy	67.5-79.3				31
2	Kalra L, Hamlyn AN(1988)	154	Known cases	81-90				21
3	Graser A, Stieber P(2009)	307	CT colonograph y colonoscopy			83.3		32
4	Sung JJ, Chan FK(2003)	505	Colonoscopy			77.8	83.9	33
5	Schoenfeld P, Lipscomb S(1999)	3028	Repeat sigmoidoscopy, performed by a gastroenterologist			79		34
6	Saito Y, Slezak P(1989)	675	DCBE		88.8-100			35
7	Dubow RA, Katon RM(1985)	258				98		36
8	Farrands PA, Vellacott KD(1983)	227	Colonoscopy DCBE	94.2	98			37
9	Hardcastle JD, Farrands	20525	Known cases		97.7			38

	PA(1983)							
10	Jensen J, Kewenter J(1990)	853	Follow up after 1-2 years			86		39
11	Rozen P, Ron E(1987)	1176	Colonoscopy	80	95	93.8		40
12	Jensen J, Kewenter J(1986)	458	DCBE	82				41

CT colonography

	Authors	Pub year	Sample size	Gold standard	Sensitivity (percent)			Specificity			Ref number
					for large polyps	for cancer	over ally	For large polyps	For cancer	over ally	
1	Rockey DC, Paulson E	2005	614	Air contrast barium enema,CTcolonography,Colonoscopy	51-59			96			15
2	Hoppe H, Netzer P	2004	100symptomatic	CT colonography,Colonoscopy	61-95			88-98			16
3	Graser A, Stieber P	2009	307	CT colonography colonoscopy			96.7				32
4	Johnson CD, Toledano AY	2003	341	Colonoscopy and pathology reports			75			73	73
5	Walleser S, Griffiths A	2007	-	-	63	89		95	97		22
6	Chen SC, Lu DS	1999	23	Colonoscopy	95						74
7	Suzuki K, Yoshida H	2008	73	Colonoscopy		96.4					75
8	White TJ, Avery GR	2009	150 (High risk)	Colonoscopy	91	100				99.2	76
9	Selçuk D, Demirel K	2006	48(High risk)	Colonoscopy	85-100		86			98	77
10	Cotton PB, Durkalski VL	2004	615	CT colonography, colonoscopy	39-55			90.5-96			23
11	Ng CS, Doyle TC	2002	1031	Pathological and cancer registration records, together with colonoscopy +BE			85			91	78

12	Wong BC, Wong WM	2002	71	Colonoscopy	92		59	100		88	79
13	Laghi A, Iannaccone R	2002	66	Colonoscopy	84.6-92.8	93.7				94.1	80
14	Spinzi G, Belloni G	2001	99	Colonoscopy			57.8			92.6	81
15	Mendelson RM, Foster NM	2000	100	Colonoscopy	73						82
16	Miao YM, Amin Z	2000	201	Colonoscopy	73	100		94	99		83
17	Kay CL, Kulling D	2000	38	Colonoscopy	66.7-90			75-82.1			84
18	Fenlon HM, Nunes DP	1999	100	Colonoscopy	82-91			84	100		85
19	Beaulieu CF, Jeffrey RB Jr	1999	-	Panoramic endoscopic volume-rendered studies	68						86
20	Johnson CD, Chen MH	2008	2531	Colonoscopy and histologic review	78-84	90				86	87
21	Kim YS, Kim N	2008	241	Colonoscopy	60.4-86.7						88
22	Summers RM, Handwerker LR	2008	104	Colonoscopy	82.1-97.6						89
23	Juchems MS, Ernst A	2009	79	Colonoscopy	58.3-60.4					75	90
24	Jensch S, de Vries AH	2008	168	Colonoscopy	70-82			79-97			91
25	Johnson CD, Chen MH	2008	114	Colonoscopy	53-93					71-100	87
26	Roberts-Thomson IC, Tucker GR	2008	202	Colonoscopy	71		50	67		48	92
27	Yun JY, Ro HJ	2007	399	Colonoscopy	89-91						93
28	Arnesen RB, von Benzon E	2007	231	Colonoscopy	66-81			91-98			94
29	Baker ME, Bogoni L	2007	30	Computer-aided detection			81				95
30	Chaparro Sánchez M, del Campo Val L	2007	50	Colonoscopy	75-80			75-80		94	96

31	Sallam BM, Pilch-Kowalczyk A	2007	77	Colonoscopy and/or barium enema and pathomorphological examinations	100			98		97
32	Purkayastha S, Athanasiou T	2007	-	Colonoscopy			96		100	98
33	Kalra N, Suri S	2006	42	Colonoscopy	97-100			83-100		99
34	Reuterskiöld MH, Lasson A	2006	111	Colonoscopy	86-91	100		92	45	100
35	Dehmeshki J, Halligan S	2007	138	Computer assisted detection	87.8-95.2					101
36	Duff SE, Murray D	2006	112	Follow up after 1 years			87.5		97.1	102
37	Wessling J, Fischbach R	2006	-	Colon phantom	87-100					103
38	Juchems MS, Fleiter TR	2006	21	Colonoscopy	56.3-100					104
39	Summers RM, Yao J	2005	792	Colonoscopy	89.3					105
40	You YT, Chang Chien CR	2006	434	Colonoscopy, surgical finding, and clinical follow-up	100				83	106
41	Abdel Razek AA, Abu Zeid MM	2005	32	Colonoscopy			86.7		100	107
42	Iannaccone R, Catalano C	2005	88	Colonoscopy	84-86		62		82	24
43	Halligan S, Altman DG	2005	-	-	86-93			86-97		108
44	Wessling J, Domagk D	2005	78	Colonoscopy	81-100	100			86	109
45	Anupindi S, Perumpillichira J	2005	7	Colonoscopy	66.7					110
46	Mulhall BP, Veerappan GR	2005	-	Colonoscopy	70-85			93-97		111
47	Arnesen	2005	41	Colonoscopy	67-75			84-95		112

	RB, Adamsen S									
48	Park SH, Ha HK	2005	56	Colonoscopy	75-79					113
49	Iannaccone R, Laghi A	2004	203	Colonoscopy	89.9-95.5				92.2	114
50	Pickhardt PJ, Choi JR	2004	1233	Colonoscopy	85.7-92.2					115
51	Van Gelder RE, Nio CY	2004	249	Colonoscopy	75-84			92		116
52	Johnson CD, MacCarty RL	2004	837	Colonoscopy +DCBE	56-79			96-99		117
53	Macari M, Bini EJ	2004	68	Colonoscopy	52.9-100			89.7		118
54	Pickhardt PJ, Choi JR	2003	1233	Colonoscopy	88.7-93.8			79.6-96		25
55	Iannaccone R, Laghi A	2003	158	Colonoscopy	83.3-100	100	96		96.6	119
56	Sosna J, Morrin MM	2003	-	-	62-88			95		120
57	Munikrishnan V, Gillams AR	2003	80	Colonoscopy	83-100	97	74	98	96	121
58	Johnson CD, Harmsen WS	2003	703	Colonoscopy	43.8-50.5				86-98	122
59	Gluecker T, Dorta G	2002	50	Colonoscopy	33-82				90	123
60	Yee J, Akerkar GA	2001	300	Colonoscopy	80.1-90	100	90.1		72	124
61	Spinzi G, Belloni G	2001	99	Colonoscopy			57.8		92.6	81
62	Britton I, Dover S	2001	50	Pathology, colonoscopy, barium enema ERCP and clinical follow-up	100	82		94		125
63	McFarland EG, Brink JA	2001	-	Colon phantom	61-100		89-92		-72 83	126
64	Civelli EM, Gallino G	2000	53	Known cases		100			78.7	127

Barium Enema

	Authors	Published year	Sam-ple size	Gold standard	Sensitivity (percent)			Specificity	Ref .Number
					For large polyps	For cancer	over ally		
1	Rockey DC, Paulson E	2005	614	CT colonography, Colonoscopy	35-48			90	15
2	Kalra L, Hamlyn AN	1988	154	Known cases		79-81			21
3	Thorson AG, Christensen MA	1986	176	Colonoscopy	42-58	68-78			128
4	McPherson A, Payne JE	1983	108	Colonoscopy			90	57	129
5	Ribet A, Escourrou J	1980	603	FS			41		72
6	Wolff WI, Shinya H	1975	500	Colonoscopy	58	75			130
7	Saito Y, Slezak P	1989	675	Colonoscopy	64.7-83.3				35
8	Farrands PA, Vellacott KD	1983	227	Colonoscopy	74	76.5			37
9	Hardcastle JD, Farrands PA	1983	3613	Known cases	62	75			38
10	Johnson CD, MacCarty RL	2004	837	Colonoscopy +CTC	39-56			99-100	117
11	Sosna J, Sella T	2008	Meta anal ysis	-	70.2-71.5				131
12	Leslie A, Virjee JP	2002	70	Follow up after 5 years			93		132
13	Rockey DC, Koch J	2004	100	Colonoscopy	27-33			97-100	133
14	Culpan DG, Mitchell AJ	2002	239	Follow up after 3 years		90.6			134
15	Connolly DJ, Traill ZC	2002	880	Follow up after 2 years		90.2		99.5	135
16	Smith GA, O'Dwyer PJ	2001	1389	Follow up after 1-2 years	21.7	83			26
17	Gillespie JS, Kelly BE	2001	160	Follow up after 2 years		96.5			136
18	Rex DK, Rahmani EY	1997	2193	Medical records			81.8 - 85.2		27
19	Jaramillo E, Slezak P	1992	288	Colonoscopy	98	100			137
20	Jensen J, Kewenter J	1990	853	Follow up after 1-2 years	72				39
21	Ahovuo J, Linden H	1990	57	Colonoscopy	81				138
22	Reiertsen O, Bakka A	1988	303	Known cases			85		28
23	Myllylä V, Päivänsalo M	1984	112	Known cases and medidal records		82-83			139
24	Thoeni RF, Petras A.	1982	53	Known cases			88		29
25	Fork FT.	1981	250	Known cases			90	96.5	30
26	Jensen J, Kewenter J	1986	458	FS	77				41

Table 5. Range of sensitivity/specificity of screening methods obtained from systematic review of related articles

Type	Colonoscopy	Sigmoidoscopy	Barium enema	FOBT	CT Colonography
Sen[1] for large polyps	74-100	82-100	21.7-98	4-41	33-100
Sen[1] for cancer	80-100	67.5-94.2	68-100	5.6-100	82-100
Overall sen*	76-97	77.8-93.8	41-93	14.3-82	50-100
Spc[2] for large polyps**	-	-	-	-	67-100
Spc[2] for cancer**	-	-	-	-	97-100
Overall sSpc[2]	99.6-100	83.9***	57-100	59.4-98	45-100

1. Sen: Sensitivity
2. Spc: Specificity
*Overall sensitivity does not mean the sum of other sensitivities. This term was exactly reported in some articles (refer to previous tables).
**For all methods except CT colonography specificity for large polyps, cancer and overall specificity are pooled together because of inadequacy of evidences and is explained as overall specificity.
***There was only one article that reported this value.

Table 6. Average sensitivity/specificity of screening methods ± standard deviation obtained from systematic review of related articles

Type	Colonoscopy	Sigmoidoscopy	Barium enema	FOBT	CT colonography
Sen[1] for large polyps	92.5±6.2	93.6±6.9	57.6±20.8	18.5±11.8	79.9±15.9
Sen[1] for cancer	94.7±4.6	82.0±9.3	82.3±8.7	45.7±26.5	95.7±5.9
Overall sen*	84.9±8.5	86.3±8.1	81.75±16.8	37.0±19.4	80.1±15.6
Spc[2] for large polyps**	-	-	-	-	90.1±8.3
Spc[1] for cancer**	-	-	-	-	98.5±1.3
Overall Spc[2]	99.8±0.2	83.9***	92.4±14.7	87.6±11.4	85.0±14.0

1. Sen: Sensitivity
2. Spc: Specificity
*Overall sensitivity does not mean the sum of other sensitivities. This term was exactly reported in some articles (refer to previous tables).
**For all methods except CT colonography specificity for large polyps, cancer and overall specificity are pooled together because of inadequacy of evidences and is explained as overall specificity.
***There was only one article that reported this value.

Conclusion

In overall all of the tests except stool exams have acceptable sensitivity and specificity for detecting colorectal cancer. Based on available evidences, colonoscopy has the best sensitivity and specificity among the selected screening methods and fecal occult blood test has the lowest sensitivity. Doing an analysis of cost effectiveness among these methods in encouraged.

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Conflict of Interest

The authors declare that they have no conflict of interest in this article.

Authors' Contribution

EMH designed the study and contributed to analyzing the data. DM contributed to designing the study, analyzing the data, writing the paper and literature review. AZ carried out the study, reviewed the literature, analyzed the data and wrote the paper. All authors read and approved the final manuscript.

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