Systematic Review and Meta-analysis of the Role of Routine Colonic Evaluation After Radiologically Confirmed Acute Diverticulitis

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Objective: To determine the yield of colorectal cancer at routine colonic evaluation after radiologically proven acute diverticulitis.

Background: Acute diverticulitis accounts for 152,000 hospitalizations in the United States alone. Current guidelines recommend routine colonic evaluation after acute diverticulitis to confirm the diagnosis and exclude malignancy. However, research suggests that the yield of colorectal cancer after computed tomography–proven uncomplicated diverticulitis may be low. In the era of widespread computed tomographic scanning for diverticulitis, routine colonic evaluation after diverticulitis may represent a nonessential burden on health care resources.

Methods: The PubMed (MEDLINE), EMBASE, BIREME, CINAHL, and the Cochrane Library databases were searched. Original studies of colonic evaluation after proven acute diverticulitis were included. Meta-analysis of data from included studies was performed using a DerSimonian Laird random effect proportion analysis.

Results: Eleven studies from 7 countries were included in the analysis. Out of a pooled population of 1970 patients, cancer was found in 22. The pooled proportional estimate of malignancy was 1.6% (95% confidence interval [CI], 0.9%−2.8%). Of the 1497 patients with uncomplicated diverticulitis, cancer was found in 5 (proportional estimate of risk 0.7%; CI, 0.3%−1.4%). Of the 79 patients with complicated disease, cancer was found in 6 (proportion estimate of risk 10.8%; CI, 5.2%−21.0%).

Conclusions: The risk of malignancy after a radiologically proven episode of acute uncomplicated diverticulitis is low. In the absence of other indications, routine colonoscopy may not be necessary. Patients with complicated diverticulitis still have a significant risk of colorectal cancer at subsequent colonic evaluation.

Keywords: cancer, colonic evaluation, colonoscopy, diverticulitis, meta-analysis, uncomplicated diverticulitis

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Diverticulosis and diverticulitis are significant problems in Western countries. The incidence has increased over the past century.[1] Up to 60% of people living in industrialized countries will develop colonic diverticula.[2] Acute diverticulitis is one of the commonest causes of acute surgical admission. It affects up to 25% of patients with diverticulosis. The annual costs of diverticular disease have been estimated at around US$2.7 billion per year, with around 152,000 yearly hospitalizations.[3,4]

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The management of acute diverticulitis has evolved over the past 2 decades. There is greater use of computed tomography (CT) to confirm the diagnosis and a trend to conservative management instead of resection.[5,6] Current internationally accepted guidelines and professional bodies recommend routine colonic evaluation after an episode of acute diverticulitis to confirm the diagnosis and exclude malignancy.[7,8] However, this practice dates back to the time before widespread use of cross-sectional imaging to diagnose acute diverticulitis. This may be a reflection of limitations in diagnosis and diagnostic methods previously used, rather than a true indication of risk of malignancy.

Improvement in the accessibility of CT has led to its routine use in the diagnosis of diverticulitis and its complications. Technological improvement in quality and resolution of CT has led to better evaluation of the colon in the affected segment and accurate staging of complications of diverticulitis.[9] Because of this, the role of routine colonic evaluation after acute diverticulitis has been questioned.

Routine colonoscopy after acute diverticulitis places a significant resource burden on already-stretched health care systems.[10] There is also a small, but real risk of morbidity and mortality associated with invasive procedures. In addition, endoscopy may be technically more difficult in these patients due to bowel spasm, luminal narrowing, and fixation of the colon due to inflammation and pericolic fibrosis.

To our knowledge, there are no prospective, randomized trials demonstrating a benefit of routine colonic evaluation after acute diverticulitis. Current recommendations are based largely on small- to medium-sized cohort studies performed before the widespread use of CT.

The objective of this study was to perform a systematic review and meta-analysis of published studies of colonic evaluation after an episode of diverticulitis to determine the yield of colorectal cancer and nonmalignant colorectal polyps.

METHODS

The meta-analysis was performed in concordance with the PRISMA Statement for preferred reporting of systematic reviews and meta-analyses.[11]

Data Source and Search Strategy

A search of online databases, including PubMed (MEDLINE), EMBASE, BIREME, CINAHL, and the Cochrane Library, was performed. All published articles and abstracts were included. The following search terms were used: diverticulitis, colonoscopy, acute diverticulitis, colon cancer, endoscopy, colonography, colonic evaluation, cancer risk after diverticulitis. There was no predetermined study design type, language limit, or publication year.

Study Inclusion Criteria

Studies were eligible if patients received direct colonic evaluation associated with an episode of acute diverticulitis. Studies

were included if diverticulitis was diagnosed with radiological confirmation. We included patients who received flexible sigmoidoscopy alone, computed tomographic colonography (CTC) alone, incomplete colonoscopy, or contrast enema studies. All potentially relevant studies were then screened by 2 researchers (consultant colorectal surgeon and surgical fellow). The full texts of relevant articles were obtained. A further evaluation was performed of the bibliographies of the articles to identify further potentially relevant studies not identified in the initial search. Data from the included studies were then extracted, tabulated, and analyzed.

Study Exclusion Criteria

Studies were excluded where the diagnosis of diverticulitis was made solely on clinical grounds. Studies or data from studies were excluded if there was no direct colonic evaluation. This included follow-up of patients via cancer registry alone. Studies where the primary method of evaluation of the affected segment was from histopathology after surgery were excluded. Studies on emergency surgery in diverticulitis without prior colonic evaluation were also excluded.

Study Selection

The flowchart in Figure 1 demonstrates the method of literature review. Of a total of 691 articles identified, 11 were included for meta-analysis. There was complete agreement between the authors as to the inclusion of studies.

Data Synthesis and Analysis

Data were extracted from included studies and tabulated. The data were then analyzed using MetaAnalyst Beta 3.13 Software[12] (Tufts Medical Center).

The primary outcome of the systematic review was the yield of colorectal cancer in all patients who underwent routine colonic evaluation after an episode of acute diverticulitis. A DerSimonian Laird random effect proportion analysis of these data was undertaken using MetaAnalyst 3.13 software.

The included studies were then further analyzed for reporting of uncomplicated and complicated diverticulitis. Uncomplicated diverticulitis was defined as the presence of colonic diverticular disease with localized wall thickening and/or stranding of pericolic fat on CT scan. Complicated diverticulitis was defined as the presence of abscess, perforation (including any pericolic or extraluminal gas), obstruction or fistula formation, protracted disease with symptoms, or an associated mass lesion. Crude and pooled malignancy proportions were then calculated.

All included studies were then analyzed for reporting of non-malignant colorectal polyps and crude and pooled proportion analysis was also performed on these data.

Assessment of Heterogeneity

Heterogeneity in the included studies was assessed using Cochran's Q test. The Q test was also performed on all subgroup analyses.

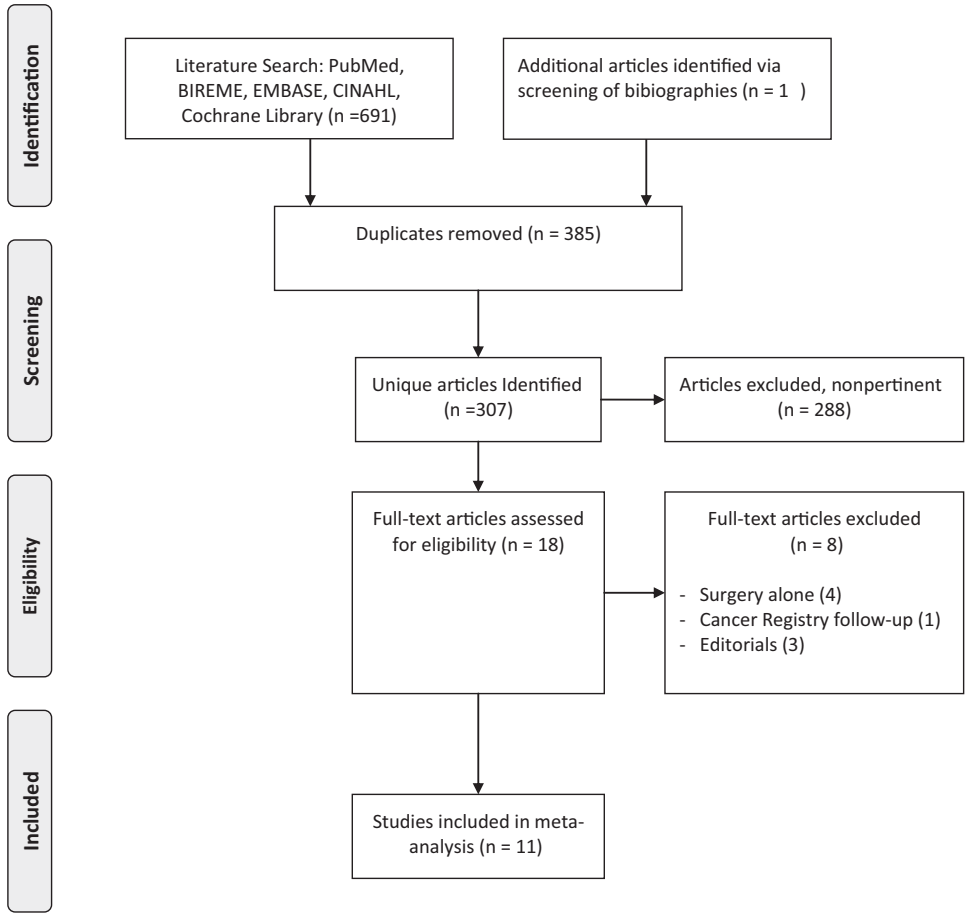

FIGURE 1. PRISMA 2009 flow diagram of study selection process.

RESULTS

Characteristics of Studies

The baseline characteristics of the included studies are summarized in Table 1. Of the included studies, 4 were performed in Israel, 2 in Sweden, 1 each in Australia, New Zealand, France, the United States, and The Netherlands. Ten articles were published in full, whereas 1 article was published only as an abstract.

All studies had CT as the primary method of diagnosis of acute diverticulitis. One study used ultrasound scan (USS) and CT in all patients, whereas another used USS or CT. Three studies looked at the role of early or inpatient colonoscopy in acute diverticulitis. One study looked at the role of colonoscopy in protracted symptoms of diverticulitis. One study looked at the role of antibiotics in acute diverticulitis, 1 compared CTC with colonoscopy, and 1 study compared USS with CT.

The nature of diverticular disease, methods, and time of colonic evaluation reported in the included studies are summarized in Table 2. There was significant heterogeneity in the design and the primary outcomes of these studies.

Of a total population of 3358, 1970 patients underwent colonic evaluation. Colonoscopy was the commonest method of colonic evaluation in almost all studies, followed by CTC. Two studies used either CTC or colonoscopy, 1 study used CTC concurrently with colonoscopy. Only 1 study by Pradel et al[13] had a significant proportion of patients with surgery. In this study, patients presenting acutely with abdominal pain were assessed with CT and ultrasound and followed up for a final diagnosis. From this study, only patients with a final diagnosis of acute diverticulitis who subsequently underwent colonic evaluation were included. Patients who had emergency surgery at index admission, surgery without colonic evaluation, and a final diagnosis other than acute diverticulitis were not included in the final analysis.

Out of the total population pool of 3358 patients with acute diverticulitis, 1388 patients were excluded from the final analysis. The commonest reason for exclusion was lack of direct colonic evaluation. Where stated, the reported reasons for not performing a colonic evaluation included lack of radiological evidence of diverticulitis, refusal of consent for procedure, severe medical comorbidities precluding a safe procedure, and proceeding to surgical resection without prior colonic evaluation. Three studies primarily considered the role of early colonoscopy in diverticulitis and excluded patients with evidence of perforation on initial CT. Although 769 of the 1388 patients who did not receive colonic evaluation were followed up using regional cancer registries alone, they were still excluded from the final analysis.

The timing of colonic evaluation after an episode of acute diverticulitis is also shown in Table 2. Two studies performed colonoscopy at index admission. Most studies performed colonic evaluation within 6 to 8 weeks after the index attack. One study performed it within 3 months, 1 within 1 year and 1 within 2 years. The approach of different studies to prior evaluation of the colon was also heterogeneous. Out of the 11 included studies, 4 excluded patients who had received colonic evaluation up to 1 year before index admission.[14–17] Four studies did not report if colonic evaluation had been performed before that related to the index attack.[13,18–20] Schmilovitz-Weiss et al[21] reported that 11% of patients had received a colonoscopy before the index admission for diverticulitis, but did not report the timing of this. One study specified colonic evaluation was performed if this had not been carried out within 1 year before admission.[20] Finally, one study considered colonic evaluation only within the study period of 4 years.[22]

TABLE 1. Baseline Characteristics of Studies Included in Systematic Review

Study	Year	Country	Design	Total Patients	Patients With Colonic Evaluation	Comments
Pradel et al[13]	1997	France	Prospective cohort	64	26	Only patients with diverticulitis and colonic evaluation included
Sakhnini et al[14]	2004	Israel	Prospective longitudinal	122	93	Early colonoscopy in diverticulitis.
Hjern et al[15]	2007	Sweden	Prospective cohort	50	50	Compared computed tomographic colonography to colonoscopy
Lahat et al[16]	2007	Israel	Prospective longitudinal	154	73	Early colonoscopy in diverticulitis
Lahat et al[17]	2008	Israel	Prospective longitudinal	306	224	Early colonoscopy in patients with protracted symptoms and acute diverticulitis
Elramah et al[18]	2010	USA	Retrospective longitudinal	188	130	
Lau et al[19]	2011	Australia	Retrospective cohort	1088	319	769 followed up by Cancer Registry alone
Westwood et al[20]	2011	New Zealand	Retrospective longitudinal	292	205	
Chabok et al[21]	2012	Sweden	Multicenter randomized	582	545	Primarily looked at role of antibiotics in acute uncomplicated diverticulitis
Schmilovitz-Weiss et al[22]	2012	Israel	Retrospective cohort	220	100	Compared colonoscopy vs no colonoscopy after acute diverticulitis
Van der Wall et al[23]	2012	The Netherlands	Retrospective cross sectional	307	205	
Total				3358	1970	

Of the 11 studies, 8 further divided patients into uncomplicated or complicated diverticulitis groups. Three studies were in patients with only uncomplicated diverticulitis. Only 1 study was targeted primarily at patients with complicated disease. This was performed on patients with protracted symptoms despite adequate treatment.

Findings of Malignancy and Nonmalignant Colorectal Polyps

All of the 11 included studies reported the number of malignancies found. Table 3 summarizes the overall finding of malignancies in the included studies, and the reported numbers of patients with uncomplicated and complicated disease.

Out of a pooled population of 1970 patients, a colorectal malignancy was found in 22. The crude proportion of encountering a malignancy was 1.12%. DerSimonian Laird proportional analysis showed a pooled proportion of 1.6% (95% confidence interval [CI], 0.9%-2.8%). There was no significant heterogeneity, the Q value was 0.938 ($P = 0.117$). Figure 2 illustrates the Forrest plot of the estimated proportion of malignancy after an episode of acute diverticulitis.

Seven studies reported findings of nonmalignant colorectal polyps. In 2 studies, the polyps were further stratified to include advanced adenoma. Advanced adenomas were defined as an adenoma of 10 mm or greater in diameter, or with high-grade dysplasia, or with greater than 25% villous components. Table 4 summarizes the findings of nonmalignant colorectal polyps in these studies. Nonmalignant colorectal polyps were found in 220 patients out of a pooled population of 1125 patients. The crude proportion of finding a nonmalignant polyp was 19.5%. The estimated pooled proportion of finding a nonmalignant polyp was 16.5% (95% CI, 11.2%-23.8%). There was significant heterogeneity, and the Q value was 0.977 ($P \leq 0.001$). Figure 3 shows the Forrest plot of the estimated proportion of nonmalignant colorectal polyps per patient after an episode of acute diverticulitis. As only 2 studies reported advanced adenomas within this subset of colonic polyps, proportional analysis of this subset was not performed.

Uncomplicated Diverticulitis

Of the 11 included studies, 3 did not classify patients into uncomplicated or complicated diverticulitis. Five studies reported

TABLE 2. Nature of Disease, Methods, and Time of Colonic Evaluation

Study	Diagnosis	Nature of Disease	Colonic Evaluation	Timing
Pradel et al[13]	CT and USS	All acute diverticulitis	Colonoscopy, contrast enema and surgery	Within 120 d
Sakhnini et al[14]	CT	Uncomplicated and complicated diverticulitis	Colonoscopy	At index admission
Hjern et al[15]	CT	All acute diverticulitis	Colonoscopy and CT colonography	Within 4 wks
Lahat et al[16]	CT	Uncomplicated diverticulitis	Colonoscopy	Early (within 6 wks) or late (within 1 y)
Lahat et al[17]	CT	Complicated (symptoms failing to resolve after 1 wk of conventional treatment)	Colonoscopy	At index admission
Elramah et al[18]	CT	All acute diverticulitis	Colonoscopy	Within 6 mos
Lau et al[19]	CT	All left-sided diverticulitis	Colonoscopy	Within 1 y
Westwood et al[20]	CT	Uncomplicated diverticulitis	Colonoscopy	Within 2 y
Chabok et al[21]	CT	Uncomplicated diverticulitis	Colonoscopy, barium enema, or CT colonography	Within 8 wks of discharge
Schmilovitz-Weiss et al[22]	CT	All acute diverticulitis, excluding haematochezia	Colonoscopy	Within 6 wks
Van der Wall et al[23]	CT, USS, or both	All acute diverticulitis	Colonoscopy	Within 6 wks

CT indicates computed tomography; USS, ultrasound scan.

TABLE 3. Nature of Diverticulitis and Crude Proportion of Malignancy in Included Studies

Study	Included Patients	Mean/Median Age	Patients With Uncomplicated Diverticulitis	Patients With Complicated Diverticulitis	Patients With Malignancy	% (Crude)
Pradel et al[13]	26	64	NA	NA	2	7.8
Sakhnini et al[14]	93	63	87	6	2	2.1
Hjern et al[15]	50	56	NA	NA	0	0.0
Lahat et al[16]	73	60.3	73	0	0	0.0
Lahat et al[17]	224	NA	201	23	3	1.3
Elramah et al[18]	130	63.7	115	15	3	2.3
Lau et al[19]	319	59.8	NA	NA	9	2.8
Westwood et al[20]	205	60 (M); 63 (F)	205	0	1	0.5
Chabok et al[21]	545	57.1	545	0	0	0.0
Schmilovitz-Weiss et al[22]	100	61.8	86	14	0	0.0
Van der Wall et al[23]	205	57.3	185	21	2	1.9
Total	1970		1497	79	22	1.2

NA indicates not available.

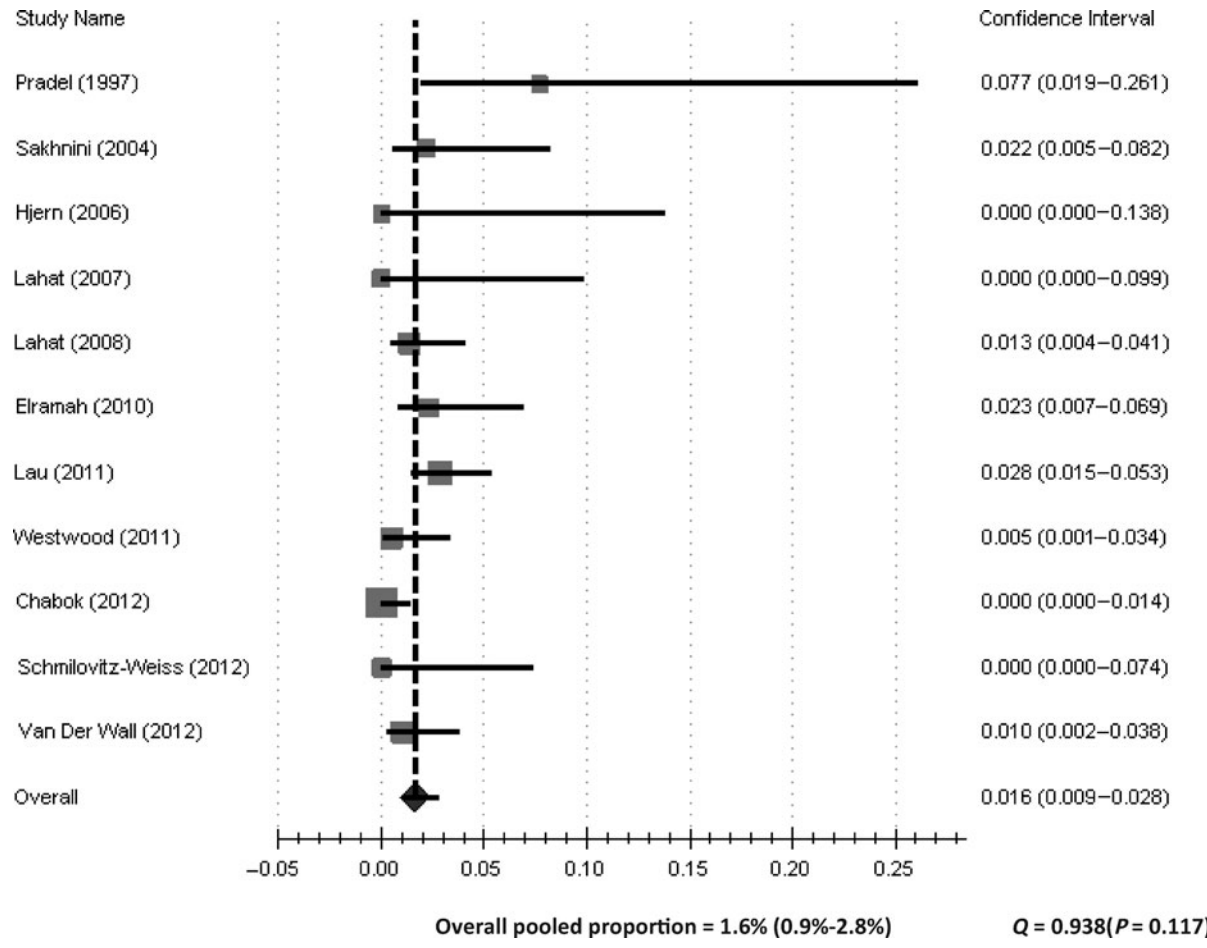

FIGURE 2. Pooled estimate of proportion of colorectal cancer at colonic evaluation after acute diverticulitis

TABLE 4. Finding of Nonmalignant Colorectal Polyps in Reporting Studies

Study	Included Patients	Patients With Nonmalignant Polyps (% Crude)	Reported Histology of Polyps Found
Sakhnini et al[14]	93	9 (9.6%)	11 polyps in 9 patients, 9 Adenoma, 1 TVA, 1 TVA with cancer
Lahat et al[15]	73	5 (6.8%)	8 polyps in 5 patients, 2 VA, 5 TA, 1 TVA
Elramah et al[16]	130	2 (1.5%)	TA in 2 patients.
Lau et al[17]	319	82 (27.5%)	TA/VA in 42%, HP 40%
Westwood et al[18]	205	50 (24.4%)	HP in 20 patients, Adenoma in 19 patients, Advanced adenoma in 10 patients
Schmilovitz-Weiss et al[19]	100	32 (32%)	42 polyps, 5 HP, 36 adenoma, 1 advanced adenoma
Van der Wall et al[20]	205	40 (19.5%)	HP in 15 patients, Adenoma in 18 patients, Advanced adenoma in 7 patients.
Total	1125	220 (19.5%)	

HP indicates hyperplastic polyp; TA, tubular adenoma; VA, villous adenoma; TVA, tubulovillous adenoma.

patients with uncomplicated and complicated diverticulitis. Three studies were performed solely on patients with uncomplicated diverticulitis. Table 5 summarizes the findings of studies reporting uncomplicated diverticulitis. In these 8 studies, a pooled population of 1497 patients had uncomplicated diverticulitis, representing 76% of the total population in all included studies. Within the 8 studies in this subgroup, unless performed solely on patients with uncomplicated diverticulitis, uncomplicated disease accounted for more than 95% of patients.

A colorectal malignancy was found in 5 patients. The crude proportion of the finding of a malignancy after an episode of acute diverticulitis was 0.3%. The pooled proportional rate of a colorectal malignancy in patients with uncomplicated diverticulitis was 0.7% (95% CI, 0.3%-1.4%). There was no significant heterogeneity. The Q value was 0.774 ($P \leq 0.458$). Figure 4 illustrates the Forrest plot of estimated effect.

Of these 8 studies, 6 reported findings of nonmalignant colorectal polyps. Of 1497 patients, 138 were reported to have

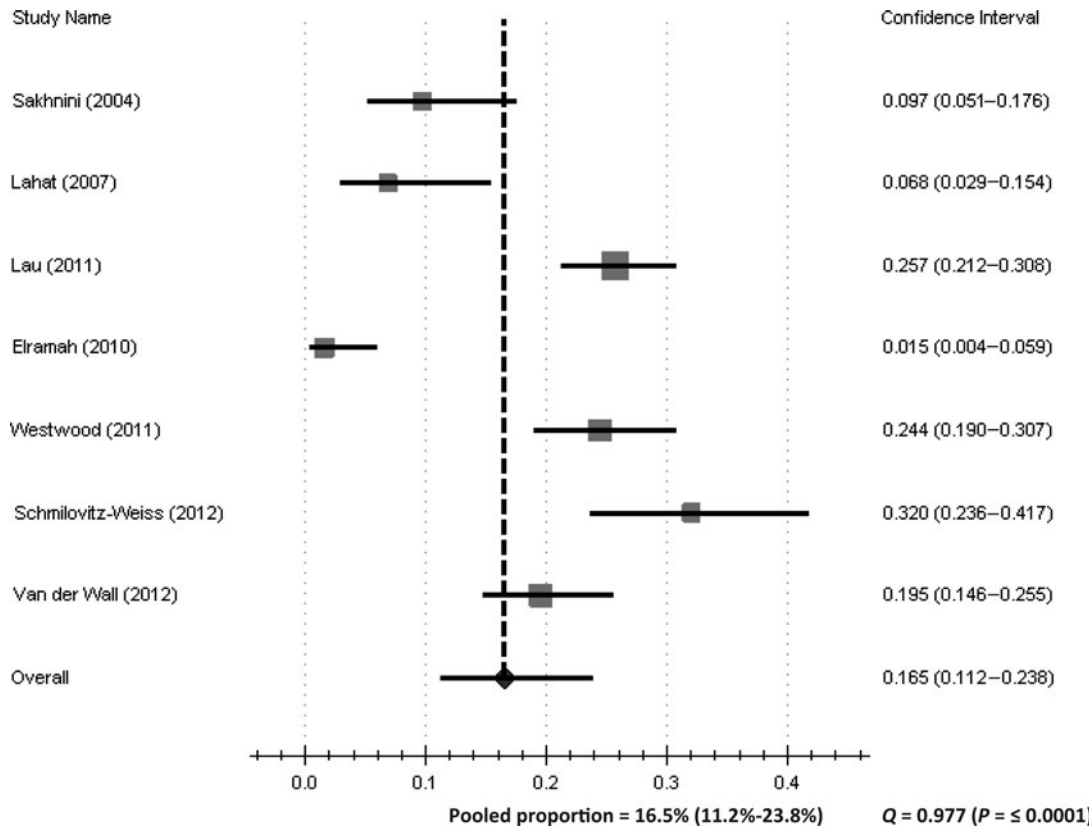

FIGURE 3. Pooled estimate of proportion of nonmalignant colorectal polyps at colonic evaluation after acute diverticulitis.

TABLE 5. Summary of Findings in Studies Reporting Patients With Uncomplicated Diverticulitis

Study	Total Patients	Patients with Uncomplicated Disease	Patients With Malignancy	% (Crude)	Patients With Nonmalignant Colorectal Polyps	% (Crude)
Sakhnini et al[14]	93	87	1	1.1	9	10.3
Lahat et al[15]	73	73	0	0	5	6.8
Lahat et al[16]	224	201	0	0	NA	NA
Elramah et al[17]	130	115	1	0.9	2	1.7
Westwood et al[18]	205	205	1	0.5	50	24.4%
Chabok et al[19]	545	545	0	0	NA	NA
Schmilovitz-Weiss et al[20]	100	86	0	0	32	32
Van der Wall et al[21]	205	185	2	1.1	40	21.6
Total	1575	1497	5	0.3	138	9.2

NA indicates not available.

nonmalignant polyps. This, however, represents polyps in the total pool of patients rather than polyps in patients with uncomplicated disease alone. Unless the study was performed solely on uncomplicated diverticulitis, no study specifically reported polyps in uncomplicated disease alone. As the proportion of patients with uncomplicated diverticulitis within these studies was more than 95%, a reasonably accurate estimate can be obtained from the data. The crude proportion of nonmalignant colorectal polyps at subsequent colonic evaluation was 9.2%. The pooled proportional estimate was 15.1% (95% CI, 8.7%-24.9%). There was significant heterogeneity, and the Q value was 0.977 ($P \leq 0.001$). Figure 5 shows Forrest Plot of estimated effect. No study specifically reported the age of patients with nonmalignant colorectal polyps.

Complicated Diverticulitis

Of the 8 studies reporting the nature of disease, 5 had patients with complicated disease. Table 6 summarizes the findings of studies included in this group. In total, there were 79 patients with complicated diverticulitis, representing less than 5% of the total pool of all included patients.

Six colorectal malignancies were reported in these patients. The crude rate of finding a malignancy was 7.6%. The proportional

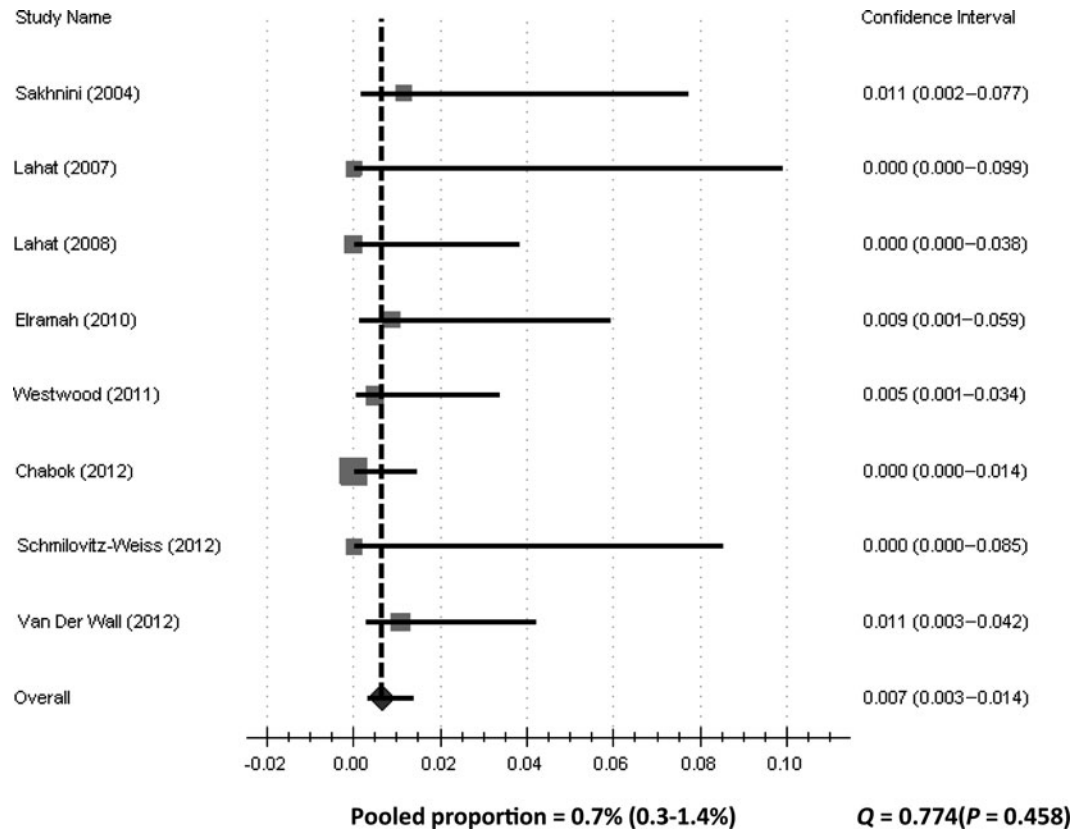

FIGURE 4. Estimated proportion of colorectal malignancy after an episode of uncomplicated colonic diverticulitis.

pooled rate of finding a malignancy in this patient population was 10.8% (95% CI, 5.2%-21%). Heterogeneity was not statistically significant with a Q value of 0.716 ($P = 0.391$). As the number of patients was low and no study reported the specific rate of finding polyps in patients with complicated disease, subgroup analysis for this was not performed. Figure 6 shows the Forrest plot of estimated effect among patients.

DISCUSSION

Routine colonic evaluation after an episode of diverticulitis has been standard practice for the past few decades, as reflected by recommendations of professional bodies and accepted international guidelines[7,8,23]; however, there is a paucity of literature supporting this practice.

Before the widespread use of cross-sectional imaging, acute diverticulitis was diagnosed on the basis of clinical findings and contrast enema studies. The accuracy of the clinical diagnosis of acute diverticulitis is low, with up to 37% of diagnoses changed with cross-sectional imaging.[24] Although contrast enema has a high sensitivity and specificity for diverticulosis, accurate recognition of an associated neoplasm within a colon with diverticulitis can only be made about 50% of the time.[25] Contrast enema is also dependent on operator experience and the quality of the images obtained. The origin of the practice of routine colonic evaluation stems from these initial difficulties in differentiating acute diverticulitis from colorectal cancer.

Computed tomographic scan has revolutionized the diagnosis and management of diverticular disease. Computed tomography has a sensitivity and specificity approaching 99% for the diagnosis of diverticulitis and its complications.[26] Computed tomographic guidance allows for percutaneous drainage of diverticular abscesses. Most tertiary institutions now use multidetector CT scans, capable of producing high-resolution images with thinner slices than previously available. Improvements in technology has allowed for high-resolution reconstruction of images in coronal and sagittal sections, leading to better evaluation of the target area.[9] These improvements in diagnostic accuracy have raised the question of the necessity of routine colonic evaluation after an episode of diverticulitis.

In this systematic review and meta-analysis, the risk of encountering a malignancy with routine colonic evaluation after an episode of acute diverticulitis in all patients was 1.6% (0.9%-2.8%). On stratifying for disease severity, those with *complicated* diverticulitis diagnosed by imaging still had a high yield of malignancy at subsequent colonoscopy (10.8%); however, in those with CT diagnosed *uncomplicated* diverticulitis, the yield was low (0.7%).

A recent meta-analysis by Niv et al[27] of colorectal cancer screening with colonoscopy in an asymptomatic population showed an invasive cancer rate of 0.78% (95% CI, 0.13%-2.97%) in a pooled population of 68,324 patients. Comparing these data with the present study suggests that the risk of colorectal malignancy after an episode of radiologically proven acute uncomplicated diverticulitis is not significantly different from that of the general asymptomatic population. This suggests that a selective approach to colonoscopy after CT-proven diverticulitis may be an acceptable practice.

The yield of nonmalignant colorectal polyps of 19.5% (11.2%-23.8%) in this study was also similar to that documented by Niv et al.[27] In that analysis of screened asymptomatic individuals at least

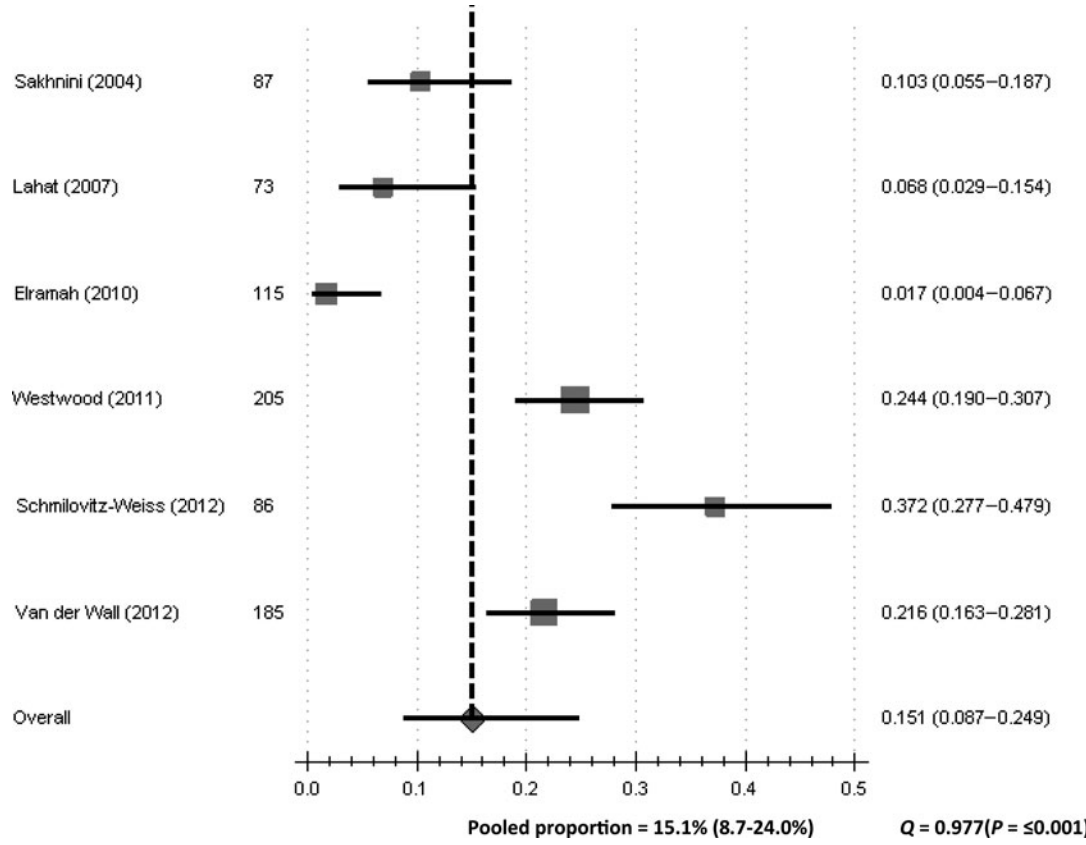

FIGURE 5. Estimated proportion of nonmalignant colorectal polyps in patients with uncomplicated diverticulitis.

TABLE 6. Summary of Studies Reporting Complicated Disease

Study	Included Patients	Patients With Complicated Disease	Malignancy	% (Crude)
Sakhnini et al[14]	93	6	1	16.7
Lahat et al[15]	224	23	3	13.1
Elramah et al[16]	130	15	2	13.3
Schmilovitz-Weiss et al[17]	100	14	0	0
Van der Wall et al[18]	205	21	0	0
Total	752	79	6	7.6

one adenoma was found in 19% of patients (15%-23%).[27] This finding has to be interpreted with caution; however, as there was significant heterogeneity evident in the present meta-analysis when polyps were considered. Of the included studies, only 2 specifically reported findings of advanced adenoma within the subgroup of colorectal polyps. The most widely accepted definition of advanced adenoma includes adenomas of greater than 10-mm diameter, or with high-grade dysplasia, or with more than 25% villous architecture. In the present review, van de Wall et al[22] and Westwood et al[28] reported advanced adenoma in 3.4% and 5.4% of patients, respectively. These findings are once again comparable with Niv et al's aforementioned large study of asymptomatic screened individuals where advanced adenoma was found in 5% of cases.

It has been well documented that the risk of colorectal neoplasia increases with age and, therefore, age may be expected to influence the yield of colonoscopy after an episode of acute diverticulitis. Unfortunately, the vast majority of studies in the present meta-analysis did not specify the ages of the patients with colorectal neoplasia separately. The only included study that addressed age did not find a statistically significant difference in the rate of advanced colorectal neoplasia in patients younger than 50 years and those older than 50 years.[28] The median ages of the included study populations ranged from 57 to 64 years. This was once again similar to the age range in the screening population used here for comparison and reinforces the fact that the yield of malignancy at colonoscopy after CT-proven diverticulitis is likely to be similar to that population.

There is no internationally agreed acceptable yield of colonoscopy and this figure will depend on the population investigated. As with any invasive procedure, the indications depend on the potential risks and benefits to the individual patient, in addition to the resources available to the community. All invasive procedures carry a small but real risk of morbidity and mortality. Colonoscopy has an overall perforation rate of 0.1% to 0.2% and CTC has an overall complication rate of 0.02%.[29] There are significant regional variations and local patterns in colorectal cancer, and the provision of colonoscopy has to take this into account. Many countries report a

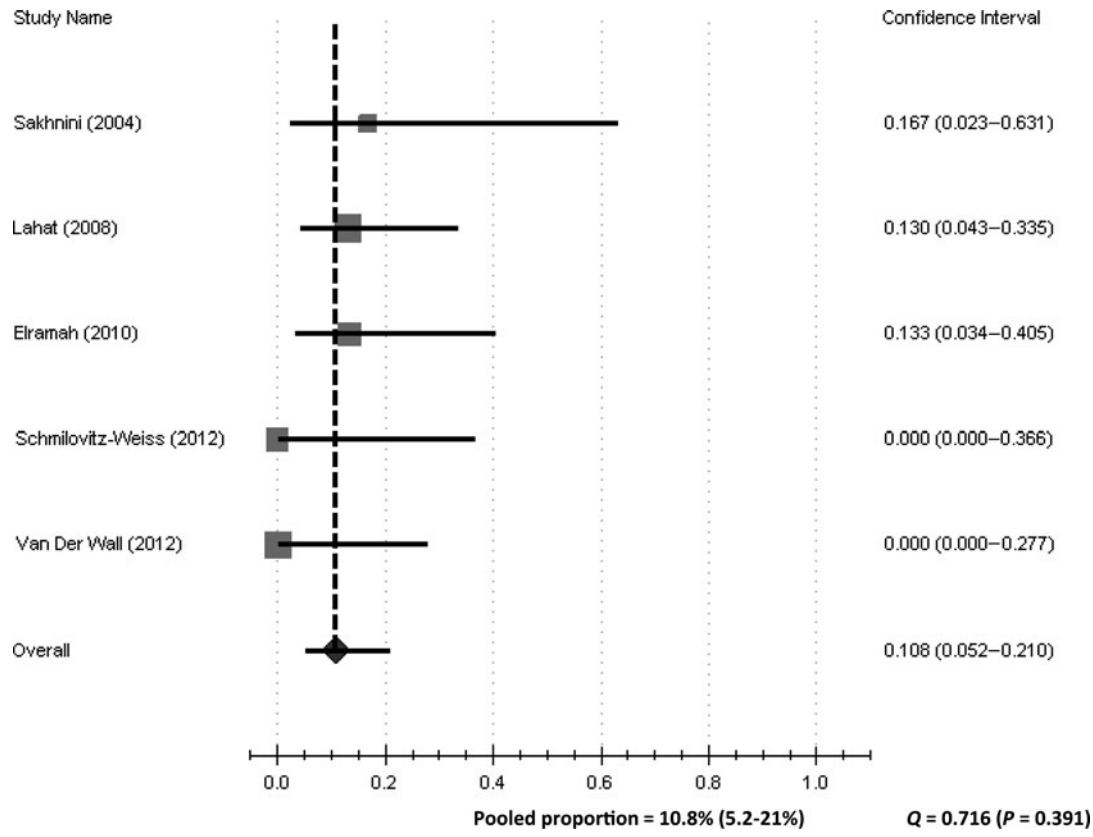

FIGURE 6. Pooled estimate of proportion of malignancy after an episode of complicated diverticulitis.

gap between the provision of and demand for colonoscopy.[10,30] The fact that colorectal cancer outcomes are improved with early diagnosis and treatment increases the importance of targeting the available colonoscopy resources to those at greatest risk.

Many countries now offer national CRC screening programs, and fecal occult blood tests, flexible sigmoidoscopy, and colonoscopy have all been demonstrated to be effective strategies. Nontargeted CT without colonography has a sensitivity of 72% in the detection of CRC.[31] Nontargeted CT performed for diverticulitis should not be used as a substitute for CRC screening. If sufficient resource is available, colonoscopy after CT-proven diverticulitis may present an opportunity to offer *de facto* screening; however, in the setting of an effective screening program, it is likely redundant. Given the rising prevalence of diverticular disease and the ageing population, a strategy of routine colonoscopy after CT-proven uncomplicated diverticulitis may limit the timely provision of colonoscopy to those at greater risk of colorectal carcinoma.

There are a number of limitations in this meta-analysis that deserve further consideration. Any systematic review and meta-analysis are limited by the quality of the studies included and the data from these studies. There was significant variability in design and methodology in the individual studies. The patient populations studied were also heterogeneous, ranging from acute admissions with uncomplicated diverticulitis to patients with persisting symptoms despite adequate treatment. Of the 11 included studies, 5 were retrospective. The study populations in many reports were small with only 1 study containing more than 500 patients, and this accounted for approximately 25% of the total pooled population. Despite these differences in the population, design, methodology, and primary outcomes among studies, there was no significant heterogeneity in the pooled estimate of malignancy from the meta-analysis. In addition, no significant heterogeneity existed for the pooled estimates related to the uncomplicated and complicated diverticulitis subgroups, suggesting that the studies produced consistent estimates of the risk of malignancy.

Of the 3358 patients in the 11 studies, 1388 patients were excluded from this analysis as they did not undergo colonic evaluation. Patients who went to surgery directly were excluded as the affected segment was removed; hence, it was neither available for colonic evaluation nor at risk of a missed cancer. Some 769 of the patients who did not receive colonic evaluation were followed up using cancer registry data. Although this was not included in the meta-analysis, the cancer registry data did not suggest a high risk of CRC in these patients. In fact, when Westwood et al[28] included accurate national cancer registry follow-up with the group that underwent colonic evaluation, the rate of malignancy after acute diverticulitis dropped from 0.5% to 0.3%.

The timing and method of colonic evaluation were also variable. Colonic evaluation was performed at differing time points ranging from the initial inpatient admission with acute diverticulitis to within 2 years of the episode. Colonoscopy was the most popular method of evaluation followed by CTC. Although CTC has a similar sensitivity to colonoscopy for colorectal cancer,[32] contrast enemas have a lower accuracy.[33] The heterogeneity described limits the conclusions that can be drawn from these data and a well-designed, prospective, multicenter study investigating the incidence of malignancy after CT confirmed diverticulitis could provide more conclusive evidence in the future.

In using a selective approach for colonoscopy after acute uncomplicated diverticulitis, there are several other factors that need to be considered. The reporting of the initial diagnostic CT is operator dependent and accuracy will vary among institutions and with the experience of radiologists. There are significant regional variations in the incidence of CRC, and local institutions need to consider these. At the individual patient level, clinical history, family history, and examination findings must all be considered in the decision whether or not to perform colonoscopy. Clinical features may exist that mandate colonoscopy, irrespective of the CT findings. Most acute uncomplicated diverticulitis responds rapidly to treatment. Persistence of symptoms after optimal treatment should be an indication for further investigation. This meta-analysis focused on CRC; however, other pathology, such as inflammatory bowel disease, may require exclusion depending on the clinical circumstances. It is noteworthy that the only studies considering alternative colorectal pathology also showed a very low rate of diagnosis of inflammatory bowel disease after CT diagnosed diverticulitis.[20,29]

Despite the aforementioned limitations, the available data presented in this meta-analysis suggest the yield of malignancy at colonoscopy after CT-proven acute *uncomplicated* diverticulitis is low. These data support a selective approach to colonoscopy after an episode of CT-proven diverticulitis. Patients with *uncomplicated* diverticulitis have a low risk of malignancy and can be prioritized similarly to the asymptomatic population. Patients with *complicated* diverticulitis represent a much higher-risk group and should undergo routine colonic evaluation. However, in view of the overall paucity of high-quality data, further large-scale studies are needed before practice recommendations can be made.

REFERENCES

1. Weizman AV, Nguyen GC. Diverticular disease: epidemiology and management. *Can J Gastroenterol*. 2011;25:385–389.
2. Floch MH, White JA. Management of diverticular disease is changing. *World J Gastroenterol*. 2006;12:3225–3228.
3. Sandler RS, Everhart JE, Donowitz M, et al. The burden of selected digestive diseases in the United States. *Gastroenterology*. 2002;122:1500–1511.
4. Warner E, Crighton EJ, Moineddin R, et al. Fourteen-year study of hospital admissions for diverticular disease in Ontario. *Can J Gastroenterol*. 2007;21: 97–99.
5. Peppas G, Bliziotis IA, Oikonomaki D, et al. Outcomes after medical and surgical treatment of diverticulitis: a systematic review of the available evidence. *J Gastroenterol Hepatol*. 2007;22:1360–1368.
6. Janes S, Meagher A, Frizelle FA. Elective surgery after acute diverticulitis. *Br J Surg*. 2005;92:133–142.
7. Rafferty J, Shellito P, Hyman NH, et al. Practice parameters for sigmoid diverticulitis. *Dis Colon Rectum*. 2006;49:939–944.
8. Andersen JC, Bundgaard L, Elbrond H, et al. Danish national guidelines for treatment of diverticular disease. *Dan Med J*. 2012;59:C4453.
9. Destigter KK, Keating DP. Imaging update: acute colonic diverticulitis. *Clin Colon Rectal Surg*. 2009;22:147–155.
10. Bowles CJ, Leicester R, Romaya C, et al. A prospective study of colonoscopy practice in the UK today: are we adequately prepared for national colorectal cancer screening tomorrow? *Gut*. 2004;53:277–283.
11. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Int Med*. 2009;151:264–269.
12. Wallace BC, Schmid CH, Lau J, et al. Meta-Analyst: software for meta-analysis of binary, continuous and diagnostic data. *BMC Med Res Methodol*. 2009;9:80.
13. Pradel JA, Adell JF, Taourel P, et al. Acute colonic diverticulitis: prospective comparative evaluation with US and CT. *Radiology*. 1997;205:503–512.
14. Lahat A, Yanai H, Menachem Y, et al. The feasibility and risk of early colonoscopy in acute diverticulitis: a prospective controlled study. *Endoscopy*. 2007;39:521–524.
15. Lahat A, Yanai H, Sakhnini E, et al. Role of colonoscopy in patients with persistent acute diverticulitis. *World J Gastroenterol*. 2008;14:2763–2766.
16. Lau KC, Spilsbury K, Farooque Y, et al. Is colonoscopy still mandatory after a CT diagnosis of left-sided diverticulitis: can colorectal cancer be confidently excluded? *Dis Colon Rectum*. 2011;54:1265–1270.
17. Sakhnini E, Lahat A, Melzer E, et al. Early colonoscopy in patients with acute diverticulitis: results of a prospective pilot study. *Endoscopy*. 2004;36:504–507.
18. Elramah MM, Horwitz JP, Einstein MM, et al. S1538: colonoscopic evaluation after acute diverticulitis: is there an association with colonic malignancy? *Gastrointest Endosc*. 2010;71:AB188.
19. Hjern F, Jonas E, Holmstrom B, et al. CT colonography versus colonoscopy in the follow-up of patients after diverticulitis—a prospective, comparative study. *Clin Radiol*. 2007;62:645–650.
20. Chabok A, Pahlman L, Hjern F, et al. Randomized clinical trial of antibiotics in acute uncomplicated diverticulitis. *Br J Surg*. 2012;99:532–539.
21. Schmilovitz-Weiss H, Yalunin E, Boaz M, et al. Does a colonoscopy after acute diverticulitis affect its management?: a single center experience. *J Clin Gastroenterol*. 2012;46:317–320.
22. van de Wall BJ, Reuling EM, Consten EC, et al. Endoscopic evaluation of the colon after an episode of diverticulitis: a call for a more selective approach. *Int J Colorectal Dis*. 2012;27:1145–1150.
23. Ferzoco LB, Raptopoulos V, Silen W. Acute diverticulitis. *N Engl J Med*. 1998;338:1521–1526.
24. Toorenvliet BR, Bakker RF, Breslau PJ, et al. Colonic diverticulitis: a prospective analysis of diagnostic accuracy and clinical decision-making. *Colorectal Dis*. 2010;12:179–186.
25. Schnyder P, Moss AA, Thoeni RF, et al. A double-blind study of radiologic accuracy in diverticulitis, diverticulosis, and carcinoma of the sigmoid colon. *J Clin Gastroenterol*. 1979;1:55–66.
26. Rao PM, Rhea JT, Novelline RA, et al. Helical CT with only colonic contrast material for diagnosing diverticulitis: prospective evaluation of 150 patients. *AJR Am J Roentgenol*. 1998;170:1445–1449.
27. Niv Y, Hazazi R, Levi Z, et al. Screening colonoscopy for colorectal cancer in asymptomatic people: a meta-analysis. *Dig Dis Sci*. 2008;53:3049–3054.
28. Westwood DA, Eglinton TW, Frizelle FA. Routine colonoscopy following acute uncomplicated diverticulitis. *Br J Surg*. 2011;98:1630–1634.
29. Pickhardt PJ. Incidence of colonic perforation at CT colonography: review of existing data and implications for screening of asymptomatic adults. *Radiology*. 2006;239:313–316.
30. Parry S, Richardson A, Green T, et al. Prospects for population colorectal cancer screening in New Zealand. *NZ Med J*. 2007;120:U2633.
31. Ozel B, Pickhardt PJ, Kim DH, et al. Accuracy of routine nontargeted CT without colonography technique for the detection of large colorectal polyps and cancer. *Dis Colon Rectum*. 2010;53:911–918.
32. Sabanli M, Balasingam A, Bailey W, et al. Computed tomographic colonography in the diagnosis of colorectal cancer. *Br J Surg*. 2010;97:1291–1294.
33. McDonald S, Lyall P, Israel L, et al. Why barium enemas fail to identify colorectal cancers. *ANZ J Surg*. 2001;71:631–633.

