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A prospective study assessing the efficacy of abdominal computed tomography scan without bowel preparation in diagnosing intestinal wall and luminal lesions in patients presenting to the emergency room with abdominal complaints

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Abstract

AIM: To evaluate the positive predictive value of abdominal non-prepared computed tomography (CT) for diagnosing intestinal lumen or wall lesions in patients presenting to the emergency room (ER) with abdominal complaints.

METHODS: For 1-year we prospectively evaluated all ER patients hospitalized after abdominal CT scan detected either intraluminal or intestinal wall lesions. These patients underwent colonoscopy serving as gold standard. Patients with prior abdominal pathology or CT findings of appendicitis or diverticulitis were excluded.

RESULTS: Five hundred and sixty-eight abdominopelvic CT scans were performed in the ER, 96 had positive colonic findings. Sixty-two patients were excluded, 46 because of diverticulitis or appendicitis, 16 because of prior abdominal pathology. Of the remaining 34 patients, 14 did not undergo colonoscopy during hospitalization. Twenty eligible patients were included in the study. The positive predictive value of the CT scans performed in the ER was calculated to be 45% (95% CI 25-67).

CONCLUSION: CT findings correlated with colonoscopic findings only in approximately half of the cases. Relying on non-prepared CT scan findings in planning patient management and colonoscopy may lead to unnecessary diagnostic work-ups.

Key words: Abdominal computed tomography; Intestinal lesions; Emergency room

INTRODUCTION

Abdominal computed tomography (CT) scan plays an important role in the diagnostic work-up of patients presenting to the emergency room (ER) with abdominal complaints. CT findings can include lesions in the intestinal lumen or in the intestinal wall. The presumed ability of no-bowel-preparation CT (NPCT) scan to diagnose these lesions may stem from extrapolation of data concerning computed colonography.

Computed colonography, also known as virtual colonoscopy, is a recently introduced imaging modality with improved diagnostic accuracy[1]. Contrast-enhanced CT colonography requires a bowel preparation similar to that used in colonoscopy, with laxatives, enema and bowel inflation. Abdominal NPCT does not include bowel preparation and is commonly used in ER settings for the evaluation of patients with abdominal complaints.

After receiving oral contrast medium, patients undergo a single abdominal survey with, or rarely without, intravenous contrast material. The results are interpreted by the on-call radiologist who, in our institute, is usually a resident. A previous study showed a 7.5% error rate in interpreting these scans and concluded that the primary determinant of error rates in body CT is the skill of the interpreting radiologist[2].

Patients whose scan reveals an abnormal abdominal finding are often admitted to the hospital for further diagnostic work-up. CT was shown to play an impact on further management decisions such as surgery or colonoscopy[3].

The value of CT for the diagnosis of luminal and mucosal lesions under these specific circumstances has not been fully evaluated. We hypothesized that under these conditions the CT scan may be an overly sensitive, poorly specific diagnostic procedure with a high false-positive rate (in that many patients could be found to have abnormal findings, which would later be ruled out by a consecutive colonoscopy). Up to now, only a few studies have compared CT with

colonoscopy in diagnosing bowel diseases. Moreover, the results of these studies have very little relevance to the ER setting where the scans are performed under sub-optimal conditions without colonic preparation.

The goal of the present study was to determine the positive predictive value (PPV) of abdominal NPCT scans performed in the ER for the diagnosis of colitis or tumors, by comparing it to conventional colonoscopy, which served as the gold standard.

Patients and methods

We prospectively evaluated all patients subsequently hospitalized because abdominal CT scan in the ER detected either intraluminal or intestinal wall lesions. We focused on these lesions because their discovery usually leads to a request for colonoscopy and because there is no data concerning the PPV of the exam. We did not evaluate other CT findings for which there are other diagnostic or treatment modalities and the specificity and sensitivity of CT is well known. The study took place at the Hadassah- Hebrew University Medical Center, which is a 1 000-bed tertiary referral center in Jerusalem, Israel. All abdominal CT scans performed on ER patients over a period of 1 year, from December 2002 to January 2004, were evaluated. This was done by daily scrutinizing the written results of all abdominal CT scans performed in the ER. Patients whose scans detected bowel wall thickening or luminal findings were included. Patients with a prior diagnosis of inflammatory bowel disease, abdominal malignancy, those with CT findings of appendicitis or diverticulitis, or those deemed too ill to undergo colonoscopy by their attending physician were excluded. The patients signed an informed consent form and underwent full colonoscopy. The study was approved by the institutional ethical committee. CT was performed in accordance with hospital radiology department instructions. The decision to perform the CT scan was at the ER physician's discretion. Helical CT scan (Philips MX 8000 Haifa, Israel) was performed using 5-mm sections from diaphragm to symphysis pubis (0.825 pitch) with or without intravenous contrast. Most patients received intravenous contrast material. A few with disturbed renal function or known allergy to contrast material did not. (The decision to administer intravenous contrast material was made following consultation between the ER physician and the on-call radiologist.) Oral contrast medium [15 mL Loxitalamate de méglumine 300 mg/mL (Telebrix® Promedico, Petach-Tikva, Israel) dissolved in 400 mL water] was administered twice, 2 h and 90 min before the scan. No colonic purging solution was used. Images were assessed by the on-call radiologist and revised the next day by a senior radiologist. A senior gastroenterologist performed colonoscopy as soon as possible and no longer than 1 mo following the CT. The gastroenterologist was not blinded to the CT results. Bowel preparation lasted 2 d and consisted of a low residue diet (no fruits, vegetables, wholegrain bread, nuts or seeds) followed by a day of liquid diet. In the evening before the colonoscopy, two 45-mL bottles of monobasic sodium phosphate 2.4 g and dibasic sodium phosphate 0.9 g (Soffodex® Dexxon, Hadera, Israel), each diluted in 100 mL water, were administered orally, one at 17:00 and the other 5 h later. The patient was instructed to drink 2 L of water following ingestion of each bottle. On the day of the procedure, a fleet enema was performed. Informed consent was obtained. Biopsies were taken when a pathological finding was identified.

The sample size for our study was estimated by the following power analysis. The positive predictive value of an abdominal CT scan has been shown to reach 88.1% for the detection of colorectal cancer[4], 81% for the detection of diverticulitis[5] and between 75% and 94% in the detection of acute appendicitis[6,7]. We aimed to show that a NPCT scan performed in the ER has a positive predictive value of 50% rather than 80% as suggested by the above-mentioned literature. To get power of 80% to detect such a difference at a significant level of 0.05, a sample size of 15 patients was needed, using a one-tailed test.

RESULTS

During the study period, 568 abdominal CT scans from the ER were assessed, 96 of which had some positive colonic finding. Sixty-two patients were excluded, 46 because of diverticulitis or appendicitis. Twelve had a prior diagnosis of inflammatory bowel disease and four of colon malignancy. Of the remaining 34 patients, 14 did not undergo colonoscopy during hospitalization because of refusal to sign an informed consent form or because of complete resolution of symptoms. One patient died.

Twenty eligible patients were included in the study. Mean age was 60.85 years (range 23-83 years, 12 male, 8 female). Their presenting symptoms are summarized in Table 1.

Table 1 Presenting symptoms

Symptom	Number of patients
Abdominal pain	15
Diarrhea	4
Constipation	4
Vomiting	3
Weight loss	2
Anemia	4
Change in bowel habits	1
Rectal bleeding	3

The clinical diagnoses made by the ER physicians and consultants were recorded from the CT scan order form (which requires a diagnosis to be listed prior to the performance of a CT scan) and were as follows: inflammatory bowel disease (4), colonic tumor (5), acute diverticulitis (4), acute appendicitis (4), colitis (2), bowel obstruction (2), acute cholecystitis (2), and one case each of acute pancreatitis, renal colic, pelvic inflammatory disease and gastric carcinoma (in some cases, more than one clinical diagnosis was offered). CT scans suggested the following diagnoses: colonic carcinoma (10), inflammatory bowel disease (9), colonic polyp (1).

Extra-colonic abnormalities were identified in three patients and consisted of liver masses in a patient with intramural colonic mass (1), hepatosplenomegaly (2) and ovarian cyst (1). Colonoscopy revealed the following findings: normal (7), colonic carcinoma (6), inflammatory bowel disease (2),

colonic polyp (4), angiodysplasia (1). Average time between CT scan and colonoscopy was 13 d (range 5-30 d). The histopathological results confirmed all colonoscopy diagnoses except for one case in which both the CT scan and the colonoscopy had mistaken acute or chronic colonic ischemia for a tumor. The data is presented in Table 2.

There was agreement between the diagnoses of CT and colonoscopy in nine out of 20 patients: six were diagnosed with colonic carcinoma (as mentioned before, one turned out to be ischemic colitis), two had inflammatory bowel disease and one had a colonic polyp. These CT scans were considered true-positive scans.

Disagreement between the diagnoses of the two modalities occurred in the remaining 11 patients. While CT diagnosed four cases of colonic carcinoma and seven cases of inflammatory bowel disease, the colonoscopies ruled all of them out. These scans were considered false-positive scans. In addition, colonoscopy revealed three colonic polyps and one case of angiodysplasia that were missed by the CT. The results are summarized in Table 3.

Table 2 Diagnoses made by ER physicians and CT *vs* colonoscopy findings and histology results

Patient number	ER physician's clinical diagnoses (prior to the CT scan)	CT findings and suggested diagnoses	Colonoscopy findings	Histology (when available)
1	Bowel obstruction	Ascending colon tumor	Ascending colon tumor	Well-differentiated adenocarcinoma
2	Inflammatory bowel disease	Inflammatory bowel disease of terminal ileum	Inflammation, ulceration and pseudopolyps by the ileo-cecal valve	Active chronic inflammation
3	Acute appendicitis or acute diverticulitis	Descending colon tumor	Obstructing descending colon tumor	Well-differentiated adenocarcinoma
4	Colonic tumor	Transverse colon tumor	Mid-transverse colon tumor	Moderately to poorly differentiated adenocarcinoma
5	Acute diverticulitis	Sigmoid colon wall thickening and polyp	Erythematous sigmoid colon mucosa and a sessile polyp	Hyperplastic mucosal glands
6	Acute diverticulitis	Right colon wall thickening from cecum to hepatic flexure	Right colon congested and erythematous mucosa with mucopurulent exudate	Acute inflammation with ulceration and fibrinopurulent exudates
7	Acute appendicitis	Ascending colon tumor	Ascending colon fungating tumor	Acute and chronic ischemic changes. No neoplastic process
8	Colonic tumor	Cecal tumor with liver metastasis	Cecal tumor	Moderately differentiated adenocarcinoma
9	Gastric or colonic carcinoma	Cecal tumor	Cecal tumor	Ulcerated moderately to poorly differentiated adenocarcinoma
10	Colitis	Diffuse colon wall thickening	Normal	
11	Colonic tumor	Transverse colon tumor	20-mm large base cecal polyp with villous appearance	Tubulo-villous adenoma with low-grade dysplasia
12	Colonic tumor	Sigmoid colon tumor	Normal	
13	Pelvic inflammatory disease or inflammatory bowel disease	Diffuse bowel wall thickening, suspected Crohn's disease	Normal	
14	Acute appendicitis	Cecal and ascending colon wall thickening	Normal	
15	Acute diverticulitis or renal colic	Descending colon tumor	Cecal polyp	Tubular adenoma with focal high-grade dysplasia
16	Acute appendicitis or acute cholecystitis	Cecal tumor, hepatosplenomegaly	Diffuse angiodysplasia	
17	Inflammatory bowel disease or infectious colitis	Terminal ileum wall thickening, suspected Crohn's disease	Normal	
18	Inflammatory bowel disease	Inflammatory changes in the ileo-cecal valve area	Normal	
19	Acute pancreatitis or acute cholecystitis	Terminal ileum wall thickening, hepatosplenomegaly, right ovarian cyst	Normal	
20	Bowel obstruction	Ascending to mid-transverse colon wall thickening	2-mm colonic polyp	Inflamed sessile adenomatous polyp

Table 3 True-and false-positive frequency, positive predictive value (with 95%CI), for NPCT scan, according to specific CT diagnosis

CT diagnoses	Total number	True positive	False positive	Positive predictive value (95%CI)
Colonic tumor	10	6	4	60% (29-86)
Inflammatory bowel disease	9	2	7	22% (4-56)
Colonic polyp	1	1	0	100% (5-100)
Total number	20	9	11	45% (25-67)

As we hypothesized, the PPV of the CT scans performed in the ER was low. According to our results, it was calculated to be only 45% (95%CI 25-67), significantly lower than the accepted 80% ($P<0.05$).

Fourteen patients did not undergo colonoscopy despite a positive colonic finding on the CT and were excluded from the analysis. We managed to contact seven of them by telephone at least 6 mo following their discharge in order to ascertain their outcome. Five of them underwent colonoscopy following discharge, and only one had a positive finding, a colonic tumor. Two patients did not undergo a colonoscopy and six patients were lost to follow-up. One patient died from septic shock secondary to pneumonia during her hospitalization. If data of these patients is added to the analysis, the PPV of a conventional CT finding of either an intra-luminal or intestinal wall lesion drops to 40% (Table 4).

Table 4 True-and false-positive frequency, positive predictive value for NPCT scan, including patients with delayed colonoscopy

CT diagnoses	Total number	True positive	False positive	Positive predictive value (95%CI)
Colonic tumor	11	7	4	63% (34–87)
Inflammatory bowel disease	13	2	11	15% (3–42)
Colonic polyp	1	0		100% (5–100)
Total number	25	10	15	40% (22–60)

As mentioned above, three patients had extra-colonic findings. The patient with the liver metastasis was scheduled for hepatectomy following his colon surgery. The hepatosplenomegaly turned out to be an old finding in one patient (who also had an ovarian cyst), secondary to myelodysplastic syndrome. The third patient underwent liver biopsy that revealed non-active cirrhosis.

DISCUSSION

Since it was first introduced three decades ago, CT has become an integral part of clinical practice[8]. In our ER, 568 abdominal CT scans were performed during the course of a year. CT has shown considerable diagnostic accuracy in diagnosing abdominal pathology including abdominal masses, liver metastases[9,10] and retroperitoneal lymphadenopathy[11]. Its accuracy in diagnosing colonic inflammation and intra-

luminal disease is still unknown. Recent studies suggest that it is an important tool in the evaluation of patients with suspected colonic inflammation, and in the assessment of both the intraluminal and extraluminal components of inflammatory bowel disease[12]. The location of the involved segment and the extent and appearance of wall thickening may help distinguish Crohn's disease from ulcerative colitis[13].

Other studies have shown that CT has an unacceptable sensitivity for detecting inflammation of the bowel wall[14] and its role should be limited to the assessment of mural disease, its effect on luminal diameter and the differential diagnosis of mesenteric disease[15].

Two studies evaluated the use of minimal preparation CT for investigation of suspected colon cancer in frail or elderly patients. Accuracy of CT was assessed against patient's clinical outcome. According to the first study, overall sensitivity and specificity of CT for the detection of colon cancer was 100% and 87%, respectively[16]. In the second study, positive scans were reported as showing definite (>90% certain), probable (50-90% certain) or possible (<50% certain) neoplasm. The results were analyzed twice: assuming all CT lesions test positive and considering "possible" lesions test negative (brackets). Sensitivity was 88% (75%), specificity 47% (87%), positive predictive value 18% (43%) and negative predictive value 97% (96%)[17].

To the best of our knowledge, no study has compared NPCT to colonoscopy in diagnosing bowel diseases. One prospective study compared the accuracy of abdominal CT and colonoscopy in diagnosing colonic pathology in an elderly population. CT was as accurate as colonoscopy in detecting colonic carcinoma and colitis. There was poor correlation for the diagnosis of diverticular disease between the two modalities (possibly related to under-reporting of diverticular disease at colonoscopy). Also, certain mucosal lesions such as angiodysplasia and small polyps (under 2 mm) were not detectable by CT.

CT scan has several advantages: it is non-invasive, detects extra-colonic pathology, is preferred by patients and costs less. Its disadvantages on the other hand, are the inability to diagnose or sample small mucosal lesions, false-positive findings due to poor bowel distention[18] and the association with contrast-material adverse reactions and nephropathy. Failure to adequately opacify the bowel wall may lead to scans that are difficult to interpret, or to over estimation of bowel wall thickening[19]. The finding of extra-intestinal lesions can lead to additional diagnostic or therapeutic considerations. Some of these findings are clinically important, whereas others are previously known or lead to unnecessary workup and anxiety[20]. Moderate incremental costs are incurred based on additional radiologic procedures generated during short-term follow-up (average added costs per CT examination $34.33)[21]. A recent study showed that only 56% of the extra-colonic findings on abdominal CT scan performed because of suspected colorectal carcinoma were deemed to be correct (by further investigation, autopsy and/or clinical follow-up), while the remainder 44% were incorrect, indeterminate or had no follow-up. Ten percent of the patients had extracolonic findings that could potentially have accounted for their presenting symptoms[22].

A different study, designed to evaluate the impact of

early abdominal CT scan in patients with acute abdominal pain of unknown cause on accuracy of diagnoses, found that only 51% of diagnoses made by early CT scan were correct at 6-mo follow-up. There was also no significant impact of the CT scan findings on reducing the length of hospital stay[23].

In our study we aimed to evaluate the efficacy of CT in the unique clinical setting of an ER.

Often, when the initial assessment of patients with abdominal pain or other gastrointestinal complaints does not yield a diagnosis, an abdominal CT scan is performed without prior colonic preparation. About 45 such scans are being performed in our institute per month, 10-20% of which report the finding of wall thickening (suggesting colitis), intraluminal findings (suggesting a tumor), diverticulitis or appendicitis. We chose to focus on the first two findings because we hypothesized that the CT may not be an accurate modality for these lesions under ER conditions. When compared to colonoscopy, which served as the gold standard, CT had a positive predictive value of only 45% and lower than the accepted figure of 80% for CT with contrast material under elective conditions.

Our study has several limitations. Firstly, it is small and because of its design we were unable to assess the sensitivity, specificity, negative predictive value and likelihood ratios of the procedure. However, in order to obtain the data for this particular setting, a large number of colonoscopies will have to be performed in low-risk populations. Such a study design is unlikely to be conducted in the near future. Secondly, the gastroenterologists who performed the colonoscopies were not blinded to the CT findings. Since the CT findings were the indication for colonoscopy, we considered it unethical to conceal the data from the performing gastroenterologist. However, since this potential bias could only have raised the CT true positive rate (by increasing the number of pathological colonoscopies), we feel that it does not determine the validity of the study.

Thirdly, due to various logistical reasons, colonoscopies were sometimes performed after a time delay from the CT, thus leading to a possible bias. However, because colonoscopies were performed only if the symptoms did not fully abate and because the diagnoses by CT were mostly considered to be chronic in nature (colitis and tumors), we do not think this created a significant bias. Nevertheless, we cannot rule out that some of our patients had a reversible cause of the CT findings that resolved by the time of the colonoscopy, for example infectious colitis.

The strength of our study stems from the fact that it is prospective and deals with a "real-life" situation of patients with abdominal symptoms requiring an imaging study under conditions where bowel preparation is impractical. The findings of this imaging study ultimately affect the patient's management. In light of our results, it seems that NPCT findings of intra-luminal or intestinal wall lesions in ER patients should be interpreted cautiously as they have a high false-positive rate. This high false-positive rate may lead not only to inaccurate diagnoses and anxiety, but also to hospitalization and further investigations such as colonoscopy, which is both expensive and potentially dangerous. Although our study did not examine in-depth the utility of NPCT in

the ER setting, it appeared to provide a correct diagnosis in approximately half the examined patients (a true positive rate of 45%), making it a potentially important diagnostic tool. Further studies are needed to evaluate its sensitivity, specificity and cost-effectiveness in the ER setting.

Computed colonography has a greater diagnostic accuracy[24]. However, since it requires bowel preparation, its application in the ER setting is not always practical. In conclusion, abdominal CT scan can be a valuable diagnostic tool in the ER management of patients with abdominal symptoms. Nonetheless, it does not replace good clinical skills and judgment. Although it did lead to a diagnosis in approximately half the cases, its over-sensitivity can lead to a large number of needless diagnostic work-ups. Cost-effectiveness of the studies can help determine whether its use in the ER setting should be restricted. If CT can be postponed until bowel preparation is feasible, it can then be performed with a higher diagnostic yield. A diagnostic or therapeutic conventional colonoscopy could be performed soon after whenever real indication exists.

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