Acute Lower Intestinal Bleeding: Feasibility and Diagnostic Performance of CT Angiography

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Purpose:
To assess the diagnostic performance of computed tomographic (CT) angiography as the initial diagnostic examination for patients presenting to the emergency room with acute lower intestinal bleeding.

Materials and Methods:
The study was reviewed and approved by the ethics committee, and written informed consent was obtained from each patient or their closest relative when the clinical condition precluded consent by the patient. This prospective study comprised 47 patients (27 men, 20 women; mean age, 68 years) with acute lower gastrointestinal tract bleeding who were referred to undergo emergency colonoscopy for evaluation. CT angiography was performed in all patients shortly after arrival to the emergency room. Findings identified at CT angiography included active extravasation (ongoing hemorrhage) or hyperattenuating intraluminal contents on noncontrast material–enhanced images (recent hemorrhage). Presence and location of bleeding and likely cause of hemorrhage were determined and compared with the standard of reference (angiography, colonoscopy, or surgical findings). Data collected were analyzed with a statistical software package. Sensitivity, specificity, and positive and negative predictive values of CT angiography in depicting ongoing or recent hemorrhage were calculated and compared with those of standard of reference.

Results:
CT angiography demonstrated active bleeding in 14 patients and intraluminal hyperattenuating material in six patients. The sensitivity, specificity, positive predictive value, and negative predictive value of CT angiography in depicting active or recent bleeding were 100% (19 of 19), 96% (27 of 28), 95% (19 of 20), and 100% (27 of 27), respectively. Findings of CT angiography and the standard of reference were concordant for determining definite or potential cause of bleeding in 44 of 47 patients (93% accuracy).

Conclusion:
CT angiography performed in the emergency setting in patients with acute lower intestinal bleeding is feasible and correctly depicts the presence and location of active or recent hemorrhage, as well as the potential cause, in the majority of patients.

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Acute gastrointestinal bleeding remains a diagnostic and therapeutic challenge that may threaten a patient’s life depending on the severity and duration of the event. Gastrointestinal tract hemorrhage can arise anywhere, from the esophagus to the rectum, and its severity varies, from a mild self-limited and often recurrent episode to massive acute bleeding. Overall mortality ranges from 8% to 16% but can reach 40% when bleeding is severe, and patients with advanced age and comorbid conditions are at the greatest risk (1). Rapid identification of the source and cause of bleeding is the primary objective in the evaluation of gastrointestinal hemorrhage to guide proper treatment. This usually requires a multidisciplinary approach (2). Although colonoscopy is the initial procedure of choice in cases of acute intestinal bleeding that occur distal to the ligament of Treitz (3,4), its implementation in the emergency setting poses a variety of challenges, such as availability, the need for bowel preparation, or the potential for poor visualization of the bowel owing to the presence of intraluminal blood clots (2). Scintigraphy with technetium 99m-labeled red blood cells is regarded as the standard of reference (9–13), included a limited number of cases (14–17), or were purely experimental investigations (18–20). To our knowledge, the role and optimal timing to perform CT angiography in acute lower intestinal bleeding have not been established yet. Current protocols suggest that CT angiography may serve as an alternative procedure when upper endoscopy and colonoscopy findings are negative (10,21,22) or for selecting patients prior to conventional angiography (23,24). Some authors have speculated (23,25) or proposed (12,26) that CT angiography should be included in the diagnostic algorithm of acute lower intestinal bleeding. The aim of our study was to assess the diagnostic performance of CT angiography as the initial diagnostic examination for patients presenting to the emergency room with acute lower intestinal bleeding.

**Materials and Methods**

**Patients**

During a 22-month period (August 2008 to May 2010), we conducted a prospective study of adult patients (<18 years old) who visited our emergency department with the chief complaint of acute lower intestinal bleeding. Our ethics committee reviewed and approved the study, and written informed consent was obtained from each patient or their closest relative when the clinical condition precluded consent by the patient. Candidates for inclusion were all patients with acute lower intestinal or rectal bleeding (hematochezia, melena) who had an indication for emergent colonoscopy, angiography, or laparotomy, as determined by the emergency room physician. Exclusion criteria included concomitant upper gastrointestinal hemorrhage confirmed with upper endoscopy (n = 8); contraindication to intravenous contrast material (n = 3) due to history of allergy to iodine (n = 1) or impaired renal function, with serum creatinine greater than 2 mg/dL (n = 2); and pregnancy (n = 0). Two patients who underwent the CT examination were excluded due to lack of an acceptable standard of reference. Forty-seven consecutive patients (27 men, 20 women; mean age, 68 years) met these criteria and were included in the study.

**CT Angiographic Technique**

No oral contrast material or fluid was administered. All CT examinations were performed with a 64-detector CT scanner (Aquilion 64; Toshiba, Tokyo, Japan). A triphasic CT examination protocol specifically designed for the purpose of this study was applied to all patients, with a scan range from the diaphragm to the inferior pubic ramus. The tube voltage was set to 120 kVp, and an automatic tube current modulation (in milliampere-seconds) technique in x-, y-, and z-axes was routinely used to minimize the radiation dose. Section thickness of 1 mm,
reconstruction interval of 0.8 mm, and gantry rotation time of 0.5 second were used for all three phases. A preliminary unenhanced CT scan was routinely obtained by using a low-dose radiation technique (standard deviation of the noise index: 15) to depict any pre-existing intraluminal hyperattenuating material. Subsequently, 100–125 mL of intravenous contrast material (Optiray Ultraject 350; Mallinkrodt, Dublin, Ireland) was administered with a power injector at a rate of 4 mL/sec, followed by 50 mL of a saline solution (also at a rate of 4 mL/sec), through an antecubital vein. The arterial phase scan was obtained by using automated bolus triggering and started when attenuation in the proximal abdominal aorta reached 150 HU. The portal venous phase scan was obtained 70 seconds after beginning of contrast material injection.

Image Interpretation

CT angiographic results were interpreted prospectively by one of two emergency radiologists, who had more than 4 (M.M.) and 8 years (J.M.A.) of experience and were blinded to the patients’ clinical condition. Studies were interpreted at an independent workstation (Vitrea; Vital Images, Minnetonka, Minn). Axial data sets of the three phases were presented to the radiologists, who were allowed to generate two-dimensional (multiplanar) and three-dimensional (volume rendered, maximum intensity projection) reconstructions, as needed, to interpret the CT angiograms. The radiologists recorded the following findings: (a) presence and location of active extravasation of contrast-enhanced blood, characterized as an intraluminal focal collection or “jet” visible in the arterial and/or portal venous phase but not on the unenhanced scan; (b) presence of hyperattenuating (>60 HU) intraluminal material on the unenhanced scan, which indicates recent bleeding; and (c) possible cause of acute bleeding (although specific criteria for each diagnosis were not set by the investigators). For the purpose of determining the location of acute bleeding, the gastrointestinal tract was divided into three main segments: jejunum and ileum; ascending, transverse, and descending colon; and rectosigmoid.

Optical Colonoscopy

Optical colonoscopy was performed by gastroenterologists with more than 5 years of experience, who decided on the basis of clinical and laboratory data on the timing and the need and type of intestinal preparation. Overall clinical examination was conducted by the emergency surgery team in accordance with the standard clinical protocol for management of acute lower intestinal bleeding. Since CT angiography was not yet part of the standard of care for patients, the decision was made to treat patients without providing information about the results of CT angiography. Disclosing the findings of CT angiography could have introduced bias in the study. This method was approved by the ethics committee of our institution, and patients signed the informed consent form that explained this aspect of the study in detail.

Standard of Reference

The medical records of all patients were reviewed by one of the investigators (M.M.). This review was conducted after the interpretation of findings of CT angiography was completed. Results of colonoscopy and, when available, conventional angiography, surgery, or pathologic examination were recorded to establish standard of reference for comparison with findings of CT angiography. The site and cause of gastrointestinal bleeding were established by the same investigator who reviewed the medical records.

Statistical Analysis

Data collected were analyzed with a statistical software package (SPSS 9.0; SPSS, Chicago, Ill) by using descriptive statistical tools and by means of parametric and nonparametric tests, depending on data patterns. Sensitivity, specificity and positive and negative predictive values of CT angiography for depicting ongoing or recent hemorrhage were calculated and compared with the standard of reference. Results were considered true-positive when CT angiography showed active extravasation or hyperattenuating endoluminal material, and acute or recent bleeding was confirmed with the standard of reference. Results were considered true-negative when neither CT angiography nor the standard of reference demonstrated any evidence of active extravasation or hyperattenuating material (on the unenhanced scan). False-positive results were considered when active or recent bleeding was present on a CT angiogram but was not found with the standard of reference. Finally, false-negative results were considered when CT angiogram failed to show signs of bleeding that were present with the standard of reference. For patients in whom both the CT angiogram and the standard of reference showed active or recent bleeding, concordance between the two studies in the location of the bleeding site and potential cause of bleeding were determined. These results were considered concordant if the colonic segment where bleeding was found and the cause of the bleeding matched between CT angiography and the standard of reference.

Results

Presence and Location of Bleeding

Evidence of active extravasation indicating ongoing hemorrhage was seen on CT angiograms in 14 (30%) of the 47 patients, with the following distribution by location: jejunum/ileum (n = 4), colon (n = 8), and rectosigmoid (n = 2). Hyperattenuating intraluminal material (> 60 HU) on unenhanced scan but without active extravasation on CT angiogram was found in six cases: two in the colon and four in the rectosigmoid. Of the 14 patients who were found to have active bleeding at CT angiography, seven patients were transferred directly to the angiography suite for possible embolization and seven patients were immediately taken to the operating room. Conventional angiography confirmed the presence and location of the bleeding suggested at CT angiography in six of the seven cases referred for embolization: two in the jejunum/ileum, three in the colon, and one in the rectosigmoid.
region. For determination of the presence of active bleeding, there was concordance between CT angiography and conventional angiography in these six patients, and results were considered true-positive (Fig 1). In one patient, CT angiography depicted active extravasation in the colon, but the bleeding had ceased at the time of conventional angiography. This case was considered a false-positive result (Fig 2).

Among seven patients who were treated with emergency laparotomy, active bleeding with a specific bleeding site was found in five: two in the jejunum/ileum and three in the colon (Fig 3). In the other two patients, there was evidence of recent (but not active) bleeding in the colon (one patient) and rectosigmoid region (one patient). There was concordance between CT angiographic and surgical findings about the presence of active or recent bleeding and location of the bleeding site in these seven patients (true-positive CT angiograms).

In six patients, CT angiography demonstrated intraluminal hyperattenuating material, indicating recent bleeding, without active extravasation. The location of the bleeding was the colon in two patients and rectosigmoid in four patients. In these six patients, colonoscopy also depicted clots and/or evidence of recent bleeding, without ongoing hemorrhage, in the same segment indicated with CT. Findings of these CT examinations were considered true-positive.

CT angiography depicted no evidence of active extravasation or hyperattenuating endoluminal material in 27 of the 47 patients. Nine of these 27 patients ultimately required laparotomy (including five patients who also underwent preoperative colonoscopy) and 18 patients underwent only colonoscopy. No active hemorrhage or evidence of recent bleeding was found at colonoscopy or laparotomy in these 27 patients and, thus, the interpretations of multidetector CT angiography were considered true-negative.

As compared with the standard of reference, CT angiography correctly helped established the presence or absence of acute or recent bleeding in 46 (19 true-positive and 27 true-negative findings) of the 47 patients (accuracy, 98%). There was one false-positive finding and no false-negative findings. Thus, the diagnostic performance of CT angiography in depicting active or recent bleeding was a sensitivity of 100% (19 of 19), negative predictive value of 100% (27 of 27), specificity of 96% (27 of 28), and positive predictive value of 95% (19 of 20). Regarding the location of the bleeding, there was concordance between CT angiography and the standard of reference in all 19 patients who had evidence of active or recent bleeding with the standard of reference.

Cause of Bleeding

Among the 19 patients with ongoing and/or recent hemorrhage found at both CT angiography and the standard of reference, the specific cause of bleeding was correctly diagnosed with CT angiography in 15 patients (79%): bleeding diverticulum in four, tumor in three (Fig 4), vascular lesions (angiodysplasia, vasculitis, hemorrhoids) in seven, and bleeding at the polypectomy site in one (Fig 5). No lesion was identified at CT angiography in the remaining four patients, all with hyperattenuating endoluminal content but no active hemorrhage. Findings of colonoscopy in these four patients were inconclusive. The final diagnosis was coagulopathy in one patient and bleeding duodenal ulcer in one patient; in two patients, no specific source of bleeding was found, but both had favorable outcome. One patient, in whom CT angiography depicted active extravasation in the colon but bleeding was not confirmed with conventional angiography, was ultimately diagnosed with colitis, which was also suggested by CT.

In 23 (85%) of the 27 patients who did not have active or recent hemorrhage, CT findings suggested the following likely cause of bleeding: colitis (n = 12), tumors (n = 7), small bowel ischemia (n = 2), sigmoid stricture (n = 1), and proctitis (n = 1); in all cases, the diagnosis was confirmed with laparotomy and/or colonoscopy and histopathologic findings. In three patients, no potentially bleeding lesion was identified at CT angiography, but colonoscopy depicted a likely source: one rectal ulcer and two colonic polyps. In the remaining patient, no source of bleeding was found at either CT or colonoscopy. Thus, for determining the definite or potential cause of bleeding, CT angiography and the standard of reference were both positive and concordant in 39 of 47 patients (83%) and negative and concordant in five (11%) patients, and CT angiography failed to depict the potential cause of bleeding eventually diagnosed with the standard of reference in three (6%) patients (accuracy, 93%; 44 of 47).

Discussion

Lower intestinal bleeding is a common symptom in patients visiting the emergency room, especially in the elderly, because of the higher prevalence of colonic diverticulosis and vascular disease (1). Acute presentations, that is, acute lower intestinal bleeding, are responsible for 1%–2% of hospital emergencies, and 15% of them manifest as massive, life-threatening bleeding.

Clinical management focuses on identifying the site and cause of bleeding, and the most commonly used diagnostic procedures are scintigraphy, arteriography, and colonoscopy (4,5,7). Optical colonoscopy is the procedure of choice (1–4), but its use poses some challenges in the emergency setting. Administration of bowel preparation, not always feasible in cases of massive bleeding, means a delay of several hours (27), and presence of clots, blood, and stool in patients without preparation may hinder the visualization of the bleeding point and increase the rate of incomplete studies when compared with nonemergent examinations. Furthermore, in 10%–12% of cases, the source of bleeding may be extracolonic (1,6). Angiography is an invasive procedure usually reserved for therapeutic purposes in patients with more severe, life-threatening bleeding (7). Technetium 99m-labeled red blood cell scintigraphy is more sensitive than arteriography for depicting slower rate bleeding (28), but access to
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this procedure in the emergency setting is variable between different practices. At our institution, scintigraphy is not readily available on a 24-hour basis and, therefore, this test was not used in the patients included in this investigation.

CT and, more specifically, CT enterography is commonly used as a second-line procedure in nonemergent patients with unexplained gastrointestinal bleeding after negative upper and lower endoscopy examinations (10,21,22). CT is rapid, noninvasive, and highly reproducible and, thus, is commonly used in the acute setting for evaluating patients with traumatic and nontraumatic abdominal emergencies (29,30). In this study, we explored the potential application of CT and CT angiography in patients with acute lower intestinal bleeding. Relevant findings evaluated in our study were the presence and location of active or recent bleeding and the identification of the potential bleeding lesion. Active bleeding was identified in 30% (n = 14) of the patients included in our study, slightly lower than in other series that included only massive or severe bleeding (21,22,24). We found signs of recent bleeding, without active hemorrhage, in an additional 13% (n = 6) of patients.

Factors influencing the ability to visualize active bleeding at CT are multiple and include the nature of the bleeding lesion (bleeding rate, intermittence), patient factors (hemodynamic status, body mass index) (13), the CT technique (rate of injection, concentration of iodine in contrast material, number of phases, type of scanner, postprocessing), and the experience of the radiologist. The addition of imaging phases to the CT angiography study may provide more information but also increases the total radiation dose. Findings of recent studies (18,20) suggest that the highest sensitivity for detecting intestinal bleeding is achieved by means of a dual-phase protocol (arterial and portal venous phases). The two-phase protocol improves depiction of extravasated contrast medium during the arterial phase alone and also provides information about the cause of the bleeding. The preliminary unenhanced scan minimizes misinterpretations of hyperattenuating material.

Figure 1: Images in 33-year-old woman with systemic lupus erythematosus and vasculitis previously treated for distributive shock secondary to intestinal infection with cytomegalovirus. She returned to the emergency department owing to acute onset of severe lower intestinal bleeding (hemoglobin, 9 g/dL; hematocrit, 26.4%). (a, b) Contrast-enhanced CT images of the pelvis in (a) arterial and (b) venous phases show active extravasation of contrast-enhanced blood into the lumen of the jejunum (arrow). Intraluminal pooling of active contrast material extravasation increased from arterial to venous phase. Note free intraperitoneal fluid (*). (c) Coronal maximum intensity projection reformation of arterial phase data set shows the blush of extravasated blood (arrow). (d) Selective mesenteric angiogram confirms the site of extravasation (arrow); (e) the bleeding point was embolized and the bleeding subsided.
that can mimic contrast medium extravasation and can be a cause of false-positive results, such as retained contrast material in diverticula, medications, wall suture material, hemostatic clips, or calcifications (13). To minimize the radiation dose, we obtained the non-enhanced scan with a low-dose radiation technique using radiation modulation system. We used a contrast medium with a 350 mg/mL of iodine concentration injected at a rate of 4 mL/sec and followed by a 50-mL saline chaser. This protocol is frequently used in detecting acute hemorrhage elsewhere in the body. The performance of CT angiography in our study is similar to that reported by other investigators, who also found a good correlation between conventional angiography and CT angiography in the identification of the source of bleeding (3,9,24), including a recent meta-analysis (31). In some circumstances, the sensitivity of CT angiography may even exceed that of conventional angiography (10).

The inclusion of CT angiography in the diagnostic algorithm of acute lower intestinal bleeding helps identify patients with active bleeding and accurately determine the site of the bleeding. This information is helpful for directing therapy and, when necessary, for selecting the most appropriate hemostatic intervention: endoscopic, angiographic, or surgical. Precise anatomic localization of the bleeding point allows a targeted endovascular embolization, with a reduction in the number of angiographic series and a resulting savings in time, radiation dose, and the load of contrast material administered (15,28). Since even massive gastrointestinal tract hemorrhage can be intermittent, the finding of active bleeding or a potential hemorrhagic lesion (32–34) serves to direct the interventional radiologist to the area of concern and increases the success rate of endovascular therapeutic techniques (9,24). Conversely, a completely negative CT angiogram decreases the likelihood of subsequent angiographic identification of bleeding and might warrant a more conservative treatment and an initial “wait-and-see” strategy, with the possibility of repeating the CT angiogram in cases of re-bleeding (16).

The identification and anatomic localization of the lesion that is potentially
We must acknowledge some of the limitations of our study. First, the total number of patients included was small. Although we could have included all patients presenting with a main complaint of lower gastrointestinal hemorrhage, we elected to limit the study to only those patients for whom an emergent colonoscopy was requested by the admitting emergency physician. We did this to increase the proportion of patients who would be expected to have a valid standard of reference to compare with the results of CT angiography. For the same reason, we did not have a true control group, which is another limitation of our study. We did not attempt to use the severity of the hemorrhagic episode as a criterion for inclusion in the study. Again, we preferred to consider as potential candidates all patients who required a colonoscopy. Finally, other limitations of CT angiography for this clinical application include the lack of a therapeutic option, the use of ionizing radiation, and risks associated with intravenous contrast media, mainly allergic reactions and renal function damage (especially in older individuals). In summary, CT angiography is a noninvasive, rapid, reproducible, and widely available technique that can be performed successfully in the majority of patients presenting with an acute episode of acute lower intestinal bleeding, without the need for colonoscopy preparation. Rather than restricting it to cases where colonoscopy fails initially (35), in the majority of cases, we propose CT angiography as the first step in diagnostic evaluation of patients with substantial bleeding for confirmation of active or recent hemorrhage and correct identification of the site and cause of bleeding. In this setting, despite some limitations, findings of our study confirm the high diagnostic performance of CT angiography, allowing us to propose CT angiography as a good alternative for the emergent evaluation of patients with acute lower intestinal bleeding.

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