Angiography for Preoperative Evaluation in Patients With Lower Gastrointestinal Bleeding

Are the Benefits Worth the Risks?

Stephen M. Cohn, MD; Beth A. Moller, MSN; Paul M. Zieg, MD; Kerry A. Milner, MSN; Peter B. Angood, MD

Objective: To evaluate the benefits and risks of selective angiography for the evaluation of acute lower gastrointestinal (GI) bleeding to identify the site of bleeding and theoretically limit the extent of colonic resection.

Design: Retrospective chart review.

Setting: Tertiary care hospital.

Patients: Sixty-five patients undergoing 75 selective angiograms for evaluation of acute lower GI bleeding. Mean age was 71 years (range, 27-93 years), and 37 (57%) were women.

Main Outcome Measures: Demographic data were collected that included any associated medical problems, potential factors contributing to an increased risk for bleeding, and the diagnostic methods used in evaluating the source of lower GI bleeding. The details of angiography procedures were recorded with special attention to the impact of the procedure on clinical management and any associated complications.

Results: Twenty-three patients (35%) had positive angiography findings, and 14 of them (61%) required operations. Forty-two patients (65%) had negative angiography findings, and 8 of them (19%) required operations. Surgery for the 22 patients included hemicolectomy in 11 patients, subtotal colectomy in 10 patients, and small-bowel tumor resection in 1 patient. In 9 patients, a hemicolectomy was performed on the basis of angiography findings. Three patients (2 with negative angiography findings) experienced rebleeding after a hemicolectomy and required a subsequent subtotal colectomy. Overall, only 8 (12%) of the 65 patients underwent a segmental colon resection that was based on angiography findings and did not bleed after their operation. Complications from angiography occurred in 7 patients (11%).

Conclusion: Selective angiography appears to add little clinically useful information in patients with acute lower GI bleeding and carries a relatively high complication risk.

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Agressive surgical management with total abdominal colectomy for acute lower gastrointestinal (GI) bleeding was associated with a significant mortality rate in the 1950s and 1960s. The physiologic impact of surgery was thought to be more significant with subtotal colectomy than segmental colectomy. In addition, frequent bowel movements or those that interfered with daily life were believed to be less common after hemicolectomy. Angiography gained popularity as a means to localize the site of colonic bleeding, making segmental colectomy possible while avoiding the risk of rebleeding associated with “blind” hemicolectomy. Initial reports were associated with lower mortality rates, and angiography gained a place in the algorithm for evaluation of acute lower GI bleeding.

Unfortunately, angiography frequently fails to demonstrate the source of GI hemorrhage. In addition, multiple sites of bleeding are common in diverticulosis and angiodysplasia, increasing the potential for bleeding after limited colonic resections. The concept that subtotal colectomy with ileorectal anastomosis leads to greater morbidity and mortality rates is also debatable. Thus, many of the original assumptions that supported the use of angiography to limit the extent of colectomy now appear to be unsubstantiated.

Our purpose was to evaluate the impact of selective angiography on the clinical decision making in the management of...
SUBJECTS AND METHODS

The medical records of 65 patients undergoing 75 angiography studies for evaluation of acute lower GI bleeding at Yale–New Haven Hospital, New Haven, Conn, from January 1, 1989, to March 31, 1995, were reviewed. The angiograms included catheterization of the celiac, superior, and inferior mesenteric arteries to identify the site of bleeding. Vasopressin (Pitressin) was used to arrest identified active hemorrhage in most instances. If bleeding sites were not found, provocative medications (heparin sodium, urokinase, or vasodilators) occasionally were used to induce bleeding.

Demographic data were collected that included any associated medical problems, potential factors contributing to an increased risk for bleeding, and the diagnostic methods used to evaluate the source of lower GI bleeding. The details of angiography procedures were recorded, with special attention paid to the impact of the procedure on clinical management and any associated complications. The specific findings at angiography or surgery were also noted. Clinical outcome data were tabulated, and specific attempts were made to contact physician offices to determine the long-term bowel habits of the surviving patients.

lower GI bleeding and determine the associated morbidity of the procedure.

RESULTS

DEMOGRAPHICS

Mean patient age was 71 years (range, 27-93 years). Of the patients, 37 (57%) were women. Many patients had multiple medical illnesses at the time of presentation, including hypertension in 30, coronary artery disease in 20, diabetes in 12, cancer in 10, chronic obstructive pulmonary disease in 8, and chronic renal insufficiency in 4. Sixteen patients had a history of lower GI bleeding, and 8 patients were receiving oral anticoagulants at the time of admission. Overall, these patients received transfusions consisting of a mean of 3 U of packed red blood cells (range, 0-10 U) during the 24 hours before angiography and 9 U (range, 0-40 U) during their hospitalization. The patients were treated by a variety of surgeons, and the documented indications for angiography were the presence of active clinical bleeding (40 patients [62%]) and positive results of nuclear medicine scans (44 patients [68%]).

SELECTIVE ANGIOGRAPHY

Sixty-five patients underwent 75 selective angiograms as part of their workup for acute lower GI bleeding. Nine patients had multiple studies (8 patients had 2, and 1 patient had 3). Twenty-three patients (35%) had active clinical bleeding (40 patients [62%]) and positive results of nuclear medicine scans (44 patients [68%]). Twenty of these 23 patients received intra-arterial vasopressin, after which bleeding stopped in 14. One patient underwent successful embolization, but 6 of the remaining patients receiving vasopressin subsequently required operations. Ultimately, 14 of the 23 patients with positive angiography findings required operations, and 9 were treated nonoperatively. Forty-two patients had negative angiography findings, and 8 subsequently required operations. Provocative induction of hemorrhage was initiated in 5 patients with negative angiography findings, using heparin (2 patients bled), urokinase (1 patient bled), and tolazoline hydrochloride (1 patient bled). One of the 5 patients with induced bleeding required an operation. The time to angiography averaged 3.8 days after admission (range, 0-62 days).

Patients requiring an operation needed transfusion of a mean ± SD of 4 ± 2 U of packed red blood cells in the 24 hours before angiography, whereas those not requiring surgery needed only 2 ± 2 U. Unfortunately, the number of blood transfusions before angiography did not predict the likelihood of extravasation. Patients with positive angiography findings received 3 ± 2 U before the procedure, whereas those with negative findings received 3 ± 3 U.

SURGERY

A total of 22 patients (34%) required surgery, and continued hemorrhage was noted in the medical record as the indication for surgery in 19 (86%). The mean transfusion requirement was 4 U of packed red blood cells before angiography in patients undergoing operation (and 11 U for their entire hospital stay). The remaining 43 patients not requiring operation received a mean of only 2 U before angiography and 7 U for their entire hospitalization. Surgery in the 22 patients included hemicolectomy in 11 patients, subtotal colectomy in 10 patients, and small-bowel tumor resection in 1 patient (Table 1). Pathological findings are noted in Table 2. In 9 patients, hemicolectomy was performed on the basis of selective angiography findings. Three patients (2 with negative angiography findings) experienced rebleeding after hemicolectomy and required an emergency subtotal colectomy, and 1 of these patients died (Figure 1). For completeness, 1 case in this series was that of a 77-year-old man with a history of lower GI bleeding who underwent 2 angiograms as part of his evaluation for acute hemorrhage. Results of the first angiogram were negative, but the second demonstrated bleeding from the splenic flexure. Vasopressin was infused but did not terminate the bleeding, and the patient underwent a segmental colectomy. Twelve months later, the patient returned with another episode of massive bleeding and required a complete hemicolectomy.

COMPLICATIONS

Angiography-related complications occurred in 7 patients (11%), including on-table abdominal pain and extravasation of contrast material and a bleeding site noted on angiography, as seen in the following tabulation:

<table>
<thead>
<tr>
<th>Site</th>
<th>No. (%) of Angiograms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right colon</td>
<td>10 (13)</td>
</tr>
<tr>
<td>Left colon</td>
<td>9 (12)</td>
</tr>
<tr>
<td>Sigmoid colon</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Superior mesenteric artery</td>
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Twenty of these 23 patients received intra-arterial vasopressin, after which bleeding stopped in 14. One patient underwent successful embolization, but 6 of the remaining patients receiving vasopressin subsequently required operations. Ultimately, 14 of the 23 patients with positive angiography findings required operations, and 9 were treated nonoperatively. Forty-two patients had negative angiography findings, and 8 subsequently required operations. Provocative induction of hemorrhage was initiated in 5 patients with negative angiography findings, using heparin (2 patients bled), urokinase (1 patient bled), and tolazoline hydrochloride (1 patient bled). One of the 5 patients with induced bleeding required an operation. The time to angiography averaged 3.8 days after admission (range, 0-62 days).

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bradycardia in 2 patients, incisional hemorrhage secondary to urokinase and heparin administration in 1 patient, loss of pedal pulses in 1 patient, groin hematoma in 2 patients, and sepsis at catheter site in 1 patient. There were no anastomotic complications related to the surgical resection. Death occurred in 6 patients (9%), including 3 patients who underwent an operation. Death was related to multiple organ failure in 4 patients, exsanguination in 1 patient, and neurologic deterioration with a “do not resuscitate” order in 1 patient.

OUTCOMES

The 19 surviving patients who underwent colectomy were reviewed for long-term follow-up of their bowel habits. Only 6 (32%) of the 19 patients had the number of bowel movements noted in their office records, and all had normal function (or <3 bowel movements per day). The remaining patients could not be contacted directly, but there was no mention in their records of abnormal bowel function.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Total</th>
<th>Positive Angiography-Findings</th>
<th>Angiography-Directed Operation</th>
<th>Rebleeding</th>
<th>Died</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemicolectomy</td>
<td>11</td>
<td>9</td>
<td>9</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Subtotal colectomy</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Small-bowel tumor resection</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>14</td>
<td>9</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

A review of the natural history of lower GI bleeding is necessary to compare the risks and benefits of angiography adequately. Boley et al clearly demonstrated the recurrent nature of colonic hemorrhage in the elderly, as 56% of patients with diverticulosis and 85% with angiodysplasia manifest multiple bleeding episodes. McGuire and Haynes reviewed the literature from 1956 to 1971 and found 473 cases of massive lower GI bleeding. More than three fourths of patients underwent successful nonoperative treatment, with only 3% mortality but a 22% rate of rebleeding. Twenty-two percent overall required surgery, with an operative mortality of 20%. In these 103 operations, 28 (45%) of the 62 patients with hemicolec- tomy experienced rebleeding after surgery, and 9 (14%) of the 62 died. Only 3 (9%) of 34 patients undergoing subtotal colectomy died, and none experienced rebleeding after surgery. Recently, McGuire also reviewed the natural history of 79 patients with 108 episodes of acute lower GI bleeding. Bleeding stopped spontaneously in 76%, but 25% required emergency surgery. In the 65 patients with lower GI bleeding who required transfusion of more than 3 U/d packed red blood cells, 99% stopped spontaneously. When more than 3 U/d were transfused, 25 (60%) of 42 patients needed emergency surgery.

A currently accepted algorithm for the workup of acute lower GI bleeding usually includes exclusion of upper GI bleeding, some form of nuclear medicine scan, and, if results of the scan are positive, selective angiography. Segmental colectomy is subsequently planned in those patients in whom the site of bleeding is demonstrated by angiogram, when there is clinical evidence of ongoing hemorrhage. The need for this myriad of diagnostic studies evolved from the premise that subtotal colectomy was to be avoided, and the benefits of segmental colectomy outweighed the risks of angiography and associated delay in surgical intervention. Subtotal colectomy was associated with a higher mortality rate and incidence of disabling diarrhea than hemicolecotomy.

The traditional view that subtotal colectomy with ileorectal anastomosis leads to higher morbidity and mortality rates is debatable. Early studies, even before current sophisticated critical care management, demonstrated subtotal colectomy for lower GI bleeding to be quick, safe, and effective at preventing rebleeding. Drapanas et al described 35 patients undergoing subtotal colectomy for lower GI bleeding and noted 4 deaths, for mortality of 11%, and no patient experienced rebleeding. Fazio et al reviewed 163 patients undergoing elective ileorectal anastomosis and found only a 1.2% leak rate and 1.9% operative mortality. A high leak rate (28%-33%) for ileorectal anastomosis, however, has been noted in some studies when it is performed in the emergency setting. The surgeon must strongly consider fecal diversion, avoiding construction of a tenuous anastomosis in hypoperfused patients undergoing an emergency colectomy to minimize the risk for an anastomotic dehiscence. There were no diversionary ostomies or anastomotic leaks or breakdowns, however, in the patient population of our study (Table 2).

In addition, it now appears that severe disabling diarrhea usually does not occur after subtotal colectomy with ileorectal anastomosis. Most patients’ bowel habits are relatively normal following subtotal colectomy, averaging 2 to 4 bowel movements per day after emergency or elective surgery for cancer, ulcerative colitis, or acute lower GI bleeding. The length of remaining ileum, the “water wringer of the intestine,” longer than 15 cm, is critical to maintaining normal bowel habits.

The principal findings of this study were as follows. (1) Identification of the specific site of lower GI bleeding by angiography and the subsequent performance of a segmental colon resection was successful in only 8 (12%) of the 65 patients studied. (2) Angiography was associated with a significant overall complication rate (11%). (3) Most patients with lower GI bleeding and traditional indications for angiography did not require surgery (9/23 [39%]), even with positive angiography findings (9/23 [39%]).

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appears to have little impact on stool volume, electrolyte composition,18,19 or the number of bowel movements.20 In fact, ileorectal anastomosis markedly reduces the fluid and electrolyte losses when compared with ileostomy alone.21,22 Thus, in the absence of extensive resection of the ileum, subtotal colectomy rarely causes difficulties with frequent defecation. Review of the surviving patients undergoing colectomy in our study also revealed no mention of excessively frequent bowel movements in office records.

Angiography has been used to identify sites of intestinal bleeding for more than 3 decades.23 In addition, the use of therapeutic angiography (with vasopressin and/or embolization) may minimize the need for operative intervention. Whereas angiography occasionally localizes the origin of hemorrhage, findings are negative in more than 50% of patients requiring emergency operation.2 Moreover, the angiogram can be misleading, showing only some multiple bleeding sites, leading to an inadequate segmental resection. When rebleeding occurs in this situation, reoperation and subtotal colectomy are required in a critically ill patient.1

Earlier reports from our institution ascribed a low mortality rate due to lower G1 bleeding to the use of angiography and subsequent limited colectomy.1 However, only 2 of 96 patients required emergency operation. One had a subtotal colectomy, and the other underwent a hemicolectomy that was followed by massive rebleeding. In our study, only 11 of 65 patients underwent hemicolectomy, with rebleeding in 3, all of whom required subtotal colectomy. Only 8 (12%) of the 65 patients in our patient popu-

**Table 2. Operations for Acute Gastrointestinal Bleeding**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>PRBC, No. of U 24 h Before Angiogram/Total</th>
<th>Bleeding Scan Finding†</th>
<th>Angiography Finding†</th>
<th>Results of Vasopressin (Pitressin) Administration</th>
<th>Rebleeding</th>
<th>Operation</th>
<th>Pathology</th>
<th>Complication or Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5/27 Positive L colon</td>
<td>Positive jejunum</td>
<td>Negative</td>
<td>No STC</td>
<td>Diverticulosis</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4/9 Positive L colon</td>
<td>Positive sigmoid</td>
<td>Negative</td>
<td>No STC</td>
<td>Diverticulosis</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3/11 Positive R colon</td>
<td>Positive R colon</td>
<td>Positive, continued to bleed</td>
<td>No HC</td>
<td>Angiodyplasia</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>6/10 Negative × 2</td>
<td>Negative</td>
<td>Negative</td>
<td>Positive</td>
<td>SC</td>
<td>Angiodyplasia</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4/5 Positive RLQ</td>
<td>Positive tumor</td>
<td>Negative</td>
<td>No SBR</td>
<td>Stomal tumor</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>4/10 Positive cecum</td>
<td>Negative</td>
<td>Negative</td>
<td>No STC</td>
<td>Carcinoma</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2/12 Positive L abd, 1 negative</td>
<td>Negative</td>
<td>Negative</td>
<td>No STC</td>
<td>Diverticulosis</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>5/10 Positive L colon</td>
<td>Negative, positive L sigmoid</td>
<td>Positive bleeding and rebled</td>
<td>No HC</td>
<td>Diverticulitis</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>3/5 Positive RUQ</td>
<td>Positive cecum</td>
<td>Positive, bleeding stopped</td>
<td>No HC</td>
<td>Angiodyplasia</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3/9 Positive LLQ × 2</td>
<td>Positive IMA, negative</td>
<td>Positive, continued to bleed</td>
<td>No HC</td>
<td>Diverticulosis</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1/6 Positive L colon</td>
<td>Positive L colon</td>
<td>Positive, stopped bleeding</td>
<td>No STC</td>
<td>Diverticulosis</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>5/12 Positive sigmoid × 1, negative × 2</td>
<td>Negative</td>
<td>Stop bleeding</td>
<td>No STC</td>
<td>Diverticulosis</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>6/10 Positive R colon</td>
<td>Positive hepatic flexure</td>
<td>Stopped bleeding</td>
<td>No HC</td>
<td>Diverticulosis</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>2/4 Positive L colon</td>
<td>Positive IMA</td>
<td>Stopped bleeding</td>
<td>No HC</td>
<td>Diverticulosis</td>
<td>Groin hematoma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>2/10 Positive R</td>
<td>Negative</td>
<td>Negative</td>
<td>No STC</td>
<td>Diverticulosis</td>
<td>. . .</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>4/12 Positive R abd, negative × 1</td>
<td>Positive, positive cecum</td>
<td>Positive, continued bleeding</td>
<td>No HC</td>
<td>Diverticulosis</td>
<td>. . .</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>0/22 None</td>
<td>Negative</td>
<td>Positive</td>
<td>Yes HC, STC</td>
<td>Diverticulosis</td>
<td>Rebleeding and needed completion STC, sepsis, death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>6/9 None</td>
<td>Positive R colon</td>
<td>Positive, continued bleeding</td>
<td>No HC</td>
<td>Diverticulosis</td>
<td>. . .</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>4/10 Positive L abd</td>
<td>Negative, positive splenic flexure</td>
<td>Positive, continued bleeding</td>
<td>Yes HC</td>
<td>Diverticulosis</td>
<td>12 mo later needed HC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>3/9 Positive LUQ</td>
<td>Negative, positive splenic flexure</td>
<td>Positive, continued bleeding</td>
<td>No STC</td>
<td>Angiodyplasia</td>
<td>. . .</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>2/5 Negative × 2</td>
<td>Negative</td>
<td>Negative</td>
<td>No TPC</td>
<td>Diverticulosis, Crohn colitis</td>
<td>. . .</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>5/25 Negative × 1, positive transverse</td>
<td>Negative</td>
<td>None</td>
<td>Yes HC, STC</td>
<td>Diverticulitis, diverticular abscess</td>
<td>7 d after HC needed STC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*PRBC indicates packed red blood cells; LLQ, left lower quadrant; RUQ, right upper quadrant; abd, abdominal; IMA, inferior mesenteric artery; STC, subtotal colectomy; HC, hemicolectomy; SBR, small-bowel resection; TPC, total proctocolectomy; and MS, mental status.
†Some patients underwent angiography more than once.
larly, Britt et al\textsuperscript{26} found that 11 of 40 patients undergoing angiography for lower GI bleeding received a segmental resection. Therefore, only 4 (8\%) of the 50 patients had segmental colonic resections with therapeutic angiography to be greater than one year. Nath et al\textsuperscript{24} reported their experience with angiography for lower GI bleeding for 10 years. In 10 of 49 patients undergoing evaluation, angiography led to a segmental resection. Similariy, Britt et al\textsuperscript{26} found that 11 of 40 patients undergoing angiography for lower GI bleeding received a segmental resection. Browder et al\textsuperscript{27} had an experience similar to ours in 50 patients undergoing angiography for lower GI bleeding. Eight of the 50 had emergency operations, but 4 of the 8 underwent subtotal colectomy for multiple-site bleeding. Therefore, only 4 (8\%) of the 50 patients had segmental colectomy because of angiography findings. More recently, Leitman et al\textsuperscript{28} found 16 of 68 patients had segmental colectomies after angiography. However, 2 patients died directly as a result of angiography complications, ie, 1 of mesenteric infarction and 1 of acute myocardial infarction secondary to a vasopressin infusion. Seven of our 65 patients experienced some complication related to the angiogram. Furthermore, it is unclear what impact the delay in performing a definitive operative intervention may have had on the development of organ failure and death in our patient population.

Therapeutic angiography has been used with variable success to stop bleeding with vasoconstrictive agents\textsuperscript{29} and embolization.\textsuperscript{30,31} Angiography has also been used to induce and identify occult bleeding sites by using anticoagulants, fibrinolytic agents, and vasodilators.\textsuperscript{32} In a review of 83 patients with intra-arterial infusion of vasopressin for colonic bleeding, 41\% experienced rebleeding.\textsuperscript{27} Others have shown the incidence of “major” complications with therapeutic angiography to be greater than one third.\textsuperscript{33} The long-term consequences of angiographic control of hemorrhage are unknown, but the colon appears to be at increased risk for ischemia and colonic stricture after transcatheter embolization.\textsuperscript{34,35} In our study, we found that 6 of the 20 patients who received vasopressin still required urgent operation after the infusion was initiated, and 8 of the remaining 14 patients ultimately underwent a colon resection. Seventy percent of our patients in this group, therefore, had surgery. It is impossible to estimate how many of these patients would have stopped bleeding spontaneously in the absence of vasopressin.

There are a number of potential criticisms of our study. We performed a retrospective review of a limited patient population undergoing care by a number of surgeons. The patient care protocol, in general, was to perform a nuclear medicine scan before angiography and then surgery for continued bleeding. This algorithm, however, was subject to the discretion of the attending clinician. Likewise, the perioperative critical care management and surgical decision making were individualized. We specifically did not review our experiences with the nuclear medicine scans, which are currently used at many institutions (including ours) as a screening method for active bleeding before angiography. There are ample data to support the concept that these studies fail to localize bleeding in most patients with lower GI bleeding (85\%) and that they do not aid or direct surgical intervention.\textsuperscript{36,37} In addition, our mortality data could not be statistically analyzed comparing hemicolec- tomy with subtotal colectomy, due to the limited patient numbers. We also did not mention the risk for missing lesions of noncolonic (small bowel) origin when not performing angiography. This has been touted as another reason to avoid blind subtotal colectomy.\textsuperscript{38} These types of lesions are relatively rare, occurring, for example, in only 10 cases at Cook County—University of Illinois medical centers, Chicago, for 9 years.\textsuperscript{39} Furthermore, we did not obtain entirely complete information regarding the frequency of incapacitating bowel movements after emergency colectomy in our patients, but assumed that this finding would have been noted in the office records. Subtotal colectomy (or total abdominal colectomy) was performed on only 10 of our patients. This limited experience and sporadic follow-up does not permit us to judge the associated adverse effects of this procedure.

Study design weaknesses aside, given our current results and review of the medical literature, an algorithm for the management of acute lower GI bleeding can be rea-

![Figure 1](http://archsurg.jamanetwork.com/pdfaccess.ashx?url=/data/journals/surg/5325/ on 06/16/2017)

*Figure 1. The experience of Yale–New Haven Hospital, New Haven, Conn, with angiography evaluation of lower gastrointestinal bleeding. OR indicates operating room. Numbers in parentheses indicate number of patients.*

![Figure 2](http://archsurg.jamanetwork.com/pdfaccess.ashx?url=/data/journals/surg/5325/ on 06/16/2017)

*Figure 2. Proposed algorithm for evaluation of lower gastrointestinal (GI) bleeding.*
reasonably proposed that eliminates angiography and nuclear medicine studies from the clinical decision making for these patients in most instances (Figure 2). Clinical decisions regarding the need for and timing of surgery should focus more on the hemodynamic stability of the patients and their blood transfusion requirements. This should lead to appropriate and well-timed surgical intervention for most patients and a more effective use of resources. Most patients will actually stop bleeding and can then be investigated on a nonemergent basis with colonoscopy.

Patients requiring transfusion of less than 4 U/d packed red blood cells are extremely unlikely to require urgent operation and should be observed in a monitored setting (Figure 2). These are the candidates for elective colonoscopic evaluation. In the subset of patients requiring transfusion of at least 4 U/d for lower GI bleeding (about 25%), the clinical management benefits of therapeutic angiography and subsequent segmental colectomy must be weighed against the risks of the angiogram and morbidity of subtotal colectomy. As there is little evidence supporting the superiority of hemicolecotomy over subtotal colectomy, we believe that subtotal colectomy should be performed in surgical candidates. Since angiography carries a significant risk of complications, we suggest that this invasive procedure is indicated only for acute lower GI bleeding in those patients who cannot undergo surgery because of technical reasons or are deemed unsuitable surgical candidates because of underlying medical conditions.

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