New Trends in Management of Vascular Lower GI bleeding between Endoscopy and Angiography: Literature review

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ABSTRACT
Vascular lower gastrointestinal (GI) bleeding remains a challenging condition to manage due to its potential severity and diverse etiologies. This review examines recent advances in the management of vascular lower GI bleeding, focusing on endoscopic and angiographic modalities. Endoscopic innovations, including high-definition imaging, narrow-band imaging, and improved hemostatic devices, have enhanced diagnostic accuracy and therapeutic efficacy. Conversely, angiographic techniques, especially computed tomographic angiography (CTA) and superselective embolization, offer alternative and often complementary solutions, particularly for patients in whom endoscopy is not feasible or effective. Comparative analysis highlights the unique strengths and limitations of each approach, underscoring the importance of patient-specific factors such as age, comorbidities, and bleeding site. Future directions in this field include artificial intelligence integration in endoscopy, novel embolic agents in angiography, and hybrid approaches that combine these modalities for optimal patient outcomes. The findings suggest a shift toward a more personalized, integrative approach in managing vascular lower GI bleeding, informed by ongoing research and technological advances.

1. Introduction

Vascular lower gastrointestinal (GI) bleeding is a clinically significant condition, presenting substantial diagnostic and therapeutic challenges in gastroenterology and emergency medicine. Defined as bleeding originating distal to the ligament of Treitz, it constitutes a primary cause of morbidity and occasionally mortality, particularly among older adults and patients with comorbid conditions [1, 2]. Vascular lower GI bleeding encompasses a range of etiologies, from diverticulosis and angiodysplasia to ischemic colitis and inflammatory bowel disease (IBD). The variability in presentation and bleeding sources often complicates the identification and management of vascular lower GI bleeding [3, 4].

Clinically, patients may present with symptoms ranging from mild hematochezia to massive, life-threatening hemorrhage. The hemodynamic stability of the patient significantly influences the choice of diagnostic and therapeutic approach, necessitating a balance between rapid intervention and accurate localization of the bleeding source [5]. Traditionally, lower GI bleeding has been diagnosed and managed through a variety of methods, including colonoscopy, radionuclide scanning, and angiography. Colonoscopy has been the preferred initial approach due to its ability to identify and treat certain lesions simultaneously. However, it has limited sensitivity in acute bleeding cases, often necessitating complementary diagnostic strategies [1, 6, 7].

In addition to colonoscopy, nuclear medicine techniques, particularly technetium-99m-labeled red blood cell scintigraphy, have been applied to detect active bleeding sites. Although capable of detecting slow bleeds, scintigraphy lacks specificity and does not provide a therapeutic option [8]. Angiography, often reserved for patients with ongoing hemorrhage unresponsive to endoscopic treatment, enables both diagnosis and intervention through selective embolization. While effective, traditional angiographic techniques require a considerable rate of bleeding for optimal visualization and are associated with risks, including ischemic complications [9, 10].

The advent of endoscopic advancements, particularly high-definition imaging, has expanded the diagnostic and therapeutic potential of endoscopy in GI bleeding cases. Meanwhile, angiographic techniques have evolved, allowing for more precise localization and minimally invasive intervention in bleeding control [11]. These innovations are critical in addressing the gaps left by traditional approaches and present new avenues for managing vascular lower GI bleeding effectively and efficiently.

Problem Statement

While traditional diagnostic and therapeutic modalities, such as colonoscopy and angiography, have been instrumental in managing vascular lower GI bleeding, they present notable limitations that can impact patient outcomes. Colonoscopy, for instance, remains the first-line diagnostic tool in most cases of lower GI bleeding but has limited efficacy when performed in the setting of active, profuse bleeding due to poor visualization of the bleeding source [12]. This limitation often necessitates additional imaging or repeated procedures, which can delay treatment and increase the risk of complications [13]. Furthermore, colonoscopy is less effective in identifying small, subtle vascular lesions, such as angiodysplasia, that may be the source of intermittent bleeding [14].

Radionuclide imaging, while useful in detecting bleeding, is constrained by its low resolution and lack of therapeutic capacity. Its sensitivity varies significantly based on the rate of bleeding, with a minimum rate of 0.1 mL/min required for optimal detection [15]. This technique is often less useful in unstable patients due to the time required for imaging, and it cannot provide real-time bleeding localization as effectively as other modalities [16].

Angiography has historically been the primary method for diagnosing and managing severe, ongoing lower GI bleeding. It is especially valuable in cases where colonoscopy and radionuclide scanning have failed to localize the source. However, conventional angiography requires an active bleeding rate of approximately 0.5 mL/min for effective visualization, which limits its utility in patients with intermittent or slower bleeds [17]. Additionally, the therapeutic application of angiography through embolization, while often effective, carries a risk of bowel ischemia, particularly in cases where bleeding is multifocal or when the bleeding vessel is in close proximity to critical blood supply areas [18, 19].

In recent years, advancements in endoscopic technology, such as the introduction of high-definition imaging, narrow-band imaging, and enhanced magnification, have allowed for more precise visualization of bleeding sources within the GI tract [20]. These technologies facilitate the identification of subtle vascular abnormalities, which might otherwise be missed with standard colonoscopy [21]. Moreover, new hemostatic tools, including over-the-scope clips and hemostatic powders, have expanded the therapeutic capabilities of endoscopy, enabling prompt control of bleeding in a minimally invasive manner [22]. However, access to these advanced technologies is often limited by availability, cost, and the need for specialized training, which can restrict their use to larger healthcare centers with adequate resources [23].

2. Methods

1. Study Design

This literature review was designed to systematically evaluate and synthesize recent advances in the management of vascular lower gastrointestinal (GI) bleeding, with a specific focus on endoscopic and angiographic techniques. The aim was to provide a comprehensive overview of the latest trends, tools, and strategies that have emerged in recent years, highlighting their impact on diagnostic and therapeutic practices.

The literature review approach was chosen to capture a broad range of findings from diverse clinical studies, case reports, systematic reviews, and meta-analyses. This approach allowed for an inclusive synthesis of data across various healthcare settings and patient populations, ensuring a balanced perspective on the benefits, challenges, and comparative efficacy of new endoscopic and angiographic interventions in managing vascular lower GI bleeding.

2. Data Sources and Search Strategy

A thorough and systematic search of the literature was conducted across multiple databases to gather relevant studies. To ensure comprehensive coverage, the following databases were utilized:

- PubMed: Due to its extensive biomedical literature and relevance to GI bleeding and endoscopic advancements.
- Embase: To capture international studies and literature not always indexed in PubMed.
- Cochrane Library: Known for systematic reviews and high-quality evidence, relevant for evaluating comparative studies.

- Google Scholar: Used for supplementary searches to identify grey literature, including conference proceedings, preprints, and additional case reports.

Search Period: The search focused on articles published within the last ten years (January 2014 to September 2024). This period was selected to ensure the review reflects the most recent developments in technology and practice in both endoscopic and angiographic management of vascular lower GI bleeding.

Search Terms and Syntax: A combination of Medical Subject Headings (MeSH) terms and relevant keywords were used to maximize the sensitivity and specificity of the search. The main terms included:

- "vascular lower GI bleeding" OR "lower gastrointestinal bleeding" AND "endoscopy" OR "endoscopic treatment" OR "angiography" OR "transcatheter embolization"
- "hemostatic techniques in endoscopy," "advanced imaging for GI bleeding," "computed tomographic angiography" OR "CTA for GI bleeding"
- Synonyms and closely related terms were included using Boolean operators (AND/OR) to refine search results, ensuring coverage of all relevant advancements.

The search was restricted to English-language studies. Duplicates were removed manually and by using database functions where available.

3. Inclusion and Exclusion Criteria

Inclusion Criteria: To ensure that only relevant and high-quality studies were reviewed, the following criteria were applied:

- Type of Study: Original research articles, case series, systematic reviews, meta-analyses, and clinical guidelines related to the management of vascular lower GI bleeding.
- Population: Studies involving adult patients with vascular lower GI bleeding, including conditions such as angiodysplasia, Dieulafoy's lesions, or other vascular abnormalities.
- Interventions: Studies focusing on endoscopic and/or angiographic approaches for diagnosis and treatment, particularly those describing recent advances (e.g., high-definition endoscopy, narrow-band imaging, over-the-scope clips, computed tomographic angiography, superselective embolization).
- Outcome Measures: Articles reporting outcomes related to diagnostic accuracy, treatment efficacy, complications, and comparative studies between endoscopy and angiography.
- Time Frame: Publications from January 2014 to September 2024.

Exclusion Criteria: Studies were excluded based on the following:

- Non-English language articles.
- Studies focusing solely on upper GI bleeding or unrelated gastrointestinal conditions.
- Articles without clear descriptions of advanced endoscopic or angiographic techniques.
- Reviews lacking clinical evidence or studies with insufficient methodological quality.

3. Results

Advances in Endoscopic Management of Vascular Lower GI Bleeding

The management of vascular lower gastrointestinal (GI) bleeding has evolved significantly, particularly in the field of endoscopy. Advances in imaging technologies and therapeutic tools have enabled healthcare providers to precisely identify bleeding sites and apply effective treatments. These advancements are pivotal in reducing morbidity, hospitalization duration, and the need for surgical interventions in patients with lower GI bleeding.

Imaging Enhancements

One of the most impactful advances in endoscopy is the introduction of high-definition endoscopy (HDE). Traditional endoscopic imaging often missed smaller or less prominent vascular lesions, contributing to diagnostic challenges and incomplete treatment [24]. HDE has transformed this approach, offering increased resolution that enables the detailed visualization of mucosal surfaces. The clarity provided by HDE has improved

lesion detection rates, especially for angiodysplasia and other small vascular malformations [25]. Studies have shown that HDE enhances diagnostic accuracy, making it an essential tool in the early detection of subtle lesions that might otherwise be overlooked [26]

Narrow-band imaging (NBI) is another significant enhancement that has bolstered the efficacy of endoscopic visualization. Unlike traditional white-light imaging, NBI uses specific wavelengths of light that accentuate vascular structures and mucosal patterns, aiding in the identification of potential bleeding sources [27]. NBI improves contrast between blood vessels and surrounding tissues, allowing clinicians to detect vascular lesions with greater precision [28]. Studies demonstrate that NBI's ability to highlight vascularity in mucosal lesions leads to a more accurate diagnosis of angiodysplasia, which is a common cause of obscure GI bleeding [29]. The combined use of HDE and NBI can increase diagnostic yields in detecting and evaluating GI bleeding lesions, particularly in challenging cases where bleeding sources are difficult to identify [30].

Therapeutic Tools

In addition to improvements in imaging, advancements in therapeutic tools have significantly enhanced endoscopic management. Among these, over-the-scope clips (OTSCs) and hemostatic powders are notable for their effectiveness in achieving hemostasis in bleeding lesions [31].

OTSCs represent a considerable advancement over traditional clipping methods. OTSCs are larger and provide a more robust closure of the tissue, effectively managing complex lesions, such as those found in angiodysplasia and diverticular disease [32]. OTSCs allow for a full-thickness closure, which is critical in situations where the bleeding vessel is situated within deep mucosal or submucosal layers [33]. Studies have indicated that OTSCs are highly effective in controlling acute GI bleeding, with success rates surpassing traditional clips, especially in difficult-to-access areas [34]. The utility of OTSCs has been shown in both acute and prophylactic settings, where they help prevent rebleeding by providing a durable seal over the lesion [35].

Hemostatic powders, such as TC-325 (also known as Hemospray), offer a non-contact, topical method of controlling bleeding. This powder adheres to the mucosal surface upon application, creating a mechanical barrier that promotes clotting [36]. Hemostatic powders are particularly useful in cases where conventional methods are ineffective or challenging to apply, such as diffuse bleeding or in areas with complex anatomy [37]. Recent studies demonstrate that hemostatic powders are effective in achieving primary hemostasis in 80-90% of cases, providing a valuable adjunct to other endoscopic interventions [38]. The versatility and rapid deployment of hemostatic powders make them ideal for initial control of bleeding, allowing for stabilization before more definitive therapy if required [39].

Studies and Outcomes

Recent studies and meta-analyses support the efficacy of these advanced imaging and therapeutic techniques. A systematic review by Ryou et al. [40] analyzed the impact of HDE and NBI on lesion detection rates in patients with vascular lower GI bleeding. The review concluded that patients undergoing HDE or NBI had significantly higher lesion detection rates compared to those undergoing standard endoscopy, with detection rates increasing from 50% to 75% [41]. These findings indicate that advanced imaging modalities not only improve diagnostic accuracy but also potentially reduce the need for repeat procedures [42].

Similarly, a meta-analysis on the use of OTSCs in lower GI bleeding demonstrated that OTSCs achieved hemostasis in 95% of cases, which was notably higher than the success rates of traditional clips [43]. Furthermore, OTSCs were associated with lower rebleeding rates, with follow-up studies showing a recurrence rate of less than 10% [44]. This evidence suggests that OTSCs provide a durable solution for managing difficult bleeds, particularly in patients with recurrent or refractory bleeding [45].

3. Innovations in Angiographic Management

Diagnostic Developments

The introduction of computed tomographic angiography (CTA) has significantly advanced the diagnostic process for vascular lower gastrointestinal (GI) bleeding, providing a rapid, non-invasive method for bleeding localization [46]. CTA offers the advantage of quickly pinpointing active bleeding sources, allowing clinicians to make timely and informed decisions about further intervention [47]. This modality operates through the detection of extravasated contrast media in the gastrointestinal tract, thereby identifying the specific location and rate of bleeding [48]. Compared to conventional angiography, CTA boasts a higher sensitivity in detecting

small-volume bleeds, which are frequently encountered in lower GI bleeds [49].

CTA's ability to offer three-dimensional imaging enhances visualization, particularly in complex anatomical regions like the pelvis, where traditional methods might miss subtle vascular abnormalities [50]. Furthermore, CTA is useful as a preliminary imaging technique for triaging patients and guiding subsequent invasive interventions, such as selective angiography or endoscopy [16]. Studies have shown that CTA can detect bleeding rates as low as 0.3 mL/min, thereby improving diagnostic accuracy and increasing the likelihood of successful localization and treatment [51, 52]. Its non-invasive nature also makes CTA a favorable option for patients who may be at higher risk for invasive procedures due to comorbidities [53].

In recent years, there have been advancements in CTA technology, including dual-energy CTA and multiphase CTA, which provide enhanced detection of bleeding sources with reduced radiation exposure [54]. Dual-energy CTA, for example, differentiates between extravasated blood and surrounding tissues by utilizing varied energy levels to highlight subtle contrast differences [55].

Interventional Techniques

Following CTA diagnosis, catheter-based angiography with superselective embolization has emerged as a primary interventional technique for the management of vascular lower GI bleeding. Superselective embolization has transformed the angiographic approach by enabling targeted intervention at the precise site of bleeding, thereby sparing adjacent tissues and reducing complications [9, 56]. This technique leverages advancements in microcatheter technology, allowing for high precision in navigating the intricate vascular architecture of the GI tract [57].

The evolution of microcatheters has made it possible to access smaller and more distal vessels than ever before, enhancing both the efficacy and safety of the procedure [58]. These microcatheters, often ranging between 1.7 and 2.0 French, facilitate selective embolization by minimizing catheter size while preserving flexibility and control [59]. Newer microcatheters also incorporate hydrophilic coatings, which improve catheter maneuverability and reduce the risk of vessel damage, an essential factor in achieving positive clinical outcomes in delicate vascular procedures [60]. Additionally, superselective embolization often employs embolic agents like microspheres, gelfoam, or coils, each chosen based on factors such as bleeding severity, vessel size, and patient stability [61].

A particularly noteworthy development in superselective embolization is the use of drug-eluting beads as embolic agents, which combine hemostatic effects with localized drug delivery [62]. These beads provide dual benefits by simultaneously controlling bleeding and delivering anti-inflammatory agents to the affected site, potentially reducing recurrence rates and enhancing patient recovery [63].

Multidisciplinary Strategy

Endoscopic intervention is the primary modality for diagnosing and managing vascular lower GI bleeding due to its minimally invasive nature and therapeutic capabilities, such as direct visualization, tissue sampling, and localized hemostasis with devices like over-the-scope clips or hemostatic powders [40]. However, endoscopy has limitations, particularly in cases where visualization is impaired by active bleeding, or in cases where bleeding originates from deeper or anatomically challenging regions. In such instances, angiography serves as a valuable adjunct, especially when endoscopic treatment is either ineffective or contraindicated [64].

Angiography, particularly with the use of computed tomographic angiography (CTA) or catheter-based angiography, allows for precise localization of bleeding sites, guiding endoscopic intervention [16]. This non-invasive visualization is especially beneficial in acute settings where rapid diagnosis is essential. The role of superselective embolization in angiography allows targeted occlusion of bleeding vessels, minimizing collateral damage and effectively stopping the hemorrhage in cases where endoscopy cannot achieve hemostasis [9]. By combining endoscopy and angiography, clinicians can quickly localize and treat the bleeding source while reducing procedural time and improving patient outcomes [65].

4. Discussion

Comparison of Modalities

Endoscopy and angiography serve as cornerstone techniques in managing vascular lower gastrointestinal (GI) bleeding, yet they exhibit unique strengths and limitations that influence clinical decision-making based on

patient-specific factors.

Endoscopy, notably colonoscopy, is typically the first-line diagnostic and therapeutic tool for lower GI bleeding. Its advantages include direct visualization of the bleeding source, which facilitates immediate intervention through various therapeutic tools, such as over-the-scope clips, epinephrine injections, and hemostatic powders [66]. Narrow-band imaging and high-definition endoscopy have further enhanced its diagnostic capabilities, allowing endoscopists to more precisely locate and treat elusive vascular lesions like angiodysplasia [67]. These innovations have shown promising outcomes in initial hemostasis and recurrence prevention, particularly in elderly patients prone to vascular anomalies [68, 69]. However, limitations exist; endoscopic intervention can be limited by poor bowel preparation, patient instability, and an inability to reach specific anatomical sites, such as the proximal small intestine [70].

Conversely, angiography offers a robust alternative for patients in whom endoscopy is contraindicated or unsuccessful. Traditionally a second-line modality, angiography has evolved with the advent of computed tomographic angiography (CTA), which allows non-invasive and rapid identification of bleeding foci [71, 72]. Digital subtraction angiography, coupled with advancements in microcatheter technology, enables superselective embolization—targeting precise bleeding vessels while preserving adjacent tissues, thereby minimizing the risk of ischemia [73]. This precision is critical for patients with multiple comorbidities or those who are hemodynamically unstable and unable to undergo extended endoscopic procedures [74]. However, angiography carries inherent risks, including contrast-induced nephropathy and radiation exposure, which are especially concerning in older adults or those with renal insufficiency [75].

Comparatively, endoscopy is preferred for direct and immediate intervention with lower cost and generally lower procedural risk, while angiography is favored in cases where bleeding sites are less accessible or persistent after endoscopic attempts [76]. Patient age, comorbid conditions, and specific bleeding source characteristics ultimately guide modality choice, emphasizing the need for a tailored, patient-centered approach [77, 78].

Future Directions

Ongoing research and technological advancements continue to refine the use of endoscopy and angiography in managing vascular lower GI bleeding, with promising innovations on the horizon.

In endoscopy, artificial intelligence (AI)-driven software is being integrated to assist endoscopists in real-time identification of bleeding lesions [79]. Preliminary studies have shown that AI-enhanced endoscopy can reduce the rate of missed lesions and enhance diagnostic accuracy, particularly in the detection of subtle vascular abnormalities [80]. Furthermore, innovations in hemostatic agents are underway, including the development of biodegradable hemostatic clips and bio-adhesive sprays that can provide more durable bleeding control, which is essential for patients with recurrent or refractory bleeding [81].

Emerging technologies also extend to angiography, where lower-radiation dose protocols and contrast agents with reduced nephrotoxicity are being explored to address safety concerns, particularly in elderly and renal-impaired patients [82]. Additionally, novel embolic agents, such as microspheres with drug-eluting properties, are being tested for their potential to reduce rebleeding rates by offering both mechanical and pharmacological hemostasis [83].

In addition, hybrid approaches are gaining traction, combining the strengths of both endoscopy and angiography in a multidisciplinary treatment model. In some cases, computed tomographic angiography (CTA) is now employed to localize bleeding sites preemptively, guiding endoscopic intervention and enabling targeted treatment [84]. When endoscopy fails, angiography offers a seamless transition to catheter-based interventions, exemplifying a growing trend toward integrated care models in lower GI bleeding management [85].

Finally, advancements in personalized medicine hold promise for individualized GI bleeding management. Genetic and biomarker studies are beginning to identify patients at higher risk for vascular bleeding based on genetic predispositions, such as hereditary hemorrhagic telangiectasia [86]. Leveraging this data could enable clinicians to select more appropriate and preventive interventions, reducing the need for emergency procedures and improving overall patient outcomes [87, 88]. These developments underscore the potential for a precision-medicine approach, which could optimize GI bleeding management by tailoring diagnostic and therapeutic decisions to each patient's unique genetic and physiological profile [89, 90].

5. Conclusion

The management of vascular lower gastrointestinal bleeding has seen significant advancements through both endoscopic and angiographic modalities. Endoscopy, with innovations such as high-definition imaging and advanced hemostatic tools, allows for precise and minimally invasive bleeding control. In contrast, angiography, especially through developments in computed tomographic angiography and superselective embolization, provides a crucial alternative for patients where endoscopy is either contraindicated or insufficient. Each modality presents unique strengths, making the choice dependent on patient-specific factors, including bleeding location, hemodynamic stability, and overall health profile.

Future directions in this field promise to further improve outcomes and patient safety. Artificial intelligence in endoscopy, innovations in hemostatic agents, safer contrast materials in angiography, and emerging hybrid approaches represent exciting areas of progress. Additionally, as personalized medicine advances, clinicians may increasingly tailor interventions to individual patient profiles, optimizing efficacy and minimizing procedural risks.

Ultimately, an integrative, patient-centered approach that leverages the strengths of both endoscopic and angiographic techniques, with insights from evolving technologies, can enhance the management of vascular lower GI bleeding and improve patient quality of care.

Data availability statement

All data relevant to the study are included in the article.

Ethics statements

Patient consent for publication

Not applicable.

Ethics approval

All data collected contained no personal health identifiers.

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