Ann Med Res

Current issue list available at Ann Med Res

Annals of Medical Research

journal page: annalsmedres.org

Transcatheter arterial embolization for refractory non-variceal gastrointestinal bleeding: Outcomes and prognostic indicators

Sinan Karatoprak [a,*], Mustafa Bilgili [a], Oguz Aslan [a], Gamze Turk [a], Nur Betul Karatoprak [a], Ferhat Omurca [b]

[a]Kayseri City Training and Research Hospital, Department of Radiology, Kayseri, Türkiye
[b]Kayseri City Training and Research Hospital, Department of Gastroenterology, Kayseri, Türkiye
*Corresponding author: snnkrtprk@hotmail.com (Sinan Karatoprak)

MAIN POINTS

- Transcatheter arterial embolization (TAE) achieved a high technical success rate (97.9%) and a low complication rate (6%) in patients with non-variceal gastrointestinal bleeding refractory to endoscopic therapy.
- Rebleeding occurred in 30% of patients and was significantly associated with comorbidity status, multi-vessel embolization, and negative endoscopic findings.
- In-hospital mortality was associated with higher Rockall scores and lower platelet counts, whereas overall mortality during follow-up was associated with elevated INR and higher Rockall scores.
- Length of hospital stay was independently associated with comorbidity burden, transfusion requirements, delayed embolization, and lower baseline hemoglobin.
- These findings underscore the prognostic importance of comorbidity and the role of preprocedural optimization in improving TAE outcomes for refractory gastrointestinal bleeding.

Cite this article as: Karatoprak S, Bilgili M, Aslan O, Turk G, Karatoprak NB, Omurca F. Transcatheter arterial embolization for refractory non-variceal gastrointestinal bleeding: Outcomes and prognostic indicators. *Ann Med Res*. 2026;33(5):230–237. doi: 10.5455/annalsmedres.2025.10.306.

ABSTRACT

Aim: Transcatheter arterial embolization (TAE) is increasingly used as second-line therapy for non-variceal gastrointestinal bleeding (NVGIB) when endoscopic hemostasis fails. This study investigated factors influencing rebleeding, mortality, and length of hospital stay (LOS) following TAE.

Materials and Methods: We retrospectively analyzed 50 patients (mean age 64.8 years; 72% male) who underwent TAE for acute NVGIB between April 2023 and April 2025. Demographic variables, comorbidities, laboratory values, endoscopic/angiographic findings, embolic materials, and outcomes were reviewed. Primary outcomes were rebleeding and in-hospital mortality; secondary outcomes were LOS and overall mortality.

Results: Technical success was 97.9%. Rebleeding occurred in 30% (15/50) of cases, predominantly within the first week. Risk was higher with malignancy (45.5%), systemic disease or bleeding disorders (29.4%), multivessel embolization (66.7% vs. 21.1%), and negative endoscopic findings (75% vs. 25.6%) (all $p < 0.05$). In-hospital mortality was 32% (16/50) and was associated with higher Rockall scores ($p = 0.001$) and lower platelet counts ($p = 0.037$). Overall mortality reached 52% (26/50) at a median follow-up of 16 months and was significantly associated with elevated INR ($p = 0.005$) and Rockall score ($p = 0.032$). Among survivors, mean LOS was 15.5 days and was correlated with comorbidity burden, transfusion requirements, and delayed embolization; lower baseline hemoglobin predicted longer stays. Complications occurred in 6% of patients: two minor access-site hematomas and one ischemic event.

Conclusion: TAE is a safe and effective treatment for NVGIB that is refractory to endoscopic therapy and is associated with high technical success and low complication rates. Mortality and rebleeding are primarily influenced by comorbidities, disease severity, and procedural complexity rather than by embolic technique, emphasizing the importance of individualized risk assessment and multidisciplinary management.

Keywords: Transcatheter arterial embolization, Gastrointestinal bleeding, Non-variceal hemorrhage, Rebleeding, Mortality, Prognostic factors

Received: Oct 15, 2025 **Accepted:** Dec 24, 2025 **Available Online:** May 22, 2026

INTRODUCTION

Gastrointestinal (GI) bleeding is a potentially life-threatening clinical emergency with significant morbidity, mortality, and healthcare costs worldwide [1]. Non-variceal upper gastrointestinal bleeding (NVUGIB) is most commonly caused by peptic ulcer disease, erosive gastritis, Mallory–Weiss tears, and malignancies [2]. Lower gastrointestinal bleeding (LGIB), on the other hand, is frequently caused by diverticulosis, angiodysplasia, ischemic colitis, colorectal neoplasia, or hemorrhoids [3,4].

Endoscopy and colonoscopy remain the first-line diagnostic and therapeutic approaches, enabling hemostasis in most pa-

https://doi.org/10.5455/annalsmedres.2025.10.306

tients with NVUGIB or LGIB [1,5]. Despite advances in endoscopic technologies, a subset of patients still experiences refractory or recurrent bleeding for which endoscopic management either fails or is technically infeasible [5].

Historically, surgery was the next line of therapy. Yet, surgical intervention in acute GI bleeding is associated with substantial morbidity and mortality, particularly among elderly patients and those with comorbidities [2,6]. Over the past few decades, transcatheter endovascular therapy, especially transcatheter arterial embolization (TAE), has emerged as a widely adopted salvage treatment, with its safety and efficacy for NVUGIB well documented in systematic reviews and clinical series [7–9].

In this context, we present our single-center experience with the endovascular management of patients with NVUGIB and LGIB refractory to endoscopic or colonoscopic therapy.

MATERIALS AND METHODS

This study was designed as a retrospective, single-center study and was approved by the Non-Interventional Clinical Research Ethics Committee of Kayseri City Hospital (Approval No: 548).

Patient selection

This retrospective study included 50 patients with acute nonvariceal upper or lower gastrointestinal bleeding who underwent transcatheter arterial embolization (TAE) at our institution between April 2023 and April 2025. Patients were eligible if bleeding could not be controlled endoscopically or if endoscopy was not feasible (e.g., gastrectomy). In such cases, TAE was performed prior to surgery when massive transfusion was required (more than four units of packed red blood cells [pRBCs] within a 24-hour period) or when hemodynamic instability was present, defined as hemorrhagic shock, systolic blood pressure of < 100 mmHg, or heart rate exceeding 100 beats per minute.

For each patient, demographic variables, presenting symptoms, medication histories, comorbidities, and previous gastrointestinal bleeding episodes were documented. Pre-embolization laboratory values (hemoglobin, INR, platelet count, lactate), pre-embolization transfusion requirements, prior imaging findings, Rockall scores, Forrest classification (if applicable), bleeding location, time from symptom onset to embolization, angiographic findings, type of embolic material used, and number and identity of occluded vessels were also recorded.

Embolization procedure

All angiographic procedures were performed by interventional radiologists with at least five years of experience. Vascular access was obtained via the common femoral artery in all cases. Procedures were typically performed under local anesthesia, with additional conscious sedation or general anesthesia administered when clinically required. A 6-French vascular sheath was introduced, and selective catheterization of the celiac trunk and the superior mesenteric artery was routinely performed using various 5-French diagnostic catheters (Taha Medical, Turkey; Cordis Medical, USA); the inferior mesenteric artery was catheterized when indicated. Iodinated contrast medium was used for all angiographic injections.

A coaxial microcatheter system (Carnelian, Tokai Medical, Japan) with a diameter of 1.9F–2.7F, selected according to the target vessel caliber was then advanced through the diagnostic catheter to perform selective angiography of the suspected bleeding site. When necessary, cone-beam computed tomography (CBCT) was performed either through the diagnostic catheter or selectively via the microcatheter to better localize the bleeding source. All procedures were performed with a digital subtraction angiography system (Artis zee, Siemens Healthcare, Forchheim, Germany) under standard fluoroscopic guidance.

Angiographic findings were categorized as direct or indirect signs of bleeding. Direct findings included contrast extravasation and pseudoaneurysm formation. Indirect findings included vascular irregularity, vasospasm, and abnormal mucosal or tumoral blush. Embolization was performed when there was direct evidence of active bleeding or indirect signs suggestive of ongoing hemorrhage. In addition, when no angiographic signs of bleeding were identified, empiric embolization was performed if supported by complementary findings from endoscopy, colonoscopy, computed tomography angiography (CTA), or red blood cell scintigraphy.

Embolic agents used in this study included detachable coils (Prestige Plus, Balt, France), calibrated microspheres (Embosphere, Merit Medical, USA), and a mixture of n-butyl-2-cyanoacrylate (NBCA; Histoacryl, B. Braun, Germany) and Lipiodol (Lipiodol Ultra Fluid, Guerbet, France). Coils were selected according to the vessel anatomy and diameter. Microspheres were generally preferred in patients with tumoral blush to achieve distal embolization, whereas NBCA was chosen in cases of vasospasm or massive hemorrhage requiring rapid occlusion. NBCA was mixed with lipiodol in ratios ranging from 1:4 to 1:8, determined by the vessel diameter and whether proximal or distal embolization was intended.

Technical success was defined as the successful embolization of the intended target vessel or vascular territory, with achievement of the planned angiographic endpoint; this definition included empiric embolization of the arterial supply to the suspected bleeding site when supported by preprocedural localization. Clinical success was defined as immediate hemostasis and the absence of rebleeding during follow-up.

Definitions of clinical outcomes

The primary outcomes of this study were rebleeding and in-hospital mortality. Rebleeding was defined as the recurrence of hematemesis, melena, or hematochezia after initial stabilization, associated with either a decrease in hemoglobin of

https://doi.org/10.5455/annalsmedres.2025.10.306

≥2 g/dL or the need for an additional transfusion or urgent intervention within 30 days. Secondary outcomes included length of hospital stay and overall mortality during follow-up. Procedure-related complications were also assessed and classified according to the Society of Interventional Radiology (SIR) guidelines as minor or major adverse events.

Statistical analysis

Statistical analysis was performed using SPSS Statistics software version 24.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation, median, and minimum–maximum values, whereas categorical variables were presented as counts and percentages. The Shapiro–Wilk test was used to assess normality and the Levene test to evaluate homogeneity of variances. For comparisons between groups, an independent-samples t-test was used for normally distributed variables, whereas the Mann–Whitney U test was used for non-normally distributed variables. Associations between categorical variables were analyzed using Pearson's chi-square test, and effect sizes were quantified using the Phi coefficient for 2×2 contingency tables or Cramér's V for larger contingency tables. Correlations between continuous variables were assessed with Pearson's or Spearman's correlation coefficients, depending on distributional assumptions. A p-value <0.05 was considered statistically significant for all tests.

Because this retrospective cohort included all consecutive patients undergoing TAE within the study period, no a priori sample size calculation was performed. Post hoc power analyses were conducted. These analyses were based on observed effect sizes obtained from the dataset and were performed using two-sided tests with an α level of 0.05. Power values were calculated for categorical comparisons (Chi-square tests) and for continuous variables (correlation analyses) to assess whether the major associations investigated had adequate statistical power.

RESULTS

Patient characteristics

The study cohort consisted of 14 women and 36 men, with a mean age of 64.8 ± 16.7 years (median, 64.5 years; range, 15–92 years). Seven patients (14%) presented with lower gastrointestinal bleeding, while 43 patients (86%) had upper gastrointestinal bleeding (Table 1).

The most frequent symptom was melena, observed alone (n=23, 46%), in combination with hematemesis (n=9, 18%), or with hematochezia (n=7, 14%). Isolated hematemesis occurred in 6 patients (12%) and isolated hematochezia in 3 patients (6%). In addition, bleeding was detected in the surgical drains of two patients (4%).

Eleven patients (22%) had no comorbid conditions. Malignancy was present in 22 patients (44%); 12 had gastrointestinal malignancies and 10 had non-gastrointestinal malignancies. Fourteen patients (28%) had systemic diseases, including diabetes mellitus, hypertension, coronary artery disease, chronic kidney disease, liver cirrhosis, and cerebrovascular disease. In addition, three patients (6%) had bleeding disorders (immune thrombocytopenic purpura or von Willebrand factor deficiency). Nineteen patients had one comorbidity; nine had two comorbidities; nine had three comorbidities; one had four comorbidities; and one had five comorbidities.

Regarding medication history, 12 patients (24%) were receiving antiplatelet or anticoagulant therapy, and 9 (18%) were undergoing chemotherapy. 25 patients (50%) had no regular medications, while 4 patients (8%) were receiving other medications, including steroids, anti-HIV therapy, and antiparkinsonian medications.

Pre-procedural laboratory values and transfusion

Mean pre-procedural hemoglobin, platelet count, and INR were 7.2 ± 1.3 g/dL (range: 4.2–10.5), 166 ± 90 $\times 10^9$/L (range: 29–428), and 1.28 ± 0.18 (range: 1.05–1.81), respectively. The median lactate level was 1.1 mmol/L (range: 0.4–16.0). The median number of units of pRBCs transfused prior to the procedure was 6.5 (range: 1–26); the mean was 8.3 ± 5.6 (Table 2). The mean interval between symptom onset and TAE was 4.7 ± 3.7 days (median: 4.0 days, range: 0–15 days).

Endoscopic evaluation and risk stratification

Except for the two patients who presented with bleeding from surgical drains and one patient with a prior gastrectomy, all pa-

Table 1. Baseline demographic and clinical characteristics

Variable	Value
Age (years)	64.8 ± 16.7 (median 64.5; range 15-92)
Sex	
- Male	36 (72%)
- Female	14 (28%)
Bleeding site	
- Upper GI	43 (86%)
- Lower GI	7 (14%)
History of GI bleeding	
- No	35 (70%)
- Yes	15 (30%)
Comorbidity count	
- 0	11 (22%)
- 1	19 (38%)
- 2	9 (18%)
- 3	11 (22%)
Medication	
- None	25 (50%)
- Antiplatelet/anticoagulant	12 (24%)
- Chemotherapy	9 (18%)
- Other (steroid, anti-HIV, anti-parkinsonian)	4 (8%)

GI: Gastrointestinal.

https://doi.org/10.5455/annalsmedres.2025.10.306

Table 2. Pre-procedural laboratory values and diagnostic work-up.

Variable	Value
Pre-procedural Hb (g/dL)	7.2 ± 1.3 (range 4.2-10.5)
Pre-procedural Plt (×10³/μL)	166 ± 90 (range 29-428)
Pre-procedural INR	1.28 ± 0.18 (range 1.05-1.81)
Pre-procedural lactate (mmol/L)	1.8 ± 2.4 (range 0.4-16.0)
Blood transfusion requirement (units of pRBCs)	8.3 ± 5.6 (median 6.5; range 1-26)
Endoscopy/colonoscopy	
-Not performed	2 (4%)
-Positive findings	44 (88%)
-Negative findings	4 (8%)
Rockall score	5.0 ± 1.8 (range 2-9)
Forrest classification	37
-1a	8
-1b	16
-2	10
-3	3
CTA/red blood cell scintigraphy	
-Not performed	25 (50%)
-Positive findings	16 (32%)
-Negative findings	9 (18%)

Hb: Hemoglobin; Plt: Platelet count; INR: International Normalized Ratio; pRBCs: packed Red Blood; Cells; CTA: Computed Tomography Angiography.

Table 3. Procedural findings, embolization details and outcomes.

Variable	Value
Time from symptom onset to DSA (days)	4.7 ± 3.7 (median 4; range 0-15)
DSA/CBCT	
- Positive findings	
• extravasation	18 (36%)
• blush	13 (26%)
• vasospasm	4 (8%)
• pseudoaneurysm	2 (4%)
• vascular irregularity	1 (2%)
- Negative findings	12 (24%)
Embolic agents	
-None	3 (6%)
-Coils	31 (62%)
-Microspheres	9 (18%)
-NBCA	7 (14%)
Number of embolized vessels	
-None	3 (6%)
-1	38 (76%)
-≥2	9 (18%)
Periprocedural complications	
-Minor	2 (4%)
-Major	1 (2%)

DSA: Digital Subtraction Angiography; CBCT: Cone-beam Computed Tomography; NBCA: N-butyl-2-cyanoacrylate.

tients underwent either an upper endoscopy or a colonoscopy prior to angiography.

Endoscopic findings were negative in 4 patients (8%). Among the patients with ulcer bleeding (n=37), Forrest classification revealed that the majority were classified as Ib (43.2%), followed by Ia (21.6%); the remainder were distributed across IIa, IIb, IIc, and III categories. The mean Rockall score for the entire cohort was 5.0 ± 1.8 (median, 5; range, 2–9) (Table 2).

Procedural findings

Angiographic evaluation revealed contrast extravasation (Figure 1) in 17 patients (34%) and tumoral blush (Figure 2) in 12 patients (24%); these were the most frequent angiographic findings. No angiographic abnormality was detected in 14 patients (28%); however, cone-beam CT demonstrated mucosal blush or extravasation in two of these patients.

Embolization was not performed in 3 patients (6%): in 2 patients (4%) because there was no bleeding and therefore no

https://doi.org/10.5455/annalsmedres.2025.10.306

Table 4. Outcomes.

Outcome		
Rebleeding	15 (30%)	Comorbidity status: p=0.035 -Malignancy (45.5%) -Systemic or bleeding disorders (29.4%) -None (0%) Multivessel embolization: p=0.006 Negative endoscopic findings: p=0.035
Management of rebleeding -Conservative -Repeat embolization -Surgery	 6 (12%) 6 (12%) 4 (8%)	
In-hospital mortality	16 (32%)	Rockall score: p=0.001 Plt count(inversely correlated): p=0.037
Overall mortality	26 (52%)	Rockall score: p=0.032 INR: p=0.005
Length of hospital stay (days) *	15.5 ± 8.1 (median 14; range 1-43)	Number of comorbidities: p=0.019 Transfusion requirement: p<0.001 Bleeding to TAE time: p<0.001 Hb (inversely correlated): p=0.042

Plt: Platelet count; INR: International Normalized Ratio; Hb: Hemoglobin. * The length of hospital stay was calculated after excluding patients who died during the index hospitalization.

indication for empiric embolization, and in 1 patient (2.1%) because catheterization of the left gastric artery failed (technical failure). Accordingly, the overall technical success rate was 97.9% (47/48). Among the 47 patients who underwent embolization, 38 (81%) underwent single-vessel embolization, while 9 (19%) underwent embolization of multiple vessels (≥2). Coils were the most frequently used embolic material, applied in 31 patients (66%). Microspheres were used in 9 patients (19%) and NBCA-lipiodol mixture was used in 7 patients (15%).

Three patients (6%) experienced periprocedural complications. Minor complications consisted of two femoral access-site hematomas, both of which were managed conservatively. One major complication was non-target embolization that led to ischemia in a patient who subsequently required surgery because hemostasis could not be achieved.

Rebleeding

Rebleeding occurred in 15 patients (30%) within 30 days after the index procedure. The majority of rebleeding episodes (12 of 15, 80%) occurred during the first week.

When patients were stratified by comorbidity status, no rebleeding was observed in those without comorbidities (0/11, 0%). Rebleeding occurred in 10 of 22 patients (45.5%) with malignancy, the majority of whom (9 patients) had underlying gastrointestinal cancers. Among 17 patients with systemic diseases or bleeding disorders, rebleeding was observed in 5 (29.4%). This association was statistically significant ($\chi^2(2) = 6.705$, $p = 0.035$), with a moderate effect size (φ/Cramér's $V = 0.370$).

Rebleeding was also significantly associated with the number of embolized vessels. Rebleeding occurred in 8 of 38 patients (21.1%) who underwent single-vessel embolization, compared with 6 of 9 patients (66.7%) in the multiple-vessel group. This difference was statistically significant (Fisher's exact test, $p = 0.006$) and had a moderate-to-strong effect size (Phi = 0.444).

Furthermore, patients with negative endoscopic or colonoscopic findings prior to embolization (n = 4) had a markedly higher rate of rebleeding (3/4, 75%) compared with those with positive endoscopic findings (11/43, 25.6%). This association was statistically significant ($\chi^2(1)=4.437$, $p=0.035$), with a moderate effect size (Phi=0.304).

No significant associations were found between rebleeding and pre-procedural laboratory values (hemoglobin, INR, platelet count, lactate), age, sex, time from symptom onset to procedure, Forrest classification, Rockall score, or the type of embolic agent used (all $p > 0.05$).

Among the 15 patients who developed rebleeding, 6 were managed conservatively (1 in-hospital death), 5 underwent repeat TAE (1 in-hospital death), and 4 required surgery (3 in-hospital deaths).

Mortality

In-hospital mortality occurred in 16 patients (32%). A significant association was observed between the Rockall score and in-hospital mortality ($p = 0.001$). In addition, pre-procedural platelet levels were significantly lower in patients who died in the hospital (128 ± 73 vs. $184 \pm 92 \times 10^3/\mu L$, $p = 0.037$). No significant associations were found with other laboratory parameters (hemoglobin, INR, lactate).

When medication groups (chemotherapy, antiplatelet/anticoagulant therapy, and no regular medication) were analyzed, no

https://doi.org/10.5455/annalsmedres.2025.10.306

statistically significant association between medication group and in-hospital mortality was found (p = 0.209).

In-hospital mortality was higher in patients with comorbidities than in those without (36% vs. 18%; odds ratio approximately 2.5), although the difference was not statistically significant (p = 0.266). When stratified by comorbidity burden, mortality rates were 18.2% for no comorbidities, 36.8% for one comorbidity, 22.2% for two comorbidities, and 45.5% for three or more comorbidities. While these findings suggest a trend toward increased mortality with higher comorbidity burden, the association did not reach statistical significance (p = 0.479).

Overall mortality was 52% (26/50) during follow-up, which ranged from 4 to 28 months (median 16 months). Both pre-procedural INR (p = 0.005) and Rockall score (p = 0.032) were significantly associated with overall mortality, whereas other baseline laboratory and demographic parameters were not significantly associated (all p>0.05). Mortality was 27.3% in patients without comorbidities, compared with 54.5% in those with malignancies and 64.7% in those with systemic diseases or bleeding disorders. Similarly, overall mortality varied by comorbidity burden: 63.2% in patients with one comorbidity, 55.0% in those with two or more, and 27.3% in those without comorbidities. Although these findings suggest a clinically relevant trend toward higher overall mortality in patients with comorbidities, the differences did not reach statistical significance (p = 0.146 for type; p = 0.156 for count).

Length of stay

Length of hospital stay (LOS) was analyzed for the 34 patients discharged alive; patients with in-hospital mortality were excluded. The mean LOS was 15.5 ± 8.1 days, with a median of 14 days (range: 1–43 days).

A significant positive correlation was also found between the number of comorbidities and LOS (r=0.399, p=0.019). Similarly, LOS was positively correlated with units of pRBCs transfused (r = 0.593, p<0.001) and with the time interval between symptom onset and embolization (r = 0.636, p < 0.001). Pre-procedural hemoglobin levels were inversely correlated with LOS (r = -0.350, p = 0.042), indicating that patients with lower baseline hemoglobin had longer hospital stays.

No significant associations were found between LOS and age, sex, platelet count, INR, Rockall score, Forrest classification, angiographic findings, or the type of embolic agent used (all p>0.05).

Procedural findings and outcomes are summarized in Tables 3 and 4.

Post hoc power analyses demonstrated that the association between multivessel embolization and rebleeding (χ^2 = 9.08, w ≈ 0.44, N = 47) had statistical power of approximately 0.85. The correlation between length of stay and transfusion requirement (r = 0.59, n = 34) showed a power of approximately 0.98. For moderate correlations, such as the relationship between length of stay and comorbidity count (r≈0.40; n=34), the achieved power was approximately 0.70. Smaller effect sizes yielded correspondingly lower power levels.

DISCUSSION

In our study, TAE demonstrated a high technical success rate and acceptable clinical outcomes, consistent with previously published reports. While the efficacy and safety of TAE have been well documented in both upper and lower GI bleeding, considerable variability persists across studies with regard to rebleeding, mortality, and complication rates. Therefore, placing our results in the context of current evidence provides valuable insights into patient selection, procedural factors, and outcome predictors. Moreover, current international guidelines recommend TAE as the preferred second-line therapy after failed endoscopy, reserving surgery for refractory cases [10,11].

Our rebleeding rate of 30% falls within the broad range of 9–56% reported in prior studies [12–15]. Importantly, our findings underscore specific risk factors for recurrence. Rebleeding was significantly more common in patients with malignancy (particularly gastrointestinal cancers), in those undergoing multi-vessel embolization, and in those in whom no bleeding source was identified endoscopically prior to TAE. These factors have also been highlighted in previous reports. Dablan et al., focusing exclusively on non-variceal upper GI bleeding, identified multi-vessel embolization and comorbidity as predictors of recurrence [16], while Yu et al., in a meta-analysis of lower GI bleeding, found malignancy and coagulopathy to be significant risk factors [17]. In addition, Lee et al. reported a rebleeding rate of 37.3% in a mixed cohort of upper and lower GI bleeding, with coagulopathy and massive transfusion independently associated with recurrence [15]. Extrat et al. similarly reported an early rebleeding rate of 25% and identified the units of pRBCs as the main predictor of recurrence [18]. By contrast, we observed no significant association between rebleeding and demographic variables, baseline laboratory parameters, or embolic material. Taken together, our results suggest that rebleeding after TAE is determined more strongly by underlying disease burden, procedural complexity, and the adequacy of bleeding source localization than by demographic characteristics or the choice of embolic agent.

In-hospital mortality was 32, and overall mortality during follow-up was 52%. These rates are relatively high compared with those in the most recent series, in which 30-day mortality has been the primary outcome. Ozen et al. [13] reported a 30-day mortality rate of 22%; Lee et al. [15] reported a rate of 18.6%; and Loffroy's meta-analysis reported a wide range from 4% to 46% [12]. Dablan et al. [16] reported a 30-day mortality rate of 48.2%, which is broadly comparable to that observed in our population. Extrat et al. observed a 30-day mortality rate of 22.1%, with hyperlactatemia (≥2 mmol/L) emerging as the strongest predictor of early mortality [18].

https://doi.org/10.5455/annalsmedres.2025.10.306

We identified higher Rockall scores and lower platelet counts as predictors of in-hospital mortality, while elevated INR and Rockall scores were associated with overall mortality. The finding that INR was not predictive of short-term mortality but was predictive of long-term outcomes is particularly noteworthy because it may reflect the influence of subclinical coagulation abnormalities, frailty, and the cumulative burden of comorbidities beyond the acute hemodynamic phase of bleeding.

Rockall score, by contrast, consistently correlated with both in-hospital and overall mortality, as expected given its established prognostic value. Compared with prior studies, our results partially diverge; Yu et al. [17] highlighted coagulopathy, malignancy, and massive transfusion as predictors of mortality, while Lee et al. [15] identified coagulopathy as a significant factor.

In our series, malignancy and transfusion burden were not statistically significant, though clinically relevant trends were observed. Another important observation is that overall mortality rates substantially exceeded in-hospital mortality rates, underscoring the long-term vulnerability of this patient group, particularly those with malignancy and systemic disease. This emphasizes the need for structured long-term follow-up and multidisciplinary management, including oncology, internal medicine, and supportive care teams [19].

The mean length of stay (LOS) was 15.5 days, calculated only for patients discharged alive to avoid spuriously shortened LOS values due to early in-hospital deaths. This survivor-only approach provides a more accurate reflection of the hospitalization burden, yet it makes direct comparisons with prior studies difficult, as LOS has rarely been systematically reported in TAE cohorts. Among the few that did report, Nykänen et al. [20] documented a median LOS of 7 days (range, 1–91) after TAE for lower GI bleeding, which is considerably shorter than that observed in our series. Extrat et al. [18] similarly reported a median LOS of around 12 days following TAE, while Twene et al. [21], in a comparative analysis, demonstrated that patients treated with TAE had shorter hospitalizations than those undergoing surgery. Our finding of a longer LOS likely reflects, in our cohort, the higher comorbidity burden, greater transfusion requirements, delayed embolization, and lower baseline hemoglobin levels. These associations are consistent with prior observations that disease severity, massive transfusion, and low hemoglobin are more influential than procedural variables in determining resource utilization after TAE. Taken together, our results suggest that prolonged LOS in this setting primarily reflects underlying disease complexity and delayed presentation rather than the embolization procedure itself, underscoring the importance of early referral and optimization of preprocedural status.

Procedure-related complications occurred in three patients (6%), consisting of two minor femoral access-site hematomas and one major event that was identified intraoperatively in a patient who underwent surgery for persistent bleeding. This rate is at the lower end of the spectrum reported in the literature, where complication rates vary widely from 0% to 26% [12]. Extrat et al. observed peri- and post-procedural complications in nearly 30% of cases, with ischemia being the most frequent adverse event, and Nykänen et al. reported a complication rate of 36% in lower GI bleeding [18,20]. Compared with these findings, our series demonstrates a relatively low complication burden, which may reflect the use of superselective techniques. Importantly, consistent with previous reports, we found no significant difference between empiric and selective embolization with respect to complications or clinical outcomes [22,23]. This supports current evidence that empiric embolization, when guided by reliable pre-procedural findings, is a safe and effective option for carefully selected patients. Overall, TAE offers an acceptable safety profile and remains a less invasive and safer option compared with surgery for refractory gastrointestinal bleeding.

Limitations

This study has several limitations that should be acknowledged. First, its retrospective and single-center design may introduce selection bias and limit the generalizability of our findings. Second, the sample size was relatively small, which may have reduced the statistical power to detect associations for some variables and may partly explain the discrepancies with previous reports. Third, although we analyzed both upper and lower gastrointestinal bleeding together to reflect real-world practice, this heterogeneity may have influenced the outcome measures, because prognostic factors can differ between these populations. Fourth, variations in embolic materials and empirical versus selective embolization techniques were determined by clinical context rather than by random allocation, which may have introduced procedural bias. And finally, non-significant associations with small-to-moderate effect sizes should be interpreted with caution, as post-hoc power analyses indicated limited statistical power for detecting weaker effects.

CONCLUSION

Transcatheter arterial embolization (TAE) is a safe and effective option for non-variceal gastrointestinal bleeding refractory to endoscopic therapy, offering high technical success rates and low complication rates. Rebleeding was primarily linked to malignancy, multi-vessel embolization, and negative endoscopic findings, while mortality correlated with Rockall score, platelet count, and INR. These results emphasize that outcomes are mainly determined by comorbidity burden and disease severity rather than procedural technique. Overall, TAE remains a less invasive and reliable alternative to surgery.

Ethics Committee Approval: Approved by the Ethics Committee of Kayseri City Hospital, Non-Interventional Clinical Research (Approval No:548).

https://doi.org/10.5455/annalsmedres.2025.10.306

Informed Consent: This was not deemed necessary because the study was retrospective.

Peer-review: Externally peer-reviewed.

Conflict of Interest: The authors declared no competing interests.

Author Contributions: S.K. and M.B. contributed to the conception and design of the study. S.K. wrote the paper. S.K., O.A., and F.O. performed data collection and image analysis. N.B.K. and G.T. contributed to statistical analysis and interpretation of results. All authors participated in drafting and critically revising the manuscript, approved the final version, and agree to be accountable for the integrity of the work.

Financial Disclosure: No financial support was obtained for this study.

Artificial Intelligence Disclosure: The authors declare that an artificial intelligence–based tool (ChatGPT, OpenAI, version 5.0) was used solely for language editing and improving the clarity and readability of the manuscript. The AI tool did not contribute to the study design, data analysis, interpretation of results, or scientific conclusions. All content was critically reviewed and approved by the authors, who take full responsibility for the manuscript.

REFERENCES

1. Barkun AN, Almadi M, Kuipers EJ, et al. Management of Nonvariceal Upper Gastrointestinal Bleeding: Guideline Recommendations From the International Consensus Group. *Ann Intern Med.* 2019;171(11):805-822. doi: 10.7326/M19-1795.
2. Laine L, Jensen DM. Management of Patients With Ulcer Bleeding. *Am J Gastroenterol.* 2012;107(3):345-60. doi: 10.1038/ajg.2011.480.
3. Oakland K. Changing epidemiology and etiology of upper and lower gastrointestinal bleeding. *Best Pract Res Clin Gastroenterol.* 2019;42-43:101610. doi: 10.1016/j.bpg.2019.04.003.
4. Strate LL, Gralnek IM. ACG Clinical Guideline: Management of Patients With Acute Lower Gastrointestinal Bleeding. *Am J Gastroenterol.* 2016;111(4):459-74. doi: 10.1038/ajg.2016.41.
5. Kamboj AK, Hoversten P, Leggett CL. Upper Gastrointestinal Bleeding: Etiologies and Management. *Mayo Clin Proc.* 2019;94(4):697-703. doi: 10.1016/j.mayocp.2019.01.022.
6. Ghassemi KA, Jensen DM. Lower GI bleeding: epidemiology and management. *Curr Gastroenterol Rep.* 2013;15(7):333. doi: 10.1007/s11894-013-0333-5.
7. Loffroy R, Favelier S, Pottecher P, et al. Transjugular intrahepatic portosystemic shunt for acute variceal gastrointestinal bleeding: Indications, techniques and outcomes. *Diagn Interv Imaging.* 2015;96(7-8):745-55. doi: 10.1016/j.diii.2015.05.005.
8. Ini' C, Distefano G, Sanfilippo F, et al. Embolization for acute nonvariceal bleeding of upper and lower gastrointestinal tract: a systematic review. *CVIR Endovasc.* 2023;6(1):18. doi: 10.1186/s42155-023-00360-3.
9. Chevallier O, Comby PO, Guillen K, et al. Efficacy, safety and outcomes of transcatheter arterial embolization with N-butyl cyanoacrylate glue for non-variceal gastrointestinal bleeding: A systematic review and meta-analysis. *Diagn Interv Imaging.* 2021;102(7-8):479-487. doi: 10.1016/j.diii.2021.03.004.
10. Gralnek IM, Dumonceau JM, Kuipers EJ, et al. Diagnosis and management of nonvariceal upper gastrointestinal hemorrhage: European Society of Gastrointestinal Endoscopy (ESGE) Guideline. *Endoscopy.* 2015;47(10):a1–a46. doi: 10.1055/s-0034-1393172.
11. Laine L, Barkun AN, Saltzman JR, Martel M, Leontiadis GI. ACG Clinical Guideline: Upper Gastrointestinal and Ulcer Bleeding. *Am J Gastroenterol.* 2021;116(5):899-917. doi: 10.14309/ajg.0000000000001245.
12. Loffroy R, Rao P, Ota S, De Lin M, Kwak BK, Geschwind JF. Embolization of acute nonvariceal upper gastrointestinal hemorrhage resistant to endoscopic treatment: results and predictors of recurrent bleeding. *Cardiovasc Intervent Radiol.* 2010;33(6):1088-1100. doi: 10.1007/s00270-010-9829-7.
13. Ozen C, Al-Hashimi M, Tornby Stender M, Thorlacius-Ussing O, Larsen AC. Transarterial embolization of gastroduodenal peptic ulcer bleeding: a single-center study of safety and efficacy. *Langenbecks Arch Surg.* 2025;410(1):117. doi: 10.1007/s00423-025-03695-8.
14. Matsumoto T, Yoshimatsu R, Shibata J, et al. Transcatheter arterial embolization of nonvariceal gastrointestinal bleeding with n-butyl cyanoacrylate or coils: a systematic review and meta-analysis. *Sci Rep.* 2024;14(1):27377. doi: 10.1038/s41598-024-79133-4.
15. Lee S, Kim T, Han SC, Pak H, Jeon HH. Transcatheter arterial embolization for gastrointestinal bleeding: Clinical outcomes and prognostic factors predicting mortality. *Medicine (Baltimore).* 2022;101(31):e29342. doi: 10.1097/MD.0000000000029342.
16. Dablan A, Uluman YB, Güzelbey T, Cingöz M, Kınacı E, Kılıçkesmez Ö. Identifying Predictors of Early Rebleeding Following Transcatheter Embolization in Acute Non-Variceal Upper Gastrointestinal Bleeding: A Retrospective Analysis. *Osmangazi Journal of Med.* 2025;47(4):556-566. doi: 10.20515/otd.1578761.
17. Yu Q, Funaki B, Ahmed O. Twenty years of embolization for acute lower gastrointestinal bleeding: a meta-analysis of rebleeding and ischaemia rates. *Br J Radiol.* 2024;97(1157):920-932. doi: 10.1093/bjr/tqae037.
18. Extrat C, Grange S, Mayaud A, et al. Transarterial Embolization for Active Gastrointestinal Bleeding: Predictors of Early Mortality and Early Rebleeding. *J Pers Med.* 2022;12(11):1856. doi: 10.3390/jpm12111856.
19. Oakland K, Chadwick G, East JE, Guy R, Humphries A, Jairath V. Diagnosis and management of acute lower gastrointestinal bleeding: guidelines from the British Society of Gastroenterology. *Gut.* 2019;68(5):776–789. doi: 10.1136/gutjnl-2018-317807.
20. Nykänen T, Peltola E, Kylänpää L, Udd M. Transcatheter Arterial Embolization in Lower Gastrointestinal Bleeding: Ischemia Remains a Concern Even with a Superselective Approach. *J Gastrointest Surg.* 2018;22(8):1394-1403. doi: 10.1007/s11605-018-3728-7.
21. Twene P, Ogunti R, Asemota J, et al. In-Hospital Outcomes of Transcatheter Arterial Embolization vs Surgical Control of Refractory Bleeding Peptic Ulcer Disease: A Propensity Score-Matched Analysis. *Am J Gastroenterol.* 2020;115(Suppl):S296. doi: 10.14309/01.ajg.0000704416.26752.a6.
22. Yu Q, Funaki B, Navuluri R, et al. Empiric Transcatheter Embolization for Acute Arterial Upper Gastrointestinal Bleeding: A Meta-Analysis. *AJR Am J Roentgenol.* 2021;216(4):880-893. doi: 10.2214/AJR.20.23151.
23. Hermie L, Dhondt E, Vanlangenhove P, De Waele J, Degroote H, Defreyne L. Empiric cone-beam CT-guided embolization in acute lower gastrointestinal bleeding. *Eur Radiol.* 2021;31(4):2161-2172. doi: 10.1007/s00330-020-07232-7.