Predictors of in-hospital outcomes for diverticular bleeding patients: a retrospective analysis of National Inpatient Sample data (2016-2020)

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Abstract

Background Diverticular bleeding is the leading cause of lower gastrointestinal bleeding, affecting 3-5% of patients with diverticulosis. Current management protocols include resuscitation, diagnosis via direct visualization, computed tomography imaging, endoscopic interventions, angioembolization, and surgery when needed. However, predictive factors for outcomes and optimal interventions remain ambiguous.

Methods This retrospective cohort study analyzed data from the National Inpatient Sample (NIS) database (2016-2020) to determine predictors of adverse in-hospital outcomes in diverticular bleeding patients without perforation or abscess. Demographic and clinical data were extracted, and multivariate regression models were applied. Analysis was conducted using R statistical software (version 4.1.3), with significance set at $P<0.05$.

Results A total of 28,269 patients hospitalized for diverticular bleeding were identified. Age >85 years, moderate to severe Charlson Comorbidity Index, hypovolemic shock, blood transfusion requirement, and requirement for colectomy were significantly associated with greater in-hospital mortality. Factors such as late colonoscopy timing and colon resection led to longer hospital stays, while arterial embolization was predicted by older age, Black race, hypovolemic shock, and blood transfusion. Predictors of colon resection included advanced age, presence of colon cancer, and hypovolemic shock.

Conclusions Our retrospective study identified significant predictors of in-hospital outcomes among patients with diverticular bleeding, informing risk stratification and management strategies. Further research is warranted to validate these findings and refine management algorithms for improved patient care. Integrating these insights into clinical practice may enhance outcomes and guide personalized interventions in diverticular bleeding management.

Keywords Diverticular bleeding, gastrointestinal bleeding, colonoscopy, arterial embolization

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Introduction

About half of people aged 60 and higher have diverticulosis and the incidence is rising, predominantly in the age groups 18-64. Bleeding diverticulosis is the most common cause of lower gastrointestinal hemorrhage and is a major contributor to hospitalization burden, given the risk of recurrence [1]. The vast majority of bleeding episodes subside spontaneously, though death occurs in up to 5% of cases [2]. Although the pathogenesis is unclear, it is hypothesized that repetitive injury to the *vasa recta* from muscular contraction is the reason behind bleeding. Risk factors include non-steroidal anti-inflammatory drugs (NSAIDs), anti-coagulants, and hypertension [3]. Our study aimed to investigate the predictors of adverse outcomes related to diverticular bleeding, with a focus on mortality, length of stay, and requirement for embolization or colonic resection.

Materials and methods

Study design and data source

Data for this retrospective cohort study were collected from the National Inpatient Sample (NIS) database, provided by Healthcare Cost and Utilization Project, for the period from January 1, 2016, to December 31, 2020 [4]. NIS is the largest, all-payer, inpatient care database publicly available in the United States and represents approximately 20% of all discharges in United States hospitals. It stores de-identified information about individual hospitalizations, including demographic characteristics, diagnoses and procedures in the form of ICD-10-CM codes (International classification of Diseases, Tenth Revision, Clinical Modification) [5]. The database's internal validity is maintained by annual quality assessments, and its external validity is preserved through comparison with the National Hospital Discharge Survey from the National Center for Health Statistics, American Hospital Association Annual Survey Database, and the MedPAR inpatient data from the Centers for Medicare and Medicaid Services [6].

Ethical considerations

The NIS database, devoid of personal identifiers, is exempt from Institutional Review Board approval in view of its retrospective nature. Formal consent was unnecessary for this study, given its retrospective design and the absence of personal identifiers in the registry data.

Study population

Using the NIS data, patients aged 18 years and above, admitted with diverticular bleeding without perforation or abscess between January 1, 2016 and December 31, 2020, were included in this study. ICD-10-CM diagnosis codes K57.31 and K57.51 were used to identify patients admitted for diverticular bleeding without perforation or abscess. Only the primary and secondary discharge diagnoses columns were screened for these codes, to ensure that the hospital admission was specifically for diverticular bleeding.

Study objective

The primary objective of this study was to understand the predictors of adverse in-hospital outcomes in patients admitted for diverticular bleeding without perforation or abscess. The primary outcome assessed in this study was all-cause in-hospital mortality during the index hospitalization. Secondary outcomes assessed were length of stay, need for arterial embolization, and colonic resection.

Study variables

Demographic variables including age, sex and race/ethnicity, and clinical variables such as comorbid medical conditions, were directly extracted from the NIS data. Age was recorded as a categorical variable with 4 levels. Long-term use of antiplatelet and anticoagulant medication, NSAIDs or systemic steroids was identified using specific ICD-10-CM codes (Supplementary Table 1). Data on blood transfusion, arterial embolization, colonoscopy and resection were extracted using the corresponding ICD-10-PCS (International Classification of Diseases, Tenth Revision, Procedure Coding System) codes (Supplementary Table 2). Time from admission to first colonoscopy was recorded as a binary categorical variable: early (within 24 h) or late (after 24 h). Data on inpatient mortality and length of stay were extracted directly from the NIS data.

Statistical analysis

Continuous variables were summarized using means and standard deviations and compared using a *t*-test. Categorical variables were summarized using proportions and compared using the chi-square test. Bivariate analyses were performed using simple linear and logistic regression models for continuous and categorical variables, respectively. Multivariate regression models were then developed using predictor variables that were found to have statistically significant association with the outcome variables in the bivariate analyses. Multivariate logistic regression models were used for hospital mortality, arterial embolization and colonic resection. For length of stay a multivariate linear regression model was used. A forward selection method was used to find the optimal model with the best fit. The odds ratio (OR) and beta coefficient outputs of the regression models were reported with a 95% confidence interval, at a 0.05 level of significance. All data cleaning and analysis were performed using R statistical software version 4.1.3 (2023) [7].

Results

Patient characteristics

A total of 28,269 patients hospitalized for diverticular bleeding between 2016 and 2020 were included in our study. Mean age was 75±11 years, and 51% of the patients were male. The majority of patients identified as White, comprising 64% of the total. In this population, 93% of all patients underwent at least 1 colonoscopy during their hospitalization. Hypovolemic shock, defined as shock resulting from insufficient blood volume for maintenance of adequate cardiac output, blood pressure and tissue perfusion, occurred in 5.7% of all admissions. Hypovolemic shock was significantly more frequent in patients who died in comparison to those who were alive at discharge (31% in Deceased vs. 5.5% in Alive) (Table 1).

Table 1 Baseline patient characteristics

Characteristics	Categories	Overall	Alive	Deceased	P-value
Total ±(n)		28269	28044	219	
Age (years), mean±SD		75.3±11.3	75.3±11.3	78.2±10.3	<0.001
Age categories (%)	<65	5297±18.7	5272±18.8	25±11.4	0.002
	65-74	6441±22.8	6391±22.8	46±21.0	
	75-84	9752±34.5	9675±34.5	75±34.2	
	>85	6779±24.0	6706±23.9	73±33.3	
Sex (%)	Male	14425±51.0	14299±51.0	122±55.7	0.186
	Female	13841±49.0	13742±49.0	97±44.3	
Race/Ethnicity (%)	White	17547±63.7	17392±63.6	152±70.0	0.350
	Black	6437±23.4	6394±23.4	41±18.9	
	Hispanic	2119±7.7	2105±7.7	13±6.0	
	Asian/Pacific Islander	752±2.7	747±2.7	5±2.3	
	Native American	117±0.4	117±0.4	0±0.0	
	Other	586±2.1	580±2.1	6±2.8	
Charlson Comorbidity Index (%)	Mild	18598±65.8	18507±66.0	86±39.3	<0.001
	Moderate	5747±20.3	5665±20.2	82±37.4	
	Severe	3924±13.9	3872±13.8	51±23.3	
Colon cancer (%)		120±0.4	118±0.4	2±0.9	0.552
Chronic kidney disease		7013±24.8	6928±24.7	84±38.4	<0.001
Moderate to severe liver disease		417±1.5	400±1.4	16±7.3	<0.001
Long term NSAID use		855±3.0	853±3.0	2±0.9	0.102
Long term antiplatelet/anticoagulant use		7062±25.0	7017±25.0	44±20.1	0.110
Long term steroid use		503±1.8	498±1.8	5±2.3	0.757
Hypovolemic shock		1605 (5.7	1537 (5.5	68 (31.1	<0.001
Blood transfusion during hospitalization		9916±35.1	9796±34.9	119±54.3	<0.001
Number of units transfused	No transfusion	18353±64.9	18248±65.1	100±45.7	<0.001
	1-2 units	9711±34.4	9597±34.2	113±51.6	
	3-4 units	171±0.6	165±0.6	6±2.7	
	More than 4 units	34±0.1	34±0.1	0±0.0	
Time from hospitalization to first colonoscopy	<24 h	12894±45.6	12814±45.7	78±35.6	<0.001
	≥24 h	13425±47.5	13343±47.6	79±36.1	
	No colonoscopy	1950±6.9	1887±6.7	62±28.3	
Embolization during hospitalization (%)		1188±4.2	1153±4.1	35±16.0	<0.001
Colon resection during hospitalization (%)		1969±7.0	1892±6.7	76±34.7	<0.001

SD, standard deviation; NSAID, non-steroidal anti-inflammatory drug

Outcomes

In-hospital mortality

The overall in-hospital mortality rate in the cohort was 0.8%. Factors associated with higher odds of in-hospital death included age above 85 years, presence of moderate-to-severe Charlson Comorbidity Index, hypovolemic shock during hospitalization, requirement for blood transfusion, and need for colon resection. However, the timing of the first colonoscopy was not found to be significantly associated with in-hospital mortality (Table 2).

Length of stay

Age >75 years and Black race were associated with a greater length of stay by half a day. The presence of colon

Table 2 Predictors of in-hospital mortality during index hospitalization for diverticular bleed

Characteristics	Categories	Unadjusted			Adjusted		
		OR	95%CI	P-value	OR	95%CI	P-value
Age (years)	<65 years	Ref	—	—	Ref	—	—
	65-74 years	1.52	0.94-2.51	0.094	1.37	0.84-2.27	0.2
	75-84 years	1.63	1.05-2.62	0.034	1.50	0.96-2.42	0.087
	> 85 years	2.30	1.48-3.69	<0.001	2.31	1.47-3.75	<0.001
Charlson Comorbidity Index	Mild	Ref	—	—	Ref	—	—
	Moderate	3.11	2.30-4.22	<0.001	2.87	2.10-3.92	<0.001
	Severe	2.83	1.99-4.00	<0.001	2.61	1.82-3.72	<0.001
Hypovolemic shock		6.45	4.46-9.10	<0.001	3.21	2.15-4.67	<0.001
Blood Transfusion during hospitalization		2.22	1.70-2.90	<0.001	1.63	1.14-2.43	0.011
Number of units of blood transfusion during hospitalization		1.45	1.28-1.63	<0.001	1.11	0.85-1.33	0.4
Colonoscopy during hospitalization		0.14	0.10-0.19	<0.001	0.79	0.31-1.74	0.6
Time from admission to first colonoscopy	<24 h	Ref	—	—	Ref	—	—
	≥24 h	0.98	0.71-1.34	0.9	0.90	0.66-1.25	0.5
	No colonoscopy	5.42	3.85-7.61	<0.001	1.59	0.66-3.27	0.2
Embolization during hospitalization		4.44	3.03-6.31	<0.001	1.19	0.45-3.56	0.7
Colon resection during hospitalization		7.35	5.52-9.71	<0.001	4.74	3.37-6.58	<0.001

OR, odds ratio; CI, confidence interval

cancer and a moderate-to-severe Charlson Comorbidity Index extended the stay by 1-2 additional days. Intervention-related factors exerted significant influence on length of stay, with late colonoscopy (performed >24 h after hospitalization) and the necessity for colon resection significantly prolonging the duration of hospitalization. For each additional colonoscopy required, the stay lengthened by 2.1 days (Table 3).

Arterial embolization

A total of 1188 patients needed embolization, with 618 individuals undergoing the procedure in a branch of the superior mesenteric artery and 570 undergoing it in a branch of the inferior mesenteric artery. Notably, 26 patients underwent embolization in branches of both those arteries.

Age >85 years and Black race increased the odds of requirement for arterial embolization. Female sex decreased the odds of requiring arterial embolization (OR 0.74, 95%CI 0.64-0.86; P<0.001). The presence of hypovolemic shock significantly elevated the odds of requiring arterial embolization (OR 3.11, 95%CI 2.38-4.03; P<0.001). A need for blood transfusion during hospitalization (OR 1.7, 95%CI 1.3-2.3; P<0.001) and each additional colonoscopy were associated with increased odds of arterial embolization (Table 4).

Colon resection

Age >85, female sex, long term antiplatelet or anticoagulation use and arterial embolization were associated with lower odds of colon resection, whereas the presence of colon cancer, hypovolemic shock, and the number of blood transfusions were associated with higher odds of colon resection. Time to first colonoscopy was not significantly associated with the odds of colon resection (Table 5).

Discussion

Our retrospective study, using NIS data from 2016-2020, aimed to elucidate predictors of in-hospital mortality, length of hospital stay, arterial embolization, and colon resection among patients with diverticular bleed. We identified advanced age (over 85 years), presence of medical comorbidities as indexed by the Charlson Comorbidity Index, hypovolemic shock during hospitalization, and requirement for colon resection as risk factors for greater mortality. Conversely, we did not find the need for blood transfusions or the timing of the initial colonoscopy to significantly impact hospital mortality. Identifying the predictors of outcomes in diverticular bleeding is crucial in order to risk-stratify patients and provide personalized care. Patients identified to be at higher risk of

Table 3 Predictors of length of stay in patients admitted for diverticular bleed

Variables	Categories	Unadjusted			Adjusted		
		Beta	95%CI	P-value	Beta	95%CI	P-value
Age	<65 years	Ref	—	—	Ref	—	—
	65-74 years	0.26	0.10-0.41	0.001	0.19	0.06-0.33	0.006
	75-84 years	0.33	0.19-0.47	<0.001	0.28	0.15-0.41	<0.001
	>85 years	0.54	0.39-0.69	<0.001	0.61	0.47-0.75	<0.001
Sex	Male	Ref	—	—	Ref	—	—
	Female	0.13	0.03-0.23	0.011	0.07	-0.02-0.16	0.14
Race	White	Ref	—	—	Ref	—	—
	Black	0.78	0.66-0.90	<0.001	0.54	0.43-0.65	<0.001
	Hispanic	-0.05	-0.24-0.14	0.6	0.07	-0.10-0.24	0.4
	Asian/Pacific Islander	-0.26	-0.57-0.05	0.10	-0.16	-0.43-0.11	0.3
	Native American	-0.11	-0.88-0.66	0.8	0.00	-0.68-0.68	>0.9
	Other	0.42	0.07-0.77	0.019	0.41	0.10-0.71	0.009
Charlson Comorbidity Index	Mild	Ref	—	—	Ref	—	—
	Moderate	1.3	1.2-1.4	<0.001	0.97	0.86-1.1	<0.001
	Severe	2.0	1.8-2.1	<0.001	1.5	1.3-1.6	<0.001
Colon cancer		6.1	5.4-6.9	<0.001	2.2	1.6-2.9	<0.001
Hypovolemic shock		3.4	3.2-3.7	<0.001	0.48	0.33-0.63	<0.001
Blood transfusion during hospitalization		1.4	1.3-1.5	<0.001	0.41	0.22-0.60	<0.001
Colonoscopy during hospitalization		-3.7	-4.0 to -3.5	<0.001	-2.2	-2.7 to -1.8	<0.001
Number of colonoscopies during hospitalization		-0.27	-0.41 to -0.12	<0.001	2.1	2.0-2.3	<0.001
Time from hospitalization to first colonoscopy	<24 h	Ref	—	—	Ref	—	—
	≥24 h	1.8	1.7-1.9	<0.001	1.7	1.6-1.8	<0.001
	No colonoscopy	3.5	3.3-3.7	<0.001	0.92	0.61-1.2	<0.001
Embolization during hospitalization		2.5	2.3-2.8	<0.001	-0.08	-0.79-0.63	0.8
Colon resection during hospitalization		5.6	5.5-5.8	<0.001	5.2	5.0-5.4	<0.001

CI, confidence interval

death may benefit from closer monitoring, more aggressive treatment and early surgical or radiology consultation.

Our study showed an in-hospital mortality rate of 0.8% among patients with colonic diverticular bleed (CDB), whereas mortality reports from previous literature vary between 2-20% [2,8-10]. The significantly lower mortality rate in our cohort could be because our study assessed hospital mortality only. On the other hand, this may reflect advances in medical practice, with improved diagnostic tools and interventional management. For example, the introduction of endoscopic band ligation and endoscopic detachable snare ligation offered more effective hemostasis than traditional thermal coagulation and clipping [11]. Recently, a novel treatment strategy, the over-the-scope clip method, has shown effectiveness in severe diverticular bleeding after failure of conventional endoscopic procedures [1].

We identified increased odds of in-hospital mortality in patients with age >85 years or a moderate-to-severe Charlson Comorbidity Index, findings consistent with those of previous studies [2,10]. Similarly, hypovolemic shock during hospitalization and a need for bowel resection were identified as predisposing factors, paralleling the findings from previous studies [10]. Interestingly, the need for blood transfusion and the duration until colonoscopy were not found to significantly impact mortality, in contrast to what was seen in previous studies, suggesting that other factors, such as the severity of the initial bleeding and the effectiveness of early management strategies, may play a bigger role [10].

Our study identified age >75 years, Black ethnicity, the presence of colon cancer and a moderate-to-severe Charlson comorbidity index as predictors of lengthy hospitalization. In addition, intervention-related factors, such as late colonoscopy (performed >24 h after hospitalization) and the necessity for colon resection, significantly extended the duration of hospital stay. There are mixed results with regard to the impact of urgent colonoscopy on hospital stay. Our study aligns with

Table 4 Predictors of odds of embolization during hospitalization

Variables	Categories	Unadjusted			Adjusted		
		OR	95%CI	P-value	OR	95%CI	P-value
Age (years)	<65 years	Ref	—	—	Ref	—	—
	65-74 years	1.20	0.99-1.45	0.063	1.23	0.97-1.57	0.089
	75-84 years	1.19	1.00-1.42	0.053	1.32	1.05-1.65	0.017
	>85 years	1.32	1.10-1.59	0.003	1.60	1.26-2.04	<0.001
Sex	Male	Ref	—	—	Ref	—	—
	Female	0.75	0.67-0.85	<0.001	0.74	0.64-0.86	<0.001
Race	White	Ref	—	—	Ref	—	
	Black	1.41	1.23-1.61	<0.001	1.53	1.28-1.82	<0.001
	Hispanic	0.82	0.63-1.05	0.14	0.95	0.68-1.29	0.7
	Asian/Pacific Islander	1.68	1.22-2.26	<0.001	1.72	1.15-2.52	0.007
	Native American	0.22	0.01-0.97	0.13	0.14	0.01-0.81	0.073
	Other	1.46	0.99-2.06	0.043	1.49	0.91-2.35	0.10
Charlson Comorbidity Index	Mild	Ref	—	—	Ref	—	—
	Moderate	1.26	1.09-1.45	0.001	1.19	0.99-1.43	0.063
	Severe	1.18	1.00-1.39	0.052	1.09	0.88-1.36	0.4
Blood transfusion during hospitalization		1.68	1.50-1.89	<0.001	1.70	1.30-2.28	<0.001
Number of units of blood transfusion during hospitalization		1.33	1.23-1.43	<0.001	0.93	0.74-1.14	0.5
Hypovolemic shock		5.99	5.01-7.13	<0.001	3.11	2.38-4.03	<0.001
Colonoscopy during hospitalization		0.2	0.1-0.54	<0.001	0.3	0.15-0.67	<0.001
Number of Colonoscopies during index hospitalization		0.02	0.01-0.02	<0.001	1.73	1.31-2.22	<0.001
Time from hospitalization to first colonoscopy	<24 h	Ref	—	—	Ref	—	—
	≥24 h	0.70	0.57-0.85	<0.001	0.70	0.57-0.85	<0.001
	No colonoscopy	34.2	29.3-40.2	<0.001	0.88	0.42-1.63	0.7

OR, odds ratio; CI, confidence interval

several other retrospective studies that showed that urgent colonoscopy within 24 h shortened the hospital stay [12-15]. On the other hand, 2 randomized clinical trials presented inconsistent results [16,17] and a more recent randomized controlled trial (RCT) reported that urgent colonoscopy did not affect the length of hospital stay [18]. The discrepancy in the findings between retrospective studies and RCTs may stem from the timing of the procedures. Specifically, in retrospective studies urgent colonoscopies tend to happen more on weekdays, whereas the design of RCTs does not limit the procedure to specific days of the week [15]. This points towards the need for further research to fully understand the impact of colonoscopy timing on length of hospital stay in patients with colonic diverticular bleed.

Endoscopic hemostasis has a success rate of 88-100% in CDB [19,20]. Current guidelines recommend arterial embolization when endoscopic hemostasis is difficult to achieve because of massive bleeding, or when persistent or recurrent bleeding occurs despite endoscopic intervention [21]. In our study, the need for arterial embolization was found to be more common in those aged >85 years, of Black ethnicity, in the presence of shock and in patients undergoing multiple colonoscopies. Similarly, a retrospective study from a tertiary center in Japan, which included 608 patients requiring hospitalization for CDB, identified shock with a blood pressure of ≤90 mmHg, positive extravasation on contrast-enhanced computed tomography, 2 or more episodes of recurrent bleeding, and the right colon as the source of bleeding as significant risk factors that necessitated arterial intervention [22]. In particular, the state of shock was the risk factor with the highest OR, an observation that was also corroborated by our study. This is crucial, as these predictors could aid clinicians in the early identification of patients who might benefit from arterial embolization, facilitating prompt referral and intervention.

Interestingly, female sex was associated with lower odds of requiring arterial embolization and colon resection in our study. Colonoscopy during hospitalization decreased the odds

Table 5 Predictors of odds of colon resection during hospitalization

Variables	Categories	Unadjusted			Adjusted		
		Beta	95%CI[1]		Beta	95%CI[1]	
Age	<65 years	Ref	—	—	Ref	—	—
	65-74 years	1.00	0.87-1.14	>0.9	1.05	0.90-1.24	0.5
	75-84 years	0.88	0.78-1.00	0.057	0.98	0.84-1.15	0.8
	>85 years	0.65	0.56-0.75	<0.001	0.73	0.61-0.87	<0.001
Sex	Male	Ref	—	—	Ref	—	—
	Female	0.84	0.76-0.92	<0.001	0.85	0.76-0.94	0.002
Race/ethnicity	White	Ref	—	—	Ref	—	—
	Black	1.18	1.05-1.31	0.004	0.2	0.96-1.24	0.2
	Hispanic	0.89	0.73-1.07	0.2	0.7	0.70-1.08	0.2
	Asian/Pacific Islander	1.05	0.78-1.39	0.7	0.7	0.67-1.30	0.7
	Native American	1.16	0.54-2.16	0.7	0.7	0.31-1.72	0.6
	Other	1.07	0.77-1.46	0.7	0.92	0.62-1.32	0.7
Charlson Comorbidity Index	Mild	Ref	—	—	Ref	—	—
	Moderate	1.07	0.95-1.20	0.3	1.06	0.92-1.21	0.4
	Severe	1.14	1.00-1.30	0.053	1.11	0.95-1.29	0.2
Long term NSAID use		0.72	0.52-0.96	0.035	0.87	0.61-1.19	0.4
Long term antiplatelet/anticoagulant use		0.64	0.57-0.72	<0.001	0.68	0.60-0.78	<0.001
Colon cancer		26.8	18.4-39.5	<0.001	10.5	6.12-17.6	<0.001
Hypovolemic shock		3.70	3.13-4.37	<0.001	2.95	2.40-3.60	<0.001
Blood transfusion	No transfusion	Ref	—	—	Ref	—	—
	1-2 Units	1.28	1.16-1.40	<0.001	1.20	1.08-1.35	<0.001
	3-4 Units	3.02	1.98-4.46	<0.001	2.87	1.73-4.55	<0.001
	More than 4 units	5.33	2.35-11.0	<0.001	4.71	1.72-11.2	0.001
Time from hospitalization to first colonoscopy	<24 h	Ref	—	—	Ref	—	—
	≥24 h	0.99	0.89-1.11	>0.9	0.99	0.88-1.12	0.9
	No colonoscopy	11.1	9.82-12.6	<0.001	1.91	1.40-2.56	<0.001
Embolization during hospitalization		2.17	1.82-2.58	<0.001	0.03	0.02-0.05	<0.001

1 OR, odds ratio; CI, confidence interval; NSAID, non-steroidal anti-inflammatory drug

of requiring arterial embolization, because of the effectiveness of endoscopic interventions in stopping bleeding. However, each additional colonoscopy increased the odds of arterial embolization, probably indicating failure to stop bleeding via colonoscopy. Additionally, a delayed first colonoscopy (more than 24 h after hospitalization) was associated with reduced odds of needing embolization. This observation may be attributed to less severe bleeding in patients undergoing colonoscopy after the initial 24-h hospitalization period.

In general, surgical resection is rarely required in CDB, given the high success rate at controlling bleeding via nonsurgical means [23]. In patients with uncontrolled bleeding that requires surgery, mortality is often high because of hypotension and comorbid conditions [24-26]. There is scarce literature on what the predictors of colon resection are in CDB. In our study, we observed that advanced age (>85 years) was associated with a decreased likelihood of undergoing colon resection. This could be attributed to the lower propensity for surgical intervention among older patients. Long-term use of antiplatelets/anticoagulant medication did not impact mortality among patients with CDB. Interestingly, their use was associated with a lesser need for colon resection, although it cannot be known from this database whether these medications were withheld during hospitalization. Assuming they were, that may partially have mitigated the severity of bleeding. The association with anticoagulant/antiplatelet use is particularly interesting, as these medications are commonly prescribed in the elderly population. Patients who underwent arterial embolization showed lower odds of requiring colon resection, probably due to the intervention's efficacy in controlling bleeding.

Identifying predictors of outcome has important implications, enabling clinicians to stratify patients based on their risk of adverse outcomes. This may entail assigning patients with a higher risk to undergo closer monitoring, aggressive resuscitation efforts, and an early multidisciplinary approach involving gastroenterology, interventional radiology, and action by a surgical team when necessary. Furthermore, the conflicting findings regarding the effect of urgent colonoscopy in shortening the duration of hospital stay warrant further research. The potential for early colonoscopy to improve other outcomes, such as arterial embolization and surgical intervention, also merits more investigation. In addition, addressing anticoagulant and antiplatelet therapy during the peri-hospitalization period has the potential to enhance patient outcomes through a reduction in the need for more invasive interventions.

While our study provides valuable insights, it was subject to various limitations that warrant consideration. First, the retrospective nature of our analysis limits our ability to establish causation between the identified predictors and outcomes. Second, our study did not distinguish between patients presenting with first-time episodes of CDB and those experiencing rebleeding, a distinction that could significantly influence outcome. A third limitation of our study is the absence of data regarding the exact location of bleeding and whether the source was identified, both of which can influence the selection of intervention strategies. Fourth, the database does not have Current Procedural Terminology codes to identify specific colonoscopic interventions that might have affected the outcome, such as a need for subsequent interventions, length of stay and mortality. Finally, the absence of propensity matching between baseline groups could introduce associations observed because of baseline differences among patients, rather than the factors under investigation. These limitations highlight the need for prospective studies to further validate the predictors identified in this retrospective analysis.

In summary, our study underscores the importance of early risk identification and stratification in patients with CDB. By employing a tailored, multidisciplinary approach and addressing modifiable risk factors, clinicians can improve patient outcomes. Further research is needed to assess the impact of early colonoscopy and other interventions on the length of hospital stay.

The identification of predictive factors in CBD has the potential to drive significant advancements in patient care. The future of healthcare systems lies in the integration of artificial intelligence (AI) into clinical practice [27,28]. AI will not only refine risk stratification models with great precision, but also identifies subtle patterns and interactions among variables not readily apparent to human analysis. This contributes to the broader themes in healthcare, with advances in precision medicine and personalized patient care.

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Summary Box

What is already known:

- Diverticular bleeding is the most common cause of lower gastrointestinal bleeding, with colonoscopy being the first-line intervention for diagnosis and therapeutic purposes
- Antiplatelet and anticoagulant medications increase the risk of diverticular bleeding in patients with diverticulosis, although their impact on outcomes is unclear
- Management algorithms include resuscitation, diagnosis via direct visualization and/or computed tomography imaging, endoscopic interventions, angioembolization and surgery when needed

What the new findings are:

- Long term use of antiplatelets/anticoagulation did not increase the odds of requiring arterial embolization or bowel resection, or mortality
- Black race was associated with greater odds of requiring arterial embolization and a prolonged hospital stay for diverticular bleeding
- Female sex was associated with lower odds of requiring arterial embolization and colonic resection for diverticular bleeding

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Supplementary material

Supplementary Table 1 ICD-10 CM codes used for variables

Condition	ICD-10 CM Codes
Diverticulosis with bleeding with out abscess or perforation	K57.31, K57.51
Long term antiplatelet/ anticoagulant use	Z79.01, Z79.02
Long term NSAID use	Z79.1
Long term systemic steroid use	Z79.52
Colon cancer	C18.0, C18.1, C18.2, C18.3, C18.4, C18.5, C18.6, C18.7, C18.8, C18.9
Hypovolemic shock	R57.1, R57.8, R57.9

NSAID, nonsteroidal anti-inflammatory drug

Supplementary Table 2 ICD-10 PCS codes used for variables

Procedures	ICD-10 PCS Codes
Colonoscopy	0DJD8ZZ
Embolization	04L50CZ, 04L50DZ, 04L50ZZ, 04L53CZ, 04L53DZ, 04L53ZZ, 04L54CZ, 04L54DZ, 04L54ZZ, 04V50CZ, 04V50DZ, 04V50ZZ, 04V53CZ, 04V53DZ, 04V53ZZ, 04V54CZ, 04V54DZ, 04V54ZZ, 04L60CZ, 04L60DZ, 04L60ZZ, 04L63CZ, 04L63DZ, 04L63ZZ, 04L64CZ, 04L64DZ, 04L64ZZ, 04V60CZ, 04V60DZ, 04V60ZZ, 04V63CZ, 04V63DZ, 04V63ZZ, 04V64CZ, 04V64DZ, 04V64ZZ, 04L70CZ, 04L70DZ, 04L70ZZ, 04L73CZ, 04L73DZ, 04L73ZZ, 04L74CZ, 04L74DZ, 04L74ZZ, 04V70CZ, 04V70DZ, 04V70ZZ, 04V73CZ, 04V73DZ, 04V73ZZ, 04V74CZ, 04V74DZ, 04V74ZZ, 04L80CZ, 04L80DZ, 04L80ZZ, 04L83CZ, 04L83DZ, 04L83ZZ, 04L84CZ, 04L84DZ, 04L84ZZ, 04V80CZ, 04V80DZ, 04V80ZZ, 04V83CZ, 04V83DZ, 04V83ZZ, 04V84CZ, 04V84DZ, 04V84ZZ, 04LB0CZ, 04LB0DZ, 04LB0ZZ, 04LB3CZ, 04LB3DZ, 04LB3ZZ, 04LB4CZ, 04LB4DZ, 04LB4ZZ, 04VB0CZ, 04VB0DZ, 04VB0ZZ, 04VB3CZ, 04VB3DZ, 04VB3ZZ, 04VB4CZ, 04VB4DZ, 04VB4ZZ
Resection	0DTC0ZZ, 0DTC4ZZ, 0DTC7ZZ, 0DTC8ZZ, 0DBC0ZX, 0DBC0ZZ, 0DBC3ZX, 0DBC3ZZ, 0DBC4ZX, 0DBC4ZZ, 0DBC7ZX, 0DBC7ZZ, 0DBC8ZX, 0DBC8ZZ, 0DTH0ZZ, 0DTH4ZZ, 0DTH7ZZ, 0DTH8ZZ, 0DBH0ZX, 0DBH0ZZ, 0DBH3ZX, 0DBH3ZZ, 0DBH4ZX, 0DBH4ZZ, 0DBH7ZX, 0DBH7ZZ, 0DBH8ZX, 0DBH8ZZ, 0DTE0ZZ, 0DTE4ZZ, 0DTE7ZZ, 0DTE8ZZ, 0DBE0ZX, 0DBE0ZZ, 0DBE3ZX, 0DBE3ZZ, 0DBE4ZX, 0DBE4ZZ, 0DBE7ZX, 0DBE7ZZ, 0DBE8ZX, 0DBE8ZZ, 0DTF0ZZ, 0DTF4ZZ, 0DTF7ZZ, 0DTF8ZZ, 0DBF0ZX, 0DBF0ZZ, 0DBF3ZX, 0DBF3ZZ, 0DBF4ZX, 0DBF4ZZ, 0DBF7ZX, 0DBF7ZZ, 0DBF8ZX, 0DTK0ZZ, 0DTK4ZZ, 0DTK7ZZ, 0DTK8ZZ, 0DBK0ZX, 0DBK0ZZ, 0DBK3ZX, 0DBK3ZZ, 0DBK4ZX, 0DBK4ZZ, 0DBK7ZX, 0DBK7ZZ, 0DBK8ZX, 0DBK8ZZ, 0DTL0ZZ, 0DTL4ZZ, 0DTL7ZZ, 0DTL8ZZ, 0DTLFZZ, 0DBL0ZX, 0DBL0ZZ, 0DBL3ZX, 0DBL3ZZ, 0DBL4ZX, 0DBL4ZZ, 0DBL7ZX, 0DBL7ZZ, 0DBL8ZX, 0DBL8ZZ, 0DBLFZZ, 0DTG0ZZ, 0DTG4ZZ, 0DTG7ZZ, 0DTG8ZZ, 0DTGFZZ, 0DBG0ZX, 0DBG0ZZ, 0DBG3ZX, 0DBG3ZZ, 0DBG4ZX, 0DBG4ZZ, 0DBG7ZX, 0DBG7ZZ, 0DBG8ZX, 0DBG8ZZ, 0DTM0ZZ, 0DTM4ZZ, 0DTM7ZZ, 0DTM8ZZ, 0DTMFZZ, 0DBM0ZX, 0DBM0ZZ, 0DBM3ZX, 0DBM3ZZ, 0DBM4ZX, 0DBM4ZZ, 0DBM7ZX, 0DBM7ZZ, 0DBM8ZX, 0DBM8ZZ, 0DBMFZZ, 0DTN0ZZ, 0DTN4ZZ, 0DTN7ZZ, 0DTN8ZZ, 0DTNFZZ, 0DBN0ZX, 0DBN0ZZ, 0DBN3ZX, 0DBN3ZZ, 0DBN4ZX, 0DBN4ZZ, 0DBN7ZX, 0DBN7ZZ, 0DBN8ZX, 0DBN8ZZ, 0DBNFZZ.
Blood transfusion	30233N0, 30233N, 30243N1