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Early Colonoscopy in Hospitalized Patients With Acute Lower Gastrointestinal Bleeding: A Nationwide Analysis

Kuldeepsinh P. Atodaria^{a, c}, Samyak Dhruv^b, Joseph M. Bruno^c, Brisha Bhikadiya^d, Shrivya R. Ginnaram^a, Shreeja Shah^a

Abstract

Background: Performing colonoscopy within 24 h of presentation to the hospital is the accepted standard of care for patients with an acute lower gastrointestinal bleed (LGIB). Previous studies have failed to demonstrate the benefit of early colonoscopy (EC) on mortality. In this study, we wanted to see if there was a change in inpatient deaths (primary outcome), length of stay (LOS), and hospitalization charges (TOTCHG) (secondary outcomes) with EC compared to previous studies.

Methods: Adults diagnosed with LGIB were identified using the International Classification of Disease 10th Revision codes from the National Inpatient Sample database for 2016 to 2019. EC was defined as the procedure performed within 24 h of hospitalization. Delayed colonoscopy (DC) was defined as a procedure performed after 24 h of presentation. The patient population was divided into EC and DC groups, and the effects of several covariates on outcomes were measured using binary logistic and multivariate regression analysis. Inverse probability treatment weighting (IPTW) was performed to adjust for confounding covariates.

Results: There were 1,549,065 cases diagnosed with LGIB, of which 285,165 cases (18.4%) received a colonoscopy. A total of 107,045 (6.9%) patients received early colonoscopies. EC was associated with decreased inpatient deaths (0.9% in EC, and 1.4% in DC, $P < 0.001$). However, upon IPTW, this difference was not present. EC was associated with a decreased LOS (median 3 days vs. 5 days, $P < 0.001$) and TOTCHG (median \$32,037 vs. \$44,092, $P < 0.001$). Weekend admissions (WA) were associated with fewer EC (31.6% in WA, and 39.5% in non-WA, $P < 0.001$). WA did not affect inpatient deaths.

Conclusions: EC was not associated with decreased inpatient deaths. There was no difference in endoscopic interventions in both EC and DC groups. The difference in inpatient deaths observed between the two groups was not evident upon adjusting the results for confounders. EC was associated with a decreased LOS, and TOTCHG in patients with LGIB.

Keywords: Lower gastrointestinal bleed; Early colonoscopy; Mortality; Length of stay; Hospitalization charges; Outcomes

Introduction

Lower gastrointestinal bleed (LGIB) remains a common cause of hospitalization, especially in the elderly. LGIB is defined as any bleed originating from small intestine distal to ligament of Treitz, colon, rectum or anus and presenting with melena or bright red/burgundy-colored stools [1-5]. Most common causes of LGIB include colonic diverticulosis (30%), internal hemorrhoids, ischemic colitis, and post-polypectomy bleeding. Other causes include colorectal cancer, inflammatory bowel diseases, mesenteric ischemia, anal fissures, etc. [1]. Eighty percent of LGIBs stop spontaneously, with re-bleeding occurring in 25% of cases. Identifying the source of the bleed can be challenging despite performing a colonoscopy [6, 7]. Performing colonoscopy within 24 h of presentation to the hospital is the accepted standard of care and part of the American College of Gastroenterology Guidelines [8]. American Society for Gastrointestinal Endoscopy suggests performing a colonoscopy within 24 h [9]. In this study, early colonoscopy (EC) is defined as a procedure performed within 24 h of presentation, and delayed colonoscopy (DC) is performed after 24 h. Performing colonoscopies within 24 h of presentation is not always possible. Moreover, whether EC is beneficial in mortality outcomes remains widely debated. Randomized controlled trials and prospective studies have not shown a significant correlation between EC and improved mortality outcomes [10-14]. Systematic reviews and meta-analysis have been performed that showed similar results [4, 15-20]. Retrospective studies from single and multiple institutions and national databases have reported non-significant results [21-28].

Most of these studies showed a decrease in length of stay

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Table 1. Frequency of LGIB Etiologies Based on Presence of ICD-10 Codes, in the Total Population, and in Cases That Received a Colonoscopy (N = 1,549,605)^a

| Diagnosis | Frequency (% ^b) | Frequency for colonoscopy patients (% ^b) |
|--|-----------------------------|--|
| Anorectal bleed | 119,330 (7.7%) | 23,940 (8.4%) |
| Diverticulosis | 271,095 (17.5%) | 122,720 (43.0%) |
| Diverticulitis | 44,430 (2.9%) | 7,835 (2.7%) |
| Angiodysplasia | 90,420 (5.8%) | 12,920 (4.5%) |
| Dieulafoy lesion | 5,585 (0.4%) | 1,190 (0.4%) |
| Melena | 896,325 (57.8%) | 112,870 (39.6%) |
| LGIB (primary diagnosis) with polyps, or benign neoplasm of large intestine (as secondary diagnosis) | 49,070 (3.2%) | 7,695 (2.7%) |
| LGIB (primary diagnosis) with malignant neoplasm of large intestine (as secondary diagnosis) | 5,190 (0.3%) | 635 (0.2%) |
| LGIB (primary diagnosis) with malignant neoplasm of anus (as secondary diagnosis) | 135 (0%) | 10 (0%) |
| LGIB (primary diagnosis) with malignant neoplasm of small intestine (as secondary diagnosis) | 295 (0%) | 15 (0%) |
| LGIB (primary diagnosis) with ischemia of intestine (as secondary diagnosis) | 10,965 (0.7%) | 2,365 (0.8%) |
| LGIB (primary diagnosis) with noninfectious colitis (as secondary diagnosis) | 11,705 (0.8%) | 1,535 (0.5%) |
| LGIB (primary diagnosis) with infectious colitis (as secondary diagnosis) | 1,305 (0.1%) | 75 (0%) |
| LGIB (primary diagnosis) with Crohn's disease (as secondary diagnosis) | 13,560 (0.9%) | 1,065 (0.4%) |
| LGIB (primary diagnosis) with ulcerative colitis (as secondary diagnosis) | 48,515 (3.1%) | 2,410 (0.8%) |
| LGIB (primary diagnosis) with large intestinal fistula (as secondary diagnosis) | 1,015 (0.1%) | 350 (0.1%) |
| LGIB (primary diagnosis) with anal fissure (as secondary diagnosis) | 75 (0%) | 15 (0%) |
| Patients that received a colonoscopy | 285,165 (18.4%) | |
| Patients that received an early colonoscopy | 107,055 (6.9%) | |

^aAll numbers are weighted by NIS weight. ^bThe sum of all % values may add up to > 100 as some patients may have multiple diagnoses listed in their problem list. LGIB: lower gastrointestinal bleed; NIS: National (Nationwide) Inpatient Sample; ICD-10: International Classification of Disease 10th Edition.

(LOS) and cost of hospitalization or total charges (TOTCHG) with EC [4-6, 10-12, 19, 20, 26, 27]. Studies also report an improved ability to detect the source of the bleed with EC. Past studies using data spanning multiple years have shown increasing total hospitalizations for LGIB, with unchanging trends in patients getting EC versus DC [25].

Many of these studies had a small sample size and thus did not have statistically significant results.

We decided to investigate how previous studies have affected the approach of gastroenterologists towards acute LGIB in recent years and whether mortality outcomes have changed compared to previous studies.

Materials and Methods

Nationwide Inpatient Sample (NIS) is an administrative database and part of the Healthcare Cost and Utilization Project (HCUP). The NIS is the largest publicly available all-payer inpatient healthcare database designed to produce US regional and national estimates of inpatient utilization, access, cost, quality, and outcomes. Unweighted, it contains data from more than 7 million hospital stays each year. Weighted, it estimates more than 35 million hospitalizations nationally.

All adult patients with the International Classification of Disease 10th Revision (ICD-10) diagnosis codes for conditions associated with a LGIB were extracted from the NIS database from 2016 to 2019. Cases included were those with a primary diagnosis of anorectal bleed, bleed from diverticulosis, and unspecified gastrointestinal bleeds. Unspecified gastrointestinal bleeds include nonsteroidal anti-inflammatory drugs (NSAID) use, coagulopathies, angiodysplasia, radiation colitis, rectal varices, rectal foreign bodies, etc. Patients were further differentiated based on secondary diagnosis codes for conditions usually associated with an LGIB (Table 1) (Supplementary Material 1, www.gastrores.org). The diagnosis codes included were angiodysplasia, malignant large intestinal neoplasm, malignant anal neoplasm, malignant small intestinal neoplasm, benign neoplasms/polyps of the large intestine, ischemic bowel disease, hemorrhoids, infectious/noninfectious colitis, Crohn's disease, ulcerative colitis, anal fissures, and fistulas of the large intestine. In theory, melena is a diagnosis of an upper gastrointestinal bleed (UGIB). In practice, melena often gets used as an all-encompassing term for bloody bowel movements, dark or otherwise. To maximize the number of cases with LGIB included in the analysis, we decided to include patients diagnosed with melena. Cases with other diagnoses of UGIB were not included in this analysis. Excluding

the cases that had a procedure code for esophagogastroduodenoscopy (EGD) did not change the mortality, LOS, or TOTCHG numbers for EC and DC groups in any meaningful way. Thus, we decided not to exclude cases with an EGD during the hospitalization for regression analysis.

Charlson Comorbidity Index (CCI) was calculated based on the presence of diagnosis codes for 22 comorbidities that are standard for calculating CCI. The CCI is a well-validated measure of comorbidity used to predict 1-year mortality in patients [29, 30]. Race, sex, type of insurance, weekend admissions (WA), and location/teaching status of the hospital were other considered variables. Other comorbidities considered were hypovolemia/hypovolemic shock, acute renal failure/acute kidney injury (AKI), acute respiratory failure (ARF), a requirement for transfusion of any blood products, and requirement for hemodialysis. The presence of ARF was determined using ICD-10 procedure codes for ventilator support, insertion of nasopharyngeal/oropharyngeal airways, endotracheal intubation, and tracheostomy placement.

The values of age, LOS, and TOTCHG were not normally distributed. Age was transformed using the square root transformation, and LOS and TOTCHG underwent logarithmic transformation before regression analysis [31]. Cases with a Z score > 2.68 and < -2.68 (for either LOS or TOTCHG) were excluded from the regression analysis to prevent the outliers from affecting the regression model. Outliers represented 2.2% of the cases.

Binary logistic regression was performed to predict mortality for the hospitalization using covariates that showed a statistically significant relationship with mortality independently. The covariates included were EC versus DC, age, CCI, gender, race, insurance type, AKI, respiratory failure, hypovolemia/shock, and endoscopic intervention. The goodness of fit was determined using the receiver operating curve (ROC) analysis.

Two separate multiple linear regressions were performed with LOS and TOTCHG as dependent variables, respectively, and the same variables mentioned above as independent covariates to determine their effects on LOS and TOTCHG. Finally, the predicted values obtained after regression analysis were reverse-transformed to obtain interpretable predicted outcomes.

To adjust for confounding effects of covariates namely AKI, chronic kidney disease (CKD), hemodialysis and ARF on the association between EC and inpatient death rates, we performed inverse probability treatment weighting (IPTW) analysis.

Outcomes

Primary outcome of the study was death during hospitalization or inpatient deaths. Secondary outcomes of the study were LOS and TOTCHG.

Statistical analysis

The data used for this study were de-identified patient data and were thus exempt from the Institutional Review Board pro-

cess. The study was conducted in compliance with the ethical standards of the responsible institution on human subjects as well as with the Helsinki Declaration.

All the analyses were performed using IBM SPSS Statistics 28.0.0.0 (International Business Machines Statistical Package for Social Sciences Version 28.0.0.0), which originated in Armonk, NY, USA. Chi-square tests were utilized to compare and determine the association between categorical variables like death, admission on a weekend, sex, race, type of insurance, and location of hospital/teaching status. Mann-Whitney U tests were utilized to compare continuous variables (LOS and TOTCHG) with categorical variables, and the median values were reported. However, we did also run the *t*-tests and reported the mean values along with standard deviations (SD) for readers that might be interested in knowing them.

The NIS database provides the discharge-level weight "DISCWT" used to statistically weigh the results to produce an estimate of discharges from hospitals at the national level [32].

Results

A total of 1,549,065 cases were identified with a diagnosis of LGIB. This number represented 1.3% of the total hospitalizations from 2016 to 2019. Of these, 285,165 patients (18.4%) received a colonoscopy. Of patients who received colonoscopies, 107,045 (37.5%) patients received early colonoscopies.

Table 1 shows the distribution of patients based on etiologies of LGIB regardless of whether they received a colonoscopy. Diverticulosis was the most common cause of LGIB (17.5%). Amongst the patients that received a colonoscopy, the proportion of patients diagnosed with diverticulosis was 43%.

Table 2 shows how various demographic, insurance and hospital characteristics affected whether the patients received EC.

Patients that received a colonoscopy had a significantly lower rate of inpatient deaths (1.2%) compared to patients that did not receive a colonoscopy (3.9%) ($P < 0.001$). In the patient population that received colonoscopies, EC was associated with a significantly lower inpatient deaths, with 1,005 inpatient deaths (0.9%) as compared to patients who received delayed colonoscopies, with 2,530 deaths (1.4%) ($P < 0.001$). Admission on the weekend did not affect mortality ($P = 0.399$).

EC was associated with a decreased LOS (median 3 days with EC and 5 days with DC, $P < 0.001$) and decreased total charges of hospitalization (median \$32,037 with EC and \$44,092 with DC, $P < 0.001$). The difference in median LOS between patients that received EC versus patients that received DC was 2 days. The difference in the median hospitalization charges (TOTCHG) was \$12,055.

Table 3 reviews how EC and DC correlated with interventions, and adverse events, and summarizes the differences between LOS and TOTCHG for the two groups.

On binary logistic regression analysis, the model that was generated was able to predict the observed outcome (death dur-

Table 2. Demographic Differences in Patients That Received Early Versus Delayed Colonoscopy^a (N = 285,165)

| Characteristic | Early colonoscopy | Delayed colonoscopy | P value/total number |
|-------------------------------------|-------------------|---------------------|----------------------|
| Age, median ^b | 73 | 73 | < 0.001 |
| Age, mean (SD) | 70.90 (14.45) | 70.59 (14.39) | < 0.001 |
| Age group, (in years) | | | < 0.001 |
| 18 - 35 (% within age group) | 2,790 (37.9%) | 4,580 (62.1%) | 7,370 (100%) |
| 36 - 50 | 7,650 (37.7%) | 12,625 (62.3%) | 20,275 |
| 51 - 65 | 21,815 (36.4%) | 38,130 (63.6%) | 59,945 |
| > 66 | 74,800 (37.9%) | 122,775 (62.1%) | 197,575 |
| Gender | | | < 0.001 |
| Male (% within gender group) | 56,835 (39.3%) | 87,735 (60.7%) | 144,570 (100%) |
| Female | 50,190 (35.7%) | 90,350 (64.3%) | 140,540 |
| Race | | | < 0.001 |
| White (% within race group) | 68,995 (38.1%) | 112,245 (61.9%) | 181,240 (100%) |
| Black | 19,610 (35%) | 36,475 (65%) | 24,725 |
| Hispanic | 9,245 (37.4%) | 15,480 (62.6%) | 24,725 |
| Asian/Pacific Islander | 3,130 (43.4%) | 4,075 (56.6%) | 7,205 |
| Native American | 560 (35.2%) | 1,030 (64.8%) | 1,590 |
| Other | 2,300 (37.9%) | 3,765 (62.1%) | 6,065 |
| Type of insurance | | | < 0.001 |
| Medicare (% within group) | 75,360 (37.2%) | 127,485 (62.8%) | 202,845 (100%) |
| Medicaid | 6,850 (31.8%) | 14,710 (68.2%) | 21,560 |
| Private | 19,845 (42%) | 27,450 (58%) | 47,295 |
| Self-pay | 2,545 (36.1%) | 4,510 (63.9%) | 7,055 |
| No charge | 270 (36.7%) | 465 (63.3%) | 735 |
| Other | 2,070 (38.7%) | 3,280 (61.3%) | 5,350 |
| Charlson Comorbidity Index grouping | | | < 0.001 |
| 0 (% within group) | 4,740 (43%) | 6,280 (57%) | 11,020 (100%) |
| 1 | 5,565 (41.9%) | 7,705 (58.1%) | 13,270 |
| 2 | 9,170 (44.1%) | 11,640 (55.9%) | 20,810 |
| ≥ 3 | 87,580 (36.5%) | 152,485 (63.5%) | 240,065 |
| CCI, median ^b | 5 | 5 | < 0.001 |
| CCI, mean (SD) | 4.62 (2.37) | 5.12 (2.48) | < 0.001 |
| Hospital location/teaching status | | | < 0.001 |
| Rural (% within group) | 2,090 (39.7%) | 3,180 (60.3%) | 5,270 (100%) |
| Urban nonteaching | 7,350 (40.9%) | 10,600 (59.1%) | 17,950 |
| Urban teaching | 17,155 (37.6%) | 28,500 (62.4%) | 45,655 |
| Admission day of the week | | | < 0.001 |
| Weekday admission (% within group) | 84,940 (39.5%) | 130,165 (60.5%) | 215,105 (100%) |
| Weekend admission | 22,115 (31.6%) | 47,945 (68.4%) | 70,060 |

^aNumbers weighted by NIS weight. The total numbers in each category may not necessarily add up to n = 285,165 as some of the values may not have been reported in the database, leading to those cases being excluded from these calculations. ^bMedian values would be a more accurate measure of central tendency as compared to mean for this data. NIS: National (Nationwide) Inpatient Sample; CCI: Charlson Comorbidity Index; SD: standard deviation.

Table 3. Adverse Events and Intervention Data Reported in Patients With Lower Gastrointestinal Bleeding That Received Early Versus Delayed Colonoscopy (N = 285,150)

| Event/intervention | Early colonoscopy (n = 107,045) | Delayed colonoscopy (n = 178,105) | P value |
|---|------------------------------------|--------------------------------------|---------|
| Transfusion of any blood products | 34,535 (32.3%) | 66,185 (37.2%) | < 0.001 |
| Transfusion of red cell related products only | 33,645 (31.4%) | 64,905 (36.4%) | < 0.001 |
| Hypovolemia or shock | 7,660 (7.2%) | 11,990 (6.7%) | < 0.001 |
| Acute kidney injury | 15,925 (14.9%) | 41,140 (23.1%) | < 0.001 |
| Dialysis | 1,525 (1.4%) | 4,330 (2.4%) | < 0.001 |
| Acute respiratory failure | 1,420 (1.3%) | 3,835 (2.2%) | < 0.001 |
| Ventilator support (h) | | | < 0.001 |
| < 24 h | 480 (0.4%) | 970 (0.5%) | |
| 24 - 96 h | 825 (0.8%) | 1,995 (1.1%) | |
| > 96 h | 510 (0.5%) | 2,485 (1.4%) | |
| Endoscopic destruction of large intestine lesions | 620 (0.6%) | 1,040 (0.6%) | 0.871 |
| Outcomes | | | |
| Death (% within colonoscopy group) | 1,005 (0.9%) | 2,530 (1.4%) | < 0.001 |
| Median length of stay (LOS) | 3 days | 5 days | < 0.001 |
| Median total charges (TOTCHG) | \$32,037 | \$44,092 | < 0.001 |
| Mean ^a LOS (Standard deviation) | 3.99 days (4.64) | 7.10 days (8.40) | < 0.001 |
| Mean ^a TOTCHG (SD) | \$49,722 (71,486) | \$77,048 (133,027) | < 0.001 |

^aAlthough we reported the mean values, the median value would be a more accurate measurement of central tendency for this data set. LOS: length of stay; TOTCHG: total charges of hospitalization; SD: standard deviation.

ing hospitalization) with 99.0% accuracy ($P < 0.001$). Furthermore, the ROC curve made using the predicted and observed values for death showed 0.867 area under the curve ($P < 0.001$), which represents excellent discrimination, or in other words, a good fit (Table 4, Fig. 1). Despite the statistically significant difference in inpatient deaths observed between the EC and DC groups, some covariates, namely AKI, CKD, hemodialysis and ARF had very significant odds ratios which could be confounding the results of the regression analysis. When adjusted for using IPTW, the difference in inpatient deaths between the two groups disappeared (odds ratio of 0.945, 95% CI: 0.877 - 1.019, $P = 0.142$).

On linear regression analysis, predicted unstandardized values of the LOS and TOTCHG were obtained. The predicted median LOS for patients who received an EC was 3.90 days versus 5.92 days for patients that received a DC. The difference between these two values was 2.02 days, which closely resembles the 2-day difference in median values observed in the actual data.

The median predicted TOTCHG for patients who received an EC was \$31,659.87, compared to patients with a DC for whom the median TOTCHG was \$43,208.76. The difference in the predicted total charges for early versus late colonoscopies was \$11,548.89, which again was close to the actual observed difference of TOTCHG at \$12,055. The coefficients obtained from the regression analyses are reported in Tables 5 and 6.

The median age for both EC and DC groups was 73 years.

The mean CCI for EC and DC was 4.62 (SD 2.37) and 5.122 (SD 2.48) ($P < 0.001$), respectively.

WA, on Saturday or Sunday, made the patient less likely to receive an EC (31.6% for WA, and 39.5% for non-WA, $P < 0.001$). WA was not associated with increased inpatient deaths (1.3% for WA and 1.2% for non-WA, $P = 0.399$). Being admitted on the weekend did not affect the median LOS (4 days for both groups) and TOTCHG (\$39,018 for WA and \$39,258 for non-WA). Mean LOS (5.90 days for WA and 5.94 days for non-WA, $P = 0.183$) and mean TOTCHG (\$66,037 for WA and \$67,051 for non-WA, $P = 0.043$).

Discussion

On initial analysis, we noticed a decrease in inpatient death rates (which was the primary outcome) in patients in the EC group compared to the DC group. However, when adjusted for confounders, this difference disappeared. There was no difference in the proportion of patients that received endoscopic intervention to control the source of the bleed in the two groups. The patients in the DC group were more likely to have other complications such as AKI, CKD, requirement for hemodialysis, or respiratory failure requiring intubation and mechanical ventilation. This suggests that the patients in this group are inherently more unstable, requiring additional time for initial resuscitation, thus preventing them from receiving an EC. This also explains the higher inpatient

Table 4. Multivariate Analysis of Predictors of Mortality for Patients That Received a Colonoscopy During Hospitalization for an LGIB

| Covariate/predictor | Adjusted odds ratio | 95% confidence interval | | P value |
|--|---------------------|-------------------------|-------|---------|
| | | Lower | Upper | |
| Age (square-root transformed value) ^a | 0.991 | 0.963 | 1.020 | 0.533 |
| Gender (female) | 1.006 | 0.926 | 1.092 | 0.894 |
| Early colonoscopy | 0.902 | 0.827 | 0.985 | 0.022 |
| Race | | | | < 0.001 |
| White | 0.789 | 0.627 | 0.992 | 0.043 |
| Black | 0.449 | 0.351 | 0.575 | < 0.001 |
| Hispanic | 0.741 | 0.570 | 0.962 | 0.024 |
| Asian/Pacific Islander | 0.693 | 0.492 | 0.976 | 0.036 |
| Native American | 1.445 | 0.939 | 2.222 | 0.094 |
| Type of insurance | | | | < 0.001 |
| Medicare | 0.828 | 0.612 | 1.121 | 0.222 |
| Medicaid | 1.044 | 0.748 | 1.457 | 0.800 |
| Private | 0.743 | 0.539 | 1.023 | 0.069 |
| Self-pay | 1.271 | 0.853 | 1.895 | 0.238 |
| No charge | 0 | 0 | 0 | 0.991 |
| Charlson Comorbidity Index | 1.154 | 1.133 | 1.176 | < 0.001 |
| Hypovolemia/shock | 2.961 | 2.694 | 3.255 | < 0.001 |
| IV blood product transfusion | 1.147 | 1.057 | 1.244 | < 0.001 |
| AKI | 0.306 | 0.282 | 0.333 | < 0.001 |
| Dialysis | 3.584 | 3.041 | 4.225 | < 0.001 |
| Respiratory failure | 21.916 | 19.873 | 24.17 | < 0.001 |
| Endoscopic intervention | 0.486 | 0.257 | 0.919 | 0.026 |

^aTransformation was performed on the value to make its distribution more normal, to have a more stable regression. LGIB: lower gastrointestinal bleed; IV: intravenous; AKI: acute kidney injury.

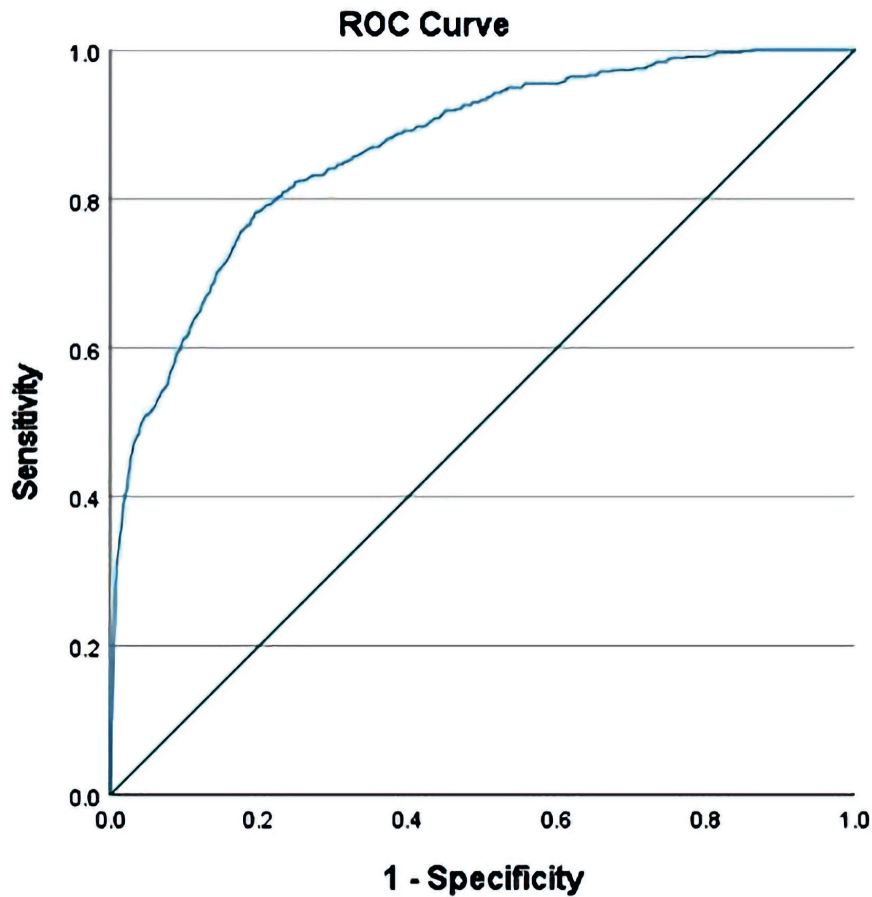
deaths observed in the DC group of patients before adjusting for confounders. Furthermore, pre-procedure preparation is difficult to finish in an unstable patient in a timely fashion, thus providing another reason why performing EC in such patients would be challenging [8]. The absence of a significant difference in inpatient deaths between the EC and DC groups was consistent with the findings of the previous studies [10-28]. The secondary outcomes of our study were LOS and TOTCHG. We noticed a significantly decreased LOS and TOTCH among the patients in the EC group when compared to the DC group. These findings are consistent with previous studies [4-6, 10-12, 15, 26, 27]. The difference in the CCI between the EC and DC groups although statistically significant, was very small. This suggests that the acuity of the patients' presentation was more important in whether the patient received an EC, as compared to the patients' past histories of comorbidities.

Another important finding of our study was the decreased number of patients in the EC group requiring transfusion of blood products compared to patients in the DC group. This result was again consistent with the findings of previous studies [13, 22-24, 33]. It is difficult to ascertain

the exact reason for this decreased requirement for transfusion in the EC group. It could be because the patients in the EC group were relatively more stable, thus requiring fewer transfusions, or it could be because the patients in the EC group received the endoscopy earlier, allowing for a quicker diagnosis of the bleeding etiology and achievement of hemostasis. However, given that we did not observe a difference in the proportion of patients that received interventions during the endoscopy between the EC and DC groups, the latter explanation seems less likely.

Data for the newer years showed a shift away from performing EC (37.5%) compared to older data, where 45% of cases received EC [25]. This could represent a shift in the preferences of the gastroenterologists when it comes to performing EC, based on the findings of several past studies that failed to show mortality benefits with EC.

WA were less likely to receive EC, but this did not increase inpatient deaths, LOS, or TOTCHG. The reason for fewer EC being performed for WA is likely because of decreased availability of medical personnel in the hospital during the weekends. However, the fact that this does not increase inpatient deaths, LOS or TOTCHG is reassuring, and perhaps further



Diagonal segments are produced by ties.

Area Under the Curve

Test Result Variable(s): Predicted probability

| Area | Std. Error ^a | Asymptotic Sig. ^b | Asymptotic 95% Confidence Interval | |
|------|-------------------------|------------------------------|------------------------------------|-------------|
| | | | Lower Bound | Upper Bound |
| .867 | .004 | .000 | .860 | .874 |

The test result variable(s): Predicted probability has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Figure 1. Receiver operating curve (ROC) comparing the predicted values of mortality obtained after the binary regression when compared with the observed values for the cases in the study.

strengthens the claim that EC does not have a mortality benefit in case of LGIB.

Strengths of the study

Our study included newer data from 2016 to 2019, making it

more relevant to the present day. Patients included were from various demographic, economic, race, and socio-cultural backgrounds. Thus, the results obtained would be generalizable to the population of the USA. We had a large sample size and detected significant associations between different variables. The newer NIS data uses ICD-10 diagnosis and procedural codes that are more descriptive in terms of details of medical conditions and

Table 5. Multivariate Analysis of Predictors of Length of Stay (LOS) for Patients That Received a Colonoscopy During Hospitalization for an LGIB

| Covariate/predictor | Unstandardized coefficients after reverse transformation ^a | 95% confidence interval | | P value |
|--|---|-------------------------|--------|---------|
| | | Lower | Upper | |
| Constant | 3.715 days | 3.508 | 3.926 | < 0.001 |
| Age (square-root transformed value) ^b | 1.052 | 1.049 | 1.054 | < 0.001 |
| Gender (female) | 1.028 | 1.023 | 1.033 | < 0.001 |
| Early colonoscopy | -1.44 | -1.448 | -1.435 | < 0.001 |
| Race | | | | |
| White | 1.005 | -1.006 | 1.016 | 0.433 |
| Black | 1.045 | 1.033 | 1.057 | < 0.001 |
| Hispanic | -1.011 | -1.026 | 1 | 0.055 |
| Asian/Pacific Islander | -1.039 | -1.056 | -1.023 | < 0.001 |
| Native American | -1.035 | -1.062 | -1.007 | 0.016 |
| Type of insurance | | | | |
| Medicare | 1.072 | 1.014 | 1.132 | 0.015 |
| Medicaid | 1.167 | 1.104 | 1.233 | < 0.001 |
| Private | 1.072 | 1.014 | 1.132 | 0.016 |
| Self-pay | 1.084 | 1.026 | 1.148 | 0.005 |
| No charge | 1.007 | -1.062 | 1.074 | 0.864 |
| Charlson Comorbidity Index | 1.045 | 1.042 | 1.045 | < 0.001 |
| Hypovolemia/shock | 1.256 | 1.245 | 1.265 | < 0.001 |
| IV blood product transfusion | 1.135 | 1.132 | 1.14 | < 0.001 |
| AKI | 1.239 | 1.233 | 1.247 | < 0.001 |
| Dialysis | 1.183 | 1.167 | 1.199 | < 0.001 |
| Respiratory failure | 1.671 | 1.644 | 1.698 | < 0.001 |
| Endoscopic intervention | 1.268 | 1.236 | 1.297 | < 0.001 |
| Weekend admission | -1.028 | -1.033 | -1.023 | < 0.001 |

^aTransformation was performed on the value to make its distribution more normal and to have a more stable regression. The values in this table are reverse-transformed to make them more interpretable. ^bAge underwent square-root transformation making interpretation of numbers difficult in this case. For categorical variables, the +/- sign represents the direction of the effect, and the coefficient represents the percentage change attributed to the said covariate. For example, respiratory failure, if present, causes the LOS to increase by (1.671 - 1 = 0.671) or 67.1%. LGIB: lower gastrointestinal bleed; IV: intravenous; AKI: acute kidney injury.

interventions than ICD-9 codes used for the older data reported in the previous studies. We also used advanced statistical methods to address the non-normalcy of the data using transformation, and to adjust for the confounding variables using IPTW.

Limitations of the study

NIS is an administrative database. All the diagnoses, treatments, and procedures were detected using the ICD-10 diagnostic and procedure codes. The accuracy of the results depends on the accuracy with which data were reported in NIS. Clinical details, laboratory values, and procedure reports of the patients were not available. Longitudinal follow-up of the patients and occurrence of re-bleeds could not be obtained. The presence of anticoagulation in these patients was not studied. Further studies are needed to address the limitations of this study.

Conclusions

EC did not decrease inpatient deaths in patients presenting to the hospital with LGIB. The difference in inpatient deaths between the EC and DC groups that was observed on initial analysis was not evident when adjusted for confounders. EC was associated with a decreased LOS and TOTCHG in these patients. Thus, EC would be warranted in patients with LGIB with the goal to decrease the LOS and TOTCHG. WA received fewer EC, but this did not affect inpatient deaths.

Supplementary Material

Suppl 1. Secondary diagnosis codes for conditions usually associated with an LGIB.

Table 6. Multivariate Analysis of Predictors of Total Charges (TOTCHG) for Patients That Received a Colonoscopy During Hospitalization for an LGIB

| Covariate/predictor | Reverse-transformed values of unstandardized coefficients ^a | 95% confidence interval | | P value |
|--|--|-------------------------|--------|---------|
| | | Lower | Upper | |
| Constant | 16,982 | 15,631 | 18,450 | < 0.001 |
| Age (square-root transformed value) ^b | 1.052 | 1.050 | 1.054 | < 0.001 |
| Gender (female) | 1.002 | 0.998 | 1.009 | 0.357 |
| Early colonoscopy | -1.288 | -1.294 | -1.279 | < 0.001 |
| Race | | | | |
| White | 1.153 | 1.135 | 1.172 | < 0.001 |
| Black | 1.175 | 1.156 | 1.197 | < 0.001 |
| Hispanic | 1.459 | 1.432 | 1.486 | < 0.001 |
| Asian/Pacific Islander | 1.426 | 1.393 | 1.459 | < 0.001 |
| Native American | 1.033 | 0.991 | 1.074 | 0.119 |
| Type of insurance | | | | |
| Medicare | 1.153 | 1.067 | 1.250 | < 0.001 |
| Medicaid | 1.259 | 1.161 | 1.365 | < 0.001 |
| Private | 1.183 | 1.091 | 1.282 | < 0.001 |
| Self-pay | 1.194 | 1.102 | 1.297 | < 0.001 |
| No charge | 1.186 | 1.079 | 1.306 | < 0.001 |
| Charlson Comorbidity Index | | | | |
| Hypovolemia/shock | 1.514 | 1.496 | 1.531 | < 0.001 |
| IV blood product transfusion | 1.186 | 1.18 | 1.194 | < 0.001 |
| AKI | 1.312 | 1.303 | 1.321 | < 0.001 |
| Dialysis | 1.253 | 1.230 | 1.279 | < 0.001 |
| Respiratory failure | 2.466 | 2.410 | 2.523 | < 0.001 |
| Endoscopic intervention | 1.250 | 1.205 | 1.294 | < 0.001 |
| Weekend admission | -1.019 | -1.026 | -1.011 | < 0.001 |

^aTransformation was performed on the value to make its distribution more normal and to have a more stable regression. The values in this table are reverse-transformed to make them more interpretable. ^bAge underwent square-root transformation making interpretation of numbers difficult in this case. For categorical variables, the +/- sign represents the direction of the effect, and the coefficient represents the percentage change attributed to the said covariate. For example, respiratory failure, if present, causes the TOTCHG to increase by (2.466 - 1 = 1.466) or 146.6%. LGIB: lower gastrointestinal bleed; IV: intravenous; AKI: acute kidney injury.

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Conflict of Interest

We do not have any conflict of interest to disclose.

Informed Consent

The data used in the study is a nationally available de-identified database. The question of obtaining consent from study subjects is not applicable to this study.

Author Contributions

Kuldeepsinh P. Atodaria MD: conceptualization, data acquisition, statistical analysis, writing original draft, review, and editing. Samyak Dhruv MD: statistical analysis, review, and editing. Joseph M. Bruno MD: conceptualization, review, and editing. Brisha Bhikadiya DO: writing original draft, review, and editing. Shravya R. Ginnaram MD: writing original draft, review, and editing. Shreeja Shah MD: review and editing.

Data Availability

The result files of the statistical analysis (which was performed using IBM SPSS 28.0) were available to the reviewers of the manuscript from the corresponding author upon reasonable request.

Abbreviations

LGIB: lower gastrointestinal bleed; EC: early colonoscopy; DC: delayed colonoscopy; HCUP: Healthcare Utilization Project; NIS: National (Nationwide) Inpatient Sample; ICD-10: International Classification of Disease 10th Edition; ICD-9: International Classification of Disease 9th Edition; CCI: Charlson Comorbidity Index; LOS: length of stay; TOTCHG: total charges of hospitalization; AKI: acute kidney injury; SD: standard deviation; ROC: receiver operating curve; WA: weekend admissions

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