Original Article

Angiography versus colonoscopy in patients with severe lower gastrointestinal bleeding: a nation-wide observational study

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Aim: Clinical guidelines for acute lower gastrointestinal bleeding (LGIB) recommend non-endoscopic treatment when endoscopic treatment is difficult or the patient is hemodynamically unstable. The aim of this study was to investigate whether angiography should be prioritized as initial treatment for severe LGIB patients over colonoscopy.

Methods: We undertook a retrospective cohort study using the Japanese Diagnosis Procedure Combination inpatient database. We compared adult patients who underwent colonoscopy or angiography within 1 day of admission for severe LGIB from 2010 to 2017. The primary outcome was in-hospital mortality. Secondary outcomes included surgery carried out within 1 day after admission and surgery carried out between 2 and 7 days of admission. Propensity score-matched analyses were undertaken to adjust for confounders.

Results: We identified 6,546 eligible patients. The patients were divided into the colonoscopy group (n = 5,737) and angiography group (n = 809). After one-to-four propensity score matching, we compared 3,220 and 805 patients who underwent colonoscopy and angiography, respectively. The angiography group was not significantly associated with reduced in-hospital mortality compared with the colonoscopy group. In contrast, the number of patients who underwent surgery within 1 day of admission was significantly lower in the angiography group than in the colonoscopy group.

Conclusions: The present study revealed that in-hospital mortality did not significantly differ between colonoscopy and angiography, even in severe LGIB patients. Although this study was unable to identify which subgroups should undergo angiography for primary hemostasis, angiography might be a better option than colonoscopy for initial hemostasis in more severe cases of LGIB.

Key words: Angiography, colonoscopy, endoscopic treatment, gastrointestinal bleeding, shock

INTRODUCTION

LOWER GASTROINTESTINAL BLEEDING (LGIB) refers to a hemorrhage from a source distal to the ligament of Treitz.[1] The common causes of acute LGIB include diverticulosis, post-polypectomy bleeding, ischemic colitis, colorectal polyps/neoplasms, rectal ulcers, and varices.[1] Lower gastrointestinal bleeding requires hemostasis by colonoscopy, angiography, or surgery in approximately 15% of all cases.[2] Although mortality in patients with LGIB is relatively low (1–4%),[3,4] in cases of massive hemorrhaging compounded by hemodynamic instability and/or requiring a transfusion of more than 4 units of red blood cells within 24 h, mortality increases to 21–40%.[5]

The American College of Gastroenterology released a clinical guideline for acute LGIB in 2016.[1] Colonoscopy is considered the mainstay of diagnosis and hemostasis in cases of acute LGIB.[6] In patients with high-risk features

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Received 14 Mar, 2020; accepted 26 May, 2020
Funding information
This work was supported by grants from the Ministry of Health, Labour and Welfare, Japan (19AA2007 and H30-Policy-Designated-004) and the Ministry of Education, Culture, Sports, Science and Technology, Japan (17H04141).

and active bleeding, colonoscopy is recommended within the first 24 h following a colon purge.[1] However, emergency colonoscopy for LGIB is commonly plagued by poor visualization, which increases the risk of perforation.[7] On the opposite end of the spectrum, angiography has been used effectively to control LGIB when the endoscopic approach is either impossible or ineffective.[8] Recently, advances in microcatheter technology and embolization have aided in super-selective embolization to emerge as a selective treatment for LGIB.[9] These hemostatic methods recommended in the guidelines are supported based on small retrospective observational studies comparing angiography and colonoscopy for LGIB.[10] Additionally, with regard to severe LGIB patients, no comparative studies have been undertaken to date to determine whether these patients should receive angiography or colonoscopy for primary hemostasis.

Using a nationwide inpatient database in Japan, the present study aimed to investigate the applicability of colonoscopy in primary hemostasis in patients with severe LGIB as compared with angiography.

MATERIALS AND METHODS

Data source

THIS WAS A retrospective cohort study, using the Japanese Diagnosis Procedure Combination inpatient database. This database consists of discharge abstracts and administrative claims data from more than 1,200 emergency hospitals in Japan.[11] The database contains data such as age, sex, diagnoses, comorbidities on admission, procedures, including devices used during hospitalization, prescriptions, and discharge status. The diagnoses are coded by the International Classification of Diseases, 10th Revision codes (ICD-10) with text data entered in Japanese. This study was approved by the Institutional Review Board of the University of Tokyo. Because of the anonymous nature of the data, the requirement for informed consent was waived.

Study cohort

We selected patients over the age of 16 years who were admitted to an acute care hospital by ambulance and underwent angiography or colonoscopy within 1 day of admission for severe LGIB between April 2010 and March 2017. We defined severe LGIB as the following: transfusion ≥4 units of red blood cells or the use of vasopressors within 1 day of admission.[5] The diagnosis of LGIB was defined by ICD-10 code: gastrointestinal hemorrhage, unspecified (K922); melena (K921); diverticular disease of large intestine without perforation or abscess (K573); hemorrhage of anus and rectum (K625); and ulcer of anus and rectum (K626).

We excluded patients with a primary diagnosis of upper gastrointestinal diseases (Table S1). Also excluded were patients with a length of hospital stay ≤1 day (to avoid immortal time bias). The database includes four main diagnoses and we adopted inclusion and exclusion criteria based on these primary diagnoses. The patients were divided into two groups: those who underwent colonoscopy (colonoscopy group) or angiography (angiography group) within 1 day of admission. Patients who underwent both colonoscopy and angiography within 1 day of admission were categorized as the colonoscopy group. In cases undergoing surgery within 1 day of admission, we assumed that surgery was carried out after colonoscopy and angiography.

Outcomes and variables

The primary outcome of the present study was in-hospital mortality. Secondary outcomes included surgery carried out within 1 day after admission and surgery carried out between 2 and 7 days of admission. Table S2 shows the list of surgeries adopted as outcomes. Level of consciousness was evaluated by the Japan Coma Scale on admission. Previous studies have shown a respectable correlation between the Japan Coma Scale and the Glasgow Coma Scale.[12] Charlson comorbidity index provides a method for predicting mortality and has been widely used to measure case mix and disease burden.[13] Activity of daily living and mobility at admission is evaluated using the Barthel index.[14]

Statistical analysis

Propensity score matching was applied to account for the differences in baseline characteristics between patients who underwent colonoscopy or angiography. We calculated the propensity score using a logistic regression model for angiography. To account for clustering within hospitals, a generalized estimating equation was linked to the model. The following potential confounders were included in the propensity score calculations: age; sex; Charlson comorbidity index; Barthel index at admission; Japan Coma Scale score at admission; procedures carried out within 1 day of admission; prescriptions within 1 day of admission (tranexamic acid, vasopressors [dopamine, dobutamine, norepinephrine, and vasopressin], fresh-frozen plasma, and platelets); amount of transfusions within 1 day of admission; type of hospital; intensive care unit (ICU) admission; use of ambulance; and diagnoses.

A one-to-four propensity score-matched analysis was undertaken between the colonoscopy and angiography

groups. We used nearest neighbor matching with replacement within a caliper of 20% of the standard deviation of the estimated propensity scores on the logit scale.[15] The characteristics of LGIB patients who underwent colonoscopy or angiography were compared before and after propensity score matching using the standardized difference. An absolute value for the standardized difference of <10% was regarded as balanced.[16] In the propensity-matched analysis, the outcomes were compared using the χ^2-test.

In addition, we undertook subgroup analyses of in-hospital mortality and examined the significance of interactions using the Breslow–Day test. The subgroups were defined for the following baseline variables: (i) age (16–64 or ≥65 years); (ii) vasopressor used within 1 day of admission; (iii) transfusions (4–9 or ≥10 units of red blood cells within 1 day of admission); (iv) use of ICU within 1 day of admission; and (v) mechanical ventilation within 1 day of admission.

Finally, we repeated the same analyses described above but this time excluding patients who required both colonoscopy and angiography within 1 day of admission in order to confirm the primary analysis.

We described the patient characteristics and summarized them as counts and proportions or medians and interquartile ranges. A two-sided *P*-value of <0.05 was considered statistically significant. All statistical analyses were undertaken using Stata MP 15 software (Stata, College Station, TX, USA).

RESULTS

We identified 6,546 eligible patients from 979 facilities during the study period. The patients were divided into the colonoscopy (n = 5,737) and angiography (n = 809) groups. Within the colonoscopy group, 144 patients underwent both colonoscopy and angiography. After one-to-four propensity score matching, we compared 3,220 and 805 patients who underwent colonoscopy and angiography, respectively (Fig. 1). The C-statistic for the propensity score model was 0.85.

Table 1 shows the baseline characteristics of the two groups before and after propensity score matching. Prior to propensity score matching, the patients were more likely to receive angiography if they were younger in age, had a lower Barthel index, and/or presented with a lower level of consciousness on admission. Furthermore, a higher percentage of patients in the angiography group required mechanical ventilation, contrast-enhanced computed tomography, intra-arterial blood pressure monitoring, vasopressors, blood transfusions, and ICU admission. After propensity score matching, the baseline patient characteristics were well balanced between the two groups.

Table 2 shows the proportions of the outcomes for the two groups after propensity score matching. Patients in the angiography group were not significantly associated with reduced in-hospital mortality compared with the colonoscopy group (risk ratio, 1.14; 95% confidence interval, 0.95–1.36; P = 0.16). The number of patients who underwent surgery within 1 day of admission was significantly lower in the angiography group than in the colonoscopy group (risk ratio, 0.44; 95% confidence interval, 0.29–0.67; P < 0.001). The prevalence of surgery being undertaken between 2 and 7 days of admission did not significantly differ between the angiography and colonoscopy groups (risk ratio, 1.15; 95% confidence interval, 0.79–1.67; P = 0.46).

Figure 2 shows the results of the subgroup analyses for in-hospital mortality in the propensity score-matched cohort. Significant interactions in the subgroups of admission to ICU and mechanical ventilation within 1 day of admission were noted. In patients who were not admitted to the ICU, nor required mechanical ventilation, the colonoscopy group was associated with a better outcome.

In additional analyses excluding patients who required both colonoscopy and angiography within 1 day of admission, the results were similar to the primary analyses.

DISCUSSION

In this nationwide study, we examined the effects of angiography versus colonoscopy in patients with severe LGIB. After adjusting for numerous confounding factors using propensity score matching, in-hospital mortality and surgery carried out between 2 and 7 days of admission did not significantly differ between the angiography and colonoscopy groups. In contrast, angiography was significantly associated with a lower prevalence of surgery carried out within 1 day of admission than colonoscopy. In patients who were not admitted to the ICU or did not require mechanical ventilation, the colonoscopy group was associated with a better outcome.

The American College of Gastroenterology guideline for acute LGIB indicates that angiography should be considered when colonoscopy is difficult or when the patients are hemodynamically unstable. However, due to the lack of investigations comparing colonoscopy and angiography under hemorrhagic shock, the evidence level was characterized as "very low" in the guideline.[1] A small observational study that compared colonoscopy (n = 33) with angiography (n = 20) in patients with severe LGIB showed that colonoscopy was associated with shorter hospital stay, increased diagnostic yield, and fewer red blood cell transfusions. The prevalence of therapeutic intervention and incidence of death did not differ significantly between the two groups.[10]

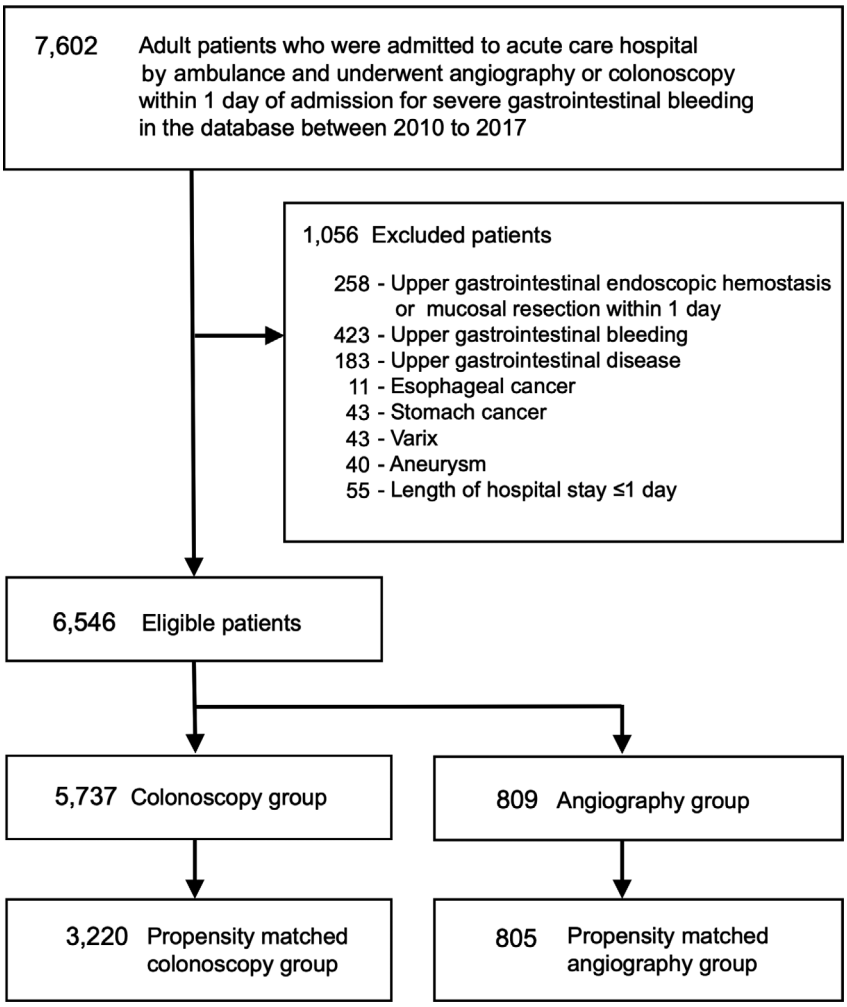

Fig. 1. Study flowchart showing selection of Japanese patients who underwent colonoscopy or angiography within 1 day of admission for severe lower gastrointestinal bleeding.

The strength of our study was the use of a large number of participants from numerous facilities and the use of mortality as a hard outcome. This is the first nationwide study comparing colonoscopy versus angiography in severe LGIB patients.

Colonoscopy has both diagnostic and therapeutic roles in acute LGIB; most notably, colonoscopy can identify the hemorrhage site and transition to direct observational hemostasis.[1] One of the major weaknesses of urgent colonoscopy in acute LGIB cases is poor visualization due to large amounts of stool or blood in the colon lumen. Although bowel preparation can clear the lumen of residual blood and clots, an active hemorrhage could quickly reoccupy the lumen and again impair visualization.[3] In our study, although angiography was not associated with reduced mortality, the colonoscopy group was more prone to requiring surgery within 1 day of admission than the angiography group. It should also be noted that 144 patients in the colonoscopy group required angiography on the same day. These results suggest that patients who undergo colonoscopy might require additional hemostasis.

In contrast to colonoscopy, angiography can control severe bleeding without the need for bowel preparation. The goal of angiography is to undergo transarterial embolization while allowing mucosal viability through collateral circulation.[5] In recent years, the development of microcatheters with a small caliber and various embolic materials have enabled super-selective embolization.[17] Lower gastrointestinal bleeding can be rapidly treated at a high rate of success by angiography.[9] A known disadvantage of angiography is the risk of intestinal ischemia.[6,18] The outcome of surgery undertaken

Table 1. Baseline characteristics of patients with severe lower gastrointestinal bleeding

Variable	Before propensity score matching			After propensity score matching		
	Colonoscopy group (*n* = 5,737)	Angiography group (*n* = 809)	ASD (%)	Colonoscopy group (*n* = 3,220)	Angiography group (*n* = 805)	ASD (%)
Age (years), median (IQR)	77 (67–83)	72 (63–81)	29.9	73 (62–81)	72 (63–81)	5.5
Male, *n* (%)	3577 (62.3)	524 (64.8)	5.0	2081 (64.6)	522 (64.8)	0.5
Japan Coma Scale, *n* (%)						
0 (alert)	4672 (81.4)	488 (60.3)	56.5	1917 (59.5)	488 (60.6)	7.1
1–3 (delirium)	827 (14.4)	168 (20.8)		757 (23.5)	168 (20.9)	
10–30 (somnolence)	182 (3.2)	62 (7.7)		239 (7.4)	62 (7.7)	
100–300 (coma)	56 (1.0)	91 (11.2)		307 (9.5)	87 (10.8)	
Charlson comorbidity index, *n* (%)						
0	2532 (44.1)	387 (47.8)	12.7	1425 (44.3)	384 (47.7)	12.8
1	1521 (26.5)	220 (27.2)		942 (29.3)	219 (27.2)	
2	929 (16.2)	126 (15.6)		443 (13.8)	126 (15.7)	
≥3	755 (13.2)	76 (9.4)		410 (12.7)	76 (9.4)	
Barthel index, *n* (%)						
0 (worst disability)	1421 (24.8)	402 (49.7)	58.0	1629 (50.6)	398 (49.4)	5.9
1–99	1944 (33.9)	139 (17.2)		528 (16.4)	139 (17.3)	
100 (full activity)	1291 (22.5)	118 (14.6)		420 (13.0)	118 (14.7)	
Missing	1081 (18.8)	150 (18.5)		643 (20.0)	150 (18.6)	
Prescriptions within 1 day, *n* (%)						
Vasopressor	521 (9.1)	224 (27.7)	49.5	906 (28.1)	220 (27.3)	1.8
Tranexamic acid	2234 (38.9)	309 (38.2)	1.5	1173 (36.4)	307 (38.1)	3.5
Albumin (g)						
<12.5	5246 (91.4)	650 (80.3)	33.5	2500 (77.6)	646 (80.2)	6.9
≥12.5, <25	278 (4.8)	68 (8.4)		289 (9.0)	68 (8.4)	
≥25	213 (3.7)	91 (11.2)		431 (13.4)	91 (11.3)	
Red blood cells (units)						
0–1	137 (2.4)	76 (9.4)	79.1	221 (6.9)	74 (9.2)	9.5
2–3	97 (1.7)	16 (2.0)		80 (2.5)	16 (2.0)	
4–5	4131 (72.0)	315 (38.9)		1251 (38.9)	315 (39.1)	
6–7	878 (15.3)	163 (20.1)		662 (20.6)	163 (20.2)	
8–9	297 (5.2)	92 (11.4)		390 (12.1)	92 (11.4)	
≥10	197 (3.4)	147 (18.2)		616 (19.1)	145 (18.0)	
Fresh-frozen plasma	588 (10.2)	334 (41.3)	75.9	1364 (42.4)	332 (41.2)	2.3
Platelets	98 (1.7)	94 (11.6)	40.5	321 (10.0)	92 (11.4)	4.7
Procedures within 1 day, *n* (%)						
Mechanical ventilation	114 (2.0)	173 (21.4)	63.3	610 (18.4)	169 (21.0)	5.1
Renal replacement therapy	165 (2.9)	24 (3.0)	0.5	146 (4.5)	24 (3.0)	8.2
Intra-arterial blood pressure monitoring	369 (6.4)	355 (43.9)	95.6	1492 (46.3)	351 (43.6)	5.5
Contrast enhanced computed tomography	2501 (43.6)	608 (75.2)	67.8	2436 (75.7)	604 (75.0)	1.4
Diagnosis, *n* (%)						
Colonic diverticulum bleeding	3243 (56.5)	302 (37.3)	39.2	1299 (40.3)	302 (37.5)	5.8
Colon cancer	129 (2.2)	10 (1.2)	7.7	40 (1.2)	10 (1.2)	0.1
Rectal ulcer	265 (4.6)	9 (1.1)	21.1	25 (0.8)	9 (1.1)	3.5
Rectal bleeding	77 (1.3)	13 (1.6)	2.2	61 (1.9)	13 (1.6)	2.1
Rectal cancer	63 (1.1)	11 (1.4)	2.4	42 (1.3)	11 (1.4)	0.5

Table 1. (Continued)

Variable	Before propensity score matching			After propensity score matching		
	Colonoscopy group (*n* = 5,737)	Angiography group (*n* = 809)	ASD (%)	Colonoscopy group (*n* = 3,220)	Angiography group (*n* = 805)	ASD (%)
Admission site, *n* (%)						
Teaching hospital	5003 (87.2)	731 (90.4)	10.0	2901 (90.1)	727 (90.3)	0.7
Intensive care unit	557 (9.7)	387 (47.8)	92.8	1622 (50.4)	383 (47.6)	5.6

ASD, absolute standardized mortality; IQR, interquartile range.

Table 2. Outcomes after propensity score matching

Outcomes	Angiography group % (*n*)	Colonoscopy group % (*n*)	Risk ratio (95% confidence interval)	*P*-value
Primary outcome				
In-hospital mortality	15.9% (128/805)	14.0% (450/3220)	1.14 (0.95–1.36)	0.16
Secondary outcomes				
Surgery performed within 1 day	2.9% (23/805)	6.5% (210/3220)	0.44 (0.29–0.67)	<0.001
Surgery performed between 2 and 7 days	4.2% (34/805)	3.7% (118/3220)	1.15 (0.79–1.67)	0.46

between 2 and 7 days in the present study could reflect the degree of complications associated with colonoscopy and angiography; however, the incidence of surgery during this post-admissions period did not significantly differ between the groups. Therefore, one can make the argument that angiography could be carried out in patients with severe LGIB without an increasing prevalence of complications.

Although colonoscopy could require additional hemostasis, it might be favorable in patients with relatively milder cases of LGIB (without mechanical ventilation and no ICU admission). It would therefore be reasonable to recommend colonoscopy as an option for initial hemostasis in the LGIB guidelines. Further investigations should be endeavored in order to identify which subgroups should be assigned to undergo angiography for primary hemostasis.

There are several limitations associated with the present study that should be addressed. First, the database does not include detailed clinical information such as vital signs, the amount of bleeding, or laboratory data, including hemoglobin. In lieu of these parameters, we selected patients who received a transfusion ≥4 units of red blood cells and/or use of vasopressors within 1 day of admission. Second, this was a retrospective cohort study using a claims database and hence suffered from potential selection and ascertainment biases. Although we adjusted for numerous factors that might contribute to the allocation and outcomes, propensity score analysis cannot adjust for unmeasured confounders. Third, the database only identifies which procedures were undertaken on any given day and therefore the sequence of treatment (for example, whether colonoscopy was carried out before angiography) remains unknown. Although we categorized patients who underwent both colonoscopy and angiography under the colonoscopy group, the sensitivity analysis that excluded the patients who required both interventions showed similar results. Finally, this database is incapable of tracking individual patient movements at a fine-scale level. For example, if a patient were to be transferred from one hospital to another, it remains unclear if colonoscopy was carried out before the transfer. In such cases, a favorable bias will be introduced into the colonoscopy group. For this reason, patients with a length of hospital stay ≤1 day were excluded from this study to avoid immortal time bias. On the opposite end of the spectrum, the bias discussed above can be considered a disadvantage for the angiography group. It can be assumed that if a patient necessitates transfer to another more advanced hospital, the patient is likely in a more severe condition. Therefore, severe cases, along with those involving a considerable amount of time elapsed since the hemorrhage started might tend to

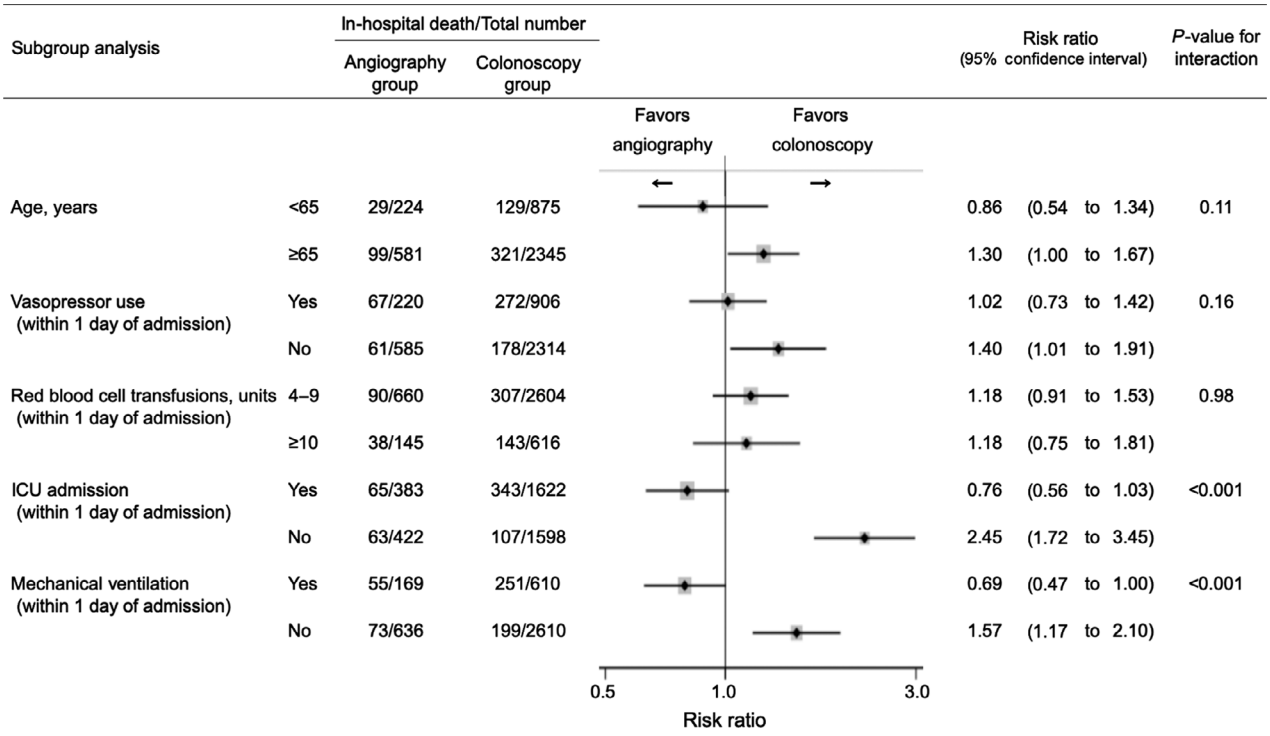

Fig. 2. Subgroup analyses for in-hospital mortality in the propensity score-matched cohort of Japanese patients who underwent colonoscopy or angiography within 1 day of admission for severe lower gastrointestinal bleeding.

aggregate in the angiography group. Even under such circumstances in which angiography is in a disadvantageous position, in-hospital mortality and surgery carried out between 2 and 7 days of admission did not significantly differ between the angiography and colonoscopy groups. It should further be noted that angiography was significantly associated with a lower prevalence of surgery carried out within 1 day of admission than colonoscopy.

CONCLUSION

THIS NATIONWIDE DATABASE study showed that in-hospital mortality did not significantly differ between colonoscopy and angiography in cases of severe LGIB. However, the number of patients who underwent surgery within 1 day of admission was significantly lower in the angiography group than in the colonoscopy group. Although this study was unable to identify which subgroups should undergo angiography for primary hemostasis, angiography might be a better option than colonoscopy for initial hemostasis in more severe cases of LGIB. Further prospective studies are warranted to confirm the effectiveness of angiography for patients with LGIB.

DISCLOSURE

Approval of the research protocol: This study was approved by the Institutional Review Board at The University of Tokyo (No. 3501).
Informed consent: Because of the anonymous nature of the data, the requirement for informed consent was waived.
Registry and registration no. of the study/trial: N/A.
Animal studies: N/A.
Conflict of interest: None.

REFERENCES

1 Strate LL, Gralnek IM. ACG clinical guideline: management of patients with acute lower gastrointestinal bleeding. Am. J. Gastroenterol. 2016; 111: 459–74.
2 Abbas SM, Bissett IP, Holden A *et al*. Clinical variables associated with positive angiographic localization of lower gastrointestinal bleeding. ANZ J. Surg. 2005; 75: 953–7.
3 Angtuaco TL, Reddy SK, Drapkin S *et al*. The utility of urgent colonoscopy in the evaluation of acute lower gastrointestinal tract bleeding: a 2-year experience from a single center. Am. J. Gastroenterol. 2004; 96: 1782–5.

4 Benoit D, Decruyenaere J, Depuydt P *et al*. Artificial neural networks in predicting outcome of gastrointestinal haemorrhage. Lancet 2004; 363: 170–1.
5 Zahid A, Young CJ. Making decisions using radiology in lower GI hemorrhage. Int. J. Surg. 2016; 31: 100–3.
6 Maleux G, Roeflaer F, Heye S *et al*. Long-term outcome of transcatheter embolotherapy for acute lower gastrointestinal hemorrhage. Am. J. Gastroenterol. 2009; 104: 2042–6.
7 Defreyne L, Vanlangenhove P, De Vos M *et al*. Embolization as a first approach with endoscopically unmanageable acute nonvariceal gastrointestinal hemorrhage. Radiology 2013; 218: 739–48.
8 El-Tawil AM. Trends on gastrointestinal bleeding and mortality: where are we standing? World J. Gastroenterol. 2012; 18: 1154–8.
9 Kodani M, Yata S, Ohuchi Y *et al*. Safety and risk of superselective transcatheter arterial embolization for acute lower gastrointestinal hemorrhage with n-butyl cyanoacrylate: angiographic and colonoscopic evaluation. J. Vasc. Interv. Radiol. 2016; 27: 824–30.
10 Strate LL, Syngal S. Predictors of utilization of early colonoscopy vs. radiography for severe lower intestinal bleeding. Gastrointest. Endosc. 2005; 61: 46–52.
11 Yasunaga H, Matsui H, Horiguchi H. Clinical epidemiology and health services research using the diagnosis procedure combination database in Japan. Asian Pacific J. Dis. Manag. 2013; 7: 1–2.
12 Shigematsu K, Nakano H, Watanabe Y. The eye response test alone is sufficient to predict stroke outcome-reintroduction of Japan Coma Scale: a cohort study. BMJ Open 2013; 3: 10–4.
13 Lundgren RS, Kramer CB, Rivara FP *et al*. Influence of comorbidities and age on outcome following burn injury in older adults. J. Burn Care Res. 2009; 30: 307–14.
14 Shah S, Vanclay F, Cooper B. Improving the sensitivity of the Barthel Index for stroke rehabilitation. J. Clin. Epidemiol. 1989; 42: 703–9.
15 Austin PC. An introduction to propensity score methods for reducing the effects of confounding in observational studies. Multivariate Behav. Res. 2011; 46: 399–424.
16 Austin PC. Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. Stat. Med. 2009; 28: 3083–107.
17 Kwon JH, Kim MD, Han K *et al*. Transcatheter arterial embolisation for acute lower gastrointestinal haemorrhage: a single-centre study. Eur. Radiol. 2019; 29: 57–67.
18 D'Othée BJ, Surapaneni P, Rabkin D *et al*. Microcoil embolization for acute lower gastrointestinal bleeding. Cardiovasc. Intervent. Radiol. 2006; 29: 49–58.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1 Upper gastrointestinal diseases as exclusion criteria

Table S2 Surgeries adopted as outcomes