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Visible Bleeding is the Strongest Predictor of a Positive CT Mesenteric Angiogram in the Setting of Lower Gastrointestinal Bleeding

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Abstract

Aims: This study aimed to evaluate factors predictive of a positive computed tomography angiography (CTA) result in patients with lower gastrointestinal bleeding (LGIB) to guide clinical decision-making and determine which patient group has the highest diagnostic yield and which patients may be safely managed without a CTA

Methods: This retrospective study analyzed data from 526 patients who underwent CTA at a tertiary center to investigate LGIB between 2012 and 2020. A univariate and multivariate analysis was performed to identify clinical factors outcomes associated with a positive CTA result.

Results: The study found that patients presenting with visible bleeding on admission and requiring a blood product resuscitation were most likely to have a positive CTA result; in patients with a positive CTA, 80% required further invasive management, including angiography, transcatheter embolization, endoscopy, or surgery. There was no difference in positive CTA rates in patients taking antiplatelets, anticoagulants, or hemodynamic or severity of bleeding as defined by the modified severity index (MSI) and Oakland scores. Patients with a positive CTA had a shorter time to CTA from the last episode of LGIB than those without a blush, supporting the notion that sensitivity is improved with the expediating timing of CTA.

Conclusions: CTA is an effective first-line diagnostic tool in severe acute LGIB. This study highlights the clinical utility of CTA in patients with LGIB, stressing the need for judicious and efficient use of CTA. Medical and conservative management should be prioritized for patients without a negative CTA. Patients with a positive CTA are highly likely to require further invasive intervention and should be transferred to a tertiary center capable of providing these services.

Keywords: Lower Gastrointestinal bleeding; Angioembolization; Colorectal Surgery; CTMA; Diverticular bleed

1. Introduction

Lower gastrointestinal bleed (LGIB) is defined as bleeding from a point distal to the ligament of Treitz (1). LGIB is a common acute surgical presentation to hospitals and is resource-intensive (2). While most bleeding is minor and 80-85% resolve spontaneously, patients with severe bleeding may develop hemorrhagic shock, and hence LGIB carries an overall mortality of 2-3% (2). The annual incidence of LGIB in the United States of America is 20.5 to 35.7 per 100,000 and increases with age, especially from 30 onwards (3). Similarly, the annual incidence in the United Kingdom is 33 to 87 per 100,000, accounting for 3% of emergency surgical referrals (4). The differential diagnosis for an LGIB is broad. Bleeding may originate from multiple points, such as in mucosal ischemia, or from a single bleeding point, such as in diverticular bleeding. The management of bleeding is influenced heavily by the site, cause and severity of bleeding.

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Computed tomography angiography (CTA) is a first-line investigation in the assessment of LGIB due to its usefulness in determining bleeding location, severity, cause, and ease of access with minimal side effects (5,6). CTA has a reported sensitivity of 90% and a specificity of 92% (6) and can detect bleeding rates as low as 0.3-1.0ml/min (7). The accurate location of a bleeding point identified as a contrast blush permits escalation of care from supportive management to definitive management with invasive angiography, transcatheter angioembolization, endoscopy, or surgery (7). If patients present to a peripheral hospital with LGIB and a positive CTA, there is a strong argument for transfer to a tertiary center capable of providing these interventions. The inclusion and exclusion criteria governing the indication for CTA for LGIB varies between hospitals. Limited published data has been analyzed, and factors that predict a positive CTA have been identified (8). The selection of patients for whom CTA will change management in LGIB is key to reducing cost and limiting patients' exposure to unnecessary risks from radiation and intravenous contrast.

Royal North Shore Hospital (RNSH) is a tertiary referral center in Sydney, Australia, with interventional radiology, endoscopy, and operational capability. At RNSH, CTA is the favored method for investigating patients presenting with LGIB. If required, patients in peripheral hospitals with a positive blush are transferred to RNSH for further monitoring and invasive intervention. Inpatients with a positive blush who are hemodynamically unstable are initially managed with angiography and transcatheter embolization followed by escalation to endoscopy or surgery failing this. This study aimed to identify clinical variables that predict a positive CTA result and guide its use in patients presenting with LGIB.

2. Materials and methods

This retrospective cohort study was performed at a single tertiary hospital in Sydney, Australia. Ethics approval was submitted in March 2020 via modification of an existing protocol (NSLHD Ref: 2019/ETH08162), which analyses patients presenting to our center with hematochezia. All patients who had a CTA for LGIB between January 2012 and May 2020 were initially reviewed, and the following definitions were applied;

LGIB is defined as bleeding distal to the ligament of Treitz. Patients were excluded if a) the bleeding point was proximal to the ligament of Treitz or b) the CTA was not performed to investigate LGIB. Visible LGIB is defined as visible blood per ano-rectum. Length of stay is the number of days as an inpatient. Transferred patients were those transferred to our facility from an associated peripheral hospital. Time to CTA is the time in minutes from clinical suspicion or detection of LGIB to the time at which the CTA was complete. In the absence of visible LGIB in patients presenting with a history of bleeding, this was taken from the time of triage.

The modified shock index (MSI) was used to measure hemodynamic status. The MSI is defined as HR divided by mean arterial pressure (MAP). An MSI < 0.7 or > 1.3 strongly predicts death at presentation to an emergency department (9). The Oakland score aims to identify patients at low risk of experiencing adverse outcomes from LGIB and avoid hospitalization. It is a method of assessing the severity of LGIB (10). The Oakland score was calculated from seven inputs, age, sex, previous hospital admission with LGIB, digital rectal examination results, heart rate, systolic blood pressure, and hemoglobin concentration, to calculate a maximum score of 35 points. A score ≤ 8 indicates low risk and identifies a safe patient for outpatient management (10).

2.1. CT procedure technique

Patients underwent supine craniocaudal scanning by multi-detector row CT while breath holding. The scanning coverage area extended from the diaphragm to the symphysis pubis. Preliminary unenhanced scans display pre-existing hyper-attenuated material in the bowel lumen as a comparative measurement against the suspected region of active bleeding location. After this, 100ml of iodine-containing contrast was injected intravenously at 2-3ml/sec via an automatic injector, followed by a normal saline flush of 50ml. Images are acquired at a 0.5mm section width and 5-7mm reconstruction interval. Images from equilibrium-phase scanning performed 90 seconds after the start of contrast material injection are then analyzed for bleeding detection. Diagnostic features of a positive CTA bleed or blush include focal or circumferential bowel wall densities, contrast material in the bowel lumen greater than 90 Hounsfield units, or increased density of bowel content. Venous phase imaging is then performed to detect missed bleeding during the arterial phase.

2.2. Statistical analysis

Statistical analysis was performed using RStudio software (Vienna, Austria). Firstly, summative data analysis was performed. Binary variable frequency was calculated, and continuous variables' mean, median, range, and standard deviation were assessed. A comparison of quantitative variables (if normal distribution) was performed using the paired t-test. The paired-Z test was used for categorical data. Potential predictive factors for blush, embolization, and rebleeding were initially assessed using univariable analysis, and then p values <0.1 were included as part of the

multivariable analysis. Logistic regression was used for multivariate analysis where the outcome was binary, and least squares regression (OLS) for multivariate regression analysis where the outcome was continuous.

3. Results

3.1. Demographics

A total of 526 patients underwent CTA for the investigation of LGIB. The majority, 349 patients (66%) were male. The mean age was 74 years, and each patient's median length of hospital stay was 6 days. Demographic statistics are summarized in **Table 1.**

Table 1 Demographics and scoring criteria: standard deviation (SD)

Gender	**Number (%)**
Male	349 (66)
Female	177 (34)
Age	
Mean ± SD (min-max)	74.7 ± 15.1 (19-97)
Median	77
Length of stay	
Mean ± SD (min-max)	12.2 ± 22.4
Median	6
Modified shock index	(%)
Mean ± SD (min-max) Median	1.01± 0.32 0.97
Values <0.7	60 (11)
Values >1.3	71 (13)
Oakland score	
Mean ± SD (min-max) Median	19.8 +- 6.8 20
Patients with Oakland >8	451 (86)

3.2. Clinical presentation

Of a total of 526 patients who underwent CTA, 436 (83%) patients presented with syncope, and 489 patients (93%) of patients presented with visible bleeding on initial examination. The mean hemoglobin on admission was 102 ± 27 (39 – 176) and INR was 1.3 ± 0.7 (0.8 – 6.2). The mean modified shock index value was 0.97, with 60 patients (11%) and 71 patients (13%) having a shock index < 0.7 or > 1.3, respectively, indicating a significant LGIB. The mean Oakland score was 19.8, with 451 patients (86%) having an Oakland score of > 8, suggesting that most patients had bleeding requiring admission to hospital Table 1.

3.3. Past Medical History

317 (60%) patients had a history of previous LGIB. Of these, 205 patients (39%) had a diagnosed cause of this bleed Table 2. The most common diagnosis was diverticular bleeding in 71 patients (13.5%), followed by post-procedure bleeding in 35 patients (7%) Table 2. Relevant medical comorbidities were also recorded, and the most common comorbidities are presented in Table 2. The most common diseases were hypertension 277 patients (53%), ischemic heart disease 150 patients (29%), and diabetes mellitus 99 patients (19%).

Table 2 Past medical history: Cardiac procedure includes coronary artery bypass and valvular surgery, arterial venous malformation (AVM)

History of LGIB	317 (60)
Without diagnosis	112 (21)
With Diagnosis	205 (39)
Diverticular disease	71 (13)
Hemorrhoids	19 (4)
IBD	5 (1)
Inflammatory colitis	14 (3)
Angiodysplasia/AVM/vascular pathology	13 (2)
Polyp	18 (3)
Ulcer/erosion	16 (3)
Iatrogenic/post procedure	35 (7)
Blood thinner	6 (1)
Infective	3 (1)
Anal abscess/fissures	1 (0)
Malignancy	4 (1)
Comorbidity	Number (%)
Hypertension	277 (53)
Ischemic heart disease	150 (29)
Diabetes	99 (19)
Stroke	81 (15)
Other cancer	53 (10)
Anemia	65 (12)
Cardiac stents	35 (7)
Colonic cancer	22 (4)
Cardiac procedures	15 (3)

3.4. Antiplatelets/Anticoagulation

A total of 221 patients (42.0%) were taking some form of antiplatelet therapy, with aspirin only (n=135, 25.7%) and a combination of aspirin and clopidogrel (n=45, 8.6%) being the most common. 30 patients (5.7%) took a non-steroidal anti-inflammatory drug. Of anticoagulant medications, 49 patients (9.3%) were taking enoxaparin, 43 patients (8.2%) were taking warfarin, and 46 patients (8.7%) were taking a direct oral anticoagulant tablet (DOAC); this data is summarized in Table 3.

Table 3 Blood thinning medications, non-steroidal anti-inflammatory (NSAIDs), direct oral anticoagulant (DOAC)

Total	**Number (%)**
Taking antiplatelet agents	221 (42)
Aspirin	135 (26)
Clopidogrel	36 (7)

Aspirin and clopidogrel	45 (9)
Aspirin and ticagrelor	3 (1)
Aspirin and prasugrel	2 (0)
NSAIDS	30 (6)
Anticoagulant	101 (19)
Heparin	9 (2)
Clexane	49 (9)
Warfarin	43 (8)
DOAC	46 (9)
Apixaban	12 (2)
Rivaroxaban	25 (5)
Dabigatran	9 (2)

380 patients received packed red blood cells, 73 received platelets, 80 received fresh frozen plasma, and 24 received cryoprecipitate. In general, transfusion volumes were greater in patients taking blood thinners when required. For example, on average, patients on antiplatelet therapy needed 3.0 vs. 2.5 units ($p = 0.03$), and on enoxaparin, 3.6 units vs 2.7 units ($p = 0.02$). Platelet transfusion volumes were more significant in those taking antiplatelet therapy at 0.23 vs. 0.12 units ($p < 0.01$), and anticoagulated patients required more substantial volumes of FFP at 0.91 units vs 0.31 units ($p < 0.01$).

3.5. CT Angiogram (CTA)

Of the total 526 CTAs performed, 192 patients (37%) had a positive CTA with a blush. The most common cause for bleeding was being diverticular (78 patients, 41%) Table 4. When analyzed by vascular territory of origin, 14 (7%) were bleeding branches of coeliac axis origin, 95 (49%) of superior mesenteric artery origin, 77 (40%) of inferior mesenteric artery origin, and 6 (3%) of internal iliac origin. Correspondingly, the small bowel (47 patients, 24%) and right colon (50 patients, 26%) were common locations of bleed detection as well as the sigmoid colon (53 patients, 28%) and rectum (24 patients, 13%) Table 4.

Table 4 Analysis of CTA findings diagnosis, location and timing, standard deviation (SD)

Diagnosis of positive CTA	**Number (%)**
Diverticular	78 (41)
Unknown	52 (27
Iatrogenic/post procedure	24 (13)
Angiodysplasia	17 (9)
Ulcer/erosion	7 (4)
Haemorrhoids	4 (2)
Crohn's/Ulcerative	2 (1)
Malignancy	2 (1)
Polyp	1 (1)
Blood thinner	1 (1)
Infective	1 (1)
Anatomical location of bleed	Number (%)
Sigmoid	53 (28)

Right colon and caecum	50 (26)
Small bowel	47 (24)
Descending colon	24 (13)
Rectum	24 (13)
Hepatic flexure	21 (11)
Transverse colon	11 (6)
Splenic flexure	8 (4)
Anal canal	2 (1)
Entire colon	1 (1)
Time from detection of bleed to CTA	Minutes
Mean ± SD (min-max)	616 ± 998 (12- 6556)
Median	240

Of the 526 patients who underwent CTA, 288 (54.8%) were managed medically without further invasive intervention. Of those requiring intervention, 42 (8.0%) underwent angiography, 95 (18.1%) underwent angiography and embolization. Other management included 74 (14.1%) requiring inpatient colonoscopy, 15 (2.9%) patients undergoing operative management, and 12 (2.3%) patients either died or were palliated Table 5.

Of the 192 patients with a blush, 150 (78%) required some form of intervention, compared to 88 (26%) of the 334 patients without a blush. In the patients with a blush, 125 (65%) required angiography, and 87 (70%) of these patients proceeded to transcatheter embolization (Table 5). Of those without a blush, 246 (74%) did not require intervention. If an intervention was needed, inpatient colonoscopy was the majority, with 60 (68%) of patients proceeding with colonoscopy and only 12 (4%) requiring invasive angiography Table 5. This finding reflects the use of CTA in dictating further interventional management in that those with a positive blush are likely to undergo angiography and embolization, whilst those without a blush are most likely to be managed conservatively and, if requiring intervention will proceed with an urgent not emergent colonoscopy.

3.6. Factors influencing the time to CTA

The mean time from the last LGIB to CTA was 616 minutes (median 240 minutes). On univariate analysis, there is no evidence that patients transferred to our facility have a shorter time to CTA (590 minutes for transferred patients vs 625 minutes, $p = 0.33$). Significantly ($p = 0.02$), patients with visible LGIB had a mean time to CTA of 582 minutes, compared to patients without visible LGIB, who had a mean time to CTA of 1188 minutes. There is no evidence that patients with increased modified shock index ($p = 0.44$) scores on admission have a shorter time to CTA. There is no evidence that hemoglobin concentration on admission is associated with reduced time to CTA ($p = 0.59$). There is strong evidence that patients with a positive CTA receive their scan more quickly (421.6 minutes vs 732.7 minutes, $p < 0.01$). This likely reflects a timing bias in that patients with a positive CTA are more likely to be clinically unwell and have visible bleeding, hence an expedited CTA.

3.7. Predictors of positive CTA

Univariate analysis found a significant correlation between blush and those presenting with visible LGIB, with a background of hypertension or ischaemic heart disease (IHD), and antiplatelets see **Table 6**. NSAID use was protective, with significantly fewer patients having a blush who were taking NSAIDs. There was no association between gender or medication affecting anticoagulation, such as enoxaparin, DOAC, or warfarin (Table 6)**.**

There is no evidence that patients with a higher MSI (1.01 in patients with positive CTA vs 1.02 in patients with negative CTA, $p = 0.63$) will have a positive CTA. There was no evidence of a higher Oakland score in patients with positive CTA vs. negative CTA, with Oakland scores of 19.7 vs. 19.8, respectively. There is no difference in hemoglobin level in patients with a positive CTA vs. negative CTA findings (103.0 g/L in patients with positive CTA vs 101.4 g/L in patients with negative CTA, $p = 0.23$) nor with INR (1.27 in patients with positive CTA vs 1.32 in negative CTA, $p = 0.79$). Patients with a positive CTA required more significant volumes of resuscitation products than those without a blush, indicated by the

volume of blood products transfused with CTA-positive patients requiring transfusion of pRBCs (3.3 vs. 2.4, $p < 0.01$), FFP (0.48 units vs 0.31 units, $p = 0.04$) and platelets (mean 0.26 vs 0.12 units, $p < 0.01$).

Table 5 Management of patients with a positive (blush) or negative (no blush) CTA

Outcome of CTA	All patients (%)	Positive (%)	Negative (%)
Conservative management	288 (54)	42 (22)	246 (74)
Invasive angiography	42 (8)	38 (20)	4 (1)
Embolization	95 (18)	87 (45)	8 (2)
Endoscopy	74 (14)	14 (7)	60 (18)
Operative	15 (3)	6 (3)	9 (3)
Death	12 (2)	5 (3)	7 (2)

Table 6 Univariate and multivariate analysis for clinical factors predictive of a positive blush on CTA: IHD (Ischaemia heart disease), lower gastrointestinal bleeding (LGIB), non-steroidal anti-inflammatory (NSAIDs), direct oral anticoagulant (DOAC), packed red blood cells (PRBC), CI (Confidence interval)

Univariate	No blush (%)	Blush (%)	z	p-value	Multivariate	OR	CI	p-value
Male	64	38	-1.3	0.10				
Female	35	32	-1.3	0.80				
Transferred	34	42	-1.6	0.04				
Hypertension	30	40	-1.8	0.04				
IHD	32	45	-2.6	0.01				
Visible LGIB	8	38	-3.7	0.01	Visible LGIB	8.65	1.93-38.67	<0.01
NSAIDS	37	20	1.8	0.03	NSAIDS	0.31	0.10-0.89	<0.01
Antiplatelets	33	40	-1.8	0.03				
Clexane	37	23	1.5	0.90				
DOAC	35	46	-1.5	0.06				
Warfarin	36	34	0.3	0.66				
Transfusion PRBC	31	78	-2.9	0.01	Transfusion PRBC	1.17	1.07-1.27	0.03

Multivariate logistic regression was then performed to assess for predictors of positive CTA. A total of 12 variables ($p < 0.1$, or if clinically relevant) were included: patient transfer status, receiving antiplatelets, pRBCs or FFP on admission, history of use of enoxaparin, warfarin, NSAID or DOAC, visible LGIB on admission, history of previous LGIB or ischemic heart disease and Oakland score on admission. Patients presenting with visible LGIB and patients who have been transfused pRBCs on admission have a significantly higher risk of a positive blush. Patients who have a history of NSAID use are less likely to have positive blush Table 6.

4. Discussion

CTA is a valuable diagnostic tool in the assessment of LGIB. A negative result is reassuring that a patient is unlikely to require further urgent intervention, and a positive result can diagnose the cause of the bleeding location and direct further management. This includes transfer to a tertiary hospital for urgent interventional procedures, including angioembolization, endoscopy, or surgery, which is necessary for ~80% of patients with a blush on CTA. Due to the ease of access to CTA in a modern hospital environment, CTA is now frequently performed in subacute stable LGIB settings. Indeed, Jacovides et al. found that a negative CTA in a hemodynamically stable patient has a high negative predictive

value for the need for operative or angiographic intervention (11). In our cohort, 25% of patients in the blush-negative group required an intervention, which, for the majority of these patients, was an inpatient colonoscopy. It is, therefore, safe for patients at peripheral hospitals to be monitored who have a negative blush on CTA as they are unlikely to require an invasive urgent intervention other than endoscopy, which is often available at peripheral hospitals and performed in a subacute manner.

From our multivariate analysis, the strongest predictor of blush on CTA is in patients presenting with visible LGIB and, more weakly, those requiring blood transfusion on admission. Patients requiring >3 units of blood and higher volumes of FFP and platelets are also more likely to have a blush. These findings indicate that direct clinical signs of high-volume bleeding, such as visible blood or larger resuscitation volumes, can predict a positive blush.

Measures of hemodynamic status such as MSI and Oakland score were not associated with a blush; neither was INR, hemoglobin, anti-platelet, or anticoagulant use. A visible bleed implies a higher volume of active hemorrhage and is a more specific indicator of active bleeding than hemodynamic status. Hemodynamic instability is likely not a sensitive sign for ongoing active bleeding as hemodynamic status is multifactorial and dependent not only on the volume and frequency of bleeding but also on other factors such as circulatory resilience and adequate resuscitation. This finding implies that rather than practicing a liberal policy of CTA in all patients with LGIB, patients with visible bleeding or requiring transfusion of blood products should be prioritized for CTA rather than those with hemodynamic instability.

Nonetheless, it was surprising that there was no correlation between hemodynamic status measured by the MSI and Oakland scores and a positive CTA. Foley et al. report 9 positive CTAs of 13 hemodynamically unstable patients compared to 1 positive CTA of 7 hemodynamically stable patients and a p-value = 0.06, a statistically non-significant finding in a very small sample population (12). Scheffel et al. defined hemodynamically unstable patients based on systolic blood pressure <100 mmHg, heart rate >100 bpm, hemoglobin concentration less than 100 g/L, and transfusion requirement greater than 4 units, and found that 11 of 11 hemodynamically unstable patients had a positive CTA compared to 1 of 6 hemodynamically stable patients. However, this small data set included both upper and lower GI causes of bleed, with the 'stable' cohort comprising 2 patients with pseudoaneurysms of the coeliac axis and 3 with intestinal tumors (13). These pathologies are expected to undergo catastrophic and occult bleeding, respectively, with pseudoaneurysm rupture likely to occur into the retroperitoneal space but otherwise not bleed at all and tumor bleeding to continue at a minimal rate (13). Smith et al. found hemodynamics did not correlate with a positive blush with HR > 100 or systolic blood pressure < 100 mmHg, failing to show significance on multivariate analysis (8).

MSI and Oakland scores are evidence-based, validated tools for assessing hemodynamic status and risk in LGIB (9,14). In our cohort of 526 patients, which consists of 192 positive CTAs, we found a mean MSI of 1.01 in patients with positive CTA and 1.02 in patients with negative CTA (p = 0.63). Liu et al. describe an MSI > 1.3 as indicative of a hyperdynamic state, suggesting low stroke volume and systemic vascular resistance, and an MSI <0.7 as suggestive of hyperdynamic circulation (9). These scenarios occur in large-volume bleeding, easily detectable above the threshold CTA rate of >0.3ml/min bleed. Our study's mean Oakland score was 20, with 451 scores >8, indicating that CTA was performed in 75 patients who may have been appropriate for safe discharge and outpatient management. There was no difference in Oakland score between patients with and without a blush, indicating this score is unlikely to be helpful in triaging patients for CTA.

The use of anticoagulation and antiplatelets is a well-known risk factor for LGIB bleeding. Overall, NSAID use is associated with a 1.4 times increased risk of LGIB, aspirin with a 2 times increased risk, and anticoagulants with a 4.1 times increase in risk (15). The use of blood thinning medication was every day in our cohort, with antiplatelet use in 221 patients (42%), an anticoagulant in 101 patients (19%), and NSAIDS in 30 (6%). These patients are understandably vulnerable to GI bleeding, but interestingly, using anticoagulants or anti-platelets was not associated with a positive blush on CTA in multivariate analysis. This finding contrasts with Smith et al., who found a correlation between a positive CTA and antiplatelet use in multivariate analysis (8). NSAIDS use lowered the incidence of blush in this study cohort. An explanation may be that LGIB from anticoagulant, antiplatelet, or NSAID use, whilst familiar, is of low volume and below the threshold of CTA to detect. Patients are likely to present with LGIB, but as it is below the sensitivity of CTA, they are less likely to have a positive blush.

A confounding factor in this study is that patients presenting with visible bleeding or hemodynamic instability are likely to receive a CTA more urgently, thus increasing the proportion of patients with a positive CTA result. This is common clinical practice and is supported by the findings of Umezawa et al., who prospectively examined the role of CTA diverticular bleed and found that the interval from the last episode of LGIB until CTA was shorter in the blush-positive group than in the blush-negative group (mean 3.06 hours +/- 2.18 vs. 4:47 hours +/- 3.38, p= 0.01) (16). The authors found that the rate of positive CTA findings varies inversely with time elapsed since the last episode of LGIB. CTA

performed within 1 hour of and up to 4 hours after the previous episode of LGIB resulted in favorable CTA rates of 56% and 34%, respectively. CTA should, therefore, be performed urgently in patients following LGIB. In our center, the median time to CTA was 4 hours, with a mean time of more than 10 hours. Despite this, our contrast extravasation-positive rates are 192 of 526 CTAs performed (37%).

Unfortunately, reporting diagnostic accuracy, sensitivity, and specificity was impossible in this study per the STARD guidelines due to a lack of granular data (17). Although many CTAs were reported as positive or negative, they often lacked a reference standard – the majority of negative CTAs were managed conservatively, with cause and location of bleed not determined, and many of those patients underwent outpatient investigation in a variety of locations, of which data was not available within our medical record. The retrospective study design and relatively small sample size are also limitations, and a more significant number of patients, particularly in subgroups, would lend greater power to the statistical analysis. Further subgroup analysis of patients presenting with Oakland score <10 undergoing CTA is warranted. The outcomes of these patients, deemed safe for discharge, would add to the volume of validation data surrounding using the score.

Abbreviations

- Computed tomography angiography (CTA)
- Lower gastrointestinal bleed (LGIB)

5. Conclusion

A positive blush on CTA is a valuable investigation in assessing patients with LGIB. Patients with visible bleeding or those who require blood product transfusion on admission should expeditiously proceed to CTA. Of those identified with a positive blush, ~80% will require an intervention, and hence, transfer to a center capable of providing invasive angiography, endoscopy, and surgery is indicated. Most LGIB can be managed conservatively and confidently in patients with a negative CTA. Hemodynamic status is not a reliable predictor of patients who will be positive on CTA; neither is anticoagulation or antiplatelet status.

Compliance with ethical standards

Disclosure of conflict of interest

The authors agree with the content of the manuscript and confirm that this work is original, has not been published elsewhere, and is not under consideration by another journal. The first author is a Colorectal surgeon in training.There are no conflicts of interest to disclose.

Statement of ethical approval

This Study adhered to the Declaration of Helsinki

Ethics approval was submitted in March 2020 via modification of an existing protocol (**NSLHD Ref: 2019/ETH08162)**, which analyses patients presenting to our centre with haematochezia. Ethics approval was granted in May 2020. By North Sydney Local Health District, Human Research Ethics Committee.

The need for consent to participate was waived by an Institutional Review Board (IRB) of the Northern Sydney Local Health District, Royal North Shore Hospital, Sydney, NSW.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

Availability of data and materials

All datasets on which the conclusions of the paper rely are included within the manuscript.

Authors' contributions

- Dr Ali Mohtashami – Data collection and synthesis, drafting of original manuscript, review and revisions
- Dr Jonathan Hew – Data collection and synthesis, review of manuscript and revisions

- Dr Krishna Kotecha– Data collection and synthesis, review of manuscript and revisions
- Dr James Foote- Data collection.
- Dr Winnie Hsu- Data collection
- Dr Kah Hoong Chang – Conceptualisation, review of manuscript and revisions

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