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Derivation and validation of a novel risk score to predict need for haemostatic intervention in acute upper gastrointestinal bleeding (London Haemostat Score)

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ABSTRACT

Background Acute upper gastrointestinal bleeding (AUGIB) is a common medical emergency, which takes up considerable healthcare resources. However, only approximately 20%–30% of bleeds require urgent haemostatic intervention. Current standard of care is for all patients admitted to hospital to undergo endoscopy within 24 hours for risk stratification, but this is difficult to achieve in practice, invasive and costly.

Aim To develop a novel non-endoscopic risk stratification tool for AUGIB to predict the need for haemostatic intervention by endoscopic, radiological or surgical treatments. We compared this with the Glasgow-Blatchford Score (GBS).

Design Model development was carried out using a derivation (n=466) and prospectively collected validation cohort (n=404) of patients who were admitted with AUGIB to three large hospitals in London, UK (2015–2020). Univariable and multivariable logistic regression analysis was used to identify variables that were associated with increased or decreased chances of requiring haemostatic intervention. This model was converted into a risk scoring system, the London Haemostat Score (LHS).

Results The LHS was more accurate at predicting need for haemostatic intervention than the GBS, in the derivation cohort (area under the receiver operating curve (AUROC) 0.82; 95% CI 0.78 to 0.86 vs 0.72; 95% CI 0.67 to 0.77; p<0.001) and validation cohort (AUROC 0.80; 95% CI 0.75 to 0.85 vs 0.72; 95% CI 0.67 to 0.78; p<0.001). At cut-off scores at which LHS and GBS identified patients who required haemostatic intervention with 98% sensitivity, the specificity of the LHS was 41% vs 18% with the GBS (p<0.001). This could translate to 32% of inpatient endoscopies for AUGIB being avoided at a cost of only a 0.5% false negative rate.

Conclusions The LHS is accurate at predicting the need for haemostatic intervention in AUGIB and could be used to identify a proportion of low-risk patients who can undergo delayed or outpatient endoscopy. Validation in other geographical settings is required before routine clinical use.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Acute upper gastrointestinal bleeding (AUGIB) is a common medical emergency but only approximately 20%–30% of bleeds require urgent haemostatic intervention. Current standard of care is for all patients admitted to hospital to undergo endoscopy within 24 hours for risk stratification, but this is difficult to achieve in practice, invasive and costly. Pre-endoscopy stratification tools, such as the Glasgow Blatchford Score (GBS), are able to identify a small proportion of patients (GBS<1) who are at very low risk of requiring hospital intervention or of death and are safe to discharge from the emergency department, but does not accurately predict need for haemostatic intervention.

WHAT THIS STUDY ADDS

⇒ We developed and validated a novel pre-endoscopic risk stratification tool—the London Haemostat Score (LHS)—for AUGIB which was of good accuracy (area under the receiver operating curve, AUROC 0.82) in predicting need for haemostatic intervention and superior to the GBS (AUROC 0.72). The LHS cut-off of <1 was able identify 32% of inpatients with AUGIB who were at low risk of needing haemostatic intervention and could undergo delayed or outpatient endoscopy for diagnostic purposes.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study builds on the GBS by expanding the group of patients with AUGIB who can be identified as low risk without need for endoscopic risk stratification. For patients who do not satisfy safe discharge (GBS>1), adoption of the LHS in an in-patient population could decrease the need to provide in-patient endoscopy within 24 hours and consequently, the potential to avoid urgent invasive tests, and reduce inpatient stays and costs.

INTRODUCTION

Acute upper gastrointestinal bleeding (AUGIB) is the most common medical gastrointestinal emergency, with an incidence of 103–172 per 100 000 adults, and a mortality of 8%–14% in the UK.[1] The clinical severity of gastrointestinal bleeding at presentation is heterogeneous and ranges from insignificant bleeding to exsanguinating haemorrhage. In the majority of cases, however, the bleeding has stopped by the time the patient has presented to the hospital, with only around 20%–30% having underlying high-risk stigmata, such as visible vessels. These are recognised as significant risk factors for rebleeding, and require haemostatic intervention[2] via endoscopy, radiological intervention or surgery.[3] The majority of bleeding is from low-risk lesions, such as clean-based peptic ulcer disease or erosive disease, which are not associated with a significant rebleeding risk or mortality.[4 5]

In practice, it is difficult to determine the need for haemostatic intervention on clinical grounds alone, so the vast majority of patients are admitted to hospital and ideally undergo endoscopy within 24 hours, as recommended by consensus guidelines.[6–8] This approach is not only invasive, but costly and difficult to provide at a national level. The most recent UK nationwide audit of AUGIB[4] and the National Confidential Enquiry into Patient Outcome and Death[9] reported that only 50%–60% of patients with AUGIB had an upper GI endoscopy within 24 hours, and only half of hospitals had a consultant-led out-of-hours rota. Prolonged inpatient stays waiting for endoscopy expose patients to increased risk of hospital-acquired infections, and are also costly for the health service.[10]

A number of non-endoscopic risk scores have been developed for AUGIB, but none are available for routine use that predict need for haemostatic intervention with a high enough accuracy[7 11] so expert guidelines identify this as an unmet research need.[7] The Glasgow-Blatchford Score (GBS),[12] at a cut-off of <1, has demonstrated the ability to identify a proportion of patients who are at low risk for the composite outcome of blood transfusion, intervention and death, and therefore, provides for safe discharge from the emergency department (ED) without endoscopy.[12–14] However, the GBS is not highly accurate at predicting the need for haemostatic intervention and is, therefore, not recommended for this outcome.[11 15] The poor accuracy may be because variables such as anaemia, tachycardia, hypotension and urea rise are not specific for AUGIB, and can become deranged in presentations such as sepsis or renal failure.[16] We aimed to develop a novel risk score (London Haemostat Score, LHS), which was accurate in predicting the need for haemostatic intervention using variables that increase and decrease the chance of needing haemostatic intervention. We compared it to the GBS, which is the most commonly used non-endoscopic score in clinical practice for AUGIB.

METHODS

Development of proposed risk score for predicting haemostatic intervention in AUGIB

The derivation cohort has been described in detail previously.[13] It includes consecutive patients presenting with an AUGIB between 3 November 2015 and 31 January 2018 who were initially assessed in the emergency departments (ED) of Charing Cross Hospital (CCH), St. Mary's Hospital (SMH) and Hammersmith Hospital (HH) in London, UK. The inclusion criteria were patients aged 18 years or over presenting to the ED with a primary diagnosis of AUGIB based on a history of haematemesis, coffee-ground emesis or melaena. From this cohort, all patients discharged from the ED (GBS<1) were excluded for this study as clinicians had decided, using the GBS, that the need for intervention and death was low.[13] Patients with a GBS of <1 admitted to an inpatient bed (usually for treatment of acute illnesses) were included. The derivation cohort did not have patients who developed an AUGIB as an inpatient.

Validation of proposed risk score for predicting haemostatic intervention in AUGIB

A validation cohort was generated by prospectively identifying consecutive patients with an AUGIB who were referred for endoscopy after being admitted to an inpatient bed from February 2019 to February 2020 at CCH, SMH and HH. In this cohort, the inclusion and exclusion criteria were the same as the derivation cohort, except that this cohort included patients who developed AUGIB as an inpatient.

Comparison of proposed risk score with GBS

We compared the discriminative ability of the new risk score with the GBS in predicting need for haemostatic intervention as the GBS is the only score recommended by international consensus guidelines for identifying low risk patients with AUGIB, although for a different end point (composite need for blood transfusion, haemostatic intervention and death). We chose not to compare other risk scores such as admission Rockall or AIMS65 as these scores have been shown to have a lower area under the receiver operating curve (AUROC) for predicting need for endoscopic intervention than the GBS in a large multicentre study.[11 17]

Follow-up

Patients in the derivation and validation cohorts were followed up for 30 days using electronic records, telephone calls to patients and primary care providers.

Outcomes

The predetermined outcome of this study was the need for haemostatic intervention. Patients were determined as needing haemostasis, and therefore, high risk, if they had attempted appropriate endoscopic therapy, interventional radiology (IR) or surgery to achieve haemostasis or rebled during the study period. As the delivery of haemostasis can be subjective, we examined the appropriateness

of therapy in those who underwent endoscopy by a secondary endpoint which was the presence of high-risk stigmata which required therapeutic intervention, and which was assessed independently by blinding to final risk scores. Low-risk patients were defined as those patients who had not received any of these interventions. Anonymised endoscopy findings were independently reviewed for the presence of high risk endoscopic stigmata, defined in accordance with international consensus statements.[18]

Data collection

Data were collected at each site by dedicated doctors or medical students. The variables collected have been described below.

Candidate variables selection

At the start of the study, candidate predictor variables were selected a priori based on previous studies, encompassing patient characteristics and clinical and laboratory variables that were believed to be plausibly related to the outcome.[19–23] The data collected were collected with blinding to final risk scores and limited to those routinely collected during hospital admission and included variables necessary to calculate the GBS (online supplemental table 2) for comparative assessment which were: melaena, syncope at presentation, systolic blood pressure (SBP, mm Hg), heart rate (HR, beats per minute), serum urea (mmol/L), haemoglobin (Hb, g/L), hepatic disease and cardiac disease.[12] Additional fields in the database were populated from electronic health data: age, sex, albumin (g/L), creatinine (µmol/L), shock index (SI, HR/SBP), urea/creatinine ratio (urea/Cr), prothrombin time (seconds), regular use of oral antiplatelet or non-steroidal anti-inflammatory drugs, use of anticoagulants, white cell count (10^9 cells per L), C reactive protein (CRP, mg/dL), acute alternative explanations for anaemia, haemodynamic instability or urea rise (see online supplemental material) and comorbidities (renal failure and malignancy). Endoscopic treatment and findings, IR, surgery, 30-day mortality and rebleeding within 7 days were also recorded for each patient.

General treatment of patients

Management of patients with AUGIB followed UK National Institute for Health and Care Excellence guidelines.[8]

Statistical analysis

Categorisation of variables are outlined in online supplemental table 3 with cut-offs for continuous variables selected from the published literature in prediction of outcome in AUGIB[19–23] or normal laboratory ranges at Imperial Healthcare NHS trust. The exception to this was CRP, for which no published data exist in the context of AUGIB and an upper limit of normal of 5 mg/dL was analysed and found not predictive. A cut-off of 50 mg/L was then instead selected based on clinical experience as more likely to be indicative of another ongoing disease process. A univariable analysis was performed by using the χ^2 test, testing each variable versus the need for haemostasis. Variables which were predictive were subsequently tested in a multivariable logistic regression analysis using forward stepwise selection.

Regression coefficients were scaled to integer values for the sake of clinical usability and were subsequently used to create a risk score. The score is calculated by assigning points to each predictive variable and adding the points to produce a total score, ranging from −4 to 13.

AUROCs were constructed by assigning the outcome variable a score of 0 if no endoscopic, radiological or surgical intervention was performed, and one if any combination of these interventions were performed. The accuracy of the scoring systems was assessed by calculation of the AUROC and corresponding 95% CIs, sensitivity, specificity, positive predictive values (PPV), negative predictive values (NPV) and the proportion of patients classified as high risk or low risk.

Univariable and multivariable analyses were performed using STATA V.15.0 (StataCorp). For comparative assessment, we calculated a GBS for each patient (online supplemental table 2). The discriminative ability of the prediction of the need for haemostasis by the two scoring systems, as measured by AUROCs, was assessed using the method by DeLong *et al*.[24] A $p<0.05$ was considered to be statistically significant.

RESULTS

Patient cohorts

The derivation cohort as described in the methods was obtained from a previously published database of 569 patients attending the ED of three major London hospitals with an AUGIB. One hundred and three patients had been discharged directly from ED, leaving 466 in the analysis. The validation cohort comprised 404 patients who were admitted to an inpatient bed from ED with an AUGIB or who developed a bleed as an inpatient (32.4%) and referred for endoscopy. The patient demographics and clinical characteristics are outlined in table 1.

Within the derivation and validation cohorts, 30% and 26% of patients underwent an intervention to achieve haemostasis, respectively. A similar proportion of patients required endotherapy in each cohort: 112 (24.0%) and 105 (25.7%), respectively. The rebleeding rate in the validation cohort was higher than the derivation cohort (14.4% vs 1.5%, $p<0.001$), but the overall mortality rate was similar.

Development and validation of the LHS

Of the 22 candidate variables, 14 variables were associated with the need for interventional haemostasis on univariable analysis (online supplemental table 3). The final multivariable regression included the variables: tachycardia, low Hb, raised urea/Cr and presence of chronic liver disease (CLD), which independently increased the likelihood of requiring haemostasis. A raised CRP or an acute alternative diagnosis for anaemia,

Table 1 Characteristics of the derivation and validation cohorts

	Derivation cohort (n=466)	Validation cohort (n=404)
Patient characteristics		
Age, median (IQR), years	61 (48–78)	67 (54–77.3)
Sex (male), n (%)	269 (57.7)	268 (66.3)
Syncope, n (%)	46 (9.8)	66 (16.3)
Melaena, n (%)	231 (50.0)	299 (74)
Oral antiplatelet drugs or NSAIDs, n (%)	112 (24)	99 (24.5)
Oral anticoagulants, n (%)	71 (15.2)	69 (17.1)
Alternative diagnosis*, n (%)	74 (15.8)	155 (38.4)
Laboratory measurements		
HR, median (IQR), beats/min	92 (78–108)	90 (77.3–103)
SBP, median (IQR), mm Hg	124 (111–141)	111 (99.8–127)
SI (HR/SBP), median (IQR)	0.74 (0.6 0.89)	0.78 (0.65 0.97)
CRP, median (IQR), mg/L	7 (2.1–22.6)	12 (3–41)
Hb, median (IQR), g/L	109 (85.128.8)	86 (70–107)
Urea, median (IQR), mmol/L	8.7 (5.2–13.4)	9.6 (5.8–15)
Creatinine, median (IQR), µmol/L	77.5 (66 – 105)	80.5 (65–119.3)
Urea/creatinine, median (IQR)	98.3 (65.143.3)	100 (64.9–148)
PPI use in last week	Not available	156 (38.6)
Comorbidities		
Cardiac, n (%)	27 (5.7)	58 (14.4)
Chronic liver disease, n (%)	95 (20.3)	97 (24)
Renal, n (%)	31 (6.7)	66 (16.3)
Malignancy, n (%)	16 (3.4)	96 (23.8)
COPD, n (%)	27 (5.8)	25 (6.2)
Hypertension, n (%)	106 (22.7)	172 (42.6)
Stroke, n (%)	23 (4.9)	34 (8.4)
Diabetes, n (%)	78 (16.7)	117 (29)
Dementia, n (%)	19 (4.1)	22 (5.4)
Treatments		
Blood transfusion, n (%)	161 (34.5)	228 (56.4)
Endotherapy, n (%)	112 (24.0)	105 (26)
Radiological intervention, n (%)	8 (1.7)	3 (0.7)
Surgical intervention, n (%)	10 (2.1)	3 (0.7)
Outcomes		
Rebleeding, n (%)	7 (1.5)	58 (14.4)
Mortality, n (%)	30 (6.4)	28 (6.9)

*Acute alternative diagnosis for anaemia, haemodynamic instability or urea rise.
COPD, chronic obstructive pulmonary disease; CRP, C reactive protein; Hb, haemoglobin; HR, heart rate; NSAID, non-steroidal anti-inflammatory drugs; PPI, proton pump inhibitor; SBP, systolic blood pressure; SI, Shock Index.

urea rise or haemodynamic instability, decreased the likelihood of requiring haemostasis (see table 2). The simplified risk scoring system and associated component values are shown in table 3. Three candidate versions of the LHS were created when scaling the regression coefficients obtained from multivariable analysis. For the first, we rounded the coefficients to the nearest two decimal places; for the second, we rounded them to the nearest whole number; and for the third, we rounded the coefficient for CLD down to one instead of two. We regressed each scoring system against the need for haemostatic intervention, and found that they were all similar, but the second version had the best predictive capacity. Using this score, we considered all cut-off points

Table 2 Multivariable logistic regression model in derivation cohort

	OR	P value	95% CI
Tachycardia (HR ≥100 beats/min)	2.26	<0.01	1.33 to 3.82
Low Hb (<125 g/L)	2.16	<0.01	1.55 to 3.01
Urea to creatinine ratio >100	3.58	<0.01	2.07 to 6.19
Chronic liver disease	3.17	<0.01	1.78 to 5.65
High CRP (>50 mg/L)	0.41	<0.01	0.21 to 0.79
Alternate diagnosis*	0.17	<0.01	0.07 to 0.42

*Acute alternative diagnosis for anaemia, haemodynamic instability or urea rise.
CRP, C reactive protein; Hb, haemoglobin.

from −4 to +13 and calculated the sensitivity, specificity, PPV and NPV of using each for predicting the need for haemostasis (see table 4). We also did this for the GBS for comparison (table 4).

Comparison of the LHS with the GBS

In comparative assessment, the LHS had a superior discriminative ability at predicting the need for haemostatic intervention compared with the GBS both in the derivation cohort (LHS AUROC 0.82, 95% CI (0.78 to 0.86); GBS AUROC 0.72, 95% CI (0.67 to 0.77); p<0.001) and in the validation cohort (LHS AUROC 0.80, 95% CI (0.75 to 0.85); GBS 0.72, 95% CI (0.67 to 0.78); p<0.001) (see figure 1).

Prioritising a high sensitivity (98%) for clinical safety to identify low-risk patients, the optimum LHS cut-off was <1 corresponding to a sensitivity of 98%, specificity of 42%, a PPV of 35% and an NPV of 98% (see table 4). Two patients out of the 404 (0.5%) in the validation cohort would score an LHS <1 but actually require haemostasis. A GBS score of <3 provided a matched sensitivity of 98%, but lower specificity of 18%, PPV of 30% and NPV of 97%. To put this into context, in an theoretical cohort of 600 patients with AUGIB (estimate of numbers presenting to our healthcare system/year) (see figure 2), an LHS <1 identifies 156/492 (32%) of who are admitted to an inpatient bed with an AUGIB, who could be triaged to delayed or outpatient endoscopy. Three patients (0.5%) would falsely test negative using the LHS score, which is in line with the false negative rate of other scoring systems such as the Oakland Score.[25]

A GBS cut-off value of >12 has been suggested as the cut-off to rule in high-risk patients who may require endoscopic treatment.[26] At this cut-off, the GBS in our study had a specificity of 85% and sensitivity of 36%. At a similar/matched sensitivity (37%), an LHS cut-off of >9 had a superior specificity of 92%.

Table 3 The London Haemostat Score

Characteristic	Score given
Tachycardia (HR>100 beats/min)	+2
Low Hb	
<100–125 g/L	+2
<100 g/L	+4
Urea to creatinine ratio >100	+4
Chronic liver disease	+3
High CRP>50 mg/L	−3
Alternate diagnosis*	−6

*Acute alternative diagnosis for anaemia, haemodynamic instability or urea rise.
CRP, C reactive protein; Hb, haemoglobin; HR, heart rate.

DISCUSSION

In this multicentre cohort study, we derived a novel risk stratification tool which accurately predicts the need for interventional haemostasis in AUGIB and provides a cut-off (LHS<1), which identifies a cohort of patients who are at very low risk of requiring haemostatic intervention.

Several scores such as the GBS, Rockall Score, AIMS65 and ABC have been developed to predict different outcomes in AUGIB, but none have been recommended for routine clinical use to predict need for haemostatic intervention due to moderate accuracies (<80%).[12 20 27 28] Studies show the GBS predicts need for haemostatic intervention with AUROCs ranging from 0.58 to 0.78 for endoscopic therapy[11 21 29] and 0.61 to 0.71 for the need for IR or surgery.[21 29] These values are consistent with the AUROC of 0.72 for predicting need for haemostatic interventions found in our study, compared with a better AUROC of 0.82 for LHS. An important feature of the LHS, which enhances its clinical utility, is the cut-off value of <1 which had a sensitivity of 98% and specificity of 42% for need for haemostatic intervention, which would translate to 32% fewer urgent endoscopies being performed. The high sensitivity would mean that few patients who need haemostatic intervention would be missed and this group could be triaged to a delayed or outpatient endoscopy. If patients are discharged to outpatient endoscopy after a period of observation/treatment this could shorten length of stay but we acknowledge this is uncertain and would need further study. If clinicians opt for a delayed endoscopy this may not shorten length of stay but would reduce pressure for urgent endoscopy and allow for treatment of conditions such as sepsis before endoscopy which may be safer. This cut-off had a better specificity than the GBS score <3 (18%) for a matched sensitivity (98%). We would, however, envisage the LHS being a supplement to the GBS score as we have outlined in figure 2 by which those with a GBS of <1 who attend the ED are discharged home and those admitted to an inpatient bed risk stratified with the LHS to endoscopy within 24 hours or later. This is consistent with our cohorts in which patients with a GBS of <1 who were discharged from the ED were excluded before creating the LHS score. Higher LHS scores (≤2) were not chosen as the sensitivity drops 95%

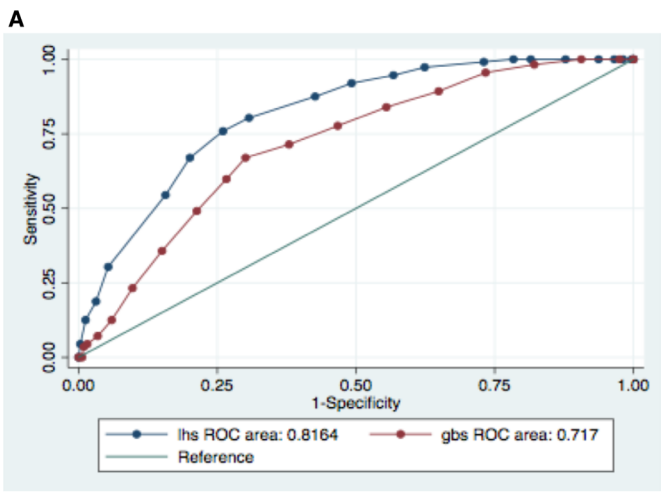
Table 4 Sensitivity, specificity, PPV and NPV for LHS (A) versus GBS (B)

(A)					
Cut-off LHS	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**False positive rate**
−4	1.00	0.05	0.27	1.00	0.95
−3	1.00	0.09	0.28	1.00	0.91
−2	1.00	0.18	0.30	1.00	0.82
−1	1.00	0.20	0.31	1.00	0.80
0	1.00	0.25	0.32	1.00	0.75
1	0.98	0.42	0.35	0.98	0.58
2	0.95	0.47	0.37	0.96	0.53
3	0.93	0.55	0.38	0.94	0.45
4	0.89	0.67	0.41	0.91	0.33
5	0.81	0.67	0.47	0.91	0.33
6	0.77	0.72	0.49	0.90	0.28
7	0.71	0.79	0.54	0.89	0.21
8	0.61	0.82	0.54	0.86	0.18
9	0.37	0.92	0.61	0.80	0.08
10	0.29	0.96	0.70	0.79	0.04
11	0.19	0.97	0.68	0.77	0.03
12	0.07	0.99	0.80	0.75	0.01
13	0.04	1.00	0.83	0.75	0.00
(A)					
Cut–off GBS	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**False positive rate**
0	1.00	0.00	0.26	0.00	1.00
1	1.00	0.03	0.26	1.00	0.97
2	1.00	0.09	0.28	1.00	0.91
3	0.98	0.18	0.30	0.97	0.82
4	0.96	0.27	0.31	0.94	0.73
5	0.89	0.35	0.33	0.90	0.65
6	0.84	0.53	0.35	0.89	0.47
7	0.78	0.62	0.37	0.87	0.38
8	0.71	0.62	0.40	0.86	0.38
9	0.67	0.70	0.44	0.86	0.30
10	0.60	0.73	0.44	0.84	0.27
11	0.49	0.79	0.45	0.81	0.21
12	0.36	0.85	0.45	0.79	0.15
13	0.23	0.90	0.46	0.77	0.10
14	0.13	0.94	0.42	0.75	0.06
15	0.07	0.97	0.42	0.75	0.03
16	0.04	0.98	0.50	0.75	0.02
17	0.04	0.99	0.57	0.75	0.01
18	0.00	0.99	0.00	0.74	0.01

.GBS, Glasgow Blatchford Score; LHS, London Haemostat Score; NPV, negative predictive value; PPV, positive predictive value.

or below, which would probably be unacceptable to clinicians prioritising clinical safety.

The LHS and GBS have common and different elements (table 5) .The LHS is partly distinguished by its use of negative scoring but this has been used in other clinical scores such as the diagnosis of autoimmune hepatitis. To improve the score's specificity, we included high CRP and acute alternative diagnoses for presentation.



ROC, receiver operating curve

ROC, receiver operating curve

Figure 1 ROC in derivation (A) and validation cohort (B). ROC, receiver operating curve.

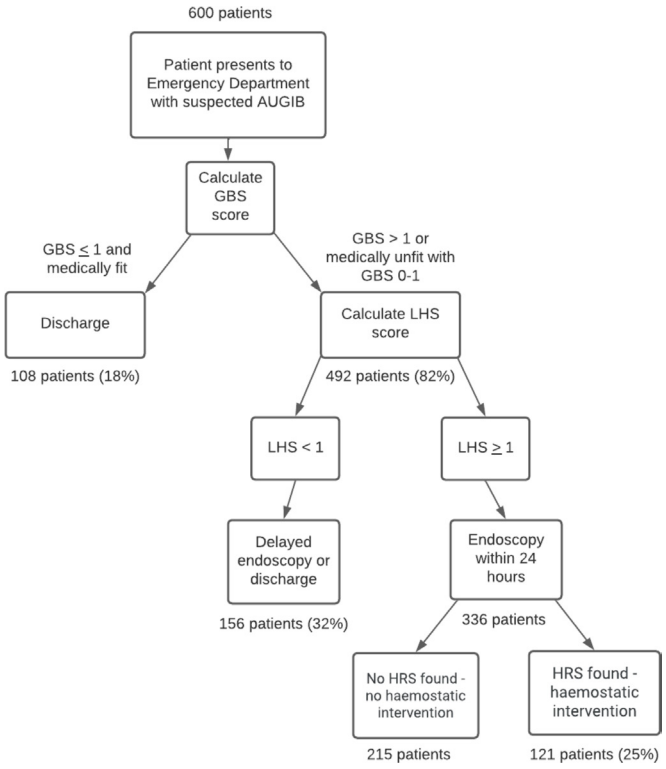


Figure 2 Theoretical cohort of patients presenting to the emergency department with AUGIB and undergoing risk stratification with LHS and GBS score. AUGIB, acute upper gastrointestinal bleeding; GBS, Glasgow-Blatchford Score; LHS, London Haemostat Score.

To the best of our knowledge, this was the first study exploring the impact of acute alternative diagnoses to predict the need for haemostasis in AUGIB, although alternative diagnoses have been incorporated in other scoring systems such as the Wells' Score for Deep Vein Thrombosis.[30] We identified high urea to creatinine ratio (UCR) as significant predictor for the need for haemostasis. There is conflicting evidence regarding the value of the UCR in identifying severe AUGIB.[31–33] The GBS score includes uraemia as a variable, but we found UCR as a better predictor of need for haemostasis on multivariable analysis. This may be due to being better able to exclude patients with chronic kidney disease who are falling positive by default when using the GBS.

Several studies in AUGIB have included RBC transfusion and mortality as endpoints.[12 14 25 27 34 35] We chose not to do this as transfusion requirements can arguably be ascertained by Hb levels or vital signs,[36] and risk of death by clinical assessment of decompensation of comorbidities or other risk scores.[27]

Table 5 Summary of candidate predictor variables considered a priori and included in the final GBS and LHS models

	GBS	LHS
Syncope	+	x
Melaena	+	x
Alternative diagnosis*	N/A	+
HR, beats/min	+	+
SBP, mm Hg	+	x
CRP, mg/L	N/A	+
Hb, g/L	+	+
Urea, mmol/L	+	x
Urea/creatinine	x	+
Cardiac disease	+	x
Chronic liver disease	+	+

'N/A' indicates a variable that was not considered in score development; 'x' indicates a variable that was considered but not included; '+' indicates a variable that was considered and included in the final model.
*Acute alternative diagnosis for anaemia, haemodynamic instability or urea rise.
CRP, C reactive protein; GBS, Glasgow-Blatchford Score; Hb, haemoglobin; HR, heart rate; LHS, London Haemostat Score; N/A, not available; SBP, systolic blood pressure.

Strengths of this study include the multicentre design and validation in a separate cohort. Importantly, the score has a good accuracy and provides a cut-off, which offers the clinician the option to make a different clinical decision than is currently routine, that is, the option to not do an urgent endoscopy. Many previous studies have focused on subgroups of patients, such as those with non-variceal upper gastrointestinal bleeding,[37–40] limiting their score's ability to generalise to an unselected population, which is not the case in our cohorts. Also, as proposed by Stanley *et al*, a high-quality score should be easy to calculate, accurate and capable of early, pre-endoscopy risk assessment, which the LHS satisfies.[11]

This study has limitations in that while the results were validated in a separate cohort, replicating this in other geographical locations and settings would be necessary as the study was based on clinical thresholds at Imperial College Healthcare NHS Trust. The LHS has variables which are clinician dependent, for example, alternative diagnoses, so scoring may vary between clinicians, but this also applies to the GBS which incorporates medical diagnoses like chronic liver disease and subjective variables like melaena. The LHS score cut-off of <1 does not identify all patients at low risk of requiring haemostatic intervention but would be an improvement on current recommended clinical practice in which all patients with a GBS>1 are admitted to an inpatient bed for an endoscopy within 24 hours, which is difficult to deliver in many healthcare systems. The cut-off of <1 also does not have a NPV of 100% (98%), which means that some patients with high-risk endoscopic stigmata may not undergo urgent endoscopy within 24 hours. However, this is the scenario in routine clinical practice and patients are already in hospital so can be triaged to more urgent endoscopy if deterioration occurs. In addition for acute lower gastrointestinal bleeding an Oakland score of <8 predicts a 95% chance of safe discharge[25] and has been recommended for use in routine clinical practice[41] demonstrating that clinicians recognise that 100% certainty from risk scores or clinical impression are impractical.

CONCLUSION

The pre-endoscopic LHS is accurate in predicting need for haemostatic intervention in AUGIB. It identifies a cohort of low-risk patients who may undergo delayed or outpatient endoscopy with the potential to avoid urgent invasive tests, reduce inpatient stays and costs. Validation in other geographical settings is required before routine clinical use.

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