Acute Upper Gastrointestinal Bleeding in Childhood: Development of the Sheffield Scoring System to Predict Need for Endoscopic Therapy

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ABSTRACT

Background/Aims: Upper gastrointestinal bleeding (UGIB) is a rare and potentially life-threatening condition in childhood. In adults with UGIB, validated scoring systems exist, but these are not applicable to children. The aim of this study was to construct a clinical scoring system to accurately predict the need for endoscopic haemostatic intervention.

Methods: A retrospective data collection occurred during a 3-year period at a tertiary children's hospital. A total of 69 patients who had had endoscopic assessment were divided into group 1 (no intervention required) and group 2 (intervention required). A wide range of clinical parameters were collated including preexisting conditions, melaena, haematemesis and degree, transfusion requirement, parameters of hypovolaemia, presenting haemoglobin (Hb), Hb drop during 24 hours, platelet count, coagulation indices, liver function tests, and urea/electrolytes.

Results: Parameters that reached statistical significance for endoscopic intervention (group 1 vs group 2) were the presence of significant preexisting condition, melaena, large haematemesis, heart rate (HR) >20 mean HR for age, prolonged capillary refill time (CRT), Hb drop of >20 g/L, need for fluid bolus, need for blood transfusion (Hb < 80 g/L), and need for other blood products. Using these parameters, a number of scoring models were tested, and the most predictive resulted in a scoring system constructed with a total of 24 and a cutoff for intervention of 8. According to this design, there were 4 false-negatives in the interventional group with 3 false-positives in the noninterventional group. This resulted in a positive predictive value (PPV) of 91.18% (95% confidence interval [CI] 76.3–98.04), negative predictive value (NPV) of 88.57% (95% CI 73.24–96.73), sensitivity of 88.7% (95% CI 73.24–96.73), and specificity of 91.18% (95% CI 76.3–98.04).

Conclusions: In our study population, we were able to formulate a scoring system with reasonable PPV and NPV to predict the need for endoscopic intervention in acute UGIB in children. Prospective evaluation is now required.

Key Words: children, endoscopy, gastrointestinal bleeding

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In adults with upper gastrointestinal bleeding (UGIB) (with or without comorbidities), there exist reasonably reliable predictive scoring systems (Rockall, Blatchford [aka Glasgow], Addenbrooke) to identify which patients are high risk (of mortality, repeat bleeding, need for blood transfusion, and surgical intervention) and require immediate endoscopic intervention and those at low risk who can be safely discharged (1–6). These depend on morbidity assessment and are weighted for variables such as urea level, age, presence of ''shock,'' presence of comorbidities such as ischemic cardiac disease, renal failure, and malignancy, and are preendoscopic (Blatchford and Addenbrooke scoring systems) and full or postendoscopic (Rockall scoring system) (Tables 1–3). Prospective validation of these scoring systems has occurred (8–11). There are scoring systems specific to particular bleeding lesions, such as the Acute Physiology and Chronic Health Evaluation score, which relate to peptic ulcer bleeds (12,13). Other systems have looked to identify those at low risk when presenting with acute UGIB (14). Yet other groups have looked at the risk of early repeat bleeding and mortality risk in UGIB (15–18). A prospective comparison study identified the Forrest classification as the most accurate in predicting repeat bleeding rate and mortality (19).

These scoring systems have not been applied to children presenting with UGIB because most of the physiological and haematological/biochemical parameters on which they are based are not applicable to children. Indeed, pathologies leading to UGIB also differ between the age groups. Therefore, to date, no such validated scoring systems exist in paediatrics, which may predict the requirement or otherwise for endoscopic haemostasis therapy.

Furthermore, the application of life-saving endoscopic therapy in such circumstances has recently been the subject of a review by the UK National Institute of Clinical Excellence. This extensive review limited its remit, however, to the age group >16 years.

The matter is further complicated by the wide variability of the following important practical factors in the provision of such life-saving techniques for childhood medicine:

1. Availability of appropriately trained paediatric therapeutic endoscopists
2. Availability geographically of units with the adequate and appropriate equipment
3. Agreed-upon guidelines/algorithms of care for this clinical emergency with no universal view of when and how to intervene endoscopically

This is further compounded by an absence of knowledge of the size of the clinical problem in paediatrics. As this remains undetermined, it requires urgent clarification and quantification. Many paediatric endoscopists would not encounter an acute

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TABLE 1. Glasgow-Blatchford bleeding scoring system (2)

Admission parameters	Score value
BUN, mg/dL	
>6.5 to <8	2
>8 to <10	3
>10 to <25	4
>25	6
Hb, g/dL	
Men	
12 to <13	1
10 to <12	3
<10	6
Women	
10 to <12	1
<10	6
Systolic BP, mmHg	
100–109	1
90–99	2
<90	3
Other parameters	
Pulse >100	1
Melaena at presentation	1
Syncope	2
Hepatic disease	2
Cardiac failure	2

Scores of ≥6 are associated with a >50% risk of needing an intervention.
BP = blood pressure; BUN = blood urea nitrogen; Hb = haemoglobin.

upper gastrointestinal (GI) bleeding case more than a handful of times each year. A case, then, may be made for centralisation of such units and skills, but the caveat to this is the need for safe transport of a child who may be actively bleeding to such a centre.

It can be seen, therefore, that there are many variable and unanswered dilemmas and questions surrounding this area, and it is an emergency in childhood that has received little attention to date in the literature.

This article attempts to address some of these issues and propose a scoring system that may be used and adapted in clinical practice to inform when and how a child should receive potentially life-saving endoscopic haemostatic treatments. In other words, it is hoped that this may form a template for further more sophisticated attempts at predictive clinical scoring systems that may allow appropriate and timely application of endoscopy to save lives in this emergency in children.

TABLE 3. Addenbrooke preendoscopic risk stratification (7)

Risk group	Variables
High	Recurrent bleeding (any of resting tachycardia and supine hypotension with no obvious cause, further fresh blood haematemesis, melaena, falling Hb concentration more than that can be expected by haemodilution)
	Persistent tachycardia (>100 bpm despite resuscitation)
	History of oesophageal varices
	Systolic blood pressure <100 mmHg supine
	Coagulopathy (prothrombin time >17 s)
	Thrombocytopaenia (platelet count <100)
	Postural hypotension >20 mmHg on negative
	Chronotropes (eg, β-blockers)
Medium risk	Age >60 y
	Hb <11 g/dL (on admission)
	Comorbidities (any clinically significant coexisting disease)
	Passage of melaena or presence on digital rectal examination
	Excessive alcohol (>28 U/wk or >10 in the last 24 h)
	NSAIDs (present or recent intake of NSAIDs)
	Previous GI bleed or peptic ulceration
	Abnormal liver biochemistry (transaminitis, bilirubin, or alkaline phosphatase)
	Postural hypotension >10 mmHg (sitting or standing compared with supine)
	Systolic blood pressure <20 mmHg compared with patient normal if known
Low risk	None of the aforementioned factors

GI = gastrointestinal; Hb = haemoglobin; NSAIDs = nonsteroidal anti-inflammatory drugs.

METHODS

A retrospective data collection occurred during a 3-year period at a tertiary children's hospital with a dedicated paediatric GI endoscopy team, with requisite skills and equipment, which are detailed subsequently. Children <16 years of age presenting with acute GI bleeding were identified—those with either haematemesis, profound rectal bleeding, or melaena. A wide range of clinical parameters were collated (Table 4). These included preexisting conditions such as liver disease; family history such as coagulation abnormalities and peptic ulcer disease; transfusion requirement; parameters of hypovolaemia (CRT; systolic, diastolic, and mean

TABLE 2. Rockall scoring system (a score of <3 carries a good prognosis but a total score >8 carries a high risk of mortality) (1)

Variable	Score 0	Score 1	Score 2	Score 3
Age, y	<60	60–79	>80	
Comorbidity	Nil major		Congestive heart failure, ischemic heart disease	Renal failure, liver disease, metastatic cancer
Source of bleeding	Mallory-Weiss tear	All of the other diagnosis examples: oesophagitis, gastritis, peptic ulcer disease, varices	Malignancy	
Shock	No shock	PR > 100	Systolic blood pressure <100	
Stigmata of recent bleeding	None		Adherent clot, spurting vessel	

PR = pulse rate.

TABLE 4. Patient demographics

Demographics	Noninterventional group (n = 34), group 1	Interventional group (n = 35), group 2
Age, y, median (range)	11 (0.2–16)	5 (0.25–17)
>10	18	11
5–10	4	4
<5	12	20
Sex		
Male	13	19
Female	21	16
Referring hospital		
Tertiary centre	24	17
Peripheral hospital	10	18
Ethnicity		
White	21	20
Other ethnic background	7	8
Not documented	6	7

arterial blood pressure, heart rate—all expressed in the context of age and size of child compared with standard medians); need for agents such as octreotide and omeprazole; and blood indices including haemoglobin (Hb), Hb drop during 24 hours, platelet count, coagulation indices, liver function tests, and urea/electrolytes. A scoring system, based on statistical modelling weighted for these variables and their independent influence, was then constructed and tested. The need or absence of need for endoscopic intervention was used as the primary outcome in order to devise a threshold for the scoring system, which may usefully produce a positive predictive value (PPV) and negative predictive value (NPV) for the need for endoscopic intervention.

Five senior paediatric endoscopists, experienced in all of the variceal and nonvariceal haemostatic techniques intervened endoscopically in these children, supported by an endoscopy nursing team similarly experienced, in a theatre environment, and all of the procedures occurred under general anaesthesia. Decision to perform endoscopy was based at the discretion of the gastroenterologist. Techniques used were standard and included variceal banding, gastric fundal variceal histoacryl glue injection, argon plasma coagulation, endoclips, monopolar and bipolar electrocautery, and, where necessary, epinephrine and thrombin injections. Hemospray is not yet available for the paediatric population but may become available soon.

Patients were separated into those who required no endoscopic haemostatic management, as judged by the experienced endoscopist performing the procedure (group 1). Those in whom endoscopic haemostatic intervention was needed (ie, with ongoing haemorrhage, a visible vessel in an ulcer, varices grade $\geq$2, and obvious angioectatic lesions likely in the view of the endoscopist to bleed imminently or who were actually actively bleeding) constituted group 2. One case of actively bleeding Meckel diverticulum treated surgically was excluded.

The clinical audit was registered with the Trust Audit Office and Clinical Audit and Effectiveness Committee of Sheffield Children's Hospital NHS Foundation Trust and approved.

RESULTS

Sixty-two children (34 boys) with 69 bleeding episodes, median age 7.0 years (range 0.16–6 years), were identified. Demographic details are outlined in Table 4, having separated the cases into the 2 groups outlined above. Patients were de novo cases with no previous contact with medical services for GI/hepatological problems, although some cases received >1 endoscopic assessment. Intravenous (iv) octreotide infusions ($3–5\,\mu g \cdot kg^{-1} \cdot h^{-1}$) were administered in 40 (57%), iv omeprazole in all of the 69 (100%), and blood transfusion in 33 (47%). Clinical signs suggestive of hypovolaemia, compared with age-related means, were identified as follows: prolonged CRT in 18 (26%), increased heart rate (>20 bpm above mean heart rate for age) in 23 (33%), low mean arterial pressure in 17 (25%), low systolic pressure in 16 (23%), and fluid resuscitation requirement in 18 (26%). Five (7%) children had a history of NSAID ingestion in the 48 hours before the bleeding episode and 8 (12%) were taking steroids. Family history included peptic ulcer disease in 2 (3%) children. Clinical signs of portal hypertension/splenomegaly were present in 8 (12%) patients.

Significant comorbidities included liver disease and portal hypertension (9), malignancy (5), cerebral palsy with gastrostomy (5) and without gastrostomy (1), vascular malformations (2), undifferentiated autoimmune inflammatory disease (2), eosinophilic enteropathy (2), Crohn disease (1), Glanzmann thrombasthenia (1), alcohol misuse (2), and juvenile rheumatoid arthritis on high-dose NSAIDs (1).

Table 5 describes the risk factor differences between the 2 groups giving their odds ratios and statistical significance. The statistically significant differences in presentation between the 2 groups were significant preexisting conditions, documentation of ''large'' haematemesis, presence of melaena, heart rate at presentation >20 bpm above the mean heart rate for age, prolonged CRT of >2 seconds, drop of Hb of >20 g/L (compared with a premorbid known Hb for the patient or, if none available, compared with the lower limit of normal range for age), requirement for blood transfusion as determined by the acute paediatrician during stabilisation of the patient or preanaesthetic, and need for fluid resuscitation and/or other blood products as determined by the acute paediatrician during stabilisation of the patient or preanaesthetic.

Statistical modelling between these 2 groups then occurred as detailed below, and a practical scoring system to predict the necessity for endoscopic intervention was constructed. Weight was then given/applied to the significant variables mentioned above, and different modelling was applied in order to obtain a scoring system with the best PPVs and NPVs, sensitivity, and specificity.

Stepwise multiple logistic regressions with R2 calculation were applied using the SPSS software version 19 (IBM SPSS Statistics, Armonk, NY). This analysis showed blood transfusion as the most significant variable that differentiated the interventional from the noninterventional group.

In our practice, blood transfusions were administered to patients deemed to be haemodynamically unstable because of bleeding (low systolic blood pressure, prolonged capillary refill/significant tachycardia with history of frank haematemesis) and in addition to those patients with an Hb of <70 g/L because of bleeding.

A scoring system with weighting of parameters based on statistically significant differentiating factors and influenced by the odds ratios between the interventional and noninterventional group for different variables in the univariate logistic regression was constructed. The significance level was set at 0.05 (Table 5).

To produce a robust scoring system, the 2 groups' data were tested for PPV, NPV, sensitivity, and specificity with different manual modelling. Hence, the final model was arrived at following this refinement process to obtain the highest mix of PPV, NPV, sensitivity, and specificity for the prediction for the need for endoscopic intervention. This scoring system (Table 6) has a total score of 24 and a cutoff for intervention of 8. According to this design, there were 4 false-negative patients in the interventional

TABLE 5. Comparison of significant risk factors in the interventional and noninterventional groups

Risk factor	Noninterventional group (group 1) n = 34	Interventional group (group 2) n = 35	Odds ratio	95% CI	*P*
Age, >5 y	12	20	2.444	0.9257–6.4551	0.07
Significant preexisting condition	8	22	5.5	1.9287–15.689	0.0014
Large amount of fresh haematemesis (reported/observed)	6	17 (3 nonspecified)	5.2889	1.7217–16.2469	0.0036
Presence of melaena	15	25	3.166	1.1672–8.5912	0.0236
Previous GI surgery	2	6	2.9143	0.5494–15.4576	0.2089
Use of NSAIDS	2	3	1.4571	0.229–9.2711	0.6901
Family history of GI bleed/PUD	2	0	0.1944	0.0090–4.1969	0.296
HR >20 bpm from the mean HR for age	6	17	4.4	1.4625–13.2819	0.0084
Prolonged central capillary refill (>2 s)	1	14	23.1	2.819–189.29	0.0027
Reduced conscious level	0	4	8.7465	0.4536–168.6426	0.1509
First recorded Hb after bleed <10 g/L	12	26	5.2963	1.8831–14.8961	0.0016
Raised urea level above the upper limit of normal range for age	5	12	3.0	0.9058–9.9363	0.0722
Hb drop of >20 g/L	6	26	13.48	4.2145–43.1249	0.0001
Platelet drop from previous value	2 (6 recorded)	15 (22 recorded)	2.045	0.362–11.534	0.4174
Need for fluid bolus	2	17	15.111	3.1285–72.989	0.0007
Need for blood transfusion	3	31	80	16.535–387.8637	<0.0001
Need for other blood product (FFP/platelets)	0	8	21.3273	1.1783–386.0165	0.0384

CI = confidence interval; FFP = fresh frozen plasma; GI = gastrointestinal; Hb = haemoglobin; HR = heart rate; NSAIDs = nonsteroidal anti-inflammatory drugs; PUD = peptic ulcer disease.

group with 3 false-positive values in the noninterventional group. This resulted in PPV of 91.18% (95% confidence interval [CI] 76.3–98.04), NPV of 88.57% (95% CI 73.24–96.73), a sensitivity of 88.7% (95% CI 73.24–96.73), and a specificity of 91.18% (95% CI 76.3–98.04).

Differences in variables including fall in platelet count, raised urea level, age, and diastolic and systolic blood pressure difference from the mean blood pressure for age were also calculated but none reached statistical significance, and hence were not included in the scoring system calculations. More patients had a lower diastolic blood pressure (compared with mean for age) in the interventional group than in the noninterventional group, but the total analysis was insignificant as this variable was masked by other patients with raised blood pressure in the interventional group (which may occur because of the distress of sick children/inaccuracies of measuring blood pressure in the emergency department).

DISCUSSION

Haemostatic techniques associated with endoscopy have long been recognised as lifesaving in adult GI cases in emergency circumstances. The parallel of a child entering a hospital bleeding to death from a preventable GI cause, however, has received little attention despite the advances in endoscopic therapeutic techniques that have transformed adult practice in the last 20 years. This is an avoidable situation and merits immediate attention and review.

In adults, there are well-validated and robust scoring systems that can predict for the necessity or otherwise of endoscopic haemostatic intervention (1–6). There are also scoring systems that, following endoscopic assessment, will stratify a patient in terms of risk from further bleeding or indeed mortality based on both clinical and endoscopic analyses (12–19). These are extremely useful, practical, and dependable scoring devices with reasonable levels of clinical prediction. In paediatrics, no such predictive scoring systems exist to date. This is possibly because of the relative infrequency of clinical presentation, lack of experience of endoscopists involved (both in terms of whether to intervene and if so with what technique), and the availability of endoscopic expertise predicated by such circumstances as geography and experience, with the issue of the interaction or otherwise with local adult GI endoscopy services also being important.

To our knowledge, this assessment represents the first attempt to define risk factors for acutely presenting UGIB in children. The aim was to identify those children presenting de novo with endoscopically treatable GI bleeding, and in addition whether it would be possible to produce a clinically useful scoring system for prediction of those who are at greater or lesser risk, and

TABLE 6. Idealised scoring system

History taking
- Significant preexisting condition: 1
- Presence of melaena: 1
- History of large amount of haematemesis: 1

Clinical assessment
- HR >20 from the mean HR for age: 1
- Prolonged capillary refill: 4

Laboratory findings
- Hb drop of >20 g/L: 3

Management and resuscitation
- Need for a fluid bolus: 3
- Need for blood transfusion (Hb of <80 g/L): 6
- Need for other blood product: 4

Total score 24: cutoff 8
- Interventional group: true-positive = 31, false-negative = 4
- Noninterventional group: true-negative = 31, false-positive = 3
- Sensitivity: 88.57%, 95% CI 73.24–96.73
- Specificity: 91.18%, 95% CI 76.30–98.04
- PPV: 91.18%, 95% CI 76.30–98.04
- NPV: 88.57%, 95% CI 73.24–96.73

CI = confidence interval; Hb = haemoglobin; HR = heart rate; NPV = negative predictive value; PPV = positive predictive value.

by inference, those who require endoscopic haemostatic therapy or not.

Important clinical parameters and predictors that emerged were preexisting diseases including liver disease and portal hypertension, the requirement for blood transfusion, the requirement for acute iv volume support, a raised heart rate of >20 bpm above the mean for age, a raised CRT of >2 seconds, the presence of a ''large'' haematemesis, the presence of melaena, and a fall of Hb of >20 g/L. Using a number of constructed models weighted for importance per each parameter's calculated potential to differentiate the child who would need endoscopic haemostatic techniques to be used or not, it was then possible to devise an ideal scoring system with maximum PPV, NPV, sensitivity, and specificity, which could be robust, practical in the emergency setting, and reliably predictive for endoscopic intervention. The multiple regression analysis allowed modelling with a number of different numerical importance assigned to each statistically differentiating parameter, and these were tested for PPV, NPV, sensitivity, and specificity until the best model for these was arrived at.

Clinical scoring systems of course are no substitute for clinical assessment of a child's requirement for therapeutic intervention, but this emergency is slightly different from others in that it involves a decision for therapeutic intervention that most paediatricians first coming into contact with the child are, not unreasonably, unable to objectively provide. Hence, some objective measures of individual risk would seem to be a clinical imperative. Furthermore, adult-specific risk predictors are not applicable to children, given their adult-oriented genesis and validation (1–6,8–11). It was therefore believed important to devise a tool to assist the frontline paediatricians in their decision as to whether urgent endoscopic referral/assessment would be needed. This could be used in the emergency room as a quick reference and could point towards which children were at risk, who would benefit from referral to gastroenterologists, and in turn would benefit from endoscopy to allow therapy to stop any detected bleeding. In turn, such a tool may help the identified endoscopist (paediatric or adult endoscopist background) to determine whether endoscopic intervention would be likely to be required during the procedure and, if so, potentially which tools of endoscopic haemostasis to make available to them. The infrequency of such an event in childhood means that it has not been easy to produce even a first version of such a clinical device, and as such we hope that this attempt can be refined by validation prospectively on a multicentre level to perfect and adapt its robustness, reliability, and predictability.

In adult circles, such a model is a common aid to this emergency situation. It is long overdue that this is now possibly available in an age-appropriate version to paediatricians, paediatric gastroenterologists/hepatologists/endoscopists, and nonpaediatric endoscopists, who have historically been in a difficult clinical position when asked to decide whether to intervene with an endoscopy or not. The higher the score the more expeditious endoscopic intervention should be. If this score can be validated, then it could be foreseen that this could change practice as the adult Rockall and Blatchford scores have done with the dual conclusion of avoidance of unnecessary endoscopy and the identification of those requiring urgent or semiurgent endoscopic intervention. Hence, further multicentre prospective work on validation is needed to allow this scoring system to attempt to prevent preventable mortality in childhood acute GI bleeding.

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