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Assessment of end-tidal carbon dioxide levels in patients presenting to the emergency department with gastrointestinal bleeding

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ABSTRACT

Objectives: Gastrointestinal bleeding is a common condition in emergency departments and can be fatal if diagnosis and treatment are delayed. In this study, we aimed to explore the relationship between end-tidal carbon dioxide (ETCO2) levels and Glasgow Blatchford Score (GBS) and AIMS65 scores, as well as its impact on assessing morbidity and mortality in patients presenting to the emergency department with gastrointestinal bleeding.

Methods: The research involved 103 eligible patients diagnosed with gastrointestinal bleeding. ETCO2 measurements were taken on admission and data on hospitalization, GBS/AIMS65 scores, endoscopically detected active bleeding and 30-day mortality were recorded. Statistical analysis was performed on the collected data.

Results: When ETCO2 values obtained from the patients were compared according to hospitalization status, GBS score, AIMS65 score, presence of endoscopically detected active bleeding and mortality status; ETCO2 levels were significantly lower in patients with active bleeding, those who died, patients with AIMS65 scores ≥2, and those with GBS scores ≥12 ($P<0.05$).

Conclusions: This study demonstrates that ETCO2 levels are significantly lower in patients with gastrointestinal bleeding, especially in those with active bleeding, high mortality risk, and elevated GBS or AIMS65 scores. ETCO2 may serve as a rapid and practical marker for assessing hypovolemia and clinical status in emergency settings.

Keywords: Gastrointestinal bleeding, end-tidal capnography, Glasgow Blatchford score, AIMS65 score

Gastrointestinal (GI) bleeding is a common condition in emergency departments and can lead to fatal outcomes if diagnosis and treatment are delayed. Upper GI bleeding represents 5% of emergency department admissions [1]. Mortality rates range from 2% to 15% [2]. In most cases, GI bleeding may resolve spontaneously without the need for endoscopic intervention, blood transfusion, or surgery. Nevertheless, timely intervention is crucial for patients with life-threatening bleeding [3]. For this purpose,

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commonly used and validated risk stratification tools, such as the Glasgow Blatchford Score (GBS) and the AIMS65 score, are utilized [4, 5].

Capnography is a noninvasive method for measuring the partial pressure of carbon dioxide (CO_2) throughout the respiratory cycle. It offers valuable insights into ventilation (the effectiveness of carbon dioxide removal), perfusion (vascular transport of CO_2), and metabolism (CO_2 production from cellular processes). The principle behind end-tidal capnography is to detect carbon dioxide levels in the exhaled breath. Variations in the end-tidal CO_2 ($ETCO_2$) waveform provide physicians with crucial information in various scenarios, such as evaluating disease severity, assessing cardiac arrest (quality of chest compressions, return of spontaneous circulation, correct endotracheal tube placement, prognosis), guiding procedural sedation, and predicting critical illness [6-13].

In this study, we sought to explore the relationship between $ETCO_2$ levels and GBS and AIMS65 scores, and assess their effectiveness in evaluating morbidity and mortality in patients presenting to the emergency department with GI bleeding.

METHODS

This study was conducted as a prospective observational study at İzmir Atatürk Training and Research Hospital. The study commenced following the approval of the ethics committee (dated 12.05.2020, approval number 702) and was conducted from 1st June 2020 to 31st December 2020. Patients who were admitted to our emergency department, a tertiary education and research hospital, diagnosed with GI bleeding, and met the inclusion criteria were included in the study.

Inclusion criteria were patients presenting to the emergency department with signs of GI bleeding (blood from the mouth, blood from the rectum, black-colored stools, vomiting like coffee grounds, fainting), those who consented to participate in the study, and patients aged 18 years and older. Exclusion criteria were patients under 18 years of age, pregnant women, trauma patients, individuals with respiratory conditions that elevate CO_2 levels (such as asthma, COPD, pneumonia, etc.), patients transferred from other hospitals, those with heart failure, and patients who declined participation in the study.

Upon admission to the emergency department, ETCO2 measurement was performed with a UTECH VS2000® capnography device under 2 L/min oxygen support for approximately 5 minutes using a Mediplus A202Mx capnomask® mask and recorded on the prepared case form. Demographic data (age, gender), blood pressure, and pulse rate, comorbid diseases (liver failure, heart failure), history of syncope, and the presence of melena on rectal examination were recorded on the patient's form. Endoscopy/colonoscopy results (with/without active bleeding), international normalized ratio (INR), albumin levels, and blood urea nitrogen (BUN) levels, and hemoglobin (Hb) values of laboratory parameters were recorded via the automation system. GBS and AIMS65 scores were calculated using the obtained

Table 1. Glasgow Blatchford score (GBS)

Admission risk marker	Score component value
Blood urea (mmol/L)	
6.5-8.0	2
8.0-10.0	3
10.0-25.0	4
>25.0	6
Haemoglobin (g/dL) for men	
12.0-12.9	1
10.0-11.9	3
<10.0	6
Haemoglobin (g/dL) for women	
10.0-11.9	1
<10.0	6
Systolic blood pressure (mm Hg)	
100-109	1
90-99	2
<90	3
Other markers	
Pulse ≥100/min	1
Melaena	1
Syncope	2
Hepatic disease	2
Cardiac failure	2

data (Tables 1 and 2). Patients were grouped as GBS≥12 and GBS<12 according to the GBS score and AIMS≥2 and AIMS<2 according to the AIMS65 score [14, 15]. Hospitalization status (discharged, admission to the ward, admission to the intensive care unit) was recorded. Within 30 days, any death due to GI bleeding was followed up, and 30- day mortality was recorded.

Sample Size

The sample size was calculated using G Power 3.1.9.6. Since there was no other study similar to ours, the sample size was determined based on the effect size. With the effect size established at 0.7, the sample size was calculated as 45 for each group, totaling 90 total.

Statistical Analysis

The data collected were analyzed using the SPSS 23.0 software package. For demographic variables, categorical data such as gender were expressed as frequencies and percentages, while other numerical variables were presented as means and standard deviations. The normality of continuous variables in independent groups was assessed using histogram curves and the ShapiroWilk test. For comparisons between two independent groups, the Student's t-test was used for normally distributed data, while the Mann-Whitney U test was applied for non-normally distributed data. One-way ANOVA was used to compare more than two groups, as the data were normally distributed. A P-value of <0.05 was considered statistically significant in all tests.

RESULTS

During the study period, a total of 402 patients presented to the emergency department with symptoms of gastrointestinal bleeding. Of these, 191 were diagnosed with GI bleeding, and 103 patients who met the inclusion criteria were included in the study. The mean age of the patients was 67.89±16.55 years, with 51.5% of the participants being male.

Syncope occurred in 4.9% of the patients. Additionally, 18.4% had an AIMS65 score ≥2, and 77.7% had a Glasgow-Blatchford score (GBS) ≥12. 32.1% of our patients were hospitalized in the intensive care unit (ICU), while 42.7% were admitted to the general ward. The mortality rate was 18.4% (Table 3). When comparing the $ETCO_2$ values obtained from patients based on hospitalization status, GBS score, AIMS65 score, presence of actively bleeding detected endoscopically, and mortality status, it was found that $ETCO_2$ values were statistically significantly lower in patients with active bleeding, deceased patients, patients with AIMS65 ≥2, and patients with GBS >12 (P<0.05) (Table 4).

Table 2. AIMS65 Score

Variable	Score
Albumin level <3.0 mg/dL	1
INR >1.5	1
Altered mental status	1
Systolic blood pressure ≤90 mm Hg	1
Age >65 years	1

INR=international normalized rate

Table 3. Demographic characteristics of patients and distribution of variables

Variable		Data
Age (years)		67.89±16.55
Gender	Male	53 (51.5)
	Female	50 (48.5)
Syncope	Yes	5 (4.9)
	No	98 (95.1)
Melena	Yes	59 (57.3)
	No	44 (42.7)
Active bleeding	Yes	52 (49.5)
	No	51 (50.5)
AIMS65	<2	91 (81.6)
	≥2	12 (18.4)
GBS	<12	23 (22.3)
	≥12	80 (77.7)
Hospitalization	ICU	33 (32.1)
	Ward	44 (42.7)
	Discharged	26 (25.2)
Mortality	Yes	19 (18.4)
	No	84 (81.6)

Data are shown as mean±standard deviation or n (%).
GBS=Glasgow Blatchford score, ICU=Intensive care unit

Table 4. Relationship of ETCO2 value with AIMS65, GBS and patient outcomes

Variable		ETCO2	P value
Active bleeding	Yes	23.34±5.40	**0.031***
	No	26.01±6.80	
AIMS65	AIMS<2	25.08±6.11	**0.026***
	AIMS≥2	21.48±6.91	
GBS	GBS<12	28.44±5.95	**0.001***
	GBS≥12	23.58±5.97	
Hospitalization	ICU	22±23±6.02	0.481***
	Ward	24.91±5.99	
	Discharged	27.32±6.12	
Mortality	Exitus	20 (15.70-23.40)	**0.002****
	Survivor	26.10 (20.70-29.58)	

Data are shown as mean±standard deviation or median (IQR:25-75). ETCO2=end-tidal carbon dioxide, GBS=Glasgow Blatchford score, ICU=Intensive care unit.

*Student T test, **Mann whitney U test, ***One way ANOVA

DISCUSSION

Gastrointestinal bleeding is an important clinical picture because it is frequently encountered as a reason for presentation to the emergency department, associated mortality, high cost of diagnosis and treatment, and may require hospitalization and subsequent intensive care follow-up. Predicting the severity of the disease and mortality is important in the approach to the emergency unit [3]. Previous studies have established $ETCO_2$ as an effective predictor of critical illness and mortality. Ladde *et al*. [16] assessed the utility of $ETCO_2$ in emergency department triage, finding mean levels of 33 mmHg (range 32-34) in survivors and 22 mmHg (range 18-26) in deceased patients [16]. They also highlighted $ETCO_2$ as a valuable indicator in patients requiring intensive care unit admission. In contrast, our study specifically focused on patients presenting to the emergency department with gastrointestinal bleeding. Among studies evaluating $ETCO_2$ in hemorrhagic conditions, Guzman *et al*. [17] demonstrated its effectiveness in detecting supply dependency, noting rapid increases in $ETCO_2$ correlating with changes in oxygen consumption during resuscitation in experimentally induced hemorrhagic shock in dogs. Similarly, Okamoto *et al*. [18] investigated $ETCO_2$'s relationship with circulation and respiration in canine models, showing $ETCO_2$ elevation alongside increases in blood flow, cardiac output, and hemoglobin concentration, influencing CO_2 elimination rates. Belenky *et al*. [19] reported that $ETCO_2$ levels below 20mm Hg predict hemorrhagic shock severity, decreasing further with shock progression in animal models. These experimental studies underscore the impact of blood volume reduction on $ETCO_2$ levels via CO_2 transfer dynamics influenced by blood flow, hemoglobin, and cardiac output. In human studies, Bulger *et al*. [20] noted lower $ETCO_2$ levels (26.5 mmHg vs. 32.5 mmHg) in trauma patients with hemorrhagic shock compared to those without, emphasizing its potential as an indicator for hemorrhagic shock. Wilson *et al*. [21] identified a threshold $ETCO_2$ value of 35 mmHg for predicting hemorrhagic shock and massive transfusion need in trauma patients. In the study by O'Connor *et al*. [22], were evaluated 56 patients admitted to the emergency department with GI bleeding. The mean $ETCO_2$ value was measured as 30.52±5.30 mmHg in the group with bleeding and 37.43±4.11 mmHg in the group without bleeding and $ETCO_2$ value was found to be significantly lower in patients with bleeding [22]. Similarly, our measurements in GI bleeding patients showed $ETCO_2$ levels of 26.01±6.85 mmHg in those without active bleeding versus 23.34±5.40 mmHg in those with active bleeding, confirming $ETCO_2$'s predictive value in identifying bleeding events. $ETCO_2$ measurement reflects CO_2 production in tissues transported to the lungs via blood; decreased blood volume in GI bleeding impairs oxygen delivery to tissues, reducing CO_2 production and excretion via respiration, thereby lowering $ETCO_2$ levels. Additionally, ventilation perfusion mismatch due to impaired lung perfusion further contributes to $ETCO_2$ reduction. Thus, $ETCO_2$ serves as an early indicator of hypovolemia in GI bleeding patients, detecting tissue-level hemorrhage effects. These findings underscore $ETCO_2$'s utility as a marker for assessing hypovolemia severity in GI bleeding.

The GBS is a scoring system used to assess the severity of bleeding in patients with gastrointestinal bleeding and to predict which patients can be safely discharged from the emergency department and which require emergency endoscopy. Gonçalves *et al*. [23]. reported that GBS can predict the need for blood transfusion in patients with GI bleeding. Chaudhary *et al*. [14], in a study evaluating endoscopy time in patients with GI bleeding, reported that patients with GBS ≥12 should be urgently taken to endoscopy and even severe bleeding should be suspected in these patients. In our study, we found that the $ETCO_2$ value obtained from patients with GBS ≥12 (23.58±5.97 mmHg) was statistically significantly lower than the $ETCO_2$ value obtained from patients with GBS <12 (28.44±5.95 mmHg). These findings indicate that low levels of $ETCO_2$ in patients with GBS ≥12 are a marker of severe bleeding. $ETCO_2$ level is a value that can be obtained quickly and noninvasively. However, GBS is a challenging condition to evaluate in the emergency department due to the time required to obtain laboratory results for the necessary parameters, the difficulty in distinguishing melena, especially in patients using iron medication, and the inability of patients and anxious relatives to fully describe the syncope condition. Therefore, we believe that in patients with GI bleeding, ETCO2 levels provide more practical and rapid results compared to the GBS, allowing us to assess the presence and severity of bleeding in the emergency department.

Another scoring system considered in our study is the AIMS65 score [5]. A statistically significant difference in $ETCO_2$ values was observed between the groups of patients classified based on the AIMS65 score. When evaluated from this perspective, we see that the $ETCO_2$ value of patients with an AIMS65 score ≥2 is lower than that of patients with an AIMS65 <2. This score is a system used to predict the risk of mortality in patients with gastrointestinal bleeding. An AIMS65 score of ≥2 is associated with a high mortality risk [5, 15]. However, specific laboratory tests such as albumin, which are not routinely examined in emergency departments, are required for the calculation of the AIMS65 score. The low $ETCO_2$ value in patients with an AIMS65 score ≥2, which is considered to be at high risk for mortality, indicates that $ETCO_2$ can also be used to predict the risk of mortality. Furthermore, when assessed in relation to mortality, we found a statistically significant difference between the $ETCO_2$ values of deceased patients (20 mmHg) and surviving patients (26.10 mmHg). We can conclude that $ETCO_2$ is a good predictor of survival. Supporting our thesis, Campion *et al*. [24] reported that trauma patients in hemorrhagic shock with a pre-hospital measured $ETCO_2$ value of 18 mmHg resulted in patient mortality, while those with a value of 33 mmHg survived.

In our study, 51.5% of the 103 patients were male. Research has demonstrated that gastrointestinal bleeding is more prevalent in men than in women [25, 26]. The mean age of the patients in our study was 67.89±16.55 years, which is consistent with the average age reported in the literature [22, 25]. The patient population in our study aligns with findings in existing studies.

Limitations

This study was conducted as a single-center prospective observational study with a limited sample size, which may restrict the generalizability of the findings. Moreover, $ETCO_2$ measurements were obtained only at the time of admission, and changes over the course of follow-up were not evaluated. $ETCO_2$ levels may be influenced by various factors, particularly patient-related conditions such as altered mental status, anxiety in confined spaces, and poor compliance with the capnography device, all of which may affect the accuracy of the measurements. Furthermore, the 30-day mortality follow-up relied solely on hospital records, and deaths occurring after discharge may not have been captured.

CONCLUSION

This study shows that $ETCO_2$ levels in patients admitted to the emergency department for gastrointestinal bleeding are significantly lower in cases of active bleeding, increased mortality risk, GBS ≥12, and AIMS65 ≥2. These findings suggest that $ETCO_2$ could serve as a valuable marker for detecting hypovolemia and evaluating the patient's clinical condition. Additionally, compared to GBS and AIMS65 scores, $ETCO_2$ appears to be a faster, more practical, and applicable value in the emergency department. This result suggests that $ETCO_2$ may offer greater advantages in predicting the presence of bleeding, its severity, and the need for transfusion, compared to the GBS and AIMS65 scores. Our study has demonstrated the potential advantages of $ETCO_2$ in the evaluation of gastrointestinal tract bleeding, which is critical for rapid and effective intervention in the emergency department setting. Future studies involving larger patient populations and diverse clinical scenarios will provide a deeper understanding of how these findings can be applied in clinical practice.

Ethical Statement

This study was approved by the İzmir Kâtip Çelebi University Non-Interventional Clinical Research Ethics Committee (Decision no. 702, date: 12.05.2020).

Authors' Contribution

Study Conception: EK, RK, AK, FET; Study Design: EK, AK, EEG; Supervision: RK, AK, HA, FET; Funding: EK, AK, RK, FET; Materials: EK, EEG, AK, HA; Data Collection and/or Processing: EK, RK, EEG, HA; Statistical Analysis and/or Data Interpretation: EK, RK, AK, FET; Literature Review: EK, AK, EEG, HA; Manuscript Preparation: EK, RK, EEG and Critical Review: RK, AK, EEG, FET.

Conflict of interest

he authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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Generative Artificial Intelligence Statement

The author(s) declare that no artificial intelligence-based tools or applications were used during the preparation process of this manuscript. The all content of the study was produced by the author(s) in accordance with scientific research methods and academic ethical principles.

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