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Original article

The Role of plasma ammonia level in detecting intra-abdominal hemorrhage following blunt abdominal trauma

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Abstract:

- ***Background*:** Blunt abdominal injury is a major cause of death in trauma cases. It will be very helpful if intra-abdominal bleeding can be predicted by laboratory tests. The aim of our study is to evaluate the accuracy of plasma ammonia in detecting intra-abdominal hemorrhage in patients with blunt abdominal injury.
- ***Methods:*** In this study, 60 patients admitted to Azadi teaching hospital complaining from blunt abdominal trauma were included. On admission to emergency room, plasma ammonia levels were measured. Demographic data, vital signs, and GCS reports were written down. Findings of abdomino-pelvic computed tomography scan and intraoperative laparotomy were supposed as a gold standard for abdominal injuries. We excluded patients with preexisting liver diseases or impairment.
- ***Result:*** In this study 60 patients were involved. 6 patients had intra-abdominal bleeding and their mean plasma ammonia level was much higher than the rest. (205.33±100.2 vs. 51.29±23.38, $P < 0.001$). ROC curve analysis revealed Accuracy 96.7% Sensitivity 83.3% Specificity 98.1%.
- ***Conclusions:*** The study results advocate that an increase in plasma ammonia level in patients with blunt abdominal trauma would be a useful predictor for intra-abdominal hemorrhage. This can be a great opportunity for hospitals lacking advanced facilities like contrast enhanced CT scan or diagnostic laparoscopy.
- **Keywords:** Plasma ammonia, blunt abdominal trauma, hemorrhage

INTRODUCTION

The term “trauma” originates from the Greek word meaning “wound” and refers to tissue damage resulting from the application of external energy beyond the body’s physiological tolerance, often compounded by ischemia and reperfusion-induced cell death (1,2). Trauma is the leading cause of death in individuals aged 1 to 44 years and remains the third most common cause of death across all age groups (1).

Among trauma-related injuries, the abdomen is the third most frequently affected region, occurring in approximately 7%–10% of all trauma cases. Of these, blunt abdominal trauma accounts for nearly 70%–80% (3,4). Uncontrolled hemorrhage continues to be a major contributor to trauma-related mortality, responsible for up to 40% of deaths—a figure that underscores the importance of early detection and intervention.

Abdominal trauma is generally classified as either blunt or penetrating. Blunt trauma is more common and is frequently associated with motor vehicle accidents, particularly in rural and agricultural regions. In contrast, penetrating injuries, more prevalent in urban areas, are most often caused by stab wounds (1,2). Unlike penetrating injuries, which are typically straightforward to diagnose, blunt abdominal injuries can be difficult to detect, especially in patients with altered consciousness or distracting injuries, necessitating a high index of suspicion and comprehensive assessment (6).

The initial management of trauma patients is guided by principles established in the Advanced Trauma Life Support (ATLS) program, developed by the American College of Surgeons in the late 1970s. ATLS emphasizes structured, timely care within the "golden hour" to improve outcomes. The management protocol begins with a primary survey focused on the rapid identification and treatment of life-threatening conditions, using the "ABCs" approach: Airway with cervical spine protection, Breathing, and Circulation (2).

To predict morbidity and mortality in trauma patients and guide management decisions, several scoring systems are used. These include physiologic scoring tools such as the Glasgow Coma Scale (GCS) and Revised Trauma Score (RTS), as well as anatomical scoring systems like the Injury Severity Score (ISS) (1,2).

In terms of diagnostic tools, ultrasonography—particularly the Focused Assessment with Sonography for Trauma (FAST)—has become a key component of the initial evaluation of patients with blunt abdominal trauma. It is especially valuable in hemodynamically unstable patients due to its noninvasive nature, ease of use at the bedside, and lack of radiation exposure, unlike computed tomography (CT) scanning. FAST has thus become an indispensable tool in modern emergency care settings (14).

In this study, we aimed to investigate the clinical utility of serum ammonia level estimation as a potential predictor of internal hemorrhage in patients with blunt abdominal trauma.

PATIENT and METHOD

This prospective observational study was conducted over a four-month period, from November 2020 to February 2021, and included all patients presenting with blunt abdominal trauma to the emergency department of Azadi Teaching Hospital. Patients were enrolled consecutively upon presentation. Several exclusion criteria were applied: patients with cardio-respiratory arrest or suppression, those with penetrating injuries, pre-existing liver or kidney disease, injuries associated with significant hemorrhage, and patients who had received pre-hospital intravenous fluids or blood products prior to sampling, as this could affect plasma ammonia concentrations. Additionally, cases in which the time elapsed between trauma and blood sample collection exceeded one hour were excluded, given that plasma ammonia has a short half-life of less than 20 minutes, and delayed sampling could compromise accuracy.

Included patients had sustained blunt abdominal trauma resulting from mechanisms such as motor vehicle collisions, falls from height, or direct abdominal impact. Upon admission to the emergency department, all patients were assessed using the Advanced Trauma Life Support (ATLS) protocol, which prioritizes initial evaluation using the ABCD approach—Airway, Breathing, Circulation, and Disability (neurological status) (1,2).

For each patient, demographic data including name, age, gender, and address were recorded. Vital signs (blood pressure, pulse rate, respiratory rate) and Glasgow Coma Scale (GCS)

scores were documented on arrival. Blood samples were collected for routine investigations including blood glucose, renal function tests, complete blood count (CBC), and virologic screening. Radiological evaluation, including X-ray, ultrasonography, and non-contrast CT scan, was performed as clinically indicated.

Laparotomy was considered the gold standard to confirm the presence of intra-abdominal hemorrhage. At the time of admission, an additional blood sample was collected to measure plasma ammonia levels.

For ammonia testing, five milliliters of venous blood were drawn from the antecubital vein and placed into a sterile EDTA-containing tube. Extreme care was taken to maintain a cold environment and minimize processing time. The samples were centrifuged at 5000 rpm for five minutes, and the plasma supernatant was used for analysis.

Plasma ammonia concentration was measured using a spectrophotometric method with a kit supplied by Biolabo SAS (France). The test relied on glutamate dehydrogenase (GLDH) activity, with measurements exceeding 9300 IU/L considered elevated (20).

RESULTS

A total of 60 patients with blunt abdominal trauma were enrolled in the study. The mean age of participants was 29.71 ± 12.75 years, and the majority were male (88.3%). Clinical parameters recorded on admission included a mean pulse rate of 88.7 ± 17.45 bpm, systolic blood pressure of 122.18 ± 18.39 mmHg, diastolic blood pressure of 75.31 ± 9.95 mmHg, respiratory rate of 17.66 ± 3.85 breaths per minute, and Glasgow Coma Scale (GCS) score of 14.71 ± 0.94. Most patients (90%) were managed conservatively (Table 1).

Table 1: Demographic and Clinical Data

Variable	Mean ± SD or n (%)
Age (years)	29.71 ± 12.75
Gender (Male)	53 (88.3%)
Pulse Rate (PR)	88.7 ± 17.45
Systolic BP (SBP)	122.18 ± 18.39
Diastolic BP (DBP)	75.31 ± 9.95
Respiratory Rate (RR)	17.66 ± 3.85
GCS	14.71 ± 0.94
Plasma Ammonia	66.7 ± 59.45
Management (Conservative)	54 (90%)

The overall mean plasma ammonia level in the cohort was 66.7 ± 59.45 µmol/L. Upon stratification by the presence of intra-abdominal hemorrhage, patients without hemorrhage (n = 54) had a significantly lower mean ammonia level of 51.29 ± 23.38 µmol/L compared to those with hemorrhage (n = 6), who exhibited markedly elevated levels averaging 205.33 ± 100.2 µmol/L (Table 2). Notably, only one hemorrhage-positive patient had a normal ammonia level; this individual had a splenic injury.

Table 2: Plasma Ammonia by Hemorrhage Status

Group	Mean Ammonia (µmol/L)	SD	n
No Hemorrhage	51.29	23.38	54
Hemorrhage	205.33	100.2	6

Chi-square analysis demonstrated a statistically significant association between elevated plasma ammonia levels and intra-abdominal hemorrhage, with a chi-square statistic of 39.84 and a p-value < 0.00001. This significance persisted after applying Yates correction (χ^2 = 31.30, p < 0.00001) (Table 3).

Table 3: Chi-Square Contingency Table

	Positive Hemorrhage	**Negative Hemorrhage**	**Total**
High Ammonia	5	1	6
Normal Ammonia	1	53	54
Total	6	54	60

An independent t-test revealed a significant difference in mean pulse rate between groups with normal and elevated plasma ammonia levels ($p = 0.0069$). The mean difference was 22.0 bpm, with a 95% confidence interval ranging from 6.16 to 37.84. The t-value was 2.75 ($df = 118$), with a standard error of difference of 7.999.

Receiver Operating Characteristic (ROC) curve analysis confirmed the strong diagnostic performance of plasma ammonia in predicting intra-abdominal hemorrhage. The fitted ROC area was 0.92, while the empirical ROC area was 0.90. The overall accuracy was 96.7%, with a sensitivity of 83.3% and specificity of 98.1%. Only one false-negative and one false-positive case were observed. These results highlight the potential utility of plasma ammonia as a rapid, reliable biomarker in the emergency evaluation of blunt abdominal trauma (Figure 1).

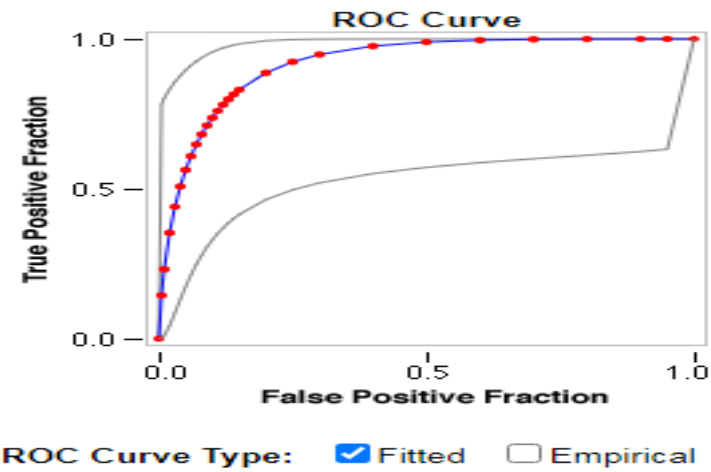

Figure 1: ROC Curve for Plasma Ammonia Predicting Hemorrhage

DISCUSSION

In this study, road traffic accidents were the predominant cause of blunt abdominal trauma, accounting for 56 out of 60 cases. This high incidence may be attributed to the increasing number of vehicles on the roads and a possible trend of reckless driving, particularly among young adult males—40 of the cases involved individuals under 30 years of age, and 53 were male.

The standard initial assessment of blunt trauma patients includes clinical examination, laboratory tests, and imaging studies. However, in resource-limited settings where advanced imaging modalities such as contrast-enhanced CT scans or diagnostic laparoscopy are not readily available, the use of a simple laboratory parameter that could predict intra-abdominal hemorrhage would be highly beneficial. In our study, we observed that plasma ammonia levels were significantly elevated in patients with confirmed intra-abdominal bleeding.

Physiologically, intra-abdominal hemorrhage leads to hypoperfusion of the liver, resulting in impaired hepatic function. This dysfunction disrupts the metabolic conversion of ammonia into urea and glutamine. Specifically, decreased perfusion impairs urea synthesis in periportal hepatocytes and glutamine synthesis in pericentral hepatocytes, leading to an accumulation of ammonia in the bloodstream (13,18). In addition, ammonia is produced in the intestine by bacterial enzymes acting on nitrogenous compounds. This ammonia diffuses freely into the

circulation, and when hepatic clearance is compromised by reduced blood flow, plasma levels rise further (15,16,17).

Our findings align with previous studies. Hagiwara and Sakamoto conducted a similar study involving 282 trauma patients, comparing those with and without intra-abdominal hemorrhage. They found that the mean plasma ammonia level was significantly higher in the hemorrhage group (113 ± 52.2 µg/dL) compared to the non-hemorrhage group (55.4 ± 20.8 µg/dL), with sensitivity and specificity values of 82% and 89%, respectively. Although our results showed a higher mean ammonia level (205.33 ± 100.2 µmol/L) in hemorrhagic cases, the patient sample was smaller, and we explored multiple cutoff points rather than a single threshold of 77 µg/dL used in their study (12).

Similarly, Davood Farsi and colleagues investigated the diagnostic performance of plasma ammonia levels and reported sensitivity ranging from 80% to 100% and specificity between 91% and 95.5% across five different cutoff points (19). Our findings fall within this range, with sensitivity and specificity values of 83.3% and 98.1%, respectively, further supporting the diagnostic value of plasma ammonia in detecting intra-abdominal bleeding.

In addition, our study demonstrated a statistically significant correlation between plasma ammonia levels and pulse rate, with an independent t-test yielding a p-value < 0.001. Patients with elevated ammonia levels had a mean pulse rate of 123.8 ± 11.63 bpm, suggesting a physiological response to internal bleeding. All patients with confirmed intra-abdominal

injuries (validated intra-operatively) had elevated plasma ammonia levels, whereas patients with less severe injuries and low ammonia values were managed conservatively, with follow-up imaging and clinical evaluation confirming the absence of hemorrhage.

We encountered one false-positive result—a patient with a pelvic fracture—highlighting that elevated plasma ammonia may also be influenced by other forms of internal trauma or reduced hepatic perfusion.

These findings suggest that in cases of blunt abdominal trauma, elevated plasma ammonia levels may serve as an early biochemical marker indicating the need for further diagnostic work-up or surgical intervention. In settings where advanced imaging is unavailable, this simple, rapid, and cost-effective test could significantly enhance decision-making and improve outcomes.

CONCLUSION

Determining the need for surgical intervention in patients with blunt abdominal trauma remains a critical clinical challenge, particularly in the absence of definitive diagnostic tools for intra-abdominal hemorrhage. The findings of this study suggest that plasma ammonia level, when measured at the time of admission, may serve as a valuable adjunct in identifying patients with occult intra-abdominal bleeding. While promising, these results warrant further validation through larger-scale studies to more comprehensively assess the diagnostic accuracy and clinical utility of plasma ammonia as a predictive biomarker.

Ethical Clearance:

Ethical approval was obtained from the scientific and ethical committee of the Iraqi Board for Medical Specialization, and verbal informed consent was secured from all participants after explaining the study's aims and ensuring data confidentiality.

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Nil.

Conflicts of interest:

There are no conflicts of interest.

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