

## Role of Base Excess as a Predictor for Head Injury Outcome among Patients Admitted to Intensive Care Unit

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### Abstract

**Background:** To determine the association between Base Excess (BE) and Glasgow Outcome Scale (GOS) and whether BE can be a useful predictor for such outcome.

**Aim of Study:** In this study, most head trauma patients had BE disturbance, mainly in the form of negative BE. This finding may be explained by that the cranial cavity is isolated and limited. Therefore, blood loss and its consequences may not be as in systemic trauma, although, severe head injuries with hypoperfusion may induce coagulation disturbances, and subsequently hemodynamic and acid-base disturbances.

**Patients and Methods:** This study followed a retrospective research design. Data were collected from adult head trauma patients' files and the Registrar's Database of Asir Central Hospital, Saudi Arabia. All patients with head injury who were admitted to Asir Central Hospital Intensive Care Unit (ICU) during the period from January 2015 till December, 2017, were included.

**Results:** The data of 171 adult head trauma patients were included in this study, with their age (mean  $\pm$  SD) of  $25 \pm 11$  years. A significant association was observed between BE and GOS. There were associations between abnormal BE and both prolonged stay in ICU and low GCS.

**Conclusions:** There is a significant association between BE and GOS. The association between BE with length of stay in ICU can provide moderate accuracy in predicting patients' length of ICU stay. Therefore, BE can help in head trauma patient's management and assessment.

**Key Words:** Head injury – Base excess – Glasgow Coma Score – Glasgow Outcome Scale.

### Introduction

**BASE** Excess (BE) is considered a great precise index for the non-respiratory part of acid-base balance. BE usually measures the disorder of acid-base ratio in the human blood. An abnormally negative BE (e.g.,  $-3\text{mmol/L}$ ) indicates metabolic acidosis, while an abnormally positive BE (e.g.,  $+3\text{mmol/L}$ ) indicates metabolic alkalosis. The higher the integer number, the more severe is the metabolic disturbance. A negative BE is sometimes referred to as a "base deficit". BE plays a vital role in evaluation of symptoms related to the management of acid-base ratio, and it has a significant role in early diagnosis/assessment and treatment of the patients [1-5].

Several studies considered BE as a leading and valued predictor of presence of abdominal injury in trauma, assessment of fluids requirements, effectiveness of resuscitation, and prediction of mortality in trauma patients [4,6].

For critically ill trauma patients admitted to surgical intensive care unit, for instance, an abnormal BE of  $\geq 8\text{mmol/L}$  predicted a 25% mortality rate in patients in the age group of 55 years or less [7]. Nevertheless, very little has been published in prediction of outcome in head injury patients based on BE [8].

Starting decades ago, it was observed the very least negative correlation between the BE and the Glasgow Coma Score (GCS) levels ( $r=-0.27$ ) [9]. However, a recent study reported the weak negative correlation between BE and GCS ( $r=-0.239$ ) [8].

Therefore, the purpose of this study is to determine the association between BE with GOS, length

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of stay in ICU and GCS; as well as to assess if BE is a valid predictor for GOS.

**Material and Methods**

This is a retrospective, hospital records-based study. Data were collected from patients' files and the registrar's database of Asir Central Hospital after obtaining the ethical approval of King Khalid University and Asir Directorate of Health combined committee.

This study was conducted during June 2018. It included the data of head trauma among adult patients (aged 18 years or more) admitted to Asir Central Hospital ICU during January, 2015 till December, 2017. A total of 171 adult patients were included.

The study variables included patients' demographic data, GCS, GOS, type of injury (isolated head injury or head injury with other systemic injuries), mechanism of injury, arterial blood gases, including BE upon admission.

BE values ranging from  $-2\text{mEq/L}$  to  $+2\text{mEq/L}$  were considered as "normal". BE values above  $+2\text{mEq/L}$  are considered "positive BE", which indicate metabolic alkalosis, while values less than  $-2\text{mEq/L}$  were considered as negative BE or "base deficit" and indicate "metabolic acidosis" [1,2].

The Statistical Package for Social Sciences (SPSS Ver. 20) was used for data entry and analysis. Descriptive statistics were obtained (i.e., mean, Standard Deviation (SD), frequencies, and percentages). Chi-square test of significance was applied. *p*-values less than 0.05 were considered as statistically significant.

**Results**

Table (1) shows characteristics of the patients with head trauma admitted to the ICU. Patients' age (mean  $\pm$  SD) was  $25.0 \pm 11.0$  years. Out of 171 patients, 90.1% were males, and 88.3% were Saudi. Motor vehicle accidents constituted the main cause for injury (93.6%), with 30.4% of patients having isolated head trauma, while 69.6% were exposed to other systemic trauma in addition to their head trauma. Patients' Glasgow Coma Score (GCS) was  $<8$  in 67.8% of patients, while it was  $>8$  in 32.2%. the Glasgow Outcome Scale (GOS) was 1-3 in 4.7% of the patients, while it was 4-5 in 95.3%. More than two thirds of patients (69%) received blood transfusion and 43.9% stayed in ICU for 10 days or more.

Table (1): Characteristics of study patients with head trauma.

Demographic characteristics	No	%
Age (mean $\pm$ SD)	25.0 $\pm$ 11.0 years	
<i>Gender:</i>		
Male	154	90.1
Female	17	9.9
<i>Nationality:</i>		
Saudi	151	88.3
Non-Saudi	20	11.7
<i>Cause of injury:</i>		
Motor vehicle accident	160	93.6
Falls	7	4.1
Others	4	2.3
<i>Sites affected by trauma:</i>		
Isolated head trauma	52	30.4
Multiple sites	119	69.6
<i>Glasgow Coma Score:</i>		
$<8$	116	67.8
$>8$	55	32.2
<i>Glasgow Outcome Scale:</i>		
1-3	8	4.7
4-5	163	95.3
<i>Blood transfusion:</i>		
Yes	118	69.0
No	53	31.0
<i>Length of stay in ICU:</i>		
$<10$ days	96	56.1
$>10$ days	75	43.9

Table (2) shows the mean  $\pm$  SD for pH ( $7.30 \pm 0.3$ ),  $\text{PCO}_2$  ( $39.6 \pm 9.7\text{mmHg}$ ),  $\text{PO}_2$  ( $66.1 \pm 52.5\text{mmHg}$ ), and  $\text{HCO}_3$  ( $20.8 \pm 4.2\text{mEq/L}$ ). About two thirds of patients (66%) showed abnormal Base Excess (BE) upon admission (5.8% had positive BE, while 33.9% had negative BE), as shown in Fig. (1).

Table (2): Values of arterial blood gases (mean  $\pm$  SD).

Variable	Mean	S.D.
pH	7.3	0.3
$\text{PCO}_2$ (mmHg)	39.6	9.7
$\text{PO}_2$ (mmHg)	66.1	52.5
$\text{HCO}_3$ (mEq/L)	20.8	4.2

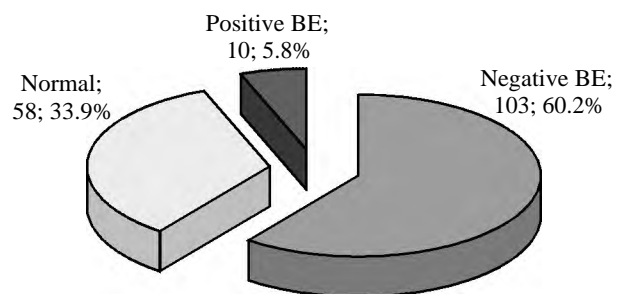


Fig. (1): Base Excess (BE) among head injury patients admitted to ICU.

Table (3) shows that abnormal Base Excess (BE) was more among patients with multiple trauma than those with isolated head trauma (69.7% and 57.7%, respectively). However, difference was not statistically significant. Those who needed blood transfusion had higher prevalence of abnormal BE than those who did not (68.6% and 60.4%, respectively). However, difference was not statistically significant. Patients who had low Glasgow Coma Score (i.e., <8) had higher prevalence of abnormal BE than those who had higher scores (70.7% and 56.4%, respectively). However, difference did not reach statistical significance ( $p=0.065$ ).

Table (3): Base Excess (BE) condition according to patients characteristics.

Characteristics	Normal BE		Abnormal BE		p-value
	No	%	No	%	
<i>Sites affected by trauma:</i>					
Isolated head trauma	22	42.3	30	57.7	0.126
Multiple trauma	36	30.3	83	69.7	
<i>Glasgow Coma Score:</i>					
<8	34	29.3	82	70.7	0.065
>8	24	43.6	31	56.4	
<i>Glasgow Outcome Scale:</i>					
<4	0	0.0	8	100.0	0.038
4-5	58	35.6	105	64.4	
<i>Length of stay in ICU:</i>					
<10 days	38	39.6	58	60.4	0.077
>10 days	20	26.7	55	73.3	
<i>Blood transfusion:</i>					
Yes	37	31.4	81	68.6	0.291
No	21	39.6	32	60.4	

All patients with low Glasgow Outcome Scale (i.e., <4) had abnormal BE, compared with only 64.4% of those whose Scale was 4-5. Difference in BE according to Glasgow Outcome Scale was statistically significant ( $p=0.038$ ). Patients with prolonged stay in ICU (i.e., <10 days) had higher prevalence of abnormal BE than those who stayed in ICU for less than 10 days (73.3% and 60.4%, respectively). However, difference did not reach statistical significance ( $p=0.077$ ).

### Discussion

Generally, BE is considered a strong predictor of outcome in trauma patients. However, in head injuries, whether being isolated or associated with trauma to other systems, the relationship remains unclear [10-13].

Findings of the present study showed that most head trauma victims were Saudi (88.3%), males

(90.1%), whose cause of injury was motor vehicle accidents (93.6%). More than two thirds of head injury patients admitted to ICU had additional trauma to other sites. GCS was low (<8) in two thirds of patients, while the GOS was low (i.e., <4) in 4.7%. Most patients received blood transfusion and almost half of them (43.9%) stayed for 10 days or more in ICU.

These characteristics indicate the population most vulnerable to head trauma in the community. Therefore, health education directed to minimize exposure among those at risk of head injury should be addressed.

In this study, most head trauma patients had BE disturbance, mainly in the form of negative BE. This finding may be explained by that the cranial cavity is isolated and limited. Therefore, blood loss and its consequences may not be as in systemic trauma, although, severe head injuries with hypoperfusion may induce coagulation disturbances, and subsequently hemodynamic and acid-base disturbances [8].

Results of this study showed statistically significant difference in BE according to level of GOS. However, there was no significant difference according to number of sites affected by trauma.

The association of BE with morbidity and mortality in head injury patients has been recently highlighted in few studies. Shallwani et al., [8] in their extensive study on 108 subjects reported that, despite the correlation between the GCS and BE at presentation, BE was not a significant predictor of outcome. This finding contradicted that of Mutschler et al., [14], who reported a strong association between BE and outcome among head injury patients, and demonstrated that higher BE is associated with bad prognosis. However, they included head injury patients with other systemic injuries whereas the study of Shallwani et al., was limited to isolated head injury [14].

Zehtabch et al., [13] studied 131 isolated head trauma patients and suggested to utilize BE as a guide in those patients, for the presence of other systemic injuries. Bazzazi et al., [15] conducted a prospective study on 70 severe head trauma patients, and concluded the non-significance of BE in prediction of outcome, and the lack of correlation between GCS and BE. In contrast, Seigel et al., [16] postulated that BE can reflect the impact of severity of systemic injuries on traumatic head injury patients [16].

Although patients in our study were exclusively adults, two recent studies on children concluded a strong relationship between BE and mortality, although one study considered admission BE while the other considered BE on day 2. Nonetheless, their conclusions were similar [17,18]. Also, among elderly, BE was found as a strong predictor of outcome in normotensive trauma patients [19]. However, our current study couldn't confirm this finding as the study has only four patients aged above 60 years.

Results of the present study reflected a tendency of more abnormal BE among head trauma patients with low GCS. However, the association between GCS and BE remains equivocal, in terms of its clinical significance, although this can be interpreted by that worse BE may add extra impact and would lead to worse GCS at presentation. Therefore, care toward correction of this BE at presentation should be carried to eliminate metabolic effect [9].

One of the interesting things in the current study is that, despite the association between BE and GOS in the whole study patients, abnormal BE was more observed among head injury patients with other trauma, compared with isolated head injury patients. However, differences were not statistically significant.

Findings of the present study showed that abnormal BE was more prevalent among those who had prolonged stay in ICU. However, difference in BE according to ICU length of stay was not statistically significant. The reason for the lack of a significant association may be attributed to the variation among intensivists in discharge criteria from ICU to the general wards, and the availability of intermediate care unit as a transition zone before sending patients to the general wards. However, length of stay in ICU cannot be predicted based on BE. The length of stay in ICU is a major concern for both neurosurgeons and intensivists. It is their concern in terms of morbidities associated with prolonged stay and burden on health care system from the cost point of view; from one perspective, and the decreased bed turnover for new patients [8,14,20].

In the present study, there was no significant association between BE abnormality and the blood transfusion for head injury patients. Several studies have reported the association between BE and the need for blood transfusion in trauma patients in general. However, this has not been thoroughly studied in head injury patients [3,21-23].

#### *Strengths and limitations of the study:*

The relatively large number of patients in this study (n=171) is a point of strength, in comparison to most of the published studies, where most of them had less than 140 patients. In addition, this study included both isolated head injuries and head injuries associated with other systemic injuries. However, some study limitations do exist, e.g., the retrospective nature of the study design, the lack of time lapse data which may influence initial BE when delay occurred, and the potential selection bias as only patients with complete records could be included.

In conclusion, there is a strong association between BE and GCS. BE shows only moderate accuracy in predicting GOS. However, the length of ICU stay cannot be predicted from BE. BE can help in assessment and management trauma patients. However, it can be useful in predicting the outcome of head injury patients.

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## دور "الفائض القاعدي" كعامل متنبئ بنتيجة إصابة الرأس بين مرضى وحدة العناية المركزة

هدف البحث: تحديد التعايش بين الفائض القاعدي (BE) ومقياس نتائج غلاسكو (GOS)، وما إذا كان BE يمكن أن يكون مؤشراً مفيداً لمثل هذه النتيجة.

منهجية البحث: إتبعنا هذه الدراسة نمط البحوث بأثر رجعي. ولقد تم جمع البيانات من ملفات المرضى البالغين المصابين بإصابات الرأس، وقاعدة البيانات بمستشفى عسير المركزي بالمملكة العربية السعودية. تم تضمين بيانات جميع المرضى البالغين الذين يعانون من إصابة بالرأس، الذين تم إدخالهم إلى وحدة العناية المركزة في مستشفى عسير المركزي خلال الفترة من يناير ٢٠١٥ حتى ديسمبر ٢٠١٧.

النتائج: كان متوسط أعمار المرضى ١٦±٢٥ سنة. وقد لوحظ وجود ارتباط بين BE وGOS. كانت هناك ارتباطات بين BE غير الطبيعي وكل من البقاء لفترة طويلة في وحدة العناية المركزة وGCS المنخفضة.

الإستنتاجات: هناك ارتباط ذو دلالة معنوية بين BE وGOS. ويمكن أن توفر العلاقة بين BE وطول مدة الإقامة في وحدة العناية المركزة دقة معتدلة في التنبؤ بمدى بقاء المرضى في وحدة العناية المركزة. مما يمكن أن يساعد في تقييم وعلاج حالات إصابات الرأس.