Validity of base excess as a prognostic factor of mortality in trauma patients

Validez del exceso de bases como factor pronóstico de mortalidad en pacientes traumatizados

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Abstract

Background: Base excess is used to determine the magnitude of metabolic abnormality secondary to hemorrhage or direct organ damage of patients with polytrauma

Objective: To determine what are the values of change that BE can have over time and that allow predicting early mortality in patients with polytrauma.

Methods: Retrospective cohort study in subjects older than 18 years, who were admitted to the intensive care unit for any type of trauma. The response to the change of the base excess at 6, 12 and 24 hours after the trauma was evaluated.

Results: 261 subjects were included, 22.6% (59/261) died. Polytrauma occurred in 73.2% (191/261) and traf- fic accident was the most common mechanism of trauma in the study population with 75.9%. The change in BE between admission and the first 6 hours was 1.7 mEq/L (SD: 4.02) in the living population and 1.9 mEq/L (SD: 8.1) in the deceased (p<0.001). The change in mEq/L between admission and first 6 hours showed a low receiver operating characteristics curve area of 0.661 (95% CI: 0.523-0.8; p=0.025).

Conclusión: The change in base excess between the first 6 to 12 hours after patient admission can be used to estimate mortality in patients diagnosed with trauma.

Keywords: Trauma; Base excess; Intensive Care Unit.

Resumen

Antecedentes: El exceso de bases se utiliza para determinar la magnitud de la anomalía metabólica secundaria a hemorragia o daño orgánico directo de pacientes con politraumatismos.

Objetivo: Determinar cuáles son los valores de cambio que puede tener la EB en el tiempo y que permitan predecir la mortalidad temprana en pacientes con politraumatismos.

Métodos: Estudio de cohorte retrospectivo en sujetos mayores de 18 años, que ingresaron a la unidad de cuidados intensivos por algún tipo de traumatismo. Se evaluó la respuesta al cambio del exceso de base a las 6, 12 y 24 horas del traumatismo.

Resultados: se incluyeron 261 sujetos, el 22,6% (59/261) fallecieron. El politraumatismo ocurrió en el 73,2% (191/261) y el accidente de tránsito fue el mecanismo de traumatismo más frecuente en la población de estudio con el 75,9%. El cambio de BE entre el ingreso y las primeras 6 horas fue de 1,7 mEq/L (DE: 4,02) en la población viva y de 1,9 mEq/L (DE: 8,1) en los fallecidos (p<0,001). El cambio en mEq/L entre el ingreso y las primeras 6 horas mostró un área de curva de características operativas del receptor baja de 0,661 (IC 95%: 0,523-0,8; p=0,025).

Conclusión: El cambio en el exceso de base entre las primeras 6 a 12 horas después del ingreso del paciente puede utilizarse para estimar la mortalidad en pacientes diagnosticados con trauma.

Palabras llave: Trauma; exceso de base; Unidad de Cuidados Intensivos.

Introduction

Trauma is the sixth leading cause of mortality and fifth cause of disability, mainly in the population between 15 and 45 years of age worldwide[1,2]. In North America, it is estimated that there is a percentage of all-cause trauma mortality in the intensive care unit (ICU) greater than 10%[3]. This mortality is associated with the severity of polytrauma and multiorgan involvement secondary to trauma, with subjects requiring ventilatory support and vasopressor being the highest risk[4]. The initial assessment of the severity of polytrauma using tools such as the Injury Severity Score (ISS), the Sequential Organ Failure Assessment (SOFA) and biomarkers allows establishing a therapeutic approach and determining mortality in these patients[4,5,6]. The ISS identifies the severity of the traumatic event and assigns therapeutic priorities in the emergency department, among the biochemical markers studied are interleukins, metalloproteases, growth factors and tissue perfusion markers that also provide information on the impact of the injury on the patient[5-7].

In trauma, several biochemical markers of tissue perfusion are recognized that may reflect the clinical and prognostic status of the patient, including base excess (BE)[7,8]. The BE is the amount of acid necessary to stabilize blood pH and achieve an acid-base balance, whose values are normally between -2 and +2 mEq/L, and periodic evaluation of its values can inform the patient's evolution[9-11]. Scores such as the SOFA offer information on the severity of organ dysfunction and the clinical evolution of the patient over time. Because BE is used to determine the magnitude of metabolic abnormality secondary to hemorrhage or direct organ damage, it could be a complementary tool to SOFA and ISS in the evaluation of the evolution of patients with polytrauma[12,13].

Ho et al. observed that changes in BE levels were related to an increase in complications and mortality in trauma patients, being able to recognize early those patients at high risk of clinical deterioration[10]. However, despite these findings, information on the values of BE change to determine the risk of complications in polytrauma patients is limited[6,7,9,10]. The objective of this study is to determine what are the values of change that BE can have over time and that allow predicting early mortality in ICU of patients with polytrauma.

Methods

A retrospective cohort study was conducted in a third-level clinic in Chía, Colombia, between 2010 and 2017. These data were obtained by reviewing clinical records of care during the hospitalization period.

Eligibility criteria

Subjects over 18 years of age were included, who were admitted to the ICU for any type of trauma, performing three arterial blood gas (ABG) shots between admission and 24 hours later, at established times. Subjects who presented modifications of the diagnosis of admission during their hospital stay, those who were admitted to the Institution 72 hours after the event and subjects with deficiencies in the information of scales and / or severity indices used within the study were excluded.

Variables

Age, sex, type of trauma, mechanism of trauma, fall from height, SOFA, ISS and Acute Physiology and Chronic Health Evaluation II (APACHE II) sedation were identified as study variables. The first ABG was obtained between admission and the first 6 hours, the second between 6 and 12 hours and the third from 12 to 24 hours. To reduce the risk of bias, the personnel in charge of obtaining information from medical records received prior training and additionally double verification was carried out in data collection.

Sample size

All study subjects who met the selection criteria were entered, data were collected by trained personnel reviewing clinical records, data review was performed by two investigators to avoid possible errors in transcription.

Statistical analysis

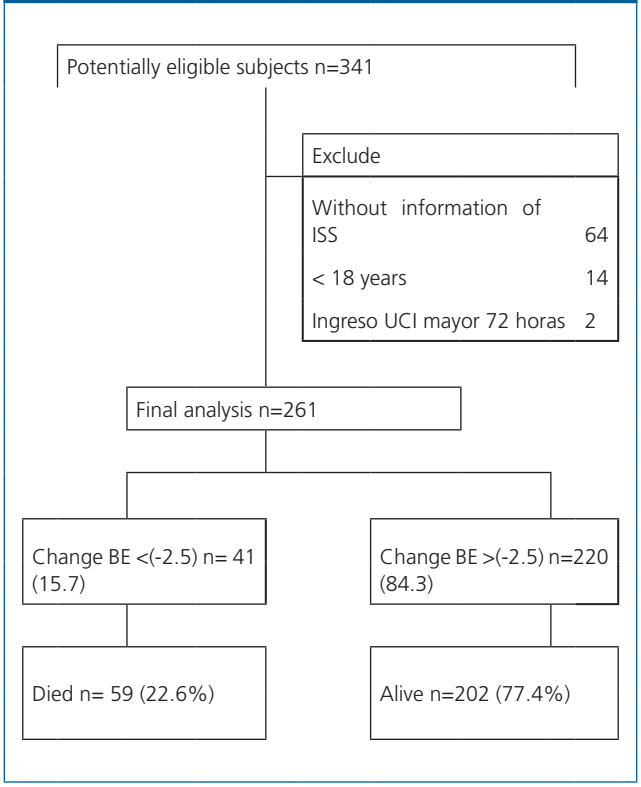
Data processing was performed with the statistical program SPSS version 25, an initial descriptive analysis summarizing the quantitative variables with normal distribution on mean and standard deviation (SD), variables with non-normal distribution in medians and interquartile range, qualitative variables were summarized in frequencies and percentages. A bivariate analysis was performed comparing the quantitative variables according to their distribution with the student's t-test and U Mann Whitney, and the qualitative variables were compared with the chi square test. The BE difference values of admission, at 6, 12 and 24 hours, were calculated to the area under the curve of receiver operating characteristics (AUROC), comparing living and deceased subjects. A $p<0.05$ was considered statistically significant.

Ethical considerations

The protocol was presented to the ethics committee of the institution, and the explanation of informed consent was made in each subject before their entry into the study.

Of 341 potentially eligible patients, a total of 261 were included in the final analysis Figure 1.

Figure 1. Flow chart of the study cohort



Notes: ISS, Injury severity score; UCI, unit critical care; BE, base excess.

The mean age was 5.7 years higher in deceased patients (p=0.039). In the total population, polytrauma occurred in 73.2% (191/261), in living patients in 77.2% (156/202) and in deceased patients in 59.3% (35/59) (p=0.033). In patients who survived the trauma, the proportion of presentation in the chest region was 2% (2/202), abdomen 2% (2/202), pelvis 2% (2/202), bone 2% (2/202) and vascular 2% (2/202). Traffic accidents were the most common mechanism of trauma in the study population with 75.9% (198/261), followed by falls from height with 10% (26/261) (p=0.322). The demographic characteristics of the total population are shown in table 1.

The patients who died had a pH at admission of their hospitalization of 7.27 (SD: 0.15) compared to 7.32 (SD: 0.09) of the group of survivors (p=0.005) table 2. There were no statistical differences in the rest of the AG variables. The hematocrit was higher in the group of living patients 39.4 (SD: 7.48) compared to the group of patients who died 37.0 (SD: 9.08) due to trauma (p=0.218).

Table 1. Demographic characteristics

Variables	Total population n=261	Alive n=202	Dead n=59	p-value
Age x (SD)	38.6 (15.01)	37.3 (13.03)	43.0 (19.89)	0.039
Male sex n(%)	203 (77.8)	167 (82.7)	36 (61.0)	<0.001
Type of trauma n(%)				
Polytrauma	191 (73.2)	156 (77.2)	35 (59.3)	0.033
TBI	59 (22.6)	35 (17.3)	24 (40.7)	
Mecanism				
Traffic accident	198 (75.9)	152 (75.2)	46 (78.0)	0.322
Fall from height	26 (10.0)	20 (9.9)	6 (10.2)	
Firearms	18 (6.9)	15 (7.4)	3 (5.0)	
Sedation n(%)	77 (29.5)	55 (27.2)	22 (37.3)	0.136
APACHE x(SD)	15,4 (7.21)	14 (6.63)	20,1 (7.21)	<0.001
ISS x(SD)	28,0 (20.31)	24.8 (17.67)	38,9 (24.72)	0.042

Notes: x, mean; SD; standard deviation; n, number; TBI, traumatic brain injury; APACHE II, Acute Physiology and Chronic Health Evaluation II; ISS, Injury severity score.

Table 2. Laboratory tests on admission

	Total population n=261	Alive n=202	Dead n=59	p-value
pH x(SD)	7.33 (0.11)	7.32 (0.09)	7.27 (0.15)	0.005
PaO2 x(SD)	119 (71.13)	115.2 (67.77)	132.3 (80.83)	0.214
HCO3 x(SD)	17.5 (3.6)	17.8 (3.44)	16.4 (3.92)	0.372
FiO2 x(SD)	0.61 (0.32)	0.61 (0.31)	0.64 (0.34)	0.536
PaO2/FiO2 x(SD)	283.9 (200.71)	276.9 (180.31)	307.7 (259.18)	0.070
Sodium x(SD)	141 (5.11)	140.7 (4.66)	142.0 (6.35)	0.058
Potassium x(SD)	3.86 (0.76)	3.89 (0.7)	3.74 (0.95)	0.061
Creatinine x(SD)	0.95 (0.37)	0.95 (0.36)	0.99 (0.42)	0.272
Urine output x(SD)	2.1 (1.87)	1.9 (1.73)	2.5 (2.25)	0.102
Hematocrit x(SD)	38.9 (7.91)	39.4 (7.48)	37.0 (9.08)	0.218

Notes: x, mean; SD, standard deviation; PaO2, arterial oxygen pressure; FiO2, inspired fraction of oxygen; HCO3, bicarbonate; PaO2/FiO2, arterial oxygen pressure relative to inspired fraction of oxygen.

Change of base excess

The change in BE between admission and the first 6 hours was 1.7 mEq/L (SD: 4.02) in the living population and 1.9 mEq/L (SD: 8.1) in deceased patients (p<0.001) table 3. The change in BE between 6 and 12 hours was 3.5 mEq/L (SD: 6.57) in the deceased population.

Response to the change of the base excess

A change in BE between 6 and 12 hours presented a sensitivity of 94.9%, and for a change in BE between 12 and 24 hours a specificity of 84.7% was presented table 4. The change in BE between admission and first 6 hours showed an AUROC of 0.661 (95% CI 0.523-0.8; p=0.025).

Table 3. Change of base excess

	Total population n=261	Alive n=202	Dead n=59	p-value
Average change in BE between admission and first 6 hours x(SD)	1.8 (5.21)	1.7 (4.02)	1.9 (8.1)	<0.001
Average change of BE between 6 and 12 hours x(SD)	2.5 (5.87)	2.2 (5.63)	3.5 (6.57)	0.279
Average change in BE between 12 and 24 hours x(SD)	0.8 (5.88)	0.5 (5.56)	1.5 (6.86)	0.186

Notes: x, mean; SD, standard deviation; BE, base excess.

Table 4. Validity of the change of base excess and SOFA for mortality

	Se	Sp	PPV	NPV	LR+	LR-	AUROC (IC95%)	p-value
Average change in BE between admission and first 6 hours	71.2%	13.4%	0.194	0.614	0.822	2.156	0.661 (0.523-0.844)	0.025
Average change of BE between 6 and 12 hours	94.9%	3.0%	0.222	0.667	0.978	1.712	0.517 (0.339-0.695)	0.839
Average change in BE between 12 and 24 hours	32.2%	84.7%	0.380	0.810	2.098	0.801	0.621 (0.509-0.743)	0.034
SOFA	71.2%	54.5%	0.313	0.866	1.563	0.529	0.693 (0.609-0.776)	<0.001

Notes: BE, base excess; SOFA, Sequential Organ Failure Assessment Score; Se, sensitivity; Sp, specificity; PPV, positive predictive value; NPV, negative predictive value; LR+, positive likelihood ratio; LR- negative likelihood ratio; AUROC, area under the curve of receiver operating characteristics.

Discussion

The performance of the BE changes in the first 6, 12 and 24 hours after the trauma was evaluated as a marker of mortality, finding an acceptable performance between the first 6 to 12 hours from the patient's admission to the ICU. At the same time, the SOFA and ISS were evaluated and showed a good capacity to predict mortality in the study population.

In trauma, are three types of mortality that are established in relation to the time elapsed between the causal event and death: immediate, which begins from the moment of the trauma until before the first hour after the event, early, which occurs between the first hour and 24 hours after the event, and delayed, after 48 hours[7,14]. The evaluation of the BE change values routinely performed in the ICU in polytraumatized patients during the first 12 hours can provide information on the patient's situation and prognosis, establishing the necessary therapeutic measures that can impact the outcomes in the late phase of the polytraumatized patient[7,15].

Peñasco et al.[8] determined the association between BE levels and mortality in 249 patients older than 65 years with a diagnosis of thoracic trauma hospitalized in the ICU, reporting an association with mortality in patients presenting a BE value at admission lower than -6 mmol/L with an OR of 3.12 (95% CI: 1.51-6.42). We found that a decrease in BE was related to mortality outcome, suggesting an imbalance between hydrogen ion production and elimination of ion in subjects with persistent impairment of hypercatabolic processes and multiorgan failure secondary to trauma[9,10].

The acid-base balance may be influenced by different variables to EB, among them, in polytrauma with extensive organic compromise, with a state of hypoventilation may occur secondary to the pH decrease and hypoxemia, which causes a deterioration of the respiratory system and the breathing muscles function that increases the carbon dioxide pressure[16,17]. In addition, abnormal levels of albumin, electrolytes (Na+, K+, Ca2+ and Cl-), patients with advanced age and chronic diseases with high levels of urea nitrogen, urea and creatinine, can generate biases at the time of the actual measurement of BE in relation to pH[9,10]. However, in our study, the predominant population is young adults with polytrauma and no underlying chronic

diseases, which decreases the possibility of biased values in BE levels by other physiological variables.

Qi et al.[11] compared the predictive values of EB, lactate and pH change for 72-hour mortality in polytrauma patients, showing that patients who died were older (p<0.001), had higher lactate (p<0.001), worse BE (p<0.001) and lower pH (p<0.001). Furthermore, the predictive value of mortality for BE change had an AUCOR of 0.693 (95% CI: 0.675-0.712) with a decrease of 4.6 mEq/L, similar to that described in our study with an AUCOR of 0.661 at 12 hours and a decrease of 2.4 mEq/L.

As for other scores for the evaluation of multiorgan failure and mortality in trauma patients, the SOFA shows a good ability to predict mortality[18,19]. Zygun et al.[20] in a prospective cohort study, the SOFA scale was evaluated against Multiple Organ Dysfunction in patients with severe traumatic brain injury treated in the ICU. The SOFA showed an AUCOR of 0.75 for mortality due to cardiovascular failure and 0.73 for mortality due to neurological deterioration. On the other hand, the ISS is based on the Abbreviated Injury Scale, whose function is to estimate the severity and stratification of injuries to the human body and the mortality associated with polytrauma[4-6]. However, due to limitations in the stratification of patients with multiple lesions located in the same region of the body, they use the New Injury Severity Score[5,6], presenting a better index score for predicting mortality in patients with penetrating trauma (AUCOR: 0.86; p<0.001) [6]. More studies are needed to evaluate whether the combined measurement of SOFA, ISS and BE in the first 12 to 24 hours is a useful tool to adequately estimate prognosis and decision making in the critically ill because of the trauma patient..

Limitations

Among the weaknesses of our study is that the information was obtained retrospectively from clinical records, increasing the risk of information bias; however, the researchers of the team were trained to collect the data adequately. Single center study in a young population without a high burden of chronic diseases, that limits the extrapolation of these results to the population of older adults with comorbidities. However, it is considered that the number of subjects analyzed supports the findings obtained. Future studies are needed to evaluate the consistency of these findings in other populations.

Conclusions

The change in BE in the first 12 hours presents a good ability to estimate mortality in patients with a diagnosis of trauma under treatment in the ICU. Future studies are needed to evaluate the consistency of these findings in other populations.

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