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ORIGINAL ARTICLE

Profile of acid-base disturbances in an intensive care unit of Fortaleza, Ceará, Brazil.

Perfil dos distúrbios ácido-básicos em uma unidade de terapia intensiva de Fortaleza, Ceará, Brasil.

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Abstract

Introduction: Acid – base disturbances are entities caused by the deregulation of the concentration of bicarbonate ions, the concentration of hydrogen ions and the partial pressure of carbon dioxide in the blood. These disturbances modify most cell fuctions when present, damaging the proper functioning of organs. **Methods:** Transversal study based upon data collected from medical records of patients in ICU as seen from August 1 to December 31, 2013 at the Dr. José Frota Institute in Fortaleza, Ceará. The variables studied were: age, sex, cause of ICU admission, pH, HCO3-, pO2, pCO2, glomerular filtration rate (GFR), serum concentratrion of potassium and magnesium and serum levels of creatinine and hemoglobin. The chi-square and Fisher exact test were used to compare the proportions according to the number of cases. For quantitative variables, the analysis of variance (ANOVA) was used and the Kruskal-Wallis test if the Bartlett test presented $p<0.05$. **Results**: The most frequent disorders were primary respiratory alkalosis with 33 (38.4%) cases, 30 (34.9%) of metabolic alkalosis, 13 (15.1%) of metabolic acidosis, 7 (8.2%) did not present acid-base disorders and respiratory acidosis 3 (3.5%). Patients admitted with TBI had respiratory alkalosis as the most common primary disorder, followed by metabolic alkalosis, 16 (47.0%) and 13 (38.2%), respectively. The main disturbances mixed respiratory alkalosis with metabolic alkalosis and respiratory alkalosis with metabolic alkalosis found in 15.12% of patients in each of these combinations. Comparative evaluation of the means of the variables between groups of primary disorders were older ($p=0.047$), anion gap ($p=0.037$) and bicarbonate ($p=0.013$), with a statistically significant relationship. **Conclusion**: Patients who have suffered traumatic brain injury presented as primary disorder more common the respiratory alkalosis and the metabolic alkalosis. Ionic disturbances related to potassium and magnesium showed no statistically significant relationship when related to the acid-basic disturbances

Key-words: Acidosis; Alkalosis; Blood Gas Analysis; Intensive Care Units.

Resumo

Introdução: Os distúrbios ácido-básicos são causados pela desregulação da concentração de íons bicarbonato, de hidrogênio e da pressão parcial de dióxido de carbono no sangue. Esses distúrbios modificam a maior parte das funções celulares quando presentes, comprometendo o adequado funcionamento dos órgãos. Métodos: Estudo transversal, baseado em dados coletados de prontuários de pacientes em UTI no período de 1 de agosto – 31 de dezembro de 2013, no Instituto Dr. José Frota, em Fortaleza, Ceará. As variáveis estudadas foram: idade, sexo, causa da internação na UTI, pH, HCO3-, pO2, pCO2, taxa de filtração glomerular (TFG), concentração sérica de potássio, concentração sérica de magnésio, níveis séricos de hemoglobina e creatinina. Utilizou-se o teste qui-quadrado e o teste exato de Fisher para comparar as proporções de acordo com o número de casos. Para as variáveis quantitativas, utilizou-se análise de variância (ANOVA) e o teste de Kruskal-Wallis, se o teste de Bartlett apresentasse $p<0,05$. Resultados: Os transtornos primários mais frequentes foram a alcalose respiratória com 33 (38,4%) casos, 30 (34,9%) de alcalose metabólica, 13 (15,1%) da acidose metabólica, 7 (8,2%) não tinham distúrbios ácido-base e acidose respiratória 3 (3,5%). Os admitidos com TCE tiveram a alcalose respiratória como distúrbio primário mais frequente, seguido pela alcalose metabólica, 16 (47,0%) e 13 (38,2%), respectivamente. Os principais distúrbios mistos foram a alcalose respiratória com alcalose metabólica e alcalose respiratória com alcalose metabólica encontrados em 15,12% dos pacientes em cada uma dessas combinações. Avaliação comparativa das médias das variáveis entre os grupos de distúrbios primários apresentaram idade ($p=0,047$), anion gap ($p=0,037$) e bicarbonato ($p=0,013$), com uma relação estatisticamente significativa. Conclusão: Os pacientes que sofreram traumatismo cranioencefálico apresentaram como distúrbio primário mais frequente a alcalose respiratória e a alcalose metabólica. Os distúrbios iônicos relacionados ao potássio e ao magnésio não apresentaram relação estatisticamente significante quando relacionados com os distúrbios ácido-básicos

Palavras – chave: Acidose; Alcalose; Gasometria; Unidade de Terapia Intensiva.

INTRODUCTION

The regulation of hydrogen ion concentration in the blood (H+) is crucial, since it influences the chemical reactions of almost all body systems. Thus, the change in the concentration of this ion in the blood largely modifies the functions of the

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different cell types, making it essential to the maintenance of the hydrogen equilibrium for normal cell function[1]. To that body homeostasis is maintained, a balance between production and removal of hydrogen ions is needed. This balance is maintained by mechanisms that regulate its concentration, such as the chemical buffer system of the body fluids, regulating the removal of carbon dioxide (CO2) from the blood into the lungs and maintaining the concentration of hydrogen ions (H+) in the extracellular fluid by the kidneys[2,3,4]. However, in some situations, the natural homeostatic mechanisms are unable to maintain a proper balance, generating acid-base disorders[5].

These imbalances can be characterized according to changes in the relative amount of bicarbonate ions (HCO3-) and H+ or changes in the partial pressure of carbon dioxide (pCO2) in the blood. When the disturbances are directly related to the concentration of ions, they are considered metabolic, and may be a metabolic acidosis or a metabolic alkalosis. When they relate to changes in pCO2, respiratory acidosis or alkalosis occurs. Also very important are mixed disorders, which arise from faulty compensatory mechanism that would correct some primary pathological changes in the concentration of acids and bases in the blood[6,7,8].

Basic disorders may be present in several conditions, such as pulmonary embolism, which results in a respiratory alkalosis, the use of diuretics, which can cause a metabolic alkalosis. In sepsis, which is typically present with metabolic acidosis; and asthma, closely associated with respiratory acidosis. It is concluded that these disorders may have a primary pathological origin, develop as an iatrogenic act or be present in several other clinical conditions[9]. Thus, the recognition of homeostatic controlling devices are essential for the acid-base balance for health professionals, since the disturbances in these mechanisms are associated with an increased risk of dysfunction of organs and systems, causing death in patients mainly hospitalized in intensive care. Therefore, an efficient interpretation of these disorders is necessary depending, on the correct analysis of the patient's blood gases[10].

The arterial blood gas analysis is a routine procedure performed on patients admitted to the Intensive Care Unit (ICU), and it is indicated for the evaluation of the acid-base balance disorders, pulmonary arterial blood oxygenation and alveolar ventilation[11]. Arterial Blood Gases present data such as blood partial pressure of oxygen (pO2), partial pressure of carbon dioxide (pCO2), hydrogenation potential (pH), lactate, HCO3-concentration of sodium ions (Na +) and chloride (Cl-), Based on this assertation, the kind of acid-base disorder that affects the patient can be diagnosed[12]. Therefore, it is common to use only the data for critical care blood gas analysis in order to reach a medical diagnosis. However, it is recommended that the use of compensation formulas and dosage of electrolytes and other substances for a diagnosis be used for greater accuracy because the proper treatment will be directly dependent on the correct diagnosis[13]. A very traditional method is the Adrogue and Madias, in which arterial blood gas analysis provides information about the existence and type of acid-base disturbance, although it does not establish causal mechanisms[14].

This study aims at evaluating the profile of acid-base disorders and checking the differences between the groups of disorders as the variables.

Materials and Methods

A transversal study was conducted. The study included patients over 18 years of age who were admitted to the Intensive Care Unit of Dr. José Frota Institute (IJF), located in Fortaleza, Ceará, Brazil in the period from August 1 to December 31, 2013.

Data were obtained through consultation to the patient's medical records taken at the time of admission to their ICU stay. The study variables were age, sex, cause of ICU admission, pH, HCO3, pO2, pCO2, glomerular filtration rate (GFR), serum potassium and magnesium concentrations, hemoglobin and creatinine. Blood gas analysis was performed by the traditional approach of Henderson-Hasselbalch equation, which is defined in three steps: (1) Check the primary disorder; (2) Check the secondary disorder; (3) Calculate the gaps: anion-gap and delta-anion-gap.

For the analysis of the data it was obtained an absolute and percentage distribution unvaried and information two bivaried statistics and measures: mean and standard deviation. The chi-square and the Fisher exact test were employed in the comparison of proportions, depending on the number of cases. For quantitative variables, using the analysis of variance (ANOVA) and the Kruskal-Wallis test case Bartlett presented $p<0,05$.

The descriptive statistical analysis of the data was performed by the software SPSS (Statistical Package for Social Sciences) for Windows, version 16.0. P-value<0,05 was considered significant for all tests. The study protocol was approved by the Ethics Committee of the Institute of development and education (IPADE) under the number: 354.550.

Results

Eighty-six patients were included in the study, 74 (86%) were male and 12 (14%) were female. The mean age was 36.42 (17-77) years old. The reason for hospitalization in the ICU was the most frequent brain trauma injury with 7 cases (43.0%), followed by polytramas with 21 cases (24.42%). Major complications during admission were: 80 (93.0%) on mechanical ventilation, 10 (10.5%) with acute renal failure, 8 (9.3%) with respiratory infection, 5 (5.8%) patients developed septic shock (Figure 1).

Evaluating primary disorders were 33 (38,4%) cases of respiratory alkalosis, 30 (34.9%) of metabolic alkalosis, 13 (15.1%) of metabolic acidosis, 7 (8.2%) had no disorders of acid-base and 3 (3,5%) respiratory acidosis. Regarding the secondary disorders were 22 cases (25.6%) of respiratory alkalosis, 19 (22.1%), metabolic acidosis, 12 (14.0%) of respiratory alkalosis, 8 (9.3%) Respiratory acidosis and 25 patients (29.1%) had no secondary acid-base disturbance. Analyzing the tertiary disorders, 8 (9.3%) patients had metabolic acidosis 3 (3.5%)

had metabolic alkalosis, 1 (1.2%) had respiratory acidosis and 74 (86.0%) had no tertiary disorders. Eighteen (20.9%) patients had a single disorder, 48 (55.8%) had double and 14 disorder (16.3%) had triple disorder. The mixed acid-base disorders that were the most frequent in this study were the metabolic alkalosis with respiratory alkalosis and respiratory alkalosis with metabolic alkalosis, 15.1 % respectfully (Table 1).

The traumatic brain injury (TBI) presented the respiratory alkalosis as the most frequent primary disorder, followed by metabolic alkalosis, 16 (47.0%) and 13 (38.2%), respectively (Figure 2). The patients presented 9 (42.86%) cases of respiratory alkalosis and 6 (28.57%) of metabolic alkalosis, however the cause of admission in intensive care was not significant different when compared to the types of primary disturbance (p=0.07) (Table 2).

Figure 1. Causes of ICU admission

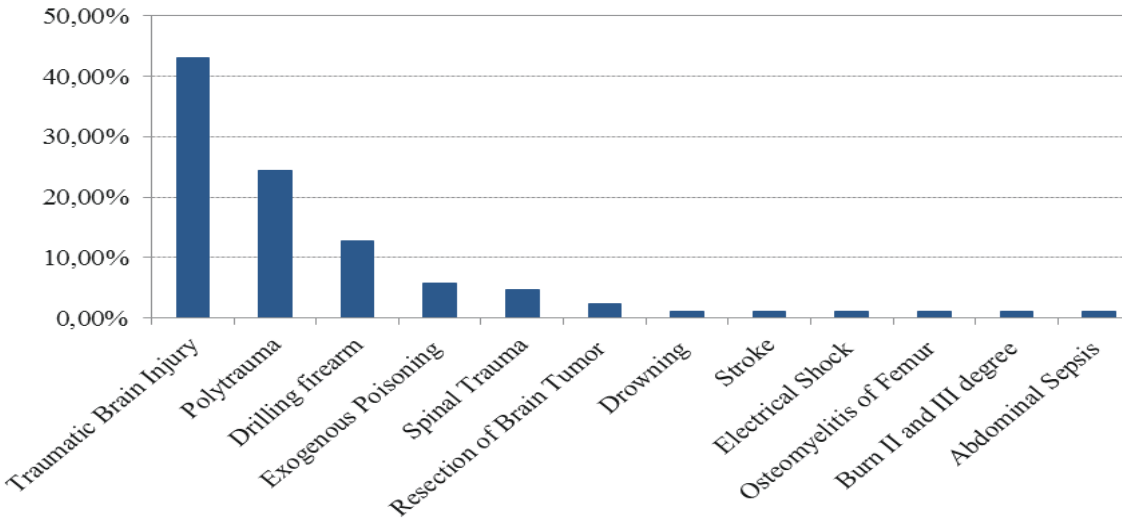


Table 1. Percentage of types of acid-base disturbances of patients admitted to ICU.

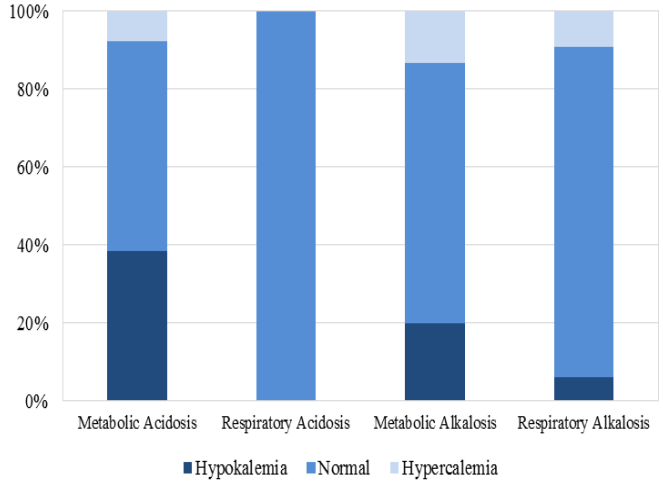
Disorder or combination of acid-base disorders	Nº of Patients	%
Metabolic acidosis	5	5,81
Metabolic acidosis and respiratory alkalosis *	7	8,14
Metabolic acidosis, respiratory alkalosis and metabolic alkalosis*	1	1,16
Respiratory acidosis and metabolic acidosis *	1	1,16
Respiratory acidosis and alkalosis metabolic *	1	1,16
Respiratory acidosis, metabolic alkalosis and metabolic acidosis *	1	1,16
Metabolic alkalosis	5	5,81
Metabolic alkalosis and metabolic acidosis *	2	2,33
Metabolic alkalosis, respiratory acidosis and metabolic acidosis *	1	1,16
Metabolic alkalosis and acidosis Respiratory *	5	5,81
Metabolic alkalosis, respiratory acidosis and metabolic acidosis *	2	2,33
Metabolic alkalosis and respiratory alkalosis *	13	15,12
Metabolic alkalosis, respiratory alkalosis and metabolic acidosis *	2	2,33
Respiratory alkalosis	8	9,30
Respiratory alkalosis and metabolic acidosis *	13	15,12
Respiratory alkalosis, metabolic acidosis and metabolic alkalosis*	2	2,33
Respiratory alkalosis and metabolic alkalosis *	7	8,14
Respiratory alkalosis, metabolic alkalosis and metabolic acidosis*	3	3,49
No acid-base disturbances	7	8,14

*Mixed disorders

Patients with metabolic acidosis as a primary disorder, 5 (38.46%) (p = 0.27) had hypokalemia (Figure 3). Hypomagnesaemia was not associated with metabolic alkalosis or respiratory alkalosis, with 11 (36.67%) with p = 0.12 and 10 (30.30%) with p = 0.16, respectively. Analyzing serum creatinine of 30 patients who had primary disorder as metabolic alkalosis, 24 had a serum creatinine less than 1.2 mg / dL (p = 0,14).

Analyzing the mean serum creatinine in each group of types of primary disorders no significant difference was found between groups (p = 0.10). No differences in glomerular filtration rate between primary disorders (p = 0.63) were observed (Table 2).

Figure 2. Evaluation of the percentage of patients: Relationship between serum potassium levels and primary acid-base disturbances.



DISCUSSION

Acid-base disorders are comnom clinical problems in ICU patients13. In this study, 91.8% of patients had some kind of these disturbances.

In this present study, patients with TBI showed more cases of respiratory and metabolic alkalosis as primary disorder and ionic disturbances related to potassium and magnesium showed no significant relationship with the acid-basic disturbances. The knowledge that acid-basic disturbances can be caused by diseases or conditions, such as diarrhea and vomiting, is of fundamental importance for the intensive care physician, since these disorders are associated with higher rates of mortality.

Almost half of the patients in this study had suffered TBI, the primary acid-base disturbance associated with TBI is respiratory alkalosis, since this injury in the central nervous system can be extended to the respiratory center located in the brain stem, modifying the responsiveness of the changes of CO2 concentrations[16,17]. In this study 38,4% of primary disorders were respiratory alkalosis. In a study that analyzed the main causes of ICU admission in a city in the state of Paraíba, in the Northeast of Brazil, diseases of the cardiovascular system, such as stroke and congestive heart failure, and diseases of the respiratory tract, such as acute respiratory tract infection and respiratory insufficiency, were the most diagnosed[18].

Figure 3. Evaluation of the percentage of patients: Relationship between serum magnesium levels and primary acid-base disturbances.

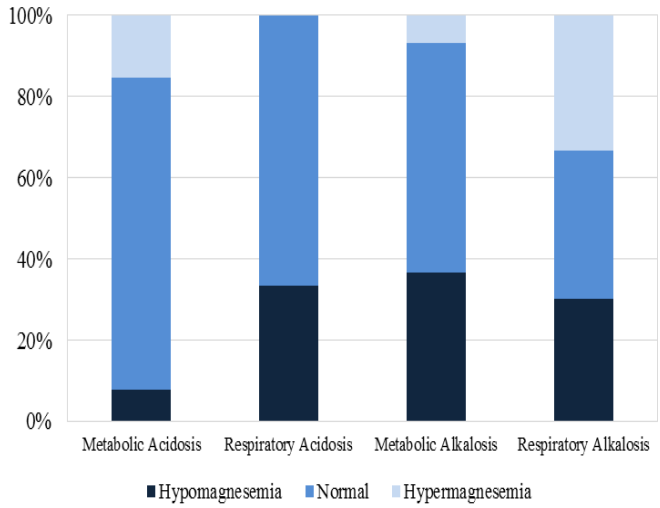


Table 2. Comparative analysis between the means of the demographic and laboratory variables with the types of primary acid-base disturbance.

Demographic and Laboratory Variables	Age	Hemoglobin	HCO3-	pCO2	Anion Gap	PO2	Urea	Creatinine	Estimated GFR
Metabolic Acidosis	37.92 ± 17.55	10.38 ± 1.94	27.22 ± 2.79	37.64 ± 5.03	5.42 ± 3.82	134.36 ± 60.07	48.00 ± 34.67	1.44 ± 1.68	99.04 ± 49.43
Respiratory Acidosis	51.33 ± 16.20	9.80 ± 1.15	27.47 ± 1.59	32.20 ± 3.15	0.27 ± 3.32	165.60 ± 73.63	25.67 ± 8.62	0.90 ± 0.53	119.05 ± 62.40
Metabolic Alkalosis	31.57 ± 13.16	9.96 ± 1.98	24.61 ± 4.86	37.34 ± 9.15	7.46 ± 13.52	129 ± 55.78	34.83 ± 27.14	1.43 ± 1.86	152.73 ± 50.33
Respiratory Alkalosis	36.91 ± 12.89	9.54 ± 1.38	25.75 ± 6.42	33.91 ± 7.78	5.67 ± 7.57	161.85 ± 45.55	37.19 ± 24.91	0.82 ± 0.68	146.25 ± 68.67
It Has No Acid-Base Disturbance	45.71 ±16.07	8.07 ± 0.9	20.59 ± 3.13	30.83 ± 8.86	13.13 ± 7.38	178.29 ± 56.6	84.00 ± 70.12	2.11 ± 1.90	78.34 ± 63.35
Value p	0.047	0.052	0.013	0.162	0.037	0.068	0.062	0.100	0.630

Ionic disorders are quite common in acid-base disturbances, mainly in acidosis and metabolic alkalosis. The main ionic disturbances are related to calcium, magnesium and potassium 19,20. The evaluation as to whether the existence of any relationship between hypokalemia and metabolic acidosis was carried out, since this ionic disorder was present 38.46% of patients who had metabolic acidosis, but there was no significant statistical correlation. Hypomagnesemia and hypermagnesemia presented no statistically significant association.

The main disturbances were mixed respiratory alkalosis with metabolic alkalosis and metabolic alkalosis with respiratory alkalosis, both present in 15.12% of patients. This is mainly due to the type of the underlying disease that was responsible for ICU admission. These combined disorders are caused by errors in the compensatory mechanisms that are activated to repair the primary acid-base disturbance. Rahimi et al. which assessed basic acid disorders were more frequent in the admission of patients with TBI, the most common primary disorder in this study was metabolic acidosis (26.3%), while the combination of disorders was more frequent metabolic acidosis with respiratory alkalosis[21].

The main limitation of this study was the small sample, therefore, a larger sample is needed to have greater representation on the acid-basic disturbances and their relationships with the parameters evaluated in this study. However, there are not many studies that evaluate the profile of acid-basic disturbances of intensive care units. It is important to establish the profile of these disorders in ICUs, once the patient is admitted to the ICU. The doctor should in mind the most likely acid-basic disturbances that could affect the patient, correlating with the cause of admission.

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