Evaluation of gasometric parameters in trauma patients during mobile prehospital care

Avaliação dos parâmetros gasométricos dos traumatizados durante o atendimento pré-hospitalar móvel

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A B S T R A C T

Objective: To evaluate gasometric differences of severe trauma patients requiring intubation in prehospital care. **Methods**: Patients requiring airway management were submitted to collection of arterial blood samples at the beginning of pre-hospital care and at arrival at the Emergency Room. We analyzed: Glasgow Coma Scale, respiratory rate, arterial pH, arterial partial pressure of CO_2 ($PaCO_2$), arterial partial pressure of O2 (PaO_2), base excess (BE), hemoglobin O_2 saturation (SpO_2) and the relation of PaO_2 and inspired O_2 (PaO_2/FiO_2). **Results**: There was statistical significance of the mean differences between the data collected at the site of the accident and at the entrance of the ER as for respiratory rate (p = 0.0181), Glasgow Coma Scale (p = 0.0084), PaO_2 (p <0.0001) and SpO_2 (p = 0.0018). **Conclusion**: tracheal intubation changes the parameters PaO_2 and SpO_2. There was no difference in metabolic parameters (pH, bicarbonate and base excess). In the analysis of blood gas parameters between survivors and non-survivors there was statistical difference between PaO_2, hemoglobin oxygen saturation and base excess.

Key words: Patients. Wounds and injuries. Emergency medical services. Prehospital care. Blood gas analysis.

INTRODUCTION

Traumatic injuries are a growing public health problem, especially in developing countries, either due to high rates of mortality or the high costs of treatment and rehabilitation of patients[1]. Pre-hospital care (PHC) in Brazil is currently going through refinement of its existing units and expansion of its regional centers, thus there are few studies evaluating the impacts of this public health service. The Brazilian Ministry of Health has determined that patients in critical states or at high risk can only be removed from an accident site in the presence of a full PHC team (doctor and nurse) manning an ambulance with advanced life support[1].

The transport of critically ill patients can be intra-hospital (when there is a need for additional tests, therapeutic interventions or admission to the intensive care unit (ICU)) or inter-hospital (when there is a need for more manpower or diagnostic and therapeutic procedures that are absent in the hospital of origin or during PHC advanced life support). Both modalities involve risks, among which the most frequent is failure in controlling the cardiorespiratory functions[2]. A U.S. study conducted by Kue *et al.*[3] reported that the rate of clinically significant adverse events during the transport of critically ill patients, when performed by a specialized team, is relatively low, around 2%.

Most studies that show physiological changes during transport of critically ill patients are observational, and associate these alterations with greater morbidity during their stay in closed units (ICUs) and restrictions in intra-hospital transport[4]. Waydhas *et al.*[5] analyzed respiratory deterioration during intra-hospital transportation and noted that 84% of patients experienced a worsening of PaO_2/FiO_2, and in 43% of patients the deterioration was over 20% above the baseline, with effects that lasted for over 24 hours in 20% of subjects. During this mode of transport, in most cases patients are hemodynamically stable. Zuchelo and Chiavone[6] and Gervais *et al.*[7] reported that gasometries

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of critical patients transported within the hospital environment display pH changes, with a tendency to alkalosis and decreased $PaCO_2$ and oxygenation.

The assessment of acid-base status is essential in the treatment of the critically traumatized. Measurements of pH and base excess are not only important in the diagnosis of acidemia, but essential in monitoring the progression of resuscitation[8]. The use of an arterial line is routine in critically ill patients in emergency rooms, intensive care units and operating rooms. Unquestionable indications are patients in shock with the need for vasoactive drug therapy, as well as patients with respiratory failure, necessitating ventilator support, those with disorders of severe acid-base balance and patients undergoing complex surgical procedures[9]. The use of arterial catheters is a remarkably safe method, with few complications. However, the puncture and installation of arterial lines are rarely used in PHC. Wilder *et al*.[8] reported that there are no studies on the subject to date, stating that the reasons for such reluctance are attributed to economic factors and cost-benefits, besides the absence of scientific proof of the successful transfer of techniques from critical hospital care to PHC.

Bilello *et al*.[10] concluded that patients with blunt trauma and repeated episodes of hypotension have significantly higher mortality, and those with transient hypotension and base excess less than -6 are twice as likely to develop repetitive hypotension, which reinforces the need for early arterial gasometry.

The aim of this study was to evaluate the gasometric features of severe trauma patients requiring orotracheal intubation during the prehospital treatment.

METHODS

We conducted an observational, longitudinal prospective study with the help of the Brazilian Mobile Emergency Care Service (Brazilian acronym - SAMU) in the city of Catanduva, in the state of São Paulo, during treatment administered by the Advanced Support Unit. The study included trauma patients who required definitive airway management (orotracheal intubation) at the scene of the accident. Exclusion criteria were: age under 18 years, failure during orotracheal intubation and patients who died during transport. The study was approved by the FIPA Ethics in Research Committee (72/10; CAAE 0072.0.218.001-10). The subjects and/or their guardians received all information and clarifications necessary on the objectives and method of the research. Thus, those who agreed to participate signed a Free Consent form and a feedback report, according to human research execution standards, clause 196/96 of the National Health Advisory Board and the Helsinki Declaration (clause nº 404/2008).

We collected two samples of arterial blood, preferably through a radial or femoral artery puncture, with a syringe containing heparin calcium balanced with 1.6 ml of calcium, and guaranteed their closure with an airtight lid for each sample. One sample was drawn during care at the scene of the accident by a pre-hospital care team of SAMU, and the other during the initial care by the hospital staff. The samples were cooled in previously refrigerated containers (temperature close to 0°C) during transport to the hospital. For gas analysis, we used a gasometric device, a Radiometer ABL 5 (Reagents/Electrodes & Accessories, São Paulo, Brazil).

During pre-hospital care all vital signs were recorded before the advanced medical procedures were carried out. After medical assessment the need for definitive airway management (intubation) was verified, following PHTLS protocols (Pre-Hospital Trauma Life Support)[11]. All patients were sedated with midazolam (15mg) and fentanyl (50mcg) and oral tracheal intubation was carried out using the direct laryngoscopy technique. Collection of blood for the first gasometric analysis was concurrent with the intubation procedure. During the PHC treatment, 1000ml of 0.9% saline solution was infused, and all patients were transported with mechanical respirators in assisted ventilation mode, volume-cycled and pressure-limited, with 6ml/kg of volume flow, respiratory rate of 14 breaths per minute, inhalation/exhalation ratio 1:2 and 100% inspiratory oxygen. In the emergency unit of a tertiary hospital the patient was transferred from the mobile ventilator to a hospital one for definitive care, using the same parameters. A blood sample for the second gasometric analysis was taken soon after the patient was connected to the hospital ventilator.

Demographic data were collected from medical records (age, gender, systolic blood pressure, Glasgow Coma Scale) as well as indices of trauma severity (Revised Trauma Score - RTS, Injury Severity Score - ISS and Trauma Injury Severity Score - TRISS[12]), cause of injury, need for emergency surgery, clinical complications and treatment outcome (survival or not). The gasometric results analyzed were pH, CO_2 partial arterial pressure ($PaCO_2$), O_2 partial arterial pressure (PaO_2), base excess (BE), O_2 hemoglobin saturation ($satO_2$) and the ratio of PaO_2 to inhaled O_2 (PaO_2/FiO_2). The times to reach the scene of the accident (T1) were provided by the SAMU Regulation Center, as well as treatment time at the scene of the accident associated with the time from the scene to the hospital (T2).

Using a base of pH 7.30, we used the Student t test for two paired samples in 12 patients to show changes of 10%, with a statistical power of 80%, an error rate of 0.05 and a loss calculation of 10%. The numerical results were expressed as mean and standard deviation, whereas the categorical variables were expressed as absolute numbers and percentages. Statistical tests were applied according to the distribution of values (Kolmogorov-Smirnov test). For comparison of numerical variables, we applied the Student t test. For correlations between variables the

Pearson linear correlation test was used. We adopted the value of $p<0.05$ for statistical significance.

RESULTS

Eighteen patients were included in the study, 15 male (83.3%), with a mean age of 30.7 ± 10.1 years. The mean time taken (T1) for the advanced support vehicle to travel from the initial call to the site of the accident was 14.2 ± 6.3 minutes, and the average time of care at the scene plus the time of transport to the emergency unit (T2) was 24.3 ± 8.9 minutes. Blunt trauma was the most prevalent cause of injury (16 cases - 88.9%), 14 of these (77.7%) being land transport accidents (eight motorcycles and six automobiles), one was personal violence (5.6%) and one a fall (5.6%). Two cases were injuries by firearm (11.1%). Regarding the severity indices, the means were: RTS 4.3 ± 1.6, ISS 22.9 ± 9.5, and TRISS 62.6 ± 33.1% of survival expectancy.

Regarding the need for emergency surgery, most patients (61.1%) were taken to the operating room (11 patients). Regarding observed complications, 11 patients had neurological sequelae (61.1%), three had hemorrhages (16.7%), two had lung complications (11.1%), one a cardiac disorder (5.6%) and one had an infection (5.6%). Survival rate was 66.7% (12 patients).

There was a statistical significance of the mean differences between the data collected at the site of the accident and the ones at admission to the ER as for the respiratory rate (p=0.0181), the Glasgow Coma Scale (p=0.0084), the partial arterial oxygen pressure (PaO_2, $p<0.0001$) and the hemoglobin oxygen saturation (p=0.0018), as shown in table 1.

Table 2 shows the comparison of the mean differences in the variables between the two groups regarding outcome (survivors and non-survivors) as well as the statistical test (p) for independent samples. A statistical significance was obtained in the partial oxygen pressure (PaO_2, $p<0.0001$), in the PaO_2/FiO_2 ratio ($p<0.0001$) and in the hemoglobin saturation ($p<0.0001$).

On analysis of the correlations between the trauma severity index variables and data provided by the gas analysis, we observed a positive correlation between the severity index TRISS and pH at admission to the emergency unit (r=0.5501, p=0.018) and negative correlations between ISS and pH (r=-0.5347, p=0.022) and bicarbonate (r=-0.5221, p=0.026), both at admission to the emergency unit (Figure 1).

DISCUSSION

Trauma is the disease with the highest incidence in the young population. In a study by Barros *et al.*[13] it was observed that teenagers and young adults are those who have more years to lose, the external cause being the motivation for this study. Epidemiological data from autopsy studies of the administrative region of Catanduva, São Paulo, showed that the mean age of trauma victims was 40.5 ± 18.4 years and they were predominantly male (77.9%)[14]. Another study from the same administrative region showed similar data with respect to the profile of patient treatment by pre-hospital care: 38.5 ± 18.4 years and 67.5% respectively[1]. In the present study, we found a predominance of young adults (30.7 ± 10.1 years), who were mostly male (83.3%). The travel time of the ambulance to the treatment site, as well as the time for treatment at the site and on to the reference hospital are both consistent with previous studies in the same macro-region[1].

In the analysis of the trauma causes, there is agreement with published studies demonstrating a higher prevalence of blunt trauma[1,12,14,15]. It is well-known that the frequency of motorcycle vehicles involved in trauma causes is increasing, in line with what has been reported by

Table 1 - Comparison between the variables assessed at the scene of the accident and on admission to the ER.

Variables	At the scene of the accident	On admission to the ER	*p*
Systolic arterial pressure (mmHg)	97.8 ± 34.6	98.2 ± 30.7	0.9433
Respiratory rate	19.6 ± 9.3	13.8 ± 0.5	0.0181*
Glasgow coma scale	5.3 ± 3.0	3.2 ± 0.9	0.0084*
pH	7.212 ± 0.19	7.268 ± 0.15	0.2224
PaO_2 (mmHg)	95.84 ± 73.7	215.97 ± 89.4	<0.0001*
$PaCO_2$ (mmHg)	42.86 ± 14.8	37.95 ± 14.2	0.2709
PaO_2/FiO_2	222.84 ± 98.1	270.8 ± 167.2	0.2920
Bicarbonate (mmol/l)	19.3 ± 6.4	18.0 ± 5.0	0.3677
Base Excess (mmol/l)	-7.8 ± 5.3	-8.0 ± 5.2	0.8777
Hemoglobin saturation (%)	74.6 ± 29.0	96.8 ± 6.3	0.0018*

p*: Student t test for paired samples, α = 5%*
** Statistical significance*

Table 2 - Comparison of the differences in means of the variables between the two care scenarios categorized by survivors and non-survivors.

Variables	Difference in the means of survivors (12 patients)	Difference in the means of non-survivors (6 patients)	*p*
pH	0.16 ± 0.12	0.15 ± 0.09	0.9668
PaO_2 (mmHg)	115.54 ± 71.27	153.4 ± 146.49	< 0.0001*
$PaCO_2$ (mmHg)	15.43 ± 11.35	13.63 ± 12.08	< 0.0545
PaO_2/FiO_2	78.51 ± 62.48	206.05 ± 230.16	< 0.0001*
Bicarbonate (mmol/l)	5.37 ± 3.84	5.7 ± 3.42	0.7381
Base Excess (mmol/l)	-3.36 ± 2.38	-5.78 ± 2.90	0.0078*
Hemoglobin saturation (%)	11.33 ± 16.37	43.78 ± 27.69	< 0.0001*

p*: Student t test for paired samples, α = 5%*
** Statistical significance*

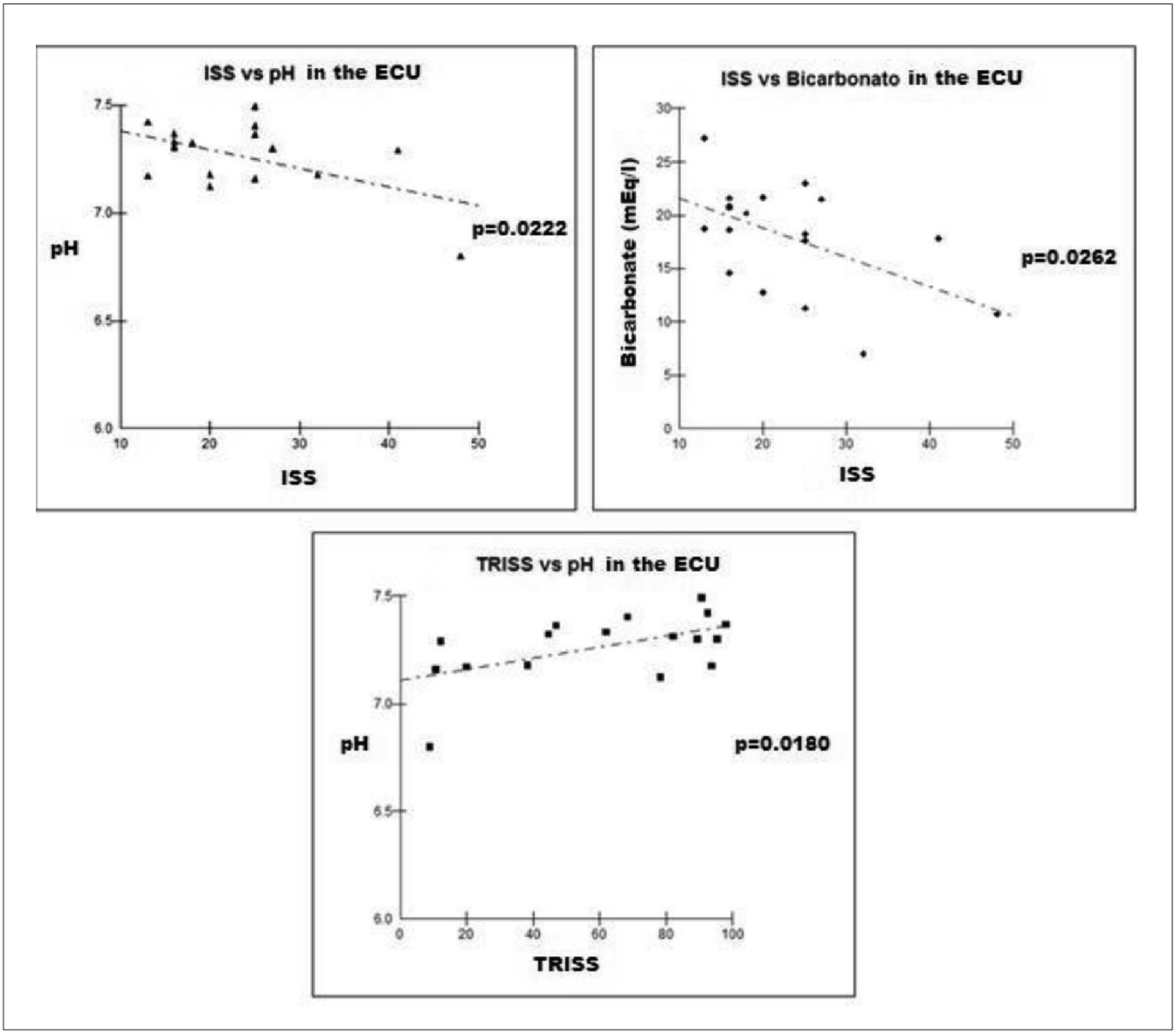

Figure 1 - *Linear Pearson correlation of the variables with statistical significance (á = 5%). ECU: Emergency Care Unit.*

other researchers[16,17]. With regard to trauma rates, an analysis of the national literature shows data similar to those found in this study[1,12,15]. An analysis of complications and the frequent need for emergency surgery must take into account the critical clinical situation of the victims, as demonstrated by the severity indices[12].

In this study, significant statistical changes were found in respiratory rate and in the Glasgow Coma Scale on analysis of treatment at the accident site and on admission to the hospital emergency unit. In fact, such differences were expected, since all patients underwent advanced airway management (orotracheal intubation), sedation and mechanical ventilation. Regarding changes in oxygen partial pressure and hemoglobin saturation, both variables sensitively depend on oxygen supply through ventilation. Studies assessing critical patient transport outside of the hospital environment are scarce and much knowledge has been transferred from intra-hospital observations. According to Pereira Júnior *et al.*[2], adequate transportation of the patient has been neglected by care teams and health professionals. Lima Junior *et al.*[4], studying the transport of patients in a hospital, noted that the use of transport ventilators causes little effect on blood gases due to the method of transport of these patients. In our sample study, the mechanical ventilator was used during the transport of patients from the time of orotracheal intubation until arrival at the emergency unit. This may explain the low impact found on $PaCO_2$, pH, bicarbonate and base excess. A Brazilian study[6] showed that blood gas changes found during the transport of critically-ill intra-hospital patients display a pH with a tendency to alkalosis and a reduction of CO_2. In this study, these data were not observed.The said study also reported that there is a tendency for a decrease in oxygenation during transport; this fact was also not evident.

When the pH and bicarbonate were analyzed in isolation, it was observed that the means were 7.268 and 18.0 mEq/l, respectively, on admission to the emergency unit. The use of base excess (BE) and pH as tools for monitoring resuscitation with intravenous fluid in the PHC is advocated by several authors, since their tendency to normalization is correlated with the re-establishment of adequate tissue perfusion. There are portable devices on the market that are easy to use and that can be accommodated in advanced support ambulances[8,18,19]. A Canadian study reinforces that gas analysis, BE and lactate should be available to all trauma surgeons for proper management of critical patients[20]. An experimental study by Darlington *et al.*[21] demonstrated that acidemia leads to hypocoagulability and that a simple correction of pH with bicarbonate is not enough to correct the coagulopathy, demonstrating the importance of early monitoring of tissue perfusion in critical trauma patients. As for correlations with the severity indices, it is clear that the more severe the trauma, the greater the acidemia and hence the lower dosages of serum bicarbonate[9,12,22].

When studying two groups of survivors and non-survivors, statistical significance was obtained in partial oxygen pressure, oxygen saturation, the PO_2/FiO_2 ratio and base excess. In fact, the first three variables are directly related with oxygen supply, which is greater in the patient at the time of admission to the emergency unit, since all the patients had pervious definite airways and high breathing fractions of oxygen. The statistical significance of the variable BE was due to its rise in patients with low tissue perfusion. Thus, the non-surviving patients had a BE absolute elevation greater than survivors[4,5,9,10,18-22].

A question raised by the authors was the usefulness of orotracheal intubation at the scene of the accident. A German study conducted by Hussmann *et al.*[23] analyzed paired samples of 1,200 patients, of which 600 did not undergo orotracheal intubation whilst under the care of the pre-hospital care team. The results indicated that pre-hospital intubation was associated with a prolonged recovery (non-intubated, 64.8 minutes; intubated, 82.3 minutes, *p*d"0.001) and a higher infusion volume (non-intubated, 911.3 ml; intubated, 1,573.8ml, *p*d"0.001). In intubated patients, coagulation parameters, such as the proportion of prothrombin time and platelet count, decreased, as well as the hemoglobin value (*p*d"0.001). Intubation at the site of the accident resulted in a high rate of infection (non-intubated, 1.5%; intubated, 3.7%, *p*d"0.02) and a high prevalence of organ dysfunction (intubated, 9.1%; non-intubated, 23.4%, *p*d"0.001). Thus Hussmann *et al.*[23] concluded that pre-hospital intubation in trauma patients is associated with a number of risks and should be critically analyzed, use only in cases with clear indicators. A Brazilian study showed no statistical difference between PHC services performed by a physician or not[1]. In our study, we found no statistical difference in the pH variables, bicarbonate dosage and base excess between the accident scene and admission to the hospital emergency unit, supporting the question raised by the German group of the real need for invasive procedures at the treatment scene, such as orotracheal intubation.

As a limitation, the current study was done with calculations using a small sample size to show differences greater than 20% in the parameters directly related to blood gases. There is not enough power to correlate our results with adverse events or outcomes such as complications and mortality. Although there was a higher number of patients in the group of survivors, this may reduce the value of our results. However, even with the theoretical disadvantage of the non-survivors, there was a lower incidence of blood gas alterations in this group[4,24].

The results found in this study show that, in critically ill patients, tracheal intubation changes the parameters PaO2 and hemoglobin oxygen saturation, with no differences in metabolic parameters (pH, bicarbonate

and base excess). The analysis of blood gas parameters of survivors and non-survivors observed statistical differences between PaO2, hemoglobin oxygen saturation and base excess.

RESUMO

Objetivo*: avaliar diferenças gasométricas dos pacientes traumatizados graves que necessitaram de intubação orotraqueal no atendimento pré-hospitalar.* ***Métodos:*** *foram colhidas amostras de sangue dos pacientes que necessitaram de manejo de via aérea no início do atendimento pré-hospitalar e ao dar entrada na Unidade de Urgência****.*** *Foram analisados: pH, pressão arterial de CO_2 ($PaCO_2$), pressão arterial de O_2 (PaO_2), excesso de base (BE), saturação da hemoglobina por O_2 ($satO_2$) e a relação PaO_2 e a fração inspirada de O_2 (PaO_2/FiO_2).* ***Resultados****: houve significância estatística entre as diferenças das médias entre os dados coletados no local do sinistro e na entrada da UUE na Frequência respiratória (*p*=0,0181), na Escala de Coma de Glasgow (*p*=0,0084), na pressão parcial arterial de oxigênio (PaO_2;* p*<0,0001) e na saturação da hemoglobina pelo oxigênio (*p*=0,0018).* ***Conclusão:*** *a intubação orotraqueal altera os parâmetros PaO_2 e saturação de oxigênio pela hemoglobina. Não houve diferença nos parâmetros metabólicos (pH, Bicarbonato e excesso de base). Na análise dos parâmetros hemogasométricos dos sobreviventes e não sobreviventes observou-se diferença estatística entre o PaO_2, saturação de oxigênio pela hemoglobina e excesso de base.*

Descritores: *Pacientes. Ferimentos e lesões. Serviços médicos de emergência. Assistência pré-hospitalar. Gasometria.*

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