

# Hemodynamic Changes Following Routine Fluid Resuscitation in Patients With Blunt Trauma

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## Abstract

**Background:** The management of trauma patients is often difficult. The American college of surgeons suggests using advanced trauma life support (ATLS) measures. ATLS is regarded as the gold standard for the resuscitation of cases with acute life threatening injuries.

**Objectives:** To assess the change in base excess (BE) values and central venous pressure (CVP) one and six hours after injection of 1000 cc normal saline in trauma patients admitted to the ICU.

**Patients and Methods:** According to the inclusion and exclusion criteria, patients were randomly selected to participate in the project. Inclusion criteria included trauma patients admitted to the ICU with a CVP line and who had indication for hydration. In trauma patients, at the zero time period, BP, PR, RR and CVP were measured, and a blood gas test was used to assess Hb, pH, BE, PO<sub>2</sub>, HCO<sub>3</sub> and PCO<sub>2</sub>. Then 1000 cc of normal saline was injected, and after one and six hours, the same values were re-evaluated.

**Results:** The mean age of the patients was 38.1 ± 3.9 (range 15 - 60). The mean duration of hospitalization was 7.4 ± 4.4 (range 1 - 21) days. The mean ISS for these patients was 14.33 ± 5.3. BE changes in both groups of patients, based on Hb primary division, showed a significant difference ( $P \leq 0.05$ ). The results showed that there was no significant relation between the measured ISS and the changes in base values ( $P \geq 0.05$ ).

**Conclusions:** According to our results, the infusion of one liter normal saline will cause a statistically significant decrease only in BD, after one hour, in patients with moderate to severe ISS. The changes in SBP, PR, CVP and also pH, HCO<sub>3</sub> and Hb were not statistically remarkable.

**Keywords:** Fluid Therapy, Multiple Trauma, Hemodilution

## 1. Background

The management of trauma patients is often difficult. The American college of surgeons suggests using advanced trauma life support (ATLS) measures. ATLS is regarded as the gold standard for the resuscitation of traumatic cases with acute life threatening injuries. Since uncontrolled hemorrhaging is the major preventable cause of death after trauma, fluid resuscitation by replacement of an appropriate fluid remains an important issue. On the other hand, hemodynamic monitoring and reorganization of metabolic alterations during resuscitation efforts is also important (1-4). Central venous pressures (CVP) and base deficit (BD) are some of the proper indicators that can be used for managing adequacy of fluid replacement in trauma patients. It seems that the increased intravascular

volume may have various effects on the clinical and para-clinical aspects of these patients. Although there are some studies in this field, the effects of fluid replacement on these hemodynamic and metabolic factors in trauma patients are not clearly recognized (5-10).

Lactate, BD and pH are favored as indicators of adequacy of fluid therapy (11-17). Previous studies have specified that abnormal BD is an indicator of a raised fluid requirement and also connected to a higher incidence of complications and increased mortality. Furthermore, it has been recommended as a monitoring parameter for successful resuscitation (18-20).

## 2. Objectives

The results of previous studies on the effects of fluid therapy revealed various findings, which could be due to different situations, the severity of injury, and the initial hemodynamic and metabolic status of patients. To determine these effects, the present study aimed to assess the changes in biochemical markers of trauma patients who were admitted to the ICU after infusion of 1000 cc normal saline.

## 3. Patients and Methods

This study prospective cross-sectional study was conducted at Shahid Rajaei hospital, Shiraz, Iran in 2012 - 2013. Patients enrolled were those who were referred to the trauma intensive care unit (ICU) and had a central venous line (CVL) and indication for hydration. Patients with diagnosed chronic heart failure, diagnosed chronic renal failure and anemia ( $Hb < 8$ ), pregnant patients, subjects younger than 16 and older than 60 and patients admitted to the ICU for more than two weeks were excluded from this study. Individuals who had received blood and blood products in the previous eight hours or less than eight hours and those who were rehydrated during the six hours after the primary hydration did not participate in this study. Patients admitted to the ICU after emergency operation or after resuscitation were recruited. Data were collected by a questionnaire that was filled during the ICU course. Demographic information, vital signs and CVP were recorded for all trauma patients. The intensity of the trauma patient's injury was graded according to the injury severity score (ISS). Blood pressure (BP), pulse rate, respiratory rate (RR) and CVP were measured on admission. We also measured pH, BD,  $PO_2$ ,  $PCO_2$ ,  $HCO_3$  and Hb by using a blood gas test. All patients received a bolus of 15 cc/kg (about 1000 cc) normal saline 0.9%, via a 16-gage line of the central venous catheter. For each patient these parameters were measured again one and six hours later.

Data were analyzed using the SPSS statistical software package, version 21. Repeated measures analysis of variances (ANOVA) was used to compare the clinical and biochemical values of patients at one and six hours after fluid therapy with baseline.  $P < 0.05$  was considered significant.

## 4. Results

Overall, 82 patients were included in the study and the mean age was found to be  $38.1 \pm 13.9$  (range 15 - 60) years. The mean duration of hospitalization was  $7.4 \pm 4.4$  (range 1 - 21) days. The main causes of trauma were vehicle accidents (86.6%), fall from heights (11%) and assault (2.4%). The mean

ISS for these patients was  $14.33 \pm 5.3$ , and 61% of patients had ISS lower than 16. Table 1 shows the baseline characteristics of patients before fluid administration in the ICU.

### 4.1. Vital Signs

As shown in Figure 1, routine fluid resuscitation did not cause significant changes in pulse rate ( $88.1 \pm 19.6$  vs.  $85.8 \pm 17.6$ ;  $P = 0.1$ ), respiratory rate ( $17.5 \pm 7.8$  vs.  $17.3 \pm 7.8$ ;  $P = 0.69$ ), SBP ( $121.0 \pm 13.2$  mmHg vs.  $122.1 \pm 13.8$  mmHg;  $P = 0.45$ ) and DBP ( $77.6 \pm 9.7$  mmHg vs.  $77.8 \pm 10.6$  mmHg;  $P = 0.88$ ) one hour after injection compared to pretreatment. However, this intervention led to a significant increase in CVP ( $12.7 \pm 3.0$  mmHg vs.  $13.9 \pm 2.7$  mmHg;  $P < 0.001$ ) and decrease in Hb ( $10.9 \pm 1.4$  mmHg vs.  $10.6 \pm 1.4$  mmHg;  $P = 0.001$ ) one hour after.

At the six hour follow up, fluid resuscitation caused no significant change in pulse rate ( $87.0 \pm 13.1$ ;  $P = 0.56$ ), respiratory rate ( $17.5 \pm 5.5$ ;  $P = 0.99$ ), SBP ( $121.6 \pm 12.2$  mmHg;  $P = 0.65$ ), DBP ( $78.4 \pm 9.6$  mmHg;  $P = 0.44$ ), CVP ( $13.1 \pm 2.4$  mmHg;  $P = 0.1$ ) and Hb ( $10.9 \pm 1.3$  mEq/L;  $P = 0.96$ ).

### 4.2. Arterial Blood Gas Parameters

Routine fluid resuscitation did not cause significant changes at the one hour level of  $PaO_2$  ( $101.9 \pm 27.2$  mmHg vs.  $99.0 \pm 32.6$  mmHg;  $P = 0.49$ ),  $PaCO_2$  ( $32.9 \pm 5.4$  mmHg vs.  $32.1 \pm 4.9$  mmHg;  $P = 0.15$ ), PH ( $7.46 \pm 0.05$  vs.  $7.45 \pm 0.06$ ;  $P = 0.07$ ) and BE ( $-2.2 \pm 4.1$  vs.  $-2.8 \pm 2.8$ ;  $P = 0.17$ ) compared to pretreatment, but  $HCO_3$  level ( $23.4 \pm 4.0$  mEq/L vs.  $22.3 \pm 4.0$  mEq/L;  $P = 0.01$ ) significantly decreased. In addition, the six hours follow up showed  $PaO_2$  ( $102.4 \pm 40.7$  mmHg;  $P = 0.92$ ),  $PaCO_2$  ( $32.0 \pm 5.8$  mmHg;  $P = 0.12$ ), PH ( $7.46 \pm 0.07$ ;  $P = 0.84$ ), BE ( $-3.0 \pm 2.6$ ;  $P = 0.12$ ) and  $HCO_3$  levels ( $23.4 \pm 8.7$  mEq/L;  $P = 0.96$ ) did not change significantly compared to pretreatment.

## 5. Discussion

According to the findings of the present study, routine fluid resuscitation can lead to increase of CVP and decrease in Hb, BD and  $HCO_3$  levels. These changes were prominent one hour after administration and faded six hours later.

Some studies have claimed that CVP is a marker for volume assessments in fluid resuscitation, and in contrast, some others have revealed that CVP is not a reliable marker, however, as there is no other available marker, CVP should be measured, accompanied with other markers (10, 20-22).

The mean and distribution of the laboratory critical values at time zero of these patients were in the normal range, but BD data indicated that fluids need to be given. In several studies the application of BD with lactate levels in order to determine the severity of the injury, required

**Table 1.** Vital Signs and Arterial Blood Gas of Traumatic Patients Before Fluid Administration in the ICU

Values	Mean $\pm$ SD	Min	Max
Systolic blood pressure, mmHg	121.0 $\pm$ 13.2	80.0	160.0
Diastolic blood pressure, mmHg	77.6 $\pm$ 9.7	50.0	100.0
Pulse rate, per minute	88.1 $\pm$ 19.6	58.0	128.0
Respiratory rate, per minute	17.5 $\pm$ 7.8	6.0	65.0
Central venous pressure, mmHg	12.7 $\pm$ 3.0	6.0	23.0
Hemoglobin, g/L	10.9 $\pm$ 1.4	8.0	14.1
pH	7.5 $\pm$ 0.05	7.3	7.6
Base deficit	-2.5 $\pm$ 4.0	-7.6	11.9
HCO <sub>3</sub> , mEq/L	23.5 $\pm$ 4.0	13.5	34.7
PaO <sub>2</sub> , mmHg	101.2 $\pm$ 27.3	57.0	174.0
PaCO <sub>2</sub> , mmHg	33.0 $\pm$ 5.3	22.0	44.0

Abbreviations: HCO<sub>3</sub>, Bicarbonate; PaO<sub>2</sub>, Partial pressure of oxygen in arterial blood; PaCO<sub>2</sub>, Partial pressure of carbon dioxide in arterial blood; SD, Standard deviation.

tissue oxygenation, prognosis and mortality of trauma patients has been emphasized. BD changes recorded in these patients have shown considerably different results (11, 13, 14, 16, 20).

Use of normal saline in the treatment protocol and the value of BD are correct, but in this study, the results indicated that the effect of fluid therapy on these factors was not as expected (21, 22).

After fluid therapy in these patients, BD was more negative, while the goal of fluid therapy is positive BD. However, further results have shown that patients with initial Hb of less than 11 or greater than 10 had a more acceptable response to fluid therapy, and BD changes in the second time period were positive. Values recorded for the patient's vital signs that changed substantially contributed to the results. Blood pressure in these patients increased during the specified times, but blood pressure changes in these patients first increased in delta 1 then decreased in delta 2 but never returned to the level of admission; Therefore, it is concluded that fluid resuscitation first increases the blood pressure, then after six hours, due to the compensatory system in the body, the blood pressure decreases.

Heart rate was assessed as an indicator for fluid resuscitation and the heart rate decreased in this study, which is in concord with other studies (4, 20).

A CVP change in these patients suggested the enhancing effect of fluids on CVP. CVP initially increased at one hour after injection of the fluid, and this was significant, however, at six hours after, CVP decreased and the rate of change was less than the second time. Other studies have shown that CVP increases after resuscitation, but it is not a reliable marker for volume assessment (10, 19, 21, 22).

BD changes recorded in these patients have shown considerably different results. After fluid therapy, BD was more negative in these patients, while BD was supposed to be

positive. However, patients with Hb lower than 11 or Hb higher than 10 had a positive change in BD.

After fluid resuscitation, blood pressure increased, but the differences in the second time period were more significant than the third time. This means that the blood pressure first increased rapidly, but after six hours of compensatory regulating mechanisms, blood pressure returned to normal level.

### 5.1. Conclusion

It seems that the infusion of one liter of normal saline during one hour will cause a statistically significant decrease only in BD, after one hour in traumatic patients with moderate to severe ISS. The changes in CVP, and also pH, HCO<sub>3</sub> and Hb were not statistically remarkable. The changes in SBP, PR and RR could be due to changes due to pain relief or limb splints compared to pretreatment conditions and cannot definitively be related to the efficacy of hydration.

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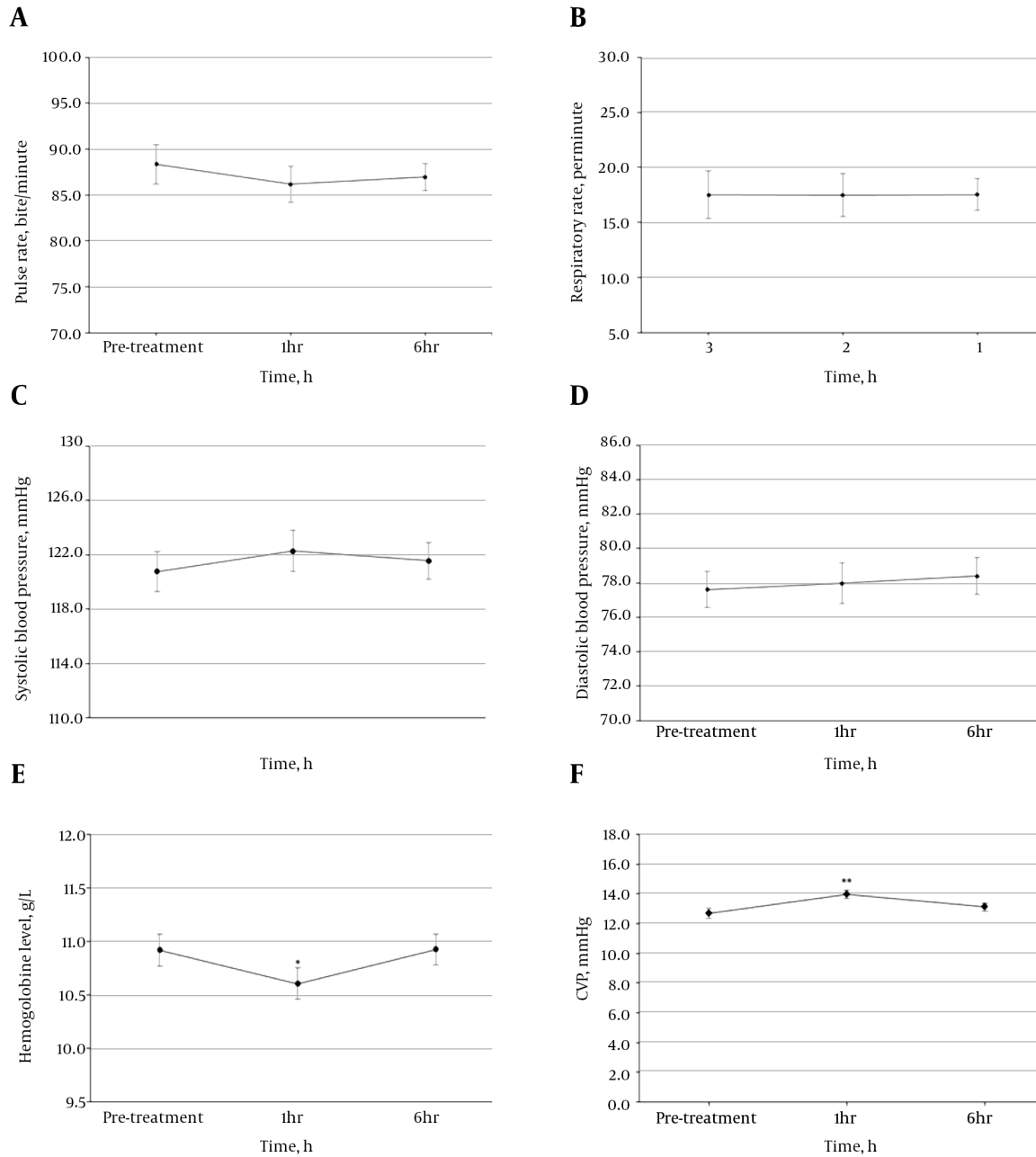
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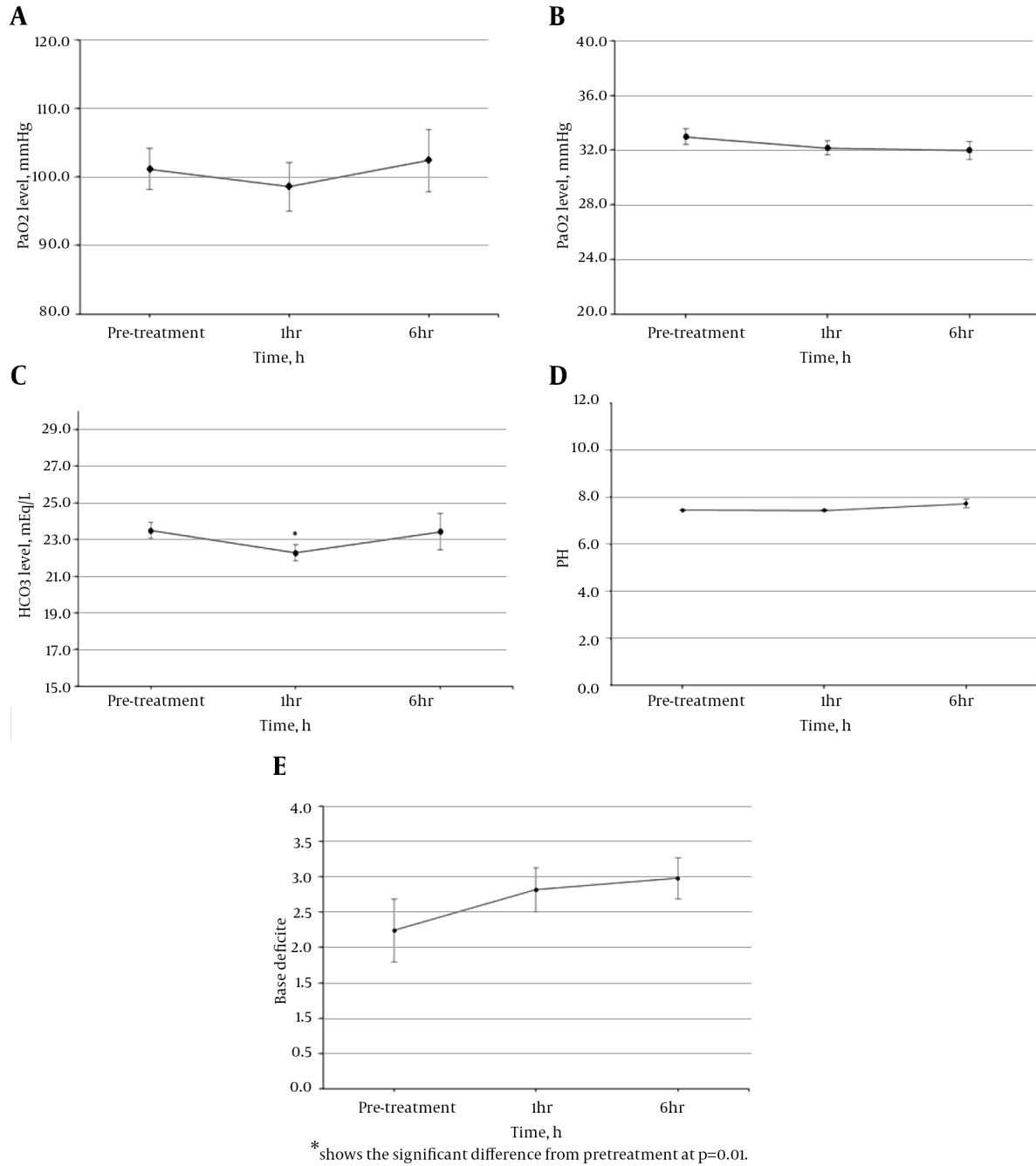
**Figure 1.** Vital sign, Hemoglobin, and Central Venous Pressure Trend Over Pretreatment, One Hour and Six Hours After Routine Fluid Resuscitation



\*shows the significant difference from pretreatment at  $p < 0.01$ ;  
 \*\*shows the significant difference from pretreatment at  $p < 0.001$ .

\*, Shows a significant difference from pretreatment ( $P < 0.01$ ); \*\*, Shows a significant difference from pretreatment ( $P < 0.001$ ).

**Figure 2.** Trend of Blood Gas Parameters Over Pretreatment, One Hour and Six Hours After Routine Fluid Resuscitation



\*, Shows a significant difference from pretreatment at P= 0.01.

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