

## Hemorrhagic Shock in Phase II. Effect of 10% Hydroxy-Ethyl-Starch on Cardiac Output

José Luis Carranza Cortés<sup>1\*</sup> and Adelina Brito Madrid<sup>2</sup>

<sup>1</sup>Professor, Investigador Hospital Universitario- BUAP, Mexico

<sup>2</sup>Ex Resident Hospital, Universitario de la Benemérita, Universidad Autónoma de Puebla, Mexico

\*Corresponding Author: José Luis Carranza Cortés, Professor, Investigador Hospital Universitario- BUAP, Mexico.

Received: July 23, 2018; Published: August 28, 2018

### Abstract

**Introduction:** Maintenance of Cardiac Output (Qt), in the patient with hemorrhagic shock in phase II, is determinant to prevent it from evolving to multiple organic failure in the immediate postoperative.

**Objective:** To determine whether there is an increase in cardiac output in the patient with hemorrhagic shock in phase II, with the administration of hydroxy-ethyl-starch at 10%.

**Material and Method:** A case series study, Prospective and longitudinal, was carried out in patients with hemorrhagic shock in phase II. The patients were administered hydroxy-ethyl-starch at 10%. At a rate of 15 ml/kg, as a single dose and were assessed in three stages, the variables of cardiac output and systemic oxygenation, through ANOVA of repeated measurements with  $P < 0.05$ .

**Results:** A total of 20 patients (N = 20) were studied. An increase in Qt and Disponibility or Transport Oxygen observed ( $DO_2$ ), mainly in stages II and III of the study, with no statistical impact. Oxygen consumption ( $VO_2$ ), remained constant throughout the study. The Oxygen Extraction Rate ( $O_2ER$ ), observed in normal range and Total Peripheral Resistances (TPR), had a descent without significant evidence.

**Discussion:** The Qt,  $DO_2$ , and systemic oxygenation had adequate behavior. No oxygen debt data during the study. It is concluded that the hydroxy-ethyl-starch at 10%, it was useful and supports cardiac output in patients with hemorrhagic shock in phase II.

**Keywords:** Cardiac Output; Hydroxy-Ethyl-Starch at 10%; Hemorrhagic Shock

### Introduction

Hemorrhagic shock is a clinical entity, in which there is a blood loss that exceeds 40% of the Total Blood Volume (TBV). In the event of this eventuality, there are mechanisms of rapid compensation, such as endogenous release of adrenaline and noradrenaline, activity of the renin-angiotensin-aldosterone system, as well as that of the atrial natriuretic factor and the inhibition of the hormone antidiuretic. Subsequently, the less rapid compensation mechanisms are appearing; the extravasation of the fluid from the intracellular space to the extracellular, and from the interstice space to the intravascular space, all this is to favor cardiac expenditure.

Several solutions have been used for the reanimation of the hemorrhagic shock, with different physicochemical characteristics. The crystalloids solutions - lactating ringer-which have the advantage of rapid diffusion in the intravascular space; its distribution is greater towards the interstitial space in the order of the 75% of the volume infused. Its dilucional activity on plasma proteins and the large volume required to restore a milliliter of lost blood, have made its administration restricted to losses blood no greater than 30% del VST [1,2].

Solutions containing gelatin have also been used in volume replenishment. According to the criteria of some authors, there is an adequate activity on cardiac expenditure, higher than the results offered by crystalloids solutions; they have as a drawback a duration that oscillates between 3 and 4 hours, with few anaphylactoid effects [3-5].

Several authors consider that albumin administration is not based on acute reposition, despite its physicochemical characteristics. They indicate their use for phase II and III of the hemorrhagic shock, where their oncotic effect may favor the redistribution of fluids [6,7].

Starch-Containing solutions [8-10], represents advantages over all other replacement solutions. Its properties ensure a sufficient oncotic pressure that lasts longer; this effect favors the increase of cardiac output and the balance of oxygen, necessary in patients who study with this physiological commitment. A recent meta-analysis did not find an increase in mortality or increased incidence of acute renal damage, which is related to the administration of hydroxy-ethyl-starch in the perioperative [11].

The solutions contained in dextran have been excluded from the arsenal of our hospital, by virtue of its negative effect on some coagulation factors and its negative commitment to renal function - its elimination is of the order of 70% by renal route-its administration is associated with renal tubular obstruction; Particularly in patients with hypovolemia, with the presence of oliguria and renal dysfunction. It has also been attributed to Dextran anaphylactic response-antigen/antibody-as reaction [12].

### Definition of the problem

The patient carrying hemorrhagic shock presents alterations in macro and microcirculation that alter cardiac output and systemic oxygenation. Most replacement solutions that are used represent certain benefits. However, after the correction of hemostasis, which includes the end of phase I, the largest number of solutions managed - crystalloids and gelatins. It's already been eliminated by the renal route. In the crystalloids solutions that were administered, an important quantity appears in the interstitial space, which can increase the intrapulmonary volume in the immediate postoperative, which is the beginning of phase II. The higher risk is that cardiac output decreases and this represents acute renal injury and multisystemic compromise.

In the advantages of the infusion of starches, it can be observed that at the beginning of this phase, its oncotic pressure favors the redistribution of fluids and thus, sustain the cardiac expenditure and the rest of components of the systemic oxygenation, during the period of the Immediate postoperative.

In the face of these arguments, we ask ourselves the following question: Exists Response in Cardiac output and systemic oxygenation, when administering hydroxy-ethyl-starch at 10% in patients with hemorrhagic shock in phase II?

The general objective of the study was to determine whether there are changes in cardiac output and systemic oxygenation in patients with hemorrhagic shock in the postoperative phase, with the administration of hydroxy-ethyl-starch at 10%.

### Material and Method

A descriptive study was conducted-series of cases-, with the following design; Prospective, observational, longitudinal, open and unicentric, in postoperative patients of trauma surgery and with hemorrhagic shock, and who entered the Post-anesthesia Care Unit (PACU), under the following criteria.

The following patients were included: a) who were reanimated from hemorrhagic shock, under total endovenous anaesthesia - double-compartment Ketamine +  $O_2$ = Wire<sub>2</sub>: 1-; b) with blood losses greater than 30% of the VST, during phase I; c) with Arterial oxygen content ( $CaO_2$ ), as a lower limit of 15 volumes %; d) with urinary volume in minimum amounts of 1 ml/kg/hour; and e) with average blood pressure not less than 70 mmHg .

**Method**

Patients were kept in the Post-Anesthesia Care Unit (PACU), with ventilatory support, with FIO<sub>2</sub> of 1, with monitoring of the hemodynamic variables by the principle of Fick-cardiac output (Qt), Disponibility of Oxygen (DO<sub>2</sub>), oxygen consumption (VO<sub>2</sub>), Oxygen Extraction Rate (O<sub>2</sub>ER) and Total Peripheral Resistances (TPR). It was also monitored cardiac frequency (FC), direct Mean Arterial Pressure (MAPd) and urinary volumes per hour.

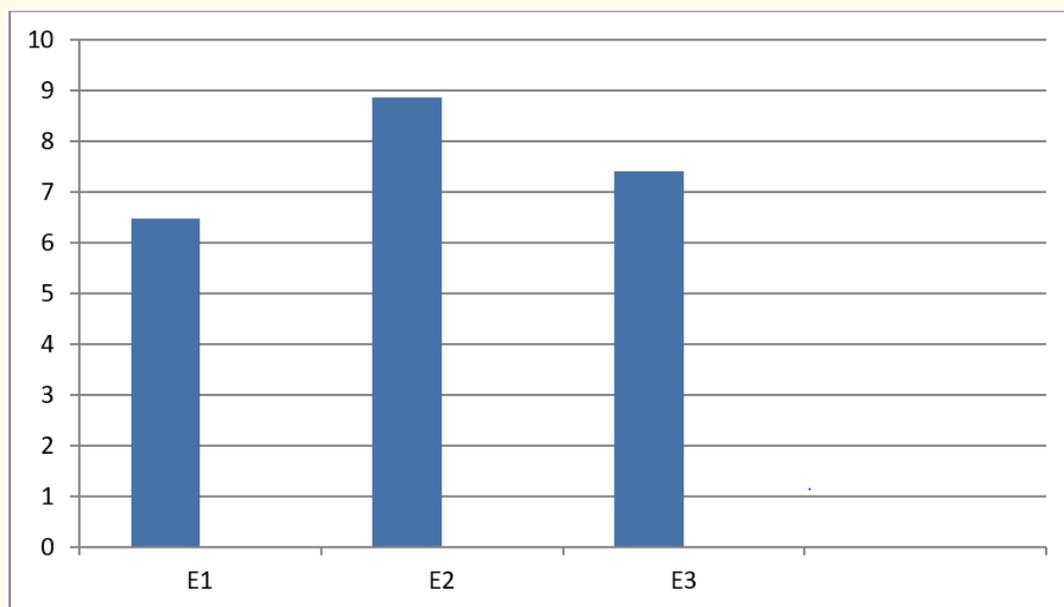
The study was conducted in three stages: E1; Entering the unit and it was before the starch infusion at 10% at a rate of 15 ml/kg, in a single dose; E2: It was the next 3 hours of infusion; E3: The next 3 hours. The sedation of patients was with flunitrazepam 0.030 mg/kg, nalbuphine at the rate of. 100 mg/kg and pancuronium bromide as a neuromuscular relaxant at 0050 mg/kh. The insensitive and maintenance losses were calculated in a standard of 120 ml/hour with lactated ringer solution.

The statistical analysis applied in the variables of the study-parametric was; ANOVA of repeated measurements with two degrees of freedom, with a P < 0.05.

**Results**

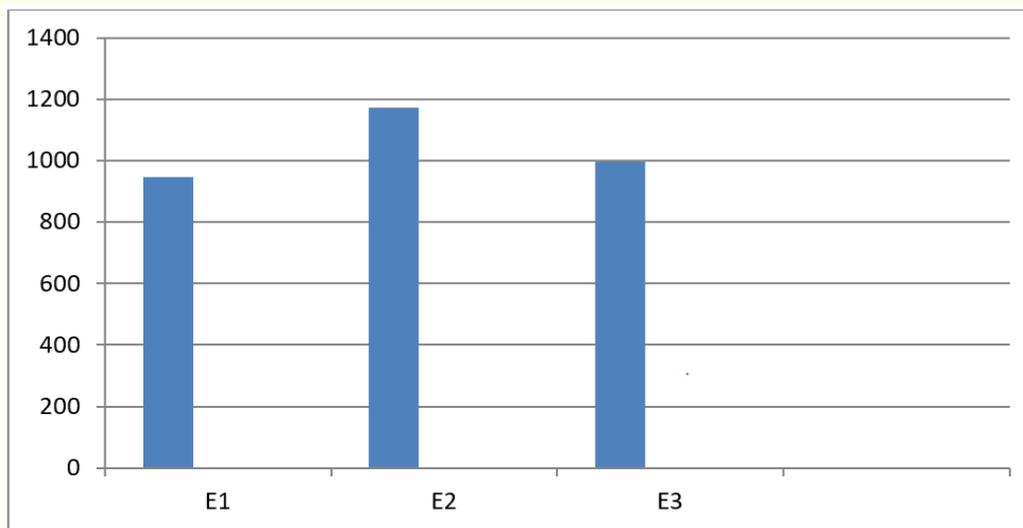
A total of 20 patients were studied, which covered the inclusion criteria. It was found in this population that patients entered the operating room evaluated as high anesthetic-surgical risk. To the entry to the UCP 8 patients (40%) were assessed as physical state (ASA) III and 12 patients (60%), such as EF-IV.

Age with a range of 20 to 32 years, with an X = 23.8 +/- DE 4.71. X = 69 +/- weight of 16.7 kg, the hemodynamic behavior presents the following results: FC: There was a slight increase in phases E2 and E3. The same behavior was for MAP. The Qt presented a more notable growth phase E2, in supraoptimal values, without being represented statistically significant differences. This behavior lasted throughout the study phase. These results are exhibited in figure 1.



**Figure 1:** Cardiac Output-Qt-(liters/minute).  
 (Values in arithmetic Media +/- standard deviation) ANOVA P < 0.05.  
 E1. X = 6.49 L +/- DE 2.37  
 E2. X = 8.86 L +/- DE 5.22  
 E3. X = 7.42 L +/- DE 3.57

La  $DO_2$  it has a similar behavior to that of the  $Qt$ , during the whole procedure without showing statistically significant differences (Figure 2).



**Figure 2:** Disponibility of Oxygen- $DO_2$  (milliliters per minute per square metre of body surface).

Values in arithmetic mean  $\pm$  standard deviation.

E1.  $X = 946.5 \pm 371$

E2.  $X = 1172.5 \pm 576$

E3.  $X = 998.5 \pm 377$

The  $VO_2$  it presents continuous values during the whole study phase. The  $O_2ER$  presents a behavior in ranges of normality, i.e. an adequate oxygen extraction is shown to the tissues. TPR shows a decrease in E2 mainly, which is maintained in the E3 phase.

The values of the hemodynamic parameters and the equilibrium of the oxygens are represented in table 1; and are described in arithmetic mean values and standard deviation.

Variable	E1	E2	E3	P < 0.05
FC (Years/min)	99 $\pm$ 10.2	103 $\pm$ 10	100 $\pm$ 14	NS
MAPd (mmHg)	82 $\pm$ 10.9	89 $\pm$ 16.7	93.8 $\pm$ 14	NS
$VO_2$ (ml/min/m <sup>2</sup> )	224 $\pm$ 36	230 $\pm$ 33	229 $\pm$ 33	NS
$O_2ER$ (Volumes%)	25.7 $\pm$ 15	25.1 $\pm$ 16	28.1 $\pm$ 14	NS
TPR (D/cm <sup>3</sup> )	1043 $\pm$ 326	887 $\pm$ 48	980 $\pm$ 329	NS

**Table 1:** Hemodynamic parameters and oxygen equilibrium.

Arithmetic mean values  $\pm$  standard deviation. ANOVA  $P < 0.05$ .

The surgical indications for patients in the study population are shown in table 2; all patients are postoperative trauma.

Surgery	Number of patients
Deep abdomen contusion	4
Polytraumatized patients	2
Penetrating neck wound	4
Penetrating abdomen wound	4
Double penetrating	6
Total	20

**Table 2:** Surgical interventions.

In none of the study variables, statistically significant differences were observed, analyzed by ANOVA of repeated measurements with a  $P < 0.05$ .

The urinary volumes yielded the following figures  $X = 3.18$  ml/k/hour, values suitable for the effect of the starch. Blood losses of  $X = 1775$  ml +/- 512 were reported during the Trans- anesthesia. No (X) study patients were transfused during the study phase.

Patient evolution was satisfactory, patients subsequently entered their treating service, with no further complications.

### Discussion and Conclusion

An inadequate volume reposition regimen to intravascular space during perioperative results in a decrease in cardiac output, with a reduction in the capacity of oxygen availability to tissues, which can be associated with increases in morbidity-mortality. However, excess fluid loads may also favor postoperative complications. Major surgery is exposed to more frequent complications, if it is considered that a systemic inflammatory response and a subsequent neuroendocrine reaction may occur [13].

Resuscitation targets should be aimed at favoring cardiac spending and oxygen transport. These variables can be affected in the postoperative period by virtue of the exclusion of the intravascular liquid by the average life of the managed solutions, which during their infusion migrate in large percentage to the interstitial space. The redistribution phase of fluids is a stage in which the patient may fall into fluidity, in addition to the presence of fluid in the interstitial space that threatens to cause non-cardiogenic pulmonary edema. The positive oncotic pressure effect of starches, favors the outflow of the existing fluid in the interstitial space and that helps its redistribution and acts preventively for the non-formation of pulmonary iatrogenic edema.

In our study as one of the main points of the inclusion criteria, it was considered to contemplate the value of the  $CaO_2$ . As an indicator that is more like the actual state that keeps the transport of oxygen, in which it integrates as one of the fundamental components along with cardiac expenditure. In such a way that we do not contemplate to evaluate the levels of hemoglobin as an indicator of need for transfusion or not, so as not to fall into errors of appreciation and of criterion has been widely reported by several authors [14-16]. Where the debate is present and active, on which is the smallest limit of hemoglobin to indicate the transfusion homologous and which conduct to follow for it; Clerical or restrictive?

The results found in the present study suggest that starch at 10%, it can be used in patients carrying hemorrhagic shock especially at the end of phase I and the beginning of phase II. This is; phase I comprises from the time of injury and onset of hematic loss to control of hemostasis. Phase II comprises from the end of phase I and when the patient begins to gain weight as a result of the redistribution of fluids. The physico-chemical properties of the hydroxy-ethyl-starch at 10%, cover the requirement for your administration in this clinical entity. We observed an increase in cardiac output at levels that can be considered as supraoptimal, favorable for these patients who present during this phase decreases that may have multiorganic repercussions.

The effect of HES of intermediate molecular weight and low degree of hydroxyethyl starch (HES 200/0.5), about coagulation is practically null and is not cause of hemorrhagic problems. It has a half-life of action of 3 to 6 hours, it has been shown that 500 ml of HES expands to 800 ml after an hour of its infusion. The advantages of this starch is that it has no risk of infection, its affordable cost and has minimal side effects [17].

Usually the synthetic colloids containing gelatin, which are used in the trans-operative, have already been eliminated by renal route, their average life is much shorter than that of the starches. This may be one of the reasons for the significant decrease in cardiac output in patients carrying hemorrhagic shock primarily in the immediate postoperative.

It has been described that the use of starches in the phase of redistribution of fluids after resuscitation in the state of haemorrhagic shock, has been useful because the increase in oncotic pressure favors the distribution of fluid from the interstitial to the intravascular space. The administration of starches in this phase is prescribed when hemodynamic stability exists and the only objective is to maintain an oncotic load in the intravascular space, which favours the maintenance of cardiac output and systemic oxygenation.

Here in Mexico, starches are present in hospitals as replacement solutions; the limitations of its administration is the recommended dose per day (> 50 ml / kg / day), in patients with prolonged coagulation factors and renal involvement. In our study group, the patients had been successfully resuscitated during the trans operative period and had hemodynamic stability, with adequate urinary volumes. The dose administered (15 ml / kg) was lower than indicated for safety; besides not presenting alterations in the registries in the haemorrhagic tendency tests.

It was also observed that the consumption of oxygen remained constant, which favors the patient, if one has present that a  $VO_2$  decreased, it can condition oxygen debt and present a lower survival rate.

These concepts of survival have been discharged by other authors [18,19], who suggest maintaining cardiac output at supraoptimal levels.

Our Working Group concludes that the hydroxy-ethyl-starch at 10%, it is useful in the reanimated patient of hemorrhagic shock in the postoperative phase - phase II-, for the following reasons:

1. The  $Qt$  was increased mainly in the two phases after its infusion.
2. The systemic oxygenation presented a behavior that is understood as adequate, with the levels of  $C_2$  increased. The  $VO_2$  was constant; the  $O_2ER$  was adequate which guarantees the proper use of oxygen. The TPR were decreased but at levels that are considered acceptable; This is attributed to the effect on the blood viscosity, with a direct impact on the post-charge, which reduces the final work of the left ventricle by reducing it.
3. It is possible the presence of oncotic pressure growth, clinically correlates this behavior with urinary volumes and there was no evidence of signs of intrapulmonary fluid overload in any of the patients in the study, which helps To think about the withdrawal of ventilatory support.
4. All these arguments show adequate hemodynamic behavior during the study and the appropriate postoperative evolution in its treating service.

Finally we mention that the findings of the present study cannot be conclusive, if we have present in the sample size; however the results report that the infusion of hydroxy-ethyl-starch to 10%, in patients in phase II of hemorrhagic shock, it is useful and can be considered for use in the patient who present this clinical entity.

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**Volume 4 Issue 9 September 2018**

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