Hemodynamic Response of Modified Fluid Gelatin Compared with Lactated Ringer’s Solution for Volume Expansion in Emergency Resuscitation of Hypovolemic Shock Patients: Preliminary Report of a Prospective, Randomized Trial

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Abstract. The objective of this study was to compare the cardiac and hemodynamic responses to a rapid infusion of 1000 ml of modified fluid gelatin (group A) or 1000 ml of lactated Ringer’s solution (group B) in emergency room patients suffering from shock. This prospective, randomized, open, noncrossover study was performed at a medical center university hospital in a surgical resuscitation room in the emergency department. The subjects were 34 patients with either hypovolemic or neurogenic shock who were admitted to the emergency room. A resuscitation protocol according to Advanced Trauma Life Support (ATLS) with an additional central venous line or Swan-Ganz catheters for hemodynamic monitoring was used. Physical parameters and hemodynamic variables were measured at baseline and 15 minutes, 30 minutes, and 1 hour after the infusion of each fluid. In both groups the mean arterial blood pressure (MAP), systolic and diastolic pressure, central venous pressure (CVP), and pulmonary artery occlusion pressure (PAOP) increased significantly. The CVP and PAOP increased significantly more in the modified fluid gelatin resuscitation group. In patients with traumatic or neurogenic shock due to acute volume deficiency, there was significantly better hemodynamic improvement, judged by CVP and PAOP measurements using the modified fluid gelatin for volume replacement than with lactated Ringer’s solution during the first hour of resuscitation.

All types of shock may be present in trauma patients, although hemorrhage is the most common cause of shock in the injured patient. Normally, an intravenous crystalloid solution or a blood component infusion is used for initial resuscitation of these patients. A colloid solution is preferred, as it provides a better volume effect and tissue perfusion, and the resuscitation is more rapid despite the low risk of allergic reactions (0.007–0.240%) [1].

Volume replacement therapy of hypovolemic (particular trauma) patients is, together with control of airways and support of breathing, one of the three top priorities for urgent resuscitation. Although whole blood use is ideal in many cases, its limited availability, the delays that occur with crossmatching, and the risks associated with the use of noncrossmatched blood may make whole blood an unsatisfactory choice for initial use in the emergency setting. Use of human plasma has also been limited by its high expense, associated risk of infection, and reduced availability.

Although plasma substitutes are widely used worldwide, all clinical studies comparing them with crystalloid infusions have been done under well prepared circumstances: anesthesia of patients in the operating theater or intensive care units and beginning with a stable condition [2, 3]. Alternatively, the investigations were experimental in animals [4, 5]. No data are available from the emergency setting based on our review of the recent literature.

Many colloid fluids had been introduced in the continuing search for an ideal plasma substitute. Modified fluid gelatin (MFG) is a relatively inexpensive colloid that increases the circulating plasma volume, pulmonary artery occlusion pressure (PAOP), cardiac index, and oxygen delivery with no adverse effect on pulmonary function, hemostasis, or crossmatching. Gelatins are the most frequently used artificial colloids worldwide. The objective of this study was to test the hypothesis that the physiologic response of shock patients in the emergency room to 4% modified fluid gelatin (Gelofusine; B. Braun Medical, St. Gallen, Switzerland) and to determine how it is different from the response to lactated Ringer’s solution.

Materials and Methods

Study Subjects

Patients eligible for this study were adults or adolescents who were admitted to the emergency room (ER) trauma resuscitation room at the Veterans General Hospital, Taipei. The patients fulfilled the following inclusion criteria: age ≥ 16 years; mean arterial pressure (MAP) < 80 mmHg; systolic blood pressure < 100 mmHg; impression of hemorrhagic or spinal shock. Any pregnancy patient, patients with a history of congestive heart disease, intubated mechanically ventilated patients, or patients...
refractory to initial fluid challenge were excluded. Patients who completed the study protocol were included in the final study analysis.

**Study Interventions**

Patients admitted to our ER trauma resuscitation room with hypotension, major trauma, or any critical clinical upsets are resuscitated by the trauma team, which consists of an attending trauma surgeon, trauma service chief resident, emergency physician, surgical junior resident, nurses, and a resident anesthesiologist. For patients with suspected hypovolemic shock, the resuscitation protocol is based on the Advanced Trauma Life Support (ATLS) Course of the American College of Surgeons. Shock patients of class II/III were enrolled in this prospective study [6]. Systemic blood pressure, pulse, oxygen saturation, and electrocardiogram were monitored by a noninvasive, multifunction monitor (HP 78354C; Hewlett-Packard, Andover, MA, USA). After large-bore peripheral intravenous access was obtained, a 7.0F to 8.5F rapid infusion catheter kit with guidewire (Arrow International, Reading, PA, USA) was inserted through the femoral or internal jugular vein. The venous access was used for fluid resuscitation and a central line monitor. Central venous pressure (CVP) was measured by manometer (Baxter Healthcare, Valencia, CA, USA). If the Swan-Ganz catheter (AH-0500-H; Arrow International, Reading, PA, USA) was applied, the PAOP (HP 78354C; Hewlett-Packard) was obtained. Blood samples were drawn for laboratory analyses.

**Human Subjects Review**

The study was approved by the hospital ethics committee, Veterans General Hospital, Taipei. Informed consent was obtained from the patient’s relatives before the start of the study.

**Study Protocol**

Shock patients were randomly allocated to infusion of (1) 1000 ml of MFG 4% in sodium chloride (group A), which contains succinylated gelatin 40.0 g, sodium chloride 7.01 g, sodium hydroxide 1.36 g, and water 969 g in each 100 ml MFG solution; or (2) lactated Ringer’s solution (group B). After baseline measurement, 1000 ml of the respective fluid was rapidly infused within 10 to 15 minutes assisted by two manually inflated pneumatic pumps. Measurements were repeated at 15-, 30-, and 60-minute intervals. During the study period, another 1000 ml of lactated Ringer’s solution was continually infused in both groups. Patients who required surgical intervention, blood transfusion, or intubation with positive-pressure ventilation were dropped from the study. In particular, no other intravenous fluids, inotropic drugs, or vasopressor agent were administered. The hemoglobin level, hematocrit, prothrombin time (PT), and activated partial thromboplastin time (APTT) were checked at the beginning and end of the study.

**Statistical Analysis**

Data are expressed as the mean ± standard deviation (SD) and analyzed with SPSS software (SPSS 6.1 for Windows, SPSS, Chicago, IL, USA). Paired tests were used to compare changes within treatment groups, and repeated measures of analysis of variance (ANOVA) were used for comparisons between groups. Significance was based on \( p < 0.05 \).

**Results**

During an 8-month study, from July 1, 1997 to February 24, 1998, there were 41 patients with hypotension enrolled in the study. Seven were dropped from the final analysis: five due to blood transfusion and another two required surgical intervention during the first hour of resuscitation. In group A (MFG), 18 patients entered the final study analysis (13 men, 5 women; age 18–79 years). Ultimately, 2 of the 18 patients died, and 16 survived to leave the hospital. In group B (lactated Ringer’s solution only), 16 patients entered the final study analysis (8 men, 8 women; age 20–86 years). Of these 16 patients, 3 died and 13 survived to leave the hospital. Of these final 34 patients, only 11 in group A and 8 in group B had completed all of the PAOP data collection via Swan-Ganz catheter. The demographic data of all the patients are shown in Table 1.

Although group A had a younger mean age than group B, the difference was not significant (41.3 ± 19.1 vs. 47.8 ± 19.1 years). At baseline there were also no significant differences in any variables between the groups. The effects of MFG and lactated Ringer’s solution on measured and derived hemodynamic variables are shown in Table 2.

The vital signs in most patients improved after the initial fluid resuscitation. In group A the MAP and systolic and diastolic blood pressures significantly increased after 30 and 60 minutes. There was no significant change in group B. The decreases in heart rate in the whole study were variable, and there were no differences between the two groups. The PAOP results are based on small numbers: In group A only 11 of 18 and in group B in 8 of 16 patients had conclusive PAOP results. The hemodynamic status (CVP and PAOP) of patients in group A was significantly improved \((p < 0.05)\) as quickly as 15 minutes after baseline. In group B it was significantly improved after 60 minutes (Figs. 1, 2).

The hemoglobin and hematocrit levels also decreased owing to the hemodilution effect. The average hemoglobin level of all patients was 13.6 ± 1.9 g/dl before resuscitation, shifting to 11.0 ± 1.6 g/dl 1 hour later. From the beginning, group A (13.4 ± 2.1 g/dl) and group B (13.8 ± 1.8 g/dl) were diluted to 10.7 ± 1.6 and 11.4 ± 1.5 g/dl, respectively. The PT and APTT (the coagulation function of patients) were prolonged to about 1.5 times normal, but this was not statistically significant.

After infusion of either fluid the repeated measures ANOVA disclosed some statistically significant differences between the groups (Figs. 1, 2). Group A had better hemodynamic changes than group B in terms of the MAP, systolic and diastolic blood