A TRIAL OF A PLASMA VOLUME EXPANDER (HAEMACCEL) IN SHOCK*

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The safe, efficient treatment of the severely shocked patient following trauma and haemorrhage is of great importance to all involved in resuscitation: surgeons, anaesthetists and general practitioners alike. The physiological changes of shock are very complex, and it was felt that this complexity demanded more than the replacement of blood loss and the administration of balanced salt solutions so commonly used today, and that the use of plasma volume expanders was possibly being neglected. It was thus felt that a clinical trial of a plasma volume expander in the shocked patient would be both interesting and informative.

MATERIAL AND METHODS

The plasma volume expander used in this trial is composed of polymers from degraded gelatine. Degraded gelatine molecules are cross-linked by urea bridges and the mean molecular weight of the substances as used clinically is approximately 35,000. It has a relative viscosity of 1·7 - 1·8 (plasma 1·9 - 2·3; serum 1·6 - 2·2) and the pH of the infusion solution is 7·2 - 7·3. The 3·5% solution which is the preparation used clinically exerts a pressure of 350 - 390 mm.H_2O and is therefore slightly hypertonic as compared with plasma. Removal of water from the tissues is thus promoted and oedema formation prevented.

One hundred ml. of the solution contains:

Polymers from degraded gelatine	3·5 G
NaCl	0·85 G
KCl	0·038 G
$CaCl_2$	0·07 G
Sterile distilled water	ad.100
Other electrolytes Mg++, PO_4^{---}, SO_4^{--}	0·002%

This is equivalent to the following electrolyte concentrations:

Cations		Anions	
Na+	145 mEq./litre	Cl⁻	162·6 mEq./litre
K+	5·1 mEq./litre		
Ca++	12·5 mEq./litre		

The substance contains no preservative and remains stable indefinitely. Should freezing occur there is no change in physicochemical properties. Generally 500 ml. is given to adults in 1 - 2 hours. In shock, 500 ml. can be given in 5 - 10 minutes. In children dosage is calculated on the basis of ml./kg.

The trial consisted of the administration of plasma volume expander to 48 patients for operation, of whom 25 were in a severe degree of shock. In 14 of these resuscitation had already been attempted by conventional means. The remaining 23 were in various degrees of moderate shock. Resuscitation entailed the rapid administration of plasma volume expander by intravenous drip, and was considered to be adequate when the blood pressure had risen to a systolic pressure of 100 mm.Hg. Anaesthesia was then induced by minimal intravenous thiopentone

followed by relaxant and intermittent positive-pressure ventilation with a Manley ventilator. During the operation blood was replaced according to estimated loss, and in addition Ringer's lactate was administered in some cases where operative sequestration of fluids was thought to be taking place. Where patients were profoundly hypotensive before administration of plasma volume expander, sodium bicarbonate was also given in amounts varying from 50 to 100 milliequivalents.

The amounts of plasma volume expander given were 500 ml. in 32 cases, 1,000 ml. in 13 cases and the remaining 3 cases received 1,500 ml. each. In a further 10 patients for routine surgery selected at random, biochemical investigations were done, namely prothrombin index, liver-function tests, blood sugar, haemoglobin and packed-cell volume. The prothrombin index, liver-function tests and blood sugar were measured before the administration of 500 ml. of plasma volume expander, and again 24 hours later. Blood sugar was also measured immediately after the administration of the plasma volume expander, and the 24-hour specimen was a random one.

RESULTS

The response to pre-operative resuscitation of the shocked patient by administration of plasma volume expander can clearly be divided into two groups. The 25 cases in severe shock fall into group I and those in moderate degrees of shock fall into group II.

Group I: The average systolic blood pressure before resuscitation was 52 mm.Hg, with a range of 0 - 70 mm.Hg. After resuscitation with plasma volume expander the average systolic blood pressure was 115 mm.Hg with a range of 100 - 130 mm.Hg.

Group II: The average systolic blood pressure before resuscitation was 88 mm.Hg, with a range of 70 - 100 mm.Hg. After receiving plasma volume expander the average systolic blood pressure was 115 mm.Hg, with a range of 110 - 140 mm.Hg.

For the total of 48 cases the average systolic blood pressure before resuscitation was 69·06 mm.Hg, with a range of 0 - 100 mm.Hg. After receiving plasma volume expander the average systolic blood pressure was 120·0 mm.Hg, with a range of 100 - 140 mm.Hg.

Although it was impossible to measure skin temperature or peripheral blood flow, it was noticed postoperatively that, despite their critical condition before resuscitation, all these patients were warm and dry, did not shiver, and stated that they felt comfortable. Another striking feature was that in all cases blood clotting was undisturbed during the operation and none of the cases had to return to theatre for control of postoperative haemorrhage.

The biochemical investigations carried out in 10 cases showed no marked deviations from normal of the prothrombin index, serum glutamic oxaloacetic transaminase, serum glutamic pyruvic transaminase and blood sugar. The packed-cell volume showed no significant difference when estimated pre-operatively and 24 hours later.

The details of 5 severely shocked cases are given, as these illustrate the dramatic response to the administration of the plasma volume expander.

Case 1

This patient was a 42-year-old Bantu female in whom blood pressure could not be recorded. The patient had already been given 3 litres of blood in the ward. The diagnosis of a ruptured uterus was made and it was decided that she was to undergo laparotomy with the possibility of a hysterectomy. After the rapid administration of 1,000 ml. of Haemaccel her blood pressure began rising within 5 minutes and reached 90/60 mm.Hg within 10 minutes.

Anaesthesia was induced and during the operation the blood pressure remained stable at a systolic pressure of 100 mm.Hg. The duration of operation was 90 minutes, and during this time 1,500 ml. of blood to replace estimated blood loss was also given. Postoperatively the patient's condition was good.

Case 2

A 21-year-old Bantu female had a pre-operative blood pressure of 68 mm.Hg systolic and a pulse rate of 120 beats per minute. The diagnosis of a ruptured uterus had been made and she was to undergo laparotomy with the possibility of a hysterectomy. Five hundred ml. of Haemaccel (plasma volume expander) was given and her blood pressure began rising rapidly; within 10 minutes it had reached 80 mm.Hg systolic and within 20 minutes it was 100 mm.Hg systolic.

Anaesthesia was induced and the duration of the operation was 65 minutes. During the operation blood pressure remained stable at 120 mm.Hg systolic and the pulse rate was 100 beats per minute. During the operative period 50 mEq. of 8% sodium bicarbonate was given together with 2,000 ml. blood and 1 litre of Ringer's lactate.

Case 3

This patient was an 18-year-old Bantu male. Preoperatively—despite the fact that he had received 6 litres of blood—he was cold and clammy, his mucous membranes were pale, his pulse was not palpable and the blood pressure was not recordable. The diagnosis of bleeding from a stab wound was made, the site of haemorrhage probably being the superior gluteal branch of the internal iliac artery. He was to undergo packing of the wound to control haemorrhage. After the rapid administration of 1,000 ml. of plasma volume expander his blood pressure rose from 0 to 70/40 mm.Hg. Within 5 minutes his blood pressure had reached 100/80 mm.Hg.

Anaesthesia was induced and the duration of operation was 20 minutes, during which time the blood pressure remained stable at 90/60 mm.Hg. During the operation 1,000 ml. of blood to replace operative blood loss, 75 mEq. of 4.2% sodium bicarbonate, 1 litre of Ringer's lactate and 1 G of fibrinogen were also administered.

Case 4

This patient was a 30-year-old Bantu female with a preoperative blood pressure of 55/30 mm.Hg and pulse rate of 140 beats per minute. She was cold and sweating and the mucous membranes were very pale. The diagnosis was ruptured uterus. After rapid administration of 1,000 ml. of Haemaccel her blood pressure rose within 5 minutes to 80/40 mm.Hg and 10 minutes later it was 100/80 mm.Hg. The pulse rate fell from 140 to 120 beats per minute.

Anaesthesia was induced and during the operation blood pressure remained stable at 110/80 mm.Hg. The duration of the operation was 75 minutes. One litre of blood was also given during the operation.

Case 5

This patient was a 26-year-old Bantu female with a ruptured uterus. Her blood pressure was 60/40 mm.Hg and her pulse rate was 130 beats per minute. Five hundred ml. of plasma volume expander was given rapidly and within 5 minutes the blood pressure rose to 100/70 mm.Hg. After a further 500 ml. plasma volume expander the blood pressure was 130/90 mm.Hg. The pulse rate fell from 130 to 100 beats per minute.

Anaesthesia was induced. The duration of operation was 60 minutes and during this time the blood pressure remained stable at 120/80 mm.Hg. In addition, 1,500 ml. of blood was given and 2 litres of Ringer's lactate was administered.

DISCUSSION

In the clinical syndrome commonly known as shock, irrespective of cause, the following phases are seen: Phase I—vasoconstriction; phase II—increase in vascular space; phase III—sludging; and phase IV—irreversible shock.

Adequate fluid administration will reverse refractory shock as it will improve circulation and prevent sludging. The blood volume lost must be overcompensated for, because as a result of phase II the total circulatory capacity is now much greater than normal, and consequently a normal blood volume is inadequate. Adequate fluids also dilute the catecholamines responsible for phase I and thus vasoconstriction with its critical reduction in tissue oxygenation is returned towards normal. It is thus clear that intravenous fluids are vital in the treatment of shock, and the following types of intravenous therapy are theoretically available:

1. *Blood transfusion.* The disadvantages of blood transfusion are the possibility of incompatibility and pyrogen contamination. Citrate intoxication, hypothermia, hyperkalaemia and acidosis may complicate massive transfusions. Decreased pulmonary compliance has also been recorded.[1]

2. *Ringer's lactate or Ringer's lactate with sodium bicarbonate.* The disadvantages of these solutions is that they are not retained in the circulation and may cause tissue oedema. The profound diuresis which can occur may cause hypovolaemia, hypokalaemia, rise in the haematocrit and hypotension.[2]

3. *Higher molecular weight plasma expanders.* These plasma volume expanders with a molecular weight of 42.000 - 120.000 may interfere with blood grouping and blood clotting and renal damage may also occur.

4. *Low molecular weight colloidal plasma volume expander (Haemaccel).* This substance, which has not been much used in South Africa, has been widely used in Europe. It would appear to have definite advantages as it does not cause any of the complications associated with the other forms of therapy.

SUMMARY

The treatment of shock depends on improving circulating blood volume and in order to do this various intravenous fluids can be used. In this series 48 cases were treated for acute and moderate shock with Haemaccel, a plasma volume expander, with highly gratifying results. It would seem to be highly valuable in reinforcing adequate blood replacement and may have definite advantages over balanced salt solutions and higher molecular weight plasma volume expanders.

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