Haemodilution with a Plasma Expander as Priming Solution in Cardiopulmonary Bypass

D. G. MOYES

SUMMARY

A gelatin plasma expander (Haemaccel) was used as a priming fluid in 10 cases of mitral valve replacement. Measurements of acid-base, coagulation, electrolytes, platelets, urinary output and oxygenation were comparable to those with other priming solutions.

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Haemodilution has become accepted practice in the conduct of cardiopulmonary bypass in recent years, and 5% dextrose in water or a balanced salt solution is commonly used to prime cardiopulmonary bypass apparatus. During bypass and in the immediate period thereafter the fluid and electrolyte load is redistributed extravascularly and excreted in the urine. This often necessitates frequent 'topping up' of the bypass apparatus, and the need to make decisions regarding the choice of 'top-up' fluids. The use of blood in bypass procedures presents the problems of availability, considerable use of skilled time in providing accurate matching, and in large amounts the production of homologous blood syndrome.

Consequently we decided to investigate the place of a plasma expander as a priming solution. There is some evidence that dextrans have the ability to promote improved flow in the microcirculation and thereby prevent stagnation. However, they have the disadvantage of interfering with coagulation mechanisms when used in large amounts. This could lead to difficulties in haemostasis after bypass in the heparinised patient. Haemaccel, a modified gelatin, has been shown to be free of adverse effects on coagulation mechanism. In a comparison with dextrans, Eichler and Stephan[1] showed that factor V is increased with Haemaccel, but reduced with dextrans, whereas factors VIII and IX are unaffected by the gelatins, but decreased with the dextrans.

The osmolarity of the agent is slightly greater than that of blood, and for this reason it has been recommended in the management of hypovolaemic shock. The limits of haemodilution have not been precisely defined in man, although there is a wealth of clinical experience which indicates that haematocrits of between 20% and 30% are best tolerated during cardiopulmonary bypass. Evidence has shown that a progressive acidosis develops during perfusion with very low haematocrits.

Haemaccel has been investigated as a diluent for donor blood. In a series of mock perfusions 5% dextrose/water has been compared with Haemaccel and polyvinylpyrollidine (Periston-N; Bayer). Leutschaff[2] demonstrated that the *in vitro* haemolysis was higher with dextrose and suggested that the acidic pH of dextrose/water may have been the cause. He demonstrated changes in the erythrocyte diameter and volume during haemodilution, which was more pronounced with glucose and with the presence of acidic pH. Silvay *et al.*[3] demonstrated the effect of diluting blood with Haemaccel, both in animals and in man, as a diluent at cardiopulmonary bypass. Haemaccel, a modified gelatin preparation, is slightly hypertonic and has an osmolarity of 350 - 390 mmHg. The sodium, potassium and calcium levels are 145, 5,1 and 12,5 mEq/litre, respectively. Anions are provided in the form of chloride and polypeptide. The solution thus has a high calcium and high chloride content. The pH is between 7,2 and 7,3 and the solution has a relative viscosity (1,7) similar to that of plasma.

PATIENTS AND METHODS

Ten adult patients selected for mitral valve replacement were studied. They were selected at random and the clinical status of each patient was comparable; they had all received digitalis and diuretics as part of the presurgical preparation. The standard practice is to discontinue digitalis 48 hours before surgery. The Temptrol oxygenator used in these studies has a priming volume of 2,2 litres. In this study the prime was made up of 1,5 litres of Haemaccel and 0,7 litres of Ringer's lactate. The premedication used was papaveretum and hyoscine.

The anaesthetic sequence followed in this study was thiopentone, muscle relaxant, nitrous oxide/oxygen, and controlled moderate hyperventilation. In addition, small doses of droperidol and fentanyl were used. The bypass procedures were carried out at normothermia. The following parameters were monitored as a routine during the procedure: radial artery pressure, central venous pressure, ECG, nasopharyngeal temperature, urine volume, acid-base status, coagulation studies, and serum electrolytes. The last 4 measurements were taken after induction of anaesthesia, before bypass, at half-hourly intervals on bypass, and hourly after bypass. The parameters were measured finally at 24 hours.

Department of Anaesthetics, University of Natal, Durban
D. G. MOYES, M.B. CH.B., M.R.C.S., L.R.C.P., F.F.A.
Principal Anaesthetist/Senior Lecturer

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RESULTS

Coagulation: The prothrombin index, thrombotest, clotting time, thrombin time, fibrin index, recalcification test, fibrinolysis, and prothrombin consumption index were measured regularly as described. Values obtained were similar to those noted in association with bypass procedures in which dextrose/water or Ringer's lactate was used as priming solution. There was no clinical evidence of deficient haemostasis, and no evidence of anaemia in the postoperative stage at 24 hours.

Urinary output: Pre-operatively the glomerular filtration ratios varied from 35% to 88%, with a mean of 58%. During cardiopulmonary bypass the lowest output was 2,5 ml/kg/hour. In the postoperative phase output was in general good, and with one exception exceeded 60 ml/hour. This patient required two incremental doses of furosemide.

Electrolytes: Sodium, potassium, chloride and total serum calcium were measured throughout this procedure. Two patients required intravenous potassium after bypass to counteract hypokalaemic dysrhythmia. The levels of chloride and calcium remained within normal limits.

Platelets: In our experience with other priming solutions, cardiopulmonary bypass depresses the platelet count to about 50% of control values, recovering to about 67% at 24 hours. The platelet values in the patients receiving Haemaccel followed this pattern.

Acid-base status: The use of Haemaccel tended to cause a slight metabolic alkalosis, and sodium bicarbonate was not required. The lowest base deficit recorded was −1,5 mEq/litre.

Oxygenation: There was no difference in the arterial oxygen level in this study compared with others in which dextrose/water or Ringer's lactate were used as priming media.

Blood loss: The mean recorded blood loss in the first 24 hours was 2,5 litres. Haematocrits returned to pre-bypass levels 2 - 3 hours after bypass in every patient. In a large series of mitral valve replacements with other priming media the mean loss was 2,9 litres.

DISCUSSION

Haemaccel can be recommended theoretically as a priming fluid at cardiopulmonary bypass by virtue of its pH, flow characteristics, absence of effect on coagulation mechanisms, absence of antigenic propensities, and stability in storage. The molecular size of Haemaccel ranges from 5 000 to 50 000, with a mean molecular weight of between 30 000 and 35 000 and a half-life of between 8 and 10 hours.

Extensive clinical experience has indicated that haemodilution to a haematocrit of 20 - 30% produces the best results in terms of tissue respiration and electrolyte and coagulation haemostasis. It is desirable that the diluent chosen will not challenge these ends. For ease of management, it is desirable that the diluent will stay within the *vascular space* for the duration of cardiopulmonary bypass, and that renal elimination should occur to restore the haematocrit to within 10% of normal in the immediate postoperative period. Haemaccel appeared in this short study to fulfil the criteria outlined above, and merits further intensive clinical trial.

REFERENCES

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