MANAGEMENT OF MASSIVE BLOOD REPLACEMENT

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SYNOPSIS

The management of 6 cases who received massive blood replacement, one of which received a total of 20.7 litres of blood, is described. The general problems associated with massive blood replacement are reviewed and discussed. The intra-operative and post-operative management is outlined.

INTRODUCTION

Massive blood loss reduces the circulating blood volume and seriously impairs tissue perfusion. Transfusion is aimed at restoring the cardiac output and oxygen transport to the tissues. The body possesses many compensatory mechanisms but it is important to remember that stored blood is altered biochemically and not only the total quantity of blood given but speed of administration of any part of it must be taken into account. The present communication is an account of the management of massive blood replacement during emergency surgery for internal haemorrhage trauma and elective surgery where rapid and massive blood loss occurred, with consideration of the problems involved.

MATERIAL AND METHOD

The cases presented consist of four emergency cases who had massive internal haemorrhage and two elective surgical cases who had rapid and massive blood loss. The details of the cases are given in Table 1.

Anaesthetic technique

The four emergency cases were first resuscitated and premedicated with atropine 0.6 mg intravenously prior to induction. Preoxygenation was carried out and the patients were induced with oxygen 50% and nitrous oxide 50% with a titrating dose of thiopentone. Endotracheal intubation was facilitated by a dose of suxamethonium. Anaesthesia was maintained by IPPV with pancuronium as the relaxant of choice.

TABLE I. Details of Patients and Transfusion

Case No.	Age (yrs)	Sex	Diagnosis	Stored Blood	Fresh Blood	FFP	Haemaccel	Crys Falloids	Post-Op Coagulation Test	Remarks
1	20	M	Lacerated liver	2.25 L	3.6 L	—	2.0 L	3.0 L	Not done	Post Op IPPV × 8 hours
2	21	M	Lacerated liver and retroperitoneal haematoma	5.4 L	1.0 L	—	1.0 L	3.0 L	Platelets 53 × 10^3/mm^3	IPPV Post Op × 16 hours
3	27	F	Ectopic preg irreversible shock	5.5 L	2.2 L	—	2.0 L	5.0 L	Platelets 30 × 10^3/mm^3 FDP +	Died 18 hours Post Op IPPV
4	26	M	Lacerated liver	6.3 L	1.0 L	0.5 L	1.5 L	2.5 L	Platelets 140 × 10^3/mm^3	IPPV Post Op × 12 hours
5	53	F	Presacral teratoma	6.9 L	1.8 L	0.5L	2.0 L	5.0 L	Platelets 63 × 10^3/mm^3	IPPV Post Op 12 hours
6	62	F	Ca rectum A-P Resection	18.0 L	2.25 L	0.5 L	5.5 L	7 L	Platelets 67 × 10^3/mm^3	Pack in perineal wound IPPV × 48 hours

The two elective cases were premedicated with Pethidine 50 mg and Promethazine 12.5 mg Intramuscularly 1 hour pre-operatively. The patients were intubated and anaesthesia was maintained by IPPV using Curare as the relaxant. However, when masive blood loss occurred with hypotensive, further top-up doses of relaxants required were changed to Pancuronium.

Blood Loss Estimation and Replacement

Blood loss was estimated by swab weighing and measurement of blood in suction apparatus. During rapid blood loss, the rate of replacement were based upon the physiological responses to changes in the circulation rather than upon attempts to measure the loss.

The oesophageal stethoscope was found to be a simple and invaluable aid for monitoring besides monitoring the pulse, the blood pressure and the central venous pressure. It enabled monitoring of the heart rate and rhythm when the pulse became impalpable. Also, the intensity of the heart sounds is a good indicator of the contractility of the heart and also the venous return.

Method of Rapid Infusion

A large bore intravenous cannula was inserted to offer least resistance to blood flow. A Fenwal blood infuser was used to facilitate rapid infusion by the application of positive pressure on the plastic pack. Two or more intravenous cannulae were inserted if a single cannula proved inadequate to keep up with the blood loss.

Heat Conservation during Surgery

All the blood infused was warmed with a blood warmer of the water-bath design (Portex), thermostatically maintained at 38-39°C. The patients were laid on a warming blanket which was maintained at 38°C. Despite these measures to conserve heat, the body temperature of the patients fell by 2-3°C at the end of operation.

Sodium Bicarbonate Administration

Sodium bicarbonate was given intravenously at intervals throughout the operation. Approximately 6 mEq to 10 mEq of sodium bicarbonate was given per litre of blood transfused. .The post operative pH estimation ranged from 7.25 to 7.4 whilst the base excess varied from -2 mEq/litre to 8 mEq/litre; excepting the case with irreversible shock who subsequently died post-operatively (case no. 3).

TABLE 2 Amount of $NaHCO_3$ and Calcium Laevulinate Given

Case No	Total Amount Blood Transfused (Litres)	$NaHCO_3$ mEq	Cal. Laevulinate 10% (ml)
1	5.8	44.6	30
2	6.3	66.8	35
3	8.1	89.2	50
4	7.2	89.2	40
5	9.4	89.2	50
6	20.7	223	100

Calcium Administration

Exogenous calcium was given intravenously, in the form of calcium laevulinate 10% solution, after 1.5 litres of blood had been given rapidly. An average of 0.5 ml-0.75 ml calcium laevulinate per 100 ml blood transfused was used. The value of calcium intravenously was illustrated by improvement of the pulse and blood pressure after the administration of calcium. It must be noted that widely divergent views are held on the rationale of the administration of calcium during massive blood replacement. It must be given in a peripheral vein and at a very slow rate.

Steroids

Dexamethasone 5 mg intravenously was administered in 3 of the 6 cases as these cases had prolonged periods of hypotension.

Control of Bleeding

Eventual control of haemorrhage was achieved in all the cases. However, in the case of abdominal-perineal resection of rectum carcinoma, final control of bleeding from presacral space was achieved by the use of a pack in the perineal space after the patient had received approximately 20 litres of blood. It should be noted that the more frequent use of a pack to control massive haemorrhage may avoid exposing the patient to the dangers of such a massive blood replacement. In fact, fourty-eight hours later when the pack was removed, there was hardly any bleeding.

Post-operative Management

In the immediate post-operative period, the following were undertaken:—

(i) Elective ventilation for a short period varying from 12-18 hours to ensure adequate oxygenation and also as a precaution against recurarisation as the patient rewarmed.

(ii) Monitoring of the blood gases and acid-base status to detect development of the shock-lung syndrome and also residual metabolic acidosis.

(iii) Coagulation studies to detect dilutional coagulopathy, consumptive coagulopathy or fibrinolysis. 3 cases had dilutional thrombocytopenia whilst one had consumptive coagulopathy and finally succumbed.

(iv) Monitoring of the urine output and specific

TABLE 3 Investigation for Coagulation Defects Post-operatively

Test	Dilutional	Consumptive	Primary Fibrinolysis
Platelet count	severely decreased	moderately decreased	normal
Promthrombin time	increased	increased	normal
Partial thromboplastin time	increased	increased	normal
Factor Assays			
I	normal	decreased	decreased
V	decreased	decreased	variable
VIII	decreased	decreased	variable
Clot stability	stable	stable	rapid lysis
Euglobulin lysis time	normal	normal	decreased
Plasmin	normal	normal	increased
Fibrin split products	negative	positive	positive
Ethanol gelatin	negative	positive	negative
Protamine sulphate	negative	positive	negative

gravity of the urine to detect the development of renal shutdown.

DISCUSSION

Any definition of massive blood replacement should include a reference to the patient's weight or preferably the patient's estimated blood volume as well as the speed of transfusion. The following are the various definitions that have been given:—

(1) Any transfusion equal to half the patient's blood volume in less than an hour (Stewart 1962).
(2) Acute administration of more than one and a half times the patient's estimated blood volume (Miller 1973).
(3) Transfusion of 0.5 units of blood per kilogram body weight (Howland and Schweitzer 1974).
(4) Transfusion of the patient's own blood volume within a 12 hour period (Wallace 1977).

The problems of massive and rapid blood transfusion and its management are an important part of anaesthetic practice as the anaesthetist will be directly involved in many instances where massive blood loss takes place for example surgery for controlling internal haemorrhage following trauma or vascular surgery.

Methods of Obtaining Rapid Infusion

Rapid infusion of blood may be achieved by the following methods:—

(a) Use of two or more large bore intravenous cannulae.
(b) Martin's pump.
(c) Fenwal blood infuser — this applies a positive pressure on the plastic blood pack compressing it thereby aiding rapid transfusion.
(d) Rapid emptying of blood stored in bottles by syringing or pumping air with a syphgmomanometer bulb through the air inlet of the bottle to cause rapid emptying of blood.
(e) Manual pump devices on giving sets.
(f) Use of a large syringe and a 3 way adaptor so that blood is drawn rapidly from the blood pack and then rapidly syringed to the patient's cannula using the 3-way adaptor.

Damage to the red blood cells may lead to haemolysis. There is increased likelihood of air embolism. Air can enter the circulation through a leak in the giving set such as a break or puncture in the tubing or through a leakly adaptor.

Filters

Aggregates of leucocytes, platelets and fibrin are present in stored blood and can lead to systemic or pulmonary embolisation. The standard filter on giving sets has a pore size of approximately 170 μm. With rapid transfusion, debris reduce the surface area available for filtration so that after every two to four units of blood transfused, the giving set has to be changed in order to maintain the rapid rate of infusion.

Microfilters are available in 3 forms, namely

(i) Depth filter using Dacron wool or polyurethrane foam.
(ii) Screen filters with polyester mesh.
(iii) Combined depth and screen filters.

The microfilters have a pore size of 40 μm and formed elements of blood together with particulate matter are trapped, leading to coagulation deficiencies postoperatively.

Metabolic Acidosis

One unit of ACD blood has an absolute base deficit of 6-8 mEq. (Howland, Schweitzer and Boyan, 1965). At rapid rates of transfusion, there is a tendency to metabolic acidosis due to this base deficit in the stored blood. This tendency is accentuated by tissue response to trauma, accumulation of metabolic products with hypotension or depressed hepatic and renal function. Howland, Schweitzer and Boyan (1965) recommended buffering the metabolic acidosis with sodium bicarbonate 44.6 mEq per 5 units of blood transfused. Administration of base will correct the effects of metabolic acidosis such as impaired myocardial contractility and hyperkalaemia. However, over-correction could be disadvantageous as alkalosis shifts the oxygen dissociation curve to the left, impairing the release of oxygen to the tissues.

In our practice, 6-10 mEq of sodium bicarbonate per litre of blood transfused was used. Serial acid-base estimation will aid accurate correction of the metabolic acidosis.

Citrate Intoxication and Calcium Administration

High levels of citrate are found with rapid massive blood replacement due to inadequate metabolism of citrate in the liver. An associated transient fall in serum ionic calcium was found (Bunker et al 1955) and this was associated with cardiovascular depression and reduced cardiac output. However, it is suggested that although the serum ionic calcium falls initially in the presence of excess citrate, it will rapidly rise again due to mobilization of the skeletal reservoirs (Howland, Schweitzer and Boyan, 1964). More prolonged hypocalcaemic states may be seen in patients with hepatic or renal dysfunc-

tion. Hypothermia can aggravate this state by depressing hepatic function. With hypocalcaemia, the electrocardiogram may show depressed P wave, prolonged QT interval and depressed T wave changes (Nakasone et al 1954). Direct monitoring of serum calcium levels is now available and will help rational calcium therapy (Drop and Laver 1975).

Current recommendations regarding calcium administration indicate widely divergent views. Howland, Schweitzer and Boyan (1964) suggest that calcium is not only unnecessary but dangerous as it may cause ventricular fibrillation. Burton (1968) recommends administration of 10 ml calcium gluconate, 10 per cent, per litre of blood when 1.5-2 litres of blood is given at a rate of 100 ml/min. In our limited experience, the administration of calcium intravenously was associated with an improvement of the cardiovascular status of the patients.

Hyperkalaemia

In stored blood, potassium passes out of the red cells so that serum potassium levels are high. However, on warming blood much of the potassium returns to the interior of the red cell. In spite of the administration of hyperkalaemia blood, no consistent rise in potassium is found (Bunker et al 1955). Possible reasons for this include shift of potassium into the interior of the red cells on warming, transfer to extracellular compartments and transcellular sodium/potassium exchange (Kliman, 1965). However, high serum potassium has been found in exchange transfusions in children, possibly an accumulative effect (Farquhar and Smith, 1958). It appears reasonable to assume that in the absence of massive tissue damage, hyperkalaemia is seldom a problem with buffered blood.

Hypothermia

Hypothermia is undoubtedly the most important problem of a massive blood replacement. A dramatic fall in the temperature of the recipient leading to ventricular fibrillation or asystole, the danger persisting long into the post-operative period. Further, there will be a reduction in citrate metabolism with a concurrent fall in the rate of release of calcium ions, aggravating and prolonging hypocalcaemia. Myocardial depression also occurs with hypothermia. Oxygen delivery to the tissues is reduced due to a shift of oxygen dissociation curve to the left with hypothermia.

To minimise the drop in temperature of the patient, it is essential to warm both the blood infused and the patient. Blood warmer are basically of two types: Source heating (by warming the bottle or plastic) or in-line heating (by passing the blood through a suitable heat exchanger en route to the patient. The disadvantage of source heating is that it increases the fragility of red cells and predisposes to infection. This is reduced by use of radio-frequency induction heater (either microwaves or macrowaves). In-line blood warmers are based on water-bath principle with a coiled tubing in the transfusion line placed in the water bath.

Coagulation defects

Per-operative and post-operative bleeding in the form of oozing from the surgical wound, petechiae or ecchymoses may be associated with massive transfusion. In such a situation, one has to distinguish between coagulopathies due to consumption, dilution of factors V, VII, VIII or thrombocytopenia or fibrinolysis.

Various laboratory investigations may be carried and these are summarised in Table 3.

Dilutional coagulopathy may be prevented by the use of fresh blood or fresh frozen plasma. Thrombocytopenia may be corrected by platelet concentrates. Howland and Schweizer (1974) recommend one unit of Fresh Blood or Fresh Frozen plasma for every 5 units (2.5 litres) of stored blood transfused. However, the coagulation profile of the patient who has received massive blood replacement should be monitored and corrected accordingly in the post-operative period.

CONCLUSION

Whilst the mortality and morbidity following massive blood replacement has been reduced considerably, it is essential to prevent massive blood loss. The anaesthetist can anticipate this in some operation and prepare to cope with it should it occur. The surgeon's contribution is careful and meticulous dissection to avoid massive bleeding. The anaesthetist can help in preventing excessive bleeding by preventing marked rises in the blood pressure of the patient or by providing induced hypotension with regional techniques, e.g. epidural blocks, or with peripheral vasodilators and posture.

The following are the recommendations for the management of massive blood replacement:—

(a) Maintenance of body temperature by warming the blood transfused and the patient throughout the operation and the immediate post-operative period.

(b) Rate of replacement must be based upon the physiological responses to the circulation rather attempts to measure blood loss; using pulse, blood pressure, a central venous pressure measurement and perhaps an oeso-

phageal stethoscope.

(c) Monitoring of the cardiac rhythm using an oesophageal stethoscope and an electrocardiogram which will also show changes with hypocalcaemia or hyperkalaemia.

(d) Fresh blood is ideal but this is not freely available usually. 1 unit of fresh blood or fresh frozen plasma should be given for every 5 units (2.5 litres) of stored blood transfused.

(e) Buffering of the acid load by giving sodium bicarbonate 1mEq per 100 ml blood infused if more than twenty-five per cent of the effective blood volume is transfused.

(f) Administration of calcium intravenously in a dose of 0.75 ml calcium laevulinate or chloride 10% solution per 100 ml blood infused.

(g) Administration of dexamethazone intravenously if there is any period of prolonged hypotension to help reduce cerebral oedema.

(h) Administration of dexamethazone intravenously if there is any period of prolonged hypotension to help reduce cerebral oedema.

(h) Maintenance of oxygenation in the post-operative period by oxygen therapy or IPPV, keeping a close watch for recurarisation as the patient warms and the development of shock lung syndrome.

(i) Intra-operative and Post-operative monitoring of the acid base and blood gases and the renal status.

(j) Monitoring of the coagulation profile and replacement of deficient factors or platelets in the post-operative period.

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