ACUTE HAEMODILUTATIONAL AUTOTRANSFUSION IN THE SURGICAL MANAGEMENT OF SCOLIOSIS

GUILLAUME DU TOIT, JOHN E. S. RELTON, ROBERT GILLESPIE

From The Hospital for Sick Children, Toronto

Homologous blood transfusions are not without risks, especially in young women and girls. In patients undergoing certain elective surgical procedures autologous blood transfusion is a good alternative. Normovolaemic haemodilution in association with autotransfusion offers the additional advantages of reduced loss of red cell mass during the operation and an increase in tissue blood flow.

In this study twenty-seven adolescent patients undergoing Harrington instrumentation for idiopathic scoliosis had haemodilutional autotransfusions during their operations, none requiring homologous blood. Eighteen were given an average of 750 millilitres of homologous blood in the postoperative period which compared favourably with controls who required 1280 millilitres.

The complications of homologous blood transfusion are well recognised (Gruber 1969; Mollison 1972) and there is therefore increasing interest in autologous blood transfusion for patients undergoing major surgical procedures.

Careful screening for hepatitis antigen, the use of volunteer blood donors and transfusion with frozen washed red cells have significantly diminished the risk of hepatitis after the transfusion. In spite of these precautions a definite risk still exists and this risk is directly related to the number of units of homologous blood transfused (Conrad 1976).

Sensitisation to known and unknown antigens in homologous blood remains a particular hazard to potentially childbearing young girls who require blood transfusions. Autologous blood transfusion which is readily available completely eliminates these hazards.

Three methods of autologous blood transfusion have been described. Blood may be obtained from the patient before the operation and stored in the conventional way (Cowell and Swickard 1974). This blood, although perfectly compatible with the patient’s own blood, has some of the inherent disadvantages of stored blood, such as depleted clotting factors and platelets, a diminished oxygen-carrying capacity, lowered pH and increased potassium concentration. In addition, it requires the services of a well-organised blood bank and involves the logistical problems of obtaining, storing and retrieving the blood. Alternatively, autotransfusion may be performed during the operation by aspiration of blood from the operation site, defoaming, filtering and reinfusing the same blood. This technique has limited application in orthopaedic surgery and is more useful where blood can be aspirated from large serous cavities. It also requires the use of a special pump and filters which are not always readily available.

The third method of autotransfusion is that associated with the use of acute normovolaemic haemodilution (Messmer 1975). This is based on the principle that haemodilution causes decreased blood viscosity which results in an improved blood flow and tissue perfusion, decreased stasis in the capacitance vessels and therefore a diminished risk of venous thrombosis, and, importantly, a reduction in the loss of red cell mass during the operation. To achieve normovolaemic haemodilution a venesection is performed and the volume of blood withdrawn isovolaemically replaced *pari passu* with either a colloid solution, for example dextran or albumin, or a crystalloid solution, usually Ringer-lactate. The autologous blood is reinfused during the operation, usually while the wound is being closed.

A preliminary study was conducted from July to December 1976 at The Hospital for Sick Children, Toronto, to assess the feasibility of acute normovolaemic haemodilutional autotransfusion.

**MATERIAL AND METHODS**

Twenty-seven healthy adolescent patients undergoing Harrington instrumentation and spinal fusion for idiopathic scoliosis were studied. Haemoglobin and haematocrit estimations were performed before the
operation to give a baseline. The patient's circulating blood volume was calculated on a basis of 65 to 75 millilitres per kilogram of body weight depending on the degree of obesity.

**Anaesthetic technique.** After routine induction a wide-bore intravenous cannula was introduced for the administration of Ringer-lactate solution. A venesection of a peripheral vein was then performed and between 15 and 25 per cent of the patient's blood was withdrawn into a sterile, plastic bag containing 60 millilitres of citrate phosphate dextrose solution, the precise amount of blood being determined by the preoperative haemoglobin concentration and the estimated volume of the circulating blood. This blood was kept at room temperature during the operation. The blood was immediately replaced with three times its volume of Ringer-lactate solution.

The venesection usually caused a brief fall in blood pressure and an increased pulse rate which were immediately restored to normal by the crystalloid infusion. The haematocrit was monitored immediately before and after venesection and at intervals during the operation. The blood pressure and pulse were monitored in the conventional way and all the autologous blood was replaced after the muscle layer was closed.

**Blood loss.** During the operation blood loss was kept to the minimum by the following methods.

*Posture.* The patient was placed prone on a scoliosis operation frame (Relton and Hall 1967). External abdominal pressure was thereby reduced, avoiding obstruction of the inferior vena cava and consequent engorgement of the vertebral venous plexuses (Batson 1940).

*Vasoconstriction.* The operation site was infiltrated to the level of the transverse processes with a large volume of a 1:500 000 solution of adrenaline in saline.

*Controlled hyperventilation* ensured peripheral vasoconstriction.

*Surgical technique* comprised meticulous subperiosteal plane dissection, firm packing and expeditious application of instruments.

*Low mean intrathoracic pressure.* In patients with normal pulmonary function, the application of a small negative pressure of not more than five centimetres of water in the expiratory phase encouraged venous return and helped to minimise blood loss (Mushin et al. 1959). This technique, however, does encourage closure of the airway and should always be monitored by serial measurements of partial pressure of oxygen. It is contra-indicated in patients with impaired pulmonary function.

Alternative methods of blood conservation have been advocated, for example the staging of complex procedures, autotransfusion by extracorporeal pump, or the use of induced arterial hypotension, but all add to the risk and complexity of the operation. The induction of arterial hypotension by ganglion-blocking agents, such as trimetaphan or sodium nitroprusside, may achieve excellent operating conditions but induces certain hazards: an inadvertent obstruction of a major vessel, for example the inferior vena cava, may so reduce venous return that circulatory failure occurs while the compensatory reflexes are ablated; and ischaemia of the spinal cord may occur in circumstances where, due to spinal cord manipulation, stretching, or compression, a normal rather than a hypotensive arterial blood supply is desirable. A neurological deficit is infrequent after operations for scoliosis but nonetheless it is a recognised complication. In the authors' view, it is more likely to occur if the blood supply to the spinal cord is reduced by inducing hypotension during correction of the curvature (Relton 1977).

**RESULTS**

The average haemoglobin of the patients in this series before operation was 13.8 grams per decilitre with an average haematocrit of 39.5 per cent. After venesection and replacement with Ringer-lactate the average fall in haematocrit was 8.2 per cent, the lowest haematocrit value being 24 per cent.

No patient received an homologous transfusion during the operation. However, all the autologous blood was reinhaled either during or immediately after the operation. Nine patients required no homologous transfusion during their hospital stay. Their average blood loss at operation was 465 millilitres. The remaining eighteen patients, with an average blood loss of 670 millilitres, received an average of 750 millilitres of homologous blood during the first four days after operation.

A previously reported series (Relton and Hall 1967) was used as a control. It comprised twenty-four patients undergoing the same operation and anaesthetised by the same anaesthetist using an identical technique. The average blood loss (566 millilitres) was comparable with that of the present series (567 millilitres). However, they required an average of 1280 millilitres of homologous blood during and after the operation, a 70 per cent increase in the amount of homologous blood required by patients in the group under review.

**DISCUSSION**

There were no complications using this technique of blood replacement. Postoperative blood transfusion, commonly administered on the third to fifth day after Harrington instrumentation, was left to the discretion of a surgeon who was not involved in this study and assessed the need on purely clinical grounds. Blood was usually given when the haemoglobin concentration fell below 10 grams per decilitre. Frequently, however, in those patients who did not receive homologous blood the haemoglobin increased spontaneously by 1 or 2 grams per decilitre by the time they were allowed out of bed, usually two weeks after operation. The average healthy adolescent patient undergoing Harrington instrumentation has a normal haemopoietic potential and therefore does not require blood transfusion if the haemoglobin is greater than 9 grams per decilitre. On this basis a further five of our patients would have avoided homologous transfusion.

The value of autologous blood transfusion is well established (Milles, Langston and Dalessandro 1962; Langston, Milles and Dalessandro 1963; Turner 1968; Newman, Hamstra and Block 1971; Milles, Langston and Dalessandro 1971; Cowell and Swickard 1974). The concomitant use of acute normovolaemic haemodilution has the advantage of reducing the haematocrit, thereby reducing the loss of red cells during the operation. The theoretical disadvantage in this technique is the reduction of oxygen-carrying capacity of the blood. It has, however, been shown experimentally that the increased tissue blood flow occurring as a result of the haemodilution is sufficient to maintain adequate tissue oxygenation if the haematocrit is maintained above 20 per cent (Messmer et al. 1973).

Messmer (1975) recommends the use of a colloid solution such as dextran or albumin as the isovolaemic
replacement for venesected blood. This has the advantage of maintaining the circulating blood volume more accurately and allows the removal of a larger volume of blood for autotransfusion, but fluid overload may be a more difficult problem. We therefore preferred the use of a crystalloid solution, replacing a smaller volume of venesected blood with three times its volume of Ringer-lactate solution.

With the extensive decortication of bone in Harrington instrumentation it is not possible to control continued blood loss after the operation. A certain percentage of patients may therefore always require additional transfusion. However, with careful attention to blood loss during the operation and increasing experience with this technique of autotransfusion one can reduce homologous blood transfusion to a minimum.

Autologous transfusion with blood which has been collected previously and stored until the time of operation has two disadvantages: if the operation has to be postponed for any reason the blood may be wasted; and the clotting factors deteriorate during storage. Acute normovolaemic haemodilution, with venesection immediately after induction of anaesthesia and before the operation avoids both of these disadvantages. In addition, the patient is spared the repeated venesections in the weeks before the operation.

Some 80 per cent of scoliotic patients undergoing Harrington instrumentation are female. Every effort should therefore be made to spare them the complications of homologous blood transfusions. Haemodilutional autotransfusion is one method of eliminating or reducing the quantity of homologous blood required for this procedure.

REFERENCES


