Pre-donated autologous blood transfusion in scoliosis surgery

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We studied the use of autologous pre-donated blood transfusion in surgery for scoliosis in 45 patients who were divided into two groups; 27 who pre-donated autologous blood (group 1) and 18 who were planned recipients of allogenic blood (group 2). Normovolaemic haemodilution and intra-operative blood salvage was used in six patients in group 1 and three patients in group 2.

The two groups did not differ significantly with respect to age, American Society of Anaesthesiologists score, mean operative time, number of vertebral segments fused, total blood loss, length of stay in intensive care and length of stay in hospital. The risk of requiring allogenic blood transfusion was found to be significantly less in group 1 (7.4% v 88.9%, $p < 0.001$). Only 5.21% of autologous units were wasted. Although intra-operative blood salvage reduced the total blood loss in both groups, it did not affect the need for subsequent allogenic transfusion or reduce the number of pre-donated autologous units which were given ($p < 0.67$). Autologous blood transfusion required extra time, personnel, resources and cost £28.88 per patient more than allogenic transfusion, however, the projected costs at May 2002 make this programme cost-effective by £51.54 per patient.

Pre-donated autologous blood transfusion is acceptable and safe in scoliosis surgery. It significantly reduces the subsequent requirement of allogenic transfusion. Although the cost is currently more than allogenic transfusion, with the increase in the costs of the

latter and the decrease in potential donors which is anticipated, pre-donation of autologous blood will become comparatively cost-effective.

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Autologous blood transfusion involves the collection and reinfusion of the patient's own blood by using pre-donated blood, peri-operative blood in the form of acute normovolaemic haemodilution, the salvage and reuse of blood from the operative field, or post-operative salvage, by which blood is collected in drains and reinfused within six to eight hours. In order to minimise blood loss and reduce the need for transfusion, several other factors need to be considered, including controlled hypotensive anaesthesia, meticulous haemostasis and sound clinical judgement in deciding when transfusion is required. Autologous transfusion has several clear advantages over allogenic transfusion. It reduces the risks of immunomodulatory side effects, graft v host disease, post-transfusion purpura and the transmission of infection, and may be used for patients with rare blood groups, multiple allo-antibodies or religious objections to allogenic blood.¹⁻³

More than 60% to 80% of patients with scoliosis are adolescent girls with idiopathic disease. In an attempt to avoid allogenic transfusion and its associated risks, especially subsequent graft v host disease in pregnancy, autologous transfusion is becoming increasingly popular. To date, however, there is no information regarding its use in scoliosis surgery in the UK.

The objective of this study was, therefore, to investigate the blood transfusion practice in scoliosis surgery and to determine the potential use of autologous transfusion, the risks of subsequently requiring allogenic blood and the cost-effectiveness of these two forms of transfusion.

Patients and Methods

A retrospective review of medical notes, anaesthetic charts, operation notes and blood bank records was undertaken for 45 consecutive patients who underwent surgery for scoliosis between January 1998 and December 2001. They were divided into two groups, 27 received pre-donated autolo-

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Table I. Details of the 27 patients who pre-donated blood and the 18 who were planned recipients of allogenic blood during surgery for scoliosis

Aetiology of scoliosis	Number of patients	Mean age (years)	Mean length of hospital stay (days)	Intensive care stay (days)
Pre-donated blood				
Idiopathic adolescent scoliosis	23	19.2	8.74	2.04
Juvenile scoliosis	2	38	11	2.5
Infantile scoliosis	1	15	8	2
Adult degenerative scoliosis	1	56	10	1
Total	27	21.8	8.92	2.03
No pre-donated blood				
Neurogenic scoliosis	6	15	9.7	4.7
Idiopathic adolescent scoliosis	5	32	9.4	2.4
Spina bifida	3	16.7	43.3	10
Neurofibromatosis	2	13	8.5	2
Congenital scoliosis	1	16	4	1
Revision of scoliosis fusion	1	15	9	2
Total	18	19.8	14.7	4.3

gous blood (group 1) and 18 patients were either not offered or declined to donate autologous blood (group 2).

Once surgery was scheduled, suitable patients were counselled about the use of pre-donated blood well in advance of the operation and informed consent was obtained. A venous sample was taken for routine haematological screening. The first unit of blood (400 to 450 ml) was taken not more than five weeks before the date of the operation, and iron sulphate (200 mg three times daily) was started. The patients returned each week to have their haemoglobin levels measured and if greater than 11 g/dl, a further unit of blood was taken. This continued until four units (or as near as possible) were obtained. The blood was stored in the blood bank in a citrate phosphate dextrose with adenine preservative at 4°C until surgery, or for a maximum of five weeks. The Haemocell ABT 350 cell saver was used for all the intra-operative blood salvage. The surgeon and the consultant anaesthetist decided when, how much and which blood products should be transfused. Blood loss, the type and quantity of transfusion, and potential surgical and administrative risk factors for each patient were analysed

using the SPSS statistic program (version 10 SPSS Inc, Chicago, Illinois).

Results

The details of the patients are shown in Table I. Patients in group 1 were usually healthy women, with scoliosis as their only medical condition. Their mean American Society of Anaesthesiologists Score (ASA) was 1.14 (1 to 2). None had previously received allogenic blood products. The mean ASA score of the patients in group 2 was 1.83 (1 to 3). There was no significant difference in age ($p < 0.55$), ASA score ($p < 0.21$), the length of stay in hospital ($p < 0.18$) or intensive care ($p < 0.11$). Two of the five patients with idiopathic adolescent scoliosis in group 2 declined to pre-donate blood because of a dislike of the concept involved, the third patient was difficult to cannulate. Most underwent posterior spinal fusion using dual rod transpedicular fixation in the thoracolumbar spine, and hook or screw fixation in the thoracic spine. Three patients in group 1 and six in group 2 had an isolated anterior fusion. There was no significant differ-

Fig. 1

Total blood loss, blood loss with a cell saver and acute normovolaemic haemodilution (ANH), and blood loss with no cell saver or ANH for the 27 patients in group 1 (□) who pre-donated blood and the 18 in group 2 (■) who did not.

Table II. The five patients in the pre-donated blood group who received additional allogenic blood

Case	Indication	Months into programme	Packed red blood cells (units)	Fresh-frozen plasma (adult units)
1	Disseminated intra-vascular coagulopathy	3	7	7
2	Low haemoglobin (7.9gd/l), hypotension, abnormal clotting	8	4	6
3	Low haemoglobin (9.0gd/l)	6	2	-
4	Mildly abnormal clotting 12 h post-operation	2	1	-
5	Mildly abnormal clotting 12 h post-operation	6	-	2
Total		<8	14	15

Table III. The cost and projected cost at May 2002 for the 27 patients who pre-donated blood and the 18 who were planned recipients of allogenic blood during surgery for scoliosis.

	Pre-donated blood group				No pre-donated blood group			
	Number of patients	Number of units	Cost (£)	Projected cost	Number of patients	Number of units	Cost (£)	Projected cost
Allogenic blood	6	14	651.42	1399.30	3	57	4705.45	5697.15
Fresh frozen plasma		15	277.05	310.80		31	609.94	609.94
Cryoprecipitate		0	0	0		16	379.71	398.40
Cell saver		946.56	946.56	473.28		473.28		
Pre-donated blood		96	8160.00	6720.00		0	0	0
Total			10035.03	9376.66			6168.38	7178.77
Cost per patient with cell saver	27		371.67	347.28	18		342.69	398.82
Cost per patient without cell saver	27		336.61	312.23	18		316.39	372.53

ence in blood loss between the anterior and posterior fusions ($p < 0.34$). The groups did not differ in the number of vertebral segments fused, with 10.2 ± 2.8 in group 1 and 11.1 ± 3.9 in group 2 ($p < 0.4$). The mean length of the operation was 248.67 ± 58.88 min, with no significant difference between the groups ($p < 0.09$).

The mean total blood loss for all procedures was 1262 ± 724.24 ml. Blood loss was analysed for each group with and without the cell saver (Fig. 1). There was no significant difference between the two groups ($p < 0.89$). The cell saver reinfused 49.67% of blood salvaged in group 1, and 40.28% in group 2. Although the intra-operative blood salvage reduced the total blood loss in both groups, it did not affect the need for subsequent allogenic transfusions nor significantly reduce the number of pre-donated autologous units which were given ($p < 0.67$). The patients who pre-donated (group 1) had a total of 96 units taken, with a mean of 3.6 per patient and 91 (94.8%) were subsequently reinfused. One unit was discarded due to mislabelling. Only 5.21% of the autologous blood was wasted. Five patients received additional allogenic blood consisting of 14 units of packed cells and 15 of fresh-frozen plasma. Three received allogenic blood inappropriately in the initial stages of the programme (Table II). In group 2, 112 units of packed cells were crossmatched and 57 were administered (50.89%). A total of 104 units of allogenic blood products were administered with a mean of 5.78 per patient with

only two patients not requiring blood. The risk of a patient in the pre-donation programme receiving allogenic blood was 18.5%. This, however, reduced to 7.4% during the last three years of the four-year study period. The risk of patients receiving allogenic blood if they did not pre-donate blood was 88.9%. This is significantly higher ($p < 0.001$) than in those who pre-donated autologous blood. In group 1, there was very little correlation ($pr = 0.43$) between blood loss and the number of allogenic or autologous units which were transfused ($p < 0.23$). In group 2, there was a strongly positive correlation ($pr = 0.91$) between the total blood loss and the number of allogenic units which were transfused.

Complications and length of hospital stay were similar in the two groups. The mean haemoglobin in group 1, prior to starting the autologous programme, was 13.9 g/l (SD, 0.51), which decreased to 11.6 g/l (SD, 0.84) within 24 hours of the operation. The platelets decreased and the white cells increased after surgery with a significant drop in haematocrit in both groups. There was, however, no significant change in the mean corpuscular haemoglobin, thus confirming a haemodilution. In most patients pre-operative clotting profiles were not undertaken, however, there was no significant difference between the two groups with regard to post-operative activated partial prothrombin time ($p < 0.21$), International normalised ratio ($p < 0.84$) or fibrinogen ($p < 0.34$).

After calculating the cost of the transfusions per patient, we compared the costs of pre-donated transfusion with those of allogenic blood, and those quoted by the National Blood Service for May 2002 (Table III). This programme is cost-effective by £51.54 per patient with and £60.30 without the cell saver.

Discussion

Allogenic blood transfusion in the UK is currently as safe as it has ever been.⁴ With an increasingly elderly population requiring increasingly complex medical and surgical procedures, demand for blood increases by 2% to 3% each year.⁵ Moreover, serious concerns regarding the risk of transmission of variant Creutzfeldt-Jakob disease (vCJD), hepatitis C and the human immune-deficiency virus have led to measures being instituted to increase the safety of donated blood. Despite the increasing demands for blood products, donor response has remained inadequate partly due to an increasing public awareness and the issue as to whether vCJD is transmitted in blood products, which requires all donor samples to be tested. As a result, the National Blood Service faces the possibility of a further reduction in blood donors. It increased the cost of one unit of red blood cells to £99.95 for the year starting May 2002; and an adult unit of fresh-frozen plasma to £20.72. The Serious Hazards of Transfusion committee highlighted these facts in 1999 and suggested numerous measures by which blood could be used more effectively and by which departments and hospitals should audit their use of blood.

In the USA, autologous donation represents 5% of all blood usage.⁶ In spite of the efforts of the Autologous Transfusion Special Interest Group of the British Blood Transfusion Society and several enthusiasts, very little autologous transfusion occurs in the UK, the least of which is pre-donated autologous blood transfusions.⁷ This is a multifactorial problem. Pre-operative donation requires careful organisation, a guarantee that surgery will proceed, as the donated blood has a shelf life of five weeks, excellent communication between the surgeons, anaesthetists and other specialist personnel, such as the neurophysiologists for spinal monitoring, and the staff of the intensive care unit.

Three patients who pre-donated blood received inappropriate allogenic blood during the initial eight months of the study. This was given inadvertently by the on-call evening staff, as they failed to appreciate the need to avoid allogenic blood. This was a major concern especially when fresh-frozen plasma was transfused, as it is obtained from large, pooled samples and thus would increase the likelihood of the patient developing antibodies and developing graft v host disease in the future. No allogenic blood products are now given without the permission of the surgeon or anaesthetic consultants in charge. This has prevented further inappropriate allogenic transfusions and reduced

the risk of those who have pre-donated receiving allogenic blood to 7.4%, which is significantly lower than the 88.9% in those who did not pre-donate. Murray et al⁸ have shown that predonating blood decreases the risk of receiving allogenic blood and that most patients with neurogenic scoliosis will receive allogenic blood. The 5.21% of pre-donated autologous blood units which were wasted compares favourably with the much higher figures which have been previously reported.⁹ There was no significant reduction in the number of autologous units which were given in group 1 with haemodilution and the use of the cell saver ($p < 0.67$).

The costs of using the cell saver and acute normovolaemic haemodilution were included in the total cost as these are now routinely used in scoliosis surgery as in other forms of major surgery.^{10,11} Acute normovolaemic haemodilution is carried out in the immediate pre-operative period. Blood is withdrawn from the patient during the induction of anaesthesia and replaced with colloid or crystalloid, resulting in dilution of the red blood cell mass. This causes a reduction in the haematocrit and in the number of red blood cells which are lost due to bleeding. The blood with a high haematocrit is replaced during or at the end of the procedure, when haemostasis has been achieved. There are practical limitations, such as the patient's medical condition and co-existing disease, particularly pulmonary, cardiac and renal, the amount of blood withdrawn, the limits of tissue oxygenation, the effects on the coagulation system and the length of time the salvaged blood can be stored.¹² Acute normovolaemic haemodilution should, therefore, only be considered when the potential blood loss is likely to be greater than 20% of the blood volume, the pre-operative haemoglobin is greater than 11.0 g/dl, there are no clinical contra-indications and the correct blood collection packs (standard anticoagulant/blood ratio) are available.¹³

Autologous transfusion has been used more frequently in the USA where acute normovolaemic haemodilution has been shown to be cost-effective and to reduce allogenic transfusions.¹⁴ There is still some debate as to its efficacy and benefit in association with pre-donated autologous blood transfusion. The Haemocell 350 ABT intra-operative cell-saver system is designed to meet the specific requirements of low to medium blood loss, between one and four units of blood. Although the cell saver reduces blood loss, there is little evidence to suggest that it reduces the requirement for subsequent allogenic transfusions, or that it is cost-effective when used with other autologous transfusion techniques. Although there were significant changes in the haematological parameters between 24 and 36 hours following surgery, most returned to normal by four days, unless a complication developed.

The pre-donation of autologous blood cost approximately £30.00 more per patient during the four years of our study. There is an additional four outpatient consultations, usually with a haematology consultant and/or specialist nurse, additional intravenous cannulations and patients have

to take oral iron sulphate tablets. Projected costs indicate, however, that this programme will soon become cost-effective by more than £50.00 per patient.

We believe that this programme of pre-donating blood, with or without acute normovolaemic haemodilution and an intra-operative cell saver (Haemocell ABT System 350), is safe for the patient. There were no complications from the use of these procedures, it reduces the risk of receiving allogenic blood and is, therefore, cost-effective in scoliosis surgery, as has been shown in vascular surgery in the USA.¹⁴ It is the prevention of these young women developing graft v host-disease with future pregnancies which provides its indication in scoliosis surgery. In patients who have rare blood groups or rare allo-antibodies, this form of transfusion is a solution in both scoliosis surgery and general orthopaedic surgery and is rapidly becoming more cost-effective. With the price of allogenic blood rising, the limitations on plasma, the increasing problems of supply and demand and the possibilities of vCJD screening influencing future donors, the use of autologous blood with hypotensive anaesthesia and the intermittent use of acute normovolaemic haemodilution, with or without an intra-operative cell saver, is an alternative which with motivated staff, the correct facilities and good communication can be easily implemented.

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