

British Orthopaedic Association

PATRON: H.R.H. THE PRINCE OF WALES



BLOOD CONSERVATION IN ELECTIVE ORTHOPAEDIC SURGERY

Published by the British Orthopaedic Association, April 2005

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This booklet has been produced by a Working Party established by the British Orthopaedic Association. Principal authors are Mr A J Hamer [Sheffield](chairman), Dr P M S Dobson [Sheffield], Mr P H Earnshaw [London], Dr S Knowles [Epsom] and Mr J H Newman [Bristol]

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PREFACE

This document aims to provide guidance for better blood transfusion practice in orthopaedic surgery in the UK, through the employment of blood sparing strategies to reduce dependence on donor (allogeneic) blood. Serious complications of allogeneic blood transfusion occur at a rate of one in 67,000 and blood transfusions should only be given when the expected benefits exceed the risks and an alternative strategy is not feasible. Furthermore, with the emerging evidence of transfusion-transmitted vCJD, the four UK Departments of Health have decided to exclude all previously transfused donors. This reduction in the UK donor base will increase the likelihood of future blood shortages, which in turn will impact upon the blood supply available for elective orthopaedic procedures.

INTRODUCTION

Blood conservation in orthopaedic surgery goes hand-in-hand with good orthopaedic surgical practice. Any surgical procedure should be done with the minimum of blood loss and, if possible, any lost blood should be returned to the patient. However, since pre-operative anaemia increases the likelihood of allogeneic transfusion, all anaemias should be investigated and, where possible, corrected prior to elective surgery.

Specialist Practitioners in Transfusion (SPOTs) are being appointed in many hospitals around the United Kingdom, and may provide assistance in implementing guidelines such as these, via hospital transfusion committees.

The advice in this document relates specifically to elective orthopaedic surgery but certain techniques (eg cell salvage) may be appropriate to trauma patients.

The structure of the guidance covers three important areas:

- Pre-operative assessment and optimisation
- Intra-operative blood conservation, and cell salvage
- Post-operative conservation, including indications for transfusion, and post-operative cell salvage

A successful blood conservation programme will require attention in all these areas simultaneously to be most effective.

PRE-OPERATIVE MANAGEMENT

At time of referral

- A pre-operative haemoglobin of less than 12 g/dl increases the likelihood of transfusion threefold¹. The GP letter should identify any pre-existing problems of anaemia, bleeding tendencies and relevant drug therapy.
- Local referral protocols with GPs should incorporate the identification and treatment of anaemia prior to the initial orthopaedic consultation.
- If this is not possible, a full blood count should be performed at the time of the initial consultation. If a patient is identified as anaemic, then appropriate liaison should occur between the hospital and referring GP to investigate and/or treat underlying anaemia.

Pre-operative Assessment Clinic

- By the time the patient is seen in the Pre-operative Assessment Clinic (PAC), pre-existing anaemia should ideally have been recognised and treated.
- A further full blood count should routinely be done at the PAC and the results should be reviewed prior to the patient's admission.
- All patients should have a sample taken for a blood group and antibody screen. Patients with red cell alloantibodies will require phenotyped blood and the transfusion laboratory should be given notice of their intended date of surgery.
- An accurate drug history should be taken from the patient, including the use of anticoagulants, antiplatelet drugs (e.g. Aspirin, Clopidogrel) and non-steroidal anti-inflammatory drugs.
- A maximum surgical blood-ordering schedule (MSBOS) should be available at the PAC to allow staff to order blood only if required (for an example, see Appendix 1). Local schedules should be agreed between surgeons and blood providers but the ratio of the number of units of red cells cross-matched to the number of units transfused – the C:T ratio – should not exceed 2:1.
- Recent pre-transfusion testing guidelines recommend that samples for cross-matching should only be kept for one week and if the interval to surgery is longer, patients will require cross-matching on admission.
- 'Electronic issue' of banked blood is becoming more widely available. This system uses computer software to permit release of ABO-identical or

compatible units without a serological cross-match, provided that the patient has been grouped twice and there is no current or historical evidence of red cell alloantibodies. Hence, blood can be rapidly issued only when required.

- If 'electronic issue' of banked blood is available, patients require a blood group and antibody screen at the PAC and a second sample at the time of admission.
- Patients who are already on anticoagulants, antiplatelet agent and non-steroidal anti-inflammatory drugs should be managed as per local protocols. (for an example, see Appendix 2) These should be designed to minimise intra-operative blood loss, whilst allowing for adequate thromboprophylaxis.

Iron Therapy

- Adequate iron stores are necessary to allow increased erythropoiesis following surgical blood loss.
- Iron should be prescribed for those patients who are known to have a low ferritin or who are being treated with erythropoietin (EPO).
- Some evidence suggests that ferrous sulphate, given for four weeks pre-operatively to all patients undergoing elective orthopaedic surgery, leads to improved post-operative haemoglobins.
- Pre-operative intravenous iron therapy may be beneficial in some patients with anaemia of chronic disease, for example in rheumatoid arthritis. This should be given in consultation with local haematologists.

If the availability of blood becomes inadequate, or if there are patients with religious objections to the use of allogeneic blood, the following should be considered:

Erythropoietin

- EPO is known to be beneficial in the reduction of the need for allogeneic transfusion.
- EPO is safe, with relatively few side effects, but adequate iron stores must be present. All studies of its use included chemical thromboprophylaxis.
- Three or four injections (300-600iu/kg) at weekly intervals prior to surgery are recommended.

- EPO is particularly effective in the management of mild to moderate anaemia prior to surgery (Hb 10-13g/dl).
- EPO can be very useful when used in conjunction with other modalities. It can increase the yield and reduce the anaemia of pre-operative autologous donation (PAD) and can optimise outcome when used with cell salvage.
- The cost/benefit ratio will improve if there is a significant shortage of allogeneic blood.

Pre-operative Autologous Blood Donation (PAD)

- PAD is not routinely recommended for primary joint arthroplasties, when studies have shown wastage rates of up to 45%.
- PAD does not eliminate some of the major risks of blood transfusion, namely mis-transfusion (giving the patient the wrong blood) and bacterial contamination.
- PAD may also create an artificial anaemia and, in primary joint surgery, whilst reducing the rate of allogeneic transfusion will increase the overall transfusion rate.
- This technique is recommended for those patients with multiple red cell alloantibodies or extremely rare blood types for whom the provision of allogeneic blood is difficult.
- It should only be used for those procedures with particularly large blood loss that regularly require blood transfusion and when there is a guaranteed date of admission and surgery.

Patient Information

Patient information leaflets about the risks of blood transfusion should be given to patients at the time of their pre-operative assessment visit. National Blood Service (NBS) leaflets can be obtained from local Blood Centres.

Information concerning blood transfusion in surgery is available on-line at www.blood.co.uk Click on “All about blood” then “Blood transfusion”.

SUMMARY

- Anaemia should be identified and treated pre-operatively.
- The pre-assessment clinic is vital in this process and should take place at least four weeks before the operative date.
- Local blood ordering schedules (MSBOS) should be reviewed regularly and amended on the basis of audits of blood usage.
- Consider the use of iron therapy, EPO and PAD in specific patients.

INTRA-OPERATIVE MANAGEMENT

Surgical Technique

- This is vitally important in blood conservation. Careful soft tissue handling is essential and rigorous haemostasis at the time of exposure will lower blood loss.
- Patient positioning can have a significant influence on bleeding, particularly during spinal surgery. Pressure on the abdomen and inferior vena cava should be minimised.
- Tissue adhesives derived from human proteins (sealants) or animal proteins (glues) may have a useful place in blood management during spinal surgery, revision arthroplasty or bilateral knee replacement. They have also been shown to reduce blood loss in primary hip and knee arthroplasty, but further work is needed to establish their cost-effectiveness².
- It is not clear whether minimally invasive surgical techniques reduce overall blood loss and they may not be appropriate for all patients.
- New developments in diathermy technology may help to reduce blood loss.

Anaesthetic Technique

- Intra-operative transfusion triggers should be decided on an individual patient basis and near patient testing (eg 'Haemocue' device) can be used to closely monitor haemoglobin concentration.
- The use of hypotensive anaesthesia (mean arterial pressure 50-60mmHg) significantly reduces blood loss safely, provided patients are selected and monitored appropriately. It is vital that hypovolaemia is avoided.
- Blood loss may be less in patients having regional anaesthesia and/or general anaesthesia with spontaneous ventilation compared with general anaesthesia combined with positive pressure ventilation.
- Maintenance of normothermia reduces blood loss. Suitable fluid warming and forced air warming devices are essential for major surgical cases.
- Coagulation parameters should be monitored during major surgery with significant blood loss, eg greater than 40% estimated blood volume, and abnormalities should be treated promptly.
- The type of intravenous fluid administered may influence coagulation. Balanced salt solutions (eg Hartmanns), gelatine based colloids and medium

molecular weight starches (eg Voluven) cause fewer coagulation problems than Dextrans and other Starches.

- The efficacy and safety of acute normovolaemic haemodilution (ANH) is not proven. Limited information in orthopaedic patients suggest its use when blood loss is expected to be high and the patient is fit enough to withstand a greatly reduced haematocrit. Acute hypervolaemic haemodilution may be safer than ANH but its efficacy in reducing blood loss is unproven.

Intra-operative Red Cell Salvage

- Intra-operative red cell salvage can greatly reduce the need for allogeneic blood transfusion and can be life-saving³. The technique, which washes salvaged red cells before re-suspending them in saline, should be considered for non-infected revision arthroplasty (especially hips), major spinal and pelvic surgery and major trauma surgery, when blood loss of greater than 1000mls is anticipated.
- Introducing a cell salvage programme requires initial training of personnel but does not require additional staffing. The cost of capital equipment is usually included in the price of disposables, such that the system is cost-neutral if one unit of red cells is saved per case. The mean reduction in allogeneic transfusion for revision arthroplasty is significantly greater than this.
- Salvage techniques are mostly contra-indicated in surgery in the presence of infection or malignancy.
- These techniques may be more appropriate in patients where the risk/benefit favours salvage, eg Jehovah's Witnesses.
- The use of irrigants, such as hydrogen peroxide and chlorhexidine, is not a contra-indication to cell salvage provided that adequate lavage of the wound using saline is performed.
- A separate suction system should be employed to remove irrigation fluid.
- Data from the author's unit shows a reduction in allogeneic blood usage in revision hip surgery from a mean of 5.6 units to 1.8 units per case.
- Newly introduced cell salvage devices (eg 'Orthopat'), which allow both intra-operative and post-operative collection, may become cost effective in primary total hip and total knee arthroplasty.

- Information on setting up a cell salvage programme can be obtained by contacting the Trent Transfusion Alternative Group via *debra.marples@nbs.nhs.uk*
- An example of standard operating procedures is attached in Appendix 3.

Pharmacological Agents

- There is evidence that aprotinin reduces blood loss in hip and knee arthroplasty and tranexamic acid reduces blood loss following knee arthroplasty when an intra-operative thigh tourniquet is used. Further evaluation is required before routine use can be recommended^{4,5}.
- The use of aprotinin or tranexamic acid should be considered for operations where major blood loss is anticipated, other blood conservation techniques are inappropriate, eg Jehovah's Witnesses or the presence of multiple antibodies, or when allogeneic blood is unavailable or in short supply.
- There is no evidence to support the use of desmopressin except in patients with pre-existing coagulation disorders.
- Recombinant Factor VIIa is unlicensed for use in massive haemorrhage. However it has been used successfully in life threatening haemorrhage, which persisted despite timely attempts to correct thrombocytopenia or a coagulopathy.

Artificial Blood Substitutes

- Perfluorocarbons and haemoglobin solutions may have a role to play but minimal data is available in the field of orthopaedic surgery and they are not yet licensed for general use.

SUMMARY

- Surgical technique aimed at reducing blood loss is vital.
- Anaesthetic technique (in particular blood pressure control), maintenance of normothermia and coagulation indices will affect blood loss.
- Intra-operative red cell salvage can reduce blood requirements in non-infected

revision arthroplasty and major pelvic, spinal and trauma surgery.

- At present, intra-operative cell salvage is not cost effective in uncomplicated primary hip and knee arthroplasty.
- Aprotinin and tranexamic acid significantly reduce blood loss but currently have limited indications due to potential thrombotic complications.
- Intra-operative transfusion triggers should be decided on an individual patient basis.

POST OPERATIVE MANAGEMENT

Unwashed Cell Salvage Systems

- If wound drains are used, reinfusion of unwashed drainage has proved effective in reducing the need for transfusion of bank blood following total knee replacement⁶.
- The method has been shown to be safe and has been used in many thousands of cases over the last 10 years with minimal reported problems⁷. (See appendix 4 for an example of a standard operating procedure.)
- Unwashed reinfusion systems are best used with an expected blood loss of between 500 and 1000 ml. If greater loss is anticipated, a washing system should be used.
- Most systems are cost-effective as they save the need for bank blood (which now costs over £130 per unit) in a worthwhile number of cases.
- There is some preliminary evidence that reinfusion of the unwashed drainage has a beneficial immuno-stimulatory effect and might reduce postoperative infections⁸.
- There is some evidence that this method of blood management is effective during primary hip replacement and this may become clearer with the advent of systems allowing both intra- and post-operative collection.
- Training of recovery and ward nursing staff in the use of these devices is essential.
- Most Jehovah's Witnesses find these systems acceptable.

Washed Cell Salvage Systems

- Systems are available for combined intra- and post-operative washed red cell salvage.
- The haematocrit of the reinfused blood is higher (approx 75%) than with unwashed systems.
- Larger volumes of blood can be returned to the patient than with unwashed systems but salvaged blood must not be reinfused more than 6 hours after the start of collection.

Transfusion Triggers

- Patients should not normally be transfused if the haemoglobin concentration is above 10g/dl.
- A strong indication for transfusion is a haemoglobin concentration below 7 g/dl.
- Transfusion will become essential when the haemoglobin concentration decreases to 5 g/dl.
- A haemoglobin concentration between 8 and 10 g/dl is a safe level, even for those patients with significant cardio-respiratory disease.
- Symptomatic patients should be transfused.
- There is little data on the effect of haemoglobin levels on postoperative mobilisation.
- It is appropriate to use a one-unit transfusion to exceed the transfusion threshold if necessary.

Post-operative Iron Therapy

- There is little evidence that the use of oral iron therapy in the immediate post-operative phase hastens the recovery of the patient's haemoglobin.

SUMMARY

- Post-operative cell salvage should be considered routinely in total knee arthroplasty.
- Washed systems may allow greater volumes of blood to be reinfused.
- Most stable patients without ischaemic heart disease should tolerate a post-operative haemoglobin of 8g/dl.
- Oral iron therapy is of no proven benefit in the immediate post-operative phase.

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APPENDIX 1

Example of local blood ordering schedule (this should be tailored to individual hospital practice)

PROCEDURE	PRE OP Hb >12g/dl males, >11g/dl for females (A)	MANDATORY 2 nd SAMPLE	CELL SALVAGE AVAILABLE	RED CELL UNITS CROSS MATCHED (B)	ELECTRONIC CROSS MATCH ready within 15 min (C)
#NOF	N	Y	N	2	Y
#NOF	Y	Y	N	0 (2)	Y
Primary TKR	Y	Y	Y	0 (2)	Y
Primary THR	Y	Y	N	0 (2)	Y
Bilateral or REV THR or TKR	Y	Y	Y	2 – as a guide, to be tailored for individual patient	Y
Bilateral or REV THR or TKR	Y	Y	N	4- as a guide, to be tailored for individual patient	Y
Shoulders or elbows	Y	Y	N	0	Y

(Y = yes, N = No)

A: Anaemic patients for elective surgery should be deferred pending investigation + treatment.

B: Figures in brackets indicate number of units cross-matched if cell salvage is not available, if the patient is chronically anaemic (eg Rheumatoid Arthritis) or if electronic issue not applicable.

C: Electronic issue is dependent on having two samples and having staff readily available to collect blood from blood bank

APPENDIX 2

An example of a protocol for the peri-operative management of patients already on oral anti-coagulation therapy

Indication	Pre-operative	Post-operative
Atrial Fibrillation	Stop warfarin 4 days pre-operatively. Admit 1 day prior to surgery and check INR on admission. Start Enoxaparin 40mg od s/c when INR <2.0.	Continue Enoxaparin and re-start warfarin at the maintenance dose on the day after surgery. When INR >2.0 on two consecutive days stop Enoxaparin.
Venous/Arterial Thromboembolic Disease	Stop warfarin 4 days pre-operatively. Admit 1 day prior to surgery and check INR on admission. Start Enoxaparin 40mg od s/c when INR <2.0.	Continue Enoxaparin and re-start warfarin at the maintenance dose on the day after surgery. When INR >2.0 on two consecutive days stop Enoxaparin.
Recent Arterial/Venous Thromboembolic Events (within 3 months)	Ideally, delay procedure for 8-12 weeks otherwise consider IV heparin peri-operatively. For surgery with recent DVT/PE consider using an IVC filter, discuss with Vascular Surgery/Radiology	
Prosthetic Heart Valves All patients should be discussed with cardiac surgery team prior to admission	Stop warfarin 4 days pre-operatively. Admit 2 days prior to surgery and check INR and APTT on admission. Start IV heparin when INR <2.5. Heparin dose: <ul style="list-style-type: none"> • Use weight-adjusted dose chart • No loading dose • Aim for APTT range 1.8-2.7 Discontinue IV heparin 6 hours pre-operatively. Check INR + APTT 2 hours pre-operatively and ensure results are satisfactory for the operation.	Re-start IV heparin 6 hours post-operatively. <ul style="list-style-type: none"> • No loading dose • Aim for APTT 1.8-2.7 Use dose range established pre-operatively. Re-start usual dose of warfarin on the day following surgery, stop heparin when INR >2.5 on two consecutive days. If high risk of post-operative bleeding may need to defer heparin until following morning to ensure adequate haemostasis and therefore delay re-starting warfarin.

APPENDIX 3

Standard operating procedures for intra-operative cell salvage

Indications:

Surgery in a clean operative field when anticipated blood loss is greater than 20% of blood volume or approximately one litre in an adult. For example, the technique is widely used during cardiac surgery, non-infected major joint revision arthroplasty, scoliosis surgery, aortic surgery and trauma surgery.

Contraindications:

- Patient declines the procedure.
- Contamination of the surgical field with faeces, urine or amniotic fluid.
- The presence of infection in the operative field.
- The presence in the operative field of malignant tumours with the potential for metastatic spread.
- Patients with sickle cell disease, trait and other red cell disorders.

Some of these contraindications are relative. For example, the use of cell salvage in the presence of tumours with the potential for metastatic spread remains controversial. Also, cell salvage has been used successfully during obstetric surgery. There may be situations where the potential benefit outweighs the unquantifiable risk ie the lack of allogeneic blood is life threatening. If blood is salvaged in these situations it should be reinfused through a log 5 cell filter.

Avoid collecting agents not intended for parenteral use, eg betadine/chlorhexidine, hydrogen peroxide, alcohol, distilled water, some antibiotics, fibrin adhesives, topical clotting agents (collagen, thrombin), bone cement.

During surgery this problem can be minimised by using two sets of suction apparatus, one to the cell salvage collection reservoir and the other to unsterile collection for disposal, and by ensuring that the surgical field is irrigated well with normal saline or a balanced salt solution before recommencing collection for cell salvage.

Conditions for use:

- Use of cell salvage should be discussed with the patient in advance (when possible) and this should be documented
- The cell salvage operator must have received specific training and be on a theatre register of trained operators.
- The responsible medical officer should be familiar with the clinical aspects of cell salvage.
- The equipment must be used in accordance with the manufacturer's instructions and salvaged blood packs must be clearly labelled with the patient's name, hospital number, date of birth and a 'use by' time.
- Beware dilutional coagulopathy and anaemia with large volume losses. Measure haematocrit/haemoglobin/coagulation profile during the procedure.

APPENDIX 4

Standard operating procedures for post-operative cell salvage

Indications:

Patients undergoing primary total knee replacement.

Contraindications:

- 1 Contamination of the surgical field by betadine, chlorhexidine, hydrogen peroxide, antibiotics or other agents not for parenteral use. NB the use of these agents intraoperatively is **not** a contraindication to post-operative cell salvage providing adequate lavage of the wound using physiological saline is performed prior to closure.
- 2 Surgical team, anaesthetist or nursing staff is unfamiliar with the use of the technique.
- 3 The patient refuses use of the technique.
- 4 Patients with sickle cell disease, trait and other red cell disorders.
- 5 The presence of infection or malignancy in the operative field.

Conditions for use.

- 1 No contraindication for use of the technique.
- 2 Use of the technique discussed with the patient in advance and documented.
- 3 The anaesthetist or surgeon takes responsibility for prescribing the salvaged blood.
- 4 Strict sterility, following the manufacturer's instructions.
- 5 Salvaged blood must not be reinfused more than 6 hours after the start of collection.
- 6 A 40micron blood filter must be used during reinfusion.
- 7 Do not reinfuse greater than 1200mls.
- 8 Label the bag with the patient's details.

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TERMS OF REFERENCE

The Council of the British Orthopaedic Association has approved guidance issued in this document. This information will be circulated to:

- BOA members, as a 'Blue Book', and via the BOA website
- Hospital Transfusion Committees
- Association of Anaesthetists
- British Blood Transfusion Society

This guidance will be reviewed every three years to ensure information is up-to-date.

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