Scottish Intercollegiate Guidelines Network

54

Perioperative Blood Transfusion for Elective Surgery

A national clinical guideline

THER OR NOT TO TRANSFUSE

to transfuse any patient for a given indication
e the risks of not transfusing, influenced for
disease prognosis, against the risks of
influenced for example by the probable
patient survival and the incubation time of
tive agents.

ntial risks, however small, each allogeneic
st have a valid, defined and justifiable

on for each transfusion should be documented in
records.
ynamically stable patient, one unit of concentrated
uld be transfused at a time, allowing the benefit of
ssessed at 24 hourly intervals.

leucodepleted allogeneic blood should not be
erns over increased cancer recurrence or
nfection.

l anaesthetic units should have protocols:
anticoagulated patients for all types of surgery
in thrombosis prophylaxis in the preoperative

CEDURAL ERROR

mmittee for Standards in Haematology
uideline for the administration of blood and

HAEMOGLOBIN TRANSFUSION THRESHOLDS

The transfusion threshold is the haemoglobin value at which transfusion will normally be indicated, under stable conditions, and in the absence of other clinical signs or symptoms of anaemia.

☑
- A transfusion threshold should be defined as part of an overall strategy to provide optimal patient management.
- The transfusion threshold should be viewed as the haemoglobin value below which the patient should not fall during the perioperative period, particularly in the context of ongoing or anticipated blood loss.

PREOPERATIVE THRESHOLDS

☑ All patients undergoing major elective surgery should have a full blood count performed prior to surgery, to avoid short-term cancellation and to allow those patients presenting with anaemia to be investigated and treated appropriately (e.g. iron therapy).

C **Where possible, anaemia should be corrected prior to major surgery, to reduce exposure to allogeneic transfusion.**

INTRAOPERATIVE THRESHOLDS

There is no indication that thresholds should differ during this period but the use of intraoperative transfusion must reflect the ongoing rate of surgical blood loss, continued haemodynamic instability, and anticipated postoperative bleeding.

POSTOPERATIVE THRESHOLDS

D C
- **Transfusion is required at haemoglobin values <70 g/l.**
- **Patients with cardiovascular disease, or those expected to have a high incidence of covert cardiovascular disease** (e.g. elderly patients or those with peripheral vascular disease)

PREDICTING THE NEED FOR TRANSFU

Nine risk factors which predict the need for a have been defined:

- low preoperative haemoglobin/haematoc intervention or on day of surgery
- low weight
- small height
- female sex
- age over 65 years
- availability of preoperative autologous bl
- estimated surgical blood loss
- type of surgery
- primary or revision surgery.

BLOOD ORDERING EQUATIONS

Blood ordering schedules relate the ordering that a transfusion will be required, taking i operation and an individual patient's risk fact

C
- All hospitals should use a maximum s schedule to provide concentrated red
- When ordering blood, all nine factors and degree of transfusion should be t example by using Mercuriali's formul

MERCURIALI'S FORMULA

Expected blood loss	=	Preoperative red cell volume	-	Postopera red ce volume

ous blood donation (PABD) can be used to
od exposure, although it does increase the
sfusion episodes.

ous blood donation should be offered
le to guarantee admission and operative

eted to:
with haemoglobin 110-145 g/l
ent with haemoglobin 130-145 g/l.

fely in elderly populations with diverse

g surgical procedures currently served by
olicy is unsuitable for preoperative

imary hip and knee surgery with a presenting
g/l should be discouraged from autologous

ould be targeted to patients aged under
eduled for major blood losing surgery and
g haemoglobin < 130 g/l.

e used to prepare patients with objections
sion for surgery that involves major blood

ngs about a >0.50 rise in the patient's
l venesection should be undertaken.

ACUTE NORMOVOLAEMIC HAEMODILUTION (ANH)

ANH is potentially most useful for a patient meeting all of the following criteria:

- a substantial anticipated blood loss
- a relatively low target haemoglobin (intraoperatively and postoperatively)
- a relatively high initial haemoglobin.

D **ANH should be limited to patients with a haemoglobin level sufficiently high to allow 1,000 ml of blood to be removed, and in whom a relatively low target haemoglobin is deemed appropriate.**

☑
- ANH should only be implemented where the logistics of blood removal and replacement can be undertaken without detracting from patient care.
- Hospitals considering ANH must address organisational issues, including the provision of appropriate support to the anaesthetist.
- Autologous blood should be labelled and stored according to the British Committee for Standards in Haematology blood transfusion guideline, with particular care being taken where autologous blood transfusion is initiated postoperatively.

- procedures with an increased risk of *(e.g. bilateral and revision)*
- circumstances when other blood conser are not appropriate *(e.g. treatment of Jeh*

- Tranexamic acid can be used to reduce bloo transfusion requirements in patients under replacement surgery, when other blood cor techniques are inappropriate and where ma anticipated.

CELL SALVAGE

C **Reinfusion of washed shed mediastinal blood r reduce allogeneic transfusion in cardiac surger**

D **In orthopaedic surgery, unwashed postoperativ drains should be considered in patients in who postoperative blood loss of between 750 ml a expected** (e.g. bilateral joint replacement).

B **In orthopaedic surgery, washed intraoperative be considered in patients in whom an intraope of more than 1,500 ml is anticipated** (e.g. majo or uninfected revision surgery).

Cell salvage using either unwashed or washed r may be considered as a means of significantly r of exposure to allogeneic blood.

KEY A B C D Grade of recommend

☑ Good practice point

ENCE

ty meta-analyses, systematic reviews of RCTs, or RCTs with a very
bias

ucted meta-analyses, systematic reviews, or RCTs with a low risk of bias

yses, systematic reviews, or RCTs with a high risk of bias

ty systematic reviews of case control or cohort studies
ty case control or cohort studies with a very low risk of confounding or bias
probability that the relationship is causal

ucted case control or cohort studies with a low risk of confounding or bias
erate probability that the relationship is causal

ol or cohort studies with a high risk of confounding or bias
ificant risk that the relationship is not causal

tic studies, e.g. case reports, case series

ion

OMMENDATION

e meta-analysis, systematic review, or RCT rated as 1^{++}
y applicable to the target population; *or*

evidence consisting principally of studies rated as 1^{+}, directly applicable to
opulation, and demonstrating overall consistency of results

evidence including studies rated as 2^{++}, directly applicable to the target
, and demonstrating overall consistency of results; *or*

ed evidence from studies rated as 1^{++} or 1^{+}

evidence including studies rated as 2^{+}, directly applicable to the target
and demonstrating overall consistency of results; *or*

ed evidence from studies rated as 2^{++}

evel 3 or 4; *or*

ed evidence from studies rated as 2^{+}

E POINTS

nded best practice based on the clinical experience of the guideline
nt group

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psilon-aminocaproic acid
acute normovolaemic haemodilution
oronary artery bypass surgery
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ariant Creutzfeldt-Jakob disease

1.1 THE NEED FOR A GUIDELINE

The importance of blood transfusion in the development of modern surgery anc safe performance of major operations cannot be overstated. Without blood a thousands of surgical procedures could not be performed safely. However, goc and outcome data establishing the benefits and risks of transfusion for a patient i setting are not available. Nor are there good data on the optimal haemoglobin (H for recovery and rehabilitation following specific surgical interventions.

It is now seven years since variant Creutzfeldt-Jakob disease (vCJD) was first des with a total of 101 cases recorded to the end of June 2001.[2] How far this rare but spread in society is not known, making its impact on medical practice gen transfusion in particular, difficult to predict. Precautionary measures such as th donor plasma from fractionation, and the universal leucodepletion of all bloc have been introduced to minimise the spread of vCJD by transfusion, but th discounted and remains a serious cause of concern for all who prescribe blooc

1.2 OBJECTIVE OF THE GUIDELINE

This guideline aims to provide a rational and practical framework on which tc decisions and practice. It aims to maximise patient safety by:

- helping clinicians to decide when allogeneic red cell transfusion is appropr
- minimising the avoidable risks of transfusion
- helping clinicians to provide appropriate advice on options for treatment, ir patients are anxious about the risks of transfusion.

The guideline also provides more detailed information for cardiac and orthopae as the major users of red cells.

The provision of clear verbal and written information about the risks and ben blood transfusion is emphasised as good clinical practice. Whenever possib transfusion should be discussed with the patient in advance of need, to allow their delivery to be put in place.

This guideline and its recommendations do not address the emergency man blood loss, but could affect the decision to transfuse once the patient has been s does the guideline address perioperative blood transfusion in paediatric surger

1.3 USE OF DONOR BLOOD IN ELECTIVE SURGERY

In the UK, transfusion of donor (allogeneic) red blood cells (RBCs) remains th management of the patient who has, or is considered to be at risk of, major s Over 313,000 units of concentrated red cells (CRCs) were issued in Scotla majority of patients transfused are aged over 65 years.

Although there are no national figures for the number used for all elective surge the actual number of units of red cells transfused in the South Glasgow Univers Trust during the year 2000. Over 50% of red cells transfused were prescrib specialties, though the increasing use of standard and high dose chemotherap steady rise in medical, oncological and haematological transfusion. The most v bank computer systems do not discriminate between blood used in an emergenc part of an elective surgical programme. A 1996 Canadian survey indicated that

	Cross-matched units	Transfused units	C:T ratio*	Specialty usage (% total units transfused
d vascular	4,035	2,468	1.6 :1	18%
ics	4,110	1,983	2.1 :1	14%
ery	3,340	1,123	2.9 :1	8%
	616	343	1.8 :1	2.5%
cal	-	1,454	-	10.5%
	515	159	3.2 :1	1%
gy	407	297	1.4 :1	2%
gy	3,287	3,040	1.1 :1	22%
edicine cs	3,832	3,021	1.3 :1	22%

ed to transfused ratio (see section 4)

N IN TRANSFUSION PRACTICE

ts show variation in transfusion practice for comparable groups of surgical patients spitals.[5,6,7] Blood use audits in Scotland show that large variations also exist among ractitioners or operating teams within a hospital.[6] Variations in rates of transfusion to many factors, including differing opinions on the threshold level of haemoglobin n a patient needs to be transfused, differences in surgical and anaesthetic techniques, ces in casemix. The first may reflect uncertainty about the relative benefits and risks of and the second different perceptions of the value of minimising blood loss and transfusion.

ive cohort study of hip fracture patients with significant comorbidities used a statistical ke account of the clinical variables in this patient population.[8] Existing variations in ractice between university, teaching and community hospitals changed as more variables ced into the model. In the final analysis, despite making allowance for these variables, practice variation remained. Therefore, extreme care is required in interpreting variation n practice.

ce of controlled trials on the risk and benefits of transfusion there is no "ideal transfusion ven operation such as hip replacement. Analysis cannot determine which hospitals t transfusion practices, only whether transfusion rates are high or low.

ND UPDATING

ne was issued in October 2001 and will be considered for review in 2004, or sooner nce becomes available. Any updates to the guideline will be available on the SIGN w.sign.ac.uk.

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The risk of transfusion in terms of morbidity and mortality is not known, ma impact of a transfusion can be impossible to separate out in complex clinical c potentially life saving operation can only be undertaken with transfusion suppo transfusion are likely to far outweigh the risks. In contrast, a postoperative tra raise haemoglobin level in a stable patient may provide little or no clinical b transfusion risk, although small, may not be balanced against any predictable b

Confidential reports of more serious complications and transfusion-related deat part of the Serious Hazards of Transfusion (SHOT) scheme which covers a subst of all UK red cell transfusions, amounting to three million units per annum (se

Table 2: Transfusion transmitted infections reported to SHOT

	1995	1996	1997	1998	1999
Hepatitis A	-	1	-	-	-
Hepatitis B	1	1	-	2	1
Hepatitis C	-	1	-	1	1
HIV	-	3	-	-	-
Bacteria	1	1	3	1	5
Malaria	-	-	1	-	-

2.1 TRANSFUSION TRANSMITTED INFECTIONS

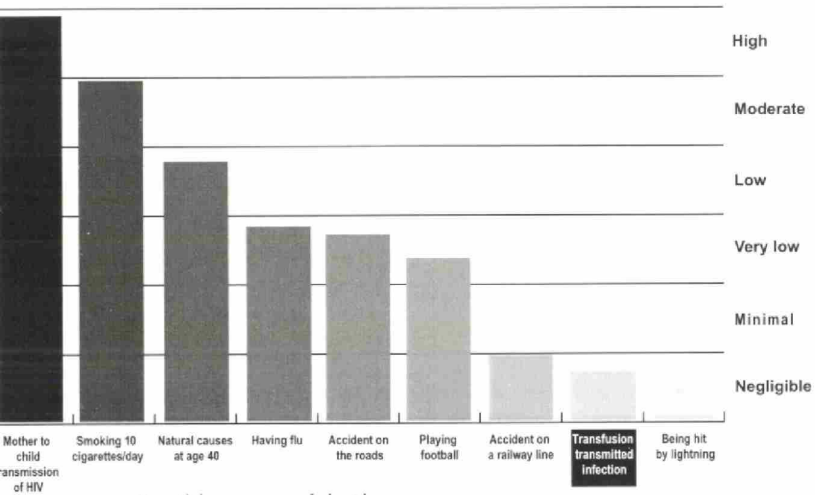
2.1.1 VIRAL

Since 1996, only 12 incidents of viral infection have been recorded.[9-12] Given this ve direct assessment of transfusion transmitted infection (TTI) by virus is difficult a the development of mathematical models. The total TTI risk has been estim 1:100,000 and 1:1,000,000 in the American population.[14] The European Prot Association, analysing retrospective data from the US, Australia and Europe, fou donors seroconversions are detected as follows: 1:2,323,778 for anti-HIV scree for anti-hepatitis C (HCV), and 1:398,499 for hepatitis B (HBV).[15]

A study prospectively following up 20,000 units transfused in the UK in 5,57 nine month period detected no transfusion-associated episodes of human T-ly (HTLV), HIV, HCV or HBV. The risks of viral TTI should be regarded as be minimal compared to other life risks[16] *(see Figure 1)*.

2.1.2 BACTERIAL

SHOT has recorded 10 significant episodes of bacterial TTI over the last four ye associated with platelet therapy. In 1998/9 two fatalities occurred, one due to *Yersir* the other to *Escherichia Coli*, indicating a high mortality from a rare compl Zealand between 1992 and 1997 *Y. Enterocolitica* infection led to eight transfu infections resulting in four deaths.[17] This incidence of 1:65,000 transfusions is 1:500,000 infection rate reported in the US.[18] In both countries there was a si onset of symptoms and a high mortality, at 12 out of 20 reported cases. The



Possible causes of death

MMUNE INJURY

five major transfusion reactions (acute and delayed) in 1999, three of which were er syndromes, such as post-transfusion purpura, transfusion-related acute lung injury sion-associated graft versus host disease, were collectively responsible for eight deaths 3
0 serious transfusion incidents. These complications could not have been predicted, rly recognition and appropriate therapy might help to reduce the associated morbidity.

OMODULATION

atory setting, allogeneic blood has been shown to have the capacity to depress immune [23] an effect mediated mainly by transfused white blood cells.[20,21,24,25] 3

ner with concern over the potential for increased risk of cancer recurrence[26-28] when allogeneic blood in the perioperative period, has historically led to some surgeons conservative transfusion policy. 2+

d controlled trials using both leucodepleted and autologous blood have not demonstrated in either the risk of cancer recurrence or of infection.[29-31] Attempts to demonstrate this linical context have been confounded by the difficulty of establishing an appropriate up. In addition, any risk of postoperative infection is likely to be minimised by the tion process.

lysis[32] of three randomised[33-35] and two cohort studies[36,37] where control groups received odepleted or autologous blood transfusion found no significant difference in cancer . Due to the small number of patients taking part in trials, the meta-analysis was tly powerful to detect a difference of less than 20% in risk. The inability of these exclude a small effect is of less significance now that leucodepletion of blood for is universal in the UK. 1+

nsfusion of leucodepleted allogeneic blood should not be limited by concerns over eased cancer recurrence or perioperative infection.

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The blood transfusion process can be complex and crosses many disciplines an study identified over 40 steps between the patient and their transfusion, all potential human error.[38] When an error leads to the incorrect administratio blood, the consequences can be disastrous. It has been suggested that in the occurs in approximately 1:24,000 transfusions.[39] SHOT estimates that in the affects around 1:25,000 transfusions. This reduces to 1:67,000 if only serious considered.[12]

Given the paucity of data and the lack of evidence about safe systems o administration should follow best practice as set out in the British Committe Haematology (BCSH) guideline, with educational initiatives undertaken to e safe protocols by staff.[40,41]

D **The BCSH collaborative guideline for the administration of blood and b and management of transfused patients should be implemented in all where transfusion takes place.**

☑ A final check of the patient's wrist identity band against the identity g component to be transfused is essential for safe practice.

2.5 ALL RISKS

Overall, the total risk from blood transfusion in Scotland is low, at approxim per 12,000 transfusions (derived from SHOT reports).[9] Serious complications, su haemolysis, transfusion-induced coagulopathy, renal impairment and failure, adr care, persistent viral infection, and death, occur at a rate of 1 in 67,000 trans SHOT scheme started in 1996, 47 deaths have been reported that were associate Over the same period more than 12 million blood components were issued in

The actual contribution of transfusion morbidity and mortality for an individua to evaluate, mainly as the direct impact of a transfusion can be impossible to as factors include:

- **Patient factors:** age, preoperative haemoglobin, general health (e.g. base Society of Anesthesiologists preoperative risk score, which assess comorbi surgery).[42]
- **Surgical factors:** type and complexity of surgery, duration of anaesthesia, p expertise of surgeon.
- **Type of illness**: local or systemic, benign or malignant.

In the past, infections caused by HBV, HCV, and HIV were the main causes of In each case, once the causal agent was identified, procedures were introduced from infection. Unfortunately, by the time preventive testing had been introduce had been infected.

Nowadays the risk of contracting HBV, HCV or HIV from blood transfusio *section 2.1.1)* and probably falling. Other viruses such GB virus C, human her virus still need to have their transmissibility assessed and their prevalence in the established, although none has yet been relevant to transfusion practice.[43]

No transmission of variant Creutzfeldt-Jakob disease (vCJD) by transfusion documented. The four UK Departments of Health have instituted major precau including the exclusion of UK donor plasma from fractionation, and the introd leucodepletion of all blood prepared for transfusion. Such well-publicised ac protect the public, may well have increased awareness and concern about transfusi

ndication for each transfusion should be documented in the patient's records.

haemodynamically stable patient, one unit of concentrated red cells should be used at a time, allowing the benefit of each to be assessed at 24 hourly intervals.

NOT BEING TRANSFUSED

od transfusion becomes, the more the risk of not transfusing blood must be considered, f perioperative anaemia. The rate of fatal complications due to anaemia in 16 reports al management in Jehovah's Witnesses ranges between 0.5% and 1.5%.[44]

nt retrospective survey of a similar patient population indicates that, if confounding ken into consideration, mortality does not increase as the haemoglobin (Hb) falls to is not possible to comment on mortality changes at Hb levels below 80 g/l, as 90% nts receive transfusions. Evidence from observational studies suggests that the elderly tients suffering from cardiovascular and peripheral vascular disease are less tolerant of e anaemia and should therefore be transfused at a higher haemoglobin level threshold for transfusion).[45] 2+

to transfuse any patient for a given indication must balance the risks of not transfusing, or example by disease prognosis, against the risks of transfusion, influenced for he probable duration of patient survival and the incubation time of known infective

TIVE ANTICOAGULANT THERAPY

nt of patients with atrial fibrillation with oral anticoagulant therapy is becoming common. In addition, outpatient management of patients with thromboembolic g low molecular weight heparin is also widely practised. Both of these medications isk of thrombosis by prolonging clotting times. Their principal complication is to risk of haemorrhage. Patients on either of these treatments who present for surgery for oagulant dose attenuation is required should have their doses modified in good time, r to surgery, to reduce the risk of increased blood loss.[46,47] 4

rgical and anaesthetic units should have protocols:

prepare anticoagulated patients for all types of surgery

r deep vein thrombosis prophylaxis in the preoperative period.

o given in the SIGN guideline on prophylaxis of venous thromboembolism, which ection on the management of anticoagulation in the perioperative period.[48]

9.4.1 NATIONAL OPEN MEETING

A national open meeting is the main consultative phase of SIGN guideline develo the guideline development group presents their draft recommendations for th national open meeting for this guideline was held at the Royal College of Physici on 30th May 2000. The draft guideline was also available on the SIGN web period at this stage to allow those unable to attend the meeting to contribute to of the guideline.

9.4.2 SPECIALIST REVIEW

The guideline was reviewed in draft form by a panel of independent expert ref asked to comment primarily on the comprehensiveness and accuracy of inte evidence base supporting the recommendations in the guideline. SIGN is very these experts for their contribution to this guideline.

Professor James AuBuchon	*Professor of Pathology, Dartmouth-Hitchcock M New Hampshire, USA*
Dr James Beattie	*General Practitioner, Inverurie*
Mr Ivan Brenkel	*Consultant Orthopaedic Surgeon, Queen Margaret Hospital, Dunfermline*
Dr Alex Colquhoun	*Consultant Anaesthetist, Glasgow Royal Infirma*
Dr John Colvin	*Consultant Anaesthetist, Ninewells Hospital, D*
Dr Michael Desmond	*Consultant Anaesthetist, Liverpool NHS Trust, L*
Mr Alan Faichney	*Consultant Cardiac Surgeon, Western Infirmary,*
Mr Eric Gardener	*Consultant Orthopaedic Surgeon, Victoira Infirm*
Professor Tim Goodnough	*Professor of Medicine in Pathology, Washington University School of Medicine, US*
Professor Michael Greaves	*Professor of Haematology, University of Aberde*
Dr Mike Higgins	*British Heart Foundation Senior Lecturer in Card Honorary Consultant Anaesthetist, Glasgow Roy*
Mr Richard Holdsworth	*Consultant Vascular Surgeon, Stirling Royal Infir*
Dr Paul Kelsey	*Consultant Haematologist, Victoria Hospital, Bl*
Dr Harry MacFarlane	*Consultant Anaesthetist, Aberdeen Royal Infirm*
Mr Ian McLean	*Consultant Orthopaedic Surgeon, Dumfries & Galloway Royal Infirmary*
Mr John Martin	*Senior Assistant Editor, British National Formul*
Mr John Newman	*Consultant Orthopaedic Surgeon, Bristol Royal*
Professor Martin Pippard	*Professor of Haematology, Ninewells Hospital & Medical School, Dundee*
Dr Lorna Williamson	*Consultant in Transfusion Medicine, East Anglia Blood Centre, Cambridge*

9.4.3 SIGN EDITORIAL GROUP

As a final quality control check, the guideline is reviewed by an Editorial Grou relevant specialty representatives on SIGN Council to ensure that the peer revie have been addressed adequately and that any risk of bias in the guideline develo a whole has been minimised. The Editorial Group for this guideline was as foll

Dr Douglas Adamson	*Junior Doctor representative*
Dr Doreen Campbell	*CRAG Secretariat, Scottish Executive Departmer*
Dr Patricia Donald	*Primary Care Adviser to SIGN*
Mr Douglas Harper	*Royal College of Surgeons of Edinburgh*

UCTION

collaborative network of clinicians, other health care professionals, and patient
ns, funded by the Clinical Resource and Audit Group (CRAG) of the Scottish Executive
artment. SIGN guidelines are developed by multidisciplinary groups using a standard
gy, based on a systematic review of the evidence. Further details about SIGN and the
velopment methodology are contained in *SIGN 50: A guideline developer's handbook*,
www.sign.ac.uk.

DELINE DEVELOPMENT GROUP

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lor	*Patient representative, Innerleithen*
Welch	*Consultant Vascular Surgeon, Southern General Hospital, Glasgow*

TIC LITERATURE REVIEW

e base for this guideline was synthesised in accordance with SIGN methodology. A
eview of the literature was carried out using an explicit search strategy devised by the
nation Manager in collaboration with members of the guideline development group.
re restricted to systematic reviews, meta-analyses, and randomised controlled trials.
ting to children; blood plasma, leukocyte, or platelet transfusions; emergency surgery;
niques; and national strategies for transfusion services was specifically excluded from
Internet searches were carried out on the Web sites of the Canadian Practice Guidelines
New Zealand Guidelines Programme, and US National Guidelines Clearinghouse.
re also carried out on the search engines Northern Light and OMNI, and all suitable
d up. Database searches were carried out on Cochrane Library, Embase, Healthstar,
from 1985 - May 1999. A number of ancillary searches were carried out on specific
uring the guideline development process. The Medline version of the main search
notes on the coverage of ancillary searches can be found on the SIGN website, in the

The transfusion threshold is the haemoglobin value at which transfusion will norr
under stable conditions and in the absence of other clinical signs or symp
Transfusion should be limited to the smallest amount of blood required to lift
the transfusion threshold. Each hospital laboratory has its own definition of a
the normal range for the local population.

☑ A transfusion threshold should be defined as part of an overall strategy t
patient management.

☑ The transfusion threshold should be viewed as the haemoglobin value
patient should not fall during the perioperative period, particularly
ongoing or anticipated blood loss.

3.1 PREOPERATIVE

Preoperative anaemia increases the likelihood of allogeneic transfusion [49] and sho
and, where possible, corrected prior to major elective surgery (in this context m
to procedures for which blood is routinely grouped preoperatively). Howeve
evidence available on appropriate preoperative haemoglobin concentrations. Wh
a blood transfusion, preoperative haemoglobin is an important determinant of o
particularly in patients with ischaemic heart disease.[49-51]

☑ All patients undergoing major elective surgery should have a full blood
prior to surgery to avoid short term cancellation and to allow those p
with anaemia to be investigated and treated appropriately (e.g. iron the

C **Where possible, anaemia should be corrected prior to major surgery to
to allogeneic transfusion.**

3.2 INTRAOPERATIVE

When there is ongoing surgical blood loss, haemoglobin measurements shoulc
the context of a multifaceted clinical assessment, which should include clin
blood volume status. There is no indication that thresholds should differ durir
the use of intraoperative transfusion must reflect the ongoing rate of surgical bloc
haemodynamic instability, and anticipated postoperative bleeding.[52]

Accurate measurement of intraoperative blood loss is difficult, although during
bypass (CPB) frequent haematocrit evaluations are available. Two large prospec
studies of patients undergoing CPB for primary coronary artery bypass graft (CA
postoperative mortality and severe ventricular dysfunction were related to low h
bypass. Though both studies showed increased risk when the haematocrit fell l
was no agreement about the safe critical haematocrit value that indicat
transfusion.[53,54]

Rapid intraoperative measurement of haemoglobin levels using near patient tes
safety margins and avoid unnecessary transfusion.[55,56] Prospective assessmen
these new techniques during the intraoperative and immediate postoperative p
required.

natic reviews,[52,57,58] five randomised controlled trials,[59-63] seven cohort studies[45,49-51,64-66] onsensus statements [67-73] were judged to be of an appropriate standard for inclusion in base for the guideline. All trials and studies were performed using non leucodepleted differences in haemoglobin and/or transfusion thresholds were described in relation perative and postoperative periods only. However, no trial or study has examined hresholds in patients with chronic disease undergoing elective surgery so it has not e to make evidence-based recommendations for this group of patients.

t 12 years, guidelines and consensus statements have consistently expressed the hreshold as a range, usually between 70 and 100 g/l haemoglobin, with clinical rther defining the need for allogeneic transfusion in between.[67,69,73] 4

[4] found a statistically significant increase in postoperative myocardial infaction (MI) ients whose haematocrit was greater than 0.33 on the first postoperative day. However, confirmed by a retrospective assessment of a similar postoperative CABG population lespite the fact that both studies had a similar overall mortality and postoperative MI idence was found to suggest that cardiovascular function is improved at haemoglobin 0 g/l. 2+

fusion is unjustified at haemoglobin levels > 100 g/l.

d experimental data and expert opinion were identified on which to base a ation on the lower limit of haemoglobin below which transfusion should take place. l data from healthy animals indicates that electrocardiogram (ECG) changes of schaemia appear at haemoglobin levels below 50 g/l.[75] Dogs with experimental stenoses nary artery circulation developed ECG and functional changes at Hb 70 g/l.[76] During mic haemodilution in healthy fit resting adults it has been shown that adequate delivery as sustained down to a haemoglobin of 50 g/l.[77]

consensus statements[58] supported a lower limit of 70 g/l and also suggested that cardiovascular problems should have this limit raised to 80 g/l. A large retrospective ical patients confirmed that, allowing for confounding factors, there was no difference using a lower threshold of either 80 or 100 g/l.[45] No conclusions could be drawn ower threshold, as 90% of patients were transfused at Hb < 80 g/l. 4

sfusion is required at haemoglobin levels < 70g/l.

nce exists on which to base an upper limit for the transfusion range. The largest controlled trial (RCT) of transfusion thresholds was performed in over 800 patients intensive care.[63] Patients were randomised to a conservative (70-90 g/l) or liberal) threshold and no difference in 30 or 60-day mortality was found. In addition, there ficance difference in severe ventricular dysfunction, with the overall mortality in this exceeding 20%. 1+

nalysis indicated that patients under 55 years of age, or with less severe disease, had better survival using the conservative policy, but clearly this requires care in n. A large number of patients (598) were not entered in the study because of physician ddition, caution should be applied before extrapolating observations in patients in a context to patients having routine surgery, as the patients' characteristics, patterns of nd mortality and levels of physiological monitoring are all different.

tudy,[62] 428 low risk CABG patients were randomised to a restrictive (< 80 g/l) or 0 g/l) transfusion policy. No difference in mortality, postoperative MI, or significant complications was seen, nor was there any significant effect on patient rehabilitation. tatistically significant lower volume of red blood cells were transfused in the restrictive 1+

1. Development of improved computer programmes for routine hospital blood blood use for given surgical operations to be measured.
2. Prospective study of the effect of haemoglobin/anaemia on the rate of recov hospital stay after operation.
3. Large randomised controlled studies comparing different blood conservation st economic assessments.
4. A large prospective randomised control trial of the use of aprotinin with mor infarction and transfusion as primary outcomes.
5. A prospective controlled trial evaluating the therapeutic effect of increasing preoperatively in anaemic patients.
6. A randomised controlled trial examining the safety aspects and potential bene acid used as part of an overall blood conservation package in orthopaedic s
7. Prospective assessment of near-patient haemoglobin techniques in the operati postoperative period.

8.4 KEY MESSAGES FOR PATIENTS AND THE PUBLIC

These key messages are not intended for direct dissemination to patients, bu possible use by clinicians in discussing treatment options with patients who are transfusion. They may be incorporated into local patient information materials

- The risks from blood transfusion have never been lower, the risk of any adver small, at 1 in 12,000, less than the risk of being killed in a road traffic acc from flu.
- No transmission of variant Creutzfeldt-Jakob disease by transfusion has yet b and the risk of contracting HBV, HCV or HIV from blood transfusion is m
- Blood transfusion remains essential for the continued safe performance of m 300,000 units of blood are issued for use in Scotland every year.
- "Bloodless surgery" does not imply safer surgery. The fact that profound tolerated perioperatively does not mean that it is advisable or acceptable.
- In a healthy patient, mild degrees of anaemia are well tolerated and transfusio
- Autologous donation is only appropriate for surgical patients undergoing m operations, where there is a likelihood that it will be used. If a patient's hae greater than 145 g/l then for most common operations autologous blood shoul as 90% would only be discarded.
- Improvements in the quality of transfused blood, by, for example, the remo cells, eliminate the theoretical risk that transfusion might lead to canc postoperative infection.

PLEMENTATION

ion of national clinical guidelines is the responsibility of each NHS Trust and is an
of clinical governance. It is acknowledged that every Trust cannot implement every
mediately on publication, but mechanisms should be in place to ensure that the care
eviewed against the guideline recommendations and the reasons for any differences
, where appropriate, addressed. These discussions should involve both clinical staff
ment. Local arrangements may then be made to implement the national guideline in
ospitals, units and practices, and to monitor compliance. This may be done by a
eans including patient-specific reminders, continuing education and training, and
t.

ion of the guideline and compliance with the Scottish Office MEL Executive (1999)9
Transfusion[173] depends not only on the commitment of clinicians but also the support
nospital managements to provide organisational resource to enable:

sion assessments 3-6 weeks before operation

o be given fixed admission dates if pre-donation or preoperative erythropoietin therapy
agreed

ty of erythropoietin for the limited number of patients in whom it is clearly indicated

ty of blood salvage equipment where caseload is shown to justify its use

ty of suitable anaesthetic support if ANH is being used

audit of transfusion practice locally through the hospital Blood Transfusion Committee

audit of transfusion practice nationally

f all staff involved in the transfusion process.

TS FOR AUDIT

AUDIT

consistent method for collecting information on blood use.

l audit of blood requirements in cardiac and orthopaedic surgery.

quirements for revision hip in Scotland.

tion in the use of blood between hospitals and between operating teams.

a national transfusion register recording:

Erythropoietin

e effects of autologous transfusion.

DIT

of blood used per surgeon per operation:

of surgeon

operation.

tched to transfusion ratio.

ive Hb.

ative/target Hb.

ve audit of discharge haemoglobin in patients undergoing major blood losing surgery.

nce and timing of preoperative Hb check

< 80 g/l compared with patients whose haemoglobin was maintained above 1
small randomised trial in patients undergoing elective vascular reconstruction fo
in mortality or morbidity when comparing a transfusion threshold of 90 g/l to
group of patients in whom the incidence of cardiovascular disease would be ex
high. However, both trials had inadequate analytical power to show signific
mortality/myocardial events.

A small observational study of similar patients found an increase in myocardi
myocardial events in patients with a postoperative haemoglobin < 90 g/l. An in
of myocardial ischaemia was also detected in an observational cohort study
undergoing radical prostatectomy when their haemoglobin fell below 90 g/l.

A further retrospective subgroup analysis of the original Transfusion Requiremer
(TRICC) study population[63] identified 357 patients who had a primary or secor
cardiovascular disease, or where cardiovascular disease represented a sign
condition.[78] Despite having a significantly different mean haemoglobin compared
(85 v 103 g/l), there was no difference in 30 or 60 day mortality, nor in ventricul
with the original study,[63] the authors felt that particular care should be exercis
had significant peripheral vascular disease, recent MI, or unstable angina.

C **Patients with cardiovascular disease, or those expected to have covert card**
(e.g. elderly patients or those with peripheral vascular disease) **are likel**
transfusion when their haemoglobin level falls below 90 g/l.

RS OF ALLOGENEIC TRANSFUSION

ne risk factors which predict the need for allogeneic transfusion has been defined in dies covering a heterogeneous population (with regard to case-mix and comorbidity) 00 patients, including a wide variety of surgical procedures.[5,79-82] All the studies made educe confounding factors and were remarkably consistent in the risk factors found to evels of statistical significance.

etermining risk of allogeneic transfusion are:[5,79-82]

perative haemoglobin/haematocrit, either before intervention or on day of surgery
ht
ght
x
65 years
ty of preoperative autologous blood donation (PABD)
l surgical blood loss
rgery
r revision surgery.

ordering blood, all nine factors determining the risk and degree of transfusion d be taken into account, for example by using Mercuriali's formula *(see below).*

RDERING EQUATIONS

SURGICAL BLOOD ORDERING SCHEDULE

behind blood ordering schedules is to relate the ordering of blood to the likelihood sion will be required. At a simple level this is done through a maximum ordering ted to the type of operation, but this has been extended to try and take account of an tient's risk factors *(see section 4.2.2)*.

rgical blood ordering schedules (MSBOS) have been introduced in Scotland by most sfusion departments. Each surgical operation is allocated a tariff of transfusion, which by national and hospital practice but locally agreed by clinicians and blood providers. he number of units of crossmatched red cells for a given operation to the number of transfused – the C:T ratio – should not exceed 2:1.[83,84]

S, patients for whom the likelihood of blood transfusion is less than 30% do not rossmatched but instead have their blood group established and their serum checked s. This "group and save" provision allows rapid blood delivery in an emergency. The ch surgery can be covered by this provision largely depends on practical, local issues, istance between operating theatre and transfusion department.

BOS has improved the efficiency of blood ordering,[83] it does not account for individual transfusion requirements between different patients undergoing the same surgical MSBOS cannot identify over-transfusion, nor does it impact on institutional variation practice.

spitals should use a maximum surgical blood ordering schedule to provide concentrated lls.

been excluded. There is considerable capital cost for the basic equipment nee washed cell salvage, although the costs of disposables are similar to those involved of unwashed red cells.

B **Washed intraoperative salvage should be considered in patients in whom blood loss of more than 1,500 ml is anticipated** (e.g. major pelvic, spin revision surgery).

The recent introduction of small battery powered red cell recovery and washi the same disposable equipment to be utilised during and after a procedure. T relatively economical intra- and postoperative salvage.

A meta analysis[88] of the effectiveness of cell salvage in minimising periope transfusion concluded that, in orthopaedic surgery, devices producing either was cells decreased the frequency of exposure to allogeneic blood to a similar degre with a control.

B **In orthopaedic surgery, cell salvage using either unwashed or washed re be considered as a means of significantly reducing the risk of expos blood.**

acid has been used at 10-15 mg/kg prior to release of the tourniquet. As tranexamic alf-life of two hours[155] there are theoretical advantages to administering further doses vely. One study continued tranexamic acid eight hourly for three days, but the majority r treatment at either three, three and six hours, or as an infusion for 12 hours vely.[154-156]

evidence suggesting any benefit from limiting the use of tranexamic acid to the ve period to control bleeding.[160]

ONS

sed controlled trials[156-161] have investigated the effect of tranexamic acid, given prior et release, on blood loss and blood transfusion requirement in patients undergoing y. These show a reduction in blood of between 43% and 54%, as well as a significant n both the total number of units transfused and the number of patients exposed to lood.

otinin, the major concern with tranexamic acid is the potential risk of thrombosis.[158,162] mall study was identified that had routinely screened patients for DVT and only by No increase in DVT was demonstrated. None of the other studies[156-161] reported an linically detected DVT, although one did show a trend to an increase in both clinically d venographically proven DVT in the treated patients.[159] The introduction of tranexamic utine practice must await larger and more comprehensive studies of its safety in patients.

examic acid can be used to reduce blood loss and transfusion requirements in patients rgoing knee replacement surgery, when other blood conservation techniques are propriate and where major blood loss is anticipated.

ESSIN

e was identified to support the use of desmopressin (DDAVP) in routine orthopaedic educe bleeding. It has a major role to play in patients with defined coagulopathies Willebrand's disease and haemophilia, but these patients should be treated under the an experienced haematologist in a recognised haemophilia centre.

AGE

e retransfusion of blood from wound drains uses unwashed blood which is filtered to ger cell aggregates but not bacteria.[163-165] There have been some reports of coagulation lowing reinfusion of large volumes.[166,167] Duncan[168] recommended that no more than alvaged blood should be reinfused. Due to the risks of infective colonisation, salvaged d not normally be reinfused later than six hours following collection.

rs have questioned the use of this technique in unilateral arthroplasty due to the all amounts of blood obtained.[169,170]

shed postoperative salvage using drains should be considered in patients in whom a perative blood loss of between 750 ml and 1,500 ml is anticipated (e.g. bilateral replacement).

nique is the intraoperative collection of cells which are washed prior to retransfusion.[171] on with postoperative salvage, large volumes can be transfused without significant tient.[172]

Using basic physiological principles, simple equations can be derived which in risk factors for transfusion directly and can be altered by others:[85,86]

Blood loss = Circulating red cell volume reduction (preop to postop) + Red ce

Larocque[87] used the risk factors listed in section 4.1 to allocate points for preopera weight in kg, type of surgery (knee versus hip) and primary or revision. A sco meant a high risk of allogeneic transfusion. When prospectively applied, th appeared to work in practice, with a high point score being associated with allogeneic transfusion rates.[88] When a similar formula was used in 250 co prostatectomies, a very close relationship was found between the equation-deriv and the calculated blood loss in theatre. No relationship was found between op blood loss estimates and actual blood loss.[85]

Mercuriali[89] produced an algorithm based on an accurate calculation of patients cell volume, taking height and weight into account:

Preoperative red cell volume - Postoperative red cell volume = Operative blood loss - Ext sup

Using the same data and a threshold haematocrit, the **lowest** red cell volume surgical team for that operation can be established. The level of postoperati haematocrit should be set following clinical assessment, local transfusion proto guidelines. Using this algorithm over a 10 year period, Mercuriali demonstrate blood exposure in primary total hip surgery was restricted to less than 20% c wastage rate of only 10% of autologous units.

Table 3 indicates how patient-specific, independent risk factors for transfusio influence Mercuriali's equation. The patient's age, height, weight, sex, pre- a haemoglobin assessments form the basic data set, along with the type of surg postoperative haemoglobin/haematocrit should be set following clinical assessm

Table 3: Patient factors influencing Mercuriali's blood ordering equation

Preoperative red cell volume	Postoperative red cell volume	Operative blood loss	Ext sup
▪ Preoperative Hb ▪ Weight/height ▪ Sex	▪ Postop/target Hb ▪ Weight/height ▪ Sex ▪ Age/medical history	▪ Primary/revision ▪ Knee/hip ▪ Local factors	▪ All ▪ PA ▪ AN

Nuttall[90] also developed a surgical blood ordering equation which accounted for H blood provision to be tailored more closely to the individual patient. This sche lower cross match to transfusion ratio than MSBOS, indicating a higher efficiency i

This approach, as well as individualising each patient's transfusion requiremer

- each surgical team to develop its own local transfusion system
- each surgical team to set its own minimum transfusion levels for fit and un
- each surgical/anaesthetic team to audit operative blood loss for different op

ell units = Predicted Hb - [preoperative Hb (g/dl) -
d for a fall (g/dl) postoperative threshold Hb (g/dl)]
peration

mples of the starting haemoglobin level required to avoid transfusion in different e undergoing total hip arthroplasty

	Transfusion threshold (Hb g/l)		
height	**80**	**90**	**100**
60cm	153	163	173
80cm	136	146	156
/190cm	123	130	140

mples of blood loss in specific operations

	Predictable Hb loss		
	No. RBCs (g/dl)		RC volumes (ml)
	Nuttall 2000 [90]	Mercuriali 1996 [86]	Mercuriali 1996 [86]
ip	4.7 ± 1.7	4.8	907
nee	3.8 ± 1.2	4.0	764
hip	4.8 ± 2.4	8.0	1,531
ip	-		2,020
arthrodesis	-	11.0	890
nee	5.4 ± 2.4	4.0	-
	4.7	4.0	890

SION PROTOCOLS

reviews of allogeneic red cell transfusion[40,91] have found only two RCTs that address reducing variation in transfusion practice, using a transfusion treatment algorithm or n outreach programme.[92,93] Though both found statistically significant and sustained in red blood cell prescribing, the total number of interventions was small (63 and

c review of observational studies[40] assessing the ability of education and protocol o improve practice has shown reductions in "transfusion triggers". However, the used and the quality of the individual studies were heterogeneous.

ly poor quality of the literature in this area emphasises the need for careful evaluation of transfusion intervention, ideally in a randomised controlled trial. It is worth ng that in two meta-analyses addressing autologous transfusion[95] and acute emic dilution,[118] the presence of a transfusion protocol had an impact on allogeneic

7.1 OVERVIEW

The orthopaedic procedures most frequently requiring blood transfusion are pri joint arthroplasties. Factors that may contribute to reducing allogeneic transfusion orthopaedic surgery include:

- use of lower haemoglobin thresholds in transfusion protocols
- increased use of perioperative red cell salvage
- use of hypotensive techniques and regional anaesthesia.

Predonation of red cells has not been widely used in Scotland and the pc developments such as the use of drugs to reduce blood loss, the use of tissue sea of blood substitutes have not yet been fully evaluated. However, the gradually i of bilateral and revision procedures will continue to make considerable demar

7.2 APROTININ

Aprotinin has been shown to reduce blood loss in cardiac and liver surgery.[142] Its surgery also raises concerns about side effects, namely:

- inadvertent re-exposure of a patient to aprotinin, with a high risk of an anaj
- a possible increase in thrombosis using a drug with anti-fibrinolytic proper

7.2.1 DOSE

The dose required for a significant effect on blood loss appears to be high, wi studies using a loading dose of 2 million units followed by 0.5 million units/ho A smaller dose of 20,000 units/kg was not shown to be effective in one large s

7.2.2 APPLICATIONS

In view of the relatively high blood loss that may be associated with elective ort aprotinin has been investigated for hip replacements – unilateral,[144-146] bilateral – as well as in knee replacement,[148] spinal surgery,[149] septic prosthesis rem surgery.[150] These studies show a reduction in blood loss of 25-60%, with a more seen in patients undergoing procedures associated with higher blood loss. The r loss correlates with a reduction in the total number of units of blood transf limited evidence of any significant reduction in the number of patients requ Though the quality of these randomised controlled trials is high, the total n taking part is less than 1,000, which along with concerns over an enhanced th surgical circumstances of high thrombotic risk, suggests its application should

B **Aprotinin may be considered to reduce blood loss in hip and knee art use should be restricted to:**

- **procedures with an increased risk of high blood loss** (e.g. bilateral
- **circumstances when other blood conservation techniques are** (e.g. treatment of Jehovah's Witnesses).

7.3 TRANEXAMIC ACID

Tranexamic acid inhibits fibrinolysis by blocking the lysine binding sites of plasm It has been used primarily in gynaecology to reduce menstrual blood loss. M also been shown to be effective in reducing bleeding in cardiac surgery.[110] Its pc

ents on preoperative aspirin therapy.[137,138]

in (DDAVP) is not of benefit to all patients but may have a role in patients on
e aspirin therapy.[128] A reduction in the use of blood and blood products has been
tients on aspirin who are given desmopressin perioperatively. It should be noted that
high use of blood and blood components in the control group of one of the studies
d there was a significantly increased risk of MI in the treated group (OR 2.39, CI 1.02-

AGE

has been used to minimise the requirement for allogeneic transfusion in cardiac
aoperative cell salvage during the period of heparinisation simply involves the re-
of any "spilt" blood from the operative field. A sucker returns blood to the bypass
d following filtration to remove particulate debris, it is re-transfused. At the end of the
he contents of the cardiotomy reservoir may be returned to the patient and additional
dministered to cover this heparinised autologous blood transfusion.

rinisation, salvage may be undertaken using a conventional cell salvage device and
be utilised following reversal of heparin with protamine. Blood from chest drains
ansfused following filtration in the immediate postoperative period.

alysis of 2,061 patients, where one primary end-point was the proportion of patients
least one unit of allogeneic packed red cells, collection and re-infusion of unwashed
inal blood after bypass decreased allogeneic exposure (RR 0.85, 95% CI 0.79-0.92).
alone also reduced exposure to allogeneic blood (RR 0.84, 95% CI 0.77-0.93).[88] This
s did not include trials of shed **washed** mediastinal blood and may therefore
te the value of re-infusion of shed mediastinal blood, since washing salvaged blood
an induced coagulopathy.[139]

ve analysis of autologous blood salvage in cardiac surgery, involving over 3,000
d that more blood products were given to patients who received salvaged autologous
ugh this may have been a marker for more complex cases.[140]

domised trial of 38 patients, allogeneic transfusion requirements were compared in
e collected red cells were either washed or discarded. There was a significant reduction
n of allogeneic RBCs and platelets in the washed group.[141]

**sion of washed shed mediastinal blood may be used to reduce allogeneic transfusion
diac surgery.**

c evaluation of using shed washed mediastinal salvage would be helpful, as in many
fficient blood is salvaged to make processing worthwhile.

5.1 WHO WILL BENEFIT?

Blood sparing strategies should be considered for all patients who may requ
(Mercuriali's formula may be used to identify these patients) and who have consen
There are also specific circumstances where blood sparing strategies should be giv
for example for patients who:

- are Jehovah's Witnesses
- have multiple antibodies
- have serious anxieties about the transfusion of allogeneic blood.

However, a minimum provision should be made for every patient undergoing m
surgery.

☑ All patients undergoing major blood losing surgery, and who have consen
must have as a minimum provision a blood specimen grouped and s
hospital bank.

Blood sparing strategies currently available include:

- preoperative autologous blood donation (PABD) *(see section 5.2)*
- erythropoietin *(see section 5.3)*
- acute normovolaemic haemodilution (ANH) *(see section 5.5)*
- anti-fibrinolytic drugs *(see sections 6.2, 7.2 and 7.3)*
- cell salvage *(see sections 6.4 and 7.5)*.

5.2 PREOPERATIVE AUTOLOGOUS BLOOD DONATION

In the elective surgical setting, preoperative autologous blood donation (PABD
predictable, safe and widely practised form of transfusion support. Though its
use in Scotland has been very limited, it is regarded in many countries as the sta
major blood-losing operations, with the aim of minimising allogeneic blood
studies cover cardiac, orthopaedic and cancer surgery in American and European
type and extent of surgery in these studies is broadly similar to that practised in
is not widely practised in Scotland, although the Scottish National Blood Tra
(SNBTS) has established collection systems in the major population centres.

5.2.1 PRACTICAL ASPECTS OF PABD COLLECTION

PABD cannot be made available to all patients, since it requires time to pre-don
haemoglobin greater than 110 g/l,[94] which effectively excludes most emergency s
a transfusion strategy, its use carries the same risk of collection, storage, ic
administration errors as allogeneic blood, but it does avoid the immunological
of allogeneic transfusion. For a preoperative autologous blood donation prog
hospital admission and operative dates must be guaranteed, as donated blo
storage life of 35 days.

From the patient's perspective, collection can often present logistical difficulti
difficult with increasing age, immobility and co-existing medical and surgical c
not in itself a contraindication to PABD, which has been practised safely in
undergoing cardiac surgery.[95]

to which PABD reduces a patient's exposure to allogeneic blood was studied in a is of six RCTs and nine well-conducted cohort studies.[95] Patients who predonated blood were less likely to receive allogeneic blood in both the RCTs (933 patients, OR CI 0.08-0.32) and the cohort studies (2,351 patients, OR 0.19, 95% CI 0.14-0.26). he meta-analysis also showed that autologous donors were statistically more likely to nsfusion with allogeneic and/or autologous blood (OR 3.03, 95%CI 1.7-5.39). 1+

D can be used to reduce allogeneic blood exposure, although it does increase the total ber of transfusion episodes.

patient undergoing surgical procedures currently served by a Group & Screen policy suitable for preoperative donation.

lment to autologous blood programmes is reported as ranging from 54-65% [79-82] and borted as high as 100%,[96] possibly indicating that some studies are biased towards a t population. These cohort studies covered [14,153] orthopaedic surgery patients with rbidities and with a mean age of 66 years, ranging from 19-92 years. 2+

D can be used safely in elderly populations with diverse comorbidities.

ust be struck between collecting sufficient PABD units to minimise allogeneic exposure llection, leading to a high discard rate. Observational studies indicate that PABD is in primary joint surgery when the presenting haemoglobin is greater than 145 g/l.[79,80] BD collection to two units for total hip arthroplasty (THA) and one unit for total knee (TKA) was sufficient to avoid most allogeneic exposure without a high PABD discard 2+

nts undergoing primary hip and knee surgery with a presenting haemoglobin greater 145 g/l should be discouraged from autologous donation.

nting haemoglobin is between 110-145 g/l in men and between 130-145 g/l in women, een shown to reduce the expected number of patients exposed to allogeneic blood to of the total number of patients. Women with a lower presenting haemoglobin (110- likely to require additional transfusion support, for example, erythropoietin, to achieve ogeneic transfusion rate.[81,90] 2+

D should be targeted to:

en who present with haemoglobin 110-145 g/l
omen who present with haemoglobin 130-145 g/l.

POIETIN

thropoietin is a glycoprotein hormone that regulates erythropoiesis. Hypoxic or gic stress results in the secretion of erythropoietin by the kidney. Erythropoietin is recombinant human erythropoietin (epoietin α and β) and has been widely used in the f anaemia of chronic renal failure.

ONS OF ERYTHROPOIETIN

f erythropoietin in minimising allogeneic blood exposure compared to placebo has d in patients undergoing orthopaedic [97,98] cardiac [97] or colon cancer surgery.[99,100] The er of patients randomised exceeds 1,100 and, with the exception of one study, [99] all gnificant reduction in allogeneic transfusion (OR 0.36, 95% CI 0.24-0.56, p<0.0001 dic patients; OR 0.25, 95%, CI 0.06-1.04, p<0.06 in cardiac patients). The postoperative 1+

has shown that although there is an almost identical overall myocardial infarcti effect of high dose aprotinin is compared with that of low dose aprotinin, the MI higher (OR 2.15, 95% CI 1.12-4.11).

A non-systematic review of six RCTs found wide variation in graft occlusion rat and 12.7%). This probably reflects the differing methodologies and timing inte all the six studies.[107]

The International Multicentre Aprotinin Graft Patency Experience (IMAGE) trial[129] 870 patients undergoing first time myocardial revascularisation, found that pa aprotinin had a significantly higher graft occlusion rate: 15.4% in compariso patients in the control arm (p = 0.03). Over the range of cardiac operations co the mean amount of blood saved per patient treated with aprotinin varied betw units. The value of such a saving in primary revascularisation would be more t a small real increase in graft occlusion, given that in the above trial overall significantly different with or without aprotinin.

At present there is insufficient high quality evidence to recommend the use of ap CABG.

☑ In low risk primary CABG the routine use of aprotinin is not recomme

B **The use of aprotinin or tranexamic acid is recommended for patients u surgery which carries a high risk of transfusion** (e.g. repeat cardiac op valve replacements, thoracic aortic operations, patients on preoperati and procedures with anticipated long bypass times).

6.2.2 OTHER COMPLICATIONS

Aprotinin is associated with a transient deterioration in renal function, indicat of serum creatinine above baseline, which returns to normal post-surgery. The o renal failure in cardiac surgery is not affected. Up to 6% of patients exposed t second time develop significant allergic reactions. This incidence falls as the aprotinin exposures increases.[130]

6.3 ASPIRIN

The most commonly prescribed antiplatelet drug is aspirin and its importance patency following CABG is well recognised.

Aspirin increases blood loss in patients undergoing first time or re revascularisation.[131,132]

Aspirin is an irreversible inhibitor of cyclo-oxygenase, which platelets (unlike vas are unable to regenerate. Aspirin therapy should therefore, in theory, be disc days (the life span of a platelet) prior to surgery. Concern has been expressed a deleterious effects of withdrawing aspirin treatment prior to surgery, on the gr who have their aspirin therapy withheld may be more vulnerable to ischaemia period, and that this may be more hazardous than the consequences of bleedin postoperative period.

Although aspirin increases postoperative bleeding,[131,132] this is not always ac increased requirement for allogeneic transfusion.[133,134] Re-operation for control surgical haemorrhage is more common in those patients who receive preop However, a case control study of 8,641 patients found significantly higher mo

ery has been identified as one of the major users of donor blood and blood products.[4]
e increasing number of cardiac operations being undertaken, any procedure with the
afely reduce blood loss or transfusion requirements will have a significant impact on
blood pool, in addition to reducing any risk from allogeneic transfusion. A variety of
luence perioperative transfusion requirements in cardiac surgery. The principal therapies
e considered include aprotinin and other antifibrinolytic drugs, which could have
to decrease blood loss, and aspirin and anticoagulant drugs, which could increase
Variation in the requirement for allogeneic transfusion during and following
nary bypass (CPB)[123,124] involves factors such as the transfusion threshold and the
f cell salvage strategies. Surgical factors such as the time to confirm complete surgical
are also important, as is the institution in which the surgery takes place.[4,123]

ls setting a transfusion threshold should be encouraged.

N AND ANTIFIBRINOLYTIC DRUGS

a serine proteinase inhibitor which preserves platelet function following CPB by a
which may be independent of its potent antifibrinolytic activity. Its use was first
1987 in 84 patients undergoing repeat open heart surgery, when it was shown to
reduce blood transfusion in these high risk cases.[125]

2+

aprotinin used is the high dose schedule, unless otherwise stated, i.e.:
Kallikrein Inactivator units pre-sternotomy
Kallikrein Inactivator units in pump prime volume
Kallikrein Inactivator units/hour discontinued on return to ITU if no further significant

ysis has evaluated the potent antifibrinolytic drugs, aprotinin, tranexamic acid and
ocaproic acid ((ε-ACA).[110] End points included the need to transfuse one or more
ells, the mean transfusion requirement and the need to re-operate for bleeding. The
atients (5,808) were treated with aprotinin, which was found to significantly reduce
ood exposure (OR 0.44, 95% CI 0.27-0.73, p = 0.001). This was independent of
s used for primary or repeat operation, or whether the patient was receiving preoperative
y. Aprotinin use was also associated with a significantly reduced re-sternotomy rate
tive bleeding (OR 0.31, 95% CI 0.25-0.39, p = 0.0001). Tranexamic acid decreased
n of patients transfused (OR 0.5, 95% CI 0.34-0.76, p = 0.0009).[110]

1++

erall patient numbers were low, the meta-analysis also found no difference in efficacy
in was compared with tranexamic acid; both drugs significantly reducing blood loss
on requirements.[110] An RCT focusing on patients at high risk of bleeding[126] (e.g.
c operations, multiple valve replacements, thoracic aortic operations, procedures
ass times) found no major differences between the effects of aprotinin and tranexamic
gh only aprotinin offered protection against blood loss associated with increased
on.

1+

olytic agent, (ε-ACA did not demonstrate any significant reduction in the proportion
ansfused following cardiac surgery (OR 0.2, 95% CI 0.04-1.12).[110]

AL INFARCTION AND GRAFT PATENCY

ggested that that the use of aprotinin may lead to a heightened thrombotic state. In

where clinical symptoms warranted this. Despite this, allogeneic transfusion ra
groups ranged from 30% to 70%. In addition there was a consistent and statist
rise in preoperative Hb of between 10 g/l and 20 g/l in those randomised to ery

De Andrande[108] stratified 316 orthopaedic patients into those with presenting basel
above and below 130 g/l. The allogeneic transfusion rate fell in the erythropoie
from 45% to 16% in those with Hb < 130 g/l (p = 0.024) and fell from 13% to
levels > 130 g/l, a non-significant change.

Subgroup analysis has confirmed this finding in other studies.[103,104] Erythrop
significant role when preparing patients with objections to allogeneic transfus
Jehovah's Witnesses) for surgery that involves major blood loss.[105]

B **Erythropoietin use should be targeted to patients aged under 70 years wl
for major blood losing surgery and who have a presenting haemoglobir**

D **Erythropoietin can be used to prepare patients with objections to alloge
for surgery that involves major blood loss.**

5.3.2 DOSE OF ERYTHROPOIETIN

The optimal dose of erythropoietin is not known. The two dosing schedules most

- 300 u/kg subcutaneously for 14 days beginning 10 days preoperatively
  £2600/course/80 kg)
  or
- 600 u/kg subcutaneously three times weekly and on day of surgery (approxir
  course/80 kg)

Both regimens are of proven benefit and seem equivalent in safety and efficacy.
treatment has always been accompanied by oral or intravenous iron therapy bu
support schedule has not been defined.

5.3.3 COMPLICATIONS OF ERYTHROPOIETIN

Faught et al [107] found little evidence on the frequency and severity of side effe
erythropoietin use. However the number of patients treated with erythropoietin r
small, especially in cardiac surgery. As yet no trial or meta-analysis is of sufficien
important adverse effects at low incidence. In the de Andrande study[108] the r
thrombosis (DVT) was increased in erythropoietin treated patients with bas
130 g/l but was similar to controls when baseline Hb was 100-130 g/l. One
patients found seven deaths (four thrombotic) in 126 erythropoietin treated pa
deaths in 56 control patients.[109] This difference was not statistically significant ar
to mortality rates reported in the literature for cardiac bypass (CABG) surgery.
numbers of cardiac patients studied in randomised trials of erythropoietin alon
seem wise to avoid its use without PABD in cardiac patients, especially wl
130 g/l. Concerns about thrombotic risk and hypertension have meant that trials
have very strict entry criteria, restricting recruitment to a small number of fit pati
age of 65 years and few co-existent diseases. Even given these limitations, stu
there is no increase in thrombotic complications or uncontrolled hypertension.[1]

☑
- If erythropoietin brings about a > 0.50 rise in the patient's haema
  venesection should be undertaken.
- Patients receiving erythropoietin should have weekly haematocrit che

erythropoietin plus PABD on the incidence of allogeneic transfusion has been studied
dic and cardiac surgery patients. A meta-analysis of 11 orthopaedic RCTs, enrolling
s, found a statistically significant decrease in the proportion of patients transfused
eic blood (OR 0.42, 95% CI 0.28-0.62, $p < 0.0001$).[110] The mean volume of allogeneic
was not large, at 0.14 units. In the five cardiac RCTs included in this meta-analysis,
significant decrease in the proportion of patients transfused with allogeneic blood
nd (OR 0.25, 95% CI 0.08-0.82, $p = 0.02$), but the total number of cardiac patients
small, at 224.[110]

**patients undergoing major surgery, erythropoietin can be used in combination with
ogous blood collection to reduce allogeneic transfusion.**

ll RCTs [89,111,112] standard PABD was randomised against erythropoietin supported
hree-week preoperative period, 80% of patients treated with erythropoietin were able
ignificantly more units than the standard PABD group. The patients receiving
tin also had a significantly higher day of surgery haemoglobin ($p < 0.0002$), a finding
other studies.[113,114]

tin and PABD may be practical in young patients undergoing surgery with currently
logeneic requirements (e.g. spinal surgery or revision total hip surgery) and when used
cell salvage, although there is little specific information on these indications.

**patients undergoing major surgery, erythropoietin can be used to obtain multiple
ogous red cell donations while maintaining an adequate day of surgery haemoglobin.**

TS OF COMBINATION PABD AND ERYTHROPOIETIN

ects of erythropoietin and PABD, such as vasovagal episodes, were commonly reported,
he blood donation component.[89,111-114] As the patients in these studies were young
50-69 years) with minimal comorbidity, a similar multiple donation protocol could
mmended for the more standard hip replacement/general surgical populations.

ORMOVOLAEMIC HAEMODILUTION

ovolaemic haemodilution (ANH) is the removal of whole blood and the restoration of
ne with acellular fluid, shortly before anticipated significant surgical blood loss. In
f elective surgery this may be performed prior to surgery or during the early part of the
cedure, if this period is associated with minimal anticipated blood loss. For example,
surgery blood may be withdrawn intraoperatively with reinfusion postoperatively.
um volume of blood that can be withdrawn during haemodilution depends on the
e haemoglobin, the lowest acceptable intraoperative haemoglobin and the estimated
ne.[85,115,116]

ntially most useful for a patient meeting all of the following criteria:

tial anticipated blood loss

ly low target haemoglobin (intraoperatively and postoperatively)

ly high initial haemoglobin

al models have been developed that allow users to identify when a given combination
e factors would save a unit of packed cells.[115] Such models indicate that ANH is
only a minority of patients, i.e. healthy adults in whom a low target haemoglobin is
with an anticipated surgical blood loss exceeding 50% of estimated blood volume
igh initial haemoglobin.[117] For example, modelling predicts a maximum saving of

D **ANH should be limited to patients with a haemoglobin level sufficie
1,000 ml of blood to be removed, and in whom a relatively low targ
deemed appropriate.**

A meta-analysis of ANH trials[118] found overall support for such mathematica
number of patients exposed to allogeneic transfusion was reduced when mor
blood were withdrawn, though there was no reduction in the average volume o
transfused. Trials in which blood loss was in excess of 1,000 ml were associate
reduction in the average number of allogeneic units transfused, though not
patients exposed to allogeneic blood. No significant reduction was found wh
loss was less than 1,000 ml. However, no benefit was identified when trials wit
protocol were excluded.

In a more recent randomised study[119] of ANH inpatients undergoing unilateral
where measured perioperative blood loss was less than 1,000 ml, ANH was
decreased total transfusion of allogeneic blood, but there was no reduction
patients exposed to allogeneic blood. In all groups, allogeneic transfusion was ad
a transfusion protocol.

Much of the research into ANH has been done at a single American centre where
technicians and nurses undertake the procedure.[120] A recent randomised st
compared ANH with preoperative autologous donation and found no difference i
red cell saving (approximately one unit) or exposure to allogeneic transfusion
loss was approximately 1400 ml, with an allogeneic haematocrit transfusion
The authors suggest that ANH should be preferred to preoperative autologou
(PABD) on the basis of lower cost and a lesser potential for transfusion error
used without a negative impact on theatre time, organisational issues must be

In summary, the evidence for the benefit of ANH is equivocal. The procedure c
contribution to the avoidance of allogeneic exposure in prescribed circumstanc
have received training in undertaking the procedure.

☑
- ANH should only be implemented where the logistics of blood remov
can be undertaken without detracting from patient care.
- Hospitals considering ANH must address organisational issues, inclu
of appropriate support to the anaesthetist.
- Autologous blood should be labelled and stored according to the Brit
Standards in Haematology blood transfusion guideline,[122] with par
taken where autologous blood transfusion is initiated postoperativel

CARDIAC AND ORTHOPAEDIC SURGERY

APROTININ & ANTIFBRINOLYTICS

B

- **The use of aprotinin or tranexamic acid is recommended for patients undergoing cardiac surgery which carries a high risk of transfusion**
  (e.g. repeat cardiac operations, multiple valve replacements, thoracic aortic operations, patients on preoperative aspirin therapy and procedures with anticipated long bypass times).
- **Aprotinin may be considered to reduce blood loss in hip and knee arthroplasties but its use should be restricted to:**
  - **procedures with an increased risk of high blood loss** *(e.g. bilateral and revision)*
  - **circumstances when other blood conservation techniques are not appropriate** *(e.g. treatment of Jehovah's Witnesses).*
- **Tranexamic acid can be used to reduce blood loss and transfusion requirements in patients undergoing knee replacement surgery, when other blood conservation techniques are inappropriate and where major blood loss is anticipated.**

CELL SALVAGE

C **Reinfusion of washed shed mediastinal blood may used to reduce allogeneic transfusion in cardiac surgery.**

D **In orthopaedic surgery, unwashed postoperative salvage using drains should be considered in patients in whom a postoperative blood loss of between 750 ml and 1,500 ml is expected** *(e.g. bilateral joint replacement).*

B **In orthopaedic surgery, washed intraoperative salvage should be considered in patients in whom an intraoperative blood loss of more than 1,500 ml is anticipated** *(e.g. major pelvic, spinal or uninfected revision surgery).*

B **Cell salvage using either unwashed or washed red blood cells may be considered as a means of significantly reducing the risk of exposure to allogeneic blood in orthopaedic surgery.**

KEY

A B C D Grade of recommendation

☑ Good practice point

The Scottish Intercollegiate Guidelines Network (SIGN) supports improvement in the quality of health care for patients in Scotland by developing and disseminating national clinical guidelines and facilitating their implementation into practice. SIGN guidelines provide recommendations for effective healthcare based on current evidence.

The recommendations are graded A B C D to indicate the strength of the supporting evidence.

Good practice points ☑ are provided where the guideline development development group wish to highlight specific aspects of accepted clinical practice.

Details of the evidence supporting these recommendations and their application in practice can be found in the full guideline, available on the SIGN website: **www.sign.ac.uk.**

This guideline was issued in October 2001 and will be considered for review in 2004.

For more information about the SIGN programme, contact the SIGN executive or see the website.

SIGN Executive
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Perioperative Blood Transfusion for Elective Surgery

DECIDING WHETHER OR NOT TO TRANSFUSE

The decision to transfuse any patient for a given indication must balance the risks of not transfusing, influenced for example by disease prognosis, against the risks of transfusion, influenced for example by the probable duration of patient survival and the incubation time of known infective agents.

D **Given the potential risks, however small, each allogeneic transfusion must have a valid, defined and justifiable indication.**

☑
- The indication for each transfusion should be documented in the patient's records.
- In a haemodynamically stable patient, one unit of concentrated red cells should be transfused at a time, allowing the benefit of each to be assessed at 24 hourly intervals.

B **Transfusion of leucodepleted allogeneic blood should not be limited by concerns over increased cancer recurrence or perioperative infection.**

D **All surgical and anaesthetic units should have protocols:**
- **to prepare anticoagulated patients for all types of surgery**
- **for deep vein thrombosis prophylaxis in the preoperative period.**

AVOIDING PROCEDURAL ERROR

D **The British Committee for Standards in Haematology collaborative guideline for the administration of blood and blood components and management of transfused patients should be implemented in all Scottish hospitals where transfusion takes place.**

☑ A final check of the patient's wrist identity band against the identity given on the blood component to be transfused is essential for safe practice.

HAEMOGLOBIN TRANSFUSION THRESHOLDS

The transfusion threshold is the haemoglobin value at which transfusion will normally be indicated, under stable conditions, and in the absence of other clinical signs or symptoms of anaemia.

☑
- A transfusion threshold should be defined as part of an overall strategy to provide optimal patient management.
- The transfusion threshold should be viewed as the haemoglobin value below which the patient should not fall during the perioperative period, particularly in the context of ongoing or anticipated blood loss.

PREOPERATIVE THRESHOLDS

☑ All patients undergoing major elective surgery should have a full blood count performed prior to surgery, to avoid short term cancellation and to allow those patients presenting with anaemia to be investigated and treated appropriately (e.g. iron therapy).

C **Where possible, anaemia should be corrected prior to major surgery, to reduce exposure to allogeneic transfusion.**

INTRAOPERATIVE THRESHOLDS

There is no indication that thresholds should differ during this period but the use of intraoperative transfusion must reflect the ongoing rate of surgical blood loss, continued haemodynamic instability, and anticipated postoperative bleeding.

POSTOPERATIVE THRESHOLDS

D
- **Transfusion is required at haemoglobin values < 70 g/l.**

C
- **Patients with cardiovascular disease, or those expected to have a high incidence of covert cardiovascular disease** (e.g. elderly patients or those with peripheral vascular disease) **are likely to benefit from transfusion when their haemoglobin level falls below 90 g/l.**

D
- **Transfusion is unjustified at haemoglobin values > 100 g/l.**

PREDICTING THE NEED FOR TRANSFUSION

Nine risk factors which predict the need for allogeneic transfusion have been defined:

- low preoperative haemoglobin/haematocrit, either before intervention or on day of surgery
- low weight
- small height
- female sex
- age over 65 years
- availability of preoperative autologous blood donation (PABD)
- estimated surgical blood loss
- type of surgery
- primary or revision surgery.

BLOOD SPARING STRATEGIES

Blood sparing strategies should be considered for all patients who may require a transfusion (Mercuriali's formula may be used to identify these patients) and who have consented to transfusion.

☑ All patients undergoing major blood losing surgery, and who have consented to transfusion, must have as a minimum provision a blood specimen grouped and screened by their hospital bank.

PREOPERATIVE AUTOLOGOUS BLOOD DONATION

B **Preoperative autologous blood donation (PABD) can be used to reduce allogeneic blood exposure although it does increase the total number of transfusion episodes.**

D **PABD should be offered only when it is possible to guarantee admission and operative dates.**

C **PABD should be targeted to:-**
- **men who present with haemoglobin 110-145 g/l**
- **women who present with haemoglobin 130-145 g/l.**

C **PABD can be used safely in elderly populations with diverse comorbidities.**

☑ Any patient undergoing surgical procedures currently served by a Group and Screen policy is unsuitable for preoperative donation.

☑ Patients undergoing primary hip and knee surgery with a presenting haemoglobin >145 g/l should be discouraged from autologous donation.

ERYTHROPOIETIN

B **Erythropoietin use should be targeted to patients aged under 70 years who are scheduled for major blood losing surgery and who have a presenting haemoglobin < 130 g/l.**

D **Erythropoietin can be used to prepare patients with objections to allogeneic transfusion for surgery that involves major blood loss.**

☑ If erythropoietin brings about a >0.50 rise in the patient's haematocrit, a 500 ml venesection should be undertaken.

COMBINING PABD & ERYTHORPOIETIN

B **In fit patients undergoing major surgery, erythropoietin can be used:**
- **in combination with autologous blood collection to reduce allogeneic transfusion**
- **to obtain multiple autologous red cell donations while maintaining an adequate day of surgery haemoglobin.**

ACUTE NORMOVOLAEMIC HAEMODILUTION (ANH)

ANH is potentially most useful for a patient meeting all of the following criteria:

- a substantial anticipated blood loss
- a relatively low target haemoglobin (intraoperatively and postoperatively)
- a relatively high initial haemoglobin.

D **ANH should be limited to patients with a haemoglobin level sufficiently high to allow 1,000 ml of blood to be removed, and in whom a relatively low target haemoglobin is deemed appropriate.**

☑
- ANH should only be implemented where the logistics of blood removal and replacement can be undertaken without detracting from patient care.
- Hospitals considering ANH must address organisational issues, including the provision of appropriate support to the anaesthetist.
- Autologous blood should be labelled and stored according to the British Committee for Standards in Haematology blood transfusion guideline, with particular care being taken where autologous blood transfusion is initiated postoperatively.

BLOOD ORDERING EQUATIONS

Blood ordering schedules relate the ordering of blood to the likelihood that a transfusion will be required, taking into account the type of operation and an individual patient's risk factors.

C
- **All hospitals should use a maximum surgical blood ordering schedule to provide concentrated red cells.**
- **When ordering blood, all nine factors determining the risk and degree of transfusion should be taken into account, for example by using Mercuriali's formula.**

MERCURIALI'S FORMULA

Expected blood loss = Preoperative red cell volume − Postoperative red cell volume + Red cells transfused

- *preoperative red cell* volume is influenced by: preoperative haemoglobin, weight, height, sex
- *postoperative red cell* volume is influenced by: postoperative target haemoglobin, weight, height, sex, age, medical history
- *red cells transfused* is partly determined by the potential use of blood sparing strategies such as salvage, PABD, ANH