Patient blood management: an update of current guidance in clinical practice

Patient blood management is a global, evidence-based, multidisciplinary initiative to reduce unnecessary blood transfusion while optimizing other available techniques. This article summarizes current patient blood management strategies and highlights future developments in UK practice.

Patient blood management is a term used to encompass an evidence-based, multidisciplinary approach to the use of blood components. Transfusion can be life saving and use of blood components for actively bleeding patients should be guided by the treating physician in line with national and local haemorrhage protocols (Hunt et al, 2015; National Blood Transfusion Committee, 2016). Transfusion can also cause harm. With perioperative data demonstrating a relationship between allogeneic blood transfusion and inferior patient outcomes (Hofmann et al, 2011), the call for individualized, evidence-based, blood-sparing strategies is growing.

Patient blood management initiatives aim to improve patient outcomes and safety by preventing unnecessary transfusion, pre-empting its need and optimizing physiological factors and techniques. Patient blood management empowers patient choice by encouraging discussion and exploring available management options. By carefully considering component use, wastage will reduce, enhancing the self-sufficiency of a limited blood supply, a process which relies on voluntary non-remunerated donors (World Health Organization, 2010).

In 2010, patient blood management was introduced to the World Health Organization member states, with resulting successful strategies seen in Australia, the USA and parts of Europe (Shander et al, 2012b; National Blood Transfusion Committee, 2014). Patient blood management was formally introduced in England in 2012, with collaboration between the Department of Health, National Blood Transfusion Committee and NHS Blood and Transplant. This built on the successful 'Better Blood Transfusion' initiatives that lead to a reduction of red cell use in the UK by over 20% in 10 years (National Blood Transfusion Committee, 2014). In Scotland and Wales, the term 'Better Blood Transfusion' is still used to describe the initiative.

Patient blood management is an established practice in the UK and continues to evolve. Of particular interest are the National Institute for Health and Care Excellence (2015a) clinical transfusion guidelines, the 'Choosing Wisely' transfusion principles (Murphy, 2015; Choosing Wisely, 2016) and the 'Use of platelet transfusions' guidance (Estcourt et al, 2016). These, alongside other key publications and recommendations, are reviewed to enhance an understanding of patient blood management principles from the wealth of resources currently available. The guidance summarized in this article relates to adults only.

Owing to the high prevalence of perioperative anaemia (Shander et al, 2012b), guidance will be considered in terms of general patient blood management principles and those relating to perioperative care.

Anaemia investigation and management is important in all patient groups, particularly medical and obstetric specialities. The National Comparative Audit of use of Blood in Adult Medical Patients (2012, 2013) found poor anaemia recognition and investigation within the medical specialities with subsequent increase in unnecessary transfusion. The use of higher transfusion thresholds and failure to investigate and treat the underlying cause were among the suggested reasons for the excess in blood component use. The red cell usage survey in England and North Wales replicated this finding, demonstrating that medical specialities transfuse red cells more frequently (67% of total units) than surgical and obstetric specialities (27% and 6% respectively) (Tinegate et al, 2016).

Challenges with transfusion

In addition to the cost and challenges associated with maintaining a national blood supply, there are several reasons why clinicians should be operating an evidence-based approach to transfusion.

Despite significant advances in the manufacturing of components (including the routine use of pre-storage leucodepletion), transfusion is not risk free. Some risks of acute transfusion reactions are hard to negate and operator and selection error still occurs (Bolton-Maggs et al, 2015). Although very rare, transfusion-transmitted

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infection is possible, highlighted with detection of hepatitis E in the UK blood supply (Hewitt et al, 2014). Repeated transfusion can lead to the emergence of red cell antibodies and, without chelation, chronic transfusion strategies can lead to iron overload. Studies have linked the use of allogeneic blood transfusion with immunomodulatory effects, with an increased risk of infection and lung injury seen (Spahn, 2010; Hofmann et al, 2011; Clevenger et al, 2015). An increased risk of cancer reoccurrence for those receiving blood transfusions has been reported (Hofmann et al, 2011; Clevenger et al, 2015) and data further demonstrate an association between allogeneic blood transfusion and adverse patient outcomes with an increase in both morbidity and mortality observed (Spahn, 2010).

Choosing wisely

By rationalizing which tests to perform and by operating an evidence-based approach to investigation and management, needless testing and treatment can be avoided. This reduces unnecessary costs, avoidable waste and makes urgent investigations more readily available for those in need. The 'Choosing Wisely' campaign captures this movement in health care.

Choosing Wisely, an initiative by the American Board of Internal Medicine Foundation, empowers patients by providing questions to ask clinicians when a test or treatment is recommended (Callum et al, 2014). This encourages patient engagement in the decision process, stimulating discussion as to whether the proposed intervention is necessary and what alternatives exist. In the USA, the Choosing Wisely ethos stimulated a range of medical organizations to develop a series of principles relevant to the areas of potential observed waste within each speciality (Murphy, 2015).

In 2015, the recommended UK Choosing Wisely principles for transfusion medicine were submitted to the Academy of Medical Royal Colleagues by Murphy. These principles, for consideration of inclusion into the final national guidance (*Table 1*), develop upon the key points from the AABB (former American Association of Blood Banks). They also reflect UK patient blood management values by featuring themes of patient consent and restrictive platelet usage. The UK Choosing Wisely guidance was subsequently released in late 2016 (Choosing Wisely, 2016). The selected principles include restrictive red cell thresholds, single unit red cell use (for non-haemorrhagic patients), limiting use of O RhD-negative red cells and adopting a platelet threshold of $10x10^9$/litre for those undergoing chemotherapy (when not bleeding or undergoing procedures carrying a bleeding risk) (Choosing Wisely, 2016).

Table 1. Suggested UK Choosing Wisely principles for transfusion

Do not transfuse more units of blood than are absolutely necessary
Do not transfuse red blood cells for iron deficiency without haemodynamic instability
Do not transfuse O RhD-negative blood except to O RhD-negative patients and in emergencies for women of childbearing potential with unknown blood group
Do not routinely transfuse platelets for patients with chemotherapy-induced thrombocytopenia if the platelet count is >10 x 10^9/litre in the absence of bleeding
Do not transfuse a patient without informing the patient about the risks and benefits of transfusion

From Murphy (2015)

Red cell and platelet transfusion: when to transfuse?

National Institute for Health and Care Excellence guidance on blood transfusion provides a comprehensive guide to blood component indications including red cell and platelet use (National Institute for Health and Care Excellence, 2015a). Quality standards have been published to further embed best practice (National Institute for Health and Care Excellence, 2016b).

The National Institute for Health and Care Excellence (2015a) recommendation supports the use of restrictive red cell thresholds for patients deemed appropriate and encourages single unit red cell transfusion with post-transfusion reassessment. Guidance is summarized in *Table 2*. More recently, a British Society for Haematology guideline recommended changes to previously accepted platelet thresholds, e.g. lowering the platelet threshold for lumbar puncture from $>50x10^9$/litre to $\geq 40x10^9$/litre (Estcourt et al, 2016). Consideration of avoiding platelet transfusion by favouring interventional or surgical approaches carrying a reduced bleeding risk is recommended, e.g. a transjugular approach for a renal biopsy in a thrombocytopenic patient. Sparing platelet exposure to potential transplant recipients reduces the risks of alloimmunisation (Estcourt et al, 2016).

The use of single dose platelet transfusions is recommended except for patients bleeding in critical sites (e.g. eyes and CNS) where multiple doses may be indicated. Procedures with a low bleeding risk (e.g. bone marrow biopsy and central venous access) do not require platelet transfusion support. In the absence of bleeding, platelets are not routinely recommended for patients with irreversible chronic bone marrow failure syndromes or for immune driven conditions (National Institute for Health and Care Excellence, 2015a; Estcourt et al, 2016). Non-bleeding patients should be reassessed after each unit transfused, including re-checking a full blood count, to gauge if further transfusion is required.

To assume that a single threshold for red cell transfusion can be applicable for all patients would be inappropriate. In the absence of bleeding, clinicians assessing the potential need for transfusion should use a risk *vs* benefit

Table 2. Abbreviated red cell and platelet transfusion recommendations

Summary of general and perioperative recommendations	Reference(s)
When using a restrictive threshold (for those without haemorrhage, acute coronary syndrome or requiring transfusion for chronic anaemia), a value of 70 g/litre should be used with a post-transfusion target haemoglobin between 70 and 90 g/litre	National Institute for Health and Care Excellence (2015a)
A red cell threshold of 80 g/litre should be considered for patients with acute coronary syndrome with a post-transfusion target haemoglobin between 80 and 100 g/litre	
For patients requiring regular blood transfusions for chronic anaemia, individual thresholds should be considered	
Single unit red cell transfusions for adults should be considered (in patients with no active bleeding)	
In the non-bleeding patient, reassessment should be made after each red cell unit (unless on a chronic transfusion programme)	National Institute for Health and Care Excellence (2016a)
For patients who may require transfusion of blood components, written and verbal information should be given	
In the absence of bleeding or requiring a procedure, give platelets to those with reversible bone marrow failure (i.e. undergoing chemotherapy or allogeneic stem cell transplant) to maintain a count ≥$10x10^9$/litre	Estcourt et al (2016)
In the absence of bleeding, consider not giving prophylactic platelets for those undergoing autologous stem cell transplant or those who are asymptomatic and with irreversible bone marrow failure (unless on intensive treatment)	
For patients who have additional risk factors for bleeding, consider increasing the platelet threshold to between 10 and $20x10^9$/litre	
Where possible use a procedure or equipment associated with the lowest risk and use local measures to reduce post-procedure bleeding risk	Estcourt et al (2016)
A platelet threshold of above $50x10^9$/litre ■ For those patients undergoing invasive procedures or surgery A platelet threshold of 50–$75x10^9$/litre ■ For those patients undergoing invasive procedures or surgery with a high bleeding risk A platelet threshold of above $100x10^9$/litre ■ For those patients having invasive procedures or surgery in critical sites (such as the CNS)	National Institute for Health and Care Excellence (2015a)

approach. Factors influencing this decision include the patient's physiological status, comorbidities (particularly cardiovascular) (Docherty et al, 2016) and signs or symptoms attributable to anaemia. Consideration of the cause and chronicity is also recommended. Stable, asymptomatic patients with chronic anaemia may tolerate a lower haemoglobin level than recommended by trigger values and attention should be paid to correcting the underlying cause, rather than initiating transfusion based on a haemoglobin value alone.

As both anaemia and blood transfusion have associated hazards, the minimum quantity of red cell units to obviate the risk and symptoms of anaemia is desirable in a stable, non-bleeding patient. Restrictive transfusion strategies have been the subject of many studies, particularly in critical care. A large systematic review, involving over 30 trials and 9800 patients, demonstrated no additional mortality or morbidity (including myocardial infarction) in those with a restrictive transfusion strategy. Conversely, no advantage was found for a liberal transfusion approach. Adopting a restrictive transfusion threshold was therefore felt safe for most patients (Holst et al, 2015).

The decision to transfuse should involve the patient and family members with exploration of potential alternatives. Both written and verbal information should be provided to support the decision-making process, including risks *vs* benefits. A patient leaflet to aid decision-making is available from: http://hospital.blood.co.uk/media/28307/160511-27360-will-i-need-a-blood-transfusion-final.pdf

The decision and reason to transfuse should be documented in the patient's records (National Institute for Health and Care Excellence, 2015a).

Perioperative considerations

Perioperative principles can be considered under three central themes:

1. Measures to optimize haemopoiesis
2. Techniques and adjuncts to minimize blood loss
3. Interventions to harness and optimize tolerance to anaemia.

The 'three pillars' are widely cited and provide a structured approach to patient blood management in surgical management (Hofmann et al, 2011).

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Pillar 1: optimizing haemopoiesis

Identification and investigation of anaemia

The following summary of guidance relates to perioperative anaemia management, but key themes are relevant for all patient groups.

Optimization of haemopoiesis is centred on the following principles:

- Timely detection and investigation of the anaemia
- Deferral of non-urgent surgery to allow correction of anaemia
- Treatment of underlying cause including ensuring iron, folate and vitamin B_{12} stores are adequate, consideration of other methods of stimulating erythropoiesis.

Anaemia, described as a haemoglobin level <130 g/litre for men and <120 g/litre for non-pregnant women (World Health Organization, 2011), is highly prevalent in the preoperative patient (Shander et al, 2012b). Muñoz et al (2015) report the prevalence to vary between 11% and 48%; this incorporated data from over 650 000 patients in 18 large observational studies. Preoperative anaemia has been linked to worse postoperative outcomes with increased morbidity and mortality reported (Shander et al, 2012b).

In the preoperative period, identifying anaemia early, and prompt investigation and initiation of corrective treatment are imperative. Formalization of integrated anaemia pathways for referral, investigation and management is called for (Kotzé et al, 2015), both in primary and secondary care. Correction of anaemia before surgery is preferable and, if surgical intervention is non-urgent, this should be scheduled to allow adequate time for treatment (Kotzé et al, 2015). This recommendation is echoed by the National Institute for Health and Care Excellence (2015a) guidance. For anaemic patients requiring urgent surgery, steps should be taken to optimize the patient with the remaining time by prompt investigation and initiation of treatment (Kotzé et al, 2015).

Initiatives to introduce dedicated anaemia or preoperative anaemia clinics exist nationally with the aim of centralizing and standardizing investigation, unifying best practice using patient blood management principles and improving patient outcomes. One such example is the Orthopaedic Anaemic Project run in Northumbria where early anaemia screening and treatment lead to a reduced length of stay and reduced re-admission post joint replacement (Laverty, 2015).

Causes of preoperative anaemia are varied, can be multifactorial and may reflect the surgical complaint (e.g. malignancy). Shander et al (2012b) suggests anaemia of chronic disease as a common aetiology. Other causes, particularly iron deficiency, should be investigated.

Iron deficiency

Iron deficiency anaemia can be a challenge to diagnose with combined causes of anaemia masking the classic iron-deficient indices and inflammatory processes masking the pathognomonic hypoferritinaemia (Kotzé et al, 2015). Recommendations are summarized in *Table 3*. Oral iron supplements have traditionally been used as the first-line route of replacement in iron deficiency because of their low cost and wide availability. The disadvantages of oral therapy are well documented and include poor tolerance (with dose-associated gastrointestinal side effects leading to poor compliance) and the slow, prolonged course required to adequately replete stores. Oral preparations can be poorly absorbed in patients with chronic disease and in inflammatory states, further reducing the bioavailability (Clevenger and Richards, 2015). Intravenous iron is recommended in those with inflammatory bowel disease and is commonly used first line in those with cardiac disease and chronic renal impairment (Clevenger and Richards, 2015). Newer intravenous preparations have improved safety profiles with the risk of anaphylaxis much less than historically seen (Clevenger and Richards, 2015).

More high-quality randomized control studies to determine the optimal route of iron replacement are required to unify best practice and improve patient outcomes. The PREVENTT study is currently ongoing. This double-blinded, randomized control trial is assessing the outcomes of those with preoperative anaemia undergoing major abdominal surgery receiving preoperative intravenous iron infusions *vs* a placebo with primary end points including the need for blood transfusion, postoperative recovery and length of inpatient stay (Richards et al, 2015).

Table 3. Guidance on iron replacement

Summary of general and perioperative recommendations	Reference(s)
Oral iron preparations should be offered first line to patients presenting with iron deficiency	Kotzé et al (2015)
The use of intravenous iron replacement is indicated in: ■ Those who cannot tolerate oral preparations ■ Those who have a diagnosis of functional iron deficiency ■ Those who require prompt replacement (e.g. surgery that cannot be delayed)	National Institute for Health and Care Excellence (2015a, 2016b)
Do not transfuse red blood cells for iron deficiency without haemodynamic instability	Murphy (2015)
Use oral iron for patients with iron deficiency if surgery is non-urgent	Kotzé et al (2015)
Use oral iron before and after surgery for patients with iron deficiency anaemia	National Institute for Health and Care Excellence (2015a, 2016b)
Give oral iron replacement to those who are non-anaemic but have evidence of low iron stores with a predicted >1200 ml loss as a measure to prevent postoperative anaemia	Kotzé et al (2015)

Erythropoietin-stimulating agents

Erythropoietin is renally excreted in response to poor oxygen delivery. This stimulates erythropoiesis, increasing

Table 4. Guidance on the use of erythropoietin-stimulating agents

Summary of general and perioperative recommendations	Reference(s)
The use of erythropoietin-stimulating agents may be indicated for patients who refuse blood components for personal or religious reasons (including Jehovah's Witnesses). Decision for the use of erythropoietin-stimulating agents is based on individual acceptance of this recombinant product and consideration of pros *vs* cons	London Regional Transfusion Committee (2012)
A trial of erythropoietin-stimulating agent therapy in iron-replete patients with renal anaemia is recommended only after the prescribing physician and patient (and family members or carers if appropriate) come to a mutual agreement after individualized discussion of pros and cons in view of comorbidities and prognosis	National Institute for Health and Care Excellence (2015b)
Erythropoietin-stimulating agents are recommended as options for treating anaemia in people with cancer who are having chemotherapy	National Institute for Health and Care Excellence (2014)
The routine use of erythropoietin is not recommended in the perioperative setting unless the patient meets the criteria for transfusion of blood components but is unable to receive this (either for personal or religious reasons) or the patient has red cell antibodies and the most appropriate blood is not available	National Institute for Health and Care Excellence (2015a, 2016a)

red cell production as a physiological compensatory mechanism. Patients with chronic renal impairment can be deficient in this hormone with subsequent loss of feedback and resultant anaemia. National Institute for Health and Care Excellence (2015b) guidance on managing anaemia in renal disease suggests considering a renal cause if the estimated glomerular filtration rate is <60ml/min/1.73m^2 and describes a detailed assessment of iron status in renal impairment where transferrin saturation and serum ferritin levels are not reliable. *Table 4* gives guidance for the use of erythropoietin-stimulating agents. The use of erythropoietin-stimulating agents in patients undergoing chemotherapy is recommended in National Institute for Health and Care Excellence (2014) guidance, but the 2012 Cochrane review indicates that their use in this population is associated with increased risk of cardiovascular and thromboembolic events including death (Tonia et al, 2012).

Preoperative allogeneic blood transfusion

Preoperative anaemia guidance advises clinicians to adopt an individual risk *vs* benefit approach to the recommendation of blood transfusion (Kotzé et al, 2015).

Pillar 2: minimizing blood loss

Coagulation parameters

Preoperative measures to reduce blood loss and adequately prepare the patient for surgery include, where possible, stopping anticoagulant and antiplatelet agents in a timely manner. Direct oral anticoagulants should be discontinued in patients with a normal renal function (creatinine clearance ≥80 ml/min for dabigatran, ≥30 ml/min for rivaroxaban, edoxaban and apixiban) for 24 hours before low bleeding risk procedures or surgery. This extends to 48 hours if the procedure or surgery carries a high bleeding risk. In the presence of renal impairment, guidance on omitting the drug before surgery can vary between 48 and 96 hours depending on the degree of renal impairment, bleeding risk of surgery and direct oral anticoagulant used (Keeling et al, 2016).

National guidance should be used to carefully identify those individuals who require perioperative bridging of anticoagulation as some evidence suggests that in some patients bridging may increase postoperative bleeding without reducing the perioperative thrombosis risk (Keeling et al, 2016).

Administration of vitamin K is recommended for those taking a vitamin K antagonist (warfarin or sinthrome) with a preoperative international normalized ratio ≥1.5 on the day before surgery (Keeling et al, 2011). Since the availability of prothrombin complex concentrate, fresh frozen plasma should not be used for the emergency reversal of vitamin K antagonists (National Institute for Health and Care Excellence, 2015a). The humanised monoclonal antibody fragment, idarucizumab, is licensed for the reversal of dabigatran for both emergency surgery and life-threatening bleeding. Other direct oral anticoagulant reversal agents are in development but currently unavailable (Keeling et al, 2016). *Table 5* summarizes guidance to normalize coagulation parameters.

Tranexamic acid

Tranexamic acid is an anti-fibrinolytic agent that binds reversibly to plasmin, preventing the breakdown of fibrin clots. The use of tranexamic acid as an adjunct is recommended for those with low platelet levels (Desborough et al, 2016). Its use is commonplace within most surgical specialities with urological, orthopaedic, cardiac, obstetric and gynaecological surgery demonstrating a reduction in transfusion requirements associated with its use (Roberts et al, 2012). National Institute for Health and Care Excellence (2016a) transfusion quality standards recommend consideration of tranexamic acid use for patients undergoing surgery with expected moderate blood loss. A large, multicentre, retrospective cohort study with over 870 000 patients compared outcomes

Table 5. Guidance on blood component use to normalize coagulation parameters

Summary of general and perioperative recommendations	Reference(s)
The use of fresh frozen plasma is indicated in massive haemorrhage, local protocols should be followed for suggested red cell:fresh frozen plasma ratios	Hunt et al (2015)
Fresh frozen plasma is not the first choice component to reverse the abnormal coagulation in patients on warfarin	Hunt et al (2015), National Institute for Health and Care Excellence (2015a)
Prothrombin complex concentrate is recommended for the emergency reversal of warfarin for: ■ Patients with severe bleeding ■ Patients with a head injury with suspected intracerebral haemorrhage ■ Patients having emergency surgery (consider depending on level of anticoagulation and the bleeding risk) ■ Patients (16 years or over) with major trauma who have active bleeding	National Institute for Health and Care Excellence (2015a, 2016b)
There is no evidence to support the use of fresh frozen plasma in patients with liver disease who are not bleeding, even if in the presence of a prolonged prothrombin time	National Blood Transfusion Committee (2016)
Cryoprecipitate should be given to maintain a fibrinogen level >1.5 g/litre in those with clinically significant bleeding	National Institute for Health and Care Excellence (2015a), Estcourt et al (2016)
Fresh frozen plasma should not be offered to correct abnormal coagulation in patients who are not bleeding (unless they are having invasive procedures or surgery with a risk of clinically significant bleeding)	National Institute for Health and Care Excellence (2015a)

for those who had received perioperative tranexamic acid while undergoing total hip or knee arthroplasty to those who had not. For patients receiving tranexamic acid, the requirement for blood transfusion reduced by up to 69% (Poeran et al, 2014). There was no increased risk of thromboembolic events and a reduced length of hospital stay was observed.

The use of tranexamic acid in massive haemorrhage and trauma has also demonstrated significant benefits. The CRASH-2 study concluded that early administration of tranexamic acid in trauma leads to a significant reduction in all-cause mortality and deaths from bleeding (The CRASH-2 Collaborators, 2011). The results of two ongoing trials into tranexamic acid use – one in postpartum haemorrhage (WOMAN trial) and the other in gastrointestinal bleeding (HALT-IT study) – are widely anticipated.

Table 6 summarizes indications for tranexamic acid.

Intraoperative cell salvage

Intraoperative cell salvage, the retrieval of the patient's red cells during surgery with the return of the patient's own washed cells, is a widely used technique. A systematic review of 75 trials concluded that use of intraoperative cell salvage in orthopaedic and elective cardiac surgery significantly reduced the risk of requiring subsequent allogeneic transfusion (Carless et al, 2010). Intraoperative cell salvage is commonly used in vascular, cardiac, orthopaedic and obstetric surgical practice and its use in major haemorrhage should be considered. Hunt et al (2015) recommend a 24-hour intraoperative cell salvage service to be available in all British trauma, cardiac, obstetric and vascular centres.

For procedures including pelvic reconstruction, scoliosis surgery, major obstetric and also cardiac and complex vascular surgeries, National Institute for Health and Care Excellence (2015a) guidance recommends the use of intraoperative cell salvage with tranexamic acid.

Table 6. Guidance on the use of tranexamic acid

Summary of general and perioperative recommendations	Reference(s)
Tranexamic acid is indicated in massive haemorrhage: ■ For those patients presenting with trauma (early administration of 1 g bolus administered over 10 minutes intravenously followed by 1 g over an 8-hour infusion) ■ For non-traumatic massive haemorrhage a 1 g bolus dose is recommended	Hunt et al (2015), Estcourt et al (2016)
For patients with thrombocytopenia secondary to chronic bone marrow failure, consider the use of tranexamic acid in addition to or as an alternative to therapeutic platelet transfusion	Estcourt et al (2016)
Tranexamic acid should be offered to all patients expected to have >500 ml blood loss or moderate blood loss undergoing surgery (unless contraindicated)	National Institute for Health and Care Excellence (2015a, 2016a), Estcourt et al (2016)
Tranexamic acid should be considered in high-risk surgery (e.g. cardiac and spinal surgery), a dose of 10 mg/kg followed by 1 mg/kg/hr is recommended based on cardiopulmonary bypass protocols	Hunt et al (2015)
Tranexamic acid should be used with intraoperative cell salvage	National Institute for Health and Care Excellence (2015a)

KEY POINTS

- Anaemia should be promptly investigated and treated.
- For patients undergoing urgent surgical intervention, efforts should focus on using the available time to investigate the cause of anaemia and promptly start treatment.
- In the absence of bleeding, a restrictive haemoglobin threshold and single unit transfusion should be encouraged for stable, asymptomatic patients who have no adverse cardiovascular risk factors.
- Where possible, patients should be involved in the decision-making process regarding the need for blood transfusion with risks *vs* benefits discussed and alternatives explored.
- Perioperatively, haemopoiesis and tolerance of anaemia should be optimized alongside strategies to minimize blood loss.

Reduction in intraoperative and postoperative blood loss

Minimizing intraoperative blood loss is a balance between reducing blood flow and ensuring sufficient perfusion to vital organs. In addition to surgical technique, methods such as tourniquet use to promote a bloodless surgical field, the use of cautery to seal incised vessels and use of vasoconstrictive agents can be effective (Shander et al, 2012a). Topical haemostatic agents such as fibrin sealants and tranexamic acid may also be considered (Clevenger et al, 2015). A 2003 Cochrane review found the use of topical fibrin sealants to be efficacious in reducing postoperative blood loss and also reducing the need for subsequent blood transfusion (Carless et al, 2003).

General considerations such as avoiding postoperative hypothermia, acidosis and hypocalcaemia so as to not promote coagulopathy and platelet dysfunction are recommended (Shander et al, 2012a; Hunt et al, 2015).

In the postoperative period, ongoing clinical assessment for blood loss is required with consideration of the patient's bleeding risk and status before re-commencing blood-thinning agents (Clevenger et al, 2015).

Pillar 3: harness and optimize tolerance of anaemia

Attempts to optimize oxygen delivery, cardiac output and factors affecting ventilation should be made perioperatively. Oral iron is recommended to continue in the postoperative period if deficiency has been identified in the preoperative phase (National Institute for Health and Care Excellence, 2015a). Guidance also supports the use of oral iron for those who have hypoferritinaemia preoperatively in the absence of anaemia (Kotzé et al, 2015).

Future considerations

As demonstrated by the wealth of recent published guidance relating to patient blood management principles, this is a dynamic, evolving field with clear advantages to both resource preservation and clinical outcomes. Education plays a central role in patient blood management as some clinicians may be unaware of the recent evidence-based advances. In England, both hospital and regional transfusion committees currently support the implementation of patient blood management together with the regional patient blood management teams in NHS Blood and Transplant. A patient blood management toolkit has been developed to aid education and provide reference and resources (http://hospital.blood.co.uk/patient-services/patient-blood-management/).

The use of technology to reduce human error in transfusion practice and aid patient identification is considered in the blood transfusion National Institute for Health and Care Excellence (2015a) guidance and also features in the major haemorrhage guidance (Hunt et al, 2015). The use of electronic decision aids may become commonplace in NHS trusts, guiding the clinician's decision-making process and challenging practice when the use of blood components does not conform to patient blood management principles (National Institute for Health and Care Excellence, 2015a). **BJHM**

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