Transfusion alternatives in orthopaedic surgery

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Summary

The volume of orthopaedic surgery is large and growing – over 200,000 hip and knee arthroplasties were performed in the USA alone last year – and these patients are at particularly high risk of requiring a blood transfusion. Orthopaedic surgeons can significantly reduce the amount of allogenic blood transfused by following simple guidelines. Accurate data gathering has allowed us to better target those most at risk. A wide range of strategies is available including, but not limited to, review of transfusion triggers, autologous predonation, haemodilution techniques, blood salvage and the use of perioperative erythropoetin. Some techniques are particularly suited to orthopaedic surgery and the use of an algorithm can help us to select the best approach for the individual patient.

CHAPTER SUBHEADINGS

INTRODUCTION

The problems of allogenic transfusion are already well documented both in the reduced availability of blood and the multitude of potential risks with its use. Orthopaedic surgeons along with cardiac/vascular surgeons are probably the biggest users of blood products. Even small changes to routine procedures can lead to enormous benefits for patients, physicians, hospitals and society in general.

Until recently the true scale of the problem has been very difficult to elucidate. Simple questions such as " How much blood is lost in hip replacement surgery?" or "How much does a unit of packed cells cost?" have been impossible to answer. An amazingly wide range of figures is quoted from different sources. How can the problems be solved without this basic information? Recently, greatly improved data collection has clarified such information giving us a better starting point when trying to address the problems

Orthopaedic surgery can be divided into the fields of elective orthopaedics and trauma. The elective aspects, particularly joint replacement and spinal surgery, are well suited to the many techniques available to help reduce the use of allogenic blood. Trauma by definition is acute, unpredictable and a much bigger challenge.

The day to day practise of orthopaedic surgery varies widely between countries, hospitals and even individual surgeons. There are many choices and often difficult decisions to be made - Which type of surgery? Which anaesthetic? Is a predonation programme available? Is erythropoetin cleared for use by the regulatory bodies? What are the cost benefits of any of these programmes?

Much of the recent literature in the field of transfusion alternatives has come from orthopaedic departments in Europe and N. America. All are agreed on the necessity of reducing the exposure to allogenic blood but there still remains a great deal of controversy on the best way to do it. This chapter will set out the options available and attempt to provide a consensus on today's žbest practice' for the orthopaedic community.

THE SCALE OF PROBLEM - DATA COLLECTION

Orthopaedic surgeons make high demands on blood banks. In the USA each year as many as 300,000 people sustain a hip fracture. Almost all of these require surgery and a high percentage require transfusion of allogenic blood. This is only a single part of the increasing volume of trauma seen in most orthopaedic centres. As our population ages and our technology improves we have seen an explosion in the amount of elective orthopaedic work, particularly in the field of joint replacement and spinal surgery. In the United Kingdom last year nearly 100,000 hip and knee arthroplasties were performed with perhaps half of these patients receiving allogenic blood.

Surprisingly, it is only recently that useful data has been collected on a large scale. Until then the data was usually from individual surgeons or units. This data allows us to see the scale of the problem. 330 Orthopaedic surgeons across the USA combined the information of blood management for patients having hip or knee arthroplasty. In the USA, the "standard of care" is usually to offer autologous predonation. A transfusion (autologous or allogenic) was given to 46% of the 9482 patients. The prevalence was higher in hip arthroplasty (57%) than knee arthroplasty (39%) Despite the high collection rate of autologous blood, only 55% of these units were actually given back to the patient. Unilateral knee arthroplasties, primary and revision, were associated with the most wastage. Breakthrough transfusions of allogenic blood in patients who had predonated blood were necessary in 9% of patients. As expected this was most likely with revision hip arthroplasty.

In formulating a strategy for blood management, it is important to identify the patients most at risk. This allows the treatment to be tailored to the individual. Not only is this beneficial in the clinical setting but also in providing the most cost-effective solutions. It seems rather simplistic to state that a patient with a lower preoperative Hb is more likely to need a transfusion. Nevertheless, many studies have detailed the likelihood of transfusion based upon the patient's preoperative status. Most institutions use the maximal surgical blood order schedule (MSBOS). This certainly improves the efficiency of blood ordering practices but only deals with the group as a whole not the individual.

Estimated blood loss, age, weight and aspirin use are all indicators but by far the strongest predictor is the preoperative Hb level. Whenever this falls in the range of 10 – 13g/dl the patient has a significantly higher risk of requiring allogenic blood. By utilising this simple data it was possible in one Orthopaedic centre to reduce the amount of blood crossmatched for total hip arthroplasty from 676 units to 265 units, a decrease

of 61% with significant cost savings. Put another way, the crossmatch to transfusion ratio was reduced from 1: 3.14 to 1: 1.23. More recently, the use of an algorithmic approach has been suggested

Unfortunately, despite this data collection, there are still many as yet unexplained variables Even with a well-defined situation i.e. primary total hip arthroplasty, the transfusion rate can vary between hospitals from as low as 25% to nearly 100% (Table 4).

TECHNIQUES APPLICABLE TO ORTHOPAEDIC SURGERY

These techniques are discussed in more detail in other chapters but it is helpful to remind ourselves of the available options. Although there are many choices, it is quite rare to find an orthopaedic centre that can offer the whole range. In the USA and many European countries predonation of blood for autologous transfusion is perhaps the most widely utilised method.

Lowering Transfusion Triggers

This is the simplest method of reducing the use of allogenic blood. Too often blood is given to patients on an empirical basis. In my own institution, for many years, blood was ordered and given to over 60% of patients undergoing hip and knee surgery, usually on the basis that "most patients need it anyway". At times patients undergoing total knee arthroplasty with a tourniquet inflated were transfused even before any blood was lost! It is essential to educate the relevant staff members who may order this transfusion. This may be the anaesthetist, the junior surgical staff or, not infrequently, the surgeon himself who is unwilling to change his practice despite overwhelming evidence to the contrary. By realising and acting upon the simple fact that the majority of patients can tolerate haemoglobin of 8 or 9gm we were able to halve our transfusion rate almost overnight.

Choice of Surgical Procedure

Some choices are obvious and mainstream now. The use of closed techniques for nailing long bone fractures significantly reduces blood loss. Similarly, the use of external fixators for unstable pelvic fractures not only reduces blood loss but at times can be life saving. Early open surgery is not infrequently associated with catastrophic blood loss.

Preoperative Planning

It is essential that the surgeon is familiar with the patient, the procedure, the instruments and the implants. Preoperative planning and rehearsal can save valuable time and reduce blood loss

Modification of surgical techniques

This is another very simple and cost effective way of reducing the use of allogenic blood. Adherence to good surgical principles will lower the blood loss often dramatically. This may involve taking more time to identify and control bleeding vessels before the surgery proceeds. Many procedures have their own potential problems. Perforating branches of profunda femoris artery are often injured when approaching the shaft of the femur. Branches of the circumflex vessels are at risk with a posterior approach to the hip. The superior lateral geniculate artery may be cut during knee surgery. A few extra seconds to locate and avoid or control these arteries can make a big difference to overall blood loss.

Positioning

Appropriate positioning can help lower blood loss. This is particularly helpful in spinal surgery where the intra-abdominal pressure can be lowered with the use of special frames or supports thus preventing congestion of the epidural veins.

Choice of Anaesthesia

It has long been recognised that spinal anaesthesia for total hip replacement surgery can have significant advantages. More recently the beneficial effect of hypotension on intraoperative blood loss during total hip surgery under epidural anaesthesia has been reported. Using this technique led to significantly lowered blood loss, improved bony surfaces for implant fixation and shorter surgical time. The surgical blood loss was reduced from 700ml to approximately 250ml.

Perioperative Use of Pharmacological Agents

There is only limited experience in the use of these agents in orthopaedic Surgery. It is suggested the use of Desmopressin with Harrington rod spinal fusion surgery can reduce blood loss by 32.5%. No benefit was noted with total hip surgery however. Aprotinin has been reported to reduce blood loss in total hip arthroplasty.

Preoperative Optimisation of Medical Status

The majority of patients undergoing orthopaedic surgery have a number of comorbid conditions, which need to be addressed preoperatively. Probably half are hypertensive. Many are taking aspirin, non-steroidal anti-inflammatory agents or anticoagulants. Coagulopathies should be recognised and treated.

Perioperative Erythropoetin

A large number of studies have recently been completed confirming the safety and efficiency of erythropoeitin. Used alone in the perioperative period or as an adjunct to maximise a predonation programme, red blood cell production is increased and allogenic transfusions are reduced. Recent studies are helping to define more clearly the patients who will most benefit from the use of this agent.

Predonation of Autologous Blood

Predonation has been the" standard of care" in many orthopaedic units across the world for a number of years. Although generally effective there are increasing concerns related to cost factors, the increase in preoperative anaemia and the large number of wasted units.

Haemodilution Techniques

As yet there is only limited information available in the orthopaedic setting. There are probably indications for its use when blood loss is expected to be moderately high and the patient has no coronary artery, renal, hepatic or pulmonary disease. Skill levels need to be high and the time and costs need to be considered.

Blood Salvage – Intra and Post operatively

Simple drainage systems which collect, filter and reinfuse shed blood postoperatively are very popular and will be discussed further in relation to specific procedures. It is possible to reinfuse an average of 437ml after primary total hip replacement and 883ml

after primary total knee replacement. Intraoperative salvage is much more costly in the use of time and staff and has more limited applications. It is perhaps useful for extensive spinal surgery. Blood salvage does reduce the need for allogenic blood transfusion but not in all cases. It is particularly effective when combined with other techniques such as predonation or perioperative erythropoeitin.

Blood Substitutes

Perfluorocarbons and haemoglobin solutions may yet have a significant role to play but are still in the phase II testing stage. Minimal data is available in the field of orthopaedic surgery.

RECENT STUDIES AND RECOMMENDATIONS FOR SPECIFIC ORTHOPAEDIC PROBLEMS

Primary Total Hip Replacement

Total hip arthroplasty (THA) is one of the commonest elective procedures in orthopaedics. Current data suggests over half of these patients will receive a transfusion of allogenic or autologous blood. The true blood loss is hard to accurately assess and this causes problems when trying to compare reports from different sources. The measured loss – suction, sponge weighing and drainage – is invariably much lower than the true loss if this is calculated using the pre and postoperative Hb levels. The true loss is variable and depends upon both the patient and the surgeon with an average around 1600ml. Overall 53% of patients received a transfusion, on average 2 units.

The majority of patients participate in a predonation programme (65%). In the remainder, with no predonated blood, 32% received an allogenic transfusion compared to a 16% breakthrough rate in the predonation group. There is also a great increase in the transfusion rate when preoperative anaemia is present.

A predonation programme obviously does decrease the need for allogenic blood in primary THA. However, there are still some serious concerns:

1.) Autotransfusion is not completely žsafe'. Clinical errors and infection can still occur.
2.) There is a high level of wastage. About half the units are not used.
3.) Preoperative anaemia is more likely with predonation. The erythropoeitic response to phlebotomy is unexpectedly rather poor.
4.) Predonation is neither cheap nor easy to arrange.

The usual recommendations of performing the procedure adhering to good surgical principles in a timely fashion need not be repeated.

The use of hypotensive epidural anaesthesia has been shown to reduce the blood loss significantly and is used in many orthopaedic centres routinely.

Acute haemodilution is safe and effective but probably not required for the majority of primary THAs. It requires a high level of skill and is time consuming.

There is some debate concerning the effect of different implants. 25 matched pairs of THAs, half uncemented and half hybrid or cemented, were compared. There was no significant difference noted in the blood loss and transfusion rate.

Intraoperative salvage is costly in time and staffing and rarely warranted in primary THA. Postoperative reinfusion drains can be used but most blood loss is intraoperative and the trend is now to avoid the routine use of drains.

Suggestions

Predonation is very popular but it is very wasteful for all patients to participate. If an individual insists upon participating then 1 unit would usually be adequate rather than the usual 2 units. The management must be tailored to the individual. If he is otherwise healthy with a Hb > 13gm/dl then transfusion is very unlikely. For the anaemic patient or one who is unwilling or unable to predonate blood, a perioperative course of erythropoeitin is appropriate. Erythropoeitin alone may be as effective as a predonation programme. Postoperative drains are not routinely indicated.

Revision Hip Replacement

Revision surgery is accounting for an increasing percentage of hip arthroplasty. The implants inserted in the 70s and 80s are now reaching 15-20yr follow up and the failure rate is rising significantly. Revision surgery is much less predictable than primary surgery and preoperative planning is more difficult. At times the surgery is no worse than a primary procedure, but more likely there will be problems with dense scar tissue, large areas of exposed bone, osteolysis and fractures and a greatly increased operative time. All this adds up to increased blood loss, typically 50-100% greater than a primary procedure. Typically 3 units of blood are transfused. Breakthrough allogenic transfusion with a predonation programme is highest with revision hip surgery at 21% in one series.

Suggestions

As with primary surgery, it is still important to optimise the preoperative status and stop aspirin and non-steroidal agents well in advance. Meticulous surgical technique is even more important. Templating and rehearsal of the procedure and familiarity with the instruments and implants are vital. Hypotensive epidural anaesthesia is usually preferred.

Predonation remains the standard for many orthopaedic surgeons. On top of the usual problems is the need to provide more units of blood than primary surgery. Typically 4 units have been ordered but 2 or possibly 3 would be adequate for the vast majority. For higher predonation levels, erythropoetin supplementation has repeatedly been shown to improve the yields of donated blood.

Erythropoetin alone has been shown to be safe and effective in reducing the exposure to allogenic blood. A dosing schedule of 600iu/kg x 4 weekly doses seems most efficient. A study comparing perioperative erythropoeitin with a predonation programme in total joint arthroplasty involved 490 patients. Erythropoeitin treated patients had a mean rise in preoperative Hb of 1.5g/dl compared to a 1.2g/dl decrease in the predonation group. This led to a total transfusion of 53 units of allogenic blood in the erythropoeitin group compared to 325 units (79 allogenic) in the predonation group.

Haemodilution techniques may be particularly helpful in these situations of higher blood loss but are not widely available. Similarly intraoperative salvage techniques can be helpful when the loss is high but the salvaged blood is often of poor quality. There is usually contamination of the blood with irrigation fluid and the general debris of cement, polyethylene and metal. Of more concern is the occasional presence of infection, which would prevent reinfusion. As before, postoperative drains are probably of only limited value.

Primary Total Knee Arthroplasty

In 100 consecutive primary total knee arthroplasties at Guy's Hospital in 1998 the measured blood loss ranged from 50 – 2590ml with an average of 780ml. When calculated (based upon pre and postoperative Hb and the transfusion given) this average was closer to 1300ml. The average loss in males was much higher than in females

980ml vs. 650ml. Typically the loss and transfusion rate is less than total hip arthroplasty but a 40-50% rate is not uncommon. In a study of 477 patients only the preoperative Hb was a predictor of transfusion risk. If > 13.5g/dl there was only a 2.8% risk but if < 10g/dl this rose to 33%. When predonation is utilised there is high wastage – often at least 50% but in one study as high as 80%. Another approach is to give back all the predonated blood whatever the loss.

This actually could produce a lower complication rate but is not generally accepted as good practise.

Haemodilution and intraoperative salvage are not appropriate for most primary TKAs as many are performed under tourniquet and the blood loss and transfusion rate is not particularly high in most cases.

Suggestions

For most patients simply lowering the transfusion trigger is enough to avoid the need for transfusion. Predonation is generally not warranted in primary knee replacement. As with total hip surgery, if the patient insists upon predonation then a single unit is sufficient unless anaemia is present preoperatively. Perioperative Erythropoeitin is effective for use in the anaemic patient.

Postoperative reinfusion drains are becoming increasingly popular. Some claim there to be no benefit but many recent studies show a marked reduction in transfusion rates, in our unit from nearly 50% to as low as 3%.

Revision Total Knee Arthroplasty

The blood loss is not much different from that seen in primary surgery. The rate of transfusion and the number of units given are higher but not greatly so. Most recommendations for primary knee arthroplasty apply in these cases.

Bilateral Knee Arthroplasty

The blood loss is significantly higher than that seen in unilateral cases leading to an increased transfusion rate. In patients with no predonation this rises from 18% to 57%. This necessitates the application of one or more techniques to avoid allogenic blood.

Suggestions

As before, predonation of autologous blood remains the choice in many orthopaedic centres. Frequently 4 units are drawn and, not unexpectedly, the problems of predonation are magnified. If this technique is used, in the great majority of cases, a single unit for each knee is more than adequate. Erythropoeitin is again very effective in these patients both alone and to improve the yield of the predonation.

Postoperative salvage and reinfusion is also particularly useful but one must exercise care when large volumes are involved. We try to restrict our total reinfusion to 1500ml, usually within the first 6 – 8hrs.

Spinal Surgery

The blood loss in spinal surgery is very variable. The loss ranges from negligible amounts in minimally invasive procedures to as high as 20litres in multilevel, revision or fusion procedures. Bone graft harvest is a further source of blood loss. Coagulopathy is found in a high percentage of these cases perioperatively. The main predictors of transfusion include low preoperative Hb, tumour surgery, and the number of levels operated on. Data is still relatively sparse but hypotensive anaesthesia has long been recognised to be of value. Erythropoeitin used alone in 178 patients reduced the transfusion rate from 24% to 4% in surgery for idiopathic scoliosis.

Normovolaemic haemodilution can be very effective but its use is not widespread and data is still limited.

Suggestions

Autologous predonation is commonly utilised (typically 2-4 units are collected). There are problems collecting larger amounts and supplementary erythropoeitin is of value, often raising the yield by 30%. Erythropoeitin alone may be just as effective but well controlled studies are still rather limited.

Care with the operative technique is vitally important. This would include careful sub-periosteal elevation of tissues, meticulous haemostasis and the use of hot or laser scalpels.

This is probably the most useful area for intraoperative salvage despite the costs in time and manpower and an estimate that only 30% of the blood may be utilised. Postoperative drains may be of supplemental benefit.

Paediatric Spinal Surgery

Generally speaking the problems are similar to those seen in adult surgery. The blood volume is lower and any loss is much more significant as a percentage of total volume.

There are real problems trying to obtain large volumes of autologous blood in children both physiologically and from the trauma of repeated visits and phlebotomies. Early studies of perioperative erythropoeitin (10,000u x 3 weekly doses) and iron suggests the costs and efficiency compare favourably with a predonation programme and may even reduce the length of stay.

Orthopaedic Infection

The problems of orthopaedic infection are particularly difficult to manage. Typically, the orthopaedic surgeon has to deal with an infected joint prosthesis or osteomyelitis not infrequently associated with a fracture. The patients are often chronically ill with a refractory anaemia and multiple comorbidities.

The treatment of an infected total knee prosthesis usually involves a two stage reimplantation. The transfusion rate is extremely high. In an ongoing study, 80% of patients required transfusion at the time of prosthesis removal and 82% at reimplantation. Only 12% of patients escaped allogenic transfusion. This causes great concern not least because of the immunomodulation effects of allogenic transfusion and risk of further infection. Most modalities of treatment are not possible in these patients. Predonation is difficult due to the pre-existing anaemia and salvage techniques are inappropriate in the presence of infection.

Suggestions

Erythropoeitin seems particularly suited to these problems. 40,000u of erythropoeitin sc. with iron supplementation are given at the time of removal of the prosthesis. The treatment continues until after reimplantation, typically 6-8 weeks later. Early results show promise with a rise in Hb from 1.5 to 6.2g/dl (av. 3.3) and a reduction in transfusion rate to 35% [35].

Orthopaedic Oncology

Two major problems are associated with the surgical treatment of oncology cases. First is the chronic anaemia present in a high percentage of cases. This is due to the disease itself and also the effects of chemotherapy and radiotherapy. This anaemia obviously has potential for surgical problems but it also adversely affects the efficacy of the therapies used. Secondly, the immunomodulation effects of an allogenic transfusion are known to cause an increase in tumour recurrence rates and reduce survival

times. Orthopaedic literature is rather sparse but soft tissue sarcoma survival can be greatly reduced after allogenic transfusion. The five-year rate drops from 85% to 63%. Even the number of units seems important.

Suggestions

Predonation of autologous blood remains the favoured option in many centres. The anaemia can adversely affect the yield. Normovolaemic haemodilution is probably effective but experience is limited. Salvage techniques are contraindicated due to the risk of haematogenous spread of the tumour cells. Erythropoeitin has been shown to be effective as part of the general medical treatment of malignancies. The level of Hb was seen to rise in patients undergoing radiotherapy from 11.9 to > 14g/dl in 80% of cases (5% with placebo). Studies have recently started on the use of erythropoeitin in the perioperative setting particularly to help accelerate the time to surgery.

Orthopaedic Trauma

This is a particularly difficult area for effective blood management. The numbers involved are huge and rising; some 300,000 hip fractures occur each year in the US alone. Many patients are elderly and frail with multiple comorbidities and not infrequently are anaemic at the time of the injury. Many of these cases require transfusion of allogenic blood. Pelvic fractures are associated with major blood loss with transfusion requirements ranging from 3.6units to 14.8units (5.9av.) Acetabular fracture fixation is associated with transfusion in over 50% of cases. After initial stabilisation, early fixation of long-bone fractures will reduce the blood loss as well as reducing other complications particularly to the lungs. Closed techniques and the use of fixators will reduce the operative blood loss. Further surgery is often required during the first few days with further blood loss. Later, the problems of rehabilitation arise. Much work is now being done on the effects of anaemia on postoperative recovery, vigour, length of hospital stay and costs.

It is increasingly clear that allogenic transfusion can have detrimental effects on the overall condition of the patient. The infection rate is probably doubled, not just the orthopaedic wound but also the rate of chest and urinary tract infection.

Unfortunately the nature and timing of these injuries precludes the use of many modalities. Predonation is obviously impossible and haemodilution and hypotensive techniques can be risky in these patients.

Suggestions

Allogenic blood is still necessary in a number of cases despite the potential drawbacks. This may be given in the acute phase i.e. pre or intraoperatively or later to correct the problems associated with severe anaemia.

Blood salvage can be of value in cases of high blood loss such as pelvic fracture fixation. Most blood loss will occur intraoperatively but postoperative salvage drains can be of additional help with up to half the loss recoverable.

Erythropoeitin may have great potential in orthopaedic trauma but studies are still limited. Early studies suggest a reduced transfusion rate when given as 5 daily doses to hip fracture patients undergoing operative fixation. In more major cases it could only be used in the post-operative period but should also help reduce the transfusion rate by improving the erythropeitic recovery and help to avoid the complications, particularly the increased infection rate.

The Future

It has taken many years for orthopaedic surgeons to realise the importance of an effective blood management programme. Even now many centres have minimal planning and rely heavily on allogenic blood. It has been clearly shown that even the sim-

plest techniques such as lowering the transfusion trigger can, at times, halve the transfusion rate or better. In the immediate future, much can be achieved with good education making surgeons better aware of the dangers of allogenic transfusion and the options already available to reduce its use. Attempts will continue to make allogenic blood safer with more effective screening but this is only part of the problem.

Predonation programmes will likely continue in the foreseeable future but much can be done to refine them. It is unacceptable to spend so much time and effort only to discard half of the units obtained. An algorithmic approach, which can more accurately predict the expected blood loss in an individual, should be very helpful. It is only after studies involving the gathering large amounts of data that we realise who is really at risk-certainly not the primary knee replacement in an otherwise healthy individual. In more difficult cases requiring large predonations, erythropoeitin will become more commonplace in improving the yield.

Erythropoeitin in the perioperative period has many potential benefits. A large number of studies will be completed in the next one or two years and these should further clarify the individuals most likely to benefit and also the most effective dosing regime. There is still concern about the cost of this treatment but it appears it may be cheaper than a predonation programme for some patients.

There is still a great deal of confusion when trying to compare different treatments. Most methods work to a greater or lesser extent but some are much more time consuming or difficult to set up. Some are potentially very costly and require a large input from highly trained staff. More studies are underway to help with these comparisons, both the efficacy of the treatment and increasingly the costs to the individual and society.

Blood substitutes have gone through a long and difficult testing and validation process. There have been a number of "false dawns" but many of the earlier limitations and side effects seem to have been overcome and early clinical testing is underway.

The process of disseminating this knowledge should become simpler. The Internet and electronic publishing will provide an easily accessible source of information which can be rapidly updated. Laptop or hand-held computer based algorithms are being developed for use in general clinical practice and also as research tools.

Conclusions

It will be some time before the concept of "bloodless surgery" is finally realised but great strides have already been made, particularly in the last ten years. The initial problem of making the orthopaedic community aware of the risks of allogenic transfusion is being solved with better education. A wide array of treatment options are now available and the indications for and effects of each are being defined more accurately. The future is increasingly exciting, as blood substitutes become available. Until that time, we must strive to make the best use of the techniques already available in order to achieve the best possible outcome for our patients.

Key Points

1.) Orthopaedic surgeons are amongst the biggest users of blood products

2.) Extensive data is now available setting out the likelihood of transfusion in specific orthopaedic procedures

3.) A number of treatment options are available including Predonation of autologous blood, haemodilution, modifications to anaesthesia and surgical technique, intra and post-operative salvage and the use of pharmaceutical agents such as erythropoeitin.

4.) The results of recent studies are discussed in detail showing how the use of these techniques can be tailored to individuals and specific operations to effectively reduce the need for allogenic blood