

# Getting Started in Patient Blood Management

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## PREFACE

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**T**his primer is intended to introduce institutions to the concepts of patient blood management (PBM) and facilitate their learning in preparation for implementing facility-specific PBM programs.

Much has been written about PBM, and this primer does not intend to duplicate that information. Instead, it aims to 1) provide a brief overview to illustrate that the principles of PBM represent core values in transfusion medicine that deserve broad application and 2) point the reader to more definitive sources of information about the rationale, structure, and function of a PBM program.

This primer should provide sufficient encouragement and direction to readers to allow them to advance from basic knowledge to sources of detailed information that will facilitate the development of programs in their own institutions. The information contained herein is only a start, not a definitive set of policies and procedures. Even so, we hope it provides encouragement to move toward PBM program implementation.

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## **INTRODUCTION: WHAT'S IT ALL ABOUT?**

Patient blood management (PBM) is an evidence-based, multidisciplinary approach to optimizing the care of patients who might need transfusion. The intent of PBM is to apply transfusion as a therapeutic modality only when it is in the patient's best interest to do so. The concept certainly involves using the best available evidence to decide when to transfuse so that patient benefit from the transfusion can be predicted.

However, PBM goes beyond just the decision whether to transfuse. PBM includes considering the patient's entire (projected) course to determine whether the reason for transfusion could be avoided in the first place and/or possibly treated in another manner. Because these clinical analyses and interventions are usually undertaken by those other than transfusion medicine specialists, a successful PBM program will undoubtedly involve nurses and administrators as well as physicians in multiple medical disciplines. Of course, the patient's involvement in the decision making process is also important.

There are many reasons to limit transfusions. From the patient's perspective, if benefit cannot be predicted, why take the risk? Although transfusion is safer than it ever has been, some risks are inherent and unavoidable. There's also the cost perspective to consider. A blood component itself may cost the hospital up to a few hundred dollars, and the entire transfusion event (including testing and clinical care) may cost several times this amount. Thus, there are both medical and economic reasons to consider PBM. In some cases, religious beliefs also come into play. PBM programs facilitate handling the requests of those who have religious objections to receiving transfusions.

Avoiding a therapy when it is not needed makes good sense and has long been promoted by transfusion medicine specialists. Yet, a significant proportion of transfusions still occur in situations where patient benefit is difficult to predict. Involvement in a PBM program by members of the disciplines that frequently transfuse patients has two major benefits. It allows intervention to prevent the patient from reaching the point that a transfusion is inevitable. It also involves these specialists in productive dialog around the risks, benefits, and

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alternatives to transfusion. This may, in turn, make them responsive to studies that highlight the benefits of more conservative transfusion practice.

PBM programs vary in their size, scope, cost, and effectiveness. Starting a full-fledged program that includes all possible specialties and interventions may appear to be a formidable and expensive undertaking in a hospital that previously had none of the capabilities under consideration. Just mentioning the development of a business plan to a group of physicians is likely to generate sufficient negative sentiment to quash the idea! However, encouragement can be taken from the recognition that PBM programs come in all sizes and shapes. They can certainly start small and uni-focal and later build on initial successes to address particular issues at the institution and expand to other disciplines. A knowledgeable and determined champion is most important to have!

### **RATIONALE FOR LIMITING TRANSFUSION**

Most patients already have a clear view of the risks of transfusion, which they label “AIDS” and “hepatitis.” Although these viral risks remain, of course, they are minuscule compared to previous risks, having been reduced by effective donor screening and testing to essentially undetectable frequencies. This may have relieved physicians from anxiety about the most notable transfusion risks, but it certainly has not promoted additional conservatism in transfusion decision making.

Yet, there are many untoward consequences of transfusion that remain. Some of these are well known, yet are underappreciated for their frequency. Others are still putative or theoretical, but worthy of consideration in a clinical scenario. Attempting to include their frequencies in a calculation of the risks vs the benefits of a transfusion is problematic, however. Quantifying or projecting the benefits of a planned transfusion (in terms of reducing the risk of a myocardial infarction, for example) is not currently possible due to a lack of applicable data in most circumstances.

However, the publication of an increasing number of studies indicating a lack of patient benefit after a traditional or more liberal transfusion strategy would suggest that the presumed benefits in many circumstances may not be as great as thought. Conversely, the risks associated with not transfusing in many situations where it pre-

viously would have been automatic are not as great as many physicians had assumed. Therefore, cogent arguments can be made that more conservative transfusion strategies are warranted.

Table 1 is a brief enumeration of some of the risks of transfusion and an approximation of their frequency as events per million transfused units. Additional information can be found in standard texts. (See Resources.)

Numerous studies have investigated whether transfusion of any Red Blood Cell (RBC) unit or of a unit that has been in storage for a longer time confers additional risk of morbidity or mortality to the recipient. Although associations have been found between transfusion and poorer outcomes or transfusion of older units with increased morbidity or mortality, most of these studies have significant methodologic limitations that prevent assignment of causation to transfusion. (Prospective, randomized, controlled trials to address the effect of the storage period of RBCs are currently under way.) The explanation may be that sicker patients are more likely to be transfused and to receive older units. Nevertheless, discretion would be advised in all transfusion decisions to ensure that the projected benefits of the transfusion for the patient outweigh certainly the known risks as well as the potential risks to the extent that they are believed relevant.

## OVERVIEW OF CONCEPTS INVOLVED

### Concept 1: Limiting Loss through Phlebotomy for Testing

Laboratory blood tests are an integral component of the diagnostic workup of patients and play a critical role through all phases of patient management. Laboratory tests provide vital information on red cell mass, the coagulation system, electrolyte status, renal function, infection, and pregnancy. Because of the severity of their illness, intensive care unit (ICU) and other critically ill patients undergo extensive laboratory testing. In spite of the importance of the data that test results can provide, the magnitude of blood loss from hospitalized patients for diagnostic purposes has long been a concern.

Blood loss through phlebotomy of hospitalized patients for diagnostic laboratory testing is associated with decreases in hemoglobin and hematocrit levels and can contribute to anemia and the need for

**Table 1. Risks of Transfusion and Their Approximate Frequencies**

<b>Transfusion Risk</b>	<b>Frequency (per million units transfused)</b>
<b>Immunologic</b>	
Acute hemolysis (fatality)	1.5
Mistransfusion/wrong blood component or recipient	100
Delayed hemolysis	200
Urticarial	10,000
Febrile, nonhemolytic	5,000
Anaphylaxis	33
Transfusion-related acute lung injury	1,000
Alloimmunization	10,000
Graft-vs-host disease	Rare
Posttransfusion purpura	Rare
Transfusion-related immunomodulation	Uncertain
<b>Infectious diseases</b>	
HIV	0.5
Hepatitis B virus	2
Hepatitis C virus	1
HTLV-I	2
Chagas disease	<1
Transfusion-associated bacterial sepsis	
red cells	1
platelets	20
West Nile virus	<1
Malaria	0.5
Babesia	1
Syphilis	<0.01
<b>Other</b>	
Transfusion-associated circulatory overload	5,000
Iron overload	Dependent on transfused volume
Nonimmune hemolysis	Rare
Air embolism	Rare
Creutzfeldt-Jakob disease	Not reported in US

blood transfusion. In 1986, a landmark paper evaluated the impact of phlebotomy on the need for blood transfusion. According to the study, a mean volume of 762.2 mL of blood per patient was drawn during the hospital stay and 47% of this cohort required a blood transfusion. Similarly, other studies have evaluated transfusion practices in a multidisciplinary ICU at a tertiary care center; 85% of patients required a mean of 2 to 3 RBC units transfused *per week*. This group of transfused patients had an average of 70 mL/day of blood drawn solely for diagnostic purposes. Blood losses for laboratory testing as described above are not trivial. It has been reported that for each 100 mL of blood collected for laboratory testing, a patient's hemoglobin level might decrease an average of 0.7 g/dL.

In another study, 151 medical patients admitted to a medical ICU had a mean of 63 mL/day of blood drawn exclusively for diagnostic laboratory purposes. The investigators concluded that routine use of diagnostic laboratory testing was a major health problem for the ICU medical patient. A recent report evaluating trauma patients showed a potential for significant blood loss to occur as a result of phlebotomy, causing an additional burden on top of the blood loss that the patients experienced with their injuries.

Phlebotomy losses may not be entirely avoidable, but they may be partially preventable by implementing strategies to limit the number of tests ordered and the associated blood loss collected for each ordered test. Thus, while not the only factor for the development of hospital-acquired anemia, phlebotomy for diagnostic testing can be an actionable target for intervention.

## **Concept 2: Optimizing Patient Hemoglobin Levels Before Surgery**

Anemia is frequently defined as a hemoglobin level less than 12 g/dL (or hematocrit less than 36%) for adult females and a hemoglobin level less than 13 g/dL (or hematocrit less than 39%) for adult men. Undiagnosed anemia before surgery is common and, along with the type and complexity of surgery, one of the major predictors for perioperative transfusions. Depending on the need for surgery, the patient's overall health, and definition of anemia, 5% to 75% of patients may present with preoperative anemia. A national audit demonstrated that 35% of patients scheduled for joint replacement surgery had a hemoglobin level less than 13 g/dL on preadmission testing. Anemia before an elective surgical procedure can expose the surgical patient to blood transfusion (intraoperative and/or postoper-

ative). In addition, anemia has been associated with increased post-operative complications, such as increased length of stay, longer ventilation times, and increased risk for infection.

Preoperative preparation and planning for optimization of the patient's hemoglobin can decrease the risk for blood transfusion and improve patient outcomes. However, all too commonly, presurgical laboratory testing is performed within days of, or at the most 2 weeks before, the scheduled surgery date. Even worse, these laboratory results are not reviewed until 1 or 2 days before surgery, leaving little or no opportunity to address an unexpected anemia. Thus, early identification of high-risk patients (eg, presurgical laboratory tests at least 30 days in advance) is essential and allows for earlier intervention and management, if needed.

The use of standardized protocols or clinical pathways for identification and management of anemia and for discontinuation of anticoagulation medications before surgery can also help guide clinicians on best practice for perioperative patient blood management. A collaborative approach between the primary care physician and surgeon (or, increasingly popular, preadmission/preoperative anemia clinics) provides an efficient and patient-focused approach for optimization of the hemoglobin level before surgery.

### **Concept 3: Using Autologous Donation and Red Cell Recovery Techniques**

Presurgical autologous blood donation (PAD) is the process whereby the patient donates his or her own blood days to weeks before an upcoming surgical procedure. The blood product(s) are then stored for use either during surgery or in the postoperative period. The use of PAD peaked in the 1980's at the height of concern over human immunodeficiency virus (HIV) and hepatitis transmission. Its utilization has markedly declined in the current era of viral safety, with estimated per unit risk for HIV and hepatitis C virus (HCV) both below 1 in 2 million.

The decline in PAD use may be attributed to several additional factors:

1. Nearly 50% of autologous blood is wasted.
2. Optimal practice requires a significant interval for red cell regeneration between collection and surgery, which is rarely observed and often leads to increased risk of preoperative anemia.

3. Per-unit acquisition cost for PAD is approximately \$300 or more, which is frequently not fully recovered for transfused units, and is completely lost when the unit is not transfused.
4. Indications for transfusion of autologous blood should not differ from those for volunteer, allogeneic blood.

Transfusion of autologous blood has many of the same risks as allogeneic blood (eg, administrative errors, bacterial contamination, volume overload) and the decision to transfuse should be based on clinical assessment of the patient—not on a perceived increased safety of the autologous unit. Errors related to production and handling of PAD units are common (1 in 149 to 1 in 322 units collected) with one quarter of the errors related to the units not being available at the start of surgery. PAD should be reserved for those elective surgical patients with special needs, such as patients with multiple red cell antibodies or an antibody against a high-frequency antigen [eg, anti-U or anti-Diego(b)] or for high complexity, high blood loss surgical cases when there is sufficient time for collection with use of iron therapy, with or without erythropoietin, so as to limit preoperative anemia.

An alternative option for those surgical procedures in which significant blood loss may be anticipated and when the patient's hemoglobin level has been optimized is acute normovolemic hemodilution (ANH). ANH involves the removal of whole blood before the start of surgery into a standard blood bag containing anticoagulant, while simultaneously giving volume replacement with asanguinous intravenous fluids such as crystalloids and colloids. The blood can be stored at room temperature for up to 8 hours and still maintain viable platelets and coagulation factors. The primary goal of this technique is to create a *relative* anemia in the patient so that blood shed during the surgical procedure effectively has a reduced red cell content. Once the threat of (further) blood loss is diminished, the ANH blood is returned to the patient. Although this technique provides the ability to avoid or limit allogeneic red cell transfusion, the ANH whole blood may also provide, to a small extent, platelets and coagulation factors to aid hemostasis.

Red cell recovery techniques (ie, cell “salvage” methods) for patients who may experience significant surgical blood loss are another means to minimize allogeneic RBC transfusions. Although the resulting mean reduction in allogeneic RBC transfusions may at times seem small (such as less than a unit), the amount may represent significant exposure reductions for many patients.

Blood recovery includes both intraoperative and postoperative techniques in which shed blood is collected and reinfused to the patient. In the operating room, once a sufficient volume of shed blood is recovered, it is concentrated (via centrifugation) and washed with normal saline. During this process, the plasma, platelets, red cell stroma, contaminants, and anticoagulant are removed. The washed red cells are transferred to a separate bag, which is then administered to the patient in much the same way that allogeneic blood would be administered. Ideally, the recovered autologous red cell product should have a hematocrit of at least 45% to 55%. (Some instrumentation can achieve higher hematocrits.) Substantial volumes of red cells can be recovered for reinfusion in high blood loss cases. Intraoperative blood recovery may be considered for several surgical procedures, including cardiothoracic, orthopedic, neurosurgery, obstetrics, gynecology, urology, and vascular procedures.

Postoperative blood recovery involves the recovery and reinfusion of shed blood from surgical drains and/or wounds and is predominantly used in cardiac and orthopedic surgical cases where the volume of shed blood can be significant. Blood recovered postoperatively can be either washed or unwashed, and the minimum volume for reinfusion is considered to be 200 mL. For the unwashed product, blood is collected in a device where it is filtered; once a sufficient volume is reached, the filtered blood is transferred to an infusion bag for administration. For the washed product, once sufficient shed blood is collected in the surgical drain, it is further processed by washing and then transferred to a bag for reinfusion.

Although controversial, reinfusion without washing is more commonly applied, particularly for joint replacement surgery. In the absence of washing, the product has a hematocrit ranging from 20% to 30% and contains activated clotting and complement factors, inflammatory mediators, cytokines, and fat particles that can increase the risk for febrile reactions. Despite these negative effects, unwashed postoperative recovered blood has been shown to reduce allogeneic blood transfusions in orthopedic surgery, but has been less effective in reducing such transfusion in cardiac surgery.

Improved product quality and safety—hematocrit ranging from 60% to 80% with removal of contaminants—can be achieved by using devices that wash and concentrate the postoperative wound drainage blood (eg, CardioPAT, OrthoPAT, Haemonetics, Braintree, MA). However, the higher costs associated with these devices and the maintenance of competency by nursing staff may be a disadvantage for some institutions. Washed postoperatively recovered blood

has been effective in reducing the proportion of patients receiving allogeneic RBC transfusions in both cardiac and orthopedic surgery.

#### **Concept 4: Minimizing Perioperative Blood Loss**

In the operative period, the fundamental methods of blood management are good surgical technique and utilization of allogeneic transfusion threshold guidelines. However, in many surgical procedures, such as multi-level spine fusion or thoraco-abdominal aneurysm repair, heavy blood loss is highly probable and expected. In strategizing intraoperative transfusion management, consideration should be given to reducing allogeneic RBC transfusion by use of ANH and/or blood recovery techniques, as previously described.

A number of drugs (desmopressin,  $\epsilon$ -aminocaproic acid, tranexamic acid, recombinant Factor VIIa) have been advocated for reduction in surgical bleeding. Tranexamic acid and  $\epsilon$ -aminocaproic acid have been demonstrated to reduce blood loss during cardiac surgery. At this time, use of recombinant Factor VIIa should be limited due to the high cost and limited clinical trials demonstrating efficacy. Topical use of tranexamic acid has recently been popularized in orthopedic surgery.

In the face of significant hemorrhage, most anesthesiologists and surgeons will not tolerate turnaround times typically associated with a laboratory-based test and will transfuse blood components based on clinical observation of bleeding and blood loss. Point-of-care testing devices with more rapid turnaround times are better positioned to allow the anesthesiologist or surgeon to make decisions based on quantitative data rather than estimating the patient's needs. In addition to helping physicians make better decisions, point-of-care testing allows for smaller volumes of blood to be used to obtain the desired laboratory parameter. For example, a HemoCue device (Quest Diagnostics, Madison, NJ) requires 10  $\mu$ L of blood to obtain a hemoglobin measurement. Devices in the hospital laboratory will require several milliliters of blood for the same measurement. Table 2 lists several point-of-care testing devices.

Reduction of the mean arterial pressure, or what is termed "controlled or deliberate hypotension," can be used to reduce surgical blood loss. This blood pressure reduction can be achieved through use of inhaled anesthetic agents, nitroprusside, nitroglycerin, hydral-

**Table 2. Examples of Currently Available Point-of-Care Testing Devices**

Function	Device	Manufacturer
Viscoelastometry	Sonoclot Analyzer	Sienco, Inc. (Arvada, CO)
	TEG	Haemonetics Corporation (Braintree, MA)
	ROTEM	Tem Systems, (Durham, NC)
Hemoglobin measurement	HemoCue	Quest Diagnostics, (Madison, NJ)
	Hemopoint H2	Stanbio Laboratory (Boerne, TX)
PT/PTT measurement	CoaguChek	Roche Diagnostics Corp (Indianapolis, IN)
	i-STAT	Abbott Point of Care, Inc (Princeton, NJ)
Platelet function monitoring	PFA-100	Siemens Healthcare Diagnostics (Deerfield, IL)
	Plateletworks	Helena Laboratories (Beaumont, TX)

PT = prothrombin time; PTT = partial thromboplastin time.

azine, or several other less commonly used agents. It is important to be cognizant of the effect that this deliberate hypotension might have on patients with potential compromised cerebral, cardiac, or renal function. In general, a mean arterial pressure of 50 mm Hg is desired. This pressure is thought to be on the low end of brain autoregulation. *Significant caution should be used when combining this technique with aggressive normovolemic hemodilution.*

Attention should also be paid to the patient's body temperature. Maintenance of normothermia during surgery is critical for normal platelet and coagulation function. Vasodilation from anesthetic agents facilitates heat loss in cold operating rooms. As a result, patients progressively lose body heat during the course of a surgical procedure. Thus, every effort should be applied to maintain body temperature. This is most effectively achieved through forced air warming devices, reducing radiant heat loss (blankets, covering patient adequately), and use of blood and intravenous fluid warmers where there is significant blood loss or fluid infusion.

As with temperature, deviation from acid-base homeostasis leads to coagulation dysfunction. As pH falls, the rate of Factor II conver-

sion by the Factor Va/Xa complex decreases. Acidosis can arise from multiple sources. It can occur from hypovolemia and hypotension with a resulting lactic acidosis. A less commonly recognized mechanism is excessive normal saline administration. Normal saline creates a hyperchloremic metabolic acidosis because of the high chloride load.

In spinal surgery, placing pressure on the abdominal contents will obstruct inferior vena cava blood flow. As a result, venous return to the heart takes an alternative route through the epidural venous plexus, making these veins engorged and prone to bleeding. Thus, the abdomen should be padded in such a fashion that it is not under pressure. Certain spinal tables will allow for the abdomen to hang freely. Similarly, regional anesthesia has been demonstrated to reduce blood loss from a reduction in central venous pressure

Ultimately, blood loss is the responsibility of the surgeon. Adequate surgical exposure is a prerequisite for a safe, controlled, dissection. Techniques for reduction of surgical blood loss are beyond the scope of this document and are specific to each specialty. For instance, in cardiac surgery, blood loss can be affected by minimizing intravenous fluid before cardiopulmonary bypass, use of off-pump coronary artery bypass grafting, robotic-assisted techniques, use of heparin-bonded circuits, minimizing priming volume of the bypass circuit, and use of retrograde autologous priming, microplegia systems, and ultrafiltration/modified ultrafiltration.

### **Concept 5: Making Evidence-Based Hemotherapy Decisions**

Although the rationale for RBC transfusion is based on the need to increase oxygen delivery to key tissues, assessing whether a clinically important oxygen delivery deficiency exists and whether it is best remedied by transfusion are difficult decisions that should be based on more than a determination of hemoglobin concentration. The patient's status and capacity are also important points to consider. For example, is the patient showing any signs or symptoms of anemia, and are these being tolerated? Is the patient's cardiovascular system able to respond to the anemia by increasing the heart rate or by dealing with an increased blood volume? In acute anemia, it is additionally important to return the patient to or toward normovolemia. Then, the extent of the acute blood loss can be better understood and the ability of the patient to withstand the anemia more evident.

Normal subjects tolerate anemia down to a hemoglobin concentration of 5 to 6 g/dL with compensatory mechanisms allowing only temporary functional deficits to be seen. Concerns have been expressed, however, whether patients with significant co-morbidities can tolerate such a decrease in oxygen-carrying capacity. One study reported that normovolemic patients in the ICU not only tolerated a transfusion threshold of 7 g/dL (as opposed to 10 g/dL) but had lower mortality and less organ dysfunction. A subgroup analysis suggested that ventilation time was not prolonged in the group kept at a lower hemoglobin. The approach not only appeared to be associated with better outcomes but also reduced the usage of red cells by half. Similarly, patients randomly assigned to a restrictive transfusion strategy after repair of a hip fracture recovered their ability to walk as quickly and suffered no more morbidity (such as myocardial infarction) than if transfused under a liberal strategy (10 g/dL). Indeed, a meta-analysis of the studies comparing liberal (or traditional) vs restrictive transfusion thresholds indicates that the latter is close to being statistically demonstrated as providing *better* outcomes.

What about patients with active cardiovascular conditions? A secondary analysis of patient data from a Medicare database suggested that acute myocardial infarction patients with an admission hematocrit below 30% would benefit from RBC transfusion. However, two subsequent retrospective analyses of similar datasets did not identify any threshold below which transfusion was beneficial. Although cardiac reserve certainly needs to be considered in any transfusion decision, data are lacking to identify a specific threshold at which benefit outweighs risk in adults.

The current data to support evidence-based guidelines for plasma transfusion are surprisingly weak. After a systematic review, an expert panel found that the primary supportable indications were in the settings of massive transfusion and reversal of warfarin anticoagulation in patients with intracranial hemorrhage. The panel regarded the question of the optimal ratio of RBC: plasma in massive transfusion as lacking sufficient data to issue a recommendation.

Likewise, in other clinical scenarios, such as surgery without massive transfusion or warfarin reversal in the absence of intracranial hemorrhage, a practice guideline was not developed due to insufficient data. The panel recommended against plasma infusion in situations that typically might result in prophylactic plasma infusion, such as acute pancreatitis or critically ill nonsurgical noncardiac patients. In these types of patients where coagulopathy or bleeding was

absent, the risk of lung injury and possible increased mortality outweighed any perceived benefit.

Coagulation tests are commonly used to predict who might bleed, but are notoriously inaccurate in doing so. Multiple professional associations have noted that unless the prothrombin time (PT) or partial thromboplastin time (PTT) is more than 1.5 times the upper limit of the reference range, the patient is not at increased risk of hemorrhage. [Note that this is not necessarily equivalent to an international normalized ratio (INR) of 1.5.] Thus an “abnormal” coagulation test result is certainly not equivalent to a clinically significant coagulopathy. This is also true in cirrhotic patients where the reduced synthesis of procoagulant proteins is counterbalanced by a similar reduction in the concentration of the “anticoagulant” proteins that slow down or turn off the clotting system.

## GETTING STARTED

### Identifying and Recruiting Relevant Constituencies

From the perspective of a clinician, writing an order for a unit of allogeneic blood to be administered is easy. Patient blood management is not as easy, which may be why these strategies have not been more universally adopted. Change is frequently difficult. In his book, *Leading Change* (Harvard Business School Press, Boston, MA, 1996), John Kotter outlines an eight-point strategy for leading change that is relevant to the implementation of a PBM program. The first steps in this strategy involve recognizing that a problem exists and creating a sense of urgency around the problem. It appears that more and more hospitals are recognizing that the cost of allogeneic blood is significant and that the use of these products may worsen patient outcome. Thus, Kotter’s first step has already been completed on a national scale.

To continue the change, Kotter advocates putting together a leadership team that creates a strategy and provides guidance in change management. The natural starting point for this leadership team is the Transfusion Committee or its equivalent. However, many of these committees are not adequately empowered to make change. Most committees are attended primarily by transfusion service per-

sonnel who frequently don't have the authority to implement change nor do they have the expertise to do so.

Kotter advocates that, "Major change is often said to be impossible unless the head of the organization is an active supporter." Thus, it is imperative that senior leadership is involved in any efforts to implement blood management. Whether this is the head of the organization or his/her delegate, it must be clear that this is a project of high importance to the organization. In addition to senior leadership involvement, having the right individuals involved with blood management change is critical. For instance, if electronic medical records are to be used within the structure of a PBM program, it is critical to have an expert in the hospital's information technology be part of the team. Likewise, surgeon and anesthesiologist leadership is necessary.

In conclusion, Kotter recommends that a general strategy be developed to help guide the program development. A general strategy for implementing a PBM program is summarized as below:

1. Develop a preoperative hemoglobin optimization program.
2. Develop an AABB-accredited intraoperative red cell recovery program, and/or programs in normovolemic hemodilution, component sequestration, and platelet gels.
3. Implement point-of-care monitoring within the operating room environment.
4. Establish an auditing mechanism to ensure reasonable blood utilization by physician.
5. Establish physician education to enhance awareness of transfusion issues.

A comprehensive strategy as outlined here can significantly reduce the use of blood products, enhance patient outcome, and provide an economic boost to the hospital.

### **Engaging the Transfusion Committee**

The success of a PBM program is dependent on a multidisciplinary approach. Implementing a PBM program can best be achieved by providing key stakeholders, including physicians from services that are frequent users of blood and blood components, an opportunity to focus on strategies to optimize their transfusion practices. In most institutions, the Transfusion Committee could offer such an opportunity and serve as a perfect forum to initiate a PBM program. If a hospital does not have a Transfusion Committee, other committees that

are charged with the responsibility to oversee blood utilization can play a similar role. Engaging the Transfusion Committee or its equivalent right from the beginning can greatly facilitate the development and launching of a PBM program through a team-based approach.

It is desirable that the PBM program champion collaborate with the Transfusion Committee chair for many reasons. First, a typical Transfusion Committee is an established multidisciplinary group consisting of medical administration, nurses, transfusion medicine specialists (pathologists, hematologists, or other specialists), clinical laboratory scientists, and physicians, including but not limited to surgeons, anesthesiologists, and hematologists, whose involvement would be essential for the success of the program. The committee meetings can be used to introduce the PBM concepts to its members and seek their input and approval.

Second, the Transfusion Committee can provide an easy path to obtaining all of the other approvals that might be necessary for starting a new program, a task that can be very time-consuming and tedious. Because the Transfusion Committee in most institutions has a direct reporting relationship with one or more leadership committees (eg, Medical Executive Committee), it can help expedite the overall approval and integration process.

Third, Transfusion Committees routinely discuss most of the core elements of a typical PBM program and can easily assist with their review and implementation. For example, auditing blood utilization practices to minimize overutilization is a standard function of most Transfusion Committees. Transfusion Committees also lead or participate in the development of transfusion practice guidelines (indications). Autotransfusion policies and procedures are usually presented at the Transfusion Committee meetings even when this service is provided by an outside vendor. With the development of a PBM program, the Transfusion Committee can ensure that the program's criteria for ordering transfusions and auditing transfusions are standardized and distributed across the institution through its members and that autotransfusion procedures are implemented and reviewed as needed.

Fourth, the PBM program champion can leverage Transfusion Committee resources such as information technology to promote staff education about the program. The Transfusion Committee can have its own website on the hospital's intranet. The PBM program description and its requirements can be posted on the website for easy and immediate access by hospital staff and faculty members.

Finally, once the program has been implemented, the Transfusion Committee can assist with the monitoring of the program's success. The hospital bylaws and various accrediting organizations [eg, AABB, College of American Pathologists (CAP)] recommend that the Transfusion Committee meet on a regular basis (at least quarterly). The PBM program update can become a standing agenda item for discussion by the program champion at every meeting. Opportunities for improvement can be identified and assigned to appropriate stakeholders for action and follow-up at the next meeting. The Transfusion Committee chairperson can also disseminate the blood product use reports to the relevant service chiefs to keep them abreast of the current PBM efforts in their departments.

In summary, because of its multidisciplinary membership and reporting structure, early engagement of the Transfusion Committee can make a significant contribution to a PBM program's success. The committee's involvement offers advantages at every step of the process including the development, approval, implementation, and ongoing education and evaluation of a PBM program.

### **Auditing Current Practice to Identify Opportunities**

AABB, CAP, and The Joint Commission require accredited hospitals to monitor ordering practices and appropriateness of use of blood and blood components with the aim of improving quality of care, treatment, and services. Traditionally, monitoring blood utilization has been retrospective—reviewing approximately 30 to 50 cases per month randomly selected by the quality department or transfusion review committee. For those cases that “fall outside” institutional audit criteria and when little or no documentation is present to support the transfusion, the transfusion is all too often deemed “acceptable” either after review by peers on the Transfusion Committee or by direct communication with the ordering physician. Such limited, random selection raises the question “Are we effectively monitoring our physicians' transfusion practices to identify opportunities to improve patient care, and updating physicians on their current state of evidence-based transfusion practices?”

For an effective change process, one needs to first establish what the current blood utilization practice is. Then one can share the data with physicians, plan and implement any interventions, and continue to audit and track utilization to evaluate the change and monitor success. An initial step in establishing the current practice is to

collect “global” data—overall and individual blood component usage adjusted per 1000 patient days or hospital admissions and collate those data quarterly or annually, based on volumes at that institution. This provides a better means for benchmarking against similar hospitals with a similar patient mix. Additionally, blood usage should be collated by medical specialty (eg, internal medicine, surgery, hematology/oncology) and even more specifically down to physician groups and/or individual clinicians. Collating blood usage by medical specialty allows one to focus efforts on those medical service areas utilizing the most blood products and thereby target the areas where education and change will have the greatest yield.

Other metrics that may provide assessment of current practice include mean pretransfusion hemoglobin level (or hematocrit) for RBC transfusions to ICU patients, mean pretransfusion INR for plasma transfusions, frequency of blood crossmatched but not given in surgery, and percent of single-unit RBC transfusions. Again, collection of data for these metrics by medical service areas or medical specialties can identify the best opportunities for practice improvement.

Depending on the hospital’s patient population and surgical specialties, high-yield areas may include orthopedic surgery, cardiovascular surgery, intensive care, and/or hematology/oncology. Often it is helpful to begin by auditing medical and/or surgical specialty areas where a lot of information on transfusion practice has already been published (eg, orthopedics, cardiac surgery). The published data can be used for comparison with local physicians’ utilization data and for demonstrating best practice when presenting the data to the transfusing physicians. At the onset, it is advisable to start small—with only one or two medical or surgical specialty areas to audit. Additional patient or laboratory parameters can be collected in addition to the transfusion information to help influence change and optimize transfusion practice (eg, admission hemoglobin, pretransfusion hemoglobin, discharge hemoglobin, PAD use, blood recovery use, number of RBC units per transfusion order, hospital length of stay, use of iron and/or erythropoietin therapy).

It is wise to use existing data sources. If not already implemented, can reports be generated from the blood bank or laboratory computer system? The hospital quality department can be contacted to determine what data they may already be collecting. With the Surgical Care Improvement Project (SCIP) sponsored by the Centers for Medicare & Medicaid Services (CMS) certain data (eg, antibiotic use and infections) are routinely being collected on all orthopedic sur-

gery cases. Additional information on blood transfusion may be easily captured as an extended element, thereby allowing extraction for analysis and reporting. If coronary artery bypass procedures are performed at the hospital, data on percent of patients who received each of the specific blood components may already be collected as part of submission to the Society of Thoracic Surgery (STS) Adult Cardiac Surgery database.

Data can drive change but needs to be accurate or the effort will quickly lose credibility. If data are pulled from an electronic database, some manual chart review will likely still be needed to verify the accuracy. For example, most laboratory information databases identify the ordering physician; however, this physician may not be the one who ordered the actual transfusion. Statistical evaluation (such as establishing means and confidence limits) can help “validate” the integrity and importance of the reported data.

It is important to provide physicians with regular reports. Continuous data collection with periodic feedback not only maintains awareness but also encourages physicians’ interest in their own transfusion patterns, potentially increasing their motivation to look for better ways to reduce avoidable transfusions. Including outcome data in relationship to the transfusion rates and comparison with their peers and/or best practices is more likely to motivate practice changes. Some PBM “champions” share non-physician-specific data with as many physicians as possible and ask to present the data at department meetings, hospital quality meetings, and medical executive committee. Table 3 lists some key points for presenting reports. For examples of some reports, see the Appendices.

## **TAKING POSITIVE FIRST STEPS**

This section offers suggestions for practical applications of the concepts described above.

### **Step 1: Limiting Loss through Phlebotomy for Testing**

There are several potential steps that can be taken to limit the volume of blood collected for laboratory testing. These include efforts to reduce the frequency of phlebotomy to what is absolutely medically necessary and to limit the volume of each sample collected to the

**Table 3. Key Points for Transfusion Practice Audits**

- 
- Data must be clear, concise, and accurate.
  - Compare physicians to their peers.\*
  - Include patient outcomes (eg, length of stay, infection, re-admission) if readily available.
  - Include transfusion “alternatives” (eg, blood recovery, use of iron therapy) to evaluate impact on transfusion rate and/or patient outcomes.
  - “Normalize” data for how sick patients are [eg, use Case Mix Index (CMI) or Severity of Illness (SOI)].
  - Compare data to published data or similar sized hospital with similar services.
  - Provide reports to physicians, department chairs or chiefs, hospital quality department, and medical executive committee on a regular basis.
- 

\*Note: Care should be taken to discern whether the ordering physician identity is accurately captured in the records and whether this physician is truly the one responsible for decision making in the case. Additionally, physicians with substantial standing in the institution may need to be approached by someone in an authoritative position.

minimum needed to run the required assays. Methods for reducing the frequency of phlebotomy include:

1. *Identify key stakeholders who can be called to action to address the problem of excessive phlebotomy loss for diagnostic testing.* Typically this would include representatives from the following functional groups/clinical services within the institution:

- Laboratory
- ICUs (medical, surgical, burn, pediatric, obstetrics, etc)
- General medical and surgical
- Obstetrics/Gynecology
- Nursing
- Hospital administration

Once a working group is identified, the following items can be addressed.

2. *Limit the ordering of tests to those that are medically necessary.* This requires defining what constitutes unnecessary or inappropriate laboratory testing.

Unnecessary laboratory testing is widely perceived as being pervasive. Health-care providers often order clinical laboratory tests that are not medically necessary. This perception is supported by 1) widely varying test ordering patterns at different sites for similar patient populations, 2) the observation that test order-

ing varies by the day of the week even though the patient population remains constant, and 3) variability in individual physician test ordering to determine the number of tests necessary for diagnosis and patient management. In some clinical settings, the threshold for laboratory testing is the approach of midnight or noon, when protocol-driven tests are initiated, regardless of the patient's immediate clinical condition. Further complicating this issue is the apparent lack of agreement about what constitutes appropriate laboratory testing.

3. *Launch educational efforts directed at changing physician practice.* The practice of medicine is a constant balancing act between weighing risks and benefits for the patient. One of the risks of ordering a laboratory test is the impact of the sample collection on the patient's blood counts.

Education of physicians and nurses about the potential risk of anemia as a consequence of phlebotomy should be a first step in improving test utilization. In addition, other techniques such as reporting of cumulative volumes of phlebotomy to physicians may help raise awareness of the risk. However, education by itself is probably insufficient to sustain reduced test ordering by clinicians. Although educational efforts directed at changing physician practice have demonstrated small decreases in laboratory test ordering, such decreases appear to be transient and time-limited.

This issue is compounded in teaching hospitals because the least experienced physicians, the interns and residents (ie, house staff), are responsible for ordering laboratory tests. In addition to being inexperienced, interns and residents tend to be short-term employees in the hospital, and, with each new group, education in proper laboratory test utilization needs to start all over again. Thus, unnecessary and/or inappropriate laboratory testing is perceived as most frequent in teaching hospitals.

4. *Redesign the laboratory test requisition form (hard copy).* Changes in requisition design have had a durable effect but are labor-intensive to create and require substantial subspecialty expertise.
5. *Redesign the computer-displayed test order screens.* Changes in the display of computer-based test ordering systems, like changes in hard copy requisitions, can have a durable effect; however, they require substantial subspecialty expertise from informatics staff as well as laboratory staff.

6. *Eliminate the “standing order.”* One of the key contributors to excessive frequency of phlebotomy is the so-called “standing order,” which triggers repetitive phlebotomy for certain tests, such as coagulation assays, complete blood counts, and routine chemistries. It has been argued that such standing orders should be eliminated to the extent possible from the ICU test menu because such standing orders generate data that usually does not impact acute patient care management decisions.
7. *Employ newer technology.* The advent of computerized provider order entry systems and expert systems for test ordering and interpretation has created a new opportunity to intervene and intercept unnecessary laboratory test orders. Numerous studies have demonstrated their effectiveness in targeted areas or for targeted diseases, many by embedding specific disease treatment clinical guidelines into ordering pathways. To date, however, there has been no overarching system that can be applied reliably to all cases to exclude all unnecessary and/or inappropriate laboratory test orders.
8. *Limit the volume of the samples collected to the minimum needed to perform the requested assays.*
  - Use small tubes. The volume of blood required to perform clinical assays using modern analytic equipment is extremely small. Thus, it seems reasonable that the volume of sample collected be a little as possible. This can be accomplished using collection tubes designed for pediatric patients.  
Unfortunately, such small tubes often cannot be loaded onto some automated specimen processing systems and/or analyzer instrumentation, causing the laboratory staff to have to manually process and present these specimens to the analyzers. This, in turn, can cause a prolongation of the turnaround time. Thus, laboratories that rely on automation to process and transport specimens for testing may find themselves in conflict with requests to use pediatric tubes as a routine for all adult testing.  
However, several manufacturers make low-volume tubes with the same external diameter and height as traditional tubes, and use of such tubes can facilitate the conversion to low-volume phlebotomy practice.
  - Use point-of-care testing. Point-of-care testing devices, although more expensive to operate per test performed and arguably less accurate/reproducible, require much less sam-

ple volume from the patient and may be appropriate for application in certain situations.

### **Step 2: Optimizing Patient Hemoglobin Levels Before Surgery**

Referring the presurgical patient to a preoperative medical clearance or anemia clinic for assessment and management would be ideal. However, if not already in place, the establishment of such a service takes time, money, and personnel—resources that are scarce at most hospitals these days. However, there are some simple first steps that can help promote better patient blood management:

1. Generate awareness of the prevalence of presurgical anemia
  - Prepare patient and physician information sheets and distribute throughout the hospital (see [www.anemia.org](http://www.anemia.org)).
  - Include preadmission hemoglobin level in the blood utilization reports for the surgical specialties to promote awareness and possible practice change.
2. Perform an audit of preadmission hemoglobin levels of the next 50 or more patients who undergo elective knee or hip replacement surgery. Present the data to the Orthopedic or Surgery Department meeting. Don't be surprised if one or more surgeons will show an interest, which could lead to a collaboration and partnering for advancing presurgical anemia assessment.
3. Advocate for early presurgical laboratory testing, at a minimum hemoglobin or hematocrit. Testing at least 30 days before the surgical procedure would allow time for evaluation and management so as to optimize hemoglobin levels.
4. Collaborate with pharmacy and/or a clinical champion to develop guidelines and standardized protocols for anemia evaluation and management of presurgical patients. (See Resources.)
5. Network with colleagues or visit a nearby preoperative anemia clinic to gain insight for "first steps" and "lessons learned." This approach cannot be emphasized enough.

### **Step 3: Using Autologous Donation and Blood Recovery Techniques**

As mentioned previously, presurgical autologous donation is losing favor as ANH and blood recovery are becoming more cost-effective alternatives. PAD should be reserved for those patients for whom there is limited availability of compatible blood (eg, patients with IgA

deficiency, patients with multiple red cell alloantibodies, or patients with antibody to a high-frequency antigen) or when sufficient time after collection allows for regeneration of the collected red cell mass. Due to personal reasons and/or public perception of blood safety, certain patients may still insist on PAD for their upcoming surgical procedure. Many facilities encourage such patients to donate sufficiently early to allow for an erythropoietic response. Regardless for the reason for donation, it is important for hemoglobin optimization before and after the donation.

Advanced planning and evaluation of the patient is important for PAD to be of benefit for PBM. In contrast to the standard collection protocols at most blood centers, PAD is most effective when collection occurs 4 to 6 weeks before surgery to allow sufficient interval for red cell regeneration. Donating as early as possible, donating the minimal amount, and being evaluated for and receiving iron replacement therapy with or without erythropoietin before donation are important strategies for avoiding allogeneic transfusions.

Blood recovery, both intraoperative and postoperative, and ANH are essential elements of a program for limiting allogeneic blood exposure in surgical patients. The particular techniques a hospital chooses to undertake will often depend on the type and number of surgical cases, surgeons' preferences, and personnel resources. The AABB has developed and published *Standards for Perioperative Autologous Blood Collection and Administration*, which includes a guidance document to facilitate compliance with these standards. These standards will help ensure that the patient undergoes therapy utilizing skilled, competent personnel trained in proper procedures and equipment operation to avoid procedure-associated morbidity.

#### **Step 4: Minimizing Perioperative Blood Loss**

Methods for engaging surgeons and anesthesiologist in a movement to minimize perioperative blood loss are similar to those for involving those same groups in deliberations of the Transfusion Committee, discussed above.

1. Identify factors—individuals or groups; policies, processes, or procedures; patient mix; hospital size; etc—that might facilitate a change in the level of blood loss during or after surgery. Identify similar factors that might be barriers to making improvements. Try to neutralize the negative factors and take advantage of the positive factors.

2. Determine the most effective means of providing knowledge to surgical specialists, or combine any that might work well in unison: individual education/feedback, group education/feedback, dissemination of evidence-based practice guidelines, or guidelines embedded in order-entry software.
3. Use meaningful benchmarks. Anesthesiologists may be more receptive to practice guidelines developed or supported by their peers in the American Society of Anesthesiologists. Any given surgical specialty group may be motivated to improve if there is a rivalry between local hospitals for the designation as “premier” practice group. Meaningful benchmarks are not always the most commonly used ones. For example, operating room (OR) “take-backs” is one common benchmark that can work against postoperative efforts to minimize blood loss. To avoid returning to the surgical suite, physicians may respond to unexpected, profound blood loss by transfusing more blood. The willingness of the surgeon to return to the OR to stop the bleeding can be enhanced when the “take back” benchmark is replaced by one that focuses on average blood use per diagnosis-related group (DRG). Surgeons may be more receptive to change if such a benchmark is adjusted for different levels of procedural difficulty and patient morbidity.
4. Consider all options. In addition to blood use, benchmarking data for surgeons might address size and proximity of sutures, suture ligation for damaged vessels, placement of central venous catheters without lacerating nearby vessels, minimizing the priming volume in cardiopulmonary bypass circuitry, and other technique-related issues unique to each surgical specialty. Cooperation will be enhanced if the surgeons play a role in choosing the benchmarks themselves. Similarly, for anesthesiologists, benchmarking options might include use of controlled hypotension, maintenance of normothermia, and control of acid-base homeostasis. Again, engaging anesthesiologists in the process for selecting benchmarks may boost the rate of success in minimizing perioperative blood loss.

### **Step 5: Making Evidence-Based Hemotherapy Decisions**

There are multiple ways to promote and implement new transfusion indication guidelines. All are based on the assumption that physicians want to do the best thing possible for their patients. If their current

practice cannot be supported by available objective evidence, the issue most likely is lack of knowledge or comprehension of the data.

Knowing the status of current practice, by physician and/or by service, is a good starting point. Auditing current transfusion decisions can indicate where the greatest improvements might be made, which physicians are already applying the available data, and which will pose the greatest challenge. Many laboratory information or electronic medical record systems can be programmed to provide the necessary data to facilitate such an audit with a minimum of additional “legwork.”

Engaging practicing clinicians in the process of setting new guidelines, assessing current practice, and convincing others to adopt the new approach is essential. Having physician proponents of evidence-based blood utilization (who can share the success of their application of the approach) provides strong argument for adoption. Including some with misgivings about the approach may also be beneficial in providing an insight into the thinking of the “opposition” and an entrée to services that might otherwise reject the concept but that would be persuaded after the “conversion” of one of their own. Including nurses in the process can position them to support clinicians as they implement a new strategy.

Every hospital has its preferred means of educating physicians. Multiple approaches, including lectures, presentations at departmental meetings, and newsletters, will probably be needed. Using the “champions” identified from the initial practice audit to carry the message will likely be most effective, especially when those advocates are armed with data from meetings, the scientific literature, and professional society websites. Showing physicians how they compare with their peers in blood utilization is also very powerful, particularly when those colleagues using less blood are seen as having outcomes that are as good as or better than those using more blood.

Embedding evidence-based guidelines in the ordering process provides another, timely reminder of optimal practice. Some electronic ordering systems, for example, can scan recent laboratory values and remind the prescriber of any potential noncompliance with guidelines. Paper forms can also be modified to provide these reminders. Review of situations as orders are received or after the transfusion can provide other opportunities for a knowledgeable physician (such as a transfusion medicine specialist or other physician with appropriate knowledge and experience) to interact with the clinician regarding wise application of available data.

## RESOURCES ONLINE

### **AABB Publications** ([www.aabb.org/marketplace](http://www.aabb.org/marketplace))

Technical Manual

Chapter 8. Infectious disease screening

Chapter 20. Hemotherapy decisions and their outcomes

Chapter 24. Patient blood management

Chapter 27. Noninfectious complications of blood transfusion

Chapter 28. Approaches to blood utilization auditing

Standards for Perioperative Blood Collection and Administration

Transfusion Therapy: Clinical Principles and Practice

Rossi's Principles of Transfusion Medicine

Blood Management: Options for Better Patient Care

Perioperative Blood Management: A Physician's Handbook

The Transfusion Committee: Putting Patient Safety First

Circular of Information for the Use of Human Blood and Blood Components

Transfusion Reactions

Bacterial and Parasitic Contamination of Blood Components

TRALI: Mechanisms, Management, and Prevention

Guidelines for Quality Assessment of Transfusion

Guidelines for Blood Recovery and Reinfusion in Surgery and Trauma

Guidelines for Patient Blood Management and Blood Utilization

Guidelines for the Use of Blood Warming Devices

Guidelines for the Management of Transfusion-Related Acute Lung Injury

### **AABB Website** ([www.aabb.org/pbm](http://www.aabb.org/pbm))

How Hospital Executives View Laboratory and Rising Blood Costs

How Should the Blood Center-Hospital Relationship Evolve?

AABB News, November, 2010 (devoted to Patient Blood Management)

### **Society for the Advancement of Blood Management Website**

([www.sabm.org](http://www.sabm.org))

Order sets for transfusion including standard indications

Business plans for PBM programs

Presentations from annual meeting

### **Other Websites**

[www.health.vic.gov.au/bloodmatters/](http://www.health.vic.gov.au/bloodmatters/)

[www.cec.health.nsw.gov.au/programs/blood-watch/myths](http://www.cec.health.nsw.gov.au/programs/blood-watch/myths)  
[www.anemia.org](http://www.anemia.org)  
[www.optimalblooduse.eu/](http://www.optimalblooduse.eu/)

## RESOURCES IN PRINT

### *Acute normovolemic hemodilution*

Bennett J, Haynes S, Torella F, et al. Acute normovolemic hemodilution in moderate blood loss surgery: A randomized controlled trial. *Transfusion* 2006;46:1097-103.

Olsfanger D, Fredman B, Goldstein B, et al. Acute normovolemic hemodilution decreases postoperative allogeneic blood transfusion after total knee replacement. *Br J Anesth* 1997;79:317-21.

Testa LD, Tobias JD. Pharmacologic drugs for controlled hypotension. *J Clin Anesth* 1995;7:326-37.

### *Anemia*

Bader AM, Sweitzer B, Kumar A. Nuts and bolts of preoperative clinics: The view from three institutions. *Cleve Clin J Med* 2009;76(Suppl 4):S104-11.

Goodnough LT, Shander A, Spivak JL, et al. Detection, evaluation and management of anemia in the elective surgical patient. *Anesth Analg* 2005;101:1858-61.

Kumar A. Perioperative management of anemia: Limits of blood transfusion and alternatives to it. *Cleve Clin J Med* 2009;76(Suppl 4):S112-18.

### *Applying PBM*

Bierbaum BE, Callighan JJ, Galante JO, et al. An analysis of blood management in patients having a total hip or knee arthroplasty. *J Bone Joint Surg Am* 1999;81:2-10.

### *Autologous donation*

Domen RE. Adverse reactions associated with autologous blood transfusion: Evaluation and incidence at a large academic hospital. *Transfusion* 1998;38:301-6.

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*Red cell recovery*

- Blevins FT, Shaw B, Valeri CR, et al. Reinfusion of shed blood after orthopaedic procedures in children and adolescences. *J Bone Joint Surg Am* 1993;75:363-71.
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- Singbartl G, Schreiber J, Singbartl K. Preoperative autologous blood donation versus intraoperative blood salvage; intraindividual analyses and modeling of efficacy in 1103 patients. *Transfusion* 2009;49:2374-83.

## Appendix 1. Anemia Order Set—Example 1

PHYSICIAN'S ORDERS	Date/Time/Initials
<b>ANEMIA MANAGEMENT ORDERS</b>	
<b>Blood Management</b>	
<small>MD: Please indicate order selections with an "X" and sign at end.</small>	
<p><b>ALLERGIES:</b> _____</p> <p><b>LAB Orders</b></p> <p><input type="checkbox"/> CBC   <input type="checkbox"/> Baseline Iron panel (Serum Iron, TIBC, TSAT%, Ferritin)</p> <p><input type="checkbox"/> Hct 5-7 days after ESA</p> <p><input type="checkbox"/> Iron panel: 2-3 days after Ferrlecit therapy completed or   <input type="checkbox"/> 2-3 weeks after Iron Dextran</p> <p>◆ Add comment on order: Draw minimum volume sample</p> <p><b>SUPPLEMENTAL MEDICATIONS</b></p> <p><input type="checkbox"/> Ferrous Sulfate – hold during IV iron therapy   <input type="checkbox"/> Vitamin C   <input type="checkbox"/> Prenatal Vitamin   <input type="checkbox"/> Docusate stool softener</p> <p>325 mg po TID (one hour before meals)   500 mg po   1 po once daily   250 mg po daily PRN constipation</p> <p><input type="checkbox"/> Folate 1 mg po once daily   twice daily with iron</p> <p><b>ESA THERAPY: (ESA = Erythropoietic Stimulating Agent)</b></p> <div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 5px auto;"> <p>Hold therapy if hemoglobin is greater than or equal to 11 gm/dL.</p> </div> <p><b>IRON ADMINISTRATION ORDERS</b></p> <p><i>Most patients will receive oral or IV iron supplementation during the course of ESA therapy. (IV iron supplements may be necessary when lab values are: Serum Ferritin less than 200 mg/ml; % Saturation less than 20%)</i></p> <p><input type="checkbox"/> Sodium ferric gluconate complex (Ferrlecit) 125 mg/100 ml NS IV daily over 60 minutes for _____ days</p> <p>• Recommended therapy 3 to 8 days</p> <p><b>If patient cannot receive full IV therapy of 4 doses of Ferrlecit, may use Iron Dextran:</b></p> <p><input type="checkbox"/> Pretreat with diphenhydramine 50 mg po or IV</p> <p><input type="checkbox"/> Test dose Iron Dextran 25 mg in 50 ml of NS over 30 minutes</p> <ul style="list-style-type: none"> <li>• Observe for 1 hour for allergic reactions</li> <li>• Subtract test dose of 25 mg from full calculated replacement dose</li> </ul> <p><input type="checkbox"/> Iron Dextran _____ mg/500 ml 0.9% NaCl</p> <ul style="list-style-type: none"> <li>• Infuse over 4-6 hours; watch for allergic reaction</li> </ul> <p><input type="checkbox"/> Iron Dextran Pharmacist to calculate dose: _____</p> <p><b>IRON DEXTRAN DOSING:</b></p> <p>To calculate dose in ml (50 mg/ml) of IV Iron Dextran the patient should receive for iron deficient anemia: Dose (ml) = 0.0442 (desired Hgb – observed Hgb) x LBW + (0.26 x LBW)</p> <p><b>ALLERGIC REACTION</b></p> <p>See ANAPHYLACTIC Protocol</p> <p>For Non-Anaphylactic Reaction (nausea, itching, joint pain)</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Stop IV drip</li> <li><input type="checkbox"/> Give: Diphenhydramine (Benadryl) 50 mg IV</li> <li><input type="checkbox"/> Give: Hydrocortisone 125 mg IV</li> <li><input type="checkbox"/> Wait 30 minutes</li> <li><input type="checkbox"/> When symptoms subside: Restart iron dextran infusion at 50 ml per hour, then gradually increase the infusion rate as tolerated.</li> </ul> <p><b>Chemotherapy Induced Anemia, Anemia of Chronic Disease, HIV:</b></p> <p><input type="checkbox"/> Darbepoetin (Aranesp) 100 mcg SQ weekly   <input type="checkbox"/></p> <p><input type="checkbox"/> Epoetin alfa (Procrit) 10,000 units SQ weekly</p> <ul style="list-style-type: none"> <li>• Alternative dosing for dialysis patients is Epoetin alfa 4,000 units per dialysis session</li> </ul> <p><b>Presurgical Treatment/Blood Conservation Patients:</b></p> <p><b>Epoetin alfa (Procrit) 600 units/kg SQ per weekly pre-surgical guidelines</b></p> <ul style="list-style-type: none"> <li>• Weekly recommended dose is 600 units/kg weekly – Day -21, -14, -7 and day of surgery</li> <li>• Substitution with Darbepoetin is not indicated for presurgical anemia or Bloodless Patients</li> <li>• Pharmacy will round dose to nearest available vial size</li> </ul> <p><input type="checkbox"/> IV fluid: _____</p> <p><input type="checkbox"/> Other medications: _____</p> <p><input type="checkbox"/> Other Instructions: _____</p> <p><b>DATE:</b> _____ <b>TIME:</b> _____ <b>Practitioner:</b> _____</p>	
<p style="font-size: small;">A DRUG EQUIVALENT MAY BE DISPENSED UNLESS CHECKED</p> <p style="background-color: #cccccc; padding: 5px; text-align: center;"><b>SIGNATURE IS REQUIRED FOLLOWING ENTRY OF EACH ORDER</b></p>	

PHYSICIAN'S ORDERS

**Appendix 2. Blood Data Report—Example 1**

**HealthCare System  
Hospital 1  
RBC Blood Report, 2009q3**

		ALL TRANSFUSION CASES				NON-BLEEDING TRANSFUSION CASES				ALL
		Cases Reviewed	Units Transfused	Units Per Transfusion Mean(Range)	Pre Transfusion HgB Mean(Range)	Cases Reviewed	Pre Transfusion HgB Mean(Range)	Cases with a Pre Transfusion HgB > 8.0 N(%)	Cases that had more than 1 unit RBC ordered N(%)	Informed Consent Completed
Hosp 1	All FamPrac	38	62	1.6(1-3)	8.1(5.1-10.2)	36	8.1(5.1-10.2)	22(63%)	31(86%)	87%
	All IntMed	169	246	1.5(1-2)	7.9(5.5-9.7)	159	7.9(6.2-9.7)	70(45%)	103(65%)	76%
	All Hospitalists	50	61	1.2(1-2)	8.0(6.2-11.3)	44	7.9(6.2-9.6)	18(41%)	21(48%)	78%
All Hospitals	All FamPrac	134	219	1.6(1-4)	8.1(5.1-10.5)	113	8.2(5.1-10.5)	67(60%)	55(49%)	91%
	All IntMed	332	506	1.5(1-5)	7.9(3.8-11.3)	292	7.9(3.8-10.3)	124(43%)	145(50%)	86%
	All Hospitalists	90	125	1.4(1-2)	7.9(5.0-11.3)	79	7.9(5.0-9.6)	30(39%)	47(60%)	83%

**Appendix 3. Blood Data Report—Example 2**

**HealthCare System  
Section of Orthopedic Surgery  
Blood Report, 2008q1  
Physician xxxxx**

Procedure	SURGICAL CASES		TRANSFUSION CASES							Informed Consent Completed
	Cases	Severity Level 3,4	Cases Transfused	Units Transfused	Units Per Transfusion Mean(Range)	Admit Hgb Mean(Range)	Pretransfusion Hgb Mean(Range)	Discharge Hgb Mean(Range)		
Total Hip & Revision of Hip	17	71%	12%	4	2.0(2-2)	9.7(9-10)	7.6(7-8)	8.3(7-10)	100%	
Total Knee & Revision of Knee	36	5.6%	2.8%	2	2.0(2-2)	8.7(9-9)	7.4(7-7)	11(11-11)	100%	
Other Procedures	19	32%	21%	10	2.5(2-4)	9.5(8-11)	8.1(7-9)	10(9-11)	100%	
PHYS TOTAL	72	28%	9.7%	16	2.3(2-4)	9.4(8-11)	7.8(7-9)	9.7(7-11)	100%	
All Ortho Surgeons: Total Hip & Revision of Hip	210	57%	25%	135	2.5(1-16)	11(7-14)	8.2(5-10)	9.7(7-12)	100%	
All Ortho Surgeons: Total Knee & Revision of Knee	300	10%	15%	83	1.9(1-6)	11(8-15)	8.3(7-10)	9.6(8-12)	98%	
All Ortho Surgeons: Other Procedures	572	25%	9.1%	127	2.4(1-7)	11(7-16)	8.8(7-14)	10(8-12)	92%	
All Ortho Surgeons: TOTAL	1082	27%	14%	345	2.3(1-16)	11(7-16)	8.4(5-14)	9.8(7-12)	97%	