Actionable Patient Safety Solutions (APSS):

Patient Blood Management

How to use this guide

This guide gives actions and resources for Patient Blood Management. In it, you'll find:

Patient Safety MOVEMENT

Executive Summary

The Problem

1 in 10 in-patients receive at least one unit of blood, making red blood cell (RBC) transfusions one of the most common procedures for hospitals in the US and Europe (Cost et al., 2009). This frequency, coupled with the use of transfusions to manage anemia, a condition impacting 1 in 3 people worldwide (Kassebaum et al., 2014), highlights patient blood management and standardization of policy as key focus areas for patient safety.

Although blood transfusions can be life-saving procedures, there are a significant number of potential problems associated with poor patient blood management, including poor process, inadequate evaluation of need, and lack of standardized processes once a transfusion is deemed necessary. Determining who and when to transfuse after evaluation of all alternative therapies is a challenge for hospitals and the controversy has continued in recent years regarding the ideal transfusion 'trigger'.

The Cost

Research has shown that blood transfusions are an expensive process that costs approximately $1,200 for transfusing one unit of red blood cells (Shander, 2014). By implementing patient blood management protocols with proper, judicious evaluation of patients potentially in need of a transfusion, such programs can reduce blood transfusions by 20 to 30 percent (Shander, 2014).

The Solution

Many healthcare organizations have successfully implemented and sustained improvements and reduced death from poor patient blood management. These organizations have focused on projects that included **implementing a clear, standard patient blood management and transfusion protocol.**

This document provides a blueprint that outlines the actionable steps organizations should take to successfully improve patient blood management and summarizes the available evidence-based practice protocols. This document is revised annually and is always available free of charge on our website. Hospitals who make a formal commitment to improve patient blood management and transfusion practice and share their successes on the PSMF website have access to an additional level of consulting services.

Leadership Checklist

On a monthly basis, or more frequently if a problem exists, the executive team should review the outcomes of patients who have had a transfusion. Use this checklist as a guide to determine whether current evidence-based guidelines are being followed in your organization:

- ☐ Measure and report transfusion protocol compliance monthly (the number of patient deaths with untreated and treated preoperative anemia /Total number of anemic patients undergoing elective surgery). Note trends in areas with low compliance and high adverse reactions. Routinely reassess outcomes.
  - ☐ Prepare a monthly report for public presentation on blood components usage.
- ☐ If adverse transfusion reaction rates indicate room for improvement, initiate a PI (performance improvement) project. If a problem is not indicated, routinely reassess to identify gaps, and ensure integrity of the data collected.
- ☐ Evaluate and approve the resources needed for the patient blood management plan.
- ☐ Ensure frontline involvement in patient blood management improvement activities. Maintain their engagement and remove barriers to progress.
- ☐ If a PI plan is put in place, measure the associated process outcomes.
- ☐ Ensure that patient blood management protocols are embedded into clinical workflows, whether electronic or paper.
- ☐ Ensure there are enough staff to effectively manage necessary care.
- ☐ Ensure adequate training and documentation of transfusion competencies and skills.
  - ☐ Develop a patient blood management education program with routine checkpoints.
- ☐ Eliminate barriers to making rapid and seamless updates to documentation templates and order sets.
- ☐ Debrief on a regular basis to solicit team feedback about barriers to sustained compliance. Adjust the plan quickly and nimbly as needed.
- ☐ Hold staff accountable for providing the standard of care and reward success.
- ☐ Ensure that leaders have a simple process to oversee patient blood management improvement work while also considering how it aligns with other initiatives across the organization.
  - ☐ Establish a patient blood management committee and assign an individual to be responsible and accountable.
- ☐ Establish conservative blood management practices, including:
  - ☐ Minimizing unnecessary laboratory tests.
  - ☐ Minimizing how often providers draw blood, as well as the amount drawn.
  - ☐ Minimizing discarded dead space blood volumes within catheters.
  - ☐ Using a consistent protocol to manage platelet inhibitors and other anticoagulants before surgery.
- ☐ Integrate proven technology for blood work to improve patient care, such as:
  - ☐ Continuous, non-invasive hemoglobin monitoring
  - ☐ Dynamic volume assessments to determine plasma volume
  - ☐ Red cell recovery technology in the operating room
- ☐ Set protocols for transfusions.
  - ☐ Set a single unit transfusion policy for non-bleeding patients who need a transfusion and advocate for more restrictive transfusion practices.
  - ☐ Record hemoglobin levels before and after each blood transfusion.
  - ☐ Check for and maintain normal blood volume (normovolemia) before restricting transfusion.
  - ☐ Use the Mercuriali algorithm to calculate RBC deficit.
  - ☐ Consider alternative therapies to RBC transfusions such as intravenous iron and erythropoietin stimulating agents (ESAs).
  - ☐ Consider both the change in a patient's hemoglobin level from their baseline, as well as their current level, as indicators for transfusion.
  - ☐ Use hemoglobin monitoring and NIRS tissue oxygen monitoring technologies to augment lab tests.
  - ☐ Make transfusion decisions based on signs and symptoms, in addition to hemoglobin level and NIRS tissue oxygen values.
- ☐ Set protocols for surgery patients.
  - ☐ Mandate anemia testing before surgeries.
  - ☐ Before surgery, test for problems with blood coagulation and manage platelet inhibitors and other anticoagulants.
  - ☐ Use minimally invasive surgical techniques.
  - ☐ Use surgical techniques to minimize bleeding including use of electrocoagulation, bipolar, and argon beam.
  - ☐ Consider acute normovolemic hemodilution (minimize blood loss by removing blood before surgery and replacing it afterward).
  - ☐ Many blood sparing techniques exist for cardiac surgery, such as minimized extracorporeal circuits, retrograde

autologous priming, modified ultrafiltration, blood cardioplegia, and meticulous hemostasis in saphenous vein graft removal.

- ☐ Create protocols for hemorrhage identification and control.
  - ☐ Adhere to extended hemorrhage protocols for high-risk patients, such as postpartum, anemic, and trauma patients, to optimize coagulation and reduce bleeding (see Proposed Algorithm for Detection, Evaluation, and Management of Preoperative Anemia).

1. ASSESS POSSIBILITY OF ALTERNATIVE OPTIONS

Consider alternatives to a transfusion. Transfusion should only be considered as a viable option after all other possibilities and alternatives have been considered and deemed inappropriate. Transfusions are high-risk procedures and therefore should only be performed as absolutely necessary. Alternatives to a transfusion to consider include:

- Intraoperative blood salvage
  - Is the patient in a controlled surgical procedure with a high likelihood of significant blood loss? If not, eliminate the option for intraoperative blood salvaging.
  - Benefits include avoidance of allogeneic transfusion, time saving, and the greater number of units available compared with other autologous techniques.
  - Exercise caution to ensure salvaged blood is not mixed with other fluids. Blood salvage cannot be used when there is any possibility for inadvertent simultaneous collection of hemostatic products. Assess on a case-by-case basis the risk of bacterial infection.
  - Evaluate patients with active malignancy on a case-by-base basis to aid in the decision making of intraoperative blood salvage. Consider factors such as risk of major intraoperative bleeding, the need for transfusion, and the availability of allogeneic blood (Klein et al., 2018).
- Preoperative autologous donation
  - Is the procedure planned? If so, consider having the patient donate their own blood weeks in advance.
- Acute normovolemic hemodilution
  - This may be a possibility for those who refuse blood transfusions based on religious reasons or for those unable to participate in preoperative autologous blood donation, potentially due to the need for emergency surgery. This should be considered for patients with normal initial hemoglobin levels who are expected to lose between 500-750 mL during surgery. Avoid in patients with impaired cardiac or renal function, low baseline hemoglobin (below 11g/dL), or low concentrations of coagulation proteins or platelets (Shander et al., 2020).
- Volume expanders
  - Does the patient need more oxygen or an increase in blood cells? If so, eliminate the option for volume expanders.
- Growth factors
  - Is the patient actively bleeding/does the patient need the blood replaced immediately? If so, eliminate the option for growth factors.
- Medications for Prevention and Management

2. ASSESS ON A CASE-BY-CASE BASIS THE NECESSITY OF A TRANSFUSION BASED ON INDICATIONS

A transfusion should only be performed if it has been determined that it is the safest option available and all other alternatives have been deemed inferior. Only after thorough deliberation and evaluation should the decision for a transfusion be confirmed. See the "Indications for a transfusion" section for more information.

As an overview, the following are uses for certain blood components:

- Whole blood: to treat patients with significant blood loss.
- Red blood cells: to treat anemia, sickle cell disease, and blood loss.
- Platelets: for use in cancer patients, organ transplants, thrombocytopenia, and platelet function abnormalities.
- Cryoprecipitate: for use in patients with blood clotting deficiencies such as hemophilia, Von Willebrand's disease and other conditions in which the patient's clotting ability is compromised (Blood Components, 2020).

3. IF A TRANSFUSION HAS BEEN DEEMED NECESSARY, START BY PERFORMING TYPE AND SCREEN AND CROSSMATCH TESTING.

Type and Screen

- Confirm physician order.
- Confirm that a new sample is required. The same sample can be used for three days, with day zero being the day the sample was drawn.
- Collect samples.
  - Use two patient identifiers. These can be from the patient's wristband, medical record, or from an open-ended question.
  - Compare the patient's armband with the patient labels to confirm that this is the intended patient.
  - Write the date, time, and name of the collector on the blood band.
  - Attach the blood band around the patient's arm.
  - Peel off the label and place on the tube. Ensure the armband shows a carbon copy of the same information.
  - Collect the specimen, using a sterile technique, and fill tube. The minimum collected should be 6cc.
  - Gently invert the EDTA tube 8-10 times after collection.
  - Place a printed label on the purple top tube.
  - Specimens should be labeled in the presence of the patient with the patient's first and last name, unique identification number, date of collection, and name of collector.
- Complete the transfusion specimen time out form. Before leaving the bedside, review the labels and type and screen time out form for accuracy.
  - Send the sample and carbon copy of the time out form to the transfusion service immediately.

4. ACQUIRE FROM BLOOD BANK

Blood components should only be issued upon receipt and confirmation of the patient. Ensure family name, first name, date of birth, hospital identification number, and ward match on collection slip, addressograph label, patient case notes, and prescription form. **Any discrepancy between the patient details and pack labelling should be a red flag to hold the blood until the discrepancy is resolved.** For additional details, see "Blood Bank Procurement".

Only after patient identity has been confirmed with the pack label, prepare for dispatch of blood products:

- Use blood-tracking barcodes and record identity and accreditation of the person collecting the blood.
- Record the time a component is removed from a controlled temperature environment.
- Visually check samples for leakage, expiration, and label peeling.
- Adhere to the '30-minute rule', where blood should not return to the blood bank for reissue after 30 minutes. The 4-hour rule states that transfusion of RBCs should be completed within 4 hours of their removal from controlled temperature storage.
  - See page 11 of the World Health Organization's Clinical Transfusion Practice guideline for further information on maximum recommended duration from commencement to transfusion for each blood component.

5. CONDUCT AN IMMEDIATE PRE-TRANSFUSION ASSESSMENT

- Confirm physician order, including type, amount, date, time, duration, modifications, and sequence.
- Verify the need for pre- or post-medication administration.
- Obtain the patient's history, including any previous transfusions, reactions, or known allergies.
- Confirm that type and crossmatch have been completed within 96 hours (See Appendix A).
- Ensure IV cannula is patent.
- Properly identify patient.
- Evaluate laboratory data, including platelet count and coagulation values.
- Confirm that the patient has filled out all necessary paperwork and consent forms.
- Ensure the patient understands why they are receiving the transfusion.
- Record baseline vitals.
  - Ensure emergency equipment, such as oxygen, is readily available.
- Confirm that documentation is complete.

6. INITIATE TRANSFUSION, ONLY AFTER COMPLETING THE IMMEDIATE PRE-TRANSFUSION ASSESSMENT THOROUGHLY AND COMPLETELY.

- Initiate or evaluate venous access.
- Initiate primary infusion at TKVO.
- Document vital signs, especially those that may be confused with a reaction due to transfusion.
- Obtain products from transfusion within 30 minutes of scheduled transfusion.
- Visually assess the blood product for any leaks, clumps, discoloration etc.
- Compare the transfusion documentation with the patient record and confirm patient name and unique identifier number, physician order, consent, and patient ABO grouping. Compare the transfusion documentation with the product label. **If there are any discrepancies, stop immediately.**
- Administer pre-ordered medications.
- Complete final verification of patient, transfusion documentation, and product.
- Perform the transfusion.

Resources for specific blood component administration:

- Storage, inspection, and administration guidelines from New Delhi, India
- Transfusion of blood components from JPAC
- Administration of blood components

7. MONITOR PATIENT POST-TRANSFUSION FOR SIGNS OF ADVERSE REACTIONS

During the transfusion, the blood product should be administered slowly at 1 to 4 hours for each unit of blood. During administration, the provider should monitor for:

- Fever
- Ucitaria (hives)
- Fluid overload
- Lung Injury
- Back pain
- Chills
- Flank pain (either side)
- Shortness of breath
- Skin flushing (pale)
- Itching
- Fainting or dizziness
- Dark urine
- Wheezing
- Low blood pressure

8. MANAGE ADVERSE REACTIONS, IF NECESSARY.

In some cases, complications arise. Such reactions can occur within seconds of the transfusion, minutes, or even up to a few weeks. These reactions can include:

- Allergic reactions
  - Mild allergy
  - Anaphylaxis
  - Febrile nonhemolytic
  - Septic
  - Acute hemolytic
  - Transfusion-associated circulatory overload (TACO)
  - Transfusion-related acute lung injury
- Delayed reactions
  - Delayed hemolytic
  - Transfusion-related graft versus host (Suddock and Crookston, 2020).

Immediate patient management upon a suspected reaction includes stopping the transfusion, reperforming the pretransfusion checklist, documenting observations, providing immediate patient care, and contacting the medical officer. Follow the below steps if a reaction is suspected based on change or deterioration in patient's condition (Adverse Effects of Transfusion, 2003).

- Stop the transfusion.
- Check vital signs.
- Maintain IV access but do not flush the existing IV line.
- Verify details on the blood pack.
- Treat the patient as required based on reaction.
  - See guidelines from Royal Children's Hospital Melbourne for details regarding treatment for different types of adverse reactions.
- Notify the blood bank and nurse in charge.
- Document suspected reaction in EHR.
  - Record signs and symptoms.
  - Record volume transfused.
  - Order transfusion reaction evaluation in EHR.

Use the following resources for further, specific information:

- Monitor and Report Reactions Immediately
- Acute Transfusion Reaction Clinical Workflow Infographic
- Transfusion Reactions
- Approach to the Patient with a Suspected Acute Transfusion Reaction

9. POST-TRANSFUSION MANAGEMENT, IN THE CASE OF NO ADVERSE REACTION

Continue to monitor and observe for signs/symptoms of adverse reactions for 24 hours after completion of transfusion of blood products.

After transfusion is complete, disconnect the line and flush the IV with normal saline. Discard any residual product in a biohazard waste container.

Complete all necessary documentation per facility policy:

- Transfusion record form
- Vital signs
- Any adverse reactions, etc.

Continue to monitor labs, CBC (complete blood count), and notify the healthcare provider of any abnormal findings.

Performance Improvement Plan

Follow this checklist if the leadership team has determined that a performance improvement project is necessary:

☐ **Gather the right project team.** Be sure to involve the right people on the team. You'll want two teams: an oversight team that is broad in scope, has 10-15 members, and includes the executive sponsor to validate outcomes, remove barriers, and facilitate spread. The actual project team consists of 5-7 representatives who are most impacted by the process. Whether a discipline should be on the oversight team or the project team depends upon the needs of the organization. Patients and family members should be involved in all improvement projects, as there are many ways they can contribute to safer care.

Complete this Lean Improvement Activity:
Conduct a SIPOC analysis to understand current state and scope of the problem. A SIPOC is a lean improvement tool that helps leaders to carefully consider everyone who may be touched by a process, and therefore, should have input on future process design.

RECOMMENDED PATIENT BLOOD MANAGEMENT IMPROVEMENT TEAM	
• Admitting and registration staff	• Physicians
• Phlebotomists	• Clinical educators
• Blood bank technicians	• Quality and safety specialists
• Nurses	

Table 1: Understanding the necessary disciplines for a patient blood management improvement team

☐ **Understand what is currently happening and why.** Reviewing objective data and trends is a good place to start to understand the current state, and teams should spend a good amount of time analyzing data (and validating the sources), but the most important action here is to go to the point of care and observe. Even if team members work in the area daily, examining existing processes from every angle is generally an eye-opening experience. The team should ask questions of the frontline during the observations that allow them to understand each step in the process and identify the people, supplies, or other resources are needed to improve patient outcomes.

Create a process map once the workflows are well understood that illustrates each step and the best practice gaps the team has identified (IHI, 2015). Brainstorm with the advisory team to understand why the gaps exist, using whichever root cause analysis tool your organization is accustomed to (IHI, 2019). Review the map with the advisory team and invite the frontline to validate accuracy.

PATIENT BLOOD MANAGEMENT PROCESSES TO CONSIDER ASSESSING	
• Evaluation of alternative therapies, including pharmacological	• Pre-surgical test for coagulation
• Anemia testing and monitoring before, during, and after surgery	• Identification of patients at risk for hemorrhage
• Laboratory test order process	• Proper documentation and confirmation of blood products from type and screen through transfusion
• Hemoglobin documentation before and after transfusion	• Proper patient identification prior to transfusion
• Transfusion decision process	

Table 2: Consider assessing these processes to understand where the barriers contributing to poor patient blood management may be in your organization

☐ **Prioritize the gaps to be addressed and develop an action plan.** Consider the cost effectiveness, time, potential outcomes, and realistic possibilities of each gap identified. Determine which are a priority for the organization to focus on. Be sure that the advisory team supports moving forward with the project plan so they can continue to remove barriers. Design an experiment to be trialed in one small area for a short period of time and create an action plan for implementation.

The action plan should include the following:

- Assess the ability of the culture to change and adopt appropriate strategies
- Revise policies and procedures
- Redesign forms and electronic record pages
- Clarify patient and family education sources and content
- Create a plan for changing documentation forms and systems
- Develop the communication plan
- Design the education plan
- Clarify how and when people will be held accountable

TYPICAL GAPS IDENTIFIED IN PATIENT BLOOD MANAGEMENT	
• Lack of standardized processes for patient identification and confirmation pre-transfusion • Poor blood product labeling • Lack of thorough evaluation of alternatives to transfusion • Lack of standardization of storage protocols	• Unclear standards for labeling products • Lack of emphasis on monitoring for post-transfusion reactions • Lack of reliable processes to check entries in EHR

Table 3: By identifying the gaps in patient blood management compliance, organizations can tailor their project improvement efforts more effectively

☐ **Evaluate outcomes, celebrate wins, and adjust the plan when necessary.** Measure both process and outcome metrics. Outcome metrics include the rates outlined in the leadership checklist. Process metrics will depend upon the workflow you are trying to improve and are generally expressed in terms of compliance with workflow changes. Compare your outcomes against other related metrics your organization is tracking.

Routinely review all metrics and trends with both the advisory and project teams and discuss what is going well and what is not. Identify barriers to completion of action plans, and adjust the plan if necessary. Once you have the desired outcomes in the trial area, consider spreading to other areas (IHI, 2006).

Read this paper **from the Institute for Healthcare Improvement to understand how small local steps can integrate into larger, system changes**

It is important to be nimble and move quickly to keep team momentum going, and so that people can see the results of their labor. At the same time, don't move so quickly that you don't consider the larger, organizational ramifications of a change in your plan. Be sure to have a good understanding of the other, similar improvement projects that are taking place so that your efforts are not duplicated or inefficient.

PATIENT BLOOD MANAGEMENT COMPARATIVE OUTCOMES	
• Number of laboratory tests ordered • Frequency of blood draws • Amount of blood discarded and reason documentation	• Platelet inhibitors and other anticoagulants used before surgery • Anemia testing before surgeries

Table 4: Consider evaluating related metrics to better understand adverse reaction presence due to poor patient blood management

What We Know About Patient Blood Management

Patient Blood Management (PBM) is the timely application of evidence-based medical and surgical concepts designed to manage anemia, optimize hemostasis, and minimize blood loss in order to improve patient outcomes. Errors in the use of blood components are a significant cause of hospital patient morbidity and mortality (Meybohm et al., 2017).

A significant component of PBM is the use of properly timed, evidence-based practices to manage anemia. While healthcare providers normally use blood transfusions to treat anemia, these often don't treat the underlying cause and introduce risk of error each time a patient receives a transfusion.

Transfusion should only be used when the benefits outweigh the risks. It is important to acknowledge that there is no universal 'transfusion trigger'. All patients should be clinically assessed using evidence based guidelines before a transfusion decision is made. Alternative methods should always be considered before making a transfusion decision.

1 in 10 in-patients receive at least 1 unit of blood, making red blood cell (RBC) transfusions one of the most common procedures for hospitals in the US and Europe (Cost et al., 2009). However, laboratory hemoglobin values, a primary indicator for RBC transfusions, are only checked on occasion and often delayed – leading to transfusion decisions without knowing if they will help (Frank, 2012). This evidence illustrates a significantly underreported patient safety concern related to PBM: the lack of an adequate process to determine alternatives to transfusions.

To improve patient safety, hospitals should:

- Establish a universal protocol for determining need for a transfusion.
- Outline transportation, storage, testing, and identification protocols that should be employed for every transfusion.
- Implement a continuous monitoring system or practice to ensure stability after the transfusion.

Clinical and Financial Implications

10 units of blood within a 24 hour time period or five units of blood within four hours are both considered to be major transfusions (De Pietro, 2018). While performing blood transfusions has become a refined technique, the risks for reaction and complications still exist.

Transfusions are often used to manage anemia, a problem that impacted around 1 in 3 people worldwide (Kassebaum et al., 2014). Anemia is the source for 68.3 million years lived with disability and 8.8% of all ailments globally (McLean et al., 2009). In hospitals, anemic patients have been shown to have a 30-day mortality rate of 13 times more than their non-anemic counterparts (Musallam et al., 2011). Additionally, anemic patients have a higher likelihood of death (+20%), longer hospital stays, are at an increased risk for falls, and are more likely to contract a hospital-acquired infection (Baron et al., 2014).

The prevalence of anemia, coupled with the increased likelihood of reliance on transfusions in surgical procedures, highlights patient blood management as a key focus area for patient safety.

Research has shown that blood transfusions are an expensive process that costs approximately $1,200 for transfusing one unit of red blood cells (Shander, 2014). By implementing patient blood management and enforcing proper protocols, such programs can reduce blood transfusions by 20 to 30 percent (Shander, 2014); thereby, allowing for the hospital to save money in the process (Shander, 2014). By reducing blood transfusions by 25 percent in the hospital through PBM implementation, a 500-bed hospital that transfuses 4,000 units of red blood cells per year would be able to save approximately $960,000 annually (Shander, 2014). Specifically, a cost benefit analysis from the University Hospital Frankfurt revealed that PBM was associated with a reduction in transfusion rate, a reduction in the transfused RBC units per patient, and a reduction in the length of hospital stay, subsequently yielding a mean savings of yielding to mean savings of €150 per patient (Meybohm et al., 2019). Furthermore, it was found that implementing PBM measures reduced RBC transfusion rate by 39 percent and decreased the mortality rate of patients by 11 percent (Meybohm et al., 2019).

See Appendix B for a case study of the successful PBM program.

Anemia

Healthcare providers often give RBC transfusions to patients with anemia to raise their oxygen carrying capacity. Yet many RBC transfusions are overused and may cause undue risk or harm. The Institute of Medicine (IOM) defines overuse as "in circumstances where the likelihood of benefit is negligible or zero, and therefore the patient is exposed to the risk of harm".

Recent studies show that anemia can have a serious impact on surgical outcomes, making it an independent risk factor for patients. In a study with data including 227,425 patients undergoing any kind of non-cardiac surgery, non-anemic patients had a 30-day mortality rate of 0.78% (over 158,000 patients) (Musallam et al., 2011). In contrast, patients with only mild anemia (Hb level of 10-13 g/dL in men and 10-12 g/ dL in women) had a mortality rate 4.5 times higher than non-anemic patients (3.52% in over 57,000 patients). When patients were severely anemic (Hb level below 10 g/dL) their 30-day mortality rate increased to 13 times more than non-anemic patients (more than 11,000 patients) (Musallam et al., 2011).

Hospital-acquired anemia is an example is an example of a clinical complication that can result from poor patient blood management. Those with a higher length of stay are at an increased risk for developing hospital-acquired anemia, primarily due to the large amounts of blood drawn for diagnostic tests repeatedly (Makan et al., 2018). Other populations at risk include adults over 65, females, neonates, and those who are malnourished (Makan et al., 2018). The treatment for hospital-acquired anemia may include RBC transfusions to replenish hemoglobin levels. Upon transfusion, it is essential to consider the normal hemoglobin level for that patient. Normal and healthy blood hemoglobin levels in men adults is 13.5 to 17.5 grams per deciliter

(g/dL) and for women it is 12.0 to 15.5 grams per deciliter (Estcourt et al., 2017). Additionally, it is important to consider the overall clinical context of the patient (Carson et al., 2016).

All patients should be screened for anemia as early as possible before an elective surgery.

See here for an algorithm for the detection, evaluation, and management of preoperative anaemia.

Components of Whole Blood Overview

The components of the blood include the packed red blood cell (PRBC) concentrate, platelet concentrate, fresh frozen plasma and cryoprecipitate (Basu and Kulkarni, 2014). Whole blood can be described as the blood that is directly taken from the body via venipuncture from which none of the components have been removed (Basu and Kulkarni, 2014).

- **Packed red blood cell concentrate (PRBC):** Used primarily in the treatment of hypoxia, PRBCs are red blood cells from the blood that have been separated for blood transfusion (Muller et al., 2015). PRBCs should be administered in accordance with the ABO manner (See Appendix A).

  When determining if necessary to administer packed RBC to the patient, distinguish between acute hemorrhage and chronic anemia (Muller et al., 2015):

  - **Acute hemorrhage** is an acute loss of blood occurring from damage to a blood vessel.
  - **Chromic anemia** is a condition in which the patient's blood lacks an adequate supply of health RBCs. Chronic anemia can be linked to other comorbidities such as autoimmune diseases (rheumatoid arthritis), chronic infections (HIV/AIDS), or inflammation in the body.
- **Platelet concentrate:** Platelet concentrate (PC) can be described as autologous blood-derived products that are composed of the WBCs and platelets (Mariani and Pulsatelli, 2020). These blood derived products contain quantitatively-enriched blood platelets that come from one or more than one blood donors (Platelet Concentrates, 2009).
  - Upon obtaining the platelets, they are to be either resuspended in the donor plasma solution or put in an additive solution (Platelet Concentrates, 2009).
  - PC allows the care team to administer molecules released by a concentrated pool of activated platelets to a specific site of tissue injury. This contributes to the regulation of inflammation, angiogenesis, and the immune response, thereby enhancing the repair of damaged tissues (Mariani and Pulsatelli, 2020).
- **Fresh frozen plasma:** Fresh frozen plasma (FFP) is the fluid portion of a unit of whole blood (Khawar et al., 2020). It is typically isolated and frozen within eight hours post-collection (Khawar et al., 2020).
  - FFP must be ABO compatible with the patient.
  - FFP is typically employed for patients at risk for bleeding, with vitamin K deficiency, in emergency and trauma patients to stop bleeding, burn and shock patients, severe liver disease patients, and those with clotting factor deficiencies.
- **Cryoprecipitate:** Cryoprecipitate is the frozen blood product prepared from blood plasma (Lliassa, et al., 2016).
  - Cryoprecipitate is used to prevent or control bleeding in patients whose own blood does not clot on its own, such as in the case of hypofibrinogenemia (Lliassa, et al., 2016)

Medications for Prevention and Management

See JPAC's "Pharmacological measures to reduce transfusion" for more information on medications, dosing, and appropriate administration.

- **Iron:** Iron does not typically interact with other medications, but patients who are taking calcium or thyroid medication may be at risk for an interaction (London Health Sciences, 2020). Side effects of iron may include heartburn, cramps, nausea/vomiting, constipation, and/or diarrhea (London Health Sciences, 2020).
- **Erythropoiesis Stimulating Agents (ESAs):** Erythropoietin is a natural hormone and plays a key role in regulating RBC production in the bone marrow. ESAs are the artificial medication for patients with low hemoglobin (typically less than 130 g/L). Erythropoietin may help reduce the need for transfusions by complementing the body's hemoglobin production, thereby making it easier for the body to adjust for blood loss during surgery (London Health Sciences, 2020). ESAs are standard therapy in renal anemia and some chemotherapy patients (Joint UK Blood Transfusion) The typical treatment is administered via injection once per week for two to four weeks (London Health Sciences, 2020). Patients on ESAs should be monitored frequently for hypertension and thromboembolic complications (Joint UK Blood Transfusion).
- **Tranexamic Acid:** Tranexamic acid is a pro-hemostatic drug known to reduce the need for transfusion in surgical and trauma patients by reducing the degradation of fibrin, which is involved in blood clotting (Joint UK Blood Transfusion) and (Tranexamic Acid, 2020).
- **Thrombopoietin Mimetics (Romiplostim and Eltrombopag):** Although both Romiplostim and Eltrombopag are still in clinical trials, thrombopoietin mimetics as a class increase the platelet production and can be administered via subcutaneous inject (Romiplostim) or orally (Eltrombopag) (Joint UK Blood Transfusion). However, their efficacy versus risk cannot yet be established.

Determining Transfusion Alternatives

A blood transfusion is like a tissue transplant, therefore, this is highly dangerous and should be avoided unless determined absolutely essential. Transfusions carry risks such as incompatibility and disease transmission. Because many blood transfusion adverse events result from human and process error, transfusion is considered a safe process if precautions are followed extraordinarily meticulously.

Any mechanism to reduce patient exposure to allogeneic blood during their hospital stay is beneficial to avoid potential complications (Silvergleid and Heath, 2020). Alternatives to a transfusion include:

- Intraoperative blood salvage
  - See AABB's Standards for Perioperative Autologous Blood Collection and Administration.
  - Is the patient is a controlled surgical procedure with a high likelihood of significant blood loss? If not, eliminate the option for intraoperative blood salvaging.
  - Potential complications of perioperative blood salvage include coagulopathy, transfusion-related volume overload, bacterial contamination, and embolism.
- Preoperative autologous donation: In the case of elective surgeries, patients can donate their own blood in the weeks prior.
  - Preoperative autologous donation carries the risk of inducing anemia, coagulopathy, transfusion-related volume overload, bacterial contamination, embolism, and compromising blood integrity through storage. Weigh the risks and benefits of this route based on the patient circumstance (Silvergleid and Heath, 2020).
- Acute normovolemic hemodilution
  - Potentially advantageous compared to preoperative autologous donation because of the avoidance of compromised blood integrity due to storage and no risk of patient identification errors (Goodnough and Shander, 2012).
- Volume expanders
  - Does the patient need more oxygen or an increase in blood cells? If so, eliminate the option for volume expanders.
- Growth factors
  - Is the patient actively bleeding/does the patient need the blood replaced immediately? If so, eliminate the option for growth factors.
- Basic conditions for hemostasis, reversal of anticoagulants, point-of-care diagnostics in coagulopathic patients, optimized coagulation management with the use of clotting factor concentrates, and the use of antifibrinolytic agents or desmopressin are further important considerations.

Indications

- **Indications for a Blood Transfusion:** The inadequacy of discrete hemoglobin concentrations lends itself to the need for a transfusion. Typically, it is suggested that transfusion offers little benefit when hemoglobin concentrations are greater than 10 g/dL. These transfusions may be beneficial when concentrations are below 6g/dL (Goodnough and Shander, 2012). For patients in the 6-10g/dL hemoglobin range, the benefit of the transfusion should depend on evaluation of the patient's clinical status and should be compared with the potential risks (McCullough et al., 2015).
- **Indications for Plasma Transfusion:** Plasma transfusions are recommended for very few indications, including trauma patients with significantly hemorrhage, patients undergoing complicated, high-risk cardiovascular surgery, and for patients with cranial bleeding requiring urgent reversal of coagulopathy associated with warfarin (Goodnough and Shander, 2012).
- **Indications for Platelet Transfusion:** Platelet transfusions are indicated for acute leukemia, haemopoietic stem cell transplant, chronic stable thrombocytopenia, or in prophylaxis for surgery. A platelet count of 10,000/mm is typically appropriate for prophylactic platelet transfusions. European and American guidelines currently recommend a transfusion trigger of 10 x 10 9 /L for platelets transfused prophylactically. See Veen et al., 2003, Schiffer et al., 2001 for specific indications.

The Decision for a Transfusion: A transfusion should only be performed if it has been determined that it is the safest option available and all other alternatives have been deemed inferior. Thorough evaluation and deliberation should take place before making the decision for a transfusion.

Type and Screen and Crossmatch: The type and screen is performed on patients who may need a transfusion of blood. Type and screen assessments are used to identify the patient's ABO group and Rh type and detect expected and unexpected antibiotics in the patient's serum. This is followed with a cross-match compatibility test to ensure that there are no antibodies present in the patient's serum which may adversely react with the donor's blood. In this test, a portion of donor blood is combined with patient plasma/serum to assess for incompatibility.

Both a type and screen and a crossmatch should be performed for every transfusion and results should be obtained and evaluated prior to transfusion.

Blood Bank Procurement (WHO): Available blood stock includes blood products that have been processed, grouped, and tested non-reactive for transfusion-transmissible infections. This stock has been passed for use by the quality assurance team

and only after passing these tests is the blood considered 'in stock' for use upon request.

Issuing Blood Products for Use and Confirmation of Patient: Blood components should only be issued upon receipt and confirmation of the following information on the collection slip, addressograph label, patient case notes, and/or prescription form:

- Family name
- First name
- Date of birth
- Hospital identification number
- Ward

Any discrepancy between the patient details and pack labelling should be a red flag to hold the blood until the discrepancy is resolved.

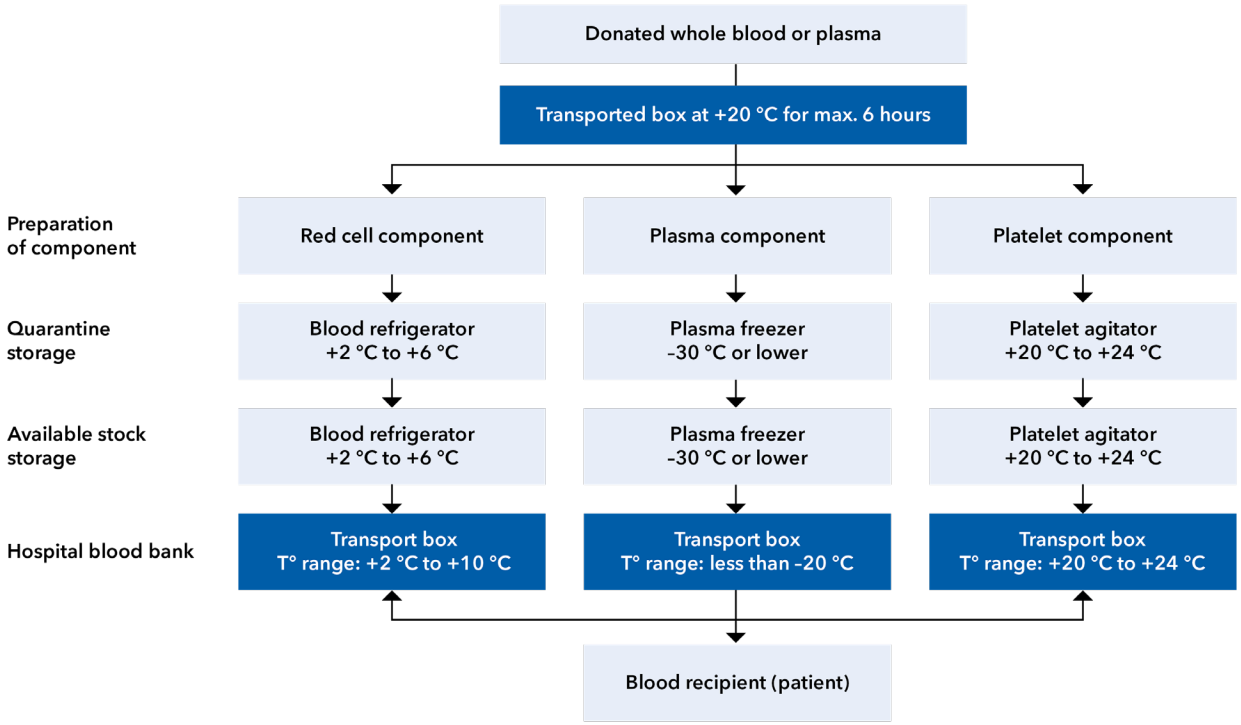
Dispatch of Blood Products: Only **after** the patient identity has been confirmed with the pack label, prepare for dispatch of blood products to the appropriate attending staff member.

- Use the blood-tracking barcodes to check and record the identity and accreditation of the person collecting the blood.
- Ensure once more that the details on the collection documents reflect the details on the blood pack exactly. Ensure the blood pack has not expired.
- Record the time a component is removed from a controlled temperature environment, as mandated by Blood Safety and Quality Regulations (BSQR). This data must be kept for 15 years (Collection of Blood, 2013). **Red cells that have been out of controlled refrigeration for more than 30 minutes must not be reissued for transfusion.** Although the rationale for the '30-minute rule' is brought into question based on current research postulating that red blood cells show no impairment in a 60-minute window after being removed from a temperature controlled environment, suspicion remains regarding the bacterial safety after 30 minutes. Further research is needed to support an amendment to this 30-minute policy (Collection of Blood, 2013).
- Visually check the blood component for acceptable appearance, expiry dating, blood group labels, and possible leakage.
- Follow thawing procedures for frozen plasma and cryoprecipitate.

Transportation of Blood Components (Blood Transfusion, 2020; WHO): Donated blood passes through several stages before reaching the recipient and it is essential that the blood is managed properly at each stage to retain its life saving properties.

As a rule of thumb, adhere to the '30-minute rule', where blood should not be outside its temperature range for more than 30 minutes.

Figure 4. The Blood Cold Chain from collection to transfusion. Information courtesy of the WHO.



Administration and Storage of Blood Components

Once issued by the blood bank, the transfusion should commence within 30 minutes. Transfusion of a unit of blood should be completed within a maximum of four hours after the component is removed from the refrigerated storage. The unit should be discarded if it has been removed for over four hours (Clinical Transfusion Practice, 2000).

Doses, transfusion rates, and storage by blood component, adopted from JPAC: Transfusion of blood components and Storage, inspection, and administration guidelines from New Delhi, India

BLOOD COMPONENT	ADMINISTRATION	STORAGE
Red blood cells in solution	• Transfusions must be completed within four hours of removal from refrigerated storage. • Many patients can be safely transfused over 90–120 minutes per unit. • A dose of 4 mL/kg raises Hb concentration by approximately 10 g/L. The risk of transfusion-associated circulatory overload (TACO) is reduced by careful pre-transfusion clinical assessment and use of single-unit transfusions, or prescription in millilitres, for elderly or small, frail adults where appropriate. • Rapid transfusion may be required during major bleeding events. Rapid transfusion is defined as 5-10 minutes per unit.	• Should be stored at a temperature between 2 degrees C and 6 degrees C. • Depending on the blood bag used, the shelf life can vary between 35-42 days. • Date of collection and expiration should be noted on the container.
Platelet concentrate	• One adult therapeutic dose (ATD) typically raises the platelet count by 20–40×10^9/L. • Usually transfused over 30–60 minutes per ATD. • Platelets should not be transfused with mechanisms that are already transfusing other blood components. • Start transfusion as soon as possible.	• Prepare platelets within eight hours of phlebotomy. • Store between 22-24 degrees C. Prevent movement or agitation. • Shelf life of 3-5 days. Do not store longer, as to prevent bacterial growth. • Do not refrigerate.
Cryoprecipitate	• Typical adult dose is two five-donor pools. • Will increase fibrinogen concentration by approximately 1g/L in a typical adult. • Administered 10-20 mL/kg/hour.	• Store at -18°C or colder. • Shelf life of 1 year. • For pooled cryo, the expiration date is 12 months from the earliest date of FFP collection. • To prepare for transfusion, thaw quickly at 30-37°C and then stored at room temperature (20-24°C). Thawed single cryo and pooled cryo have a shelf life of six hours. • Transfuse within 30 minutes. • If not transfused, do not refreeze. Discard.
Fresh frozen plasma (FFP)	• Dose typically 12–15 mL/kg, but should be confirmed by clinical indication, pre-transfusion and post-transfusion coagulation tests and clinical response. • Infusion rate typically 10–20 mL/kg/hour. • Because of the high volumes required to produce a haemostatic benefit, patients receiving FFP must have careful haemodynamic monitoring to prevent TACO. • FFP should not be used to reverse warfarin. • Requires thawing before transfusion. Place in a thawing bath at 30-37 degrees C for about 30-45 minutes. Infuse within 30 minutes of thawing. Do not refreeze.	• Should be frozen within eight hours of collection. • Should be stored in temperatures of -40 degrees C or colder. • Shelf life of one year for frozen plasma. • Shelf life for thawed plasma is 24 hours to five days depending on the plasma product being stored. • Thaw in a water bath at 30-37 degrees C for 20-30 minutes.

Immediate Pre-Transfusion Assessment (Doyle and McCutcheon, 2015):

- Confirm physician order. Verify type, amount, date, time, duration, modifications, and sequence.
- Verify the need for pre- or post- medication administration.
- Obtain the patient's history, including any previous transfusions, reactions, or known allergies.
- Confirm that type and crossmatch have been completed within 96 hours (See Appendix A).
- Ensure IV cannula is patent.
- Properly identify patients.
- Evaluate laboratory data, including platelet count and coagulation values.
- Confirm that the patient has filled out all necessary paperwork and consent forms.
    - o Ensure the patient understands why they are receiving the transfusion.
- Record baseline vitals.

- Ensure emergency equipment, such as oxygen, is readily available.
- Confirm that documentation is complete.

Transfusion Initiation (Doyle and McCutcheon, 2015):

- Initiate or evaluate venous access.
- Initiate primary infusion at TKVO.
- Document vital signs, especially those that may be confused with a reaction due to transfusion.
- Obtain products from transfusion within 30 minutes of scheduled transfusion.
- Visually assess the blood product for any leaks, clumps, discoloration etc.
- Compare the transfusion documentation with the patient record and confirm patient name and unique identifier number, physician order, consent, and patient ABO grouping. Compare the transfusion documentation with the product label. **If there are any discrepancies, stop immediately.**
- Administer pre-ordered medications.
- Complete final verification of patient, transfusion documentation, and product.
- Perform the transfusion.

Routine Reassessment: During the transfusions, the blood product should be administered slowly at one to four hours for each unit of blood (Sarode, 2020). During administration, the provider should be monitoring for (Sarode, 2020):

- Fever
- Ucitaria (hives)
- Fluid overload
- Lung Injury
- Back pain
- Chills
- Flank pain (either side)
- Shortness of breath
- Skin flushing (pale)
- Itching
- Fainting or dizziness
- Dark urine
- Wheezing
- Low blood pressure

The total blood transfusion procedure should take anywhere from one to four hours and the patient should be monitored the entire time (Blood Transfusion, 2017). Potential risks of a transfusion include infection, reaction, ABO mismatch, patient misidentification, volume overload, iron overload, and/or immunomodulation (Goodnough and Shander, 2012).

Adverse Reactions: In some cases, complications arise. Such reactions can occur within seconds of the transfusion, minutes, or even up to a few weeks or a month (Saint Luke, 2020).

Information courtesy of (Saint Luke, 2020)

REACTION	TIMING	SIGNS AND SYMPTOMS
Mild allergic reaction	Within seconds to minutes during transfusion or up to 24 hours after the transfusion	Hives, red welts, itching, rash, swelling, red face, shortness of breath
Anaphylactic reaction	Within seconds to minutes during transfusion or up to 24 hours after the transfusion	Hives, red welts, itching, rash, swelling, red face, labored breathing, chest tightness, cramps, low blood pressure
Transfusion-related acute lung injury (TRALI)	Within one to two hours during transfusion or up to six hours after transfusion	Shortness of breath, trouble breathing, low blood pressure, fever, pulmonary edema
Transfusion-related circulatory overload	Near the end of the transfusion or up to six hours after transfusion	Shortness of breath, rapid heart rate, abnormal blood pressure
Post-transfusion purpura	Within one week of transfusion	Purple spots on skin, nosebleeds, bleeding from urine, fever, chills
Delayed transfusion-related acute lung injury	Within 72 hours after transfusion	Sudden onset of respiratory distress or trouble breathing
Delayed hemolytic reaction	Between three days to several weeks after transfusion	Fever, chills, jaundice, chest pain, nausea

Resources

For patient blood management improvement:

- WHO: Blood Management
- A Framework to Support Nurses and Midwives Making the Clinical Decision and Providing the Written Instruction for Blood Component Transfusion
- Acute Transfusion Reaction Clinical Workflow Infographic
- Storage, Inspection, and Administration Guidelines from New Delhi, India
- JPAC: Transfusion of Blood Components

For general improvement:

- CMS: Hospital Improvement Innovation Networks
- IHI: A Framework for the Spread of Innovation
- The Joint Commission: Leaders Facilitating Change Workshop
- IHI: Quality Improvement Essentials Toolkit
- SIPOC Example and Template for Download
- SIPOC Description and Example

Education for Patients and Family Members

The outline below illustrates all of the information that should be conveyed to the patient and family members by someone on the care team in a consistent and understandable manner.

Explain why the patient is being considered for a transfusion and for blood management alternatives. Patient blood management (PBM) is an integral aspect of a multifaceted patient care approach that ensures safety and optimized care of patients during blood transfusion. A member of the healthcare team should elaborate on the need for blood transfusion and should provide a basic overview of the management of the transfusion. The care team member should help the patient understand the risks and benefits associated with a blood transfusion, as well as explaining the alternatives available and why one or more than one alternative may be an option, based on the individual's circumstance.

Although the patient may be clinically best suited for one method of blood management over another, it is important to consider the patient's preferences, religious or otherwise.

Illustrate what the patient can expect during the transfusion and why the patient is receiving the transfusion, if applicable.

- **The patient should understand that they have a right to refuse the transfusion.**
- Explain that a transfusion will occur due to an abnormal level of some or all blood components and why a transfusion is the best plan of care over alternative therapies.
- Communicate the blood component the patient will be receiving and why.
- Provide a timeframe duration for the transfusion. For example, a red blood cell transfusion can last between two to four hours while platelet transfusions can last up to an hour. Therefore, the patient should understand how their condition will impact the duration of the transfusion.
- Patients should understand that they should maintain their normal diet and activities prior to the transfusion, if planned.

The patient and family members should understand the basic components involved in the blood management process, including, but not limited to, the importance of patient identification and testing, the uses of each blood component, and which blood component will be used for the patient. Clinicians should provide a high-level overview of the processes in place at their organization to ensure safety of the patient before the transfusion. This demonstrates competence of the organization, will likely bolster patient and family comfort, and will provide the patient and family members with information for which to reference if they may be suspicious of a problem post-transfusion.

Explain what can be expected post-transfusion. It is common for patients to feel aches in the hand or arm after the transfusion. It is recommended that the patient rest for 24-48 hours post-transfusion. The patient and family members should understand that the care team is monitoring for post-transfusion reaction. While it should have been disclosed pre-transfusion, the patient and family member should understand the potential signs and symptoms of an adverse or allergic reaction so they too can help monitor for a reaction.

Family members should know exactly when to call for help, where to go for help, and with whom they should speak. It is essential that patients and family members understand that they should not be ashamed to ask any of their questions and that many patients in similar situations often have similar questions. In addition to explaining when to call for help in the case of a potential emergency, healthcare providers should also thoroughly explain the typical treatment that can be expected before, during, and after any transfusion. Additionally, it is important to discuss potential post-transfusion complications.

Family members can serve as an extra pair of eyes and ears and can alert medical staff if something might be wrong. If the patient has undergone a transfusion, family members should have an understanding of what to look for that may indicate reactivity to the transfused blood component:

- Fever
- Ucitaria (hives)
- Flank pain (either side)
- Shortness of breath
- Skin flushing (pale)
- Itching
- Wheezing
- Low blood pressure

In order to adequately welcome patients and family members into the care team, it is not enough to explain "what" patients and family members should look for or "what" is going to happen in their care. The "what" must always be followed with a "why" to aid in genuine understanding.

Instead of employing a directive conversation style, an active, engaging conversation should take place, leaving capacity for questions and repeat-back strategies. When patients and family members understand the signs and symptoms that could be indicative of a problem, they are able to serve as an extra set of eyes in order to elevate this concern as early as possible.

By engaging in these conversations before a problem arises, family members can be prepared in the circumstance of necessary treatment and will have an understanding of where to go to find out more information about their loved one's condition.

Explain what is expected of them during their care. By giving patients and family members a "job" while they are in the

hospital, they can be immersed fully in the routine care, can hold other team members accountable, can feel more confident voicing their concerns or opinions, and can serve as an extra set of informed and vigilant eyes to optimize blood management and transfusion safety. This team involvement can also reduce their anxiety by transforming concern into proactive action.

Patients and family members can:

- Engage in conversations around current potential health conditions such as diabetes
- Ask for clarification on the different types of transfusion and which particular transfusion the patient will receive
- Ensure that the donor blood has been matched with the blood of the patient
- Monitor temperature and speak up if there are any abnormalities in the vitals
- Encourage the patient to discontinue smoking and consuming alcohol
- Monitor for hand hygiene in all healthcare providers and visitors
- Ensure that their family member is feeling well throughout the entire transfusion process
- Watch for any signs of an post transfusion reactions, including unsuspected fever, decreased blood pressure, ucitaria (hives on the skin), minor or major aches and pains, shortness of breath, and elevate to care team

Planning for life after the hospital, whether in assisted living, returning home, or another option, should begin as early as possible between the healthcare providers and the patient and family.

- Describe the organization's blood and transfusion management standards that were followed.
    - If any of the protocols changed due to this specific patient's circumstance, articulate that to the patient and family members.
- Have a discussion with the patient and family around end of life care and advanced directives.
    - Make an attempt to thoroughly understand the religious or cultural nuances in any of the patient's or family members' decisions or questions.
- Ensure thorough explanation of necessary post-discharge appointments, therapies, medications, and potential complications.
    - Assess for patient preference in time and location of follow-up appointments, if possible.
- Set realistic goals and expectations with the patient and family members included in the conversation.
    - Provide any encouragement, tools, or resources necessary to help the patient achieve his/her goals.
- Provide patients and family members resources, including direct contact phone numbers, to the hospital for post-discharge questions.
    - Make sure the resources are in their own language.
- Provide thorough instructions to the patient and family members in the days leading up to discharge regarding post transfusion and recovery after transfusion (What you should know, 2020).
    - If additional care is required after discharge, set aside time with the patient and family member more than once to ensure their understanding and confidence.

Each conversation with a patient and family member should be inclusive and void of bias. Additionally, these conversations should leave ample time for discussion and the facilitator should encourage questions from the patient and family members.

Patients and family members should understand that, although all clinicians in the hospital do their best, no one is ultimately coordinating their care. Patients and family members should understand that they are the managers of their care and as such, should demand to be an active part of the care team including conversations and decisions.

Measuring Outcomes

Key performance indicators

Anemia and transfusion management:
For patients with untreated and treated preoperative anemia, find:

- Rate of transfusion (Number of preoperative patients with anemia who receive a transfusion per total number of preoperative patients with anemia)
- Adverse events (AE)
- Patient deaths

per 1,000 patients who undergo elective surgery

Outcome measure formula:

Establish Baseline Harm using:

Numerator: the number of patient deaths with untreated and treated preoperative anemia (you may keep these numbers separate or combine for this measure)

Denominator: Total number of anemic patients undergoing elective surgery

Metric recommendations

Direct Impact:
All patients undergoing elective surgery

Lives Spared Harm:
$$Lives\ Spared\ Harm = (Adverse\ Events_{baseline} - Adverse\ Events_{measurement}) \times Elective\ Anemic\ Surgery\ Patients_{measurement}$$

Lives Saved:
$$Lives\ Saved = (Mortality\ Rate_{baseline} - Mortality\ Rate_{measurement}) \times Elective\ Anemic\ Surgery\ Patients_{measurement}$$

Notes

The table below contains the levels WHO uses to define anemia (WHO, 2011):

Table 1
Haemoglobin levels to diagnose anaemia at sea level (g/l)±

Population	Non -Anaemia*	Anaemia*		
		Mild[a]	Moderate	Severe
Children 6 - 59 months of age	110 or higher	100-109	70-99	lower than 70
Children 5 - 11 years of age	115 or higher	110-114	80-109	lower than 80
Children 12 - 14 years of age	120 or higher	110-119	80-109	lower than 80
Non-pregnant women (15 years of age and above)	120 or higher	110-119	80-109	lower than 80
Pregnant women	110 or higher	100-109	70-99	lower than 70
Men (15 years of age and above)	130 or higher	110-129	80-109	lower than 80

± Adapted from references 5 and 6
* Haemoglobin in grams per litre
a "Mild" is a misnomer: iron deficiency is already advanced by the time anaemia is detected. The deficiency has consequences even when no anaemia is clinically apparent.

Data collection

Data sources may include electronic billing data, data through manual chart review, or a hybrid method of chart review and electronic billing data.

Settings:
All in-patients (≥ 18 years) undergoing a surgical procedure and with at least one overnight stay

Mortality:
This will be calculated by the Patient Safety Movement Foundation

Endnotes

Conflicts of Interest Disclosure

The Patient Safety Movement Foundation partners with as many stakeholders as possible to focus on how to address patient safety challenges. The recommendations in the APSS are developed by workgroups that may include patient safety experts, healthcare technology professionals, hospital leaders, patient advocates, and medical technology industry volunteers. Workgroup members are required to disclose any potential conflicts of interest.

Workgroup

Co-Chairs

Aryeh Shander	Englewood Hospital and Medical Center
Kai Zackarowski	University Hospital Frankfurt

Members

This list represents all contributors to this document since inception of the Actionable Patient Safety Solutions.

William Floyd	iPASS, Inc.
Steven J. Barker	Patient Safety Movement Foundation; Masimo
Michel Bennett	Patient Safety Movement Foundation (formerly)
Josiah Huse	University of California, Irvine
Ariana Longley	Patient Safety Movement Foundation
Jacob Lopez	Patient Safety Movement Foundation (formerly)
Stacey Orsat	Masimo
Tomas Sanabria	Patient Safety Movement Foundation
Racharl Sarnowski	
Kerry Tomlin	Medtronic
Jonathan Walter	University of Pittsburgh Medical Center
Mary Kay Wisniewski	University of Pittsburgh Medical Center
Thomas Zeltner	Bluewin

Metrics Integrity

Robin Betts	Kaiser Permanente, Northern California Region

*This Workgroup member has reported a financial interest in an organization that provides a medical product or technology recommended in the Technology Plan for this APSS.

References

Adverse effects of transfusion. (2003). Retrieved from https://www.rch.org.au/bloodtrans/adverse_effects/Adverse_effects_of_transfusion/

American Society of Anesthesiologists Task Force on Perioperative Blood Management. Practice Guidelines for for Perioperative Blood Management: an Updated Report by the American Society of Anesthesiologists Task Force on Perioperative Blood Management*. *Anesthesiology*. 2015 Feb;122(2):241-75.

Anastasiadis K, Antonitsis P, Deliopoulos A, Argiriadou H. (2017). A Multidisciplinary Periopera- tive Strategy for Attaining "More" Physiologic" Cardiac Surgery. *Perfusion*, 32(6), 446-453.

Baron, D. M., Hochrieser, H., Posch, M., Metnitz, B., Rhodes, A., Moreno, R. P., Metnitz, P. (2014). European Surgical Outcomes Study (EuSOS) group for Trials Groups of European Society of Intensive Care Medicine; European Society of Anaesthesiology. Preoperative Anaemia is Associated with Poor Clinical Outcome in Non-cardi- ac Surgery Patients. *Br J Anaesth*, 113(3), 416–23.

Basu, D., & Kulkarni, R. (2014). Overview of blood components and their preparation. *Indian Journal of Anesthesia*, 529-537.

Blood Components: How can one donation help multiple people? (2020). Retrieved from https://www.redcrossblood.org/donate-blood/how-to-donate/types-of-blood-donations/blood-components.html#:~:text=Whole%20blood%20is%20used%20to,blood%20drive%20or%20blood%20center.&text=Red%20blood%20cells%20(RBCs)%2C,give%20blood%20its%20distinctive%20color

Blood Donation: What are the minimum requirements to become a blood donor? (2020). Retrieved from http://www.aabb.org/tm/donation/Pages/donatefaqs.aspx

Blood Transfusion Services. (2020). Retrieved from ww.utmb.edu/bloodbank

Carson, J. L., Carless, P. A. and Hebert, P. C. (2012). Transfusion Thresholds and Other Strategies for Guiding Allogeneic Red Blood Cell Transfusion... *Cochrane Database Syst Rev*, CD002042.

Carson, J. L. (2012). Red Blood Cell Transfusion: A Clinical Practice Guideline From the AABB. *Annals of Internal Medicine*, 157(1), 49. doi:10.7326/0003-4819-157-1-201206190-00429.

Carson, J. L., Guyatt, G., & Heddle, N. M. (2016). Clinical Practice Guidelines From the AABB Red Blood Cell Transfusion Thresholds and Storage. *Special Communication.*

Chaparro, C. M., & Suchdev, P. S. (2019). Anemia epidemiology, pathophysiology, and etiology in low- and middle-income countries. *The New York Academy of Science*, 15-31.

Clinical Transfusion Practice: Guidelines for Medical Interns. (2000). World Health Organization.

Collection of blood components and delivery to clinical areas. (2013). Joint United Kingdom (UK) Blood Transfusion and Tissue Transplantation Services Professional Advisory Committee, 8.

Cost, H., (HCUP, U. P. and others. (2009). HCUP Facts and Figures: Statistics on Hospital-based Care in the United States, 2007.

De Pietro, M. (2018). Blood transfusions: Is there a limit? *Medical News Today*.

Doyle, G. R., & McCutcheon, J. A. (2015). Transfusion of Blood and Blood Products. *BC Campus*.

Duncan, J. (2020). Pre-transfusion Testing. *Canadian Blood Services*.

Estcourt, L. J., Malouf, R., Trivella, M., Fergusson, D. A., Hopewell, S., & Murphy, M. F. (2017). Restrictive versus liberal red blood cell transfusion strategies for people with haematological malignancies treated with intensive chemotherapy or radiotherapy, or both, with or without haematopoietic stem cell support. *Cochrane Library*.

Frank, S. M. (2012). Blood Transfusions Still Overused and May Do More Harm Than Good in Some Patients. *John Hopkins Medicine*.

Freedman, J. (2014). Transfusion–Whence and Why... *Transfus Apher* Sci, 50, 5–9.

Friedman, A. J., Chen, Z., Ford, P., Johnson, C. A., Lopez, A. M., Shander, A., ... van, W. D. (2012). Iron Deficiency Anemia in Women Across the Life-Span.. *J Womens Health (Larchmt),* 21, 1282–9.

Goodnough, L. T., Maniatis, A., Earnshaw, P., Benoni, G., Beris, P., Bisbe, E., ... Szpalski, M. (2011). Detection, Evaluation, and Management of Preoperative Anaemia in the Elective Orthopaedic Surgical Patient: NATA guidelines... *Br J Anaesth*, 106, 13–22.

Goodnough, L. T. and Marques, M. B. (2017). Zika Virus and Patient Blood Management. *Anesthesia & Analgesia*, 124(1), 282–289. doi:10.1213/ane.0000000000001770.

Goodnough, L. T. and Shander, A. (2013). Current Status of Pharmacologic Therapies in Patient Blood Management. *Anesthesia & Analgesi*a, 116(1), 15–34. doi:10.1213/ane.0b013e- 318273f4ae.

Goodnough, L. T. and Shander, A. (2012). Patient Blood Management. *Anesthesiology*, 116(6), 1367–1376. doi:10.1097/aln.0b013e318254d1a3.

Hill, S. E., Broomer, B., Stover, J. and White, W. (2011). Accuracy of Estimated Blood Loss in Spine Surgery. In Proceedings of the American Society of Anesthesiologists (ASA) 2011 *Annual Meeting*.

Iliassa, I. I., Zahiruddin Wan Mohammad, W., Tan, J. J., & Ayob, Y. (2016). A retrospective review of cryoprecipitate transfusion practice in Kuala Lumpur Hospital. *Asian Journal of Transfusion Medicine*, 145-149.

Institute for Healthcare Improvement. Overview of the 100,000 lives campaign. Retrieved from patient.sm/100k-lives-campaign.

Joint Commission. (2011). Implementation guide for The Joint Commission Patient Blood Management Performance Measures 2011. *Oakbrook Terrace, IL: The Joint Commission*, 1–180.(2012). Jt Comm Perspect, 32, 4, 8.

Joint United Kingdom (UK) Blood Transfusion and Tissue Transplantation Services Professional Advisory Committee. (2020).

Kassebaum, N. J., Jasrasaria, R., Naghavi, M., Wulf, S. K., Johns, N., Lozano, R., ... Murray, C. J. (2014). A Systematic Analysis of Global Anemia Burden from 1990 to 2010.. *Blood*, 123, 615–24.

Khawar, H., Kelley, W., & Guzman, N. (2020). Fresh Frozen Plasma (FFP). *Stat Pearls*.

Klein, A. A., Bailey, C. R., Charlton, A. J., Evans, E., Fisher, M. G., McCrossan, R., . . . Torella, F. (2018). Association of Anaesthetists guidelines: Cell salvage for perioperative blood conservation 2018. *Anaesthesia*, 1141-1150.

Koch, C. G., Li, L., Sun, Z., Hixson, E. D., Tang, A., Phillips, S. C., ... Henderson, J. M. (2013). Hospital-acquired Anemia: Prevalence, Outcomes, and Healthcare Implications. *Journal of Hospital Medicine*, 8(9), 506–512. doi:10.1002/jhm.2061.

Leahy, M. F., Roberts, H., Mukhtar, S. A., Farmer, S., Tovey, J., Jewlachow, V., ... Towler, S. (2014). A Pragmatic Approach to Embedding Patient Blood Management in a Tertiary Hospital... *Transfusion*, 54, 1133–45.

Leal-Noval SR, Arellano-Orden V, Munoz-Gomez M, et al. (2017). Red Blood Cell Transfusion Guided by Near Infrared Spectroscopy in Neurocritically Ill Patients with Moderate or Severe Anemia: A Randomized, Controlled Trial. *J Neurotrauma*, 34(17), 2553-2559.

Lejus C, De Windt A, LeBoeuf-Pouliquen D, Le Roux C, Bérard L, Asehnoune K. A Retrospective Study about Cerebral Near-infrared Spectroscopy Monitoring During Paediatric Cardiac Surgery and Intraoperative Patient Blood Management. Anaesth Crit Care Pain Med. 2015 Jun 9 [Epub ahead of print].

Levi, M. (2014). Twenty-five Million Liters of Blood into the Sewer. *Journal of Thrombosis and Haemostasis*, 12(10), 1592–1592. doi:10.1111/jth.12656.

London Health Science: Iron. (2020). Retrieved from https://www.lhsc.on.ca/perioperative-patient-blood-management-program/iron

Makam, A. N., Nguyen, O. K., Clark, C., & Halm, E. A. (2018). Incidence, Predictors, and Outcomes of Hospital-Acquired Anemia. Journal of Hospital Medicine.

Mariani, E., & Pulsatelli, L. (2020). Platelet Concentrates in Musculoskeletal Medicine. *International Journal of Molecular Science*.

Marik, P. E., Pastores, S. M., Annane, D., Meduri, G. U., Sprung, C. L., Arlt, W., ... Vogeser, M. (2008). Recommendations for the Diagnosis and Management of Corticosteroid Insufficiency in Critically Ill Adult Patients: Consensus Statements from an International Task Force by the American College of Critical Care Medicine... *Crit Care Med*, 36, 1937–49.

Masimo Corp. (2012). Masimo Corporation Estimate.

McCullough, J., Refaai, M. A., & Cohn, C. S. (2015). Blood Procurement and Red Cell Transfusion. *William's Hematology*.

McLean, E., Cogswell, M., Egli, I., Wojdyla, D. and de, B. B. (2009). Worldwide Prevalence of Anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993-2005... *Public Health Nutr,* 12,444–54.

Meybohm, P., Froessler, B., Goodnough, L. T., Klein, A. A., Muñoz, M., Murphy, M. F., ... Zacharowski,K. (2017). Simplified International Recommendations for the Implementation of Patient Blood Management (SIR4PBM). *Perioperative Medicine*, 6(1). doi:10.1186/s13741- 017-0061-8.

Meybohm, P., Herrmann, E., Steinbicker, A. U., Wittmann, M., Gruenewald, M., Fischer, D., ... Zacharowski, K. (2016). Patient Blood Management is Associated With a Substantial Reduction of Red Blood Cell Utilization and Safe for Patient's Outcome: A Prospective, Multicenter Cohort Study With a Noninferiority Design... *Ann Surg,* 264, 203–11.

Meybohm, P., Richards, T., Isbister, J., Hofmann, A., Shander, A., Goodnough, L. T., ... Zacharows- ki, K. (2017).Patient Blood Management Bundles to Facilitate Implementation... *Transfus Med Rev*, 31, 62–71.

Meybohm, P., Straub, N., Füllenbach, C., Judd, L., Kleinerüschkamp, A., Taeuber, I., . . . Choorapoikayil, S. (2019). Health economics of Patient Blood Management: A cost- benefit analysis based on a meta-analysis. *Vox Sanguinis*.

Moskowitz, D. M., McCullough, J. N., Shander, A., Klein, J. J., Bodian, C. A., Goldweit, R. S. and Ergin, M. A. (2010). The Impact of Blood Conservation on Outcomes in Cardiac Surgery: Is it Safe and Effective?. *Ann Thorac Surg*, 90, 451–8.

Müller, M. M., Geisen, C., Zacharowski, K., Tonn, T., & Seifried, E. (2015). Transfusion of Packed Red Cells Indications, Triggers and Adverse Events. *Deutsches Arzteblatt*, 507-518.

Murphy, G. J., Reeves, B. C., Rogers, C. A., Rizvi, S. I. A., Culliford, L. and Angelini, G. D. (2007). Increased Mortality Postoperative Morbidity, and Cost After Red Blood Cell Transfusion in Patients Having Cardiac Surgery. *Circulation*, 116(22), 2544–2552. doi:10.1161/circulationa- ha.107.698977

Musallam, K. M., Tamim, H. M., Richards, T., Spahn, D. R., Rosendaal, F. R., Habbal, A., ... Jamali, F. R. (2011). Preoperative Anaemia and Postoperative Outcomes in Non-cardiac Surgery: a Retrospective Cohort Study *Lancet*, 378, 1396–407.

National Quality Forum. (2010). Safe Practices for Better Healthcare–2010 Update.

Oklahoma Blood Institute: Receiving a Blood Transfusion: Information for Patients. (n.d.). Retrieved from https://obi.org/patients/blood-transfusion/

Oliver, J. C., Griffin, R. L., Hannon, T. and Marques, M. B. (2014). The Success of our Patient Blood Management Program Depended on an Institution-wide Change in Transfusion Practices... *Transfusion*, 54, 2617–24.

Platelet Concentrates. (2009). *Transfus Med Hemother,* 372-382.

Ranasinghe, T. and Freeman, W. D. (2014). 'ICU vampirism' - Time for Judicious Blood Draws in Critically Ill Patients... *Br J Haematol*, 164, 302–3.

Saint Luke's: When You Need a Blood Transfusion (Adult). (2020). Retrieved from https://www.saintlukeskc.org/health-library/when-you-need-blood-transfusion-adult

Salisbury, A. C., Reid, K. J., Alexander, K. P., Masoudi, F. A., Lai, S. M., Chan, P. S., ... Kosiborod, M. (2011). Diagnostic Blood Loss from Phlebotomy and Hospital-acquired Anemia During Acute Myocardial Infarction... *Arch Intern Med*, 171, 1646–53.

Sarode, R. (2020). Precautions and Adverse Reactions During Blood Transfusion. *MSD Manual*.

Schiffer, C. A., Anderson, K. C., Bennett, C. L., Bernstein, S., Elting, L., Goldsmith, M., . . . Wagnon, A. H. (2001). Platelet transfusion for patients with cancer: Clinical practice guidelines of the American Society of Clinical Oncology. *Laboratory Medicine and Pathology*, 19(5), 1519-1538.

Shander, A., Silvergleid, A. J., & Mark, J. B. (2020). Surgical blood conservation: Acute normovolemic hemodilution.

Shander, A., Goodnough, L. T., Javidroozi, M., Auerbach, M., Carson, J., Ershler, W. B., ... Lew, I. (2014). Iron Deficiency Anemia Bridging the Knowledge and Practice Gap.

Transfusion Medicine Reviews, 28(3), 156–166. doi:10.1016/j.tmrv.2014.05.001.

Shander, A., Hofmann, A., Ozawa, S., Theusinger, O. M., Gombotz, H. and Spahn, D. R. (2010). Activity-based Costs of Blood Transfusions in Surgical Patients at Four Hospitals. *Transfusion*, 50(4), 753–765. doi:10.1111/j.1537-2995.2009.02518.x.

Shander, A., Isbister, J. and Gombotz, H. (2016). Patient Blood Management: the Global View... *Transfusion*, 56 Suppl 1, S94–102.

Silvergleid, A. J., & Heath, M. (2020). Surgical blood conservation: Blood salvage. Retrieved from https://www.uptodate.com/contents/surgical-blood-conservation-blood-salvag

Suddock, J. T., & Crookston, K. P. (2020). Transfusion Reactions. *Statpearls*.

Theusinger, O. M., Kind, S. L., Seifert, B., Borgeat, L., Gerber, C. and Spahn, D. R. (2014). Patient Blood Management in Orthopaedic Surgery: a Four-year Follow-up of Transfusion Requirements and Blood Loss from 2008 to 2011 at the Balgrist University Hospital in Zurich, Switzerland... *Blood Transfus*, 12, 195–203.

Tranexamic acid saves lives, reduces transfusions. So why does no one use it? (Review). (2020). *PulmCCM*.

Tynngård, N. (2009). Preparation, storage and quality control of platelet concentrates. *Science Direct*, 41(2), 97-104.

Veen, J., Vora, A., & Welch, J. (2003). Guidelines for the use of platelet transfusions. *British Committee for Standards in Hematology, Blood Transfusion Task Force*, 122(1), 10-23.

Vretzakis G, Georgopoulou S, Stamoulis K, Tassoudis V, Mikroulis D, Giannoukas A, Tsilimingas N, Karanikolas M. (2013). Monitoring of Brain Oxygen Saturation (INVOS) in a Protocol to Direct Blood Transfusions During Cardiac Surgery: a Prospective Randomized Clinical Trial. *J Cardiothorac Surg*, 8(145).

Weiser, T. G., Regenbogen, S. E., Thompson, K. D., Haynes, A. B., Lipsitz, S. R., Berry, W. R. and Gawande, A. A. (2008). An Estimation of the Global Volume of Surgery: a Modelling Strategy Based on Available Data... Lancet, 372, 139–44.

What Happens to Donated Blood: Your blood journeys through many steps and tests that ensure our blood supply is as safe as possible and helps as many people as possible. (2020). Retrieved from https://www.redcrossblood.org/donate-blood/blood-donation-process/what-happens-to-donated-blood.html#:~:text=Red%20cells%20are%20stored%20in,for%20up%20to%20one%20year.

Whitlock, E. L., Kim, H. and Auerbach, A. D. (2015). Harms Associated with Single Unit Perioperative Transfusion: Retrospective Population Based Analysis. *BMJ*, 350(jun12 21), h3037–h3037. doi:10.1136/bmj.h3037.

World Health Organization. (2010). Availability, Safety and Quality of Blood Products. *Sixty-Third World Health Assembly*, 21.

World Health Organization. (2011). Haemoglobin Concentrations for the Diagnosis of Anaemia and Assessment of Severity.

Appendices

Appendix A

Compatible transfusion of packed red blood cells (PRC). Courtesy of Muller et al., 2015.

PATIENT'S BLOOD GROUP	COMPATIBLE PACKED RED CELLS
A	A or O
AB	B or O
B	AB, A, B, or O
O	O

Appendix B

The PBM strategy was officially established under the Wolff Center in 2013. Over the past five years, their PBM strategy has resulted in significant blood and blood product procurement and services cost reductions ($10M), while increasing patient safety (Patient Safety Movement Award 2015). The University of Pittsburgh Medical Center (UPMC) PBM program is nationally and internationally recognized as a model of excellence in blood management (**Figure 1**).

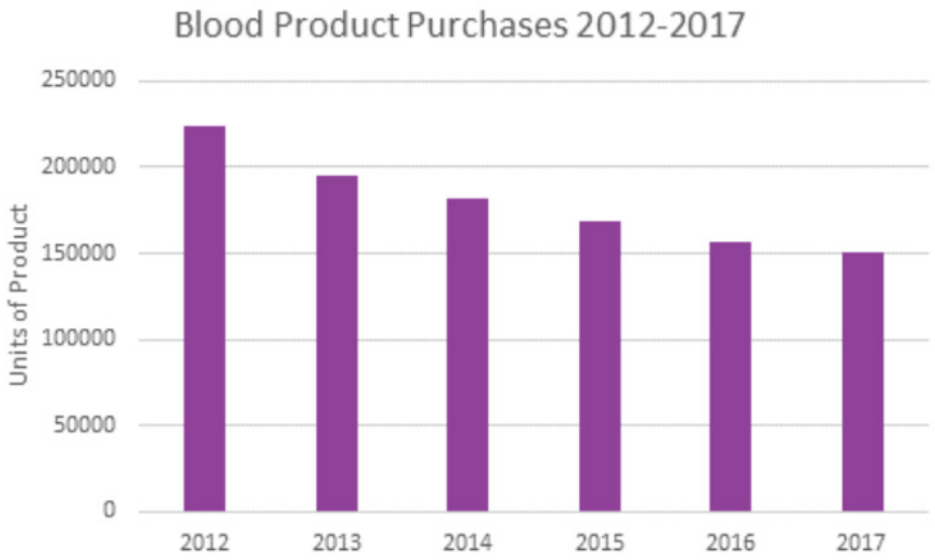


Figure 1: The reduction in blood product used over the last five years at the Wolff Center, which reduced costs by $10M by implementing the 6-point strategy for PBM

The largest multicenter trial (almost 130,000 patients) in the world shows that integrating PBM greatly reduces the amount of transfused blood, costs, and kidney damage. Overall, the implementation of PBM is safe and effective (Meybohm et al., 2016).

Technology to support laboratory hemoglobin measurements, such as noninvasive and continuous hemoglobin monitoring, can give clinicians more real-time trending information to determine if hemoglobin values are changing, which permits clinicians to make more informed and early RBC transfusion decisions.

Hospitals with robust PBM programs commit, not only to reduce transfusion as a safety measure, but also to recognize and incorporate the diagnosis and proper treatment of anemia. A careful assessment of the patient's condition includes finding the cause of their anemia and should direct the clinician to employ the best and safest intervention.

Research shows that fewer RBC transfusions through process changes and using technology can save the US healthcare system more than $5 billion per year, while greatly improving quality and safety (Masimo Corp, 2012). Healthcare institutions must commit to action with specific leadership, action, and technology plans to close their performance gap on this issue.

Integrating PBM greatly reduces the amount of transfused blood, costs, and kidney damage. Technology to support laboratory hemoglobin measurements, such as noninvasive and continuous hemoglobin monitoring, can give clinicians more real-time trending information to determine if hemoglobin values are changing, which permits clinicians to make more informed and early RBC transfusion decisions.