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Blood Management for the Orthopaedic Surgical Patient

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Prevention and management of anemia and blood loss in the orthopaedic patient undergoing surgery is a major concern for healthcare providers and patients. Although transfusion technology can be lifesaving, there are risks to blood products that have led to increased awareness of blood management and development of hospital patient blood management programs. Use of patient blood management can be effective in addressing preoperative anemia, a major modifiable risk factor in patients undergoing surgery. In this informational article, evidence-based practice guidelines for perioperative blood management are addressed. A case scenario is introduced focusing on a patient whose religious preference is Jehovah's Witness having "no blood wishes" undergoing elective orthopaedic surgery. Orthopaedic nurses can facilitate optimal patient blood management through multidisciplinary collaboration.

A major concern in the care of patients undergoing orthopaedic surgery is the prevention and management of preoperative anemia (a major modifiable risk factor), surgical blood loss, and the impact on patient outcomes. Although transfusion technology has been available for many years and can be lifesaving, there are risks to blood products leading to increased understanding of blood management, also known as blood conservation, and the development of hospital patient blood management (PBM) programs. These programs have been instituted in numerous medical facilities across the United States and around the world to address blood management concerns of anemia and blood loss in patients undergoing surgical procedures as well as for nonsurgical care.

Basic information and evidence-based practice guidelines for blood management are highlighted in this article and applied to the roles of orthopaedic nurses and the multidisciplinary healthcare team in the care of the perioperative orthopaedic patient. The goal is to help provide guidance and greater awareness of alternatives to blood transfusions and promote optimal PBM. A case scenario is presented addressing a patient having an elective total knee revision whose religious preference is Jehovah's Witness with no blood wishes.

Case Scenario

The following case scenario illustrates the planning of care for an orthopaedic surgical patient who is a Jehovah's Witness expressing the desire to decline blood transfusion(s). Mrs. R. is a 66-year-old woman scheduled for a right total knee revision for chronic right knee pain. History includes hypertension, anxiety, depression, and chronic bronchitis. Hemoglobin of 12.0 g/dl was noted 12 days prior to surgery and all other laboratory test results including coagulation studies and platelet count were within normal limits. At the time of Mrs. R.'s office visit with the orthopaedic surgeon, she informed the surgeon that she was of the Jehovah's Witnesses faith and has no blood wishes. The blood conservation program coordinator was contacted and reviewed the no blood wishes with the patient. A blood directive form was completed after discussion with the patient regarding her decision.

Mrs. R. would not accept transfusion of primary blood components (red blood cells [RBC], platelets, plasma, whole blood) even if her life was in danger from profound anemia. She also refused cryoprecipitate (considered a minor fraction by Jehovah's Witnesses and thus a matter of personal conscience) but would accept other minor fractions including albumin and medications containing human and animal proteins as well as transplanted tissue and organs. Mrs. R. would accept blood salvage (cell saver).

On the day of surgery, the schedule reflected the patient's "No Blood" status. In addition to her identification bracelet, Mrs. R. received a No Blood bracelet (white bracelet with an image of a red blood bag and a line through it, with bold No Blood lettering).

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The orthopaedic surgeon requested that blood salvage be set up and ready to use intraoperatively in the event of severe hemorrhage. Mrs. R. underwent an adductor canal nerve block with ropivacaine 0.5%. A preprocedural "Time-out" was conducted during which the patient's No Blood wishes were reiterated with the entire operating room team and the blood directive was reviewed by the circulating nurse to ensure that all products used during the surgery were acceptable to the patient's wishes. General anesthesia was induced, and Mrs. R. remained hemodynamically stable throughout the case.

Tranexamic acid 1,850 mg intravenously was administered during the case for antifibrinolysis to augment hemostasis. A mid-thigh tourniquet was applied for a total of 1 hour, 8 minutes at 300 mmHg. Estimated blood loss was 50 ml. Total intravenous fluids included 1,500 ml lactated ringer's solution. On postoperative Day 1, Mrs. R. was satisfactorily recovered with a hemoglobin of 11.7 g/dl.

Blood Transfusion: A Historical Overview

A brief overview of the historical development of blood transfusion by the American Red Cross (2022a) begins in the 1600s with William Harvey's breakthrough of identifying blood circulation and Swammerdam's discovery of RBCs. In the early 1800s, the first blood transfusion for postpartum hemorrhage was conducted by Dr. James Blundell. Then in the early 1900s, three human blood groups were discovered by Landsteiner and the first blood transfusion using blood typing and crossmatching was done by Ottenberg. By the 1940s, the national program for blood collection was developed by the U.S. government and during WWII, albumin was used to treat shock. Later, in 1964, plasmapheresis was introduced to collect plasma for fractionation. In 1970, U.S. blood banks moved toward an all-volunteer blood donor system with the Food & Drug Administration regulating U.S. blood and plasma centers. Additive solutions were used in 1983 to extend shelf life of RBCs to 42 days. Red Cross Blood Services began testing newly donated blood in 1985 for the antibody to human immunodeficiency virus (HIV).

Benefits and Risks of Blood Transfusions

Blood transfusions have risks and benefits. Allogeneic blood transfusion refers to the donor and the recipient of the transfusion not being the same person; the blood is provided by another individual (Society for the Advancement of Patient Blood Management [SABM], 2019e). Refer to Table 1 definitions of terms for blood management. This is in contrast to an autologous blood transfusion that refers to the donor and the recipient being the same individual (SABM, 2019e).

The benefit of transfusion occurs when individuals are in situations that are life threatening such as traumatic injuries that result in the need of RBCs to carry oxygen to vital organs (American Red Cross, 2022b). Red blood cells are made by the body through erythropoiesis (Zivot et al., 2018). Major components (fractions) in whole blood include RBCs, white blood cells [WBCs], platelets, and plasma. Cryoprecipitate is the portion of plasma that is rich in clotting factors (American Red Cross, 2022c).

Potential risks/complications of blood transfusion (although the risk is low) may include allergic reaction, transfusion-related acute lung injury, transfusion-associated circulatory overload, and transfusion-related immunomodulation that can also lead to infection (Centers for Disease Control and Prevention, 2020; McEvoy & Shander, 2013; SABM, 2019b). Blood-borne infections may occur such as HIV and hepatitis B and C, and donated blood is tested for these viruses (American Red Cross, 2022b).

Individuals may decline the use of blood transfusions for multiple reasons that may include fear of infection, concern for adverse reactions, and religious reasons (Scharman et al., 2017). Some patients request not to have blood products unless being in danger of serious morbidity or mortality from anemia whereas others may outright refuse blood products even if death may occur without the transfusion.

Cost of Blood Transfusions

Cost of blood transfusions can be translated in a variety of ways including economic as well as health risks (SABM, 2022b). Results of the 2019 National Blood Collection and Utilization Survey identified the mean dollar amount paid per blood product unit (in U.S. dollars) reported by hospitals in the United States in 2017 for a unit of leukoreduced RBC as $213 and in 2019 as $215 (Mowla et al., 2021). There is concern that with the aging population the supply for blood will not meet the demand (SABM, 2022b) especially with the COVID-19 pandemic's effect on healthcare and U.S. blood collection and use (Kracalik et al., 2021; Mowla et al., 2021).

Reduced use of transfusions can lead to enhanced patient outcomes, decreased hospital length of stay (LOS), less use of resources, and decreased risk of harmful events (SABM, 2022b).

Jehovah's Witnesses Beliefs

Jehovah's Witnesses decline blood transfusions. This Christian religion was established in 1870 and has more than 8 million members worldwide (Jehovah's Witnesses, 2022a). Individuals base their beliefs on the Bible's principles of the Old and New Testaments to guide their lives (Jehovah's Witnesses, 2022c). Jehovah's Witnesses beliefs in relation to health and medical care include refusal of blood products based on translating Bible passages that address refraining from receiving blood (no blood wishes) as stated in the following scripture passages (Jehovah's Witnesses, 2022d, Spence et al., 2006; Watch Tower Bible and Tract Society, 1961). "Only flesh with its soul—its blood—you must not eat." (Genesis 9:. 4) "You must not eat the blood of any sort of flesh, because the soul of every sort of flesh is its blood. Anyone eating it will be cut off" (Leviticus 17:.14). The scripture is perceived by Jehovah's Witnesses as excluding transfusions of whole blood and primary blood components (RBCs, WBCs, platelets, plasma; Crowe & DeSimone, 2019).

Table 1. Definition of Terms for Blood Management

1.	Allogeneic Blood Transfusion	The donor and the recipient of the transfusion are not the same person; the blood was provided by a different individual (SABM, 2019d).
2.	Autologous Blood Transfusion	The donor and the recipient are the same individual (SABM, 2019d).
3.	Anemia	A condition in which the number of red blood cells or the hemoglobin concentration is lower than normal (WHO, 2021).
4.	Blood Component	Whole blood comprises RBCs, WBCs, and platelets. RBCs comprise approximately 45% of an individual's total blood volume, all suspended in plasma. The remaining 55% is plasma (American Red Cross, 2022c; Crowe & DeSimone, 2019).
5.	Cryoprecipitate (cryo)	Cryoprecipitate Antihemophilic Factor is the portion of plasma that is rich in clotting factors. Examples of clotting proteins in cryo are fibrinogen, Factor VIII, and Factor XIII (American Red Cross 2022c).
6.	Erythropoiesis	The body's production of RBCs (SABM, 2019d; Zivot et al., 2018).
7.	Erythropoietin	A hormone developed by the kidneys assisting in making RBCs and regulating transport of oxygen to peripheral tissues (Broxmeyer, 2013).
8.	Hematopoiesis	The body's formation of blood cells such as RBCs, WBCs, and platelets (Jagannathan-Bogdan & Zon, 2013).
9.	Major Fractions (blood components)	Major blood fractions include whole blood, platelets, RBCs, and plasma (American Red Cross, 2022c).
10.	Minor Fractions	Substances from human blood derived from the plasma include, for example, albumin and clotting factors such as fibrinogen, cryoprecipitate, and immunoglobulin (American Red Cross, 2022c).
11.	Patient Blood Management	A multidisciplinary approach to manage and preserve the patient's own blood by screening, diagnosing, and treating anemia, promoting blood homeostasis and reducing blood loss (Shander et al., 2022).
12.	Recombinant Blood Products	Products developed in the laboratory using biotechnology offering useful pharmaceuticals avoiding plasma-derived products. Examples of recombinant products are albumin-free coagulation factors, recombinant hemoglobin, and recombinant human erythropoietin (Scharman et al., 2017; Seeber & Shander, 2013; Spence et al., 2006).

Note. RBCs = red blood cells; WBCs = white blood cells.

Regarding transplants, Jehovah's Witnesses may accept stem cell infusion and other tissue and organ transplants (Jehovah's Witnesses, 2022b; Park et al., 2019). It is important to have a confidential discussion with the Jehovah's Witness patient about the drugs and products that are and are not acceptable. Tailoring the use of products for medical and surgical interventions needs to be done well in advance of the surgery date to uphold the wishes of the Jehovah's Witness patient.

Options for Jehovah's Witnesses

There is a range of perspectives that Jehovah's Witnesses have on blood fractions. Major blood components (fractions) are not acceptable and include whole blood, platelets, RBCs, and plasma. Jehovah's Witnesses may accept minor fractions but will need information about the products and engage in discussion with the medical provider(s) as well as conduct prayerful meditation to conscientiously make a sound decision (Jehovah's Witnesses, 2000; Muramoto, 2001). Refer to Figure 1 addressing individual decisions involving blood transfusion. Examples of minor fractions of RBC that are potentially acceptable include hemoglobin solutions (Klein et al., 2019). Minor fractions from plasma includes albumin, cryoprecipitate (rich in clotting factors), fibrinogen, immunoglobulins, and other blood fractions that do not have cellular components. These can help stop intraoperative bleeding and stimulate healing.

Recombinant blood products are developed in the laboratory, not made from human blood products, and may be an option for the Jehovah's Witnesses patient. Biotechnology in blood management offers useful pharmaceuticals because therapy with plasma-derived products is avoided and recombinant products can be used for PBM such as albumin-free coagulation factors and recombinant hemoglobin (rHb) (Seeber & Shander, 2013; Spence et al., 2006).

Recombinant erythropoietin drugs, known as erythropoietin-stimulating agents, promote the manufacture of RBCs and increase hemoglobin levels (Shander, 2014). Erythropoietin (EPO), a hormone developed by the kidneys, assists in making RBCs and regulates transport of oxygen to peripheral tissues (Broxmeyer, 2013). A decrease of EPO can lead to anemia, for example, in individuals with kidney disease since EPO production may be decreased.

It is important to discuss well in advance the products and procedures that are acceptable to the patient based on interpretation of their beliefs regarding what they can and cannot receive. A bloodless medicine and/or surgery approach, PBM, integrates combinations of drugs, equipment, and/or medical/surgical techniques to decrease or

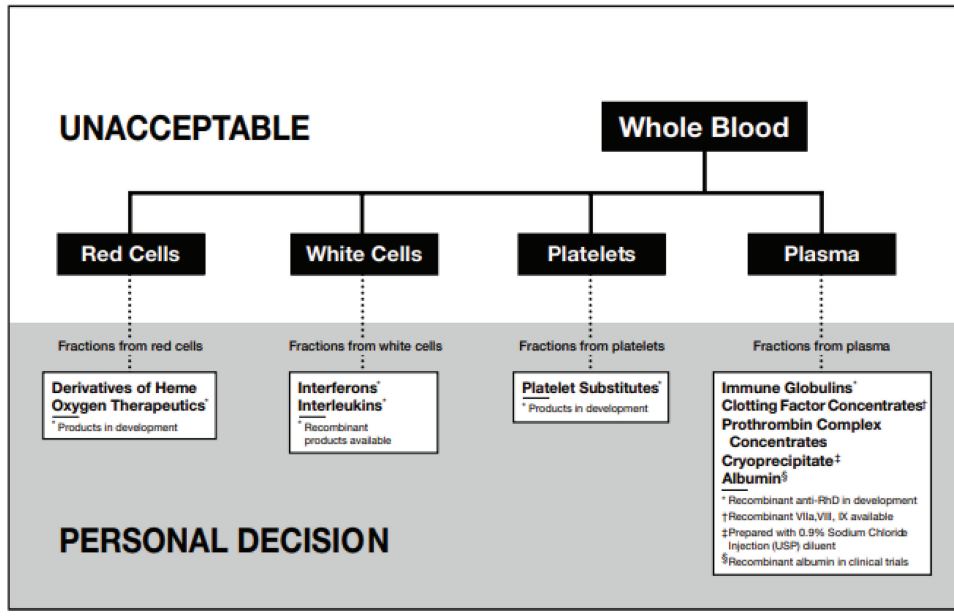

Figure 1. Individual decisions involving blood transfusion. From Chapter 37. Surgery in the Jehovah's Witness. In B. D. Spiess, R. K. Spence, & A. Shander (Eds.), *Perioperative Transfusion Medicine* (*2nd ed.*, Figure 37.1, p. 505), by R. K. Spence, A. Shander, Z. Bodnaruk, and M. Huber, 2006, Lippincott Williams & Wilkins. Used with permission.

prevent blood loss and improve the patient's own blood production (Jehovah's Witnesses, 2022b).

There are helpful resources for health professionals on the Jehovah's Witnesses website www.JW.org available by searching the phrase Medical Information for Clinicians. Clinical strategies for Jehovah's Witnesses patients without blood transfusion for various procedures are addressed in the document *Religious and Ethical Position on Medical Therapy and Related Matters* (Jehovah's Witnesses, 2022b). Local representatives from the Jehovah's Witness Hospital Liaison Committee Network are available in the United States and worldwide 24/7 for healthcare professionals to answer questions on proper treatment of Jehovah's Witnesses patients (go to https://www.jw.org/en/medical-library, click on *Contact Local Representative*; in the United States call +1 718-560-4300 or email hid.us@jw.org).

Patient Blood Management

The risk of infection, transfusion reactions, religious doctrine, and cost all contribute to the goal of reducing or avoiding transfusions. This has led to increased awareness of blood management, also known as blood conservation, and the development of PBM programs.

Definition

Blood conservation and bloodless surgery are terms that refer to components of PBM. The Society for the Advancement of Blood Management (SABM), founded in 2001, is a not-for-profit professional organization that defines PBM as the application of evidence-based medical and surgical concepts in a timely manner to maintain hemoglobin concentration, optimize hemostasis, and minimize blood loss for improving patient outcomes (SABM, 2022b). SABM helps educate both the public and healthcare providers about clinical issues related to blood transfusion and the influence on patient outcomes (SABM, 2022b).

Globally defined, PBM focuses on informed choice and is "… a patient-centered, systematic, evidence-based approach to improve patient outcomes by managing and preserving a patient's own blood, while promoting patient safety and empowerment" (Shander et al., 2022, p. 1). To improve outcomes in patients undergoing elective orthopaedic surgery, PBM provides a multidisciplinary road map to manage and preserve the patient's own blood by screening, diagnosing, and treating anemia, promoting blood homeostasis and reducing blood loss (Shander et al., 2022). The most simple and effective strategies of early detection and management of anemia are often disregarded (Munoz et al., 2015).

The World Health Organization (WHO, 2021) has made an urgent call for healthcare systems to implement PBM as a standard of care worldwide for managing anemia and preserving the patient's own blood through a multidisciplinary approach. A Policy Brief was recently published by WHO titled, The Urgent Need to Implement Patient Blood Management (WHO, 2021). This policy addresses the advantages of implementing PBM for patients, healthcare professionals, policymakers, healthcare systems, and economies, and its impact on decreasing the need for blood and blood components and reliance on transfusions. Barriers to implementation of PBM and solutions are addressed on how to incorporate PBM into healthcare. Over the next several years, WHO (2021) will be creating the PBM implementation guideline framework for healthcare leaders of WHO Member States to then develop their own regional clinical PBM guidelines. These will incorporate geographic differences in epidemiology, etiology of anemia and blood loss, resources, and socioeconomic determinants of health.

Management of Anemia

The use of PBM can be effective in addressing anemia, a major modifiable risk factor, in patients undergoing surgery and a global health issue, considered an epidemic (Shander & Javidroozi, 2016; WHO, 2021) affecting 1.95–2.36 billion people in the general population worldwide (Global Burden of Disease and Injury Incidence and Prevalence Collaborators, 2018; WHO, 2021). Preoperative anemia is common, requiring astute assessment to treat the underlying cause (Shanbhag et al., 2019). The goal of diagnosing and treating the anemia preoperatively is to help improve patient outcomes (SABM, 2019c). Anemia may be an indicator of underlying diseases/conditions because of the relationship between anemia and poor outcomes (Shander & Javidroozi, 2016). It is a frequent complication of common diseases such as chronic heart failure, chronic kidney disease, and inflammatory bowel disease because these diseases are related to issues with iron absorption and metabolism (SABM, 2019c).

As the population ages, there is an increase of anemia in the elderly (Cappellini & Motta, 2015). In orthopaedic patients, anemia can be common, particularly in the aged and is associated with a variety of complications that may include longer length of hospital stay, infection, increased blood transfusion rates, and complications in the genitourinary and cardiovascular systems (Shanbhag et al., 2019). A golden opportunity for individuals having elective surgery is early recognition and management of anemia throughout the preoperative period (Munoz et al., 2015).

According to the WHO, anemia is defined as a hemoglobin (Hg) level in women as less than 12 g/dl and in men as less than 13 g/dl (WHO, 1968). Using the WHO's guidelines for anemia, Lasocki et al. (2015) conducted a multicenter observational study of approximately 1,500 individuals having major elective orthopaedic surgery and identified the incidence of preoperative anemia according to the surgery site as 12.9% hip, 13.2% knee, and 21.6% spine. In a study of elective hip and knee arthroplasties, Wan et al. (2020) identified that preoperative anemia significantly associated with higher risks of allogeneic blood transfusion, prolonged LOS, and increased costs with a trend of rising complications and mortality.

There are many types of anemia caused by a variety of issues, for example, nutritional anemia (low levels of iron, folate, and vitamin B), EPO deficiency (chronic disease, renal insufficiency, and infection), hemolysis (drug reactions and toxins), coagulation abnormalities (thrombocytopenia, sepsis, liver disease, and viral infection), and blood loss (excessive phlebotomy, trauma, surgery, and gastrointestinal bleeding; McEvoy & Shander, 2013). Iron deficiency anemia is the most common type of microcytic anemias consisting of smaller RBCs. Normocytic anemias are often produced by various diseases such as chronic kidney disease and sickle cell disease. Examples of macrocytic anemia include Vitamin B_{12} deficiency in the elderly and in individuals after gastric bypass surgery (Shanbhag et al., 2019).

A preoperative anemia management algorithm developed by SABM (2019b) addresses laboratory tests required for evaluating preoperative anemia. First tier laboratory tests needed to determine the cause of the anemia include complete blood count, reticulocyte count, Vitamin B_{12}, folate, iron studies (transferrin saturation, ferritin, iron, and iron-binding capacity), and serum creatinine (SABM, 2019c).

Blood Management for Bloodless Medicine and Surgery

Bloodless medicine and bloodless surgery refer to treatment of patients medically or surgically without using allogeneic blood transfusion (Okorie & Pisters, 2019). The first bloodless surgery program was developed for the Jehovah Witness community and created as transfusion free (Tokin et al., 2009).

The term "patient blood management (PBM)" is broader and more commonly used incorporating blood conservation (Tibi et al., 2021). It is a PBM program that is hospital-centered with an interdisciplinary team approach to assess and treat a patient's blood management needs using evidence-based practice (SABM, 2019b, 2019c). The team works to develop a plan of care that includes use of pharmaceuticals, technology, and techniques so that blood loss is limited and blood production is improved (SABM, 2019c). PBM reduces or eliminates the need for a blood transfusion through four guiding principles: interdisciplinary blood conservation modalities, patient-centered decision making, managing anemia, and optimizing coagulation to improve patient outcomes (SABM, 2019b, 2019c; Tibi et al., 2021). As a result, there are improved patient outcomes, lowered complications, reduced morbidity and mortality, decreased LOS, and decreased cost to the patient and the healthcare system. PBM programs are increasing around the world. SABM (2022a) maintains a searchable directory of these programs in the United States and Canada located at this website: https://sabm.org/patient-blood-management-programs/.

Clinical Practice Guidelines for PBM

The 2021 updated Clinical Practice Guidelines on Blood Management was developed by a multidisciplinary group of experts assembled by The Society of Thoracic Surgeons (STS) and included the Society of Cardiovascular Anesthesiologists (SCA), The American Society of ExtraCorporeal Technology (AmSECT), and the SABM (Tibi et al., 2021). A systematic review of PBM was conducted to develop recommendations for patients having cardiopulmonary bypass that are evidence-based, multimodal, and multidisciplinary for preserving blood resources and enhancing outcomes for individuals' high risk for blood transfusion (Tibi et al., 2021). The recommendations use a patient care paradigm for guidelines across the continuum of care with a shared decision-making approach.

Blood Management in Orthopaedic Surgery

Both elective and urgent orthopaedic surgical procedures entail varying amounts of blood loss with the main goal to provide optimal PBM shown to be effective in orthopaedic patients. Clinical outcomes in a retrospective study by Gupta et al. (2018) of patients

aged 65 years and older undergoing orthopaedic surgery resulted in improved patient outcomes with use of a PBM program. PBM was related to a reduction in blood use and improvement in outcomes of morbidity, LOS, and readmission rates.

In a review of blood management research for elective orthopaedic surgery, Palmer et al. (2020) addressed the effectiveness of using perioperative blood management strategies. Vrontis et al. (2020) reviewed evidence-based blood conserving techniques in total hip arthroplasty. To attain the goal of avoiding blood transfusion(s) in the Jehovah's Witness surgical patient, approaches are needed that manage blood loss, control autologous blood (reinfusing the patient with their own blood/blood components), improve hematopoiesis (the body's formation of blood cells—RBC, WBCs, platelets), and maximize tolerance of anemia through blood conservation (Jehovah's Witnesses, 2019). With the increase in minimally invasive orthopaedic surgery, the issue of major blood loss is decreasing. In a metanalysis to determine the effect on blood conservation of total knee arthroplasty done via computer navigation, Han et al. (2016) found that patients had less hemoglobin and blood loss.

Perioperative Blood Management in Orthopaedic Surgery

A multidisciplinary approach is key for promoting patient outcomes for the Jehovah's Witness patient undergoing surgery (Chae et al., 2020; SABM, 2022b). This team may include the primary care physician, orthopaedic surgeon, orthopaedic nurse(s), hematologist, anesthesiologist, pharmacist, and PBM coordinator. Elective orthopaedic surgery can be successfully performed for Jehovah's Witness patients through in-depth preparation to facilitate treatment optimizing the patient in anticipation of potential intraoperative blood loss. Perioperative blood management refers to blood transfusion and adjuvant therapies during the preoperative, intraoperative, and postoperative phases of surgery (American Society of Anesthesiologists Task Force on Perioperative Blood Management, 2015). In the perioperative setting, strategies for managing anemia are foundations of PBM (Shander & Javidroozi, 2015).

Perioperative blood management strategies applied to the patient undergoing surgery are depicted in a three-pillar, nine-field structure to provide patient-centered evidence-based PBM for minimizing allogeneic blood transfusions (Goodnough & Shander, 2012). Refer to Figure 2, the three-pillar, nine-field matrix of perioperative PBM depicting the three pillars: optimizing erythropoiesis (production of RBCs), minimizing blood loss, and managing anemia addressed in the three perioperative phases. Safe blood management begins with enhancing the patient status before surgery and reviewing blood conservation techniques according to each phase of perioperative care.

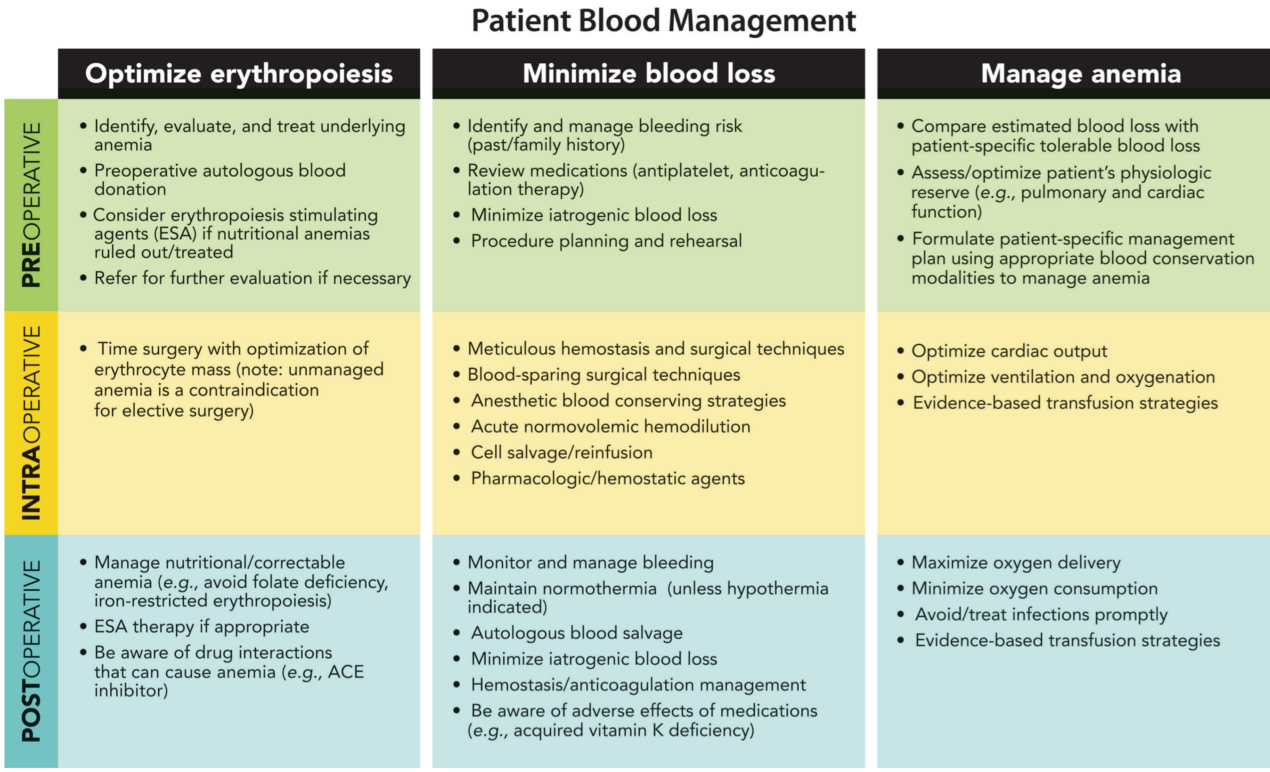

Figure 2. The three-pillar, nine-field matrix of perioperative patient blood management. These principles applied in the perisurgical period enable treating physicians to have the time and tools to provide patient-centered evidence-based patient blood management to minimize allogeneic blood transfusions. The color version of this figure is available in the online issue at https://journals.lww.com/orthopaedicnursing. ACE = angiotensin-converting enzyme. From "Patient Blood Management," by L. T. Goodnough and A. Shander 2012, *Anesthesiology, 116*(6), 1367–1376. https://doi.org/10.1097/ALN.0b013e318254d1a3. Used with permission.

Preoperative Management

Preoperative blood management should start with clear communication and comprehensive informed consent that involves in-depth dialogue regarding risks, benefits, the plan for surgery and anesthesia, anticipated blood loss, anemia assessment, and the patient's preferences in relation to blood transfusions and blood product alternatives (Rashid et al., 2021). Complex and multiple-site surgeries need to be well planned, possibly staged, such as having one hip or knee arthroplasty at a time to minimize blood loss with the most essential procedure done first. Following recuperation of the patient's blood volume and coagulation status, subsequent surgery/surgeries would then be performed (Goodnough & Shander, 2012).

An accurate history and physical must be conducted for identification, management, or prevention of anemia and risk for bleeding. Erythropoietin-stimulating agents may need to be considered. The patient's physiological reserve (cardiac and pulmonary function) needs to be assessed. Determine whether the patient's medications may interfere with coagulation, such as anticoagulants, and even herbal supplements; these may need to be discontinued or stopped for a period of time prior to surgery (Guinn et al., 2021; Jehovah's Witnesses, 2019).

It is critical to identify individuals who are not eligible to be transfused or refuse transfusion early on prior to surgery so that appropriate therapies can be identified (Guinn et al., 2021). Individuals who are Jehovah's Witnesses do not consider transfusion of major blood fractions (erythrocytes, platelets, unfractionated plasma; Guinn et al., 2021). However, the individual can decide on receiving minor fractions (cryoprecipitate, albumin, immunoglobulins, and individual clotting factors).

The protocol of a routine type and crossmatch for potential blood transfusion(s) in patients undergoing elective surgical procedures such as the patient who is a Jehovah's Witness is not as commonly practiced, particularly when there is a mechanism in place through a blood conservation program to stop the use of this protocol. This has resulted in cost savings by avoiding unnecessary laboratory testing. In a retrospective study of routine crossmatching in orthopaedic surgery, Hasan et al. (2018) identified orthopaedic surgeries having poor blood transfusion restriction parameters such as total hip and knee replacements and arthroscopic surgeries leading to considerable wasting of blood products.

Another area for guiding whether to pursue the use of a blood transfusion is the application of a transfusion threshold. This is the use of a lower hemoglobin concentration as a threshold for guiding RBC transfusion that is a factor under increased consideration in PBM programs. In a systematic review of 48 randomized controlled trials addressing transfusion thresholds to guide transfusion of RBCs, an evaluation of published evidence showed that transfusing at a restricted approach of a hemoglobin concentration threshold of 7.0 g/dl to 8.0 g/dl, compared with a liberal threshold of 9.0 g/dl to 10.0 g/dl, in a broad scope of hospitalized patients did not have an adverse effect on clinical outcomes (30-day mortality, myocardial infarction, congestive heart failure, infection, stroke, pneumonia, and blood clots, infection; Carson et al., 2021). In orthopaedic surgery trials, the 8.0 g/dl threshold was often used as the restrictive strategy and had a comparable risk profile for mortality as higher transfusion thresholds. However, it is not feasible to presume that 7.0 g/dl is as effective as 8.0 g/dl, without trials examining lower thresholds (Carson et al., 2021).

Intraoperative Management

The surgical technique that is performed needs to be meticulous with a focus on hemostasis to control blood loss. The focus on intraoperative management is to maintain the patient's own blood (Guinn et al., 2021; Jehovah's Witnesses, 2019). For most Jehovah's Witness patients, this can be done during surgery via cell salvage (blood salvage, autotransfusion) for blood lost and autologous normovolemic hemodilution as long as these devices remain attached to the patient during the surgery (Guinn et al., 2021).

To improve hemostasis, systemic pharmacological agents such as tranexamic acid may be used (Jehovah's Witnesses, 2019). This is an antifibrinolytic that competitively deters plasminogen activation providing clot stabilization (Palmer et al., 2020). Monitoring the patient who receives tranexamic acid for possible signs of deep vein thrombophlebitis, pulmonary embolism, and decreased kidney function is essential as well as communicating with health team members intraoperatively and postoperatively (Suggs & Holt, 2015).

Optimizing cardiac output and ventilation/oxygenation is critical (Goodnough & Shander, 2012). Implementation of controlled hypotension through the anesthetic can lower mean arterial pressure during surgery and decrease bleeding; however, the anesthetic needs to be carefully administered to maintain organ perfusion (Palmer et al., 2020). Use of interventions to avoid hypothermia via temperature management with reflective blankets and warm IV fluids is important because hypothermia can affect platelet function thereby contributing to blood loss (Guarino et al., 2014; Palmer et al., 2020).

Postoperative Management

Postoperative strategies include maximizing oxygen delivery, maintaining normothermia, minimizing iatrogenic blood loss, monitoring for adverse effects of medications, and avoiding/treating infections (Goodnough & Shander, 2012). It is essential to closely monitor the perioperative patient especially the individual who is at risk for postoperative bleeding and anemia (Shander et al., 2020). Management of anemia does not stop with the completion of surgery. Various strategies are key and include ongoing continued assessment of coagulation status, volume management and careful use of non-blood volume expanders, avoidance of hypertension and hypothermia, and limited phlebotomy (Jehovah's Witnesses, 2019). Optimization of erythropoiesis can be

achieved through managing nutritional and correctable anemias and being alert to drug interactions that can result in anemia. Postoperative assessment for signs of bleeding should continue upon discharge to home or a rehabilitation facility.

Developing a PBM Program

The SABM provides educational sources for PBM based on evidence-based practice for promoting effective and optimal PBM as a standard of care for improving patient outcomes (SABM, 2022b). There are a variety of resources available to SABM members to help in developing a PBM program such as the Executive Guide for Patient Blood Management Programs (SABM, 2019d) that includes video modules addressing the how and why of adopting a PBM program and business plan templates for developing a PBM program. SABM also provides mentorship programs with experienced, established blood conservation specialists coaching newer associates in developing programs. For patients, a SABM education pamphlet is available (SABM, 2019a).

The challenge of developing a PBM program may be overwhelming and needs to occur in small steps beginning with pilot projects that will then build on achievements (American Association of Blood Banks [AABB], 2015). This can be useful for educating key healthcare providers about PBM program outcomes and can lead to a long-term productive program.

To develop a PBM program, individuals in the clinical setting need to be identified who can champion the goal and help educate hospital leaders about the benefits and potential outcomes (AABB, 2015). In facing possible resistance, champions will need to provide education by securing resources, develop enthusiasm for the endeavor, and empower staff. A clear PBM program business plan is essential, one that is understood by all. Development, implementation, and maintenance of the components of the PBM program are necessary and challenging for achieving measurable improvement outcomes such as decreased LOS, infection, cost savings, and readmission rates for those needing a transfusion (AABB, 2015).

Implications

Orthopaedic nurses can facilitate optimal PBM in patient care throughout a variety of settings as patient advocates and as educators (McSporran, 2021). Communication with the patient and the healthcare team is key as nurses identify and assess patients for anemia throughout the perioperative period. Acknowledgment of patients' beliefs and perspectives regarding blood transfusions is critical for promoting a trusting nurse–patient relationship. This awareness is particularly essential as the aging population increases and numbers of individuals in need of joint arthroplasty rise resulting in more surgical procedures being conducted in the ambulatory setting requiring orthopaedic nurses to use evidence-based practice for safe, quality care (Smith et al., 2021).

The WHO's urgent call for global PBM (WHO, 2021) as a standard of care places nurses in a key role for multidisciplinary collaboration to help develop regional clinical PBM guidelines addressing anemia and blood loss. This will build on the socioeconomic determinants of health and public health agendas for health equity through promoting PBM across all levels of healthcare. The PBM global and nationwide initiative provides an opportunity for nurses and healthcare providers to promote health equity as delineated in the recommendations of *The Future of Nursing 2020-2030: Charting a Path to Achieve Health Equity* (National Academies of Sciences, Engineering, and Medicine, 2021) and application of the recommendations to orthopaedic nursing (Sedlak et al., 2022).

Major groups benefiting from PBM include not only individuals with anemia or at risk for anemia and blood loss but also healthcare professionals including nurses and healthcare institutions. Schools of healthcare including nursing and medicine will need to take the lead in implementing PBM education for developing informed practitioners of PBM (WHO, 2021). Involvement of administrative leaders in healthcare institutions including nursing will be essential in representing economic and business interests.

Conclusion

Orthopaedic patients may be at risk for significant blood loss during the various surgical procedures that they undergo. Medical facilities can have a major impact on the well-being of patients by being prepared with protocols that provide blood conservation and blood management programs. Patient blood management programs provide the structure to facilitate blood conservation while acknowledging patients' personal and religious preferences regarding use of blood products.

Preoperative anemia screening and treatment, intraoperative use of hemostatic materials and surgical techniques, postoperative hemostasis, and vigilance are all components of comprehensive PBM. The many resources accessible for PBM offer a wealth of information to assist orthopaedic nurses and the healthcare team in providing ultimate patient care outcomes.

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