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Patient Blood Management Bundles to Facilitate Implementation

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ABSTRACT

More than 30% of the world's population are anemic with serious economic consequences including reduced work capacity and other obstacles to national welfare and development. Red blood cell transfusion is the mainstay to correct anemia, but it is also 1 of the top 5 overused procedures. Patient blood management (PBM) is a proactive, patient-centered, and multidisciplinary approach to manage anemia, optimize hemostasis, minimize iatrogenic blood loss, and harness tolerance to anemia. Although the World Health Organization has endorsed PBM in 2010, many hospitals still seek guidance with the implementation of PBM in clinical routine. Given the use of proven change management principles, we propose simple, cost-effective measures enabling any hospital to reduce both anemia and red blood cell transfusions in surgical and medical patients. This article provides comprehensive bundles of PBM components encompassing 107 different PBM measures, divided into 6 bundle blocks acting as a working template to develop institutions' individual PBM practices for hospitals beginning a program or trying to improve an already existing program. A stepwise selection of the most feasible measures will facilitate the implementation of PBM. In this manner, PBM represents a new quality and safety standard.

Contents

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More than 30% of the world's population are anemic. Anemia is increasingly recognized as a risk factor for a number of adverse outcomes, including hospitalization, morbidity, and mortality. The high global prevalence of insufficiently treated anemia also possesses a major economic burden including reduced work productivity and increased social expenditures [1]. In hospitalized patients, incidence of anemia increases within the processes of care, such as procedural blood loss and phlebotomy [2].

Patient blood management (PBM), as defined by the Society for the Advancement of Blood Management [3], refers to "the timely application of evidence based medical and surgical concepts designed to maintain haemoglobin concentration, optimise haemostasis and minimise blood loss in an effort to improve patient outcome." It requires rejecting the standard dogma and one-size-fits-all approach, whereby red blood cell (RBC) transfusions are used as the primary solution to correct low hemoglobin levels in the hospitalized patient.

In recent years, a few reviews, standards, and guidelines have been published providing detailed information on PBM [3–11]. Briefly, PBM must be executed by an institutionally empowered multidisciplinary team that works in a concerted fashion with 4 guiding principles of PBM: The first principle or strategy is to manage the patient's anemia, which primarily involves instituting methods of early detection and using nutritional and pharmaceutical treatments to support erythropoiesis, if it is not mainly genetic or cancer related. While actively treating anemia, the physiologic tolerance of anemia can be enhanced by minimizing oxygen consumption and/or enhancing delivery. The second PBM strategy involves optimizing coagulopathy. This involves determining the patient's current coagulation status and assessing those medications that affect this, correcting any abnormalities and, if present, rapidly assessing the cause of bleeding. The third guiding PBM principle entails using interdisciplinary blood conservation modalities. Physicians can adhere to this principle by ensuring that their surgical techniques are precise enough to minimize blood loss. Any blood loss should be diagnosed and stopped immediately. In addition, intraoperative and postoperative blood conservation techniques should be used, including autologous conservation modalities. Attention should be given to phlebotomy volume and frequency with the intent to minimize or eliminate this common source of iatrogenic blood loss, which can either induce or exacerbate anemia. The final principle that also especially embodies the overall PBM approach, and optimal blood use is the concept of patient-centered decision making. This involves thorough communication with the patient regarding his/her treatment. It is necessary to effectively communicate the risks and benefits of the various potential interventions and to decide on the right course of action together with the patient. The patient's own preferences and values should be considered when developing a medical plan [3,4,12].

There is a large amount of research evidence that the successful implementation of PBM reduces perioperative blood loss and transfusion needs [13–20], perioperative morbidity [13,16], mortality [14,16], length of hospital stay [14,16], and costs [21]. In this respect, the World Health Organization has officially been urging member states to implement PBM since 2010 (WHA63.12). Patient blood management programs have already been rolled out successfully in some hospitals in Western Australia [19], Europe [13,18], United States [14,17], and now starting in Asia. Notable, outside Australia, no national PBM programs have been established, and many hospitals worldwide seek guidance with its implementation.

Despite the demonstrated benefits of PBM, many barriers and challenges limit translation of PBM guidelines into clinical practice [22–25], in particular due to lack of knowledge (eg, staff members are not aware of the latest discoveries and new guidelines; imprudent practice is endorsed by common misconceptions), lack of interdisciplinary commitment (eg, many patients have contact with different clinicians from different departments with different opinions about the "best treatment"; resistance from hospital's "culture"), lack of resources (eg, limited staff with limited time; hospital administrators need to invest initially before saving money), and concerns (eg, PBM may initially "cut down" jobs in blood donor service or transfusion medicine).

Strategies for overcoming the hurdles associated with incorporating guidelines into clinical practice often include the use of multimodal "care bundles."

This article provides comprehensive bundles of PBM components encompassing more than 100 different PBM measures acting as a working template to develop institutions' individual PBM practices.

Methods

After an informal meeting on PBM, held at Frankfurt in January 2015, and attended by several of the authors (PM, CFW, SC, DS, and KZ), further authors (TR, JI, AS, LTG, and MM) and a group developing an European Guide on Good Practices for Patient Blood Management (AH and HG) were invited to participate drafting a manuscript on a new implementation concept, based on current practice and experience in implementation of PBM of the authors, actively working in Australia, Europe, and United States. During several revisions, comments and contributions from the different authors to subsequent versions of the manuscript were harmonized, until agreement on paper content was reached. We would like to stress that this article contains the

authors' independent opinions based on experience as well as evidence-based practices supported by clinical studies. No pharmaceutical company has funded the development or writing of the manuscript. It is the primary aim of the authors to provide a new tool/concept for change management process and to tackle the key question "How to implement PBM."

In this article, therefore, we propose simple, cost-effective measures enabling any hospital to reduce both anemia and RBC transfusions focusing on both the methodology of how and of what to implement. The article refers to hospitals beginning a program or trying to improve an already existing program. It is strongly recommended to enlarge the scope of PBM to all subgroups of patients—surgical, medical, and pediatric patients. Medical patients, for example, may present many conditions that can be prevented or improved by PBM programs, for example, renal anemia, blood loss due to chronic dialysis, massive hemorrhage after gastrointestinal bleeding, hospital-acquired anemia in intensive care patients, transfusion decision in hematology-oncology patients, and others.

Results and Discussion

The "bundle" concept, as firstly defined by the Institute for Healthcare Improvement (Cambridge, MA) in 2001, refers to "a straightforward set of evidence-based interventions for a defined patient population that, when implemented together, will result in significantly better, more penetrating and sustainable outcomes than when implemented individually" [26]. In other fields of complex interdisciplinary medicine, for example, intensive care medicine, similar barriers could be observed. To overcome these barriers, care bundles have been widely implemented with success in terms of compliance to guidelines and beneficial impact on care processes and outcomes [27–31]. Thus, a bundle for PBM is highly desired.

Similar to the bundle approach, a few nationwide health care quality change initiatives were launched recently to overcome the barriers. For example, the National Blood Authority of Australia has published a "National Patient Blood Management Guidelines Implementation Strategy" recommending the use of a multifaceted approach with several tools to support the implementation of PBM and the appropriate transfusion practices [9]. In the UK, PBM has recently become a quality improvement process initiated by the transfusion service NHS Blood and Transplant [10]. The Consumers, Health and Food Agency of the European Commission has initiated the developing of a European Guide on Good Practices for Patient Blood Management, focusing on the methodology of how and not primarily of what to implement in terms of clinical modalities. This also includes the application of proven change management methodologies for overcoming the often deeply embedded cultural and institutional hurdles of behavior-based medicine [32]. However, it is also important to have a more clinical/technical template of what can be implemented and to identify low hanging fruit in doing this, which is at the core of this approach of PBM bundles [32,33].

Creating a PBM Program That Fits to the Local Hospital

An ideal PBM program would include a wide spectrum of administrative and clinical standards of PBM measures [3–12,34–42]. The more components incorporated into clinical routine, the higher the overall potential of a successful PBM program [9]. However, it is important to respect that many important factors such as infrastructure, staff, equipment, and economic resources greatly differ between hospitals worldwide, and individualization is vitally important for the acceptance of any new standard [43]. For this reason, PBM programs need to be specifically designed according to local conditions.

Although recent reviews [5,12,34–36] and guidelines/recommendations/standards [3,6–8,10,11,37–42] provided detailed information on what should be implemented and only a few reported strategies on how PBM should be implemented [9], we now strongly suggest that the implementation should be based on stepwise selection of the most doable measures that fit to the local hospital. To facilitate the implementation of PBM in clinical routine, this article provides a comprehensive checklist of multiple PBM bundles that can easily be adopted using a stepwise approach by every institution. The PBM bundles encompass 107 different PBM measures, divided into 6 bundle blocks. The PBM bundles are based not only on the aforementioned guidelines/recommendations [3,6–8,10,11,37–42], reviews [5,12,34–36], and the Australian "National Patient Blood Management Guidelines Implementation Strategy" [9] but also on the authors' experiences gleaned from recent PBM activities in Australia [34,44], Europe [18,22,41,45–48], and United States [14–16,49] and launching the German PBM Network [50]. Having success in PBM does not follow an "all-or-non-law," but rather a different grading of successful PBM implementation based on the total number of measures achieved. The total number of points may then be assigned to a semiquantitative PBM program level. Starting and having small success then moving forward with larger steps is a recipe for higher success. What small steps the hospital first takes is certainly dependent on that hospital, their resources, their faculty, and their administration. This one of the most important strengths of our PBM bundle approach.

Where applicable, it may also provide a technical template/checklist for both hospital audit and accreditation of PBM in future.

Patient Blood Management Bundles

A comprehensive PBM program may include more than 100 different measures/tasks, divided into 4 bundle blocks according to the aforementioned four PBM strategies completed by 2 additional blocks providing important information about general PBM project management and PBM-related metrics. The more individual measures successfully implemented in clinical routine, the higher the overall potential of PBM. However, because the conditions are highly variable in hospitals, a self-selected stepwise approach is recommended. Based on the total number of implemented measures within the 6 blocks (minimum, $n = 0$; maximum, $n = 107$) and the weighted degree of implementation (multiplier of 0, "none/rarely", <10%; 1, "moderate", 10%-50%; or 2, good, >50%), the total number of points can be calculated (minimum, 0; maximum, $n = 214$). The total number of points may then be assigned to a semiquantitative PBM program level. The more measures successfully implemented, the higher the total PBM score, and the higher the semiquantitative PBM program level (eg, bronze, silver, gold, platinum, or diamond, respectively; Supplementary Figure S1 in the Supplementary data).

Using these bundles checklists, 2 scenarios might be feasible: (i) internal self-assessment, for example, to start a project or to advance ongoing projects similar to quality management initiatives, and/or (ii) external assessment for peer review of PBM/audit of PBM/accreditation for PBM.

Block 1: PBM Project Management

Involvement of Key PBM Stakeholders

To recruit a general PBM coordinator is one of the most important tools to the success of any PBM program (Table 1). The PBM coordinator has a central role for transparency, communication, networking, education, documentation, and benchmarking. Therefore, we suggest protected time (eg, 50% dedicated effort) to run the PBM program, as time and resource constraints are common and reasonable hamper project management. The PBM coordinator and her/his team should engage in early communication to key stakeholders, for example, chief medical officer, chief executive officer, surgeons, anesthesiologists, intensive care specialists, nurses, transfusion medicine specialists/transfusion committee, gastroenterologists, hematologists, cardiologist, general practitioners, and finance administrative and quality management personnel for a successful implementation and sustainable support. An official directive from the hospital board of directors may enhance the PBM

Table 1
Patient Blood Management project management

Block 1: General PBM project management	
Involvement of key PBM stakeholders [role]	
PBM coordinator with protected time [central role for communication, networking, education, documentation, and benchmarking]	0 ☐ 1 ☐ 2 ☐
Hospital board of directors (eg, chief medical officer, chief executive officer, chief nursing officer) [support; official directive]	0 ☐ 1 ☐ 2 ☐
Surgeons (eg, orthopedic/trauma, cardiac, vascular, visceral, trauma, urology, neurosurgery) [interdisciplinary consensus]	0 ☐ 1 ☐ 2 ☐
Anesthesiologists/intensive care specialists [central role for perioperative care]	0 ☐ 1 ☐ 2 ☐
Transfusion medicine specialists/transfusion committee [prevention of blood wastage, optimal blood use, changes in donor blood management]	0 ☐ 1 ☐ 2 ☐
Internists/gastroenterologists/hematologists/cardiologists/ nephrologists [anemia management, optimal blood use]	0 ☐ 1 ☐ 2 ☐
General practitioners/family doctors [determine the necessity for elective surgery, assign patients to a hospital, preoperative anemia management]	0 ☐ 1 ☐ 2 ☐
Patient's representative [need to be informed about the different alternatives to treat anemia/create awareness]	0 ☐ 1 ☐ 2 ☐
Pediatrics [mainly refers to blood conservation strategies]	0 ☐ 1 ☐ 2 ☐
Central laboratory/laboratory scientists [smaller blood collecting tubes]	0 ☐ 1 ☐ 2 ☐
Pharmacists/purchasing department [introduction of new drugs for the management of anemia and coagulopathy]	0 ☐ 1 ☐ 2 ☐
Information technology department [sampling of routine data and key performance metrics]	0 ☐ 1 ☐ 2 ☐
Finance department [finance experience for program budget plan, initial project costs; hospital-wide cost savings]	0 ☐ 1 ☐ 2 ☐
Quality management [project management experience; PBM as a fixed part of a quality improvement initiative]	0 ☐ 1 ☐ 2 ☐
Public affairs [dissemination channels/marketing of the PBM project (eg, via journals/Intranet/e-mails/posters/roll-ups/press conferences)]	0 ☐ 1 ☐ 2 ☐
Undergraduate and postgraduate education	
Undergraduate education (nursing school/medical school)	0 ☐ 1 ☐ 2 ☐
Postgraduate education of physicians/clinicians (lectures, workshops; initial and once a year)	0 ☐ 1 ☐ 2 ☐
Postgraduate education of nurses (intensive care unit, normal ward; initial and once a year)	0 ☐ 1 ☐ 2 ☐
Certificate (eg, by online E-learning courses)—to enhance PBM education and knowledge transfer	0 ☐ 1 ☐ 2 ☐
Local standard operating procedures/protocols	
Standard operating procedures for PBM	
Anemia management	0 ☐ 1 ☐ 2 ☐
Coagulation management	0 ☐ 1 ☐ 2 ☐
Blood conservation	0 ☐ 1 ☐ 2 ☐
Optimal blood use/transfusion of blood products (list of index procedures for "type and screen" or "type and crossmatch (and supply)")	0 ☐ 1 ☐ 2 ☐
Massive hemorrhage protocols (including such as damage controlled surgery, arterial embolization, hemotherapy algorithm)	
Massive hemorrhage (in general)	0 ☐ 1 ☐ 2 ☐
Postpartum hemorrhage	0 ☐ 1 ☐ 2 ☐
Trauma associated hemorrhage	0 ☐ 1 ☐ 2 ☐
Cardiac surgery associated hemorrhage	0 ☐ 1 ☐ 2 ☐

program by adding authority. In addition, the following stakeholders should also be involved at an early stage: central laboratory for smaller blood collecting tubes [51,52], Information Technology Department for sampling of certain routine data and key PBM performance metrics, pharmacists for the introduction of new drugs for the management of anemia and coagulopathy, and patients' representatives. Patients and their relatives should have access to information regarding PBM, including the risks and benefits of blood transfusion, alternatives and adjuvant options, and an explanation of restrictive practice. In collaboration with the department for public affairs, an active marketing and dissemination strategy is recommended for the promotion of the desired paradigm shift in transfusion practice and to make sustainable progress in implementation of PBM. For example, a distinctive PBM logo might be placed on hospital Web page, posters, pens, shirts, flyers, nametags, and ties to establish a "brand." Other ways to propagate the PBM concept are press conferences and meetings with journalists from medical and general newspapers as well as television delegates. Further general dissemination channels are suggested, for example, journals, Intranet, emails, posters, roll-ups, social media, and others.

Undergraduate and Postgraduate Education

A comprehensive PBM education program should be developed for emergency and elective admissions. This should be targeted to medical students, physicians, nurses, pharmacists, and other health care staff and focused on PBM program's goals, structure, and scope. Patient blood management education is also recommended for both inpatients and outpatients, surgical patients, and interventional and endoscopic units. Educational activities should occur initially and regularly, at least annually, and should be endorsed by public and medical authorities. The learning materials should be easily accessible, for example, via a Web site [53], Intranet, or a central virtual room for documents, guidelines, posters, education materials. As hemotherapy and transfusion medicine have been taught inadequately at many medical schools in the past [54,55], it would be beneficial for the relevant medical staff to pass online e-learning courses to receive a "PBM certificate" [56–58]. In most EU countries, physicians have to attend further education constantly to obtain credit points and to preserve professional competence. In this respect, PBM lectures and workshops need to be created to provide an ideal platform for training.

Local Standard Operating Procedures/Protocols

Standard operating procedures (SOPs) are crucial for many aspects of a PBM program. Therefore, written interdepartmental SOPs, for example, clinical protocols, guidelines, visual aids, and checklists, focusing on the 4 strategies of PBM need to be available to the staff at any time. These SOPs will facilitate implementation, practice, and process and will ensure sustainability of the PBM program. Risk-adjusted protocols and lists of index procedures should be developed for "type and screen" in patients with lower risk of bleeding/transfusion and "type and crossmatch" or rather "type and crossmatch and temporary supply" in patients with higher risk of bleeding/RBC transfusion (eg, >10% probability threshold of RBC transfusion), respectively. Alternatively, to decrease the amount of time spending to assign or crossmatch status, the maximum surgical blood order schedule described by Friedman et al [59] could be implemented. A massive hemorrhage protocol should be available that encourages early detection, definitive intervention, and treatment of acute hemorrhage according to an established algorithm [40,42,60–62]. Where clinically appropriate, this protocol includes damage-controlled surgery, early return to the operating room for correction of a surgical source of bleeding, early referral for interventional radiology, "balanced ratio" of RBCs to plasma to platelets and embolization, and early use of endoscopy/colonoscopy. Where indicated, massive hemorrhage protocols should be extended by specific algorithms for different subgroups of high-risk patients, for example, postpartum, trauma, cardiac surgery, or transplantation of solid organs with associated hemorrhage. Hemorrhage protocols should include guidelines for laboratory testing (including viscoelastic testing) and hemotherapy (including transfusion of RBC, plasma, platelets, cryoprecipitate, and factor concentrates).

Block 2: First Strategy—Manage Patient's Anemia

Preoperative Management of Anemia (Subgroup of Surgical Patients)

A full blood count is a widely available low-cost laboratory test and should be performed on all patients at presentation or better with referral from primary care for operation (Table 2). If this cannot be done, a list of elective surgical procedures for which preoperative anemia management screening is most likely reasonable should be designed. For example, these may include the surgical procedures with a greater than 10% probability of RBC transfusion. Patients scheduled for one of these procedures should be identified and assessed ideally 3 to 4 weeks before surgery to allow sufficient time to diagnose and manage anemia, unless,

Table 2
Anemia management

Block 2: First strategy—manage the patient's anemia	
Preoperative management of anemia (subgroup of surgical patients)	
Diagnosis of anemia	
Identification of anemic patients (screening)	0 ☐ 1 ☐ 2 ☐
Diagnosis of iron deficiency anemia (eg, blood count, ferritin, transferrin saturation, calculation of the individual iron deficit)	0 ☐ 1 ☐ 2 ☐
Diagnosis of vitamin B12 or folic acid deficiency	0 ☐ 1 ☐ 2 ☐
Extended diagnostic of anemia (eg, consultant for gastroenterology, endoscopy; hematology, bone marrow biopsy)	0 ☐ 1 ☐ 2 ☐
Diagnosis of anemia ideally 3-4 wk before surgery	0 ☐ 1 ☐ 2 ☐
Diagnosis of anemia although time to surgery is shorter than 3-4 wk	0 ☐ 1 ☐ 2 ☐
Anemia clinic; anemia/PBM nurse	0 ☐ 1 ☐ 2 ☐
Treatment of anemia	
Administration of intravenous iron	0 ☐ 1 ☐ 2 ☐
Administration of vitamin B12 and/or folic acid	0 ☐ 1 ☐ 2 ☐
Administration of erythropoietin	0 ☐ 1 ☐ 2 ☐
Optimizing cardiovascular and pulmonary function to improve tolerance of anemia	
Increase of oxygen delivery (increase of inspiratory oxygen concentration); decrease of oxygen consumption	0 ☐ 1 ☐ 2 ☐
Hemodynamic monitoring in high-risk procedures/patients (normovolemia, optimization of cardiac output)	0 ☐ 1 ☐ 2 ☐
Acute normovolemic hemodilution	0 ☐ 1 ☐ 2 ☐
Management of anemia in hospitalized patients and/or after surgery	
Diagnosis of anemia	
Diagnosis of iron deficiency anemia	0 ☐ 1 ☐ 2 ☐
Treatment of anemia	
Administration of intravenous iron	0 ☐ 1 ☐ 2 ☐
Administration of erythropoietin	0 ☐ 1 ☐ 2 ☐
Absence of unnecessary therapies, eg, "top up" RBC transfusion	0 ☐ 1 ☐ 2 ☐

Table 3
Optimization of coagulopathy

Block 3: Second strategy—optimizing coagulopathy	
Preoperative management of coagulopathy	
Algorithm for management of patients with oral/parenteral anticoagulation and/or antiplatelet therapy	0 ☐ 1 ☐ 2 ☐
Questionnaire/tests of hemostasis	0 ☐ 1 ☐ 2 ☐
Hemostasis management in hospitalized patients	
Physiological conditions of hemostasis	
Body temperature >36°C (normothermia)	0 ☐ 1 ☐ 2 ☐
pH > 7.2/ionized Ca^{2+} > 1.1 mmol/L	0 ☐ 1 ☐ 2 ☐
Point-of-care diagnostic in coagulopathy	
Coagulation system (eg, viscoelastic methods)	0 ☐ 1 ☐ 2 ☐
Platelet function (eg, aggregometric methods)	0 ☐ 1 ☐ 2 ☐
Use of a coagulation algorithm for administration of blood products, clotting factor concentrates, tranexamic acid	0 ☐ 1 ☐ 2 ☐
Empiric administration of tranexamic acid in certain procedures (particular in cardiac, orthopedic, transplant surgery, massive hemorrhage)	0 ☐ 1 ☐ 2 ☐
Empiric therapy of platelet dysfunction (eg, desmopressin)	0 ☐ 1 ☐ 2 ☐

of course, the surgery is of an urgent nature [22,45,63–66]. If the time interval is shorter than 3 to 4 weeks, any preoperative attempt to diagnose and treat anemia is still indicated [48,67,68]. Screening and subsequent laboratory testing should be performed to detect anemia and to allow diagnosis of the common causes of anemia including iron deficiency anemia, anemia of inflammation, or folate or vitamin B12 deficiency. In cases of anemia of unclear etiology, extended diagnostic testing and referral to a specialist should ideally be feasible [63]. It is preferable for screening to be performed at the time of surgical indication. A screening-directed laboratory assessment will reduce workload and costs and, therefore, should be well received by hospital/department managers [22]. In addition, this will mitigate the diagnostic-associated blood loss postsurgery. Noninvasive screening monitoring of hemoglobin may further reduce workload, blood loss, and costs for anemia screening, although further technical developments are needed to optimize precision [69]. An anemia clinic and/or a PBM nurse practitioner with delegated authority to carry out specified clinical procedures are additional ways to comply with the PBM concept. Outpatient preoperative treatment with parenteral iron, vitamin B12, folic acid, and/or erythropoiesis-stimulating agents should be used when clinically indicated.

Optimizing Cardiovascular and Pulmonary Function to Improve Tolerance of Anemia

A patient's physiologic tolerance of anemia can be harnessed by optimizing oxygenation, decrease of oxygen consumption, ensuring normovolemia, and optimized hemodynamics (eg, invasive hemodynamic monitoring in high-risk procedures) [70]. Consider intraoperative acute normovolemic hemodilution to reduce allogeneic blood transfusion in patients at high risk for excessive bleeding (eg, major cardiac, orthopedic, thoracic, or liver surgery) [38].

Management of Anemia in Hospitalized Patients and/or After Surgery

Comparable to preoperative anemia management, there should also be an algorithm for diagnosis and therapy of anemia in hospitalized patients and/or after surgery, including workup of iron deficiency, calculation of iron deficit, and the use of intravenous iron, vitamin B12, folic acid, and/or erythropoiesis-stimulating agents, when indicated [47,48,71,72]. Unnecessary therapies such as "top up" transfusion should be prevented.

Block 3: Second Strategy—Optimizing Coagulopathy

Preoperative Management of Coagulopathy

Local standard operation procedures (eg, questionnaires/tests of hemostasis, algorithms for bridging in patients with preoperative anticoagulants, and antiplatelet medications) should clearly define preoperative evaluation and management of coagulopathy (either unknown or drug induced) [73,74] (Table 3).

Hemostasis Management in Hospitalized Patients

Adequate coagulation management needs to be a precondition before RBC transfusion is considered. In this respect, the use of a coagulation algorithm is recommended [75,76]. In addition, basic conditions for hemostasis (eg, temperature, calcium, pH), reversal of anticoagulants, point-of-care diagnostics in coagulopathic patients, optimized coagulation management with the use of clotting factor concentrates, and the (empiric) use of antifibrinolytic agents or desmopressin are further important considerations [40,60,77,78]. The one-size-fits-all dogma of fresh frozen plasma (FFP) transfusion to correct or prevent coagulopathy needs be critically questioned due to known risks of allogeneic blood products [40]. Similarly, evaluation of platelet function should be considered first in the setting of surgical and interventional procedures to tailor treatment of coagulopathy, instead of liberal transfusion of numerous platelet concentrates [40].

Block 4: Third Strategy—Interdisciplinary Blood Conservation Modalities

Reduction of Diagnostic-Associated Blood Loss

A key element of PBM is prevention of blood being unnecessarily removed from the patients, particular by reducing phlebotomy blood loss within daily laboratory analyses (Table 4). This can be achieved in several ways. First, as mentioned above, early preoperative anemia screening is instrumental in reducing the need for phlebotomy when the patient is hospitalized or postsurgery. Second, when sampling blood, phlebotomists should use the smallest collection tube size that is practical for the required analysis. In addition, reducing unnecessary laboratory tests, unnecessary blood culture draws, the frequency of sampling, the "discard" volume when samples are obtained from indwelling lines, and the blood waste by the use of closed in-line flush blood sampling devices for arterial and central venous lines are recommended [51,52,79]. In addition to the medical benefits of this approach, patients will also appreciate fewer painful blood draws.

Table 4
Blood conversation strategy

Block 4: Third strategy—interdisciplinary blood conservation modalities	
Reduction of diagnostic-associated blood loss	
Reduced size of blood collection tubes	
EDTA tube	0 ☐ 1 ☐ 2 ☐
Citrate tube	0 ☐ 1 ☐ 2 ☐
Lithium-heparin/serum tube	0 ☐ 1 ☐ 2 ☐
Type and screen tubes	0 ☐ 1 ☐ 2 ☐
Restrictive frequency of blood collection	0 ☐ 1 ☐ 2 ☐
Appropriate timing of postoperative blood tests and not daily judicious use/"weekend" plan	0 ☐ 1 ☐ 2 ☐
Reduced sampling for blood cultures in daily routine (limit to established indications)	0 ☐ 1 ☐ 2 ☐
Closed in-line flush devices (arterial pressure transducer systems, central venous blood collection)	0 ☐ 1 ☐ 2 ☐
Reduction of surgery-related blood loss (subgroup of surgical patients)	
Extreme attention to minimize blood loss (eg, diathermy for tissue dissection), hemostatic adjuncts	0 ☐ 1 ☐ 2 ☐
Laparoscopic surgery/minimal invasive techniques/modern surgical instruments	0 ☐ 1 ☐ 2 ☐
Limited numbers of swabs for blood absorption/swab washing and cell salvage ("single swab")	0 ☐ 1 ☐ 2 ☐
Controlled hypotension (if no contraindication is present)	0 ☐ 1 ☐ 2 ☐
Autologous blood collection and retransfusion (cell salvage)—intraoperatively and postoperatively	
Nononcological procedures: if expected blood loss >500 mL	0 ☐ 1 ☐ 2 ☐
Oncological procedures: if massive blood loss	0 ☐ 1 ☐ 2 ☐
Oncological procedures: if expected blood loss >500 mL (radiation of washed blood; filtration using leukocyte depletion filters)	0 ☐ 1 ☐ 2 ☐
Cardiac surgery	
Small extracorporeal circuits (priming volume <1.2 L; 3/8″ lines; minimized extracorporeal circuits)	0 ☐ 1 ☐ 2 ☐
Extracorporeal circuits (retrograde autologous priming; blood cardioplegia, modified ultrafiltration/hemofiltration)	0 ☐ 1 ☐ 2 ☐
Bloodless saphenous vein graft removal/immediate wound closure/endoscopic vein removal	0 ☐ 1 ☐ 2 ☐

Table 5
Optimal blood use

Block 5: Fourth strategy—optimal blood use with patient-centered decision making	
Patient-centered decision making	
Individual PBM plan with transfusion triggers based on the patient's risk profile/tolerable erythrocyte deficit	0 ☐ 1 ☐ 2 ☐
Written patient information form/informed consent for allogeneic blood products (in emergency after transfusion)	0 ☐ 1 ☐ 2 ☐
Clinician who ordered blood products can be identified (important for feedback and audit)	0 ☐ 1 ☐ 2 ☐
Single-unit policy (RBC units, platelet concentrate)	0 ☐ 1 ☐ 2 ☐
Intelligent electronic ordering system for blood products (including patient's lab results, alert function)	0 ☐ 1 ☐ 2 ☐
Use of dosage for blood components instead of units	0 ☐ 1 ☐ 2 ☐
Indication list for each of the following hemotherapy products (eg, pocket card, supply note, poster, etc)	
RBC units	0 ☐ 1 ☐ 2 ☐
Platelet concentrate	0 ☐ 1 ☐ 2 ☐
FFP units	0 ☐ 1 ☐ 2 ☐
Coagulation factors (prothrombin complex concentrate, fibrinogen, recombinant VIIa, recombinant XIII)	0 ☐ 1 ☐ 2 ☐
Documentation of the indication for each of the following hemotherapy products (eg, by paper-/electronic-based ordering)	
RBC units	0 ☐ 1 ☐ 2 ☐
Platelet concentrate	0 ☐ 1 ☐ 2 ☐
FFP units	0 ☐ 1 ☐ 2 ☐
Coagulation factors (prothrombin complex concentrate, fibrinogen, recombinant VIIa, recombinant XIII)	0 ☐ 1 ☐ 2 ☐

Reduction of Surgery-Related Blood Loss (Subgroup of Surgical Patients)

The surgical use of blood and blood products has decreased significantly in the last 5 years. This can be attributed primarily to surgical technique, role of laparoscopic surgery, and physicians' mindfulness regarding limiting blood loss. Nevertheless, judicious use of diathermy dissection, appropriate suction and cell salvage, and controlled hypotension in bleeding patients as well as application of topical haemostatic agents/tissue adhesives are also important tools to reduce surgery-related blood loss.

The use of intraoperative/postoperative autologous blood collection and retransfusion should be standardized including indications and contraindications [80]. In oncology patients, cell saving might be indicated after radiation or filtration of washed blood, using leukocyte depletion filters or in cases of massive bleeding [81]. In addition, a focus on the number of swabs used for blood absorption and the reuse of washed swabs combined with autologous cell salvage allows reduction of irreversible blood loss. In cardiac surgery, a wide spectrum of blood-sparing techniques have been described in the literature, for example, minimized extracorporeal circuits, retrograde autologous priming, modified ultrafiltration, blood cardioplegia, and meticulous hemostasis in saphenous vein graft removal [82].

Block 5: Fourth Strategy—Optimal Blood Use With Patient-Centered Decision Making

Patient-Centered Decision Making

A predefined individual PBM plan with transfusion triggers based on the individual patient's risk profile and calculation of tolerable erythrocyte deficit is suggested (Table 5). To optimize utilization of blood products and to identify the ordering physician in case of any audit, it is beneficial to adopt a physician order entry with a clinical decision support based on electronic medical records [14,17]. For the purposes of obtaining informed consent from a patient for the transfusion of allogeneic blood products before transfusion (or after it, when urgently needed), handwritten or computer-generated forms (ideally a separate sheet of paper) should be used that comprehensively includes a detailed outline of transfusion benefits, risks, and alternatives. Both using a system that electronically identifies patients to improve the safety and efficiency of the blood transfusion process and appropriate verbal and written information to the patient and/or carer were also highlighted by the recent recommendations from the National Institute for Health and Care Excellence on blood transfusion [83].

Policies and procedures for ordering, dispensing, and transfusing blood components need to comply with available national guidelines [83–85]. Indication for transfusion takes into consideration patient specific factors (eg, age, diagnosis, comorbidity), laboratory values (eg, hemoglobin, platelet count, coagulation testing), presence or absence of bleeding, and physiologic factors (eg, oxygenation, hemodynamic status). When RBC transfusion is clinically indicated in the nonbleeding patient, only a single unit of RBC should be prescribed, followed by clinical reassessment of the patient ("single unit policy"; "transfuse and assess strategy") [17,19]. Interestingly, the general terminology for blood components is unit, bags, and others, but the concept of dosage is still not used apart from coagulation factors. There might be significant variations in volume and content of blood component units, as a reflection of donors' characteristics.

Pocket cards, supply notes, posters, apps, and others can spread education regarding the indication of hemotherapy products. In addition, documentation of the indication of the total spectrum of hemotherapy products can be facilitated by either paper- or computer-based ordering system with required checkboxes. When the ordering physician must indicate the reason for application as part of the ordering process, this allows concurrent utilization self-review [14]; importantly, this effective promotion of hemotherapy practices has been shown to be associated with improved clinical patient outcomes [15].

Block 6: PBM-Related Metrics, Patient's Outcome, Benchmark

Patient Blood Management–Related Metrics

Patient blood management–related metrics and blood usage should be collated itemized for each department to allow identification of potential areas for improvement due to overutilization or underutilization and, if desired, even more specifically down to physician groups and/or

Table 6
Patient Blood Management–related metrics

Block 6: PBM-related metrics/patient's outcome/benchmark	
PBM-related metrics	
Anemia—itemized for each department with percentage of patients	
Preoperative anemia	0 ☐ 1 ☐ 2 ☐
Hospital-acquired anemia	0 ☐ 1 ☐ 2 ☐
Treated anemic patients (eg, parenteral iron, vitamin B12, folic acid, erythropoiesis-stimulating agents)	0 ☐ 1 ☐ 2 ☐
Use of blood conservation techniques—itemized for each department with number of units and percentage of patients	
Use of hemostatic agents (tranexamic acid, desmopressin)	0 ☐ 1 ☐ 2 ☐
Use of cell salvage	0 ☐ 1 ☐ 2 ☐
Hemotherapy product use—itemized for each department with number of units/dosage and percentage of patients	
Blood products (RBC units, platelets concentrates, FFP units)	0 ☐ 1 ☐ 2 ☐
Coagulation factors (prothrombin complex concentrate, fibrinogen, recombinant VIIa, XIII)	0 ☐ 1 ☐ 2 ☐
Transfusion episodes where a single unit of RBCs/platelet issued	0 ☐ 1 ☐ 2 ☐
Indications for blood product use—mean pretransfusion levels (hemoglobin, platelet count, INR)	0 ☐ 1 ☐ 2 ☐
Blood product use that falls outside of hospital or professional transfusion guidelines	0 ☐ 1 ☐ 2 ☐
Blood wastage—number of units	
Crossmatch (supply)/transfusion ratio (aim: as low as possible; ratio <1.7:1)	0 ☐ 1 ☐ 2 ☐
Discarded blood products (RBC units, platelet concentrates, FFP units)	0 ☐ 1 ☐ 2 ☐
Report to clinicians/administrative departments about PBM-related metrics (once a year)	0 ☐ 1 ☐ 2 ☐
Patient's outcome	
Mortality (inhospital)	0 ☐ 1 ☐ 2 ☐
Morbidity (eg, ICD-10 codes)	
Infections (sepsis, pneumonia), acute renal failure, acute myocardial infarction, acute ischemic stroke	0 ☐ 1 ☐ 2 ☐
Length of stay in hospital/intensive care unit	0 ☐ 1 ☐ 2 ☐
Hemovigilance (transfusion reactions, transfusion-associated cardiac overload, transfusion-associated acute lung injury)	0 ☐ 1 ☐ 2 ☐
Benchmarking	
Internal/external benchmarking (eg, for selected surgical procedures)	0 ☐ 1 ☐ 2 ☐
Membership of a PBM network	0 ☐ 1 ☐ 2 ☐
Program budget for PBM	
Initial/ongoing project costs (personnel resources, dissemination); PBM-related cost savings (reduced blood products, laboratory analyses)	0 ☐ 1 ☐ 2 ☐
Hospital audit for PBM	
Participation in hospital audit for PBM practice and transfusion decisions in a sample of scheduled cases	0 ☐ 1 ☐ 2 ☐
Hospital accreditation for PBM	
Participation in a hospital certification (accreditation) program for PBM	0 ☐ 1 ☐ 2 ☐

Abbreviations: INR, international normalized ratio; *ICD-10, International Statistical Classification of Diseases, 10th Revision*.

individual clinicians (Table 6). Patient blood management–related metrics include percentage of patients with diagnosis and therapy of anemia and use of blood conservation techniques as well as use of hemotherapy products. Data should also include transfusion episodes where a single unit of RBC/platelet issued, indications for blood product use with mean pretransfusion levels, and blood product use that falls outside of hospital or professional transfusion guidelines, for example, patients receiving RBC transfusion with a pretransfusion Hb of greater than 8 g/dL (5 mmol/L), nonbleeding hematooncology patients receiving a platelet transfusion with a pretransfusion platelet count of greater than 10 000/μL. By this way, a monitoring and feedback system may be useful, which electronically registers each hemotherapy product as well as corresponding laboratory data and reports results to clinicians regularly, as it has recently been implemented at the University Hospital of Zurich [86].

Analysis of the institution's own data about the ratios of both "crossmatch to transfused" and "supplied to transfused" blood units, measures to decrease this ratio reflecting overordering of blood compared with actual transfusion, immediate canceling of requested and returning of temporary supplied but unneeded units, and analysis of discarded blood products allow optimized utilization of the blood products and reduction of unnecessary blood wastage. All PBM-related metrics should be reported to involved clinicians and administrative departments, for examples, once a year.

Patient's Outcome

For an effective change process, one needs to first establish what the current PBM practice is. Then one can share the data with physicians, plan and implement any interventions, and continue to audit and track utilization to evaluate the change and monitor success. The impact of PBM on clinical outcomes should be evaluated on a regular basis (eg, once a year). Clinical end points could be monitored by means of the hospital information system, where the relevant diagnoses are encoded. In addition, data should include inhospital mortality and length of stay at both the intensive care unit and the hospital. In accordance with current regulations, all patient-related data need to be anonymized to allow analysis. Hemovigilance data, including transfusion reactions, transfusion-associated cardiac overload, and transfusion-associated acute lung injury, need to be reported.

Benchmarking

As PBM has been identified as a strategy to improve patient outcomes, internal and/or external benchmarking may be one of the most important tools in medical change management and to ensure sustainability [87].

In addition, collaboration within a PBM network project at different levels (eg, local/regional/national/European-wide) would be worthwhile. For example, membership could imply free access to master files, documents, checklists, central data collection, data analysis, benchmarking of PBM-related metrics, and key clinical outcomes for specified procedures.

Program Budget for PBM

A detailed program budget needs to cover initial and ongoing project costs for personnel resources, equipment needs, and other project-related resources that support dissemination. A PBM program, however, can result in hospital-wide cost savings, particular due to reduced costs of blood products, blood wastage, laboratory analyses, and reduced expenses associated with adverse events, thereby, successful implementation of PBM may fund the program itself [49].

Hospital Audit for PBM

Hospital audit highlights areas of good practice as well as variability in practice and enables hospitals to prioritize implementation of PBM initiatives. In the UK, for example, the auditor collects information on PBM practice and transfusion decisions in a sample of scheduled surgical cases who have received RBC transfusion on a case-based tool [88].

Hospital Accreditation for PBM

In future, the quality of PBM programs within the local hospital may be assessed by hospital accreditation. Accreditation may be granted for different PBM-related topics, for example, anemia management, management of coagulopathy, blood conservation, or optimal blood use. In Australia, where the Australian Commission on Safety and Quality in Health Care has made PBM a national priority, implementation of PBM is 1 of the 10 National safety and quality health service standards [89]. Furthermore, the A` and the Joint Commission recently announced a collaborative partnership to provide a joint hospital certification (accreditation) program for PBM to promote patient safety and quality by combining an internationally accepted quality management system structure with appropriate PBM technical requirements [7]. This promoted an increased focus on PBM by hospital executives and provided an opportunity to promote PBM as a key mechanism to improve patient outcomes.

Conclusion

Despite the demonstrated benefits of PBM, many barriers limit translation of PBM guidelines into clinical practice worldwide, particularly due to lack of knowledge, lack of interdisciplinary commitment, lack of resources, and general concerns. Under the precondition of applied change management principles, an effective PBM program needs to include a comprehensive spectrum of administrative and clinical standards of PBM principles. Strategies for overcoming the hurdles often include the use of multimodal "care bundles" and specific designed measures according to local conditions. Therefore, the PBM "bundles" approach, which incorporates individual, low-threshold stepwise selection of the most feasible measures, depending on local cultural conditions, may serve as a new concept of "how to implement PBM." It should enable PBM's patient-centered approach to be delivered in a way that is also hospital centered and, therefore, compatible with each institution. The institution's initial success should drive further motivation and activities in the field of PBM.

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