Essential Role of Patient Blood Management in a Pandemic: A Call for Action

Aryeh Shander, MD,* Susan M. Goobie, MD,† Matthew A. Warner, MD,‡ Matti Aapro, MD,§ Elvira Bisbe, MD, PhD,¶ Angel A. Perez-Calatayud, MD,¶ Jeanie Callum, MD,# Melissa M. Cushing, MD,** Wayne B. Dyer, PhD,†† Jochen Erhard, MD,‡‡ David Faroani, MD, PhD,§§ Shannon Farmer, MBS, ||||| Tatyana Fedorova, PhD,§§ Irwin Gross, MD,¶¶ Nicole R. Guinn, MD,### Thorsten Haas, MD,#### Jeffrey Hamdorf, MD, PhD,##### James P. Isbister, MD,#### Mazyar Javidroozi, MD, PhD,* Hongwen Ji, MD,$$$$ Young-Woo Kim, MD,$$$$ Daryl J. Kor, MD,$$$$ Johann Kurz, PhD,############ Sigismondo Lasocki, PhD, PhD,#### Michael F. Leahy, MBChB,##### Cheuk-Kwong Lee, MD, $$$$$ Jeong Jae Lee, MD, PhD,|||||| Vernon Louw, MBChB, PhD,|||||| Jens Meier, MD,#### Anna Mezzacasa, PhD,****** Manuel Munoz, PhD, PhD,****** Sherri Ozawa, RN,PhD,****** Marco Pavesi, MD,$$$$$$ Nina Shander, BS,||||||| Donat R. Spahn, MD,|||||| Bruce D. Spiess, MD,##### Jackie Thomson, MBChB,****** Kevin Trentino, MPH, PhPhD,#### Christoph Zenger, PhD,$$$$$$$ and Axel Hofmann, Dr.relmic,||||||| on behalf of the International Foundation of Patient Blood Management (IFPBM) and Society for the Advancement of Blood Management (SABM) Work Group

The World Health Organization (WHO) has declared coronavirus disease 2019 (COVID-19), the disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a pandemic. Global health care now faces unprecedented challenges with widespread and rapid human-to-human transmission of SARS-CoV-2 and high morbidity and mortality with COVID-19 worldwide. Across the world, medical care is hampered by a critical shortage of not only hand sanitizers, personal protective equipment, ventilators, and hospital beds, but also impediments to the blood supply. Blood donation centers in many areas around the globe have mostly closed. Donors, practicing social distancing, some either with illness or undergoing self-quarantine, are quickly diminishing. Drastic public health initiatives have focused on containment and “flattening the curve” while invaluable resources are being depleted. In some countries, the point has been reached at which the demand for such resources, including donor blood, outstrips the supply. Questions as to the safety of blood persist. Although it does not appear very likely that the virus can be transmitted through allogeneic blood transfusion, this still remains to be fully determined. As options dwindle, we must enact regional and national shortage plans worldwide and more vitally disseminate the knowledge of and immediately implement patient blood management (PBM). PBM is an evidence-based bundle of care to optimize medical and surgical patient outcomes by clinically managing and preserving a patient’s own blood. This multinational and diverse group of authors issue this “Call to Action” underscoring “The Essential Role of Patient Blood Management in the Management of Pandemics” and urging all stakeholders and providers to implement the practical and commonsense principles of PBM and its multiprofessional and multimodality approaches. (Anesth Analg 2020;131:74–85)

GLOSSARY

ABC = Anemia, Blood loss and Coagulopathy; ANH = acute normovolemic hemodilution; COVID-19 = coronavirus disease 2019; COX2 = cyclooxygenase-2; DOAC = direct oral anticoagulants; EACTS/EACTA = European Association for Cardio-Thoracic Surgery/European Association for Cardio-Thoracic Anaesthesiology; ECDC = European Centre for Disease Prevention and Control; ESA = erythropoiesis-stimulating agent; ESMO = European Society for Medical Oncology; EU = European Union; Fio2 = fraction of inspired oxygen; GI = gastrointestinal; H1N1 = influenza A virus subtype H1N1; ICU = intensive care unit; IFPBM-SABM = International Foundation of Patient Blood Management-Society for the Advancement of Blood Management; NAT = nucleic acid testing; NATA = Network for the Advancement of Patient Blood Management, Haemostasis and Thrombosis; NSAID = nonsteroidal anti-inflammatory drug; PBM = patient blood management; PCC = prothrombin complex concentrate; PPI = proton-pump inhibitor; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2; SOP = Standard Operating Procedures; TACO = transfusion-associated circulatory overload; TRALI = transfusion-related acute lung injury; WBC = white blood cell; WHO = World Health Organization

From the *Department of Anesthesiology, Critical Care and Hyperbaric Medicine, Englewood Health, Englewood, New Jersey; †Department of Anesthesiology, Critical Care and Pain Medicine, Boston Children’s Hospital, Harvard Medical School, Boston, Massachusetts; ‡Department of Anesthesiology and Perioperative Medicine, Mayo Clinic, Rochester, Minnesota; §Cancer Center Clinique Genolier, Genolier, Switzerland; #Department of Anesthesiology, Perioperative Medicine Research Group, Hospital del Mar Medical Research Institute (IMIM), Barcelona, Spain; ¶¶¶¶¶¶¶####### July 2020 • Volume 131 • Number 1
Given the recent emergence of the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the ensuing worldwide, widespread human-to-human transmission of the related coronavirus disease 2019 (COVID-19), the World Health Organization (WHO) has declared a pandemic status for this virus and the virus-related disease. As one of the corollaries, public health authorities and blood services are concerned with decreasing blood donations, ultimately resulting in blood shortages that will unquestionably lead to difficult and controversial transfusion rationing decisions by frontline health care providers. Considering that blood is a perishable commodity with a very short expiration time, as with past pandemics, blood services are being challenged to maintain their inventory during the current COVID-19 pandemics. On the other hand, analyses after past natural and man-made disasters have demonstrated either no change or a reduction in the demand for blood and its use.\(^1\,^2\)

**BLOOD SUPPLY CHALLENGES DURING PANDEMICS**

The influenza A virus subtype H1N1 (H1N1) pandemic had a significant impact on the blood supply due to donors’ fear of exposure to the virus at a hospital or a free-standing donor facility.\(^3\,^4\) Similarly, the COVID-19 pandemic has already led to significantly reduced blood supplies due to the cancellation of numerous community-based and mobile blood drives, as well as a marked reduction in donors arriving for scheduled appointments. For instance, as a result of the current pandemic and restrictions on congregating through social distancing, to date in the United States, nearly 4000 American Red Cross blood drives have been canceled across the country. Hospital-based collections have been canceled due to institutional concerns regarding donors spreading COVID-19 to hospitalized patients or vice versa. These cancellations have resulted in some 130,000 fewer blood donations in only a few weeks. More than 80% of the blood the American Red Cross collects comes from drives held at nonpermanent collection locations. According to the Chief Executive Officer of New York Blood Center, the main blood supplier for New York City, around 75% of their incoming blood supply was interrupted during the week of March 16, 2020, when schools, businesses, and religious institutions closed due to the coronavirus outbreak.\(^5\)

Moreover, the number of eligible donors in the course of a pandemic will inevitably decrease due to an increasing number of individuals being infected or in self-quarantine after exposure to infected persons or persons under investigation. In addition, blood collection facilities have put additional screening criteria in place, declining donors with the history of travel.
Role of PBM in pandemics

from infection “hot spots” in the preceding 14 days, at a time when a large proportion of the population had travelled for school spring breaks. Finally, older persons, who often represent the most reliable donor pool, are also apparently among the most vulnerable to the COVID-19 pandemic.

The default response to reduced blood supplies and the limited capacity of health care facilities is the suspension of elective surgical procedures regardless of the lack of uniform definitions for “elective.” Yet, blood utilization for urgent and emergent interventions that can actually represent a greater demand on the blood supply is likely to remain unchanged. The same will likely be true for chronically transfusion-dependent patients, including those with malignancies, hematologic conditions (eg, sickle cell, thalassemia, myelodysplastic syndrome), and chemotherapy-induced anemia. In some cases, cancellation of elective surgeries may permit disease progression resulting in more complex and urgent situations, as the pandemic further progresses.

Calls from blood centers for more donors do not sufficiently alleviate this problem. In the context of pandemics, the pressure on blood collection facilities and hospital transfusion medicine services and their staff is also increased as more and more staff members are required to self-isolate, self-quarantine, or become ill. In addition, the effort to continue standard blood donor recruitment will be diverted in part by the growing initiative to manufacture convalescent plasma from patients who have recovered from COVID-19. While this treatment option remains under investigation on a limited basis and is not currently a major source of demand for blood donations, the rapidly evolving nature of the pandemic might quickly change the landscape, creating a substantial new demand.

It should also be noted that supply chains are often affected by travel restrictions, factory closings, and decreased manufacturing output, which may in turn affect the ability of blood services to maintain their testing and production facilities in times of increasing need.

Another remote but significant issue is possible virus transmission via donated blood. At some stage of the pandemic, we expect that a considerable percentage of the population will be unknowingly infected by SARS-CoV-2, including the young blood donor population in which asymptomatic cases will be common. In the absence of nucleic acid testing (NAT) for blood donor screening for SARS-CoV-2, we cannot exclude, albeit theoretical at this time, the possible transmission via a blood transfusion, if some of the donated blood may be contaminated. Thus, we are facing significant unknowns, and only future studies will elucidate the true risks of transfusion-transmitted SARS-CoV-2 if any.

ESSENTIAL ROLE OF PATIENT BLOOD MANAGEMENT

For all of the above reasons, the medical community must adopt other solutions to continue and/or resume care of our patient population. Thus, the immediate and global implementation of patient blood management (PBM) should be mandated. PBM is defined as an evidence-based bundle of care to optimize medical and surgical patient outcomes by clinically managing and preserving a patient’s own blood (www.ifpbm.org) or alternatively, as the timely application of evidence-based medical concepts designed to maintain hemoglobin concentration, optimize hemostasis, and minimize blood loss, in an effort to improve patient outcomes (www.sabm.org).

The National Blood Authority (Australia) evidence-based PBM Guidelines are an exhaustive systematic review of the literature with an attendant rigorous methodology for developing recommendations, practice points, and expert opinion points. The 6 modules contain 52 Recommendations, 142 Practice Points, and 56 Expert Opinion Points. The PBM Toolbox (Tables 1–2) summarizes the practical concepts of PBM. Numerous large observational studies, several randomized controlled trials, and meta-analyses have demonstrated significantly improved patient outcomes with PBM, while substantially reducing blood utilization. The concept of PBM proactively focuses on patient needs as well as the conditions that usually lead to transfusions, namely, blood loss, coagulopathies, platelet dysfunction, and anemia. PBM shifts the focus from reactive transfusion of patients with allogeneic blood components to preventive measures by optimally managing the patient’s own blood.

The PBM concept was endorsed in 2010 by the World Health Assembly through resolution WHA63.12. In 2017, it was recommended as standard of care by the European Commission. In the recent WHO Action Framework to advance universal access to safe, effective, and quality-assured blood components in 2020–2023, the effective implementation of PBM is listed as 1 of 6 goals. Despite these strong recommendations and the available evidence demonstrating that the PBM model is not just an option but rather a necessity, practice change still lags very far behind. Furthermore, while expert consensus demonstrates that the PBM model improves clinical outcomes, increases patient safety, and reduces costs, hospitals with organized PBM programs are few and far between.

CALL TO ACTION

In the face of the current crisis, the European Centre for Disease Prevention and Control (ECDC) in its rapid risk
**Table 1. The ABC Toolbox for PBM (From the IFPBM-SABM Workgroup)**

| Tools | Anemia and Iron Deficiency | Blood Loss and Bleeding | Coagulopathy |
|-------|---------------------------|-------------------------|--------------|
| 1. Program implementation methodology | • Change culture across your institution\(^{13,12}\) | • Point-of-care coagulation and platelet function testing and goal-directed treatment\(^{24-25}\) | • Point-of-care coagulation and platelet function testing and goal-directed treatment\(^{24-25}\) |
|       | • Disseminate evidence-based PBM guidelines/recommendations and detect and discourage nonevidence practices\(^{14-22}\) | • Rapid diagnostic tests for the presence of DOACs if available\(^{27}\) | • Rapid diagnostic tests for presence of DOACs if available\(^{27}\) |
|       | • Translate evidence-based guidelines/recommendations into clinical practice\(^{13,23}\) | • Erythropoiesis-stimulating agents\(^{30,32,33}\) | • Fibrinogen concentrate\(^{40}\) |
|       | • Identify practice areas that need improvement | • Pre- and postoperative cell recovery (cell saver)\(^{28}\) | • PCC\(^{40}\) |
| 2. Diagnostic devices | • Point-of-care hemoglobin analyzers | • Oral/intravenous iron\(^{30-33}\) | • Other clotting factors |
|       | • Point-of-care testing for iron deficiency if available | • Folic acid\(^{34}\) | • Vitamin K intravenously |
|       | | • Vitamin B\(_12\)\(^{34,35}\) | | |
|       | | • Erythropoiesis-stimulating agents\(^{30,32,33}\) | | |
| 3. Treatment devices | | • Antifibrinolytics (tranexamic acid, amidoperoxid acid)\(^{36-39}\) | | |
| 4. Pharmaceuticals | | • Topical hemostatic agents | | |
|       | | • Local vasoconstrictive agents | | |
|       | | • WBC and platelet-stimulating agents where appropriate | | |
|       | | • Consider high F\(_2\)O\(_2\) (1.0) in patients with life-threatening anemia | | |
| 5. Vigilance with nutritional and pharmacological interactions | | • Educate physicians on indications and dosage | | |
|       | | Identify and manage drug therapies and/or nutrition that | | |
|       | | • Can contribute to anemia and hematocrit deficiencies (eg, PPIs) | | |
|       | | • Can increase iron absorption (eg, ascorbic acid) | | |
|       | | • Can impair absorption (eg, some vitamin and herbal supplements, tea, coffee, or dairy products) | | |
| 6. General principles | | • Educate physicians on indications and dosage | | |
|       | | Identify and manage drug therapies and/or nutrition that | | |
|       | | increase the bleeding risk, for example: | | |
|       | | • NSAIDs (including COX2 inhibitors), antidepressants, statins, antiarrhythmics | | |
|       | | • Vitamin and herbal supplements including vitamin E, vitamin K, garlic, ginger, Ginkgo biloba, fish oil, chamomile, dandelion root, etc | | |
|       | | Identify and manage drug therapies and/or nutrition that | | |
|       | | increase the bleeding risk, for example: | | |
|       | | • NSAIDs (including COX2 inhibitors), antidepressants, statins, antiarrhythmics | | |
|       | | • Vitamin and herbal supplements including vitamin E, vitamin K, garlic, ginger, Ginkgo biloba, fish oil, chamomile, dandelion root, etc | | |
|       | | Be aware of drugs associated with red blood cell disorders\(^{42}\) | | |
|       | | Anemia management program for prehospital, hospital, and postdischarge patients | | |
|       | | Focus on patients with comorbidities (diabetes, chronic kidney disease, and congestive heart failure)\(^{43-44}\) | | |
|       | | Meticulous surgical hemostasis | | |
|       | | Optimize surgical technique | | |
|       | | Patient positioning | | |
|       | | Efforts to stop bleeding immediately | | |
|       | |Minimally invasive surgical techniques | | |
|       | | Restrictive fluid administration and permissive hypotension until bleeding is controlled | | |
|       | | Achieving euvolemia once bleeding controlled | | |
|       | | Deliberate induced hypotension | | |
|       | | Careful blood pressure and fluid management | | |
|       | | Prevent hypothermia,\(^{43}\) hypoperfusion, and acidosis | | |
|       | | Maintaining normal circulating volume (euvolemia) | | |
|       | | Minimize iatrogenic blood loss,\(^{45,44}\) minimize number of blood draws and volume, minimize volume of blood wasted (microtainers/small phlebotomy tubes) | | |
|       | | Staging and packing | | |
|       | | Interventional radiologic embolization | | |
|       | | Restrictive transfusion strategy\(^{46-51}\) (reduce volume of transfusion, adhere to restrictive transfusion thresholds) | | |
|       | | Watch for signs of postoperative bleeding | | |
|       | | Monitor throughout withholding/bridging/recommencement of DOACs and antiplatelet agents | | |
|       | | Prevent GI bleeding (enteral feeding/food, GI acid-lowering agents) | | |
|       | | Avoid/treat infections promptly | | |
|       | | Address clinically significant coagulopathy early by identifying the source and/or coagulation defect | | |

(Continued)
assessment of March 12, 2020, on COVID-19 states that the “Implementation of Patient Blood Management (PBM) ... is strongly advisable.” Furthermore, the interim guidance on March 20, 2020, from the WHO on maintaining a safe and adequate blood supply during the COVID-19 pandemic recommends “Good patient blood management” to safeguard blood stocks. In the current pandemic setting, both the severe limitation of available health care resources and the growing shortage of donor blood clearly support that the rapid implementation of PBM is the optimal way forward. Beyond beneficial effects on blood utilization, PBM-associated improvements in clinical outcomes, specifically, a reduction in hospital-acquired infections and reduced lengths of stay, may further decrease the burden on an overwhelmed health care system.

Therefore, health care leaders and clinicians are urged and called on to immediately champion change and improve their institutional infrastructure and processes to ensure the following:

**Identify, Evaluate, and Treat Iron Deficiency and Anemia in Both Medical and Surgical Patients With Appropriate Pharmacological Agents**

In 2015, a total of 2.36 billion people or 32% of the world population were affected by anemia, representing the most prevalent of all impairments globally. In >60% of all cases, iron deficiency was the cause of anemia. However, the prevalence of anemia in hospitalized patients is significantly higher than in the general population and can reach up to 75% in specific surgical populations. Anemia is associated with increased blood utilization, worse patient outcomes, and increased morbidity and mortality in surgical and medical patients of all ages.

Prevention, early diagnosis, and prompt treatment directed by the etiology of anemia can decrease blood utilization and improve patient outcomes. Iron deficiency, with and without anemia, is common and is associated with increased mortality in cardiac surgery and may be treated with oral or intravenous iron supplementation. Oral therapy is often poorly tolerated, has a slower onset of action than intravenous iron, and is insufficient to correct iron deficiency in the presence of ongoing bleeding. Intravenous iron therapy is preferred for those with intolerance to oral therapy, severe anemia (ie, hemoglobin < 10 g/dL), or planned surgical procedures or obstetrical delivery within 6 weeks. There are many formulations that allow for rapid, safe, and complete correction of iron deficiency. Women and adolescent girls presenting for obstetrical care or with...
As folate and vitamin B12, may, in many cases, be correlated to other nutritional deficiencies, such as iron deficiency. Severe iron deficiency must be offered intravenous iron supplementation. Menorrhagia to emergency medicine departments with severe iron deficiency should be offered intravenous iron to mitigate the risk of a preventable transfusion.

Anemia related to other nutritional deficiencies, such as folate and vitamin B12, may, in many cases, be corrected with oral therapy, with both folate and vitamin B12 typically dosed at 1 mg daily.

Erythropoiesis-stimulating agents (ESAs) are exogenous forms of erythropoietin, including epoetin alfa, the longer-acting darbepoetin alfa, and other emerging ESAs, which may be used to stimulate erythropoiesis. While ESAs are often used in the long-term management of anemia in patients with chronic kidney disease and chemotherapy-induced bone marrow suppression, there has been increasing expansion to short-term use in those with preoperative anemia, particularly when anemia is deemed secondary to anemia of inflammation. In preoperative patients and in the critically ill, ESA utilization with either 100,000 units of epoetin alfa, 300,000 units of darbepoetin alfa, or 600/kg of recombinant human erythropoietin, may, in many cases, be corrected with oral therapy, with both folate and vitamin B12 typically dosed at 1 mg daily.

Erythropoiesis-stimulating agents (ESAs) are exogenous forms of erythropoietin, including epoetin alfa, the longer-acting darbepoetin alfa, and other emerging ESAs, which may be used to stimulate erythropoiesis. While ESAs are often used in the long-term management of anemia in patients with chronic kidney disease and chemotherapy-induced bone marrow suppression, there has been increasing expansion to short-term use in those with preoperative anemia, particularly when anemia is deemed secondary to anemia of inflammation.

In preoperative patients and in the critically ill, ESA utilization with either 100,000 units weekly in the intensive care unit (ICU) or 600/kg in the preoperative period results in higher hemoglobin concentrations and reduced transfusion utilization.

Identify and Rapidly Address Coagulation/Hemostatic Issues Perioperatively

Coagulopathy, when not promptly recognized and corrected, can perpetuate a cycle of bleeding, blood utilization, and patient morbidity. There are several evidence-based strategies available for appropriate management of coagulopathy. Point-of-care viscoelastic testing, including thromboelastography and rotational thromboelastometry, facilitates near real-time identification of coagulation abnormalities, thereby allowing rapid and targeted correction of the impaired pathway, rather than relying on unguided administration of plasma and platelets.

Transfusion therapies can often be avoided altogether by the utilization of clotting factors such as prothrombin complex concentrates or fibrinogen concentrate. In addition to transfusion-sparing effects, clotting factors also decrease the risk of transfusion-related complications, such as transfusion-related acute lung injury (TRALI) and transfusion-associated circulatory overload (TACO), the leading causes of transfusion-related morbidity and mortality. Antifibrinolytic agents, including tranexamic acid and episilon amino-caproic acid, are widely available, inexpensive, highly effective, and safe pharmacological agents that may be used to stabilize clot formation and prevent hyperfibrinolysis. The use of these agents has consistently been associated with bleeding reduction, transfusion reduction, and improved outcomes across numerous surgical procedures and in trauma settings.

Use All Effective Blood Conservation Methods in Both Medical and Surgical Patients

There are numerous modalities available for perioperative blood conservation. These include avoiding hemodilution, restrictive transfusion strategies for all types of allogeneic blood components, optimizing physiological response to anemia, early treatment of coagulopathy, and the use of topical hemostatic agents. Cell salvage, which involves the collection of a patient’s own blood loss, filtering and washing to ensure the removal of impurities, and direct return of the autologous component to the patient, is associated with reductions in allogeneic blood component
Role of PBM in Pandemics

utilization. Therefore, it is recommended for all procedures with moderate-to-large volume blood loss.28,90

Acute normovolemic hemodilution (ANH) is a process by which a controlled volume of a patient’s own blood is removed before the surgical insult followed by replacement with crystalloids or colloids.91 In adults, this results in less red blood cell loss during the surgical procedure and allows for the reinfusion of autologous blood, rich in red blood cells, platelets, and clotting factors, when it is needed intraoperatively or postoperatively.92 ANH provides autologous fresh whole blood or can be sequestered to deliver red blood cells, plasma, or platelets as needed, but its use is more likely to be beneficial in procedures with significant blood loss. ANH should thus be considered on a case-by-case basis.

For both medical and surgical patients, it is also essential to limit iatrogenic blood loss. Most often this occurs through diagnostic phlebotomy. Methods to reduce iatrogenic blood loss include the minimization of unnecessary blood sampling, the use of pediatric small vacuum blood draws, which allow for testing on hospital automated chemistry lines, and the employment of closed-loop sampling devices.30

Carefully Monitor Patients’ Condition After Surgery and Rapidly Intervene by Either Interventional Radiology or Endoscopy for Unexpected Bleeding Depending on the Source

Bleeding postoperatively and postobstetrical delivery are common and are associated with increased resource utilization and worse clinical outcomes. Therefore, it is essential that all patients receive serial evaluation for bleeding, including assessments of drain output, frequent monitoring for hemodynamic status, and physical examination. In patients with suspected bleeding or coagulopathy, point-of-care viscoelastic testing and hemoglobin assessments may be used for the rapid identification of bleeding and coagulation abnormalities, as well as the rapid employment of surgical and interventional radiology intervention to immediately achieve source control.

Thoroughly Inform and Educate Medical Professionals, Patients, and Their Caregivers on the Importance of PBM; Involve Patients in Treatment and Management Decisions and Obtain Formal Consent

It is important to involve these key stakeholders in the decision-making process and let them know that their well-being and the health of their loved ones are at the center of this comprehensive effort. Patients who are chronically transfused need prompt and frequent messaging to reassure them that all efforts are being deployed to maintain their access to transfusion. Difficult decisions will need to be made for patients requiring massive transfusion for traumatic injury, gastrointestinal bleeding, and cardiovascular surgery—all with a very poor chance of short- and long-term survival. Transfusing multiple units of blood components to a single patient is not only associated with high morbidity and mortality, but such massive transfusions could also compromise the transfusion support for many other patients in need.93

CONCLUSIONS

Faced with the substantial challenges during the COVID-19 pandemic that has left no one worldwide safe or unaffected, medical contributions—large or small—are urgently needed to provide the optimal and most compassionate care while using every modality to conserve resources. Appropriate resource conservation will allow for better allocation to those patients in absolute need. The authors of this “Call for Action” document represent diverse backgrounds and specialties, yet they come together with a cohesive message, underscoring “The Essential Role of Patient Blood Management in the Management of Pandemics” and urging all to implement the practical and commonsense principles of PBM and its multi-professional and multimodality approaches.

CONTRIBUTORS

This manuscript is prepared and presented on behalf of the International Foundation of Patient Blood Management (IFPBM) and Society for the Advancement of Blood Management (SABM) Work Group. All members of the work groups are also authors of the manuscript and they include Aryeh Shander, Susan M. Goobie, Matti Aapro, Elvira Bisbe, Melissa M. Cushing, Wayne B. Dyer, Jochen Erhard, Shannon Farmer, Bernd Froessler, Hans Gombotz, Irwin Gross, Thorsten Haas, Jeffrey Hamendorf, James P. Isbister, Hongwn Ji, Young-Woo Kim, Sigismund Lasocki, Michael F. Leahy, Jeong Jae Lee, Jens Meier, Sherri Ozawa, Marco Pavesi, Donat R. Spahn, Bruce D. Spiess, Kevin Trentino, Christoph Zener, and Axel Hofmann for IFPBM and Aryeh Shander, Susan Marie Goobie, Melissa M. Cushing, Steven M. Frank, Irwin Gross, Nicole R. Guinn, Daryl J. Kor, Sherri Ozawa, Bruce D. Spiess, and Axel Hofmann for SABM.

DISCLOSURES

Name: Aryeh Shander, MD.

Contribution: This author helped initiate the call for action, develop the first draft and Anemia, Blood loss and Coagulopathy (ABC) Toolbox for patient blood management (PBM), critically revise the draft, and approve the final version to be published.

Conflicts of Interest: A. Shander has been a consultant to Masimo Corp, Viñor, Octapharma, CSL Behring, HBO2 Therapeutics, Daiichi, Griffols, and Baxter and a speaker for Merck.

Name: Susan M. Goobie, MD.

Contribution: This author helped develop the first draft and ABC Toolbox for PBM, critically revise the draft, and approve the final version to be published.
Conflicts of Interest: S. M. Goobie is a PBM executive section editor for Anesthesia & Analgesia (A&A), has served as a scientific data safety and monitoring chair for an Octapharma trial, has been a sponsored speaker for Masimo, and was a scientific advisory consultant for Haemonetics.
Name: Matthew A. Warner, MD.
Contribution: This author helped develop the first draft, critically revise the draft, and approve the final version to be published.
Conflicts of Interest: None.

Name: Matti Aapro, MD.
Contribution: This author helped critically revise the draft and approve the final version to be published.
Conflicts of Interest: M. Aapro has received consulting fees from Vifor Pharma.
Name: Elvira Bisbe, MD, PhD.
Contribution: This author helped critically revise the draft and approve the final version to be published.
Conflicts of Interest: E. Bisbe has received honoraria for lectures and/or travel support from Vifor Pharma, OM-Pharma, Takeda, Sysmex, and Zambon.
Name: Angel A. Perez-Calatayud, MD.
Contribution: This author helped identify additional references, critically revise the draft, and approve the final version to be published.
Conflicts of Interest: A. A. Perez-Calatayud has received honoraria from LFB Biomédicaments, Octapharma, IL-Werfen, Cheetah Medical, Baxter, Vifor, and Takeda.
Name: Jeannie Callum, MD.
Contribution: This author helped critically revise the draft and approve the final version to be published.
Conflicts of Interest: J. Callum has received research support from Canadian Blood Services, Canadian Institute for Health Research, CSL Behring, and Octapharma.
Name: Melissa M. Cushing, MD.
Contribution: This author helped critically revise the draft and approve the final version to be published.
Conflicts of Interest: M. M. Cushing has received honoraria from Cerus and Octapharma for consulting.
Name: Wayne B. Dyer, PhD.
Contribution: This author helped critically revise the draft and approve the final version to be published.
Conflicts of Interest: W. B. Dyer has been an employee of the Australian Red Cross Lifeblood.
Name: Jochen Erhard, MD.
Contribution: This author helped critically revise the draft and approve the final version to be published.
Conflicts of Interest: J. Erhard has received honoraria for lecturing from Vifor.
Name: David Faraoni, MD, PhD.
Contribution: This author helped critically revise the draft and approve the final version to be published.
Conflicts of Interest: None.
Name: Shannon Farmer, MBS.
Contribution: This author helped develop the ABC Toolbox for PBM, critically revise the draft, and approve the final version to be published.
Conflicts of Interest: S. Farmer has received travel and meeting support from National Blood Authority (Australia).
Name: Tatyana Fedorova, PhD.
Contribution: This author helped critically revise the draft and approve the final version to be published.
Conflicts of Interest: None.
Name: Steven M. Frank, MD.
Contribution: This author helped critically revise the draft and approve the final version to be published.
Conflicts of Interest: None.

Name: Ange A. Perez-Calatayud, MD.

Name: Takeda, Sysmex, and Zambon.

Name: Elvira Bisbe, MD, PhD.

Name: None.

Name: Matthew A. Warner, MD.

Name: Matti Aapro, MD.

Name: None.

Name: Irwin Gross, MD.

Name: None.

Name: Hongwen Ji, MD.

Name: Steven M. Frank, MD.

Name: Joanne Kurz, PhD.

Name: D. J. Kor is on the Scientific Advisory Board with Terumo Medical Corporation, Consultant with Instrumentation Laboratory, UpToDate, Consultant at the National Institutes of Health (NIH), and received grant funding from NIH.

Name: Johann Kurz, PhD.

Name: James P. Isbister, MD.

Name: Jeffrey Hamdorf, MD, PhD.

Name: Mazyar Javidroozi, MD, PhD.

Name: Young-Woo Kim, MD.

Name: Sigismond Lasocki, MD, PhD.
Role of PBM in Pandemics

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: S. Lasocki is a consultant for Vifor Pharma; has been a sponsored speaker for Masimo, Vifor, and Pfizer; was a scientific advisory consultant for i-SEP; and was the investigator coordinator of the Hip Fracture: Iron and Tranexamic Acid (HiFIT) study, for which Pharmacosmos gives iron for free.

Name: Michael F. Leahy, MBChB.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: None.

Name: Cheuk-Kwong Lee, MD.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: None.

Name: Jeong Jae Lee, MD, PhD.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: None.

Name: Vernon Louw, MBChB, PhD.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: V. Louw received honoraria and/or travel support and/or grant funding from the following: Acino, Austell, Novartis Oncology, Pharmacosmos, Takeda, and Vifor. He serves as a nonexecutive director on the Board of the Western Cape Blood Service.

Name: Jens Meier, MD.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: None.

Name: Anna Mezzacasa, PhD.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: A. Mezzacasa is an employee of Vifor Pharma.

Name: Manuel Munoz, MD, PhD.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: M. Munoz received honoraria for consultancy and/or lectures from Pharmacosmos, PharmaNutra, Vifor Pharma, Zambon, and Celgene.

Name: Sherri Ozawa, RN.

Contribution: This author helped develop the ABC Toolbox for PBM, critically revise the draft, and approve the final version to be published.

Conflicts of Interest: None.

Name: Marco Pavesi, MD.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: None.

Name: Nina Shander, BS.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: None.

Name: Donat R. Spahn, MD.

Contribution: This author helped identify additional references, critically revise the draft, and approve the final version to be published.

Conflicts of Interest: D. R. Spahn has received honoraria and travel support for consulting or lecturing from Danube University of Krems, Krems an der Donau, Austria; European Society of Anesthesiology, Brussels, Belgium; Bayer Pharma AG, Berlin, Germany; B. Braun Melsungen AG, Melsungen, Germany; CSL Behring GmbH, Hattersheim am Main, Germany and Bern, Switzerland; Daiichi Sankyo AG, Thalwil, Switzerland; Haemonetics, Braintree, Massachusetts; Instrumentation Laboratory (Werfen), Bedford, Massachusetts; LFB Biomédicaments, Courtaboeuf Cedex, France; Octapharma AG, Lachen, Switzerland; PAION Deutschland GmbH, Aachen, Germany; Pharmacosmos A/S, Holbaek, Denmark; Pierre Fabre Pharma, Allschwil, Switzerland; Vifor Pharma, Munich, Germany, Vienna, Austria, and Villars-sur-Glâne, Switzerland; Vifor (International) AG, St Gallen, Switzerland; and Zuellig Pharma Holdings, Singapore. His academic department is receiving grant support from the Swiss National Science Foundation, Berne, Switzerland; the Swiss Society of Anesthesiology and Reanimation (SGAR), Berne, Switzerland; the Swiss Foundation for Anesthesia Research, Zurich, Switzerland; and Vifor SA, Villars-sur-Glâne, Switzerland. He is a co-chair of the ABC-Trauma Faculty, sponsored by unrestricted educational grants from Novo Nordisk Health Care AG, Zurich, Switzerland; CSL Behring GmbH, Marburg, Germany; LFB Biomédicaments, Courtaboeuf Cedex, France; and Octapharma AG, Lachen, Switzerland.

Name: Bruce D. Spiess, MD.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: B. D. Spiess was a paid consultant to HemoSonic.

Name: Jackie Thomson, MBChB.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: None.

Name: Kevin Trentino, MPH.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: None.

Name: Christoph Zenger, PhD.

Contribution: This author helped critically revise the draft and approve the final version to be published.

Conflicts of Interest: None.

Name: Axel Hofmann, Dr.rer.med.

Contribution: This author helped initiate the call for action, develop the first draft and ABC Toolbox for PBM, critically revise the draft, and approve the final version to be published.

Conflicts of Interest: A. Hofmann has received honoraria and/or travel support from IL-Werfen, Celgene, G1 Therapeutics, Vifor, and Takeda.

This manuscript was handled by: Thomas R. Vetter, MD, MPH.

REFERENCES

1. Schmidt PJ. Blood and disaster–supply and demand. N Engl J Med. 2002;346:617–620.
2. Zaheer HA, Waheed U. Blood transfusion service in disasters. Transfus Apher Sci. 2016;55:186–190.
3. Landro L. New flu victim: blood supply. The Wall Street Journal. November 10, 2009. Available at: https://www.wsj.com/articles/SB10001424052748703808904574525570410593800. Accessed April 9, 2020.
4. Maintaining a safe and adequate blood supply during pandemic influenza: guidelines for blood transfusion services. Geneva, Switzerland: World Health Organization; 2011. Available at: https://www.who.int/bloodsafety/publications/WHO_Guidelines_on_Pandemic_Influenza_and_Blood_Supply.pdf. Accessed April 9, 2020.
5. New York Blood Center expands capacity at donors centers; urges healthy donors to schedule appointments to maintain blood supply at this critical time. New York, NY: New York Blood Center; March 19, 2020. Available at: https://nybloodcenter.org/news/articles/new-york-blood-center-expands-capacity-donors-cen-
ters-urges-healthy-donors-schedule-appointments-main-
tain-blood-supply-critical-time/. Accessed March 25, 2020.
6. McCauley D. Morrison launches COVID-19 Coordination
Commission, cancels non-urgent surgery. The Sydney
Morning Herald. March 25, 2020. Available at: https://www.
smh.com.au/politics/federal/morrison-launches-covid-
19-coordination-commission-cancels-non-urgent-surgery-
20200325-p54dpx.html. Accessed on April 9, 2020.
7. Chang L, Yan Y, Wang L. Coronavirus Disease 2019:
coronaviruses and blood safety. Transfus Med Rev.
2020;50:887–7963(20):30014–30016.
8. AABB Interorganizational Task Force on Domestic Disasters
and Acts of Terrorism. Statement on Coronavirus and Blood
Donation. AABB (Advancing Transfusion and Cellular
Therapies Worldwide). Available at: www.aabb.org/
advocacy/regulatorygovernment/Pages/Statement-on-
Coronavirus-and-Blood-Donation.aspx. Accessed March
23, 2020.
9. Hofmann A, Farmer S, Shander A. Five drivers shifting
the paradigm from product-focused transfusion practice
to patient blood management. Oncologist. 2011;16(suppl
3):3–11.
10. Spahn DR, Munoz M, Klein AA, Levy JH, Zacharowski K.
Patient blood management: effectiveness and future poten-
tial. Anesthesiology. 2020 February 24 [Epub ahead of print].
11. Kotter JP. Leading Change. Boston, MA: Harvard Business
School Press; 1996.
12. Kotter JP, Cohen D. The Heart of Change. Boston, MA:
Harvard Business School Press; 2002.
13. Gombotz H, Hofmann A, Nørgaard A, Kastner P.
Supporting Patient Blood Management (PBM) in the EU - A Practical
Implementation Guide for Hospitals. Luxembourg: European
Commission - Directorate-General for Health and Food
Safety; 2017.
14. Patient Blood Management Guidelines: Module 1 - Critical
Bleeding / Massive Transfusion. Canberra, Australia: National Blood Authority; 2011. Available at: http://www.
blood.gov.au/pbm-module-1. Accessed April 9, 2020.
15. Patient Blood Management Guidelines: Module 2 - Perioperative. Canberra, Australia: National Blood Authority; 2012. Available at: http://www.blood.gov.au/
pbm-module-2. Accessed April 9, 2020.
16. Patient Blood Management Guidelines: Module 3 - Medical.
Canberra, Australia: National Blood Authority; 2012. Available at: http://www.blood.gov.au/pbm-module-3.
Accessed April 9, 2020.
17. Patient Blood Management Guidelines: Module 4 - Critical.
Care. Canberra, Australia: National Blood Authority; 2012. Available at: http://www.blood.gov.au/pbm-module-4.
Accessed April 9, 2020.
18. Patient Blood Management Guidelines: Module 5 - Obstetrics. Canberra, Australia: National Blood Authority; 2015. Available at: https://www.blood.gov.au/pbm-mod-
ule-5. Accessed April 9, 2020.
19. Patient Blood Management Guidelines: Module 6 - Neonatal and Paediatrics. Canberra, Australia: National Blood Authority; 2017. Available at: https://www.blood.
gov.au/patient-blood-management-pbm. Accessed April 9, 2020.
20. Goobie SM, Gallagher T, Gross I, Shander A. Society for
the Advancement of Blood Management Administrative
and Clinical Standards for Patient Blood Management
Programs, 4th Edition (Pediatric Version). Paediatr Anaesth.
2019;29:231–236.
21. Kozek-Langenecker SA, Ahmed AB, Afshari A, et al.
Management of severe perioperative bleeding: guidelines
from the European Society of Anaesthesiology: First update
2016. Eur J Anaesthesiol. 2017;34:332–395.
22. Shaylor R, Weingier CF, Austin N, etc. National and
International Guidelines for Patient Blood Management
in Obstetrics: a qualitative review. Anesth Analg.
2017;124:216–232.
23. Hofmann A, Nørgaard A, Kurz J, etc. Building National
Programmes of Patient Blood Management (PBM) in the EU
- A Guide for Health Authorities. Luxembourg: European
Commission - Directorate-General for Health and Food
Safety; 2017.
24. Weber CF, Görlinger K, Meiningher D, etc. Point-of-care
testing: a prospective, randomized clinical trial of efficacy
in coagulopathic cardiac surgery patients. Anesthesiology.
2012;117:531–547.
25. Deppe AC, Weber C, Zimmermann J, etc. Point-of-care
thromboelastography/thromboelastometry-based coag-
ulation management in cardiac surgery: a meta-analysis of
8332 patients. J Surg Res. 2016;203:424–433.
26. Karkouti K, Callum J, Wijeysundera DN, etc; TACS
Investigators. Point-of-care hemostatic testing in cardiac
surgery: a stepped-wedge clustered randomized controlled
trial. Circulation. 2016;134:1152–1162.
27. Kaserer A, Kiavialaitis GE, Braun J, etc. Impact of rivaroxa-
ban plasma concentration on perioperative red blood cell
loss. Transfusion. 2020;60:197–205.
28. Klein AA, Bailey CR, Charlton AJ, et al. Association of
anaesthesists guidelines: cell salvage for peri-operative
blood conservation. 2018. Anaesthesia. 2018;73:1141–1150.
29. Zhou X, Zhang C, Wang Y, Yu L, Yan M. Preoperative
acute normovolemic hemodilution for minimizing allo-
geneic blood transfusion: a meta-analysis. Anesth Analg.
2015;121:1443–1455.
30. Warner MA, Shore-Lesserson L, Shander A, Patel SY,
Perelman SI, Guinn NR. Perioperative anemia: prevention,
diagnosis, and management throughout the spectrum of
perioperative care. Anesth Analg. 2020;130:1364–1380.
31. von Haehling S, Ebnner N, Evertz R, Ponikowski P, Anker
SD. Iron deficiency in heart failure: an overview. JACC Heart
Fail. 2019;7:36–46.
32. Weiss G, Goodnough LT. Anemia of chronic disease. N Engl
J Med. 2005;352:1011–1023.
33. Camasschella C. Iron deficiency: new insights into diagnosis
and treatment. Hematol Am Soc Hema Enduc Program.
2015;2015:8–13.
34. Devalia V, Hamilton MS, Molloy AM; British Committee
for Standards in Haematology. Guidelines for the diagno-
sis and treatment of cobalamin and folate disorders. Br J
Hematol. 2016;164:496–513.
35. Green R. Vitamin B12 deficiency from the perspective of a
practicing hematologist. Blood. 2017;129:2603–2611.
36. Goobie SM, Faroain D. Tranexamic acid and perioperative
bleeding in children: what do we still need to know? Curr
Opin Anaesthesiol. 2019;32:343–352.
37. Lier H, Maegle M, Shander A. Tranexamic acid for acute
hemorrhage: a narrative review of landmark studies and a
critical reappraisal of its use over the last decade. Anesth
Analg. 2019;129:1574–1584.
38. Pavenski K, Ward SE, Hare GMT, etc. A rationale for
universal tranexamic acid in major joint arthroplasty:
overall efficacy and impact of risk factors for transfusion.
Transfusion. 2019;59:207–216.
39. Ker K, Prieto-Merino D, Roberts I. Systematic review, meta-
analyses and meta-regression of the effect of tranexamic
acid on surgical blood loss. Br J Surg. 2013;100:1271–1279.
40. Lin DM, Murphy LS, Tran MH. Use of prothrombin complex concentrates and fibrinogen concentrates in the perioperative setting: a systematic review. Transfus Med Rev. 2013;27:91–104.

41. Beris P, Muñoz M, García-Erce JA, Thomas D, Maniatis A, Van der Linden P. Perioperative anaemia management: consensus statement on the role of intravenous iron. Br J Anaesth. 2008;100:599–604.

42. Shander A, Javidroozi M, Ashton ME. Drug-induced anemia and other red cell disorders: a guide in the age of polypharmacy. Curr Clin Pharmacol. 2011;6:295–303.

43. Mikhail A, Brown C, Williams JA, et al. Renal association clinical practice guideline on anaemia of chronic kidney disease. BMC Nephrol. 2017;18:345.

44. Macdougall IC, Canaud B, de Francisco AL, et al. Beyond iron deficiency. Haematologica. 2016;101:1319–1325.

45. Mazer CD, Whitlock RP, Fergusson DA, et al; TRICS Investigators and Perioperative Anesthesia Clinical Trials Group. 2018;19:884–898.

46. Valentine SL, Bembea MM, Muszynski JA, et al; Pediatric Acute Lung Injury and Sepsis Investigators (TAXI); Pediatric Critical Care Blood Research Network (BloodNet), and the Pediatric Acute Lung Injury and Sepsis Investigators (TAXI). Consensus recommendations for RBC transfusion practice in critically ill children from the pediatric critical care transfusion and anaemia expertise initiative. Pediatr Crit Care Med. 2018;19:968–976.

47. Koch CG, Reineks EZ, Tang AS, et al. Contemporaneous bloodletting in cardiac surgical care. Ann Thorac Surg. 2015;99:779–784.

48. Valentine SL, Bembea MM, Muszynski JA, et al; Pediatric Critical Care Transfusion and Anemia Expertise Initiative (TAXI); Pediatric Critical Care Blood Research Network (BloodNet), and the Pediatric Acute Lung Injury and Sepsis Investigators (PALISI) Network. Consensus recommendations for RBC transfusion practice in critically ill children from the pediatric critical care transfusion and anaemia expertise initiative. Pediatr Crit Care Med. 2018;19:884–898.

49. Mazer CD, Whitlock RP, Fergusson DA, et al; TRICS Investigators and Perioperative Anesthesia Clinical Trials Group. Restrictive or liberal red-cell transfusion for cardiac surgery. N Engl J Med. 2017;377:2133–2144.

50. Villanueva C, Colomo A, Bosch A, et al. Transfusion strategies for acute upper gastrointestinal bleeding. N Engl J Med. 2013;368:31–21.

51. Holst LB, Haase N, Wetterles J, et al; TRISS Trial Group; Scandinavian Critical Care Trials Group. Lower versus higher hemoglobin threshold for transfusion in septic shock. N Engl J Med. 2014;371:1381–1391.

52. Ma M, Eckert K, Ralley F, Chin-Yee I. A retrospective study evaluating single-unit red blood cell transfusions in reducing allogenic blood exposure. Transfus Med. 2005;15:307–312.

53. Naylor JM, Adie S, Fransen M, Dietsch S, Harris I. Endorsing single-unit transfusion combined with a restrictive haemoglobin transfusion threshold after knee arthroplasty. Qual Saf Health Care. 2010;19:239–243.

54. Berger MD, Gerber B, Arn K, Senn O, Schanz U, Stussi G. Significant reduction of red blood cell transfusion requirements by changing from a double-unit to a single-unit transfusion policy in patients receiving intensive chemotherapy or stem cell transplantation. Haematologica. 2012;97:116–122.

55. Warner R, Mediratta N, Chalmers J, et al. Is single-unit blood transfusion post-coronary artery bypass surgery? Interact Cardiovasc Thorac Surg. 2013;16:765–771.

56. Mukhtar SA, Leahy MF, Koay K, et al. Effectiveness of a patient blood management data system in monitoring blood use in Western Australia. Anaesth Intensive Care. 2013;41:207–215.

57. Trentino KM, Swain SG, Geelhoed GC, Daly FF, Leahy MF. Interactive patient blood management dashboards used in Western Australia. Transfusion. 2016;56:3140–3141.

58. Sazama K. The ethics of blood management. Vox Sang. 2007;92:95–102.

59. Spahn DR, Bouillon B, Cerny V, et al. The European Guideline on Management of Major Bleeding and Coagulopathy Following Trauma: Fifth Edition. Crit Care. 2019;23:58.

60. Boer C, Meesters MJ, Milojevic M, et al; Task Force on Patient Blood Management for Adult Cardiac Surgery of the European Association for Cardio-Thoracic Surgery and the European Association of Cardiothoracic Anaesthesiology (EACTA). 2017 EACTS/EACTA guidelines on patient blood management for adult cardiac surgery. J Cardiothorac Vasc Anesth. 2018;32:88–120.

61. Aapro M, Beguin Y, Boekemeyer C, et al; ESMO Guidelines Committee. Management of anaemia and iron deficiency in patients with cancer: ESMO Clinical Practice Guidelines. Ann Oncol. 2018;29:v1271.

62. Pavord S, Myers B, Robinson S, Allard S, Strong J, Oppenheimer C; British Committee for Standards in Haematology. UK guidelines on the management of iron deficiency in pregnancy. Br J Haematol. 2012;156:588–600.

63. Muñoz M, Peña-Rosas JP, Robinson S, et al. Patient blood management in obstetrics: management of anaemia and haematric deficiencies in pregnancy and in the postpartum period: NATA consensus statement. Transfus Med. 2018;28:22–29.

64. Faraoni D, Meier J, New HV, Van der Linden PJ, Hunt BJ. Patient blood management for neonates and children undergoing cardiac surgery: 2019 NATA Guidelines. J Cardiothorac Vasc Anesth. 2019;33:3249–3263.

65. SABM Administrative and Clinical Standards for Patient Blood Management Programs. 4th ed. Englewood, NJ: Society for the Advancement of Blood Management; 2017. Available at: https://www.sabm.org/publications/. Accessed April 9, 2020.

66. Leahy MF, Hofmann A, Tolwer S, et al. Improved outcomes and reduced costs associated with a health-system-wide patient blood management program: a retrospective observational study in four major adult tertiary-care hospitals. Transfusion. 2017;57:1347–1358.

67. Keding V, Zacharowski K, Bechstein WO, Meybohm P, Schnitzbauer AA. Patient blood management improves outcomes in oncologic surgery. World J Surg Oncol. 2018;16:159.

68. Schlüer F, Cervulo M, Eijaz A, et al. Implementation of a blood management program at a tertiary care hospital: effect on transfusion practices and clinical outcomes among patients undergoing surgery. Ann Surg. 2019;269:1073–1079.

69. Froessler B, Palm P, Weber I, Hodyl NA, Singh R, Murphy EM. The important role for intravenous iron in perioperative patient blood management in major abdominal surgery: a randomized controlled trial. Ann Surg. 2016;264:41–46.

70. Khalafallah AA, Yan C, Al-Badri R, et al. Intravenous ferric carboxymaltose versus standard care in the management of postoperative anaemia: a prospective, open-label, randomised controlled trial. Lancet Haematol. 2016;3:e415–e425.

71. Spahn DR, Schoenrath F, Spahn GH, et al. Effect of ultra-short-term treatment of patients with iron deficiency or anaemia undergoing cardiac surgery: a prospective randomised trial. Lancet. 2019;393:2201–2212.

72. Allhoff FC, Neb H, Herrmann E, et al; Multimodal patient blood management program based on a three-pillar strategy: a systematic review and meta-analysis. Ann Surg. 2019;269:794–804.
73. WHO action framework to advance universal access to safe, effective and quality assured blood products 2020–2023. World Health Organization. February 19, 2020. Available at: https://www.who.int/news-room/detail/19-02-2020-who-action-framework-to-advance-universal-access-to-safe-effective-and-quality-assured-blood-products-2020–2023. Accessed April 9, 2020.

74. Maintaining a safe and adequate blood supply during the pandemic outbreak of coronavirus disease (COVID-19). World Health Organization. March 20, 2020. Available at: https://www.who.int/publications-detail/maintaining-a-safe-and-adequate-blood-supply-during-the-pandemic-outbreak-of-coronavirus-disease-(covid-19). Accessed March 24, 2020.

75. Muñoz M, Acheson AG, Auerbach M, et al. International consensus statement on the peri-operative management of anaemia and iron deficiency. *Anaesthesia*. 2017;72:233–247.

76. Shander A, Goodnough LT. From tolerating anemia to treating anemia. *Ann Intern Med*. 2019;170:125–126.

77. Vos T, Allen C, Arora M, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet*. 2016;388:1545–602.

78. Muñoz M, Gómez-Ramírez S, Kozek-Langeneker S, et al. “Fit to fly”: overcoming barriers to preoperative haemoglobin optimization in surgical patients. *Br J Anaesth*. 2015;115:15–24.

79. Goobie SM, Faraoni D, Zurakowski D, DiNardo JA. Association of preoperative anemia with postoperative mortality in neonates. *JAMA Pediatr*. 2016;180:855–862.

80. Fowler AJ, Ahmad T, Abbott TEF, et al; International Surgical Outcomes Study Group. Association of preoperative anaemia with postoperative morbidity and mortality: an observational cohort study in low-, middle-, and high-income countries. *Br J Anaesth*. 2018;121:1227–1235.

81. Rössler J, Schoenrath F, Seifert B, et al. Iron deficiency is associated with higher mortality in patients undergoing cardiac surgery: a prospective study. *Br J Anaesth*. 2020;124:25–34.

82. Khadadah F, Callum J, Shelton D, Lin Y. Improving quality of care for patients with iron deficiency anemia presenting to the emergency department. *Transfusion*. 2018;58:1902–1908.

83. Froessler B, Gagic T, Dekker G, Hodyl NA. Treatment of iron deficiency and iron deficiency anaemia with intravenous ferric carboxymaltose in pregnancy. *Arch Gynecol Obstet*. 2018;298:75–82.

84. Wikkelsø A, Wetterslev J, Møller AM, Afshari A. Thromboelastography (TEG) or rotational thromboelastometry (ROTEM) to monitor haemostatic treatment in bleeding patients: a systematic review with meta-analysis and trial sequential analysis. *Anaesthesia*. 2017;72:519–531.

85. Dias JD, Sauaia A, Achnick HE, Hartmann J, Moore EE. Thromboelastography-guided therapy improves patient blood management and certain clinical outcomes in elective cardiac and liver surgery and emergency resuscitation: a systematic review and analysis. *J Thromb Haemost*. 2019;17:984–994.

86. Tanaka KA, Mazzetti M, Durula M. Role of prothrombin complex concentrate in perioperative coagulation therapy. *J Intensive Care*. 2014;2:60.

87. Stein P, Kasner A, Sprengel K, et al. Change of transfusion and treatment paradigm in major trauma patients. *Anaesthesia*. 2017;72:1317–1326.

88. Sadana D, Pratzer A, Scher LJ, et al. Promoting high-value practice by reducing unnecessary transfusions with a patient blood management program. *JAMA Intern Med*. 2018;178:116–122.

89. Steinbicker AU, Wittenmeier E, Goobie SM. Pediatric non-red cell blood product transfusion practices: what’s the evidence to guide transfusion of the “yellow” blood products? *Curr Opin Anaesthesiol*. 2020;33:259–267.

90. Carless PA, Henry DA, Moxey AJ, O’Connell D, Brown T, Fergusson DA. Cell salvage for minimising perioperative allogeneic blood transfusion. *Cochrane Database Syst Rev*. 2010:CD001888.

91. Kreimeier U, Messmer K. Hemodilution in clinical surgery: state of the art 1996. *World J Surg*. 1996;20:1208–1217.

92. Barile L, Fominskiy E, Di Tomasso N, et al. Acute normovolemic hemodilution reduces allogeneic red blood cell transfusion in cardiac surgery: a systematic review and meta-analysis of randomized trials. *Anesth Analg*. 2017;124:743–752.

93. Johnson DJ, Scott AV, Barodka VM, et al. Morbidity and mortality after high-dose transfusion. *Anesthesiology*. 2016;124:387–395.