How do I implement a hospital-based blood management program?

Mark H. Yazer and Jonathan H. Waters

Transfusion of blood products is a lifesaving therapeutic intervention in many clinical settings. There are, however, certain risks associated with these products ranging from hemolysis caused by the misadministration of a unit, to lung injury, to bacterial contamination. To avoid all of these risks of transfusion, one must simply avoid all transfusions. While few would advocate this radical strategy, the wide variety in transfusion practice that exists suggests that suboptimal patient care is occurring as both over- and underuse of blood products can be problematic. Recognizing the overuse, the University of Pittsburgh Medical Center (UPMC), a network of 12 hospitals in western Pennsylvania, has been implementing a six-point plan to reduce the use of allogeneic blood products for all patients. This plan is known as total blood management (TBM) and it represents a strategy aimed at improving and streamlining the diagnosis and management of anemia, thrombocytopenia, and coagulopathy with a focus on reducing or eliminating allogeneic transfusions. This TBM task force has representation from the transfusion service, anesthesiology, perfusion, as well as a "change specialist" from UPMC's Quality and Innovations Institute. The inclusion of the change specialist was particularly important as she acts as a liaison between the TBM task force and UPMC executives and others who have the power to implement the task force's recommendations. In this report, we describe the specific aims of our TBM plan as a framework to be used by those considering implementing a hospital-based blood management strategy.

ABBREVIATIONS: INR(s) = international normalized ratio(s); OR(s) = operating room(s); PAD = preoperative autologous donation; POA = perioperative autotransfusion; POC = point of care; TBM = total blood management; THA(s) = total hip arthroplasty(-ies); UPMC = University of Pittsburgh Medical Center.

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TRANSFUSION **;**:**-**.

IMPLEMENTATION OF EVIDENCE-BASED TRANSFUSION TRIGGERS

The topic of evidence-based transfusion triggers is vast and many reports have described the optimal use of blood products in various medical and surgical patients. From the landmark TRICC trial which demonstrated that even the sickest patients in the intensive care unit who were not undergoing acute cardiac events did not benefit from a liberal red blood cell (RBC) transfusion strategy,[1] to other studies that have demonstrated that prophylactic plasma transfusion for patients with relatively low international normalized ratios (INRs) does not result in significant clinical benefit,[2,3] the optimal use of our blood product resources is becoming clearer. However, it is not sufficient to simply generate this data—the outcomes from these studies must be put into clinical practice. Information on the evolution of knowledge in transfusion medicine is only one of myriad changing aspects of today's cutting edge medical and surgical practice. The question becomes how can we as transfusion medicine specialists disseminate what we know about how to use our products to those who actually use them?

PRESCRIBER EDUCATION AND AUDITS

As part of our blood management strategy, we have made extensive use of the information technology resources available to us at UPMC to assist with both physician education and auditing of transfusion practice. (A more detailed description of transfusion audits can be found in Haspel and Uhl.[4]) Using the computerized physician order entry interface, we have implemented a warning screen that appears when a prescriber attempts to order either RBCs or plasma on a patient whose most recent laboratory

values are in excess of the UPMC recommended transfusion guideline (Figs. 1 and 2). To avoid "warning fatigue" and to be consistent with our hospitals' transfusion guidelines we have selected a hemoglobin (Hb) level of more than 8.5 g/dL and INR of less than 1.6 as the values above and below which, respectively, the warning will appear to inform the prescriber that based on the laboratory values the transfusion does not appear to be indicated. The prescriber can override the warning with a simple mouse click for emergency situations. Although these warning messages are relatively new at UPMC, their effect has been immediate and positive. In a recent review of plasma orders during June 2011, the warning screen appeared 205 times and in 25% of these cases, the order was canceled. We have also had similar results with our RBC warning screen, where in a recent 6-month period ending May 31, 2011, fully 12% of the 5948 non–evidence-based orders were canceled simply by having provided the prescriber with information on the best practice via the warning screen at the time the decision to transfuse was occurring. While the size of the impact might not seem large, for a health system as large as UPMC, this translates to more than $600,000 of savings when annualized over a year. These results are consistent with those seen when enforcement of plasma transfusion guidelines was gradually instituted with increasing levels of scrutiny over the orders that did not meet the guidelines at a tertiary care hospital.[5] Knowing on which patients the warning screen appeared also facilitates the chart reviews performed by the transfusion committees as required by some American regulatory agencies. If the warning screen appeared but the order was not canceled, this suggests either that a clinical emergency was occurring or else that further education of the provider is required. However, the RBC and plasma alerts by themselves are probably not sufficient to eliminate non–guideline-based transfusions. Systemwide, the total number of alerts and the number of canceled orders during August 2011 (1076 and 115, respectively) were nearly identical to the corresponding mean monthly values during December 2010 through May 2011 (991 and 115, respectively). Figure 3 demonstrates these values over the two time periods at three of our high-volume RBC transfusion hospitals. Thus continued provider education and other guideline enforcement modalities appear to be required to optimize transfusion practice.

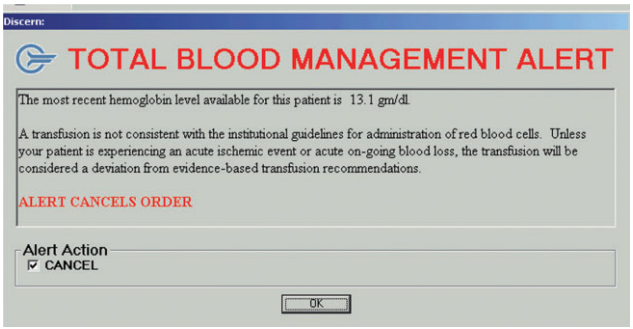

Fig. 1. Example of on-screen warning that appears when a physician at a UPMC hospital attempts to order an RBC unit on a patient whose most recent Hb value suggests that it is not necessary.

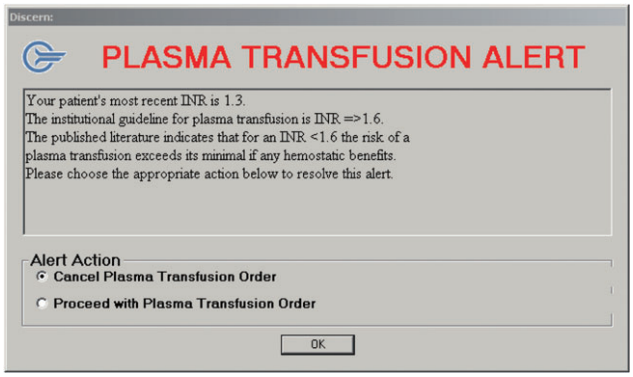

Fig. 2. Example of on-screen warning that appears when a physician at a UPMC hospital attempts to order plasma on a patient whose most recent INR value suggests that it is not necessary.

More targeted approaches to the enforcement of transfusion guidelines have been initiated with a focus on high blood loss services. For example, the RBC transfusion practice among orthopedic surgeons at our facilities who perform total hip arthroplasties (THAs) is highly variable and ranges from a few surgeons who rarely transfuse RBCs (and when they do, it is typically a small quantity) to others who routinely transfuse most of their patients with large numbers of RBCs. To begin to standardize the practice, and in anticipation of the publication of the results of the FOCUS trial that compared restrictive versus liberal Hb thresholds among THA patients using a functional endpoint, we have produced what we call a "bubble" graph (Fig. 4). This graph plots all surgeons who perform THA surgeries in our system by the frequency with which they transfuse RBCs to their patients and the mean number of RBCs that are transfused per patient. By identifying the surgeons who repeatedly transfuse large quantities of RBCs we can provide specific feedback and education to these "outliers" and perhaps inspire within them a desire to reflect and change their own practice when they see how they compare to their peers. These reports are generated on a monthly basis and forwarded to the vice president of operations for each individual hospital. In this way, strategic considerations about the surgeon's economic value to the hospital can be weighed with the cost of providing excess blood products. The vice president of operations is thought to have the best working relationship with the surgeons, as opposed to an outside TBM task force, and is thus the ideal person to present the data to them. The physicians in our health care

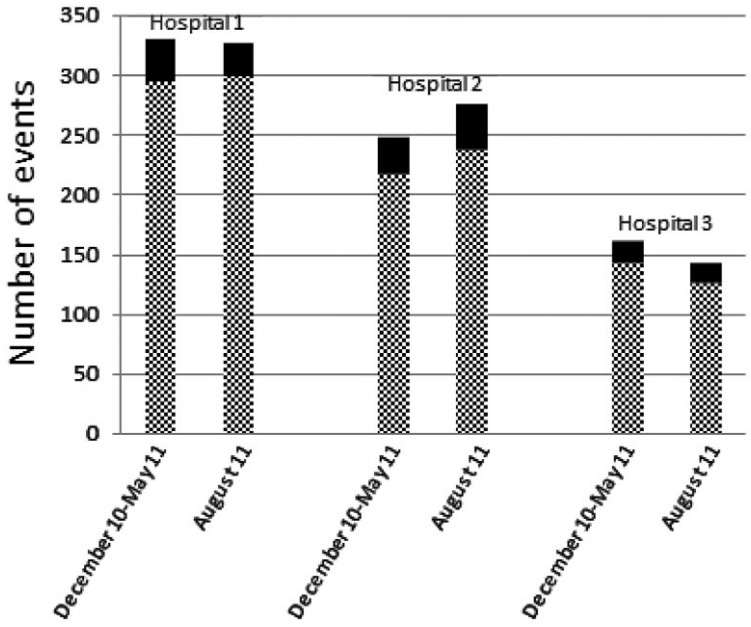

Fig. 3. Comparison of the mean monthly number of RBC alerts that were triggered between December 2010 through May 2011 and during August 2011 at three high-RBC-transfusion volume hospitals within the UPMC network. For reference, during the year 2010, Hospital 1 transfused 29,620 RBC units, Hospital 2 transfused 23,552 RBCs, and Hospital 3 transfused 8186 RBC units. The height of each bar represents the total number of alerts that were triggered, while the solid filled part of the bar represents the number of times the RBC order was canceled. ▨ Orders not canceled.

system are independent practitioners with their own experience and interpretation of the transfusion threshold literature. Since randomized controlled trials of liberal versus restrictive transfusion thresholds are not available for every medical and surgical situation, it is hoped that providing this sort of feedback will serve as its own metric for assessing the current practice and effecting change when necessary. As this type of feedback is a relatively recent development at our institute, its impact on physician behavior and patient outcomes cannot be assessed at this time.

While these electronic feedback systems provide real-time education, we also continue to provide live teaching sessions in the setting of departmental grand rounds, resident and fellow lectures, and consultation with prescribers on demand and when the blood bank identifies unusual or egregious transfusion practice (e.g., ordering a double dose of platelets or ordering a single unit of cryoprecipitate). Our teaching sessions also serve to associate a face with a voice on the end of the phone and provide a means to update our colleagues on other blood management initiatives that are under way at UPMC. We have also found that having a dedicated agenda item for blood management at each hospital's committee is an effective way of communicating our progress in implementing and enhancing our six-point plan, and it allows us to anticipate roadblocks that might hinder further progress.

MINIMIZE PREOPERATIVE AUTOLOGOUS DONATION OF RBCs

Historically preoperative autologous donation (PAD) was considered a means to avoid allogeneic transfusion by having one or more of the patient's autologous RBC units available on the day of surgery. It was thought that if the patients donated RBCs in advance of their surgery, then the RBCs that would be produced by their marrow between the time of donation and the reinfusion of the PAD units during or after the surgery would represent a net gain of RBC mass, which might obviate the need for allogeneic RBC transfusion. Unfortunately the theory does not seem to match the practice and there are some suggestions that patients who reduce their RBC mass before their surgery through PAD may require more allogeneic RBCs than those who do not donate RBCs in advance of their surgery.[6] While the use of PAD eliminates the very small risk of acquiring a transfusion-transmitted disease, it does not eliminate other more common adverse events such as bacterial contamination of the PAD unit, accidental transfusion of an allogeneic RBC unit instead of the PAD unit, and febrile reactions. Furthermore, there is evidence that patients who undergo surgeries with some degree of preoperative anemia tend to have worse outcomes compared to those who are not anemic before surgery.[7,8] Thus removing a significant amount of Hb in the form of PAD might predispose patients to worse outcomes when the goal of the procedure was to try to improve their outcome by avoiding allogeneic RBCs.

Reducing PAD utilization benefits not only the patient, but also the health care system. A PAD unit utilization rate of 50% is often cited as the benchmark. This suggests that a 50% wastage rate is acceptable, and this can be expensive at the level of the health care system. In 2008, the PAD utilization rates at two hospitals in our system that had historically collected large numbers of these units was a combined 148 of 239 (62%); while better than the benchmark rate, the wastage of these 91 units cost the system an estimated $18,000. After educating the surgeons at these facilities on the potential risks of recommending PAD for their patients, and providing alternatives to PAD that are focused on minimizing allogeneic

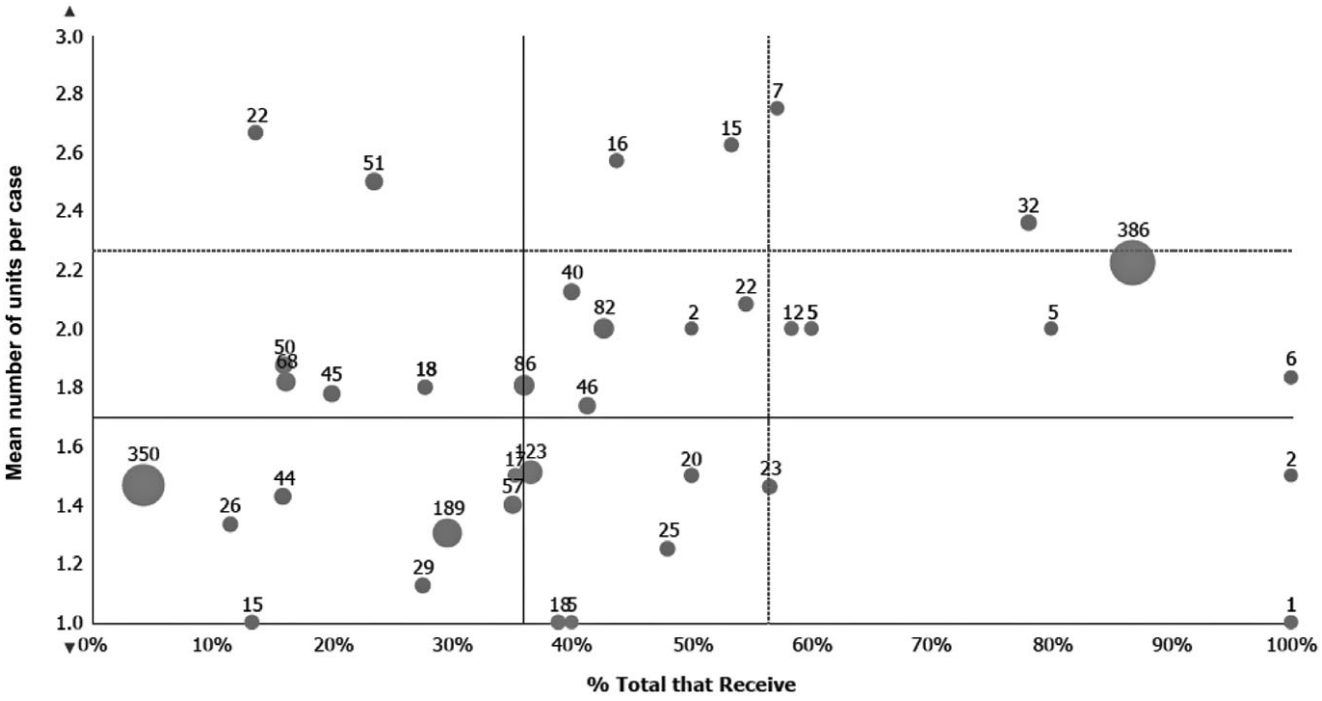

Fig. 4. Example of a "bubble" graph. This data were generated over a 3-month period and features surgeons who perform THA at UPMC hospitals. The bubbles represent individual surgeons, and the size of the bubble (and the adjacent number) represents the number of cases performed. The *x*-axis indicates the frequency with which the patients receive at least 1 allogeneic RBC unit, and the *y*-axis indicates the mean number of RBCs transfused per patient. The solid lines represent the mean values for each measure while the dashed lines represent +1 SD.

RBC transfusion (perioperative autotransfusion [POA], see next heading), we were able to completely eliminate the collection of PAD RBC units at one hospital by 2010 while cutting the number of units collected at the other hospital by nearly 40% by 2011. In our experience, offering surgeons alternatives to PAD was essential to reducing their utilization of this potentially wasteful practice. The fact that this often wasteful practice persists at some of our hospitals suggests that perhaps a systemwide policy against the use of PAD, with the exception of those patients with rare blood groups and multiple alloantibodies, might be required to completely eliminate its use.

POA

Commonly known generically as "cell salvage," POA can take several forms (reviewed in Waters[9]). Blood that is shed from the surgical site can be recovered using a suction device and then filtered and washed before it is returned to the recipient. POA can also occur *after* many different types of surgery with devices that collect, filter, and potentially wash the blood that is recovered from the wounds, although typically the majority of the postoperatively salvaged blood is not washed. The main value of POA in a blood management program is its ability to reduce the need for allogeneic RBCs by collecting and returning shed autologous RBCs back to the patient. In our system, we encouraged the use of POA among the surgeons who routinely recommended PAD to their patients by emphasizing the benefits of not reducing their patient's Hb before surgery and by ensuring that experienced perfusionists who operated the intraoperative cell salvage equipment were readily available during their cases. Some of the initial obstacles we faced when implementing the POA technologies were related to the erroneous perception that there were numerous contraindications to its use and a lack of perceived effectiveness in avoiding allogeneic transfusion. To address the list of perceived contraindications, the results of a locally conducted clinical study that demonstrated better outcomes than had been achieved without POA in terms of reducing allogeneic transfusion were presented to the surgeons for their review.[10] The perception of the lack of effectiveness of these technologies was addressed through more robust technician education and through implementation of AABB perioperative accreditation standards. Recovered blood is collected into the cell-processing machine and the washing and returning of the cells optimally takes place when a full bowl has been collected; the cost of processing a partially filled bowl might not make the process worthwhile, nor is it expected to return a significant quantity of RBCs to the patient. However, the decision to process and reinfuse a partial

bowl can be made on a patient-specific basis. Through our TBM program, a close working relationship between the subject matter experts in the transfusion medicine, anesthesiology, and perfusion services was forged with our surgeons, which helped us to reduce PAD collections, and achieve AABB accreditation in perioperative autologous blood collection at each of our 12 hospitals.

PREOPERATIVE ANEMIA OPTIMIZATION

As outlined above, anemic patients who undergo surgery tend to have worse outcomes than those who are not anemic, and preoperative anemia is a major risk factor for requiring perioperative allogeneic RBCs. In elective surgery cases there is frequently a sufficient length of time between the scheduling of the surgery and its actual date to permit the diagnosis and treatment of preoperative anemia. An audit of nearly 200 patients undergoing elective hip or knee surgery at our facilities demonstrated that approximately 27% of these patients were anemic before their surgery and that preoperative anemia led to a nearly 7.5× increased risk of requiring an allogeneic RBC transfusion compared to patients who were not anemic before their surgery ($p \leq 0.0001$). We have recently implemented a system whereby patients who are scheduled for surgery using a computer-based, systemwide surgical scheduling program (Surginet) are electronically matched with their preoperative bloodwork that is typically drawn around the time of the scheduling. Historically, this bloodwork is not examined until the day before surgery when the patient's medical record is compiled. At this late hour, correcting the anemia without changing the date of the patient's planned procedure is limited to allogeneic transfusion. Thus, to facilitate the earliest possible detection of anemia, an electronic rule matches each surgical patient to their laboratory values; when an anemic patient is discovered, the computer program automatically generates an e-mail or fax to the surgeon and primary care physician indicating that their patient is anemic and suggesting that its etiology be investigated before the surgery. The surgeon can then weigh the extent of the anemia with the anticipated blood loss for the procedure and manage the patients themselves or refer them to a specialist or to their primary care physician, depending on the nature of the anemia. The patient benefits from this automatic notification system because it alerts their physicians to the fact that they are anemic and also provides a mechanism for the patients to be assessed and treated before their surgery thereby reducing the likelihood that they will require a perioperative transfusion.

POINT-OF-CARE TESTING

Simply put, point of care (POC) can be imagined as a "laboratory on wheels" that features devices that can measure many different laboratory measures at a site that is often remote from the main laboratory and thus closer to where the patient is physically located. The main advantages of POC testing are that the turnaround times for reporting of these measures is greatly reduced, thus facilitating "real-time" decision making on the need for blood products, and that many of the POC testing devices require only microliter quantities of blood thereby preventing iatrogenic anemia from repeated sampling. A workflow analysis at our largest hospital revealed that for the operating room (OR), the mean turnaround time for a Hb level during the day was 45 minutes and even longer at night. Clearly this length of time is not conducive to real-time transfusion decision making, and so having POC machines that provide accurate values in a much shorter length of time is highly desirable. In fact, studies have shown that when POC devices were used to inform transfusion decisions, cardiac surgery patients received fewer RBC units and had less morbidity through reduced chest tube drainage and fewer returns to the OR to control excessive bleeding.[11-14] Aside from the initial capital expenditure of buying the POC devices themselves, an important consideration when developing a POC system is to ensure that these devices are placed under the aegis of a hospital department that has the expertise to design and execute protocols that validate and keep them in control. In some cases the POC devices are an extension of the main laboratory while in other systems, the OR or ED is responsible for their validation and ongoing maintenance. As part of the TBM program we have begun a program to standardize the POC devices used in the ORs throughout our hospitals and, for devices that must remain stationary (like TEG), to have the machine located in the main laboratory or in a dedicated space near the OR with its output viewable in real time in the actual ORs and intensive care units.

Blood management is a multifaceted approach to reducing allogeneic transfusion that requires the expertise of many different medical specialists and also the hospital's information technology specialists. When implemented, both the patient and the hospital system benefit from reduced use of scarce blood resources.

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CONFLICT OF INTEREST

MHY and JHW have no conflicts to disclose.

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