Blood components should be labeled for content

When we transfuse red blood cells (RBCs) or platelets (PLTs), we have only a very rough idea of the dose we administer. As a result, transfusion therapy is usually by rule of thumb and monitoring the effectiveness of transfusion is problematic.

A whole-blood donation may range from 405 to 550 mL.[1] As noted by Gorlin and Cable,[2] this range results in an almost twofold variability in RBC content, from 154 to 275 mL. We have very limited information on the actual RBC content of units in current use. An evaluation of units prepared in additive solutions in Germany, tested at time of outdate, found a mean hemoglobin (Hb) content of 46.6 ± 11.7 g per unit.[3] Because one-half of units would be expected to fall within 1 standard deviation of the mean, one can estimate that 25 percent of units may contain less than 34.9 g of Hb whereas 25 percent may contain more than 56.3 g. Significant differences between manufacturers were observed in this study. A total of 60.5 percent of units from one manufacturer contained less than 45 g compared to 34.1 percent of units from four other manufacturers. Although these units were analyzed at outdate, the data should reflect the content of indate units since the overall hemolysis was 0.54 ± 0.43 percent.

The consequence of this variability in RBC content can be dramatic. It is commonly stated that transfusion of 1 unit to a nonbleeding euvolemic adult will increase the Hb concentration by approximately 1 g per dL and the hematocrit (Hct) by 3 percent.[4] The source of this assertion is not clear, however. Vascular volume, concomitant intravenous fluid administration, renal failure, and splenomegaly all affect RBC transfusion response. Accounting just for vascular volume, transfusion of a minimum volume unit from a donor with a Hct level of 38 percent to a 100-kg man would result in an expected Hct increase of just 2 percent, whereas transfusion of a large unit from a donor with a 50 percent Hct level to a 50-kg woman would cause a 9 percent increase.[2] The effect of storage senescence can magnify these differences. If the small unit transfused to the large man in this example was near outdate, approximately one-quarter of the transfused RBCs will be rapidly cleared from circulation. The consequent Hct increase of approximately 1.5 percent is within typical day-to-day variability of hospitalized patients. How can we then tell if the transfusion was effective?

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Knowledge of actual Hb content can be used to optimize RBC transfusion. With a simple formula incorporating the desired Hb and estimated blood volume, Arslan and colleagues[5] were able to satisfy nearly 60 percent of transfusion orders with 1 unit while achieving a mean target Hb level of 9.3 g per dL. Although it remains to be seen whether similar success can be obtained with a more diverse patient population, this approach is inherently more rational than the usual practice of just ordering 2 units.

The experience with PLT transfusion is even more inexact. We typically assume that apheresis PLT units contain 3×10^{11} PLTs and whole blood–derived units contain 5.5×10^{10} PLTs. Blood centers do test a certain number of units collected for quality assurance purposes, and these minimum levels are usually achieved. Whether units in actual use are consistently at this level is questionable, however. A recent international study found that a targeted dose of 3×10^{11} to 6×10^{11} PLTs was achieved in just two-thirds of 1831 transfusions.[6] The success was slightly better with apheresis PLTs (72.9%) than with whole blood–derived PLTs made by the PLT-rich-plasma method (64.4%). There was also considerable variability between institutions, with success rates from 45.9 to 87.2 percent. This study needs to be replicated in more institutions, but it indicates that there is a wide range in the actual content of PLT concentrates.

It is well recognized that many factors including splenomegaly, medications, infection, bleeding, and antibodies affect the survival of transfused PLTs. In the evaluation of PLT transfusion refractoriness, it is very useful to calculate corrected count increments. This calculation depends on the number of PLTs transfused. In typical clinical practice, we usually assume a fixed number, such as 3×10^{11}, because we lack the actual data. A two-fold range in the actual number of PLTs transfused, however, could mean the difference between a transfusion being judged a success and one deemed a failure. This variability can be critical in selecting optimal components for difficult to manage patients.

We would be able to better manage both RBC and PLT transfusions if we knew the actual content of the units. Therefore, I advocate that RBCs be labeled with the Hb or RBC volume and PLT concentrates and plateletpheresis be labeled with the total PLT count. This requirement would require blood centers to test every unit. It will increase the cost of blood components and require additional equipment, personnel, and proce-

dures. Such assays, however, are readily available in automated systems and would likely have a small impact on costs compared to other procedures such as nucleic acid tests and bacterial detection that we are currently implementing.

Recently introduced automated blood component collection systems may allow for standardization and have predictable dosing of RBCs. At least two different systems have been shown to produce units with consistently reproducible total Hb content (coefficient of variation approximately 0.04).[7,8] This variability is less than one-half typically achieved in manually collected units.[7] Increased use of such devices may lead to de facto standardization of RBCs. Collection by apheresis, however, is relatively expensive and time-consuming. It is useful for collection of more than one component, but it is unlikely to supplant whole-blood collection for the bulk of RBCs in the foreseeable future.

How large should the standard unit be? In principle, the minimum unit (400-mL whole-blood donation with Hb concentration 12.5 g/dL) should contain 50 g. Apheresis collection of RBCs is feasible when 2 units can be collected. One-half of male donors, but virtually no female donors, could donate two 50-g units (at least in a northern European population).[9] Decreasing the unit size to 40 g would allow 94 percent of men, but still only 6 percent of women, to donate 2 units. The total RBC mass that can be collected in this population appears to be maximized at a unit size of 45 g. Collection of more units is not necessarily desirable if the volume per unit is smaller. We are in danger of "size creep," so familiar to purchasers of coffee drinks. Regardless of whatever standard we choose, we should verify that actual components meet the standard; and thus we should assay and label the final product.

Labeling of units for content will permit accurate dosage and quantification of transfusion practice. Who would order a drug today without knowing the actual dose? Yet we routinely order transfusions with no more than a guess as to what we are actually giving.

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