Variations in Transfusion Practice in Neonatal Intensive Care

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ABSTRACT. *Objective.* **To compare the transfusion practices between two neonatal intensive care units (NICUs) to assess the impact of local practice styles on the timing, number, and total volume of packed red cell transfusions in very low birth weight infants. To derive multivariate models to describe practice and to identify potential areas for improvement in the future.**

Methodology. **We reviewed phlebotomy losses and transfusion rates between two NICUs (A and B) for 270 consecutive admissions of birth weight <1500 g. We stratified for birth weight and for illness severity by the Score for Neonatal Acute Physiology (SNAP). Measures of short-term outcome were compared. We derived multivariate models to describe and compare the practices in the two NICUs.**

Results. **Patients in NICU A had smaller phlebotomy losses than those in NICU B. A lower percentage of the patients in NICU A (65% vs 87%) received transfusions, but they tended to receive a greater total volume per kg per patient (67 mL/kg vs 54.8 mL/kg). Transfusion timing differed between the NICUs; in NICU A only approximately one-half of their transfusions occurred in the first 2 weeks, whereas in NICU B almost 70% of the transfusions were given in this time period. Multivariate models showed that phlebotomy losses were significantly related to lower gestational age (GA) and higher SNAP. Hospitalization in NICU B resulted in 10.7 cc of additional losses relative to NICU A for a comparable GA and illness severity score. The volume of blood transfused per kilogram of body weight was a function of GA, SNAP, and hospital. Care practices in NICU A added an additional 19 cc of transfused volume in the first 14 days of life, and an additional 26 cc thereafter when adjusted for GA and SNAP. These differences in phlebotomy and transfusion were not associated with differences in the days of oxygen therapy or mechanical ventilation, the oxygen requirement at 28 days, the incidence of chronic lung disease, or the rate of growth by day 28.**

Conclusions. **We identified significant differences in phlebotomy and transfusion practices between two NICUs. We found no differences in short-term outcome, suggesting that the additional use of blood in one of the NICUs was discretionary rather than necessary. Our multivariate models can be used to characterize and quantify transfusion and phlebotomy practices. By predicting which patients are likely to require multiple transfusions, clinicians can target patients for erythropoietin therapy and identify those patients for whom donor exposure can be reduced by a unit of blood for multiple use. The models may help in monitoring changes in practice as they occur.** *Pediatrics* 1998;101:194–200; *newborns, transfusions, practice style variation, phlebotomy, neonatal intensive care units, illness severity scores.*

ABBREVIATIONS. RBC, red blood cell; NICU, neonatal intensive care unit; SNAP, Score for Neonatal Acute Physiology; PRBC, packed red blood cells; GA, gestational age.

Critically ill patients often require blood products as part of their therapy. This is particularly true for premature newborns. They are among the most frequently transfused groups of patients, most commonly receiving red blood cell (RBC) transfusions. It has been estimated that of the approximately 38 000 infants with birth weights less than 1500 g born annually in the United States, as many as 80% will receive multiple RBC transfusions.[1,2] Recent practice changes have led to some decrease in this percentage,[3] but the transfused patients still may receive several transfusions. Other changes in practice may have decreased the number of donor exposures from a mean of eight,[4] but it still remains an important consideration.

The need for such transfusions results from a number of factors. First, numerous laboratory tests are performed on these infants. Even with microanalysis, 0.2 to 0.5 mL of blood is required for commonly performed tests. The total resulting blood loss may exceed several mL, equivalent to 10% to 30% or more of the patient's small circulating blood volume. Second, infants of low birth weight are able to tolerate only small amounts of blood product in each transfusion and thus require multiple small transfusions. Finally, premature newborns are susceptible to anemia of prematurity, related in part to diminished production and increased metabolism of erythropoietin.[5–8]

The potential risks of blood incompatibility and transfusion reactions are well recognized. The potential infectious risks, including those from human immunodeficiency virus and hepatitis B and C[9,10] may be significantly more salient because of the relative immune incompetence of newborns. Transfusions are worrisome for parents, and the preparation and

administration of blood is costly. These factors make the minimization of transfusions a prime issue in newborn intensive care. However, the physiologic foundation for transfusion decisions in newborns is particularly limited,[1] and controversy persists regarding the indications and benefits of transfusion therapy.[11–16] The result is marked variation in transfusion practices among physicians and between hospitals.

We postulated that comparison of transfusion practices between neonatal intensive care units (NICUs) would provide an opportunity to explore the role of practice style in the number, volume, and timing of transfusions. By comparing the short-term outcome variables of similar infants, treated in different settings, we hoped to identify whether differences in practice lead to different clinical results. We hypothesized that differences in practice exist between institutions, but that such differences do not lead to differences in outcome. The comparison of practices would permit the estimation of what percentage of transfusions might be discretionary or without added benefit.

This study was designed to compare the rates of phlebotomy blood loss, selection of blood products, and transfusion rates between two geographically separated NICUs. Central to our analyses was careful control for known risk factors for transfusion, including low birth weight and severity of illness.[17] We evaluated short-term outcomes at discharge from the NICU to identify any differences in outcome that might be associated with differences in transfusion practices. As a secondary goal, we hoped to develop reference norms for transfusion according to birth weight and illness severity. By developing a quantitative model for transfusion need, these birth weight-severity-adjusted norms could be used to guide the use of recombinant erythropoietin, for administrative comparisons of blood utilization patterns between NICUs, and for monitoring interventions designed to reduce transfusion rates.[18]

METHODS

Study Sites and Data Collection

The two NICUs (Brigham and Women's Hospital in Boston, Massachusetts and Georgetown University Hospital in Washington, DC) were geographically remote from one another with no overlap in service area. In addition, the training histories (residencies, fellowships, nursing programs) of the medical and nursing staff were distinct from one another. The NICUs were similar in that they both were affiliated with large obstetrical services including high risk perinatal referrals.

Patients with birth weights less than 1500 g (very low birth weight) were selected for study because these infants have the greatest risk for transfusions. Sequential very low birth weight infants admitted in both institutions during a full year in 1990 were reviewed. Patients who died or were transferred out of the NICUs in the first day of life (because of a shortage of available intensive care beds), were omitted from consideration. Both NICUs had active programs for retrotransfer of convalescing premature infants back to local community hospitals. In these patients, study data were collected only during the course in the index NICU.

Data abstracted from medical records included: patient demographics, the number and timing of transfusions, the types of blood products used, the hematocrits both before and after transfusions, and the use of arterial catheters. Additional data were collected on the physiologic parameters used to calculate illness

severity (see below) and the outcome of these patients. Outcome data included: survival, occurrence of necrotizing enterocolitis, days in oxygen, respiratory status at 28 days of life, and weight gain. Blood preparation practices at both institutions resulted in hematocrits of the transfused blood of 70% to 75%, and both hospital laboratories required similar volumes for miniaturized analyses. Approval was obtained from the institutional review boards at both institutions. To preserve confidentiality of NICU identity, results are presented as NICUs A and B. Markers (patient number and racial composition) that would reveal identity are noted separately.

Illness Severity

To adjust for baseline differences in illness severity, we used the Score for Neonatal Acute Physiology (SNAP).[17] SNAP is an objective organ-system physiology-based illness severity index for neonatal intensive care that is similar to the APACHE used in adult intensive care units[19] and the Physiologic Stability Index[20] used for older children. Points are assigned according to the greatest degree of physiologic derangement on 34 routinely collected laboratory tests and vital signs. SNAP is the sum of all points in all organ systems during the first 24 hours of admission. Scores less than 10 are indicative of mild illness, 10 to 19 of moderate illness, and those >20 are indicative of severe illness, including the need for mechanical ventilation.

Multivariate Model Construction

A fair comparison of transfusion practice styles between NICUs can only be accomplished after birth weight and illness severity are both controlled. To model total transfusion volume we used multiple linear regression with volume transfused per kilogram birth weight as the dependent variable and clinical risk factors (birth weight, illness severity) as independent variables. The NICU of hospitalization was entered as a binary variable (NICU A = 1 or NICU B = 0). Similar linear models were developed for both the number of transfusions and the volume of blood removed for blood tests in the first 14 days. We used a stepwise backward elimination procedure to retain the most significant variables. The derived models therefore describe the experimental results in terms of significant variables, each weighted for its contribution to the total value. All analyses were performed using SAS.[21]

RESULTS

There were 383 patients eligible for study in the two institutions. Of these, 79 were eliminated because of early death or transfer in the first day of life, and 34 additional medical records were incomplete or missing. The percentage of excluded patients was nearly equal between the two institutions. Of 270 infants available for the study, 98 were patients in one NICU and 172 in the other.

Patient demographics are displayed in Table 1a. Patients in NICU B were significantly smaller, averaging 979 g versus 1073 g in NICU A ($P = .01$). This size difference is consistent with the lower average gestational age (GA) in NICU B (27.6 weeks vs 28.5 weeks). More of the patients in NICU B were identified as black (56%) compared with 14% in NICU A. The patients in NICU B were significantly more ill than those in NICU A (average SNAP score, 19.2 vs 12.4; $P < .001$). Thus, infants in NICU B were smaller and more ill despite the restriction of patient selection to a narrow birth weight stratum, and analyses must adjust for these differences.

Table 1b displays the univariate comparisons for phlebotomy and transfusions. Required volumes for laboratory tests were similar between the two institutions, and nearly all transfusions were administered in volumes of 10 mL/kg. More blood was drawn from the patients in NICU B (34.1 mL/kg vs

TABLE 1.   Univariate (Unadjusted) Patient Characteristics and Short-term Outcomes

	NICU A	NICU B	P
a) Patient characteristics			
Body weight (g)	1073 ± 280	978 ± 250	.008
GA (wk)	28.5 ± 3.2	27.6 ± 2.2	.01
Male	78 (46%)	49 (50%)	ns
SNAP	12.9 ± 6.6	19.2 ± 6.8	.0001
b) Phlebotomy and transfusion rates			
Blood drawn (mL) (days 1–14)	17.5 ± 19	34.1 ± 18.5	.0001
No. of ABGs (days 1–14)	31 ± 39	42 ± 40	.04
mL/kg of RBC transfused (days 1–14)	33.6 ± 46	32.9 ± 48	ns
mL/kg of RBC transfused (day 15+)	33.4 ± 59	21.9 ± 44	ns
No. of transfusions	4.8 ± 7.0	4.9 ± 5.4	ns
mL/kg of FFP transfused	2.4 ± 9.7	21.3 ± 38	.0001
c) Short-term outcomes			
Days in oxygen	20.8 ± 27.4	20.2 ± 24.8	ns
Fio_2 day 28	.28 ± .17	0.26 ± 0.1	ns
Chronic lung disease (%)	26.1	30.5	ns
Mechanical ventilation, day 28 (%)	22.7	21.9	ns
% Body weight day 28	122 ± 15	120 ± 24	ns

Abbreviations: GA, gestational age; SNAP, Score for Neonatal Acute Physiology; ABG, arterial blood gas determination; RBC, red blood cells; FFP, fresh frozen plasma; Fio_2, fraction of inspired oxygen.
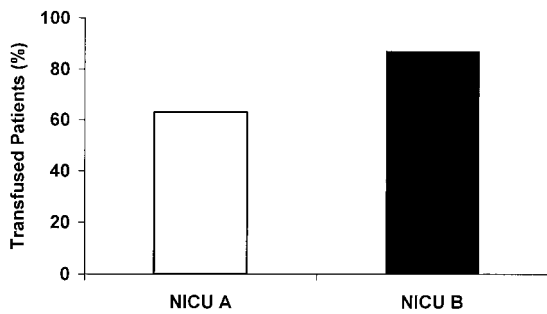

Fig 1. Percentage of patients receiving one or more transfusions in the study NICUs ($P < .05$).

17.5 mL/kg; $P = .0001$) probably reflecting the overall higher illness severity. This greater phlebotomy may be due in part to the larger number of arterial blood gases drawn (42 vs 31; $P = .04$). Despite these large differences in illness severity and phlebotomy losses, the average total volume transfused as well as the average total number of transfusions were not significantly different between the two NICUs. However, the proportion of transfused patients was quite different. In NICU B, almost 87% of the patients were transfused whereas only 65% of those in NICU A received one or more transfusions ($P = .01$) (Fig 1). This means that those patients who were transfused in NICU B received a smaller number of transfusions than the transfused patients in NICU A. There was a very large difference in the use of fresh frozen plasma (21.3 vs 2.4 mL/kg per patient; $P = .001$).

Next, we compared the number of transfusions given in each week of life. Strikingly, although two-thirds of the transfusions in NICU B were administered in the first 2 weeks of life (Fig 2), only one-half of transfusions in NICU A were given during that time period. This difference in practice between the more acute and convalescent phases of the hospital course led us to analyze the data for the two time periods separately.

The use of multivariate models offers the best way to describe our data and allow comparison of practice differences. Using the procedures detailed

above, each model defines a specific parameter as a continuous function of those variables that are statistically significant in determining its value. Each variable is weighted in the function according to its contribution. The models are shown together in Table 2.

The volume of blood drawn from each patient in the first 14 days was modeled as a function of the patient's SNAP score, the GA in weeks, and the hospital in which the infant was treated. The slope coefficient represents the mL per patient attributable to that variable. The best point estimate of phlebotomy loss for each infant can be obtained from the function mL = f (GA, SNAP, hospital), the variables
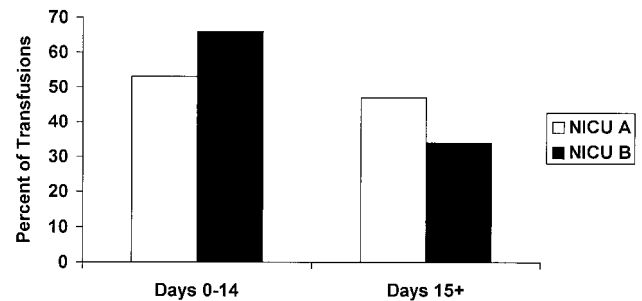

Fig 2. Timing of transfusions. Percentage of transfusions received within each of the time periods is shown ($P < .05$).

TABLE 2.   Multivariate Models for Volume of Blood Drawn/Patient and Volume Transfused

	Blood Drawn	Blood Transfused	
	mL/Patient	mL/kg/Patient, Days 1–14	mL/kg/Patient, Days 15+
Intercept	84.2*	171.9	262
Gestational age (wks)	−1.9*	−3.76‡	−5.0‡
Birth weight (kg)	—	−64.2†	−99.6*
SNAP	0.75†	1.9†	—
Hospital (A = 1, B = 0)	−10.7*	20.9†	36.8*
Adjusted R^2	0.37*	0.27*	0.24*

* $P < .001$; † $P < .01$; ‡ $P < .05$.

for which are shown in the first column of Table 2. For each week of gestation, the intercept volume (84.2 mL) was reduced by 1.9 mL. Each point of SNAP resulted in an additional 0.75 mL drawn. Hospitalization in NICU A resulted in 10.7 mL less blood being drawn. Thus, a moderately ill infant, with a SNAP score of 10 and a GA of 28 weeks, would have $84.2 + (10 \times 0.75) - (28 \times 1.9) = 38.5$ mL of blood drawn for tests in the first 14 days in NICU B but 10.7 mL less, or 27.8 mL, drawn in NICU A.

The total volume of blood (PRBC) transfused per kilogram per patient in the first 14 days of life was determined to be a function of GA, birth weight, SNAP, and hospital. This function is shown in the second column of Table 2. The intercept value for each patient is a volume of 171.9 mL/kg. For each week of GA, this volume was decreased by 3.76 mL, whereas each point of SNAP score added 1.9 mL. Each kilogram of birth weight decreased volume/kg by 64.2 mL. The hospital variable added an additional 20.9 mL for those cared for in hospital A. Thus, the hypothetical patient described above, with a birth weight of 1 kg, would receive $171.9 + (-3.76 \times 28) + (1.9 \times 10) - 64.2 = 21.4$ mL/kg if hospitalized in NICU B. The same patient, hospitalized instead in NICU A, would receive 42.3 mL/kg throughout days 1 to 14. Because both birth weight and GA remain in this birth weight-adjusted model, we infer that transfusion volume increases nonlinearly as birth weight and GA decrease (ie, lower birth weight patients get proportionately more cc's/kg than higher birth weight infants).

Because of the differences between the NICUs in transfusion timing, we developed a separate model for transfusion volume beyond 14 days of life. We expected the determinants of late transfusions (attributable predominantly to anemia of prematurity) to be different from the determinants of early transfusion (attributable mostly to phlebotomy in the context of acute intensive care). The third column of Table 2 shows the function describing the mL/kg of PRBC transfusions occurring later than 14 days of age. SNAP is no longer a contributing factor, but birth weight and GA both remain significant. The hospital variable is larger, contributing 36.8 mL/kg to the total volume transfused in NICU A. For the patient example cited above, the total volume of transfusions would be 22.4 mL/kg in NICU B, but 59.2 mL/kg in NICU A. As it was for days 1 to 14, a nonlinear relationship between transfusion volume and birth weight and GA is inferred by this model.

These models indicate that in NICU A, transfused patients receive an extra volume of transfusion, independent of birth weight, GA, or SNAP. To further explore this, we derived alternative models of transfusions, including an interactive factor that combines both SNAP and home hospital. Mathematically, this model tests for a different slope coefficient between hospitals; ie, whether transfusions are not only higher in one hospital, but rise faster per unit increase in severity. Table 3 shows the derived interactive function for volume transfused/kg during days 1 to 14 (first column) and days 15 and beyond (second column). For days 1 to 14, the volume trans-

TABLE 3. Interactive Multivariate Model of Volume Transfused (mL/kg/Patient)

	Days 1–14	Days 15+
Intercept	172.1	297.7
Gestational age (wks)	−3.7†	−6.1†
Birth weight (kg)	−60*	−71.4†
SNAP	1.6†	−1.84‡
SNAP-Hospital	—	1.4†
Adjusted R^2	0.27*	0.21*

* $P < .001$; † $P < .01$; ‡ $P < .05$.

fused/kg is a function of birth weight (−60 mL for each kg increase), GA (−3.7 mL for each advancing week), SNAP (1.6 mL/point), and hospital (17.9 mL/kg additional for NICU A). The SNAP-NICU interactive term does not reach significance, meaning that the hospital effect in the first 14 days does not increase as severity increases. For days 15 and beyond, the volume transfused is a function of birth weight, GA, SNAP, and of the SNAP-NICU interactive term. This means that the magnitude of the difference between the hospitals increases as illness severity increases. For a given infant, if the SNAP were 10, NICU A would transfuse 14 mL more than NICU B. If the SNAP were 20, the difference would be 28 mL. As in the basic models, the contribution of both body weight and GA implies a nonlinear effect in smaller infants. Note that the magnitude of severity terms are nearly equal and offset each other for NICU A patients. For NICU B, initial illness severity remains a significant factor in convalescent phase transfusions. The negative value of the SNAP term in this function suggests that the NICU B practice of nearly universal early transfusions decreases the need for transfusions later in the hospital course.

These differences in transfusion practice between the two NICUs did not result in any differences in short-term outcomes, at least among those parameters often considered in decisions to transfuse. Both sets of infants had similar weight gain during the first 28 days of life, the same number of ventilator days and days in supplemental oxygen, and equal rates of chronic lung disease (Table 1c). Although not a complete description of the overall neonatal course, the assessment at 28 days does reflect the outcome of the most acute phase.

DISCUSSION

Neonates requiring intensive care are among the most frequently transfused of patient groups. Because of the costs and potential risks[22] associated with these transfusions, many attempts have been made to identify ways to reduce the number of transfusions administered.[3] Predicting which patients will need transfusions and determining criteria for transfusion have been difficult because: a) a relative degree of anemia is normal as the hemoglobin level drops after birth[23] and oxygen affinity changes as hemoglobin shifts from HbF to HbA, and b) it is difficult to demonstrate the response to transfusion alone in critically ill infants.[24] Although Wardrop et al[25] have determined a formula for estimating available oxygen and suggested using it to identify the

need for RBC transfusion, most transfusion decisions are based on the measurement of phlebotomy losses, anemia, and an evaluation of clinical status.

Obladen et al[26] showed blood losses ranging from 24 mL/kg in healthy premature infants to 67 mL/kg in ill premature infants, and a strong correlation between the volume of blood drawn and the volume transfused, similar to results found in other studies.[27,28] Some of these losses may be attributable to excessively generous sampling,[28,29] but the bulk is likely because of equipment limits for minimum specimen volume.[30] Local practices modulate the contribution of these losses to the need for transfusions. In many NICUs, phlebotomy losses are replaced by transfusion of RBCs whenever 10% of blood volume has been removed (8 to 10 mL/kg), or when the hematocrit drops below a set level in infants requiring supplemental oxygen.[5,29] Practices like these contribute to the exposure of each infant to the blood of as many as 8 to 10 different donors.[30]

Anemia of prematurity[5,6] occurs frequently in low birth weight infants. Symptoms attributable to anemia are often subtle or poorly defined,[11–16] which makes it difficult to clearly demonstrate a therapeutic response to transfusion[13,16] or to define a specific level of hemoglobin at which a transfusion should be given. During acute illness, blood transfusions are used to treat such difficult to quantify indications as poor perfusion or marginal hypotension,[31] or to use up a patient designated unit before it expires.[31,32] After years of such practices, a local style of care is developed and perpetuated. In adult patients, such local styles lead to wide variation, up to two-fold, in transfusion practices between institutions.[33–37] This variation could not be attributed to patient demographic characteristics or phlebotomy practices.[38–40] Practice develops around local, often institutionally based, treatment protocols predicated on the knowledge and biases of individual clinicians.[41]

In the present study, we sought to examine not only which factors lead to increased transfusions in neonates, but to quantify their relative importance. We have shown that both phlebotomy and transfusion are determined primarily by illness severity, GA, and birth weight. Smaller infants of lower GA require more transfusions because of the limits on the volume of each individual transfusion, and the greater fraction of circulating blood volume drawn for each laboratory test. More severe illness contributes to increased phlebotomy and is more likely to include symptoms that are thought to be treatable by transfusion. The multivariate models quantify the relative importance of each of these variables in a continuous fashion. This provides a more accurate description of the phlebotomy losses and transfusion needs of any individual patient than is possible using conventional strata of birth weight and GA.

More importantly, we have found that these patient characteristics alone do not explain the differences in practice seen between different NICUs. Instead, we have discerned differences as great as 20% of the total mean transfused volume between the two NICUs and a marked difference in the pattern of acute and convalescent transfusions. In addition, the magnitude of these differences varies with illness severity within each NICU during the convalescent phase of hospitalization. We found that the short-term outcomes of the patients were not affected by these differences in practice, and thus, the additional transfusions offer no identifiable therapeutic advantage. We conclude that these excess transfusions are discretionary, based on local practice style. It is noteworthy that the discretionary use of PRBC seems to be the practice style at NICU A, whereas the discretionary use of fresh frozen plasma is evident at NICU B. Local practices governing the use of these two types of blood products are influenced independently.

Certain limitations of our study must be recognized. The study examines transfusion practices in 1990, many of which have changed in the intervening years.[3] Although the number or volume of transfusions may have dropped in either or both of the institutions, the differences in practice may not have similarly decreased. Second, our analysis is limited to the institutional average practices, and does not discern inter-practitioner variation within each NICU, or the potential effect of differences in parental concerns or input regarding transfusions. Third, although our results demonstrate that transfusion practices differ greatly between NICUs, the reasons why this occurs and how the differences are maintained are not illuminated by our study. Finally, we recognize that the limited sample size of this study does not allow us to comment on the effects of transfusions on less common complications, such as necrotizing enterocolitis, or on long-term outcome of the patients. It is possible that some long-term benefit, which we did not study, resulted from the increased transfusions in one of the institutions. Most transfusion therapy is undertaken to treat acute problems, however, and we are confident that the observed similarity of the two patient groups in our short-term outcome parameters suggests that there is no demonstrable advantage to either style of practice.

Studies of recombinant erythropoietin have demonstrated mixed results in reducing transfusions.[27,42,43] In one study[27] the phlebotomy losses seemed to be too great for erythropoietin therapy to overcome. The European multicenter trial[44] revealed no differences in transfusion rates between control and treated infants in the first 2 weeks of the study, probably because of liberal transfusion guidelines. The recent South African trial[45] did show a minor reduction in transfusions in the treated infants, but the overall transfusion rates were low, because a relatively healthy population was studied. The results of the multicenter United States[46] trial reported the greatest reduction in transfusions, but the benefit was attributable only partly to the erythropoietin. Significant reductions in transfusions may also have been attributable to the complementary strategies of reduced phlebotomy losses and the use of conservative standardized transfusion criteria. The utility of erythropoietin will require careful targeting to the population most likely to benefit. Patients who receive many early transfusions do so before erythro-

poietin can produce a clinical response. Erythropoietin may have its most profound effect in eliminating the requirement for blood in those patients predicted to need only one or two transfusions. Our multivariate models can identify these patients.

The identification of significant differences in practice that do not alter outcome is a key factor in the continuing process of defining acceptable guidelines for administering transfusions. Our inter-NICU comparison makes this possible in an area in which limited physiologic evidence is available for determining the best approach to care. By expanding a careful comparison of practices to a large number of NICUs, we anticipate that such guidelines can be refined. The use of empirically-derived guidelines has already been demonstrated to safely reduce the number of both transfusions and different donors to which premature infants are exposed.[47] Guidelines based on comparisons of both care practices and outcomes should be more acceptable to care givers.

These models can identify those patients most likely to require multiple transfusions. We have begun to use the models in the assignment of designated units of blood to these patients to reduce donor exposure. At the same time, the assignment of entire designated units to patients unlikely to require them can be avoided, thereby preserving resources and reducing costs. A study of the efficacy of this program is currently ongoing. Finally, the models provide a predictive estimate of expected blood use. By comparing these predictions with observed rates, it should be easy to identify and evaluate unusual or aberrant blood use.

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EXTRA CREDIT FOR DOING POORLY

Imagine an educational system that subverted the goal of education—one that discouraged students from discovering their strengths and instead encouraged them to get ahead based on their weaknesses. When it comes to learning disabilities, that is what the American educational system has become.

The way federal law has been interpreted, students with certain diagnosed learning disabilities are legally entitled to take high-stakes standardized tests without time limits and in enhanced environments that allow them, for example, food and drink or assistants to record their answers. They are entitled to extensive free tutoring in school, help with note-taking and explanations of test questions.

And, in some universities, students are excused from difficult courses, like math or foreign languages, because they have been found to have a disability in these subjects. It's no wonder, then, that some parents have sought to have learning disabilities diagnosed in their children to make them eligible for such benefits.

More than 2.5 million children are classified as having learning disabilities, and they benefit from federally financed special education programs. The cost of serving special education students, about half of whom have learning disabilities, is about $3.25 billion each year.

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