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Original Article

Reduction in Red Blood Cell Transfusions Using a Bedside Analyzer in Extremely Low Birth Weight Infants

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BACKGROUND:
Preterm infants typically experience heavy phlebotomy losses from frequent laboratory testing in the first few weeks of life. This results in anemia, requiring red blood cell (RBC) transfusions. We recently introduced a bedside point-of-care (POC) blood gas analyzer (iSTAT, Princeton, NJ) that requires a smaller volume of blood to replace conventional Radiometer blood gas and electrolyte analysis used by our neonatal intensive care unit (NICU). The smaller volume of blood required for sampling (100 *vs* 300–500 μl), provided an opportunity to assess if a decrease in phlebotomy loss occurred and, if so, to determine if this resulted in decreased transfusions administered to extremely low birth weight (ELBW) infants.

OBJECTIVE:
We hypothesized that the use of the POC iSTAT analyzer that measures pH, PCO_2, PO_2, hemoglobin, hematocrit, serum sodium, serum potassium and ionized calcium would result in a significant decrease in the number and volume of RBC transfusions in the first 2 weeks of life.

DESIGN/METHODS:
A retrospective chart review was conducted of all inborn premature infants with birth weights less than 1000 g admitted to the NICU that survived for 2 weeks of age during two separate 1-year periods. Blood gas analysis was performed by conventional laboratory methods during the first period (designated Pre-POC testing) and by the iSTAT POC device during the second period (designated post-POC testing). Data collected for individual infants included the number of RBC transfusions, volume of RBCs transfused, and the number and kind of blood testing done. There was no effort to change either the RBC transfusion criteria applied or blood testing practices.

RESULTS:
The mean (±SD) number of RBC transfusions administered in the first 2 weeks after birth was 5.7±3.74 ($n=46$) in the pre-POC testing period to 3.1±2.07 ($n=34$) in the post-POC testing period ($p<0.001$), a 46% reduction. The mean volume of RBC transfusions decreased by 43% with use of the POC analyzer, that is, from 78.4±51.6 ml/kg in the pre-POC testing group to 44.4±32.9 ml/kg in the Post-POC testing group ($p<0.002$). There was no difference between the two periods in the total number of laboratory blood tests done.

CONCLUSIONS:
Use of a bedside blood gas analyzer is associated with clinically important reductions in RBC transfusions in the ELBW infant during the first two weeks of life.
Journal of Perinatology (2005) **25,** 21–25. doi:10.1038/sj.jp.7211201
Published online 7 October 2004

INTRODUCTION

During the early weeks after birth, preterm infants commonly receive multiple red blood cell (RBC) transfusions to treat anemia. It is estimated that over 80% of infants with a birth weight $\leq$1500 g will receive one or more blood transfusions.[1] Half of the transfusions that these infants receive during their hospitalization occur during the first 2 weeks of life.[2] Intensive laboratory testing leading to phlebotomy losses during this period is one of the main causes for the anemia.[3–5] In addition, phlebotomy ''overdraw'' in excess of that needed by the laboratory is a common occurrence in preterm infants.[6] The typical weekly phlebotomy loss for a preterm infant during this period averages 15 to 30% of their total blood volume in extremely low birth weight (ELBW) infants with birth weights <1000 g, and nearly the same volume transfused in compensation.[2] RBC transfusions have the risk of incompatibility and transfusion reactions as well as viral infections.[7,8] In addition, RBC administration is costly and adds to parental anxiety. Therapeutic strategies aimed at reducing transfusions have evaluated the use of strict RBC transfusion guidelines and erythropoietin therapy, but reduction of phlebotomy loss is paramount.

For ELBW infants, laboratory blood testing using bedside devices offers a unique opportunity to reduce RBC transfusions. This practice has been referred to as ''near-patient testing'' or point-of-care testing (POC).[9] Recent technologic innovations in the design

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and fabrication of biosensors and microprocessors have led to the development of small, highly accurate bedside devices with rapid analytic turnaround time, minimal specimen volumes, and low pre-analytic error.[2,10–13] Use of these devices to measure the most commonly ordered blood tests could significantly decrease phlebotomy loss and lead to a reduction in the need for RBC transfusions among critically ill premature neonates.[14–16] In a prior study, Alves-Dunkerson et al.[14] estimated that arterial blood drawn for blood gases and electrolytes accounts for 50 to 74% of laboratory phlebotomy loss in VLBW infants in the first weeks of life.

The introduction of one such device, the bedside point-of-care (POC) analyzer (iSTAT Corp, Princeton, NJ) for blood gas analysis in our neonatal intensive care unit (NICU) during the latter half of 2001, provided us with an opportunity to determine if use of the device resulted in a clinically significant reduction in RBC transfusions in ELBW infants. The iSTAT has been shown to be a reliable alternative to traditional blood gas analyzers in the neonatal population.[12] The iSTAT measures pH, PCO_2, PO_2, hemoglobin, hematocrit, serum sodium, serum potassium and ionized calcium on 100 μl of blood. Prior to the change to the use of the iSTAT, our laboratory required 300 to 500 μl of blood for a blood gas and electrolytes, 500 μl for a complete blood count or hematocrit, 400 μl for serum electrolytes, 1000 μl for a panel of electrolytes and four additional chemistry analytes (Chemistry 8), and 1500 μl for a panel of 23 chemistry analytes that included electrolytes (Chemistry 23). Based on the decreased blood volume required for laboratory testing with the iSTAT, we hypothesized that there would be a significant reduction in the number and volume of RBC transfusions to ELBW infants during the first 2 weeks after birth.

METHODS

Study Population

A retrospective chart review was conducted of all inborn infants <1000 g admitted to the NICU that survived past 2 weeks of age during two separate years (1998 and 2002). Erythropoietin was not used during the study period.

Clinical and Laboratory Practices

Conventional bench top laboratory analysis during the first year (designated pre-POC testing) was done using the Radiometer Blood Gas and Electrolyte Analyzer (Model ABL 505, Radiometer America, Inc., Westlake, OH). Bedside blood gas analysis during the second year (designated post-POC testing) was performed using a point-of-care analyzer (iSTAT, Princeton, NJ). During and between both study periods, no uniform effort was made to modify clinical or laboratory phlebotomy practices relative to the indications for, the frequency of, or the procedure for laboratory blood testing. In addition, RBC transfusion criteria and blood banking procedures remained unchanged during the same period. The former criteria were based on clinically significant acute blood loss; a hematocrit (Hct) <35 in infants with an oxygen requirement, apnea, tachypnea (respiratory rate >70/minute), or tachycardia (heart rate >170/minute); a Hct $\leq 40\%$ in infants with pulmonary or cardiac disease; and a Hct $<50\%$ in infants with severe respiratory failure. The volume of RBCs transfused was 15 ml/kg with the mean hematocrit of the transfused blood varying between 55 and 60%.

Data Collection

Data collected by a retrospective chart review included the number of transfusions and the volume of RBCs transfused during the first 2 weeks after birth. The iSTAT analyzer measures pH, PCO_2, PO_2, hemoglobin, hematocrit, serum sodium, serum potassium and ionized calcium on 100 μl of blood. Since this was a retrospective study, we were unable to determine the exact volume of phlebotomy losses associated with laboratory blood draw. Nonetheless, an estimate of phlebotomy loss in the two groups was derived based on the number of specific blood tests on individual infants performed during each study period.

Statistical Methods

Data were compared using the Mann–Whitney test. A p-value <0.05 was considered statistically significant.

RESULTS

Data were available in 46 of 55 inborn infants admitted to the NICU in the pre-POC testing group and in all of the 34 infants in the post-POC testing group. There were no differences between study infants born during the two periods with respect to birth weight, gestational age, race or pretransfusion hematocrit (Table 1).

There was no difference in total laboratory blood tests performed on each infant between the two study periods (Table 1). Similarly there was no difference between the groups with respect to either the number of blood gas or complete blood count analyses performed. A greater number of electrolyte tests and Chemistry 8 analyses were performed by the Radiometer in the pre-POC group. However, a greater number of Chemistry 23 analyses were performed in the post-POC group (Table 1).

The approximate volume of blood removed per infant during the two study periods was estimated by multiplying the number of tests performed by the volume of blood required to perform the individual blood tests. Assuming the pre- and post-iSTAT volumes of blood required for blood gas analysis were 400 and 200 μl respectively, there was an estimated 30% reduction in the total volume of blood removed for the blood tests listed in Table 1.

The mean number of RBC transfusions from day 0 to 14 was 5.7 ± 3.74 in the pre-POC testing group and 3.1 ± 2.07 in the post-POC testing group ($p<0.001$), a 46% reduction (Figure 1). A

Table 1 Characteristics of Infants by Study Group

	Pre-POC testing (n = 46)	Post-POC testing (n = 34)
Characteristics		
Race		
White	21	14
Black	4	1
Hispanic	14	11
Asian	6	8
Unknown	1	0
Birth weight (%)		
≤750 g	20 (43)	12 (35)
751–1000 g	26 (57)	22 (65)
Gestational age (week)		
Mean ± SD	26 ± 2.2	27 ± 2
Male (%)	24 (52)	12 (53)
Pretransfusion Hct (%)	36.3 ± 4.3	34.5 ± 4.9
	n = 257	*n* = 74
Blood gases	58 ± 37	50 ± 31
	n = 46	*n* = 31
Complete blood count	15 ± 7	13 ± 4
	n = 44	*n* = 32
Serum electrolytes*	3.4 ± 4	1.6 ± 2.6
	n = 44	*n* = 33
Chemistry 8*	15.5 ± 5.6	12.4 ± 3.6
	n = 44	*n* = 33
Chemistry 23*	2.1 ± 1.2	3.9 ± 2.6
	n = 44	*n* = 32
All blood tests	94 ± 47	81 ± 33
	n = 44	*n* = 32

*Mean ± SD.
$p < 0.05$.
CBC: complete blood count, Hct: hematocrit, POC: point-of-care.

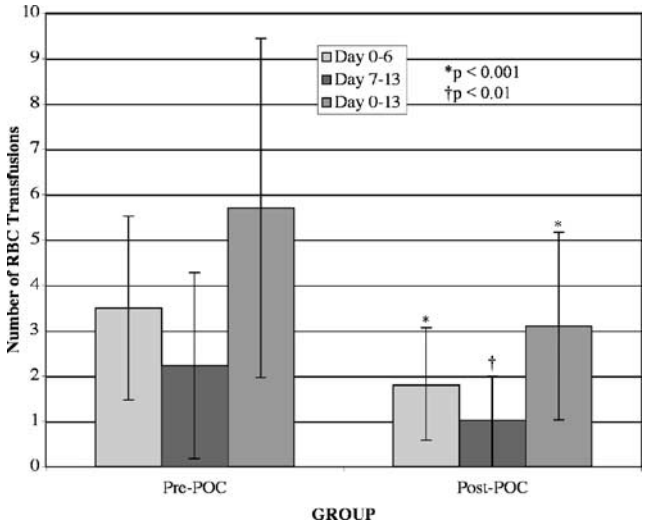

Figure 1. Number of RBC transfusions in the pre-POC testing and post-POC testing groups. The mean (±SD) of RBC transfusions that were given to infants in the pre-POC testing (pre-POC) and post-POC testing groups from day 0 to 6, day 7 to 13 and day 0 to 14 is shown.

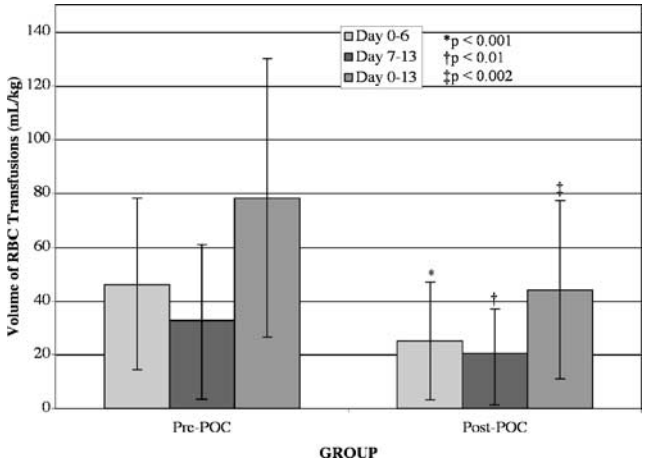

Figure 2. Volume of RBC transfusions in the pre-POC testing and post-POC testing groups. The mean (±SD) ml/kg of RBC transfusions that were given to infants in the pre-POC testing (pre-POC) and post-POC testing groups from day 0 to 6, day 7 to 13 and day 0 to 14 is shown.

statistically significant reduction in transfusions was also noted for days 0 to 6 (3.5 ± 2.02 v 1.8 ± 1.26, $p < 0.001$) and for days 7 to 13 (2.2 ± 2.08 vs 1 ± 1, $p < 0.01$). Mean volume of RBC transfusions administered was 78.4 ± 51.6 ml/kg in the pre-POC testing group and 44.4 ± 32.9 ml/kg in the post-POC testing group ($p < 0.001$), a 43% reduction (Figure 2). Statistically significant reductions in the mean volume of RBC transfusions were also noted for days 0 to 6 (46 ± 32 vs 25 ± 22 ml/kg, $p < 0.001$) and for days 7 to 13 (32 ± 29 vs 19 ± 18 ml/kg, $p < 0.02$).

DISCUSSION

Anemia in the extremely low birth weight infant continues to be a problem necessitating frequent blood transfusions. A majority of these transfusions occur in the first 2 weeks after birth.[2] Avoiding unnecessary blood transfusions and their associated complications remains an important clinical goal. Although there are several causes for anemia in premature infants, the most important continues to be excessive phlebotomy losses necessitated by the need to maintain adequate oxygenation and cardiopulmonary stability.[17–22] Several prior studies have shown that transfusions in the ELBW infant can be decreased by delayed cord clamping at delivery,[23,24] autologous placental blood transfusion,[25,26] decreased phlebotomy losses by reducing laboratory testing,[27] introduction of more conservative transfusion guidelines[21,28,29] and the use of erythropoietin.[30]

Since phlebotomy loss from laboratory testing is the major cause of anemia in the first 2 weeks after birth, a reduction in these losses should result in a decrease in blood transfusions. The availability of newer bedside POC devices that require smaller volumes for blood gas and electrolyte analysis with rapid turn around times provides the opportunity to decrease blood loss from phlebotomy and potentially decrease transfusions.

During the first 2 weeks of life, we found a statistically and clinically significant reduction in both the number of transfusions and the volume of blood transfused following the introduction of the iSTAT in the NICU. Although limited by a lack of direct measurement of phlebotomy blood loss and no comparison of severity of illness between two groups, the results of this retrospective study strongly support the role of laboratory phlebotomy loss as the primary cause of anemia leading to RBC transfusion in the early weeks of life. Introduction of the iSTAT in the post-POC period led to a decrease in the number of tests that were sent to the laboratory. An estimate of the total phlebotomy volumes based on the total number of almost all tests in both groups showed a decrease of approximately 30% in the post-POC group — a value that is close to the 43% reduction in RBC transfusions. As shown in a previous study, it is possible that in order to avoid redrawing a sample because of an insufficient volume for analysis, the amount of blood drawn by the bedside nurse or phlebotomist for a test sent to the laboratory was slightly in excess of that requested.[6] Other studies have estimated additional blood losses on to gauze and bedding at the time of drawing to be about 10%.[31] It is also possible that extra care was instituted by the bedside nurse to avoid drawing more than the exact amount of blood required when performing the test with the iSTAT at the bedside.

Other reported causes for a decrease in transfusions include the use of erythropoietin[30] and more restrictive transfusion guidelines.[21,28,29] In the present study, erythropoietin was not used in the first 2 weeks of life. Although transfusion guidelines were consistent throughout both study periods, transfusion was left to the discretion of the attending physician and it was possible that our NICU's transfusion guidelines were always strictly followed. The mean pretransfusion hematocrit was similar during both periods. Thus, the decrease in transfusions seen in the post-POC testing group was unlikely to be secondary to a higher threshold for transfusing these infants.

Another possible explanation for the difference between the two groups would be if there were a larger number of smaller and sicker infants in the pre-POC testing group.[17] As shown in Table 1, although there was a slightly higher percentage of infants with a birth weight $\leqq$750 g and a higher percentage of male infants in the pre-POC testing group, these results were not statistically significant.

In summary, the results of this study suggest that use of newer, bedside devices can help reduce blood transfusions. Since the use of the iSTAT unlike other in-line POC devices[9–14,32] does not require the presence of an arterial catheter, it can potentially contribute towards reducing phlebotomy losses and blood transfusions throughout the infant's hospital stay.

Acknowledgements

We acknowledge the technical assistance and data collection contributions of Karen J. Johnson, RN from the University of Iowa and Teresa Newton, Bethany Ball and the staff in Medical Records and the Blood Bank at Stanford University. This work was presented in part at the Society for Pediatric Research Meeting in May 2004 in San Francisco. This study was supported in part by funding provided by the NIH General Clinical Research Centers Program (Grant RR00059).

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