Point of Care Testing: The Relationship of Diagnostic Testing Sample Volume, Iatrogenic Anemia and Transfusion Requirements

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The results shown here are specific to one healthcare facility and may differ from those achieved by other institutions.
Disclosures

None of the research cited by Dr. Geaghan is industry-sponsored.

Dr. Geaghan holds an NIH grant for “Lab-on-a-chip” a point of care device using digital microfluidics.

Dr. Geaghan’s talk is sponsored by Abbott Point of Care Division.
PATIENT

↓ test

question ➔ decision ➔ action

↓

OUTCOME
Reasons for Providing Results Quickly--Clinical

- Faster stabilization
- Immediate risk stratification
- Fewer intraoperative complications
- Fewer postoperative complications
- Closer therapeutic management
- Greater patient compliance
Reasons for Providing Results Quickly--Operational

- Optimized patient triage
- Optimized intensive care stay
- Reduced unnecessary length of stay
- Optimized clinical appointments
- Optimized use of specialists time
- Reduced transport costs
- Fewer lost samples
- Optimized usage of pharmaceuticals
Reasons for Providing Test Results Quickly--Economic

• Reduced testing Required
• Reduced drug utilization
• Reduced staff requirement
• Fewer clinical visits
• Fewer complications
• Faster hospital turnaround
• Fewer working days lost
• Improved life expectancy
The commitment to improving the efficiency and effectiveness of all aspects of health care delivery is based on more accurate and rapid decision-making.
Diagnostic Testing Sample
Volume Iatrogenic Anemia
and Transfusion Requirements
The Mission of Stanford University Medical Center: To Care; To Educate; To Discover
How We Evaluate POCT Instrumentation

- **Medical necessity**
  - TAT needs
  - Performance Characteristics of the Test
  - Volume/Throughput
  - Information system connectivity
  - Patient Billing / Workload documentation
  - Financial cost analysis
  - Staffing Requirements
    - Qualified testing personnel (Test Category)
    - Clinical Laboratory Scientists staff POCT Dept
  - POCT Steering Committee Reviews Proposal
  - Medical Director approval required
Increasing Diagnostic Test Utilization Adds to Phlebotomy Burden

- Two groups of trauma patients were retrospectively compared: 360 in 2009 and 384 in 2004; the mean number of tests increased significantly (from $21.2 \pm 32.5$ to $28.5 \pm 44.4$, $p = 0.003$)
- Total blood volumes drawn increased (From $144.4 \pm 191.2$ ml to $187.3 \pm 265.1$ ml, $p=0.025$)
- 25% cost increase due to increase in lab tests
- Mortality and length of stay (ICU and hospital) unchanged

Specimen Collection Practices

- Laboratories collected a median of 2.76 ml (8.5 times) more than the analytic volume for routine CBCs, 1.75 ml (12 times) more than analytic volume for routine electrolyte panels.
- Specimen collection container size directly correlated with overcollection & discard volumes.
- Discard (unused specimen remaining after testing) volumes = 2.8 ml/tube for CBCs; 2.0 ml/tube for electrolytes.

Specimen Collection Practices: the Effect of Arterial Lines

- The presence of an arterial access line leads to increased blood drawing in ICUs
- Only 9.4% of RNs do not discard any blood when drawing from an arterial line
- Mean discard blood volume to clear an arterial line was 2.99 ml
- Patients with a-lines had increases in number of blood tests (29%, p=0.013); blood draws (30%, p =0.014) & amount of blood volume drawn (44% p < 0.001) compared with patients without a-lines

Blood Sampling in Low Birth Weight Infants within First 28 Days of Life

- Sixty VLBW infants studied (560-1450 g)
- 7998 punctures - 4.8 per infant per day - performed
- Mean blood loss = 50.3 ml/kg per 28 days¹
- In 2 days 10-15% of infant’s blood volume can be removed ²

Phlebotomy Overdraws in Neonatal Nurseries Contribute to Blood Loss

- In 578 draws analyzed, the mean draw exceeded required amount by 19% ± 1.8% per test
- Significant associations were: collection in containers without fill lines
- Blood overdraw greater with syringes
- Lighter weight infants
- NICU
- Individual phlebotomist and evening shift augments effect

High Risk of Developing Anemia for Pediatric Intensive Care Unit Patients and Transfusions are Related to Poor Outcomes

- 977 prospectively enrolled children: 74% in were anemic, including 41% who developed anemia after admission & 33% at admission
- Median blood loss 5.0 ml/day, 73% of daily blood loss is due to phlebotomy
- Age-and illness-adjusted comparison showed transfused children (vs. non-transfused children) have higher nosocomial infection rates; higher number of mechanical ventilation days; increased mortality; increased cardiorespiratory dysfunction

Small Increases in Phlebotomy Double the Odds of Transfusion

- In 155 ICU patients daily phlebotomy volume was $13.3 \pm 7.3$ ml
- 62% of patients received a mean of $3.4 \pm 5.3$ units packed red cells, mean trigger was $7.7 \pm 0.9$ g/dl after day 21
- Small increases in phlebotomy (3.5 ml/day 95% CI, 2.4-6.8 ml/day) doubled the odds of being transfused after day 21

Variability in Transfusion Practices Can Sometimes Account for Why Differences in Phlebotomy do not Equal Differences in Transfusions

Anemia in Older Adults

• Highly prevalent, >20% over 85 years of age; 9-18% in older men & 8-13% in older women

• Increased mortality

• Risk of hospitalization

• Increased risk of functional decline

The elderly are at particular risk from the effects of repeated blood draws owing to factors related to aging of the hematopoietic system and a relatively high prevalence of anemia. The elderly have limited bone marrow reserves, which limits the capacity for hematopoietic regeneration after blood losses. Human aging is characterized by a progressive decline in hematopoiesis.
Few measures are taken to reduce diagnostic blood sample size in adult intensive care units, England and Wales

- Arterial blood taken to “clear” the arterial line before sampling = 3.2 ml
- Only 18.4% of units returned to patient
- Only 9.3% of units use pediatric tubes
- In pediatric units, average volume withdrawn to “clear” line = 1.9 ml, and blood was returned in 67% of adult units

Increased mortality & morbidity in adult cardiac patients associated with RBC transfusions

• Allogeneic transfusion was studied in 25,000 Medicare cardiac patients and increased the odds of in-hospital infection 2-fold; increased in-hospital mortality 4.7-fold; 30-day readmission rates 1.4X; 30-day mortality 2.9X and was associated with infections in the: genitourinary system, respiratory tract, bloodstream, digestive tract, skin, and infection with Clostridium difficile. Each 1% increase in hospital transfusion rates provided a 0.13% increase in predicted infection rates.

• A meta-analysis of adult cardiac surgery literature included: increased mortality, and post-operative mortality e.g. serious wound and systemic infections, strokes, renal failure, MI and low cardiac index


Growing Literature Underscores Blood Transfusion Associated with Poor Clinical Outcomes

- 4892 critically ill adult patients studied in prospective multicenter study: longer LOS; increased mortality; more complications and likelihood to have complication \(^1\)
- In 802 discharges from pediatric cardiac surgery, transfusion associated with prolonged LOS \(^2\)


An association between development of necrotizing enterocolitis (NEC) and “late” blood transfusions exists

- Most blood transfusions not followed by NEC; most NEC not temporally associated with a blood transfusion
- Immunologic transfusion reaction? Anemia-related gut injury? Storage lesion in red cells?
- Feedings while administering transfusion are posited as a variable
- Pathogenesis and preventative measures unclear

An association between development of severe IVH “early” red blood cell transfusions exists

- Not all IVH temporally associated with neonatal blood transfusion
- Not all neonatal blood transfusions are followed by IVH
- Successful efforts to reduce/eliminate early PRBC transfusions in first days of life in VLBW delivery reduce severe IVH prevalence
- Delayed clamping of the umbilical cord
- Milking the umbilical cord
- Drawing all NICU baseline laboratory blood tests from fetal blood in the placenta-no initial blood draws from the neonate

Evidence-based strategies* for reduction or elimination of blood transfusions in neonates

* non-pharmaceutical
“Milking” the umbilical cord & delay cord clamping

- 40 singleton infants 24-28 wks GA randomly assigned to cord striping or early clamping “Milked” group higher hgb levels (mean 2 g / dL ); higher mean BP (mean 6 mm Hg); shorter ventilation time

- VLBW neonates with a higher initial hemoglobin level had lower odds of requiring a RBC transfusion and lower odds of developing an IVH

- 58 newborns prior to 33 wks GA randomized to cord clamping (30 sec delay) or cord striping (4 repeats): no differences between the groups in hemoglobin levels, transfusions, morbidities; milking the cord in this manner achieved a similar volume of transfusion as did delaying the cord clamping for 30 seconds


Obtaining all baseline laboratory blood tests from discarded fetal placental blood postpones or eliminates transfusions in VLBW neonates

- Prospective single-centered case-control feasibility analysis on 10 cases & 10 controls matched for sex, GA, weight, race (all 20-early cord clamping)
- At 18 hours, hgb rose in 9 cases vs 2 controls (p=0.005)
- At 72 hours, 1 case vs 5 controls qualified for/received a PRBC transfusion
- At 1 wk, cases = 4 transfusions vs. controls 16 (p = 0.02)
- No cases w/ IVH; 4 controls IVH (grade 1) and 2 IVH (grade 3) (p = 0.01)

Christenson RD, et al. Postponing or eliminating red blood cell transfusions of very low birth weight neonates by obtaining all baseline laboratory blood tests from otherwise discarded fetal blood in the placenta. Transfusion 2011; 51: 253-258.
Study Objective and Design

- Hypothesis proposed that the handheld analyzer would result in a significant decrease in the number and volume of RBC transfusions in the first two weeks of life
- Retrospective review of all extremely low birthweight infants (<1000 g) admitted to NICU that survived to two weeks of age
- Two separate one-year periods audited: conventional blood gas analyzer (period 1) & i-STAT® analyzer (period 2)
### Table 1 Characteristics of Infants by Study Group

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Pre-POC testing (n = 46)</th>
<th>Post-POC testing (n = 34)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td></td>
<td></td>
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<tr>
<td>White</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>Black</td>
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<td>1</td>
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<tr>
<td>Hispanic</td>
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<tr>
<td>Birth weight (%)</td>
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<tr>
<td>≤750 g</td>
<td>20 (45)</td>
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<tr>
<td>751–1000 g</td>
<td>26 (57)</td>
<td>22 (65)</td>
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<tr>
<td>Gestational age (week)</td>
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<tr>
<td>Mean ± SD</td>
<td>26±2.2</td>
<td>27±2.2</td>
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<tr>
<td>Male (%)</td>
<td>24 (52)</td>
<td>12 (55)</td>
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<tr>
<td>Pretransfusion Hct (%)</td>
<td>36.3±4.3</td>
<td>34.5±4.9</td>
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<td></td>
<td>n = 257</td>
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<td>Blood gases</td>
<td>58±37</td>
<td>50±31</td>
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<tr>
<td></td>
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<tr>
<td>Complete blood count</td>
<td>15±7</td>
<td>13±4</td>
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<td></td>
<td>n = 44</td>
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<td>Serum electrolytes*</td>
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<tr>
<td>Chemistry 8*</td>
<td>15.5±5.6</td>
<td>12.4±3.6</td>
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<td></td>
<td>n = 44</td>
<td>n = 33</td>
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<td>Chemistry 23*</td>
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<td></td>
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<tr>
<td>All blood tests</td>
<td>94±47</td>
<td>81±33</td>
</tr>
<tr>
<td></td>
<td>n = 44</td>
<td>n = 32</td>
</tr>
</tbody>
</table>

*Mean ± SD.  
*p < 0.05.


Results

• A 46% reduction in the number of RBC transfusions was realized following institution of POCT analyzer testing

• A 43% reduction in the volume of RBC transfusions was realized with POCT analyzer usage

• No significant difference in the total number of laboratory tests performed

Study Conclusions

• Use of a point-of-care blood gas analyzer is associated with a clinically important reduction in RBC transfusions in the ELBW infant during the first two weeks of life
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 (STAT, Princeton, NJ) that requires a smaller volume of blood to replace conventional Radiometer blood gas and electrolyte analysis by our neonatal intensive care unit (NICU). The smaller volume of blood required for sampling (100 vs 500-500 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 (STAT) analyzer that measures pH, PCO₂, PO₂, hemoglobin, hematocrit, sodium, 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 of all healthy 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 STAT (POC) device during the second period (designated post-POC testing). Data collected for individual infants included the number of RBC transfusions, volume of RBC 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 of life was 5.7 ± 3.74 (n = 46) in the pre-POC testing period and 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 45% with use of the POC analyzer, that is, from 78.4 ± 51.6 μl/kg in the pre-POC testing group to 44.4 ± 52.9 μl/kg in the post-POC testing group (p < 0.001). 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 2 weeks of life.

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 <1500 g will receive one or more blood transfusions. Half of the transfusions that these infants receive during their hospitalization occur during the first 2 weeks of life. Intensive laboratory testing leading to phlebotomy losses during this period is one of the main causes for the anemia. In addition, phlebotomy “overdraw” in excess of that needed by the laboratory is a common occurrence in preterm infants. 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. RBC transfusions have the risk of incompatibility and transfusion reactions as well as viral infections. 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). Recent technologic innovations in the design
Cost reduction associated with transfusion reduction in NICU recently validated in European study

- After implementation of POCT, reduction in number of very low birth weight infants [VLBW] requiring blood transfusion (38.9% vs. 50%, p<.05)
- Number of transfusions/infant decreased 38% (1.57 vs. 2.53, p<0.01)
- Although some test numbers increased (+12% bili; +2.5% lytes) large reduction in the number of laboratory tests performed per admission
- POCT implementation of POCT cost-efficient for the Belgian national health insurance: reduction −8.3% per neonate
- Implementation of a bedside multi-parameter POCT analyzer decreases transfusions among VLBWI by reducing iatrogenic blood loss associated with central laboratory testing.

We may be able to decrease iatrogenic anemia and potentially reduce transfusion requirement by appropriately utilizing point of care technologies.

This can potentially improve health by avoiding transfusion-related increases in clinical morbidity and mortality.
Future directions favor growth in POCT

- Key health care trends: aging population & increased longevity
- Technological advances
- Changing demands from the patient
- Hospital process re-engineering (LOS)
- More health care in the home
- Logistics support of samples and test results rapid transport
Summary

• Develop clinical algorithms to best leverage POCT
• Collaborate with clinical staff for management of quality, risk, training and audit
• Consider the clinical and economic outcomes, organizational impact and cost effectiveness of the whole patient episode along with the technical and diagnostic performance of POCT
• Growing imperative to reduce blood transfusions
• Laboratory medicine professionals take responsibility as expert advisors and quality managers for adherence to standards in the growth of POCT
Thank you

Follow up questions?
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