Effects of Blood Conservation on the Incidence of Anemia and Transfusions in Pediatric Parapneumonic Effusion: A Hospitalist Perspective

Nabil E. Hassan, MD
John Winters, MD
Kim Winterhalter, MD
Diann Reischman, PhD
Yasser El-Borai, MB, BCH

Helen DeVos Children's Hospital, Grand Rapids, Michigan.

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BACKGROUND: Children with pneumonia may develop parapneumonic effusion (PNE). The associated inflammatory process and nutritional compromise can blunt erythropoiesis. Traditional treatment for these children with PNE includes repeated phlebotomy and surgical intervention, resulting in ongoing blood losses. Blood transfusions used to treat acquired anemia are associated with multiple complications.

OBJECTIVES: This study evaluated the effect of hospitalists’ implementation of blood conservation guidelines (BCG) on the incidence of anemia and transfusion requirements in children with PNE.

DESIGN: Retrospective cohort study of hospitalized children with PNE.

SETTINGS: University affiliated Children's Hospital.

PATIENTS: Children who were admitted to the hospital with PNE and managed using BCG (Group I) were compared to simultaneous no intervention group (S) and historical no intervention group (H). Group (I) and (S) were admitted from year 2000 to 2004 and the Group (H) were admitted from year 1997 to 1999.

MEASUREMENTS: Phlebotomy frequency and volume, measured hemoglobin (Hgb) levels, and the need for red blood transfusions.

RESULTS: Children in the BCG group (n = 24) compared to simultaneous no intervention group (n = 28) and historical no intervention group (n = 29) had lesser phlebotomy volumes (14 ± 8, 18 ± 14 and 69 ± 66 mL; P = 0.001), trend toward lesser Hgb drop (1.7 ± 1.4, 2.1 ± 1.2 and 2 ± 1.4 gm%; P = 0.37), and lesser incidence of transfusion (8%, 18% and 31%; P = 0.11). Transfused children were younger (3.5 ± vs. 6.4 ± 4 years; P = 0.001) and had lower initial Hgb (9.9 ± 1 vs. 11.4 ± 1 gm%; P = 0.001), more phlebotomy (5.9 ± 7 vs. 1.1 ± 1 mL/kg., P = 0.001), longer hospitalization (18.7 ± 5 vs. 11.1 ± days; P = 0.001), and slightly higher (pediatric risk of mortality [PRISM]) scores (3.4 ± 5.7 vs. 1.6 ± 2.7; P = 0.25).


KEYWORDS: blood conservation, children with parapneumonic effusion, empyema, guidelines, hospitalist, para-pneumonic effusion, pediatric anemia, pediatric hospitalization, pediatric transfusion, transfusion incidence.

Additional Supporting Information may be found in the online version of this article.

Pediatric patients with pneumonia frequently develop parapneumonic effusion (PNE), which account for 0.4 to 6 cases per 1000 pediatric admissions. The effusion initially is in a transudative, free-flowing phase that may evolve to fibrino-purulent phase and a later organizing phase. Hospital management includes antibiotic therapy, pain control, fluids, nutritional support, diagnostic imaging and most important is fluid drainage. Fluid drainage could be through thoracentesis, chest tubes, fibrinolysis, video-assisted thoracoscopic surgery (VATS), or thoracotomy.

During hospitalization, repeated phlebotomy and surgical procedures result in ongoing blood losses while systemic inflammation and nutritional compromise may blunt erythropoiesis. Both mechanisms may result in developing anemia and subsequent need for red blood cell transfusion (RBCT). Blood transfusions are associated with multiple complications including transfusion transmitted infections, acute lung injury, hemodynamic compromise, volume overload, hemolysis, and immune compromise. Furthermore, suboptimal benefits, increased resource utilization, and risk of mortality have also been reported in Pediatric intensive care unit (ICU) patients who received blood transfusions.

A Pediatric Blood Conservation program was launched at Helen DeVos Children's Hospital in 1999, and since its inception the pediatric hospitalists have implemented blood conservation guidelines (BCG) in the management of some of the patients with PNE. The BCG incorporated into the care of the intervention group (group I) were orders for:

- Minimizing phlebotomy draws (without stating a specific frequency).
• Use of micro sampling blood collection tubes and rein- 
fusion of any blood drawn prior to obtaining a blood sam-
ple (waste return).
• Hematinics use at managing physician’s discretion (see Sup-
porting Appendices 1 and 2 in the online version of this article).

No previous studies have addressed the impact of blood 
conservation strategies on the development of anemia in 
pediatric PNE. We hypothesized that BCG implementation 
resulted in smaller phlebotomy losses, lesser incidence of 
anemia, and lower transfusion requirements.

Methods
After obtaining an approval from the institutional review 
board, a retrospective medical records review was con-
ducted of all pediatric patients (1 month-18 years) admitted 
to Helen DeVos Children's Hospital with diagnoses of PNE 
from the period of January 1997 to December 2004.

Study Groups
Intervention group (group I) included all patients who were 
admitted with a diagnosis of PNE between the year 2000 to 
2004 and had orders for BCG (as outlined above) written on 
or after admission to the hospital. That group included patients 
that were either solely managed by the hospitalists or coman-
aged by both the general pediatrician and the Hospitalist.

Simultaneous nonintervention group (group S) included 
patients with PNE who were admitted between 2000 to 2004 
and did not have BCG orders on their record. Those patients 
were either managed solely by the general pediatricians or 
the Hospitalist may have been involved but no BCG orders 
were written. It was assumed that no intervention was 
implemented.

Historical nonintervention group (group H) included 
patients with PNE admitted between 1997 and 2000 prior to 
the implementation of the blood conservation program or 
the hospitalists service. Those patients were managed by the 
general pediatricians with the Intensivists help at times and 
no blood conservation measures were implemented.

Phlebotomy frequency and volume data were collected 
from the patient’s medical record. When volume was not 
documented, an estimate was made based on the hospital 
actual practice and labs reported. If the child had central 
vascular access, a standard of 2 mL of blood was removed 
to clear the line prior to drawing the blood sample. In the S 
and H groups that volume was discarded and recorded as a 
blood loss. In Group I the blood used to clear the line was 
returned to the patients. Data regarding the patient’s hemo-
globin (Hgb) levels on admission and during hospitalization 
as well as RBCT frequency and volume were also collected. 
Other background data collected included, hospital stay, 
ICU admission, antibiotic use, isolated organisms, and PNE-
related interventions (thoracentesis, VATS and chest tube 
placement). A pediatric risk of mortality score (PRISM 
score$^{17}$) was assigned for every patient based on data col-
lected on the day of admission.

Statistical analysis was done using a Fisher exact test to 
compare qualitative data. For quantitative data Kruskal-
Wallis was used for comparison between the three groups 
while the Mann Whitney test was used for the pair wise 
comparisons. Odds Ratios and Confidence Intervals were 
calculated for variables associated with needing RBCTs.

Results
A total of 81 patients who were admitted to the hospital 
for medical and surgical management with PNE were included 
in the study. During the study period 24 patients with blood 
conservation orders on the chart were assigned to the inter-
vention group. Another 28 patients were identified during 
the same period but did not have blood conservation orders 
and were assigned to the simultaneous non intervention 
path. A historical no intervention group of 29 patients 
were identified from a 3-year period prior to the study pe-
riod. Groups were similar in age, weight, and an overall low 
PRISM score. Group H tended to have lower acuity, longer 
hospital stay, more frequent pediatric intensive care unit 
(PICU) admissions, and tended to have more chest tube 
days compared to the (I) and (S) groups (Table 1).

All groups (I, S and H) had similar initial Hgb, in-hospital 
decline in Hgb levels and time to reach a Hgb nadir. There 
was a trend toward a lower frequency of phlebotomy and 
significant difference in the phlebotomy volumes drawn 
even when corrected for patient weight and hospital stay, 
(I < S < H; P = 0.006), (Table 1).

All 3 groups had a similar pretransfusion Hgb trigger 
(7.7 ± 1 gm/dL), timing of transfusions (7.9 ± 1 day), vol-
ume of packed red blood cells (PRBCs) (19 ± 15 mL/kg), 
and magnitude of Hgb rise following transfusions (3.9 ± 1.5 
gm/dL). There was a strong trend toward lower transfusion 
need in the intervention group though it did not reach sta-
tistical significance (8.3% [I], 17.9% [S]; and 31% [H]; P = 
0.11) (Table 1 and Figure 1). Being in group (S) compared to 
(I) carried a relative risk of transfusion of 2.14 (confidence 
interval [CI], 0.46–10.06).

Of all study patients, 19.8% received RBCT. Compared to 
those who did not require transfusions they were signifi-
cantly younger, smaller (P = 0.001) and had a higher sever-
ity of illness score (PRISM) (P = 0.25). Transfused children 
had lower initial Hgb levels, more frequent phlebotomy, 
greater volume of blood drawn, and longer hospital stay 
(P = 0.001) (Table 2 and Figure 2).

A total of 36% of the patients were pretreated with antibi-
otics prior to obtaining pleural fluid cultures. Forty-eight 
patients (59%) had negative cultures, 22 (27%) grew pneu-
mococcus, 5 patients (6%) had streptococcus A, 2 patients 
had streptococcus viridans, 3 patients had staphylococci 
aureus, and 1 patient had Haemophilus influenzae. There 
was no difference between the study groups regarding the 
site of effusion, prior antibiotics therapy or culture results.
**Discussion**

This retrospective study showed that children with PNE had low Hgb upon admission to the hospital and after dropping an average of 2 gm/dL over the first week of hospitalization one-fifth of the patients required transfusion. The phlebotomy volumes significantly decreased with BCG implementation, and transfusion frequency showed a strong trend toward decline. The fact that all 3 groups had similar pretransfusion Hgb and similar Hgb decline, despite differences in the phlebotomy volumes, may implicate other factors like bone marrow suppression, malnutrition, and procedural blood losses. All of these factors have been shown to contribute to the development of anemia in the critically ill patients\(^8\) and were not accounted for in this limited retrospective review.

Transfused patients were significantly smaller, younger, and had higher illness severity scores. They had lower initial Hgb levels, more phlebotomy, and longer hospital stay than nontransfused patients.

Pretransfusion Hgb was 7.5 gm/dL to 7.7 gm/dL in all groups, consistent with Lacroix et al.\(^18\) report on the safety of lower transfusion threshold in stable PICU patients. BCG resulted in a strong trend toward less transfusion but did not reach statistical significance likely due to the small sample size. It is tempting to hypothesize that aggressive erythropoietin therapy might augment that trend; however, given the relatively short hospital stay (10–14 days), erythropoietin therapy may be less efficacious in the milder case with shorter hospital stay than those with longer hospitalization. After encouraging smaller studies\(^19\) Corwin et al.\(^20\) did not find a beneficial effect for erythropoietin in adult ICU patients nor did Jacobs et al.\(^21\) in ventilated children with bronchiolitis who had comparable length of hospitalization.

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**TABLE 1. Characteristics of the Study Population**

<table>
<thead>
<tr>
<th>Group I (n = 24)</th>
<th>Group S (n = 28)</th>
<th>Group H (n = 29)</th>
<th>Kruskal-Wallis P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>6 (±4)</td>
<td>5 (±4)</td>
<td>6 (±5)</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>26 (±19)</td>
<td>22 (±13)</td>
<td>27 (±17)</td>
</tr>
<tr>
<td>PRISM Score</td>
<td>2 (±3)</td>
<td>3 (±5)</td>
<td>(±1)</td>
</tr>
<tr>
<td>PICU admission number (%)</td>
<td>3 (12)</td>
<td>8 (29)</td>
<td>14 (48)</td>
</tr>
<tr>
<td>Chest tube days</td>
<td>7 (±4)</td>
<td>6 (±4)</td>
<td>9 (±5)</td>
</tr>
<tr>
<td>Hospital stay days</td>
<td>10 (±4)</td>
<td>13 (±6)</td>
<td>15 (±6)</td>
</tr>
<tr>
<td>Initial Hgb, gm</td>
<td>11.2 (±1.7)</td>
<td>11.2 (±1.6)</td>
<td>11.1 (±1.9)</td>
</tr>
<tr>
<td>Drop in Hgb, gm</td>
<td>1.7 (±1.4)</td>
<td>2.1 (±1.2)</td>
<td>2 (±1.4)</td>
</tr>
<tr>
<td>Days to Hgb Nadir</td>
<td>6.1 (±3–7)</td>
<td>8.5 (±5.5)</td>
<td>6.9 (±4.3)</td>
</tr>
<tr>
<td>Number of blood draws</td>
<td>7.6 (±6)</td>
<td>11 (±9)</td>
<td>12.6 (±12)</td>
</tr>
<tr>
<td>Phlebotomy volume, mL/kg/day</td>
<td>0.08 (±0.05)</td>
<td>0.14 (±0.33)</td>
<td>0.22 (±0.24)</td>
</tr>
<tr>
<td>Number of patients transfused (%)</td>
<td>2 (8.3)</td>
<td>5 (17.9)</td>
<td>9 (31)</td>
</tr>
</tbody>
</table>

**NOTE:** Results shows ± SD. I, intervention; S, simultaneous no intervention; H, historical no intervention.

**Abbreviations:** Hgb, Hemoglobin; PICU, pediatric intensive care unit; PRISM, pediatric risk of mortality; SD, standard deviation.

* H < S by Mann-Whitney test (P = 0.002).
* H > I by Chi Square test (P = 0.005).
* Fisher exact test.

**TABLE 2. Characteristics of Transfused Patients**

<table>
<thead>
<tr>
<th>Transfused (n = 16)</th>
<th>Not Transfused (n = 65)</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ages, years</td>
<td>3.5 (±4)</td>
<td>6.4 (±4)</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>16.1 (±9)</td>
<td>26.9 (±17)</td>
</tr>
<tr>
<td>Initial Hgb, gm</td>
<td>9.9 (±1)</td>
<td>11.4 (±1)</td>
</tr>
<tr>
<td>Number of blood draws</td>
<td>20 (±12)</td>
<td>8 (±6)</td>
</tr>
<tr>
<td>Total phlebotomy volume, mL</td>
<td>82 (±75)</td>
<td>23 (±25)</td>
</tr>
<tr>
<td>Total phlebotomy volume, mL/kg</td>
<td>5.9 (±7)</td>
<td>1.1 (±1)</td>
</tr>
<tr>
<td>Hospital stay days</td>
<td>19 (±5)</td>
<td>11 (±5)</td>
</tr>
<tr>
<td>PRISM score</td>
<td>3.4 (±6)</td>
<td>1.6 (±3)</td>
</tr>
</tbody>
</table>

**NOTE:** All data presented in means ± SD.

**Abbreviations:** CI, confidence interval; Hgb, Hemoglobin; PRISM, pediatric risk of mortality; SD, standard deviation.

* Mann-Whitney P < 0.001.
* Fisher Exact test.

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A specific benefit could not be attributed to iron/folate or erythropoietin therapy as neither the dosing, duration nor timing was controlled. Furthermore, given the limitations of retrospective reviews, the relative importance of the beneficial effect of limiting phlebotomy vs. hematinics use could not be determined.

The Hospitalist is focused on improving the quality and efficiency of caring for the inpatient.22–25 The initiation of the hospitalist’s service at our institution coincided with that of the blood conservation service. Consequently, the Hospitalist contributed to patient care as well as daily house staff and nursing education. For those children whose care was coordinated by the hospitalists, the study data showed a trend toward lesser admissions to the PICU and lower blood utilization. This trend further emphasizes the role a Hospitalist could play in adopting and implementing useful medical strategies lowering the cost of care. In this study, a change in patient care was observed over time with the hospitalists tending to employ more blood conservation measures when compared to the pediatrician.

In summary, children with PNE are at risk for developing severe anemia requiring transfusion. This retrospective study identified the characteristics of those likely to require transfusions. Blood conservation strategies seem to decrease the need for transfusions. The hospitalists played an important role in implementing the BCG. A prospective controlled study with adequate power is needed to examine both the various mechanisms for developing anemia and the impact of the individual components of the blood conservation strategies.