Evidence-Based Blood Conservation Education for ICU Nurses: A Pre and Post-Test Evaluation of Nursing Knowledge

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Final DNP Capstone Report

Evidence-Based Blood Conservation Education for ICU Nurses:
A Pre and Post-Test Evaluation of Nursing Knowledge

Stefanie M. Bull, DNP, BSN, RN

University of Kentucky
College of Nursing
Spring 2014

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* With special thanks to the CVICU nurses at The University of Kentucky Hospital for volunteering their time and participating in this project.
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Introduction to Final DNP Capstone Report

Stefanie M. Bull, DNP, BSN, RN

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College of Nursing
Introduction & Background

According to the World Health Organization, anemia is defined as a condition in which the number of red blood cells or their oxygen carrying capacity is insufficient to meet the physiologic needs of the body, which vary by age, sex, altitude, smoking, and pregnancy status (World Health Organization, 2013). Iron deficiency is thought to be the most common cause of anemia globally, although other conditions, such as folate, vitamin B12 and vitamin A deficiencies, chronic inflammation, parasitic infections, and other inherited disorders can all cause anemia (World Health Organization, 2013).

Anemia is also one of the most commonly encountered abnormal lab findings among critically ill patients in the Intensive Care Unit (ICU) setting (Hannon, 2013). Principle causes of anemia in this population can be grouped into one of the following three categories: blood loss, decreased red blood cell (RBC) production or increased RBC destruction (Prakash, 2012). Clinical signs and symptoms of anemia vary depending on the acuteness of onset and the severity of anemia, as well as the age and underlying health status of the patient, and the ability of the body to compensate for the anemia (Prakash, 2012). The management of anemia in the ICU typically includes the transfusion of blood products. Clinical studies have shown that transfusions are associated with worse outcomes and significantly increased healthcare costs (Goodnough & Shander, 2007). In fact, a direct relation between the number of blood transfusions a patient receives, and the mortality rate, has been demonstrated (Vincent et al., 2008). Additionally, growing awareness among healthcare providers of the risks associated with transfusions has lead to the reevaluation of transfusion practice trends.
and the evolution of blood conservation strategies aimed at decreasing iatrogenic blood loss, anemia and transfusions. The evidence on blood conservation within the published literature is strong, however, to date few institutions have developed and implemented formal blood conservation programs (Hannon, 2013). Furthermore, blood conservation practice varies greatly between institutions and is likely due to a knowledge deficit among providers regarding the impact of blood conservation on anemia and transfusion related risks (Stover & Broomer, 2013).

This practice inquiry project is an evaluation of an evidence-based blood conservation education intervention developed to improve knowledge and awareness of blood conservation in ICU nurses. The evaluation of the impact of this intervention on nursing knowledge will provide insight and guide future research on the most effective way to influence blood conservation practice among ICU nurses. This practice inquiry project includes three manuscripts each of which discusses relevant aspects of anemia, blood conservation, and transfusion medicine. Additionally, the development, implementation and evaluation of an evidence-based education intervention for ICU nurses on anemia blood conservation and transfusion medicine will be presented.

• Manuscript one is an evidence review of the literature to (i) determine the potential impact of iatrogenic blood loss on the development of anemia, and (ii) to evaluate the effectiveness of available blood conservation devices and strategies in decreasing iatrogenic anemia and blood transfusions in adult ICU patients.
• Manuscript two is a cost-analysis of the potential financial benefits of implementing a blood management program at a large university teaching hospital with a level-1 trauma center.

• Manuscript three describes the development, implementation, and evaluation of a blood conservation education intervention, and its impact on nursing knowledge and attitudes towards future implementation of blood conservation practices.
Manuscript 1

Integrative Literature Review

Stefanie M. Bull DNP, BSN, RN

University of Kentucky

College of Nursing
Abstract

Anemia is prevalent among critically ill patients. The causes of anemia in these patients are multifactorial and may include both physiological and iatrogenic etiologies. Moreover, anemia, regardless of its' cause is also an independent risk factor for poor clinical outcomes. Interestingly, iatrogenic causes of anemia in critical illness are often predictable and may even be preventable as they typically result from excessive diagnostic lab testing. Observational studies have confirmed that healthcare providers in the intensive care unit (ICU) setting excessively order lab tests, frequently drawing enough blood during the first few days of ICU admission to cause even a patient with previously normal hemoglobin on admission to become anemic. Low hemoglobin (Hgb) levels are also the most common reason for red blood cell (RBC) transfusions. Research has indicated that transfusion to augment oxygen delivery offers no survival advantage when hemoglobin concentrations exceed 7 g/dL, in most patients. Although transfusion medicine has come a long way and blood products are now safer than ever before, allogeneic blood transfusions still carry serious risks. Transfusions are frequently associated with adverse outcomes including increased risk of morbidity and mortality. Due to the growing awareness of transfusion related risks, ‘transfusion triggers’, or the Hemoglobin level at which blood transfusions are clinically indicated, has come under close scrutiny.

Blood conservation plays an important role in decreasing iatrogenic blood loss, the risk of anemia, and in preventing unnecessary blood transfusions. Blood conservation devices exist and have been shown to be highly effective in decreasing
iatrogenic blood loss. However, despite this evidence the integration of blood conservation into practice has been variable and many healthcare providers are still unaware of the many benefits that go along with blood conservation practice and transfusion avoidance.

This review explores the current evidence of the role of blood conservation devices in decreasing iatrogenic blood loss, anemia and transfusions in the critical care setting.

**Key words:** Anemia, iatrogenic, intensive care unit, blood conservation devices, VAMP device, low volume tubes, critical illness, nurses, phlebotomy, blood transfusions.
Background and Significance

Anemia remains a common problem in the critically ill that often persists throughout the duration of the patient’s ICU and hospital stay. Although anemia is often a presenting symptom in this population of patients, research has shown that of those patients who do not initially present with a low hemoglobin, 95% will become anemic by day three following ICU admission (Corwin et al., 2004). Notably, anemia is associated with less favorable outcomes and has been identified as an independent risk factor for morbidity and mortality (Goodnough & Shander, 2007). Critically ill patients face an even greater risk from the adverse effects of anemia given the cardiovascular, respiratory, and metabolic compromises that characterize critical illness (Mahdy et al., 2009).

Anemia in the ICU setting can be classified as acute or chronic. Acute anemia denotes a precipitous drop in hemoglobin due to hemolysis or hemorrhage from trauma, surgery, and even frequent phlebotomy (McEvoy & Shander, 2013; Prakash, 2012). Phlebotomy in the ICU is an often overlooked but significant contributing factor to the development of iatrogenic anemia. Blood loss due to frequent lab testing has been estimated to exceed 50cc per patient, per day in the ICU (Mahdy et al., 2009). In contrast, chronic anemia, or anemia of chronic disease is a manifestation of an underlying disease process that may include chronic kidney disease, heart failure, rheumatoid arthritis, HIV/AIDS, liver disease, cancer, or thyroid disease (Prakash, 2012). A summary of the most common causes of anemia in ICU patients is provided in Table 1 (McEvoy & Shander, 2013). Regardless of the cause, subnormal hemoglobin
levels are the most common reason for transfusion (McEvoy & Shander, 2013).

Evidence has indicated that the transfusion of allogeneic blood is synonymous with poor clinical outcomes such as prolonged ICU and hospital length of stay (LOS), increased ventilator days, infection, transfusion reaction, transfusion-associated circulatory overload (TACO), and transfusion-related acute lung injury (TRALI) (Bernard et al. 2008; Shander, 2007; Vincent et al., 2008). Table 2 delineates the risks associated with transfusions. Given the availability of evidence on the adverse effects of anemia and transfusions, clinical researchers recommend the use of blood conservation devices to minimize iatrogenic blood loss and to prevent anemia (Mahdy et al., 2009).

A number of blood conservation devices such as, low volume or pediatric phlebotomy tubes, point-of-care testing, and the Venous Arterial Management Protection (VAMP) system produced by Edwards Lifesciences© are widely available and have been shown to be effective in decreasing the amount of blood wasted with routine lab testing. A comprehensive list of evidence-based blood conservation devices and strategies that may be implemented to further reduce iatrogenic blood loss is provided in Table 3 (Fowler, 2009).

The purpose of this integrative literature review is to evaluate the current evidence on these devices and strategies, to define their impact on decreasing iatrogenic blood loss, anemia, and transfusion requirements in critically ill adult patients.

**Description of Blood Conservation Devices and Strategies**

Studies have shown that blood conservation devices such as the VAMP system manufactured by Edwards Lifesciences Corporation©, low volume phlebotomy tubes,
and point of care testing are effective in decreasing blood loss due to phlebotomy. The VAMP system is a needleless closed blood sampling system designed to reduce the volume of blood lost with phlebotomy (Figure 1). The device can be used on both arterial and central venous lines and can be accessed with a blunt cannula to reduce the risk of needle stick injuries. The device contains a reservoir that collects diluted blood and flush solution (which would otherwise be discarded to prevent contamination of the sample) distal to the sampling port. The healthcare provider is then able to use a blunt cannula to draw the required amount of blood for the sample from the sampling port without diluting the sample with the flush solution. The flush solution from the reservoir can then be re-infused to decrease the volume of blood lost by about 10cc (Edwards Lifesciences©, 2013; Stover & Broomer, 2013).

**Research Question (PICO)**

Asking a well-formulated research question is key to conducting a quality research project and in evidence-based clinical practice (Aslam & Emmanuel, 2010). A well-defined PICO question will lead to an appropriate study design and methodology, and is an essential part of the evidence review process, which includes the following elements, (a) Population, (b) Intervention, (c) Comparison, (d) Outcome (Aslam & Emmanuel, 2010). The following PICO question will serve as a guide for this evidence review. How effective are blood conservation devices in decreasing (i) iatrogenic blood loss (i.e. the volume of blood drawn and discarded during routine phlebotomy) and (ii) blood transfusions, and (iii) preserving hemoglobin levels in critically ill adult patients?
Methods

Using a predefined strategy to extract the most current and relevant research articles from the existing literature, a comprehensive search of the Cumulative Index of Nursing and Allied Health Literature (CINAHL), Medical Literature Analysis and Retrieval System Online (MEDline), and PUBMED databases was conducted using various combinations of the following key words: Anemia, iatrogenic, intensive care unit, blood conservation devices, VAMP device, low volume tubes, critical illness, nurses, phlebotomy, blood transfusions.

The goal of this review was to identify published clinical research (i) to determine the potential impact of iatrogenic blood loss on the development of anemia, and (ii) to evaluate the effectiveness of current blood conservation devices and strategies in decreasing blood loss and transfusions in adult ICU patients. Inclusion criteria were as follows: full-text, peer reviewed nursing or medical journal articles published in English after the year 2000. Additionally, the selected studies included randomized controlled trials, before and after studies, and retrospective chart reviews that evaluated the impact of one or more blood conservation devices or strategies on the volume of blood lost, Hgb levels, or transfusion requirements in adult ICU patients. Articles extracted from the database search were then systematically reviewed for clinical significance and relevance. References of the selected articles were also reviewed and evaluated for potential application to the clinical topic. Due to the limited availability of applicable nursing literature on the subject of blood conservation the majority of the reviewed
articles were selected from the medical literature. The database search ultimately resulted in the selection of five research articles (Table 4) from the medical literature.

**Results**

*Combination blood conservation strategy (VAMP and low volume tubes) vs. standard arterial line system and adult tubes:*

A combination blood conservation strategy (VAMP and low volume phlebotomy tubes) was tested in a prospective randomized, controlled trial to evaluate the effects of this combination strategy on iatrogenic blood loss in 39 adult ICU patients. Subjects were randomized into two groups. Group A (intervention group) received the combination blood conservation strategy, while group B (control) received a standard arterial line system and adult phlebotomy tubes. As expected, there was a statistically significant difference in the volume of blood lost in the intervention and control groups; about three times more blood was lost in the control group (15.16 ml vs. 45.11 ml; Mahdy et al., 2009). Furthermore, there was no discarded blood in intervention group A, as compared to almost 25 ml lost by the average patient in control group B. No patients from either group required blood transfusion during the study (Mahdy et al., 2009). The findings of this study support the use of the VAMP device and low volume phlebotomy tubes as a simple strategy to decrease phlebotomy-induced blood loss by about 30 ml per day per patient (Mahdy et al., 2009). These results may be sustained through longer admissions, and have the potential to produce significant benefits by improving outcomes, decreasing LOS, and reducing overall costs (Mahdy et al., 2009).
**VAMP vs. Standard arterial line system:**

In a larger randomized controlled trial of 160 adult ICU patients the effect of the VAMP device (intervention group) was compared to a standard arterial pressure line set attached to an arterial catheter (control group), to determine its impact on hemoglobin levels. Both groups consisted of 80 patients and were matched for age, gender, severity of illness, baseline hemoglobin on admission and ICU LOS. Both groups had a similar (median [range]) change in hemoglobin during ICU admission (VAMP-7 [-84 to +21] g/l; Control -4 [-67 to +40] g/l; P = 0.33; MacIsaac et al., 2003). The VAMP group lost significantly less blood due to phlebotomy while in the ICU (VAMP 63 [0 to 787] ml; Control 133 [7 to 1227] ml; P = 0.001; MacIsaac et al., 2003). The study demonstrated a statistically significant reduction in iatrogenic blood loss in the VAMP group. However, the reduction did not impact the decrease in Hgb in this study as expected (MacIsaac et al., 2003).

**Hemoglobin levels, phlebotomy volumes, prolonged ICU LOS, and odds of being transfused:**

A retrospective chart review of 155 patients (with an ICU LOS > 30 days) admitted to a medical-surgical ICU in a tertiary care university hospital was conducted to collect data on transfusions, phlebotomy, and outcomes to describe the impact of anemia in patients with longer ICU stays (Chant et al., 2006). Data were collected daily from days 22 to 112 of the subject’s ICU stay. Study results revealed the following: median ICU LOS was 49 days (interquartile range 36–70 days), mean Hgb remained stable at 9.4 ± 1.4 g/dl from day seven onward, mean daily phlebotomy volume was
13.3 ± 7.3 ml, and 62% of patients received a mean of 3.4 ± 5.3 units of packed red blood cells at a mean hemoglobin trigger of 7.7 ± 0.9 g/dl after day 21 (Chant et al., 2006). This study revealed that transfused patients had significantly greater acuity of illness, phlebotomy volumes, ICU LOS and mortality, and had a lower Hgb than did those who were not transfused (Chant et al., 2006). Additionally, an analysis of the data identified baseline Hgb, daily phlebotomy volume, and ICU LOS to be independently associated with the likelihood of requiring transfusion in non-bleeding patients (Chant et al., 2006). Moreover, small increases in average phlebotomy (3.5 ml/day, 95% confidence interval 2.4–6.8 ml/day) were associated with a doubling in the odds of being transfused after day 21. The study ultimately concluded that even small decreases in phlebotomy volume are associated with significantly reduced transfusion requirements in patients with prolonged ICU LOS (Chant et al., 2006).

**VAMP with restrictive transfusion strategy vs. restrictive transfusions strategy:**

A before and after study conducted in a medical ICU of a large university hospital to investigate whether the use of the VAMP device in the presence of standardized, restrictive, transfusion practice could reduce the number of units transfused per patient, per day. Subjects included 250 adult ICU patients with indwelling arterial catheters, and expected ICU LOS > 24 hours. Data were collected for six months (control group) without VAMP, immediately followed by nine months (active group) with VAMP. The results of this study revealed that the control group had higher Hgb levels on admission (12.4 ± 2.5 vs. 11.58 ± 2.8 g/dL, P = 0.02) and consistent use of the VAMP device was associated with significantly decreased requirements for transfusion (control group
0.131 unit vs. active group 0.068 unit PRBC/patient/day, P = 0.02; Mukhopadhyay et al., 2010). Additionally, the control group also had a greater decline in hemoglobin levels (2.13 ± 2.32 vs. 1.44 ± 2.08 g/dL, P = 0.02) at discharge (Mukhopadhyay et al., 2010). This study further supports that the use of a blood conservation device such as the VAMP device is associated with smaller decrease in Hgb levels in the ICU and reduced risk for transfusion.

**Volume of phlebotomy induced blood loss predicts hemoglobin levels:**

Another before and after study conducted at a large university hospital reiterated the findings of the previously described study in that researchers were able to determine that the volume of blood taken for diagnostic testing strongly predicts hemoglobin and hematocrit changes during hospitalization (Thavendiranathan et al., 2005). Subjects in this study included 404 adult internal medicine ICU patients. It was determined that for every 1mL of phlebotomy, mean (SD) decreases in hemoglobin and hematocrit values were 0.070 (0.011) g/L and 0.019% (0.003%), respectively (i.e. for 100 mL, hemoglobin and hematocrit levels would be expected to change by 7.0 g/L and 1.9%, respectively; Thavendiranathan et al., 2005). This study concluded that phlebotomy resulted in decreased hemoglobin and hematocrit levels and clinically significant changes were reported between 6.6 and 10 g/L (Thavendiranathan et al., 2005).

**Summary of Findings**

In summary, four of the reviewed studies demonstrated a statistically significant decrease in the volume of blood lost due to phlebotomy blood when a blood conservation device was used. Of the reviewed studies three identified the consistent
use of a blood conservation device to be independently associated with decreased transfusion rates. However, only two studies were able to describe the impact of blood conservation on Hgb levels by observing a relationship between the volume of blood lost and the resulting drop in Hgb levels. Several limitations were identified between the selected studies including small sample sizes, ICU LOS, patient populations, APACHE II scores, study lengths, and variable volumes of blood loss. Finally, patients with anemia of chronic disease who were also on renal replacement therapy, or those with preexisting bleeding conditions and a greater predisposition for transfusions were frequently excluded from the studies. Future studies would be valuable to identify the most effective strategies to decrease transfusions and improve outcomes in a population of patients who are at an increased risk for adverse outcomes due to the nature of their illnesses.

**Implications for Practice**

Blood conservation has significant implications for clinical practice and patient outcomes. Researchers describe blood conservation devices as an effective method to decrease iatrogenic blood loss, anemia and transfusion rates in critically ill patients. Moreover, modifying practice to incorporate the use of these devices and strategies is essential to the care of critically ill patients. Preventing the development of anemia and the risk for transfusion through blood conservation could mean a decrease in ventilator support times, fewer ICU days, shorter hospital LOS, fewer post-operative infections, decreased risk of mortality, and significantly reduced healthcare costs.
Fortunately, the blood conservation devices described in this review are readily available in most institutions and may be implemented by the bedside nurse. Nurses play an integral role in the coordination and delivery of care in the ICU and are therefore in the prime position to implement blood conservation strategies to enhance the delivery of care and improve clinical outcomes (Welden, 2010). However, blood conservation is not widely practiced despite the evidence of its many benefits. Educating healthcare providers on the benefits of blood conservation in the ICU is key to influencing practice and raising awareness of blood conservation to decrease iatrogenic blood loss and transfusions (Welden, 2010)

**Recommendations for Improving Practice**

Due to the limited availability of nursing literature, the successful translation of evidence-based blood conservation practice to bedside care is not well known, and should be further investigated from the perspective of a bedside nurse to determine the most effective strategy to increase nursing knowledge and awareness of blood conservation and to create a sustainable practice change. Blood conservation should be implemented as the standard of care for all patients. However, this will require a practice change in many institutions, and it is important to recognize that attempting to change practice in the ICU setting can be a challenging task. Therefore, implementing these strategies will require a carefully planned educational intervention and a plan to increase buy-in from staff. Educational interventions should be designed to raise awareness of available blood conservation devices and strategies that may be implemented by the bedside nurse, with a goal of increasing nursing knowledge of anemia, transfusion
indicators and adverse outcomes to improve compliance with the bedside implementation of this practice change.

**Conclusion**

Findings from the reviewed studies suggest that the amount of blood wasted with lab testing may result in the development of iatrogenic anemia, and the need for blood transfusions. Together anemia and transfusions have been shown to significantly increase the risk of adverse outcomes. Blood conservation strategies offer an array of benefits beyond simply decreasing the volume of blood wasted with lab testing (Shander et al., 2007). Blood conservation devices have been shown to effectively decrease infection rates, and reduce the risk of needle stick injuries or blood exposure to staff (Stover, & Broomer, 2013). Studies that describe the various benefits of blood conservation are limited, especially within the nursing literature. However, consistent themes identified in this review included decreased iatrogenic blood loss, decreased transfusion rates, and in some studies, preserved hemoglobin levels were achieved with the use of blood conservation devices. Evidence from the literature also indicates that most effective blood conservation strategies include the use of multiple devices (VAMP and low volume tubes) in addition to evidence-based restrictive transfusion practices. Based on the results from this review it is recommended that healthcare providers involved in the care of critically ill patients take note of the described blood conservation strategies and develop a plan to implement the recommended strategies into daily practice.
References


Table 1: Causes of Anemia in the ICU

<table>
<thead>
<tr>
<th>Type</th>
<th>Cause:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutritional Deficiencies</td>
<td>Iron deficiency</td>
</tr>
<tr>
<td>Erythropoietin Deficiencies</td>
<td>Anemia of Chronic disease</td>
</tr>
<tr>
<td>Hemolysis / Coagulopathy</td>
<td>Drug reaction / toxicity</td>
</tr>
<tr>
<td>Blood Loss</td>
<td>Phlebotomy</td>
</tr>
</tbody>
</table>

(McEvoy & Shander, 2013)

Table 2: Transfusion Associated Risks

<table>
<thead>
<tr>
<th>Category</th>
<th>Risk:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious</td>
<td>HIV, CMV, Hepatitis</td>
</tr>
<tr>
<td></td>
<td>Bacterial contamination</td>
</tr>
<tr>
<td></td>
<td>Parasitic infection</td>
</tr>
<tr>
<td>Noninfectious Immunologic</td>
<td>Allergic reaction, Anaphylaxis, TRIM, MODS</td>
</tr>
<tr>
<td></td>
<td>GVHD, HLA Alloimmunization, Hemolytic reaction</td>
</tr>
<tr>
<td></td>
<td>Febrile non-hemolytic reaction, risk of cancer reoccurrence</td>
</tr>
<tr>
<td>Noninfectious Non-immunologic</td>
<td>Iron overload, Coagulopathies, Thrombocytopenia</td>
</tr>
<tr>
<td></td>
<td>TRALI, TACO, Pulmonary edema, Human error</td>
</tr>
<tr>
<td></td>
<td>Metabolic disturbances, Electrolyte derangements</td>
</tr>
</tbody>
</table>

(Goodnough & Shander, 2007; McEvoy & Shander, 2013)
### Table 3: Blood Conservation Strategies to Prevent and Treat Anemia

<table>
<thead>
<tr>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point-of-care testing</td>
</tr>
<tr>
<td>Low volume phlebotomy tubes</td>
</tr>
<tr>
<td>Consistent use of blood conservation device (VAMP) on every arterial and central line</td>
</tr>
<tr>
<td>Reevaluate routine daily labs for necessity</td>
</tr>
<tr>
<td>GI prophylaxis for all patients at risk for stress ulcers</td>
</tr>
<tr>
<td>Antifibrinolytic agents for bleeding patients</td>
</tr>
<tr>
<td>Removal of central venous and arterial catheters lines as soon as they are no longer indicated</td>
</tr>
<tr>
<td>Combining multiple lab tests whenever possible</td>
</tr>
<tr>
<td>Nurse / Physician education</td>
</tr>
</tbody>
</table>

(Adapted from Fowler & Berenson, 2003)

---

**Figure 1. VAMP Device**

![VAMP Device Image](image)

VAMP system designed to reduce infection, needle sticks, and blood waste associated with blood sampling © 2013 Edwards Lifesciences Corporation.
## Table 4. Summary of Studies Reviewed

<table>
<thead>
<tr>
<th>Citation</th>
<th>Design &amp; Methods</th>
<th>Number of Subjects</th>
<th>Results</th>
<th>Conclusion / Recommendations</th>
</tr>
</thead>
</table>
| * Mukhopadhyay et al. (2010) | Before and after intervention study  
Evaluated the impact of a restrictive transfusion strategy and VAMP compared to control. | n = 250 Adult ICU patients  
(Control group n = 80, Active group n = 170) | Control group had higher Hb levels on admission (12.4 ± 2.5 vs. 11.58 ± 2.8 gm/dL, P = 0.02). Use of blood conservation device was associated with significantly decreased transfusion requirements (control 0.131 unit vs. active 0.068 unit RBC/patient/day, P = 0.02). Control group had a greater decline in Hb levels (2.13 ± 2.32 vs. 1.44 ± 2.08 gm/dL, P = 0.02) at discharge. | The use of a blood conservation device is associated with 1) reduced RBC transfusions and 2) smaller decrease in hemoglobin levels in the ICU. |
| * Mahdy, et al. (2009) | Prospective, randomized, unblinded controlled clinical study  
Comparing VAMP plus pediatric vials to control plus adult vials. | n = 39 Adult ICU patients  
Group A n = 20, Group B n = 19) | Statistically significant difference in sampling-induced blood loss between the groups over the first 72 hours of treatment (mean +/- standard deviation: 15.16 +/- 5.3 ml Group A vs. 45.11 +/- 14 ml Group B, p<0.001). There was a smaller decline in mean hemoglobin level, which was not statistically significant (0.79 +/- 0.6 g/dL vs. 1.30 +/- 1.13, p = 0.09). | Combined blood conservation strategy reduced measurable blood losses from phlebotomy. In larger trials it might also preserve hemoglobin levels. |
| * Thavendiranathan, et al. (2005) | Before and after study  
Determine the impact of blood loss due to diagnostic testing on hemoglobin and hematocrit changes during hospitalization. | n = 404 Adult internal medicine ICU patients | For every 1mL of phlebotomy, mean (SD) decreases in hemoglobin and hematocrit values were 0.070 (0.011) g/L and 0.019% (0.003%), respectively i.e. for 100 mL, hemoglobin and hematocrit levels would be expected to change by 7.0 g/L and 1.9%, respectively. | Phlebotomy resulted in decreased hemoglobin and hematocrit levels and clinically significant changes were reported between 6.6 and 10 g/L. |
<table>
<thead>
<tr>
<th>Study</th>
<th>Study Design</th>
<th>Sample Size</th>
<th>Findings</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chant, et al. (2006)</td>
<td>Retrospective chart review</td>
<td>n = 155 Adult ICU patients</td>
<td>This study found that of patients transfused, daily phlebotomy volume was significantly higher.</td>
<td>Even small increases in daily phlebotomy volumes were associated with twice the chances of being transfused after day 21 in ICU.</td>
</tr>
<tr>
<td>MacIsaac, et al. (2003)</td>
<td>Randomized controlled trial</td>
<td>n = 160 (80 subjects per group)</td>
<td>Both groups had a similar (median [range]) change in Hb during ICU admission (VAMP-7 [-84 to +21] g/l; Control -4 [-67 to +40] g/l; P = 0.33). The VAMP group lost significantly less blood for diagnostic testing while in ICU (VAMP 63 [0 to 787] ml; Control 133 [7 to 1227] ml; P = 0.001).</td>
<td>VAMP device significantly reduced iatrogenic blood loss in critically ill patients, but this reduction did not affect the fall in Hb that accompanies critical illness.</td>
</tr>
</tbody>
</table>
Manuscript 2

Quantifying the Value of an Evidence-Based Blood Management Program at a University Teaching Hospital with a Level-1 Trauma Center in the Southeastern United States

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Abstract

National blood shortages, rising healthcare costs, and heightened awareness of transfusion related risks have fueled the escalating sense of urgency within healthcare organizations across the nation to reevaluate current transfusion practices and spending in search of more cost effective ways to deliver safe, effective care. Consequently, the concept of blood management is being embraced by a growing number of medical centers. Blood management programs (BMPs) are gaining popularity among hospital administrators as a feasible solution with an array of benefits, including improved patient outcomes and an overall reduction in costs. The purpose of this paper is to review current blood utilization and costs at a university teaching hospital with a level-1 trauma center in the southeastern United States, and to explore the value of implementing a BMP aimed at improving clinical outcomes and decreasing healthcare costs at the institution.
Background

“The transfusion of blood products, including whole blood (WB), red blood cells (RBCs), platelets, plasma and cryoprecipitate, is the most commonly performed procedure in the hospital setting” (Landro, 2008). While a blood transfusion may be a lifesaving intervention for some patients, studies have shown that transfusions are associated with inferior clinical outcomes and increased costs (Goodnough et al., 2013; Tokin et al., 2009).

The liberal use of allogeneic blood transfusions first came under scrutiny over a decade ago when research showed that a restrictive transfusion strategy (Hgb <7) was at least as effective as and possibly superior to a liberal transfusion strategy (Hgb <10) in critically ill patients (Hébert et al., 1999). A growing body of evidence from well-designed studies continues to increase awareness about the serious risks associated with liberal transfusion practice. A positive dose-response relationship between the number of blood transfusions that a patient receives and the resulting complication rates has been confirmed (Koch, Li, & Duncan 2006). Studies show that each RBC unit transfused is associated with incrementally increased risk for adverse outcomes including, but not limited to, increased risk of morbidity and mortality, renal failure, prolonged ventilator support times, infection rates, cardiac complications, and increased Intensive Care Unit (ICU) and hospital length of stay (LOS) (Koch et al., 2006). Moreover, RBC transfusion has been associated with as much as a 40% increase in 30-day mortality, as much as a 38% increase in 30-day mortality, and as much as a 67% increase in six month mortality (Bernard et al., 2008; McEvoy & Shander, 2013).
In 2012, the Joint Commission on Accreditation of Hospitals and the American Medical Association convened a summit on overuse in healthcare, identifying blood products as one of the top five areas of overuse in healthcare today (JCAHO, 2013). Data indicates that approximately 14,000,000 units of WB/RBCs are transfused to approximately 4.5 million patients each year in the U.S. (National Blood Collection and Utilization Survey, 2011). Historically, U.S. per capita blood utilization has remained 20%-30% higher than any other industrialized country, often exceeding the world average by greater than four times (Sweeney, 2008). Excessive use of our blood supply is a growing concern as allogeneic blood collection continues to decline due to the availability of eligible donors (Sweeney, 2008). In 2011, allogeneic blood collection in the U.S. population of individuals aged 16 to 64 was 76.2 units per 1,000 persons, compared to 85.2 units per 1,000 persons aged 16 to 64 in 2008 (NBCUS, 2011). This donation rate per unit population is the lowest reported since 1997, indicating the potential for a serious discrepancy between supply and demand unless immediate changes in blood utilization occur (Leahy & Mukhtar, 2012).

The subject of blood utilization has become a popular topic of discussion over the past decade as a growing body of evidence reveals that the true cost of transfusions may in fact be much higher than expected. Research shows that understanding and estimating the true cost of transfusions is a highly complex undertaking, which requires sophisticated knowledge about transfusion medicine and economics (Shander et al., 2007). Significant progress has been made toward estimating the true cost of blood using a cost-calculating tool in addition to activity-based cost methodology (Shander et
al., 2007). This includes analysis of key cost elements such as those incurred to donors, producing blood components for transfusion, transfusion logistics and preparation within hospitals, administering and monitoring transfusions, treating adverse transfusion events, treating transfusion transmitted disease, litigation, lost productivity, and organizing and maintaining nationwide hemovigilance systems (Goodnough & Shander, 2007). Buying, processing, and transfusing blood each year costs hospitals an estimated $25 billion each year (Shander et al., 2007). Acquisition costs per allogeneic unit of RBCs vary significantly by region and institution, ranging anywhere from $270-$781 per unit (Shander et al., 2007). These acquisition costs may only represent about 20% of the total transfusion related costs (Shander & Sweitzer, 2009). Within the hospital setting alone, procurement, storage, processing, and transfusion of blood products involves other expenses, such as, laboratory supplies, pharmaceuticals, nursing time, blood supply management, and overhead (Tokin et al., 2009). The utilization of these resources for the administration of blood products to patient’s results in a 3-4 fold increase in the total cost of blood beyond the base cost of its acquisition (Boucher & Hannon, 2007). Given this data, it is evident that the actual cost of blood has been seriously underestimated. Additionally, research has shown that most US hospitals over-transfuse by at least 20-30% because of a failure to adopt more conservative, evidence-based transfusion guidelines and because of a lack of proactive management of patients at risk for transfusions (Goodnough & Shander, 2007). In addition to the previously defined blood-related costs, additional transfusion associated costs are frequently incurred due to increased LOS, ICU days, ventilator support times,
cost to treat infections and resulting complications, and litigation (Shander et al., 2010). The association between blood transfusion and LOS can markedly increase transfusion costs incurred by hospitals and patients. One study analyzed data from 502 patients to assess the relationship between RBC transfusion and hospital LOS in patients undergoing cardiac surgery. Results showed RBC transfusion to be an independent risk factor for increased LOS in patients undergoing cardiac surgery (Galas et al., 2013). Total LOS was approximately six days longer in the population of patients who received more than three RBC units and one day longer in patients receiving up to three units as compared to the non-exposed group (Galas et al., 2013). Notably, the approximate cost for a postoperative hospital day is $1300, $3700 for an ICU day, and if the patient requires ventilation, an additional $1100 can be added to their ICU day (Boucher & Hannon, 2007). Multicenter, prospective process cost analyses in the U.S. and Europe suggest that once all cost factors are considered the actual cost to transfuse a unit of blood ranged from $1200- $9404 (Shander et al., 2010).

Based on the overwhelming evidence of the risks associated with blood transfusions, regulatory and professional organizations require ongoing monitoring of blood use within institutions (AABB, 2012). The development of evidence-based transfusion guidelines has further encouraged many institutions to reevaluate their previously liberal use of this increasingly scarce resource (Toner et al., 2011). Despite the availability of these guidelines, based on evidence from research, blood management practices still vary greatly between institutions. To date less than 30% of U.S. hospitals have instituted BMPs (NBCUS, 2011). Responsible blood management is
a concern given the associated risk, cost, and the potential for a serious blood shortage. BMPs provide an effective solution for the institution to manage its blood supply responsibly, while decreasing costs, and improving patient outcomes.

**Description of an Evidence-Based Blood Management Program**

Based on the overwhelming evidence of the risks and costs associated with blood transfusions, the need to develop and implement BMPs is clear. Blood management is defined as “the appropriate use of blood and blood components with a goal of minimizing their use” (SABM, 2003). A BMP is an evidence-based, multidisciplinary approach to optimizing the care of patients who might need a transfusion. It encompasses all aspects of patient evaluation and clinical management surrounding the transfusion decision making process, including the application of appropriate indications and the minimization of blood loss and optimization of a patient’s red cell mass (NBCUS, 2011). Minimizing the exposure of patients to allogeneic transfusions can be achieved through the systematic use of multiple blood conservation principles outlined in Table 1. Blood management is most successful when multidisciplinary, proactive programs are in place so that these strategies can be individualized to needs of specific patients (Goodnough & Shander, 2007). The basic principles underlying optimization of blood usage include correcting anemia before surgery, minimizing intraoperative blood loss, and, with an understanding of an patient’s physiological tolerance of anemia, using more restrictive transfusion triggers when appropriate (Goodnough & Shander, 2007). By developing and implementing comprehensive BMPs, hospitals can promote safe, efficient, and clinically effective
blood utilization for the benefit of the healthcare system, its’ patients, and the local community (Boucher & Hannon, 2007).

**Steps to Implementing an Evidence-Based Blood Management Program**

Recognizing that attempting to change a long standing medical tradition such as transfusion practices presents significant challenges, it should be recognized that successful implementation of a BMP will require much more than a mandate from hospital administration (Galas et al., 2013). In order to be successful a BMP must incorporate a multidisciplinary, multimodal, patient-centered approach ( Tokin et. al., 2009). A three-phase BMP implementation plan including a focused planning phase, practice roll out and a maintenance phase has been used successfully in hospitals across the U.S. (Tokin et. al., 2009). The planning phase begins with the assembly of a multidisciplinary blood management committee with appropriate representation from medicine, surgery, pharmacy, nursing, clinical lab, blood bank and finance to help guide the initiative and increase organizational buy-in (Tokin et. al., 2009). Published guidelines should be reviewed for organizational fit and institution specific guidelines and algorithms must be developed and agreed upon by all members of the committee (Yazer & Waters, 2012; Galas et al., 2013). Incorporating a multimodal approach to decreasing transfusions would include the use of drug therapies to increase pre-operative blood volume and postoperative bleeding, devices to protect and conserve blood, and techniques to prevent unnecessary blood loss (Tokin et al., 2009). Additionally, education plays an essential role in the successful implementation of evidence-based guidelines and must be carefully planned. Before proceeding with a
formal program implementation it is imperative to identify key stakeholders (Yazer & Waters, 2012). These may include the Chief Nursing Officer (CNO), the Chief Executive Officer (CEO), the Chief Financial Officer (CFO), medical directors, nursing leadership, bedside nursing champions and other administrators. Sharing quality metrics with hospital executives, service-line directors, and hospital quality committees will help drive initiatives for improvement (Tokin et al., 2009). Finally, a process used to monitor adherence to guidelines must be developed. Individual dashboards can be used to capture specific benchmarks such as service line utilization, healthcare provider use, administration of blood by transfusion trigger and comparative usage by surgery type to reveal trending successes as well as challenges and opportunities for improvement (Yazer & Waters, 2012). Instituting a well-designed, multi-phase implementation plan such as this will facilitate changing practice and encourage a more mindful approach to blood transfusion.

**Review of Current Evidence to Support Blood Management**

Evidence-based innovative BMPs have significant and far-reaching implications for patient outcomes and healthcare costs. Through the implementation of these programs several hospitals have documented markedly improved outcomes and impressive financial gains. One New Jersey hospital has been practicing blood management for over a decade and has successfully decreased transfusions by over 20%, and operating room (OR) transfusions to only 5% of total transfusions, down from 50% before the implementation of the program, translating into direct financial returns for the hospital (Shander et al., 2009). Similarly, a Washington DC hospital instituted a
BMP to address the needs of a large population of Jehovah’s Witnesses it serves. Recognizing the benefits of blood management in this population of patients, the hospital extended blood management services to all of its patients; reporting a 10% reduction in transfusions and an estimated cost savings of $750,000 (Zawadsky, 2013). A recent study evaluated blood utilization and spending at a large tertiary care center, determining that for their $107,309,334 in transfusion related expenses, total transfusion related revenue only amounted to $55,553,309; leaving the institution with a loss of $51,756,025 (Stubbs, 2009). The institution now has an established BMP and recently reported a 20% decrease in transfusions. Additionally, blood use at 2 large academic medical centers on the West Coast of the U.S. declined by 10% within the first two years of implementing their BMP. Reportedly saving over 460 transfusions and $165,000 in one year (Williams, 2013).

Other research verifies the benefits of BMPs, Moskowitz et al., (2010) compared one New Jersey hospital (H-BMP) with a well-established BMP to 16 other New Jersey area hospitals (OH) who use conventional transfusion practices. Results indicated that fewer patients were transfused at H-BMP compared with OH (10.6% versus 42.5%). Additionally, H-BMP had 5 (0.8%) deaths versus 15 (2.5%) at the OH. Of the H-BMP patients, 11.1% experienced a very serious complication or serious complication versus 18.7% in the OH cohort. Transfusion was associated with an increased risk of an adverse outcome in both cohorts (H-BMP: odds ratio, 7.3; 95% confidence interval, 3.7 to 14.4 versus OH: odds ratio, 4.6; 95% confidence interval, 2.8 to 7.7). Finally, Varghese & Myers (2011) report that blood management techniques that minimize
transfusions in the perioperative period, mainly in cardiothoracic and orthopedic cases are associated with reductions in transfusion rates by 10–95%, reduced hospital LOS by 16–28% and reduced cost by 10–24%. The availability of research-based evidence such as this should command the attention of those making decisions about blood management and transfusion practice.

The Value of a Blood Management Program at a University Teaching Hospital with a Level-1 Trauma Center in the Southeastern United States

The purpose of this paper is to review current blood utilization and costs at a university teaching hospital with a level 1 trauma center located in the southeastern United States (U.S.), and to explore the value of implementing a BMP aimed at improving clinical outcomes and decreasing healthcare costs at the institution.

The institution is one of many that has not developed and implemented a formal blood management program. However, the opportunity to achieve significant savings through blood management at an institution such as this is promising. In order to quantify the value of a BMP utilization data from the hospitals blood bank were obtained and analyzed to determine the average number of transfusions per year. The results of this analysis are summarized in Table 2.

Additionally, to illustrate the average annual costs, revenue, and loss associated with transfusions, data were obtained from the hospital’s finance department. The average per unit transfusion cost, revenue, and loss is summarized in Table 3. Average transfusion costs were compared to cost data from a similar institution.
It is important to recognize that the transfusion cost per unit is an estimated cost that only includes cost of purchasing blood, the cost of transfusion logistics and preparation within the hospital, and the cost of administering and monitoring transfusions. These figures do not include additional costs such as those associated with treating adverse transfusion events or transfusion transmitted disease, increased ICU days and total LOS, litigation costs, or costs related to lost productivity. Based on the per unit transfusion cost and the average yearly number of products transfused, Table 4 provides a summary of the institution’s average yearly transfusion spending. Finally, an analysis of cost and reimbursement data revealed that transfusions ultimately result in a significant financial loss each year (table 5).

Based on the available research data and the costs calculated for the institution, it would be reasonable to assume that similar results could be achieved by instituting a BMP at the institution. Even a modest prediction of a 10% annual reduction in RBC transfusions alone would prevent 1,705 transfusions and save over $2,100,000 annually. These data are promising. Based on the available evidence, the potential to cut costs through BMPs will not compromise outcomes. Therefore, a BMP should be given serious consideration.

**Conclusion**

Blood is a costly, and increasingly scarce resource (NBCUS, 2011). Liberal use of transfusions over the years has cost the U.S. healthcare system billions of dollars (Shander et al., 2010). The principles of blood management are straightforward and the resulting benefits are well documented throughout the published literature (Shander &
Sweitzer, 2009). BMPs offer a rare opportunity to decrease healthcare costs without compromising patient safety or quality of care (Hannon, 2013). However, despite the availability of evidence to support this practice and the documented financial advantages, blood management is often met with resistance from clinicians and hospital administrators. The current emphasis on evidence-based medicine provides a cornerstone on which to gather support for a blood management initiative and provides a basis on which a program may be developed (Shander & Sweitzer, 2009). Healthcare professionals are bound by an ethical and professional responsibility to provide care that does not harm the patient (Hannon, 2013). Furthermore, recent advances in transfusion medicine and blood conservation suggest that clinicians revisit both the risk-benefit ratio and the cost-benefit of reducing transfusion rates through the development of BMPs (Hannon, 2013). Health care providers should utilize knowledge and critical thinking when making decisions about blood management that could affect patient outcomes. Through effective blood management that minimizes the use of allogeneic blood transfusions there is great potential to improve patient safety, resource allocation, and minimize the financial burden on the patient and the institution (Hannon, 2013).
References

American Association of Blood Banks (AABB, 2013) Patient Blood Management


Table 1: General Principles of Blood Management*

1. Formulate a plan of care for avoiding and controlling blood loss tailored to the clinical management of individual patients, including anticipated and potential procedures.
2. Employ a multidisciplinary treatment approach to blood conservation using a combination of interventions.
3. Proactive management by the lead clinician: anticipate and be prepared to address potential complications.
4. Promptly investigate and treat anemia, preferably preoperatively.
5. Exercising clinical judgment, be prepared to modify routine practice when appropriate.
6. Consult promptly with senior specialists experienced in blood conservation at an early stage if there is physiologic deterioration or if complications arise.
7. Restrict blood drawing for laboratory tests.
8. Decrease or avoid the perioperative use of anticoagulants and antiplatelet agents.

* (Goodnough & Shander, 2007)

Table 2: Average Yearly Blood Product Transfusions

<table>
<thead>
<tr>
<th>Product:</th>
<th>Average Yearly Transfusions (number of units):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Blood Cells</td>
<td>17,050</td>
</tr>
<tr>
<td>Platelets</td>
<td>5,737</td>
</tr>
<tr>
<td>Fresh Frozen Plasma</td>
<td>5,468</td>
</tr>
<tr>
<td>Cryoprecipitate</td>
<td>307</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>28,255</strong></td>
</tr>
</tbody>
</table>

Table 3. Average Transfusion Related Costs, Reimbursement Rates, and Loss

<table>
<thead>
<tr>
<th>Product:</th>
<th>Transfusion Cost/Unit:</th>
<th>Payment:</th>
<th>Loss:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Blood Cells</td>
<td>$1241</td>
<td>$520</td>
<td>$721</td>
</tr>
<tr>
<td>Platelets</td>
<td>$926</td>
<td>$377</td>
<td>$549</td>
</tr>
<tr>
<td>Fresh Frozen Plasma</td>
<td>$930</td>
<td>$273</td>
<td>$657</td>
</tr>
<tr>
<td>Cryoprecipitate</td>
<td>$786</td>
<td>$432</td>
<td>$354</td>
</tr>
</tbody>
</table>

(Stubbs, 2009)
### Table 4: Average Yearly Transfusion Spending

<table>
<thead>
<tr>
<th>Product:</th>
<th>Average Yearly Transfusion Costs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Blood Cells</td>
<td>$21,159,050</td>
</tr>
<tr>
<td>Platelets</td>
<td>$5,313,462</td>
</tr>
<tr>
<td>Fresh Frozen Plasma</td>
<td>$5,085,240</td>
</tr>
<tr>
<td>Cryoprecipitate</td>
<td>$241,302</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>$31,799,050</strong></td>
</tr>
</tbody>
</table>

### Table 5: Average Yearly Transfusion Related Financial Loss

<table>
<thead>
<tr>
<th>Product:</th>
<th>Average Yearly Transfusion Related Loss:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Blood Cells</td>
<td>$12,293,050</td>
</tr>
<tr>
<td>Platelets</td>
<td>$3,150,613</td>
</tr>
<tr>
<td>Fresh Frozen Plasma</td>
<td>$3,595,475</td>
</tr>
<tr>
<td>Cryoprecipitate</td>
<td>$108,678</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>$19,147,816</strong></td>
</tr>
</tbody>
</table>
Manuscript 3

An Evaluation of Evidence Based Blood Conservation Education for ICU Nurses:

A Pre/Post-test Analysis

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Abstract

**Purpose:** The purpose of this evidence-based education project was (i) to evaluate baseline nursing knowledge of anemia, blood conservation and transfusion medicine, (ii) to identify current blood conservation practice and the nurse’s prior exposure to blood conservation education (iii) to determine the potential impact of evidence-based education on nursing knowledge, and (iv) to determine the impact of education on the nurse’s attitudes towards future implementation of blood conservation practices based on the nurse’s self report.

**Setting:** The project was implemented in the Cardiovascular and Thoracic ICU (CVICU) at an 875-bed level-1 Trauma and Multi-Organ Transplant Center located in central Kentucky.

**Population:** The population for this study was a diverse sample of 48 registered nurses (RNs) who practice in the CVICU. Among the 48 participants, 77.1% were female, which is consistent with the current demographics of the national nursing workforce. The average age of participants was 31.1 years (SD = 7.4). Of the participants 18.8% were Associated Degree Nurses (ADN), and 81.3% had either a Bachelor of Science in Nursing (BSN) or Masters of Science in Nursing (MSN). On average participants had worked for 5.8 years (SD=5.6) in nursing, and had 4.7 (SD=4.3) years of ICU experience.

**Inclusion criteria:** All RNs with a current Kentucky nursing license, who practice in the CVICU.
Design & Methods: A quasi-experimental pre and post-test design was used for this project. Nurses were educated on the subjects of anemia, blood conservation, and transfusion medicine during a 45-minute face-to-face presentation. The impact of the education was measured using a pre/post test analysis of nursing knowledge and the nurse’s self report of perceived impact on future practice.

Results: A total of 48 CVICU nurses participated in the educational intervention and completed the surveys, pretests and posttests. Results showed a statistically significant difference between pretest (60.2 %) and posttest scores (98.6 %). Additionally, survey results revealed that 95.8% (n=46) of participants did not receive any education relating to blood conservation in their undergraduate nursing programs, and only 10.4% (n=5) reported receiving any education on blood conservation during their CVICU nursing orientation. Only 31.3% (n= 15) reported routine use of blood conservation devices and strategies in daily practice. Post study survey results revealed that 81.3% (n=39) of participants were “much more likely” to implement blood conservation devices and strategies into practice, and 17% of subjects reported that they were “somewhat more likely” to use blood conservation devices and strategies as a result of the knowledge they had gained through participation in the program.
Introduction

Anemia is a common problem in Intensive Care Unit (ICU) patients. It is estimated that almost 95% of ICU patients will develop anemia within the first three days of admission (Corwin, et al., 2004). Numerous studies have convincingly shown that iatrogenic blood loss due to frequent lab testing contributes significantly to the development of anemia in these patients. Silver et al. (1993) estimated the average weekly blood loss due to phlebotomy in ICU patients to be between 340 to 660 ml. In another study, the average total volume of blood drawn in a 24-hour period was was 41.1 mL per patient (Vincent, et al., 2002).

As a consequence of anemia, ICU patients often receive several blood transfusions. It is estimated that over 50% of critically ill patients will receive at least one unit of blood during their ICU stay, and this number increases to 85% in patients with an ICU length of stay (LOS) > 1 week (Corwin, et al., 2004). Of note, anemia is not only a major reason for transfusion, but also an independent predictor of morbidity and mortality (Bernard et al., 2008; Shander et al., 2006). Although lab testing is an essential part of monitoring critically ill patients, evidence suggests that excessive lab testing in these patients is a common trend that contributes to anemia and is associated with less favorable outcomes. Therefore, it is essential that any clinician involved in the management and care of critically ill patients becomes familiar with blood conservation strategies and takes a more conservative approach when making decisions regarding blood transfusions (Bernard et al., 2008).
Due to the risks associated with transfusion and the potential negative impact on patient outcomes, clinical researchers have identified the need for a practice change and greater efforts to decrease blood transfusions through blood conservation. The evidence in the literature is strong on the role of blood conservation devices in decreasing iatrogenic blood loss, anemia, and transfusions. Blood conservation methods identified to decrease iatrogenic blood loss may include the use of low volume phlebotomy tubes, a conservative approach to diagnostic phlebotomy, point-of-care testing, minimization of diagnostic sample waste with the use of a Venous Arterial blood Management Protection (VAMP) device (Edwards Lifesciences), eliminating multiple routine daily labs, a threshold-based transfusion policy, and healthcare provider education (Mukhopadhyay et al., 2011). Although research supports the use of blood conservation strategies and devices suggesting that they result in improved patient outcomes, to date few institutions have implemented standardized policies mandating the use of blood conservation devices and enforcing this practice.

With the current changing trends in our healthcare system as well as the recent shift towards evidence-based practice, many healthcare facilities are actively seeking to replace outdated practice trends with evidence-based interventions aimed at improving patient outcomes and decreasing healthcare costs. Furthermore, evidence suggests that nurses are in a prime position to implement evidence based blood conservation strategies thereby potentially improving the outcomes of critically ill patients and decreasing healthcare costs associated with the transfusion of blood products (Welden, 2010). Unfortunately, due to the limited availability of nursing literature on the subject of
implementing evidence-based blood conservation programs in the ICU, the successful translation and implementation of a practice change such as this to bedside care in the ICU is not well known. Nurses provide direct patient care around the clock and are responsible for the coordination of the patient’s care, as well as collaboration with physicians and other members of the healthcare team to ensure that optimal care is provided. The ICU nurse is in a unique position to improve the outcomes of critically ill patients by actively participating in blood conservation practices aimed at decreasing the amount of iatrogenic blood loss. Empowering nurses with current information on anemia, blood conservation, and risks associated with blood transfusions, could enhance critical thinking and lead to increased advocacy for blood conservation efforts in a population of patients already at an increased risk for adverse outcomes due to the nature of their illnesses and the complexity of care they require.

**Description of the Practice Inquiry Project**

This capstone project involved the development, implementation, and evaluation of an education program on anemia, blood conservation and transfusion medicine, for critical care nurses at an 875-bed Level-1 Trauma, and multi-organ transplant center located in central Kentucky. The project took place in the hospital’s 24-bed Cardiovascular and Thoracic Intensive Care Unit (CVICU). A one-time series Pre/Post-test analysis was used to determine the impact of the education on nursing knowledge. Additionally, nurses were surveyed to identify blood conservation practice trends prior to, and following the education to determine if the education had any effect on the nurse’s attitudes regarding blood conservation.
Goals and Objectives

The objectives of this project were: (i) to evaluate baseline nursing knowledge of anemia, blood conservation and transfusion medicine, (ii) to identify current use of blood conservation strategies or devices among CVICU nurses; and (iii) to determine the impact of evidence-based education on anemia, blood conservation, and transfusions on the nurse’s attitudes towards the implementation of blood conservation practices. Based on these objectives, the overarching goals of this project included the following: (i) improve nursing knowledge of anemia, blood conservation and transfusion medicine; and (ii) increase awareness of available blood conservation devices and strategies that may be implemented by the bedside nurse.

Methods

Study Design and Selection of Participants:

Following the development of a project proposal and approval from the capstone committee, approval was obtained from the University of Kentucky (UK) nursing research council (Appendix B). An exempt proposal was then submitted and subsequently approved by to the hospital’s Institutional Review Board (IRB) (Appendix A). Nurse administrators, service line directors, advanced practice nurses, and the ICU nurse manager were informed of the project via scheduled face-to-face meetings and hospital email communication. Approval was obtained from the director of cardiovascular services (Appendix C). The ICU manager received a formal invitation letter via email that was sent to all CVICU nurses via the unit’s email list serve, inviting them to participate in the project and informing them of the details surrounding their
participation (Appendix D). The letter stated that the project would take place during the CVICU monthly staff meeting and would involve listening to a presentation on anemia, blood conservation and transfusion medicine, and completing a study packet that included a pre-study survey, pretest, post-study survey, and a post-test (Appendix E-G). Each participant would receive study documents as a packet to enable paired t-test analysis. The only risk identified and disclosed to subjects was the potential to link a participant to their test answers with the demographic information gathered in the pre-study survey. Additionally, it was made clear that participation would require 30-45 minutes of the nurse’s time for which they would not be paid. Participation in the project was entirely voluntary and therefore voluntary participation served as informed consent. Since no study documents would contain the names or personal identifying information of the subjects, risk to subjects was minimal, and written informed consent was not necessary. Participants were notified that all study materials would be retained in a locked filing cabinet in the UK College of Nursing (CON) for six years as required by the IRB after which they would be destroyed using institution approved shredding devices. Study packets were distributed to a total of 48 voluntary participants and collected following the completion of the program, at the end of each staff meeting.

**Study Setting:**

The CVICU at an 875-bed level-1 Trauma and Multi-Organ Transplant Center located in central Kentucky was used as the setting for this study. The hospital is accredited by The Joint Commission for Accreditation of Hospitals and
is currently working towards Magnet re-designation by the American Nurses Credentialing Center (ANCC).

**Data analysis**

Data analysis was performed using SPSS ® version 22.0 (SPSS Inc., Chicago, IL). Pre and post-tests were scored and statistically analyzed to assess mean scores prior to, and following the educational intervention. Data were analyzed using descriptive statistics. Paired T-tests were conducted to compare the differences in mean test scores. This study considered values of $p < 0.0001$ to be statistically significant for the analysis.

**Results**

**Sample Characteristics**

Approximately 65 nurses met the inclusion criteria for the study, and 48 (73.8%) voluntary participants completed the education and all required study surveys and tests. Those who did not participate mostly worked night and weekend shifts. All participants were full-time registered nurses in the CVICU. Pre-study survey results included demographic information used to describe the sample. Demographics of the participants are presented in Table 1. Among the 48 participants, 77.1% were females. The average age of participants was 31.1 years (SD = 7.4). Of the participants 18.8% were Associated Degree Nurses (ADN), and 81.3% had either a Bachelor of Science in Nursing (BSN) or Masters of Science in Nursing (MSN). On average participants had worked for 5.8 years (SD=5.6) in nursing and 4.7 (SD=4.3) years in the ICU. Fifty percent (n=24) of participants reported holding advanced nursing certification (i.e.
CCRN, CEN), 95.8% (n=46) reported that they did not receive any education relating to blood conservation in their undergraduate nursing programs, and only 10.4% (n=5) reported receiving any education on blood conservation during their CVICU nursing orientation. Finally, 31.3% (n= 15) reported routine use of blood conservation devices and strategies in daily practice.

**Changes in Nursing Knowledge Regarding Blood Conservation**

Participation in the project ultimately resulted in improved levels of nursing knowledge of anemia, blood conservation, and transfusion medicine. From an initial mean pretest score of 60.2 (SD= 12.6) participants’ mean scores significantly increased to 98.6 (SD=2.5) after the educational program \([t=21.0 (df=47), p<0.0001]\) (Figure 1).

**Post-study Survey Results**

Post-study survey results revealed that 81.3% (n=39) of participants were “much more likely” to implement blood conservation devices and strategies into practice due to the knowledge they had gained through participation in the program. Nearly 17% of subjects reported that they were “somewhat more likely” to use blood conservation devices and strategies as a result of the education, and 1 participant said they were “no more likely” to change practice as a result of the education. There were no significant differences between ADN and BSN/MSN participants.

**Discussion**

Guidelines from the Society of Critical Care Medicine, The Joint Commission for Accreditation of Hospitals, The Society for the Advancement of Blood Management, and
the World Health Organization recommend the use of blood conservation devices to decrease iatrogenic blood loss, anemia, and transfusions for all hospitalized patients. Blood conservation devices and strategies may be implemented by the bedside nurse to decrease iatrogenic blood loss and transfusion risk. This study was designed to improve nursing knowledge and awareness of anemia, blood conservation, and transfusion medicine. The results showed a statistically significant difference (p<0.0001) in nursing knowledge with pre/post-test evaluation and there was no difference between BSN and MSN participants. Additionally, data collected from pre and post-study surveys revealed that nurses do not receive adequate education on blood conservation during their undergraduate nursing programs or during ICU orientation. Following the presentation, most nurses reported that they would be “more likely” to implement blood conservation strategies into practice as a result of the education.

**Limitations**

This study had several limitations that could potentially affect the validity of the reported results. First, the use of a questionnaire and open response format to collect data from participants has been known to produce biased results due to unanticipated communication barriers between the investigator and respondents. “Bias may arise from the way individual questions are designed, the way the questionnaire as a whole is designed, and how the questionnaire is administered or completed” (Choi & Pak, 2005). Additionally, this study had a relatively small sample size and results may have been different if a larger sample had been used or if the sample included nurses from more than one ICU. Finally, this study was not adequately powered to evaluate long-term
knowledge retention or impact on nursing practice. Follow-up assessment was not feasible for this study simply due to time constraints. However, future investigations such as this should note this as a significant limitation and ensure adequate time for follow up assessment at a three- or six-month interval.

**Implications for Practice**

Blood conservation has significant and far-reaching implications for the nursing profession and for improving the outcomes of ICU patients by decreasing iatrogenic blood loss, anemia, and transfusion rates. The results of this study suggest that improving nursing knowledge and awareness of blood conservation could influence the nurse’s decisions in practice and improve adherence to evidence-based guidelines. However, further investigation into the true impact of nurse-driven blood conservation practice on iatrogenic blood loss, anemia and transfusions is warranted and findings should be published in the nursing literature. Evidence from studies such as this may facilitate obtaining support from senior leadership and hospital administration for the development and implementation of a nurse-driven blood conservation protocol and a blood management program at the institution. Instituting blood conservation protocols throughout the institution will ensure that all patients receive evidence-based care related to blood conservation.

**Implications for Education**

This study provides important evidence to support the use of evidence-based education programs for ICU nurses as a means of improving knowledge related to blood conservation practices, empowering nurses with evidence-based information, and
potentially enhancing the quality of care delivered. Based on the participant’s self report it appears that nurses do not receive adequate education on blood conservation or transfusion medicine in undergraduate nursing programs or during ICU orientation. It is therefore imperative that educational interventions are developed and the information becomes available to nurses throughout the institution. Moreover, institution wide blood conservation protocols should be developed and yearly blood conservation competencies will be necessary to improve adherence to the practice change. Nurse educators should also consider including this information in the undergraduate-nursing curriculum.

**Implications for Future Inquiry**

Given the considerable lack of nursing literature on this subject future inquiry is recommended. Future studies may consider a different setting, a different study design, or possibly repeating the same study with a control group. In order to measure the true impact of the education on long-term knowledge retention future studies should consider measuring two additional data points (i.e. assessing knowledge retention with a post-test at three and six month intervals). Following the development and implementation of a nurse-driven protocol or a yearly blood conservation competency for nurses data should also be collected and reported to measure the influence/impact on practice and patient outcomes. Findings should be published in the nursing literature to help guide future research.
Conclusion

Transfusion risks and costs are extreme and require the attention of every clinician whose practice involves the management and care of patients at risk for anemia and transfusion. Based on the findings from this study, evidence-based education on blood conservation practices has been found to be effective in improving nursing knowledge and awareness of blood conservation practices. Due to the limitations of this study, researchers were not able to show that improving nursing knowledge though evidence-based education had any significant long-term or lasting impact on practice. However, a significant increase in nursing knowledge combined with nurses’ reports that they believed the education made them feel more empowered and would ultimately influence their practice is promising and warrants further investigation. Given the lack of published nursing literature on the impact of nurse education on blood conservation practices, further research is recommended to build on this educational intervention in order to design, implement and evaluate programs that are effective and sustained over time.
References


http://dx.doi.org/doi: 10.1097/01.
Table 1: Sample Demographics

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Figure 1: Differences in mean knowledge scores (N=48)
Conclusion to Final DNP Capstone Report

Stefanie M. Bull, DNP, BSN, RN

University of Kentucky
College of Nursing


**Conclusion**

This capstone project addresses an important piece of a multidisciplinary blood management initiative, educating nurses on evidence-based blood conservation practice to decrease iatrogenic blood loss, anemia, and transfusions. The nurse's role in implementing blood conservation strategies at the bedside is of crucial importance and should not be underestimated. Increased awareness of the risks and costs associated with anemia and transfusions warrant serious consideration for strategies to decrease blood loss and transfusion rates. As expected, the results of this study suggest that education plays an important role in increasing knowledge, and awareness, while empowering nurses with the ability to provide up-to-date care that is based on current best evidence.

*Strategies to increase adherence to blood conservation recommendations*

1. The development of a blood conservation committee with a champion to disseminate up to date information to staff on a regular basis.

2. The development and implementation of an institution specific blood conservation policy/protocol to guide practice and increase adherence.

3. The development and implementation of a population/service line specific transfusion algorithm.

4. The development and implementation of yearly blood conservation competencies for nurses.

5. Frequent monitoring of blood conservation practice and reporting of progress to staff.
Implications

1. Evidence supports the use of blood conservation strategies and devices as an effective method to decrease iatrogenic blood loss, anemia and blood transfusions in the critical care setting.

2. ICU nurses are in a prime position to implement evidence-based blood conservation devices and strategies, and to advocate for more restrictive transfusion practice.

3. Nurses do not receive adequate education on blood conservation during their undergraduate nursing programs and therefore require education during nursing orientation, as well as with yearly competencies to influence practice and ensure that blood conservation becomes the standard of care.

4. Empowering nurses with evidence-based education enhances their practice, and empowers them with up-to-date information to advocate for patients.

5. As the public becomes more aware of the risks associated with transfusions, the ability to offer blood conservation programs will likely improve patient satisfaction scores at the institution.

6. The growing understanding and appreciation of the costs and risks involved with transfusions makes it essential that clinicians reconsider liberal transfusion practices.

Future Study and Recommendations

The benefits of blood conservation are well documented throughout the literature and recommendations from regulatory and professional organizations state that blood conservation should become the standard of care, and a priority for healthcare
providers. Institutions should develop policies and protocols based on the available guidelines to facilitate this practice change. Provider education on blood conservation is necessary and programs should be developed to improve knowledge among nurses and resident physicians. Blood conservation practice should be monitored closely to determine the most effective methods for influencing practice, and the effects of blood conservation on outcomes. Finally, due to the lack of evidence related blood conservation education programs for nurses it is essential that further research is conducted and that findings are disseminated through publication within the nursing literature.
Appendices

Appendix A: IRB approval letter
Appendix B: Approval letter from UK Nursing Research Council
Appendix C: Approval letter from Director of Cardiovascular Services
Appendix D: Cover letter
Appendix E: Pretest
Appendix F: Post-test
Appendix G: Data collection tool
Appendix H: Outline of the education presentation
Appendix A: IRB Approval Letter

On November 25, 2013, it was determined that your project entitled, *An Evaluation of Evidence Based Blood Conservation Education for Nurses*, meets federal criteria to qualify as an exempt study.

Because the study has been certified as exempt, you will not be required to complete continuation or final review reports. However, it is your responsibility to notify the IRB prior to making any changes to the study. Please note that changes made to an exempt protocol may disqualify it from exempt status and may require an expedited or full review.

The Office of Research Integrity will hold your exemption application for six years. Before the end of the sixth year, you will be notified that your file will be closed and the application destroyed. If your project is still ongoing, you will need to contact the Office of Research Integrity upon receipt of that letter and follow the instructions for completing a new exemption application. It is, therefore, important that you keep your address current with the Office of Research Integrity.

For information describing investigator responsibilities after obtaining IRB approval, download and read the document “PI Guidance to Responsibilities, Qualifications, Records and Documentation of Human Subjects Research” from the Office of Research Integrity’s Guidance and Policy Documents web page [http://www.research.uky.edu/ori/human/guidance/PIresp]. Additional information regarding IRB review, federal regulations, and institutional policies may be found through ORI’s web site [http://www.research.uky.edu/ori]. If you have questions, need additional information, or would like a paper copy of the above mentioned document, contact the Office of Research Integrity at (859) 257-9428.
Appendix B: Approval Letter from UK Nursing Research Council

August 26, 2013

Dear Stefanie Bull:

Your proposal concerning blood conservation in ICU was reviewed during the August 14, 2013 meeting of the Nursing Research Council at the University of Kentucky Medical. We are happy to report that your proposal has been approved. If you have not yet obtained approval for your research through the University of Kentucky Institutional Review Board (IRB, you must complete this process as well.

The Nursing Research Council reviews all proposals to conduct scientific inquiry that involve UK nursing staff in an effort to assess for a number of indicators: to determine the feasibility of conducting the proposed research, to establish the level of support from nursing management or administration to conduct the research, to determine the applicability to nursing, to evaluate protection of human subjects, and to assess the completeness of the proposal. If your proposal is amended in any way such that the methods or procedures are modified significantly, your proposal must be re-submitted for review by this Council.

Please contact me if you need further assistance, have questions, or wish to discuss anything.

Sincerely,

Mary Wethington, RN, MSN, CEN, CPEN

Chair-Nursing research committee
Staff Nurse-Makenna David Pediatric Emergency Center
University of Kentucky Health Care
Appendix C: Approval Letter from Director of Cardiovascular Services

UK HealthCare
Gill Heart Institute

September 26, 2013

To whom it may concern:

As the nursing director of the CVTICU at University of Kentucky Healthcare, I give my approval for Stefanie Bull to complete her project regarding the importance of blood conservation in the unit. I have also shared this information with Dr Charles Campbell the medical director of the unit. We look forward to working with Stefanie and assisting in facilitating her project. Thank you and feel free to contact me with any further questions.

Sincerely,

Lacey Troutman Buckler, MSN, RN, APRN, ACNP-BC, NE-BC Director of Cardiovascular Nursing and Advanced Practice University of Kentucky Healthcare

Division of Cardiology, Administrative Offices
University of Kentucky • Gill Heart Institute, 900 South Limestone • 320 Charles T. Wethington Building • Lexington, Kentucky 40536-0200
Phone: 859-323-8653 • Fax: 859-257-6060 • ukhealthcare.uky.edu
Appendix D: Cover Letter / Invitation to Participate

Dear CVICU Nurse,

We are implementing an evidence based nurse education program on blood conservation in your unit and would like to formally invite you to participate. This program is part of a research study aimed at empowering nurses with knowledge of current best evidence to enhance blood conservation practice. This study is being conducted as a capstone project for a Doctor of Nursing Practice (DNP) Degree at the University of Kentucky College of Nursing (CON). The research team includes: Stefanie Bull - Primary Investigator (PI), Dr. Melanie Hardin-Pierce - academic advisor, and Dr. Andrew Bernard - clinical mentor.

The following education program will take place in HA110 during your regularly scheduled unit based meetings. If you would like to participate you will be asked to complete a brief survey and a multiple-choice test, before and after the education program. The process will last approximately 30-45 minutes. Your answers will only be used to assist with our evaluation of the efficacy of the education program. All surveys and tests will be anonymous which means no names will appear on research documents, or be used in the generated project reports or publications. In order to protect your confidentiality we will not collect any research documents containing your personal information (name, date of birth or social security number). Moreover, no one other than the research team will have access to study documents or research data.

Following the completion of the presentation, pretest and post-test, we ask that you simply implement the evidence based blood conservation interventions you will have learned about. We ask that you utilize all available blood conservation devices and implement the recommended blood conservation methods in your daily practice. Finally, you will be asked to complete an anonymous survey to evaluate the program and provide feedback about how it may have affected your practice. The surveys and tests will consist of general demographic questions, and questions regarding your experience with, and knowledge of this clinical topic. Surveys and tests will be kept for 6 years as required by the IRB, and for future reference. All study related materials will be kept in a locked filing cabinet at the CON and will be destroyed after 6 years.

Your participation in this Evidence Based Blood Conservation Education Program is entirely voluntary. You may choose not to participate in this project. Although you will not get any personal benefit from taking part in this research study, your responses may help us understand more about the impact of nurse education on blood conservation practices in the ICU. We hope to receive completed questionnaires from about 30-40 nurses. You have a choice about whether or not to complete the questionnaires. If you choose to participate, you are free to skip any questions or discontinue your participation in this study at any time. Completion of the questionnaires constitutes your consent to participate in this study.

If you have questions about the study, please feel free to ask; my contact information is given below. If you have complaints, suggestions, or questions about your rights as study participant, you may contact the staff in the University of Kentucky Office of Research Integrity at 859-257-9428. You may request a copy of the study results by providing your name and email address, separate from your survey or test submissions.

Thank you in advance for your assistance with this project.
Sincerely,

Stefanie M. Bull

Stefanie M. Bull RN, BSN
College of Nursing, University of Kentucky
PHONE: 859-576-8478
E-MAIL: Stefanie.Bull@uky.edu
Appendix E: Pretest
Subject #: ______

Evidence Based Blood Conservation Education for ICU Nurses
Pretest

1. To start, please indicate your highest level of nursing education. *Circle one.*
   a. Associate Degree in Nursing (ADN)
   b. Bachelor of Science in Nursing (BSN)
   c. Master of Science in Nursing (MSN)
   d. Doctorate in Nursing (DNP/PhD)

2. Please enter your years of experience as a registered nurse: *if less than 1 year, enter 0.*
   a. Years of experience in nursing _____________
   b. Years of experience in intensive care unit (ICU) setting _____________

3. Please enter your age ____ Years old.

4. Are you: 0. Male 1. Female
   a. 0
   b. 1

5. Do you have Advanced Nursing Specialty Certification? *For example, CCRN, CEN*  
   0. No 1. Yes
   a. 0
   b. 1 (If yes, please list?) _______________________

6. Did you receive any education relating to blood conservation in your undergraduate-nursing program? 0. No 1. Yes
   a. 0
   b. 1

7. Did you receive any information or education about blood conservation during your CVICU nursing orientation? 0. No 1. Yes
   a. 0
   b. 1

8. Do you routinely use any blood conservation devices or strategies in your daily practice? *If so please describe.*

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
Please answer each of the following questions to the best of your ability. Circle only one answer.

1. The etiology of anemia in the critically ill patient is associated with: Circle one.
   a. Traumatic/surgical blood loss
   b. Decreased red blood cell life span
   c. Decreased production of erythropoietin
   d. Chronic illness
   e. All of the above

2. What is the average volume of blood a patient in the ICU loses (over a 24-hour period) due to phlebotomy? Circle one.
   a. 10-25 ml
   b. 45-50 ml
   c. 60-70 ml
   d. 90-110 ml

3. Blood conservation will result in all of the following except: Circle one.
   a. Decreased iatrogenic blood loss
   b. Decreased transfusion rates
   c. Improved clinical outcomes
   d. Increased healthcare costs

4. Radiographic evidence of new bilateral pulmonary infiltrates following transfusion of blood components is most likely indicative of which of these common adverse events? Circle one.
   a. TACO
   b. TRALI
   c. Pneumonia
   d. All of the above
   e. A & B only

5. ______ surgery is the largest consumer of blood products in medicine. Consuming an average of 10-15% of the total U.S. blood supply each year Circle one.
   a. Trauma
   b. Cardiac
   c. Ortho
   d. Both A & B

6. Evidence suggests that RBC transfusions could be associated with: Circle one.
   a. Decreased ventilator days
   b. Increased morbidity & mortality
   c. Increased ICU days
   d. All of the
7. For which of the following patients would you notify a physician with the anticipation of receiving an order to transfuse blood? *Circle one.*
   a. Patient with chronic renal failure on dialysis with hemoglobin of 7g/dL
   b. Patient with unstable angina/ACS with a hemoglobin of 9 g/dL
   c. Patient with acute symptomatic anemia (i.e. tachycardia, mental status changes, shortness of breath)
   d. All of the above
   e. B, and C

8. Which of the following are ways a nurse can implement blood conservation in the ICU? *Circle one.*
   a. Consistent use of a VAMP device for every patient with a central or arterial line
   b. Only filling phlebotomy tubes with ½ cc – 1cc of blood
   c. Eliminating repeating daily labs
   d. Both A & C

9. What are the World Health Organization (WHO) levels of anemia for men and women? *Circle one.*
   a. Less than 9g/dL and 6g/dL
   b. Less than 20g/dL and 18g/dL
   c. Less than 15g/dL and 10g/dL
   d. Less than 13g/dL and 12g/dL

10. Research has indicated that ____ % of patients will be anemic by the third day in the ICU. *Circle one.*
    a. 25%
    b. 45%
    c. 70%
    d. 90%

11. In the ICU setting _______ is a primary contributing factor in the development of iatrogenic anemia. *Circle one.*
    a. Hemorrhagic blood loss due to trauma
    b. Intraoperative blood loss
    c. Anemia of Chronic Disease
    d. Routine phlebotomy

12. Jehovah’s Witness patients die without blood transfusion far more frequently than patients who receive blood transfusions. *Circle one.*
    a. True
    b. False

13. Anemia results in all of the following except. *Circle one.*
    a. Decreased oxygen carrying capacity of blood
    b. Increased cardiac output
    c. Left shift of the oxyhemoglobin dissociation curve
d. Increased O2 extraction at the tissues

14. A restrictive transfusion strategy is less effective than a liberal transfusion strategy in critically ill patients who are hemodynamically stable. Circle one.
   a. True
   b. False

15. Which of the following define the nurse’s role in blood conservation? Circle one.
   a. Reduce diagnostic blood loss and sample waste
   b. Reduce hemorrhagic blood loss
   c. Avoid hypoxia
   d. Support production of red blood cells
   e. Collaborate with other members of the healthcare team about blood conservation
   f. All of the above

16. In the absence of acute hemorrhage RBC transfusion should always be given in single units. Circle one.
   a. True
   b. False

17. Which of the following are indicated for alternative management and treatment of ICU anemia? Circle one.
   a. Iron supplementation
   b. Blood transfusion
   c. Nurse driven blood conservation interventions
   d. All of the above
   e. Only A & C

18. Blood Utilization is higher in the U.S than in Europe and Canada. Circle one.
   a. True
   b. False

19. Blood transfusions increase the oxygen carrying capacity of the blood and facilitate ventilator separation. Circle one.
   a. True
   b. False

20. Activity based costs associated with the transfusion of 1 unit of red blood cells amount to $______ per unit transfused. Circle one.
   a. $850
   b. $1200
   c. $9000
   d. $200
Appendix F: Post-test

Thank you for listening to this presentation. We hope that you will find the information to be of value in your practice as an ICU nurse!

Please answer each of the following questions to the best of your ability. Circle only one answer.

1. The etiology of anemia in the critically ill patient is associated with: Circle one.
   a. Traumatic/surgical blood loss
   b. Decreased red blood cell life span
   c. Decreased production of erythropoietin
   d. Chronic illness
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   d. All of the above
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5. __________ surgery is the largest consumer of blood products in medicine. Consuming an average of 10-15% of the total U.S. blood supply each year Circle one.
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   b. Patient with unstable angina/ACS with a hemoglobin of 9 g/dL
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   e. B, and C

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   d. Less than 13g/dL and 12g/dL

10. Research has indicated that ____ % of patients will be anemic by the third day in the ICU. *Circle one.*
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d. Support production of red blood cells  
e. Collaborate with other members of the healthcare team about blood conservation  
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e. Only A & C  

18. Blood Utilization is higher in the U.S than in Europe and Canada. *Circle one.*  
a. True  
b. False  

19. Blood transfusions increase the oxygen carrying capacity of the blood and facilitate ventilator separation. *Circle one.*  
a. True  
b. False  

20. Activity based costs associated with the transfusion of 1 unit of red blood cells amount to $______ per unit transfused. *Circle one.*  
a. $850  
b. $1200  
c. $9000  
d. $200
Thank you for participating in this Evidence Based Nurse Education program on Blood Conservation. Please answer the questions below to let us know your satisfaction with the program and its impact on your role as a nurse. We appreciate all your comments!

1. Are you more likely to use blood conservation devices in daily practice now that you have received this information? *Circle one.*
   a. Much more likely
   b. Somewhat more likely
   c. No more likely

2. On a scale of 0 to 10 where 0 is not at all satisfied and 10 is extremely satisfied please rank your overall satisfaction with this educational presentation.

   0  1  2  3  4  5  6  7  8  9  10

   Not at all satisfied  Extremely satisfied

3. On a scale of 0 to 10 where 0 is not at all empowered and 10 being extremely empowered please rank whether the educational presentation empowered you in your role as a nurse.

   0  1  2  3  4  5  6  7  8  9  10

   Not at all Empowered  Extremely Empowered

4. Please use the space below to comment on ways this program has changed your practice. Please indicate any barriers you continue to face as well as ways you are supported in practicing blood conservation.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

5. Would you like to receive more educational information like this on other subjects related to implementing EBP in the ICU? If yes, please indicate some additional topics you may be interested in

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
6. Do you have any suggestions to making this presentation more effective and improving this program for other ICU nurses? If yes, please indicate your suggestions.

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

THANK YOU FOR YOUR TIME & PARTICIPATION 😊
# Appendix G: Data Collection Tool

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<th># of years as ICU RN</th>
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<th>Age</th>
<th>Adv. RN cert?</th>
<th>BC education in undergrad?</th>
<th>BC education in ICU orientation?</th>
<th>Current use of BC in practice</th>
<th>Pretest Score</th>
<th>Posttest Score</th>
<th>Likely to use BC in future</th>
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<td>1</td>
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Appendix H: Overview of Education Presentation

1. Pathophysiology of ICU Anemia
2. Treatment of anemia
3. Transfusion reactions
4. Anemia, transfusions & patient outcomes
5. Alternatives to blood transfusion
6. Anemia prevention
7. Blood conservation devices
8. Nurse driven blood conservation strategies
9. Implications for nursing practice & patient outcomes
References

American Association of Blood Banks (AABB, 2013) *Patient Blood Management*


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Diagnostic Phlebotomy on Hemoglobin and Hematocrit Levels. Journal of General Internal Medicine, 20, 6, 520-524.


