WHITE PAPER

Reducing the Risk of Iatrogenic Anemia and Catheter-Related Bloodstream Infections Using Closed Blood Sampling

INTRODUCTION

In the Intensive Care Unit (ICU), critically ill patients are more numerous and severely ill than ever before.[1] To effectively care for these patients, clinicians rely on physiologic monitoring of blood-flow, oxygen transport, coagulation, metabolism, and organ function. This type of monitoring has made the collection of blood for testing an essential part of daily management of the critically ill patient, yet it is widely recognized that excessive phlebotomy has a deleterious effect on patient health. The result is a clinical paradox in which diligent care may contribute to iatrogenic anemia.

RISKS ASSOCIATED WITH CONVENTIONAL DIAGNOSTIC BLOOD SAMPLING

Iatrogenic Anemia

The process of obtaining a blood sample from an indwelling central venous or arterial catheter requires a volume of diluted blood (2–10 mL) to be discarded or "cleared" from the catheter before a sample can be taken.[2,3] Studies have shown that patients with central venous or arterial catheters have more blood sampling than ICU patients who don't have these catheters and the total blood volume drawn from patients with arterial catheters is 44% higher than patients without arterial catheters (See Table 1).[4,5]

> Use of blood sampling techniques that rely on discarding a volume of blood for each sample may contribute to iatrogenic anemia, which remains a prevalent issue affecting the vast majority of patients in the ICU.

It has also been reported that mean blood loss per cardiothoracic ICU patient stay is approximately 377 mL, 240 mL per patient stay in general surgical ICUs and 41.5 mL per patient stay in medical-surgical ICUs.[4,6] Another study found that the total average volume of blood drawn over a 7-day medical intensive care unit (MICU) stay was 257.4 mL (See Figure 1).[7] More recently, an ICU-based study found an average blood draw volume in 24 hours was 41.1 mL per patient.[8] Because the most critically ill patients may have up to 24 diagnostic blood samples drawn in a day, this frequent sampling can contribute to 17% of the total blood loss while in the ICU. [9,10,11]

Loss of blood volume causes anemia, a condition in which lowered hematocrit (HCT) and hemoglobin (Hgb) in the blood limits the ability of red blood cells (RBC) to transport oxygen to the body's tissues. Use of blood sampling techniques that rely on discarding a volume of blood for each sample may contribute to iatrogenic anemia, which remains a prevalent issue affecting the vast majority of patients in the ICU, especially those with prolonged stays.

Almost 95% of patients admitted to an intensive care unit have an Hgb concentration that is below normal by day 3 of admission, often requiring blood transfusion.[12] It has also been shown that phlebotomy accounts for 49% of the variation in the amount of RBCs transfused.[2]

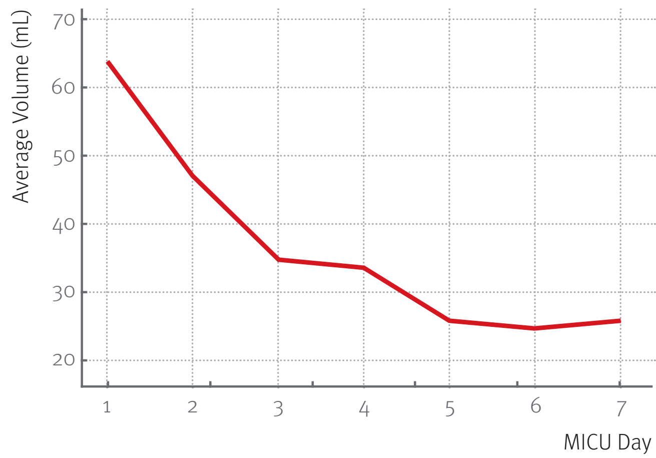
TABLE 1. COMPARISON OF NUMBER OF PROCEDURES AND VOLUME OF BLOOD DRAWN IN ARTERIAL LINE AND NONARTERIAL LINE PATIENT GROUPS* [5]

	ARTERIAL LINE	NONARTERIAL LINE	PERCENT DIFFERENCE	P VALUE
No. of procedures				
1	8.1 ± 4.7	5.8 ± 2.8	28	0.048
2	5.0 ± 2.8	3.4 ± 1.5	32	0.012
T	13.1 ± 6.8	9.2 ± 3.4	30	0.014
Volume of blood, mL				
1	70.9 ± 37.2	42.4 ± 22.1	40	0.002
2	43.5 ± 24.4	22.0 ± 11.6	49	<0.001
T	114.7 ± 53.9	63.6 ± 28.4	44	<0.001

*1=first 24-h period; 2=second 24-h period; T=total over 48 h

Despite evidence to support a restrictive transfusion practice, the transfusion of packed red blood cells (PRBC) remains a primary intervention for the treatment of ICU patients with anemia.[13] In two large, multi-facility cohort studies, 44% of patients in ICUs in the United States and 37% of those in ICUs in Western Europe received blood transfusions.[8,14] Blood transfusions are associated with negative effects on patient outcomes, including increased risk for infection, which may explain the positive correlation between organ dysfunction and the number of blood draws.[8,10,11,15] Additional risks of transfusions include allergic, anaphylactic, and hemolytic transfusion reactions and acute respiratory distress syndrome, all contributing to significant morbidity and mortality.[16,17,18,19]

FIGURE 1. LABORATORY BLOOD VOLUME[7]



The average laboratory blood volume drawn over a 7-day MICU stay. Total average volume of blood drawn for 7 days was 257.4 mL

Catheter-related bloodstream infections (CRBSI)

CRBSI is the most common nosocomial bacteremia in critically ill patients.[20] It affects nearly 50,000 patients each year in the US, with an attributable mortality of up to 35% and a financial cost of up to $30,000 per case.[21] Studies also show that CRBSIs stemming specifically from arterial catheters occur at a rate less than infection rates of short-term central venous catheters.[22,23,24,25,26]

High levels of catheter handling can facilitate hub colonization with micro-organisms derived from the patient's skin or from contact by healthcare workers.[27] The risk for bacterial ingress and arterial line contamination is also increased by catheter manipulation such as opening the system for blood sampling.[28,29] In particular, using a 3-way stopcock without a self-sealing port for blood sampling may increase contamination due to access frequency, insufficient aseptic technique, or residual blood within the ports.[30]

> One study found that patients using a blood conservation system had a 48% reduction in PRBC transfusion requirements.[31]

CLOSED, IN-LINE BLOOD CONSERVATION SYSTEMS (BCS)

BCS such as SafeSet® (ICU Medical Inc., San Clemente, CA) eliminate the need to discard the clearing volume associated with sampling through indwelling arterial catheters.[31] When performing a sample collection using a BCS, blood and flush solution are drawn into a reservoir distal to the sampling port. Then, while maintaining aseptic sampling technique, a clinician is able to return the blood clearing volume held in the sterile reservoir back to the patient after a sample has been drawn, reducing blood loss as well as the potential for bacterial ingress to the closed system. The closed, in-line BCS also reduces clinician exposure to potential bloodborne pathogens during the sampling process.

Avoiding transfusions by conserving blood

In-line BCSs have been associated with a 50% reduction in daily diagnostic blood loss, and reducing blood loss helps reduce cases of anemia in the ICU, as well as risks associated with blood transfusions.[7,32,33,34]

In a survey of members of the Society of Critical Care Medicine, most agreed that in-line BCSs could be very useful in preventing anemia.[7] Another study found that patients using a BCS had a 48% reduction in PRBC transfusion requirements as well as a smaller decrease in Hgb levels between ICU admission and discharge.[31] This finding is significant given the current worldwide shortage of PRBCs, the cost of transfusions (estimated between $500 and $1,200),[35] and the desire to avoid the significant risk of morbidity and mortality associated with transfusions.

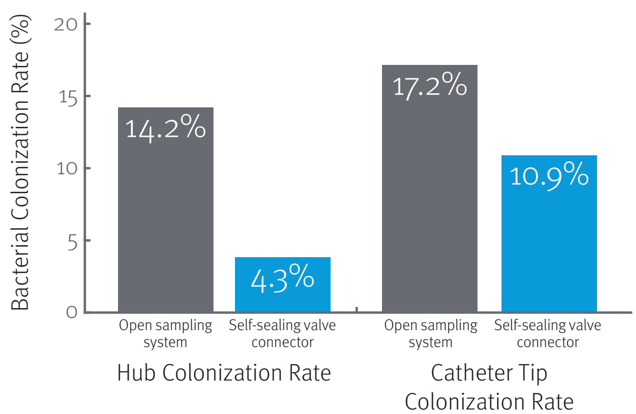
The SafeSet Closed Blood Conservation System (ICU Medical Inc., San Clemente, CA) allows clinicians to conserve blood by reinfusing the clearing volume drawn during blood sampling.

Reducing catheter contamination and the risk of CRBSI

By eliminating open systems and minimizing points for bacterial ingress, closed, in-line BCSs may significantly reduce arterial and central line contamination.[36] One study found the use of a BCS correlated with lower rates of intraluminal fluid contamination compared to a traditional 3-way open-port stopcock system. Cultures of the intraluminal fluid from the open-port stopcock system yielded growth of various species of micro-organisms, compared to any positive cultures from the BCS, which yielded growth of a single species. Another study reported that use of a closed BCS (n=60) resulted in fewer instances of intraluminal fluid contamination compared to use of a conventional 3-way stopcock system (n=70), 7% vs 61%, respectively.[37]

The ability of a BCS to prevent microbial contamination is further enhanced by incorporating needlefree connectors into the sampling port stopcock. An in vitro study found that closed systems, combined with needlefree, self-sealing valve sampling ports, maintained a barrier that minimized bacterial ingress into the catheter and reduced colonization of the sampling hub.[38] Another study comparing conventional open sampling systems to self-sealing valve connectors within a post-surgical cardiothoracic ICU reported a 4.3% hub colonization rate with valve connectors and a 14.2% colonization rate with open sampling systems.[39] The study also reported 10.9% catheter tip colonization with the self-sealing valve connectors and 17.2% colonization rate with open sampling systems (See Figure 2).

FIGURE 2. COMPARISON OF BACTERIAL COLONIZATION RATES USING OPEN SAMPLING SYSTEMS AND SELF-SEALING VALVE CONNECTORS[39]



CONCLUSION

The pervasive anemia experienced by the majority of patients in the ICU is minimized by the utilization of closed, in-line blood sampling and conservation systems. By reducing blood loss and the potential for iatrogenic anemia, closed blood sampling and conservation systems help reduce the need for and inherent risk of transfusions in the ICU. Finally, the application of closed blood sampling and conservation systems prevents the transfer of bacteria into the catheter and helps clinicians in their efforts to minimize catheter-related bloodstream infections.

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