EVALUATION OF A BLOOD CONSERVATION STRATEGY IN THE INTENSIVE CARE UNIT:
A PROSPECTIVE, RANDOMISED STUDY
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Abstract

Objective and Methods: Anemia is a common problem in the ICU population. Most patients are anemic at admission, their hemoglobin concentrations declining further thereafter. The aim of the present study was to evaluate the effect of a combination strategy, involving closed arterial blood gas sampling and the use of pediatric vials for phlebotomy (Group A), on the sampling-induced blood loss and the rate of decline in hemoglobin in adult ICU patients. Combination (Group A) was compared to the current standard technique of arterial line sampling and adult vial phlebotomy (Group B) in a prospective, randomised, ethically-approved trial for the first 72 hours of their ICU stay. Peri-operative, oncology, coagulopathic and uremic patients were excluded. All other ICU patients with arterial cannulae and predicted to stay beyond 3 days, were enrolled.

Results: 39 patients entered the study, 20 in Group A, and 19 in Group B. Data collection was complete for all. There was a 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).

Conclusions: Overall, this strategy reduced measurable blood losses from phlebotomy. In larger trials it might also preserve hemoglobin levels.

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Introduction

Anemia is a common problem in the critically ill, with many patients being mildly anemic at admission to the intensive care unit (ICU). Typically, hemoglobin concentrations decline by about 0.5 gm/dl/day during the first 3 days of intensive care and continue declining thereafter, falling more markedly in those with sepsis and more severe levels of illness. This patient population is at particular risk from the adverse consequences of anemia given the cardiovascular, respiratory, and metabolic compromise that characterise critical illness. The etiology of this anemia is multi-factorial: gastrointestinal bleeding, phlebotomy, coagulation disorders, blood loss from vascular procedures, renal failure, nutritional deficiency, bone marrow suppression and impaired erythropoietin response may be amongst the causes.

Methods aiming to decrease blood loss in intensive care are thus potentially effective. The Venous Arterial Blood Management Protection (VAMP) system is designed to reduce infection, needle-stick injury, and blood wastage associated with blood sampling. Blood sample sites incorporate familiar needleless technology for added safety. Versatile reservoir design can be bracket mounted on an IV pole next to a pressure transducer providing convenient blood withdrawal. Blood volume is held in in-line reservoir and not set aside, to be rein infused later. Another simple step that might reduce unnecessary blood loss is the use of pediatric-sized vials for phlebotomy for laboratory testing.

The aim of our study was to evaluate the effect of combining these methods (i.e., both closed arterial blood gas sampling, allowing return of dead-space blood, along with the use of pediatric blood vials) on the volume of blood lost through sampling and also on the progression of anemia, in adult ICU patients. We compared this to the current practice of arterial pressure line sampling, where dead-space blood is discarded, and adult phlebotomy vials are used. We hypothesised that this combination strategy would decrease the volume of blood lost through sampling in critically ill patients and thus reduce the rate of decline in the patients’ hemoglobin levels and, perhaps, their need for transfusion.

Methods and Materials

Approval was obtained from the Ethics and Research Committee of Cork University Hospital to conduct a pilot study in order to evaluate the VAMP system’s efficiency, in a prospective randomised unblinded controlled clinical study. The study was carried out in the Hospital’s ICU from January to March of 2006. Written consent was obtained around the time of admission from appropriate patients (or their next-of-kin). These included those who were expected to require more than 3 days of intensive care. Patients with clinical evidence of bleeding, such as perioperative or trauma patients, or those with upper and lower gastrointestinal blood (i.e., visible blood in the gastric aspirate or melena) and menstruating female patients were excluded. Also excluded were oncology patients and those requiring renal replacement therapies.

Thirty nine patients were randomised into two groups. (Study group A n = 20) had the VAMP (closed system) used for blood gas sampling, in which dead space blood is returned to the patient and the catheter flushed clear, while group B (the control group n = 19) had standard sampling systems used. The frequency of blood gas analysis and phlebotomy complied with the routine management in ICU (i.e., once daily, or at the discretion of the ICU physician and nursing staff, in turn guided by the clinical condition of the patient).

Pediatric syringes (1 ml) for blood gas analysis were used in study group A and we used pediatric vials for hematology and biochemistry analysis, which required 0.4 and 1.4 mls respectively, as compared to 2.7 and 4.9 mls for adult vials. Standard data collection for the ICU population was used with a specific
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Current trend in ICU management to accept lower hemoglobin levels than in previous generations, and thus to transfuse less blood. Nonetheless, about 40% of the critically ill population receive transfused blood during their illness such that, in the United States for example, around 11 million units of red cells are transfused annually.

The administration of blood is subject to increased public scrutiny as, despite best efforts, infectious risks remain. Such risks, due to the ongoing recognition of new pathogens such as West Nile virus, for example, cannot accurately be quantified at present. Non-infectious risks, such as circulatory overload, acute delayed transfusion reactions, microcirculatory dysfunction, immune modulation, hypocalcemia and hypothermia, are also associated with transfusion. Attempts to make the process safer incur increased costs: thus, the introduction of measures to improve the safety and adequacy of the blood supply contributed to a 51% rise in expenditure by the Canadian Blood Services.

Alternatives to transfusion are clearly desirable then, and are the subject of many diverse strands of research. These include the administration of erythropoietin, with or without iron, and therapy with blood cell substitutes or synthetic hemoglobin. Avoiding the need for transfusion is a more rational and cost-effective strategy. Many of the tenets of modern ICU contribute to this strategy: optimising patient nutrition, avoiding drugs associated with bone marrow depression, and minimising diagnostic phlebotomy, for example.

Diagnostic phlebotomy may contribute substantially to the anemia encountered in ICU. In

Results

The volumes of blood removed for analysis and the level of decline in hemoglobin levels are shown in Table 1. The control group had a 65% greater a fall in hemoglobin levels than the study group, though this difference was not statistically significant. There is a statistically significant difference, however, between the study and control groups in terms of the volume of blood drained for analysis; about three times more blood was lost in the control group (15.16 ml vs 45.11 ml). There was no discarded blood in the study group as compared to almost 25 mls lost by the average patient in the control group. No patients from either group required blood transfusion during the study.

Discussion

The consequences of anemia in the critically ill are significant both for patients and for healthcare institutions. In managing such patients, the immediate risks of reduced delivery of oxygen to the tissues must be weighed against the adverse long and short-term health effects of transfusion and the financial burden of blood collection and storage.

On the basis of recent research there is a current trend in ICU management to accept lower hemoglobin levels than in previous generations, and thus to transfuse less blood. Nonetheless, about 40% of the critically ill population receive transfused blood during their illness such that, in the United States for example, around 11 million units of red cells are transfused annually.

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### Table 1

Values of blood removed for analysis and level of decline of hemoglobin levels, in Group A and B

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test (Group A)</th>
<th>Control (Group B)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Fall in hemoglobin after 3 days</td>
<td>20</td>
<td>0.79</td>
<td>0.61</td>
</tr>
<tr>
<td>Blood lost on gas sampling</td>
<td>20</td>
<td>5.42</td>
<td>1.14</td>
</tr>
<tr>
<td>Blood discarded</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Blood phlebotomised</td>
<td>20</td>
<td>9.72</td>
<td>4.92</td>
</tr>
<tr>
<td>Total blood drained</td>
<td>20</td>
<td>15.15</td>
<td>5.32</td>
</tr>
</tbody>
</table>
critically ill surgical patients drawn volumes over 200 mls per day, are described in the literature\(^{14,15}\). However, the volumes drawn vary widely in different study populations; values of 40 to 80 mls per day are more representative of medical patients with higher values being typical on the day of admission. Interestingly, a German study found that the total amount of diagnostic blood loss was a strong predictor of later transfusion\(^9\). Another American study found that phlebotomy accounted for approximately 50\% of the variation in the amount of red blood cell later transfused\(^5\). Of course, more severely ill patients are subject to more frequent phlebotomy and thus are at higher risk of transfusion and its consequences\(^1,17\). The mean frequency of phlebotomy in critical patients varies widely among published series, ranging from 5 to more than 10 samples per day\(^4,14,17\).

Arterial blood gases are the most frequently ordered laboratory test in ICU and may account for almost 40\% of blood drawn\(^1\). The mean volume per draw depends on the particular blood test, the ICU, and clinical laboratory practice\(^{15,18,19}\). Published estimate vary from 1.5 ml to 10 ml for arterial blood gas and from 4 ml to 10 ml for hematology, coagulation and chemistry samples. The mean volume per draw in a recent study covering 145 European ICUs was 10.3 ml\(^4,15\). Patients with indwelling arterial catheters are subject to more frequent blood draws and have three fold increases in phlebotomy volumes compared with patients without such catheters\(^5,16,17\).

Each blood sample taken via an arterial or central venous catheter tends to result in blood being discarded, as blood is removed to clear infusate which might otherwise dilute the specimen. The volume lost depends on the local medical and nursing practice and it varies from 2 ml to 10 ml of discarded blood\(^4,20,21\). The discarded volume is recommended to be twice the volume of the dead space to provide accurate and reproducible blood gas analysis\(^20\). This recommendation is probably not well known though; the volume lost is certainly rarely measured.

Our present findings are that through a simple strategy of closed sampling and the use of pediatric blood vials, phlebotomy-induced blood loss can be reduced by about 30 mls per day per patient. This is likely to be sustained through longer admissions, perhaps producing a significant clinical benefit and reducing costs.

The small patient population studied and the relatively short study period (of 3 days) are amongst the limitations of the present study. While a longer study period would probably validate the hypothesis more clearly, longer lengths of stay are difficult to predict, so that complete follow up is difficult, and phlebotomy may become more invasive once arterial cannulae are removed. Most importantly, other causes of blood loss will become more frequent with longer stays, confounding results.

The venous arterial blood management protection system (VAMP) was introduced in 1989 as a simple method for clinicians to draw blood samples without using needles in a closed system\(^6\). An added advantage of this is the elimination of the risk of needle stick injuries, with obvious benefits. In our evaluation of the system, no significant problems were encountered and it succeeded in eliminating the loss of blood as discarded dead-space volume. Furthermore, no extra workload was imposed on medical or nursing staff by the introduction of this method of phlebotomy.

Previous authors have found that pediatric collection tubes can reduce blood loss by 42\%\(^{22,23}\), but their use is nonetheless not commonplace in adult medical practice. Our findings, in conjunction with these, show that it is feasible to use smaller vials in the adult ICU population. In conclusion, we suggest that the combined approach evaluated can make a modest but potentially clinically significant impact on the volumes of blood drawn from critically ill patients without adverse effect and recommend it for further evaluation or use.

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