Determining the Minimum Discard Volume for Central Venous Catheter Blood Draws

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This study aimed to determine the minimum discard volume from central venous catheters (CVCs) to avoid dilution or contamination from flush or IV fluids. In 93 adult patients with CVCs, minimum discard volume findings were 9 ml for tunneled and 6 ml for nontunneled catheters. Nurses who obtain samples from CVCs are uniquely positioned to minimize blood loss from sampling.

A t an urban, tertiary teaching hospital in 2005, the laboratory staff observed a high rate of blood sample rejection because of contaminated samples drawn by RNs. In this article, contamination is defined as residual IV fluid or flush within the blood sample. The highest frequency reported in the hospital was from central venous catheters (CVCs). The common contributing factors were variable discard volumes (5–12 ml) and inconsistent nursing practice for blood sampling from CVCs. However, limited research was available on optimal blood sampling methods from CVCs in adults. The hospital at that time had a patient safety goal to reduce the rate of rejected blood samples with redraws to 0.3% or lower—the College of American Pathologists reported top performance among hospital laboratory blood sample rejection rates as 0.3% in 1997 and 0.28% in 2000 (Zarbo et al., 2002).

Literature and Guidelines

Relevant literature includes three methods of blood sampling: discard, push-pull (mixing), and reinfusion (Almandrones, Goldbold, Raaf, & Ennis, 1987; Clemence, Walker, & Farr, 1995; Franson, Ritch, & Quebeman, 1987; Frey, 2003; Holmes, 1998; MacGeorge, Steeves, & Steeves, 1988; Mayo, Dimond, Kramer, & Horne, 1996; Odum & Drenck, 2002; Wannimolruk & Murphy, 1991). The discard method involves withdrawing one volume of fluid and then discarding that volume. The push-pull method involves inserting a needle into the catheter and aspirating 5–10 ml of blood or fluid, and then reinfusing the sample back into the patient. The reinfusion method involves leaving the needle in place and aspirating 5–10 ml of blood or fluid, and then reinfusing the sample back into the patient.

Most guidelines and standards for discard volume from CVC blood draws recommend a flush of CVCs prior to blood sampling. This method helps to minimize blood loss but has concerns of sample hemolysis and contamination. With the reinfusion method, the discard volume is aspirated into a syringe, set aside during blood collection, and then reinfused to the patient after samples have been collected. Although not commonly used, that method can prevent blood loss associated with repeat laboratory draws. Multiple concerns exist with the reinfusion method, including catheter contamination, clot formation, hemolysis, and clinician exposure to blood. The discard method is used to remove potential contaminants of blood samples that reside in the catheter. That method includes withdrawing an initial volume of blood to clear the catheter dwell volume and then discarding that blood. Next, a vacutainer system or second syringe is attached to the CVC to collect the blood specimen. Despite nosocomial blood loss, the discard method remains the most widely used method for blood withdrawal from CVCs (Clemence et al., 1995; Frey, 2003).

Push-pull or mixing method is performed by attaching a normal saline flush syringe to the catheter, flushing the line and aspirating 5–10 ml of blood or infusion, and pushing the aspirate in and out multiple times (Frey, 2003; Holmes, 1998). After mixing and reinfusing the aspirate, the syringe is removed and a new syringe or vacutainer is applied and a laboratory sample is drawn for analysis (Frey, 2003; Holmes, 1998). This method helps to minimize blood loss, but in the volume and number of times to push-pull varies in the literature, and concerns of sample hemolysis exist (Frey, 2003).

With the reinfusion method, the discard volume is aspirated into a syringe, set aside during blood collection, and then reinfused to the patient after samples have been collected. Although not commonly used, that method can prevent blood loss associated with repeat laboratory draws. Multiple concerns exist with the reinfusion method, including catheter contamination, clot formation, hemolysis, and clinician exposure to blood. (Cosca et al., 1998; Frey, 2003; Holmes, 1998; MacGeorge et al., 1988). Therefore, little support exists for this method in clinical practice.

The six studies of discard method in adults reported in the literature had small sample sizes (4–30 patients) and varied in methodology, including use of 0.9% saline flush; volume of flush (2.5–10 ml); and discard volumes of 3–6 ml for complete blood counts and electrolytes, 3–5 ml for drug levels, and 10–25 ml for coagulation tests (Almandrones et al., 1987; Franson et al., 1987; Holmes, 1998; Mayo et al., 1996; Odum & Drenck, 2002; Wannimolruk & Murphy, 1991). Only one study tested discard method in all three types of CVCs (implanted ports, tunneled lines, and non-tunneled lines) (Holmes, 1998).

Most guidelines and standards for discard volume from CVC blood draws recommend a flush of CVCs prior to laboratory specimen collection. The discard volume recommendations vary by (a) the dwell volume multiplied by a
constant (e.g., six times the dwell volume), (b) a standard discard volume, or (c) specific volumes based on line type (e.g., 1–2 ml for peripherally inserted central catheter lines, 3–5 ml for tunneled lines, and 5–10 ml for implanted ports) (Camp-Sorrell, 2011; Clinical and Laboratory Standards Institute, 2003; Infusion Nurses Society, 2011).

Standardized clinical practice helps optimize patient safety. To reduce the number of redrawn samples from CVCs, inpatient and outpatient staff nurses at the teaching hospital requested a user-friendly blood collection checklist. According to Gawande (2009), effective checklists are precise, easy to use, practical, and include reminders of the most critical or important steps. Checklists are not comprehensive how-to guides, but are quick and simple tools to aid professionals (Gawande, 2009). Outcomes of checklist use include a discipline of higher performance, improved memory recall by healthcare personnel, and improved patient safety (Gawande, 2009).

**Discard Method**

CVCs are used for patients who require routine access to venous blood to treat and manage chronic illness, or for whom vascular access has become difficult. Ideally, the discard volume will be the smallest amount possible to minimize blood loss while providing the most accurate sample that is not diluted by the infusate or contaminated by other components (e.g., dextrose, potassium).

Dwell volume depends on length, gauge, and needleless access cap (Yucha & DeAngelo, 1996). Implanted ports are designed with both a reservoir volume and the catheter dwell volume. Tunneled catheters (e.g., silastic cuffed catheters) and implanted ports are cut to size at the time of placement, based on an individual's unique anatomy. McGee et al. (1993) reported that the average vascular length of internal jugular or subclavian catheters is 14–16 cm with right-sided placements and 16–18 cm with left-sided placements. Therefore, the exact dwell volume of many CVCs is not known. That complicates the use of catheter dwell volume as a determinant of discard requirements. Most tunneled catheters are not cut to size and have a specific dwell volume based on gauge and length. For example, the Arrow Triple Lumen CatheterTM, 7 Fr gauge, 30 cm length, has a brown lumen volume of 0.49 ml. The variation in dwell volume of CVCs among patients supports the need to establish a minimum discard volume that is not based on a constant factor multiplied by the catheter volume.

Patients with cancer often have CVCs and require multiple blood draws to monitor their disease and treatments. Important clinical decisions such as hospital admission, discharge, medical and nursing treatments, and medication titration are based on laboratory results (e.g., glucose monitoring with insulin administration). Therefore, accuracy of laboratory results is critical. A standardized volume for discard from CVCs may reduce repeated sampling, which in turn would improve patient safety, minimize iatrogenic anemia, and reduce associated costs.

Because of the limited research in adults to guide the development of an optimal discard volume for a central line blood draw protocol, conducting a research study was important to provide evidence to support best practice. The goal was to determine a minimum discard volume that a bedside nurse could apply to all three CVC types when drawing blood samples, thus eliminating the need to know an exact dwell volume for each CVC. Determining the minimum discard volume would help to establish protocols, support consistent practice, and ultimately benefit patients. This research study had multidisciplinary support, including the pharmacy donating time and materials, staff nurses assisting with subject identification, and laboratory medicine conducting repeated-measure glucose levels on each discard blood tube.

The purpose of this study was to determine the minimum discard volume to avoid contamination of dextrose IV fluid for blood samples drawn from CVC lines. The specific aim was to determine the discard volume at which blood glucose values stabilized across four serial 3 ml blood samples.

**TABLE 1. Blood Glucose Confounding Factors**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Implanted Ports (N = 33)</th>
<th>Tunneled (N = 30)</th>
<th>Non-tunneled (N = 30)</th>
<th>Total (N = 93)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>5% dextrose in water IV fluid</td>
<td>8</td>
<td>19</td>
<td>21</td>
<td>48</td>
</tr>
<tr>
<td>IV antibiotics</td>
<td>6</td>
<td>7</td>
<td>20</td>
<td>33</td>
</tr>
<tr>
<td>Oral antibiotics</td>
<td>2</td>
<td>6</td>
<td>14</td>
<td>22</td>
</tr>
<tr>
<td>Steroids</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Total parenteral nutrition</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>22</td>
</tr>
</tbody>
</table>

**Methods**

**Sample**

The current study included a non-randomized convenience sample of 93 adult inpatients and outpatients who had orders for chemistry blood collection from CVCs. Study approval was obtained from the University of Washington’s Human Subjects Review Committee, and informed consent was obtained from each patient. A repeated-measures design with participants as their own control was used.

**Procedures**

CVCs were flushed with 10 ml of 5% dextrose before sampling. The dextrose was used to increase the ability to detect contamination of samples. Using a typical flush of normal saline would not be as clear, as serum sodium levels and 0.09% sodium chloride flushes are about equal. Exactly 30 seconds after the dextrose flush was administered, four 3 ml discard tubes were drawn sequentially (3, 6, 9, and 12 ml) using the vacutainer method. Glucose is a difficult molecule to quantify, as large intranidividual biologic variability exists (Sacks et al., 2002). Therefore, blood glucose measurement was repeated four times from each discard tube to increase the precision of the mean blood glucose value and the power of the statistical analysis. A separate syringe for each discard tube of blood was used for peripherally inserted central catheters per hospital policy and procedure.
hospital’s standard discard tube had a 3 ml volume. The blood samples were analyzed on a Beckman Synchron LX20 chemistry analyzer. Glucose level was analyzed four times from each discard tube to determine mean glucose values.

A checklist was created by the nurse researchers to standardize study blood collection steps and to evaluate whether use of a checklist reduced or eliminated the need for redraws. Inter-rater reliability was established by each nurse researcher performing the correct order of blood collection under direct observation by a fellow nurse researcher. Once three consecutive participants had blood collected under observation and validated by an observer, the nurse researcher then performed additional collections independently using the checklist.

**Data Analysis**

Data were analyzed according to paired t test, Bland-Altman plots, and clinical significance. Power analysis was performed prior to implementation of the study; a sample size of 30 participants per CVC group with 80% power (Cronbach α = 0.05) would be able to detect a difference of 5 mg/dl using paired t test. The paired t test analyses provided a sensitive assessment of differences. Although those differences may be statistically significant, they are not always clinically significant.

Bland-Altman plots were generated as a visual examination of the agreement between two methods of measurement, specifically the mean blood glucose values between tubes 2 and 3 and tubes 3 and 4. Patterns of difference that may exist between the two methods of measurement and outliers are visually more obvious using Bland-Altman plots versus the traditional analysis of correlation and linear regression (Bland & Altman, 1986). Bland-Altman plots were created by placing the mean results of two methods (e.g., tubes 3 and 4) on the X axis, and the difference of the two methods on the Y axis. The bias represents the average difference between the two methods.

The clinical significance of blood glucose values was evaluated using the hospital’s subcutaneous and IV high-dose insulin order sets to determine whether clinical treatment would differ for results obtained from tubes 2, 3, or 4. Clinical significance was defined as a 10% or higher difference in blood glucose levels.

**Results**

**Sample**

The sample comprised 50 women and 45 men. Participants were from the following departments: oncology (n = 76), medicine (n = 8), solid organ transplantation (n = 6), and surgical (n = 3). Blood glucose confounding factors (see Table 1), patient demographic data, and catheter characteristics were collected. No relationship or pattern was found among patients with outlier blood glucose values related to catheter characteristics or blood glucose confounding factors.

**Blood Glucose**

Discard tube 1 (3 ml) mean glucose values were very high (ports: 1,770 mg/dl; tunneled: 1,728 mg/dl; nontunneled: 855 mg/dl), as that tube included the 5% dextrose flush remaining in the catheter. With each sequential draw, the mean blood glucose significantly decreased. Blood glucose means from tubes 3 (9 ml) and 4 (12 ml) for the tunneled (135 mg/dl and 131 mg/dl, respectively) and nontunneled (124 mg/dl and 123 mg/dl, respectively) groups had a difference of 2 mg/dl or less.

The difference between glucose levels of serial specimens was analyzed with paired t tests and was statistically significant for all comparisons except for the nontunneled catheter group of 9 ml and 12 ml (see Table 2). The mean difference in glucose levels between tubes 2 and 3 was 22 mg/dl (SD = 11, 95% confidence interval [0.5, 45.5]) for tunneled catheters and 5.2 mg/dl (SD = 5, 95% confidence interval [−4.8, 15.3]) for nontunneled catheters. The blood glucose varied by 22 mg/dl for tunneled catheters and 10 mg/dl for nontunneled catheters. In addition, the mean difference in glucose levels between tubes 3 and 4 was 79 mg/dl (SD = 10, 95% confidence interval [−10.8, 26.6]) for implanted ports and 2.1 mg/dl (SD = 3, 95% confidence interval [−2.8, 7.1]) for tunneled catheters. Blood glucose varied 20 mg/dl for implanted ports and 6 mg/dl for tunneled catheters.

No redraws were requested by the hospital laboratory for the 93 participants in the current study. Based on baseline hospital data, up to three redraws would have been expected.

**Accuracy and Precision**

Bland-Altman plots were used to identify participants outside the acceptable glucose variability. For the implanted port group, the bias (i.e., the mean difference between the average glucose of tube 3 minus average glucose of tube 4) was 79 mg/dl. The precision (repeatability) of the measurements was reflected in the confidence limits (SD = 2). With those parameters, three participants exceeded the limits and were considered outliers. None of the participants in the implanted port catheter group had extreme values of blood glucose (i.e., lower than 60 or higher than 300 mg/dl), and no relationship was found among the patient and catheter factors examined that contributed to those outliers.

Bland-Altman plots4 for tube 3 versus tube 4 for each group showed increased bias and lack of precision for the implanted ports in contrast to the tunneled catheters. In addition, Bland-Altman plots for tubes 2 and 3 showed increased

### TABLE 2. Comparison of Blood Glucose Means (mg/dl) Between Groups

<table>
<thead>
<tr>
<th>Type of Catheter and Volume Group</th>
<th>X</th>
<th>SD</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implanted port</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 ml and 6 ml</td>
<td>1,572</td>
<td>456</td>
<td>[1,411, 1,734]</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>6 ml and 9 ml</td>
<td>57</td>
<td>50</td>
<td>[39, 74]</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>9 ml and 12 ml</td>
<td>8</td>
<td>10</td>
<td>[5, 11]</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Tunneled</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 ml and 6 ml</td>
<td>1,573</td>
<td>242</td>
<td>[1,483, 1,664]</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>6 ml and 9 ml</td>
<td>22</td>
<td>11</td>
<td>[18, 26]</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>9 ml and 12 ml</td>
<td>2</td>
<td>3</td>
<td>[1, 3]</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Nontunneled</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 ml and 6 ml</td>
<td>727</td>
<td>293</td>
<td>[617, 836]</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>6 ml and 9 ml</td>
<td>5</td>
<td>5</td>
<td>[3, 7]</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>9 ml and 12 ml</td>
<td>1</td>
<td>2</td>
<td>[0.1, 1]</td>
<td>0.02</td>
</tr>
</tbody>
</table>

CI—confidence interval

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4 The Bland-Altman plots for each group are available from the authors by request.
bias and lack of precision for the tunneled catheters versus the nontunneled catheters.

Clinical Significance

For the implanted port group, five patients had a blood glucose mean (mg/dl) difference of 10% or higher between tubes 3 and 4. If the tube 3 mean blood glucose value had been used to determine insulin treatment, all five patients would have received 2 units more subcutaneous insulin and as much as 9 units per hour of IV insulin. If tube 4 mean blood glucose values were used for insulin treatment, one patient would have received 1 unit more subcutaneous insulin and all five patients would have received as much as 5 units per hour of IV insulin.

None of the patients in the tunneled and nontunneled groups had a 10% or higher difference in blood glucose levels for tube 3 versus 4. Tunneled and nontunneled mean blood glucose levels for tube 2 versus 3 also were evaluated. For the tunneled group, 24 patients had a mean blood glucose difference of 10% or higher from 6–9 ml blood glucose. If 6 ml mean blood glucose values had been used for insulin treatment, 10 patients would have received an additional 3 units of insulin subcutaneously, and 16 patients would have received an increase in IV insulin rate up to 4 units per hour. For the nontunneled group, one patient had a blood glucose difference of 10% or higher. If a 6 ml blood glucose value was used for treatment, that patient would have received the same subcutaneous dose but 1.5 units per hour of IV insulin.

Discussion

The current study found that the optimal discard volume to avoid dilution or contamination sampling is 9 ml from tunneled catheters and 6 ml from nontunneled catheters. The minimum discard from implanted ports was not determined. Use of the standardized checklist eliminated blood redraws. Additional research is warranted regarding the optimal method for drawing blood from CVCs. Ideally, blood sampling techniques would minimize blood loss and exposure to bloodborne pathogens, as well as contribute to accuracy of results.

Limitations

To minimize risk to patients who often have poor peripheral access, the researchers decided not to obtain peripheral venipuncture samples for glucose. In addition, glucose tests were the only chemistry analyses performed. To control for limitations, the authors used a dextrose flush in lieu of normal saline to demonstrate contamination clearly. Finally, caution must be used when generalizing results from studies performed on adults to the pediatric population or for other serum values (e.g., coagulation, hematology, drug levels).

Conclusions

CVCs are essential devices for the treatment and management of hospitalized patients who require frequent venous access and have limited peripheral access. The discard method is described as the most common method used to draw laboratory samples from CVCs. Published standards and limited adult research studies using the discard blood sampling method from CVCs are not in agreement as to the discard volume required to avoid dilution and contamination from flush or IV fluids. Insufficient and excessive discard volume practices have implications for patient safety and cost because of redraw of samples, blood loss over hospital length of stay, delay in correct medical treatment, and blood transfusions. Evidence for the minimal discard volume to ensure accuracy of blood sampling results may lead to safer patient care and treatment outcomes.

Nursing Implications

The current study’s results have been used to revise and update nursing policy and procedure for blood sampling from CVCs. The findings have been disseminated to the institution’s professional practice council, multiple nursing education offerings (e.g., new graduate residency, vascular access workshop, unit based in-services, education cart), a regional nursing research conference, and an international cancer nursing conference. In addition, the blood sampling checklist was revised and added to the laboratory requisition form (see Figure 1). Staff nurses now take the document to the bedside and draw a standardized discard volume from CVCs based on evidence.

References


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