Peripheral venous access devices (VADs), also known as saline locks, have been in clinical use since the late 1970s. Considered the most common form of venous cannulation in hospitalized patients, VADs were introduced in 1945, when the first plastic catheter, the “intracath,” was used to deliver intravenous solutions. Historically, peripheral venous catheters were used to provide emergency and intermittent venous access for patients who were receiving fluid, blood products, and nutritional support. Patients who did not require continuous intravenous infusions often had placement of a second peripheral VAD for obtaining blood samples. The second VAD served as a dedicated intravenous site for collecting blood samples via an intermittent intravenous access port with cap or saline lock. This clinical practice eliminates use of tubing; the VAD is maintained by periodic injections of 0.9% sodium chloride solution.

The use of peripheral VADs for obtaining blood samples continues to be debated, depending on whether heparin or certain flush solutions such as 0.9% sodium chloride solution are used to keep the VAD patent. However, VADs flushed with 0.9% sodium chloride solution are simple and safe for collecting blood samples, and the resultant laboratory values based on the samples are accurate.

Many institutions have accepted VAD systems as an alternative to intravenous tubing with solutions infused at a “keep vein open” rate. To ensure accurate laboratory results, healthcare providers and hospitals have policies that direct venipuncture must be used for collecting blood samples for coagulation studies.

For patients receiving continuous intravenous heparin therapy who are admitted to the critical care unit,
obtaining blood samples every 6 hours for coagulation studies, in particular, determination of activated partial thromboplastin time (aPTT), is the standard of care. The aPTTs are used to determine the effectiveness of heparin therapy. Usually, a second peripheral VAD is placed for obtaining the blood samples for all coagulation studies except measurement of aPTT, because heparin in the blood sample might interfere with the aPTT measurement. Therefore, patients often endure painful venipunctures every 6 hours while receiving heparin therapy.

The major advantage of using a peripheral VAD is that use of the device spares patients additional discomfort. A VAD makes the use of needles unnecessary, and for patients in whom venipuncture is difficult, the device makes it easier to collect blood samples. Being able to obtain blood samples from a peripheral VAD flushed with 0.9% sodium chloride solution would save patients’ veins, eliminate patients’ discomfort, decrease the time required to collect blood samples, and reduce potential infection and bleeding complications. The continued debate between using 0.9% sodium chloride solution or heparin to keep a VAD patent is evident in clinical practice, where saline locks to keep a VAD patent is evident in clinical practice, where saline locks or VADs are used more often than heparin locks. The Intravenous Nurses Society recommends flushing VADs at established intervals with 0.9% sodium chloride solution to ensure and maintain patency. The literature supports the use of peripheral VADs flushed with 0.9% sodium chloride solution at intervals of every 8 hours to maintain patency.

If 0.9% sodium chloride solution infused alone is as effective as heparinized 0.9% sodium chloride solution in maintaining the patency of peripheral VADs, would assays of blood samples obtained via these devices for coagulation studies provide accurate measurements? If the smallest discard or “waste” volume was known and accurate test results could be obtained with the subsequent blood sample, then venipuncture, blood loss, hospital costs, nursing time, and potential infection could all be minimized. Research on this topic has been focused on blood samples obtained from intravascular catheters such as the arterial “a-line” catheters. In these studies, investigators evaluated the minimum amount of discard volume that must be withdrawn before blood specimens are obtained for coagulation assays. Patients receiving intravenous heparin therapy were excluded from studies involving aPTTs because of the possibility that heparin in the blood sample would result in inaccurate values in the coagulation tests.

**Background**

Heparin therapy is used in patients who are admitted to the critical care unit for myocardial infarction, percutaneous transluminal coronary angioplasty, and atrial fibrillation. For these patients, the acceptable therapeutic range for an aPTT is 1.5 to 2 times the normal or baseline value. A correct aPTT is crucial for the stabilization and proper management of patients receiving continuous intravenous heparin therapy.

**Coagulation Studies With Blood Samples Obtained via Peripheral VADs**

Two studies suggest that nurses can obtain accurate measurements of aPTT from blood samples collected via peripheral VADs. Powers compared use of blood samples obtained via a saline lock with samples obtained by venipuncture in a convenience sample of 32 patients. All of the patients were 18 years and older (mean 60 years), received continuous intravenous heparin therapy, and had coagulation studies ordered as part of their routine care. A total of 93% were men. All the patients had a peripheral VAD or a saline lock placed in the arm opposite to or distal to the arm used for the intravenous heparin infusion. A venipuncture sample was collected first; then 3-mL blood samples were obtained one after the other from the saline lock, representing discard volumes of 0, 2, 4, and 6 times the dead space of the catheter and extension set.

The aPTTs for the samples obtained via venipuncture differed significantly from the aPTTs for the samples obtained via the saline lock with no discard volume (zero times the dead space; P = .02). The level of significance used was .05. The aPTTs for venipuncture samples did not differ significantly from the aPTTs for saline lock samples with discard volumes of 2, 4, and 6 times the dead space (P = .01). Powers concluded that 2 times the dead space is the minimum discard volume needed to obtain accurate aPTTs with blood samples from a saline lock.

In the second study, Arrants et al evaluated patients with myocardial infarction who were receiving continuous intravenous heparin therapy. The study sample consisted of 11 men with a mean age of 63 years. Each patient had a saline lock placed. Blood samples for coagulation studies were obtained every 6 to 8 hours. For each patient, on 3 separate occasions, after a venipuncture sample was obtained,
the saline lock was flushed with 2 mL of 0.9% sodium chloride solution and 0.5 mL of blood was obtained via the lock and discarded. The next 2 blood samples were obtained by using 2 syringes with 18-gauge needles. The first sample had a discard volume of 0.5 mL; the second sample, a discard volume of 2.5 mL (0.5 mL from the initial discard volume plus 2 mL of blood).

The aPTTs determined with the samples obtained via the saline lock were comparable to the values determined with the standard venipuncture sample (P < .001). Therefore, aPTTs determined with samples obtained via a saline lock are reliable in patients who receive continuous intravenous heparin therapy and can be used in critical care. The results also indicated that blood samples obtained by using an 18-gauge saline lock and discarding 0.5 mL of blood before each sample was collected could yield accurate aPTTs.

**Coagulation Studies With Blood Samples Obtained via Peripheral Venous Catheters**

Lindley et al7 examined the accuracy of aPTTs determined with blood samples collected via a peripheral venous catheter placed in the forearm in 6 patients with hemophilia A under non-bleeding conditions. After intravenous administration of a single dose of recombinant factor VIIa at 70 mg/kg over 2 minutes, blood samples were collected concurrently from the catheter and via venipuncture in the opposite arm at 2, 3, 4, 6, 8, 10, and 12 hours. The catheter samples were obtained via an 18-gauge peripheral venous catheter with a 3-way stopcock attached. An intravenous solution of 5% dextrose in 0.45% sodium chloride solution was infused at a rate of 30 mL/h to maintain the patency of the catheter.

The mean aPTTs for the venipuncture samples (48.7 seconds, SD 13.6) were equivalent to the mean aPTTs for the catheter samples (48.3 seconds, SD 12.5). The lack of a significant difference between aPTTs determined with blood samples obtained via the 2 methods (P > .05) supports the use of peripheral venous catheters for collecting blood samples for aPTT measurements.

In another study, Hinds et al8 compared the results of 3 coagulation tests (prothrombin time, aPTT, and fibrinogen) determined with blood samples collected from heparinized tunneled venous access devices (TVADs) with the results determined with a sample obtained via standard venipuncture. The study was performed at a care center for children and adolescents who primarily had cancer and required insertion of a TVAD.

Because TVADs require heparin as the flushing solution, usually samples for blood tests are obtained via venipuncture. To lessen the pain and trouble of venipunctures, healthcare providers often ignore institutional policy and collect blood samples from the TVADs. The amount of blood discarded when a sample is obtained via a TVAD varies and can result in inaccurate results in coagulation tests. The findings of Hinds et al did not support obtaining blood samples via a TVAD even after 12 mL of blood was discarded. Of note, the focus of this study was central venous heparinized catheters.

**Coagulation Studies With Blood Samples Obtained via Arterial Catheters**

In study of 30 patients who had percutaneous transluminal coronary angioplasty, Templin et al9 investigated the accuracy of aPTTs and prothrombin times determined with blood samples obtained via a heparinized arterial catheter. For each blood sample, the volume of the dead space plus various amounts of blood was discarded. Mean aPTTs for samples obtained via the arterial catheter were significantly higher than the mean aPTTs for samples obtained via venipuncture (P < .001).

Richiuso7 compared aPTTs for blood samples obtained through a heparinized arterial catheter with aPTTs for samples obtained via venipuncture in 16 patients. The catheter dead space was 0.85 mL. The discard volumes were 8 mL and 12 mL and did not depend on the catheter dead space. The results indicated that accurate aPTTs could be determined with samples obtained via arterial catheters if the discard volume was 14 times the dead space (ie, a blood sample of 12 mL). The results of this study7 were similar to those of a study conducted by Kaplow14; however, the discard volumes were markedly higher in the study by Richiuso7.

Kaplow14 compared coagulation values determined from blood...
obtained via an arterial catheter with values determined from samples obtained via venipuncture in 50 consecutive patients who were not treated with heparin. The discard volumes were 10 mL for arterial samples and 0.5 mL for venipuncture samples. The coagulation values for samples obtained via the 2 methods were significantly different ($P < .05$).

Similar studies, such as the one conducted by Gregersen et al., indicated that accurate results in coagulation studies could be obtained with samples from heparinized arterial catheters if the discard volume was less than 10 mL. Gregersen et al used a quasi-experimental design and a nonrandomized sample of 28 patients who had cardiac surgery. Values for arterial samples were compared with values for samples obtained via venipuncture. The results indicated that a discard volume equivalent to the dead space volume plus 4.5 mL (total 5.1 mL) was sufficient to allow accurate determination of aPTTs with samples obtained via an arterial catheter. Because of the unpredictability of results for samples collected via heparinized arterial catheters, the researchers used thrombin time tests to detect heparin contamination of arterial samples, a step that increased the reliability of the results.

The National Committee for Clinical Laboratory Standards (NCCLS) guidelines state that in order to obtain accurate results in blood tests. According to NCCLS recommendations, the first 5 mL of blood should be discarded before a blood sample is obtained for coagulation studies. Both the NCCLS and the Intravenous Nurses Society support the practice of flushing with 0.9% sodium chloride solution at established intervals to ensure and maintain patency of a peripheral VAD.

Methods

This study was designed to ascertain (1) the accuracy of aPTTs determined with samples obtained from a peripheral VAD flushed with 0.9% sodium chloride solution in patients receiving continuous intravenous heparin and (2) the minimum volume of blood that must be discarded to ensure that the samples collected will provide accurate aPTTs. The study was reviewed and approved by the local human subjects committee.

The research was conducted in a 20-bed critical care step-down unit at Madigan Army Medical Center in Tacoma, Wash. A quasi-experimental design was used. The independent variables were the type of sampling technique: venipuncture versus peripheral VAD. The volumes of peripheral blood discarded when the VAD was used to collect samples were dead space volume plus 1 mL, 2 mL, and 3 mL. The dead space volume was 0.5 mL. The dependent variables were the aPTTs determined with venipuncture and VAD blood samples. The venipuncture aPTT served as the control value against which the VAD aPTTs were compared.

Sample

A convenience sample of 23 cardiac patients participated in the study. Patients were included in the study if they were between 18 and 75 years old, had a functioning peripheral VAD maintained by flushing with 0.9% sodium chloride solution every 8 hours, had had coagulation studies ordered, and were receiving continuous intravenous heparin therapy. Patients were excluded if they had a hematocrit of 0.25 or less, had anemia, had excessive bleeding as indicated by the diagnosis of gastrointestinal hemorrhage, and/or had an unstable hemodynamic status. Patients were also excluded if they had coagulation disorders such as thrombocytopenia, disseminated intravascular coagulation, or hemophilia. Women who were pregnant and patients who received intermittent (subcutaneous) heparin therapy were also excluded.

Procedure

For patients who met the inclusion criteria, the study was explained and written informed consent was obtained. Patients had infusions of a standardized concentration of heparin (25000 units of heparin in 500 mL of 5% dextrose in water) administered at a rate determined by their weight and aPTT per physicians’ orders. Blood samples for determination of aPTTs were obtained as prescribed by physicians’ orders. If a patient did not have a peripheral VAD in place, a VAD was inserted in the upper extremity opposite and/or distal to the intravenous catheter used for heparin therapy to limit the interference of heparin with aPTT results. All patients had a peripheral VAD, which consisted of a 20-gauge Jelco intravenous catheter and a 15-cm-long single male Luer-slip adapter (T-connector extension set).
For each patient, after the peripheral VAD was inserted, data collection began with the next blood sample obtained for aPTT determinations. Blood samples were collected by the nursing staff and/or study investigators according to an established protocol. Each patient had blood samples obtained first via venipuncture and then via the peripheral VAD. The amount of blood required for each sample was 4.5 mL. Each sample was placed in a 5-mL test tube containing 0.5 mL of a 3.8% sodium citrate solution to prevent coagulation. For the peripheral VAD blood sample, first a random blood volume of either the dead space plus 1 mL, the dead space plus 2 mL, or the dead space plus 3 mL was discarded. Then a 4.5-mL sample was obtained for each aPTT to be determined. The volume of 4.5 mL was needed to maintain the correct ratio of sodium citrate to blood. Each blood collection session took approximately 5 to 10 minutes to complete.

The blood samples were analyzed by using a Medical Laboratory Automation Model MLA ELECTRA 1000, APTT-XL reagent, and calcium chloride solution (0.02 M) (Pacific Hemostasis, Huntersville, NC). Each sample was analyzed in duplicate, and the aPTT was reported as the mean of the 2 values. Reliability tests with commercial controls were done at least once per 8-hour shift for quality control, and all results had to be within the established range of 2 SDs before the results were reported. Simulated coagulation tests (confidence tests) were routinely done to check the coagulizer optics and/or mechanical defects before blood samples from patients were analyzed. The coefficient of variation of all assay techniques was ±5%. All samples were blinded so that the laboratory personnel did not know they were included in a research study. The samples were assayed consecutively and in duplicate. For example, the venipuncture sample was assayed first, then the peripheral VAD sample. This procedure was then duplicated per laboratory policy.

Data Analysis
Descriptive statistics were used to analyze patients’ demographic data. An α value of .05 was used for calculations of 95% CIs and tests for statistical significance. The Pearson r correlation coefficient was computed to determine the magnitude and direction of the relationship between aPTTs determined for blood samples obtained via venipuncture (the reference standard) and aPTTs determined for samples obtained via the peripheral VAD. The venipuncture sample served as the control sample.

Results
Description of the Sample
The study group consisted of 17 men and 6 women with a mean age of 63 years. Admitting diagnoses were possible myocardial infarction, atypical chest pain, stable angina, hypertension, and atrial fibrillation. The mean length of hospital stay was 3.7 days. Of the 23 patients, 14 had 3 complete sets (pairs) of blood samples collected, that is, 3 samples from the venipuncture site and 3 from the peripheral VAD site. These sets of blood samples were collected on 3 separate occasions. Of the other 9 patients, 6 had 2 pairs of blood samples collected, and 3 had 1 pair collected. A total of 57 paired blood samples were analyzed.

Comparison of Venipuncture and Peripheral VAD aPTTs
Assays were done on a total of 20 pairs (venipuncture and VAD) for samples in which the discard volume for the VAD sample was equivalent to the dead space plus 1 mL (VAD 1), 19 pairs for samples in which discard volume for the VAD sample was equivalent to the dead space plus 2 mL (VAD 2), and 18 pairs for samples in which the discard volume for the VAD sample was equivalent to the dead space plus 3 mL (VAD 3). A total of 7 blood samples from both the venipuncture and peripheral VAD collections were excluded because the VAD sample clotted or was not collected according to the protocol, resulting in a large difference between values. The means, SDs, and SEMs for each set of aPTTs are presented in Table 1. Results from patient 6 (81 and 100 seconds) and patient 8 (57 and 100 seconds) were excluded because of collection errors. After data from these 2 patients were excluded, the total number of pairs of blood samples were 19 for VAD 1, 19 for VAD 2, and 17 for VAD 3. The means, SDs, and SEMs for the data when the outlier values are excluded are also given in Table 1.
patients 6 and 8. These are the results (outliers) that were excluded from the study because of collection errors. In addition, any result with a value of 100 seconds represents a value of more than 100 seconds. Madigan Army Medical Center used the following protocol23 to compute aPTTs: If the instrument does not detect a clot after 106 seconds, the message “no clot detected” appears. The sample is then tested again in “long-test mode,” and the machine looks for a clot for up to 212 seconds. If actual numbers (between 106 and 212) are obtained, the laboratory still reports the results as more than 100 seconds. As shown in the Figure, correlational analyses again indicated no significant difference between the variables tested; the aPTTs for the VAD samples were similar to the aPTTs for the venipuncture or control samples.

Discussion
The results of this study support the use of peripheral VADs flushed with 0.9% sodium chloride solution for obtaining blood samples for determination of aPTTs in patients receiving heparin therapy. The aPTTs for samples obtained from VADs were valid and reliable when the discard volume was dead space plus 1 mL, dead space plus 2 mL, or dead space plus 3 mL. The following hypotheses were tested and accepted: (1) there would be no significant difference between aPTTs for samples consecutively obtained via venipuncture and peripheral VADs, and (2) there would be no significant difference between aPTTs for VAD samples when dead space volume plus 1 mL, dead space volume plus 2 mL, or dead space volume plus 3 mL was discarded from the peripheral VAD before blood samples were collected (P < .05).

The results support the findings of Powers16 and Arrants et al19 that aPTTs determined with blood samples obtained from a peripheral VAD or a saline lock are reliable in patients receiving heparin therapy. The methods and design of my study were similar to those of earlier studies, but the dead space volume, discard volumes, and the sample size were smaller than those in the study by Powers. Patients in my study also included women and patients receiving heparin therapy. In addition, the peripheral VADs were flushed with 0.9% sodium chloride solution.

Clinical nurses should be familiar with the laboratory and unit standard policies at their institutions for obtaining blood samples via peripheral VADs. However, a number of different brands of peripheral VADs, saline locks, and extension sets exist in clinical practice, making it difficult to determine universal standard policies for using these devices to obtain blood samples for coagulation studies. Therefore, nurses must know the dead space volume of products in their units in order for local policies to be developed. The development of local policies could aid in decreasing the pain patients experience when numerous venipunctures are required. Studies with other groups of patients

<table>
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<th>Table 1</th>
<th>Activated partial thromboplastin times for samples obtained via peripheral venous access devices (VADs) and venipuncture</th>
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<td>Samples*</td>
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<td>Peripheral VAD 1</td>
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<td>Venipuncture 1</td>
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<td>Peripheral VAD 2</td>
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<td>Venipuncture 2</td>
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<td>Peripheral VAD 3</td>
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<td>Venipuncture 3</td>
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<td>Excluding 2 outliers</td>
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<td>Peripheral VAD 1</td>
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<td>Venipuncture 3</td>
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*The volume of blood discarded before collection of the VAD blood samples was the equivalent of catheter dead space plus 1 mL for VAD 1, catheter dead space plus 2 mL for VAD 2, and catheter dead space plus 3 mL for VAD 3.

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<th>Table 2</th>
<th>Correlation of peripheral venous access device (VAD) and venipuncture results</th>
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<td>Samples*</td>
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*The volume of blood discarded before collection of the VAD blood samples was the equivalent of catheter dead space plus 1 mL for VAD 1, catheter dead space plus 2 mL for VAD 2, and catheter dead space plus 3 mL for VAD 3.
† Significant at P < .01 (2-tailed).
and different sizes of peripheral VADs merit further discussion and research.

The limitations of the study reported here include exclusion of patients more than 75 years old and patients receiving subcutaneous heparin. The technique for obtaining blood samples for determination of aPTTs cannot be generalized to other discard volumes or to other types and/or sizes of peripheral VADs. Research is needed to evaluate coagulation, complete blood cell count, and chemistry studies done on blood samples obtained via other types of intravenous catheters. Another limitation is the lack of evaluation of catheter dead space. Evaluation of the extension set may indicate that the calculation of the amount of blood to be discarded when blood samples are obtained for coagulation studies could include a smaller value for the dead space.

When obtaining aPTTs for monitoring heparin therapy, clinicians must keep in mind that valid and reliable laboratory tests are essential for the safe and effective management of patients. My results support and validate a need to establish policies and procedures for obtaining blood samples via peripheral VADs for coagulation studies. Lopez et al examined the impact of peripheral VAD guidelines on nurses’ knowledge and practice. According to the answers on pretest and posttest questionnaires, the nurses had a higher percentage of correct answers after a 2-hour workshop. Lopez et al reported an increase in the use of 0.9% sodium chloride solution for maintaining the patency of peripheral VADs. Compliance with national and institutional guidelines is an

Scatterplots of results for activated partial thromboplastin times (in seconds) for blood samples obtained via a peripheral venous access device (VAD) and venipuncture. The volume of blood discarded before collection of the VAD blood samples was the equivalent of catheter dead space plus 1 mL (A), catheter dead space plus 2 mL (B), and catheter dead space plus 3 mL (C).
important measure to take in safely managing VADs.

Conclusion

Heparin therapy will continue to be the standard of care for patients admitted to the hospital because of possible myocardial infarction or atrial fibrillation. These patients will require collection of blood samples for coagulation studies at least every 6 hours, warranting venipunctures. Nurses can avoid the pain of venipuncture, minimize blood loss, and increase patients’ satisfaction by advocating for the use of peripheral VADs for obtaining blood samples. When a 20-gauge peripheral VAD attached to an extension set is used to obtain blood samples for measurement of aPTT in patients receiving heparin therapy, 1.5 mL of blood should be discarded before the sample for aPTT tests is collected. The results in this study provide evidence that valid measurements of aPTT can be made with blood collected via a peripheral VAD. In addition, when blood samples are obtained from a peripheral VAD flushed with 0.9% sodium chloride solution in patients receiving heparin therapy, alterations in the results of coagulation studies are minimal. Understandably, patients prefer to have blood samples collected via peripheral VAD rather than via venipuncture.

Acknowledgment

The views expressed in this article are those of the author and do not reflect the official policy of the Department of the Army, the Department of the Defense, or the US Government.

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Use of Peripheral Venous Access Devices for Obtaining Blood Samples for Measurement of Activated Partial Thromboplastin Times

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Crit Care Nurse 2006;26 30-38
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