

# Obtaining Coagulation Blood Samples From Central Venous Access Devices: A Review of the Literature

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**Background:** Central venous access devices are used for chemotherapy and other medication administration, blood product administration, parenteral nutrition, and for obtaining blood samples in patients where the vasculature is difficult to access. Patients may need additional blood samples prior to invasive procedures and when clinical situations arise during cancer care. In addition, monitoring coagulability through ongoing blood testing is common in patients with cancer and requires repeated sampling to adjust anticoagulant medications.

**Objectives:** The purpose of this review of the literature is to determine the best practices for collecting coagulation test samples from central venous access devices.

**Methods:** The authors conducted a systematic review of the literature.

**Findings:** The only method for obtaining reliable coagulation test results from central venous access devices is the flush then waste/discard method. This method has only been studied with peripherally inserted central catheters. Additional randomized, controlled trials with larger sample sizes are needed to determine the most appropriate method for drawing coagulation test results from central venous access devices.

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The use of central venous access devices (CVADs) is essential for the care of patients with cancer, and they are widely used in other specialty populations as well. During the course of treatment, many patients will require the use of CVADs, including peripherally inserted central catheters (PICCs), tunneled catheters, or implanted ports. These devices are used for medication administration, blood product administration, parenteral nutrition, and withdrawing blood specimens (blood draws) for patients who have vasculature that is difficult to access (Camp-Sorrell, 2011). Patients with CVADs often prefer blood draws from their central line because peripheral sticks can be painful and may cause complications, such as hematoma, infection, or bleeding (Rondina, Boaz, Kling, Nohavec, & Rodgers, 2007). In the Oncology Nursing Society's access device guidelines, Camp-Sorrell (2011) asserted that, to date, no studies have been conducted to provide credible solutions as to the best technique for drawing blood specimens from venous access devices. The techniques

for blood draws from CVADs often are determined by the individual facility or specialty policies with little evidence to support one technique over another. Therefore, patients may experience significant variations in care that pose concerns for safety, quality, and patient satisfaction.

The determination of the best method to draw coagulation tests from CVADs is left primarily to individual facilities. Clinically, monitoring coagulability is common in patients with cancer, but also applicable to patients in critical care settings and those with cardiac issues. Patients may be monitored for coagulability prior to invasive procedures and as the clinical situation evolves over time. The prothrombin time (PT), international normalized ratio (INR), and activated partial thromboplastin time (aPTT) are commonly used screening measures for coagulability or clotting function.

At the authors' institution, little evidence was found regarding current hospital policies and laboratory procedures pertaining to the process for collecting coagulation blood samples.

Reference was made in the institution policies to the Clinical and Laboratory Standards Institute (2008) guidelines for collecting coagulation samples from a vascular access device. According to the standards, the technique for collecting coagulation samples from central lines should include a 5 ml normal saline flush followed by a 5 ml waste or six times the dead space of the catheter (about 10 ml). This technique is attributed to Laxton and Titler (1994), who published a systematic review of all literature (related to arterial draws) available from 1971–1993 and made this recommendation based on those results. No update has been found.

At the authors' institution, a team of nurses representing several specialties convened to conduct a systematic review of the literature to determine (a) whether coagulation studies should be collected from CVADs and (b) what the preferred technique for drawing these samples was.

## Literature Review

The search strategy included Ovid MEDLINE®, CINAHL®, and ScienceDirect, as well as hand searching references from selected articles. Key words included *blood specimen collection*, *central venous access devices*, *blood coagulation tests*, and all combinations of those terms. The search yielded 106 articles, with elimination of all articles focused on laboratory processes. Nineteen articles remained for review from 1994–2014; however, only 11 research studies relating only to CVAD blood draws were evaluated (see Table 1). The research studies included descriptive, comparative, prospective non-randomized, correlational designs, and cross-section comparison.

The sample populations varied in the studies and included adult and pediatric patients with cancer, patients with renal failure undergoing dialysis, and adult patients with CVAD for unspecified reasons. Sample sizes ranged from 12–53. Articles included a variety of venous access devices, including CVADs, PICC lines, tunneled lines, and implanted devices. The studies were analyzed in clusters based on blood draw technique and device. No consensus on any one accepted blood draw technique from CVADs could be derived from the three identified CVAD blood draw techniques. Given the different practices within oncology and from other specialties and how few studies were found in the literature, the inclusion criteria were broadened to include any study of a central line, regardless of type, draw technique, or patency strategy. Draw techniques included the waste/discard method, the flush then waste/discard method, the push/pull method, and venipuncture. In addition, Frey's (2003) review of the literature was referenced to provide an overview of methods to collect blood samples from CVADs. However, Frey (2003) did not yield recommendations other than reporting that little evidence exists to support any one method from drawing blood samples from vascular devices. No additional systematic reviews on this topic were found in this 20-year review of the literature.

### Waste/Discard Method

The waste/discard method of blood collection involves aspirating a volume of blood from the central line and then discarding that sample from use, followed by use of a separate

syringe for the specimen collection (Adlard, 2008). The aPTT values and waste volumes when collected using the waste/discard method varied from as little as 3 ml to as much as 25 ml, depending on the study. Of note, the practice and volume of blood that must be wasted can be deleterious to patients. For example, MacGeorge, Steeves, and Steeves (1988) noted that adult patients undergoing bone marrow transplantation can lose an average of 95.7 ml of blood each week if 6 ml is wasted with each blood draw.

Hinds et al. (2002) studied aPTT and PT values drawn from heparinized tunneled venous access devices. In that study of 53 pediatric patients with cancer, waste volumes ranged from 6–12 times the dead space. Hinds et al. (2002) concluded that statistically significant differences existed between peripheral and CVAD draws, and recommended against drawing coagulation test results from previously heparinized tunneled CVADs.

Pinto (1994) studied the effects of instilling heparin into a venous access device 1–6 hours prior to aPTT and PT/INR blood draws. In that study, waste volumes were six times the dead-space in the catheter and ranged from 0.5–1.5 ml, depending on the type of catheter. Pinto (1994) found statistically significant differences on the aPTT and PT/INR values between the samples drawn from CVAD and peripheral lines and concluded that coagulation tests should only be drawn peripherally. Although this information is valuable, the sample included only 12 patients with varying types of access devices and varying heparin dwell times (i.e., the amount of time the heparin solution remains inside of the catheter).

In another study, Mayo, Dimond, Kramer, and Horne (1996) studied the effects of instilling heparinized normal saline into tunneled catheters on subsequent aPTT and PT values. In a sample of 20 patients with cancer, the waste volumes prior to withdrawing the sample for the tests ranged from 5–25 ml. Mayo et al. (1996) concluded that, although aPTT and PT/INR were significantly different in all samples ( $p < 0.02$ ), after 25 ml of waste, 18 of 19 aPTT values were found to be in the normal range and matched to a concurrent peripheral draw and were, therefore, all clinically useful values. However, the concern arises regarding a 25 ml volume for the patient with cancer who is already in a compromised hematologic state.

Mayo et al.'s (1996) study introduced an important concept: clinical significance versus statistical significance. Clinical significance could be useful when determining if a patient has normal coagulation values before an invasive procedure. In addition, Mayo et al. (1996) recommended that future research address the technique of flush then waste/discard prior to drawing the coagulation sample.

Mendez (2012) conducted a quality improvement project on an inpatient oncology unit to prevent blood loss by obtaining the smallest amount of blood for laboratory specimens. In the study, laboratory samples were collected and the percentage of error in specimens was calculated using the dead space blood collection method, defined as the point at which blood appears in the attached syringe when aspirating without flushing (Mendez, 2012). This technique was found to be effective in 98% of blood draws. Limitations of the study included a single cohort design, and the results did not specify which diagnostic tests were collected and how they compared to another draw technique. The researchers did not control for whether patients

TABLE 1. Literature Review

Study	Design and Setting	Type of Central Line	Laboratory Value Studied	Sampling Technique	Results and Recommendation
Adlard, 2008	<b>Design:</b> Comparative with patients serving as own control <b>Setting:</b> Pediatric inpatients (n = 30)	Tunneled catheter, implanted port	Serum chemistry panel, CBC	Compare push/pull method to standard waste technique	High degree of agreement; analyses suggest excellent agreement between assays using both methods.  <b>Level of evidence:</b> High-quality <b>Recommendation:</b> Strong
Hinds et al., 2002	<b>Design:</b> Descriptive comparative with patients serving as own control <b>Setting:</b> Pediatric patients (n = 53)	Tunneled catheter	aPTT, PT/INR, fibrinogen	Compare venipuncture to waste 3 ml, 6 ml, and 9 ml from tunneled catheter	Statistically significant difference in values between sampling techniques  <b>Level of evidence:</b> High-quality <b>Recommendation:</b> Weak
Holmes, 1998	<b>Design:</b> Prospective, standard deviation t test <b>Setting:</b> Adult outpatient infusion clinic (n = 25)	PICC, implanted port, Groshong tunneled catheter	HGB, HCT, creatinine	Compare push/pull method to discard method for drawing samples	Difference was significantly greater than zero by t test; true difference less than 3%  <b>Level of evidence:</b> Moderate-quality <b>Recommendation:</b> Strong
Humphries et al., 2012	<b>Design:</b> Prospective, quasiexperimental <b>Setting:</b> Adult hospitalized patients (n = 30)	PICC	aPTT, PT/INR, fibrinogen	Compare venipuncture to flush then waste from PICC line	High degree of agreement between samples  <b>Level of evidence:</b> High-quality <b>Recommendation:</b> Strong
Jackson-Barton et al., 2004	<b>Design:</b> Prospective, comparison, paired t test, Bland Altman <b>Setting:</b> Pediatric patients (n = 28), inpatient and clinic	CVAD (type not specified)	Hemogram, electrolytes, glucose	Compare discard method to push/pull method for drawing samples	High degree of agreement between samples, were statistically significant  <b>Level of evidence:</b> Moderate-quality <b>Recommendation:</b> Strong
Mayo et al., 1996	<b>Design:</b> Prospective, non-randomized <b>Setting:</b> Adult inpatient and outpatients of a cancer research center (n = 20)	Tunneled Hickman catheter	aPTT, PT/INR, fibrinogen	Compare discard of 5 ml, 10 ml, 15 ml, 20 ml, and 25 ml of central line versus venipuncture	Statistically significant difference in values between sampling techniques; after 10 ml discard, results were in the normal range.  <b>Level of evidence:</b> Moderate-quality <b>Recommendation:</b> Weak
McLaren et al., 2001	<b>Design:</b> Correlational, Pearson correlation coefficient, patient served as own control <b>Setting:</b> Patients receiving hemodialysis (n = 33)	Hemodialysis tunneled catheter	PT/INR	Compare discard of 25 ml prior to sampling from central line versus venipuncture and arterial bloodline sampling	High degree of correlation between sampling techniques  <b>Level of evidence:</b> High-quality <b>Recommendation:</b> Strong
Pinto, 1994	<b>Design:</b> Correlational, quasiexperimental <b>Setting:</b> Adult patients (n = 12) on a hematology/oncology unit	Tunneled Hickman catheter, port-a-cath implanted port, triple lumen catheter	PT, aPTT	Compare discard six-times the dead space of central line 1–6 hours after instillation of heparin versus venipuncture	Statistically significant difference in values between sampling techniques  <b>Level of evidence:</b> Moderate-quality <b>Recommendation:</b> Weak
Rondina et al., 2007	<b>Design:</b> Prospective, correlational <b>Setting:</b> Adult patients (n = 41) receiving anti-coagulation	Double lumen PICC	aPTT	Compare aPTT values for 20 ml flush of normal saline and then 5 ml waste from PICC line versus venipuncture	No clinically significant differences in values between sampling techniques  <b>Level of evidence:</b> Moderate-quality <b>Recommendation:</b> Strong

(Continued on the next page)

aPTT—activated partial thromboplastin time; CBC—complete blood count; CVAD—central venous access device; HCT—hematocrit; HGB—hemoglobin; PICC—peripherally inserted central catheter; PT/INR—prothrombin time, international normalized ratio

TABLE 1. Literature Review (Continued)

Study	Design and Setting	Type of Central Line	Laboratory Value Studied	Sampling Technique	Results and Recommendation
Sombolos et al., 2003	<b>Design:</b> Comparative <b>Setting:</b> Adult patients (n = 15) with end-stage renal disease	Double lumen hemodialysis catheters	aPTT	Compare aPTT values after 12 ml and 15 ml discard from CVAD versus venipuncture	Statistically significant difference values between sampling techniques  <b>Level of evidence:</b> High-quality <b>Recommendation:</b> Weak
Zu-Kei Lin et al., 2009	<b>Design:</b> Descriptive, comparative <b>Setting:</b> Adult patients (n = 39) on an inpatient unit	CVAD (type not specified)	aPTT, PT/INR	Compare values for patients receiving IV crystalloid infusion with 3 ml, 6 ml, 9 ml and 12 ml discard from CVAD versus venipuncture	Strong correlation between samples after 6 ml of discard from CVAD  <b>Level of evidence:</b> High-quality <b>Recommendation:</b> Strong

aPTT—activated partial thromboplastin time; CBC—complete blood count; CVAD—central venous access device; HCT—hematocrit; HGB—hemoglobin; PICC—peripherally inserted central catheter; PT/INR—prothrombin time, international normalized ratio

had IV fluids infusing prior to the blood draw. For example, if a patient had IV fluids infusing, the infusion was held for one minute prior to the blood sampling. This changed this blood sampling technique from a waste/discard method to the flush then waste/discard method.

McLaren, Hanna, Mills, Bourdeau, and Cowin (2001) compared three methods of blood sampling for INR values. In a sample of 33 patients, patency of the central venous hemodialysis catheters was maintained with 20,000 units of heparinized saline. The three methods for blood sampling were venipuncture, waste/discard method (with reinfusion of blood drawn from CVAD), and blood sampling from the hemodialysis arterial bloodline. The findings indicated comparable results from all sampling techniques with a Pearson correlation coefficient of 0.94 for the CVAD method and 0.97 for the arterial bloodline method. What was unique to this study was a rough cost analysis of the CVAD versus the arterial bloodline method, and it was estimated that total annual savings using the arterial bloodline instead of the CVAD would be \$2,392. Although the results are limited to INR values and hemodialysis catheters only, this study shows promise that there are methods to draw coagulation tests from previously heparinized central venous catheters at slightly higher annual costs.

In a comparison study of 15 patients with end-stage renal disease on hemodialysis, Sombolos et al. (2003) investigated aPTT values in the same patients using different waste volumes. In the study, waste volumes were compared between two groups: sample A (waste/discard), with waste totaling 12 ml; and sample B (waste/discard), with waste totaling 15 ml from the heparinized double-lumen hemodialysis catheter, previously heparinized with 2 ml of 3,750 IU of heparin, compared to a peripherally drawn sample. Even after a 15 ml waste volume, Sombolos et al. (2003) concluded that heparin contamination could not be eliminated because aPTT values were significantly elevated in the CVAD sample (sample A,  $\bar{X} = 2.87$ ,  $SD = 1.04$ ; sample B,  $\bar{X} = 2.02$ ,  $SD = 0.85$ ;  $p < 0.002$ ) compared to the peripheral sample ( $\bar{X} = 1.06$ ,  $SD = 0.14$ ,  $p < 0.0003$ ). The results of Sombolos et al. (2003) were similar to Mayo et al. (1996), Hinds et al. (2002), and Pinto (1994).

In a quasiexperimental design study, Arrants et al. (1999) compared laboratory results (PT and aPTT) drawn by venipuncture with saline-locked peripheral IV in 11 men. The findings indicate that laboratory results were equal if 0.5 ml was wasted from the saline lock peripheral IV. In a cross-section comparison study, Zengin and Enc (2007) investigated 120 hospitalized adults in an intensive care unit receiving anti-coagulation therapy. The researchers compared aPTT values obtained by venipuncture with saline-locked peripheral IVs with no statistically significant difference found between techniques. Although these did not address heparinized catheters, 0.5 ml waste could be considered if practice moved to saline-locking CVADs.

### Flush Then Waste/Discard Method

The flush then waste/discard method for blood sampling involves flushing the CVAD with normal saline, then aspirating a predetermined volume of blood from the central line and discarding (wasting) that collection from use. Then, the sample for the test is collected. Of the three studies examining this method, two investigated PICC lines only. In the three studies, aPTT values from both sources (PICC lines and other CVAD) were highly correlated when the flush then waste/discard method used at least a 10 ml flush and wasting of six times the dead space of the catheter ( $p < 0.05$ ) (Humphries, Baldwin, Clark, Tenuta, & Brumley, 2012; Rondina et al., 2007).

Using a prospective quasiexperimental design, Humphries et al. (2012) investigated aPTT, PT/INR, and fibrinogen levels in 30 hospitalized patients with PICC lines. They used the flush method for CVADs and compared these levels to levels obtained by venipuncture. The PICC lines were flushed with 10 ml of normal saline, then a new 10 ml syringe was attached to collect a 6 ml waste sample, and finally a new 10 ml syringe was attached to collect the required amount for the blood samples. After collection of the blood samples for testing, the PICC line was flushed with 10 ml normal saline and then 2 ml of heparinized saline. Pearson correlations were used to compare levels of aPTT, PT/INR, and fibrinogen from PICC lines with those from

## Implications for Practice

- ▶ Consider blood-sparing processes as best practice when collecting blood specimens.
- ▶ Understand that variations in practice will exist until randomized, controlled trials with larger samples are conducted.
- ▶ Increase awareness that nurses and healthcare providers should consider the methodology for obtaining blood samples when interpreting reported values.

venipuncture, with a range of 0.99–0.998 (highly correlated). The limitations of Humphries et al. (2012) included a small sample size, multiple people involved in the blood sampling, and the use of PICC lines only.

Zu-Kei Lin, Fowler, Dise, and Bustami (2009) investigated patients receiving continuous IV fluid infusions through multiple types of previously heparinized CVADs. After the initial 24 hours of the infusions, aPTT and PT values were drawn using three different waste and discard volumes. The peripheral draw and waste volumes were high correlations, and the 6 ml waste volume was adequate to obtain a normal coagulation test value from a CVAD that has been used for continuous infusion of IV fluids. The authors concluded that a continuous IV infusion was a suitable proxy for flush, and waste still occurred prior to specimen collection.

Rondina et al. (2007) assessed 41 hospitalized patients with PICC lines that were heparinized with unfractionated heparin or were receiving anticoagulation that included IV unfractionated heparin, low-molecular weight heparin, or warfarin. They compared aPTT values obtained from PICC lines using the flush then waste/method and compared these values to blood samples drawn from venipuncture. The blood draw technique from the PICC involved a 20 ml normal saline flush followed by a 5 ml waste, and then the 10 ml sample was drawn from the PICC line. Rondina et al. (2007) concluded that no clinical differences were noted in aPTT values comparing samples drawn from the PICC line when using the flush then waste/discard method compared with samples drawn via venipuncture.

### Push/Pull Method

A number of articles referenced the push/pull method of blood sample collection, a method used to reduce blood loss. The push/pull method involves attaching a syringe to the CVAD, either using a stopwatch or directly attaching a syringe to the line, aspirating blood into the syringe, and then re-infusing that blood and, without disconnecting the syringe, repeating the process three times (Adlard, 2008). After this push/pull method, a sterile syringe is used to withdraw the blood sample for testing. Adlard (2008) reported an extremely high level of agreement between samples drawn via the push/pull process and the waste/discard method, with intraclass correlations greater than 0.9 (highly correlated).

In this literature review, no studies were identified that used the push/pull method for obtaining blood samples for coagulation studies. Holmes (1998) compared complete blood count

(CBC) and chemistry values obtained using the discard technique and the push/pull method in 25 adult patients with PICC lines, implanted ports, or tunneled catheters. The variability in test results was less than 3% ( $p < 0.005$ ), demonstrating better results than the more widely accepted discard method for blood draw. The push/pull method may reduce blood loss in patients while producing similar results. The limitations of this study included that it had a small sample size ( $n = 25$ ), used various CVADs, and was limited to CBC and chemistry samples.

Jackson-Barton, Chase, Latham, and Rayens (2004) explored blood samples drawn from pediatric patients with CVADs in inpatient and outpatient settings. The researchers measured 438 pairs of blood values obtained from a convenience sample of 28 patients. Blood samples were obtained for hemogram, glucose, electrolytes, and certain electrolytes using the discard method and the push/pull method. Statistical analyses using Bland-Altman plot to analyze agreement on values obtained from the two methods revealed a high degree of agreement. The differences on the paired *t* tests comparing the two methods were statistically significant for 14 of 22 laboratory studies ( $p < 0.05$  to  $p < 0.0001$ ), but they were not clinically significant because the difference in value would not change clinical decision making. The researchers found the push/pull method comparable to the discard method and favored this method for the ability to achieve less blood loss in this population of patients. However, this study did not address coagulation values.

### Confounding Factors

When a team conducts a systematic review of the literature, a straight path to evidence and answers is often anticipated. A question is identified, the literature search completed, the evidence graded, findings discussed, and implications for practice are considered. However, in this literature review, a straight path was nearly impossible to follow because a number of confounding variables presented at different points. For example, it was a challenge to find the actual steps to the push/pull method (Adlard, 2008). A new factor was revealed—the impact of heparin adherence to catheters—and how this affected coagulation tests and how materials in the catheters impacted heparin adherence. The mechanism and outcome of heparin adherence to the biofilm on the inside of the venous access device was not clear (Henry-Stanley, Shepherd, Wells, & Hess, 2010).

### Implications for Nursing Practice

To summarize the evidence from this literature review, coagulation tests could be drawn from PICC lines using the flush then waste/discard method. The evidence suggests that coagulation tests should not be collected from heparinized CVADs using the waste/discard method because of the higher volume of waste required to manage dead space in the catheter. Although providers may continue to draw coagulation tests using the waste/discard method, treatment decisions should be carefully examined as this technique may falsely elevate coagulation levels. Future research using the flush then waste/discard method on each CVAD type should be conducted to see if the results can be extrapolated to all CVADs. In addition, future research

should be designed to verify the benefit of using the push/pull technique for collecting coagulation samples.

Questions still remain regarding how heparin adheres to central lines or to biofilm. Hypotheses suggest heparin adherence to venous catheters at a molecular level that may affect aPTT and PT/INR values in blood samples withdrawn from these catheters. At a practical, clinical level, the question remains as to whether a technique exists for flushing away biofilm or heparin to accurately draw coagulation tests from heparinized CVADs. Although not the primary aim of this review of the literature, future research should ensure that any proposed blood draw techniques meet current guidelines to prevent central line-associated blood stream infection (Secola et al., 2012).

## Conclusion

Although guidelines have been published for how and when to draw blood samples from CVADs and peripheral sites, there are no conclusions as to whether coagulation tests can be drawn from CVADs that produce accurate coagulation test results. Until additional randomized, controlled trials with larger sample sizes are completed, variation in practice will continue with the potential for flawed clinical decision making based on inaccurate results. Oncology nurses need evidence-based practice guidelines and support from practice leaders to protect patients from unnecessary frustration, additional testing, and blood loss to mitigate safety risks associated with blood sample collection.

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