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**TITLE: Collecting Blood from Patients with Vascular Lines**

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### Slide 1:

Hi, I'm Christine Snozek, director of chemistry, point-of-care testing, and collections and processing at Mayo Clinic Arizona. I'm very pleased to talk today about a topic of great interest at our institution, which is how best to collect blood samples from patients with vascular lines.

### Slide 2: Outline

Here is a brief outline of the topics covered in this Pearl.

### Slide 3: Vascular Lines

Vascular lines are used in a variety of clinical settings, including hospital inpatients, emergency departments, long-term care units such as those that administer chemotherapy, and clinical study units. Lines are commonly used to administer a wide variety of materials. These fluids can be very simple in nature, such as normal saline, or extremely complex, such as total parenteral nutrition (or TPN), which can include protein, lipids, electrolytes, and other components.

While lines are often utilized to infuse something into a patient, it is also possible to use vascular lines to collect blood. Central venous catheters, or CVCs, are intentionally designed to facilitate longer-term access for both infusion and blood collection. Central lines are common in critical care settings and in patients receiving protracted therapy such as parenteral nutrition or chemotherapy.

At the lower right, I'm showing an example of a two-lumen PICC or peripherally-inserted central catheter, which is a type of central line. Notice the long catheter tubing which allows the PICC to empty into a large vein near the heart, while the external lumens are located some distance away. Many vascular lines, including various types of central lines, peripheral IVs, and arterial lines can be used for sampling blood.

However, even if the patient has a line, it is possible to collect blood using venipuncture or fingerstick. The question is, which of these is the best option for collecting blood?

## Slide 4: Options for Blood Collection: What Does the Evidence Say?

When it comes to determining the best way to collect blood from vascular lines, there aren't a lot of studies in the literature, unfortunately. What evidence does exist suggests that both central and peripheral lines can usually provide adequate quality blood samples for lab testing.

However, it is worth pointing out that the few studies reported also have some limitations. One notable limitation is that most of these studies only examined a handful of tests, typically basic chemistry and hematology tests. There is some logic to this strategy, since those tests are relevant to most clinical practices, and are involved in a large number of medical decisions. However, it is possible that other tests may be compromised due to specimen integrity issues when collected from a line.

A second notable limitation of the available studies is that many of them do not explicitly detail the levels of potential analytical interferences such as hemolysis in samples collected from lines. For example, Mohler et al reported elevated potassium in some specimens collected from lines compared to venipuncture collections. This result could potentially reflect hemolysis of line-collected specimens, but no specific hemolysis data were provided to evaluate this point. Despite these limitations, the available literature is useful to guide proper procedure for sample collection from patients with vascular lines. In particular, we'll talk about the importance of pausing infusions for 2 minutes, for collecting an adequate volume of waste blood when drawing from a line, and for choosing venipuncture sites distal to or preferably opposite of a peripheral IV.

For those interested in additional reading, there are some reviews of the older literature around this topic in the references listed here.

## Slide 5: Risk of Sample Contamination

Before we get into the literature, it's important to understand why we need specific collection procedures for blood drawn from patients with vascular lines. In addition to typical pre-analytical concerns like following the correct order of draw and minimizing hemolysis, the presence of a vascular line introduces the risk for blood sample contamination. In this context, contamination refers to the mixture of blood with an infused fluid rather than microbiological contamination.

There are a few basic ways a blood sample can be contaminated by infused material. The most common is a simple dilution effect. Take the example of blood being collected from a line that was flushed with saline. If the saline flush isn't adequately removed by discarding waste blood prior to collecting lab specimens, that saline remains in the line and dilutes the blood used for lab tests. In this example, since the sodium and chloride concentrations in normal saline are similar to human blood, this form of contamination would be visible as normal or slightly high sodium and chloride levels combined with unexpectedly low results for other analytes not present in the infusate such as potassium or hemoglobin.

A second mechanism by which samples can be contaminated is when the line used for blood collection is also used to infuse a compound that adsorbs to the line or lumen material. This is not a common event, but can occur with some drugs, such as immunosuppressants used in transplant patients. It's important to note that the standard volumes for flushing and wasting

blood from a line may not fully clear adsorbed material from the catheter. Unfortunately, the literature around this phenomenon is extremely limited, so it's in each institution's best interest to evaluate both the prevalence of these kinds of infusions and their propensity for sticking to the types of lines used locally. Our institution has adopted a policy of always using venipuncture to collect blood for measuring immunosuppressant concentrations, precisely because we saw artificial elevations of tacrolimus when vascular lines were used for blood collection.

The third mechanism by which contamination can occur requires a bit more explanation of what happens after an infusion, which we'll discuss on the next slide.

### Slide 6: Equilibration

Whenever someone receives an infusion, the infused materials must equilibrate with the blood and potentially with other non-blood compartments as well. The simplest form of equilibration is just the straightforward mixing of an infusate with blood. When a fluid enters the body through a line, its local concentration is higher at the point of entry than in the rest of the vascular system. Equilibration of something like a saline drip is basically just the process of circulating enough blood around the body to ensure that the saline is more or less mixed in with the blood.

It's been shown that a healthy heart circulates the full body's volume of blood about once a minute. So the 2 min infusion pause mentioned earlier allows for two full body volumes of blood to circulate prior to collection of lab specimens. Studies have shown that this 2 min pause is generally adequate for equilibration prior to collecting blood. Thorough equilibration of infused substances with the bloodstream improves specimen quality, because it ensures that blood collected for lab tests reflect the systematic circulation, not local differences in concentration near the site of infusion.

Although this 2 min pause is supported by most studies, there is anecdotal evidence that not all infused substances equilibrate fully within this time. My colleague in Rochester, Brad Karon, has spoken about unpublished Mayo Clinic data demonstrating that magnesium and calcium levels remain elevated for at least an hour after replacement therapy. The likely mechanism is that these substances don't remain entirely in the bloodstream, but instead distribute into cells and tissues. To a lesser extent, we have noticed that pausing dextrose and TPN infusions for 2 min does not always prevent contamination of samples drawn from some patients. Unfortunately, there are no conclusive studies published addressing these potential exceptions to the 2 minute rule; thus, this is an area where the literature to develop evidence-based guidelines is lacking.

### Slide 7: Options for Blood Collection: Line Draws

With that background, we return to the question of how best to obtain blood specimens from patients with vascular lines. As is probably not surprising, patients often prefer to have blood collected from an available line, rather than undergoing venipuncture. Providers and nurses often prefer the ability to sample from lines as well, both for patient satisfaction and for the convenient workflow.

If blood is collected from a line, it's essential to follow proper procedure to get a good specimen. Whenever possible, turn off all infusions for at least 2 minutes to allow equilibration. Flushing

the line with saline clears any residual fluid present in the catheter or lumen. Finally, the volume of waste blood is important to ensure a good sample. The amount of waste blood depends on the dead volume of the line, which is based on the diameter and length of the catheter being used. CLSI guideline GP41-A6 recommends discarding two times the catheter dead-space volume for non-coagulation testing, and discarding 5 mL or 6 times the dead volume for coagulation studies. In clinical practice, however, the huge range of available catheters can make it more practical to simply choose one consistent discard volume to ensure adequate waste blood with all line collections. For example, our institution has chosen a consistent waste volume of 5 mL for adults, and 3 mL for pediatric collections.

As with any blood collection, personnel collecting blood from lines must pay attention to pre-analytical issues such as following the proper order of draw and inverting anticoagulated tubes thoroughly to prevent clotting. Hemolysis can also be more of an issue with line collections than with venipuncture. Since line collections are generally performed by nurses and other non-laboratory staff, it is essential for the laboratory to provide education and reinforcement of the importance of these pre-analytical issues to all personnel involved in blood collection.

### Slide 8: Options for Blood Collection: Peripheral IVs

Hemolysis can be a particular issue with peripheral IVs. Peripheral IVs are convenient and require less technical expertise to place than central lines. Some institutions allow the practice of collecting blood for lab testing at the time the IV is started; this practice is particularly common in the emergency department due to the perception of improved workflows and convenience for the patient.

The Centers for Disease Control (CDC) Laboratory Medicine Best Practices Workgroup recently did a systematic review of studies addressing hemolysis from peripheral IVs. Hemolysis from IV-start samples could be reduced by using 21 gauge or larger-bore needles, placing the IV in the antecubital fossa rather than more distal sites, and using partial vacuum tubes rather than full vacuum tubes or syringes. However, the group's recommendation was that the evidence consistently and significantly supported the use of venipuncture as a best practice over collecting blood from IV starts, with approximately 84% reduction in relative risk of hemolysis when samples were collected by venipuncture.

### Slide 9: Peripheral IVs:  Hemolysis at IV start

As an example of just how severely hemolyzed samples drawn from IV starts can be, I'm showing here the results of a very small quality improvement project we did with our Emergency Department (ED), in response to their request to collect blood when they started the IV. This chart shows the H-index or hemolysis level of paired serum samples, where one was collected at IV start and the other was done by venipuncture. Even with a very small n of 16, we still saw several sera from IV starts that were hemolyzed to a degree that would interfere with tests commonly ordered in the Emergency Department. I've highlighted those samples in the chart. One IV start sample was actually so hemolyzed that no chemistry testing could have been performed on it. Even though the CDC review summarized several studies demonstrating this same result, our ED was initially hopeful that newer IV materials could provide better samples.

So this small example of just how badly hemolyzed blood from IV starts can be, even with staff being very careful during collection, was much more convincing to our ED personnel.

## Slide 10: Options for Blood Collection: Venipuncture

The final option for collecting blood from patients with lines is venipuncture. As we just discussed, the lower risk of hemolysis is a major advantage to using venipuncture, even in patients with lines. And, as I mentioned earlier, venipuncture avoids contamination with materials that can adsorb to vascular lines, such as certain drugs. In addition, several studies demonstrate that venipuncture can provide uncontaminated samples for many common tests in patients with vascular lines.

Watson et al assessed blood drawn from the arm opposite to a peripheral IV while fluids were still running. The study took baseline measurements prior to administering fluids, then evaluated 10 basic chemistries and hemoglobin. They found that only glucose and phosphorous were elevated relative to baseline when blood was collected from the opposite arm with fluids running. This suggests that opposite-arm collections do not necessarily require stopping the IV, although it may be advisable for specific fluids such as dextrose. Our experience here and at the Mayo Clinic in Rochester confirms the idea that some infusions are problematic for opposite-arm draws, including dextrose resulting in elevated glucose, heparin drips affecting coagulation tests, and TPN-causing lipemia. Our preferred practice is to always shut these fluids off even when collecting from the opposite arm.

Both Watson and Ong et al evaluated distal collections, that is, venipuncture below the IV site. Ong et al evaluated 18 chemistry tests, and placed a tourniquet between the collection site and the IV. Glucose was elevated in both studies when the IV was running. Based on these studies, the CLSI guideline recommends turning off IV infusions for at least 2 minutes, and placing a tourniquet between the collection site and the IV. The guidelines also state that collections proximal to or above the IV should only be done as a last resort, based on the results of a study by Read et al showing that glucose remained elevated in proximal draws, even 3 min after shutting off the infusion.

## Slide 11: Investigating Potential Specimen Contamination

Regardless of how blood is collected, it's important to have a process for investigating potential contamination whenever blood is drawn in patients with vascular lines. There are some characteristic patterns that suggest a sample might be contaminated, which should trigger investigation. For example, seeing a mixture of normal and very low results, such as normal sodium and chloride with very low potassium and hemoglobin, could suggest saline contamination. Absurd or critical results in a stable patient can be suspicious, for example extremely prolonged PTT results reflecting heparin contamination. Similarly, elevated or erratic trough drug concentrations not associated with a dose change can indicate contamination with an infused drug. Some of these factors obviously require coordination between the laboratory and care team to notice and investigate.

Common sense is key when investigating whether suspected contamination is real. The first question that should be asked by the lab is whether the patient actually had a line at the time of

collection. It sounds silly, but it does happen where tests are canceled for contamination but there was no line. The next step is finding out what infusions were given prior to blood collection, and assessing whether they fit the pattern of abnormal results seen. For example, extremely elevated glucose in a patient receiving normal saline is clinically actionable whereas the same result in a patient receiving dextrose could be questionable. Asking whether the infusion was paused, and if so for how long, can help determine if contamination is likely. This is true for both venipuncture and line-draw samples. Finally, remember that pre-analytical issues unrelated to the presence of a line must also be considered in any investigation, such as the order of draw and other common errors.

### Slide 12: Conclusions

In conclusion, I hope you can see that the use of vascular lines presents both opportunities and risks for blood collection. Many lines such as PICCs and other central lines facilitate obtaining high-quality specimens without subjecting patients to additional venipunctures. However, all line draws have a higher risk of hemolysis, especially if collected at the start of a peripheral IV. In addition, infusion of fluids through vascular lines creates the potential for contamination of both line-collected and venipuncture-collected samples.

To avoid contamination, proper procedure is essential no matter how samples are drawn. For line draws, the key steps are pausing the infusion for at least 2 minutes, flushing the line with an adequate volume of saline, and wasting enough blood to fully clear the flush. For venipunctures, infusions should be turned off unless the draw will be done in the opposite arm; even then, consider turning off infusions if the patient is receiving dextrose or other problematic fluids. The preferred sites for collection in a patient with a peripheral IV is first the opposite arm, then the IV arm distal to the IV. Proximal draws should only be done as a last resort.

### Slide 13: References

### Slide 14: Disclosures

### Slide 15: Thank You from www.TraineeCouncil.org

Thank you for joining me, Christine Snozek, on this Pearl of Laboratory Medicine on “Collecting Blood from Patients with Vascular Lines.”