Precision
Practice & Process

Measure Twice, Access Once

The Importance of a Precise Catheter Fit

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Why Catheter-to-Vein Ratio is Key to IV Success

When placing intravenous lines, it's easy to focus on getting the catheter "in" without thinking about how much space it takes up inside the vessel—or how much of it actually dwells in the vein. But catheter-to-vein ratio (CVR) addresses these exact questions. In simple terms, CVR makes sure:

1. You have enough catheter length inside the vein to avoid accidental dislodgement.
2. The catheter's diameter doesn't occupy too much of the vein, reducing the risk of thrombosis.

Depending on which vascular access device (VAD) you're using—such as a short peripheral IV catheter (PIVC), a midline, or a PICC—you'll apply CVR a little differently. Below, we break down the two main CVR types: Length-Based and Occupation-Based.

1. Length-Based CVR

Why Length Matters for PIVCs

Today, many hospitals train nurses and other clinicians (not just vascular access teams) to use ultrasound (US) for placing PIVCs. In theory, that's great: fewer needle sticks, happier patients, and more efficient medication delivery. However, ultrasound also enables us to cannulate deeper vessels using the standard-length PIVCs we already have on hand—and that can spell trouble.

If you only have a short segment of the catheter tip inside the vein, even slight changes in patient position, limb movement, or IV tubing tension can dislodge the catheter, leading to infiltration or loss of cannulation.

How Much of the Catheter Should Be in the Vein?

According to the 2024 SOPs—Vascular Access Device Insertion (Section 32, I, E, 2):

> **"Evaluate depth of vessel when choosing a long PIVC to ensure sufficient catheter lies within the vein... one study showed a significant reduction in PIVC failure when 2/3 of the PIVC length was within the vein."** [1,2]

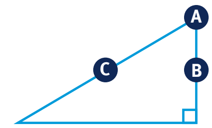
In other words, if two-thirds of the catheter isn't inside the vein, it's time to consider a different plan, such as using a longer PIVC or picking another VAD altogether.

Tips to Ensure a Good Length-Based CVR

1. Educate every US-trained clinician on the concept of CVR so they know the risks of too little dwell length.
2. Set vessel depth limits based on your team's skills and the catheter lengths you have.
3. Use alternative access if you can't keep at least 2/3 of the catheter in the vein.
4. Offer reference tools (like an angle-of-entry guide) to help clinicians visualize how much catheter length will be inside the vessel.

Angle to Entry Guide

A Angle of Entry **B** Vessel Depth **C** Length of Catheter Used to Access Vein



45° Angle of Entry	Vessel Depth	Catheter Length (2/3 in Vessel)
0.71 cm	0.5 cm	2.12 cm / 0.84 in
1.41 cm	1.0 cm	4.24 cm / 1.67 in
2.12 cm	1.5 cm	6.36 cm / 2.51 in
2.83 cm	2.0 cm	8.49 cm / 3.34 in
3.54 cm	2.5 cm	10.61 cm / 4.18 in

30° Angle of Entry	Vessel Depth	Catheter Length (2/3 in Vessel)
1.0 cm	0.5 cm	3.00 cm / 1.18 in
2.0 cm	1.0 cm	6.00 cm / 2.36 in
3.0 cm	1.5 cm	9.00 cm / 3.54 in
4.0 cm	2.0 cm	12.00 cm / 4.72 in
5.0 cm	2.5 cm	15.00 cm / 5.91 in

2. Occupation-Based CVR

Why Occupation Matters for PICCs and Midlines

Occupation-based CVR is about how wide the catheter is compared to the vessel diameter. This usually comes up when placing peripherally inserted central catheters (PICCs) or midline catheters. According to the **2025 INS SOP—Section 4: Infusion Equipment (21. VASCULAR VISUALIZATION E.):**

> "Use ultrasound to measure the catheter-to-vessel ratio prior to insertion of an upper extremity VAD; ensure a catheter-to-vessel ratio of less than 45%. The research underpinning this recommendation is specific to peripherally inserted central catheter (PICC) insertion. Consider application of this ratio to midline catheters as well, as they are placed in the same veins (refer to Standard 25, Vascular Access Device Planning and Site Selection; Standard 50, Catheter-Associated Thrombosis). S75" [2]

Why do we care about vessel occupation of 45% or less? Because filling too much of the vessel can slow blood flow and potentially lead to thrombosis. INS SOPs state:

> "Upper Extremity Deep Vein Thrombosis (UE-DVT): often associated with vascular access devices (VADs) inserted in smaller upper arm veins with lower blood flow velocity." [2]

Evidence Supporting ‹45% Occupation

Evans S, Sharp J, et al concluded "Prior DVT and surgery lasting › 1 h identify patients at increased risk for PICC-associated DVT. More importantly, increasing catheter size also is significantly associated with increased risk. Rates of PICC-associated DVT may be reduced by improved selection of patients and catheter size." [3]

A more recent meta-analysis by Dr Amit Bahl, et al identified 47 clinical studies via the SLR, and found 40 of those studies clearly reported on symptomatic DVT rates. The primary random effects meta-analysis of those 40 studies reporting on symptomatic DVT patients demonstrated that the rate of DVT increased with increasing catheter diameter (3 Fr: 0.89%; 4 Fr: 3.26%; 5 Fr: 5.46%; 6 Fr: 10.66%) with a statistically significant difference observed between 4 and 5 Fr PICC sizes.[4]

In short, the bigger the catheter relative to the vein, the higher the thrombosis risk.

To calculate CVR, simply divide the diameter of the catheter by the diameter of the target vessel and multiply by 100. Many of our modern ultrasound machines can calculate CVR for the clinician by simply "dragging" an image of the intended French size into the on-screen vessel. Even a less sophisticated ultrasound allows the clinician to freeze the vessel image and measure vessel diameter... it is then up to the clinician to take that measurement, the size of the catheter, and perform a quick calculation.

Examples of CVR Calculation

5Fr Double Lumen Catheter Diameter = **1.7mm**
Cephalic Vessel Diameter = **2.6mm**
1.7 / 2.6 = 0.6538 x 100 = 65.38 .... ›65% occupancy (unacceptable)

5Fr Double Lumen Catheter Diameter = **1.7mm**
Basilic Vessel Diameter = **3.8mm**
1.7 / 3.8 = 0.4474 x 100 = 44.74......‹ 45% occupancy (acceptable)

Note in our CVR example above the catheter is a 5Fr with 2, 18g lumens, but we used the catheter French, for our calculation. With our trimmable (MST) lines it is important to understand the correlation, and difference, between gauge and French.

Gauge corresponds to the catheter lumen, or lumens, and is the internal diameters (ID). Whereas French is the outside diameter (OD) of the catheter and all its lumens. In French sizes, a higher number indicates a larger catheter diameter. However, with gauge sizing the relationship is inverse...as the catheter size increases the number decreases.

When calculating CVR, a clinician must use the French (OD) of the catheter. Referencing the chart below, one can see the see the difference between ID and OD of the various catheters is 2-fold and using the gauge (ID) would result in grossly inaccurate CVR calculations.

French	Gauge	ID	OD
2	22	.012"/0.3mm	.025"/0.6mm
3	20	.020"/0.5mm	.037"/0.9mm
4	18	.025"/0.6mm	.047"/1.2mm
5	16	.030"/0.7mm	.065"/1.7mm

Below is a quick-reference chart to help you see at a glance which catheter diameters are generally acceptable for typical vein diameters, ensuring you stay under that 45% threshold whenever possible. Keep in mind that real-world variables like tapering or vein distension can slightly alter these numbers, but this gives you a solid starting point.

How to Prevent the Risk of Thrombosis

Source: Spencer TR, Mahoney JK. Reducing catheter-related thrombosis using a risk reduction tool centered on catheter to vessel ration. J Thromb Thrombolysis. 2017

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Another consideration when looking at CVR is tapered vs non-tapered lines. Many, if not most, MST lines have a reverse taper at the proximal end just distilled to the wings. The taper will begin somewhere near the 5cm mark and increase to the 0cm mark. It's not uncommon for the reverse taper to increase several French sizes from the advertised catheter size. If patient vasculature is superficial, all, or a portion, of the reverse taper may dwell within the vessel and must be accounted for when calculating the catheter to vessel ratio.

Beyond CVR: Other DVT Risk Factors

Even if you get CVR right, other factors can still influence thrombosis risk, such as:

- **Endothelial Damage:** Movement of the PICC in the vein (e.g., biceps contraction).
- **Immobility: Patients** who barely move may have slower venous return.
- **Hypercoagulable States**: Conditions like antiphospholipid syndrome or cancer.
- **Certain Medications:** Heparin-induced thrombocytopenia, irritants, or vesicants.

Putting It All Together

Ultimately, CVR is just one piece of the puzzle. When choosing and placing a VAD, also weigh the patient's overall clinical picture:

- Medical history and comorbidities
- Physical limitations
- Type, frequency, and duration of therapies
- Likely medication compatibility
- Proper line care resources

Whenever possible, aim for the least invasive line that gets the job done. And by paying close attention to both length-based and occupation-based CVR, you'll reduce the risk of dislodgments, thrombosis, and other complications—while giving patients a safer, smoother experience.

References

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2. *Infusion Therapy Standards of Practice, 9TH edition, revised 2024*
3. *Evans S, Sharp J, et al. Risk of Symptomatic DVT Associated with Peripherally Inserted Central Catheters. Chest 2010; 138; 803-810.*
4. *Symptomatic Deep Vein Thrombosis Associated With Peripherally Inserted Central Catheters of Different Diameters: A Systematic Review and Meta-Analysis. Clinical and Applied Thrombosis/Hemostasis. June 27, 2023*

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