CATHETER VESSEL RATIO: WHAT NOW?
A NEW PERSPECTIVE

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I have no other membership or affiliation conflicts

I have no stock/shareholding conflicts
OBJECTIVES

- Review pathophysiology of thrombosis and its clinical impact

- Review risk factors for catheter related thrombosis (CRT)

- Identify the importance of catheter to vessel ratio and its importance in reducing CRT

- Review the impact on blood flow with various catheter/vessel ratios
CLOTTING REVIEW - THREE ESSENTIAL STEPS

1) In response to rupture of the vessel or damage to the blood itself, a complex cascade of chemical reactions occurs in the blood involving more than a dozen blood coagulation factors. Formation of a complex of activated substances collectively called prothrombin activator.

2) The prothrombin activator catalyzes conversion of prothrombin into thrombin in the presence of sufficient amounts of ionic Ca++.

3) The thrombin acts as an enzyme to convert fibrinogen into fibrin fibers that mesh with platelets, blood cells, and plasma to form the clot.
<table>
<thead>
<tr>
<th>FACTOR NUMBER</th>
<th>FACTOR NAME</th>
<th>NATURE</th>
<th>SOURCE</th>
<th>PATHWAY; FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Fibrinogen</td>
<td>Plasma protein</td>
<td>Liver</td>
<td>Common pathway; converted to fibrin (insoluble weiblike substance of clot)</td>
</tr>
<tr>
<td>II</td>
<td>Prothrombin</td>
<td>Plasma protein</td>
<td>Liver*</td>
<td>Common pathway; converted to thrombin (converts fibrinogen to fibrin)</td>
</tr>
<tr>
<td>III</td>
<td>Tissue factor (TF)</td>
<td>Plasma membrane glycoprotein</td>
<td>Tissue cells</td>
<td>Activates extrinsic pathway</td>
</tr>
<tr>
<td>IV</td>
<td>Calcium ions (Ca^{2+})</td>
<td>Inorganic ion</td>
<td>Plasma</td>
<td>Needed for essentially all stages of coagulation process; always present</td>
</tr>
<tr>
<td>V</td>
<td>Proaccelerin</td>
<td>Plasma protein</td>
<td>Liver, platelets</td>
<td>Common pathway</td>
</tr>
<tr>
<td>VI</td>
<td>Proconvertin</td>
<td>Plasma protein</td>
<td>Liver*</td>
<td>Both extrinsic and intrinsic pathways</td>
</tr>
<tr>
<td>VII</td>
<td>Antihemophilic factor (AHF)</td>
<td>Plasma protein</td>
<td>Liver, lung capillaries</td>
<td>Intrinsic pathway; deficiency results in hemophilia A</td>
</tr>
<tr>
<td>VIII</td>
<td>Plasma thromboplastin component (PTC)</td>
<td>Plasma protein</td>
<td>Liver*</td>
<td>Intrinsic pathway; deficiency results in hemophilia B</td>
</tr>
<tr>
<td>IX</td>
<td>Stuart factor</td>
<td>Plasma protein</td>
<td>Liver*</td>
<td>Common pathway</td>
</tr>
<tr>
<td>XI</td>
<td>Plasma thromboplastin antecedent (PTA)</td>
<td>Plasma protein</td>
<td>Liver</td>
<td>Intrinsic pathway; deficiency results in hemophilia C</td>
</tr>
<tr>
<td>XII</td>
<td>Hageman factor</td>
<td>Plasma protein; activated by negatively charged surfaces (e.g., glass)</td>
<td>Liver</td>
<td>Intrinsic pathway; activates plasmin; initiates clotting in vitro; activation initiates inflammation</td>
</tr>
<tr>
<td>XIII</td>
<td>Fibrin stabilizing factor (FSF)</td>
<td>Plasma protein</td>
<td>Liver, bone marrow</td>
<td>Cross-links fibrin, forming a strong, stable clot</td>
</tr>
</tbody>
</table>

*Synthesis requires vitamin K

†Number no longer used; substance now believed to be same as factor V

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CASCADE OF THROMBUS DEVELOPMENT

Vascular Injury

\[ \downarrow \]
Prothrombin activator

\[ \downarrow \]
Prothrombin $\rightarrow$ Thrombin

\[ \downarrow \]
Fibrinogen $\rightarrow$ Fibrin

\[ \downarrow \]
Crosslinked Fibrin

\[ \downarrow \]
platelets
\[ \downarrow \]
blood cells
\[ \downarrow \]
plasma

Thrombus
TWO PHENOTYPES OF THROMBOSIS

- Clinically Apparent, or “Manifest”
  
  Diagnostic testing triggered by findings

- Clinically Silent, or “Sub Clinical”

  Detected by screening

  Usually in study/trial-based settings

Chopra V, AVA ASM 2013
MOST CATHETER-RELATED DVT ARE CLINICALLY SILENT!

CAUSE OF THROMBOSIS

- Thrombosis with the use of long-term central venous catheters (CVC) is a serious complication that causes morbidity\textsuperscript{11} including deep vein thrombosis (DVT), pulmonary embolism (PE) and post-thrombotic syndrome\textsuperscript{14}

- Thrombosis of any catheterized vein is a potential complication.

- Catheter-related thrombosis is more common than infectious complications in all anatomic sites, especially when smaller veins of the upper extremity are considered\textsuperscript{2}
CAUSE OF THROMBOSIS

- Earlier studies have reported risks of symptomatic CRT as high as 28%, but more recent studies suggest a much lower incidence at 5% or less\(^1\).

- Studies have suggested that catheter material, tip position, infection, previous catheterization, and other factors may influence the risk of CRT\(^1\).

- Medication can also play a role in thrombotic influence with divergent pH and osmolar values influences vessel wall dynamics\(^3\).

<table>
<thead>
<tr>
<th>Patient Groups</th>
<th>DVT Prevalence, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical patients</td>
<td>10–20</td>
</tr>
<tr>
<td>General surgery</td>
<td>15–40</td>
</tr>
<tr>
<td>Major gynaecologic surgery</td>
<td>15–40</td>
</tr>
<tr>
<td>Major urologic surgery</td>
<td>15–40</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>15–40</td>
</tr>
<tr>
<td>Stroke</td>
<td>20–50</td>
</tr>
<tr>
<td>Hip or knee arthroplasty, HFS</td>
<td>40–60</td>
</tr>
<tr>
<td>Major trauma</td>
<td>40–80</td>
</tr>
<tr>
<td>Spinal cord injury</td>
<td>60–80</td>
</tr>
<tr>
<td>Critical care patients</td>
<td>10–80</td>
</tr>
</tbody>
</table>
OTHER THROMBOSIS RISK FACTORS

- Recently, elevated levels of several coagulation factors (factor VIII, von Willebrand factor, fibrinogen) were shown to be independently associated with an increased risk of upper extremity deep venous thrombosis, as was blood group non-0 compared to 0.

- Other common social risk factors include:

  - IV drug use
  - Smoking
  - Weight lifting
  - Family history
  - Oral Contraceptives
  - Pregnancy
IV DRUG USE AND THROMBOSIS — FEMORAL HEROIN INJECTION
In a recently performed systematic review, the incidence of symptomatic CVC-related DVT in adult varied between 0.3% and 28.3%, whereas the incidence of venography-assessed cases (mostly asymptomatic) ranged from 27% to 66%.

Comparatively, the rate of PICC symptomatic thrombosis has been reported to be 3%–20%, and the rate of asymptomatic thrombosis has been reported to be 61.9%.

Pulmonary embolism has been reported to occur in 15% to 25% of patient with CVC-related DVT. Although the thrombosis rate is high, only a third (8.3%) of the thrombosed CVCs become symptomatic.
## Incidence

<table>
<thead>
<tr>
<th>Complication</th>
<th>Incidence</th>
<th>Presentation</th>
</tr>
</thead>
</table>
| Post-thrombotic syndrome                                                    | 7-46%              | • Edema, pain, “feeling of heaviness” and fatigue with exertion, skin discoloration (affected limb)  
|                                                                               |                    | • Vein distention (affected limb and upper chest)                            |
| Recurrent venous thrombosis after catheter removal with repeated catheterization same side | Up to 86%          | • Note: Removal AFTER occurrence of CRVT                                    |
| Pulmonary embolism                                                           | 13-16% (symptomatic)  
| | ≈ 50% (autopsy)                                                            | • Dyspnea, chest pain, vertigo, vision changes, low-grade fever, sinus tachycardia (overt signs) |
| Mortality                                                                    | 4.8% with cancer dx  
| | 2.6% without cancer dx                                                      | • Mortality rate within 3 months of CRVT                                    |
The Triad of Virchow - formulated in the 19th Century, still forms the basis for the current theory on thrombus formation. This pathophysiological explanation describes the precursors around three core relationships of vascular thrombosis.

1. vessel wall damage or endothelial injury (vascular injury)
2. alterations in blood flow (hematological stasis), and
3. hypercoagulability (changes in the chemical composition of blood)

deeding it significant effectors in prevention of vessel- and catheter-related complications
**Virchow's Triad**

**Hypercoagulability**
- Major surgery / trauma
- Malignancy
- Pregnancy (post-partum)
- Inherited thrombophilia
- Infection and sepsis
- Inflammatory Bowel Disease
- Autoimmune condition
- Estrogen therapy
- Inflammation
- Dehydration

**Vascular Damage**
- Thrombophlebitis
- Cellulitis
- Atherosclerosis
- Indwelling catheter / heart valve
- Venepuncture
- Physical trauma, strain or injury
- Microtrauma to vessel wall

**Circulatory Stasis**
- Immobility
- Venous obstruction (obesity, tumour, pregnancy)
- Varicose veins
- Atrial fibrillation or left ventricular dysfunction
- Congenital abnormalities affecting venous anatomy (e.g., May-Thurner and Paget-Schroetter syndrome)
- Low heart rate (bradycardia) and low blood pressure
Central venous catheters can impact this triad through stasis and direct vascular injury.

Additionally, the presence of the catheter itself provides a thrombogenic surface to further create an environment favouring thrombosis.

In many cases, patient fit all 3 core criteria for thrombosis based upon Virchow’s Triad.
THROMBOSIS SCREENING

- Each of the screening tests for DVT has strengths and limitations.

- Contrast venography (CV) is sensitive for detecting DVT; however, venography is invasive, 20 to 40% of venograms are considered non-diagnostic, and the clinical relevance of small thrombi is relatively uncertain. There is increased risk contrast-related renal failure, anaphylaxis and chemical phlebitis.

- Venous Doppler Ultrasonography (DUS) is widely available, non-invasive, and repeatable.
Venous Doppler Ultrasonography (DUS)

THROMBOSIS SCREENING
Longitudinal image of the subclavian shows enlargement and non-compressibility with the transducer (red arrowheads) and an intraluminal thrombus (red arrow).

Color Doppler image of the subclavian vein shows that the lumen is distended with hypoechoic thrombus (red arrows). Very minimal blood flow in the vein is evident. Flow is present in an adjacent artery (red arrowhead).
**THROMBOSIS SCREENING**

- Magnetic resonance imaging (MRI) technology has the advantage that it allows simultaneous imaging of both lower limbs, detection of pelvic vein and inferior vena cava thrombosis, and, if required, thoracic imaging during the same session.

- It can be used safely during pregnancy and in the presence of dressings or plaster casts.\(^8\)
US CRITERIA FOR DIAGNOSIS OF CATHETER-RELATED DVT (CR-DVT)

- Non-compressibility of vein
- Direct visualization of thrombus in vein (trans/long)
- Absent Doppler-wave form
- Color Doppler showing lack of visible flow within the vessel

Chopra V, AVA ASM 2013
Plasma D-dimers (DD) are a specific cross-linked fibrin derivative generated from the degradation of the fibrin matrix in fresh venous thromboemboli.

Given that DD are increased in any condition in which fibrin is formed then degraded, they are not a specific marker for VTE, but are highly sensitive.

They have proved a useful component in diagnostic algorithms as an adjunctive exclusionary test.¹
IDENTIFYING THROMBOSIS

SIGNS & SYMPTOMS

- Signs and symptoms of catheter-related thrombosis of the upper extremity include
  - swelling of the neck and arm,
  - the appearance of superficial veins on the anterior chest wall on the side of a catheter,
  - tenderness in the axilla when pressing on the axillary vein,
  - discoloration of the arm even in the absence of marked swelling.¹

- Patients may also present with rhinorrhea, tearing, shortness of breath, sore throat, and chest pain.
Dilatation of subcutaneous collateral veins in a patient with left-sided upper extremity deep venous thrombosis.
TREATMENT OPTIONS

- The treatment options for upper-extremity DVT include the use of heparin,
  - low-molecular-weight heparin,
  - warfarin,
  - systemic thrombolysis,
  - catheter-directed thrombolysis,
  - percutaneous mechanical thrombectomy,
  - surgical thrombectomy, and SVC filter.

- Patients having a stenosed segment of a major central vein may have patency of the vein restored by dilating and stenting the involved venous segment.
CATHETER—RELATED FACTORS

- Left sided insertions
- More than one insertion attempt
- Catheter tip located proximal to cavo-atrial junction/distal SVC
- Catheter material (polyethylene, polyvinylchloride > silicone, polyurethane)
- Number of lumens (triple lumen > double lumen > single lumen)
- Prior catheterization at same puncture sites (trauma related)
- Prolonged catheter dwell time (> 2 weeks)
- Catheter related infections/septicaemia
- Reverse tapered catheters
CATHETER-RELATED RISK FACTORS

Catheter Size

Catheter Taper
CURRENT EVIDENCE

- New standard from INS supporting 45% or less

2. Measure the vein diameter using ultrasound before insertion and consider choosing a catheter with a catheter-to-vein ratio of 45% or less (refer to Standard 52, Central Vascular Access Device [CVAD]-Associated Venous Thrombosis).

26.2 Selection of the most appropriate VAD occurs as a collaborative process among the interprofessional team, the patient, and the patient’s caregiver(s).
26.3 The VAD selected is of the smallest outer diameter with the fewest number of lumens and is the least invasive device needed for the prescribed therapy.
26.4 Peripheral vein preservation is considered when planning for vascular access.
CONSIDERATIONS

1. History of deep vein thrombosis.
2. Presence of chronic diseases associated with a hypercoagulable state such as cancer, diabetes, irritable bowel syndrome, congenital heart disease, or end-stage renal failure.
3. Surgical and trauma patients.
4. Critical care patients; hyperglycemia in nondiabetic children in critical care may be a predictor of venous thromboembolism.
6. Pregnancy or the use of oral contraceptives.
7. Age extremes in young children and older adults.
8. History of multiple CVADs, especially with difficult or traumatic insertion and the presence of other intravascular devices (eg, pacemakers).\(^{1-5}\)
E. Recognize that the majority of CVAD-associated DVT is clinically silent and does not produce overt signs and symptoms. Clinical signs and symptoms are related to obstruction of venous blood flow and include, but are not limited to:

1. Pain in the extremity, shoulder, neck, or chest.
2. Edema in the extremity, shoulder, neck, or chest.
3. Erythema in the extremity.
4. Engorged peripheral veins on the extremity, shoulder, neck or chest wall.
ARM CIRCUMFERENCE

F. Measure upper-arm circumference before insertion of a PICC and when clinically indicated to assess the presence of edema and possible DVT. Take this measurement 10 cm above the antecubital fossa; assess for the location and other characteristics such as pitting or nonpitting edema (refer to Standard 33, Vascular Access Site Preparation and Device Placement).
CATHETER TO VESSEL RATIO - DEFINITION

No real clinical definition until 2017.

Catheter to vessel ratio (CVR) may be defined as the

“indwelling space or area consumed or occupied by an intravascular device inserted and positioned within a venous or arterial blood vessel.” ¹⁶
The term CVR (Catheter to Vessel Ratio) has not been previously defined by the Infusion Nurses Society (INS). In the current 2016 INS Standards of Practice, there are only two mentions of CVR with a relationship of using <45% (S55, S112) and there is no reference or statement to the glossary or index of this document when referring to catheter to vein or vessel ratios.
CATHETER TO VESSEL RATIO

- CVAD diameter has been found to be a predictive factor for thrombosis in several studies\(^1,2\)

- Some authors have recommended use of the smallest diameter CVADs possible to reduce the rate of thrombosis\(^1,2,13,16\) Conversely, smaller-gauge PICCs occupy less cross-sectional venous area thus allowing greater blood flow around the catheter, substantially reducing this risk\(^29\)

- Larger diameter CVADs are associated with higher thrombosis rates, and taper near the hub also potentially results in an increased thrombosis rate, specially at the insertion site\(^2,13,16\)
There is now established clinical evidence that shows CRT is related to the catheter size within the intraluminal space\textsuperscript{12, 19, 27}

An increase in the number of PICC lumens also results in greater French/gauge, a factor independently associated with risk of DVT.

While PICC use has significantly increased over several years, as too has upper extremity DVT. Reported PICC- associated DVT rates have ranged from 0 to 20\% and are a greater common complication than infection\textsuperscript{27}
In evaluating risk factors for thrombosis, Itkin et al. (2013) identified a statistically significant higher rate in patients with cancer (71.9% cancer vs 66.7% non-cancer, \( P = .002 \)).\(^1\,^2\)
CONVERTING CATHETER FR. SIZE TO MM

Catheter Fr. x 0.33 = catheter outer diameter (OD) in mm

Vessel measurement is expressed in mm (or cm) on ultrasound.

Why is this important?
## SIZE + FLOW MATTERS!

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Radius of Vessel $(\text{mm})^4$</th>
<th>Length (CM)</th>
<th>Actual Diameter (mm)</th>
<th>Approx. mL/Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cephalic</td>
<td>$3^4$</td>
<td>38 cm</td>
<td>2-4 mm</td>
<td>81</td>
</tr>
<tr>
<td>Basilic</td>
<td>$4^4$</td>
<td>24 cm</td>
<td>4-6 mm</td>
<td>256</td>
</tr>
<tr>
<td>Axillary</td>
<td>$8^4$</td>
<td>13 cm</td>
<td>16 mm</td>
<td>4,096</td>
</tr>
<tr>
<td>Subclavian</td>
<td>$9.5^4$</td>
<td>6 cm</td>
<td>19 mm</td>
<td>8,145</td>
</tr>
<tr>
<td>SVC</td>
<td>$12.5^4$</td>
<td>7 cm</td>
<td>20 mm</td>
<td>24,414</td>
</tr>
</tbody>
</table>
# Catheter to Vessel Ratio

## Flow Model Chart (Nifong, 2011)

<table>
<thead>
<tr>
<th>Vein and Vein Size</th>
<th>Initial Flow (ml/min)</th>
<th>2F Catheter Inserted</th>
<th>4F Catheter Inserted</th>
<th>6F Catheter Inserted</th>
<th>8F Catheter Inserted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cephalic (4mm)</td>
<td>10</td>
<td>5ml</td>
<td>48% remaining</td>
<td>3ml</td>
<td>28% remaining</td>
</tr>
<tr>
<td>Brachial (5mm)</td>
<td>25</td>
<td>13ml</td>
<td>53% remaining</td>
<td>9ml</td>
<td>36% remaining</td>
</tr>
<tr>
<td>Basilic (6 mm)</td>
<td>52</td>
<td>29ml</td>
<td>56% remaining</td>
<td>21ml</td>
<td>41% remaining</td>
</tr>
<tr>
<td>Axillary (8mm)</td>
<td>164</td>
<td>100ml</td>
<td>61% remaining</td>
<td>79ml</td>
<td>48% remaining</td>
</tr>
<tr>
<td>Subclavian (10mm)</td>
<td>400</td>
<td>256ml</td>
<td>64% remaining</td>
<td>212ml</td>
<td>53% remaining</td>
</tr>
</tbody>
</table>
“RULE OF THUMB” (OR $\frac{1}{3} - \frac{2}{3}$ RATIO)

Calculations show that using the rule of thumb actually was better

4mm = 4FR catheter

This actually works out to be an area of only 10.89%

So the rule of thumb calculates to be more effective at associated risk reduction with C:V ratios

So we were actually working on a 11% rule, much less than 33% or even 45%
CATHETER TO VESSEL RATIO - CURRENTLY

Current guidelines say the catheter should never take up more than 1/3 of the internal vessel diameter.

<p>| Table 1 | Comparison of two-dimensional catheter diameters for 33 and 45% ratios only using the “rule of thumb” measurements |</p>
<table>
<thead>
<tr>
<th>French/min vessel size (min) (rule of thumb)</th>
<th>Catheter Ø</th>
<th>Catheter Ø</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Fr=3 mm</td>
<td>0.99 mm</td>
<td>1.38 mm</td>
</tr>
<tr>
<td>4 Fr=4 mm</td>
<td>1.32 mm</td>
<td>1.8 mm</td>
</tr>
<tr>
<td>4.5 Fr=4.5 mm</td>
<td>1.49 mm</td>
<td>2.03 mm</td>
</tr>
<tr>
<td>5 Fr=5 mm</td>
<td>1.65 mm</td>
<td>2.25 mm</td>
</tr>
<tr>
<td>5.5 Fr=5.5 mm</td>
<td>1.82 mm</td>
<td>2.48 mm</td>
</tr>
<tr>
<td>6 Fr=6 mm</td>
<td>1.98 mm</td>
<td>2.7 mm</td>
</tr>
<tr>
<td>7 Fr=7 mm</td>
<td>2.31 mm</td>
<td>3.15 mm</td>
</tr>
<tr>
<td>9 Fr=9 mm</td>
<td>2.97 mm</td>
<td>4.05 mm</td>
</tr>
<tr>
<td>10 Fr=10 mm</td>
<td>3.3 mm</td>
<td>4.5 mm</td>
</tr>
<tr>
<td>11 Fr=11 mm</td>
<td>3.63 mm</td>
<td>4.95 mm</td>
</tr>
<tr>
<td>12 Fr=12 mm</td>
<td>3.96 mm</td>
<td>5.4 mm</td>
</tr>
</tbody>
</table>
A review of the INS SOP from both 2007 [20] and 2011 [21] did not specify a recommended vessel size or measurement to set an upper limit of outer diameter for a vascular device to be placed.

The 2016 INS Standards [22] however did include more recent evidence to say that a catheter vessel ratio of ≤ 45% was a satisfactory risk prevention strategy. A supporting publication [17] showed that there was statistical significance with catheter vessel ratios ≥ 45%, with a 13-fold increase in CRT risk. [Sharp]

What was missing was the actual unit of measurement.
CATHETER TO VESSEL RATIO TOOL

- We compared the traditional ‘rule of thumb’, or 33% rule, and the recent 45% rule of CVR.

- However, these general rules are traditionally based on a single, two-dimensional measurement, not focusing on the area the catheter takes up within the vessel.

- There is a need to consider the vessel a three-dimensional object, meaning it has height, width, depth and volume - much more beyond a two-dimensional view.

- Therefore the vessel should be assessed from it ‘area’ perspective.
**CATHETER TO VESSEL RATIO TOOL**

- The simplicity and effectiveness of this tool allows for quick and accurate review along with a simple colour scheme to highlight the areas (or zones) of CVR safety, which have been colour coded accordingly:
  
  **RED ZONE** - 45% or greater—high risk zone
  **YELLOW ZONE** - 34–44%—cautionary zone
  **GREEN ZONE** - 33% or less—safe zone
Catheter Size (Fr) | Catheter OD (mm) | Radius of Catheter (mm) | Area of Catheter (mm²) | Vessel OD (mm) | Radius of Vessel (mm) | Area of Vessel (mm²) | CVR | Area of Vessel (mm²)
---|---|---|---|---|---|---|---|---
5F | 1.65 | 0.83 | 2.14 | 4.2 | 2.10 | 13.85 | CVR | 15.43%
### Behind The Scenes

<table>
<thead>
<tr>
<th>Catheter Size (Fr)</th>
<th>Catheter OD (mm)</th>
<th>Radius of Catheter (mm)</th>
<th>Area of Catheter (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1.65</td>
<td>0.83</td>
<td>2.14</td>
</tr>
<tr>
<td>Vessel OD (mm)</td>
<td>Radius of Vessel (mm)</td>
<td>Area of Vessel (mm²)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.46</td>
<td>CVR</td>
<td>45.17%</td>
</tr>
</tbody>
</table>

**Red grid represents area between 45% or greater**

<table>
<thead>
<tr>
<th>Catheter Size (Fr)</th>
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<td>Vessel OD (mm)</td>
<td>Radius of Vessel (mm)</td>
<td>Area of Vessel (mm²)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.67</td>
<td>CVR</td>
<td>38.19%</td>
</tr>
</tbody>
</table>

**Yellow grid represents area between 34 and 44% (38% is the median)**

<table>
<thead>
<tr>
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</tr>
<tr>
<td>Vessel OD (mm)</td>
<td>Radius of Vessel (mm)</td>
<td>Area of Vessel (mm²)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.88</td>
<td>CVR</td>
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**Green grid represents area between 33% or less**
**Catheter to Vessel Ratio Tool**

<table>
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<th>1mm</th>
<th>1.5mm</th>
<th>2mm</th>
<th>2.25mm</th>
<th>2.5mm</th>
<th>2.75mm</th>
<th>3mm</th>
<th>3.5mm</th>
<th>4mm</th>
<th>4.5mm</th>
<th>5mm</th>
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<tbody>
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<td>Catheter Size</td>
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</tbody>
</table>

**Legend**
- ≥45%
- 44-34%
- ≤33%
CATHETER TIP LOCATION

- The position of the catheter in the vascular system is a major determinant of CVC-related thrombosis, and tip position has been shown to be the main independent prognostic factor for malfunction and reduced duration of the device.

- Placement of the catheter tip higher (proximal) in the superior vena cava (SVC) results in a higher incidence of thrombosis than when the catheter tip is placed low in the SVC or at cavoatrial junction.¹
Catheter removal or maintenance does not influence the outcome.

Although local thrombolytic treatment may require the presence of the catheter, a poor peripheral vein status could represent a major limiting factor for most therapies, if the catheter has been removed.

CHEST (2012) guidelines recommend the active treatment of the thrombus without catheter removal.

THROMBOSIS & CATHETER REMOVAL

- In case of clinically overt or imaging-diagnosed DVT, a risk of embolization during or immediately after catheter removal has been clinically confirmed.

- Catheter should be removed with:

  1. *Infected thrombus;*
  2. *Malposition of the tip (radiologic reposition of the tip often fails, as a consequence of the inability to reach it inside the thrombus);* or
  3. *Irreversible occlusion of the lumen.*
REFERENCES