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Reducing catheter-related thrombosis using a risk reduction tool centered on catheter to vessel ratio

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Abstract In vascular access practices, the internal vessel size is considered important, and a catheter to vessel ratio (CVR) is recommended to assist clinicians in selecting the most appropriate-sized device for the vessel. In 2016, new practice recommendations stated that the CVR can increase from 33 to 45% of the vessels diameter. There has been evidence on larger diameter catheters and increased thrombosis risk in recent literature, while insufficient information established on what relationship to vessel size is appropriate for any intra-vascular device. Earlier references to clinical standards and guidelines did not clearly address vessel size in relation to the area consumed or external catheter diameter. The aim of this manuscript is to present catheter-related thrombosis evidence and develop a standardized process of ultrasound-guided vessel assessment, integrating CVR, Virchow's triad phenomenon and vessel health and preservation strategies, empowering an evidence-based approach to device placement. Through review, calculation and assessment on the areas of the 33 and 45% rule, a preliminary clinical tool was developed to assist clinicians make cognizant decisions when placing intravascular devices relating to target vessel size, focusing on potential reduction in catheter-related thrombosis. Increasing the understanding and utilization of CVRs will lead to a safer, more consistent approach to device placement, with potential thrombosis reduction strategies. The future of evidence-based data relies on the clinician to capture accurate vessel measurements and device-related outcomes. This will lead to a more dependable data pool, driving the relationship of catheter-related thrombosis and vascular assessment.

Keywords Venous thrombosis · Catheter to vein ratio · Vessel measurement · Ultrasound · Patient · Assessment · Outcomes · Standardization

Introduction

Catheter-related thrombosis (CRT) poses a serious, yet challenging situation for clinical providers working within todays current healthcare environment. The clinical issues generated by this phenomenon are problematic and often lasting well beyond the initial diagnosis and potential treatment protocols. With short and long-term issues for both patients and clinicians, such as catheter dysfunction, infection, and superior vena cava (SVC) syndrome, accompanied by the considerable costs of ongoing treatment and care, several clinical conundrums, particularly when there are varying thoughts and evidence on how-to-treat within this topic, exist. Vascular access (VA) devices continue to be the most frequently performed invasive procedure in any given healthcare institution today, and the potential for CRT increases with many contributing factors, not to mention the comorbidities that impact thrombosis risk on a pathophysiological level.

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Magnitude of the problem

Upper extremity-deep vein thrombosis (UE-DVT) refers to the formation of a thrombus within the deep vessels of the upper arm and chest: primarily the subclavian, axillary and brachiocephalic veins, but also the basilic, brachial, and the more increasingly, superficial cephalic veins, in the arm. It has been described as either idiopathic (primary) due to anatomical variants or as secondary, more associated with tumor disease, intravenous catheters, and pacemaker leads [1].

Much focus on this phenomenon has targeted the increased use of peripherally inserted central catheters (PICCs) in the last two decades [2–8] especially with its increasing demand for non-physician facilitated insertions [9–11]. Around this time, a prospective study looking at triple lumen PICCs highlighted a symptomatic thrombosis risk of 20% that was considered unacceptably high by the study oversight committee. The study was terminated due to patient risk. Venous thrombosis (symptomatic or asymptomatic) was detected in 26 of 45 patients (58%) when examined with ultrasound (US) [12].

Catheter-related thrombosis has serious implications related to the loss of vascular access, development of pulmonary embolism (PE), recurrent venous thromboembolism (VTE), infections and post-thrombotic syndrome. The pathogenesis of CRT is complex and multifactorial, with risk factors associated with the catheter, the vessel selected for insertion and the underlying patient co-morbidities and their treatments. The monitoring of the catheter to vessel ratio (CVR), whereby vessel and catheter size are measured for relationship appropriateness, may have potential influence on CRT, by potentially reducing venous stasis through improving flow dynamics around the body of the catheter.

Trerotola [12] inferred that an increase in the catheters external measurements (documented with the reverse taper fully inserted to the hub), to be 'negligible in terms of the diameter of device inside the vein—that is, whether inserted to the hub or to the zero mark, the diameter of the intravascular PICC remains roughly the same'—which not well defined. There is however, a clear increase in the catheters reverse taper component (a length of 5 or 7 cm) with an overall 2 French (Fr) size increase (33%) in outer diameter [13]. This has a theoretical impact on the intraluminal area consumed and may potentially increase venous stasis within the vessel.

Additionally, 5-Fr and 6-Fr PICCs showed an earlier time to DVT, suggesting an accelerated course towards thrombosis in patients who received these larger devices. These findings question the wisdom of the use of PICCs in patients with cancer and the use of devices of greater gauge, as their thrombogenicity may outweigh presumed benefits, especially among patients with malignancies [14].

Identifying reasons for the existence of the research gap

An early retrospective venography study [15] described high thrombosis rates with 23.3% of patients developing thrombosis after the initial PICC placement (overall thrombosis rate 38%), yet did not encompass vessel size as a potential influencing factor, citing age, sex, cannulated vein, catheter size, location, and incidence of thrombosis risks. Whilst there have been more recent considerations regarding CVRs [16–18], there is still limited evidence in its role of prospective thrombosis reduction strategies in vascular access practices.

While there has been a strong focus on larger diameter PICCs and thrombosis risk [12, 19], there has been insufficient information established on what relationship to vessel size is appropriate for a device-specific external diameter. Early references to clinical standards and guidelines did not clearly address appropriateness of vessel size in relation to external catheter diameter or consumed area.

In 2007, the Infusion Nursing Society (INS) standards recommended that a target vein for vascular access must be able to "accommodate the catheter" [20], but no specific vessel sizes or ratio was stated. This was possibly the earliest documented evidence in vascular access standards or guidelines that stated CVR should be considered in the clinical aspect of patient care, particularly the intravenous therapy arena, and further recommended that "the nurse placing a catheter should have a comprehensive understanding of anatomy and physiology, vein assessment techniques, and insertion techniques appropriate to the specific device" [20].

In 2011, the INS Standards of Practice (SOP) were subsequently updated [21], yet the standards only included that "the vasculature shall accommodate the gauge and length of the catheter required for the prescribed therapy" and that the "nurse should consider using visualization technologies that aid in vein identification and selection" [21]. It wasn't until further developing evidence was published that awareness was raised of the relationship between vessel and catheter size and its potential impact on thrombosis risk.

The currently published INS Standards [22] now address CVR, but there is still inconsistency amongst clinicians on what expression of CVR is important. We attempt to define this CVR and its direct relationship to thrombotic risk with venous intravascular devices, however the same principle may also be applied to intra-arterial vascular devices.

Definition of catheter to vessel ratio

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*." Although there is a large amount of literature on venous and arterial thromboembolism, this papers' focus is on the intravascular catheter and venous thrombotic complications. To a large extent, it comes down to annular mathematical proportions and is measureable by well-trained clinicians with ultrasound (US). However, this process is often forgotten as part of the vascular assessment process when devices are placed for intravascular therapies. A relatively simple issue, but nonetheless, a very important one which can have significant effect on the functioning of the device, as well as blood flow characteristics within the vessel.

Nifong and McDevitt [23] state the presence of a catheter within the lumen of a vein will "decrease blood flow and potentially create venous stasis, and that the size of the catheter versus the vein has significant impact, particularly with peripherally inserted central catheters (PICCs)". The understanding that catheter size may potentially influence venous stasis within the vessel and exacerbate venous thrombosis had not been scientifically explored before, and although is now gaining more attention, there is still no clear process to facilitate proper clinical standards about vessel and catheter sizes.

The use of US in medicine has been since the 1950s, although ultrasound use specific to vascular access has essentially only been from the 1980s [24]. Since its early use, the focus had been on anatomical location, vessel size and needle visualization. Ultrasound is now a widely used medical imaging modality; it is inexpensive, widely accessible, fast, and safe.

The implementation of point-of-care ultrasound (POCUS) technology enables healthcare professionals to perform precision-based procedures and treatments under direct visualization. The ever-growing number of clinical studies indicate that use of US guidance by physicians and non-physicians alike, may improve success and decrease complications. Point-of-care ultrasound has proven itself to be an effective diagnostic tool that is comparable to, and oftentimes preferable, to other forms of imaging modalities. Because ultrasound emits no ionizing radiation, it is a safe option that should be considered before selecting other diagnostic modalities that subject patients to radiation exposure.

Wider acceptance of modern POCUS in vascular access has now incorporated superior visualization and better assessment for vessel-related thrombosis (and vessel-related anomalies) at the bedside, especially in the pre- and post-device insertion phases. Today, US is used in numerous aspects of clinical healthcare, increasing the early diagnostic advantages that afford clinicians well trained in its use.

Virchow's triad

This pathophysiological explanation describes the precursors around three core relationships of vascular thrombosis. The triad consists of the following components: vessel wall damage or endothelial injury, alterations in blood flow (hematological stasis), and hypercoagulability of the blood, deeming it a significant effector in prevention of vessel- and catheter-related complications.

Vessel health and preservation

The vessel health and preservation (VHP) framework directs the clinician through a closer assessment of the patient and uses tools to ensure a thorough vascular assessment and review of the overall patient treatment plan, along with improving the clinical decision-making process. Vessel health and preservation encompasses current clinical guidelines and evidence-based literature, in doing so, creating a programme that comprehensively addresses the issues of education, assessment, placement, and daily assessment of patient condition to determine device necessity. This standardized approach to vascular access care provides a timely and reliable process demanded by modern-day healthcare practices [25].

VHP represents the pinnacle of evidence-based knowledge development as a risk reduction strategy that complies with many professional organizations:

- The Joint Commission (TJC).
- Oncology Nurses Society (ONS).
- Infusion Nursing Society (INS).
- Association for Vascular Access (AVA).
- Agency for Healthcare Research and Quality (AHRQ).
- Centers for Disease Control (CDC).
- Registered Nurses Association of Ontario (RNAO).
- Association for Professionals in Infection Control and Epidemiology (APIC).
- The Society for Healthcare Epidemiology of America (SHEA).
- Institute for Healthcare Improvement (IHI).

What is the evidence in clinical practice?

The CVR has been used in clinical practice by vascular access specialists throughout recent decades; however, many clinicians are often unware of its actual significance, giving some or little reference to the application of CVR utilization during the patient and vessel assessment.

This paper attempts to use science, mathematics and logic to develop a simple, yet robust tool to aid in vessel appropriateness and proper device selection processes, with the intention to help reduce the relative risk of thrombosis in those who require any intravascular device. Initially designed for targeting PICC and central venous catheters (CVCs), peripheral intravenous cannula (PIVC) and intra-arterial devices will have similar impact on the thrombosis risk and should also be included when these devices are being considered.

Thrombosis in cancer alone is associated with increased morbidity and mortality and a significant economic burden. Diagnosis and management of thrombotic events interrupt essential cancer (and other) therapies and carry a risk for serious bleeding complications [26]. Although many high-risk patient populations are exposed to CRT, the overall reduction of precipitative effects for all patient groups is an important step to reduce the thrombotic-related complications associated with device placement and dwell.

There is now established clinical evidence that shows CRT is related to the catheter size within the intraluminal space [12, 19, 27], and the literature regarding these adverse events emanates from two distinct patient populations: those with and without cancer. As anticipated, VTE estimates in patients with cancer and critically ill patients consistently exceed those of patients without cancer or intensive care unit (ICU) level of care [19].

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 [27]. Tran [28] noted that in non-cancer patients, asymptomatic PICC-associated DVTs are detected in up to 37% when prospectively monitored by scheduled upper extremity US. An increase in the number of PICC lumens also results in greater gauge, a factor independently associated with risk of DVT. Conversely, smaller-gauge PICCs occupy less cross-sectional venous area thus allowing greater blood flow around the catheter, substantially reducing this risk [29].

Two other studies both reported an increased risk of PICC-associated CRT compared with other CVCs, and found the presence of a PICC was a risk factor for DVT in medical inpatients [26]. In a previous study by the same author, investigators found that PICC diameter (along with surgery > 1 h) were risk factors for upper extremity CRT and this study reported a significant reduction in the rate of CRT through use of single-lumen and smaller diameter 5F triple-lumen PICCs [4].

A meta-analysis of VTE restricted to those with malignancy not only confirmed this finding, but also identified PICCs as being associated with a significantly increased thrombosis risk compared with central venous catheters [30]. Furthermore, comparisons across critically ill patients, those admitted to hospital, patients with cancer, and mixed subgroups showed important differences in PICC-related DVT. Notably, patients cared for in ICU settings and those with cancer were reported to have the greatest risk of DVT [30]. Although this meta-analysis could not directly address the CVR, as it was not reported uniformly by included studies, it did state that when PICCs inserted above the elbow into larger vessels or when the vein diameter is checked before PICC insertion, the risk of deep vein thrombosis decreases [30].

Based upon our definition of CVR, the concept of moving to a larger sized vessel and using a proportionally sized catheter, helps support the potential reduction in risk of thrombotic complications.

Other similar findings were confirmed [31], citing that the rate of symptomatic catheter-related DVTs was 1% with 4 Fr catheters, and rose to 9.8% when a 6 Fr catheter was placed. Two other publications also concluded there was a correlation between CVR and the incidence of thrombosis risk [23, 32]. They concluded that while larger or multi-luminal catheters are at times necessary, the smallest acceptable catheter should be considered and clinicians inserting them needed to balance benefits against risks.

Another retrospective, single center cohort analysis of patients with hematological malignancies with upper extremity PICCs and symptomatic upper extremity DVTs [28] demonstrated a 7.8% diagnosed DVT rate within 26 days (median) of PICC insertion. This study then prospectively reviewed all PICCs placed after a change in technique to a tunneled PICC placement in the internal jugular vein (IJV). Using the same analysis methods as the retrospective study, the observed DVT rate was 0.4%—a significant reduction through a change of insertion site and use of a larger vessel.

These published studies convincingly parallel with the theory that a high quality CVR tool would help to reduce CRT in all patient populations if used with regular, thorough clinical and US assessment of the patient and vessel.

Application of the CVR tool

We compared the traditional ‘rule of thumb’, or 33% rule, and the recent 45% rule of CVRs. However, these general rules are traditionally based on a two-dimensional measurement, not focusing on the area the catheter takes up within the vessel. (see Tables 1, 2).

Although a broad literature search was performed, no identifiable evidence was returned regarding the “rule of thumb” often inherently followed by many practicing vascular access clinicians when inserting intravascular devices, or that the ‘default’ 33% catheter vessel ratio was referenced as a standard of clinical practice. 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

Table 1 Comparison of two-dimensional catheter diameters for 33 and 45% ratios only using the "rule of thumb" measurements

French/min vessel size (min) (rule of thumb)	Catheter ⌀ 33%	Catheter ⌀ 45%
3 Fr = 3 mm	0.99 mm	1.38 mm
4 Fr = 4 mm	1.32 mm	1.8 mm
4.5 Fr = 4.5 mm	1.49 mm	2.03 mm
5 Fr = 5 mm	1.65 mm	2.25 mm
5.5 Fr = 5.5 mm	1.82 mm	2.48 mm
6 Fr = 6 mm	1.98 mm	2.7 mm
7 Fr = 7 mm	2.31 mm	3.15 mm
9 Fr = 9 mm	2.97 mm	4.05 mm
10 Fr = 10 mm	3.3 mm	4.5 mm
11 Fr = 11 mm	3.63 mm	4.95 mm
12 Fr = 12 mm	3.96 mm	5.4 mm

of outer diameter for a vascular device to be placed. It did nonetheless focus on the more practical aspects of device placement options and appropriate tip location within the lower third of the SVC.

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. An eightfold increase was also noted with a 50% or greater CVR. This result reported a high sensitivity and specificity (sensitivity 75 and specificity 83) to increase the risk of VTE, however showed there was no difference in risk when lower ratios were included in analysis, indicating that the use of < 33% catheter to vein ratio may not be necessary. An important consideration in this study is that all patients who developed VTE had a malignancy diagnosis requiring chemotherapy, which possibly increased risk independently of the cancer diagnosis [17].

The authors attempt to best describe the practical use of 'rule of thumb' (or the 33% rule), through the combined 35 + years of experience inserting vascular access devices and training healthcare professionals in these procedures. Historically, it was a readily accepted practice that when a vessel was measured, one-third (1/3) of the vein's diameter should be consumed by catheter and two-thirds (2/3) should remain unobstructed to allow adequate blood flow dynamics around the device. This 1/3 to 2/3 ratio roughly equated to the 33% rule, or what was commonly termed by practitioners as the "rule of thumb."

When used during vascular access practices, the clinician would initially assess the vessel with the US transducer from a distal to proximal movement, looking for any indications of vessel-related thrombosis, stenosis, venous valves or other potential anomalies. Then, finding the greatest outer diameter (without the use of a tourniquet), the image is then frozen to utilize the calipers to measure the largest vessel diameter. A tourniquet is not recommended during US assessment as this artificially engorges the vessel, making it appear larger than its actual size (also changing the potential CVR), and will return an incorrect CVR relationship. The aim here is to assess the vessel in a 'natural' state.

Table 2 Calculations of greatest outer diameter (OD) of catheter areas that will occupy vessel area at both 33 and 45% CVR

Diameter vessel (mm)	Radius vessel (mm)	Area of vessel (mm^2)	45% rule area (mm^2)	Radius of 45% (mm)	Max OD of catheter (mm) following 45% or less	33% rule area (mm^2)	Radius of 33% (mm)	Max OD of catheter (mm) following 33% or less
1	0.5	0.79	0.35	0.34	0.67	0.26	0.29	0.57
1.5	0.75	1.77	0.80	0.50	1.01	0.58	0.43	0.86
2	1	3.14	1.41	0.67	1.34	1.04	0.57	1.15
2.25	1.13	3.98	1.79	0.75	1.51	1.31	0.65	1.29
2.5	1.25	4.91	2.21	0.84	1.68	1.62	0.72	1.44
2.75	1.38	5.94	2.67	0.92	1.85	1.96	0.79	1.58
3	1.5	7.07	3.18	1.01	2.01	2.33	0.86	1.72
3.5	1.75	9.62	4.33	1.17	2.35	3.17	1.01	2.01
4	2	12.57	5.65	1.34	2.68	4.15	1.15	2.30
4.5	2.25	15.90	7.16	1.51	3.02	5.25	1.29	2.59
5	2.5	19.63	8.84	1.68	3.35	6.48	1.44	2.87
6	3	28.27	12.72	2.01	4.03	9.33	1.72	3.45
7	3.5	38.48	17.32	2.35	4.70	12.70	2.01	4.02
8	4	50.27	22.62	2.68	5.37	16.59	2.30	4.60
9	4.5	63.62	28.63	3.02	6.04	20.99	2.59	5.17
10	5	78.54	35.34	3.35	6.71	25.92	2.87	5.75

For example, if a 4 mm vessel was measured and then multiplied by 1/3 to adhere to the 33% rule as above, we would receive a result of 1.32 mm. Information is provided by the manufacturer on the lid stock of the catheter kits to indicate the outer diameter of the catheter. After checking this information, calculation can be made to establish if a 4 French (Fr) catheter would satisfy this rule (or not).

This process led to the "rule of thumb" taxonomy, as it became common clinical practice to place a 3 Fr catheter in a 3 mm vessel, 4 Fr catheter in a 4 mm vessel or a 5 Fr catheter in a 5 mm vessel, etc. This determination however, was based solely on the single two-dimension measurement made by the clinician. 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. This now changes the perception of the overall dimension of a vessel. Calculating the area of the 4 mm vessel using the formula $A = \pi r^2$, would result in an area of 12.57 mm^2. If we then calculate the area that would be consumed by a 4 Fr catheter with an OD of 1.32 mm, using the same calculation we used above to calculate the area of the vessel, it would result 1.37 mm^2. To then calculate the three-dimensional percentage of area the catheter has consumed within the vessel, divide 1.37 mm^2 by 12.57 mm^2, then multiply by 100, resulting in 10.89%. When now taking area into consideration as part of CVR assessment, what initially was believed as the 33% rule, was in fact the 11% rule.

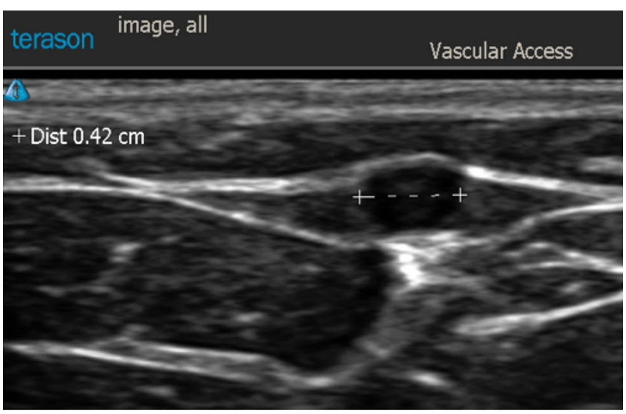

Image 1 Ultrasound measurement (with calipers) of target vessel

The authors then created a simple mathematical tool that could be integrated into practice to help clinicians abide by the 45% rule based on area. For example, if a 4.2 mm vessel was measured (Image 1), the inserting clinician could then reference the CVR tool (Image 4) to determine the maximum allowable diameter of catheter that would adhere to the rule. The mathematics behind the calculations are shown in Image 2. If a double lumen catheter was required, often a 5 Fr sized catheter, and the external measurement was possibly unknown, the OD of the catheter could be calculated in the same manner, multiplying the French size by 0.33 to convert French size to mm—$(\text{Fr} \times 0.33) = 1/3$ OD (in mm).

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

Image 3 demonstrates the 'behind the scenes' calculations for each of the three zones. Using this conversion process, along with the dataset in Table 2, the authors could determine the areas where catheter and vessel sizes were within the three zones.

This preliminary tool is designed for clinicians performing all vascular access procedures. Recognizing and understanding the CVR will lead to a safer, standardized approach to intravascular device placement. The future of evidence-based data relies on the clinician to capture accurate vessel measurements and device-related outcomes. Allowing clinicians to move from reactionary to proactive vascular access assessment, along with the use of the CVR tool, will lead to a more dependable data pool, at the same time potentially reducing catheter-related thrombosis and improving patient outcomes (Image 4).

Vascular access devices are now a highly utilized and integral part of modern-day healthcare procedures, due to relatively low insertion costs, more readily available POCUS equipment, flexible clinician insertion practices and the expedition of both in-hospital and out-of-hospital care. However, they are still associated with undesirable

Catheter Size (Fr)	Catheter OD (mm)	Radius of Catheter (mm)	Area of Catheter (mm2)
5F	1.65	0.83	2.14
	Vessel OD (mm)	Radius of Vessel (mm)	Area of Vessel (mm2)
	4.2	2.10	13.85
		CVR	15.43%

Image 2 Mathematical calculations behind Image 1 scenario

Image 3 Mathematic calculations for 3 zones of CVR tool

Catheter Size (Fr)	Catheter OD (mm)	Radius of Catheter (mm)	Area of Catheter (mm2)
5	1.65	0.83	2.14
	Vessel OD (mm)	Radius of Vessel (mm)	Area of Vessel (mm2)
	2.46	1.23	4.73
		CVR	**45.17%**

Red grid represents area between 45% or greater

Catheter Size (Fr)	Catheter OD (mm)	Radius of Catheter (mm)	Area of Catheter (mm2)
5	1.65	0.83	2.14
	Vessel OD (mm)	Radius of Vessel (mm)	Area of Vessel (mm2)
	2.67	1.34	5.60
		CVR	**38.19%**

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

Catheter Size (Fr)	Catheter OD (mm)	Radius of Catheter (mm)	Area of Catheter (mm2)
5	1.65	0.83	2.14
	Vessel OD (mm)	Radius of Vessel (mm)	Area of Vessel (mm2)
	2.88	1.44	6.51
		CVR	**32.82%**

Green grid represents area between 33% or less

Vessel Size	1mm	1.5mm	2mm	2.25mm	2.5mm	2.75mm	3mm	3.5mm	4mm	4.5mm	5mm
Catheter Size											
24G	X										
22G	X	~									
20G	X	X									
18G	X	X	~	~							
16G	X	X	X	X	X	~	~				
1 Fr											
2 Fr	~										
3 Fr	X	~									
4 Fr	X	X	~	~							
4.5 Fr	X	X	X	~	~						
5 Fr	X	X	X	X	~	~					
5.5 Fr	X	X	X	X	X	~					
6 Fr	X	X	X	X	X	X	~				
7 Fr	X	X	X	X	X	X	X	~			
8 Fr	X	X	X	X	X	X	X	X	~		

LEGEND
≥45%
44-34%
≤33%

Image 4 Catheter vessel ratio (CVR) tool

events, including CRT. While one study [18] found that a two-dimensional 45% catheter to vein ratio was the optimal cut off with high sensitivity and specificity to reduce the risk of VTE, ongoing research is still required to confirm these results.

The essence of this manuscript discusses the terms of overall CVR significance, its relational implications, importance to vascular access as a specialty field, and to medical and nursing practices. Based on our preliminary findings, a three-dimensional perspective needs to be considered in the evaluation of CVR relationship. This paper echoes the importance of a complete ultrasound vessel assessment with caliper measurement to identify an appropriately sized vessel prior to device insertion to help reduce the risk of CRT.

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Author contributions TRS and KJM were the primary authors responsible for literature search, review, generation and editing of all versions of the manuscript. Both authors designed and created the Catheter Vessel Ratio Tool discussed in this manuscript. Both authors read and approved the final manuscript before submission.

Compliance with ethical standards

Conflict of interest Timothy Spencer has received consultancy fees and speaker honorarium from Teleflex Inc. and Ethicon. Timothy Spencer is Presidential Advisor to the Australian Vascular Access Society (AVAS). Keegan Mahoney has received consultancy fees and speaker honorarium from Teleflex Inc.

Ethical approval This article does not contain any studies with human participants performed by any of the authors.

Informed consent Informed consent was not required for the study.

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