Disclosure

Contact hours are awarded after attending the educational activity and completion of the educational activity evaluation.

There is no conflict of interest for anyone with the ability to control content of the activity. No conflict of interest to report.

The Infusion Nurses Society is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center's Commission on Accreditation.

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Vascular Access-Related Thrombosis in Cancer Patients

Timothy R. Spencer RN, DipAppSc, BHSc, ICCert, APRN, VA-BC™

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Learning Outcomes

After the session, attendees will:

- Describe the pathophysiology of thrombosis and its clinical impact
- Define the risk factors for catheter related thrombosis (CRT)
- Identify the importance of catheter to vessel ratio (CVR) and its importance in to CRT
- Discuss the impact on blood flow with current catheter/vessel ratios

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Disclosures

Independent consultant/contractor for the following companies;

- Teleflex Inc.
- FUJIFILM SonoSite, Inc.
- Ethicon LLC
- Interrad Medical, Inc.

I have no other membership or affiliation conflicts,

I have no stock/shareholding conflicts.

Clotting Review - Three Essential Steps

1) In response to rupture of the vessel or damage to the blood itself, the formation of a complex of activated substances collectively called prothrombin activator occurs.

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.

Cascade of thrombus development

Vascular Injury

↓

Prothrombin activator

↓

Prothrombin → Thrombin

↓

Fibrinogen → Fibrin

↓

Crosslinked Fibrin

↓ **platelets**

↓ **blood cells**

↓ **plasma**

Thrombus

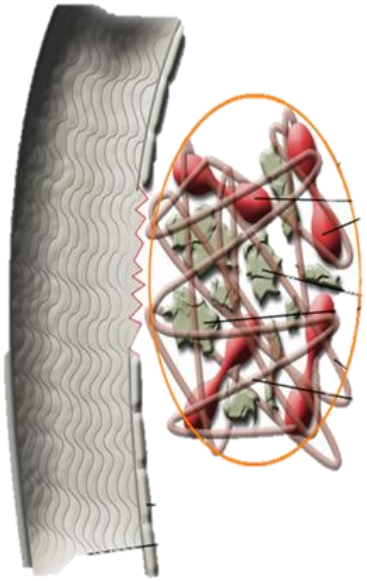

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Table 17.3 Blood Clotting Factors (Procoagulants)

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

*Synthesis requires vitamin K
†Number no longer used; substance now believed to be same as factor V

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Two Phenotypes of Thrombosis

- Clinically Apparent, or “Manifest”

  Diagnostic testing triggered by findings – “look what I found”

- Clinically Silent, or “Sub Clinical”

  Detected by screening

  Usually in study/trial-based settings – “I’m looking for it”

Chopra V, AVA ASM 2013

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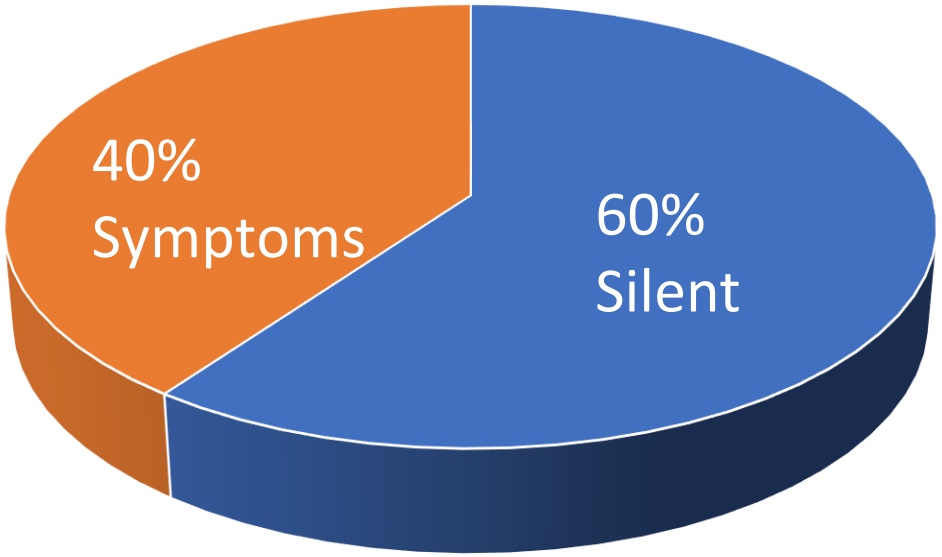
Most Catheter-Related DVT Are Clinically Silent [1]



Cause of Thrombosis

- Use of long-term central venous access devices (CVAD) is a serious complication that causes morbidity including deep vein thrombosis (DVT), pulmonary embolism (PE) and post-thrombotic syndrome[1]
- Thrombosis of any catheterized vein is a potential complication.

  PIVC => HD catheters

- Catheter-related thrombosis more common than infectious complications in all anatomic sites, especially when smaller veins of the upper extremity are considered[2]

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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 influencing vessel wall dynamics[2]

Patient Groups	DVT Prevalence, %
Medical patients	10–20
General surgery	15–40
Major gynaecologic surgery	15–40
Major urologic surgery	15–40
Neurosurgery	15–40
Stroke	20–50
Hip or knee arthroplasty, HFS	40–60
Major trauma	40–80
Spinal cord injury	60–80
Critical care patients	10–80

Blood Viscosity

- Viscosity is the thickness of fluids that affects their ability to flow.
- The viscosity of blood is directly proportional to resistance and inversely proportional to flow; therefore any condition that causes viscosity to increase will also increase resistance and decrease flow.
- e.g, imagine sipping milk, then a milkshake, through the same size straw. You experience more resistance and therefore less flow from the milkshake. Greater viscosity.
- Any condition that causes viscosity to decrease (such as when the milkshake melts) will decrease resistance and increase flow.

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Resistance is futile! But is it?

- The effect of vessel diameter on resistance is inverse.
- Given the same volume of blood, an increased diameter means there is less blood contacting the vessel wall, thus lower friction and lower resistance, subsequently increasing flow.

- A decreased diameter means more of the blood contacts the vessel wall, and resistance increases, subsequently decreasing flow.

Other thrombosis risk factors

- Recently, elevated levels of several coagulation factors (factor VIII, von Willebrand factor, fibrinogen) have been shown to be independently associated with an increased risk of upper extremity deep venous thrombosis, as was blood group non-0 compared to 0 with PICCs.[1]
- Other common social risk factors include;

IV drug use

Weight lifting

Smoking

Family history

Oral Contraceptives

Pregnancy

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Incidence

- In a 2007 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%.[1]

- 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%.[2]

Incidence

- Pulmonary embolism has been reported to occur in 15% to 25% of patient with catheter-related DVT (2007) and as high as ≥30%[2] (2019).
- Although the thrombosis rate is high, only a third (8.3%) of the thrombosed CVCs become symptomatic.
- Nonetheless, CVC thrombosis can result in clinical symptoms; loss of catheter function, higher rates of infection, post-phlebitic syndrome of the upper extremity, pulmonary embolus, and greater costs.[1]

Incidence

Complication	Incidence	Presentation
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

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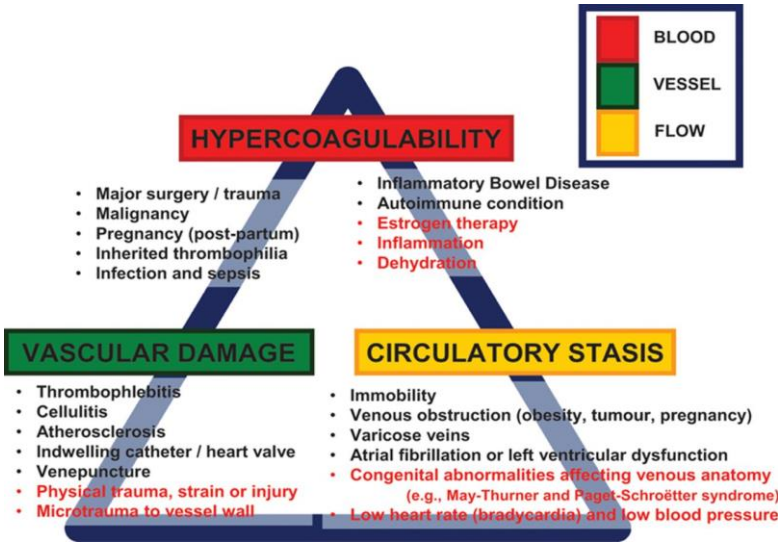
Virchow's Triad



- Formulated in the 19th Century, still forms the basis for the current theory on thrombus formation.[1]
- 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*),
    3. hypercoagulability (*changes in the chemical composition of blood).*

deeming it significant effectors in prevention of vessel- and catheter-related complications[2]

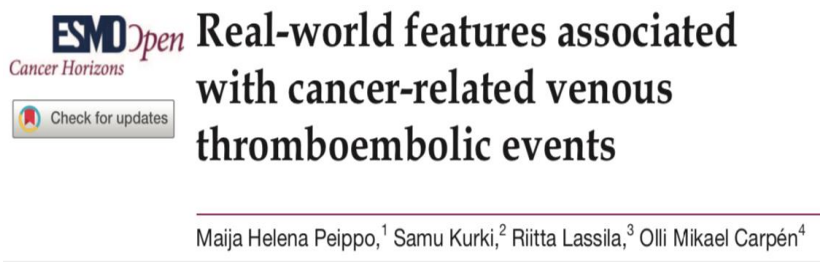
Virchow's Triad

- The length of a vessel is directly proportional to its resistance: the longer the vessel, the greater the resistance and the lower the flow.
- 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.

Cancer and Thrombosis

- Cancer is a major risk factor for VTE – >1.6 – 2.8% of cancer patient experience some form of VTE.[1]
- The incidence of venous thromboembolism is 1–2/1000 individuals.
- The VTE risk associated with cancer is up to 3 to 10-fold risk as compared with general population[1,2] and 2-fold for major bleeding risks[2]
- The pathogenesis of blood coagulation activation in cancer is complex and multifactorial.

Cancer and Thrombosis



- The risk of VTE depends on cancer type, many additional variables, which makes prognostic evaluation challenging.
- Platinum-based chemotherapy = major risk factor ($p<0.001$)[1] and serum creatinine >62.5µmol/L ($p=0.001$) were independent indicators of increased VTE risk during chemotherapy.
- The risk depends on cancer type and the highest incidence of VTE has been associated with adenocarcinomas.
- Chemotherapy, cancer surgery and radiotherapy are all also well recognized as important risk factors for VTE, as is the advanced disease stage.

Comorbidities and VTE[1]

Disease	ICD-10 code	Number of VTE†	Per cent of patients with VTE† diagnosis	Number of control patients (fivefold matching)	Per cent of control patients (from all patients)	RR	97.5% CI	P values‡
Obesity	E65–E66*	332	6.1	622	2.3	2.67	2.35 to 3.03	<0.001
Liver disease	K70*–K74*	122	2.2	269	1.0	2.27	1.84 to 2.79	<0.001
Congestive heart failure	I50*	1091	20.0	2600	9.5	2.10	1.97 to 2.24	<0.001
Asthma	J45*–J46	462	8.5	1124	4.1	2.06	1.85 to 2.28	<0.001
Varicose veins	I83*	265	4.9	647	2.4	2.05	1.78 to 2.35	<0.001
Pulmonary diseases (not asthma)	J41*–J44*, J47, J60–J70*	537	9.8	1366	5.0	1.97	1.79 to 2.16	<0.001
Rheumatoid arthritis	M05*–M06*	298	5.5	761	2.8	1.96	1.72 to 2.23	<0.001
Inflammatory bowel disease	K50*–K51*	117	2.1	302	1.1	1.94	1.57 to 2.39	<0.001
Peripheral vascular disease	I70*–I79*	507	9.3	1434	5.3	1.77	1.61 to 1.95	<0.001
Psychiatric disease	F10*–F99	795	14.6	2327	8.5	1.71	1.58 to 1.84	<0.001
Coronary heart disease	I20*–I25*	1437	26.4	4330	15.9	1.66	1.57 to 1.75	<0.001
Hypertension	I10–I15*	2296	42.1	7405	27.2	1.55	1.49 to 1.61	<0.001
Cancer	C00*–C99*	1467	26.9	4820	17.7	1.52	1.45 to 1.60	<0.001
Diabetes mellitus	E10*–E14*	869	15.9	2898	10.6	1.50	1.40 to 1.61	<0.001
Atrial fibrillation/ flutter	I48	999	18.3	3881	14.2	1.29	1.21 to 1.37	<0.001
Cerebrovascular disease	I60*–I69*	698	12.8	2751	10.1	1.27	1.17 to 1.37	<0.001
Pregnancy/delivery	O00*–O99*	155	2.8	754	2.8	1.03	0.87 to 1.22	0.752

Table 2 Incidence of VTE according to different cancer types

Cancer	ICD-10 code	Number of patients with cancer	Number of patients with VTE†	Per cent of patients with VTE† diagnosis
Mesothelioma	C45*	207	14	6.8
Gastric	C16*	898	54	6.0
Ovarian	C56*	936	53	5.7
Pancreatic	C25*	1080	59	5.5
Lung	C33*–C34*	2693	148	5.5
Myeloma	C90*	848	45	5.3
Colorectal	C18*–C21*	3727	168	4.5
Non-Hodgkin's lymphoma	C82*–C85*	1837	80	4.4
Bladder	C66*–C68*	1941	83	4.3
Endometrial	C54*	1645	67	4.1
Leukaemia	C91*–C95*	1475	46	3.1
Breast	C50*	7132	206	2.9
Prostate	C61*	7310	199	2.7
Hodgkin's lymphoma	C81*	402	11	2.7
Melanoma	C43*	1736	46	2.6
Testicular	C62*	345	6	1.7

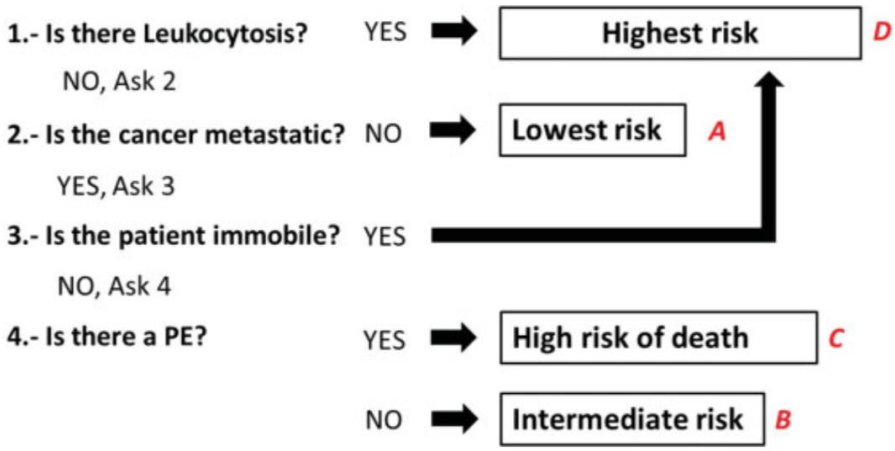
Patients with cancer overall: 42 245.
Number of patients with cancer and VTE†: 1467.
Per cent of patients with VTE† diagnosis: 3.5.
†VTE was defined as pulmonary embolism (PE, ICD-10 I26*), deep venous thrombosis (DVT, ICD-10 I80.2*) or portal vein thrombosis (PVT, ICD-10 I81*).
ICD-10, International Classification of Diseases 10th Revision; VTE, venous thromboembolism.

Thrombosis and Mortality

- Analyzed the RIETE database to identify the group of patients with cancer and thrombosis with the highest risk of death within 30 days of a thrombosis.[1]
- WCC predicted largest death count
- Metastatic disease, PE and immobility all contributed to death

Predictors of Early Mortality in Cancer-Associated Thrombosis: Analysis of the RIETE Database

Alfonso J. Tafur[1] Harry Fuentes[2] Joseph A. Caprini[1] Agustina Rivas[3] F. Uresandi[4] Rita Duce[5] Raquel Lopez-Reyes[6] Adriana Visona[7] Adel Merah[8] Manuel Monreal[9]



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 rhinorrhoea, tearing, shortness of breath, sore throat, and chest pain.

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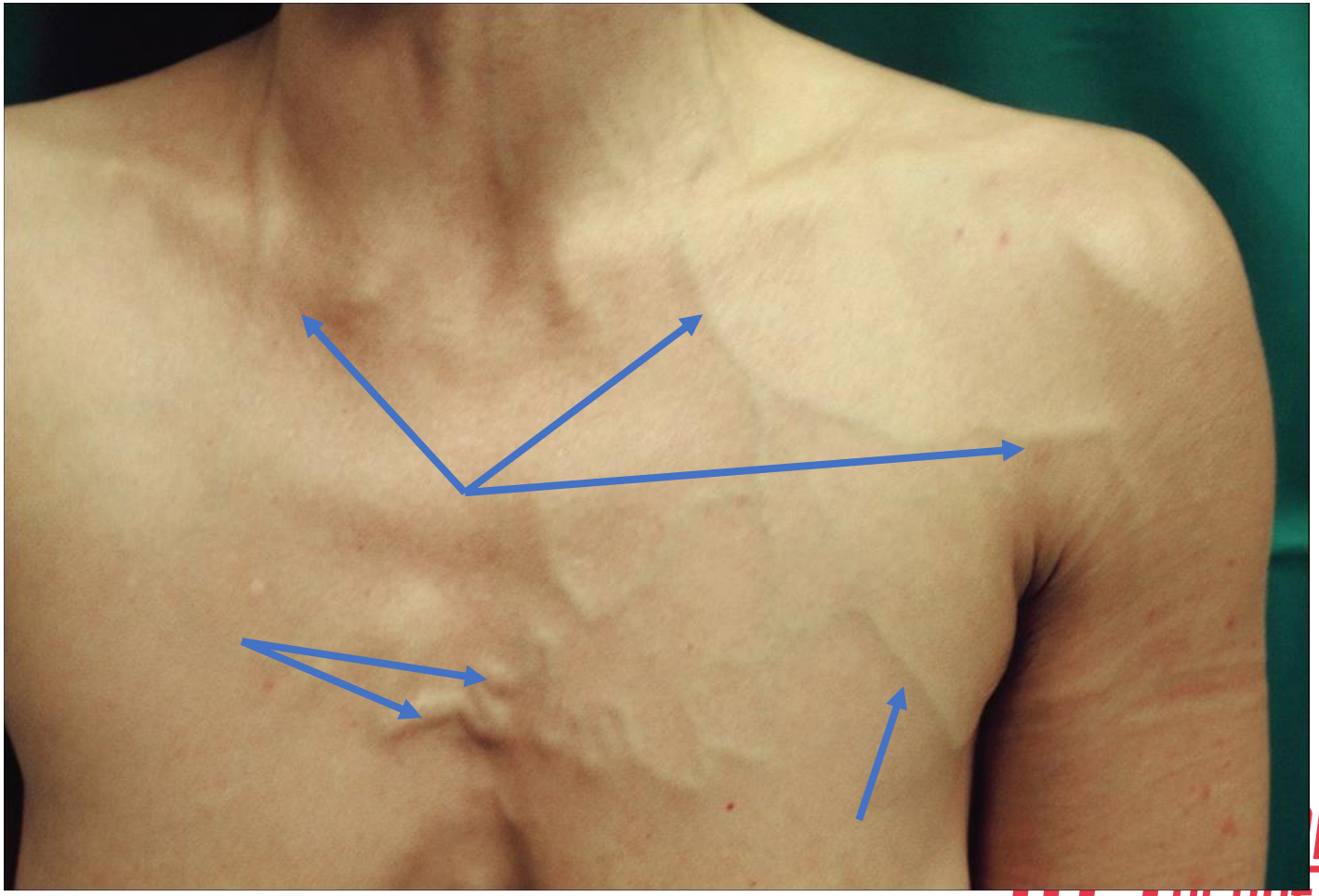
Identifying Thrombosis

Signs & Symptoms



Dilatation of subcutaneous collateral veins in a patient with left-sided upper extremity deep venous thrombosis.

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US Criteria for Diagnosis of Catheter-Related DVT (CR-DVT)

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

Review of Treatment for CRT

Contents lists available at ScienceDirect

Thrombosis Research

journal homepage: www.elsevier.com/locate/thromres

Full Length Article

Overview of VTE treatment in cancer according to clinical guidelines☆

Agnes Y.Y. Lee*

Department of Medicine, University of British Columbia, Vancouver, BC, Canada
British Columbia Cancer Agency, Vancouver, BC, Canada

• For symptomatic catheter-related thrombosis, anticoagulant treatment is recommended for a minimum of 3 months, using LMWH, noting that direct comparisons have not be done with respect to anticoagulant or duration of therapy (Guidance).

• Catheter can be kept in place if it is functional, well positioned, and non-infected with good resolution of symptoms under close surveillance (Guidance).

2012

CHEST Supplement

ANTITHROMBOTIC THERAPY AND PREVENTION OF THROMBOSIS, 9TH ED: ACCP GUIDELINES

Antithrombotic Therapy for VTE Disease

Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines

2016

Antithrombotic Therapy for VTE Disease

CHEST Guideline and Expert Panel Report

Clive Kearon, MD, PhD; Elie A. Akl, MD, MPH, PhD; Joseph Ornelas, PhD; Allen Blaivas, DO, FCCP; David Jimenez, MD, PhD, FCCP; Henri Bounameaux, MD; Menno Huisman, MD, PhD; Christopher S. King, MD, FCCP; Timothy A. Morris, MD, FCCP; Namita Sood, MD, FCCP; Scott M. Stevens, MD; Janine R. E. Vintch, MD, FCCP; Philip Wells, MD; Scott C. Woller, MD; and COL Lisa Moores, MD, FCCP

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CURRENT ONCOLOGY
A Canadian Cancer Research Journal

PRACTICE GUIDELINE

Treatment algorithm in cancer-associated thrombosis: Canadian expert consensus

M. Carrier MD MSc,* N. Blais MD MSc,† M. Crowther MD MSc,‡ P. Kavan MD PhD,§ G. Le Gal MD PhD,* O. Moodley MD,|| S. Shivakumar MD,# V. Tagalakis MD MSc,** C. Wu MD,†† and A.Y.Y. Lee MD MSc‡‡

Received: 6 January 2018 | Accepted: 4 March 2018
DOI: 10.1002/rth2.12102

REVIEW ARTICLE

rpth research & practice in thrombosis & haemostasis

Managing thrombosis in cancer patients

Tzu-Fei Wang MD[1] | Ang Li MD[2] | David Garcia MD[2]

Contents lists available at ScienceDirect
Thrombosis Research
journal homepage: www.elsevier.com/locate/thromres

Full Length Article

Prothrombotic genotypes and risk of venous thromboembolism in cancer

Olga V. Gran[a,*], Sigrid K. Brækkan[a,b], John-Bjarne Hansen[a,b]

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[b] Division of Internal Medicine, University Hospital of North Norway, Tromsø, Norway

Journal of Thrombosis and Thrombolysis
https://doi.org/10.1007/s11239-018-1708-0

CrossMark

Residual vein obstruction in patients diagnosed with acute isolated distal deep vein thrombosis associated with active cancer

F. Dentali[1] · S. Barco[2] · S. Pegoraro[1] · M. N. D. Di Minno[3] · D. Mastroiacovo[4] · F. Pomero[5] · C. Lodigiani[6] · F. Bagna[1] · M. Sartori[7] · G. Barillari[8] · N. Mumoli[9] · M. Napolitano[10] · S. M. Passamonti[11] · R. Benedetti[12] · W. Ageno[1] · M. Di Nisio[13]

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Full Length Article

Risk and prognosis of cancer after upper-extremity deep venous thrombosis: A population-based cohort study

Kasper Adelborg[a,*], Erzsébet Horváth-Puhó[a], Jens Sundbøll[a], Paolo Prandoni[b], Anne Ording[a], Henrik Toft Sørensen[a]

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Full Length Article

Risk prediction of cancer-associated thrombosis: Appraising the first decade and developing the future

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Biol Blood Marrow Transplant 24 (2018) e20–e25
Biology of Blood and Marrow Transplantation
journal homepage: www.bbmt.org
ASBMT American Society for Blood and Marrow Transplantation

Brief Article

Catheter-Related Thrombosis in Patients with Lymphoma or Myeloma Undergoing Autologous Stem Cell Transplantation

Livia Hegerova[1,*], Adam Bachan[2], Qing Cao[3], Huong X. Vu[4], John Rogosheske[4], Mark T. Reding[5,6], Claudio G. Brunstein[6,7], Mukta Arora[6,7], Celalettin Ustun[6,7], Gregory M. Vercellotti[6,7], Veronika Bachanova[6,7]

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journal homepage: www.elsevier.com/locate/thromres

Full Length Article

Risk and prognosis of cancer after upper-extremity deep venous thrombosis: A population-based cohort study

Kasper Adelborg[a,*], Erzsébet Horváth-Puhó[a], Jens Sundbøll[a], Paolo Prandoni[b], Anne Ording[a], Henrik Toft Sørensen[a]

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Contents lists available at ScienceDirect
Journal of Cardiology
journal homepage: www.elsevier.com/locate/jjcc

Review

Mechanism and management of cancer-associated thrombosis

Mikio Mukai (MD, PhD)*, Toru Oka (MD, PhD)

Osaka Prefectural Hospital Organization, Osaka International Cancer Institute, Department of Medical Check up, Onco-Cardiology Unit, Osaka, Japan

2018-2019 publications

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.

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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[1]
- Reverse tapered catheters[2]

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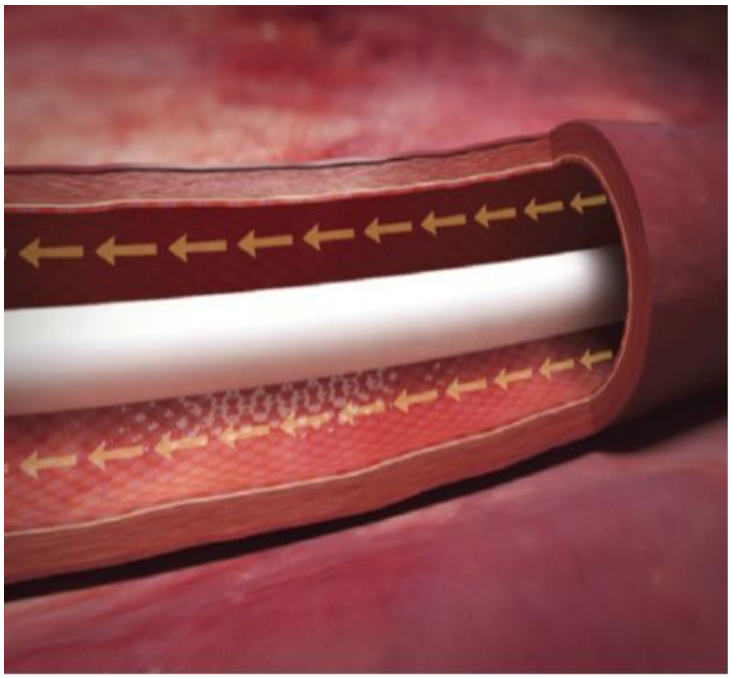
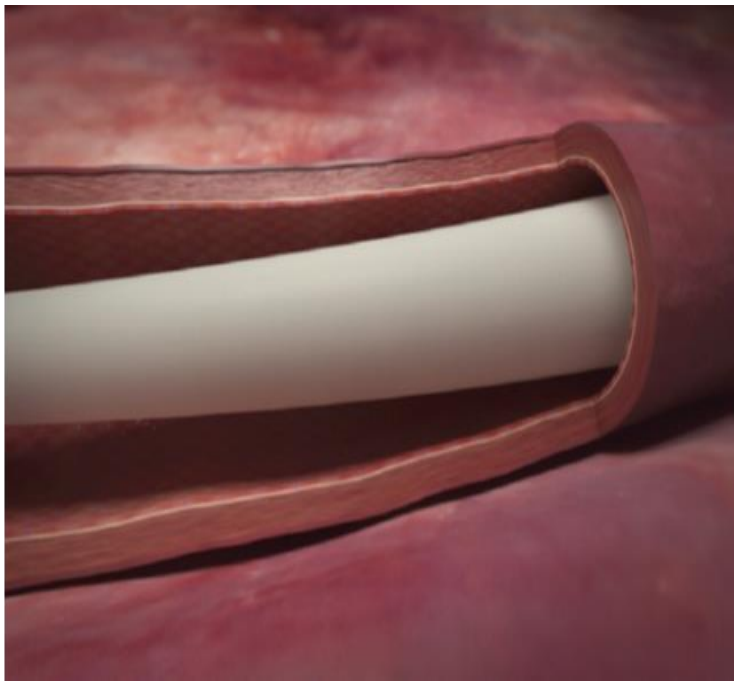
Catheter-Related Risk Factors



Catheter Size



Catheter Taper

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INS SOP

- 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

Virchow's components

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.
5. Known presence of genetic coagulation abnormalities (eg, Factor V Leiden, prothrombin mutation).
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] (II)

Ongoing Assessment

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 Vessel Ratio

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*." [1]

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Catheter Vessel Ratio

- The term CVR (Catheter to Vessel Ratio) has not been previously defined by the Infusion Nurses Society (INS).
- Prior, there was no mention of any reference to CVR in INS 2002 & 2011
- 2016 INS Standards of Practice - 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.

A little tubular physics…

- The influence of lumen diameter on resistance is dramatic

- A slight increase or decrease in diameter causes a huge decrease or increase in resistance.

- This means, for example, that if an vein/artery constricts to one-half of its original radius, the resistance to flow will increase 16 times.

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CVR and Thrombosis

- 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, 3, 4] Conversely, smaller-gauge PICCs occupy less cross-sectional venous area thus allowing greater blood flow around the catheter, substantially reducing this risk[2, 3, 4]
- 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, 3, 4]

CVR and Thrombosis

- There is now established clinical evidence that shows CRT is related to the catheter size within the intraluminal space[1,2,3,4]
- An increase in the number of PICC lumens also results in greater French/gauge, a factor independently associated with risk of DVT[5]
- 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[6]

CVR and Thrombosis

- In evaluating risk factors for thrombosis, Itkin et al, (2013) and Chopra et al (2014) 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

Why is this important?

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

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Size + Flow Matters!

	Radius of Vessel (mm)[4]	Length (CM)	Actual Diameter	Approx. mL/Min.
Cephalic 	3^4	38 cm	2-4 mm	81
Basilic 	4^4	24 cm	4-6 mm	256
Axillary 	8^4	13 cm	16 mm	4,096
Subclavian 	9.5^4	6 cm	19 mm	8,145
SVC 	12.5^4	7 cm	20 mm	24,414

Catheter to Vessel Ratio

Flow Model Chart (Nifong, 2011)		2F Catheter Inserted		4F Catheter Inserted		6F Catheter Inserted		8F Catheter Inserted	
Vein and Vein Size	Initial Flow (ml/min)	Flow Reduction		Flow Reduction		Flow Reduction		Flow Reduction	
Cephalic (4mm)	10	5ml	48% remaining	3ml	28% remaining	1.5ml	14% remaining	0.5ml	0.5% remaining
Brachial (5mm)	25	13ml	53% remaining	9ml	36% remaining	6ml	22% remaining	3ml	12% remaining
Basilic (6 mm)	52	29 ml	56% remaining	21ml	41% remaining	15ml	28% remaining	9ml	18% remaining
Axillary (8mm)	164	100ml	61% remaining	79ml	48% remaining	62ml	38% remaining	47ml	28% remaining
Subclavian (10mm)	400	256ml	64% remaining	212ml	53% remaining	175ml	44% remaining	143ml	36% remaining

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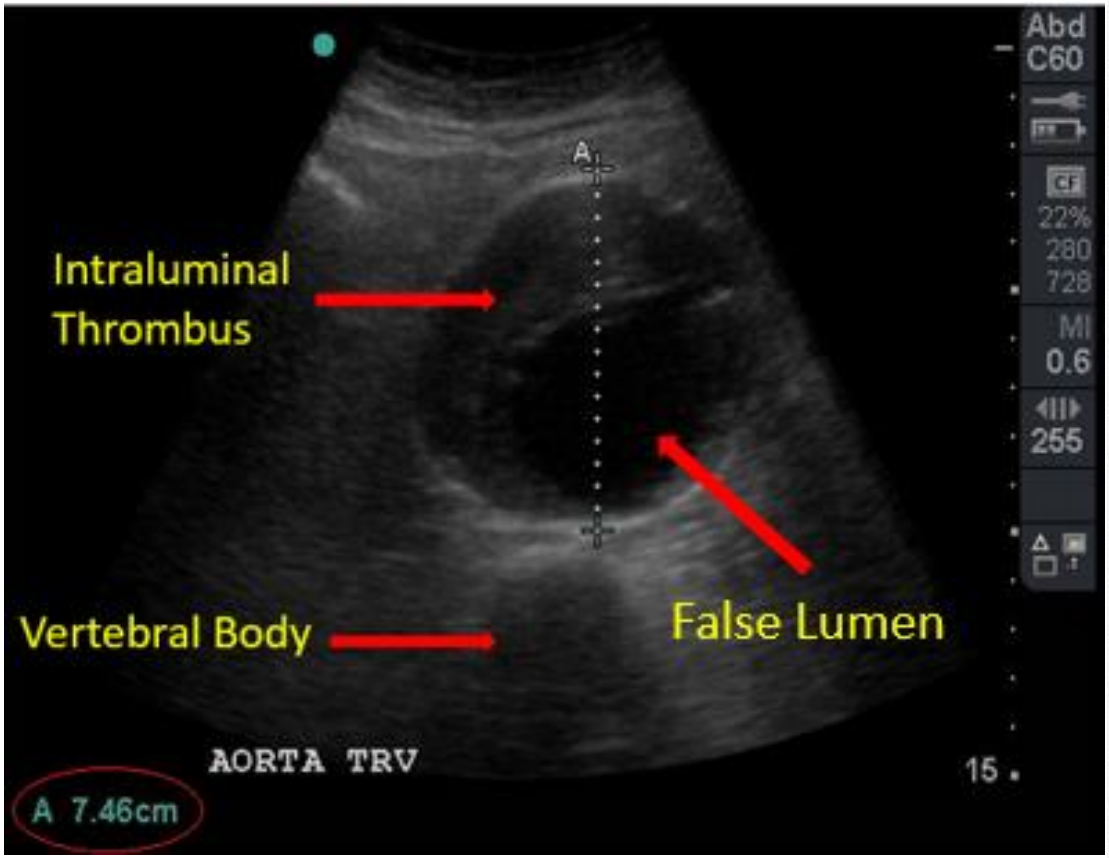
Show me the money!

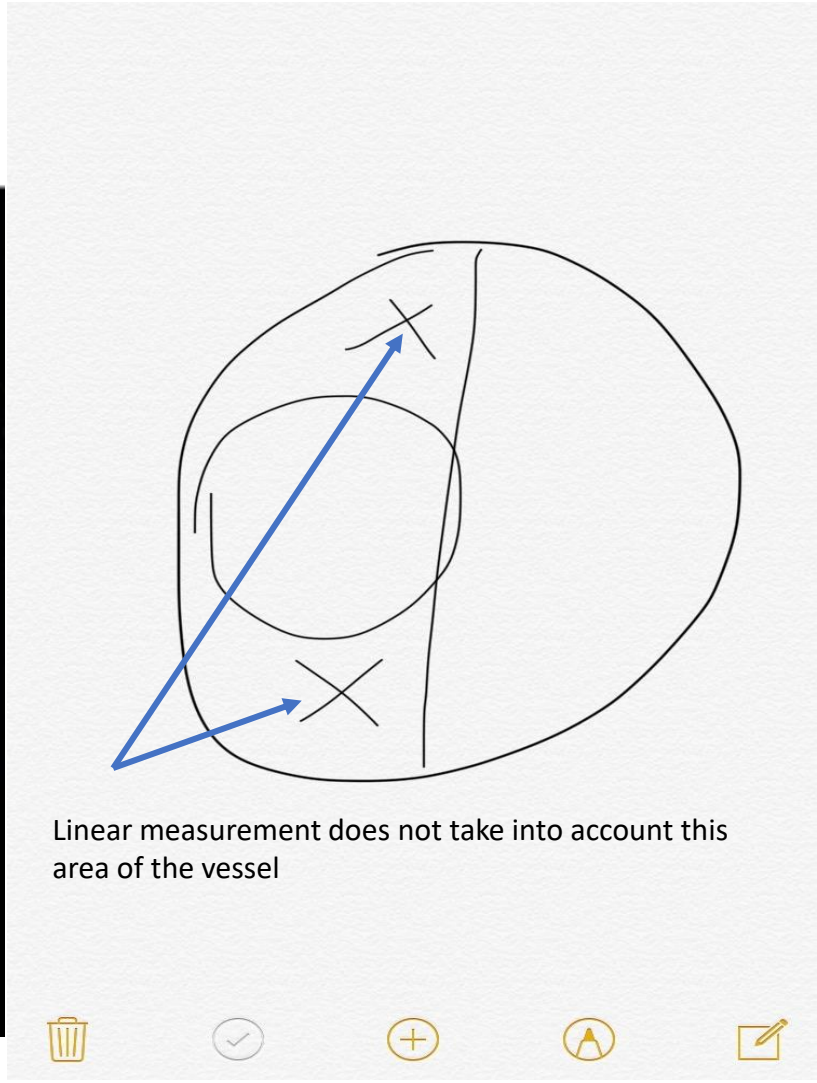
- A review of the INS SOP from both 2002 and 2011 did not specify a recommended vessel size or measurement to set an upper limit of outer diameter for a vascular device to be placed[1]
- The 2016 INS Standards[2] however did include more recent evidence to say that a catheter vessel ratio of ≤ 45% was a satisfactory risk prevention strategy. A supporting publication showed that there was statistical significance with catheter vessel ratios ≥ 45%, with a 13-fold increase in CRT risk[3]
- What is missing was the actual unit of measurement.

Catheter to Vessel Ratio tool

- Comparison of the traditional ‘rule of thumb’, or 33% rule, and the recent 45% rule of CVR[1]
- However, these general rules are traditionally based on a single, linear 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 the two-dimensional view seen on the ultrasound.

Cross-sectional area





Linear measurement does not take into account this area of the vessel

Catheter to Vessel Ratio tool

- The aim of the tool is simplicity and effectiveness. A quick and accurate review with a simple color chart scheme to highlight the areas (or zones) of CVR safety, which have been color-coded accordingly:

RED ZONE - 45% or greater—high risk zone

YELLOW ZONE - 34–44%—cautionary zone

GREEN ZONE - 33% or less—safe zone

Catheter to Vessel Ratio tool

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%

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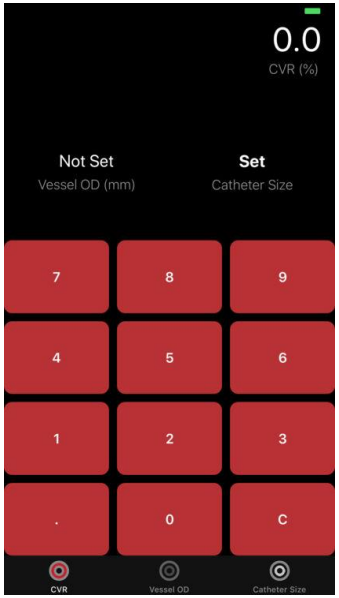

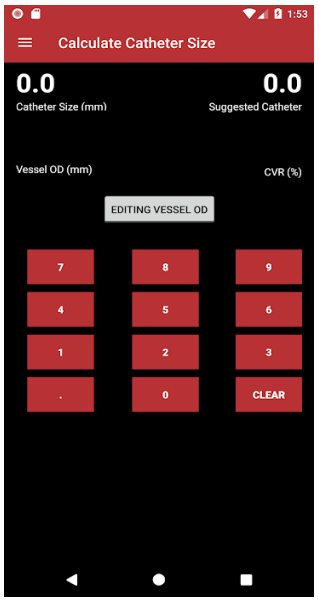

“Now there’s an app for that..”

- CVRCalc, an area based CVR tool is now available from the Apple App Store and Google Play.
- Designed to take the ‘hard math’ out of the process and assist clinicians in determining best CVR.

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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 functionality 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]

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Thrombosis & Catheter Removal

- 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.
- CHEST (2012 & 2016) guidelines recommend the active treatment of the thrombus without catheter removal[2]

https://journal.chestnet.org/issue/S0012-3692(12)X6003-3

https://journal.chestnet.org/article/S0012-3692(15)00335-9/fulltext

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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[1]
- 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 thrombotic occlusion of the lumen.*

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