Innovations in Vascular Access

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1e Post WoCoVA
De patiënt centraal

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De Eenhoorn in Amersfoort

WoCoVA
5th World Congress on Vascular Access

VIT
vereniging infuus technologie

Innovations in Vascular Access

WoCoVA
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What is new?!

- Preoperative strategy for the best location
- Insertion techniques and improvements
- New catheter designs
- Optimal catheter maintainance
- Complication diagnosis & management

Classification of central catheters

PICC

peripheral inserted central catheters
insertion in **arm veins** (brachialis, basilica, axillaris, cephalica)

CICC

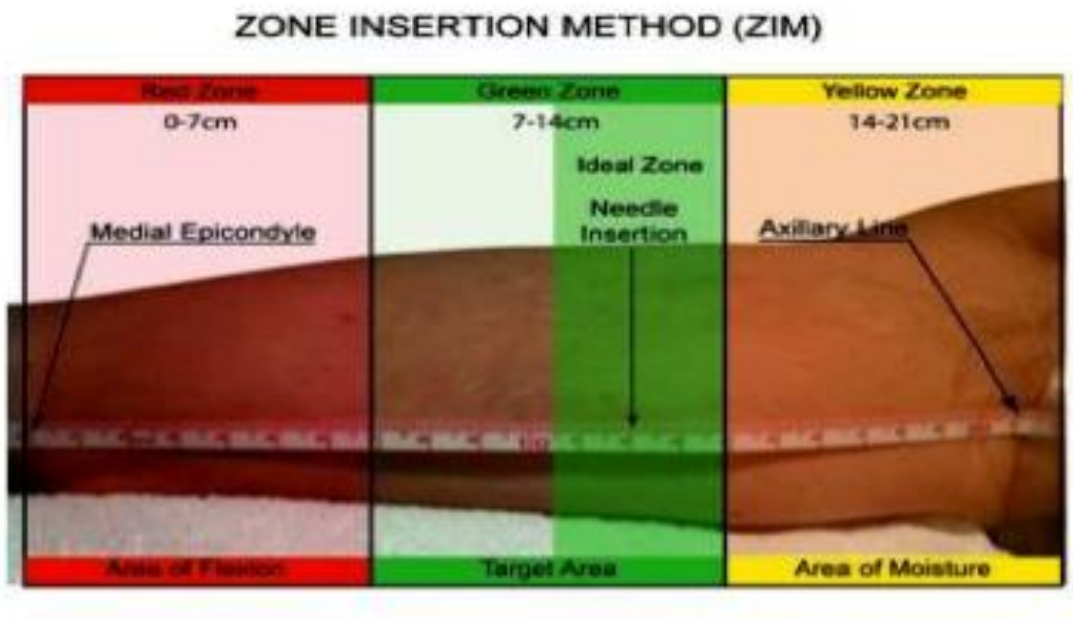
central inserted central catheters
insertion in **supra/infraclaviculaire veins** (int & ext jugularis, subclavia, brachio-cephalica, axillaris, cephalica)

FICC

femoral inserted central catheters
insertion in **groin & thigh veins** (femoralis com, femoralis sup, saphena)

Preoperative strategy for the best catheter location

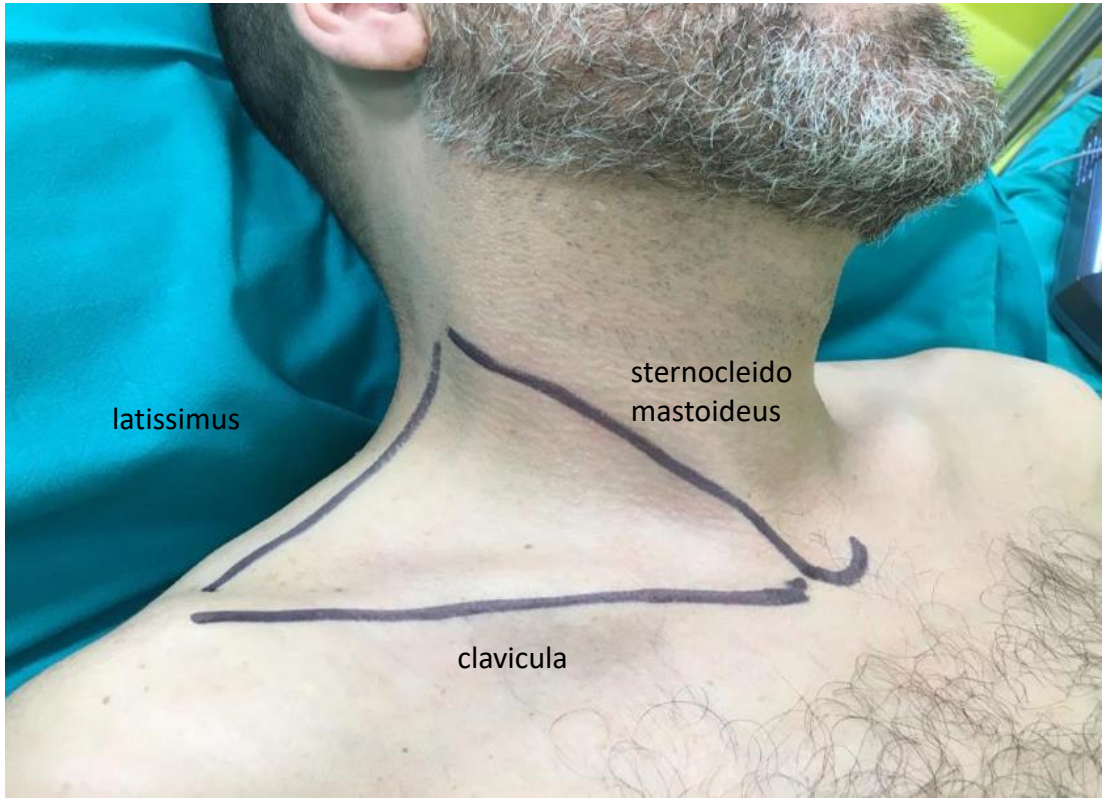
ZIM = Zone Insertion Method
PICC lines

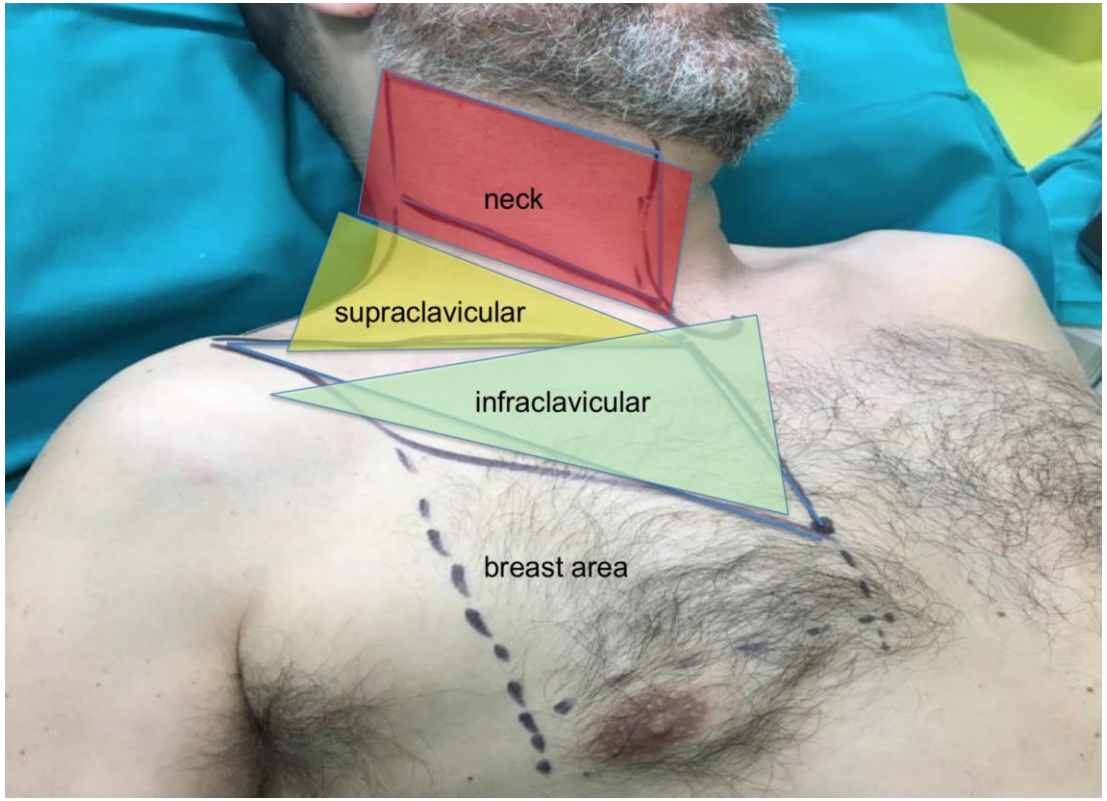


3 x 7 cm zones

Green zone most ideal

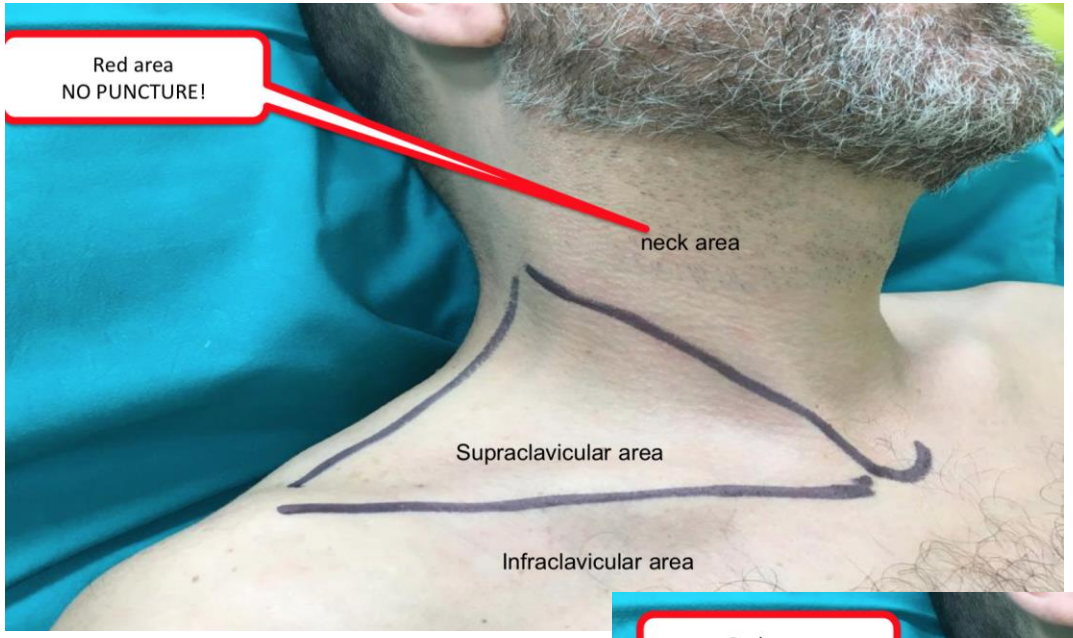
ZIM = Zone Insertion Method
CICC lines

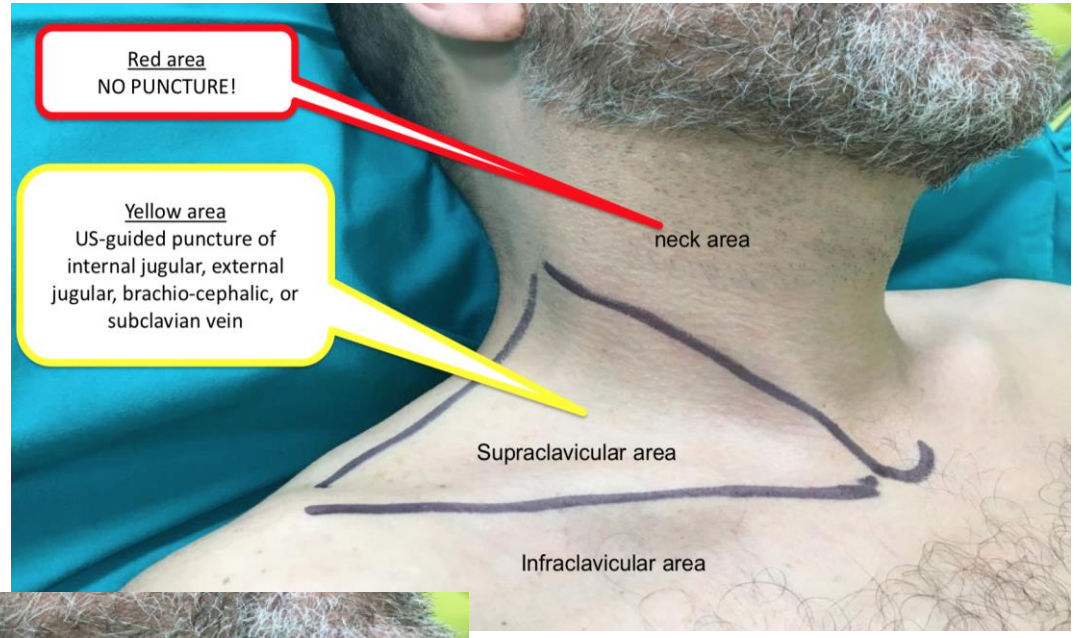




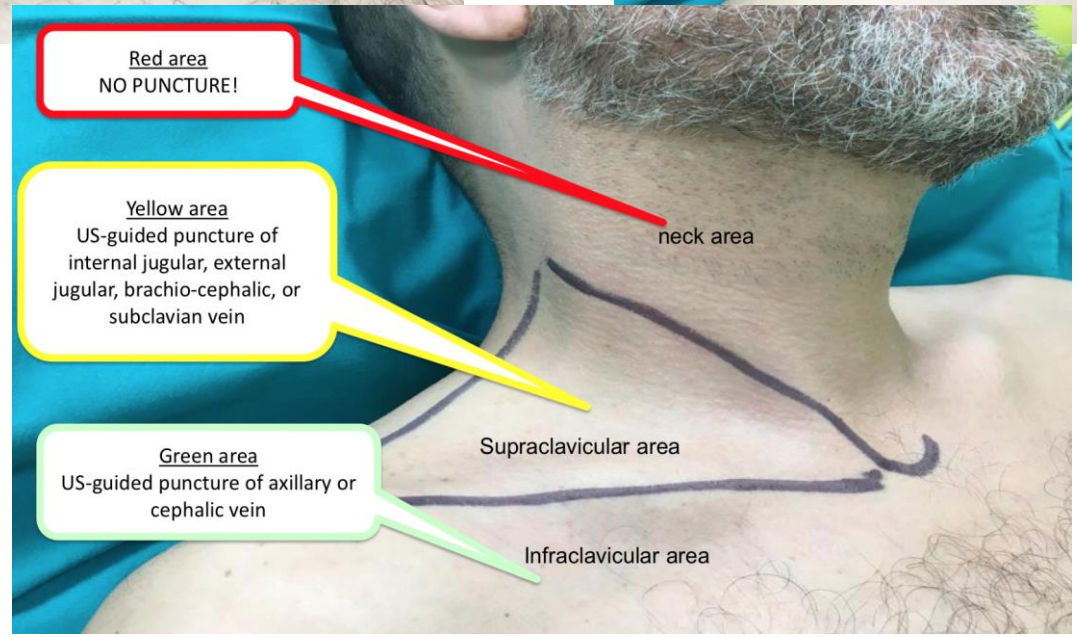
Anatomical landmarks

ZIM = Zone Insertion Method
CICC lines





Punction zones

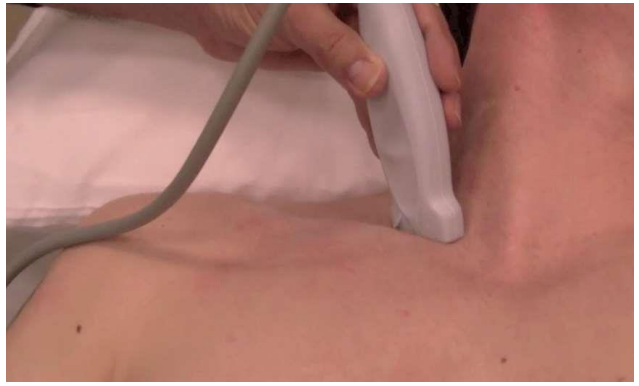


Rapid Central Veins Assessment (RaCeVA)

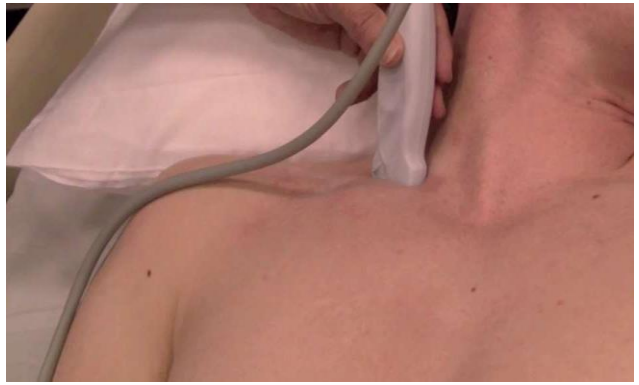
Rapid Peripheral Veins Assessment (RaPeVA)

Mid Neck
IJV + CA + TYROID

Bottom NECK
IJV (+ valves) + SA



Brachiocephalic vein



Subclavian vein (supraclavicular)
Subclavian artery

Infraclavicular (short axis)
Axillary vein and artery
Cephalic vein

Infraclavicular (long axis)
Axillary vein and artery
Cephalic vein

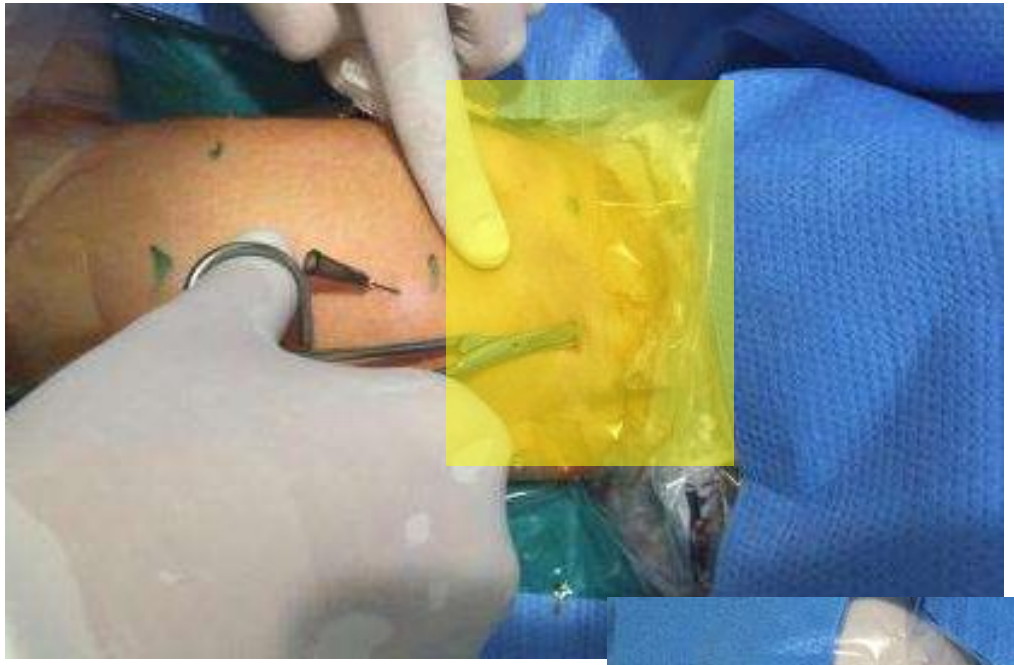
Strategy for best insertion technique/location

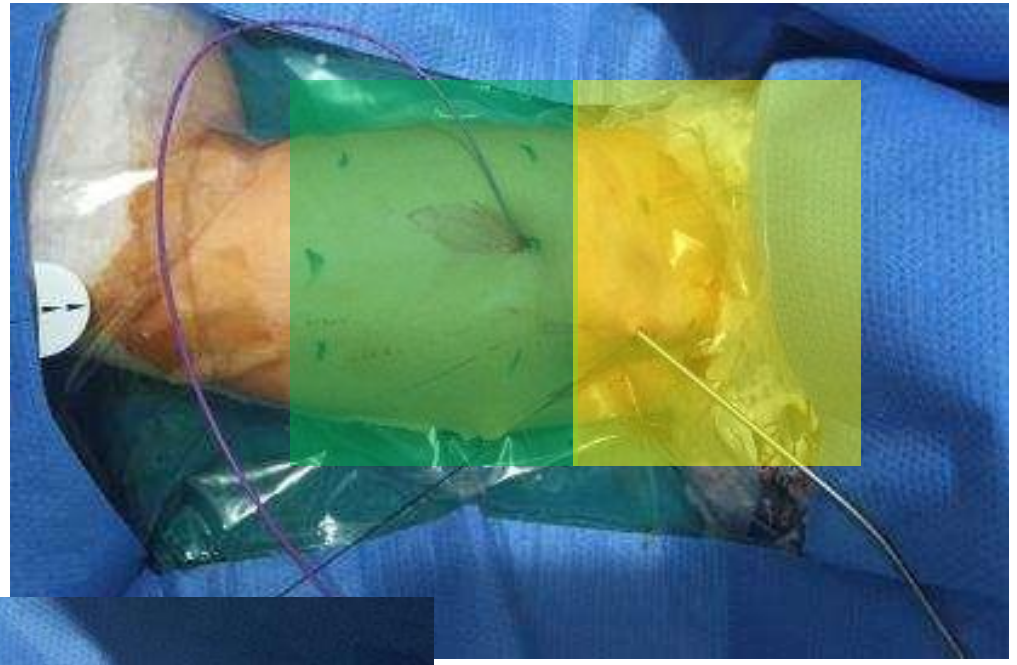
- **Minimize the trauma to the vein wall**
  - Use ultrasound to increase first-attempt success
  - Use micro-introducer kits when feasible
  - Stabilize the catheter to reduce further trauma to the vein wall

- **Minimize the reduction of residual blood flow**
  - Match properly the catheter size with the vein size. To be ‘in the safe zone’, a 33% rule is recommended: outer diameter of the catheter (Fr) equal or inferior to inner diameter of the vein (mm)

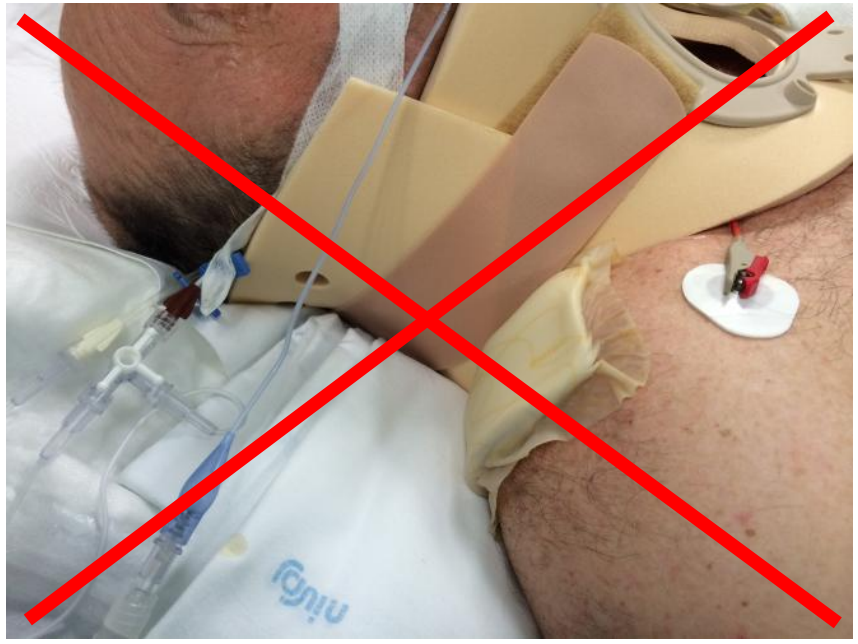
- **Locate the tip of the catheter (specifically for central catheters) so that it may be in a high flow vein and in the middle of the flow**
  - Use an appropriate method of confirmation of tip location (for central catheters)

Tunneling of PICC lines





Tunneling of CICC lines



Mid thigh femoral vein CVC (FICC)

Indications
Superior vena cava syndrome
Deep Vein Thrombosis to other upper extremity veins (e.g. axillary, subclavian, jugular, brachiocephalic)
Paresis, contractures, amputation or circulatory impairment to upper extremities; certain neurology patients, advanced Parkinson's, multiple sclerosis, Amyotrophic Lateral Sclerosis
Arteriovenous fistula to upper extremity
Trauma, surgery or tumors with impairment or limitations to circulation
Cervical/neck trauma or upper extremity abnormal venous anatomy
High risk coagulopathy, hemophilia or thrombocytopenia
Bilateral mastectomy
Pacemaker, acute or tunneled catheter
subcutaneously implanted port, defibrillator, or
SVC Filter
Inability to lie supine for supraclavicular insertion
Claustrophobia under full body drape
Skin conditions or infection impairing upper extremities
Chronic conditions where no veins in upper extremities are suitable as in sickle cell and cystic fibrosis
Inadequate upper extremity vein size

- Easy to perform
- Lower procedural complications
- Uncooperative patient
- Dependable access for less-experienced operators
- Decreased Insertion Related Risks
- Decreased Infection Risk

Tunneling of FICC lines

FICC in v saphena magna

Exit site in red zone!

Tunneling of PICC lines

Midline (green zone)

Axilla insertion (yellow zone)

		$^{2}/_{3}$ mm		$1\ ^{1}/_{3}$ mm		2 mm		$2\ ^{2}/_{3}$ mm	
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

Lower risk on trombosis

Tunneling of PICC lines

VAD	Advantages: long-time use		Osmolality range
PIV	72-96 hrs	Between 5 and 9	Under 600 mOSm/L
Extended dwell PIV	Up to 29 days	Between 5 and 9	Under 600 mOSm/L
Midline	2-4 weeks	Between 5 and 9	Under 600 mOSm/L
PICC	Less than one year	All	All
Non-tunneled CVC	3-7 days	All	All
Tunneled CVC	Greater than 6 wks	All	All
Implantable port	Greater than 1 year Or intermittent use	All	All

Tunneling of PICC lines

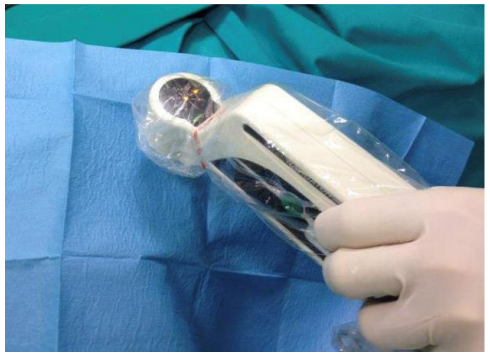
Summary

- Lower risk on thrombosis (larger veins)
- Favourable exit site (green zone)
- Lower risk on infection
- Lower risk on migration (cuff PICC)
- Long-term use is possible

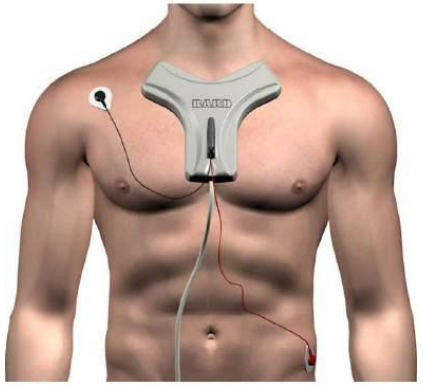
Tip navigation and positioning

Electromagnetic methods for tip navigation: which evidence?

- **Hand-held detectors**
  - CathFinder (*Pharmacia*)
  - CathTrack/Navigator
  - (*Bard, Navion, Vyasis, Corpak*)



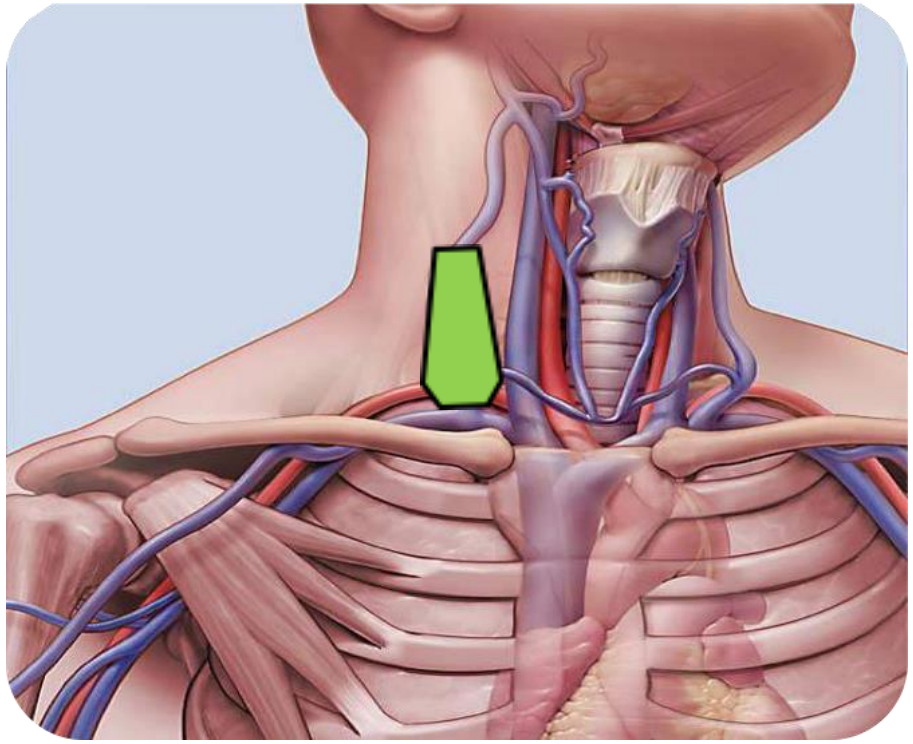
- **Fixed detectors over the chest cage**
  - CathRite (*Micronix*)
  - Sherlock (*Bard*)
  - Sherlock 3CG (*Bard*)
    - **coupled with a tip location system**
  - VPS Rhythm (*Teleflex*)
    - **coupled with a tip location system**

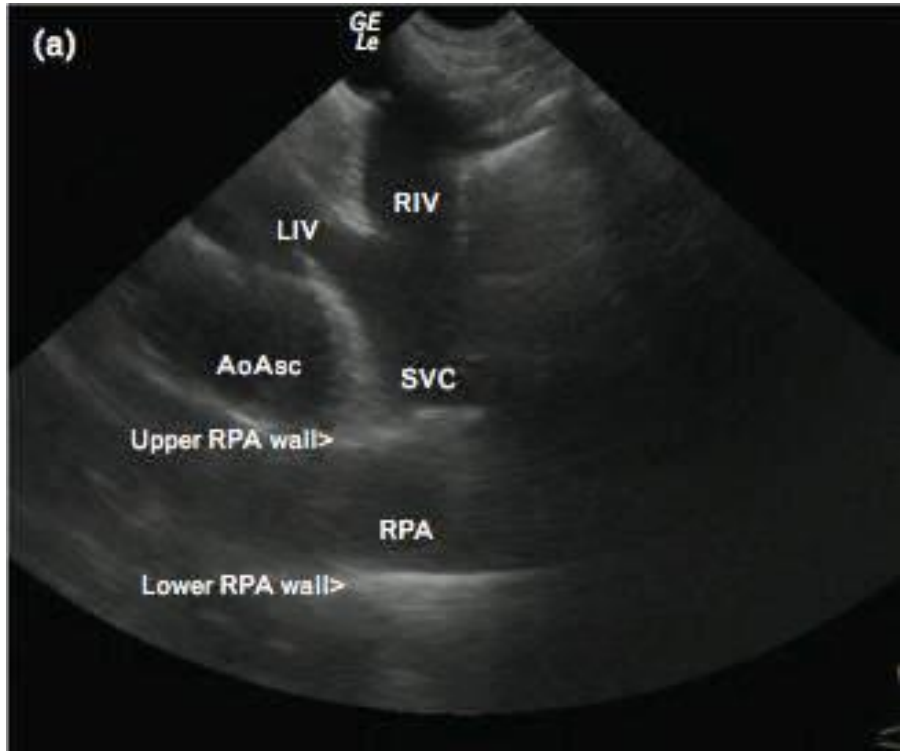


Tip navigation by electromagnetic technology

- At present, no anatomical correlation between the detected catheter signal and the surrounding environment are available for any device
- All the systems project the surface detection within the body relying on predictive relationships between the atrial-caval and the chest cage
- Waiting for real-time imaging 3D reconstruction (ultrasound?) of target position to be added to the tracking system

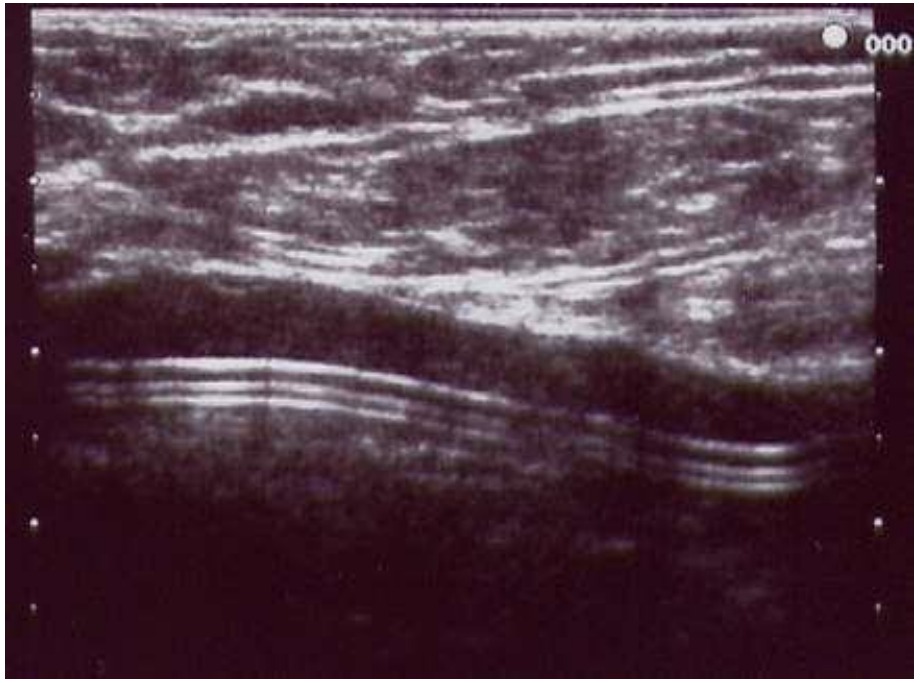
Tip navigation methods

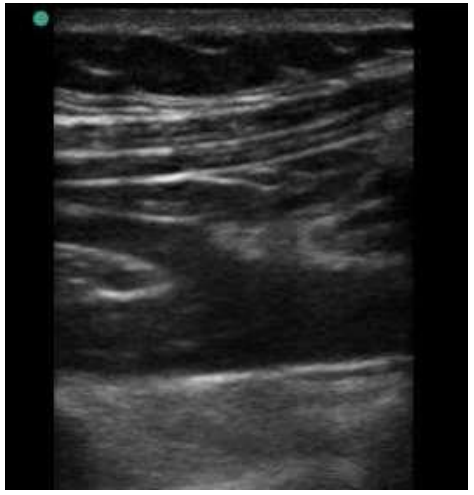




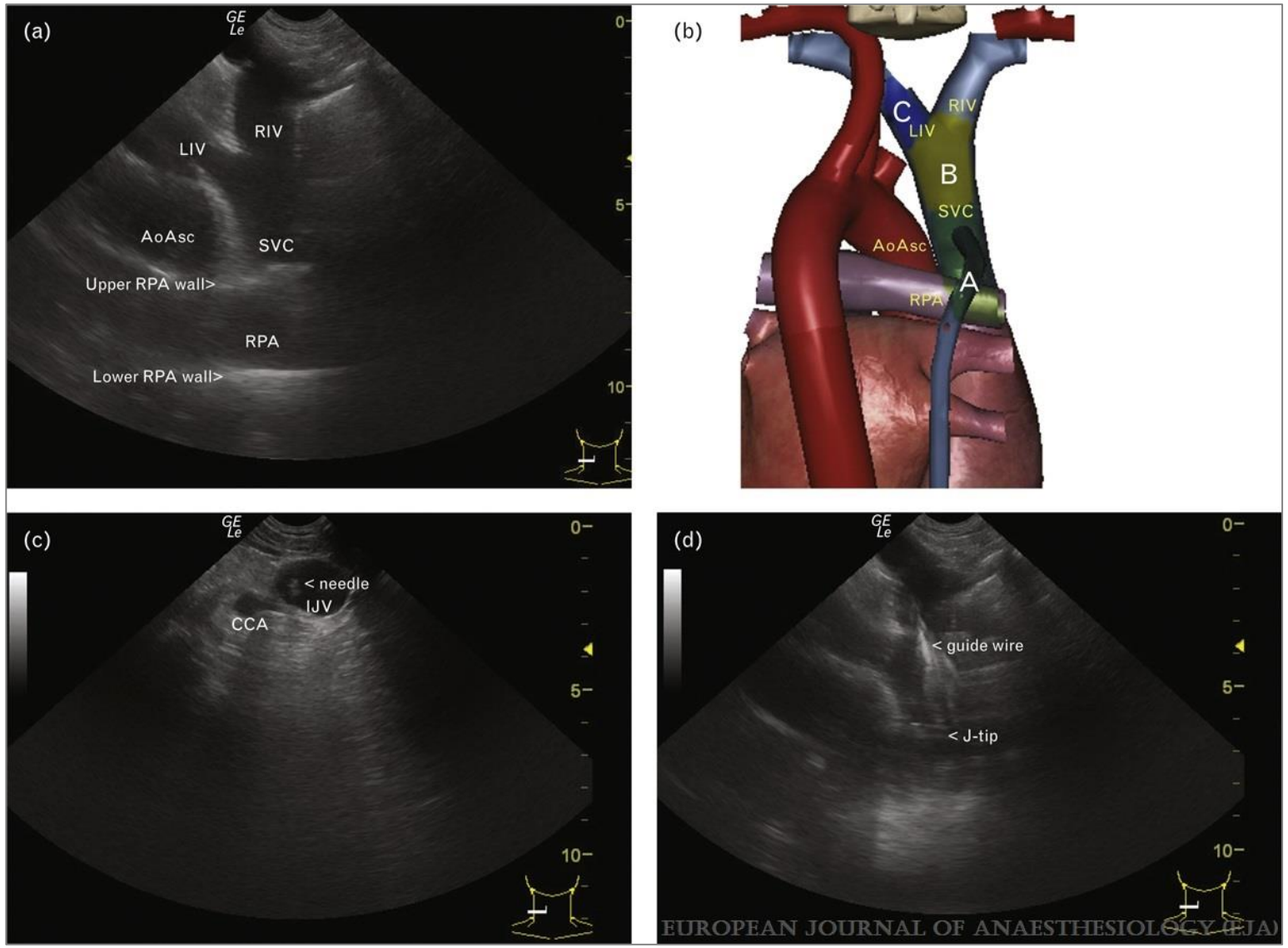
- **Ultrasound can confirm catheter position with:**
  - Supraclavicular views
  - Transthoracic echocardiographic views
  - Transoesophageal echocardiographic views

US based tip navigation technique





Ultrasound imaging central venous catheter position



a. Right supraclavicular view of left innominate vein (LIV), right innominate vein (RIV), superior vena cava (SVC), ascending aorta (AoAsc), right pulmonary artery (RPA). The upper vessel wall of the RPA was considered as target zone of the J-tip.

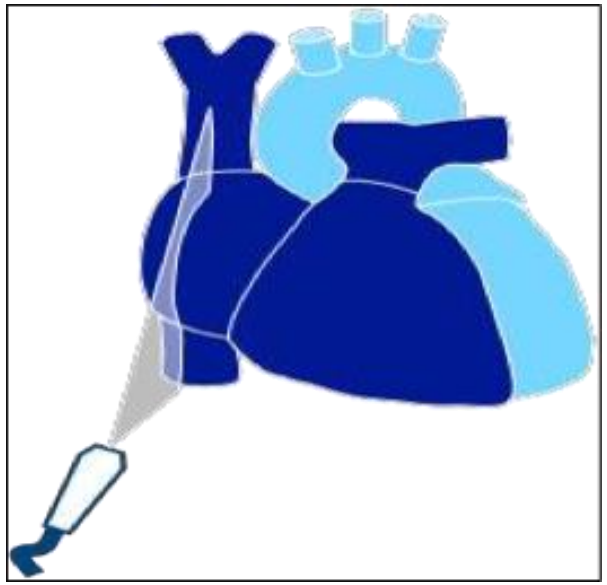
b. Posterior anatomical view of intrathoracic vessels as seen in (a). Zone A represents the lower SVC with the RPA crossing the base of the SVC. Zone B represents the junction of both innominate veins and the upper SVC. The left innominate vein lies within Zone C.

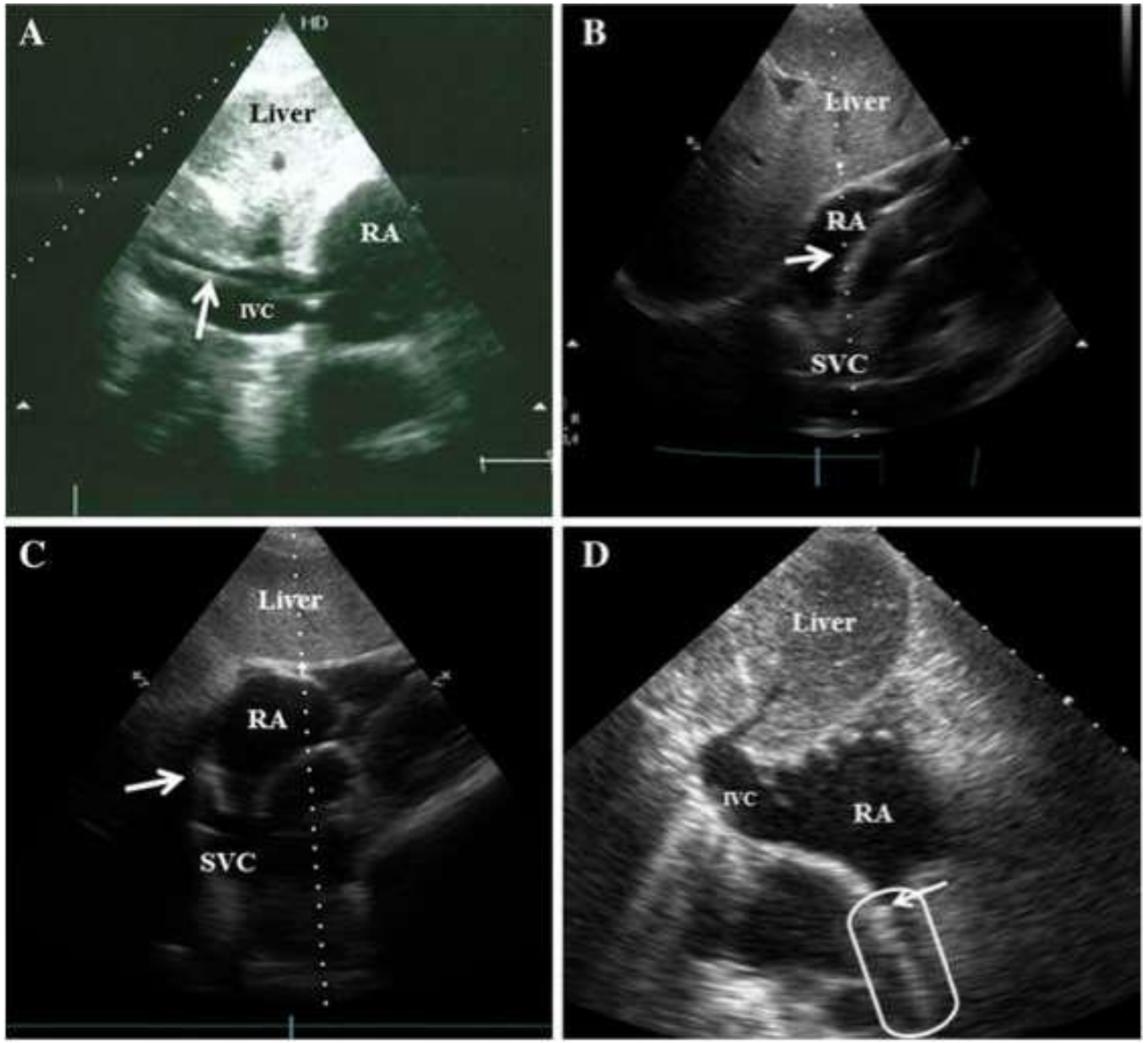
c. Venous puncture of IJV.

d. Right supraclavicular view of guidewire in the SVC.

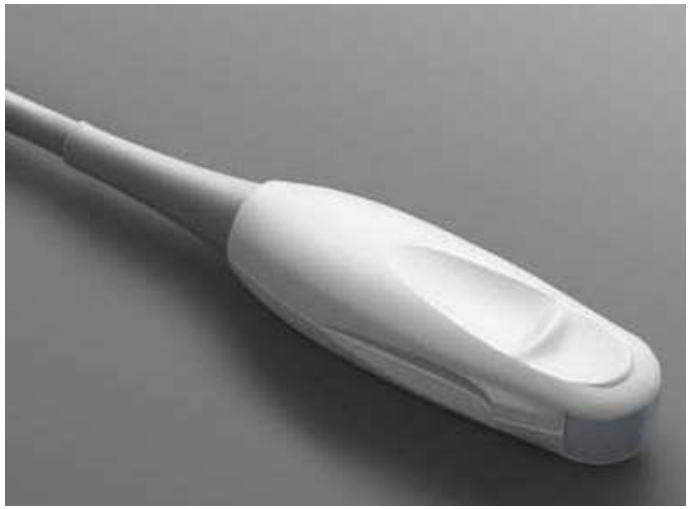
European Journal of Anaesthesiology (EJA)32(1):29-36, January 2015

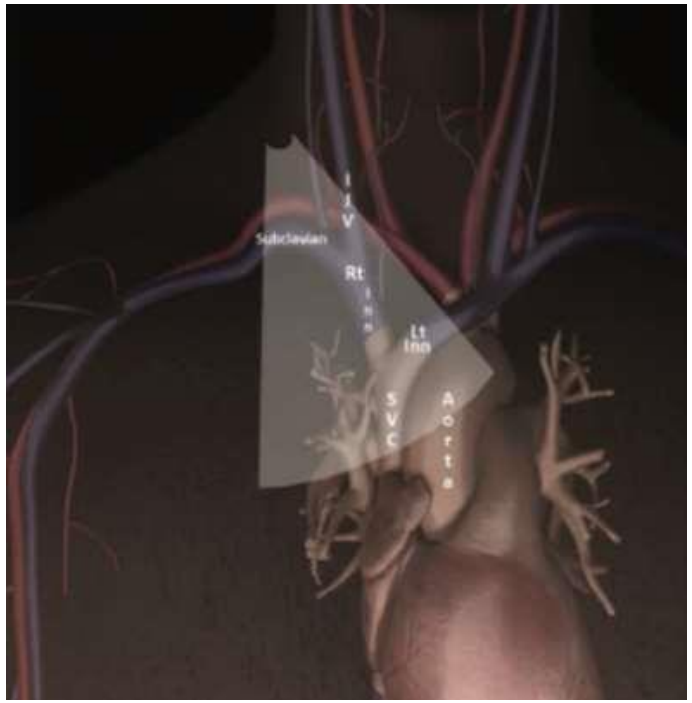
US based tip location technique





US based tip location technique





32 studies on US detection of CVC malposition

- 11 studies in which Vascular US was coupled with TTE +/- CEUS
- In 6 studies advancement of the guidewire was assessed by US
  In the remaining 26 studies the CVC was visualized by US directly after placement
- US to detect CVC malposition is feasible in 96.8% of cases
- US to detect CVC malposition as a tip location technique has an overall pooled specificity of 98.9 (95% CI: 97.8–99.5) and sensitivity of 68.2 (95% CI: 54.4–79.4)

New devices and techniques

New devices: long peripheral cannule

Short peripheral cannules

- Teflon of PUR
  Length < 52 mm
  Insertion technique: ‘catheter over needle’
  – for superficial veins (< 7mm depth)

Long peripheral cannules

- PUR, PE or PEBA
  Length 6-15 cm
  Insertion technique: Seldinger (‘cannula over guidewire’)
  Also for US-guided access to the deep veins (> 7mm depth)

New devices: long peripheral cannule

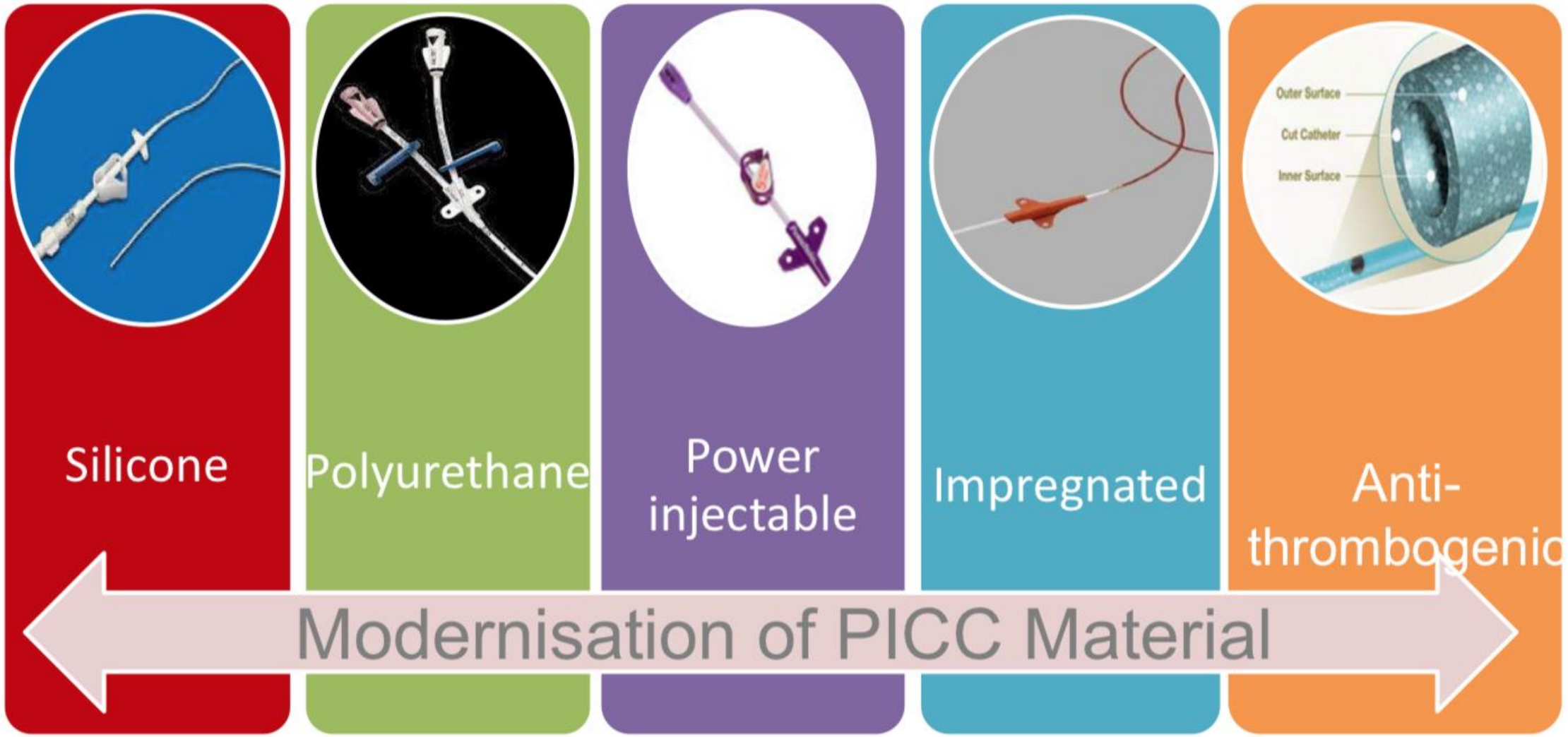
- Ultrasound-guided short cannules are suitable for a period of <24-48 hrs

- Ultrasound-guided mini-midlines are ideal for DIVA (Difficult Intra-Venous Access) patients, in acute and elective setting

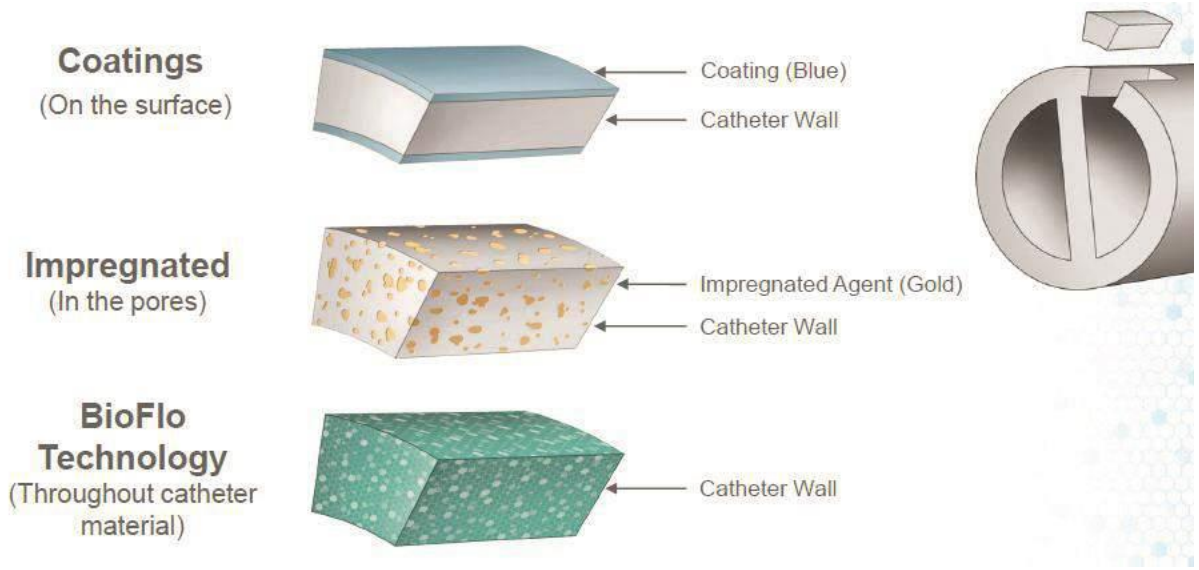
- Mini-midlines are ideal for an infusion period of 1 to 4 wks

- Traditional midlines (midclaviculair) are ideal for extramural patients

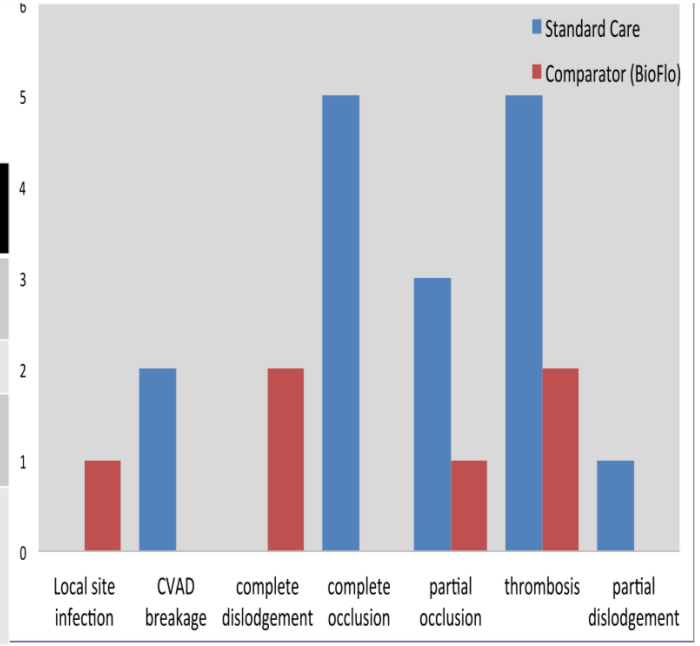
Innovation of catheter material



Innovation of catheter material



N=150	Standard Care	Endexo ®	p-value
Group size	75 (50%)	75(50%)	
Failure	16 (22%)	8 (11%)	0.087
Catheter days	1268	1097	
IRR (per 1000 days, 95% CI)	referent	0.58 (0.21-1.43)	0.172




dialysis catheter

Endexo technology is permanent, non-eluting polymer "blended" into the polyurethane from which the catheter is made

	Standard Care	Endexo®	P-VALUE
Aspiration occlusion	**12 (16%)**	**6 (8%)**	
• Fibrinolysis not attempted	3	2	
• Fibrinolysis unsuccessful	2	1	
• Resolved with fibrinolysis	7	3	
Complete occlusion	**10 (13%)**	**2 (2.5%)**	
• Fibrinolysis not attempted	2	1	
• Fibrinolysis unsuccessful	2	0	
• Resolved with fibrinolysis	6	1	
Pain during treatment (local)	**9 (12%)**	**4 (6%)**	
Redness during treatment (local)	**8 (11%)**	**1 (1%)**	
TOTAL ALL CAUSE COMPLICATION	**23 (77)**	**7(23)**	**0.009**

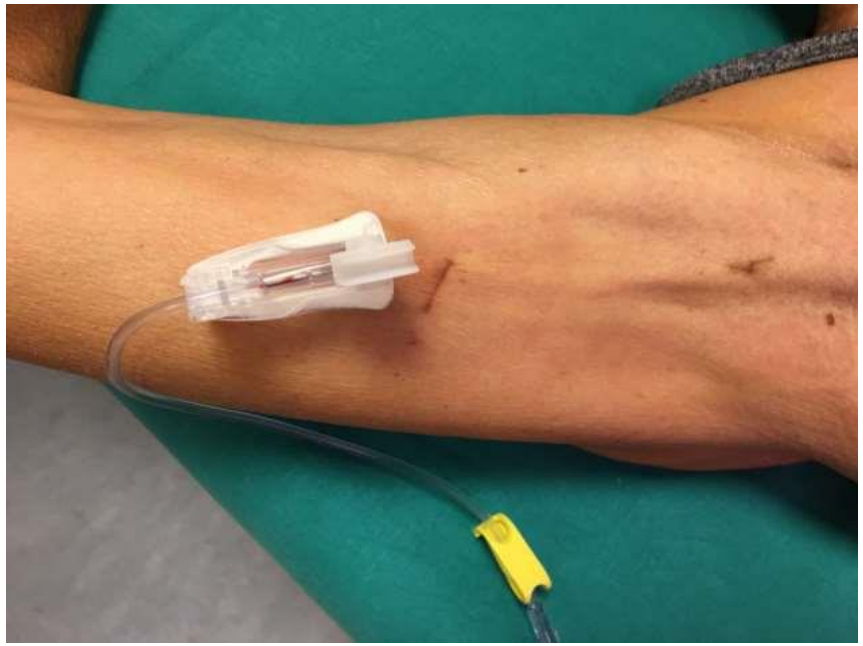
A Cost Effectiveness Analysis of Bioflo® Compared to PowerPICC Solo® Peripherally Inserted Central Catheters
The Ottawa Hospital Evaluation

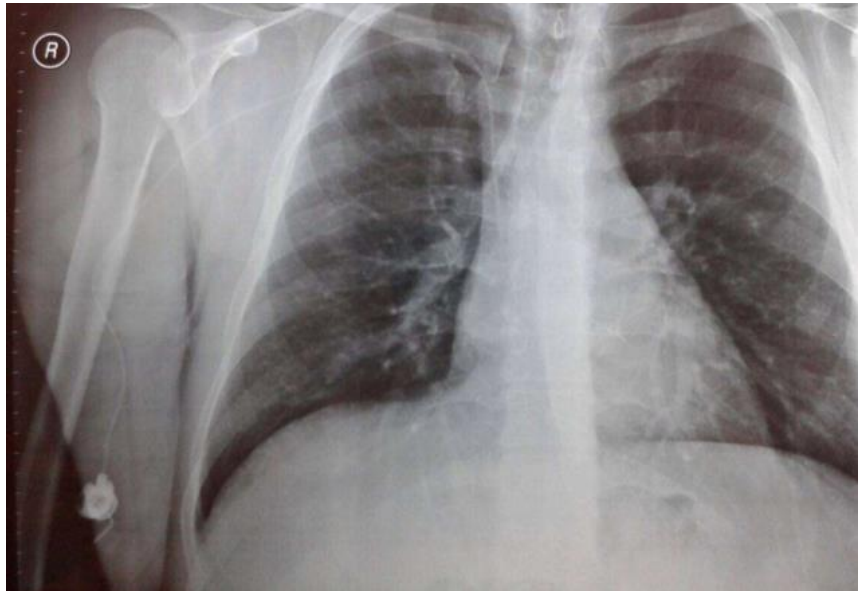
Compared to BioFlo catheters:

- PPS catheters are 51% [OR1.51 (95% CI:1.18,1.93) more likely to suffer an occlusion
- PPS catheters are 67% [OR 1.27(95% CI: 1.27,2.21] more likely to require a thrombolytic (Medicinase/Urokinase)
- Using the linear regression approach for total cost the average insertion of each PPS is expected to cost the hospital $40.07 more that the BioFlo catheter

PICC-Ports

- No major complications such as pneumothorax etc
- No visible scars
- Less invasive procedure
- Brachial artery easy to compress in case of accidental puncture
- Increased satisfaction and less pain for the patient
- Minimum exposure for the patient





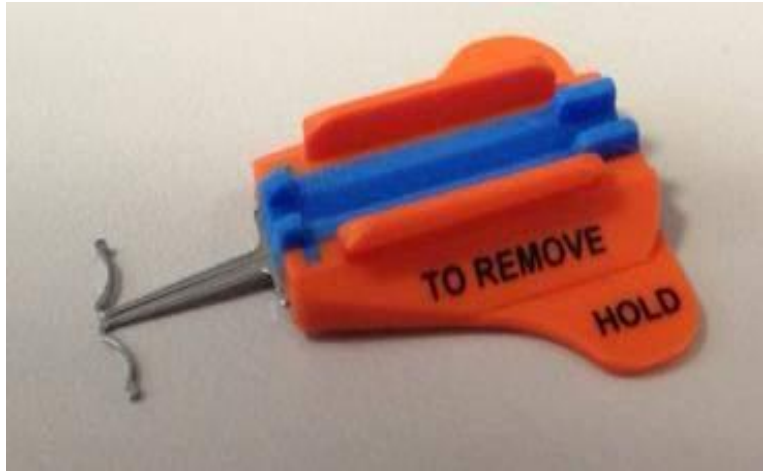
Securement of PICC, CICC and FICC

Sutureless devices + CHG + dressing

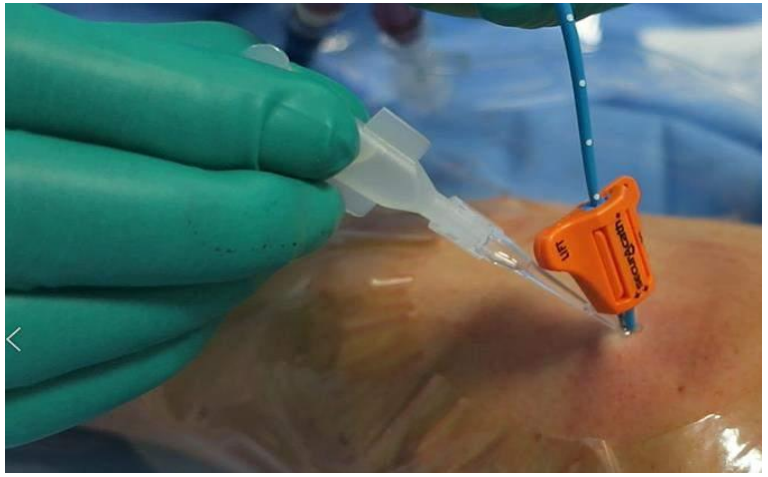
Integrated securement & dressing

Downside of sutureless devices: migration

Prevention of migration and infection

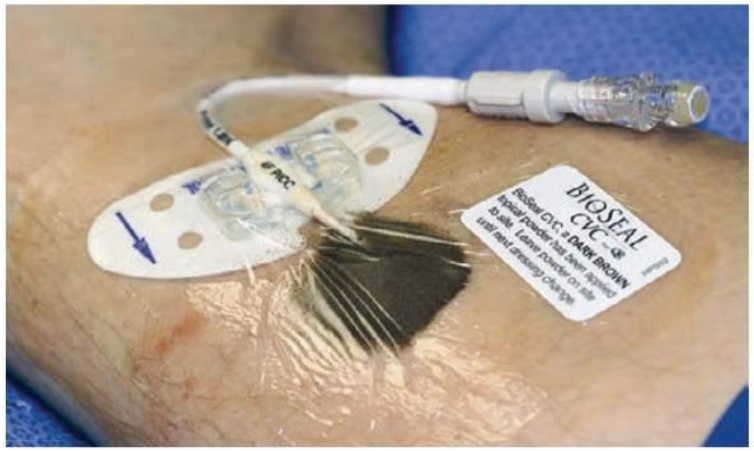


Securacath



Securacath + glue

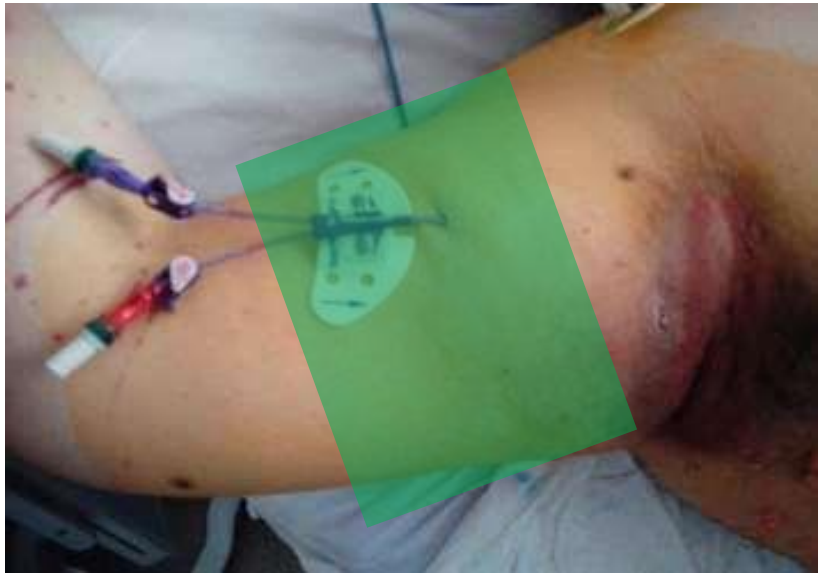
Securacath + glue + chloorhexidine dressing

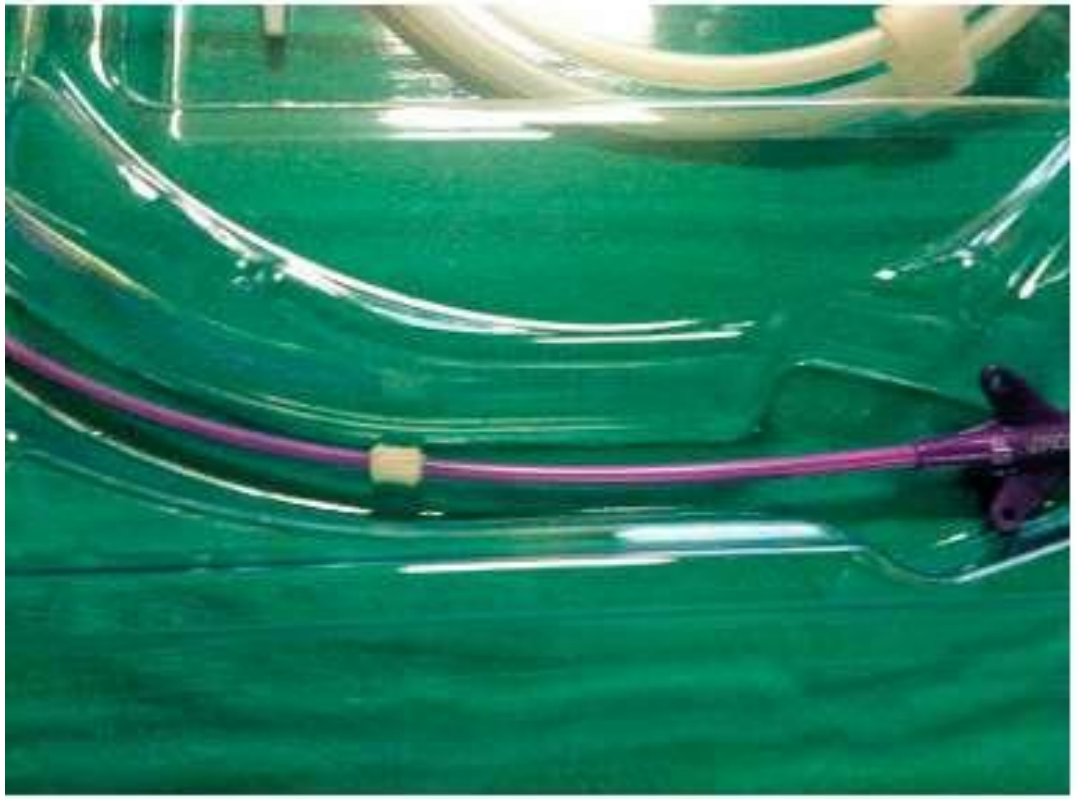


Bioseal CVC powder to prevent bleeding and infection

Tunneling of PICC lines

Indirect exit site protection





Patients with risk of catheter migration
Subcutane dacron ring PICC line

EXIT SITE INFECTION
Redness, induration (hard), and/or tenderness within 2 cm of the catheter exit site; possibly with other signs and symptoms of infection, such as fever or purulent drainage at exit site, concomitant bloodstream infections

SKIN INJURY
- Stripping: Shallow irregular lesions; shiny skin
- Tears: Partial or full thickness
- Tension blisters

SKIN IRRITATION/CONTACT DERMATITIS
Skin color change (red, dark, shiny, dull) persisting 30 min. after dressing change (often mimics shape of dressing) and/or burning, itchy skin and/or lesions (macules, papules, vesicles, bullae)

WEEPING/OOZING
(Non-infectious)
Assess color, consistency, odor, amount and location of exudate

Dressing Usage Guide for CVAD Skin Impairment Management

Dressing*	Skin Injury (e.g., tear/blister)	Skin Irritation	Drainage			Able to see site
			Low	Med	High	
Non-adherent non-woven gauze** (if skin intact or topical agent applied)		•	•			
Transparent film		•				Yes
Absorbent clear acrylic	•	•	•	•	•	Yes
Hydrocolloid (do not apply directly on CVAD exit site)		•	•	•		
Foam (silicone or low-tack)	•	•	•	•	•	
Alginate (also has hemostatic properties)	•			•	•	
Skin glue (2-octylcyanoacrylate alcohol-free topical bandage) + Cover Dressing	if skin flap can be approximated					Yes
Antimicrobial dressing***			•	•	•	

- Apply sterile alcohol-free skin barrier film prior to dressing (let dry before applying dressing)
- If skin damage/drainage is away from the exit site, isolate wound and exudate from exit site: apply absorbent dressing over area of injury and transparent dressing over exit site and prepped skin.
- If exudate leakage, use a different dressing with higher fluid handling capacity

*Stabilize catheter with securement device/dressing
**Does not provide a microbial barrier
***Assess manufacturer's contraindications. Recommend consult wound/skin specialist and/or physician.

Dressing*	(e.g., tear/blister)	Irritation	Low	Med	High	see site
Non-adherent non-woven gauze** (if skin intact or topical agent applied)		•	•			
Transparent film		•				Yes
Absorbent clear acrylic	•	•	•	•	•	Yes
Hydrocolloid (do not apply directly on CVAD exit site)		•	•	•		
Foam (silicone or low-tack)	•	•	•	•	•	
Alginate (also has hemostatic properties)	•			•	•	
Skin glue (2-octylcyanoacrylate alcohol-free topical bandage) + Cover Dressing	if skin flap can be approximated					Yes
Antimicrobial dressing***			•	•	•	

- If skin damage/drainage is away from the exit site, isolate wound and exudate from exit site: apply absorbent dressing over area of injury and transparent dressing over exit site and prepped skin.
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*Stabilize catheter with securement device/dressing
**Does not provide a microbial barrier
***Assess manufacturer's contraindications. Recommend consult wound/skin specialist and/or physician.

Try Povidone Iodine

No improvement?

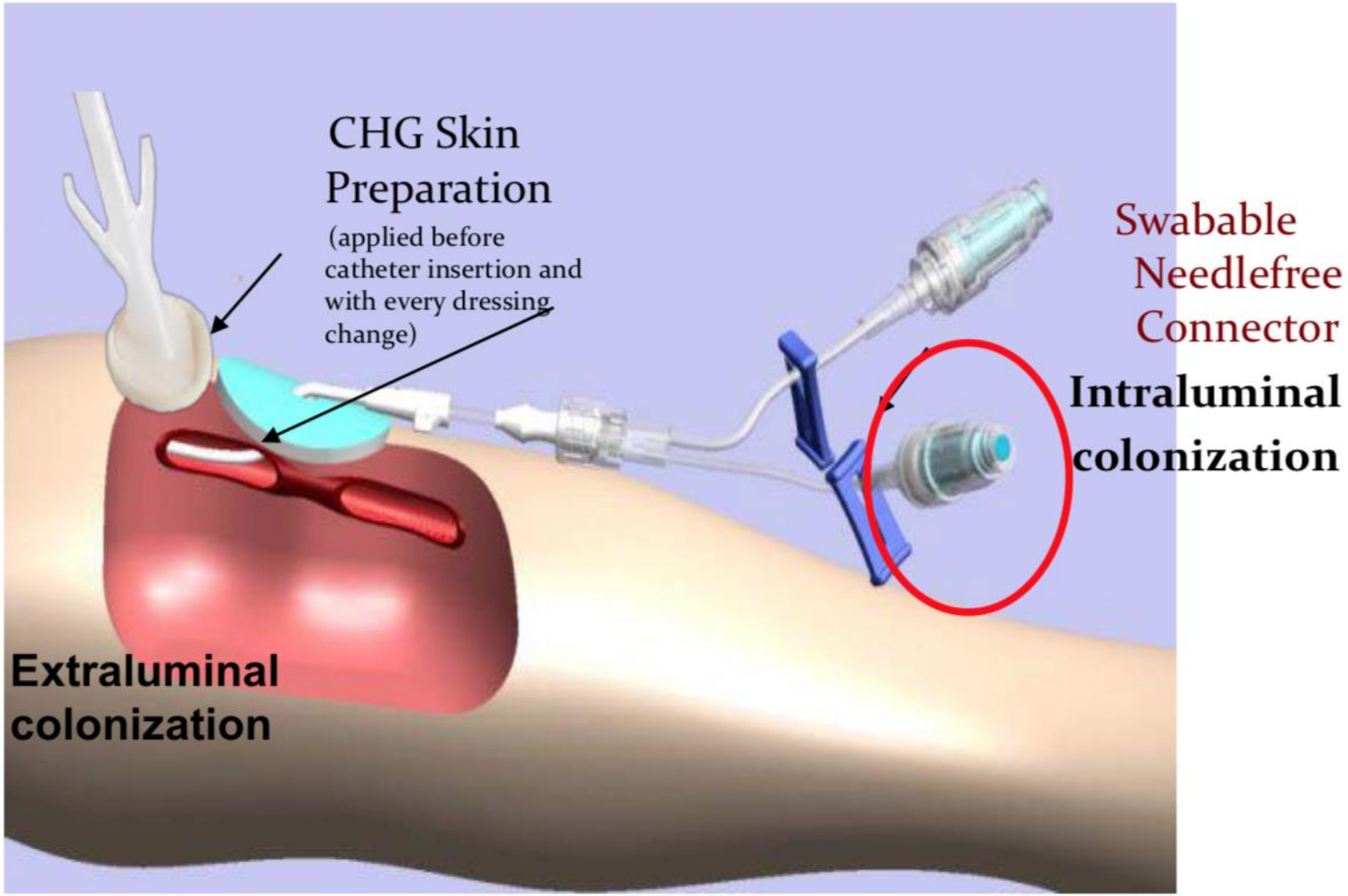
Try sterile normal saline

Fig. 2–Open Application Test
1. Apply product to forearm
2. Monitor for 30–60 min.
3. Reassess in 3–4 days for signs of dermatitis

J Wound Ostomy Continence Nurs. 2017;44(3):211-220

Diagnosis and prevention of complications

Pathogenesis of CRBSI and Prevention of extra and intraluminal colonization



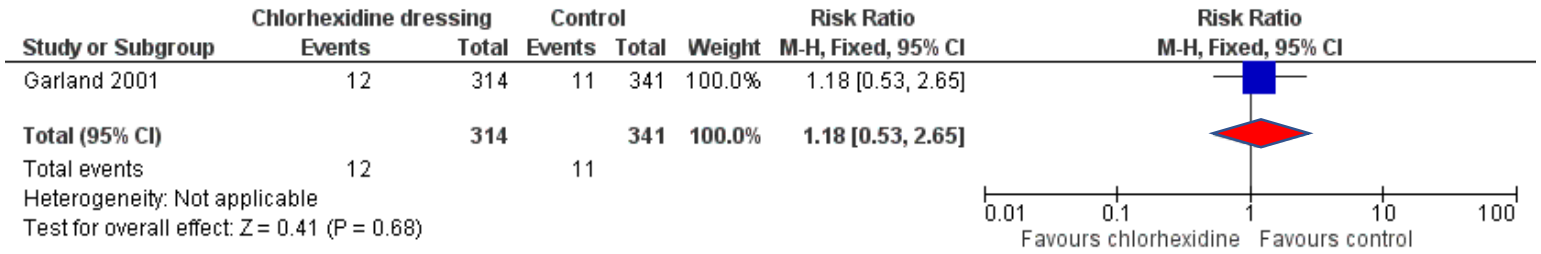
Pathogenesis of CRBSI and prevention of extra- and intraluminal colonization

- Needle free connectors are widely used in clinical practice on the hub of vascular catheters
- They are totally effective in preventing needlestick injuries for healthcare workers
- Their effect on the prevention of occlusion depends on their displacement mechanism
- They influence the risk of intraluminal contamination because of poor compliance to desinfection practices and probably because active desinfection practices are not fully standardized

Port Protectors

- The most effective and standardized desinfection for needle free connectors is passive desinfection using port protectors containing desinfecting agents

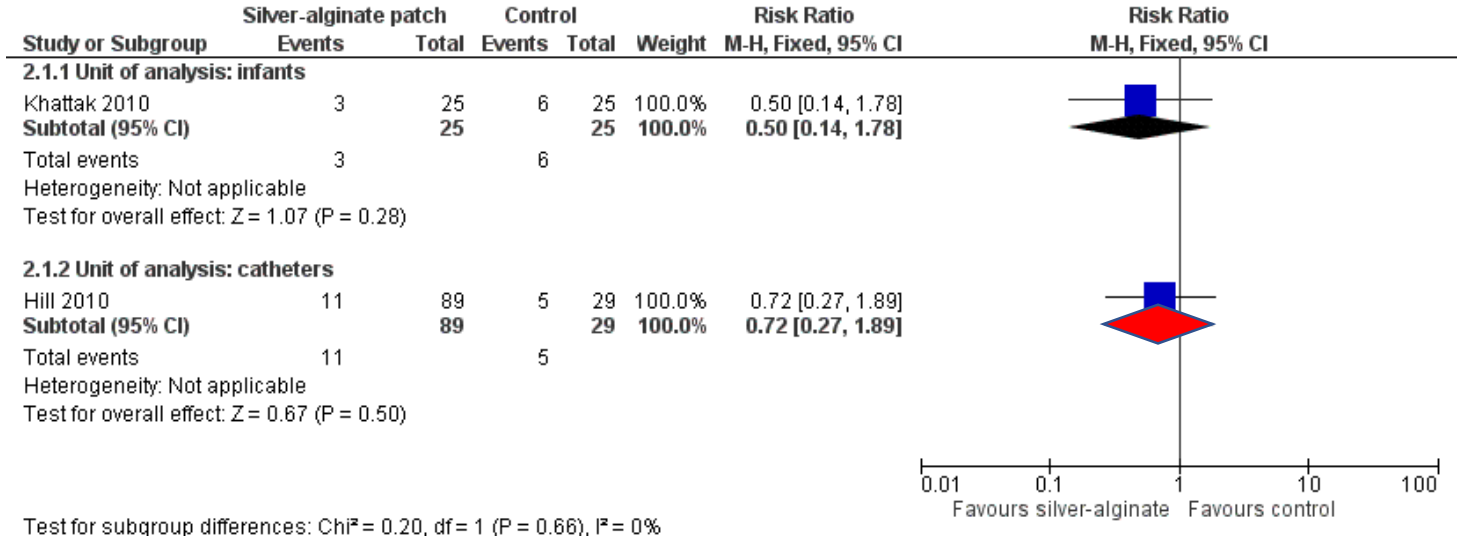
Antimicrobial dressings for the prevention of catheter-related infections



Study or Subgroup	Chlorhexidine dressing Events	Total	Control Events	Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Garland 2001	12	314	11	341	100.0%	1.18 [0.53, 2.65]
Total (95% CI)		**314**		**341**	**100.0%**	**1.18 [0.53, 2.65]**
Total events	12		11			

Heterogeneity: Not applicable
Test for overall effect: Z = 0.41 (P = 0.68)

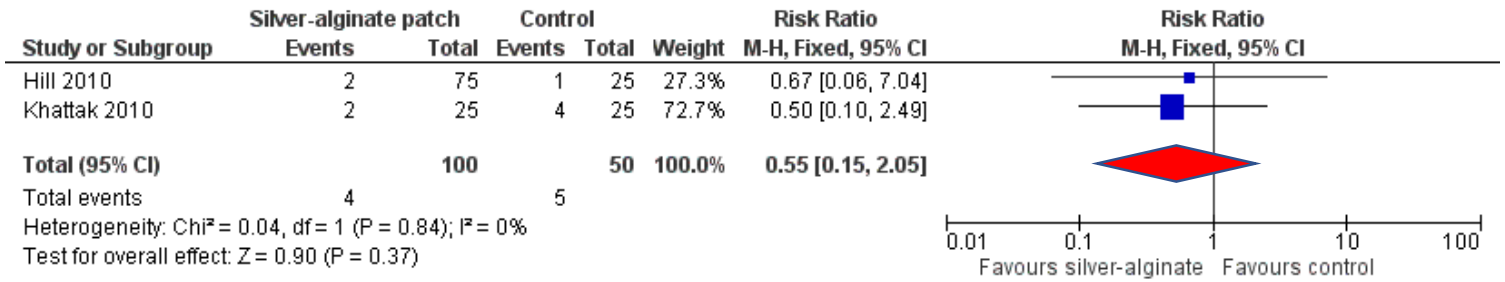
Chlorhexidine dressing following alcohol cleansing versus polyurethane dressing following aqueous povidone-iodine cleansing, outcome: CRBSI



Study or Subgroup	Silver-alginate patch Events	Total	Control Events	Total	Weight	Risk Ratio M-H, Fixed, 95% CI
2.1.1 Unit of analysis: infants						
Khattak 2010	3	25	6	25	100.0%	0.50 [0.14, 1.78]
Subtotal (95% CI)		**25**		**25**	**100.0%**	**0.50 [0.14, 1.78]**
Total events	3		6			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.07 (P = 0.28)						
2.1.2 Unit of analysis: catheters						
Hill 2010	11	89	5	29	100.0%	0.72 [0.27, 1.89]
Subtotal (95% CI)		**89**		**29**	**100.0%**	**0.72 [0.27, 1.89]**
Total events	11		5			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.67 (P = 0.50)						

Test for subgroup differences: Chi² = 0.20, df = 1 (P = 0.66), I² = 0%

Silver-alginate dressing versus control,outcome CRBSI



Study or Subgroup	Silver-alginate patch Events	Total	Control Events	Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Hill 2010	2	75	1	25	27.3%	0.67 [0.06, 7.04]
Khattak 2010	2	25	4	25	72.7%	0.50 [0.10, 2.49]
Total (95% CI)		**100**		**50**	**100.0%**	**0.55 [0.15, 2.05]**
Total events	4		5			
Heterogeneity: Chi² = 0.04, df = 1 (P = 0.84); I² = 0%						
Test for overall effect: Z = 0.90 (P = 0.37)						

Silver-alginate dressing versus control, outcon mortality

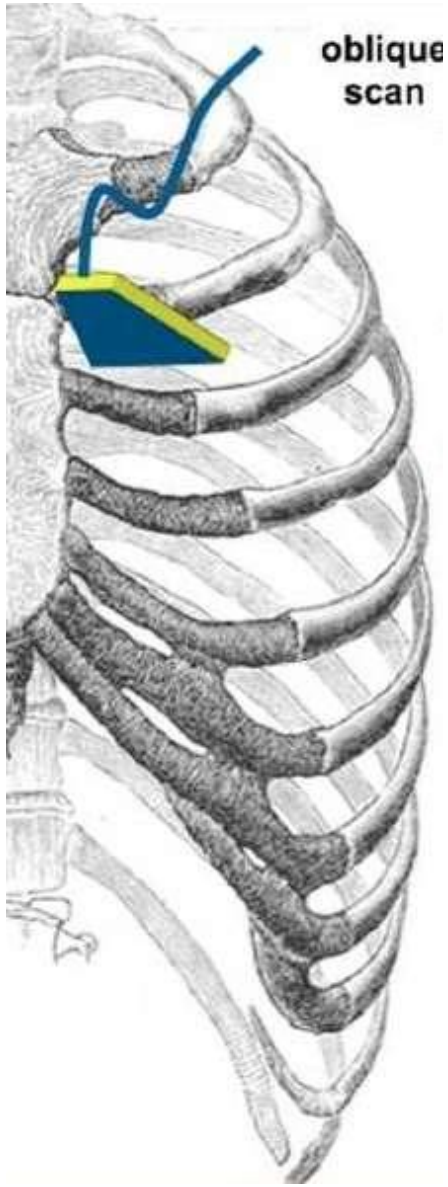
Cochrane Database Syst Rev. 2016 Mar 23;3:CD011082

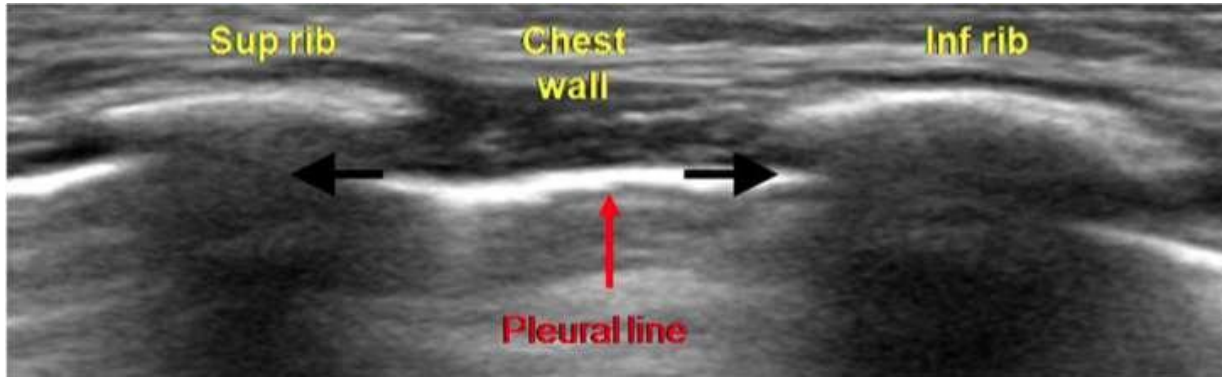
Tissue Adhesive for Vascular Access

- Apply adhesive directly to the insertion site to
  - reduce micromovement
  - create a protective barrier/seal around the insertion site
  - reduce leaking/oozing

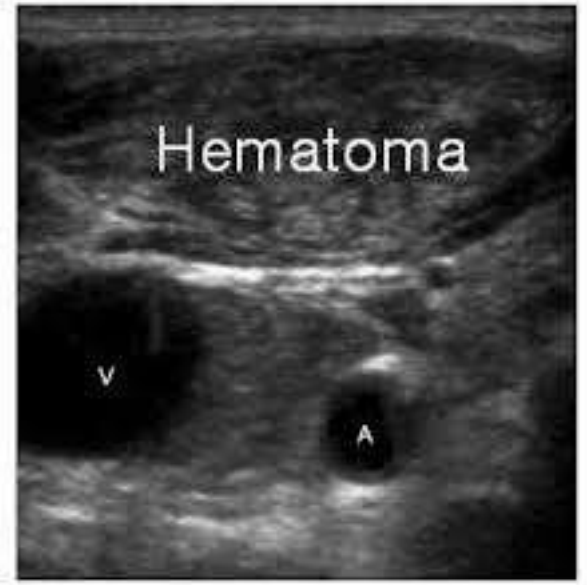
- Enhanced securement of VADs
  - wound closure by a protective barrier
  - minimizes oozing at puncture site
  - infection prevention by immobilizing and killing bacteria

Ruling out pulmonary complications with US

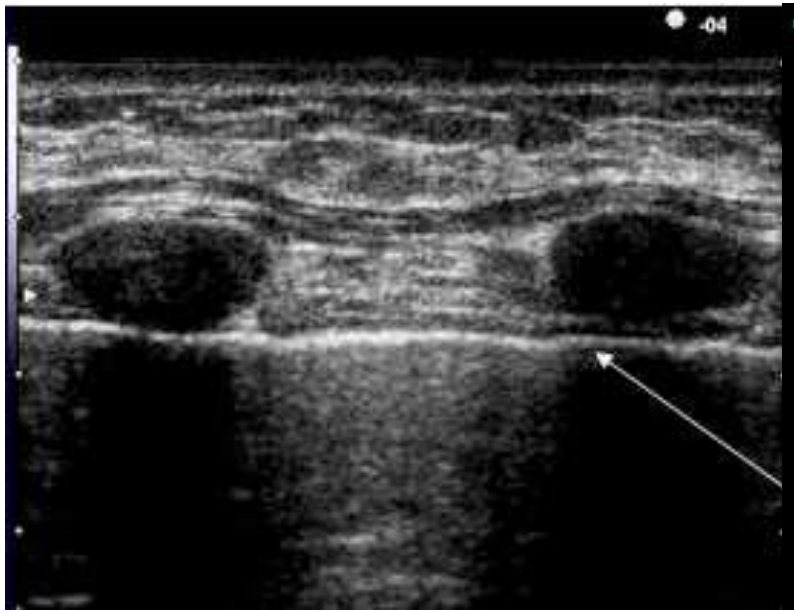




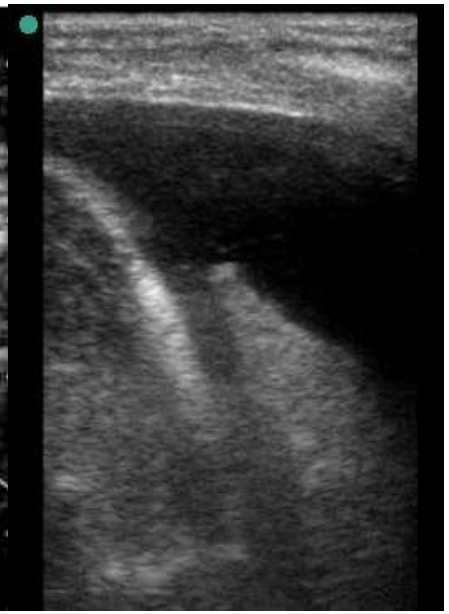
normal situation



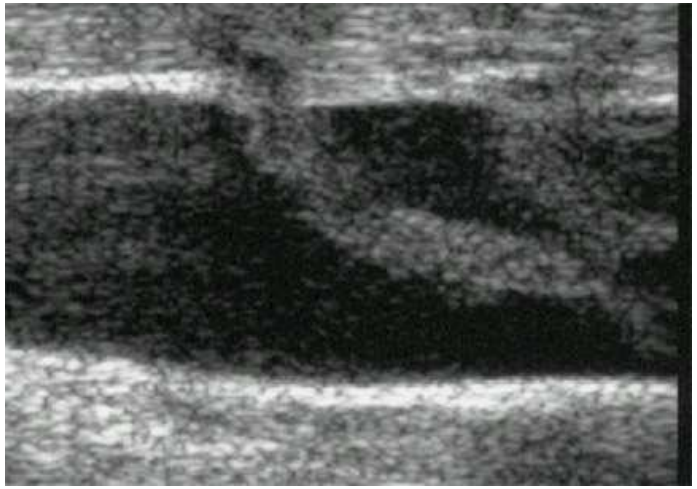
hematoma



pneumothorax



pleural fluid



fibrin sleeve

Innovations in vascular access

Modern US application in the field of VA is not only limited to US-guided venipuncture but it can be extended to assist all steps of VA

- Choice of appropriate vein and proper approach
- Prevention of malposition
- Ultrasound ‘tip navigation’ technique
- Ultrasound ‘tip location’ technique ruling out of respiratory complications
- Detection of CRT or fibrin sleeve