PICC Like a Pro: Ultrasound-guided Peripheral Central Line Insertions

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Disclosures

- RN, BSN Clinical Educator Vancouver General Hospital
- Vascular Access Nurse for 17 years
- CVAA certified
- CVAA/AVA Local Chapter Vice-President
- Sessional/Clinical Instructor: BCIT, UBC
- Previous educator for Industry Partners
- Travel expenses provided thru an educational grant from Becton Dickenson.

Learning Objectives

1. To review the venous anatomy of the upper arm and the thorax as it relates to placement of peripherally inserted central catheters.

2. To review and practice ultrasound guided peripheral venous cannulation techniques.

3. To discuss techniques to properly estimate catheter length for PICC line placement.

4. To learn tricks and tips to properly advance PICC lines into the superior vena cava.

5. To discuss issues around sterile technique during placement and care of PICC lines

6. To discuss management of complications such as displaced catheters and blocked catheters

7. Hands on Practice time

Anatomy and PICC tip position

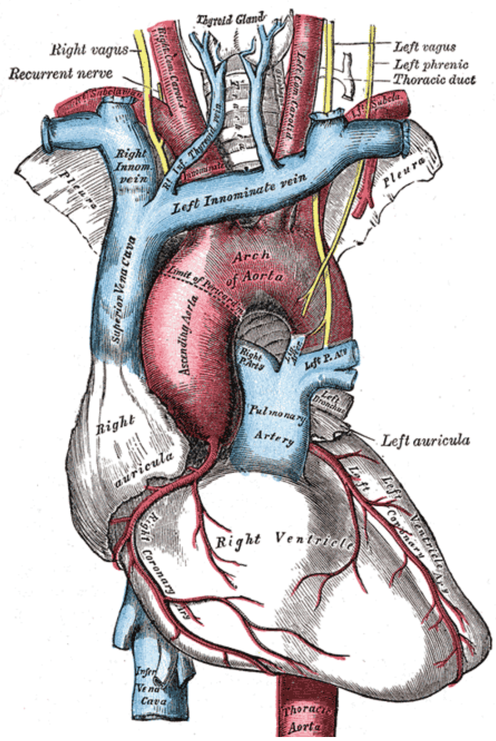
Why does it matter?

- Decreased complications
- Increased Catheter performance
- Cost savings

"PICC positioning within the lower SVC-CAJ region leads to fewer subsequent malpositions, decreased rates of catheter and venous thrombosis and infection, and better overall catheter performance."

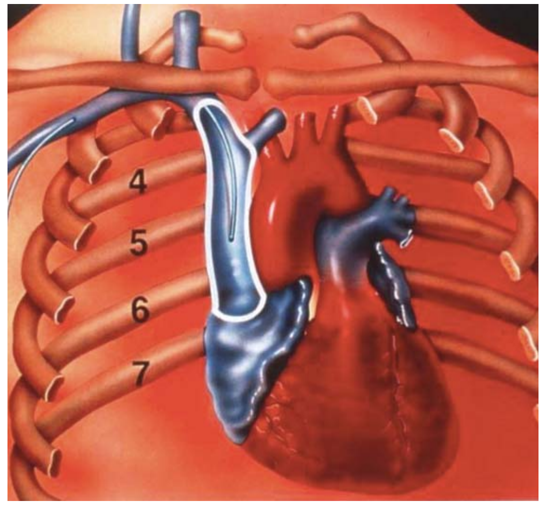
(Vesely, 2003)

Veins of the Thorax

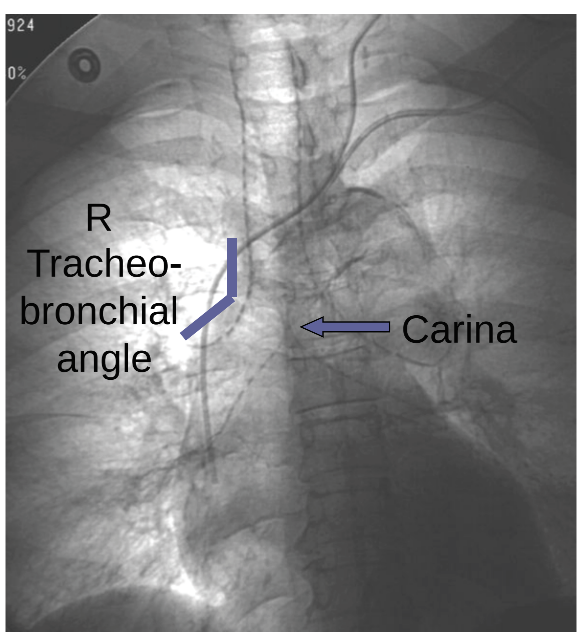


Catheter Tip Position

Traditional teaching says the catheter should be positioned in the lower SVC ~3 cm above the cavo-atrial junction (CAJ). This position is between the right posterior 5^{th} and 6^{th} ribs.



Landmark on CXR:
Carina and R Tracheobronchial Angle



Organizations of Influence

FDA: The catheter tip should be located within the SVC. The catheter tip should not be placed in, or allowed to enter, the right atrium. (1998)

AVA: The most appropriate location for the tip of a PICC is the lower one-third of the SVC close to the junction of the SVC and right atrium. (2016)

K/DOQI: Non-Tunneled Catheters : The catheter tip should be positioned at the caval-atrial junction or in the SVC.

Tunneled Catheters : The catheter tip should be positioned at the caval-atrial junction or into the right atrium to ensure optimal blood flow. (2006, Update 2015)

ONS: SVC at the junction of the Right Atrium (2004)

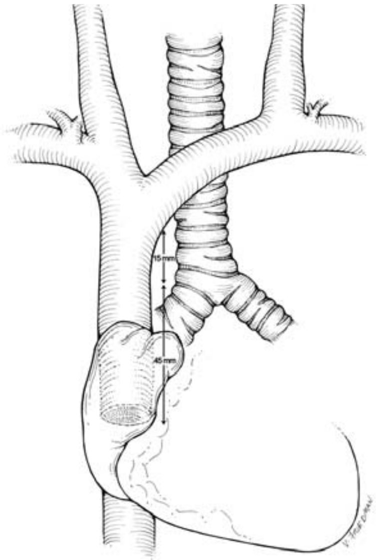
INS: Central vascular access devices shall have the distal tip dwelling in the lower one third of the SVC to the junction of the SVC and the right atrium(CAJ) (2016)

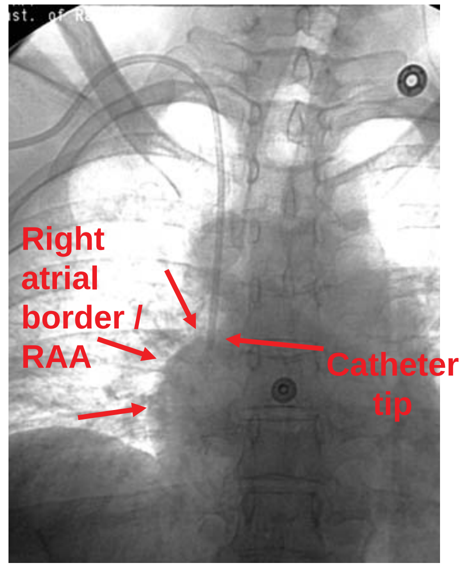
American Society of Anesthesiologists Task Force on Central Venous Access (2012) – No recommendation

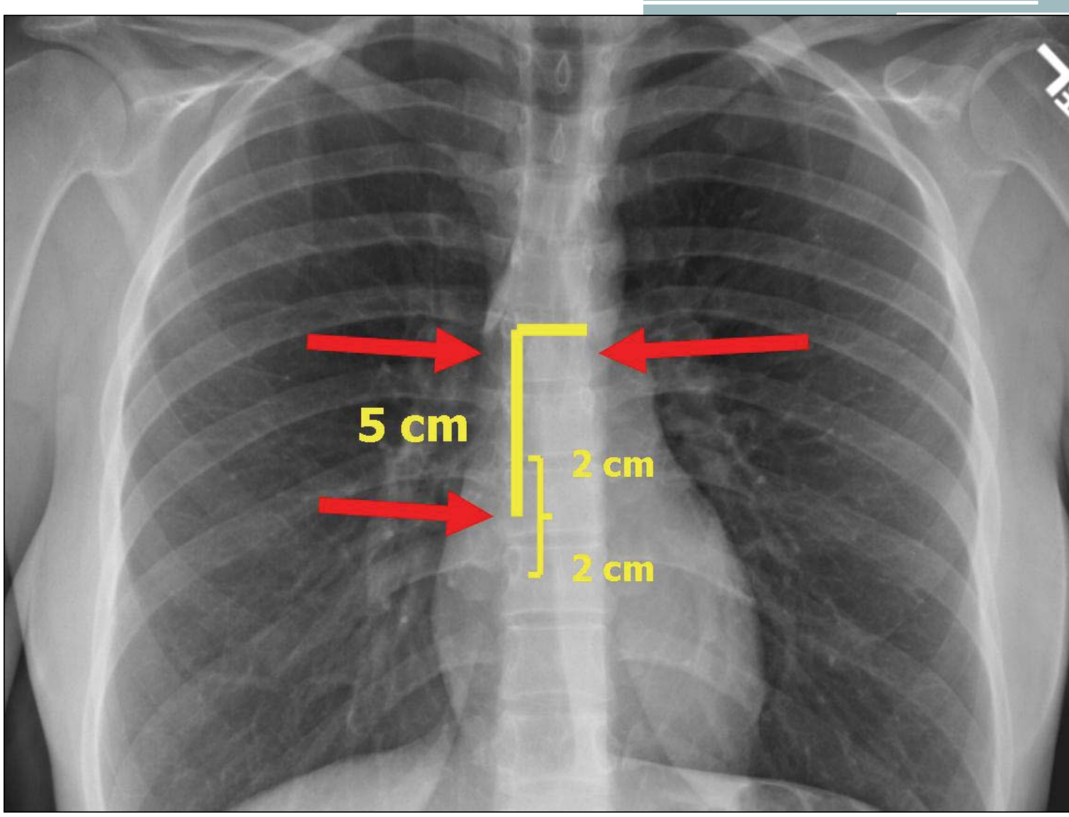
"PICC's (positioned in the lower SVC at the cavo-atrial junction) optimize the basic principles of appropriate catheter placement, including high-blood flow location, catheter lying parallel to the vessel wall, and catheter-tip motion from cardiac pulsatility and blood turbulence."

(Verhey et al. , 2008)

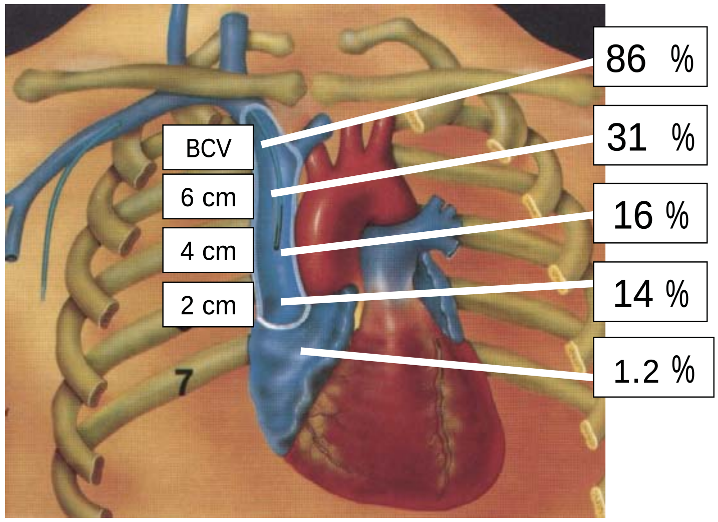
Cavo-atrial junction







Rates of Catheter Malfunction



Petersen et al, Am J Surg 1999, 178:38-41

Complications ↓

- Thrombus
- Infection
- Migration
- Intimal Injury
- Extravasation

Performance ↑

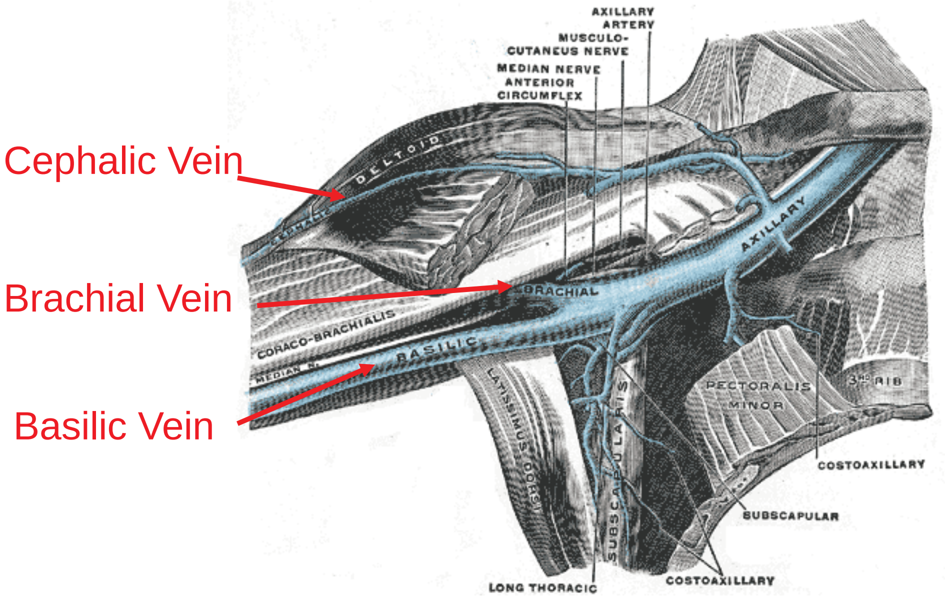
- Flow rates
- Able to draw blood
- Dwell time
- Wave forms / monitoring

Cost $avings

- Complication cost (alteplase, Anticoagulation, imaging)
- Catheter cost
- Line insertion and repeated risk
- Repeated CXR/fluoro
- Extra labor costs
- Allow a little grace in case of **accidental pull back!**

Anatomy and Vein Selection

Veins of the Arm



Line Placement

- Vessel Size
- Vessel Position

Recommendations for Catheter-to-Vein Ratio

Catheter Size*	Minimum Vein Diameter (without tourniquet)		
	Catheter-to-vein ratio ≤ 45% [1,2]	2 x's the catheter size [3]	3 x's the catheter size [4,5]
3 FR / 20 g	2.1 mm	2 mm	3 mm
4 FR / 18 g	2.7 mm	2.6 mm	4 mm
5 FR / 16 g	3.5 mm	3.3 mm	5 mm
6 FR / 14 g**	4.2 mm	4 mm	6 mm

[1] Infusion Nurses Society (2016) Infusion Therapy Standards of Practice. *Jour of Infusion Nurs.* 39(1S):S112.
[2] Sharp, R., et al. (2015) The catheter to vein ratio and rates of symptomatic thromboembolism in patients with a PICC: a prospective cohort study. *International Jour of Nurs Studies*
[3] Meyers, B.M. (2011) Managing Peripherally Inserted Central Catheter Thrombosis Risk: A Guide for Clinical Best Practice. JAVA, 16(3):144-147.
[4] Pittiruti, M. (2015) What the world needs now is an insertion bundle to prevent catheter related thrombosis. Presented at the 29th AVA Scientific Meeting, Dallas, TX.
[5] Nolan, M.E., et al. (2016) Complication rates among peripherally inserted central venous catheters and centrally inserted central catheters in the medical intensive care unit. *Jour of Critical Care*
*Use smallest size catheter and fewest number of lumens to accommodate therapy.
**The use of 6 FR PICCs have shown to significantly increase the risk of venous thrombosis.

ZONE INSERTION METHOD (ZIM)

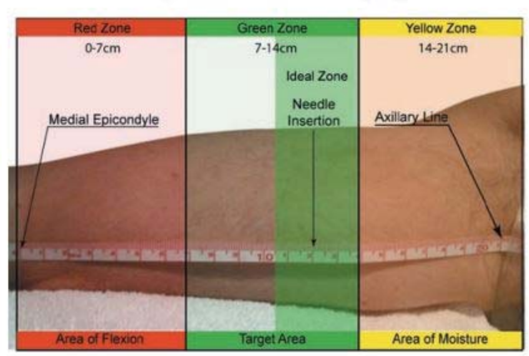


Figure 1. This person has a 21cm Total Zone Measurement (TZM), it divides into three 7cm zones to form the Red, Green and Yellow Zones. The ideal basilic vein image was located at 12cm from the medical epicondyle (MEC), in the Ideal Zone. Image by author.

Dawson, R 2016

LUM's Measurement Guide

LUM's CVC MEASUREMENT GUIDE ©

Height (in)	R.PICC (cm)	L.PICC (cm)	R.JC (cm)	L. SC (cm)	R. SC (cm)	Height (cm)
4ft 8in	42.5	46.5	13.0	18.0	14.0	143
4ft 10in	44.0	48.0	13.5	18.5	14.5	148
5ft	45.5	49.5	14.0	19.0	15.0	153
5ft 2in	47.0	51.0	14.5	19.5	15.5	158
5ft 4in	48.5	52.5	15.0	20.0	16.0	163
5ft 6in	50.0	54.0	15.5	20.5	16.5	168
5ft 8in	51.5	55.5	16.0	21.0	17.0	173
5ft 10in	53.0	57.0	16.5	21.5	17.5	178
6ft	54.5	58.5	17.0	22.0	18.0	183
6ft 2in	56.0	60.0	17.5	22.5	18.5	188
6ft 4in	57.5	61.5	18.0	23.0	19.0	193

CVC = CENTRAL VENOUS CATHETER; R = RIGHT; L = LEFT; JC = JUGULAR CATHETER;
SC = SUBCLAVIAN CATHETER; PICC = PERIPHERAL INSERTED CENTRAL CATHETER.

NOTE: STANDARD INSERTION SITE:
FOR "PICC" INSERTION : ~ 2.5 CM BELOW THE ANTECUBITAL FOSSA LINE *
FOR "SC" INSERTION : ~ 2.5 CM BELOW THE MID-CLAVICULAR BORDER (~ 2ND ANTERIOR RIB LEVEL) * **
FOR "JC" INSERTION : APEX OF THE STERNOCLEIDOMASTOID TRIANGLE OR CRICOID LEVEL*
* DEVIATION FROM STANDARD INSERTION SITE, CVC LENGTH MUST BE ADJUSTED ACCORDINGLY
** PENDULOUS BREAST MUST BE TAPED DOWN PRIOR TO "SC" INSERTION IN SUPINE OR TRENDELENBERG POSITION

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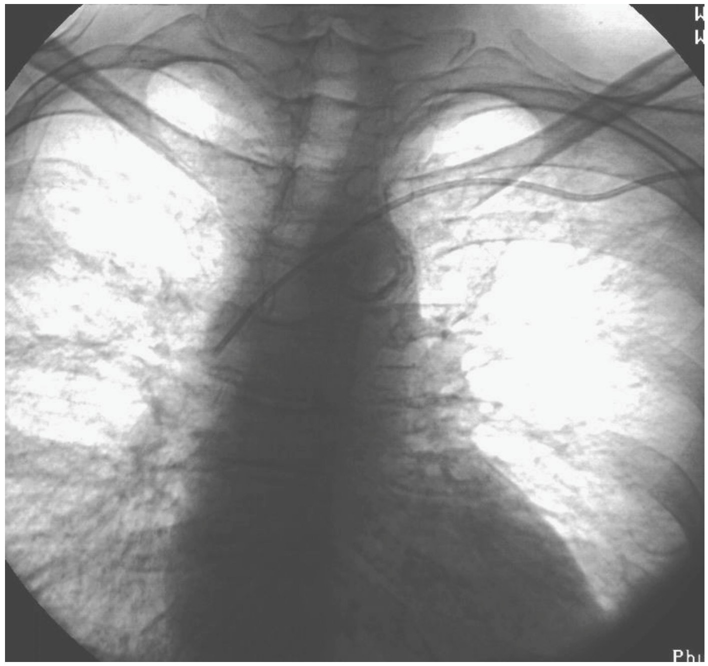
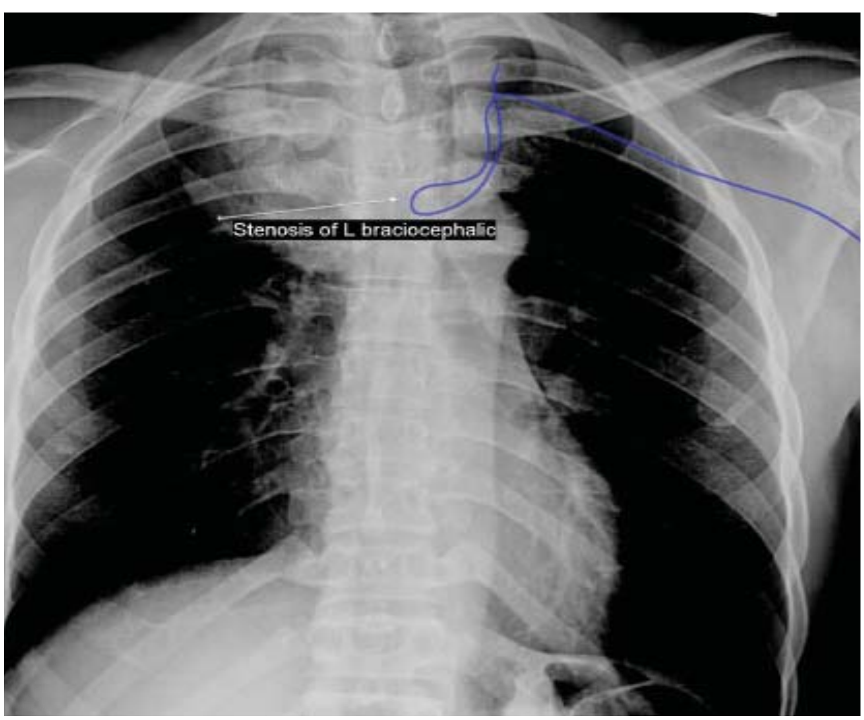
The Anatomy of Complications

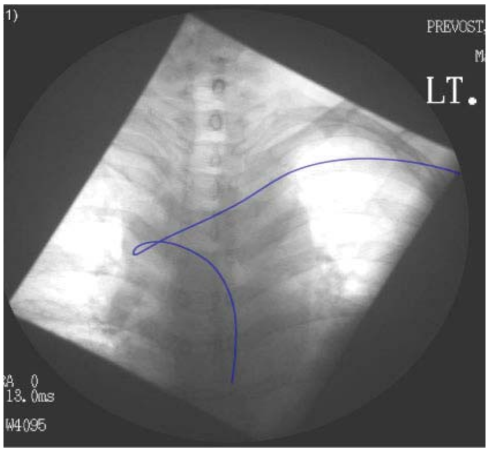
@ Insertion

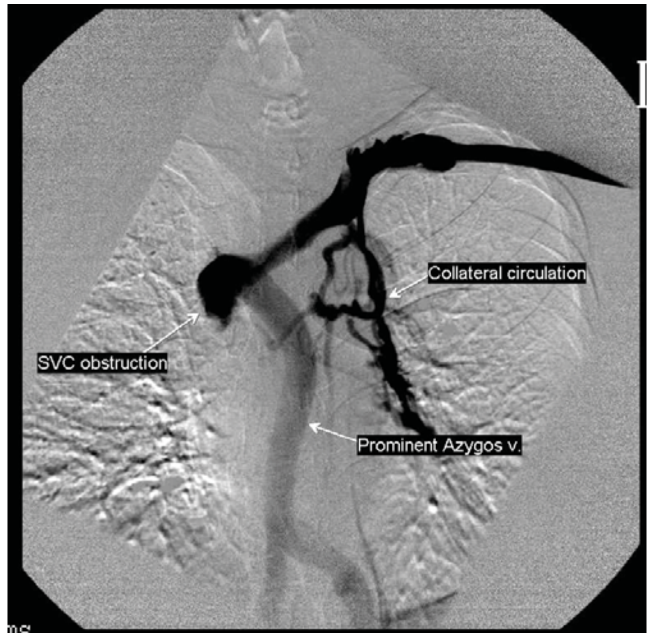
L sided catheter abutting SVC



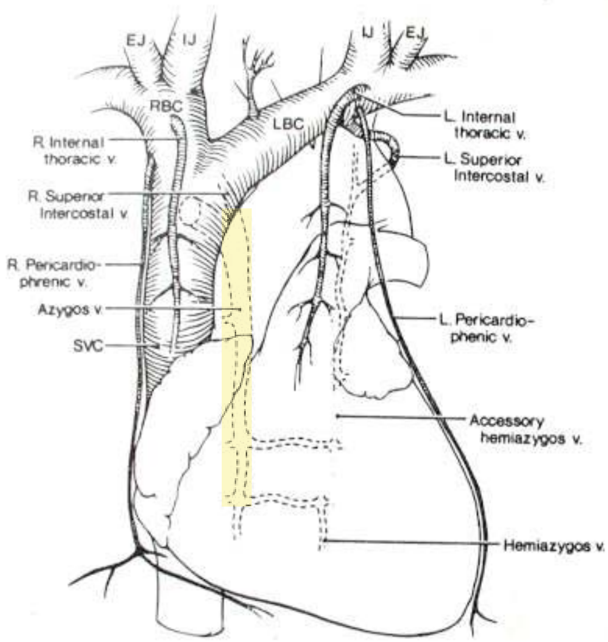


Azygos Vein

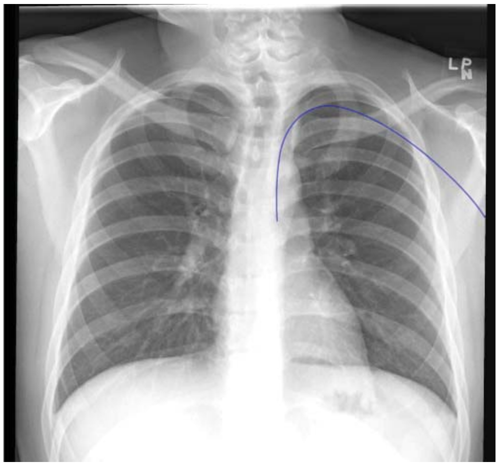


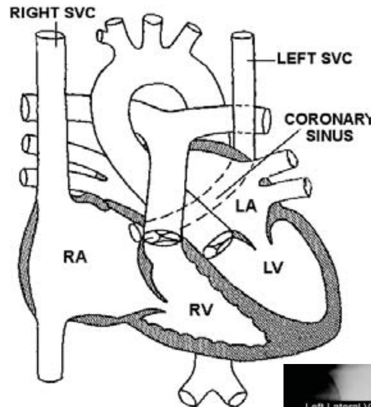


Azygos vein

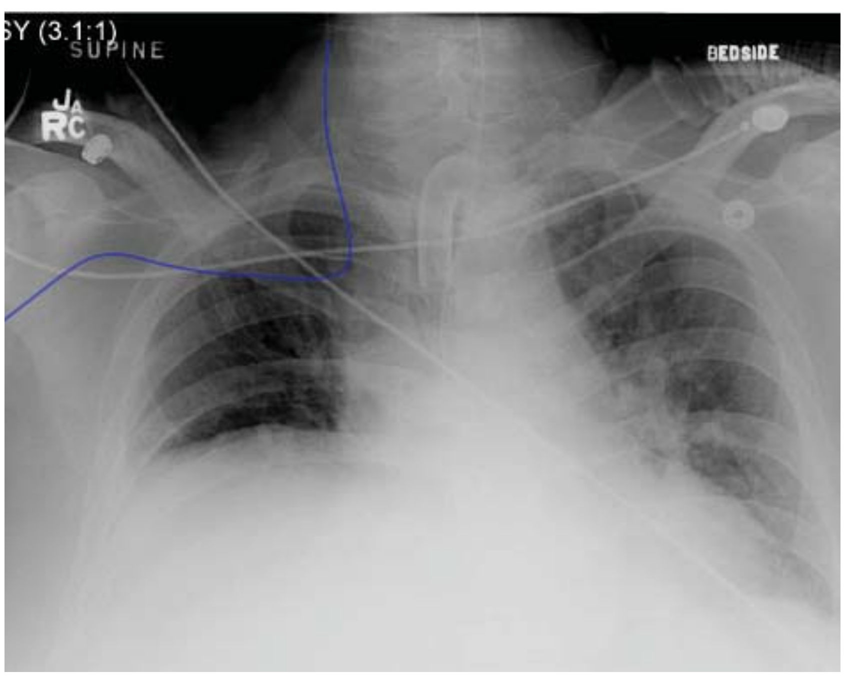


Persistent Left Superior Vena Cava





Internal Jugular



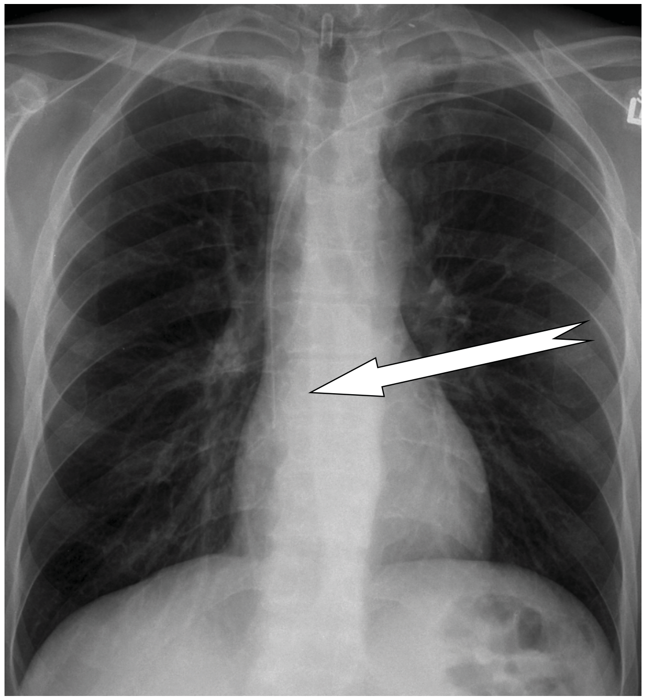
Tips to avoid Insertion Malposition

- Thread slowly
- Pt turn towards insertion shoulder and tuck chin
- Thread slowly
- Withdraw stiffening stylet 3-6cm
- Thread slowly
- Elevate HOB
- Thread slowly
- Increase intravenous volume/flow with NS
- Thread slowly

Tips to Correct Malposition

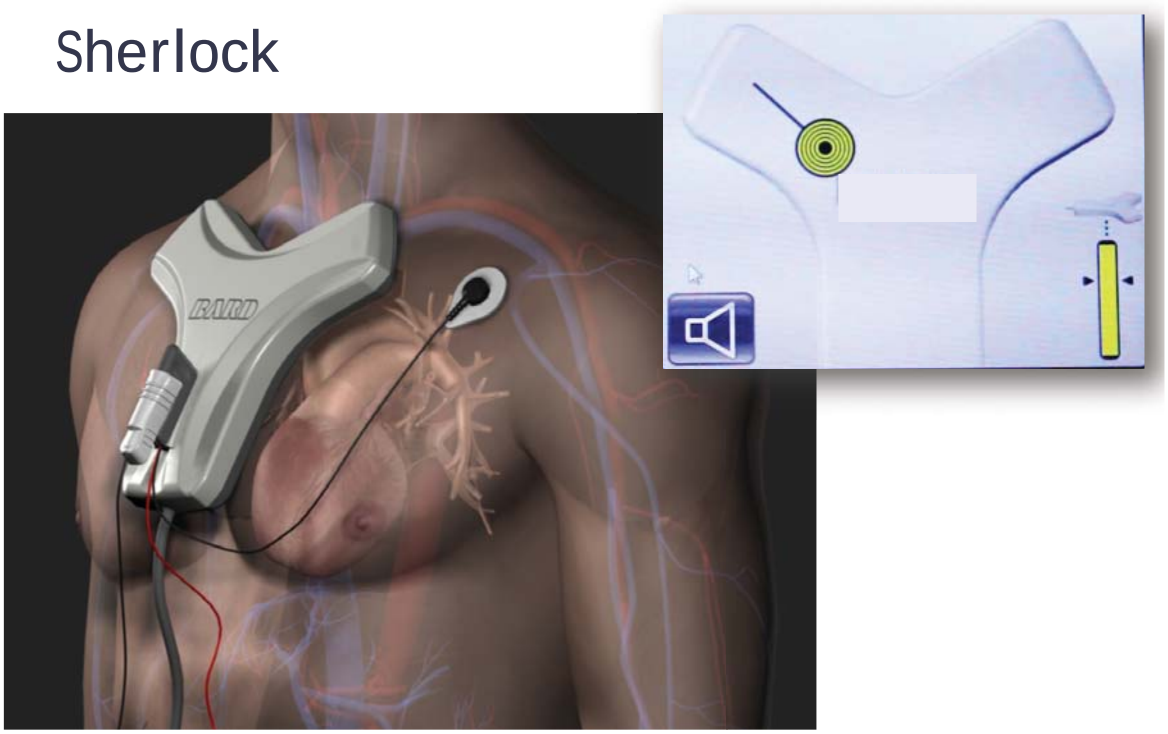
- Rapid Saline Power Flush (RSPF)
  - Indication Criteria:
    - Tip malposition on chest X-ray review (i.e., contralateral, internal jugular, azygos, subclavian)
  - Catheter type
    - Silicone (single or double only)
    - Power/polyurethane (single, double, triple)
- Pull back to safer position
- IR manipulation
- Catheter exchange

Optimal Catheter tip position



Technology and PICC placement

Sherlock



ECG placement technology

1. Guidance with Sherlock
2. Estimated measurement with Lum's
3. Deflection of the P wave
4. Max P wave amplitude

Case Studies on Care &Maintenance

Case Study 1

PICC @ ACF
- Flexion point
- Increased risk of
  - Phlebitis
  - Infection
  - Line blockage
- $$ intervention and time

Case Study 2

PICC with Securacath

- Catheter untrimmed
- Device UPSIDE DOWN
- Catheter at 90 degree angle
- Increased risk of
  - Bleeding
  - Pain
  - Infection
  - Dressing changes ++
- $$ accidental pull back, re-PICC, time, delays

CVC life is 1% insertion and 99% ongoing care and maintenance

Avoid Dermatotomy "nicks"

Troubleshooting

- Phlebitis
- Thrombus
- Line Malposition
- Accidental Pull-back
- Dressing Reaction
- Blocked lines - Alteplase

Thank you!

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PICC Zone Insertion Method™ (ZIM™): A Systematic Approach to Determine the Ideal Insertion Site for PICCs in the Upper Arm

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Abstract

The consequences of random PICC practice can be serious and manifest as deep vein thrombosis, pulmonary embolism, catheter related bloodstream infection, and post thrombotic syndrome. Risk factors related to site selection have been well established for other central venous access devices, but not for ultrasound guided PICC insertion in the upper arm. The author presents observations of upper arm PICC insertion designated by color zones to highlight the variability of PICC practice. The author also details site risk factors associated with each color zone and proposes an ideal insertion location for upper arm ultrasound guided PICC procedures.

The PICC Zone Insertion Method (ZIM) is a proposed system design for patient safety related to PICC insertions; performed by optimizing and organizing the clinical approach. It aids in identifying the Ideal Zone for upper arm needle insertion with ultrasound guidance. The significance of a systematic approach is that it is reproducible, measurable, and as a result will reduce variation in PICC insertion practice. The ZIM combines known mechanisms for vascular access insertion site complications with a systematic measuring and ultrasound scanning process, to reduce the impact of site risk factors. The impact of thrombosis cannot be underestimated, as it will likely limit the future use of veins for life saving vascular access. This issue should not be ignored by hospitals or clinicians, in fact, systematic solutions like PICC Zone Insertion Method, should be explored and supported as part of a comprehensive approach to vascular access care.

The PICC Zone Insertion Method (ZIM) is a systematic approach to PICC insertion for the purpose of optimization of results and reduction in patient risk. It aids in identifying the Ideal Zone (IZ) for upper arm needle insertion with ultrasound guidance. The ZIM looks beyond common PICC site selection practice; it reveals a specific pattern of zones that offer various risks and benefits for PICC insertion and management. The ZIM utilizes musculoskeletal, skin, and vessel characteristics that can be separated into red, green and yellow zones. Like the traffic light system, the color of the zone indicates whether or not a zone should be entered.

Observations of practice are presented to describe the benefits of the ZIM and the Ideal Zone for PICC insertion. This is a discussion of practice and a proposed methodology for selection of PICC insertion sites in the upper arm. Clinical practice from the author is reviewed as well as observations from other facilities related to PICC insertion locations in the upper arm. Permission was received to photograph and observe PICC insertion sites. The prevalence of upper arm PICC insertion by zone color is presented to highlight the variability of PICC practice. This is a proposed system design for patient safety related to PICC insertions; ZIM is a tool designed for the entire continuum of PICC practice to include: assessment, planning, intervention and evaluation.

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Significance of ZIM

The PICC Zone Insertion Method provides an objective and systematic method that should be reproducible. This is significant because it should allow for a more objective measurement and association of PICC outcomes to insertion site. Patient safety is a reflection of outcomes and events such as thrombosis, infection, bleeding, and non-adherent dressings. The Joint Commission explains that a patient safety solution is a system design that can reduce harm from the care process.[11] Therefore a safety solution for PICC insertion practice should be consistent, measurable, and reproducible in conjunction with known scientific principles for risk reduction. The variance of PICC insertion sites within a single vascular access team, or across the nation, leads to unreliable correlation of outcomes related to upper arm PICC site selection. The need to identify the relationship between complications such as thrombosis and infection with upper arm site selection is vital to the future of vein preservation.

The incidence of upper extremity thrombosis related to PICC insertion is an under-appreciated event; it is the next horizon of clinical investigation in association with PICC use. Thrombosis is serious regardless of lower or upper extremity vein origin, consequences can include: catheter related blood stream infection (CRBSI), pulmonary embolism (PE), post thrombotic syndrome (PTS), and limiting the future use of vein pathways for life saving vascular access.[2,3,4] Upper extremity deep vein thrombosis (UEDVT) associated with PICCs is often sub-clinical, and as such can occur without evaluation or intervention.[2,3] The symptomatic swelling or pain that often accompany DVTs is relatively rare in comparison to the asymptomatic prevalence.[3] Vesely[5] described that an accurate symptomatic PICC associated UEDVT rate is around 4-5%. Asymptomatic thrombosis associated with indwelling catheters is more difficult to quantify with rates ranging from 29%-72%.[2] Lobo et al.[6] reported a PICC associated venous thromboembolic event rate of 5.10/1000 catheter days. Shah et al.[2] described reports of UEDVT complication rates for pulmonary embolism at 36%, and post thrombotic syndrome as high as 90%. Abdullah et al.[7] also reported that PE rates could be above 35% when associated with UEDVT in presence of a central line. It seems the implications of PICC associated UEDVT are not fully known or understood, but enough evidence exists to suggest this issue should not be taken lightly when making decisions regarding PICC site selection.

ZIM is a clinical procedure microsystem designed to utilize ultrasound to account for the anatomy and physiology of the upper arm, in order to reduce risks associated with PICC insertion and use. It provides a metric for documentation, evaluation and comparison of site selection risk factors of the upper arm. The value of objective site selection extends to consistency in practice within a single vascular access team, and across the specialty field of vascular access. Consistent approach will lead to consistent and reliable results. Furthering the methodological rigor of PICC insertion practice will render greater confidence in the use of PICCs as a valuable, and sustainable vascular access resource.

Anatomy and Physiology of PICC Site Selection

Insertion sites have anatomical and physiological features that make them better or worse for vascular access device insertion. Complication rates associated with central lines can be directly attributed to the insertion site.[4,8,9] The three body systems primarily involved in site selection of the upper arm are vascular, musculoskeletal and integumentary. All three combine to provide a pattern of risks and benefits as the vein paths course toward the axilla. Risk or benefit is derived from known mechanisms for the most common and severe complications associated with PICC site selection: thrombosis, infection, arterial puncture and even nerve damage. The mechanisms for complications should be taken into account when assessing the main body systems involved in PICC site selection.

A common mechanism of Catheter Related Bloodstream Infections (CRBSIs) is the migration of microbes through the catheter skin junction into the bloodstream.[4] Given this pathogenesis of CRBSIs an ideal insertion site should have decreased risk of catheter pistoning, microbial colonization, and breaks in both skin and dressing integrity. The presence of body hair and sebaceous glands increases microbial colonization.[10] Moisture and hair also impact the ability for a dressing to stay clean, dry, and intact potentially impacting site colonization.[11] Catheter motion at the skin junction could serve to push microbes into the venous system along the catheter tract. Finally, it is known that excessive joint motion impacts dressing adherence and incidence of catheter-associated complications.[8,12,13]

Site selection can impact the development of catheter related thrombosis (CRT). Stokowski et al.[8] demonstrates this when switching from palpation method to ultrasound guided PICC insertion, a 9.3% symptomatic thrombosis rate without ultrasound compared to a 2.1% rate with ultrasound insertion. This is significant because technology affects the site of insertion for PICCs. Ultrasound allows for upper arm insertion far easier than the vein palpation method. Hertzog and Waybill[14] describe a study where the use of the cephalic vein for PICCs had a 57% thrombosis rate compared to a 14% basilic rate, and 10% brachial rate. Vein path impacts site risks, especially when comparing the superficial, anterolateral cephalic route to the deeper, medial routes of the basilic and brachial veins.

Thrombosis is commonly attributed to the three principles of Virchow's Triad:

- Endothelial Trauma
- Changes in Blood Flow
- Changes in Blood Coaguability or Hypercoaguability

The exact mix of Virchow elements may affect the development of thrombosis with varying significance, however, this predictive recipe is not known. The concept of a predictive thrombotic mix has been termed "thrombotic potential".[15] The potential to clot when a threshold is exceeded is the key to understanding and reducing the risk for upper arm catheter associated thrombosis. The threshold once exceeded leads to more clotting than the intravascular antithrombotic mechanisms can handle.[16] It seems that venous stasis does not necessarily lead to thrombosis but once endothelial trauma and or inflammatory mediators are present blood stasis will contribute to thrombosis, creating a more "prothrombotic" environment.[15,16,17] Further research to define the exact variables by site, vein path, and catheter/vein ratio is needed; so that clinicians can make more purposeful decisions on site and catheter selections in order to prevent thrombosis.

Joint movement and muscle flexion contribute to catheter motion, site trauma and endothelial damage.[8] Endothelial trauma occurs from the insertion process with needle puncture, guide wire advancement, and dilator introduction.[14] The insertion procedure is traumatic and the more traumatic the insertion, the greater the risk for thrombosis and possibly infection.[8,18] Stokowski et al.[8] described a study where complication rates increased from 4% to 24% when multiple attempts were needed, compared to just one attempt. Vein trauma can be reduced by site selection, attention to detail, technology, patience, and clinician skill. The combination of them all will lead to minimally traumatic procedures.

Blood flow is the physiologic feature that represents the stasis element of the triad. Blood flow in the native state is optimized with certain characteristics. Blood flow should be:

- Increased with greater vessel diameter (4th power effect)
- Laminar
- Fastest in the center

According to Poiseuille's ('Pwa-swee') Law of fluid flow in a closed tube (vein) more flow is achieved with larger diameters.[19] Applying Virchow's Triad for risk reduction a clinician should seek the most flow and the least disruption of flow as possible. Poiseuilles's Law also accounts for velocity of vessel flow. Blood flow is slowest at the vein wall and fastest moving toward the center of the vein. Friction is created when fluid comes in contact with a stationary object like the vein wall, causing flow to become more sluggish at the vein wall.[19] Passing a catheter into the vein creates more resistance to flow when the blood contacts the catheter surface. Turbulent flow is erratic and usually should not be present except in very large veins related to high flow rates.[19] Turbulence could also be created when laminar flowing blood contacts the catheter surface. Total catheter surface area impacts stasis and turbulence inside the vein. Damage of the vein wall starts a coagulation cascade that can be worsened with stasis and turbulent flow.[3] In a simulated model, Nifong and McDevitt[20] demonstrate that flow in a vessel could be reduced by 40%-93%, depending on the size of the catheter and vein used, or catheter-vein ratio. Nifong and McDevitt[20] also note that the catheter-vein ratio will result in less flow reduction as the vein increases in diameter moving proximally. A preventative thrombotic strategy would be to insert the smallest PICC necessary, in the largest vein possible, and in the most reasonably proximal zone. This should minimize catheter impact on vessel flow as it relates to Virchow's Triad.

Decreasing the impact on vessel flow as it relates to Virchow's Triad. Decreasing the impact of anatomical and physiological features that influence Virchow's Triad is the foundation of PICC risk management. In fact, by virtue of having a PICC inserted two of the three principles of Virchow's Triad are automatically satisfied: vein damage and changes in blood flow. It is also likely all three Virchow principles have been satisfied if the patient has any number of co-morbidities, or reasons for a PICC, which could include: infection, malignancy, renal disease, diabetes, or is just dehydrated. The importance of risk factor reduction in every step of the vascular access process is supported by the synergistic effect of thrombotic risk factors. Two risk factors do not just give twice the risk for thrombosis, they may give six times the risk, or increase the risk by thirty times, depending on the exact mix of variables.[15] The most predictive measure of thrombosis risk is a previous thrombosis event.[15] Thrombosis is a direct risk factor for CRBSI, PE and the viability of future vein access.[4,7,14] Prevention and management of thrombosis is vital to PICC practice.

Description of PICC ZIM

The ZIM™ was created as a result of this author consistently assessing the upper extremity basilic and brachial vein paths with ultrasound for the best insertion location and image. The vein paths were correlated with musculoskeletal and integumentary characteristics known or theorized to increase patient risk related to vascular access. The basilic vein is the primary focus for insertion as it is typically the largest and most direct vein path of the upper arm. The cephalic vein, while still considered a last option for PICC insertion, does not factor into the risk management approach of ZIM, given its higher complication rates, narrower vein diameter, and tortuous path. An ideal location does exist for PICC insertion at or above the medial mid-upper arm.

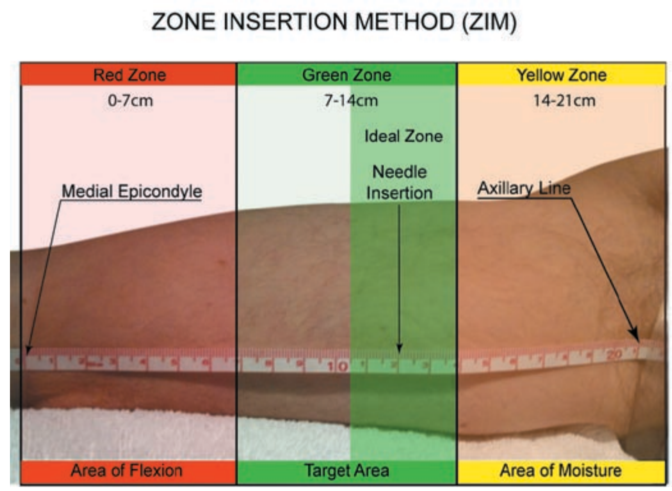

Figure 1. This person has a 21cm Total Zone Measurement (TZM), it divides into three 7cm zones to form the Red, Green and Yellow Zones. The ideal basilic vein image was located at 12cm from the medical epicondyle (MEC), in the Ideal Zone. Image by author.

The ZIM is performed by dividing the medial upper arm into three main color zones: red, green and yellow (Figure 1). The ideal target area for needle insertion is the upper half of the Green Zone. The first measurement is from the medial epicondyle (MEC) to the axillary line (AL), this is the Total Zone Measurement (TZM). The TZM is divided by three, to form equal length color zones. The TZM will vary but is most commonly between 20-22cm with an observed range from 18 – 24cm (Table 1). A TZM not easily divisible by three could be rounded to the nearest number divisible by three. Because final determination of the needle insertion site is not based on measurement alone, but in combination with ultrasound visualization of the best vein image within the Green Zone (GZ), the zone method provides some flexibility so that decimals of a centimeter will not impact ideal site selection.

The ideal area or zone is the most proximal half of the Green Zone. It represents a width usually between 3-4 cm, and will be one-half of the color zone measurement. Another way to quickly find the beginning of the Ideal Zone (IZ) is to divide the TZM in half and this number will be the start of the Ideal Zone (Figure 2). The MEC is always the start of any measurement and is the zero mark. The Red Zone (RZ) is the most distal zone, followed by the Green and Yellow Zones. The RZ, as designated by color, is not recommended for PICC insertion by this author, an explanation is located in the **Red Zone Characteristics** discussion section. The GZ starts when the RZ ends; this is an area where the clinician should start the selection process for an ideal vein image with ultrasound. The Yellow Zone (YZ) is the last zone,

Table 1.
Example Zone Measurements Observed in Practice

Total Zone Measurement MEC-AL (cm)	Red Zone (cm)	Green Zone (cm)	Yellow Zone (cm)	Ideal Zone Needle Insertion (cm)
21	0-7	7-14	14-21	10.5-14
24	0-8	8-16	16-24	12-16
18	0-6	6-12	12-18	9-12
20	0-6.7	6.7-13.3	13.3-20	10-13.3

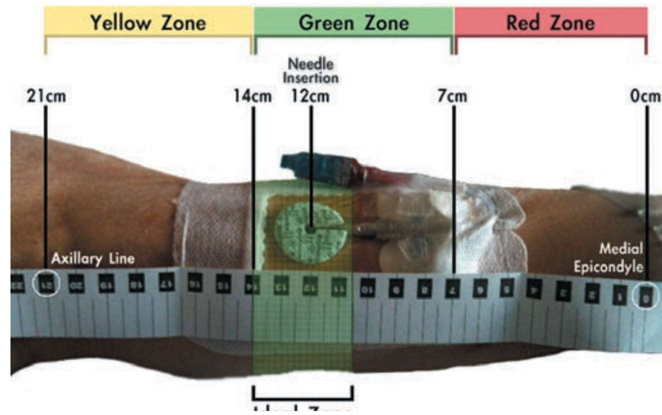

Figure 2. Example of the color zones. Highlighted in green is the Ideal Zone. Image by author.

and the most proximal zone of the upper arm; it ends at the axillary line. The YZ cautions that insertion in this area should be carefully considered; do not venture too far into it. Each zone will be described in detail corresponding to specific anatomical and physiological features that are characteristic of it.

Red Zone Characteristics

The Red Zone or RZ starts at the medial epicondyle (MEC) and extends one-third the distance to the Axillary Line. Most of the RZ is comprised of a characteristic wedge of tissue. The wedge angles inward as the wider aspect of elbow joint starts to narrow to the circumference of the upper arm, ending approximately 5-7cm above the MEC. This wedge of tissue, bone, muscle, nerves and vessels is referred to as the Elbow Triangle (ET) by the author. It corresponds with rapid changes in arm circumference and superficial vein paths coursing through the RZ. PICC insertion can be more challenging and traumatic in this area, because of the sloping and somewhat oblique path of the superficial veins. The significant veins for PICC insertion passing through the RZ include the median cubital and basilic (Figure 3). They merge to form a larger basilic vein near the end of the RZ (Figure 4). This vessel communication does vary in distance from the MEC but by the end of the RZ it is complete.

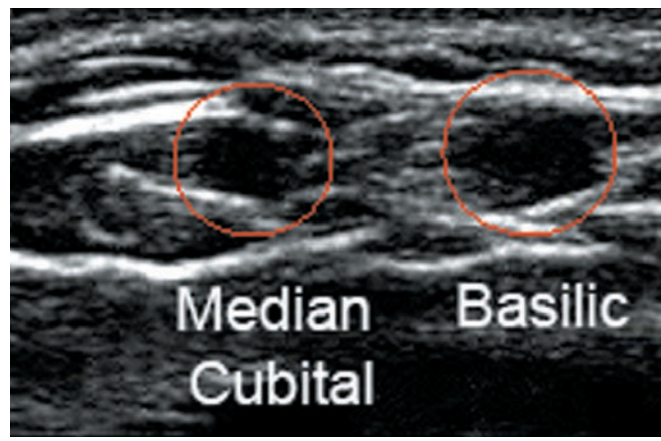

Figure 3. Red Zone, merging of median cubital and basilic veins. Image by author.

At times an area of ecchymosis is visualized just medial and or inferior to the PICC insertion site in the ET. It is likely that this, Elbow Triangle Ecchymosis (ETEC), is a result of multiple attempts during the insertion procedure, and or with post-insertion elbow flexion (Figure 5). ETEC is a migrating ecchymosis characteristic of vessel trauma, because as blood seeps out of the vessel it pools inferior to the trauma, as a result of gravity. The Elbow Triangle is also an area of compression as a result of flexion of the elbow joint. Tissue and muscle compress in this area with elbow joint flexion. The Brachialis Anticus muscle located medial to the shaft of the humerus attaches above and below the elbow and assists in compression of the vein path through the elbow triangle.[21] Compression can lead to catheter movement, bleeding, ecchymosis, and vein irritation (Figure 6).

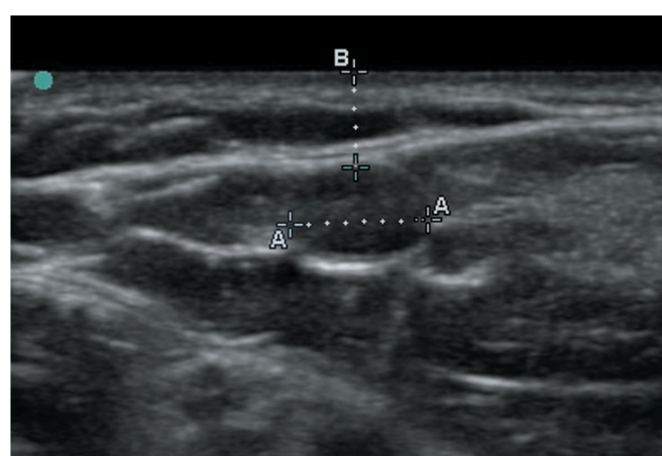

Figure 4. Red Zone, basilic vein after merging with median cubital, and just before entering the GZ. Diameter (A) = 6.2mm, Depth (B) = 4.3mm. Image by author.

Red Zone insertion can also alter blood flow related to catheter insertion. A PICC inserted low in the RZ versus the Ideal Zone will take up more space in the vein along the route to the superior vena cava. As previously mentioned, Poisueille's Law demonstrates that changes in blood flow do occur in a tube related to the size of the vessel and with resistance to flow created by a stationary wall or object.[19] It is possible that with more catheter surface area in the vein greater resistance, and obstruction to blood flow will occur, creating a more prothrombotic environment.

Red Zone PICC insertion is the site that represents the most risk for vein trauma both during and after the procedure. Furthermore, the potential for blood flow changes related to catheter surface area adds to the risk for thrombosis. Dressing adherence can be impacted by joint motion. Bleeding can be exacerbated by ET compression and reduce the adherence of the sterile dressing. The many risk factors associated with RZ characteristics should prevent any clinician from considering this area for PICC insertion when ultrasound technology is available.

Green Zone Characteristics

The Green Zone or GZ is the middle third of the upper arm. A Total Zone of 21 cm would have a GZ located between 7cm - 14cm. The most important part of the GZ is the proximal half also referred to as the Ideal Zone. A 7cm GZ will have an Ideal Zone of 3.5cm in width, and located between 10.5–14cm. The basilic vein path through the GZ is deeper than the RZ vein path. The vein diameter will be larger as the basilic vein ascends toward the axilla (Figure 8). Observations during procedures demonstrate the basilic vein path in the ideal part of the GZ is unimpeded with vein communications, easily visible, large, and stable compared to the RZ.

The defining anatomical feature of the GZ is a large band of fascia located in the mid-upper arm.[21] The fascia of the mid-upper arm corresponds with a transition to the Ideal Zone. The significance of the fascia is that it wraps the muscles and vessels of the upper arm. It corresponds with deeper, larger coursing basilic and brachial veins. Fascia applies tissue tension and stabilizes the vein for needle insertion. The mid-arm fascia provides a more ideal needle insertion point. The advantage of the mid-arm fascia may be less in emaciated or elderly persons because of muscle atrophy and loss of tissue integrity; however, it still provides some vein stabilization not found in the RZ.

Brachial veins will also become larger in diameter as they course toward the axilla but may have a more tortuous path as they wrap around the brachial artery. Additional concerns for brachial vein insertion in the GZ would be the proximity to the median nerve.[21] Careful attention to indentifying the brachial bundle features of artery and nerve is necessary to avoid insertion complications with the brachial veins. Valves still need to be contended with but this is also true of the other zones.

The GZ skin surface has minimal amounts of hair, less moisture compared with the Yellow Zone, and no direct compression of the insertion site as seen in the ET. Biceps muscle flexion does provide tissue movement but direct compression of the vein and PICC is not seen. The integumentary and musculoskeletal features of the Green and Ideal Zones also provide for better dressing adherence and maintenance. The higher up in the GZ the PICC is inserted the easier it will be to have the catheter securement device adhere to the skin. Also, stabilizing the PICC so it is parallel to the vein and muscle path allows for the dressing to be compact and less influenced by arm motion (Figure 7). It is possible that parallel positioning and securement of the PICC with the vein and muscle will also reduce vessel trauma.

Yellow Zone Characteristics

The YZ is the upper zone or the most proximal third of the upper arm. It starts at the end of the GZ and ends at the axillary line. The basilic vein in the upper most third is large and will increase in depth and diameter as it enters the axilla (Figure 9). Merging of the basilic and brachial veins may take place in the

Elbow Triangle Ecchymosis

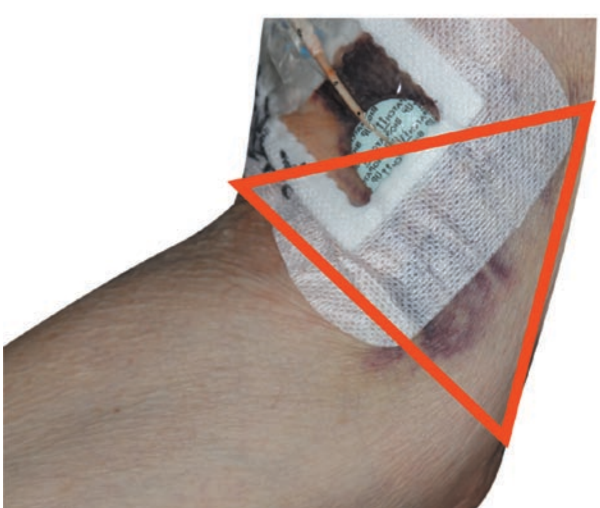

Figure 5. *Red Zone, example of Elbow Triangle Ecchymosis. Image by author.*

Figure 6. *Elbow Triangle compression and post-insertion bleeding. Notice the dressing not adhering at the edge. Permission Concord Hospital. Image by author.*

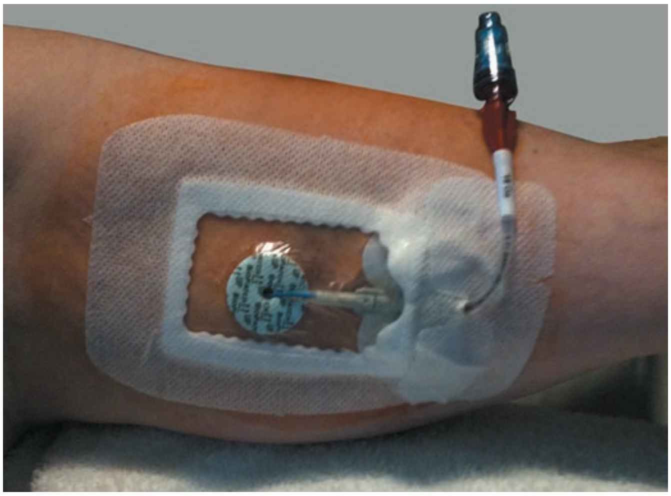

Figure 7. Ideal Zone insertion at 12cm from MEC with a Total Zone Measurement of 18cm. Permission Concord Hospital. Image by author.

YZ before becoming part of the axillary vein. The skin here is moist and usually has some amount of hair. Moisture in the axilla will likely support more bacterial colonization compared to the Green or Red Zones. Moisture from the axilla may also impact dressing adherence. Movement of the arm related to the shoulder joint may compress the catheter, vein and dressing. The lower portion of the YZ as it connects with the ideal portion of the GZ is still very characteristic of the GZ. On occasion, this author has used the junction of the Yellow and Green Zones for PICC insertion. The lower half of the YZ may still be the best location at times for PICC insertion. However, extending too far into the YZ may have consequences related to excessive moisture and dressing maintenance. Caution is advised when considering PICC insertion here.

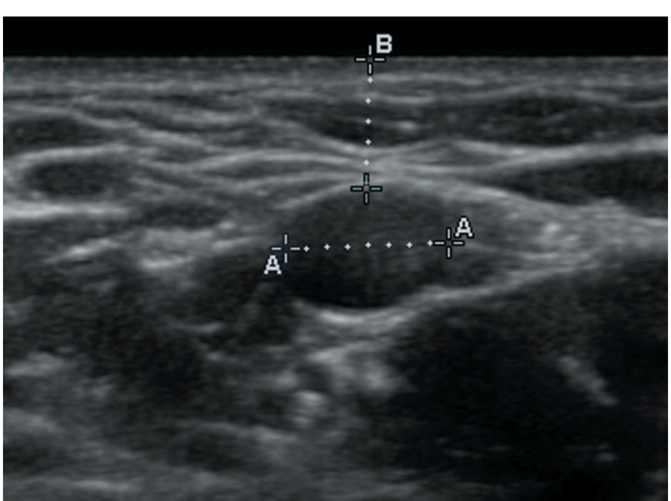

Figure 8. Green Zone basilic vein at 12cm from MEC, increased depth (B) 5.2mm, and diameter (A) 6.5mm, compared to RZ basilic vein. Image by author.

The Procedure of Ultrasound and ZIM

Patient positioning is important when using the ZIM. The patient should be as flat as possible, the head-of-bed between 0-15 degrees, the arm should be abducted 90 degrees, and externally rotated. Position the patient so that the elbow joint is resting on the bed. Often a patient will need to be in the middle of the bed or more toward the opposite side depending on arm length. A real helpful trick is to take a hospital towel, roll it up a few turns and tuck the roll under the soft tissue of the medial upper arm. The towel roll assists with arm stabilization, external rotation, and creates a flat plane of tissue for more ideal angles of insonance when scanning. Towel roll stabilization facilitates needle puncture and wire advancement with ultrasound guided insertions. This is more important for patients with loose skin, muscle atrophy and obesity. The towel roll can be made larger or smaller to accommodate patient characteristics, with the goal of providing a level surface from which to scan and work. The rolled towel makes the patients arm position and comfort easier to maintain. If the patient can not be flat than build the arm up with pillows to create a flat plane and still use the towel roll.

Once positioned, scan with ultrasound, starting in the mid upper arm. Locate the brachial artery and median nerve: these structures must be identified to avoid accidental puncture, but they are also great landmarks from which to start a systematic vein assessment. Next, identify the brachial veins near the artery and then move medially to locate the basilic vein. Follow each vein path the length of the upper arm from the antecubital veins to the axillary vein. Apply the ZIM measurements and start working the GZ to find the ideal needle insertion point.

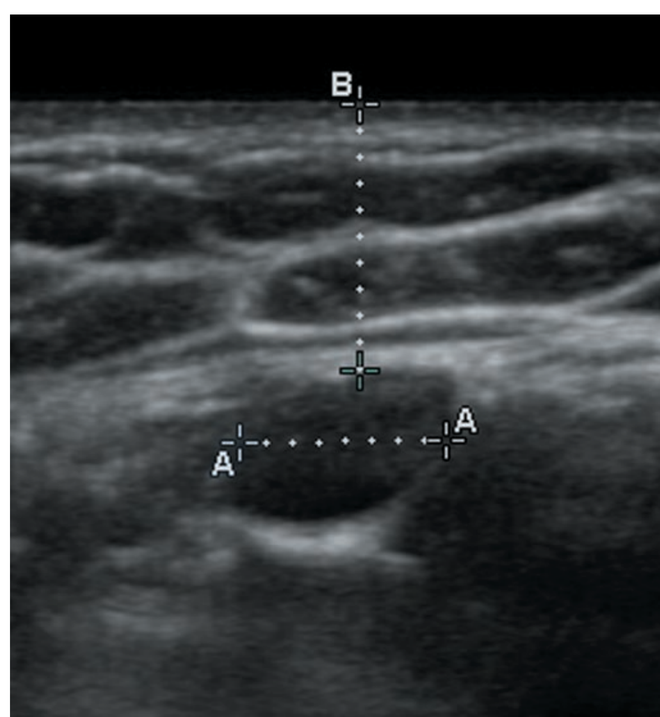

Figure 9. Yellow Zone basilic vein at 16cm from MEC, increased depth (B) 8.3mm, but not diameter (A) 6.4mm at this point, compared to IZ basilic vein. Image by author.

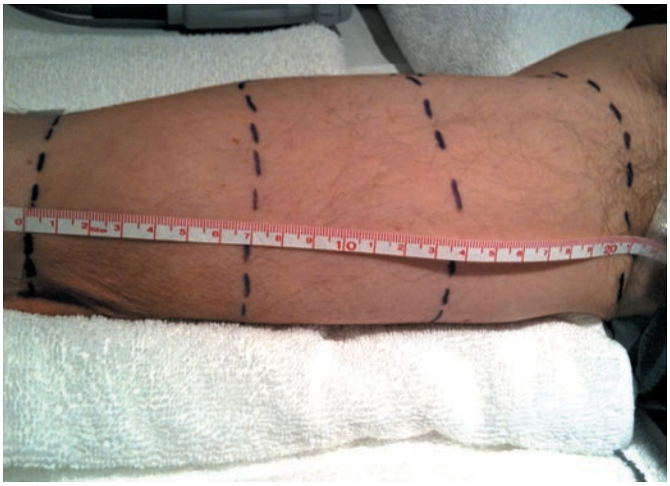

Figure 10. Arm abducted, rolled towel supporting arm. Measuring the Total Zone and dividing by three. Image by author.

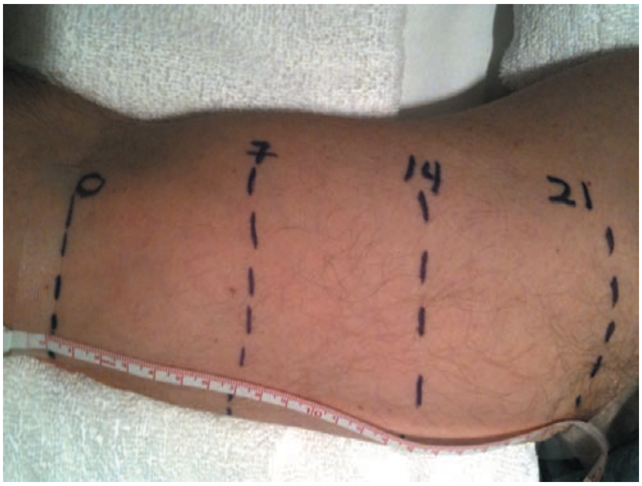

Figure 11. A 21cm TZM is divided into three 7cm zones. Image by author.

Specifically look for the best basilic vein image at or above the middle of the upper arm. Corresponding skin and musculoskeletal features that will allow for a flat, dry area to secure the PICC are essential. If visualization of the veins is difficult, insert the probe into the axilla. Visualize the large axillary vein. While keeping that image centered on the screen, move back down the arm to reach the Ideal Zone. This author consistently finds himself placing PICCs in the Ideal Zone usually between 12-15cm from the MEC. Total Zone Measurements will vary but most adults fall between 20-22cm. This is a very narrow range but extremely consistent.

Observations of ZIM Practice

Though ZIM principles have been well-defined only in the past two years, this author has been using the principles of ZIM for 6 years. In my practice, 40 PICCS have been inserted with ZIM between February 2009 and October 2010. Reasons for line removal and documentation of complications were reviewed and likely included: arm edema, leaking, pain, blood cultures from the PICC, or inadvertent line removal. In the 18-month review period in which 40 PICCs were inserted, zero infections or other complications were documented. The basilic vein was used for 38 insertions and a brachial vein used twice. Each line was removed because it was no longer needed. Some patients went home with PICCs and once discharged they were treated as if the line had been removed. The mean inpatient PICC dwell time was **9.2** days, with a maximum dwell of **37** days and a minimum of **1** day. All PICCs were inserted with the use of ultrasound and a tip locating system.

Discussion of ZIM Practice

Significant outcomes related to practice that could be measured include: insertion complications, dressing adherence, bleeding, thrombosis, line colonization, and CRBSI or CLABSI events. This author cannot reflect upon the presence of asymptomatic thrombosis, but no documentation was discovered that showed symptomatic thrombosis. A zero percent symptomatic thrombosis rate is something to consider as relevant compared to the 7% reported by Yacopetti[3] and the 4-5% described by Vesely[5]. A 100% inpatient completion of therapy rate is significant. In my experience as a consultant and clinician, an 88-90% successful completion of therapy rate would be more likely. Nichols and Humphrey[18] demonstrated an 89.3% completion of therapy with ultrasound guided PICC insertions. Stokowski et al.[8] showed an 82.9% completion of therapy rate. None of the 40 PICCs were cultured for suspected infection, which may indicate that a specific insertion site of the upper arm could influence colonization of the PICC through the catheter skin junction.

Observation of PICC Insertion Sites

The author observed the insertion location of PICCs in an acute rehabilitation hospital located in the Northeast U.S. The patients at this facility are admitted from surrounding area hospitals, many of which are large academic facilities. This hospital also contracts with a PICC insertion service. A notation was made of where the PICC was inserted on patients admitted to this facility as opportunity presented itself. After six weeks, 33 PICC sites were observed according to the ZIM color scheme (Table 3). The

Table 2.
Review of Individual Practice

PICCs Inserted	Average Dwell	Documented Complications	Max Dwell	Minimum Dwell	Completion of Therapy
40	9.2 days	0	37 days	1 day	100%

Figure 12. *Ideal Zone, basilic vein identified at 12cm from the MEC. Image by author.*

Figure 13. *Ideal Zone, image of basilic vein identified at 12cm from the MEC. Image by author.*

goal was to obtain some measure as to the prevalence of insertion by color zone. The results show that the majority of PICCs were inserted in the Red Zone at 73%, and the fewest number were inserted in the upper Green Zone or Ideal Zone at 3%.

A colleague from western Canada was intrigued by the ZIM and after learning how to measure, and define the zones, she observed PICC insertion sites by the zone color scheme at her facility (Table 4). This was an observation done on a single day. The sample was 31, 23% Red Zone, 45% Green Zone (lower half) and 32% Yellow Zone. Averaging the two sites together gives a Red Zone prevalence of 45% and a Green Zone prevalence of 32%. One out of every 3 PICCs were inserted in some part of the Green Zone and only 1.6%, or 1 out of 64 PICCs were inserted in the Ideal Zone.

Discussion of PICC Practice

The author's observations of PICC insertion sites suggest that insertion practice is highly variable, and that PICCs are often inserted too low in the upper arm. More consideration should be given to all insertion location risk factors. This may mean that more formal education and training is needed in the use of ultrasound for vascular access assessment. It may also mean that the minimum standard of quality for ultrasound machines in vascular access needs to be increased. Ultrasounds for vascular access should provide for reasonably effortless differentiation between an artery, vein, nerve, and lymph vessel. All ultrasound machines used for vascular access should be able to clearly define vessel characteristics like: path, size, flow, and the presence of echogenic material.

Ultrasound has revolutionized patient safety related to successful and less traumatic PICC insertion, evidenced by reduced complication rates and increased successful insertion rates, with the latter ranging from 96-100%.[8,18] However, evolution of practice has uncovered that successful insertion is only one-half of the PICC equation. Successful completion of therapy and the measurement of asymptomatic UEDVT may be more compelling measures to have a safe and quality PICC practice.

This presents two relevant questions:

1. Why is ultrasound use for vascular access not universal, when it is a known significant safety measure for access device insertions?
2. Why is PICC insertion practice so variable, given what we know about site risk factors?

Table 3. **Observation of PICC Insertion Sites from a Hospital in Northeast U.S.**

ZONE	PICCs INSERTED	PERCENT BY LOCATION
RED (RZ)	24	73%
GREEN (Lower GZ)	6	18%
IDEAL (Upper GZ)	1	3%
YELLOW (YZ)	2	6%
	33	**100%**

Table 4. **Observation of PICC Insertion Sites from a Hospital in Western Canada**

ZONE	PICCs INSERTED	PERCENT BY LOCATION
RED (RZ)	7	23%
GREEN (Lower GZ)	14	45%
IDEAL (Upper GZ)	0	0%
YELLOW (YZ)	10	32%
	31	**100%**

These questions are important because patients at any given hospital are typically members of that community, and therefore repeatedly seek care at the same facility. Repeated care in combination with poor site selection with or without ultrasound is a misguided application of practice. Veins are a limited and precious resource for infusion therapy. Every reasonable effort should be made to preserve veins through purposeful planning and the use of appropriate technology. Lack of the systematic use of ultrasound for PICC insertion is short sighted and a costly approach to vascular access care. It is not usually a single measurable event that will impact the value of systematic vascular access care, but the totality of all events over a longer period of time. This reactive and episodic care common to vascular access forgoes planning and system wide implementation of safety solutions. In other words, the big picture is lost and we simply solve one crisis at a time. Too often the catalyst for real change in any care process is the result of a single sentinel event and not the result of proactive planning, assessment, and intervention. Variations in vascular access practice must be reduced with the use of ultrasound and systematic processes that apply relevant evidence and theory to practice. Vascular access clinicians can no longer wait for training to find them or for guidelines to be issued to address these concerns. Facilities and clinicians must accept the challenge to fully support and implement systematic vascular access programs and the use of ultrasound technology.

Conclusion

The reduction of practice variation based on evidence and clinical theory is necessary for patient safety. The PICC Zone Insertion Method is a proposed clinical microsystem, and patient safety solution. It achieves safety by applying risk management strategies related to PICC site selection in a standardized, reproducible, and measurable manner. Site selection is a known contributor to CRBSIs, thrombosis, and phlebitis. The future use of veins for life saving vascular access may very well depend on decisions we make today when planning, assessing and performing vascular access. This author has undergone a purposeful exploration to refine and validate the principles of the PICC ZIM. The observations are limited, but should be meaningful enough to peak the curiosity of colleagues. Standardization based upon sound principles of practice is necessary for meaningful outcomes measurement, which will take PICC insertion to the next level of scientific inquiry. At the very least we owe a great deal of professional obligation to use technology and systematic care to the very best of our ability.

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LUM's CVC MEASUREMENT GUIDE ©

Height (in)	R.PICC (cm)	L.PICC (cm)	R.JC (cm)	L. SC (cm)	R. SC (cm)	Height (cm)
4ft 8in	42.5	46.5	13.0	18.0	14.0	143
4ft 10in	44.0	48.0	13.5	18.5	14.5	148
5ft	45.5	49.5	14.0	19.0	15.0	153
5ft 2in	47.0	51.0	14.5	19.5	15.5	158
5ft 4in	48.5	52.5	15.0	20.0	16.0	163
5ft 6in	50.0	54.0	15.5	20.5	16.5	168
5ft 8in	51.5	55.5	16.0	21.0	17.0	173
5ft 10in	53.0	57.0	16.5	21.5	17.5	178
6ft	54.5	58.5	17.0	22.0	18.0	183
6ft 2in	56.0	60.0	17.5	22.5	18.5	188
6ft 4in	57.5	61.5	18.0	23.0	19.0	193

CVC = CENTRAL VENOUS CATHETER; R = RIGHT; L = LEFT; JC = JUGULAR CATHETER;
SC = SUBCLAVIAN CATHETER; PICC = PERIPHERAL INSERTED CENTRAL CATHETER.

NOTE: STANDARD INSERTION SITE:
FOR "PICC" INSERTION : – 2.5 CM BELOW THE ANTECUBITAL FOSSA LINE *
FOR "SC" INSERTION : – 2.5 CM BELOW THE MID-CLAVICULAR BORDER (– 2ND ANTERIOR RIB LEVEL) * **
FOR "JC" INSERTION : APEX OF THE STERNOCLEIDOMASTOID TRIANGLE OR CRICOID LEVEL*
* DEVIATION FROM STANDARD INSERTION SITE, CVC LENGTH MUST BE ADJUSTED ACCORDINGLY
** PENDULOUS BREAST MUST BE TAPED DOWN PRIOR TO "SC" INSERTION IN SUPINE OR TRENDELENBERG POSITION

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LUM's PICC measurement guide			
Height - inch	**Right PICC - cm**	**Left PICC - cm**	**Height - cm**
4 ft 8 in	40.0	44.0	143
4 ft 10 in	41.5	45.5	148
5 ft	43.0	47.0	153
5 ft 2 in	44.5	48.5	158
5 ft 4 in	46.0	50.0	163
5 ft 6 in	47.5	51.5	168
5 ft 8 in	49.0	53.0	173
5 ft 10 in	50.5	54.5	178
6 ft	52.0	56.0	183
6 ft 2 in	53.5	57.5	188
6 ft 4 in	55.0	59.0	193
Measuring from ACF			