ECG Guided PICC Placement; The Future of Vascular Access

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Disclosures

The speaker is a employee of BD.

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Outline:

- Organizational standards for tip location
- Clinical implication of malposition
- Current practice standards for tip verification
- Challenges of Chest x-ray
- Introduction to ECG Guidance
- ECG guidance literature review
- Available technology
How Important is it?
## Standards for Tip Location

<table>
<thead>
<tr>
<th>Organization</th>
<th>Recommendation</th>
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<tbody>
<tr>
<td>AVA (1998)</td>
<td>Distal SVC close to the cavoatrial junction</td>
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<td>FDA CVC working group (1998, 1994)</td>
<td>Lower 1/3 of the SVC Catheter tip should not be in or allowed to migrate into the heart</td>
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<td>ONS (2004)</td>
<td>SVC at junction of RA PICCs lower 1/3 of SVC</td>
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<td>NKF/DOQI (2001)</td>
<td>SVC/RA junction or RA</td>
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<tr>
<td>SIR (2000)</td>
<td>SVC/RA junction</td>
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</tbody>
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Precautionary Statement, FDA/CVC working group. 1999
Access Device Guideline. ONS, 2004
2001 Kidney Disease Outcomes Quality Initiative (K/DOQI) Clinical Practice Guidelines
Reporting Standards for Central Venous Access, SIR 2000)
Why is Tip Location Important?

Dysfunction

- Above 6 cm: 87.5%
- 4.5 - 6 cm: 31.8%
- 2.5 - 4 cm: 18.5%
- 0.5 – 2 cm: 15%
- At or below CAJ: 2.3%

Why is Tip Location Important?

- CVP:
  - Improper tip location can give faulty CVP readings

Where is the CAJ?
In a study by Dr. Peter Verhey, the average length of the SVC was 7.6 cm (range, 5.0—10.5 cm, S.D. ± 1.2 cm).

Fig. 3A-E—Transverse CT images from a 36 year old female at levels slightly cephalad (A) and slightly caudal (B) to the confluence of the brachiocephalic veins (origin of the SVC); (C) at the level of the lower SVC, just cephalad to the CAJ (note the presence of a tissue separation between the SVC and right atrial appendage (white arrow)); and (D) at the level of the SVC entry into the RA (termination of the SVC at the CAJ). (E) Coronal MIP image from same patient demonstrating the SVC in its entirety (bracket).
Central Venous Anatomy

- Average length of the SVC was 7.6 cm (range, 5.0—10.5 cm, S.D. ± 1.2 cm).

- The average distance from the carina to the CAJ was 4.7 cm (range, 2.5—7.2 cm, S.D. ± 1.1 cm)

The most superior right cardiac border-forming structure on scout tomograms was the right atrial appendage (RAA) in 100% of patients.

The junction between the vertically-oriented lateral border of the lower SVC and the convexity of the right cardiac border can therefore be referred to as the SVC-RAA junction.

The average distance from the SVC-RAA junction to the CAJ was 1.8 cm (range, 1.0—3.0 cm, S.D. ± 0.5 cm).

Fig. 4A,B—Scout tomogram (A) and the corresponding transverse CT image (B) through the right superior cardiac convexity (1.0 cm below the SVC-superior cardiac border convexity junction (open arrow)) in an adult patient (57 y.o.), demonstrating the anatomic structure composing the right superior cardiac convexity on scout tomogram—the RAA (*). Note the presence of tissue separating the SVC and RAA (white arrow).
Venogram showing contrast confined to the SVC below the SVC-RAA junction

Reveals true location of the CAJ

Fluoroscopy images shot in rapid sequence, left then right, showing IV contrast confined to the SVC well below the SVC-RAA junction, then dispersing in the right atrium

Image courtesy of Jamie Santolucito, used with express permission.
The Optimal Zone

On the way to the SVC
PICC tip left IJ
PICC tip azogos vein
PICC tip RV
PICC through IVC with tip in hepatic vein
Malposition

University of Pennsylvania Medical Center

- 1,654 lines were placed w/o tip location technology
- 163 were malpositioned
- 10% malposition rate (excludes atrial malpositions)

Trerotola, S. Analysis of Tip Malposition and Correction in Peripherally Inserted Central Catheters Placed at Bedside by a Dedicated Nurse Team. JVIR, April, 2007.
Malposition

Naylor Article

- Santa Rosa Memorial Hospital
- 321 lines were placed w/o Sherlock ultrasound system*
- 43 lines were grossly malpositioned (outside of the SVC)
- 13.4% malposition rate without tip location
- 2.5% using magnetic tip location

What types of malpositions remain?

Figure 1. Malposition types before and after the institution of the Sherlock Tip Location System (Bard Access Systems, Salt Lake City, UT).

Challenges with Chest X-rays
Projecting over the SVC

In the SVC

In the region of the...

OK to use

No pneumo

Deep in the RA

What does it matter??
How accurate is Chest X-ray?

- How do your radiologists read for tip placement?
- What anatomic landmarks do they use?
  - Carina?
  - Right atrial notch?
  - Right mainstem bronchus?
  - Vertebral bodies?
- Is there consensus among radiologists?
Limitations of 2D imaging
Factors Affecting CXR Quality

- Exposure
  - Over/under
  - Patient body habitus
    - Patient Compliance
    - Patient Position (upright or supine)
      - For ICU patients typically no lateral CXR
  - Portable exam
  - Degree of inhalation

- Motion
  - Respiratory
  - Catheter
  - Positioning
    - Rotation
    - Parallax
Factors Affecting CXR Quality

INHALATION

EXHALATION
Factors Affecting CXR Quality

Underexposed  overexposed
Factors Affecting CXR Quality

Rotated right

Rotated left
Potential CXR Difficulties

- Interpretation
  - Anatomy not well-visualized
  - Anatomic variables
  - Other pathology present
Potential CXR Difficulties

May lead to:

- Increased nursing time
- Reduced productivity
- Transport and tech costs
- Repeat radiographs
  - Average radiographs per PICC insertion
FDA & JOINT COMMISSION INITIATIVES

- Both the FDA and Joint Commission have initiatives to reduce patient exposure to radiation.

- “In order to reduce the exposure of the patient to ionizing radiation, use other imaging techniques, such as ultrasound or MRI, whenever these tests will produce the required diagnostic information at a similar quality level.” – The Joint Commission

So, in review...

- Is tip location important in the safety and functioning of PICC lines?
- Where should the tip be?
- Is the CAJ easy to see on CXR?
- Can it always be found on CXR?
- We need a better way!
Using ECG Guidance for PICC Tip Confirmation

It is just a matter of anatomy
ECG GUIDANCE: REVIEW OF LITERATURE

The EKG method for positioning the tip of PICCs: results from two preliminary studies

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¹Dept. of Surgery, ²Dept. of Infectious Diseases, ³Dept. of Oncology, ⁴Intensive Care Unit
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- **OBJECTIVE:** To determine the feasibility of using ECG guidance to determine terminal tip location when inserting a PICC

- **FINDINGS:**
  - 100% of open-ended ECG-guided PICC placements (12/12) showed anticipated P-wave changes and were found to be correctly positioned in the CAJ (2-view CXR)
  - 100% of closed-ended PICCs (5/5) that showed characteristic P-wave changes were correctly positioned. A sixth placement did not show P-wave change due to ‘electrical artifacts’ in the baseline ECG reading
  - ‘ECG method may strongly improve both the cost-effectiveness and safety of the procedure for terminal tip interpretation on insertion…’

HOW CAN ECG HELP WITH TIP LOCATION?

- The SA node is a group of myocytes located high on the wall of the right atrium, near the cavoatrial junction.

- The SA node is the heart’s physiologic pacemaker and generates sinus rhythm.

- The electrical impulses spontaneously generated by the SA node cause depolarization of the atria, which is reflected as the P-wave on an ECG.
PRINCIPLES OF INTRAVASCULAR ECG TIP CONFIRMATION SYSTEMS

- In patients with a distinct P-wave, the P-wave will increase in amplitude as the catheter approaches the cavoatrial junction.

- As the catheter advances into the right atrium, the P-wave will decrease in amplitude and may become biphasic or inverted.
1. P-wave increasing as catheter approaches cavoatrial junction.
2. P-wave at maximum amplitude indicating catheter tip in proximity to the top of the cavoatrial junction.
3. P-wave with small negative deflection indicating catheter tip in proximal right atrium.
4. Biphasic P-wave indicating catheter tip in mid-right atrium.
5. Inverted P-wave indicating catheter tip approaching right ventricle.
Perspective matters...

12-lead electrocardiogram tracing
The process THEN

1. PICC Order Placed
2. PICC Insertion
3. X-Ray Image Acquired
4. Radiologist Reads X-Ray
5. Catheter Released
6. Repositioning by IR
7. Repositioning by PICC Team
8. X-Ray Image Acquired
9. Radiologist Reads X-Ray
10. Catheter Released
The process NOW

PICC Order Placed

PICC Insertion

Catheter Released
Benefits of ECG placement

- What are the benefits of ECG guided PICC placement?
  - For the patient?
  - For the PICC nurse?
  - For the Hospital?
Limitations of ECG placement

- What are the limitations of ECG guided PICC placement?
  - For the patient?
  - For the PICC nurse?
  - For the Hospital?
Standards of tip location

- “Tip location of a CVAD shall be determined radiographically or by other approved technologies prior to initiation of infusion therapy.”†

Indicated as an ALTERNATIVE METHOD to chest x-ray and fluoroscopy for PICC tip placement confirmation in adult patients. Any alterations of cardiac rhythms that change the normal presentation of the P-wave limit the use of ECG tip confirmation technology. In these instances, confirm PICC tip location using an alternative method.

† Infusion Nursing Standards of Practice (January/February 2011). Volume 34, Number 1S.
CXR—still the gold standard?

- Opponent pressures
  - Turf
  - Unfamiliarity/marketing/
  - knowledge

- Proponent strategy
  - Clear, solid evidence
  - Implementation/marketing
  - Change “standard” of care!!
Please review all relevant product IFUs prior to product usage.

This educational program is not intended to act as a substitute for, and does not replace, the relevant instructions for use of the products discussed herein. Please refer to all relevant product instructions for use for indications, contraindications, warnings, and precautions.