The Great Debate in Neonatal PICCs: Catheter Tip Location and What IS Central?

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The speaker has disclosed that she is a clinical education consultant for Argon Medical Devices, which could be perceived as having a bearing on her presentation of this subject. She has no significant financial interest or relationship with any other companies or the manufacturer(s) of any commercial product and/or service that will be discussed as part of this presentation.

Session Summary

The presenter will review of the latest evidence, including anatomical, hemodynamic and pharmacologic implications of catheter tip location, and the potential risks for serious complications associated with suboptimal tip location. Also, a look at new technological advances.

Session Objectives

Upon completion of this presentation, the participant will be able to:

- identify the difference between central and non-central catheter tip locations;
- identify the implications of catheter tip locations;
- name three complications that occur due to movement of the catheter tip location;
- identify two risk factors for malposition;
- identify at least two preventive strategies to minimize complications.

References


**Session Outline**

See presentation handout on the following pages.
The Great Debate in Neonatal PICC’s
Catheter Tip Location & What IS Central?

Elizabeth Sharpe, DNP, ARNP, NNP-BC, VA-BC
FANNP, October 2013

What are the indications for PICCs?

- Transitioning from umbilical lines
- Premature infants < 1500 gms
- Hyperosmolar (> 600 mOsm/L)
- Irritant medications
- pH <5 or >9 (INS, 2011)
- More than 6 days of hyperosmolar IV therapy (CDC, 2011)
- GI, congenital cardiac defects
- Limb anomalies, birth injuries

Osmosis and Cell Volume

<table>
<thead>
<tr>
<th>Medication</th>
<th>pH</th>
<th>Osmolarity</th>
<th>Irritant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampicillin 250 mg/ml SW</td>
<td>8.0-10.0</td>
<td>1215 mOsm/L</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>250 mg/ml SW</td>
<td>293 mOsm/L</td>
<td></td>
</tr>
<tr>
<td>Gentamicin</td>
<td>2.5-5.5</td>
<td>162 mOsm/L</td>
<td></td>
</tr>
<tr>
<td>Meropenem</td>
<td>2.3-8.3</td>
<td>-300 mOsm/L</td>
<td>X</td>
</tr>
<tr>
<td>Phenobarbital</td>
<td>9.2-10.2</td>
<td>&gt; 9000 mOsm/L</td>
<td></td>
</tr>
<tr>
<td>Piperacillin/ tazobactam</td>
<td>5-6</td>
<td>270-445 mOsm/L</td>
<td></td>
</tr>
<tr>
<td>Vancomycin</td>
<td>2.5-4.5</td>
<td>249 mOsm/L</td>
<td>X</td>
</tr>
<tr>
<td>Acyclovir</td>
<td>10.5-11.5</td>
<td>278 mOsm/L</td>
<td>X</td>
</tr>
</tbody>
</table>

Disclosures

- Clinical Education Consultant for Argon Medical Devices
- Acknowledgements for Images Permissions
  - Argon Medical Devices
  - Lumos Catheter Systems

Review

- Chemistry
- Physics
- Anatomy
- Physiology
References

<table>
<thead>
<tr>
<th>Infusate</th>
<th>mOsm/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal saline</td>
<td>308 mOsm/L</td>
</tr>
<tr>
<td>D 5 %</td>
<td>260 mOsm/L</td>
</tr>
<tr>
<td>D 10 %</td>
<td>505 mOsm/L</td>
</tr>
<tr>
<td>D 12.5 %</td>
<td>625 mOsm/L</td>
</tr>
<tr>
<td>TPN</td>
<td>&gt; 800 mOsm/L</td>
</tr>
</tbody>
</table>

Site for images: http://www.cincinnatichildrens.org/service/v/vascular-access/default/

Where is the optimal central PICC tip location?

- What is Central?
  - lower ½ to 1/3 of SVC
  - IVC above/at level of diaphragm


Catheter Tip Location

A matter of interpretation

Retrospective review of 27 films to assess CVC location: Radiologist & Junior Doctor = 96% (Bagchi, 2002)
Review of 106 radiographs by 3 observers had only 37% agreement (Odd, 2004), 2 Neo’s & radiologist


How do you determine tip location?
- Cardiac silhouette
- Carina
- Vertebra/vertebral body units

**Vessel & catheter sizes**

<table>
<thead>
<tr>
<th>Diameter/Length</th>
<th>700 grams</th>
<th>900 grams</th>
<th>Term</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brachiocepalic</td>
<td>1.1 +/- 0.3 mm</td>
<td>1.2 +/- 0.2 mm</td>
<td>8 mm</td>
<td>9 mm</td>
</tr>
<tr>
<td>Subclavian</td>
<td>2.6 +/- 0.4 mm</td>
<td>2.6 +/- 0.4 mm</td>
<td>19 mm</td>
<td>19 mm</td>
</tr>
<tr>
<td>Brachioceпалic to carotid junction</td>
<td>3.3 +/- 0.3 mm</td>
<td>3.3 +/- 0.3 mm</td>
<td>19 mm</td>
<td>19 mm</td>
</tr>
<tr>
<td>Superior Vena Cava</td>
<td>4.1 +/- 0.7 mm</td>
<td>4.1 +/- 0.7 mm</td>
<td>6.8 mm/3.5 cm</td>
<td>6.8 mm/3.5 cm</td>
</tr>
</tbody>
</table>

Vessel diameters are in millimeters
Vessel lengths are in centimeters

Cardiovascular surgeons, Dr. Robert Anderson, Eifinger et al, 2011, Clinical Anatomy

• **The CVC tip should remain outside the cardiac silhouette but still within the vena cavae:**
  - Approximately 1 cm outside the cardiac silhouette in premature infants
  - Approximately 2 cm in term infants

• Retrospective case reviews of 61 patients
• Mean gestational age 30 weeks
• Mean birth weight 1 kg

Nowlen et al. Pediatrics Vol. 110 No. 1 July 2002

• Complication rates related to catheter tip placement
  - N= 1266 PICCs in 1053 patients
  - Mean age 6.49 +/- 2 years
  - Central (SVC, RA, IVC at/above diaphragm)
    - Central group had 3.8% of complications
    - Noncentral (all other tip locations)
    - Noncentral group had 28.8% of complications

• Patients with catheter tips in noncentral locations were **8x more likely** to experience a complication!

Racadio, Dwellman, Johnson, Bean & Jacobs, Pediatrics, 2001

**Pediatric Complication Rates: Central vs. Noncentral.**

<table>
<thead>
<tr>
<th>Complication</th>
<th>Central (SVC, RA, IVC &gt; diaphragm) N = 1096</th>
<th>Noncentral (subclavian, brachiocephalic) N = 169</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phlebitis</td>
<td>1.5%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Occlusion</td>
<td>1.7%</td>
<td>6.5%</td>
</tr>
<tr>
<td>Leaking</td>
<td>1%</td>
<td>11.2%</td>
</tr>
<tr>
<td>Mechanical</td>
<td>3%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Infection</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>3.8%</td>
<td>28.8%</td>
</tr>
</tbody>
</table>

The noncentral group had shorter mean PICC duration than the central group (9.3 days vs. 16.4 days) and **was 8 times more likely to develop a complication**

Racadio et al. Pediatrics 2001

**Should we settle?**

• Complications associated with central and non-central venous catheters in a NICU
  - N= 91 noncentral (PINCCs) and 889 central (PICCs) in 750 neonates
  - Complication rates: PINCCs 44% vs PICCs 25.2%
  - Phlebitis, infection, leakage, occlusion, infiltration
  - Most common complication in PINCCs was infiltration
  - PINCCs were more than twice as likely to develop a complication compared to PICCs

Colaco, Dang, Northrup, Rosario, J Perinatology, 2012
More on tip location

- PICC tip position and risk of associated complications in neonates
  - N=319 infants: Central 203, Noncentral 116
  - Central catheters had lower rates of complication 30 vs. 46.6% vs noncentral catheters
  - Midclavicular placement: between lateral and medial border of clavicle
  - Midclavicular placement was 3x more likely to develop infiltration or mechanical complications

Jain, Deshpande, Shah, J Perinatology AOP, 2012

The latest on Tip Position

- N = 237 PICCs in 200 neonates, 207 central, 30 noncentral
- Central = SVC or IVC
- Noncentral + subclavian, CAJ, RA, iliac, axillary vein
- Mean dwell time: 11.7 days in central vs. 9.8 days in noncentral
- Noncentral had higher incidence of removal due to extravasation.


Implications for Practice

- Radiographic monitoring and consistent patient positioning support accurate catheter tip confirmation.
- Accurate knowledge of the catheter tip location is crucial in prevention of catheter-related complications, as catheters whose tips are located outside the SVC/IVC have increased risk of complications.

Keys to Consistent Monitoring of Catheter Tip Location

- Consistent positioning of the extremity to bring catheter tip to deepest location
  - Upper extremity adducted if basilic vein
  - Upper extremity abducted if cephalic vein
  - Lower extremity flexed
- In situ patient dynamics can impact catheter tip location

Risk factors related to tip location

- Noncentral PICC tip locations, age < 1 year and PICU exposure were risk factors for PICC removal.
- N = 2574 PICCs in 1807 patients (median age 5 years)
- Central = SVC or IVC
- Noncentral catheters were more likely to have complications needing removal than central (43.8% vs. 16.2%)

Jumani, Advani, Reich, Gosey & Milstone, JAMA Pediatrics 2013
What can you do when the catheter is unable to be inserted into central placement?

- If catheter tip is in brachiocephalic or subclavian, may use as a peripheral as a temporary measure if blood returns and catheter flushes
- May withdraw catheter to appropriate midline placement.
- Peripheral limitations (no > D12.5)

Risk factors for malposition

- In situ patient dynamics
  - Coughing, crying
  - Changes in thoracic or abdominal cavity pressures
  - Unfavorable positioning (consider counter-gravity)
- Iatrogenic mechanical dynamics
  - High frequency oscillator/jet ventilation
  - Infusion induced catheter movement due to forceful flushing
- Securement failure
  - Improper or inadequate securement, loose dressing

Pearls for Placement:
- Turn head towards ipsilateral side for upper extremity insertion. Level the bed.
- Premeditate to medicate?
- Coordinate with planned extubation or ventilatory support changes
- Coordinate with volume expansion, after fluid status optimized
- Coordinate after blood products support (PRBCs, platelets)
- Place before anticipated surgery
- Place before hypothermia protocol initiated
- Timing is everything!
Thank you!

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