ABSTRACT. Objective. To compare complication rates between central venous catheter tip location and noncentral tip location after peripherally inserted central catheter (PICC) placement in children.

Methods. Between 1994 and 1998, data from all children who underwent PICC placement were analyzed. Patient demographics, catheter characteristics, catheter duration, infusate composition, and catheter complications were entered prospectively into a computerized database. Catheter tip locations were determined by fluoroscopy and were defined as central if they resided in the superior vena cava, right atrium, or high inferior vena cava at or above the level of the diaphragm, and as noncentral if located elsewhere. Differences in complication rates between the central and noncentral groups were analyzed.

Results. Data from a total of 1266 PICCs were analyzed from 1053 patients with a mean age of 6.49 ± 2 years (range: 0–45.0 years). Of the 1266 PICCs, 1096 (87%) were central in tip location, and 170 (13%) were noncentral in tip location. The central group had 42 complications of 1096 catheters (3.8%), while the noncentral group had 49 complications of 170 catheters (28.8%). Controlling for patient age, catheter size, gender, and catheter duration with a logistic regression model, there remained a statistically significant increased likelihood of complication in the noncentral group versus the central group (adjusted odds ratio: 8.28; 95% confidence interval: 5.11–13.43).

Conclusions. Centrally placed catheter tips are associated with fewer complications than are noncentrally placed catheter tips. Clinicians should ensure that catheter tips reside centrally after PICC placement in infants and children. Pediatrics 2001;107(2). URL: http://www.pediatrics.org/cgi/content/full/107/2/e28; catheters, complications, PICC, central venous, children, infants, phlebitis, occlusion.

ABBREVIATIONS. PICC, peripherally inserted central catheter; SVC, superior vena cava; RA, right atrium; IVC, inferior vena cava; F, French; OR, odds ratio.

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Peripheral inserted central catheters (PICCs) have become popular in children because they allow safe long-term intravascular access, comfort, and ease of transition to home therapy. A PICC is defined as a catheter inserted percutaneously via a peripheral vein with the tip residing in a central vein. PICCs cannot always be advanced to a central venous location and are occasionally left with the catheter tip in noncentral positions, including the brachiocephalic, jugular, subclavian, axillary, or saphenous veins. There is increasing popularity in placing so-called “midline catheters” or “long IVs” whose catheter tips are intentionally left in a noncentral position. It has been suggested that central catheter tip location is unnecessary for safe intravenous access and infusion of isotonic medications. However, central catheter tip location may very well be important in providing venous access to a region of greater blood flow to achieve effective infusate hemodilution. The concept of rapid hemodilution was a driving force behind the popularization of central venous catheters and is likely to apply to PICCs because similar drugs and solutions are administered through both types of catheters. We hypothesized that central catheter tip location would result in decreased complication rates, compared with noncentral catheter tip location after PICC placement in children.

METHODS

At Children's Hospital Medical Center, all PICCs are placed by a specialized team of nurses under the supervision of pediatric interventional radiologists. The vast majority of catheters are inserted in the upper extremities at or slightly above the antecubital fossa under direct visualization or palpation of the vein. Ultrasound or contrast venography guidance by a pediatric interventional radiologist is used when veins of adequate size cannot be seen or palpated. After PICC placement, all catheter tip locations are determined by brief fluoroscopy. Catheter tips are defined as central if they reside in the superior vena cava (SVC), right atrium (RA), or high inferior vena cava (IVC) at or above the level of the diaphragm, and as noncentral if located elsewhere. Data regarding patient demographics, catheter characteristics, catheter duration, infusate composition, and catheter complications were entered prospectively into a computerized database. Between 1994 and 1998, data from all children who underwent placement of 2 French (F), 3 F, 4 F, and 5 F BARD (Salt Lake City, UT) Per-Q-Cath single lumen silicone PICCs were analyzed. Complications were recorded including leaking at the PICC insertion site, phlebitis (erythema, swelling, pain, or palpable cord), infection (positive blood and catheter tip cultures), catheter occlusion (inability to infuse or withdraw), and mechanical malfunction (catheter damage or unplanned catheter removal). All complications necessitated catheter removal.
RESULTS

Between 1994 and 1998, data from a total of 1266 PICCs were analyzed from 1053 patients with a mean age of 6.49 ± .2 years (range: 0–45.0 years). There were 541 males (51.4%) and 512 females (48.6%). Mean PICC duration was 15.4 ± 4 days (range: 0–106 days). Of the 1266 PICCs, 1096 (87%) were central in tip location (central group), and 169 (13%) were noncentral in tip location (noncentral group). There was no statistically significant difference between the types of infusates administered to the central and noncentral groups (Table 1), with antibiotics being the most common infusion in both groups.

The mean age in the central group was older than that in the noncentral group (6.8 ± .2 years vs 4.3 ± .6 years; P < .01). The mean PICC duration was greater for the central group (16.4 ± .4 days) than for the noncentral group (9.3 ± .6 days; P < .01). The distribution of catheters by size and tip location is noted in Table 2. The proportions of catheter sizes were different (Fisher’s exact test, P < .01) between the central and noncentral groups. There was a greater proportion of 2 F catheters in the noncentral group compared with the central group (59% vs 34%, respectively).

The central group had 42 overall complications of 1096 catheters (3.8%), while the noncentral group had 49 overall complications of 170 catheters (28.8%; 1.096 catheters (3.8%), while the noncentral group respectively).

There was no statistically significant difference in complication rates between 2 F and 3 F catheters. There were 2 PICC infections in catheters whose tips were located centrally and no infections in catheters whose tips were noncentral.

DISCUSSION

Recognized complications of PICCs include thrombosis, infection, catheter occlusion, phlebitis, chronic venous insufficiency, and pulmonary embolus.4–8 PICCs cannot always be advanced to a central location for a number of reasons including venospasm, venous tortuosity, and venous valves. There has not been clear evidence in the literature of an association between catheter tip location and complication rates in pediatric PICCs. Our data represent the largest study of PICCs in children and demonstrate that central catheter tip location was an important factor associated with reduced complication rates.

A previous study reported that noncentral tip location was acceptable in children.3 The investigators examined 587 PICCs, 233 (39%) of which were placed in noncentral veins, and concluded that there was no difference in complication rates between central and noncentral PICCs (27% vs 32%, respectively).3 However, these authors classified the subclavian vein for catheter tip location as central, and 46% of the central PICCs in that study had catheter tips located in the subclavian vein. In addition, the authors did not address whether the brachiocephalic vein was considered central or noncentral. We define subclavian and brachiocephalic veins as peripheral, and 10 of 49 complications (20%) in our noncentral group occurred in those catheters whose tips were in the

<table>
<thead>
<tr>
<th>TABLE 3. Types of Complications: Central Versus Noncentral Groups</th>
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<tbody>
<tr>
<td>Complication</td>
</tr>
<tr>
<td>Phlebitis</td>
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<tr>
<td>Occlusion</td>
</tr>
<tr>
<td>Leaking</td>
</tr>
<tr>
<td>Mechanical</td>
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<tr>
<td>Infection</td>
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<tr>
<td>Total</td>
</tr>
</tbody>
</table>

* One patient in each group had no data pertaining to PICC size.
TABLE 5. Definition of Central in Published PICC Studies

<table>
<thead>
<tr>
<th>Author</th>
<th>#PICCs</th>
<th>Age (Years)</th>
<th>Central</th>
<th>C Comp %</th>
<th>NC Comp %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kearns6</td>
<td>72</td>
<td>Adults</td>
<td>SVC</td>
<td>16</td>
<td>61</td>
</tr>
<tr>
<td>Kearns6</td>
<td>39</td>
<td>Adults</td>
<td>SVC</td>
<td>21</td>
<td>60</td>
</tr>
<tr>
<td>James15</td>
<td>157</td>
<td>1.4–91</td>
<td>SVC</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Donaldson14</td>
<td>222</td>
<td>0–18</td>
<td>SVC/RA junction</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Dubois10</td>
<td>285</td>
<td>0–18</td>
<td>SVC/RA junction</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Chait11</td>
<td>148</td>
<td>0–19</td>
<td>SVC/RA junction</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Frey7</td>
<td>269</td>
<td>0–27</td>
<td>SVC IVC</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Thiagarajan3</td>
<td>587</td>
<td>0–22</td>
<td>SVC RA IVC Subclavian</td>
<td>36</td>
<td>30</td>
</tr>
<tr>
<td>Crowley12</td>
<td>523</td>
<td>0–18</td>
<td>SVC RA subclavian</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Thiagarajan9</td>
<td>441</td>
<td>0–22</td>
<td>SVC RA IVC Subclavian</td>
<td>NR</td>
<td>NR</td>
</tr>
</tbody>
</table>

C Comp indicates central complications; NC Comp, noncentral complications; NR, not recorded.

* Subclavian and femoral veins “acceptable for antibiotics or nonhyperosmolar solutions.”

† Two episodes of thrombosis occurred with catheters whose tips were in left subclavian/internal jugular vein junction and left brachiocephalic/SVC junction (tip migrating to left internal jugular vein).
eters indicating great potential variability in blood flow rate and volume.

When a central venous catheter tip is positioned in the SVC, the tip is likely to lie parallel to, and not impinge on, the vessel wall. Solutions infused are rapidly diluted in this region. When the catheter tip lies peripheral to the SVC, factors such as venous tortuosity, valves, and decreased vein diameter increase the possibility of tip contact with the vein wall. This contact can disrupt the endothelial cell layer of the tunica intima, exposing the basement membrane, and triggering the clotting process.\textsuperscript{27}

**CONCLUSION**

Centrally placed catheter tips are associated with fewer complications than noncentrally placed catheter tips. Clinicians should ensure that catheter tips reside centrally after PICC placement in infants and children.

**REFERENCES**

**Pediatric Peripherally Inserted Central Catheters: Complication Rates Related to Catheter Tip Location**

John M. Racadio, Darcy A. Doellman, Neil D. Johnson, Judy A. Bean and Brian R. Jacobs

*Pediatrics* 2001;107;e28

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