Central Venous Catheterization in Infants and Children with Congenital Heart Diseases: Experiences with 500 Consecutive Catheter Placements

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SUMMARY. In a prospective study results of central venous catheter (CVC) placements in a consecutive group of 500 patients with less than 20 kg body weight undergoing cardiac surgery were evaluated. The incidence of previous cardiac surgery was 21% and the incidence of factors preventing the primary puncture of the right jugular or innominate vein was 13.4%. The anesthesiologists were free to select the catheterization technique, site of puncture, and catheter type. All CVC insertions were performed prior to surgery under continuous circulatory monitoring and optimal positioning of the anesthetized patient.

Ninety-six percent of all catheterizations were successful, 81% of them on the first attempt. In the 4% of cases where catheterization failed, a CVC had to be placed by the surgeon. Of all catheters, 66% were positioned via the right internal jugular (IJV) or innominate vein (IV), 8% via the left, 16% via an external jugular vein (EJV), and 5% via other veins. Seventy-six percent of CVC insertions were performed with the Seldinger technique. Of the four catheter types used in this study, double lumen catheters were most frequently selected (38%). Placement of 22-ga single lumen catheters was preferred in infants with less than 5 kg body weight, in spite of their tendency to kink. Observed complications (10% arterial puncture, 4% hematoma, and 1% intrathoracic bleeding) never required immediate surgical intervention. Careful selection of appropriate catheters, as well as extensive experience and knowledge of the anatomical structures involved in special heart defects, helped to keep the risk of complications low.

KEY WORDS: Central venous catheterization—Congenital heart disease—Cardiac surgery

Proper hemodynamic monitoring is essential for effective intraoperative management of patients undergoing cardiac surgery. Pressure monitoring and the administration of effective cardiovascular drugs necessitate placement of indwelling central venous and arterial catheters. However, placement of a central venous catheter (CVC), especially in young infants, can be difficult and may lead to complications. The percutaneous placement of CVC in infants and children prior to cardiac surgery is usually performed by puncture of the jugular veins, a procedure which places great demands on the attending anesthesiologist and the materials used.

The right internal jugular vein (IJV) or the innominate vein (IV) is usually preferred for anatomical reasons. However, certain operating circum-

stances (left-sided thoracotomy in coarctation of the aorta or Bland-White-Garland syndrome) or particular pathoanatomical conditions (situs inversus, absence of the right superior caval vein) can make the more difficult left IJV puncture necessary.

The relevant publications, dealing with CVC placement in infants, are limited in number but give some indication of the difficulties associated with this technique [3, 4, 11]. The literature consists of case reports or involves smaller groups of infants in the weight range of 2–10 kg [2–5, 10, 11]. These studies demonstrate higher success rates in heavier-weight groups; however, complications, such as hematoma [4, 5, 11, 13], Horner's syndrome [9, 11], pneumothorax [1, 4, 5, 13], injury of the thoracic duct (8), cerebral air embolism resulting from a right–left shunt, emphasize the need for caution.

In some countries, the legal proceedings stemming from such complications have led to a preference for transthoracic placement of the catheter by...
Table 1. Patient characteristics (n = 500)

<table>
<thead>
<tr>
<th>Age distribution (months)</th>
<th>No. of patients</th>
<th>%</th>
<th>Weight distribution (kg)</th>
<th>No. of patients</th>
<th>%</th>
<th>Body surface area (m²)</th>
<th>No. of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;12</td>
<td>293</td>
<td>59</td>
<td>&lt;5</td>
<td>175</td>
<td>35</td>
<td>&lt;0.3</td>
<td>202</td>
<td>40</td>
</tr>
<tr>
<td>&gt;12</td>
<td>207</td>
<td>41</td>
<td>&gt;5</td>
<td>325</td>
<td>65</td>
<td>&gt;0.3</td>
<td>298</td>
<td>60</td>
</tr>
</tbody>
</table>

Age distribution (months)*

<table>
<thead>
<tr>
<th>No. of patients</th>
<th>0–1</th>
<th>1–3</th>
<th>3–6</th>
<th>6–9</th>
<th>9–12</th>
<th>12–24</th>
<th>&gt;24</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>58</td>
<td>60</td>
<td>79</td>
<td>59</td>
<td>37</td>
<td>79</td>
<td>128</td>
</tr>
</tbody>
</table>

* Mean, 19 ± 21.

the surgeon during the operation over preoperative transcutaneous placement of a CVC in infants and small children.

This report outlines our experience with various catheters (Fig. 1) and approaches to CVC placement in infants and children with congenital cardiac defects including infants weighing less than 5 kg.

Methods

In this prospective study the results of 500 consecutive CVC placements in children with a body weight of up to 20 kg were documented and analyzed. All children underwent corrective or palliative surgery for congenital heart defects during the period from July 1987 to May 1989. The CVCs were placed by anesthesiologists with at least 2 years experience in pediatric cardiac anesthesia. The anesthesiologists were free to select the site of puncture and catheter type.

Our patients weighed between 2 and 20 kg; more than a third (175 patients) weighed less than 5 kg. Fifty-seven percent of the children were less than 12 months and 12% were less than 4 weeks old (Table 1). Twenty-one percent of the children had been operated on at least once previously because of their heart defect. The classification of the individual diagnoses as defined by our institution [14] is shown in Table 2.

All catheters were inserted after induction of general anesthesia, intubation, and placement of one peripheral venous and arterial cannula. The patients were mechanically ventilated maintaining PaCO₂ between 32 and 40 mmHg. Electrocardiogram, arterial blood pressure, and end-expiratory CO₂ were continuously monitored during catheter placements. One of the various sets of catheters (shown in Fig. 1) was used for CVC placement after disinfection of the skin and sterile draping. Figure 2 shows the approaches used in the selection of the puncture site. In infants, the right IJV/IV was preferred unless the selection of the left IJV was mandatory for anatomical or surgical reasons. In older children where the external jugular vein (EJV) was visible, this vein was selected as the primary puncture site.