Experience With Double-Lumen Umbilical Venous Catheters in the Low-birth-weight Neonate

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Reliable vascular access can be problematic in sick low-birth-weight neonates. Umbilical venous catheters are one form of vascular access that can be used in this population. A retrospective review of experience with umbilical venous catheters in our neonatal intensive care unit from January 1989 through December 1991 was conducted. This included 128 patients: 70 with single-lumen (Gesco Umbilicath II) and 58 with double-lumen (Beckton-Dickinson Careflow) catheters. Birth weight, gestational age, catheter life span, complications, and number of punctures for peripheral intravenous lines were analyzed. The mean birth weight, gestational age, and catheter life span did not differ significantly between catheter types. The incidence of catheter-related sepsis did not differ significantly (two single-lumen, three double-lumen) and occurred only in neonates with a catheter life span greater than 10 days. The number of intravenous punctures was significantly decreased in those neonates with double-lumen umbilical venous catheters ($p < 0.0001$). We conclude that in sick low-birth-weight infants the use of double-lumen umbilical venous catheters entails no greater risk than the use of a single-lumen umbilical venous catheter and may reduce iatrogenic stress associated with the starting of peripheral intravenous lines. (*J Perinatol* 1994;14:280-4)

Intravenous access is often necessary for administration of fluids, medications, and total parenteral nutrition (TPN) in critically ill low-birth-weight neonates. The need for multiple venous lines in these small, fragile patients can be problematic during the first weeks of life. Cannulation of extremely delicate veins and maintenance of safe, reliable venous access during this time are often hampered by the relative paucity of adequate veins.

Single-lumen umbilical venous catheters (UVCs) are occasionally used in critically ill neonates for intravenous infusions, exchange transfusions, and central venous pressure monitoring.1 Advantages of UVCs include ease of access, rapidity of placement, and relatively large size. Potential complications of UVC insertion include sepsis, paradoxical embolism, hepatic necrosis, and phlebitis.2 Recently the use of multilumen catheters for umbilical venous access in neonates has been reported.3-5

We reviewed our experience with double-lumen central venous catheters that have been widely accepted for safe infusions with increased comfort in critically ill adults and children.5-8 We hypothesized that while providing convenient venous access in critically ill low-birth-weight neonates, double-lumen UVCs would not be associated with a higher incidence of complications when compared with standard single-lumen UVCs. We further hypothesized that when a double-lumen UVC was in place in one of these neonates, there would be a decrease in the number of intravenous punctures (IPs).
Table 1 – DATA AND RESULTS FROM NEONATES WITH UVCs

<table>
<thead>
<tr>
<th></th>
<th>Single-Lumen ( n = 70 )</th>
<th>Double-Lumen ( n = 58 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (gm)</td>
<td>1006 ± 263 (470-1452)</td>
<td>979 ± 260 (437-1447)</td>
</tr>
<tr>
<td>Gestational age (wk)</td>
<td>28 ± 2.5 (22-33)</td>
<td>27.9 ± 2.2 (24-32)</td>
</tr>
<tr>
<td>Catheter life span (days)</td>
<td>8.6 ± 6.5</td>
<td>9.2 ± 5.7</td>
</tr>
<tr>
<td>Sepsis (n)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Mechanical complications</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

Values are means ± SD. Ranges are given in parentheses. 
\( p = \text{NS} \).

METHODS

The charts of neonates with birth weights less than 1501 gm who underwent umbilical venous catheterization between January 1989 and December 1991 in the level III neonatal intensive care unit (NICU) at the Santa Clara Valley Medical Center were reviewed retrospectively. Gesco Umbilicath II Silastic single-lumen catheters or Becton-Dickinson Careflow double-lumen catheters were used for umbilical venous catheterization in critically ill neonates for administration of replacement fluids, TPN, blood, and medications. One of four attending physicians determined the type of catheter necessary according to the expected severity of illness in the neonate. Minimal disease defined those infants who were intubated because of respiratory insufficiency of prematurity without hemodynamic instability, mild included those intubated for mild respiratory distress syndrome (RDS) without hemodynamic instability, moderate included those with moderate RDS requiring inotropic agents for hemodynamic instability, and severe included neonates intubated for severe RDS with inotropic agents and requiring high-frequency jet ventilation. Indications for UVC insertion included RDS requiring mechanical ventilation within the first 24 hours of life, hemodynamic instability, and an anticipated need for intravenous almentation for a minimum of 7 days. Infants with minimal and mild disease received single-lumen UVCs, whereas those with moderate and severe disease received double-lumen UVCs. In general, practice patterns are similar among the four neonatologists, all of whom are closely involved in patient care in the NICU; thus the criteria for catheter insertion and removal were adhered to by them. Catheters remained in place while the indications existed or until catheter complications developed. All UVCs were inserted in the NICU. Birth weight, gestational age, and admission diagnoses were obtained from the patients’ charts. The severity of illness, based on a scoring system, was also determined in each case.

Catheter Protocol

Catheters were placed under strict aseptic standard protocol for UVC insertion. Single-lumen radiopaque silicone elastomer (Gesco International, Inc., San Antonio, Texas) and double-lumen 3.7Fr radiopaque ViaIon material (Becton-Dickinson Critical Care Monitoring, Sandy, Utah) were used (Figure 1). The double-lumen catheters were 15 cm long and had a mean diameter of 0.046 cm. Catheter tips were adjusted radiographically to lie within the thorax in the inferior vena cava above the level of the diaphragm. Infusions given through both single- and double-lumen UVCs consisted of replacement fluids, crystalloids, blood products, inotropic agents, multiple medications, and TPN. The end- and side-hole openings of the double-lumen catheters were
Table 2 – COMPARISON OF SEVERITY OF ILLNESS IN NEONATES WITH UVCs

<table>
<thead>
<tr>
<th></th>
<th>Minimal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-lumen (n = 70)</td>
<td>24</td>
<td>16</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td>Double-lumen (n = 58)</td>
<td>13</td>
<td>2</td>
<td>18</td>
<td>25</td>
</tr>
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\( \chi^2 = 15.68, p < 0.002. \)

Table 3 – NUMBER OF INTRAVENOUS PUNCTURES DURING 5-DAY PERIOD VERSUS TYPE OF UVC

<table>
<thead>
<tr>
<th></th>
<th>Single-lumen (n = 38)</th>
<th>Double-lumen (n = 42)</th>
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<tbody>
<tr>
<td></td>
<td>With UAC (n = 35)</td>
<td>No UAC (n = 3)</td>
</tr>
<tr>
<td></td>
<td>7.0 ± 4.2* (0-18)</td>
<td>9.3 ± 2.1 (7-11)</td>
</tr>
<tr>
<td></td>
<td>7.2 ± 4.1* (0-18)</td>
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Values are means ± SD; ranges are given in parentheses.
\*p < 0.0001.
\#p < 0.0001.
Within each UVC group, number of IPs did not differ in infants with and without UACs.

1.3 cm apart. Double-lumen catheter tips were adjusted so that the side-hole opening was above the level of the diaphragm.

The end or distal lumen was used for central venous pressure monitoring and drug administration, and the side hole or proximal lumen was reserved as a closed system for TPN or maintenance fluid infusions. The patency of both lumina of the double-lumen UVC was maintained with continuous infusions at all times. All intravenous fluids, including TPN, were mixed by the pharmacy and primed by the unit nurses with 24-hour hang time. Heparin (1 U/ml) was used in all fluids infused through both single- and double-lumen UVCs. All catheters were maintained according to the same protocol. The attending neonatologist maintained a log of all invasive procedures for every NICU patient. The record included UVC type, admission diagnoses, demographic data, catheter life span (including date of insertion and removal), and any complications.

From the charts of infants with UVCs, a subgroup of 80 infants with birth weights less than 1301 gm who had catheters in place for the first 5 days of life were selected for determination of the frequency of IPs during that time period. This weight range and time period were selected because these infants were most likely to require prolonged intravenous access because of their small size, to be at their sickest, and therefore to demonstrate any benefit from the presence of a double-lumen catheter. Records of 80 infants with UVCs in place for a minimum of 5 days were analyzed retrospectively. The number of IPs for each neonate during the first 5 days of life was determined systematically from the nursing notes. Nursing policy in our NICU requires documentation of all nursing procedures. Consequently, the nursing notes reflect the number of IPs made for intravenous catheter placements. Furthermore, all peripheral intravenous line placements are performed by nursing personnel.

**Statistical Analysis**

Data were expressed as mean ± SD, and analysis of variance and \( \chi^2 \) tests were used when appropriate.

**RESULTS**

Between January 1989 and December 1991, there were 1637 admissions to the NICU. Two hundred forty-eight of these infants weighed less than 1501 gm; 51.6% of them received UVCs. A total of 128 catheters were inserted in 128 neonates with birth weights ranging from 437 to 1432 gm and gestational ages ranging from 22 weeks to 33 weeks (Table 1). Seventy neonates had single-lumen catheters, and 58 had double-lumen catheters. The mean birth weights and gestational ages in the two groups were not statistically different. There was no correlation between birth weight or gestational age and UVC life span in infants of the single- and double-lumen groups. The mean life span for catheters between the two groups was not significantly different.

The influence of catheter type and life span on infection was assessed. The mean catheter life span was not significantly different between infants with and without catheter sepsis in either the single- or double-
lumen group or when both the single- and double-lumen catheter groups were collectively included in the analysis. This was due to the limited number of infants in whom sepsis developed. Five patients had catheter sepsis, with onset at 13 and 14 days in the single-lumen group and at 10, 11, and 14 days in the double-lumen group. All of these neonates had received ampicillin and gentamicin at the time of catheter insertion for indications including abnormal white blood cell count (3/5) and maternal colonization with group B Streptococcus (1/5). The fifth neonate had been given antibiotics for presumed sepsis, but these were discontinued 4 days before sepsis was clinically evident. All five neonates showed clinical deterioration and/or abnormal white cell counts, with improvement after removal of the catheter. Staphylococcus epidermidis was isolated in four, and Staphylococcus aureus species were isolated in one.

Three infants with single-lumen catheters had mechanical complications; two of these had pericardial effusions. Review of the radiographs in one case demonstrated a coiled catheter that was not easily evident on the initial films. The effusion resolved with pericardiocentesis. Analysis of the aspirated fluid revealed a high glucose content suggestive of TPN solution. The patient died of complications of multiple congenital anomalies. A chest roentgenogram of the second infant showed an enlarged heart at 3 days of age, 2 days after removal of the catheter. Review of the films revealed that the UVC line had extended into the left atrium at initial placement but was promptly withdrawn. At the time, an echocardiogram confirmed the presence of an effusion that presumably was a result of perforation from the umbilical venous catheterization. The effusion resolved without treatment. A third infant’s catheter was removed because of obstruction due to clot formation within the catheter. Liver function tests were normal in infants of both the single- and double-lumen groups during time that the catheters were in place, as well as for the remaining period of hospitalization. Neither necrotizing enterocolitis nor air embolism occurred in either group of patients.

The severity of illness between the two groups was compared (Table 2). Infants with double-lumen UVCs in place were sicker in terms of respiratory disease than those with single-lumen UVCs ($\chi^2 = 15.68, p < 0.002$).

Of the subgroup of 80 infants selected for determination of the frequency of IPs, 29 had an umbilical arterial catheter (UAC) and a double UVC, 35 had a UAC and a single-lumen catheter, 13 had a double-lumen catheter alone, and 3 had a single-lumen UVC only (Table 3). The number of IPs was significantly decreased in neonates with double-lumen UVCs when compared with those with single-lumen UVCs for the first 5 days of life ($p < 0.0001$). A similar difference was observed between infants in the UAC–double UVC and UAC–single UVC groups. With either type of UVC, however, the number of IPs was not significantly affected by the presence or absence of a UAC.

**DISCUSSION**

Frequent traumatic venipuncture is a major problem in low-birth-weight neonates who require medications, infusions, and TPN for prolonged periods of time. Peripheral venous access in this population of neonates is frequently difficult to achieve and time consuming to maintain. Iatrogenic stress of intensive care, such as repeated venipunctures and vein cutdowns, impedes uninterrupted and painless administration of intravenous fluids and medications in the very-low-birth-weight neonates who should be disturbed as little as possible. Relatively minor manipulations in these neonates are known to result in significant hypoxemia. Marked decreases in transcutaneous oxygen pressure have been reported to occur during various procedures or crying. We recently demonstrated that venipunctures caused a significant decrease in arterial oxygen pressure. Both the hypoxic episodes and the intermittent increases in blood pressure that occur with relatively minor interventions in sick, unstable neonates have been implicated in the pathogenesis of neonatal periventricular-intraventricular hemorrhage. Frequent restarting of peripheral intravenous infusions results in exposure of infants to ambient room temperature leading to hypothermia, whereas interruption of intravenous glucose administration due to infiltration of intravenous fluid can lead to hypoglycemia. Further, infiltration of medications increases the risk of skin breakdown and sloughs.

Review of our 3-year experience with UVCs showed that the rate of sepsis and mechanical complications between infants of the single- and double-lumen catheter groups was not significantly different. Complications due to malpositioning of the UVCs include pericardial effusion with cardiac tamponade. The incidence is consistent with previously reported incidences. Inadvertent placement in the left atrium can be avoided by proper positioning of the catheter tip at or just above the diaphragm with the position confirmed by chest roentgenogram as well as by securing the catheter with sutures. Catheter sepsis occurred only in infants with a catheter life span of greater than 10 days. The number of IPs during the first 5 days was decreased significantly in low-birth-weight neonates with double-lumen catheters in place despite the fact that these patients were sicker than those with single-lumen UVCs in place. The presence of a double-lumen UVC decreased the handling of fragile, sick, low-birth-weight neonates and reduced the workload in maintenance of parenteral fluid therapy. Both of these factors would be expected to offer significant overall advantages. We did not see many of the complications of UVCs that have been described.

Reliable and painless vascular access can be critical to
the overall care and outcome of sick low-birth-weight neonates. Double-lumen catheters are an attractive option. Our experience suggests that both single- and double-lumen UVCs entail similar risks and that line infection is dependent on catheter life span and not on the type of catheter used. Furthermore, the use of double-lumen catheters in our neonatal unit has helped reduce the iatrogenic stress of intensive care by decreasing the need for repeated venipuncture, thereby avoiding the compromising effects of peripheral intravenous access well known to all who work in NICUs. We continue to monitor the use of both catheters in the NICU.

Acknowledgment

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References