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# Techniques, Materials, and Devices

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## Percutaneous and Surgical Placement of Fine Silicone Elastomer Central Catheters in High-Risk Newborns

MICHAEL P. SHERMAN, M.D., DENNIS E. VITALE, M.D., GARY W. McLAUGHLIN, M.D., AND  
BOYD W. GOETZMAN, M.D. PH.D.

*From the Departments of Pediatrics, the Universities of California at Los Angeles and Davis, and the Kaiser Foundation Hospital, Sacramento, California*

**ABSTRACT.** Percutaneous insertion of fine silicone elastomer catheters (0.6 millimeters outside diameter) have been used for central parenteral nutrition of very low birth weight and other high risk infants. Because peripheral venous access can be limited in the newborn, we report the previously undescribed surgical cannulation of the superficial arm veins with this catheter, and compare our experience with this technique and the percutaneous method in neonates. A central catheter position was attained in 88% of surgical (38 of 43) and 74% of percutaneous (17 of 23) cannulations. The two groups did not differ in birth weight or gestational age. The mean duration of catheterization was similar in the two groups (combined  $\bar{x}$  = 21.8  $\pm$  2.3 days SEM). There was no difference in weight gain (combined  $\bar{x}$  = 16.9  $\pm$  1.0 grams SEM per day) or head growth (combined  $\bar{x}$  = 1.1  $\pm$  0.1 millimeters per day) between the

groups and these rates approximated known fetal growth rates for our mean gestational age. Disseminated candidiasis, in a 770-gram infant with thymic hypoplasia, caused the only systemic infection and death among our 49 patients. The most commonly encountered problem was catheter occlusion secondary to a blood clot at the tip of these fine catheters (8 of 55). No thromboembolic events were recognized, and minor complications were not different with the two techniques. Surgical cannulation of the superficial arm veins offers a safe alternative to percutaneous central silicone elastomer catheter placement if superficial venous access is not available. Both methods provided early, adequate parenteral nutrition without excessive fluid intake in our high-risk infants, and undoubtedly contributed to a favorable neonatal outcome.

Parenteral nutrition is an important supportive therapy for certain sick newborns. Past reports have advocated central or peripheral methods of nutrient delivery,<sup>1-4</sup> different routes or techniques of catheterization<sup>5-10</sup> and different catheter types<sup>5, 7, 8, 11, 12</sup> for neonatal parenteral nutrition. Shaw<sup>8</sup> has previously described central placement of fine silicone elastomer catheters by peripheral percutaneous venous puncture in high-risk infants. However, peripheral venous access can be limited in very low birth weight and other high-risk neonates. Surgical use of the superficial veins for central catheter placement has not been previously reported in newborns. We describe this technique using fine silicone elastomer catheters (0.6 mm OD), and compare its success and complications with the peripheral percutaneous method.

### MATERIALS AND METHODS

#### *Patient Selection*

Between January 1977 and June 1981, 49 of 856 infants hospitalized in the intensive care nursery, Kaiser Foun-

dation Hospital, Sacramento, CA, received parenteral nutrition through fine Silastic catheters placed into the central venous system. Central parenteral nutrition was utilized for congenital or acquired gastrointestinal disorders or gastrointestinal dysfunction in very low birth weight (VLBW) infants (less than 1500 g) when it was anticipated that it would be 2 or more weeks before adequate enteral nutrition would be achieved. Most catheters were inserted by 7 days of age. Parental consent for surgical or percutaneous central catheter placement was obtained in all infants.

#### *Nutrient Solutions and Delivery*

Dextrose was infused at rates which maintained the serum glucose concentration below 130 mg/dl (2.5-25% solutions). The protein source was Freamine II and the maximum daily protein intake was 2.5 g/kg/day. Fat emulsion (10% Intralipid) was infused at a maximum of 1.5 g/kg/day by a piggyback technique over a 12 to 16 hr period. Supplemental vitamins, zinc, and copper were provided.

Nutrient solutions were prepared daily in a laminar flow hood, refrigerated until use, and delivered by an I-MED infusion pump. Only nutrient solutions were delivered via these catheters. Strict antisepsis and sterile techniques were used with each line interruption.

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Reprint requests to: Michael P. Sherman, M.D., University of California at Los Angeles, Center for the Health Sciences B2-325, MDCC, Los Angeles, CA 90024.

### Patient Assessment

The nursing service performed a minimum of daily weights and twice weekly head circumferences, and these measurements were graphed and reviewed by the attending neonatologist. The recommendations of Heird *et al*<sup>13</sup> were used for monitoring metabolic status. Monitoring for catheter-associated infection included thrice-weekly hemograms and at least biweekly blood cultures. The catheter tip was cultured following removal.

### Catheter Materials and Insertion

Silastic tubing of 0.6 mm OD (Dow Corning) was utilized. Talc-free gloves were used during division of the tubing into 40-cm lengths and its individual packaging for gas sterilization.

If no suitable percutaneous site was available, an antecubital vein was selected for surgical catheterization. Prior to surgical insertion, the Silastic tubing is readied for insertion by passing a sterile 3.0 cm length of 8 Fr feeding over it, and the catheter is threaded onto a 27-g blunt stainless steel needle. The catheter is secured to the needle by two 5-0 silk sutures, and the segment of feeding tube is pulled back onto the needle's hub. The feeding tube is filled with Silastic adhesive, which following hardening prevents catheter puncture by the needle (Fig 1). The length of catheter needed for central placement is determined by placing a paper tape measure from the entrance site over the anticipated route and ending at the mid-sternum.

Following a povidone-iodine prep and 1% lidocaine anesthesia, a 2 to 4 mm incision is made over the vein selected for catheterization. After vein isolation, the vessel is widened by grasping it proximally with iris forceps and a #11 Bard-Parker blade is passed distally through the upper one-third of the vein at a 45° angle. A finely-tapered catheter is introduced into the small triangular venotomy, and the catheter is advanced by 1 to 2 mm increments. If an obstruction is encountered, the catheter is partially withdrawn and again advanced. When the catheter has reached the premeasured distance, the catheter position is ascertained by injecting 0.3 cc of Renografin 60. Following any adjustments of location, the

wound is closed with subcuticular 5-0 Dexon. No subcutaneous tunneling was used with any catheters.

The superficial hand or forearm veins, the posterior auricular vein, or the superficial temporal vein were used for percutaneous catheter placement. A 19 g scalp vein needle is used for venipuncture as described by Shaw.<sup>8</sup> After successful catheterization, the 19 g needle is removed and a 27 g blunt needle is inserted as previously described. Following both methods, Betadine ointment and a sterile occlusive dressing are applied. The site was cleansed weekly with six successive applications of 70% alcohol and 0.5% povidone-iodine solutions and dressed as above.

### Data Collection and Analysis

Data were collected by chart review. Our experience with percutaneous and surgically placed catheters were compared using the Student *t*-test or Fisher exact probability test depending on the data base.<sup>14</sup>

### RESULTS

Forty-nine infants underwent 66 attempts at central catheterization. Fifty-five catheters reached the central venous system, and six infants had two central catheters placed. The success rates of central catheter placement by method and site of entry appear in Table I. With the surgical technique, a single cephalic forearm vein could not be cannulated. Usually, one or two, but never more than four, percutaneous punctures were needed to successfully enter a vein. Following successful cannulation, 88% of surgically placed and 74% of percutaneously placed catheters reached a central position. Percutaneous catheterization did not have a significantly lower success rate, but the smaller percentage of central catheters was caused by obstructions encountered when negotiating more peripheral venous branches.

Twenty-three of 38 infants with surgically placed catheters weighed less than 1500 g (10 under 1000 gms), and 10 of 17 percutaneous catheters were inserted in neonates less than 1500 g (5 under 1000 g). The two groups did not differ in birth weight, gestational age, weight gain, or head growth, and these findings are summarized in Table

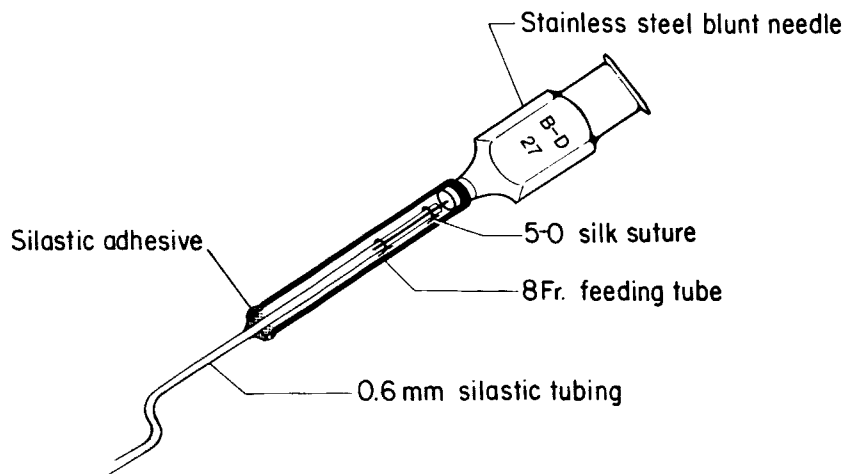


Fig. 1. Technique of catheter preparation.

II. Duration of catheterization ranged from 3 to 59 days. The two groups did not differ in the mean duration of catheterization, and the combined mean was  $21.8 \pm 2.3$  days SEM. No infant subsequently required a 4 Fr Broviac catheter.

Catheter-related complications occurred in 20 of 55 central catheters (Table III). No complication was statistically different with the two techniques. The only serious complication was *Candida albicans* septicemia in a 770-g infant with probable Di George syndrome. This baby, who required 600 mg/kg/day of calcium gluconate to prevent hypocalcemia, developed bloody diarrhea containing budding yeast at 3 weeks of age. Despite immediate catheter removal and antifungal therapy, the infant died and post mortem examination revealed thymic hypoplasia and a ventricular septal defect. This complication caused the only death among our 49 patients. A *Staphylococcus aureus* wound infection occurred at 2 weeks in a surgically placed catheter and was the only other infectious complication. Premature atrial contractions occurred in four infants and immediately resolved upon withdrawing the catheter. Four catheters dislodged because no internal fixation was utilized. The most common complication was occlusion of these fine catheters caused by a blood clot at the distal 2 to 4 mm of the tubing. Nursing awareness of blood refluxing up the catheter has recently decreased the incidence of this problem (one occlusion in 1980-1981).

We did not perform venography before catheter removal in our infants, but based upon clinical observation of jugular venous distention, blood gas analysis, chest radiography, and selective real time echocardiography, we suspected a superior vena caval thrombosis in one infant. A nuclear scan of the great veins of the infant was interpreted as normal.

TABLE I  
Success of central silastic catheter placement by specific technique and site of venous entry

Technique	Specific vein			
	Basilic	Cephalic	Posterior auricular	Superficial temporal
Surgical cutdown	24/24 <sup>a</sup>	14/19		
Percutaneous puncture	7/7	3/5	4/6	3/5

<sup>a</sup> Successful central catheters/total attempts

TABLE II  
Gestational age, birthweight, and growth of newborns receiving central parenteral nutrition through fine silastic catheters

Technique	Gestational age	Birthweight (gms)	Weight Gain (gms/day)	Head Growth (mm/day)
	wk	g	g/day	mm/day
Surgical cutdown (n = 38)	30.4 ± 0.8 <sup>a</sup>	1478 ± 140	17.8 ± 1.3	1.1 ± 0.1
Percutaneous puncture (n = 17)	31.3 ± 1.1	1593 ± 195	16.4 ± 1.4	1.1 ± 0.1
Total (n = 55)	30.7 ± 0.9	1513 ± 113	16.9 ± 1.0	1.1 ± 0.1

<sup>a</sup> Means ± SEM.

TABLE III  
Complications associated with fine central silastic catheters in high-risk neonates

	Surgical (n = 38)	Percutaneous (n = 17)
Catheter-associated septicemia	1	0
Wound infection	1	0
Nonbacterial phlebitis	1	1
Dislodged catheters	3	1
Catheter occlusion	6	2
Catheter-induced arrhythmias	2	2
Total (n = 55)	14	6

## DISCUSSION

Certain infants with congenital or acquired gastrointestinal conditions require total parenteral nutrition for prolonged periods, but the use of central parenteral nutrition for VLBW infants remains controversial.<sup>2, 15</sup> We have used central parenteral nutrition in VLBW infants who could not tolerate intestinal feedings and/or required fluid restrictions below 130 cc/kg/day because of a patent ductus arteriosus and/or chronic lung disease. The weight gain and head growth in our VLBW patients was comparable to intrauterine growth between 27 and 31 weeks of gestation.<sup>16</sup>

Although the care of our VLBW patients was complex, we believe early, adequate nutrition did decrease our mortality since 32 of 33 VLBW infants survived. Morbidity was also reduced because there was no surgical intervention for necrotizing enterocolitis, and a single infant required hospitalization beyond 6 months of age for chronic lung disease. Twenty-nine of our 32 VLBW infants who survived the perinatal period were discharged before 4 months of age.

The percutaneous or surgical veins may offer a certain degree of safety over other methods of central catheter placement in neonates. Central catheters placed by percutaneous puncture of the subclavian or internal jugular vein can result in arterial, lymphatic, neural, or pulmonary injury.<sup>10, 17, 18</sup> Catheter placement in the intensive care nursery avoids transport to the surgical suite and general anesthesia for Broviac insertion into the neck or groin of an active neonate. The Dacron cuff of the 4 Fr Broviac catheter can also erode through the skin of VLBW infants, and subcutaneous dissection of the ingrown cuff is needed for removal. Fine Silastic catheters inserted through the superficial veins by either of our methods avoids these problems, and cosmetic side effects are reduced.

Fine silicone elastomer catheters also apparently minimize the major complications associated with central parenteral nutrition, namely catheter-related infections and thromboembolic events. Catheter-induced endothelial damage promotes bacterial adherence and growth at areas of injury.<sup>19</sup> Catheter type and size may influence vascular injury. Animal and human studies utilizing intravascular silicone elastomer have found low rates of thrombus formation,<sup>20, 21</sup> and past clinical studies of infants with percutaneous<sup>8</sup> or surgically<sup>12</sup> placed silicone elastomer catheters have documented very low rates of thrombus and sepsis. Our experience supports these observations. Our single infant with disseminated candidi-

asis had thymic hypoplasia, and immunodeficiency predisposed this infant to infection. We did not recognize any thromboembolic events in our patients. In 26 surgically placed Silastic catheters, Jewell<sup>12</sup> reported no catheter-related thrombosis, and a 4% incidence of thromboembolic complications was noted in adults with percutaneously placed silicone elastomer subclavian catheters.<sup>22</sup>

Nonbacterial phlebitis seen in two of our 55 catheters may have been caused by talc, electrostatically adherent fiber, or other substances coating the catheter. Two recent reports using Silastic catheters suggested that phlebitis can be avoided by using talc-free gloves and a sterile transparent drape over the entry site.<sup>23, 24</sup>

In the recent report of Shepherd and Ong,<sup>24</sup> 22% of peripheral or central fine Silastic catheters either dislodged or became occluded. We have a similar complication rate. New methods for stabilization of central lines has recently been described,<sup>25, 26</sup> but their effectiveness must await further experience. Catheter occlusion secondary to internal thrombosis may be avoidable with Silastic slit-valve catheters,<sup>12</sup> but a 20-gauge size will make peripheral insertion more difficult. Diligent nursing observation for blood refluxing up fine Silastic catheters will prevent most occlusions.

Peripherally located Silastic catheters have a mean duration of 9 to 12 days,<sup>24, 27</sup> and central Silastic catheters lasted 17.4 days to 19.5 days in infants and children.<sup>12</sup> Our mean duration of catheterization exceeded both these experiences, and over 70% of our patients had catheters removed because full enteral nutrition was attained. The 4 Fr Broviac catheter is useful for more prolonged periods of central nutrition in infants,<sup>28</sup> but fine Silastic catheters served our patients well during the perinatal period.

We currently prefer the percutaneous method for central catheter placement, but surgical cannulation of the superficial arm veins provides an acceptable alternative when venous access is limited. With both methods, we achieved adequate growth, avoided excessive fluid intakes, and eliminated the frequent site changes and tissue injury associated with hypertonic infusates via peripheral veins. Both methods have a low rate of serious complications. Adequate nutrition provided by these centrally placed catheters probably contributed to the favorable neonatal outcome in our patients.

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