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Seldinger Technique as an Alternative Approach for Percutaneous Insertion of Hydrophilic Polyurethane Central Venous Catheters in Newborns

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ABSTRACT. The use of hydrophilic central venous catheters, percutaneously inserted by means of the Seldinger technique, was evaluated in this prospective study. Between 1988 and 1991, 138 catheters were inserted in newborns who were admitted to our neonatal intensive care unit. An adequate position of the tip, evaluated radiographically, was achieved in 130 (94.2%) of these insertions. The side effects associated with these 130 catheters and the duration of their use were

recorded. Results were compared with those of percutaneously inserted Silastic catheters described in the literature. The rate of adequate catheter placement seems comparable. Because of a high rate of minor mechanical complications, the mean catheter duration was rather short (8.3 days). However, the incidence of serious complications, especially infectious complications, was low. (*Journal of Parenteral and Enteral Nutrition* 19:151-155, 1995)

Long-term central venous access is an essential part of the care of sick (especially preterm) newborns.¹ In neonatal intensive care units, the percutaneous insertion of a small Silastic central venous catheter via a peripheral vein, as initially described by Shaw,² is used most frequently. The catheter's small outer diameter (0.6-0.635 mm) and low thrombogenicity result in appropriate mean catheter durations (7.9 to 25.4 days). The rates of serious complications such as sepsis (0% to 12.5%) and thrombosis (0% to 1.6%) are low in most studies.³⁻¹⁰ Introduction of the catheter is easy, and high success rates have been described. Insertion can be done while the patient is on the ward, thus saving time and money.¹¹ However, it is known that Silastic catheters have some disadvantages. Their small internal diameter limits the flow rate. The poor tensile strength is a potential risk for catheter rupture during flushing or removal,¹² especially if the catheter becomes lodged in the vein wall.¹³ Because of its flexibility, the catheter could be difficult to advance through the axillary or inguinal region. Moreover, the catheter can become occluded more easily as a consequence of rotation.

A possible alternative is a polyurethane catheter, which is made hydrophilic by applying a hydromer coating. This material is less thrombogenic than Silastic¹⁴ and is known to resist bacterial adhesion.¹⁵ Its greater tensile strength minimizes the risk of catheter rupture or rotation, and its relatively large internal diameter permits higher flow rates. The use of the Seldinger technique¹⁶

makes appropriate positioning easy to achieve. Venous access can be gained with a small-bore needle before insertion of the larger catheter. Vascular injury at the insertion site, an important etiologic factor for complications, is thus diminished. The risk of catheter embolus, secondary to shearing with the insertion needle, is also eliminated.

Our experience with the insertion of a hydrophilic polyurethane central venous catheter by means of the Seldinger technique is described in this prospective study. The duration of catheter use in newborns and the complications associated with its use were also evaluated. Results were compared with those of percutaneously inserted Silastic central venous catheters described in the literature.

PATIENTS AND METHODS

In the interval from March 1988 until May 1991, 138 hydrophilic polyurethane catheters (Hydrocath, Ohmeda, BOC Group, Windlesham, UK) were inserted in 110 newborns by means of the Seldinger technique. A single catheterization was performed in 94 newborns, two were performed in 13 newborns, three were performed in two newborns, and four were necessary in one newborn. Some demographic data of these newborns are shown in Table I.

Introduction of the central venous catheter was indicated when prolonged parenteral nutrition (more than 3 days) was expected or when intravenous access was still necessary after peripheral sites were exhausted. The catheters had an outer diameter of 20 or 22 gauge (1.1 and 0.9 mm, respectively) and allowed maximal flow rates of 17 and 14 mL/minute, respectively. The 10-cm-long, 22-gauge catheter was commonly used. In larger infants (weight more than 2500 g), this length

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was insufficient to reach an adequate tip location, and the 20-cm-long, 20-gauge catheter was used.

Catheters were inserted percutaneously through a peripheral vein. The most suitable peripheral vein for this technique is the medial antecubital (basilic) vein. Additional suitable sites include the axillary,¹⁷ greater saphenous, right preauricular scalp vein, and lateral antecubital (cephalic) vein. An aseptic technique is essential during the procedure. Infants were positioned (and physically restrained by an assistant) to expose the insertion site. No local anesthetic was applied. A thin-walled, 24-gauge IV cannula (Insyte, Becton Dickinson, Utah, USA) was inserted into the peripheral vein. The straight end of the guide wire was advanced gently through the cannula as far as possible. After positioning the guide wire, the IV cannula was withdrawn, and the central venous catheter was introduced over the guide wire and gently advanced. Previous widening of the skin entry site with a blood lancet made the introduction easier. If resistance was encountered, the catheter was withdrawn for 1 cm and then advanced under gentle manipulation of the extremity. If further advance was still impossible, the J-shaped end of the guide wire was introduced through the catheter. An attempt was made to advance the guide wire with some rotation. When the cardiorespiratory monitor showed abnormal electrocardiogram complexes, the tip was presumed to be in the atrial cavity; the wire was partly withdrawn, and the catheter was advanced to reach a proper position. Intraluminal position of the central venous catheter was confirmed by free aspiration of blood and flushing through the catheter. The hub of the central venous catheter was fixed to the skin with adhesive tape. The skin entry site was covered with a small piece of nonocclusive gauze, which was fixed to the skin with adhesive silk tape. The joint nearest the insertion site was splinted. Other movements of the newborn's limb were not restricted.

Tip location was verified radiographically. In case of misplacement (crossing over/opposition of flow direction), the catheter was repositioned. A catheter was defined as central when the tip was in the innominate vein, the superior/inferior caval vein, or the right atrial cavity. When the tip was in the subclavian or common iliac vein, it was defined as semicentral. If the tip of the catheter remained peripheral, the administration of parenteral nutrition or hyperosmolar solutions was not allowed. No further analysis of duration of catheter use and associated side effects was performed on this group.

The central venous catheter was used for the administration of parenteral nutrition or medication. If no other venous access was available, red-cell concentrates were also infused through it. Infusion of platelet concentrates was not permitted.

A volumetric infusion pump (Terumo, Terumo Corp, Tokyo) maintained a continuous flow (at least 2 mL/h) of a 10% dextrose solution. Heparin was added in a dose of 2 IU/h to prevent clot formation. No millipore filters were used.

The nonocclusive dressing was changed daily, and Mupirocine (Bactroban, Beecham Pharmaceuticals,

TABLE I
Demographics of the newborns in whom central venous catheters were inserted ($n = 130$)*

	Mean	Range
Actual weight (g)	1383.6	(490-4060)
Gestational age (wk)	30.5	(24-41)
Age at insertion (d)	12.0	(0-136)
Admission in neonatal intensive care unit (d)	46.2	(0-197)

* Male:female, 65:45.

Brenthford, UK) ointment was applied at the skin entry site. A nurse checked the position of the catheter (torsion, kinking, or displacement) and the aspect of the extremity (redness, swelling, tenderness, or the presence of a palpable venous cord). If any abnormality was observed, a neonatologist decided whether the catheter should be removed or if it should remain in place. Catheters were removed for the following reasons: (1) termination of parenteral nutrition/IV therapy; (2) death of the newborn; (3) suspicion of catheter-related sepsis; (4) obstruction (unrestorable); (5) thrombophlebitis (appearance of two or more of the following signs: pain, erythema, swelling, induration, or a palpable venous cord)¹⁸; (6) extravasation (isolated swelling of a limb without redness or dilated veins); (7) perforation (infusion into an extravascular cavity); (8) fluid leak from the insertion site; or (9) accidental dislodgment.

If clinical signs of sepsis were apparent, blood cultures were taken peripherally and through the catheter, and antibiotic therapy was started. When both cultures revealed the same organism, catheter-related sepsis was confirmed. When the culture drawn from the catheter was positive and the peripheral culture was negative, it was considered to be catheter colonization.^{19,20} The catheter was removed in both cases. If only the peripheral culture was positive, the catheter remained in place. In all cases, antibiotic therapy was adjusted to the sensitivity of the organism.

In the case of obstruction, the catheter was gently flushed with a saline solution. If the flushing was unsuccessful, a sufficient amount of urokinase (2500 U/mL) was incubated in its lumen. Aspiration was attempted after 3 hours.²¹ If patency was not restored and thrombosis was excluded by ultrasonography,^{22,23} the catheter was removed.

The presence of thrombosis was routinely checked by ultrasonography before catheter removal. If thrombosis was revealed, the catheter remained in place, and fibrinolytic therapy was started (urokinase: loading dose, 4400 U/kg in 10 minutes; maintenance dose, 4400 U/kg/h; adjustments on the basis of the thrombin time).^{24,25} A routine bacteriologic culture of the tip was taken at removal.

RESULTS

Central venous catheter placement was successful if the tip was in a central or semicentral position. This was achieved in 94.2% of the introductions. (Table II)

In eight cases (5.8%) the catheter tip remained peripheral. Six of the eight were due to problems in passing the axillary region which occurred three times

in the Basilic as well as cephalic vein. In two cases, a catheter inserted in the cephalic vein went distally through the basilic vein. The misplacement rates were 3.7% and 10.7%, respectively, for the basilic and cephalic vein. When the greater saphenous vein was used, the catheter tip usually reached a semicentral position because of the longer route in relation to the catheter length.

The rate of centrally positioned catheter tips decreased as birth weight increased. The group with birth weights greater than 2500 g was an exception because 20-cm-long, 20-gauge catheters were used in some of the newborns; a central position was achieved in all six placements. The use of the 10-cm long, 22-gauge catheter in this same birth weight group resulted in misplacement two times, in a semicentral position six times, and in a central position just two times (Table III).

The central venous catheters remained in place for a total of 1073 days. Mean catheter duration was 8.3 days (range, 0 to 36 days). Thirty-four catheters (26.2%) were removed electively (Table IV).

Twenty-four newborns died with catheters in place. None of the deaths were catheter-related. Catheters were removed 68 times because of minor complications such as obstruction, thrombophlebitis, extravasation, dislocation, or fluid leakage. Major complications such as thrombosis, sepsis, or perforation necessitated catheter withdrawal in four cases. Thrombosis was treated with urokinase via the same catheter in accordance with our protocol. In one case, however, the thrombus influenced catheter patency to such an extent that the catheter had to be removed.

Although it resulted in catheter withdrawal only once, thrombosis was seen as a complication five times (3.8%). The central venous catheter was removed twice after successful urokinase therapy. One newborn died because of a congenital cardiac anomaly soon after detection of the thrombus. The reasons for removal, which were recorded in these cases, were "elective" and "death," respectively. In one case, ultrasonography showed no signs of a thrombus, and the reason for removal of the central venous catheter was noted as thrombophlebitis. Two days later a thrombus was demonstrated by phlebography in the superior caval vein.

Two central venous catheters inserted into the left saphenous and right basilic vein, respectively, perforated into a cavity. In the first case, a local swelling and decreased peristaltic activity, which did not interfere with the clinical condition, were observed. A contrast radiographic study revealed contrast collection in the retroperitoneal cavity. In the second case, the newborn became dyspneic and had to be resuscitated because of bradycardia 30 hours after the central venous catheter was inserted. The chest x-ray led us to suspect pleural effusion; some atelectatic places were evident. The newborn recovered about 4 days after the central venous catheter was withdrawn and a thoracic drain (yellow fluid) was inserted.

One episode of catheter-related sepsis was seen in 1073 catheter days (0.9 episodes per 1000 days). Tip cultures and peripherally drawn cultures both revealed

TABLE II
Position* of central venous catheter reached from insertion sites

Insertion (vein)	Central	Semicentral n (% row)	Malposition	Total n (% column)
Basilic	46 (56.8)	32 (39.5)	3 (3.7)	81 (58.7)
Cephalic	15 (53.6)	10 (35.7)	3 (10.7)	28 (20.3)
Axillary	7 (77.8)	2 (22.2)	0 (0.0)	9 (6.5)
Saphenous	5 (29.4)	11 (64.7)	1 (5.9)	17 (12.3)
Scalp	2 (66.6)	0 (0.0)	1 (33.3)	3 (2.2)
All	75 (54.3)	55 (39.9)	8 (5.8)	138 (100.0)

* A catheter was defined as central when the tip was in the innominate vein, the superior/inferior caval vein, or the right atrial cavity. When the tip was in the subclavian or common iliac vein, it was defined as semicentral.

TABLE III
Position* of the central venous catheter in relation to weight of newborn

Weight (g)	Central	Semicentral n (% row)	Malposition	Total n (% column)
<1000	43 (68.3)	16 (25.4)	4 (6.3)	63 (45.7)
1000-1500	14 (51.9)	13 (48.1)	0 (0.0)	27 (19.6)
1500-2000	6 (27.3)	14 (63.6)	2 (9.1)	22 (15.9)
2000-2500	4 (40.0)	6 (60.0)	0 (0.0)	10 (7.2)
> 2500	8 (50.0)	6 (37.5)	2 (12.5)	16 (11.6)
All	75 (54.3)	55 (39.9)	8 (5.8)	138 (100)

* A catheter was defined as central when the tip was in the innominate vein, the superior/inferior caval vein, or the right atrial cavity. When the tip was in the subclavian or common iliac vein it was defined as semicentral.

TABLE IV
Reasons for catheter removal (n = 130)

	Number of removals	%
Death of the newborn	24	18.5
Elective	34	26.2
Minor complications		
Obstruction	5	3.8
Thrombophlebitis	26	20.0
Extravasation	22	16.9
Dislocation	7	5.4
Fluid leak	8	6.2
Major complications		
Thrombosis	1	0.8
Perforation	2	1.5
Catheter-related sepsis	1	0.8

a combination of microorganisms: *Enterobacter cloacae*, *Acinetobacter anitratum*, and *Citrobacter freundii*. These same organisms were also found in the spinal fluid.

Six other tips revealed growth in the routine culture. They were considered tip colonization because no signs of infection (increased number of band neutrophils and total white blood count, unstable temperature, or positive blood culture) were apparent. The organisms involved were *Candida* (once), *Staphylococcus aureus* (once), and *Staphylococcus epidermidis* (four times).

DISCUSSION

The introduction of hydrophilic polyurethane catheters by means of the Seldinger technique resulted in a high rate of adequately positioned catheters (94.2%), despite the low birth weight of the newborns. This might be due partly to the fact that the catheters were inserted

by neonatologists. Furthermore, the time available for introduction was not limited, and if necessary, more insertion attempts were made (not registered). The overall procedure lasted between 30 and 90 minutes.

Other investigators who used peripheral veins for the percutaneous insertion of Silastic central venous catheters in newborns showed lower success rates in reaching a central position: Sherman et al (74%),²⁶ Filston and Johnson (75%),²⁷ Woods et al (79%),²⁸ Puntis (84%),⁷ and Dolcourt and Bose (88%).³ These rates would have been higher if semicentrally placed catheters also had been taken into account, eg, Woods et al (94%),²⁸ Durand et al (96%),⁶ Hoekstra (93%),⁹ and Chathas et al (91%).¹⁰

The high number of semicentrally placed catheters in our study is due to the restricted length of the 22-gauge central venous catheter, which might be too short when the greater saphenous vein is used and in newborns weighing more than 2500 g. The use of the 20-cm-long, 20-gauge catheter in newborns weighing more than 2500 g always resulted in a central position. The arbitrary limit of 2500 g seems adequate when determining whether to use the 20-gauge or the 22-gauge catheter. However, estimated measurement before catheter insertion is more appropriate. The number of catheter tips placed in a central position would have been higher if different lengths of the 22-gauge catheter had been available. This problem is avoided by the introduction of a 22-gauge hydrophilic polyurethane catheter with a length of 20 cm.

Unlimited infusion management was achieved because of the large internal diameter of the central venous catheter. Although red-cell concentrates were occasionally infused through them, the number of occluded catheters remained at an acceptable level. This might be due to the use of heparin²⁹ and the continuous flow maintained by the infusion pumps.

The central venous catheter was also used for medication and hyperosmolar infusates. Complications caused by microparticulates, contamination,³⁰ or chemical irritation can occur, especially when a greater part of the blood flow is obstructed and when relatively small semicentral veins are used. These effects might also be attributed to more intense mechanical irritation. Associated side effects are typically seen in low-birth-weight newborns such as those in our study.

Our mean duration of catheter use was short compared with the results of other studies in which peripheral veins were used for the percutaneous insertion of central venous catheters.³⁻¹⁰ The high overall rate of complications was also rather disappointing. It should be noted, however, that most complications were minor mechanical ones and did not necessitate therapeutic intervention. The knowledge that these complications can develop into more serious ones has led to more cautious catheter care. Consequently, catheters were removed sooner, even within a few hours after their insertion. A duration of zero days was noted in one case. In none of the other studies were such short durations registered.

The relatively large caliber of our catheter, the weight of the newborns, and the type of infusates contributed to the high rate of complications. Furthermore, severely

compromised newborns are more sensitive to complications.⁸ The severity of illness was not registered in our study. However, the high mortality rate, which was not catheter-related, reflects the vulnerability of newborns. It also had a negative effect on the mean duration of catheter use.

The higher initial stiffness^{14,31} of the catheter, combined with the use of a guide wire, might cause vascular erosion along the vein during insertion, which is also a potential source of complications as reflected by the relatively high incidence of thrombophlebitis and extravasation. The disadvantages of a more manipulative insertion might negate the beneficial effects of a smaller venipuncture site.

Our overall rate of serious mechanical and infectious complications (3.1%) is acceptable and seems comparable to that seen by others (1.4% to 23.2%). The frequency of perforation (1.5%), a seldom seen complication, is rather high. This might also be a result of the more manipulative introduction technique and the stiffness of the catheter in use.³² Thrombosis, which occurs more often than clinical signs indicate, was the reason for catheter removal just once (0.8%). Although thrombosis was seen five times (3.8%), our rate seems comparable to that of others (0% to 1.6%). The higher detection rate, attributable to the routine ultrasonography, must therefore be taken into account.

The incidence of catheter-related sepsis (0.8%) is low compared with other studies (0% to 12.5%). Colonization of the tip, mostly with *S. epidermidis*, was seen six times; the poor adherence of staphylococci to hydrophilic polyurethane catheters might be the cause.¹⁵ Our infection rate does not support the suggestion that operating room facilities are needed when the Seldinger technique is used.³³

In conclusion, the use of the Seldinger technique in combination with a hydrophilic polyurethane catheter results in acceptable catheter tip placement, and it is a suitable alternative for central venous catheterization in newborns. Although their use is accompanied by a high incidence of minor mechanical complications, the rate of major mechanical and infectious complications remains at an acceptable level. Compared with previous results with Silastic catheters, the mean catheter duration of 8.3 days is rather disappointing; however, it seems sufficient for the period of parenteral nutrition that is needed for preterm newborns.

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REFERENCES

1. Wilmore DW, Dudrick SJ: Growth and development of an infant receiving all nutrients exclusively by vein. *JAMA* 203:140-144, 1968
2. Shaw JCL: Parenteral nutrition in the management of sick low birth weight infants. *Pediatr Clin North Am* 20:333-358, 1973
3. Dolcourt JL, Bose CL: Percutaneous insertion of Silastic central venous catheters in newborn infants. *Pediatrics* 70:484-486, 1982
4. Loeff DS, Matlak ME, Black RE, et al: Insertion of a small central venous catheter in neonates and young infants. *J Pediatr Surg* 17:944-949, 1982

5. Carrera G, Liberatore A: Cathéters percutanés siliconés chez le nouveau-né. *Pediatric* 40:285-289, 1985
6. Durand M, Ramanathan R, Martinelli B, et al: Prospective evaluation of percutaneous central venous Silastic catheters in newborn infants with birth weights of 510 to 3920 grams. *Pediatrics* 78:245-250, 1986
7. Puntis JWL: Percutaneous insertion of central venous feeding catheters. *Arch Dis Child* 61:1138-1140, 1986
8. Rudin C, Nars PW: A comparative study of two different percutaneous venous catheters in newborn infants. *Eur J Pediatr* 150:119-124, 1990
9. Hoekstra JH: Central venous Silastic catheters for parenteral nutrition in newborns [In Dutch]. *Ned Tijdschr Geneesk* 134:1990-1992, 1990
10. Chathas MK, Paton JB, Fisher DE: Percutaneous central venous catheterization: three years' experience in a neonatal intensive care unit. *Am J Dis Child* 144:1246-1250, 1990
11. Puntis JWL, Ball PA, Booth IW: Percutaneous central venous feeding lines in infants: do they perform as well as surgically positioned catheters? *Z Kinderchir* 42:354-357, 1987
12. Khilnani P, Toce S, Reddy R: Mechanical complications from very small percutaneous central venous Silastic catheters. *Crit Care Med* 18:1477-1478, 1990
13. Gladman G, Sinha S, Sims DG, et al: *Staphylococcus epidermidis* and retention of neonatal percutaneous central venous catheters. *Arch Dis Child* 65:234-235, 1990
14. Borow M, Crowley JG: Evaluation of central venous catheter thrombogenicity. *Acta Anaesthesiol Scand* 81(Suppl):59-64, 1985
15. Kristinsson KG: Adherence of staphylococci to intravascular catheters. *J Med Microbiol* 28:249-257, 1989
16. Seldinger SI: Catheter replacement of the needle in percutaneous arteriography. *Acta Radiol* 39:368-376, 1953
17. Oriot D, Defawe G: Percutaneous catheterization of the axillary vein in neonates. *Crit Care Med* 16:285-286, 1988
18. Bivins AB, Rapp PP, DeLuca PP, et al: Final in-line filtration: a means of decreasing the incidence of infusion phlebitis. *Surgery* 85:388-394, 1979
19. Bozetti F, Terno G, Bonfanti G, et al: Blood culture as a guide for the diagnosis of central venous catheter sepsis. *JPEN* 8:396-398, 1984
20. Ruderman JW, Morgan MA, Klein AH: Quantitative blood cultures in the diagnosis of sepsis in infants with umbilical and Broviac catheters. *J Pediatr* 112:748-751, 1988
21. Monturo CA, Dickerson RN, Mullen JL: Efficacy of thrombolytic therapy for occlusions of long-term catheters. *JPEN* 14:312-314, 1990
22. Bucciarelli RL, Jaffe R: Noninvasive evaluation of superior vena caval and right atrial thrombosis complicating central hyperalimentation. *Clin Pediatr* 22:302-303, 1983
23. Marsh D, Wilkerson SA, Cook LN, et al: Right atrial thrombus formation screening using two-dimensional echocardiograms in neonates with central venous catheters. *Pediatrics* 81:284-286, 1988
24. Curnow A, Idowu J, Behrens E, et al: Urokinase therapy for Silastic catheter-induced intravascular thrombi in infants and children. *Arch Surg* 120:1237-1240, 1985
25. Delaplane D, Scott JP, Riggs TW, et al: Urokinase therapy for a catheter-related right atrial thrombus. *J Pediatr* 100:149-152, 1982
26. Sherman MP, Vitale DE, McLaughlin GW, et al: Percutaneous and surgical placement of fine silicone elastomer central catheters in high-risk newborns. *JPEN* 7:73-78, 1983
27. Filston HC, Johnson DG: Percutaneous venous cannulation in neonates and infants: a method for catheter insertion without "cut-down." *Pediatrics* 48:896-901, 1971
28. Woods DG, Lumley J, Russell WJ, et al: The position of central venous catheters inserted through arm veins: a preliminary report. *Anaesth Intensive Care* 2:43-47, 1974
29. Schmidt B, Andrew M: Neonatal thrombosis: a critical appraisal of the available evidence on prevention, diagnosis and treatment. IN *Perinatal Thrombosis and Hemostasis*, Suzuki S, Hathaway WE, Bonnar J, Sutor AH (eds). Springer-Verlag, Tokyo, 1991, pp 137-144
30. Myhr K: Addition of drugs to infusion fluids: pharmaceutical considerations on preparation and use. *Acta Anaesthesiol Scand* 29:71-75, 1985
31. Stenqvist O, Curelaru I, Linder LE, et al: Stiffness of central venous catheters. *Acta Anaesthesiol Scand* 27:153-157, 1983
32. Bersten AD, Williams DRG, Phillips GD: Central venous catheter stiffness and its relation to vascular perforation. *Anaesth Intensive Care* 16:342-357, 1988
33. Linder LE, Wojciechowski J, Zachrisson BF, et al: "Half-way" venous catheters. IV. Clinical experience and thrombogenicity. *Acta Anaesthesiol Scand* 81(Suppl):40-46, 1985