Central venous catheterisation in newborn infants

Newborns may require intensive treatment because of prematurity, intrauterine growth restriction, medical complications or for surgical correction of congenital abnormalities. In very sick, extremely preterm infants and full term ventilated infants, the availability of early and reliable central venous access is paramount. This article discusses various aspects of central venous catheterisation in newborn infants, using umbilical venous catheters and percutaneous long lines, including the results of a large regional audit in south east England.

Aung Soe
FRCPCH, MRCP, DCH, MBBS
Consultant Neonatologist
Neonatal Intensive Care Unit
Medway Maritime Hospital, Kent
aung.soe@medway.nhs.uk

Keywords

central venous catheters; umbilical venous catheters; percutaneous long lines; positioning; heparin; contrast media; parental consent; cardiac tamponade

Key points

Soe, A. (2007) Central venous catherisation in newborn infants: Results of an audit. *Infant* 3(5): 172-75.

1. Regional/national guidelines on CVC insertion technique should be developed in view of the huge variations in practice.
2. The catheter tip should be positioned outside the cardiac chamber. Cardiac tamponade must be considered with acute deterioration and appropriate actions taken.
3. The position of the catheter tip must be confirmed by X-ray or ultrasound and if the catheter material is not radio-opaque, IV contrast should be routinely used.
4. Heparin use should be explored further as it reduces the incidence of catheter occlusion and increases the usable life span of the catheter.
5. Discussion should take place at a national level on the issue of consent.

Central venous catheters (CVC), including umbilical venous catheters (UVC)[1] and percutaneous long lines (PLL)[2] have been widely used in neonatal intensive care for providing stable venous access for early total parenteral nutrition (TPN) and administration of certain medications. UVCs are also used for rapid venous access during resuscitation on the Labour ward. However, there are reports of CVC complications such as malposition[3], sepsis[4], thromboembolism[5] and, most importantly, pericardial tamponade[6].

South Thames Regional Audit[7]

In June 2001, a review was commissioned by the Chief Medical Officer for England in response to public concern raised following the death of four babies due to cardiac tamponade after central venous catheterisation[8]. The review made 14 recommendations, including advice that the catheter tip should be positioned outside the heart, technical advice about insertion and how to check the position, documentation of all attempts at line placement, staff training and competency, information for parents, discussion at national level for consent and the implementation of appropriate incident reporting systems, both locally and nationally.

Accordingly in 2004 a prospective, criteria-based audit[7] was carried out to determine current clinical practice, usage and complications related to CVC use, based on the Department of Health report as the specific standard for the audit. In the South Thames region, which has about 80,000 deliveries per year, fourteen neonatal units, including five Level 3 regional neonatal units, participated in the project. Four hundred newborn babies born between July 2002 and April 2003, who had had at least one CVC successfully inserted, were recruited. A total of 592 CVC (218 UVC in 198 babies and 374 PLL in 303 babies) were include in the audit.

Results

UVC and PLL were inserted mainly for providing stable venous access to administer various fluids and medications. Fifteen percent of UVC were inserted for resuscitation in the Labour ward. Regarding catheters that needed to be reinserted, only 55% of UVC (11 of 20) and 14% PLL (10 of 71) were reinserted due to the clinical indication of the infant being unwell and significant numbers of CVC were reinserted for previous catheter-related problems (**TABLE 1**). Variable practices in informing parents and seeking consent, and CVC type and insertion techniques, were noted. In checking the line position, ultrasound was not used and contrast was used in only 70% of PLL. On initial X-ray, 19% of UVC and 26% of PLL

	Total number of catheters inserted	Total number of catheters reinserted	Clinically indicated	Previous line problems
UVC	218	20	11	9
PLL	374	71	10	48 (reasons not stated 13)

TABLE 1 Results of South Thames Audit on central venous catheter insertion. UVC = umbilical venous catheter. PLL = percutaneous long line.

were in intracardiac positions and repositioning was required in 45% and 41% respectively. UVC overall complication rate was 27% and 24% were removed due to complications (**TABLE 2**). PLL overall complication rate was 35% and 30% were removed due to complications. There were no deaths directly related to CVC complications. There was one case of cardiac tamponade with the PLL tip outside the cardiac chamber (incidence 1.7 cases per 1000 CVC or 2.7 cases per 1000 PLL). The PLL tip was noted outside the cardiac chamber on the initial X-ray, but subsequently migrated into the heart.

Complications	UVC (n = 218)	PLL (n = 374)
Total*	27%	35%
Malposition	16.5%	4%
Dislodgement	9%	NA
Sepsis	2%	14%
Blockage	1.5%	8%
Leakage	1.5%	8.5%
Extravasation	NA	7%
Cardiac tamponade	0	0.3%

TABLE 2 Complications due to umbilical venous catheter or percutaneous long line. *Incidence of complications in the lines inserted – some lines had more than one complication.

Usage/Indications

During the first two weeks of life, the umbilical vessels provide access to the main vascular compartment and the placement of a UVC represents a means of rapidly obtaining central venous access during that period. A UVC placed within the first hours of life is a relatively easy procedure[1] with a high success rate and the catheter can be left in place for up to 14 days with a low risk of complications[1]. UVC have been used in critically ill neonates for the urgent administration of resuscitation drugs, various intravenous infusions (hypertonic dextrose solution, TPN[9], inotropes, sodium bicarbonate and other various medications, blood transfusion), exchange transfusions[10], and central venous pressure (CVP) monitoring[11]. Recently the use of double[12] and triple[13] lumen catheters for umbilical venous access has been reported. These catheters are well tolerated for short-term use, decrease the number of peripheral venous lines required and entail no greater risk than single lumen UVC.

PLL placement has documented advantages including ease of insertion and multiple insertion site choices, reliable venous access and reduced procedural stress to the infant, reliable nutritional delivery and improved clinical outcome[2,14]. PLL are used for infusions of TPN, hypertonic dextrose, inotropes and various other medications. Therefore PLL is the method of choice once UVC is no longer available. However the PLL has limited functions compared to the UVC as it only has a single channel and is not suitable for all infusions, such as blood transfusion, due to its small lumen. Although double lumen PLL catheters became available recently, their effectiveness and safety have not been evaluated.

In the South Thames audit[7], CVC were used for various infusions and UVC were also used for resuscitation, exchange transfusion, blood sampling and central venous pressure measurement.

Complications

Reported UVC-related complications include malposition[3], dislodgement, leakage, haemorrhage, thromboembolism[3], sepsis[15], air embolism[16], and portal vein thrombosis and portal hypertension[17]. In addition, if the UVC tip lies within the cardiac chambers, pericardial effusion[18], pleural effusion[19], endocarditis[20] and arrhythmias[21] have also been reported.

For PLL, possible catheter complications include sepsis[4], thromboembolism[5], catheter malposition – which may result in pericardial tamponade[6], pleural effusion[22] and arrhythmia. In PLL, the catheter may rupture secondary to high pressures within the catheter[23] and it may become tethered, secondary to infection, and snap when being removed.

In the South Thames audit[7], no complications were noted in 73% of UVC and 65% of PLL. The most common complication was malposition (16.5%) for UVC and sepsis (14%) for PLL (**TABLE 2**). One infant with cardiac tamponade was treated successfully due to early diagnosis.

Catheter insertion

Unsuccessful attempts occurred in 25% of PLL insertions, 77% of these were failed insertion and the remainder were due to malposition or a problem with the line[7]. Twenty six percent of PLL reinsertion was due to catheter malfunction (blockage, leakage) and 20% for previous catheter-related sepsis. In UVC there were significant numbers of catheter-related problems which led to reinsertion, with 45% due to dislodgement. Training issues on catheter maintenance, fixture and prevention of sepsis (PLL) were identified and need to be addressed[7].

A neonatal and paediatric catheter information booklet produced by Vygon[24] describes the use of the butterfly needle, peelable cannula and breakaway needles for PLL insertion. All of these insertion techniques have the advantage that they can be removed once the catheter has been safely inserted, thereby reducing the risk of mechanical damage and infection which is present if an insertion device is left *in situ*.

However, in the South Thames audit a non-ported paediatric cannula (Venflon™/ Neoflon™) was most commonly used to insert and advance the catheter and was the device of choice in 44% of PLL insertions. In the author's experience the use of a non-ported cannula is not entirely safe unless the healthcare professional using the cannula has had proper training.

Positioning of the catheter tip

Position of CVC tip must be confirmed by X-ray[25,26] or ultrasound[27,28]. A UVC tip should be sited between thoracic vertebrae 6-10. For PLL, the preferable tip location is the superior or inferior vena cava just outside the right atrium; other acceptable tip locations include axillary, femoral, cephalic or temporal veins[2]. It is interesting to note that use of ultrasound in neonatology for cranial ultrasound and echocardiogram is now more widely practised; however ultrasound was not used to check the line position in this study, except in four cases of UVC after repositioning. Right atrial electro-cardiography has been used for the precise placement of CVC for TPN[29]. This technique is extremely accurate and failure to obtain the characteristic traces indicates malposition of the catheter tip and virtually eliminates the need for on-table radiography.

It is recommended that IV contrast

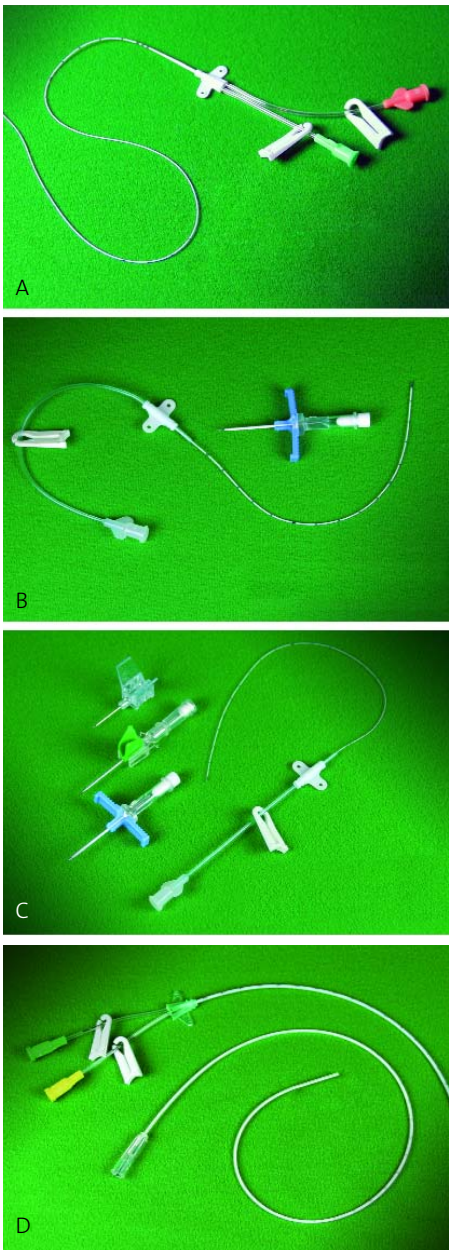

FIGURE 1 Examples of an umbilical venous catheter and percutaneous long line catheters. A) **24G Nutriline™ Twin-Flo.** Neonatal dual lumen catheter. B) **24G Nutriline™.** Peripherally inserted catheter with peelable cannula introducer. C) **Premicath™ 28G.** Neonatal catheter (PUR). D) Double and single lumen umbilical catheters. *Photos courtesy of Vygon (UK) Ltd.*

should be routinely used in the assessment of PLL position in neonates (2mL bolus of non-ionic, water-soluble contrast medium during radiographic procedure)[30]. Variable practices in the volume and the timing of contrast given were observed in the audit. It is important to note that the radiological density of the lines is similar to that of the mediastinal contents and pathological changes may further complicate demonstration of the line tip. Identification of the line position may be enhanced by the use of radio opaque contrast media, but these compounds must be used with caution. The volume of contrast required is variable depending on the length and gauge of the catheter inserted and use of an insufficient volume may falsely identify the tip in an apparently more proximal position. Paradoxically, a film taken during active injection may cause the line to appear longer due to a jet of contrast issuing from the tip of the line. In the audit, contrast was used in 2% of UVC and 70% of PLL insertions.

It is a well described phenomenon that very fine PLL tend to migrate within the vascular system[31]. Therefore, some practitioners advocate regular X-ray to check the line position, however, it is impractical and potentially dangerous to expose infants to frequent X-ray for this indication. In the audit routine X-ray for checking the line position was not a current practice despite the migration phenomenon[7].

Heparin

Use of prophylactic heparin in CVC reduces the incidence of catheter occlusion[32] and increases usable life span of the catheter. Optimal concentration may be as low as 0.5 units/mL for intravenous infusion of TPN[33]. Prophylactic heparin may reduce the presence of fibrin clots and therefore may decrease catheter-related bacteraemia, especially coagulase negative staphylococci (CNS)[34]. Although the benefits of prophylactic heparin in CVC are clearly documented, only 10% of UVC and PLL were heparinised (infusion/flush) in the study[7].

Parental information and consent

In the South Thames audit, parents were informed about indications for the procedure in 27% UVC and 49% PLL; only in surgically-inserted CVC were the parents informed about the possible complications. In 20% UVC and 38% PLL, parental consent was obtained verbally and a written consent was obtained only in surgically-inserted CVC.

Discussion

A total complication rate of 27 % in UVC and 35% of PLL is worrying and in some infants more than one complication was noted. Early insertion before the closure of the ductus venosus may reduce the incidence of malposition in UVC. The published data suggests that the sepsis rate in UVC and PLL ranges from 3%-16%; the study data showed 2% for UVC and 14% for PLL. In view of the high incidence of complications, practice should be reviewed in relation to the tip position, usage and other aspects regarding sterility, heparin use, and fixture.

There was one case of cardiac tamponade associated with PLL, where the tip was outside the cardiac position. The infant was diagnosed early and treated successfully. The suggested rarity of cardiac tamponade associated with the use of CVC implies that many centres, particularly those using small numbers of catheters, will face this problem very infrequently. With regards to the diagnosis and management of this complication, information should be issued to all units dealing with patients in the neonatal group alerting them to the fact that sudden unexpected deterioration in the child's condition when a central venous line is *in situ* may be due to cardiac tamponade and appropriate action is urgently required.

Although routine regular X-ray may not be practical; CVC tip position should be monitored. Future research and information on the use of contrast regarding the volume and timing of injection is required.

The results on parental information and consent are not surprising since there is no consensus agreement on the issue regionally or nationally, except for the surgically-inserted lines. In recent years, parents expect to be more closely involved in the decision making processes of their baby's care and in future this may require discussion of all the potential problems and complications of any treatment being proposed. It is understood that in a life-threatening situation, emergency treatment can be initiated without discussion with the parents and that complications occurring with the frequency of less than 0.5 % do not need to be communicated to the parents. However, it is important that at the earliest opportunity a discussion takes place with the parents to help them to understand why such an action has been taken. The procedure should be explained and formal consent obtained for surgically inserted lines.

The audit report made several recommendations including consideration for local/regional/national reviews on clinical practice and also for development of guidelines on consent, insertion technique and methods to check the line

tip position. The report was circulated to lead clinicians, NHS acute trusts and commissioners within London, Kent, Surrey and Sussex. Current practice in the author's unit reflects the practice identified in the audit and described in this article.

References

1. **Loisel D., Smith M., MacDonald M., Martin G.** Intravenous access in newborn infants: Impact of extended umbilical venous catheter use on requirement for peripheral venous lines. *J Perinatol* 1991; **16**: 461-66.
2. **Chathas M., Paton J., Fisher D.** Percutaneous central venous catheterisation PCVC: Three years' experience in a neonatal intensive care unit. *Am J Dis Child* 1990; **144**: 1246-50.
3. **Scott J.M.** Iatrogenic lesions in the babies following umbilical vein catheterisation. *Arch Dis Child* 1965; **40**: 426-29.
4. **Trotter C.** Percutaneous central venous catheter-related sepsis in the neonate: An analysis of the literature from 1990 to 1994. *Neonatal Network* 1996; **15**: 15-28.
5. **Mehta S., Connors A.F. Jr., Danish E.H. et al.** Incidence of thrombosis during central venous catheterisation of newborns: A prospective study. *J Pediatr Surg* 1992; **27**: 18-22.
6. **Darling J.C., Newell S.J., Mohamdee O. et al.** Central venous catheter tip in the right atrium: A risk factor for neonatal cardiac tamponade. *J Perinatol* 2001; **21**: 461-64.
7. **Soe A., Buckle R.** The usage and complications of central venous catheters (Silastic or polyurethane long lines and umbilical venous catheters) in newborn infants. Specialist Clinical Audit Programme for London, Kent Surrey and Sussex. 2004.
8. **Department of Health.** Review of four neonatal deaths due to cardiac tamponade associated with the presence of a central venous catheter. London: HMSO, 2001.
9. **Hall R.T., Rhodes P.G.** Total parenteral alimentation via indwelling umbilical catheters in the newborn period. *Arch Dis Child* 1976; **51**(12): 929-34.
10. **Diamond L.K.** Erythroblastosis foetalis or haemolytic disease of the newborn. *Proc R Soc Med* 1947; **40**: 546-50.
11. **Skinner J., Milligan D., Hunter S., Hey E.** Central venous pressure in the ventilated neonate. *Arch Dis Child* 1992; **67**: 374-77.
12. **Ginsberg H.G.** Advantages of dual-lumen umbilical vessel catheters versus single-lumen umbilical vessel catheters and additional peripheral intravenous catheters. *J Perinatol* 1997; **17**(3): 218-20.
13. **Pinheiro J., Fisher M.** Use of a triple-lumen catheter for umbilical venous access in the neonate. *J Pediatrics* 1992; **120**: 624-26.
14. **Chathas M., Paton J.** Meeting the special nutritional needs for sick infants with percutaneous central venous catheter: Quality assurance program. *J Perinatal Neonatal Nursing* 1997; **10**: 72-87.
15. **Landers S., Moise A., Farley J., O'Brian-Smith., Baker C.** Factors associated with umbilical catheter-related sepsis in neonates. Am J Dis Child 1991; **145**(6): 675-80.
16. **Kitterman J.A.** Fatal air embolism through an umbilical venous catheter. *Eur J Paediatrics* 1979; **131**(1): 71-73.
17. **Schwartz D.S., Getter P.A., Konstantino M.M. et al.** Umbilical venous catheterisation and the risk of portal vein thrombosis. *J Pediatr* 1997; **131**(5): 760-62.
18. **Purohit D.M., Levkoff A.H.** Pericardial effusion complicating umbilical venous catheterisation. *Arch Dis Child* 1977; **52**: 520.
19. **Kulkarni P.B., Dorand R.D.** Hydrothorax: A complication of intracardiac placement of umbilical venous catheter. J Pediatr 1979; **94**(5): 813-15.
20. **Symchych P.S., Krauss A.N., Winchester P.** Endocarditis following intracardiac placement of umbilical venous catheters in neonates. *J Pediatr* 1977; **90**: 287-89.
21. **Egan E.A., Eitzman D.V.** Umbilical vessel catheterisation. *Am J Dis Child* 1971; **121**: 213-18.
22. **Madhavi P., Jameson R., Robinson M.J.** Unilateral pleural effusion complicating central venous catheterisation. *Arch Dis Child Fetal Neonatal Ed* 2000; **82**: F248-49.
23. **Trotter C., Carey B.** Tearing and embolization of percutaneous central venous catheters. *Neonatal Network* 1998; **17**: 67-70.
24. **Vygon:** Neonatal & Paediatric Catheters 2006.
25. **Narla L., Hom M., Lofland G.K., Moskowitz. et al.** Evaluation of umbilical catheter and tube placement in premature infants. *Radiographics* 1991; **11**: 849-63.
26. **Racadio J.M. et al.** Pediatric peripherally inserted central catheters: Complication rates related to catheter tip location. *Pediatrics* 2001; **107**: e28.
27. **Greenberg M., Movahed., Peterson B., Bejar R.** Placement of umbilical venous catheters with use of bedside real-time ultrasonography. *J Pediatr* 1995; **126**: 633-35.
28. **Madar R.J., Deshpande S.A.** Reappraisal of ultrasound imaging of neonatal intravascular catheters. *Arch Dis Child Fetal Neonatal Ed* 1996; **75**: F62-64.
29. **Wilson R.G., Gaer J.A.** Right atrial electrocardiography in placement of central venous catheters. **Lancet** 1988; 462-63.
30. **Reece A., Ubhi T., Craig A.R. et al.** Positioning long lines: Contrast versus plain radiography. *Arch Dis Child Fetal Neonatal Ed* 2001; **84**: F129-130.
31. **Nadroo A.M., Glass R.B., Lin J. et al.** Changes in upper extremity position cause migration of peripherally inserted catheters in neonates. *Pediatrics* 2002; **110**: 131-36.
32. **Randolph A.G., Cook D.J., Gonzales C.A., Andrew M.** Benefit of heparin in central venous and pulmonary artery catheters. A meta-analysis of randomised controlled trials. Chest 1998; **113**: 165-71.
33. **Moclair A., Bates I.** The efficacy of heparin in maintaining peripheral infusions in neonates. *Eur J Pediatrics* 1995; **154**: 567-70.
34. **Appelgren P., Ransjo U., Bindslev L., Espersen F., Larm O.** Surface heparinisation of central venous catheters reduces microbial colonisation in vitro and in vivo: Results from a prospective, randomised trial. *Crit Care Med* 1996; **24**: 1482-98.