

Use of Central Venous Lines in Paediatrics—A Local Experience

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Abstract

Central venous catheters are widely used in the care of critically ill patients. This paper reviews our experience with central lines in paediatric patients requiring intensive care, between the period August 1994 and August 1995. A total of 57 insertions were performed in 40 patients, all less than 12 years of age. We found that the most common indication for catheter use was nutritional support (40%). The overall complication rate was 58%. Catheter-related infection was the most serious problem, occurring in 32% of all insertions. Coagulase-negative *Staphylococcus aureus* was the organism most frequently isolated. Maintenance problems affected 17 of our catheters in which 9 were blocked. Both infected and blocked catheters were promptly removed. We had 3 cases of perforation and 2 cases of thrombosis. There were no deaths directly attributed to catheter use. Recommendations made include: 1) staff education and new guidelines for catheter care, 2) use of bacteria filters, 3) careful prospective monitoring of catheter infection rate, 4) heparinisation when infusion rate less than 2 ml/h, 5) eliminate use of stiff polyethylene catheters and 6) routine confirmatory X-ray or waveform monitoring before catheter use, if possible.

We concluded that central venous catheterisations greatly facilitated the management of our patients. However, one must bear in mind that the use of such catheters is associated with problems which must be recognised early and promptly treated and, if possible, prevented with safe practice.

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Introduction

Peripheral access by venous cut down, once popular in the 1950s and 1960s, has almost become obsolete with the introduction of the Seldinger technique for percutaneous insertion of central venous lines.¹ In 1973, Shaw invented a technique of cannulating peripheral veins with silastic catheters, as an alternative approach to central venous lines, mainly for the purpose of parenteral nutrition, which has relatively low morbidity even in very low birth weight (VLBW) infants.²⁻⁵

Currently, percutaneous insertions of central venous lines are being practised in many centres worldwide. Studies done have shown that such catheterisations are justified in the management of critically ill paediatric patients although these can sometimes give rise to serious complications.⁶⁻⁸

The use of such catheters has become more frequent in our paediatric surgical and medical intensive care units in the last 3 years. A study was thus undertaken to review the results of our insertions.

Materials and Methods

Between August 1994 and August 1995, a total of 57

central venous catheterisations were performed in 40 patients requiring intensive care in the paediatric surgical and medical units in Singapore General Hospital. Tunnelled catheters were excluded from our study. Commonly used are paediatric sizes of Leader-cath (Vygon®); Hydrocath (Viggo®); Arrow® central venous catheters and Vygon® epicutaneous catheters.

All catheterisations were performed under aseptic technique by anaesthesiologists or intensivists, and some by residents under supervision either in the intensive care unit or the operating theatre. Central lines were inserted using the Seldinger technique. Sites of venous access included the femoral, subclavian and the internal jugular vein. In the latter, cannulation was by the anterior, posterior, or inferior route. For epicutaneous catheters, the antecubital veins were accessed, as described by Shaw. A 19-gauge butterfly needle was inserted into the vein as an introducer. The silastic catheter was then passed through the needle to a pre-measured distance from the site of insertion to the junction of the superior vena cava and the right atrium. The needle was then withdrawn and the catheter secured with Tegaderm.

Radiographic confirmation of catheter tip was done

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before utilisation whenever possible. In instances where central lines were inserted in the operating theatre, pressure waveforms were used as a guide to catheter tip position. A chest X-ray postoperatively was still mandatory.

Prospective documentation of demographic data, indication for use, catheter type, site of insertion, duration and complications was carried out. Complications were classified into 5 categories: a) catheter-related infection, b) problems associated with maintenance, c) malposition, d) perforation and e) thrombosis.

As with Casado-Flores, we defined catheter tip colonisation as the presence of a positive catheter tip culture in the absence of any sign of sepsis and catheter-related infection was classified into probable and possible infections.⁹ Probable infections were those in septic patients who had positive blood and catheter tip cultures with identical organisms and sensitivity patterns. A septic child with no obvious source of infection and had a positive catheter tip culture alone was defined as having a possible infection. A catheter was blocked when blood could not be aspirated and fluid could not be infused.¹⁰

Catheters were removed when they had served their purpose, or when complications set in compromising their use, or on demise of the patient. Whenever possible, catheter tips were sent for culture upon removal. This was done under sterile conditions to ensure that the catheter tills were not contaminated and positive cultures wrongly attributed to colonisation.

The frequency of complications was compared with the chi-square test and quantitative variables analysed with the Kruskal Wallis test. A $P < 0.05$ was accepted as significant.

Results

Most of the patients (78%) required only single catheter use. There were 2 patients who required 5 insertions during hospitalisation. All patients were less than 12 years of age, with a mean of 1 year 5 months and a median of 7 weeks. Patients weighed between 0.9 kg to 27.5 kg. The mean and median weights were 5.8 kg and 2.7 kg, respectively.

The most common indication for catheter use was nutritional support (40%) followed by infusion of drugs and fluids (39%) and monitoring (21%).

TABLE I: ANATOMICAL LOCATION AND DURATION

Location	% of insertions	Duration (days)
Internal jugular	51	9.9 ± 7.8
Femoral	25	9.3 ± 10.2
Antecubital	12	24.3 ± 11.0
Subclavian	9	10.2 ± 12.0
External jugular	3	4.0 ± 2.8

Anatomical location of the catheters and duration of use are shown in Table I. The internal jugular vein was cannulated in 51% of patients followed by the femoral vein in another 25%. The central lines lasted between 1 and 45 days. On average, they were kept in use for 11 days with a median duration of 9 days. Antecubital epicutaneous catheters were found to last significantly longer compared to catheters inserted into other sites (Table I).

Thirty-three out of 57 catheters in use (58%) ran into various complications. The list of complications and their frequencies are shown in Table II. Infection was most commonly encountered, occurring in 32% of all insertions. Only 6 patients required appropriate antibiotic treatment, having either probable or possible infections. The list of organisms isolated is shown in Table III. The bacteria most frequently isolated were coagulase-negative *Staphylococcus aureus*. We had only 1 case of *Candida* sepsis although 3 of the catheter tips had positive fungal cultures. Sepsis was not significantly related to duration of catheter use ($P = 0.1874$) although catheters which became infected were, on average, used for a longer duration of time compared to those that were not infected (11.5 days versus 7 days). Catheter location was also not an important predisposing factor ($P = 0.540$).

Maintenance problems affected 17 of our catheters (30%). Catheter blockage was the second most common complication, occurring in 9 catheters (16%). This was not significantly related to duration of catheter use ($P = 0.6296$). All occluded catheters were promptly

TABLE II: LIST OF COMPLICATIONS

Complications	Number	% of insertions
I. Catheter-related infection		
a) Colonisation	9	16
b) Sepsis-probable	4	7
Sepsis-possible	2	4
c) Exit site infection	3	5
Total	18	32
II. Maintenance problems		
a) Blockage	9	16
b) Slipped out	4	7
c) Extravasation	3	5
d) Cracked	1	2
Total	17	30
III. Malposition	7	12
IV. Perforation		
a) Cardiac tamponade	1	2
b) Pneumothorax	1	2
c) Hydrothorax	1	2
Total	3	6
V. Thrombosis	2	4

TABLE III: COMMON ORGANISMS ISOLATED

Organisms isolated	Probable infection	Possible infection	Colonisation	Total number	% of infections
Coagulase-negative <i>Staphylococcus</i>			6	6	32
Methicillin-resistant <i>Staphylococcus aureus</i>	2		3	5	26
<i>Candida</i>	2	1		3	16
<i>Klebsiella</i>	1	2		3	16
<i>Enterobacter</i>		1		1	5
<i>Morganella</i>		1		1	5
Total	5	5	9	19	100

removed. Malposition occurred in 7 patients but this was not a major problem. In 1 patient, the left subclavian was cannulated but catheter tip was located at the right subclavian vein. Repositioning was done and we managed to use the line. Ideal position of the catheter was taken to be at the junction of the superior vena cava and the right atrium. Intra-cardiac position was avoided to minimise the risk of perforation. Malpositioned catheters were adjusted or removed.

There were 3 cases of perforations and 2 cases of thrombosis. Venous thrombosis occurred in 1 patient who had femoral vein cannulation. The child was moribund and had a lymphoproliferative disorder which predisposed him to thrombus formation. He was treated with streptokinase infusion with good result. Catheter use was re-established. In another child with Down syndrome, a small right atrial thrombus was picked up on routine cardiac ultrasound. No treatment was instituted. The line was removed and the thrombus resolved spontaneously.

We did not encounter any mortality from catheter usage.

Discussion

In this study, administration of parenteral nutrition was the most common indication for central line insertion. Epicutaneous catheters were used in small infants when more than 3 weeks of parenteral nutrition was anticipated. This method was found to be cost effective and relatively free of complications.³⁻⁵ Durand et al⁵ conducted a prospective study of 53 percutaneous silastic catheterisations in newborn infants and found that the infection rate was as low as 7.5%. Thrombophlebitis or venocaval obstruction was not encountered. This was attributed to the low thrombogenicity and extreme flexibility of the silastic catheters and the addition of heparin to the infusate. The lower complication rates resulted in decreased workload and cost in the maintenance of parenteral nutrition therapy. We found this to be so as none of the 7 epicutaneous catheters we inserted became infected or thrombosed. They were in use, on average, for a longer duration of time (24.3 days) compared to the other catheters. All epicutaneous catheters were removed

electively when the indication for use no longer existed.

As with most studies, catheter-related infection was the most serious problem in our series.^{7,9,11,12} Puntis et al¹² and Eyer et al¹³ reported an infection rate of 45% and 3.3%, respectively. In our study, 15 of the 38 catheter tips sent for culture (40%) yielded positive results. Coagulase-negative *Staphylococcus aureus* was the organism most frequently isolated. Grisoni et al⁸ and Severian and Nelson¹⁴ had similar findings. All septic patients were treated based on culture results. *Candida* sepsis was treated with 6 weeks of amphotericin. No treatment was required in colonised patients. All infected catheters were removed, including those with exit site infections.

Ninety-five per cent of those who suffered infections were less than 1 year of age. The immature immunological system in this group of patients predisposed them to infections. Parenteral nutrition, instituted in 80% of affected patients, has been shown to increase the risk of infection by 2.4 times.¹⁵ Bacteria filters were not used routinely, especially when lines were used for monitoring and drug administration. All these factors could have contributed to the high infection rate. We have now instituted the use of bacterial filters for all lumens of all central lines as advocated by Francombe.¹⁶ Moller et al¹⁷ have shown that prophylactic low dose vancomycin, 5 mg/kg over 1 hour twice daily, was able to decrease the rate of coagulase-negative *Staphylococcus* sepsis in VLBW infants. We have not considered this practice as coagulase-negative *Staphylococcus* sepsis was not a major problem in our cohort (Table III).

Puntis et al¹² have shown that staff training is a key factor in reducing intravascular catheter sepsis. In their study, infection rate was reduced from 45% to 8%. In view of the high infection rate, the importance of scrupulous aseptic technique, especially during central line disconnection, was emphasised to the nursing staff and new catheter care protocols drawn up, resulting in the dramatic drop in infection rate. Following their example, we have started careful prospective monitoring of infections rates with documentation of catheter-related sepsis and frequent quality assurance reviews.

Sepsis was not significantly related to duration of catheter use ($P=0.1874$) or catheter location ($P=0.540$).

Studies have shown that the use of femoral lines does not result in an increased incidence of Gram-negative enteric sepsis.^{3,18} It was not part of our protocol to change catheters every 7 days. Eyer et al¹³ showed that frequent change of catheters does not decrease the incidence of infections.

Catheter blockage, the second most common complication, occurred in 9 catheters (16%), which were promptly removed. Only in 1 patient was blockage treated with Streptokinase infusion. Stenzel et al¹⁹ advocated that blocked catheters should not be flushed. Prompt exchange with a new catheter is prophylactic against infection and thrombosis. None of our catheters was occluded by mineral precipitates. The high incidence of blockade in our patients could be because when these multi-lumen lines were not in use, daily flushing with heparin was not carried out. Our department now practises heparinisation when the flow rate is less than 2 ml/h.

Perforation resulted in cardiac tamponade in 1 patient and leakage of total parenteral nutrition into the pleural cavity in another. Both cases were due to the use of stiff polyethylene catheters. In the first patient, a one-week-old baby with intestinal obstruction, central line was used for fluid infusion immediately after insertion. She had circulatory collapse 3 hours later and chest X-ray showed the catheter tip to be in the right ventricle. Echocardiogram confirmed a cardiac tamponade from moderate pericardial effusion. Subxiphoid drainage was performed and the patient survived the event but she died 7 weeks later from other complications of her illness.

Cardiac tamponade as a result of perforation of the heart is one of the most serious complications of central lines. Deflaque and Campbell²⁰ reported a mortality of rate of 74% in such cases. Hence proper placement of catheter tip in the superior vena cava is of utmost importance. The authors suggested that this can be achieved by estimating proper length of cannula by measuring between external anatomical landmarks, minimising patient movement, proper securing at the exit site and frequent waveform monitoring. On top of these measures, we have eliminated the use of stiff polyethylene catheters, although they may be easier to insert. Silastic catheters are used whenever possible followed by polyurethane catheters.

In the second patient, initial chest X-ray showed the catheter tip to be at a satisfactory position. However, 3 days later, he required increased ventilatory settings. A repeat chest X-ray showed a hydrothorax. A chest tube was inserted and left *in situ* for 6 days to drain the extravasated fluid.

Hydrothorax can occur as delayed complication even when the catheter tip is initially in the correct position

and the catheter functioned properly. This may be a consequence of perforation of a vein and the viscera pleura by the catheter tip. Early recognition and removal is an important way of avoiding this time-related complication. Measures such as proper estimation of catheter length, minimising patient movement and proper securing at exit sites to prevent accidental advancement of catheter tip are also applicable here. A high index of suspicion on the part of the physician can reduce the mortality and morbidity of these two potentially life-threatening complications.

Conclusion

In our study, catheter-related infection was the most frequently encountered complication. To reduce infection rate, new protocols have been drawn up for line maintenance. All nursing staff involved in the care of central lines were trained and educated on the need for absolute sterility in line management. Bacteria filters are also routinely used.

We experienced 2 cases of potentially life-threatening perforations resulting in cardiac tamponade and hydrothorax. To further minimise these complications, catheters are inserted by experienced senior staff or residents under close supervision. A high index of suspicion from any complications should be maintained so that early rectification can result in reduced morbidity.

Although this study has shown that more than half of all our catheters encountered complications, central venous catheterisations however have greatly facilitated the management of our patients—for intensive monitoring, drug and fluid administration in postoperative patients, and for nutritional support in long-term gut failure patients. Better staff training and early recognition of complications will lead to a lower complication rate.

REFERENCES

1. Seldinger S L. Catheter placement of the needle in percutaneous arteriography: a new technique. *Acta Radio* 1953; 39:368-71.
2. Shaw J C L. Parenteral nutrition in the management of sick low birth weight infants. *Pediatr Clin North Am* 1973; 20:636-7.
3. Puntis J W L. Percutaneous insertion of central venous feeding catheters. *Arch Dis Child* 1986; 16:1138-40.
4. Oriot D, Defawe G. Percutaneous catheterisation of the axillary vein in neonates. *Crit Care Med* 1988; 16:285-6.
5. Durand M, Ramanathan R, Martinelli B, Tolentino M. Prospective evaluation of percutaneous central venous silastic catheters in newborn infants with birthweights of 510 to 3,920 grams. *Pediatrics* 1986; 78:245-50.
6. Smith-Wright D L, Green T I, Lock J E, Eggar M I, Fuhrman B P. Complications of vascular catheterisations in critically ill children. *Crit Care Med* 1984; 12:1015-7.
7. Ogata E S, Schulman S, Raffensperger J, Luck S, Rusnak M. Caval catheterisation in the intensive care nursery: a useful means for providing

- parenteral nutrition to the extremely low birth-weight infant. *J Pediatr Surg* 1984; 19:258-62.
8. Grisoni E R, Mehta S K, Connors A F. Thrombosis and infection complicating central venous catheterisations in neonates. *J Pediatr Surg* 1986; 21:772-6.
 9. Casado-Flores J, Valdivielso-Serna A, Perez-Jurando L, Monleon-Luque M, Garcia-Perez J, Ruiz-Beltran A, et al. Subclavian vein catheterisation in critically ill children: analysis of 322 cannulations. *Crit Care Med* 1991; 17:350-4.
 10. Duffy L F, Kerzner B, Gebus V, Dice J. Treatment of central venous catheter occlusions with hydrochloric acid. *J Pediatr* 1989; 114:1002-4.
 11. Puri V K, Carlson R W, Bander J J, Weil M H. Complications of vascular catheterisations in the critically ill. A prospective study. *Crit Care Med* 1980; 8:495-9.
 12. Puntis J W L, Holden C E, Smallman S, Finkel Y, George R H, Booth I W. Staff training: a key factor in reducing intravascular catheter sepsis. *Arch Dis Child* 1990; 65:335-7.
 13. Eyer S, Brummit C, Crossley K, Siegel R, Cerra F. Catheter-related sepsis: prospective randomised study of three methods of long term catheter maintenance. *Crit Care Med* 1990; 18:1073-7.
 14. Severian C, Nelson J D. Frequency of infections associated with implanted systems vs cuffed, tunneled silastic venous catheters in patients with acute leukaemia. *Am J Dis Child* 1991; 145:433-8.
 15. Christensen M L, Hancock M L, Gattuso J, Hurnitz C A, Smith C, McCormick J, et al. Parenteral nutrition associated with increased infection rate in children with cancer. *Cancer* 1993; 72:2732-8.
 16. Francombe I'. Intravenous filters and phlebitis. *Nursing Times* 1988; 84:34-5
 17. Moller J C, Nachtrodt G, Richter A, Tegtmeyer F K. Prophylactic vancomycin to prevent Staphylococcal septicaemia in the very low birth-weight infants. *Lancet* 1992; 340:424.
 18. Abdulla F, Dietrich I C A, Pramanik A K. Percutaneous femoral venous catheterisations in preterm neonates. *J Pediatr* 1990; 117:788-91.
 19. Stenzel J P, Green T P, Fuhrman B P, Carlson P E, Marchessault R P. Percutaneous central venous catheterisation in a pediatric intensive care unit. A survival analysis of complications. *Crit Care Med* 1989; 17:984-9.
 20. Deflaque R J, Campell C. Cardiac tamponade from central venous catheters. *Anesthesiology* 1979; 50:249-52.