Incidence and risk factors of infections associated with peripheral intravenous catheters

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Abstract

Aim: To study the incidence and risk factors of bacterial colonisation of peripheral venous catheters during the early neonatal period.

Design: Prospective observational clinical study.

Setting: Level II neonatal intensive care unit.

Patients: Consecutive neonates in whom peripheral catheter was inserted were recruited.

Methods: The insertion site was cleaned with isopropyl alcohol and chlorhexidine for 30 s consecutively. A needleless catheter access device was attached to peripheral catheters. A dedicated observer reviewed the catheter sites regularly for complications. On removal, the tip of the catheter was cut under sterile conditions and sent to the laboratory for culture. Only catheters indwelling for >12 h were sent for culture.

Findings: Bacteria were isolated from 22 out of 154 catheter tips. Methicillin-sensitive *Staphylococcus aureus* (n = 13) was the most common organism constituting more than 50% of isolates. In five out of 22 isolates, the organism from the catheter tip was identical to the one from the skin. Systemic sepsis at enrolment was positively associated with colonisation of peripheral catheter. None of the neonates developed peripheral catheter-related bloodstream infection.

Conclusion: When proper infection control measures are in place, risk of peripheral venous catheter-related infection appears extremely low in spite of frequent colonisation of the catheter.

Keywords

Catheter-related blood stream infection, incidence, peripheral venous catheter, risk factor

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Background

Catheter-related bloodstream infection is an important cause of morbidity and mortality in sick neonates (Hodge and Puntis, 2002). Among the intravascular devices, both peripheral and central catheters can be the potential source. Central vascular access devices have dominated the lime-light due to the apparent perception of greater risk of bloodstream infections. With most clinical studies focusing on central vascular catheters, infections associated with short peripheral venous catheters have received little attention (Hadaway, 2012). The numbers of neonates with peripheral venous catheter are far larger than those having central vascular catheters. Despite the frequent use of peripheral

intravenous catheters, there is inadequate information about the bloodstream infections caused by these devices. The rate of bloodstream infections associated with peripheral intravenous catheters in neonates is considered to be very

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low (O'Grady et al., 2002). Although the rate may be low, the actual number of infections could be relatively high, with most going undetected because of short dwelling times. Biofilm formation and colonisation of indwelling catheters are central to the pathogenesis of catheter-related infection (Trautner and Darouiche, 2004). A substantial knowledge gap exists about the incidence of peripheral vascular catheter colonisation and various factors that influence peripheral catheter-related bloodstream infections.

Aim

The objective of this work is to study the incidence of bacterial colonisation of peripheral venous catheters and risk factors for colonisation during the early neonatal period in ill neonates and to study the role of peripheral venous catheters as a likely source of bacteraemia in neonates.

Methodology and research design

This prospective study was conducted in a level II neonatal intensive care unit on ill neonates admitted to the unit. Consecutive neonates in the early neonatal period (within 7 days after birth) in whom a peripheral venous catheter was inserted and the catheter was *in situ* for at least 12 h formed the study population. Neonates who needed more than one intravenous cannula, those with central vascular catheter and neonates whose parents refused consent were excluded from the study. The local ethics committee approved the study protocol. Either medical or nursing staff inserted the catheter after washing their hands for 2 min with soap and water and wearing sterile gloves. After informed consent, skin swabs were taken from the site of insertion prior to the procedure. An area of about 3 inches around the likely site of insertion was sprayed with 2% chlorhexidine and was allowed to dry for 30 s. Following this, the area was thoroughly cleansed with 70% isopropyl alcohol swab and allowed to dry naturally for 30 s. A 24-gauge peripheral catheter was inserted and the catheter was fixed with dedicated hypoallergenic transparent dressing. A needleless catheter access device was attached to the catheter. Apart from the nursing staff, a devoted observer reviewed the catheter sites regularly for any of the following complications: erythema greater than 5 cm from site; swelling more than 3 cm from site; palpable cord of the vein more than 3 cm from site; and purulent drainage at the insertion site. The catheter was removed on the occurrence of phlebitis defined as the presence of either palpable cord or purulent discharge in isolation or erythema and swelling in combination. On removal, proximal 1 cm of the catheter was cut under sterile conditions and sent for microbiological analysis and culture by roll plate technique. During the study period, a septic screen comprising total leukocyte count, absolute neutrophil count, immature to total neutrophil ratio, microerythrocyte sedimentation rate

and C reactive protein was performed at enrolment and then daily. Any neonate with one of the following – leukopenia ($<5000/\text{mm}^3$), leukocytosis ($>20,000/\text{mm}^3$), absolute neutrophil count ($<1800/\text{mm}^3$), immature to total neutrophil ratio (>0.2) and C reactive protein ($>6\text{ mg/dl}$) – was considered to have a positive septic screen (Da Silva et al., 1995; Polinski, 1996) and blood culture was repeated. The diagnosis of catheter-related bacteraemia was made by the presence of phlebitis and positive blood culture without an alternate explanation for bacteraemia (Mermel et al., 2009).

Information related to the intravenous catheter, such as the location of device, medications administered, duration of indwelling of catheter before removal, presence of complications and other relevant epidemiological data, were collected in a predesigned pro forma. Multivariate regression analysis was performed using SPSS software to identify the risk factors for colonisation and catheter-related bloodstream infection.

The sample size of the study was calculated using the incidence obtained from a pilot study. In order to avoid selection bias, consecutive cases were included both during the pilot phase and in the actual study. To prevent information bias, all the cases were strictly managed as per standardised protocols which were not changed during the study period (Jepsen et al., 2004).

Results

A total of 154 neonates were enrolled in this study. Out of these, 57 were born at the hospital, the remaining 97 were transferred from other hospitals. A total of 101 neonates were boys and the rest were girls. The weight of the babies enrolled was in the range of 1000–3850 g. The gestational age was in the range of 28–42 weeks. Nine babies had culture-positive bloodstream infection at admission. The characteristics of the study population are given in Table 1. Senior medical personnel (69.5%) inserted the majority of the peripheral catheters; junior medical personnel and trained nursing staff inserted the rest. The majority of the venous catheters (136 out of 154) were inserted in the first attempt. The left upper limb was the most preferred site of insertion followed by the right upper limb. Antibiotics had been administered via all the catheters. Intravenous fluids, antibiotics and other medications were administered through more than half of the catheters. About 20% of the intravenous cannula were removed within 24 h. Another 40% were removed within 48 h after insertion.

In total, 136 out of 154 catheters were removed due to local swelling. Five catheters were removed because of erythema, purulent discharge or palpable cord (Figure 1). In 13 catheters, bacteria were demonstrated by gram stain. Most of the catheter tips were sterile (132 out of 154) and organisms were isolated from 22 catheters. Methicillin-sensitive *Staphylococcus aureus* ($n = 13$) was the most common organism constituting more than 50% of the isolates. The

Table 1. Characteristics of the study population and demographic data.

Characteristics		n (%)
Total		154
Sex	Boys	101 (65.6%)
	Girls	53 (34.4%)
Place of delivery	Outborn	97 (63.0%)
	Inborn	57 (37.0%)
Weight (g)	<1500	27 (17.5%)
	1500–2500	70 (45.5%)
	>2500	57 (37.0%)
Inserting person	Junior medical staff	19 (12.3%)
	Senior medical staff	107 (69.5%)
	Nursing staff	28 (18.2%)
Time of insertion	08:00–14:00	40 (26.0%)
	14:00–20:00	46 (29.9%)
	20:00–02:00	31 (20.1%)
	02:00–08:00	37 (24.0%)
Number of attempts	1	136 (88.3%)
	2	15 (9.7%)
	≥3	3 (2.0%)
Site of insertion	Right upper limb	51 (3.1%)
	Left upper limb	55 (35.7%)
	Right lower limb	25 (16.2%)
	Left lower limb	23 (14.9%)
Type of intravenous infusion	Antibiotics only	20 (13.0%)
	Intravenous fluids and antibiotics	48 (31.1%)
	Intravenous fluids, antibiotics and medications	86 (55.9%)
Duration (h)	<24	31 (20.1%)
	24–48	62 (40.2%)
	48–72	48 (31.2%)
	>72	13 (8.4%)

other organisms that were isolated were *Enterobacter* species ($n = 4$), methicillin-resistant *Staphylococcus aureus* ($n = 2$), α -haemolytic *Streptococcus* ($n = 1$), coagulase negative *Staphylococcus* ($n = 1$) and *Klebsiella pneumoniae* ($n = 1$). Table 2 shows the individual catheter tip isolates, the corresponding skin culture and blood cultures at enrolment. Interestingly, only in five out of the 22 isolates was the organism grown in the catheter tip identical to the one grown from the skin. None of the neonates developed

Figure 1. Local complications associated with the use of peripheral intravenous catheters.

peripheral catheter-related bloodstream infection during the study period.

In order to identify the relationship between the various parameters affecting bacterial colonisation of the peripheral catheter, univariate Spearman rank correlation analysis was performed and a correlation matrix was obtained. Four demographic factors, three procedure-related factors, two usage-related factors, four complication-related parameters and two organism-related parameters were evaluated for a possible relationship with catheter colonisation. Of the parameters studied, only presence of systemic sepsis at enrolment was associated positively with colonisation of peripheral catheter (Table 3).

Discussion

Intravascular catheters are indispensable in the management of ill neonates, but their use involves the risk of local and systemic infection complications. The most frequently used vascular access device is peripheral venous catheter, but limited data are available about the infection risks posed by these devices. Catheter-related infection is one of the leading causes of nosocomial infection and is associated with significant morbidity and mortality in critically ill neonates. These infections are difficult to diagnose and add tremendously to the cost of healthcare. Hence, the objective was to study the role of peripheral catheters as a likely source of bacteraemia in neonates.

In this study, we found that local complications are common with the use of peripheral venous catheters, as nearly 90% of the cannula were associated with swelling. However, phlebitis was rare with only 3.2% developing this complication. Though comparable data were not available in neonates, data from an older population by Barbut et al. reported a much higher incidence of phlebitis (22%)

Table 2. Isolates from catheter tip and corresponding skin and blood cultures at enrolment.

No.	Catheter tip culture	Skin culture	Blood culture
1	Methicillin-sensitive <i>Staphylococcus aureus</i>	Methicillin-sensitive <i>Staphylococcus aureus</i>	Methicillin-sensitive <i>Staphylococcus aureus</i>
2	Methicillin-sensitive <i>Staphylococcus aureus</i>	Methicillin-sensitive <i>Staphylococcus aureus</i>	No growth
3	Methicillin-sensitive <i>Staphylococcus aureus</i>	Methicillin-sensitive <i>Staphylococcus aureus</i>	No growth
4	Methicillin-sensitive <i>Staphylococcus aureus</i>	Methicillin-sensitive <i>Staphylococcus aureus</i>	No growth
5	Methicillin-sensitive <i>Staphylococcus aureus</i>	Methicillin-resistant <i>Staphylococcus aureus</i>	No growth
6	Methicillin-sensitive <i>Staphylococcus aureus</i>	Enterobacter species	No growth
7	Methicillin-sensitive <i>Staphylococcus aureus</i>	Methicillin-resistant <i>Staphylococcus aureus</i>	No growth
8	Methicillin-sensitive <i>Staphylococcus aureus</i>	No growth	No growth
9	Methicillin-sensitive <i>Staphylococcus aureus</i>	No growth	No growth
10	Methicillin-sensitive <i>Staphylococcus aureus</i>	No growth	No growth
11	Methicillin-sensitive <i>Staphylococcus aureus</i>	No growth	No growth
12	Methicillin-sensitive <i>Staphylococcus aureus</i>	No growth	No growth
13	Methicillin-sensitive <i>Staphylococcus aureus</i>	No growth	No growth
14	Methicillin-resistant <i>Staphylococcus aureus</i>	Methicillin-resistant <i>Staphylococcus aureus</i>	Methicillin-resistant <i>Staphylococcus aureus</i>
15	Methicillin-resistant <i>Staphylococcus aureus</i>	Methicillin-sensitive <i>Staphylococcus aureus</i>	No growth
16	Alpha haemolytic Streptococcus	No growth	No growth
17	Coagulase negative Staphylococcus	No growth	No growth
18	Enterobacter species	Methicillin-resistant <i>Staphylococcus aureus</i>	Enterobacter species
19	Enterobacter species	Methicillin-resistant <i>Staphylococcus aureus</i>	No growth
20	Enterobacter species	Methicillin-resistant <i>Staphylococcus aureus</i>	Enterobacter species
21	Enterobacter species	Enterobacter species	Enterobacter species
22	<i>Klebsiella pneumoniae</i>	<i>Klebsiella pneumoniae</i>	<i>Klebsiella pneumoniae</i>

(Barbut et al., 2003). Sequential cleansing of the skin with two different antiseptic agents and routine use of a needleless access system could have contributed to the low incidence of phlebitis seen in our study group.

The most probable route of infection for short-term non-tunnelled, non-cuffed catheters is the migration of skin organisms at the insertion site along the surface of the catheter (Mermel, 2011). As the likely mechanism of peripheral venous catheter-related bloodstream infection is colonisation of the catheter followed by biofilm formation, catheter tip culture was performed in our study (Zingg and Pittet, 2009). Investigation of the catheter tip culture as a surrogate endpoint is a logical first step in studies evaluating the prevention of catheter-related infections (Rijnders et al., 2002).

Colonisation of the catheter was common as bacteria were cultured from one out of every seven catheters. However, bloodstream infection was not associated with colonisation of catheters during the study period. This suggests that when rigorous infection control practices are in place, the risk of bloodstream infection due to peripheral venous catheters is extremely low.

Another important point to note is the lack of correlation between the organisms isolated from the skin and those from the catheter tip. In 75% of the cases, different organisms were isolated from the skin and the catheter. Though this work was not designed to study the routes of spread of infection in peripheral catheters, the above observation does raise questions about the current theories regarding the pathogenesis of infections of intravascular devices (Von

Table 3. Spearman rank analysis of parameters affecting colonisation of catheter tip.

	Parameters	Spearman's coefficient	Significance
Demographic factors	Sex	0.017	0.837
	Birth weight	0.067	0.408
	Time of insertion	0.029	0.726
	Place of delivery	0.044	0.589
Procedure-related factors	Inserting person	−0.021	0.797
	Number of attempts	0.141	0.081
	Site of insertion	−0.01	0.901
Usage-related factors	Duration of stay	−0.103	0.206
	Type of medication infused	−0.059	0.471
Complications	Swelling	0.033	0.684
	Erythema	0.077	0.344
	Purulence	−0.033	0.684
	Palpable Cord	0.117	0.148
Organism-related	Skin culture	0.064	0.430
	Systemic sepsis	0.215	0.007

Eiff et al., 2005). When the various factors contributing to the colonisation were studied, a positive correlation was identified only with pre-existing systemic sepsis. None of the other factors studied influenced the colonisation of the catheter tip. This suggests that, contrary to common belief, when proper precautions are taken, colonisation of the vascular catheter is the result of haematogenous spread rather than the migration of the cutaneous organism along the catheter surface.

Another interesting fact that emerged from the current study is that there is no correlation between the length of dwell time of the peripheral intravenous cannula and isolation of organism from the catheter. This is counterintuitive to traditional thinking that peripheral intravenous device complications are likely be less with limited dwell time. Interestingly, clinical studies have also shown that duration of dwell time of peripheral intravenous catheters did not affect the incidence of phlebitis (Rickard et al., 2010, 2012; Webster et al., 2015).

Being a single-centre study, the major limitation is the generalisability of the study pending a similar research in a larger population.

Conclusion

This study addresses an important knowledge gap in the use of peripheral venous catheters in neonates. When

proper infection control measures are in place, the risk of peripheral venous catheter-related infection appears extremely low even though colonisation of the catheter with bacteria is common. However, the clinical implications of cannulation should not be underestimated, as this procedure involves introduction of a foreign body into the vein, which is a significant intervention with unrecognised and underrated infection risks.

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