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Is PIC Dwell Time Associated with Increased Infection Risk in Infants?

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Abstract

Objective: To estimate blood stream infection risk associated with catheter dwell time.

Design: We performed a retrospective study of 1540 peripherally inserted catheters placed in 882 infants from August 2002 until November 2005.

Setting: The Duke University Medical Center Neonatal Intensive Care Unit is an academic level III nursery.

Methods: A catheter related blood stream infection was defined as a positive blood culture that was documented >24 hours after catheter placement or within 72 hours of catheter removal. We used multivariable logistic regression to control for dwell time of catheter, weight at insertion, birth weight, gestational age, day of insertion, position of catheter, and gender.

Results: We identified 135 cases of catheter related blood stream infection. The mean catheter dwell time was 12.2 days (range, 0-113 days) and mean time to blood stream infection 10.8 days (range, 1-57 days). Increasing catheter dwell time was associated with a lower risk of blood stream infection (OR 0.975; 95% CI, 0.954-0.996, P=0.02).

Conclusions: No increase risk of catheter related blood stream infection was observed with increasing catheter dwell time. This may have been due to improved nutrition, decreased need for other invasive devices, and maturation of the infants' skin and immune system as catheter dwell time increased.

Keywords

nosocomial infection; central line; infant

Background

Peripherally inserted catheters (PICs) are a mainstay of therapy for newborns admitted to the Neonatal Intensive Care Nursery (NICU). Although inserted at a peripheral site (hand, foot, scalp), they may be inserted to a depth where they are considered peripheral, midline, or central. They are used for administration of total parenteral nutrition, intravenous fluids, and medications. However, presence of these catheters increases the risk for bloodstream

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infections.(1-4) Infection rates for central venous catheters are higher in the neonatal population compared with older children and adults.(1) There is concern that increasing catheter dwell time in infants is associated with an increased infection risk.(4,5) The purpose of our study was to determine the relationship between infection risk and duration of PIC dwell time in a single nursery with an established PIC nursing team, protocols for catheter insertions, and prospectively collected catheter data.

Methods

We analyzed all PICs placed in the Duke University Medical Center NICU over a 27 month period from 8/2002 to 11/2005. PIC insertions were performed by a member of the NICU PIC team under sterile conditions using povidone-iodine, gowns, caps, masks, and sterile gloves. PICs were secured with Steri-Strips® (3M Healthcare, St. Paul, MN) and covered with Tegaderm® (3M Healthcare). Dressing changes were made only when necessary. All PICs were 24 or 28 gauge single-lumen catheters.

Information regarding PIC placement and removal was recorded in a registry at the time of the procedure by a PIC team member. Blood culture results for all infants in the cohort were obtained. One blood culture (0.5-1.0 mL) is typically drawn peripherally in the Duke NICU for sepsis evaluations per unit policy. A catheter associated bloodstream infection (CABSI) was defined as the 1st positive blood culture noted in the period of time from 24 hours after catheter insertion until 72 hours after removal.(6,7) Positive cultures noted during the first 7 days after PIC placement were ignored if the same organism had been identified in the week prior to PIC insertion. Our primary outcome was development of the first CABSI.

Data were analyzed using STATA 9.0 (College Station, TX). A catheter infection was treated as binary variable. Fisher's exact and Mann Whitney tests were used where appropriate. Associations with catheter infections were examined by logistic regression with catheters clustered by patient to give robust confidence intervals. Explanatory variables analyzed included catheter dwell time (days), PIC position (central, midline, peripheral), day of life of placement, gestational age at birth (weeks), adjusted gestational age at insertion (weeks), birth weight (g), and weight at insertion (g). All variable were treated as continuous variables except PIC position. Statistical significance was determined by $p < 0.05$. We built the regression model using forward regression with a p-value of 0.5 required for entry into the model. Variables were then removed from the generated model by backward regression with a p-value of 0.1 required for each variable to remain in the final model.

This study was approved by the Duke University Medical Center Institutional Review Board.

Results

We identified 1540 PICs placed in a cohort of 882 infants. The mean number of catheters per patient was 1.8 (range, 1-13). The catheters were in place for a total of 16,438 days. The mean gestational age at birth and birth weight were 31 (SD, ± 5.1) weeks and 1749 (± 1033) g, respectively (Table 1). The mean and median day of insertion were 23 and 6, respectively (range, 0-261 days). The mean and median duration of catheter placement was 12.2 and 8 days, respectively (Table 1). The longest catheter dwell time was 113 days. This catheter was placed on day of life 23 in an infant born at 1035 g and 27 weeks gestation and was never infected.

In the 1540 PICs placed over this time period, we observed 135 (8.8%) CABSIs. Of the infants < 750 g birth weight, 47/120 (39.2%) sustained a CABSI. In contrast, only 7/407 (1.7%) of the infants > 1500 g suffered a CABSI. The median and mean time to infection was 9 and 10.9 days, respectively. The median age at onset of CABSI was 17 days. The minimum and maximum age at onset of infection were 6 and 123 days, respectively. Of the 99 infants with

CABSI, 71 had only 1 episode, 22 infants had 2 episodes, 4 infants had 3 episodes, and 2 infants had 4 episodes.

None of the 24 PICs placed in the scalp were associated with a bloodstream infection. The highest rate of CABSI was observed in PICs placed in the arm 69/574 (12.0%), and 401/546 (73.4%) of these lines were centrally placed (Table 1). The proportion of central, midline, and peripheral catheters that became infected was 100/1034 (9.6%), 16/185 (8.6%), and 12/257 (4.7%), respectively. The most commonly isolated organisms were coagulase negative *Staphylococcus* (CoNS) 64/135 (47.4%), Gram-negative organisms 16/135 (11.9%), and *Candida* species 11/135 (8.1%) (Table 2).

The overall CABSI rate was 8.9 infections/1000 catheter days. The infection rate was highest during the fifth week of catheter placement, 13.6/1000 catheter days (Table 3). However, the infection rate after the fifth week of catheter placement was only 4.5/1000 catheter days. The CABSI rate for central catheters was 8.4/1000 catheter days.

Unadjusted odds ratios (ORs) were calculated with presence of a CABSI as the indicator variable. No difference was observed for number of days of catheter dwell time (OR, 0.998; 95% CI, 0.982-1.013; $P=0.78$), presence of a midline PIC versus a central PIC (OR, 0.884; 95% CI, 0.484, 1.615; $P=0.69$), day of life of insertion (OR, 0.994; 0.986-1.002; $P=0.11$), or male gender (OR, 0.773; 95% CI, 0.510-1.173; $P=0.23$). Significant differences were observed for presence of a peripheral PIC versus a central PIC (OR=0.457, 95% CI, 0.255-0.822; $P=0.009$), gestational age at birth (weeks) (OR, 0.753; 95% CI 0.694-0.818; $P<0.001$), adjusted gestational age at insertion (weeks) (OR, 0.792; 95% CI, 0.731-0.858; $P<0.001$), birth weight (g) (OR, 0.998; 95% CI, 0.998-0.999; $P<0.001$), and weight at insertion (g) (OR, 0.998; 95% CI, 0.997-0.999; $P<0.001$). Multivariate regression modeling produced a model with the following 4 significant predictor variables: presence of a peripheral PIC versus a central PIC (OR, 0.502; 95% CI, 0.271-0.931; $P=0.03$), catheter dwell time (days) (OR, 0.975; 95% CI, 0.954-0.996; $P=0.02$), day of life of insertion (OR, 0.981; 95% CI, 0.971-0.993; $P=0.002$), and gestational age at birth (weeks) (OR, 0.717; 95% CI, 0.650-0.791, $P<0.001$). A regression with adjusted gestational age (weeks) in place of day of life of insertion and gestational age at birth yields similar results: presence of a peripheral PIC versus a central PIC (OR, 0.498; 95% CI, 0.260-0.955; $P=0.04$), catheter dwell time (OR, 0.976; 95% CI, 0.958-0.995; $P=0.01$), adjusted gestational age at insertion (OR, 0.798; 95% CI, 0.756-0.842 $P<0.001$).

Discussion

CABSI are a major complication of vascular access in critically ill infants.(4,8,9) Although previous investigators have raised concerns about length of PIC placement and infection risk, (4,5,10) current recommendations in adults and pediatric patients are not to routinely replace PICs to prevent infections.(6,11) Determining a critical dwell time in infants at which infection risk rises would be beneficial to clinicians as the catheter might be routinely replaced before this critical time was reached.

A previous review of PICs in the NICU noted a critical dwell time of 21 days after which the majority of CABSI occurred.(5) However, in this study performed from 1983-1986, only 6 episodes of CABSI were observed in 317 patients (5 of which occurred after day 21). Similarly, a multicenter cohort study examined risk factors for late-onset sepsis in 6,956 infants $\leq$ 1500 g birth weight.(4) After adjusting for center and gestational age, the investigators found that the OR for development of sepsis was 3.7 for infants with centrally placed PICs in place for $\geq$ 22 days compared with infants with 0 days of centrally placed PICs. However, the authors of this study did not examine the relationship between development of late-onset sepsis and actual presence of the catheter or duration of the catheter at the time of the infection.

The overall infection rate observed in our study was 8.9/1000 catheter days. A previous report examining the infection rate of PICs in 1617 infants with a mean birth weight of 1570 grams at 17 Canadian centers, found an infection rate of 13.1/1000 catheter days.(2) The infection rate in our cohort for infants <1000 grams birth weight was 13.2/1000 catheter days. It is unclear whether each of the units in the previous report had dedicated PIC nurses as we do in the Duke University Medical Center NICU. Also, 257/322 (79.8%) of the infections in this report were caused by CoNS compared to only 64/135 (47.4%) in our cohort. We observed a higher proportion of infections caused by *Staphylococcus aureus*, 39/135 (28.9%), and *Candida*, 11/135 (8.1%) than the Canadian NICUs, 31/322 (9.6%) and 10/322 (3.1%) respectively for other Gram-positives and *Candida*.

In our study of 1540 catheters in 882 infants representing 16,348 PIC days, multivariable modeling revealed that increasing catheter duration was associated with a decreased risk of infection when controlling for gestational age at birth, age at insertion and position of the PICs. We believe this finding is most likely related to the infant's maturing immune system, increasing size of the infant, increase in enteral feedings over this time periods, decreasing exposure to broad spectrum antibiotics, and removal of other invasive therapies. If there is an incremental increase in infection risk for leaving PICs in place for longer periods of time, this risk is outweighed by these other factors intrinsic to the clinical course of the infant.

Birth weight and gestational age were strongly associated with risk of infection. In our study, infants with birth weights < 1000 g and infants with GA < 29 weeks had the highest risk of infection. These findings are reflected in the National Nosocomial Infections Surveillance System Report which found higher infection rates in infants <1000 g birth weight (9.1 infections/1000 catheter days) versus infants >2,500 g (3.5 infections/1000 catheter days).(1)

The site of insertion of the PIC can potentially influence the risk of catheter infection. However, no particular anatomic site is recommended for PIC placement in pediatric patients to reduce infection risk.(6) In our study, none of the 24 PICs placed in the scalp became infected, and only 20/326 (6.1%) of the catheters placed in the hand became infected. PIC placement in the infant's arm was associated with the highest risk of infection, 64/574 (12.0%).

Mortality was not significantly different between infants with and without catheter infections, 42/766 (5.5%) vs. 7/99 (7.1%) $P=0.49$, respectively. Prompt removal of central venous catheters in infants who develop infections has been shown to improve outcomes in several previous studies.(12-15) In the group of infants with catheter infections, the mean time to catheter removal after positive culture for the surviving infants was 11.0 days compared to 17.4 days for the infants that died. In large observational studies mortality of premature infants with candidemia exceeds 30%.(4,15) Interestingly, none of the 8 infants with candidemia in our cohort died. The mean time to catheter removal after obtaining a blood culture positive for *Candida* in our cohort was only 2.9 days.

Strengths of this report include the size of the cohort, complete record keeping of PICs placed over this time period, and ability to examine the timing of blood culture results with PIC placement. This study was retrospective, and we made no attempt to account for an increase in CABSIs in infants with more than one PIC in place or other measures of severity of illness. Some of the CABSIs noted during the first few days of catheter placement may have not been catheter related and were simply infections that went undetected until the catheter was placed. We made an effort to avoid including these infections by not including positive cultures results during the first week after catheter placement that corresponded with cultures obtained in the week prior to PIC placement. However, we acknowledge that not all positive cultures defined as CABSIs were catheter related. In addition not all positive blood cultures of CoNS represented true infections. However, the majority of CoNS positive blood cultures are

treated as true infections with at least 7 days of antibiotics at our institution. We noted little difference in the time to positive blood culture between CoNS and other organisms (e.g. *Staphylococcus aureus* and *Candida* spp.).

We found a decreased risk of CABSIs with increasing duration of PIC dwell time in this large cohort of infants. This may have resulted from the increasing maturation of the infant's immune system and decreased reliance on other invasive therapies over the duration of the infants stay in the intensive care nursery. Decreased risk of CABSIs was associated with placement of a peripheral catheter versus a central catheter, older age at catheter placement, and increasing gestational age at birth. It is important to focus on these modifiable risk factors for PIC infection to reduce the risk of CABSIs.

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Table 1**Infants Demographics**

	Total (%)	Infected (%)
Infants	882	99 (11.2%)
Sex		
Male	524 (59.4)	52 (52.5)
Female	359 (40.6)	47 (47.5)
Birth weight		
<501	14 (1.6)	6 (6.1)
501-750	106 (12.0)	41 (41.1)
751-1000	150 (17.0)	32 (32.3)
1001-1500	204 (23.2)	13 (13.1)
1501-2000	106 (12.0)	1 (1.0)
2001-3000	159 (18.1)	5 (5.1)
>3000	142 (16.1)	1 (1.0)
Gestational age		
<25	65 (7.5)	28 (28.3)
25-29	319 (36.9)	61 (61.6)
30-36	306 (35.4)	8 (8.1)
>37	175 (20.2)	2 (2.0)
Outcome		
Died	48 (5.5)	7 (7.1)
Lived	818 (94.6)	92 (92.9)
Total # of catheters	1540	135
Type		
Central	1034 (70.1)	100 (78.1)
Midline	185 (12.5)	16 (12.5)
Peripheral	257 (17.4)	12 (9.4)
Anatomic location		
Head	24 (1.6)	0 (0.0)
Hand	326 (21.2)	20 (14.8)
Arm	574 (37.4)	69 (51.1)
Foot	488 (31.8)	37 (27.4)
Leg	46 (3.0)	5 (3.7)
Unknown	77 (5.0)	4 (3.0)

Table 2

Organisms isolated

		time to infection,
Organism	N (%)	median(days)
Gram-positive	108 (80.0)	8
CoNS	64 (47.4)	8
<i>Staphylococcus aureus</i>	39 (28.9)	7
<i>Enterococcus sp.</i>	5 (3.7)	14
<i>Candida sp.</i>	11 (8.1)	7
<i>C. albicans</i>	8 (5.9)	5.5
<i>C. parapsilosis</i>	2 (1.5)	7
<i>C. lusitaniae</i>	1 (0.7)	13
Gram-negative	16 (11.9)	13.5
<i>Klebsiella</i>	8 (5.9)	17.5
<i>Escherichia coli</i>	6 (4.4)	1.5
<i>Enterobacter</i>	1 (0.7)	30
<i>Pseudomonas</i>	1 (0.7)	8
	135 (100.0)	9

Table 3

Infection rates (/1000 catheter days)

	# of infections	# of catheter days	Infection rate
Week			
1	59	7014	8.4
2	36	4025	9.6
3	19	2376	9.2
4	11	1335	10.1
5	7	679	13.6
>5	3	845	4.5
Gestational Age			
<25 weeks	43	2384	18.0
25-29 weeks	81	8766	9.2
>29 weeks	11	3732	2.9
Birth weight			
<750 grams	59	3949	14.9
750-999 grams	55	4709	11.7
1000-1499 grams	14	3534	4.0
>1500 grams	7	2881	2.4