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Original Research Article

Open versus closed peripheral intravenous catheters in neonates: a prospective comparative study

Kavitha Gopalan, Kamalarathnam C. N.*, Ramya S.

Department of Neonatology, Institute of Child Health & Hospital for Children, Madras Medical College, Chennai, Tamil Nadu, India

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***Correspondence:**
Dr. Kamalarathnam C. N.,
E-mail: kavitha1989@gmail.com

ABSTRACT

Background: Open peripheral intravenous (IV) catheters have been routinely used in neonates. Closed catheters have resulted in a longer indwelling time and reduction in catheter related complications such as phlebitis in adults. However, there is paucity of data in neonates.
Methods: We conducted this pilot study in a pre-post study design. Open catheters were used in the first phase and closed catheters in the second phase. Hundred babies requiring intravenous fluid therapy for at least 24 hours in this neonatal intensive care unit were included in each group. Indwelling time and the complications leading to removal of the catheter were compared between the two groups.
Results: Both groups were comparable in terms of gestational age, day of life, site of cannulation, nature of intravenous fluid and drugs administered. In the open catheter group, there was significant increase in use of inotropes (38% vs 22%; p=0.014) and blood products (16% vs 5%; p=0.011). The mean indwelling time (hours) was significantly greater in closed catheter group compared to open catheter group (47.1±19.4 vs 38.04±17.9; p <0.008). Inotrope use was found to decrease the indwelling time. There was an increase in indwelling time by 8.2 (SE 2.67) hours even after adjusting for use of inotropes. The incidence of catheter related complications was similar in both groups.
Conclusions: There is a marginal but statistically significant increase in indwelling time when closed peripheral IV catheters are used in neonates. However, our results would be more meaningful if replicated in a larger randomized controlled trial.

Keywords: Closed intravenous catheter, Indwelling time, Neonates, Open intravenous catheter, Phlebitis

INTRODUCTION

Sick neonates admitted to the neonatal intensive care unit usually need an intravenous access for providing nutrition, medication and blood products. Placement of a peripheral intravenous catheter is one of the most common procedures in the intensive care unit.[1] Intravenous cannulation is challenging because of the extremely small and fragile veins.[2] Being a painful and invasive procedure, it is desirable to minimize the attempts to secure an intravenous catheter, increase the indwelling time and decrease the complications secondary to the procedure.

Peripheral intravenous catheter systems traditionally used are open systems in which a small catheter tubing with open port is used as the connecting point to an intravenous administration set. Closed catheters have a

safety intravenous catheter, extension tubing with Y connection and a needleless access system. Upon withdrawal of the needle, the tip is automatically shielded, protecting the health worker from injuries and blood contact. They have led to greater indwelling time and reduction in complications in adults.[3,4] We aimed to compare the two types of catheters in neonates as there is paucity of data.

METHODS

This study was conducted in a pre-post study design at Department of Neonatology, Institute of Child Health and Hospital for Children, Madras Medical College, Chennai between January 2019 and April 2019. The study was approved by the Institutional Ethics Committee. Informed written consent was obtained from one of the parents of the enrolled neonates. Open catheters were routinely used in the unit, whereas closed catheters were a recent introduction. However, all the nurses in the unit were trained in the insertion and fixation of both the types of catheters prior to the initiation of the study. Open catheters (24-gauge, Biomed Healthcare Products Pvt Ltd) were used in the first phase of the study and closed catheters (24-gauge, Becton Dickinson Infusion Therapy systems) in the second phase. We enrolled 100 babies in each group. These babies were included at admission to our out born unit if they needed intravenous fluid therapy for at least 24 hours. We excluded babies who had multiple attempts for placement of intravenous catheters before referral to our institute.

Standard aseptic precautions were followed for inserting and securing peripheral intravenous catheters. Site selection was done avoiding areas of inflammation or infection. There was no difference in the method of fixation of the catheters. Splints were not used for securing the catheters. Intravenous fluid therapy and drugs were administered through infusion pumps in the unit. The resident on duty monitored the insertion site every two hours for signs of removal. The catheters were removed either after completion of therapy or secondary to complications such as extravasation, phlebitis, occlusion or leak. Indwelling time was defined as the time interval between insertion and removal of the catheter. Failure of insertion was defined as inability to secure the catheter after 3 attempts. Likert 5-point scale was used to record the ease of insertion and fixation.[5] Maddox R phlebitis grading scale was used for phlebitis and catheter was removed if grade >2.[6]

Table 1: Baseline characteristics of neonates enrolled in the two groups.

Characteristic	Open catheter (n=100)	Closed catheter (n=100)	P value[¶]
Gestational age (weeks) [€]	35 (37,38)	38 (35,39)	0.13
Day of life[€]	8 (3, 14.5)	5 (1, 19)	0.59
Birth weight (grams)[§]	2401 (666)	2951 (710)	0.052
Admission weight (grams) [§]	2295 (649)	2519 (725)	0.02*
Site of cannulation*			
Hand	47	57	0.37
Wrist	11	10	
Forearm	21	19	
Elbow	2	2	
Foot	12	11	
Ankle	5	0	
Leg	2	1	
Type of IV fluid			
Dextrose containing fluid	95	97	0.14
PGE1 infusion	5	3	
Calcium gluconate	86	79	0.19
Amino acid	16	13	0.55
Lipid	1	5	0.09
Antibiotics	88	81	0.528
Anticonvulsants	19	15	0.45
Inotropes	38	22	0.014*
Blood products	16	5	0.011*
3-way stopcock	4	1	0.001*
Triple lumen extension tube	48	26	
Presence of central line	14	6	0.098

Data expressed as n (%) or median (inter-quartile range)
[§]Mean (SD) Independent T-test; [¶]Chi-square test; [€]Median (IQR) Mann Whitney U test

Table 2: Outcome measures.

Characteristic	Open catheter (n=100)	Closed catheter (n=100)	P value¶
Number of attempts to insert			
1	79	97	<0.001*
2	14	3	
3	7	0	
Number of catheters used			
1	80	97	0.001*
2	14	3	
3	6	0	
Reason for unsuccessful procedure			
None	81	96	0.017*
Vasculature anatomy	3	0	
Absence of blood reflux	6	1	
Difficulty advancing catheter	8	3	
Kinking	2	0	
Difficulty of cannula insertion			
Very easy	6	1	0.069
Easy	63	75	
Moderate	29	24	
Difficult	2	0	
Very difficult	0	0	
Difficulty of cannula fixation			
Very easy	5	1	0.02*
Easy	86	97	
Moderate	9	2	
Difficult	0	0	
Very difficult	0	0	
Reason for removal			
Complication	93	92	0.79
End of treatment	7	8	
Complication			
No complication	7	8	0.92
Phlebitis	30	28	
Extravasation	41	46	
Occlusion	9	8	
Leak	13	10	
Grade of phlebitis			
0	55	66	0.33
1	2	1	
2	42	33	
3	1	0	

Statistical analysis was done using Statistical Package for Social Sciences Version 23.0 (SPSS Inc, Chicago, IL). Baseline variables were compared using Chi square test and independent 't' test for categorical and numerical variables respectively. Mann Whitney U test was used for non- normal distribution. ANOVA and Chi Square test were used to test effect of various factors on indwelling time. A p value of <0.05 was considered significant.

RESULTS

During the study period, 771 neonates were admitted to the unit and 200 babies who required intravenous therapy greater than 24 hours were included. Both groups were comparable in terms of gestational age, day of life, site of cannulation, nature of intravenous fluid, drugs administered such as antibiotics and anticonvulsant medication. Majority of the catheters (47% open catheters

and 57% closed catheters) were inserted on the dorsum of the hand. In the open catheter group, there was significant increase in use of inotropes (38% vs 22%; p=0.014) and blood products (16% vs 5%; p=0.011). There was also greater use of triple lumen extension tube as the connection device in the open catheter group (Table 1).

Table 3: Effects of various factors on indwelling time.

Parameter		N	Indwelling time (hrs)		P-value
			Mean	Std. Dev.	
Gestational age (weeks)	≤31	12	40.00	21.10	0.758
	32-34	30	45.80	23.64	
	35-37	54	42.63	17.70	
	>37	104	41.90	18.54	
Days of life€	<7Days	99	41.35	18.40	0.376
	≥7Days	101	43.76	20.02	
Site of cannulation	Hand	104	42.40	19.99	0.008*
	Wrist	21	46.57	19.85	
	Forearm	40	49.40	18.40	
	Elbow	4	22.50	6.40	
	Foot	23	34.87	14.45	
	Ankle	5	28.40	8.65	
	Leg	3	38.67	4.62	
Type of IV fluid	PGE1+NS	8	39.50	18.42	0.221
	10% Dextrose	75	40.85	19.41	
	5% Dextrose10% Dextrose	34	44.06	17.83	
	10%+25% Dextrose	19	48.00	19.39	
	5% Dextrose	47	45.62	21.10	
	5%+25% Dextrose	17	34.12	13.63	
IV calcium€	Yes	165	42.21	18.46	0.562
	No	35	44.29	22.69	
Aminoacid€	Yes	29	40.28	15.82	0.488
	No	171	42.96	19.76	
Lipid€	Yes	6	32.00	17.16	0.172
	No	194	42.90	19.23	
Antibiotics	None	31	45.03	20.87	0.685
	Ciprofloxacin+amikacin	74	42.00	19.65	
	Piperacillin tazobactam+amikacin	26	46.38	21.76	
	Meropenem+vancomycin	32	40.75	19.46	
	Others	37	40.54	14.78	
Inotropes€	Yes	60	37.77	17.47	0.02*
	No	140	44.63	19.63	
Blood product transfusion€					
Yes		21	40.95	18.18	0.684
No		179	42.76	19.38	
Anticonvulsant€					
Yes		166	42.48	19.40	0.886
No		34	43.00	18.40	
Use of 3 way/triple lumen extension tube					
None		121	43.77	19.82	0.399
3-way stopcock		5	34.00	7.87	
Triple lumen extension tube		74	41.19	18.68	

Table 4: Previous studies on indwelling time of peripheral IV catheters in neonates.

S. No	Author and year	Type of iv cannula	Number of catheters	Median indwelling time	Factors affecting indwelling time
1.	Gupta P et al[1]	24 G Teflon	186	40 hrs (SE 2.49, 95% CI 35.12-44.88)	Cefotaxime had a significantly lower median survival time (36 vs 47 hours, p=0.007)
2.	Phelps et al[7]	Steel Vs Teflon, various gauges	151 (Patients <1 year of age)	40 hours (10 to 187 hours)	• Steel Vs Teflon cannulas (P=0.02) • IV medication Vs no medication (P=0.03) • Peripheral parenteral nutrition solutions Vs 5% or 10% dextrose solutions (P=0.014) • Increasing cannula gauge (P=0.05)
3.	Johnson et al[4]	24 G Teflon	199	33 hours	Pancuronium increased median time from 30 to 50 hours

The mean indwelling time in hours was significantly greater in closed catheter group compared to open catheter group (47.1 (SD 19.4) vs 38.04 (SD 17.9); p <0.008) (Table 2). Inotrope use was found to significantly shorten the indwelling time in both types of catheters (37 Vs 44 hours; p=0.02). However, there was an increase in indwelling time by 8.2 (SE 2.67) hours even after adjusting for use of inotropes (Table 3).

The first attempt success rate was significantly higher in the closed catheter group. There was no instance where more than three attempts were needed to secure a catheter. Nurses reported that the fixation of the closed catheters was easier than open catheters. There was no needle stick injury during the study period. Majority of the catheters were removed secondary to complications, commonest being extravasation. There was no difference in the incidence of catheter related complications such as grade of phlebitis, extravasation, occlusion or leak in the two groups.

DISCUSSION

In this study, we found that closed catheters had a longer indwelling time and higher first attempt success rate as compared to open catheters in neonates. The lifespan of open IV catheters in this study is comparable to the previous studies in neonates, both within the country and abroad. However, it is much lesser than that observed in adults, making a difference of a few hours more significant in neonates. Superiority in terms of higher first attempt success rate is significant as each attempt to secure a catheter breaches the skin, predisposing the neonate to infection. The increase in indwelling time could be related to the material of the catheter, Teflon used in open catheters vs Vialon in closed catheters. It has been previously seen that Teflon catheters were superior to steel catheters.

Among the various factors affecting the indwelling time, inotropes had a significant impact on the lifespan of the catheters. This could be related to the irritant nature of the fluid administered. Several other drugs have been found to have an impact on the indwelling time of catheters. Cefotaxime was found to lower the lifespan whereas Pancuronium increased the indwelling time (Table 4).[1,7]

The nature of complications was similar in both the groups of catheters, extravasation being the most common. This finding is similar to previous work on the use of splints in neonates in which splints were not found to be useful in prolonging the indwelling time of catheters.[8]

To the best of our knowledge, this is the first study comparing closed and open peripheral intravenous catheters in neonates. However, being a pilot observational study with a small sample size, our results would be more meaningful if replicated in a larger randomized controlled trial.

CONCLUSION

There is a marginal but statistically significant increase in indwelling time when closed peripheral IV catheters are used in neonates. However, our results would be more meaningful if replicated in a larger randomized controlled trial.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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