Peripherally Inserted Central Catheters: Evaluation of Diluted Lipid Emulsion as Lubricant for Improved Guidewire Removal in a Neonatal Population.

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Abstract

Background: Medical management of neonates is often predicated upon safe and reliable vascular access which may be related to physiological monitoring, medical treatment, supportive therapy and diagnostic or procedural purposes. For this, peripherally inserted central catheters (PICCs) are deemed safe to provide vascular access and infusion related therapy in the neonatal intensive care setting.

Purpose: PICCs are associated with a reduced incidence of complications compared to short peripheral catheters. Despite a reduced complication rate, the impact for the patient has to be considered severe. Difficult PICC guidewire removal during the insertion procedure is known to cause catheter damage, resulting in leakage or breakage of the catheter itself. The aim of this study was to assess and compare the incidence of therapy failure related to the use of preflush fluids (normal saline (NSS) versus diluted lipid solution(DLS)) used before PICC guidewire removal.

Method and Setting: This was a retrospective observational study and performed on the Neonatal Intensive Care Unit (NICU) of the Women's Wellness and Research Centre, Hamad Medical Corporation, Qatar. The single site study included 507 neonates who required intravenous therapy.

Results: The results show that the use of a diluted lipid preflush resulted in significantly less therapy failures, compared with the control group. This remains significant after adjusting for day of insertion, gestational age, birth weight and catheter type.

Conclusion: DLS preflush demonstrated a benefit over the use of a NSS preflush to enhance PICC guidewire removal in patients admitted to the NICU. The risk for the development of maintenance-related complications leading to premature removal of the device, decreased significantly if the preflush DLS was used. During the study period no known complications related to the used lipid solution were identified.

Implications for Practice and Research: This study is the first of its kind ever published in international literature and supports the enhancement of guidewire removal by using a diluted lipid preflush. When the requirement for vascular access is most pertinent, using a diluted lipid preflush is a safe and effective method to remove the guidewire in order to facilitate long-term vascular access amongst the neonatal population.

Background

Medical management of neonates is often predicated upon safe and reliable vascular access. The need for vascular access may be related to physiological monitoring (arterial or central venous pressure), medical treatment (antibiotics, analgesia, inotropes), supportive therapy (nutrition, blood transfusion, ECMO) and diagnostic or procedural purposes (contrast MRI/CT, cardiac catheterization). [1–2] Vascular access devices (VADs) such as peripherally inserted central catheters (PICCs) play a vital role.

Due to their unique developmental characteristics, preterm infants are more susceptible than most to iatrogenic harm arising from vascular cannulation and its related complications. It is widely accepted that healthcare staff should take measures to prevent, detect, promptly treat, and mitigate these risks. Internationally, most neonatal units have implemented bundles of measures to reduce and manage risks associated with vascular access. One key element of these 'care bundles' is directed towards prevention of (potential) complications, e.g. arising from larger catheters placed in small veins, pain resulting from frequent replacement of peripheral cannulas, ability to apply parental nutrition solutions or drugs that damage peripheral veins. [3]

In the neonatal intensive care setting PICCs have an estimated complication rate of 0.05–3%. [4] In general these PICCs are associated with a reduced incidence of complications compared to short peripheral catheters [5]. Despite these advantages, PICCs are still associated with complications like occlusion, infection, thrombosis, tip malposition but also catheter damage, [4–5], resulting in interrupted treatment, failed access and greater resource consumption with catheter replacement. [6–7]

Catheter damage, causing leaking and breakage of the catheter itself might be related to difficult guidewire removal during the insertion procedure, especially of the very small PICCs. [8] The inability to remove the guidewire might require removing the device and reinserting a new PICC. The etiology of this phenomena can be explained by a guidewire with approximately the same diameter as the actual inner diameter of the PICC, resulting in the wire sticking to the catheter wall. On occasions despite regimens of generous pre-flushing using a normal saline solution (NSS) prior to insertion, removing the internal PICC guidewire can be challenging. Increased resistance on removal of the guidewire after the tip position was confirmed by x-ray or ultrasound, might not only influence tip location (tip will be pulled out) but also potentially cause catheter leakage or breakage (shear and tier forces). [9] Several interventions are described to decrease guidewire resistance during removal. [8] Reduction of any tension before attempting to remove the guidewire can be achieved by straightening and untwisting the parts of the PICC still outside the body. [8] In our setting it was reported that PICC guidewire removal related complications occurred in 2.4% of all PICC insertions (11 out of 450 PICC). Despite the low numbers the potentially avoidable impact for the patient has to be considered severe. Recent evidence from large scale studies in neonatal populations regarding guidewire removal is lacking and largely absent.

One novel approach to overcome difficult guidewire removal is to use a diluted lipid solution (DLS) as a lubricant (Vygon, personal correspondence). [10] Although this has been used successfully in practice with particularly intractable removals, there are potential safety concerns such as lipid emboli and infection. [11–12] Further empirical study is required to quantify these risks and until this evidence is available this approach should be restricted to use in research. [8]

The current study aims to highlight patient- (gestation, weight) - and VAD characteristics (type, diameter and length) and assess outcomes (guidewire removal, therapy failure) between conventional normal saline solution (NSS) and diluted lipid solution (DLS) as a lubricant to enhance guidewire removal in a neonatal population.

Methods

Ethical Approval

The study design and procedures (MRC-01-20-890) were approved by the local Institution Review Board (IRB). As the data source was anonymized, the local IRB committee determined the study an 'observational chart review' and that participant consent was not required.

Design and setting

In this retrospective study, cross-sectional, routinely collected anonymized intravenous device data is used from January 2019 to July 2020. The main outcome of interest was the occurrence of therapy failure (e.g., leaking, breakage) in relation to PICC guidewire removal leading to any unplanned removal of the VAD prior to completion of therapy. The study was performed in the NICU (112 beds) of the Women's Wellness and Research Centre (WWRC) of Hamad Medical Corporation (HMC), Doha, Qatar.

Patient and public involvement statement

Study participants, nor parents were not involved in the design, conduct or reporting of this study. Retrospective data were retrieved from the data management system of the facility.

Participants and sample size

Infants who were admitted to the NICU and who needed intravenous therapy through a 1Fr./28G or 2Fr./24G PICC were included in this study. Participants were excluded from the sample if the data collection was incomplete or whenever the data was related to the use of other devices e.g., peripheral IV catheters, umbilical venous catheters (UVC) or surgically inserted central venous catheters (CVC) exceeding 2Fr./24G.

Procedure

In the patient assessment stage, the team follows a locally developed mnemonic, the "5Rs for Vascular Access" i.e., the Right device, for the Right vein, with the Right therapy, for the Right duration, for the Right patient, as described in a similar concept by Steere et al. [13] Venous cannulation is strictly performed under guidance of the local hospital policy based on international evidence-based guidelines. [14-15] In the study setting, a PICC insertion is routinely performed by doctors and nurses from the neonatal vascular access team (neoVAT). The selection of suitable veins is done using Infra-Red technology for vein visualization (VeinViewer ChristiesTM). In our practice, the choice for a central vascular access device is based on the 5Rs for Vascular Access, with the required duration of the IV therapy, fluid characteristics

(ph. and osmolarity) and patient characteristics (body weight and/or a known history of difficult vascular access). The 5Rs for Vascular Access-concept represented in figure 1 are based upon international standards [14-15] and local contexts such as: product compatibility, hospital purchasing decisions and practitioner consensus.

All preflushes were prepared at the bedside, under strict sterile circumstances. For the DLS 1 ml lipid 20% was diluted with 9 ml normal saline, the NSS was provided as prefilled 10 ml syringe flushes. Preflushes of NSS and DLS were provided alternated for the daily PICC insertions. Note: all PICCs were checked and flushed outside the patient and before the actual insertion procedure, this to avoid excessive infusion. Once the PICC was successfully inserted the guidewire was removed without further flushing with either NSS or DLS. Total filling volumes of the PICC are extremely small and would vary between a maximum of 0.09-0.12ml depending on type and length. During guidewire removal part of the DLS is removed due to cohesion from fluid and guidewire.

Measurements and data collection

Patients demographics and baseline data included sex, gestational age at birth in weeks and days, birth weight, and current body weight in grams. Data regarding the procedure of intravenous cannulation were the date and time of cannulation, as well as the number of attempts needed to successful cannulation, cannulated extremity (upper or lower), used type and size of vascular access device (1Fr., 2Fr.), the indication for intravenous treatment (duration, fluid characteristics, difficult vascular access), used preflush (NSS or DLS), resistance during guidewire removal (yes or no), date and time of PICC removal, total PICC dwell time in days, and the reason for PICC removal (elective, catheter breakage/leakage of material, infiltration/extravasation, maintenance related, phlebitis, suspected sepsis, and administrative censoring (patient transferred or expired)).

STATISTICAL ANALYSES

A total of 507 cases were collected from a retrospective data from January 2019 to July 2020. Descriptive statistics were used to summarize and determine the sample characteristics and distribution of participants' data. The normally distributed data and results were reported with mean and standard deviation (SD); the remaining results reported with median and inter-quartile range (IQR). Categorical data were summarized using frequencies and proportions. Associations between two or more qualitative data variables were assessed using Chi-square (χ^2) test or Fisher Exact test as appropriate. Quantitative data between the two independent groups were analyzed using unpaired t or Mann Whitney U test as appropriate. Univariate and multivariate logistic regression analysis (controlling and adjusted for potential predictors and confounders such as type of preflush, gender, resistance of the guidewire, days at insertion, birthweight, gestation at birth, number of attempts, extremity of cannulation, catheter characteristics, indication for intravenous therapy, indwell time) were applied to determine and assess the associations and predictive values of predictors and confounders stated above with binary outcome

variable risk for failure of intravenous access devices. For multivariate logistic regression models, predictor variables were considered if statistical $P < 0.10$ level in univariate analysis or if determined a priori to be clinically important. The results of logistic regression analyses were presented as odds ratio (OR) with corresponding 95% CI. Receiver operating characteristic curve (ROC) was computed and constructed to evaluate and assess predictive accuracy and discriminative ability of the developed logistic regression model (based on the predicted probabilities) using potential significant variables found in the multivariate logistic regression model. All P values presented were two-tailed, and P values < 0.05 was considered as statistically significant. All Statistical analyses were done using statistical packages SPSS version 27.0 (Armonk, NY: IBM Corp) and Epi-info (Centers for Disease Control and Prevention, Atlanta, GA) software.

Results

Demographics represented as gender, days or age at PICC insertion, gestational age and birthweight as well as the extremity chosen (upper or lower) for insertion are represented in table 1. The data showed 60.2% out of the total 507 samples received the DLS while 39.8% received the NSS preflush. The majority of insertions were in the lower body extremities in both type of preflush solutions. The day of life on which the PICC was inserted show an average of 7.61 days (± 17.0) with median 3 days (inter-quartile range 2 to 5) and there was no significant difference observed between both preflush groups. More detailed data regarding the type of flush showed a lower percentage in the NSS group for neonates 32-36wks gestation (NSS 16.3% vs DLS 19.3%) and in the birthweight category of 1500-2499 grams (NSS 19.8% vs DLS 24.6%). However, this showed a reversed percentage for neonates with a birthweight > 2500 gram (NSS 14.9% vs DLS 6.2%) and a gestational age of ≥ 37 wks (NSS 12.4% vs DLS 6.6%).

Table 1

Demographic Patient Factors.

Type of Flush							
	Total (<i>n</i> =507)		Normal Saline (<i>n</i> =202)		Lipid (<i>n</i> =305)		<i>P</i> -value
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Gender							0.008*
Male	277	54.6%	125	61.9%	152	49.8%	
Female	230	45.4%	77	38.1%	153	50.2%	
Days of life at insertion	7.61 ± 17.0		7.34 ± 19.0		7.78 ± 15.6		0.770
Mean±SD (median, IQR)	(3, IQR 2, 5)		(3, IQR 2, 5)		(2, IQR 2, 5)		
1-50 days	490	96.9%	197	97.5%	293	96.1%	
51-100 days	13	2.6%	3	1.5%	10	3.3%	
101-150 days	3	0.6%	1	0.5%	2	0.7%	
≥151 days	1	0.2%	1	0.5%	0	0.0%	
GA at birth (days), Mean, SD	212.0 ± 28.2		213.64 ± 30.0		210.97 ± 26.8		0.026*
23-27wks	148	29.2%	59	29.2%	89	29.2%	
28-31wks	222	43.8%	85	42.1%	137	44.9%	
32-36wks	92	18.1%	33	16.3%	59	19.3%	
≥37wks	45	8.9%	25	12.4%	20	6.6%	
Birth Weight (gm) Mean, (SD)	1421.7 ± 688.1		1494.5 ± 762.1		1373.4 ± 631.1		0.052
≤999g	133	26.2%	49	24.3%	84	27.5%	
1000-1499g	210	41.4%	83	41.1%	127	41.6%	
1500-2499g	115	22.7%	40	19.8%	75	24.6%	
≥2500g	49	9.7%	30	14.9%	19	6.2%	

Limb Extremity	87	17.2%	41	20.3%	46	15.1%	0.130
Upper	420	82.8%	161	79.7%	259	84.9%	
Lower							
IQR: inter-quartile range							

A majority of all PICC (83.2%) were inserted based on the required duration for extended total parenteral nutrition (TPN). The results of these insertion and catheter details are reflected in Table 2. The 1Fr./24G PICC were the most used type of catheter in the study population, accounted for 91.8% of all insertions. A first prick overall success rate was observed in 71.2%, these first prick attempts in PICC insertion were more common in the lipid solution group (73.4% vs 67.8%).

Table 2
Insertion and Catheter Details.

Type of Flush							
	Total (n=507)		Normal Saline (n=202)		Lipid (n=305)		<i>P</i> -value
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Reason for Insertion							0.16
Duration of Antimicrobial Therapy	17	3.4%	5	2.5%	12	3.9%	
Duration of TPN Therapy	422	83.2%	165	81.7%	257	84.3%	
Fluid characteristics	23	4.5%	14	6.9%	9	3.0%	
Difficult Vascular Access	45	8.9%	18	8.9%	27	8.9%	
Catheter Type							0.139
2. Fr. PICC 15 cm	13	2.6%	6	3.0%	7	2.3%	
2 Fr. PICC 30 cm	29	5.7%	17	8.4%	12	3.9%	
1 Fr. PICC 15 cm	12	2.4%	7	3.5%	5	1.6%	
1 Fr. PICC 20 cm	296	58.4%	111	55.0%	185	60.7%	
1 Fr. PICC 30 cm	157	31.0%	61	30.2%	96	31.5%	
Number of attempts							0.374
1	361	71.2%	137	67.8%	224	73.4%	
2	94	18.5%	39	19.4%	55	18.0%	
3	47	9.3%	23	11.4%	24	7.9%	
4	5	1.0%	3	1.5%	2	0.7%	
Guidewire resistance during removal							<0.001*
Neutral	59	11.6%	26	12.8%	33	10.85	
Negative	358	70.5%	87	43.1%	271	88.9%	
Positive	90	17.7%	89	44.1%	1	0.3%	

For this study therapy failure related to the chosen type of preflush was observed. Table 3 shows a majority (88.5%) of PICC were electively removed after the therapy was completed. More successful or elective removals were within the DLS group (90.8% vs 85.0%). All non-elective removals of PICCs occurred because of complications. Moreover, failure of therapy was more common in NSS group (15%) than when using the DLS flush (9.2%). The reasons of therapy failure like breaking or leaking of the PICC, catheter-related complications, extravasation or infiltration, and suspected sepsis were commonly reported in NSS group (12.2% vs 5.2%), whereas complications due to maintenance and phlebitis were more frequently observed in the DLS group (4.0 vs 2.8%). When neonates were transferred to another hospital or unfortunately expired (54 neonates total/10.7%), the team considered such cases as lost to follow up (administrative censoring).

Table 3

Data Representing the Different Factors of VAD Removal.

	Type of Flush						
	Total (<i>n</i> =507)		Normal Saline (<i>n</i> =202)		Lipid (<i>n</i> =305)		<i>P</i> value
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Reason for Removal							0.260
Administrative censoring*	54	10.7%	21	10.4%	33	10.8%	
Elective removal	401	88.5%	154	85.0%	247	90.8%	
Therapy failure**	52	11.5%	27	15.0%	25	9.2%	
Breakage/leakage of material	5	1.1%	4	2.2%	1	0.4%	
Catheter related complications	14	3.1%	9	5.0%	5	1.8%	
Extravasation/Infiltration	2	0.4%	1	0.6%	1	0.4%	
Maintenance related complications	13	2.9%	4	2.2%	9	3.3%	
Phlebitis	3	0.7%	1	0.6%	2	0.7%	
Suspected sepsis	15	3.3%	8	4.4%	7	2.6%	
Dwell Time (days) Mean, (SD)	12.97 ± 8.1		12.53± 8.2		13.26 ± 8.0		0.320
*Death or Transferred / ** for therapy failure administrative censoring is excluded.							
VAD: Vascular access device							

Based on the results in Table 4, birthweight in grams, gestation in weeks, number of attempts and catheter dwell time have significant effect on the likelihood of failure of therapy. Results indicate that increasing birthweight ≥ 2500 gms and gestation at birth ≥ 37 weeks were associated with an increased likelihood of failure of therapy. However, birthweight 1,500-2499gm (unadjusted OR 0.33; 95 CI 0.12, 0.93, $p= 0.036$) and 32-36 weeks of gestation (unadjusted OR 0.27, 95 CI 0.09-0.76), $p= 0.014$) were found to be significantly associated with reduced risk of failure of therapy. Increasing time of the PICC in situ were observed to be significantly associated with a reduction in the likelihood of failure of therapy. Results show that a fourth attempt to successful cannulation compared to the first attempt to successful cannulation has a significant effect on the increased risk of likelihood of failure of therapy (unadjusted OR 9.48; 95% CI 1.29-69.7, $p= 0.027$). Furthermore, fourth attempts of successful cannulation were around nine times more likely to have failure of therapy than first attempts of successful cannulation. The dwell time showed an inverse significant effect whereby the likelihood to failure was reduced when compared between 7 to 27 days. Specifically, >7 to 14 days (unadjusted OR 0.18; 95% CI 0.09-0.35, $p=$

<0.001), >14 to 21 days (unadjusted OR 0.18; 95% CI 0.07- 0.45, $p = <0.001$), and >21 to 27 days (unadjusted OR 0.11; 95% CI 0.01- 0.88, $p = 0.037$) were with significant effect to risk of failure of therapy.

Table 4

Binary Logistic Regression Analyses with Factors Affecting the Risk for Failure of Intravenous Access Devices.

Variable	Therapy failure, n (%)	Unadjusted Odds ratio (OR)	95% CI for OR	P-value
Gender				
Female	21 (10.2%)	1.0 (reference)		
Male	31(12.5%)	1.25	0.70, 2.25	0.454
Type pre-flush				
Lipid	25 (9.2%)	1.0 (reference)		
Normal saline	27 (14.9%)	1.73	0.97, 3.09	0.063
Guidewire resistance during removal				
Neutral	8 (16.7%)	1.0 (reference)		
No resistance	33(10.1%)	0.56	0.24, 1.30	0.178
Resistance	11 (14.1%)	0.82	0.31, 2.12	0.696
Birthweight (grams)				
≤999g	16 (13.6%)	1.0 (reference)		
1000-1499g	20 (10.4%)	0.74	0.37, 1.50	0.403
1500-2499g ≥2500g	5 (4.9%)	0.33	0.12, 0.93	0.036*
≥2500g	11 (26.8%)	2.34	0.98, 5.57	0.055
Gestation at birth (weeks)				
23-27 weeks	15 (14.4%)	1.0 (reference)		
28-31 weeks	21(11.1%)	0.74	0.36, 1.51	0.410
32-36 weeks	5 (4.3%)	0.27	0.09, 0.76	0.014*
≥37weeks	11 (25%)	1.98	0.83, 4.74	0.126
Number of attempts				
1	31 (9.5%)	1.0 (reference)		
2	14 (16.9%)	1.92	0.97, 3.81	0.060
3	5 (12.2%)	1.32	0.48, 3.60	0.591
4	2 (50.0%)	9.48	1.29, 69.7	0.027*
Side of cannulation				

Left	12 (11.1%)	1.0 (reference)		
Right	40 (11.6%)	1.05	0.53, 2.08	0.891
Extremity				
Lower extremity	39 (10.3%)	1.0 (reference)		
Upper extremity	13 (17.3%)	1.82	0.92, 3.61	0.085
Catheter characteristics				
2. Fr. PICC 15 cm	3 (27.3%)	1.0 (reference)		
2 Fr. PICC 30 cm	6 (21.4%)	0.73	0.15, 3.62	0.697
1 Fr. PICC 15 cm	1 (9.1%)	0.27	0.02, 3.08	0.290
1 Fr. PICC 20 cm	29 (10.9%)	0.33	0.08, 1.31	0.114
1 Fr. PICC 30 cm	13 (9.4%)	0.28	0.07, 1.18	0.082
Indication for intravenous therapy				
Duration of Antimicrobial Therapy	2 (15.4%)	1.0 (reference)		
Duration of TPN Therapy	38 (10%)	0.61	0.13, 2.87	0.534
Fluid characteristics	5 (25%)	1.83	0.30, 11.26	0.513
Difficult Vascular Access	7 (17.1%)	1.13	0.20, 6.28	0.887
Indwell time catheter				
<=7 days	23 (31.1%)	1.0 (reference)		
>7 to 14 days	18 (7.4%)	0.18	0.09, 0.35	<0.001**
>14 to 21 days	7 (7.5%)	0.18	0.07, 0.45	<0.001**
>21 to 27 days	1 (4.8%)	0.11	0.01, 0.88	0.037*
>27 days	3 (15.0%)	0.39	0.10, 1.47	0.164

CI: Confidence interval

** Significant at 0.05 level of significance **significant at 0.01 level of significance.*

The multivariate logistic regression analysis showed that both duration of gestation (weeks) indwell time catheter (days) were significantly associated with the risk of failure to therapy after controlling and adjusting potential confounders and predictors as shown in Table 5. The association between increasing duration of gestation in 32-36 weeks (adjusted OR 0.12; 95% CI 0.04- 0.38, $p < 0.001$) and the dwell time was associated with a reduction in the likelihood of failure of therapy when compared between ≤ 7 days to other categories. Specifically, >7 to 14 days (adjusted OR 0.14; 95% CI 0.06-0.30, $p < 0.001$), >14 to 21

days (adjusted OR 0.10; 95% CI 0.04- 0.29, $p = <0.001$), and >21 to 27 days (adjusted OR 0.06; 95% CI 0.01- 0.49, $p = 0.009$) and >27 days (adjusted OR 0.21; 95% CI 0.05- 0.89, $p = 0.034$) were with significant effect to risk of failure of therapy. The differences between the two types of preflush to the likelihood of failure of therapy is statistically significant at the 0.10 level of significance.

Therefore, we computed a prediction model to evaluate the discriminative ability of potentially significant predictors (observed in the developed multivariate logistic regression model) associated with risk of failure to therapy using ROC curve analysis. The value of area under the curve (AUC) observed was 0.757 (95% CI 0.68, 0.83), which is indicating that this developed regression model demonstrated an excellent fit, Figure 2.

Table 5

Multiple Logistic Regression Analyses with Factors Affecting the Risk for Failure of Intravenous Access Devices.

Factors	Therapy failure n (%)	Adjusted Odds ratio (OR)	95% CI for OR	P-value
Gestation at birth (weeks)				
23-27 weeks	15 (14.4%)	1.0 (reference)		
28-31 weeks	21(11.1%)	0.53	0.24, 1.16	0.114
32-36 weeks	5 (4.3%)	0.12	0.04, 0.38	<0.001**
≥37weeks	11 (25%)	0.61	0.21, 1.78	0.363
Indwell time catheter				
≤7 days	23 (31.1%)	1.0 (reference)		
>7 to 14 days	18 (7.4%)	0.14	0.06, 0.30	<0.001**
>14 to 21 days	7 (7.5%)	0.10	0.04, 0.29	<0.001**
>21 to 27 days	1 (4.8%)	0.06	0.01, 0.49	0.009*
>27 days	3 (15.0%)	0.21	0.05, 0.89	0.034*

CI: Confidence interval

* Significant at 0.05 level of significance **significant at 0.01 level of significance.

On the other hand, the test of association of central line associated bloodstream infections (CLABSI) and type of preflush cannot justify the findings that there are no significant effects because it fails to satisfy

the assumption of the chi-square test of independence. In this case, cross-tabulation shows that more than 50% of the cell have expected frequency less than 5.

Table 6

Association between CLABSI and Type of Pre-flush.

		Code Type Preflush		P-value
		Lipid	Saline	
CLABSI	Positive	3 (1%)	0 (0%)	0.434*
	Negative	302 (99%)	202 (100%)	

* *Chi-Square-Fisher Exact test*

Discussion

The external PICC diameter is either 0.7mm for the 1Fr PICC and 1.1mm for the 2Fr PICC. The total priming volume for the used PICC varies from 0.09 to 0.12ml, depending on the chosen type and size of the catheter (factsheet Vygon). This indicated the actual preflush volume is significant less as the guidewire requires a certain volume inside the small PICC. Moreover, part of the volume of the preflush will be removed due to cohesion of guidewire and lipids during guidewire removal.

There is an elevated risk of PICC infusion therapy failure within the clinical practice of the NICU, which negatively affects a neonate's treatment and outcome. [7] Failure of therapy, resulting in premature removal, occurred in 54 of 453 participants (11.47%) (transferred and death excluded), with a complication incidence rate of 7.91/1000 device days (total catheter days 6.576, total number therapy failure 52). The most frequently reported overall type of therapy failure for removal was a catheter related complication (e.g. tip malposition). The risk for catheter related complications was reduced in participants with DLS used as a preflush for PICC guidewire removal. In previous studies the normal and shear-and-tear forces between two opposing surfaces have been investigated. [16] Studies show lipids play a vital role at many interfaces. Low friction in general results in substantial reduction of shear-and-tear and hence reducing shear stress on the plastic of the PICC itself. Our study suggests that DLS reduces the coefficient of friction more effectively than NSS resulting in less shear-and-tear related complications. Understanding the origins of friction during the guidewire removal therefore, is of major importance in order to evaluate current practice and optimize future practice.

Neonates are an extremely vulnerable patient population. Vascular access devices provide the mainstay of all parenterally administered therapies for these often-high-risk patients. Reliability of PICC of inserting and maintaining infusion therapy is a paramount process in the continuum of infusion therapy. While there are currently only NSS flushes available to clinicians there remains a responsibility to explore better alternatives for guidewire removal in order to minimize complications.

Despite intravenous lipids provide a more ideal medium for microbial growth because of their relatively neutral pH (pH = 8), [17] the infection control department found no evidence for not safely introducing of DLS as a lubricant during the PICC guidewire removal. Additionally, this study aimed to determine the microbiologic safety of used DLS preflushes for PICC insertions in the NICU.

STRENGTH AND LIMITATIONS

To the authors knowledge, this is the first study of this kind to evaluate the effect of a catheter preflush to enhance PICC guidewire removal in the neonatal population worldwide. All eligible neonates were included, the sample size was large and representative of our neonatal PICC population. This increased the statistical power of the study's findings, helping to minimize selection bias and increase the generalizability of the findings to similar settings.

Despite these strengths, this research also has its limitations. This study was a single center, retrospectively collected dataset, and in contrast to randomized studies, this method creates risk for selection bias. For this study, every infant with a successfully inserted PICC was included to minimize the risk of selection bias. Data outcomes were not available for neonates transferred out of the facility (administrative censoring). Although this population was small, patients lost to follow-up may have a differing outcome than those who completed the study. Nonetheless, future randomized control trails should focus on the continuous introduction of novel and clinically beneficial strategies to improve infusion therapy outcomes.

Conclusion

The study demonstrated benefit from the use of DLS preflush to enhance PICC guidewire removal, impacting successful completion of infusion therapies in patients admitted to the NICU. These included reduced risk of breakage of catheter materials (e.g., damage caused by sheer and tear forces), catheter related complications (e.g., PICC tip malposition), and suspected sepsis. The risk for the development of maintenance-related complications leading to premature removal of the device, decreased significantly if the preflush DLS was used. The number of events for CLABSI rate were not significantly increased in the DLS group compared to the NSS group. When the use of PICC as a safe and reliable vascular access device is most pertinent, DLS as a preflush for guidewire removal offers a safe and effective alternative to facilitate long-term vascular access in the neonatal population.

Identifying vascular access related challenges for this vulnerable population consistently requires new innovations and other clinical advancements to play an important role towards improving patient and vascular access device-related outcomes. The use of the DLS for PICC guidewire removal in these extreme small sized catheters, is an important step for clinicians who place and care for vascular access devices in this patient population.

Extreme small amounts of the lipid solution were used during the study, even a smaller amount was actually administered in the circulation during PICC insertion. During the study period no known complications related to the used lipid emulsion were identified. Further research however should focus on potential lipid related toxicity and/or complications. Further areas of future interest are lipid interference with platelet function, which might contribute to pulmonary diffusion block, and even possibly generate fat emboli. Secondary cost effectiveness needs to be taken into account regarding the role and involvement of pharmacy and nursing in the process of distributing and administering the diluted lipid solution.

Declarations

Conflict of interest

The author, Matheus van Rens, was employed by Hamad Medical Corporation. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

MvR conceptualized and designed the study, coordinated, and supervised data collection, drafted the initial manuscript, and reviewed and revised the manuscript. RP was the primary investigator, drafted the initial manuscript and reviewed and revised the manuscript. MAM and UT critically reviewed the manuscript for important intellectual content. ALVF designed the data collection instruments, collected data, and reviewed and revised the manuscript. PC and KS carried out the statistical analyses and reviewed the manuscript. All authors approved the final manuscript as submitted.

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Consent to Publication

‘Not Applicable’.

Availability of data and materials

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Figures

Figure 1

Vascular Access Device Algorithm

Figure 2

Receiver operating characteristic curve (ROC) to evaluate and assess predictive accuracy of the developed logistic regression model (using the predicted probabilities).