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Complication risks associated with lower versus upper extremity peripherally inserted central venous catheters in neonates with gastroschisis☆

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ABSTRACT

Purpose: To compare the complication rates of lower extremity (LE) and upper extremity (UE) peripherally inserted central catheters (PICCs) in neonates with gastroschisis.
Methods: In this retrospective comparative study, neonates with gastroschisis admitted to a level IIId NICU between 2004 and 2013 were identified. Catheter dwell time and complication rates (infiltration, phlebitis, occlusion, migration, infection and thrombosis) between the initial UE and LE PICCs were compared.
Results: Forty (31%) and eighty-nine (69%) neonates with gastroschisis had their initial PICCs placed from their LE and UE, respectively. Complication rates were significantly higher when PICCs were inserted from LE, especially during silo-reduction and within 5 days after abdominal closure (LE: 20% vs. UE: 3.4%, $p < 0.01$). LE PICCs were 5.0 times more likely to have complications than UE PICCs (OR 95% CI: 1.2–21.5) during this time period. In particular LE PICCs had significantly higher rates of infiltration (LE: 11.5% vs. UE: 1.4%; $p = 0.025$) and phlebitis (LE: 11.5% vs. UE: 0%; $p < 0.01$) in patients who underwent silo-reduction.
Conclusion: LE PICCs are associated with significantly increased risks of infiltration and phlebitis in neonates with gastroschisis during silo-reduction and within 5 days after abdominal closure.
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1. Background

The incidence of gastroschisis is approximately 3 per 10,000 live births and increasing globally [1]. Surgical management includes primary versus staged closure with placement of a silo [2]. Postoperative ileus and bowel dysmotility are common problems that require bowel rest and often prolong the time to establish full enteral feedings. Therefore, long term parenteral nutrition is required in nearly all neonates with gastroschisis.

Peripherally inserted central catheters (PICCs) are commonly placed in neonates who require prolonged total parenteral nutrition (TPN). PICCs can be inserted in the veins of the upper extremity (UE) or the lower extremity (LE). A study of 629 PICCs in 559 term and preterm neonates showed no significant difference in complication rates between upper and lower extremity PICCs [3]. Conversely, Hoang et al. showed that PICCs inserted in the LE of preterm infants had a lower rate of central line-associated blood stream infections (CLABSI) and were free from complications for a longer period of time [4].

In our institution, however, we noticed a number of complications of LE PICCs in neonates with gastroschisis. Currently there is no study specifically addressing the complication rates of upper versus lower extremity PICCs in this subset of patients. Therefore in this retrospective study, we compared the complication rates of the initial PICCs inserted in the LE with those in the UE in neonates with gastroschisis. Specifically we compared complications during the period of silo-reduction and within 5 days after abdominal closure.

2. Methods

This is an institutional review board approved, retrospective study conducted at a level IIId neonatal intensive care unit (NICU). Neonates with gastroschisis admitted between 2004 and 2013 were identified through our NICU admission database. Medical charts and radiographic images were reviewed. Patients with initial PICCs placed in our NICU were included in the analysis. Any neonates with a PICC placed at an outside referring hospital, with a surgically placed central venous catheter as their initial central catheter, or without a placement of a PICC were excluded from our study.

All neonates with gastroschisis are evaluated by our surgical team at bedside as soon as they arrive at our institution. A silo is placed at bedside if the abdominal cavity is considered to be too small to accommodate all the protruding abdominal contents at once. Patients with silos are evaluated by our surgical team daily, and decisions for silo reductions are based on each patient's respiratory and hemodynamic status.

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Abdominal closure, primary or after silo-reduction, is typically performed in the operating room.

In our institution PICCs are typically placed in the first two to three days of life in neonates with gastroschisis. Under the supervision of neonatologists, specialty nurses insert and maintain the PICCs per our institution's guidelines. Two French Silicone PICCs are inserted from either the basilic or cephalic vein of the UE, or the saphenous vein of the LE. The vein selection for the PICCs is based on the nurse's preference. Radiographic studies are routinely performed to ensure the central location of the catheter tip before its use. A PICC is considered to be central in location if the catheter tip is in the superior vena cava for a UE PICC or in the inferior vena cava (at or above L3) for an LE PICC [5].

The complications that necessitated removal of the initial PICC were: phlebitis, infiltration, migration, occlusion, infection and thrombosis. Phlebitis was defined as swelling and erythema of the tissues along the course of the vein. Infiltration occurred when fluid from the PICC penetrated into the soft tissue, pleural space, or peritoneum. Migration occurred when the PICC moved from its initial central location to a peripheral location but without infiltration. Infection was defined as positive blood cultures obtained from the PICC with the same species as that from at least one peripheral blood culture. Occlusion was defined as the inability to flush the PICC unrelated to inadvertent kinks of the catheter. Venous thrombosis was defined as thrombus formation in or along the course of a PICC as confirmed by radiographic imaging with contrast. Screening duplex ultrasound to examine for deep venous thrombosis (DVT) is not routinely performed in asymptomatic patients in our institution. We compared the complication rates of the initial lower and upper extremity PICCs during the hospital stay, and during silo-reduction and within 5 days of abdominal closure.

Data analysis was performed using STATA (StataCorp, College Station, TX). Data were presented as median (interquartile range). Continuous variables were analyzed by Wilcoxon rank-sum test. Categorical data was analyzed by Fisher's Exact test. Odds ratio (OR) and the 95% confidence interval (CI) were calculated by logistic regression.

3. Results

A total of 138 neonates with gastroschisis were identified from our data base during the study period. All were outborn. Nine patients were excluded as they had PICCs placed at the referring hospital or had surgically placed central catheters as their initial central catheters. A total of 129 patients with gastroschisis qualified for data analysis. The clinical characteristics of the enrolled patients were summarized in Table 1. A total of 29 complications were observed. Significantly higher overall rates of PICC complications and shorter indwelling time were observed with LE PICCs.

Table 1
Clinical characteristics of gastroschisis patients (N = 129) with peripherally inserted central catheters (PICCs).

	UE PICCs (n = 89)	LE PICCs (n = 40)	p
Gestational age (weeks)	36 (35–37)	37 (35–37)	ns
Birth weight (g)	2516 (2214–2810)	2540 (2220–2842)	ns
Prenatally diagnosed	96 % (85)	95% (38)	ns
Preterm birth	57% (51)	45% (18)	ns
Silo-reduction	81% (72)	65% (26)	p = 0.051
Duration of silo-reduction (days)	9 (7–12)	9 (8–11)	ns
Day of life PICCs placed	2 (2–3)	2 (2–3)	ns
Duration of PICCs (days)	30 (22–50)	22 (14–32)	**p < 0.01****
Complications	15.7% (14)	37.5% (15)	**p < 0.01****
Complications/PICC days	3.8/1000	13.3/1000	**P < 0.01****

Data are presented as median (interquartile range) or percentage (number of observations).
UE: upper extremity; LE: lower extremity. ns: not significant
** (p < 0.01) statistically significant results.

For patients who underwent primary closure, the complications rates of LE PICCs were not statistically different from those of UE PICCs during silo-reduction and within 5 days after abdominal closure (Table 2). For patients who underwent silo-reduction, PICCs inserted from the LE had significantly higher rates of infiltration (LE PICCs 11.5% vs. UE PICCs 1.4%; p = 0.025) and phlebitis (LE PICCs 11.5% vs. UE PICCs 0%; p < 0.01) during silo-reduction and within 5 days after abdominal closure (Table 2).

All infiltration cases (n = 3), eighty percent of phlebitis cases (n = 4), and fifty-three percent of all the complications (n = 8) in the LE PICC group occurred either during silo-reduction or within 5 days after abdominal closure. LE PICCs were 5.0 times more likely to have complications than UE PICCs (OR 95% CI: 1.2–21.5) during this time period.

A total of three cases of infiltration with LE PICCs were seen in our study. After initial placement, the catheter tip positions for all three cases were confirmed to be in the appropriate central location with radiographs and/or contrast studies. In case 1, a right LE PICC was placed on day of life 3. The patient's abdomen was closed on day of life 8 after silo-reduction. Skin erosion was noted over the right inguinal area with drainage of "purulent-like material" within hours after abdominal closure. Fluid cultures were negative. Contrast study confirmed malposition of the PICC into the femoral vein with infiltration of contrast through the abdominal wall. In case 2, a left LE PICC was placed on day of life 1. During silo revision, TPN appearing fluid was noted in the abdominal cavity. This TPN appearing drainage resolved after the LE PICC was removed. In the last case, a right LE PICC was placed on day of life 3. This neonate had a large defect containing liver, spleen and large amount of bowel. Reduction was prolonged and a contrast study of the PICC on day of life 28 showed significant infiltration of contrast into the abdominal cavity. The serum glucose levels were maintained within normal values in all three cases.

4. Discussion

The published reported rates of PICC complications range from 0% to 33.6% with significant variations between facilities [6–8]. Common complications of PICC are occlusion and CLABSI [6]. Phlebitis, catheter migration/malposition, thrombosis and infiltration are less common [9]. Though rare, infiltration of a PICC may cause potentially life-threatening complications, such as pericardial tamponade.

The overall rate of infection in our patients with gastroschisis was 2.3% (0.63/1000 catheter days), which was lower than reported in the literature [3,4,10]. In contrast, significantly higher rates of infiltration (7.5%) and phlebitis (12.5%) with LE PICCs were observed in our neonates with gastroschisis when compared to the rate of infiltration (0%–1.4%) and phlebitis (0%–6.9%) reported in the general population [9].

The complication risks of PICCs generally increase with the length of time the catheter remains in place [10]. However in our gastroschisis patients, fifty-three percent of overall complications of LE PICCs occurred during silo-reduction and within 5 days after abdominal closure. This may contribute to the shorter indwelling time of LE PICCs compared to UE PICCs in neonates with gastroschisis.

The possible impact of increased abdominal pressure during silo-reduction or abdominal closure is of particular interest in the gastroschisis population. Abdominal compartment syndrome, increased intestinal venous congestion, and bowel ischemia have been reported with primary closure [11] and silo-reduction [12,13] in patients with gastroschisis. A PICC inserted from the lower extremity ending in veins in the abdominal cavity may cause vascular endothelial damage, which, in combination with altered venous return due to increased intra-abdominal pressure, could lead to thrombus formation and an increased risk of phlebitis and infiltration. In addition, migration of a PICC to a small vein secondary to such pressure effect may occur and further increase the risk of line infiltrations.

Table 2
Comparison of complication rates between lower and upper extremity peripherally inserted central catheters (PICCs) in neonates with gastroschisis during the period of silo-reduction and within 5 days after abdominal closure, and the period of more than 5 days after abdominal closure.

		Complications during silo reduction or within 5 days after abdominal closure			Complications more than 5 days after abdominal closure		
		UE PICCs (n = 89)	LE PICCs (n = 40)	p	UE PICCs (n = 89)	LE PICCs (n = 40)	p
Infiltration	Primary closure	0% (0/17)	0% (0/14)	ns	0% (0/17)	0% (0/14)	ns
	Silo-reduction	**1.4% (1/72)**	**11.5% (3/26)**	**p = 0.025***	1.4% (1/71)	0% (0/26)	ns
Phlebitis	Primary closure	0% (0/17)	7.1% (1/14)	ns	0% (0/17)	7.1% (1/14)	ns
	Silo-reduction	**0% (0/72)**	**11.5% (3/26)**	**p < 0.01****	0% (0/72)	0% (0/26)	ns
Occlusion	Primary closure	5.9% (1/17)	0% (0/14)	ns	5.9% (1/17)	0% (0/14)	ns
	Silo-reduction	0% (0/72)	3.9% (1/26)	ns	0% (0/72)	3.9% (1/26)	ns
Migration	Primary closure	0% (0/17)	0% (0/14)	ns	0% (0/17)	0% (0/14)	ns
	Silo-reduction	1.4% (1/72)	0% (0/26)	ns	1.4% (1/72)	0% (0/26)	ns
Infection	Primary closure	0% (0/17)	0% (0/14)	ns	0% (0/17)	0% (0/14)	ns
	Silo-reduction	0% (0/72)	0% (0/26)	ns	1.4% (1/72)	7.7% (2/26)	ns
Thrombosis	Primary closure	0% (0/17)	0% (0/14)	ns	0% (0/17)	0% (0/14)	ns
	Silo-reduction	0% (0/72)	0% (0/26)	ns	1.4% (1/72)	0% (0/26)	ns
Total	Primary closure	5.9% (1/17)	7.1% (1/14)	ns	11.8% (2/17)	21.4% (3/14)	ns
	Silo-reduction	**2.8% (2/72)**	**26.9% (7/26)**	**p < 0.01****	12.5% (9/72)	15.4% (4/26)	ns

Data are presented as percentage (number of complication/total observation). *UE: upper extremity; LE: lower extremity; ns: not significant.*
* ($p < 0.05$) statistically significant results.
** ($p < 0.01$) statistically significant results.

All of the cases of infiltration and 80% of the cases of phlebitis with LE PICCs occurred during silo-reduction and within 5 days after abdominal closure. Because we are not able to directly measure intra-abdominal pressure, we suspect that elevated abdominal pressure may contribute to the observed complications with LE placed PICCs.

Recognition of infiltration of LE PICCs can be challenging in neonates with gastroschisis, and may be underestimated. Several reasons may account for the delayed recognition of infiltration of LE PICCs in patients with gastroschisis. Signs of infiltration of a PICC within the abdominal cavity, such as erythema and edema of the abdominal wall, may be interpreted as expected post-surgical reactions. Blood glucoses may be appropriate, even with infiltration, as glucose is absorbed from the peritoneum into the systemic circulation. An initially centrally located LE PICC may migrate to a peripheral location and may be difficult to appreciate on radiography due to the radio-opaque nature of the silo.

There are a number of limitations in our study. Primarily, this study is retrospective and based on a single institution observation. The retrospective nature introduces the possibility of incomplete documentation of complications, Additionally, the lack of routine screening for deep venous thrombosis in asymptomatic patients limits our ability to detect all episodes of thrombosis. The low number of patients in the primary closure group subjects the study to an increased risk of Type II error thus, leading to an inability to detect true differences between UE and LE PICCs in this subgroup. In addition, subclinical complications may go undetected in both groups and could alter the absolute and relative rates of complications.

In conclusion, our study shows a significantly higher risk of phlebitis and infiltration with LE PICCs compared to UE PICCs in neonates with gastroschisis undergoing silo-reduction and within 5 days after abdominal closure. It is unclear if these risks apply to patients undergoing primary closure.

The site selection of PICC insertion in the gastroschisis neonates should consider many factors including ease of PICC insertion and institutional preferences and guidelines. Nevertheless, a high index of suspicion should be given for early recognition of potential complications associated with PICCs based on site insertion.

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