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Effect of implementing an Epicutaneo-Caval Catheter team in Neonatal Intensive Care Unit

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Abstract

Background: Until the 1980s, central vascular access in the Neonatal Intensive Care Unit was predominantly delivered by umbilical catheters and only and if needed by surgical cutdowns or subclavian vein catheterization through blind percutaneous venipuncture. In the early 1980s, epicutaneo-caval catheters were successfully introduced.
Methods: In our Neonatal Intensive Care Unit, a dedicated team to insert epicutaneo-caval catheters was formally established in January 2017, including 12 neonatologists and 1 neonatal nurse practitioner. A before- versus after-intervention study was designed to determine whether the establishment of the epicutaneo-caval catheter insertion team is associated with increased success rates and a decreased risk of catheter-related complications. Success rates and other catheter-related parameters were traced from 2016 onward. Collected data were analyzed for three consecutive years: 2016, 2017, and 2018.
Results: The epicutaneo-caval catheter team inserted 1336 catheters over 3 years. Both first prick (from 57.7% to 66.9%; $p = 0.023$) and overall success (from 81.7% to 97.6%; $p < 0.0001$) rates significantly improved. In 2018, the number of tunneled or surgically inserted central venous catheters came down to zero ($p < 0.0001$). Overall catheter-related complications were significantly lower following the epicutaneo-caval catheter team's establishment ($p < 0.0001$) while there was no significant decrease noted ($p = 0.978$) in central line–associated bacterial stream infection rates.
Conclusion: A dedicated epicutaneo-caval catheter team is a promising intervention to increase success rates and significantly decrease catheter-related complications in Neonatal Intensive Care Unit. Standardizing epicutaneo-caval catheter placement is important; however, standardizing catheter maintenance seems essential to the improvement of central line–associated bacterial stream infection rates.

Keywords

Epicutaneo-caval catheter, peripherally inserted central catheter, neonate, vascular access, neonatal intensive care unit

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Introduction

Umbilical venous catheters (UVCs) and peripheral intravenous catheters (PIVC) were widely used in Neonatal Intensive Care Units to obtain vascular access and provide the required infusion therapy. If needed, surgical cutdowns or subclavian vein catheterization through blind percutaneous venipuncture was used in the past to provide central venous access. These central line approaches have been associated with multiple complications, including

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infections, pneumothorax, hydrothorax, hemothorax, massive hemorrhage, vena cava obstruction, and intracardiac thrombi.

Nowadays, ultrasound-guided central catheterization is proven to be effective and safe even in small preterm infants, and therefore, surgical cutdowns or blind percutaneous venipuncture of deep veins should be completely abandoned.

Epicutaneo-caval catheters (ECCs) on the other side are catheters suitable for stable preterm infants. ECCs are less invasive than centrally inserted central catheters (CICCs) and femorally inserted central catheters (FICCs) and can be placed at the bedside without deep sedation. ECCs provide successfully parenteral nutrition, medication, and hyperosmolar fluids. Compared to PIVCs, they decrease the number of painful procedures and needle sticks, without significantly increasing the rate of sepsis.[1–5] Like other vascular access devices (VADs), ECCs are associated with various complications such as occlusion, infection, thrombosis, breakage, migration, and displacement, which lead to non-selective removal of the catheter. However, ECCs are a safe choice to deliver intravenous (IV) therapy.[6,7]

This research study was designed to investigate the assumed beneficial effect (increased first prick, overall success rates, and a decreased risk of catheter-related complications) of an ECC team implementation on neonates.

Patients and methods

The Women's Wellness and Research Center (WWRC) is the main specialist hub for women and newborns health services in the country under the umbrella of Hamad Medical Corporation (HMC), Doha, Qatar.

In January 2017, an ECC insertion team was trained and formally established to provide standardized insertion techniques, equipment, and materials of ECCs, in order to improve the success rates and minimize the catheter-related complications. The team consists of 12 neonatologists and a neonatal nurse practitioner, this to provide an ECC service round the clock. Criteria for team membership included dedicated training, proven IV insertion expertise, level of interest and motivation, Neonatal Intensive Care Unit (NICU) experience, communication, and organization skills, previous performance evaluations, and schedule flexibility. To build and maintain the team skills at the optimum level, inter-professional central line simulation workshops were conducted at 3-month intervals since 2017. During those workshops, the team was well trained to perform the two used ECC insertion techniques: (1) catheter-over-needle technique and (2) the modified Seldinger technique (MST).[8,9] In addition to the workshops, the ECC guidelines were updated to standardize our practice. IV insertion expertise was tested in simulation workshops as well as by feedback from a shadowed privileged team member. Team membership was limited to those who have at least 3 years' experience in our NICU.

The ECC team works in collaboration with 32 neonatal nurses who form the clinically advanced practice-nurse (CAP) team. The CAP team consists of highly qualified neonatal nurses, not only in ECC insertion but also in all other neonatal procedures, high-risk deliveries, and neonatal transports. The main tasks of the ECC team in our unit were the insertion of the catheters, monitoring tip location on chest radiographs, and providing staff education and training. The CAP team identified patients in need of ECC placement based on patient characteristics, fluid characteristics, and duration of therapy. They perform a daily assessment of each catheter and dressing, change dressings if needed, collect data for all VADs, and manage blood withdrawal from central catheters.

In our NICU, ECC insertion is based on patient characteristics (gestational age and weight), fluid characteristic, duration of therapy, and if identified as difficult vascular access.[6] We insert ECCs for neonates who are less than 1500 g body weight, who require IV fluids for more than 5 days, who require IV medications for more than 7 days, who require hyperosmolar IV fluid therapy more than 700 mosmol/L and those who required more than three PIVC insertions in the last 24 h. These patients are automatically prioritized for ECC placement, especially if their current access is inadequate or to fasten umbilical catheters removal. A surgically inserted central venous catheter (SCVC); either FICC or CICC is used when the placement of ECC has failed by three operators; two pricks for each. Due to the lack of trained personnel in US-guided venipuncture, surgical cutdown or blind percutaneous venipuncture was used to place SCVC.[10,11]

Four types of polyurethane central catheters are available in our unit; (Multicath2 Fr; Teleflex), (NutriLine 2 Fr; Vygon), (PremiCath 1 Fr; Vygon) and (PremiStar 1 Fr; Vygon). For all catheters, either an over-the-needle technique or MST can be used for insertion. PremiStar is miconazole and rifampicin impregnated ECC, designed and marketed to reduce the incidence of catheter-related bloodstream infections.[12] For piloting purposes, 34 PremiStar catheters were introduced from August 2017 till the end of 2018. In our study, we placed them in the same category with PremiCath due to a small number of insertions.

A well-structured data collection sheet was designed to collect all parameters in an electronic database. Another form was designed to document the procedure notes in the hospital electronic system by the inserting team. Data included current age, gestational age, birth weight, date and reason for insertion, catheter details, vein inserted, side of the body (left versus right), site of insertion (upper versus lower extremities), number of pricks, procedure outcome (successful versus failed), tip location (reflected on vertebrae), date and reason for removal, and duration of catheter insertion (dwell time).

Centers for Disease Control and Prevention (CDC) guidelines definition for central line–associated blood stream infection (CLABSI) was followed, which defines it as a primary bloodstream infection (BSI) in a patient that had a central line within the 48-h period before the development of the BSI and is not bloodstream related to an infection at another site. CLABSI rate is the total number of CLABSI divided by the total number of device days 1000.[12,13]

Strict measures were applied by the ECC and mainly by the CAP team to reduce CLABSI rate. By the end of 2015, three specific care bundles were developed in our unit: daily VAD bundle, a bundle for change of dressing, and bundle for catheter access. The main bundle elements are applying maximal standard barrier precautions, daily line need assessment, use of central line trolley/kit, scrubbing the hub by chlorhexidine, use of the transparent semipermeable dressing, use of needle-free connector and alcohol-impregnated port protector, use of two-person technique, and strictly maintaining a closed IV tubing system.[14]

We traced success rates and other catheter-related parameters in 2016 and compared them with those in 2017 and 2018. This pre- versus post-intervention study was conducted in NICU in accordance with prevailing ethical principles and local and international standard regulations and guidelines. It was approved under an exemption from Institutional Review Board (IRB) at HMC (approval ID. # MRC-01-18-059).

Statistical analysis

Descriptive statistics were used to summarize demographic, clinical, catheter-related parameters, and other characteristics of the participants. The normally distributed data and results were reported with a mean and standard deviation (SD); the remaining results were reported with a median and interquartile range (IQR). Categorical data were summarized using frequencies and percentages. Preliminary analyses were conducted to examine the distribution of the data variables using the Kolmogorov–Smirnov test.

Associations between two or more qualitative variables were assessed using chi-square (χ^2) test, Fisher exact or Yates corrected chi-square tests as appropriate. Quantitative data and outcome measures between the two and more than two independent groups were analyzed using unpaired "t" test (Mann–Whitney U-test for non-normal data) and one-way analysis of variance (ANOVA; Kruskal–Wallis test for skewed data) as appropriate. Univariate and multivariate logistic regression analysis was applied to determine the significant and potential predictors (ECC implementation and catheter types) associated with outcome variable ECC removal due to leaking (yes/no). The results of logistic regression analyses were presented as odds ratio (OR) with corresponding 95% confidence interval (CI). Pictorial presentations of the key results were made using appropriate statistical graphs. 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 22.0 (SPSS Inc, Chicago, IL) and Epi-info (CDC, Atlanta, GA) software.

Results

The team inserted 378, 508, and 450 central lines in 2016, 2017, and 2018, respectively, with a total of 1336 over the 3 years. The mean $\pm$ SD for the birth weight in babies who had ECC line was 1284.58 $\pm$ 693.80 while the mean $\pm$ SD for the gestational age was 29.56 $\pm$ 4.30.

The mean gestational age (30.38 $\pm$ 4.654) and birth weight (1400.78 $\pm$ 793.437) were observed to be significantly higher in the year 2017 compared to 2016 (mean gestation age 28.98 $\pm$ 4.508; mean birth weight 1233.34 $\pm$ 699.60) and 2018 (mean gestational age 29.13 $\pm$ 3.51; mean birth weight 1196.44 $\pm$ 533.02; $p < 0.001$).

Data from our study showed significant improvement ($p < 0.0001$) in overall success rate from 81.7% in 2016 to 88.6% in 2017 and 97.6% in 2018. The first prick success rate had also been significantly improved ($p = 0.023$) from 57.7% in 2016 to 61.8% in 2017 and 66.9% in 2018 (Table 1).

Another highlight from our study was the number of SCVC which significantly reduced ($p < 0.0001$) from 42 in 2016 to 27 in 2017 and 0 in 2018 (Table 1). The total number of PIVCs also decreased from 10,496 in 2016 to 9732 in 2017 and 8648 in 2018 despite the gradual increase in the NICU admissions.

As per our clinical practice guideline, we allow for a maximum of three pricks per day. Almost two-thirds of the cases were successful from the first attempt. We needed to deviate from our guidelines in a few special chronic cases with difficult IV access in which more than two pricks were needed. Those counts only 1%–2% across the 3 years (overall $p = 0.046$; Table 1).

PremiCath was the most popular type of catheters in the last 3 years ($p < 0.0001$; Table 1). There was no statistically significant difference observed in the overall success rate among all catheter types ($p = 0.281$). The first prick success rate was the highest in NutriLine catheters (73.7%) compared to Multicath2 (69.4%) and PremiCath (63.3%; $p = 0.009$; Table 2).

Around 58.9% of the ECCs were inserted on the right side of the body (Table 3). The team had a significant tendency to increase insertions of ECCs in the right side of the body compared to the left side ($p = 0.011$) across the 3 years (Table 1). The overall success rates did not differ significantly between the ECCs inserted in the right side of the body compared to the left ($p = 0.825$). However, the first prick success rate was significantly higher in ECCs inserted on the right side ($p = 0.02$). There was no significant difference between both sides ($p = 0.892$) in the rate of catheter-related complications and reasons for catheter removal (Table 4).

Table 1. Gestational age, birth weight, and other catheter-related parameters across three different years.

Variables	Year 2016 (n = 378)	Year 2017 (n = 508)	Year 2018 (n = 450)	p value
Overall success rate	309 (81.7)	450 (88.6)	439 (97.6)	<0.0001
First prick success rate	218 (57.7)	314 (61.8)	301 (66.9)	0.023
Number of SCVCs	42 (11.1)	27 (5.3)	0 (0)	<0.0001
Catheter type				
MultiCath2	42 (11.2)	27 (5.3)	0 (0)	<0.0001
PremiStar and PremiCath	334 (88.8)	472 (93.1)	420 (93.3)	
NutriLine	0 (0)	8 (1.6)	30 (6.7)	
Vein Inserted				
SCVC	41 (10.9)	27 (5.3)	0 (0)	<0.0001
ECC	335 (89.1)	479 (94.7)	450 (100)	
Side of the body				
Left	127 (41)	164 (36.2)	207 (46)	0.011
Right	183 (59)	289 (63.8	243 (54)	
Site of insertion				
Upper extremities	101 (32)	143 (31.4)	116 (25.8)	0.094
Lower extremities	215 (68)	312 (68.6)	334 (74.2)	
Number of pricks				
First prick	221 (58.6)	317 (64.4)	301 (67.2)	0.046
Second prick	111 (29.4)	108 (22)	88 (19.6)	
Third prick	38 (10.1)	53 (10.8)	55 (12.3)	
Fourth prick	6 (1.6)	12 (2.4)	4 (0.9)	
Fifth prick	0 (0)	1 (0.2)	0 (0)	
Sixth prick	1 (0.3)	1 (0.2)	0 (0)	
Reason for insertion				
Difficult IV insertion	0 (0)	2 (0.4)	6 (1.3)	<0.0001
Hypoglycemia	0 (0)	8 (1.6)	2 (0.4)	
Long term IV fluid therapy	378 (100)	481 (95.1)	430 (95.6)	
Long term IV medication therapy	0 (0)	15 (3)	12 (2.7)	
Reason for removal				
CLABSI	10 (3.2)	16 (3.6)	14 (3.2)	0.895
Leaking	21 (6.8)	11 (2.4)	4 (0.9)	0.0001
Accidental removal	0 (0)	7 (1.6)	1 (0.2)	0.053
Broken catheter	0 (0)	4 (0.9)	3 (0.7)	0.499
Local redness and swelling	35 (11.3)	44 (9.8)	25 (5.8)	0.090
Occlusion	12 (3.9)	16 (3.6)	14 (3.2)	0.998
Malposition	2 (0.6)	6 (1.3)	5 (1.2)	0.799
Elective removal	197 (63.8)	303 (67.3)	333 (76.9)	<0.0001
Death	9 (2.9)	17 (3.8)	13 (3)	0.699
Preventive	23 (7.4)	26 (5.8)	21 (4.8)	0.652
Gestational age				
22–28 weeks	204 (54)	194 (38.2)	205 (45.6)	<0.0001
>28–32 weeks	106 (28)	196 (38.6)	188 (41.8)	
>32–36 weeks	29 (7.7)	39 (7.7)	33 (7.3)	
>36 weeks	39 (10.3)	79 (15.6)	24 (5.3)	
Birth weight				
≤1000 g	196 (51.9)	184 (36.2)	181 (40.2)	<0.0001
>1000–1500 g	112 (29.6)	209 (41.1)	207 (46)	
>1500–2000 g	22 (5.8)	32 (6.3)	37 (8.2)	
>2000–2500 g	11 (2.9)	13 (2.6)	6 (1.3)	
>2500–3000 g	20 (5.3)	28 (5.5)	10 (2.2)	
>3000–3500 g	13 (3.4)	33 (6.5)	4 (0.9)	
>3500 g	4 (1.1)	9 (1.8)	5 (1.1)	

SCVC: surgically inserted central venous catheters; ECC: epicutaneo-caval catheters; CLABSI: central line–associated bacterial stream infection.
Values are presented in n (%)

Almost 70.5% of our total ECCs were inserted in the lower extremities (Table 3). There was no significant difference between the lower or upper extremities insertions (overall $p = 0.094$) across the 3 years (Table 1). In addition, no significant differences observed in the overall success rate, catheter-related complications, and reasons for catheter

Table 2. Association between gestational age, birth weight, and other catheter-related parameters with catheter types.

Parameters	PremiStar + PremiCath	NutriLine	p value
Vein inserted			
SCVC	0 (0)	1 (2.7)	0.029
ECC	1226 (100)	36 (97.3)	
Side of the body			
Left	469 (42.1)	15 (40.5)	0.850
Right	645 (57.9)	22 (59.5)	
Site of insertion			
Upper extremities	314 (28.2)	9 (24.3)	0.609
Lower extremities	801 (71.8)	28 (75.7)	
Upper extremities			0.007
First prick	768 (63.3)	28 (73.7)	0.007
Second prick	290 (23.9)	7 (18.4)	
Third prick	136 (11.2)	3 (7.9)	
Fourth prick	18 (1.5)	0 (0)	
Fifth prick	1 (0.1)	0 (0)	
Sixth prick	1 (0.1)	0 (0)	
Reason for insertion			
Difficult IV insertion	6 (0.5)	2 (5.3)	0.050
Hypoglycemia	9 (0.7)	1 (2.6)	
Long-term IV fluid therapy	1185 (96.7)	33 (86.8)	
Long-term IV medication therapy	25 (2)	2 (5.3)	
Success rate			
Not successful	126 (10.3)	1 (2.6)	0.123
Successful	1100 (88.4)	37 (97.4)	0.123
Reason for removal			
CLABSI	35 (3.2)	0 (0)	0.613
Leaking	23 (2.1)	3 (8.1)	0.017
Accidental removal	6 (0.5)	1 (2.7)	0.228
Broken catheter	7 (0.6)	0 (0)	0.792
Local redness and swelling	98 (9)	1 (2.7)	0.186
Occlusion	39 (3.6)	3 (8.1)	0.151
Malposition	12 (1.1)	1 (2.7)	0.368
Elective removal	780 (71.3)	24 (64.9)	0.396
Death	31 (2.8)	3 (8.1)	0.064
Preventive	63 (5.8)		0.429
Gestational age			
22–28 weeks	578 (47.1)	2 (5.3)	<0.0001
28–32 weeks	474 (38.7)	12 (31.6)	
32–36 weeks	88 (7.2)	4 (10.5)	
>36 weeks	86 (7)	20 (52.6)	
Birth weight			
≤1000 g	539 (44)	1 (2.6)	<0.0001
1001–1500 g	507 (41.4)	14 (36.8)	
1501–2000 g	84 (6.9)	3 (7.9)	
2001–2500 g	24 (2)	2 (5.3)	
2501–3000 g	36 (2.9)	9 (23.7)	
3001–3500 g	28 (2.3)	4 (10.5)	
>3500 g	8 (0.7)	5 (13.2)	

SCVC: surgically inserted central venous catheters; ECC: epicutaneo-caval catheters; CLABSI: central line–associated bacterial stream infection.
Values are presented in n (%)

removal between the upper and lower extremities ($p > 0.05$). The first prick success rate was noted to be higher in lower extremities (70.8%) compared to upper extremities (65.1%); however, this difference did not reach statistical significance ($p = 0.094$). Elective removal due to completion of therapy was found to be 68.2% in upper extremity ECCs and 70.6% in lower extremity ECCs and this difference was statistically insignificant ($p > 0.05$; Table 5).

The rate of elective ECC removal after successful completion of therapy was significantly improved following the ECC team implementation ($p < 0.0001$). Subsequently, the overall percentage of unwanted removals

Table 3. Gestational age, birth weight, and other catheter-related parameters: descriptive statistics.

Variables	(n = 1336) (%)
Birth Weight	
≤1000 g	561 (42)
1001–1500 g	528 (39.5)
1501–2000 g	91 (6.8)
2001–2500 g	30 (2.2)
2501–3000 g	58 (4.3)
3001–3500 g	50 (3.7)
>3500 g	18 (1.3)
Gestational age	
22–28 weeks	603 (45.1)
28–32 weeks	490 (36.7)
32–36 weeks	101 (7.6)
>36 weeks	142 (10.6)
Catheter type	
MultiCath2	69 (5.2)
PremiStar and PremiCath	1226 (92)
NutriLine	38 (2.9)
Vein inserted	
SCVC	68 (5.1)
ECC	1264 (94.9)
Side of the body	
Left	498 (41.1)
Right	715 (58.9)
Site of the body	
Upper extremities	360 (29.5)
Lower extremities	861 (70.5)
Number of pricks	
First prick	839 (63.7)
Second prick	307 (23.3)
Third prick	146 (11.1)
Fourth prick	22 (1.7)
Fifth prick	1 (0.1)
Sixth prick	2 (0.2)
Reason for insertion	
Difficult IV insertion	8 (0.6)
Hypoglycemia	10 (0.7)
Long-term IV fluid therapy	1289 (96.6)
Long-term IV medication therapy	27 (2)
Success rate	
Not successful	138 (10.3)
Successful	1198 (89.7)
Reason for removal	
CLABSI	40 (3.4)
Leaking	36 (3)
Accidental removal	8 (0.7)
Broken catheter	7 (0.6)
Local redness and swelling	104 (8.7)
Occlusion	42 (3.5)
Malposition	13 (1.1)
Elective removal	833 (69.9)
Death	39 (3.3)
Preventive	70 (5.9)

SCVC: surgically inserted central venous catheters; ECC: epicutaneo-caval catheters; CLABSI: central line–associated bacterial stream infection.
Values are presented in n (%)
This is a retrospective study design, and for some parameters, the data values were incomplete due to unavailability of the information in the patients' record files.

Table 4. Association between gestational age, birth weight, and other catheter-related parameters with side of the body.

Parameters	Left	Right	p value
Vein inserted			
SCVC	13 (2.6)	48 (6.7)	0.001
ECC	485 (97.4)	667 (93.3)	
Site of insertion			
Upper extremities	151 (30.3)	209 (29.2)	0.683
Lower extremities	347 (69.7)	506 (70.8)	
Number of pricks			
First prick	322 (65.3)	511 (72.3)	0.020
Second prick	115 (23.3)	134 (19)	
Third prick	47 (9.5)	58 (8.2)	
Fourth prick	9 (1.8)	3 (0.4)	
Fifth prick	1 (0.1)	0 (0)	
Sixth prick	0 (0)	1 (0.1)	
Reason for insertion			
Difficult IV insertion	1 (0.2)	7 (1)	0.357
Hypoglycemia	4 (0.8)	5 (0.7)	
Long-term IV fluid therapy	484 (97.2)	686 (95.9)	
Long-term IV medication therapy	9 (1.8)	17 (2.4)	
Success rate			
Not successful	7 (1.4)	9 (1.3)	0.825
Successful	491 (98.6)	706 (98.7)	
Reason for removal			
CLABSI	14 (2.9)	25 (3.6)	0.892
Leaking	13 (2.7)	23 (3.3)	
Accidental removal	3 (0.6)	5 (0.7)	
Broken catheter	3 (0.6)	4 (0.6)	
Local redness and swelling	45 (9.2)	59 (8.4)	
Occlusion	21 (4.3)	21 (3)	
Malposition	4 (0.8)	9 (1.3)	
Elective removal	335 (68.8)	498 (70.7)	
Death	19 (3.9)	20 (2.8)	
Preventive	30 (6.2)	40 (5.7)	
Gestational age			
22–28 weeks	224 (45)	324 (45.3)	0.267
28–32 weeks	199 (40)	256 (35.8)	
32-36 weeks	33 (6.6)	56 (7.8)	
>36 weeks	42 (8.4)	79 (11)	
Birth weight			
≤1000 g	209 (42)	299 (41.8)	0.820
1001–1500 g	214 (43)	285 (39.9)	
1501–2000 g	28 (5.6)	49 (6.9)	
2001–2500 g	9 (1.8)	15 (2.1)	
2501–3000 g	16 (3.2)	32 (4.5)	
3001–3500 g	15 (3)	25 (3.5)	
>3500 g	7 (1.4)	10 (1.4)	
Catheter type			
Multicath2	14 (2.8)	48 (6.7)	0.010
PremiStar and PremiCath	469 (94.2)	645 (90.2)	
NutriLine	15 (3)	22 (3.1)	

SCVC: surgically inserted central venous catheters; ECC: epicutaneo-caval catheters; CLABSI: central line–associated bacterial stream infection.
Values are presented in n (%)

Table 5. Association between gestational age, birth weight, and other catheter-related parameters with site of insertion.

Parameters	Upper extremities	Lower extremities	p value
Vein inserted			
SCVC	36 (10)	32 (3.7)	<0.0001
ECC	324 (90	829 (96.3)	
Number of pricks			
First prick	228 (65.1)	607 (70.8)	0.168
Second prick	78 (22.3)	172 (20.1)	
Third prick	41 (11.7)	68 (7.9)	
Fourth prick	3 (0.9)	9 (1.1)	
Fifth prick	0 (0)	0 (0)	
Sixth prick	0 (0)	1 (0.1)	
Reason for insertion			0.984
Difficult IV insertion	2 (0.6)	6 (0.7)	0.984
Hypoglycemia	3 (0.8)	6 (0.7)	
Long-term IV fluid therapy	347 (96.4)	830 (96.5)	
Long-term IV medication therapy	8 (2.2)	18 (2.1)	
Success rate			
Not successful	7 (1.9)	16 (1.9)	0.920
Successful	353 (98.1)	845 (98.1)	
Reason for removal			
CLABSI	17 (4.8)	23 (2.7)	0.315
Leaking	16 (4.5)	20 (2.4)	
Accidental removal	1 (0.3)	7 (0.8)	
Broken catheter	2 (0.6)	5 (0.6)	
Local redness and swelling	31 (8.8)	73 (8.7)	
Occlusion	12 (3.4)	30 (3.6)	
Malposition	5 (1.4)	8 (1)	
Elective removal	240 (68.2)	593 (70.6)	
Death	12 (3.4)	27 (3.2)	
Preventive	16 (4.5)	54 (6.4)	
Gestational age			
22–28 weeks	152 (42.2)	400 (46.5)	0.013
28–32 weeks	127 (35.3)	329 (38.2)	
32–36 weeks	30 (8.3)	60 (7)	
>36 weeks	51 (14.2)	72 (8.4)	
Birth weight			
≤1000 g	139 (38.6)	373 (43.3)	0.002
1001–1500 g	146 (40.6)	354 (41.1)	
1501–2000 g	18 (5)	59 (6.9)	
2001–2500 g	11 (3.1)	14 (1.6)	
2501–3000 g	16 (4.4)	33 (3.8)	
3001–3500 g	23 (6.4)	17 (2)	
>3500 g	7 (1.9)	11 (1.3)	
Catheter type			
Multicath2	37 (10.3)	32 (3.7)	<0.0001
PremiStar and PremiCath	314 (87.2)	801 (93)	
NutriLine	9 (2.5)	28 (3.3)	
Side of the body			0.683
Left	151 (41.9)	347 (40.7)	0.683
Right	209 (58.1)	506 (59.3)	

SCVC: surgically inserted central venous catheters; ECC: epicutaneo-caval catheters; CLABSI: central line–associated bacterial stream infection. Values are presented in n (%)

decreased. Unnecessary premature catheter withdrawal (preventive) also gradually decreased from 7.4% in 2016 to 4.8% in 2018.

ECC removal due to leaking significantly reduced ($p = 0.0001$) after the team implementation. It could be argued that was attributed to the gradual reduction in the use of Multicath2 (Table 1).

The results of univariate and multivariate logistic regression analysis testing for each predictor and its possible association with ECC removal due to leaking are

Table 6. Predictors associated with ECC removal due to leaking: univariate and multivariate logistic regression analysis.

	Univariate logistic regression			Multivariate logistic regression		
Predictors	Unadjusted odds ratio (OR)	95% CI for OR	p value	Adjusted odds ratio (OR)	95% CI for OR	p value
ECC team implementation						
No (year 2016)	1.0 (Reference)	0.16, 0.72	0.005	1.0 (Reference)	0.16, 0.77	0.009
Yes (year 2017)	0.34	0.04, 0.38	<0.0001	0.36	0.03, 0.39	0.001
Yes (year 2018)	0.13			0.11		
Catheter types						
Mulitcath2	1.0 (Reference)	0.05, 0.24	<0.0001	1.0 (Reference)	0.08, 0.42	<0.0001
PremiStar and PremiCath	0.11	0.12, 1.76	0.250	0.18	0.42, 10.55	0.365
NutriLine	0.45			2.11		

ECC: epicutaneo-caval catheters.

presented in Table 6. ECC removal due to leaking significantly reduced following ECC team implementation both in the year 2017 (unadjusted OR = 0.34; 95% CI = 0.16, 0.72; p = 0.005), and in the year 2018 (unadjusted OR = 0.13; 95% CI = 0.04, 0.38; p < 0.0001) compared to the year 2016 (before ECC team implementation). In addition, ECC removal due to leaking significantly reduced in PremiStar and PremiCath group compared to Muticath2 group (unadjusted OR = 0.11; 95% CI = 0.05, 0.24; p < 0.0001). A similar trend of reduction was noticed when compared NutriLine with Muticath2 group (unadjusted OR = 0.45; 95% CI = 0.12, 1.76); however, this difference was statistically insignificant (p = 0.250). In multivariable logistic regression analysis when examined the effect of ECC implementation adjusting to potential confounder and predictor variable catheter types, it was observed that ECC removal due to leaking remained significantly reduced following the ECC team implementation both in the year 2017 (adjusted OR = 0.36; 95% CI = 0.16, 0.77; p = 0.009) and in the year 2018 (adjusted OR = 0.11; 95% CI = 0.03, 0.39; p = 0.001) compared to year 2016 (before ECC team implementation).

The mean dwell time in days was 14.77 ± 11.85 in 2016, 14.77 ± 12.98 in 2017, and 13.85 ± 12.23 in 2018 with no significant difference (p = 0.473). It was noted to be significantly lower with NutriLine (9.7 ± 7.20) compared to other types of catheters (p = 0.012) and in cases of elective removals it was recorded as 14.80 ± 10.86 (Supplemental Material Table 2). In confirmed CLABSI cases, the mean dwell time was 19.50 ± 16.59 (median 13.5; range, 3–82) compared to 14.3 ± 12.2 (median 12; range, 0–159) in non-CLABSI cases (p = 0.061).

The overall success rate was noted to be the highest in the gestational age group between 28 and 32 weeks (92.4%), while the lowest was noted after 36 weeks gestation (85.2%) (p = 0.046; Supplemental Table 1).

Our CLABSI Rate was 2.27, 2.46, and 2.34 per 1000 catheter-days in 2016, 2017, and 2018, respectively. There was no significant reduction in the CLABSI rate after the ECC team implementation (overall p = 0.978). The highest CLABSI rate was observed in the gestational age of more than 36 weeks' gestation (3.8 per 1000 catheter-days), while the lowest was seen between 28 and 32 weeks' gestation (0.58 per 1000 catheter-days). It was 3.4 and 0.88 per 1000 catheter-days in the gestational age groups between 22 and 28 weeks' gestation and between 32 and 36 weeks' gestation, respectively. In the birth weight group ≤1500 g, the CLABSI rate was 2.37 per 1000 catheter-days compared to 2.39 in the birth weight groups >1500 g. CLABSI was noted to be higher in PremiCath (3.2%) than NutriLine in which no case of CLABSI has been reported (p = 0.056; Table 2).

We did not notice any major central line complication, for example, arrhythmia, tamponade, and pleural effusions during these 3 years.

Discussion

Our study demonstrates the importance of a dedicated ECC team which led to a steady increase in the overall success rate from 81.7% in 2016 to 97.6% in 2018. It is close to Li et al.,[2] Uygun et al.,[8] and Evans et al.,[15] who reported an overall success rate of 99.65%, 95%, and 94% respectively. Another study reported an increase in the success rate over 11 years ranged between 53.7% and 70.5%.[16]

Our first prick success rate increased from 57.7% in 2016 to 66.9% in 2018. It is still less than Li et al.[2] and Uygun et al.[8] who reported a first-attempt success rate of 86% and 77.77%, respectively. Our improvement was attributed to performing the same tasks repeatedly, continuously attending simulation workshops, development of an evidence-based guideline, improved procedure electronic documentation, and close procedural monitoring. CAPs were also instructed not to insert PIVC in the saphenous and cubital veins. However, still, there is room to improve our first attempt success rate in the coming years. Exceptionally, only 1%–2% of our babies needed more than three attempts for ECC insertion compared to 7.3% in another study by Badheka et al.[17]

Because of the successful ECC team implementation, the number of SCVCs gradually decreased to zero in 2018. That saved considerable extra effort, cost, and time. This achievement is explained by building up team skills with a subsequent increase in the ECC insertion success rate across the 3 years, so we did not need SCVC anymore in 2018 as we reserve SCVC only for babies who failed to get an ECC. The elective removal rate after successful completion therapy was increased from 63.8% to 76.9% after the team implementation. Link et al.[16] also observed an increase in elective removal rate from 67% to 73% after the ECC team implementation. Preventive unnecessary removal gradually decreased across 3 years. This could be related to increasing team awareness about the guidelines for prevention and control of catheter-related bloodstream infection 2011 version which recommends that ECC should never be withdrawn simply due to fever and comprehensive team evaluation should be made first.[2,12] Special latex-free gloves were used by the team for the insertion. Extra attention was paid not to touch the catheters during the procedure to prevent phlebitis.

Placement of a PIVC is a painful procedure and is prone to a complication rate. In one of the multicenter observational studies, the first-time success rate was 45%.[18] Because of ECC team implementation, the total number of PIVC was decreased across the 3 years despite the increase in NICU admissions. Our main indication to insert ECCs was the need for prolonged IV therapy and parenteral nutrition. Badheka et al.[17] and Yu et al.[19] reported the same main indication.

There was no statistically significant difference in the overall success rate among different types of catheters (NutriLine 97.4%, MultiCath2 88.4% PremiStar and PremiCath 88.4%; overall $p = 0.281$).

In our study, 58.9% of the total ECCs in 3 years were inserted on the right side of the body. Elective removal was found to be 70.7% on right-sided ECCs versus 68.8% in left with no significant difference. No significant difference was noted between ECCs inserted on the right side of the body compared to the left side in other reasons for catheter removal and overall incidence of catheter-related complications. Paquet et al.[20] reported an overall incidence of complications on the right side was 23% versus 34% on the left side.

Despite 70% of our ECCs were inserted in the lower extremities, we did not observe any difference in the success rates, reasons for catheters removal and catheter-related complications in ECCs inserted in the upper compared to the lower extremities. In three different studies, researchers reported similar findings.[21–23]

In 2018, our mean dwell time was 13.85 ± 12.23 compared to 13.6 ± 6.7 reported by Li et al.[2] In our study, CLABSI was associated with higher mean dwell time (19.50 ± 16.59). Association between longer dwell time and CLABSI has been reported in many studies, though with somewhat conflicting results regarding timing and magnitude of risk.[24–26] Our CLABSI rate was 2.27, 2.46, and 2.34 per 1000 catheter-days in 2016, 2017, and 2018, respectively. It was not significantly affected by the ECC team implementation. This might be due to the task of the ECC team which is related to the line insertion, not the line maintenance. The PREVAIL trial found no evidence of benefit or harm associated with miconazole and rifampicin-impregnated peripherally inserted central catheters (PICCs) compared with standard PICCs for newborn babies.[27] Callejas et al.[28] reported incidence of CLABSI of 4.4, 6.4, and 3.4 per 1000 catheter-days, respectively, for the scalp, upper, and lower limb ECCs. Sengupta et al.[29] reported a CLABSI rate of 2.01 per 1000 catheter-days. The ECC team states that more collaboration among the teams is needed especially during the ECC maintenance and dressing aiming for Zero CLABSI. Surprisingly, our CLABSI rate were 3.8, 3.4, 0.88, and 0.58 per 1000 catheter-days in the gestational age of more than 36 weeks' gestation, between 22 and 28 weeks' gestation, between 32 and 36 weeks' gestation and, between 28 and 32 weeks' gestation, respectively. In a descriptive cohort study, researchers reported a higher CLABSI incidence in neonates with higher birth weight.[30] It is in contrast with other reports with higher CLABSI incidences in neonates with lower birth weight.[31,32]

During these 3 years, no cases of arrhythmia, cardiac tamponade, or pleural effusion at the time of or late after ECC insertions were reported, whereas Li et al.[2] and Yu et al.[19] reported 5 (0.85%) and 3 (0.6%) cases of pleural effusion in their studies respectively. Gilbert et al.[27] reported one serious adverse event involving supraventricular tachycardia following antimicrobial-impregnated ECC placement.

The cost (in Qatari Riyals) of each catheter was as follows: PremiStar: 720 QAR; PremiCath: 305 QAR; NutriLine: 335 QAR and Multicath2: 190 QAR. The average cost (computes considering both cost for each respective catheter type and number of pricks) of ECC lines were 450.25 ± 216.08 QAR, 462.75 ± 255.07 QAR, and 490.48 ± 282.01 QAR in 2016, 2017, and 2018, respectively. The total number of pricks were found to be higher ($n = 751$) in the year 2017 compared to 2018 ($n = 658$) and year 2016 ($n = 587$). The average cost appeared to increase following ECC team implementation as opposed to our expectations. This could be explained by the higher number of ECC insertions and the introduction of PremiStar catheter, which is more expensive than other catheters. The feasibility and cost-effectiveness of the PremiStar catheter in minimizing the CLABSI rate is a promising topic for future Randomized Controlled Trials (RCTs).

Despite being out of the scope of this study and their few numbers, the main limitation is that CICC and FICC are not placed according to the actual standard of care that is., under the US guidance. Therefore, we are not able to perform a proper comparison between CICC/FICC and ECCs. Clinical evidence shows that US-guided insertion is superior to radiological methods as it precisely detects the tip position, significantly reduces the total procedural time, the number of line manipulations and the number of X-rays required. We are planning to implement US-guided insertion as a standard method for ECC tip location. Training is the biggest challenge we face. In addition to the US, a more promising method of ECC tip location is the use of intracavitary ECG. Further large studies are recommended to come up with a conclusion regarding its feasibility in neonates.[5,33–36]

Conclusion

We attribute our high success rates and low rates of major complications to a highly dedicated expert ECC insertion team, well-trained CAP nursing team, multiple simulation workshops, high insertion volumes, and novel catheter material.

The non-significant change in CLABSI rate highlights the importance of not only standardization of line placement but also attention to catheter care and maintenance.

We hope these results will motivate other hospitals to establish ECC teams in their NICUs.

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Significance

What is already known on this subject?

Institution of a dedicated ECC insertion team in NICUs was thought to be beneficial in improving the success rate and minimizing catheter-related complications.

What does this study add?

Implementation of a dedicated ECC insertion team in the NICU substantially improved the success rates and attenuated the impact of ECC insertion on newborns. An expert ECC insertion team eliminated surgically inserted central venous catheters from NICU. Despite the improvement in the success rate and reducing catheter-related complications, standardizing catheter maintenance seems essential to the improvement of CLABSI rates.

Supplemental material

Supplemental material for this article is available online.

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