Clinical trial protocol

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Ultrasound guided percutaneous catheterization of the brachiocephalic vein by small caliber catheter: An alternative to epicutaneo-caval catheter in newborn and premature infants

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Zied Merchaoui, Quitterie Laudouar, Clémence Marais, Luc Morin, Narjess Ghali, Ramy Charbel, Nada Seeman, Mostafa Mokhtari and Pierre Tissières

Abstract

Background: Umbilical Venous Catheter (UVC) and Epicutaneo-Caval Catheters (ECC) are reference catheters in the neonatal period. However, many factors such as the corpulence of neonates, poor venous capital, and anatomical variants can complicate ECC insertion or make it impossible. In newborns with failed ECC insertion, we developed an hybrid technique that combines the insertion of a long-lasting silicone or polyurethane small caliber catheter, usually used as a ECC in newborns, with the ease and speed of ultrasound guided puncture of the brachiocephalic vein (BCV).
Methods: Three years retrospective single center experience of ultrasound guided BCV insertion of silicon or polyurethane small caliber central catheter in a tertiary neonatal intensive care in case of insertion fail of ECC.
Results: Twenty-one echo guided BCV-ECC insertions were performed in 20 newborns. Median age was 16 days (range: 0–110 days), median weight was 1700 g (range: 605–4960 g) at insertion. In most cases, insertion was on the left side (17/21). No failures were noted. Only one attempt was necessary in all cases. Insertion time, when noted, was always of $<$45 min. The median duration of use of these catheters was 11 days (range 3–35 days). No complication was noted during insertion or catheter use, including catheter-related infections and thrombosis.
Conclusion: Echo guided percutaneous catheterization of the brachiocephalic vein with a long lasting silicone or polyurethane small caliber catheter is a safe alternative to the ECC if insertion has failed. However, it requires a mastery of ultrasound-guided insertion technique in term and premature neonates.

Keywords

Echo-guided percutaneous catheterization, brachio-cephalic vein, newborn, premature, central small caliber catheter, silicon, polyurethane

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Introduction

Critically ill newborn, especially premature one, often needs a central venous access. Indications are numerous, such as exclusive or partial parenteral nutrition, hypoglycemia, and administration of veno-toxic drugs or long-term medication.[1–3] Umbilical Venous Catheter (UVC) and Epicutaneo-caval catheters (ECC) are the most frequently used catheters in the neonatal period.[4] Both seem to be equally safe.[5,6] UVC is the first catheter considered at birth because it provides easy and fast access. In addition to its frequent malposition, risk of potential complications (infections, pleural or pericardic effusion, thrombosis, portal cavernoma) limiting UVC indwelling time, UVCs are

Pediatric and Neonatal Intensive Care Unit, Bicêtre Medical Centre, Paris Saclay University, AP HP, Le Kremlin Bicêtre, France

Corresponding author:
Zied Merchaoui, Pediatric and Neonatal Intensive Care Unit, Bicêtre Medical Centre, Paris Saclay University, AP HP, 78, rue du General Leclerc, Le Kremlin Bicêtre 94275, France.
Email: moez_zied_merchaoui@yahoo.fr

relayed by ECCs, which consist of long central silicon or polyurethane vascular catheter of small caliber (1–2.7 Fr). Puncture is done in a peripheral vein of the superior (upper limb, head) or inferior (lower limb) vena caval territory, and catheter tip localized at the cavo-atrial junction.[3] Since its description by Shaw,[7] ECC has become the reference central catheter in the neonatal period. However, newborn corpulence (macrosomia or low weight), poor or altered venous capital and anatomical variants can complicate catheter insertion. As a consequence, procedure can last several hours with multiple attempts by several operators significantly increasing procedural complexity.[6] In newborns and premature infants with failed ECC insertion, ultrasound-guided brachiocephalic vein (BCV) cannulation is feasible.[8] Hereby, we describe an hybrid technique combining rapid insertion of a small caliber (<3 Fr) silicone or polyurethane catheter and safe of ECC through ultrasound-guided puncture of the brachiocephalic vein (BCV).

Methods

Three years (May 2016–2019) retrospective single center experience of ultrasound guided BCV insertion of silicon or polyurethane small caliber central catheter in a tertiary neonatal intensive care in case of insertion fail of ECC.

Ethics

Our study received a favorable ethical statement from the ethics committee of the SRLF (French language intensive care society) under the reference CE SRLF 20-68.

Insertion technique

Installation. First of all, permeability of the vascular axes is checked by ultrasound.[9] The size of the vein, that should ideally match 3:1 to the size of the catheter, which is always the case with a large vein such as the BCV. Then, the baby is installed in supine position. Homolateral arm of the puncture site is positioned along the body and the head slightly turned toward the contralateral side. A cushion is placed under the shoulders perpendicular to the body axis to lift and expose the site of puncture. Intravenous sedation, preserving spontaneous ventilation, with propofol (1–2 mg/kg) or ketamine (2–3 mg/kg) combined with midazolam (10–20 µg/kg) is done before installation. In the absence of an available venous approach, intrarectal sedation is performed using ketamine (5 mg/kg).

Preparation. A four-step large cleaning of the insertion site (neck and supra-clavicular region) is done by the nurse using Codex hypoallergenic single-dose sterile liquid soap (Solvirex, Montrouge, France), and 0.5% alcoholic Chlorhexidine Gluconate (Slap, Decines, France). All equipments are installed on a cart draped with a sterile absorbent field (Foliodrape, Hartmann, Heidenheim, Germany). The operator is dressed with sterile gowns, sterile gloves, mask, and hat. A large transparent sterile bored cover Steri-Drape (3M, Neuss, Germany) is installed on the puncture site. A 0.5% alcoholic Chlorhexidine Gluconate (Slap, Decines, France) disinfection is done. Due to skin fragility in premature infants <32 weeks of gestational age, Chlorhexidine should be rinsed with sterile water after 30 s of contact to avoid skin reactions. Local anesthesia with 1% Lidocaine Hydrochloride (Aguettant, Lyon, France) is performed radially at the puncture site in term neonates.

Figure 1. BCV in a longitudinal view.

Puncture and fixation. Ultrasound tracking is done using L8-18i-D linear array hockey stick ultrasound probe transducer, with a 5–9 MHz frequency range, and 25 mm footprint connected to the LOGIQ E9 ultrasound unit (GE Healthcare, Little Chalfont, UK) and dressed in a sterile cover Microtek (Ecolab, Mosta, Malta). One hand holds the US probe while the other hand guides the needle. The probe is placed on the neck perpendicularly to its axis to locate the homolateral internal jugular vein. The latter is followed in the caudal direction until the probe hits the clavicle. The probe is then tilted to explore the area behind the clavicle. This approach allows us to clear the brachiocephalic vein in a longitudinal section allowing a puncture in plane (Figure 1). Brachiocephalic vein is punctured using a standard 18 Gauge intravenous cannula (1.3 mm × 44 mm, Jelco, Smiths Medical International, Great Britain) loosely attached on a 5 ml syringe in aspiration under ultrasound control. The needle is advanced under continuous screen visualization. As soon as a blood reflux is obtained in the syringe, probe is released and cannula is slided forward a few millimeters as to cannulate the vein. The cannula should not be inserted completely at the risk of abutting the vessel wall and preventing successful catheter insertion. Once the cannula is in place, needle is

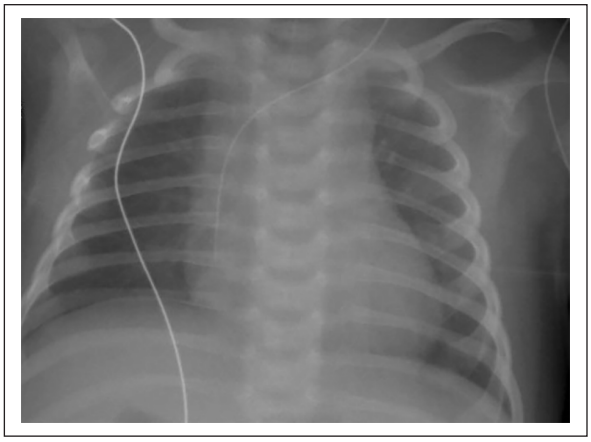

Figure 2. Chest X-ray tip position control.

Figure 3. Catheter dressing.

removed and silicone catheter Neocath 2 Fr–30 cm (Vygon, Ecouen, France) is inserted 5–7 cm with small curved forceps. Intravenous cannula is then removed after mismatching the catheter. During this delicate phase, care must be taken to ensure that the catheter does not withdraw at the same time as the cannula. Using a smaller intravenous cannula (20 Gauge or more) does not allow for safe removal with the risk of removing the catheter at the same time. The silicone part of the catheter is then readjusted on the metal part after having shortened it by 15 cm. This makes it easier to attach to the skin. The position of the tip is then checked with a chest X-ray (Figure 2). Fixation is made with Steristrip (3M, Neuss, Germany), covered with a sterile transparent adhesive dressing type Tegaderm film (3M, Neuss, Germany) or a dressing impregnated with Chlorhexidine Gluconate type Tegaderm CHG (3M, Neuss, Germany) for term newborns (Figure 3).

This technique can be used for all silicon or polyurethane catheters, including those that are not mismatchable. We've already inserted molded polyurethane catheters (non mismatchable) such as Nutriline and Nutriline Twinflo (Vygon, Ecouen, France) by replacing the standard intravenous cannula with the Microsite kit (Vygon, Ecouen, France) containing an introducer needle, a metal guide, and a peelable cannula (a sheath with a dilator). This device allows cannulation of the vein using a modified Seldinger technique. The vein is then punctured with a needle. The metal guide is inserted into the needle, which is removed thereafter. Then cannula is mounted on the guide. Afterwards, guide and cannula chuck are removed, leaving the sheath in place. Silicone or polyurethane catheter is then inserted into the sheath in the desired position and the cannula is peeled. In this case, catheter is not cut and the entire length of the remaining catheter (25 cm on average) was rolled up and fixed with Steri-strips (3M, Neuss, Germany), covered with a sterile transparent adhesive dressing type Tegaderm film (3M, Neuss, Germany) on the skin like a PICC or a dressing impregnated with Chlorhexidine Gluconate type Tegaderm CHG (3M, Neuss, Germany) for term newborns. Cutting the distal tip of the catheter was avoided so as not to increase the risk of mechanical complications. Use of surgical glue on the puncture site is possible.

Results

In a 3 years period, this technique has been used 21 times in 20 term and very low birth weight (VLBW) infants in whom ECC insertion has failed (Table 1). At insertion, these newborns had an average age of 35 days (0–110 days) and an average weight of 2223 g (605–4960 g). Three operators had placed all the catheters. All had good experience with ultrasound-guided puncture. Ventilation mode has never been changed for central venous catheter insertion. Patients were in spontaneous breathing ($n=11$), non-invasive ventilation ($n=5$), or invasive ventilation ($n=5$). Catheter was placed in the left brachiocephalic vein in most cases (17/21, 81%) for anatomical (vein diameter, punction axis), or practical convenience (Catheter already in place in one side). One puncture was needed in all cases. No failure was noted. Insertion time, including fixation and tip position check, did not exceed 45 min in all cases. Catheters remained in place for an average of 12.6 days (1–35 days). Catheter colonization (culture positive after catheter ablation) was observed in only 19% of cases (four cases), all with coagulase negative staphylococcus but no catheter-related bloodstream infection was noted. Neither catheter dysfunction nor clinically symptomatic thrombosis was observed either. However, three catheters were accidentally removed before the end of their use.

Discussion

We describe a direct and "atypical central vascular access" using ultrasound guided insertion of a small caliber (<3 Fr) silicone or polyurethane central catheter, usually used for ECC, into the brachiocephalic vein in the newborn. Although using PICC or ECC, the World Congress on

Table 1. Patients characteristics.

Patients	Catheterization pattern	At birth		At insertion			Side**	Time in place (*d*)
		Term (w/d)	Weight (*g*)	Age (*d*)	Ventilation*	Weight (*g*)		
1	Prematurity	29/1	1160	9	SV	1045	L	5
2	Post Necrotizing EnteroColitis (NEC) digestive stenosis	29/4	1140	72	SV	2800	L	17
3	Intestinal perforation	24/6	725	110	SV	1700	L	11
4	NEC	28/0	675	20	CMV	1005	L	18
5	Prematurity	25/1	795	14	CMV	980	L	35
6	NEC	30/5	580	109	NAVA	2670	R	4
7	Left Congenital Diaphragmatic Hernia (CDH)	39/0	3020	15	NIV	3250	L	11
8	Post NEC digestive stenosis	28/1	810	101	SV	2460	L	15
9	Duodenal atresia	37/0	3430	2	SV	3430	L	13
10	Intestinal perforation	24/3	660	63	SV	1670	L	33
11	Prematurity	24/5	710	3	NIV	605	L	11
12	Prematurity	24/5	710	14	CMV	735	R	28
13	Prematurity	25/3	620	10	NIV	680	R	3
14	Prematurity	32/4	1600	1	SV	1575	L	8
15	Post NEC digestive stenosis	33/5	2850	65	SV	4960	L	10
16	Duodenal atresia	37/3	2890	0	SV	2890	L	9
17	Prematurity	25/5	770	23	HFOV	890	L	11
18	Hail volvulus	36/3	1890	75	SV	3950	L	7
19	Klebsiella pneumoniaie meningitidis	40	3	26	SV	4240	L	3
20	Right CDH	38/2	4280	16	NIV	4240	R	9
21	Prematurity	26/6	940	2	NIV	920	L	4

*SV: spontaneous ventilation; NIV: non invasive ventilation; CMV: conventional mechanical ventilation; HFOV: high frequency oscillatory ventilation; NAVA: neurally adjusted ventilatory assist.
**L: left; R: right.

Vascular Access Foundation recommends new terminology for central venous access[4] defined as a cannulation of deep veins (>7 mm from the surface of the skin). The catheters we have used (Neocath or Nutriline Vygon®) unfortunately do not allow blood to be drawn. To the best of our knowledge, this is the first description in the literature of a direct ultrasound-guided central venous insertion of this kind of catheters to address the difficulties/impossibilities of insertion in some newborns.

Similarly, Pittiruti[11] had described an "atypical" PICC insertion in children and infants with veins too small for peripheral insertion. The catheter was inserted into the supraclavicular area under ultrasound guidance and then tunneled with an outlet port in the anterosuperior homolateral chest in the manner of a Broviac-type catheter. In a previous study, we showed that ultrasound guided cannulation of the BCV is possible and safe in VLBW infants with polyurethane catheters, although requiring mastery in ultrasound guided vascular cannulation.[7] This was also confirmed by Barone et al.[11] in an another study.

Technique described here is used in very low birth weight neonates and/or neonates who need small caliber (<3 Fr) catheters. The approach described could be particularly useful for infants that need IV infusions when there is no available site for cannulation at the limbs or the scalp. The use of new generation polyurethane catheter (3 Fr or more) as CVC placed into the BCV vein is advisable in the care of critically ill infants since such device offer better performances (high flow, suitable for blood products, hemodynamic monitoring etc.).

In the current series, the infant weight was similarly low, with infant weights between 605 and 4960 g at insertion time. Efficacy and safety of this technique is further confirmed with one attempt in all access without any complication. The purpose of this technique is certainly not to replace ECC, which must remain the reference long term vascular access relaying UCC in the neonatal period, but an alternative to vein cutdown or larger central venous catheter in cases of failed vascular access. In addition, the small caliber of the catheter allows it to be kept longer than larger catheter with fewer mechanical complications such as vascular thrombosis and tamponade.

The use of an 18G size cannula to allow safe removal on the catheter is certainly a limitation of technic. We believe that the latter method using modified Seldinger technic with molded catheters is better and safer since we use Microsite kit (Vygon, Ecouen, France) specially designed to introduce small caliber catheter in silicone or polyurethane and including a smaller needle size than the 18 Gauge intravenous cannula used above.

The main disadvantage of direct central catheter insertion over peripheral insertion like in ECC and PICC, is the risk of catheter-related bloodstream infection.[12,13] This has not been noted in our series since no catheter-related infections (local or general) were noted despite having some catheter for up to 35 days. Catheter bacterial colonization was found in only four cases.

The length of the un-inserted catheter (25 cm on average) encourages us to shorten it to facilitate its fixation using Steri-strip and a transparent adhesive dressing in the manner of an ECC. This fixation makes the catheter vulnerable to accidental removal. In our series, three catheters (14%) were torn off before the end of their use.

In our series, the location of the catheter tip was performed with the chest *x*-ray. This is currently outdated. US real-time or real-time IC-ECG verification should be performed.

Conclusion

Ultrasound guided percutaneous catheterization of the brachiocephalic vein with small caliber catheter (<3 Fr) in term and premature neonates is feasible. It can be used with mismatchable catheter but also with molded one using a peelable cannula in both silicone and polyurethane. This technique is a safe alternative to larger central venous catheter or venous cutdown.

Declaration of conflicting interests

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ORCID iD

Zied Merchaoui https://orcid.org/0000-0002-6131-026X

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