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LETTER

Is peripheral venovenous-arterial ECMO a feasible alternative to central cannulation for pediatric refractory septic shock?

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Dear Editor,

Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) for the management of neonatal and pediatric refractory septic shock (RSS) is a controversial intervention [1]. A recent international multicenter retrospective study [2] showed that VA-ECMO was not able to provide a significant survival benefit when compared with standard conventional therapy; however, the use of *central*, atrio-aortic VA-ECMO cannulation, achieving flow rates > 150 ml/kg/min, was associated with improved survival [2]. High-flow VA-ECMO using a *peripheral* configuration is often limited in infants and children below 20 kg due to the small size of the peripheral vessels, femoral vessels in particular [3]. On the other side, the central atrio-aortic cannulation represents a challenging approach in centers without cardiothoracic surgery [3]. Therefore, we propose an alternative peripheral "hybrid" configuration using the bidirectional internal jugular venous cannulation [4], which, in our experience, was able to overcome these limits.

We retrospectively analyzed (2013—2018) all the patients below 20 kg admitted in the pediatric intensive unit of Sabara' Children's Hospital (Sao Paulo, Brazil) with the diagnosis of RSS [5] supported with peripheral venovenous-arterial (VV-A) ECMO draining from both the cephalad jugular vein and the right atrium and reinfusing in the right carotid artery (Fig. 1a—c). Decision to cannulate was taken when the patient failed to respond to maximal medical therapy together with at least one of the following criteria: vasoactive inotropic score (VIS) > 200 or an arterial lactates increase of 1 mmol/L/6 h of care or myocardial dysfunction evaluated with cardiac ultrasound.

Ten patients were included in the analysis. Informed consent to ECMO was requested to the parents before the ECMO start. Nine patients (90%) had positive blood cultures for bacteria species and one (10%) only for yeast (Fig. 1d). Baseline characteristics of the patients included are expressed as median and interquartile range. Age: 4.5 months (IQR: 3.00—24.75); weight: 8.45 kg (IQR: 5.75—13.65); pediatric index of mortality 2: 19.55 (IQR: 17.25—24.00); time from intubation to VV-A ECMO institution: 17.80 h (IQR 11.50—24.80); PaO_2/FiO_2 before ECMO start: 44 (IQR: 40.00—50.00); bedside RSS score [5]: 3 (IQR: 2.25—4.00); vaso-inotropic score: 231.35 (IQR: 220.25—370.35); arterial lactates: 5.58 mmol/L (IQR: 4.25—7.35). Extracorporeal cardiopulmonary resuscitation with VA-ECMO was used in one (10%) patient, and then this configuration was immediately transitioned to VV-A ECMO.

Peripheral VV-A allowed us to achieve a pump flow rate of 160.50 ml/kg/min (IQR: 155.50—170.00) at 4 h after the beginning of ECMO. ECMO duration was 174 h (IQR: 125.50—215.00).

Seven patients (70%) survived to hospital discharge and three (30%) died because of multiorgan failure. Neurological complications (subclinical and clinical seizures, brain ischemia/infarct or hemorrhage) were not reported. Renal replacement therapy was used in nine (90%) patients. ECMO mechanical complications (circuit clots and disseminated intravascular coagulopathy) were reported in three (30%) patients (Fig. 1d). The

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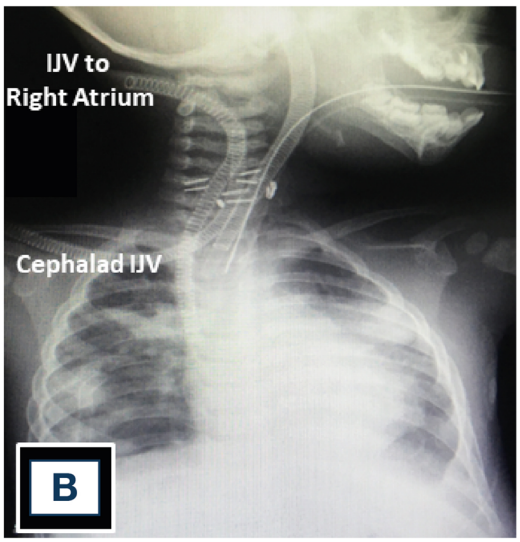

C **Peripheral VV-A ECMO Reference Table**

Weight (kg)	Arterial Cannula (Fr)	Venous Cannula (Fr) + Cephalad Cannula (Fr)	Maximum recorded circuit flow (L/min)
3 - 5	8	8/10 + 8/10	0.5 - 1.1
5 - 10	10 - 12	12-16 + 10-16	1.1 - 1.7
10 - 15	14	16-18 + 12-14	1.5 - 2.4
15 - 20	14 - 16	18-21 + 18	2.4 - 3.2

D Patient	bRSS Score	PaO2/ FiO2	Microbiology Site	Microbiology Organism	ECMO Complication	ECMO Survival
1	3	50	Blood	Streptococcus Pneumoniae	Circuit Clots	Death
2	5	40	Blood	Staphylococcus Aureus	-	Survived
3	2	60	Blood	Candida albicans	-	Survived
4	3	48	Stool	Clostridium Difficile	-	Survived
			Blood	Staphylococcus Aureus		
5	4	44	BAL + Blood	Streptococcus Pneumoniae	Circuit DIC	Survived
6	4	35	Blood	Moraxella Catarrhalis + Klebsiella Pneumoniae	-	Survived
7	5	50	Blood	Escheirichia Coli	-	Death
8	2	42	Abdominal fluid + Blood	Pseudomonas Aerugiunosa	-	Death
9	2	38	Blood	Coagulase-negative Staphylococcus	-	Survived
10	3	70	Blood	Streptococcus Pneumoniae	Circuit DIC	Survived

Fig. 1 **a** VV-A ECMO performed using the right internal jugular vein (cephalad + right atrium cannulation) and the carotid artery; **b** chest X-ray to check the correct position of the cannulas; **c** cannula size reference table for peripheral VV-A ECMO; **d** patients' characteristics and outcome (*bRSS* score bedside refractory septic shock score; *BAL* bronchoalveolar lavage; *DIC* diffuse intravascular coagulopathy)

internal jugular vein as well as the carotid artery was always reconstructed after the weaning of ECMO.

Even though the use of VA-ECMO pediatric septic shock is still not associated with improved survival compared to conventional therapy, data regarding the use of high-flow ECMO are encouraging [2, 3]. The use of the right cephalad vein cannulation [4] allowed us to reach flow rates > 150 ml/kg/min. Further prospective studies should address whether the use of this *peripheral* VV-A configuration could improve the outcome compared with *central* cannulation in pediatric RSS.

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Compliance with ethical standards

Conflicts of interest
All authors declare that they have no conflicts of interest.

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