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## Is there a best approach for extracorporeal life support cannulation: a review of the extracorporeal life support organization

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### ABSTRACT

**Background:** Neurologic complications are common, and amongst the most devastating complications in pediatric patients undergoing extracorporeal life support (ECLS). Carotid artery cannulation (CAN) has been associated with an increase in these complications, thereby shaping practices to avoid this approach in most pediatric patients in which other cannulation approaches are viable.

**Methods:** A retrospective review of children (0–18 years) in the ELSO database was undertaken from 1989 through 2013. Multivariate logistic regression analysis of rates of stroke and other neurologic complications based on cannulation technique was undertaken, adjusting for patient factors including age, underlying disease process, and severity of illness.

**Results:** A total of 30,282 ECLS runs were found in the database. CAN was associated with higher rates of stroke (5.15% vs 3.74%) and overall neurologic complications. However, when correcting for patient factors, including age, underlying disease process, and support type, CAN was not associated with an increased rate of neurologic complications or stroke ( $p > 0.05$  for both).

**Conclusion:** When correcting for patient related factors CAN is not associated with an increase in stroke or neurologic complications. CAN should be re-examined as a cannulation technique for older pediatric patients.

**Level of evidence:** III.

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Neurologic complications, such as bleeding, stroke or seizures, occur in about 20% of pediatric patients during veno-arterial (VA) extracorporeal life support (ECLS). Cannulation via the right common carotid artery (CAN) may result in higher rates of neurologic injury compared to other approaches for VA ECLS [1]. In older children with cardiac failure CAN is largely abandoned in favor of femoral artery cannulation, which is fraught with risks of limb ischemia and amputation [2]. In children on veno-venous (VV) ECLS for severe respiratory failure, the rate of stroke and neurologic complications are unclear. Finally, it is unclear whether delays in initiation of ECLS in order to establish alternative cannulation to the carotid artery is warranted in pediatric patients with profound shock.

The rates of neurologic injury and the use of CAN for VA ECLS are highest in neonates, and interestingly are higher in respiratory failure than in cardiac failure in this age group [1]. However, the risk of ischemic stroke, intracranial hemorrhage, and seizure following CAN for VA

ECLS for various age groups is unclear. The role of CAN in the genesis of neurologic injury when compared to VV ECLS is also unknown as previous studies only compare groups for VA ECLS [1].

The aim of this study is to understand the association that cannulation sites (CAN, aortic, femoral artery, and VV) and age have on rates of neurologic complications in children. We hypothesize that rates of neurologic injury and stroke will increase with CAN and increasing age. The goal is to determine a logical approach to cannulation with an understanding of the inherent risks for each age group and diagnosis.

### 1. Methods

Following an institutional review board waiver, we queried the Extracorporeal Life Support Organization (ELSO) registry from inception in 1989 through 2013. Only patients under 18 years of age who underwent a primary ECLS run were included in the analysis. The ELSO registry was used for analysis, as it includes clinical data from over 30 years, and from 160 US and 120 international centers [3].

Data abstracted included demographic information (gender, age at time of ECLS cannulation, weight, race), modifying factors [(oxygenation

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index (OI), pre-ECLS arrest, support type (Respiratory, Cardiac, or ECP), type of cannulation], and outcomes, specifically mortality and neurologic complications. Variables were chosen based on literature search for variables that affect neurologic outcome or stroke rates and expert opinion.

Patient age was stratified into clinical groups: neonates (age less than 30 days), infants (age 30 days to 1 year), toddlers (age 1–2 years of age), small children (age 2–5 years), large children (age 6–12 years), and teenagers (age 13–17 years). The clinical groups were chosen to prevent bias from a preponderance of neonatal and infant cannulations, as these groups are more likely to have neurologic complications while on ECLS and groin cannulation is extremely difficult, and generally not performed, on patients less than 5 years of age [4]. Additionally, age groups were compared with regard to many of the factors known to affect neurologic outcomes, including support type, cannulation site, and pre-ECLS factors.

Cannulation approaches included VV and VA ECLS as determined by the cannulation sites indicated in the registry data. Dual lumen and single lumen VV ECLS were included in the same group. Additional modes of cannulation, including conversions from VV to VA, or when multiple sites were used (VVA, VAV, etc.), were excluded to remove any bias. VA cannulations were further categorized by site as carotid artery (CAN), femoral (FEM), and aortic (AOR).

Neurologic complications were abstracted from the database. Seizures were diagnosed clinically or with electroencephalogram, and brain death is decided based on the reporting institution's criteria. Additionally, ischemic stroke was defined as a CNS infarct confirmed by ultrasound or CT.

We compared the rates of neurologic injury (seizures, brain death, intracranial hemorrhage) and ischemic stroke across the various age groups.

### 1.1. Statistical analysis

We matched the population of patients with the various cannulations using age, weight, gender, race, oxygenation index, pre-ECLS arrest, and

support type to create a homogenous population to compare neurologic complications for each cannulation site. Finally, we performed multivariate logistic regression analysis of neurologic complications and stroke after correcting for the factors listed above.

## 2. Results

Of a total of 30,282 runs of ECLS, 1334 non-primary runs were excluded to avoid changes in complication rates or cannulation strategies associated with multiple ECLS runs. Of VA cannulations carotid cannulation was performed in 14,517 of the runs that were performed (64%), aortic in 7237 patients (32%), and femoral cannulation in 917 patients (4%) (See Fig. 1). VV cannulations were performed in 5881 patients. Demographic data showed that there was a male predominance, with 56% of patients undergoing a primary run of either VV or VA ECLS being male, and 56% being Caucasian. All cannulation groups were similar when comparing gender, age, weight, and ethnicity between groups (Table 1). Additionally, pre-ECLS factors including oxygenation index and rates of pre-ECLS arrest were similar between groups, as was the etiology of underlying physiologic derangement requiring ECLS (Table 1). The type of cannulation technique when compared between age groups (Table 2) shows a preponderance of neonatal patients in the carotid cannulation group ( $p < 0.001$ ).

Carotid ligation was associated with a higher rate of stroke (OR 1.37), and all types of neurologic complications (OR 1.32) when compared with other sites of arterial cannulation. However, when multivariate analysis was performed to adjust for age, gender, weight, race, in addition to factors affecting the severity of illness (oxygenation index, pre-ECLS arrest, and support type) amongst patients undergoing primary ECLS runs, there was no significant difference in the rates of neurologic complications ( $p > 0.05$  for all groups), or stroke ( $p > 0.05$  for all groups) by cannulation site. Adjusted rates of neurologic injury and stroke were 19.4% and 4.35% in CAN, respectively, compared with 19.5% and 4.5% overall (Table 3).

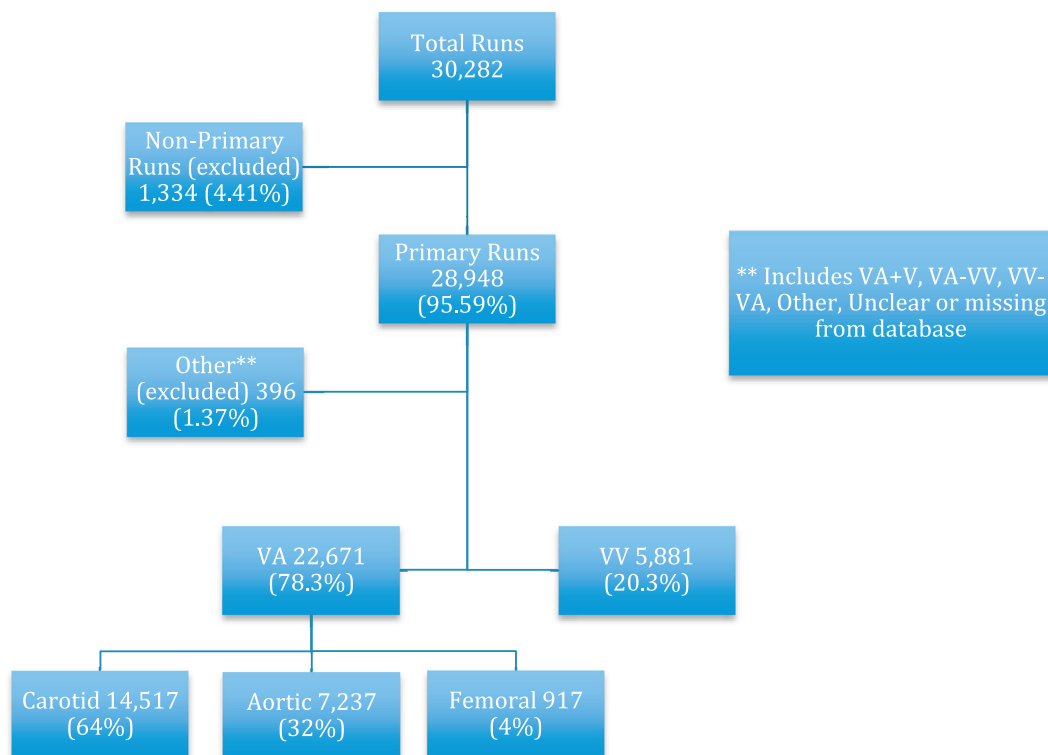


Fig. 1. Flow Chart.

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