# Neuroimaging findings in neonatal and pediatric cases during ECMO support after cardiac surgery

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## Abstract

**Background:** Using of ECMO support after pediatric cardiac surgery played a significant role in changing the survival rate of cases with complex cardiac lesions after cardiac surgeries. However, this was associated with significant increase in the incidence of neurological complications. **Objectives:** Assessment of the incidence and type of different neurological complications in neonatal and pediatric cases during ECMO support after cardiac surgery according to neuroimaging findings.

**Patients and Methods:** This is a retrospective descriptive study including all neonates, and pediatrics who need extracorporeal life support following cardiac surgery at San Donato Hospital - Milan – Italy. According to the neuroimaging findings (MRI, CT, and EEG), neurological complications were classified to ischemic stroke, hemorrhagic stroke, and epileptogenic focus.

**Results:** Neurological complications were found in (35 %) on neonates and pediatrics during ECMO support after cardiac surgery. The commonest neurological complication was the ischemic stroke (20 %), followed by hemorrhagic stroke (10 %). The commonest imaging tools used for diagnosis of neurological complications during ECMO support were brain MRI, followed by EEG, while brain CT was the least used tool. According to the images results, the commonest finding in ischemic stroke was diffuse brain injury (54.5 %), followed by Right temporal lobe infarction (36.5 %), while the commonest findings in hemorrhagic stroke were right occipital hemorrhage (28.6 %), and cerebellar hemorrhage (28.6 %).

**Conclusion:** Ischemic stroke was the commonest neurological complication in pediatric cases received ECMO support after cardiac surgery. Unilateral right sided lesions were the commonest site of neurological complications during ECMO support. The commonest form of ICH during ECMO support was intra parenchymal hemorrhage. Brain MRI was the commonest neuroimaging tool used for confirming diagnosis.



**Key Words:** ECMO – Pediatrics – Postoperative –Cardiac – Neurological complication.

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## Introduction

Using of ECMO support after pediatric cardiac surgery played a significant role in changing the survival rate of cases with complex cardiac lesions after cardiac surgeries. However, improving the survival rate was associated with significant increase in post operative complications. The rapid neuronal proliferation and development of neonatal and pediatric brain, place it at high risk for ischemia and reperfusion injury, this can explain the high incidence of neurologic injury during ECMO support after cardiac surgery. However, with the significant improvements in neonatal and pediatric cardiac surgical techniques and adopting newer neuro-protective methods, the worse neurological outcomes have been reduced from 25% to less than 5% over a decade (1).

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## Materials and Methods

Our study is a retrospective descriptive study including all neonates, and pediatrics (<18 years of age) who need extracorporeal life support following cardiac surgery at San Donato Hospital – Milan – Italy. Data were collected retrospectively from patient's medical records database of ECMO/ECLS Unit, and Post-operative cardiac ICU of San Donato Hospital - Milan – Italy.

Inclusion criteria were all pediatric patients from 1 day of age till 18 years of age, both genders were included, all cardiac operations are included (open – closed), and all pediatric patients undergoing cardiac surgery and need extracorporeal life support in operation theatre, in the post operative ICU, or post cardiotomy CPR. Exclusion criteria were patient with insufficient data, and know neurologically impaired patients prior to surgery.

Assessment of the incidence of neurological complications during ECMO support in pediatric postoperative cardiac surgery by the imaging findings (Brain CT, Brain MRI, and EEG). According to the neuroimaging, neurological complications were classified to ischemic stroke, hemorrhagic stroke, and epileptogenic focus.

### *Statistical analysis*

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Categorical data were compared using Chi-square or Fisher's exact test, while numerical data were compared using student t test.

## Results

Our study is a retrospective descriptive study including all pediatric cases who need extracorporeal life support following cardiac surgery at San Donato Hospital - Milan – Italy.

Neurological complications were found in (35 %) on neonates and pediatrics during ECMO support after cardiac surgery.

According to the imaging findings, neurological complications were classified to ischemic stroke, hemorrhagic stroke, and epileptogenic focus. The commonest neurological complication was the ischemic stroke (20 %), followed by hemorrhagic stroke (10 %).

The commonest imaging tools used for diagnosis of neurological complications during ECMO support were brain MRI, followed by EEG, while brain CT was the least used tool.

According to the images results, the commonest finding in ischemic stroke was diffuse brain injury (54.5 %), followed by Right temporal lobe infarction (36.5 %), while the commonest findings in hemorrhagic stroke were right occipital hemorrhage (28.6 %), and cerebellar hemorrhage (28.6 %).

## Discussion

Pediatric brain's rapid neuronal proliferation and development, heavy axonal growth, fragile vasculature and high metabolic rate place it at high risk for ischemia and reperfusion injury (2).



Neurologic injury associated with extracorporeal life support (ECLS) ranges from subtle neurocognitive defects to devastating intracranial hemorrhage to brain death. Injury may be sustained prior to ECLS support, during ECLS support, or after ECLS support has been discontinued. Neurologic complications reported to ELSO include hemorrhage and infarction documented by ultrasound and or computed tomography, clinical seizures, EEG documented seizures, and brain death (3).

Patients supported by ECLS are at risk of neurologic injury from pre-ECLS factors including hypoxia, acidosis, hypotension and low cardiac output, infection, and organ failure, and from ECLS factors including hemorrhage, infarction, seizures, disrupted cerebral circulation, and development of new organ failure (4).

Neurological complications occurs frequently in neonates and pediatrics after congenital cardiac surgery (5). However, with the significant improvements in neonatal and pediatric cardiac surgical techniques and adopting newer neuro-protective methods and modified by pass strategies, the worse neurological outcomes have been reduced from 25% to less than 5% over a decade (1).

In our study, a higher incidence of neurological complications was found. In contrast to previous studies higher incidence of hemorrhagic stroke during ECMO support (6, 7), our study showed that ischemic strokes were the commonest neurological finding in neuroimaging.

Cranial US is the first line imaging technique used for screening and monitoring neurological complications in neonates and infants during ECMO

support, however significant limitations leave CT and MRI as the modality of choice for confirming and demonstrating the extent of significant pathologies during ECMO support, particularly when important treatment decisions are required (8). MRI is more sensitive and specific, But ECMO equipment is not MRI-compatible, and brain MRI studies are therefore limited to the post decannulation period.

Our study has the limitation of being a retrospective, and retrieving the documented data of cranial US done to neonates and young infants during ECMO support was difficult, so confirmation of neurological complications were depending on CT, MRI, and EEG done during or after weaning of ECMO support. In our study, the commonest imaging tools used for confirmation of neurological complications during ECMO support were brain MRI for 13 times, followed by EEG for 11 times, while brain CT was the least used tool in only 4 times.

In a single center pediatric study of neurological injuries during ECMO support, the majority of strokes were bilateral, followed by unilateral right sided lesions and no patients had unilateral left sided strokes; majority of the lesions were in the anterior cerebral circulation distribution (9). Comparing to our results, unilateral right sided lesions were found in 50 % of cases with neurological complications during ECMO support, with Right temporal lobe affection in 25 %, while diffuse injuries were found in 30 % of cases, and in similar, no documented cases with unilateral left sided strokes.

In our study the commonest form of ICH during ECMO support was intra parenchymal hemorrhage (70 %), while subarachnoid hemorrhage, and subdural hemorrhage were only one case for each. Similar results were found in a study done on 65 adult patients with intracranial hemorrhage during ECMO support, intra parenchymal hemorrhage was the commonest form by 76%, while subarachnoid hemorrhage, and subdural hemorrhage, represent only 22 %, and 2 % respectively (10).

## Conclusion

Ischemic stroke was the commonest neurological complication in pediatric cases received ECMO support after cardiac surgery. Unilateral right sided lesions were the commonest site of neurological complications during ECMO support. The commonest form of ICH during ECMO support was intra parenchymal hemorrhage. Brain MRI was the commonest neuroimaging tool used for confirming diagnosis.

## Abbreviations

**CT:** Computerized tomography, **DCL:** Disturbed conscious level, **ECMO:** Extracorporeal membrane oxygenation, **EEG:** Electroencephalogram, **ICH:** Intracranial hemorrhage, **MRI:** Magnetic resonance imaging.

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## Conflict of interest

Authors declare no conflict of interest.

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