"Prolonged" venoarterial extracorporeal membrane oxygenation support for respiratory failure: Outcome in an infant

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ABSTRACT

Extracorporeal membrane oxygenation (ECMO) is a form of extracorporeal life support which provides cardiorespiratory support to patients with potentially reversible pathophysiological processes. ECMO has evolved over the past few decades as a standard technology for neonatal severe respiratory support. However, its use in the pediatric population has increased only since 2009. We report a case of a 9-month infant who required a prolonged (789 h) venoarterial ECMO for severe acute respiratory distress consequent to pneumonia probably secondary to aspiration. He was discharged after this prolonged ECMO run without any obvious unfavorable outcome and is neurodevelopmentally sound at a 26-month follow-up.

Keywords: Complications, extracorporeal membrane oxygenation run, extracorporeal membrane oxygenation, pediatric, pneumonia, survival

INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) may be utilized in children with respiratory failure unresponsive to other modalities. Extracorporeal life support (ECLS) registry of 2017 states an average run time for aspiration pneumonia in pediatrics of 241 h with 67% survival to discharge.[1] We report a case of a 9-month infant with refractory hypoxemia subsequent to pneumonia who sustained an ECMO run of 789 h 40 min. Despite an extensive literature search, we did not encounter any case report on the longest pediatric ECMO in India reporting survival to hospital discharge to date without any adverse sequelae.

CASE REPORT

A 9-month-old male weighing 9 kg presented with cough for 2 months and breathlessness for 7 days. Parents recall an episode of sudden agitation with pallor followed by a bout of cough 2 months ago. He was diagnosed with pneumonia elsewhere and managed on nebulization and antibiotics. Due to a poor response to treatment was referred to our center.

His physical examination revealed a respiratory rate of 48/min with suprasternal and subcostal retractions and coarse basal crepitations.

His oxygen saturation (SPO_2) was 90% on high flow nasal cannula at 2l/kg/min. Arterial blood gas (ABG) analysis revealed pH 7.3, PCO_2 29.4 mmHg, PO_2 54.3 mmHg, and HCO_3 19 mmol/L. Hypoxemia worsened indicating endotracheal intubation 6 h posthospitalization. Transthoracic echocardiography ruled out cardiac pathology. Chest X-ray (CXR) showed bilateral infiltrates.

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Contrast-enhanced computed tomography (CECT) of the chest revealed consolidation in the lower lobes [Figure 1]. He was diagnosed with severe Acute respiratory distress syndrome (ARDS) consequent to pneumonia, probably due to aspiration. Failing prone positioning and high-frequency oscillation, at 16 h of admission, the infant was initiated on venoarterial ECMO (Pediatric permanent life support kit with Medos, Hilite 2400 system, hollow fiber oxygenator, Germany) with heparin-coated circuit. The right common carotid artery and right internal jugular vein were cannulated using 12 Fr and 15 Fr wire reinforced cannulae (Bio-Medicus NextGen, Medtronic, USA), respectively. Venovenous ECMO, though preferable in this setting, could not be utilized owing to the unavailability of a double-lumen ECMO cannula. Pre- and postpump with postmembrane pressures were monitored.

The patient was maintained on ECMO flow rates 850–950 ml/min, FiO_2 0.21–0.4, and sweep gas flow 0.4–0.6 L/min. ABG targets were pH >7.35, PCO_2 40–45 mmHg, and PO_2 130–150 mmHg. On ECMO, "resting lung ventilation" parameters (pressure control mode frequency 10/min, PIP 10 cm H_2O, PEEP 10 cm H_20, and FiO_2 0.21) were maintained.

Activated clotting time (ACT) of 180–220 s was targeted by titrating unfractionated heparin infusion 5–10 U/kg/h. Neuromonitoring included near-infrared spectroscopy, regular pupillary reaction, and daily cranial ultrasound. Flexible bronchoscopy ruled out H-type tracheoesophageal fistula attributable to aspiration. The initial culture of blood and endotracheal tube aspirate was sterile. Empirically, antibiotics ceftriaxone and clindamycin were started. Bronchoalveolar lavage fluid tested negative for tuberculosis, Pneumocystis carinii pneumonia, and fungus. Serial CXR and CECT chest showed minimal improvement [Figure 2a]. On day 3, serum galactomannan was significant so voriconazole was added. On the 5th day, of ECMO, blood culture revealed *Stenotrophomonas* and endotracheal tube culture revealed *Pseudomonas* which was treated with injection colistin and meropenem. Episodes of melena and hematuria with cannulation site bleed necessitated cessation of heparin with a close watch on pre- and postoxygenator pressures. On day 18, oxygenator malfunction was detected and the faulty oxygenator was changed to Maquet AG (Hirrlingen, Germany). ECMO flows were re-established and a trial to wean was attempted, which was unsuccessful. At the beginning of the 3rd week of ECMO initiation, some improvement in lung mechanics and CXR were noted. A weaning trial was again attempted on day 30 which was aborted due to hypoxemia that ensued on ECMO flows below 40%.

His course was punctuated by intermittent fever spikes and thrombocytopenia. On day 20 of ECMO, endotracheal tube culture revealed *Stenotrophomonas* which was managed by amikacin. Despite sensitive antibiotics (levofloxacin, minocycline, and ceftazidime) Gram-negative septicemia persisted. After 67 days of hospitalization, he was documented free of blood and endotracheal sepsis. With cultures turning negative, thrombocytopenia gradually improved. Throughout the course, 20 units of packed red blood cells, 62 units of platelets, 8 units of fresh frozen plasma, and 8 units of cryoprecipitate were transfused to target hemoglobin >8 gm%, platelet counts 60,000–80,000/microliter, and fibrinogen >1 gm/L. The third weaning trial on day 32 of hospitalization was successful. After 18 h of stability on idle flows, the patient was decannulated [Figure 2b].

Post-ECMO, his ventilation was supported with "pressure regulated volume controlled" mode. CECT chest revealed fibrosis bilaterally in the posterior and basal lung segments which were treated with intravenous Methylprednisolone 10 mg BD (tapering dose). Transthoracic echocardiography showed no pulmonary hypertension. On the 75th day, he was successfully weaned from mechanical ventilation [Figure 2c] and discharged on day 88 of hospitalization with a tracheostomy tube and a weight of 7 kg without obvious neurological sequelae.

At 2 months postdischarge, he was decannulated off the tracheostomy tube. Cannulated neck vessels were patent in Doppler study. On regular follow-up, clinical examinations including anthropometry and SPO_2 are

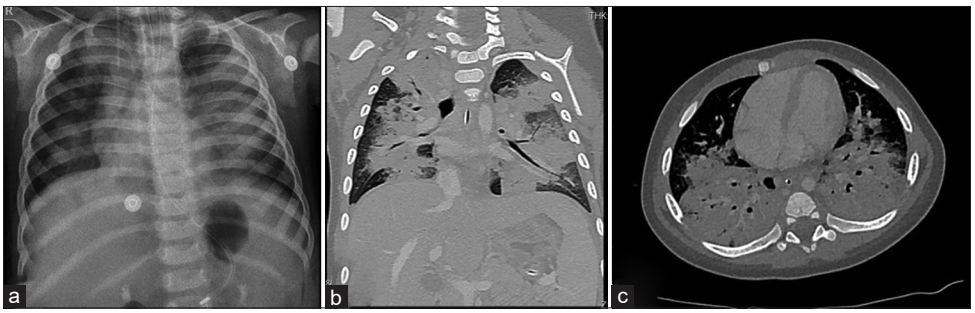

Figure 1: Images of chest X-ray (a) and CECT chest, (b and c) on admission. CECT: Contrast-enhanced computed tomography

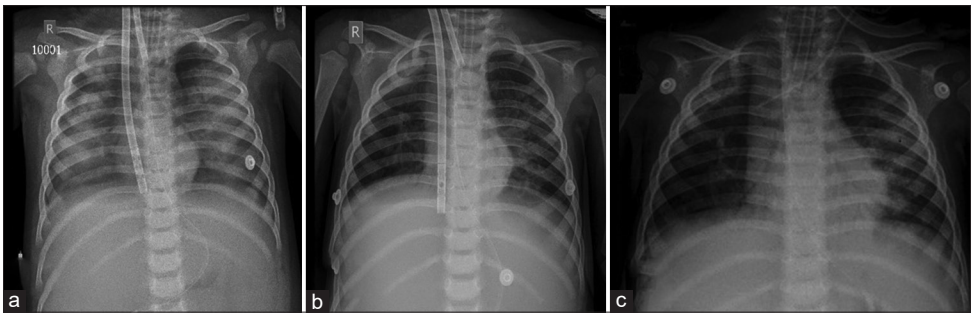

Figure 2: Serial chest X-rays (a) Day 5 on ECMO, (b) before decannulation, (c) On discharge. ECMO: Extracorporeal membrane oxygenation

measured. At 3 years postdischarge, he is clinically doing well and gaining weight (16 kg). Echocardiography, CECT chest, neurodevelopmental evaluation, and electroencephalography are normal.

DISCUSSION

ECMO has evolved as a standard treatment for neonates with unresponsive respiratory failure.[2] As per the 2021 ECLS Registry, of all neonates on ECMO for respiratory indications, 73% survived to hospital discharge versus 60% in pediatrics.[3]

The Arkansas Children's Hospital is the largest study reporting survival of children requiring ECMO >28 days.[4] Of the total of 984 runs, only 22 runs were >28 days. Of the 3 alive after 1 year, 2 had neurologic issues, and 1 awaiting a renal transplant.

As per the ECLS registry 2017, the average run time for pediatric aspiration pneumonia is 241 h; the longest being 2437 h.[1] After an extensive literature search, we did not observe any published Indian literature on "prolonged" pediatric ECMO runs. We believe that this case is the longest (789 h 40 min) reported successful ECMO run in India for pediatric respiratory failure.

The duration of conventional ventilation before ECMO support has a significant impact on survival.[5] In our patient, a short duration (10 h) of conventional ventilation, probably contributed to increased survival.

Managing anticoagulation and simultaneously preventing bleeding complications on ECMO was a challenge. In our case, ACT targeted anticoagulation, avoidance/prompt treatment of hypertensive episodes, targeting platelets around 80,000, and fibrinogen to 1 g/L was adhered to. ECMO circuit was continuously monitored for thrombi/fibrin by visual inspection and prepump and postoxygenator pressures and ABG. Heparin-coated circuit allowed a lower dose of systemic heparinization. Heparin activity was monitored with ACT every 4 h supplemented by activated partial thromboplastin time every 4 h. Thromboelastography being cost-ineffective, was done only during active bleeding. Simultaneous continuous neuromonitoring prevented the complications of intracranial bleed and stroke while on ECMO.

After initial interspersed infections, blood and endotracheal tube cultures remained positive which were managed with culture-sensitive antibiotics.

Prolonged ECMO survivors show varying neurological, gastrointestinal, and chronic lung problems.[2,4,6-8] During each follow-up visit, the growth pattern, and respiratory and neurological systems are assessed. Our patient survived a long ECMO run and has not shown any sequelae in early follow-up but long-term consequences need to be monitored.

Although recommendations have been set for the initiation of ECMO in pediatrics, guidelines for weaning/termination are scanty.[4]

Sustaining such a long ECMO run required good coordination between the intensivists, pediatric surgeons, pediatric cardiologists, anesthesiologists, and the perfusionists.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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