

Prolonged Extracorporeal Circulation In A Neonatal Meconium Aspiration: A Case Report

Nick J. Haiduc, CCP; Nancy Wetmore, R.N.;
M. R. Jefferies, M.D.; and R. H. Bartlett, M.D.

Our current series of ECMO patients includes 24 children and 16 adults. The best results have been obtained in supporting newborn infants. In our newborn series the major complications were related to intracranial hemorrhage and progression to pulmonary fibrosis despite the intervention of ECMO. The following case is presented to illustrate patient selection and ECMO management.

This infant was born 4-6 weeks post mature to a non-diabetic mother. The baby weighed 5.5 kilograms at birth and was delivered by C-section after elective rupture of membranes did not result in progression of labor. The baby had the classical symptoms of post maturity with long fingernails, etc. Meconium staining and aspiration was noted at birth. Intubation and moderate lavage was performed early after birth. A few hours after birth we were contacted to evaluate this patient as a possible ECMO candidate. At approximately 12 hours of age the baby severely deteriorated requiring a high ventilator pressure and 100% oxygen, but maintaining PO₂'s below 20. The PH dropped for the first time below 7.0 during this episode. Cardiac catheterization was done in the afternoon with the baby in an extreme moribund state. Priscoline was given into the pulmonary artery with moderate improvement (PO₂'s increased to 40, PH to 7.2). With this improvement and in the absence of other abnormalities it was elected to transfer the baby to UCI Medical Center for ECMO support.

Upon arrival to the Neonatal ICU the patient was stable and improved somewhat over the next few hours. Ventilator pressure was decreased to 50 centimeters of water and respiratory rate was increased. At these settings, PO₂'s in the 40's and 50's were maintained. The Epinephrin drip which had been instituted was stopped and no further Priscoline was required. Chest x-ray showed bilateral pneumothorax which was treated with bilateral chest tubes with further improvement. However, the baby would not tolerate less than 100% oxygen.

On the basis of the baby's deteriorating physiological condition despite maximal ventilatory and pharmacological management, and after an informed consent was obtained from the parents, we proceeded with the necessary preparations to place the child on ECMO.

Our ECMO circuit has been described in detail elsewhere (^{1,2,3}). Briefly, the circuit consisted of a two squared clinical Lande-Edwards membrane oxygenator, a Travenol infant miniprime heat exchanger, and the A-O servo-regulated pump. Quarter inch tubing was used throughout. The circuit was primed with packed cells and fresh frozen plasma. The electrolyte composition of the prime was abnormal with a sodium of 250, chloride of 130, and a glucose greater than 500. The calcium, potassium, and PH were within normal limits.

The neck vessels were cannulated without difficulty. The baby tolerated occlusion of the right carotid artery with no loss in neurological function. This artery was ligated and a #12 French Argyle chest tube was passed without difficulty into the carotid arteriotomy to the level of the aortic arch. Next, the internal jugular vein was easily cannulated with a #16 French Argyle chest tube proximally and an IV extension tube distally. Bypass was slowly started to allow adequate mixing of the prime with the baby's own blood volume. Flows of 800 cc's per minute were reached without stressing the extracorporeal system. This flow rate is considerably greater than the normal cardiac output for this baby, but we considered this high output secondary to sepsis. The perfusion flow was decreased to 500 cc's per minute and after a moderate period of stabilization, excellent bypass flows could be maintained. No volume requirement occurred and the blood pressure remained normal throughout. Baseline pulmonary artery and systemic blood pressure were equal before bypass. With the institution of bypass the PA pressure decreased to a level of approximately half that of the systemic pressure. Excellent gas exchange was obtained with the PH returning to normal. The FiO_2 was decreased to 50%.

Lung lavage was carried out. The return was relatively small and appeared to be meconium stained. The return also contained a large amount of mucus and tissue. This seemed to establish the primary diagnosis of meconium aspiration rather than respiratory distress syndrome or persistent fetal circulation.

The high levels of bypass flow and our inability to affect the systemic pulse contour when the pulmonary artery pulse contour became non-pulsatile suggested that the ductus was opened and the perfusion blood was going through the systemic circuit as well as through a patent ductus into the lungs. This appeared to be confirmed by a PO_2 in the pulmonary artery which was greater than the PO_2 in the systemic artery, but less than the PO_2 from the oxygenator. It was suggested that the patent ductus should be ligated in order to affect good peripheral perfusion in this patient.

Throughout the day satisfactory perfusion was maintained. After 10 minutes off ECMO, with an FiO_2 of 100% and a ventilator pressure of 40/5, PCO_2 was 23 from the umbilical artery and 27 from the pulmonary artery. Persistent hypernatremia with serum sodiums of 160-180 was a problem during this time. Large amounts of free water was given intravenously and diuresis was induced with Lasix. Bypass flows of 600-800 cc's per minute was necessary to maintain adequate systemic perfusion. Because of the possibility of persistent patent ductus arteriosus with left to right shunting, fluoroscopy and dye injection was planned to define the vascular anatomy in the chest.

Fluoroscopy was carried out with a portable fluoroscope and TV tape recorder. Three boluses of dye (15 cc's) were injected into the arterial perfusion catheter. Two satisfactory images were made, one in the left arterial oblique position and one in the straight AP position. These dye studies demonstrated filling of the aortic route to the aortic valve, a normal aortic arch and branches, good perfusion of the right subclavian and right vertebral, the left-sided arch vessels and the descending aorta. No ductus arteriosus or pulmonary vessels were visualized on these studies. A Swan Ganz catheter which had been placed into the pulmonary artery appeared to be through the ductus and into the mid-aortic arch. After reviewing these studies, the Swan Ganz catheter was pulled back 3 cm with

continuous pressure recording. After the catheter was pulled back into the pulmonary artery a mean pressure of 30 mmHg was attained at bypass flows of 600 cc's per minute. Over the next 10 minutes pulmonary artery pressure gradually fell to 4 mmHg suggesting that the patent ductus had closed with this maneuver. Blood gases, which had been decreasing slightly, improved considerably at this time.

The serum sodium gradually returned to normal (147) with free water loading during the day. However, urinary output was minimal and did not respond well to Lasix. The baby was generally edematous with 3-500 cc's ahead on fluid balance. This enlarged extra-vascular fluid volume accounted for some of the poor blood gases, as the large blood volume allowed a significant amount of blood to go through the pulmonary artery as well as through the bypass circuit which was flowing at 800 cc's per minute. At this point it was essential to remove a significant amount of extra-cellular fluid. If diuresis did not satisfy this requirement hemodialysis would be considered. The following day the baby was tested off bypass, lung function was minimal with PO_2 's under 20 on 100% oxygen with a ventilatory pressure of 40. The baby was extremely edematous with 600-1000 cc's ahead on fluid balance related to his renal failure. No significant diuresis occurred despite excellent bypass flows of 700 cc's per minute diuresis. Two measures were undertaken to counteract the edema. An exchange transfusion was done removing blood and substituting pack cells with an intentional negative balance of 90 cc's. This decreased the systemic blood pressure somewhat and raised the hematocrit. Following this, hemodialysis was undertaken. A Dow Hollow Fiber kidney was used. A portion of the extracorporeal blood volume was diverted from the pump arterial venous line. Approximately 100 cc's of extra-cellular fluid was dialyzed over a short period of time. This resulted in an episode of severe hypotension with a blood pressure of 25 mmHg for approximately 1/2 hour. The volume loss was replaced with colloid solution and blood with elevation of blood pressure.

Prior to dialysis, the baby was being pharmacologically treated for continuous seizures but was still responsive to stimuli and seemed to cry and suck normally. Following dialysis the baby was flacid and unresponsive and remained that way throughout the following night. The pupils were in the mid-position and did not react to light. The fontanelle became tense. Early the next day the blood pressure and pulse rate began to fall requiring albumin replacement and then Epinephrin drip to maintain blood pressure. In the absence of any other abnormalities we thought this was probably due to the brainstem compression, despite the heparinization.

The neurosurgeon was consulted to explore the subdural and ventricular space for any signs of intracranial bleeding. The findings were negative for subdural or ventricular hematoma, or hydrocephalus. It was felt that the neurologic status and the tense fontanelle probably represented cerebral edema only. A program of Decadron was instituted with a plan to continue hemodialysis. Hemodialysis was carried out for approximately four hours using a pediatric Gambro dialyzer. The take-off to the dialyzer was veno-venous. Approximately 60 cc's/hr of ECF was removed with this system. The patients blood pressure was very sensitive to the fluid volume shifts. Some blood and albumin replacement was required during this dialysis, but in general it proceeded extremely smooth. Neurological status did not improve during dialysis, although peripheral edema, periorbital edema, etc., decreased considerably. The fontanelle remained tense after dialysis. Lung function

testing after dialysis showed essentially no improvement with a PO₂ of 12, PH of 7.2. Bradycardia and hypotension occurred after two minutes of off bypass testing. Renal function appeared to be recovering and the baby voided 20 cc's of clear urine.

An electroencephalogram was performed on and off bypass following dialysis. The tracing was reviewed by the neurosurgeon who found no sign of cortical activity and concluded that the brain was irreversibly and totally damaged. This correlated well with the physical examination which included no dolls eye motion on head turning, no spontaneous respirations, no spontaneous movements, no response to any stimuli of any sort. The pupils were mid-position, fixed, and did not react to light. Lung function off bypass was evaluated. During this test period a cardiac arrest occurred and two minutes thereafter the procedure was terminated. Post mortum examination revealed extensive lung fibrosis and intra-cranial bleed.

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From the Department of Surgery, University of California at Irvine Irvine, California 92717