TITLE: PULMONARY EFFECTS OF PREOPERATIVE EXTRACORPOREAL MEMBRANE OXYGENATION IN CONGENITAL DIAPHRAGMATIC HERNIA.

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Congenital diaphragmatic hernia (CDH) has a high mortality despite improvements in perioperative intensive care. The emergency surgical repair of CDH on the day of birth compromises pulmonary mechanics (Ref 1), probably as the net result of pulmonary hypoplasia, distortion and cephalad displacement of the diaphragm, pulmonary hypertension and the hypoxia that results. Preoperative stabilization before surgical intervention may avoid deterioration in respiratory mechanics and improve the survival of affected infants.

We performed serial pulmonary function tests (PFT) in 16 newborn infants with CDH, and 4 surgical infants without pulmonary hypoplasia as controls, using passive partial expiratory flow-volume curve technique (Ref 2) to measure respiratory system compliance (Crs, ml/cm H2O/kg). All CDH patients had respiratory distress immediately after birth, and required mechanical ventilation with muscle paralysis. Twelve babies underwent emergency repair (4 survived, 8 died), of whom 9 received ECMO support after operation (1 survived, 8 died). Four with severe hypoxemia were placed immediately on preoperative ECMO for 4 to 7 days. One died from intraventricular hemorrhage; 3 survived and underwent surgical repair at 5 to 8 days after birth.

In the group with surgical repair immediately after birth, Crs failed to improve during the first week of life, a time when control infants showed a rapid increase in Crs ($p < 0.001$, Figure 1). No significant change occured in Crs during postoperative ECMO. In contrast, in the group with delayed surgery, Crs increased two-fold during a period of preoperative ECMO support ($r = 0.80$, $p < 0.001$; Figure 2). The rapid increase in Crs in preoperative ECMO patients was not seen in either patients surviving or dying after immediate repair of CDH after birth ($F = 7.47$, $p < 0.001$). The differences in Crs between preoperative ECMO and both survivors and deaths after immediate repair were significant ($p < 0.01$ and $p < 0.05$, respectively). These observations provide physiologic evidence of possible benefits of preoperative stabilization on ECMO.

Figure 1. All CDH vs controls.

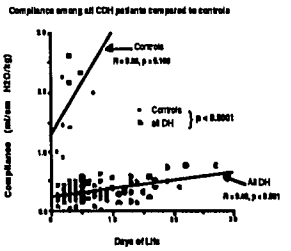
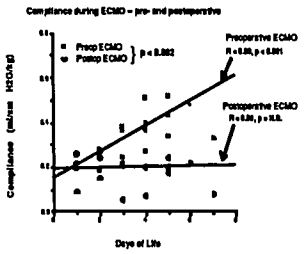


Fig. 2. Crs during pre- and postop ECMO.



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1. J Pediatr 111:432,1987.
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TITLE: HEMODILUTION FOR HEART SURGERY IN CHILDREN

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INTRODUCTION: In open heart surgery, the use of blood products has been routine. This is particularly true with pediatric patients, for whom the cardiopulmonary bypass (CPB) apparatus is primed with blood. The purpose of this study is: (1) to determine if pediatric patients can be hemodiluted during open heart surgery, and (2) to determine what factors are important in predicting the success of this bloodless technique.

METHODS: This study received the approval of the University of Michigan Institutional Review Board for Human Use. Children of ages newborn thru 14 years, weighing less than 50 kg, presenting for open heart surgery were entered into this study if their predicted Hct on bypass with a bloodless prime was greater than 15, and they were undergoing a corrective procedure for their underlying congenital malformation. If their Hct and physiology allowed removal of at least 150 ml of blood prior to bypass, and they still met the above criteria, they were phlebotomized. The CPB circuit was assembled in a fashion to minimize tubing length, and was primed with Normosol-R and albumen. Bicarbonate was added to bring the pH to 7.4 at 37°C. A Scimed® membrane oxygenator sized according to the child's weight was utilized. Careful surgical technique was used, and cell savers were utilized in children presenting for redo operations. Hemodilution was aborted if the venous saturations fell below 35%, or if there was no urine output on pump. Mannitol ± lasix was used to stimulate urine flow, if warranted. Hemoconcentration was performed using a Hemochor 0.25 during CPB. At the end of the bypass period the protamine was given, phlebotomized blood was returned, and all the blood in the bypass circuit was returned to the patient. Data was collected regarding patient age, weight, presence of cyanosis, procedure, blood volume, amount of blood removed pre-pump, bypass priming volume, cardioplegia volume, electrolytes, urine output, total fluid administration, and pump time. Hematocrits were drawn preop, pre-pump, 15 min on bypass, prior to termination of bypass, on arrival in ICU, at discharge from the hospital, and six weeks postop. Students *t*-test, contingency tables, and ANOVA were used to determine statistically significant variables between patients who could or could not be successfully hemodiluted.

RESULTS: Children as young as 7 mos., and as small as 5.6 kg., were successfully hemodiluted. There were no differences in weight, blood volume, red cell mass, cyanosis, starting Hct, the amount of blood drawn off, the first Hct on pump, sodium on pump, urine on pump, final Hct on pump, amount ultrafiltrated, intraoperative fluid, and Hct 6 weeks postop between those who were and those who were not successfully diluted. There was a significant difference† in the age means (5.1 *vs.* 3.2), total pump time (69 *vs.* 93), Hct upon arrival in ICU (29 *vs.* 36), starting Hct divided by discharge Hct (1.4 *vs.* 1.1), and pump volume (pv) divided by estimated blood volume (EBV) (1.3 *vs.*1.6) between successful & non-successful hemodilutions. A significant number† of patients who had blood drawn off pre-pump could be successfully hemodiluted.

DISCUSSION: In order to hemodilute children successfully, care must be taken to minimize blood loss preoperatively, intraoperatively, and postoperatively. The CPB circuit should be assembled so as to minimize tubing length. A brisk urine output should be stimulated to return the Hct to its highest level as quickly as possible. Serum potassium levels must be closely monitored because of the high urine flow. Though age was a significant factor in predicting success, another predictor was the ratio of pv to EBV. When the ratio was ≤1.3, there was a 77% incidence of success; if the ratio was >1.5, there was a 70% incidence of failure. The priming volume in the pump does not remain constant, but increases in a stepwise fashion as different sizes of oxygenators are used. Hemodilution may be successful for a child at the top weight for an oxygenator, but unsuccessful for a slightly larger child who is at the bottom weight for the next size larger oxygenator. Whenever possible, blood should be removed pre-pump and returned to the patient immediately post-pump. Low mixed venous saturations and lack of urine output were noted as reasons to abort hemodilution. The most common reason was predicted poor left ventricular function. There were no differences in Hct at the 6 week visit. We conclude that when our criteria is met, heart surgery in children may be performed without the use of additional blood.

†*(p<0.05)*