



Trauma/Critical Care

## Cannulating the contraindicated: effect of low birth weight on mortality in neonates with congenital diaphragmatic hernia on extracorporeal membrane oxygenation



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### ABSTRACT

**Background/purpose:** Restrictions for ECMO in neonates include birth weight less than 2 kg (BW <2 kg) and/or gestational age less than 34 weeks (GA <34 weeks). We sought to describe their relationship on mortality.

**Methods:** Neonates with a primary diagnosis code of CDH were identified in the Extracorporeal Life Support Organization (ELSO) registry, and logistic regression models were used to examine the effect of BW <2 kg and GA <34 weeks on mortality.

**Results:** We identified 7564 neonates with CDH. The overall mortality was 50%. There was a significantly higher risk of death with unadjusted odds ratio (OR) 2.39 (95% confidence interval [CI]: 1.53–3.74;  $P < 0.01$ ) for BW <2 kg neonates. The adjusted OR of death for BW <2 kg neonates remained significantly high with over two-fold increase in the odds of mortality when adjusted for potential confounding variables (OR 2.11, 95% CI: 1.30–3.43;  $P < 0.01$ ). However, no difference in mortality was observed in neonates with GA <34 weeks.

**Conclusions:** While mortality among CDH neonates with a BW <2 kg was substantially increased, GA <34 weeks was not significantly associated with mortality. Effort should be made to identify the best candidates for ECMO in this high-risk group and develop treatment strategies to optimize their survival.

**Type of study:** Case–Control Study, Retrospective Comparative Study.

**Level of evidence:** Level III.

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The recommended lower limits of neonatal ECMO are weight of 2 kg and post-gestational age of 34 weeks. The birth weight (BW) and gestational age (GA) restrictions have been suggested to maximize the benefits of ECMO. The pre-ECMO weight of less than 2 kg was suggested in light of the findings by Revenis et al. in 1992, who reported lower weight infants (2 to 2.5 kg) to have higher rates of mortality and intracranial hemorrhage compared to higher weight infants [1]. Similarly, Hardart et al. showed a linear relationship between post-conceptual age and incidence of intracranial hemorrhage, ranging from 22% at less than 32 weeks to 12% by 36 weeks [2]. There has not been a

congenital diaphragmatic hernia (CDH) specific report on the outcomes of infants treated with ECMO whose pre-ECMO weight was less than 2 kg and/or post-gestational age less than 34 weeks.

Pioneers in the field of congenital heart surgery advocate for and perform primary repair of congenital heart defects in extremely low birth weight (<1500 g) neonates [3,4]. Reddy et al., reported excellent outcomes in extremely low birth weight neonates where cardiopulmonary bypass was utilized during congenital heart surgery [3]. In parallel, Rozmiarek et al. demonstrated potentially acceptable mortality rates in infants down to a weight of 1.6 kg, for neonatal respiratory ECMO [5]. With the advances in gentle ventilation strategies, and improved anticoagulation techniques, it may be possible that infants with CDH may benefit from ECMO even if they weigh less than 2 kg or are less than 34 weeks in GA, assuming cannulation is possible and risks of anticoagulation are potentially minimized. While the weight and gestational age guidelines have remained relatively consistent to maximize

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**Table 1**  
Baseline patient characteristics by birth weight groups.

Recipients' characteristics	<2 kg (N = 100)	≥2 kg (N = 7111)	P-value
	Mean (SD)/Count (Percent)	Mean (SD)/Count (Percent)	
<b>Demographics</b>			
Gestational age	35.06 (2.16)	38.30 (1.82)	<0.0001
Gender (% male)	48 (48.0%)	4073 (57.3%)	0.0672
Race/ethnicity, %			0.2951
Whites	58 (58.0%)	4272 (60.7%)	
Hispanics	10 (10.0%)	1050 (14.8%)	
Blacks	15 (15.0%)	891 (12.5%)	
Others	17 (17.0%)	898 (12.6%)	
Apgar at 5 min	5.69 (1.97)	6.05 (2.11)	0.1047
Age (days) before ECMO	3.65 (5.26)	1.92 (3.23)	0.0015
Side of hernia			0.0330
Left	74 (74.0%)	5028 (70.7%)	
Right	14 (14.0%)	1395 (19.6%)	
Both	5 (5.0%)	100 (1.4%)	
Missing	7 (7.0%)	588 (8.3%)	
Prenatal diagnosis	71 (71.0%)	3968 (55.8%)	0.0023
Handbagging			0.5454
No	87 (87.0%)	6381 (89.7%)	
Yes	10 (10.0%)	561 (7.9%)	
Missing	3 (3.0%)	169 (2.4%)	
Patient arrested before ECMO	20 (20.0%)	763 (10.7%)	0.0056
Site of cannulation			0.0781
Central	8 (8.6%)	290 (4.6%)	
Peripheral	85 (91.4%)	6029 (95.4%)	
<b>Pre-ECMO blood gas</b>			
pH	7.21 (0.21)	7.24 (0.2)	0.1244
PCO <sub>2</sub>	63.69 (28.15)	60.84 (27.77)	0.3171
PO <sub>2</sub>	45.24 (39.97)	39.07 (30.52)	0.1327
<b>Pre-ECMO ventilator type and settings</b>			
HFOV	54 (54%)	4059 (57.1%)	0.5432
MAP	17.12 (6.97)	18.41 (7.24)	0.1030
Oxygenation index	49.67 (27.85)	61.66 (51.35)	0.0002
<b>ECMO mode, duration and pump type</b>			
ECMO mode			
VA	95 (95.0%)	5971 (84.0%)	0.0013
VV	5 (5.0%)	1140 (16.0%)	
Duration of ECMO (weeks)	1.66 (1.73)	1.54 (0.98)	0.4943
Pump type			0.6818
Roller	77 (77.0%)	5380 (75.7%)	
Centrifugal	15 (15.0%)	907 (12.8%)	
Other	2 (2.0%)	165 (2.3%)	
Missing	6 (6.0%)	659 (9.3%)	
<b>Pre-ECMO rescue therapy</b>			
Inotropes (Vasopressor/inotropic drugs/Dopamine/Dobutamine/Epinephrine/Norepinephrine)	83 (83.0%)	5831 (82.0%)	0.8959
Bicarbonate/THAM	43 (43%)	2670 (37.6%)	0.2985
Nitric oxide	55 (55%)	3794 (53.4%)	0.7630
Surfactant	24 (24%)	1091 (15.3%)	0.0247
Neuromuscular blockers	53 (53%)	4019 (56.5%)	0.4794
Milrinone	3 (3.0%)	328 (4.6%)	0.6297
Sildenafil	3 (3.0%)	47 (0.7%)	0.0317
Steroids	4 (4.0%)	254 (3.6%)	0.7827
<b>Comorbidity</b>			
CCHD	7 (7.0%)	165 (2.3%)	0.0097
MCA	0 (0.0%)	13 (0.2%)	1.0000
Chromosomal	1 (1.0%)	43 (0.6%)	0.4601
Perinatal infection	3 (3.0%)	107 (1.5%)	0.1958
Peritonitis	0 (0.0%)	8 (0.1%)	1.0000
Airleak Syndrome	4 (4.0%)	861 (12.1%)	0.0082
<b>Complications</b>			
Mechanical complications	66 (66.0%)	3966 (55.8%)	0.0427
Hemorrhagic Complications			
Pulmonary hemorrhage	4 (4.0%)	157 (2.2%)	0.2872
Other Hemorrhagic Complications	44 (44.0%)	2893 (40.7%)	0.5390
Neurologic Complications			
Seizures	5 (5.0%)	630 (8.9%)	0.2139
Severe neurologic complication	18 (18.0%)	1067 (15.0%)	0.3981
Renal Complications			
Elevated Creatinine	12 (12.0%)	583 (8.2%)	0.1957
Dialysis	30 (30.0%)	1944 (27.3%)	0.5725
Cardiac Complications			
STUN	9 (9.0%)	463 (6.5%)	0.3058
Tamponade	0 (0.0%)	116 (1.6%)	0.4126
CPR required	4 (4.0%)	189 (2.7%)	0.3443
Infectious complications/sepsis	10 (10.0%)	573 (8.1%)	0.4583

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