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Predictors of Circuit Health in Neonatal Patients Receiving Extracorporeal Membrane Oxygenation

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ABSTRACT

Background: Clot formation is the most common mechanical complication of ECMO and can lead to oxygenator failure and the need for subsequent circuit changes. The goals of this study were to identify early indicators of circuit failure to alert providers of ECMO circuit health.

Hypothesis: We **hypothesized** that patient-specific circuit parameters can predict circuit health to identify risk of early circuit failure in neonate ECMO patients. Using a retrospective chart analysis ECMO flow parameters and clotting factors were identified during the 48 hours prior to ECMO circuit change through the 24 hours post circuit change. Statistical analysis included non-parametric Mann-Whitney U-test.

Results: There was a significant increase in maximum and mean delta-p prior to need for circuit changes compared to those without (p=0.011 and p=0.0128 respectively) and a significant increase in the maximum RPM and mean RPM (p=0.0043 and p=0.0057 respectively). There was a significant increase in mean plasma free hemoglobin (hgb) (p=0.0209); however, the maximum plasma free hgb was not significant (p=0.0569). No differences were notable for sweep and venous pressure in those with circuit changes. Furthermore, clotting parameters were not found to be significant, including ACT, heparin, platelet count, fibrinogen, PT, PTT, INR, AT III (%), anti-Xa.

Conclusion: Changes in Delta-p, RPM, and flow may be valuable predictors of early circuit impairment in neonates on ECMO. Sweep, venous pressure, and clotting parameters may not reliable predictors of circuit health.

INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) is a prolonged cardiopulmonary bypass technology used for critically ill neonates who have failed maximal medical therapy. The ECMO circuit is complex as it removes deoxygenated blood from the patient's circulation that flows through an external oxygenator to allow gas exchange. The circuit pump and the oxygenator serve as an artificial heart-lung machine that can support vital organs to allow for recovery, and as a bridge to surgery or organ transplantation.

Although ECMO has been shown to improve survival in neonates and pediatric patients when needed compared to conventional therapies, it is a high-risk procedure. Clot formation is the most common mechanical complication. This can lead to oxygenator failure and the need for subsequent circuit change. For the patient completely dependent on ECMO for life support, circuit failure can have catastrophic consequences with increased morbidity and mortality especially likely with changes that occur emergently. For this reason, early indicators of circuit health may play an important role to alert providers to pending circuit change avoiding emergency events.

OBJECTIVE

We aimed to assess the relationship of specific ECMO circuit and patient clotting parameter variability with and without circuit changes due to circuit failure.

HYPOTHESIS

We hypothesized that patient-specific circuit associated parameters can predict circuit health to identify risk of early circuit failure in neonatal ECMO patients

METHODS AND ANALYSIS

- A retrospective chart review of neonates who received ECMO with and without circuit changes admitted at CHoR from 1/2015-12/31/2019 were identified.
- Study received VCU SoM IRB approval
- Circuit failure was defined as need for partial or total circuit change-out.
- Parameters collected before and after circuit change included delta pressure, RPM, Flow, Sweep, Venous pressure and factors associated with clotting.
- Statistical analysis: Non-parametric Mann-Whitney U-test with possible non-normality of measurements

RESULTS

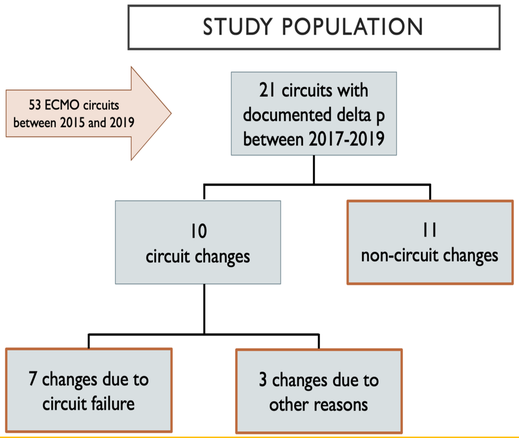


Figure 1.Patient Population: N = 53

	Patients with Circuit Change (n=7)	Patients without Circuit Change (n=14)
Birth Gestational Age* – wks ± SD	35.9 ± 4.98	36.8 ± 4.29
Birth weight – grams ± SD	2258 ± 1319	2880 ± 1022
Sex		
Male – n (%)	5 (71)	7 (50)
Race		
African American – n (%)	5 (71)	6 (55)
White – n (%)	1 (14)	3 (21)
Hispanic – n (%)	0	3 (21)
Other – n (%)	1 (14)	2 (18)

*Note. Premature infants were placed on ECMO weeks – months after birth.

Table 1. Patient Demographics: N = 21

	Circuit Change		Control Group		
Parameter	Median	[Min, Max]	Median	[Min, Max]	*p*-value
Delta P Min	0.00	[-7.00, 6.00]	0.00	[-16.00, 1452.00]	0.8918
Delta P Max	153.00	[12.00, 197.00]	16.00	[-12.00, 45.00]	0.0110
Mean Delta P	48.59	[6.71, 63.29]	8.62	[-4.30, 32.70]	0.0128
RPM Min	1830.00	[1725.00, 2160.00]	1780.00	[1235.00, 2095.00]	0.2766
RPM Max	3000.00	[2170.00, 3395.00]	2270.00	[1970.00, 2611.00]	0.0043
RPM "Average"	2452.00	[1965.00, 2667.50]	1987.50	[1827.50, 2285.00]	0.0057
Plasma Free HGB Min	22.00	[11.90, 28.00]	11.90	[11.90, 116.00]	0.0842
Plasma Free HGB Max	137.00	[34.90, 420.00]	41.00	[11.90, 277.00]	0.0569
Plasma Free HGB "Average"	76.00	[28.00, 224.00]	26.45	[11.90, 196.50]	0.0209

Table 2. Parameter Comparisons between Circuit Change and Control Group

RESULTS

Figure 1: Association of Delta P and Circuit Change

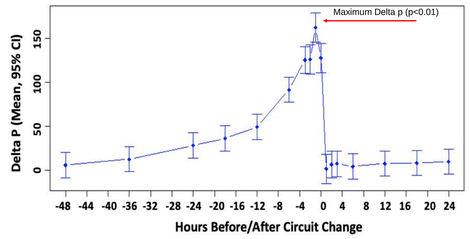


Figure 2: Association of RPM and Circuit Change

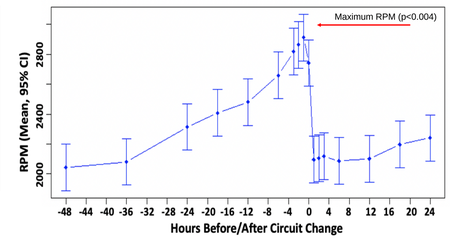


Figure 3: Association of Flow and Circuit Change

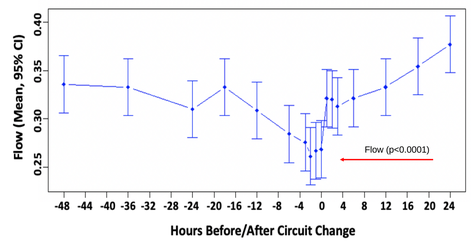
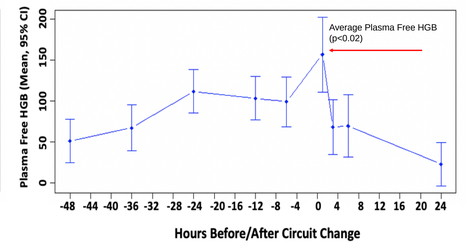


Figure 4: Association of Plasma Free HGB and Circuit Change



CONCLUSION

- Delta p, RPM and Flow specific circuit parameters were increased before the need for change in circuit
- Functional circuit parameters of sweep and venous pressure were not altered before or during circuit change.
- Clotting parameters were not significantly altered during the circuit run or during circuit change
- Average plasma free hemoglobin was altered prior to circuit change but not maximum plasma free hemoglobin.

SPECULATIONS

- Specific circuit parameters Delta p, RPM and Flow may be important to predict circuit health
- Average plasma free hemoglobin may be useful to predict circuit health, but maximum plasma free hemoglobin was not significant.
- Sweep, venous pressure or clotting parameters may not be useful in predicting of circuit health

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Acknowledgments

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