Urine Trouble! Renal Dysfunction and Renal Replacement Therapy in ECMO Patients

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Objectives

- Definition of Acute Kidney Injury (AKI)
- Incidence of AKI and Renal Replacement Therapy (RRT) in patients requiring ECMO
- Pathophysiology of AKI during ECMO
- Indications for RRT in patients requiring ECMO
- Mechanics of RRT during ECMO
- Outcomes in patients that require RRT and ECMO

Definitions of Acute Kidney Injury

	AKIN criteria*			RIFLE criteria*	
Stage	Creatinine	Urine output	Stage	Creatinine or GFR	Urine output
1	Increase of >0.3 mg/dL or 0.5–2 times (baseline)	<0.5 mg/kg/hr for >6 hr	Risk	sCr increase ×1.5 (baseline) or GFR decrease >25%	<0.5 mg/kg/hr for >6 hr
2	2-3 times (baseline)	Anuria for 12 hr or <0.5 mg/kg/hr for >12 hr	Injury	sCr increase ×2.0 (baseline) or GFR decrease >50%	<0.5 mg/kg/hr for 12 hr
3	RRT or level of 4.0 mg/dL with an acute increase of 0.5 mg/dL	<0.3 mg/kg/hr for 24 hr	Failure	sCr increase ×3.0 (baseline) or GFR decrease >75% or 4.0 mg/dL with an acute increase of 0.5 mg/dL	<0.5 mg/kg/hr for 12 hr
			Loss	Persistent AKI (loss of renal function >4 weeks)	
			ESKD	End stage kidney disease >3 months	

*KDIGO criteria for AKI very similar to AKIN
*AKI-D now often in the literature as well = AKI requiring dialysis

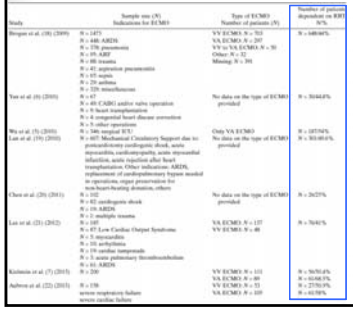
ECMO and Acute Kidney Injury – The Numbers

The Incidence of Acute Kidney Injury and its Effect on Neonatal and Pediatric ECMO Outcomes: A multicenter report from the KIDMO Study Group

Geoffrey M. Fleming, MD[1], Rashmi Sahay, PhD[2], Michael Zappitelli, MD[3], Eileen King, PhD[2], David J. Askenazi, MD[4], Brian C. Bridges, MD[1], Matthew L. Paden, MD[5], David T. Selewski, MD[6], and David S. Cooper, MD[7]

- 832 **pediatric** patients on ECMO at 6 ECMO centers
- 74% had AKI using KDIGO criteria
- 52% had AKI before initiation of ECMO, 86% by 48hrs after ECMO initiation
- 48% had AKI-D and received RRT (only 3% prior to ECMO)

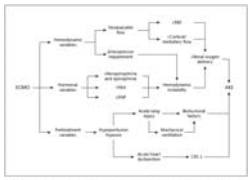
ECMO and Acute Kidney Injury – The Numbers

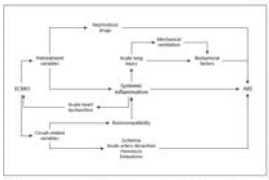


- Incidence of RRT during ECMO is around 50% for adults as well
- Abbott 2016-2018
  - ECMO = 249 patients
  - Survival after ECMO = 142 patients (57.0%)
  - CRRT = 85 patients (31.8%)
  - Survival CRRT/ECMO = 30 patients (35.3%)

ECMO and Acute Kidney Injury – Why?

- Non-ECMO Factors
  - All the usual suspects! Hemodynamics, hypo-perfusion, cardiorenal, SIRS/sepsis/cytokines, IV contrast, antibiotics, etc.
- ECMO Factors

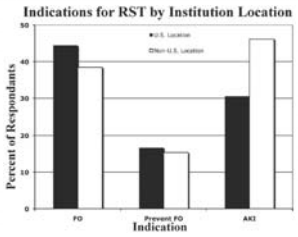




- Bottom line: under-oxygenated/perfused + overworked + poisoned

Indications for RRT in ECMO patients

- Same indications as everyone else
- But with different proportions for the indication to initiate RRT



- Indications:
  - 59% fluid overload
  - 35% AKI
  - 4% electrolyte imbalance
  - 2% other
- My experience
  - Often more than one indication
  - Fluid overload is usually the primary indication

Mechanics of RRT in ECMO

- We rarely use a dialysis catheter during ECMO

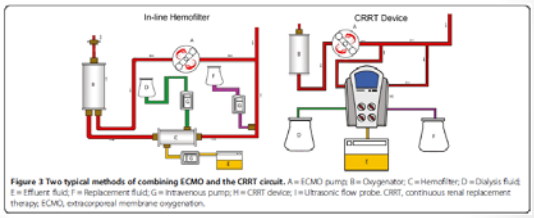


Figure 3 Two typical methods of combining ECMO and the CRRT circuit. A = ECMO pump; B = Oxygenator; C = Hemofilter; D = Dialysis fluid; E = Effluent fluid; F = Replacement fluid; G = Intravenous pump; H = CRRT device; I = Ultrasonic flow probe. CRRT, continuous renal replacement therapy; ECMO, extracorporeal membrane oxygenation.

Outcomes in Pediatric Patients Requiring ECMO/RRT

Recovery of renal function and survival after continuous renal replacement therapy during extracorporeal membrane oxygenation

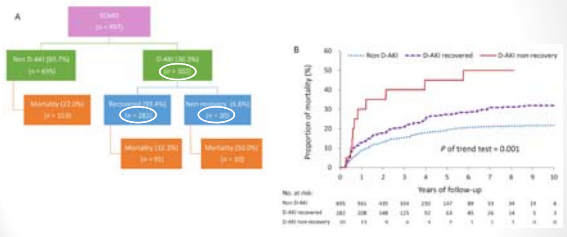
Matthew L. Paden, MD, FAAP[1], Barry L. Warshaw, MD[2], Micheal L. Heard, RN[3], and James D. Fortenberry, MD, FAAP, FCCM[3]

- 154 **pediatric** patients requiring RRT during ECMO
- 44 survived to discharge (28.6%) vs. 81/244 non-RRT patients (33.2%)
- 18 required RRT after ECMO was discontinued
- Renal recovery occurred in 96% before discharge
- Only one patient without pre-existing kidney disease did not recover renal function

Outcomes in Adult Patients Requiring ECMO/RRT

- Three largest studies of adults
  1. Germany tertiary care center, 200 ECMO patients from 2005-2010
     - 60% required RRT
     - 3 month survival 53% in ECMO vs. 17% in ECMO/RRT
  1. University of AZ, 40 ECMO + RRT patients from 2007-2012
     - 1 month survival 20%
     - 5 survivors came off RRT, 3 remained on RRT after 30 days
  1. Tawain National Database, 3,251 ECMO patients from 2003-2013
     - 54% required RRT
     - Survival to hospital discharge 26.2% in RRT/ECMO vs. 57.8% in ECMO
     - Long term survival in patients surviving at least 90 days after hospital discharge is on next slide

Outcomes in Adult Patients Requiring ECMO/RRT



Summary

- AKI is common in patients requiring ECMO with about half requiring RRT
- AKI is a marker of disease severity, but is also an independent predictor of mortality
- The mortality is high for patients requiring ECMO and CRRT, but survival to hospital discharge is >20% in most cohorts
- Most patients that require RRT during ECMO will not be dependent on RRT long term

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