ECMO in Special Populations: Pregnancy and Obesity

The Who, When, Why & How

Cara Agerstrand
Assistant Professor of Medicine
Assistant Director of the Medical ECMO Program
Columbia University Medical Center / NewYork-Presbyterian Hospital

NewYork-Presbyterian
The University Hospital of Columbia and Cornell

Columbia University Medical Center

No disclosures or conflicts of interest

ARDS during Pregnancy

- ARDS during pregnancy 16-130 cases / 100,000 pregnancies
  - 400% higher occurrence than in the general population during the H1N1 2009
- Mortality of ARDS during pregnancy 24-39%
- Associated with a 23% fetal loss

ARDS Severity	P : F	Mortality
Mild	<300	27%
Moderate	<200	32%
Severe	<100	45%

5% of US deaths during 2009 H1N1 epidemic were in pregnant woman

JAMA, 2012
Jamieson, et al. Lancet, 2009

Why are pregnant women more at risk?

Changes in immune system to allow for tolerance of paternally-derived fetal antigens

- ✓ Suppression of cell-mediated immunity
- ✓ Diminished response to antigens
- ✓ Decreased number of T-helper cells (decreased CD4:CD8 ratio)
- ✓ Decreased IgG subclass in pregnant women with severe influenza

Duarte et al, Clin Obstet Gynecol 2014
Jamieson, et al. Lancet, 2009

ECMO has been used successfully to treat pregnant and postpartum woman but limited to small series and case reports

– 2009-2017: total of 95 case reports or case series

– Concerns regarding risk of maternal & fetal bleeding, thrombotic events, and hemolysis

– No current ELSO, ACOG, or other guidelines

Modern Experience of ECMO in Pregnancy

Literature review 67 patients, 2009-2014

VV ECMO 15
VA ECMO 16
Lung assist 1

Maternal survival 80%

Fetal survival 70%

Indications for ECMO:
ARDS
Amniotic fluid embolism
Peri-partum cardiogenic shock (arrhythmia, Takasubo's)
Severe MR from iEC
Acute PE
TRALI
Cardiac arrest / ECPR

Sharma, et al. ASAIO, 2015

Peripartum ECMO during H1N1

12 patients total, ANZ 2009
Pregnant 7 (58%)
Postpartum 5 (42%)

Mean age 29
50% obese
3 (38%) preeclampsia, 1 (8%) placenta previa

10 VV or VVV / 2 VA

Maternal survival: 8 (66%) ECMO and hospital survival

Nair, et al. ICM, 2011

Compared to a non-peripartum population

Variable	Pregnant/postpartum cohort ($N = 12$)	Other women of childbearing age ($N = 18$)	p Valu
Median age (IQR) (years)	28 (24–32)	34 (27–37)	0.62
Median duration of MV (IQR) (days)	24 (17–32)	22 (12–30)	0.25
Median duration on ECMO (IQR) (days)	12 (6–17)	10 (7–13)	0.32
Bleeding rate (%)	67	50	0.45
Infection rate (%)	58	67	0.71
Median ICU length of stay (IQR) (days)	27 (21–37)	21 (13–32)	0.34
Median hospital length of stay (IQR) (days)	35 (24–43)	25 (15–33)	0.51
Mortality (%)	33	28	1.0

Nair, et al. ICM, 2011

Columbia Experience

18 pregnant or postpartum patients received ECMO (2009-2015)
4 (22.2%) pregnant at the time of ECMO initiation

Mean age 32.6 (26-39)
APACHE II 27 (23-30)
VV 14 / VAV 3 / VA 1

Indications for ECMO:
ARDS (17, 94%)
ECPR (3, 16.7%)
PE (2, 11%)
AFE (2, 11%)
PAH (1, 5.6%)

Agerstrand, et al. Ann Thorac Surg, 2016

Outcome Data

Maternal survival 16 (88.9%)
Fetal survival 14 (77.8%)

3 pregnant with viable fetus, all survived (100%)
2 delivered on ECMO
1 delivered post-ECMO

Duration 6.6 days
Extubated on ECMO 5 (27.8%)

Agerstrand, et al. Ann Thorac Surg, 2016
Sharma, et al. ASAIO, 2015

Pregnant on ECMO

Total of 45 patients in 26 publications

Indications for ECMO
H1N1 influenza 33 (73%)
Other ARDS 8 (18%)
Cardiogenic shock 3 (7%)
Cardiac arrest 1 (2%)

Mean gestational age
26.5 weeks (range 12-38 weeks)

Moore, et al. JTCVS, 2016

Pregnant on ECMO

Indication for ECLS	No. of patients	Gestational age, wk, mean	ECLS type	ECLS duration, d, mean	Outcome, mother	Outcome, fetus
H1N1 influenza	33	27.8	V-V	12.2	75.7% (25 of 33) survived	70.9% (22 of 31 survived
Respiratory failure (other causes)	8	24.4	V-V	11.9	87.5% (7 of 8) survived	62.5% (5 of 8) survived
Cardiac and respiratory failure	4	26.0	V-A	15.0	75.0% (3 of 4) survived	25.0% (1 of 4) survived
Total	45	26.5	V-V, n = 41; V-A, n = 4	12.2	77.8% (35 of 45) survived	65.1% (28 of 43 survived

Moore, et al. JTCVS, 2016

Management of the Pregnant Patient

ECMO Targets:
Blood flow 90-100% predicted CO
Target PaO_2 >80, O_2 sat > 92%
Normal pH with $PaCO_2$ >30

Anticoagulation:
Low-dose heparin gtt, aPTT 40-60 s
Held 1 hour pre / post delivery

Transfusion:
Variable by institution
Hgb >7.0 g/dL

Ventilator Management:
Avoid severe respiratory alkalosis
→ uterine artery vasoconstriction
Permissive hypercapnea not studied

Cannulation / Chatter:
Some have reported difficulties with drainage cannula

If chatter, 15-30° left-lateral tilt

Agerstrand, et al. Ann Thorac Surg, 2016
Chesnutt, et al. Crit Care Clinics 2004
Lapinsky, et al. Crit Care Med, 2010

Management of the Pregnant Patient

Fetal Monitoring:
BID heart tones
NSTs
Pelvic U/S
Steroids for lung development

Placental O_2 delivery = 10% of CO at term, 600-700 mL O_2/min

Timing of Delivery:
Optimally, support to recovery

Delivery plan in place with early MFM consultation
✓ C-section
✓ Vaginal

Consider: burden of feto-placental unit on maternal oxygenation, fetal and maternal well-being

Agerstrand, et al. Ann Thorac Surg, 2016
Lapinsky, et al. Crit Care Med, 2010

Complications

- Bleeding complications may be higher
- **Columbia series:** Patients with hemorrhage, total 10 (55.6%)
  - Hemorrhagic complications that developed on ECMO 6 (33.3%)
    - 4 instances of ACS after Cesarean section
  - DIC in 10 (55.6%)
  - Severe coagulopathy from AFE manageable
  - 15 (77.8%) received transfusions, median 2.5 u (625-750 mL, IQR 1-18.3 u)
  - Thrombotic complications include: 5 total/partial DVTs (27.8%)
  - No circuit changes

Agerstrand, et al. Ann Thorac Surg, 2016
Moore, et al. JTCVS, 2016
Nair, et al. ICM, 2011

Complications

- Bleeding complications may be higher
- **ANZ series:** H1N1 pregnant women: 8/12 total cohort (67%), though NS compared to non-peripartum (50%)
  - Pregnant women: 4/7 (57%) reported major bleeding
  - 12 (100%) received transfusions, median 3.5L (IQR 1.5-4.9 mL)
  - Bleeding was the cause of death in 3 patients
  - Two circuits required changing.
  - No significant thrombotic complications or hemolysis

Agerstrand, et al. Ann Thorac Surg, 2016
Moore, et al. JTCVS, 2016
Nair, et al. ICM, 2011

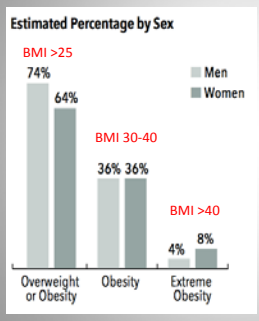
Conclusion

ECMO can be used successfully in pregnant or postpartum patients with excellent maternal and fetal survival

Even in those with severe hemorrhage and coagulopathy, though bleeding complications may be higher

ECMO in Obese Patients

Obesity and ARDS



Increased incidence of ARDS:
Obesity: OR 1.57 obese
[CI 1.3-1.9]

Morbid obesity: OR 1.67
[CI 1.04-2.68]

Kon, et al. Ann Thorac Surg, 2015
Zhi, et al. PLoS One, 2016
https://www.niddk.nih.gov

Protective Effect of Obesity?
"Obesity Paradox"

Despite increased incidence of ARDS in obese patients, there is decreased mortality

Lower IL-6, IL-8, surfactant protein D

Increased nutritional stores

Patients meeting criteria for severe ARDS may have less severe lung injury

Chest wall restriction

Stapleton, et al. Chest, 2010
Zhi, et al. PLoS One, 2016

What are the challenges in treating the obese?

- ✓ Cannulation placement
- ✓ Sufficient blood flow
- ✓ Ventilator and sedation management
- ✓ Risks of transport

Thomas V. Brogan
Ravi R. Thiagarajan
Peter T. Rycus
Robert H. Bartlett
Susan L. Bratton

Extracorporeal membrane oxygenation in adults with severe respiratory failure: a multi-center database

ELSO Data 1986-2006
Higher body weight in surviving patients

1986-2006 - 1473 patients
Survivors 76 kg
Non-survivors 72 kg
p= 0.001

2002-2006 - 600 patients
Survivors 76.5
Non-survivors 74.7
p=0.045

Brogan, et al. ICM, 2009

Suhel Al-Soufi
Hergen Buscher
Nguyen Dinh Nguyen
Peter Rycus
Priya Nair

Lack of association between body weight and mortality in patients on veno-venous extracorporeal membrane oxygenation

ELSO Data 2005-2011
No association between high body weight and mortality (n=1334)
7.25 / 59 / 57
PEEP 15

Highest decile (121-251 kg) with OR for morality 0.62 [95% CI 0.38-1.02, p=0.06)

Al-Soufi, et al. ICM, 2013

ECMO in the Super-obese?

55 patients 2009-2012
12 morbidly obese patients (BMI 49 kg/m^2)
Super-obese: subset of 6 (BMI 57 kg/m^2)

6 days of pre-ECMO mechanical ventilation
7.25 / 53 / 53

Compared to non-morbidly obese group, morbidly obese patients:

- ✓ Older age: 35 vs 43.5 years (p=0.25)
- ✓ BMI: 29 vs 49 kg/m^2 (p<0.01)
- ✓ DM2: 12% vs 42% (p=0.03)
- ✓ Creatinine: 1.2 vs 1.72 (p=0.09)

Typical ECMO Configuration:
Drainage 25 Fr
Return 21 Fr

Kon, et al. Ann Thorac Surg, 2015

ECMO in super obesity?

Variable	BMI <40 kg/m² (n = 43)	BMI ≥40 kg/m² (n = 12)	p Value	BMI ≥50 kg/m² (n = 6)	p Value*
Intensive care unit LOS (d)	15.5 (IQR: 6–37.5)	28 (IQR: 13.5–46.5)	0.35	33 (IQR: 25–45)	0.13
Hospital LOS (d)	28 (IQR: 7–55)	35 (IQR: 13.5–50)	0.77	42 (IQR: 31–45)	0.22
Weaned from ECMO	27 (63%)	9 (75%)	0.51	6 (100%)	0.16
Bridge to recovery	26 (60%)	9 (75%)	0.50	6 (100%)	0.08

Kon, et al. Ann Thorac Surg, 2015

VV ECMO in the Morbidly Obese

Article	Pts	Criteria	Etiology	VV Config	ECMO/Hosp Survival
Mongero, 2006	2	BMI > 50	ARDS post-op	D: 19, 21 R: 15, 19	100%
Swol, 2014	12	BMI >35 (mean 47.9)	ARDS	ND	9 (75%) 6 (50%)
Kon, 2015	12	BMI >40	ARDS	D: 23, 25 R: 19, 21	9 (75%) 8 (66%)
Ull, 2015	2	BMI >20	ARDS post-op	D: 23 Fr R: 21 Fr	100%
Belliato, 2016	1	BMI 70	ARDS	D: 23 Fr R: 21 Fr	100%

Belliato, et al. Clin Case Reports, 2016
Kon, et al. Ann Thorac Surg, 2015
Mongero, et al. Perfusion, 2006
Swol, Acta Anaesthesiol Scand, 2014
Ull, Am J Emerg Med, 2015

Columbia Experience

91 obese patients transported to our institution
Mixed cardiogenic shock and ARDS

63 obese (BMI 30-40 kg/m²) 28 morbidly obese (BMI ≥40 kg/m²)

10 super obese
mean 53.4 (48.6 – 79.0) kg/m²

- ✓ Worse gas exchange post-ECMO: PaO_2 70 vs. 110s
- ✓ Longer duration of ECMO: 15 vs. 8 d
- ✓ Longer ICU LOS: 32 vs. 17 d

ECMO survival: 100%
Hospital survival: 90%

Salna, et al Accepted, 2017

Conclusion

ECMO can be effective in patients with obesity, even at the extremes of weight and should not be a contraindication

Longer ECMO and ICU duration may be expected

Summary

The use of ECMO continues to grow in the adult population and can be successfully used in special populations such as pregnant and postpartum women and those with morbid obesity.

ECMO should not be withheld from these groups out of concern for poor outcomes or untenable risk of complications.