ECMO: The Ultimate Support for the Cardiopulmonary System

Nitasha Joyner, CCP, BS
Michael Petty, PhD, RN, CCNS, ACNS-BC
Nilasha Juyner, CCP, BS
ECMO Coordinator,
Pediatric Senior Perfusionist
University of Minnesota

Michael Petty,
PhD, RN, CCNS, ACNS-BC
Cardiothoracic Clinical Nurse Specialist
University of Minnesota Medical Center, Fairview
**Webinar Goal**
Apply evidence-based practices for extracorporeal membrane oxygenation (ECMO) to:
- Provide safe, effective patient care
- Optimize patient outcomes
- Detect complications and intervene early

**Session Topics**
- History of ECMO
- Technology and Components
- Managing ECMO Patients
- Outcomes
What is ECMO?

- Pump and oxygenator
  - Supports cardiac and/or pulmonary function
  - Days to weeks
- Extended use of cardiopulmonary bypass outside the OR
History of ECMO
ECMO Begins with Cardiopulmonary Bypass

1953-54
Forefathers: Drs. Gibbon and Lillehei
- Cross-circulation: parent to infant
- Extracorporeal support

1957
Silicone rubber: Spiral coil silicone membrane oxygenator

1971
Dr. Hill prolongs extracorporeal support outside the OR

1972
Father of ECMO
- Dr. Bartlett
  - First use for neonates and children, with continued success
  - 75% survival vs 10% with standard treatment


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Subsequent Successes and Failures

Circa 1989-95

Success
- Neonatal respiratory failure
- 2 randomized control trials
  Survival: 97%

Failure
- Adults
- Selection criteria of patients and hospitals impacted success
  Survival: 10%
Success Leads to ECMO Expansion

Common Indications:
- Persistent pulmonary hypertension (PPHN)
- Meconium aspiration syndrome (MAS)
- Respiratory distress syndrome
- Congenital diaphragmatic hernia
- Sepsis/pneumonia
- Cardiomyopathy, cardiogenic shock
- Postcardiotomy

Recent Indications:
- ARDS
- Bridge to (lung) transplant/decision
- ECPR

2009 CESAR*
Trial paves way for acceptance in adult ARDs patients

*Conventional Ventilation or ECMO for Severe Adult Respiratory Failure (CESAR)
ECMO’s Dramatic Expansion: 1990–2012

Centers ↑241%

2004: Greatest expansion
- New equipment design
- Indications for adult respiratory failure

Cases ↑219%
The Technology
Components of ECMO

Pump
- Provides circulatory support
- Delivers oxygenated blood

Oxygenator
- Artificial lung
- Oxygenation and CO₂ removal

Cannulae
- Access to remove and return the blood

Tubing
- Must be biocompatible
Pump

Provides ECMO flow

- 2 types:
  - Roller
  - Centrifugal


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Roller Pump: Positive Displacement

Flow is a function of tubing size and pump speed

- Faster pump spins → higher flow
- Occlusion
  - Inflow to patient: circuit blows up
  - Outflow from patient: suck/pump air


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Centrifugal Pump: Nonpositive Displacement

Flow directly related to patient condition

- Affected by:
  - Preload
  - Afterload
  - Resistance
  - RPMs

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Oxygenator

Gas exchange device:
Maximizes surface area and optimizes membrane material

- Adds O₂, removes CO₂
- Diffusion fixed variable
  - Surface area
  - Membrane material
  - Blood path thickness
- Gradient driven (from areas of high to low concentration)
  - FiO₂ for O₂ transfer
  - Net gas flow for CO₂ transfer

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Cannulae

Establishing and maintaining vascular access is essential.

- Cannulation technique depends on:
  - Type of support needed
  - Patient size
  - Clinical situation


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Cannulae (cont)

2 Types

Venovenous (VV)
- Lung support only
- No cardiac support

Venoarterial (VA)
- Heart and lung support

Access
- Peripheral
- Central


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Tubing

Biocompatibility: Having no toxic or injurious effects on biological systems

- Determined by circuit coatings
- Minimizes
  - Platelet activation, adhesion, aggregation
  - Complement activation
  - Coagulation cascade activation
  - Plasma leakage

Mechanics of biocompatibility
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Managing ECMO Patients
ECMO Requires a Team Approach

- Patient and family
- Intensivist and surgeon
- Perfusionist
- Respiratory therapist
- ICU nurse
- ECMO specialist
- Physical therapist
- Occupational therapist
- Others

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Who Can Be an ECMO Specialist?

- Respiratory Therapists
- Perfusionists
- Nurses

Fulfilling this role requires commitment!
- High-risk, low-frequency concerns
- Ongoing refresher training, simulations

A close working relationship between the bedside nurse and ECMO specialist is essential for optimal patient care.

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Goals of Nursing Care

Monitor Progress toward established goals

- Oxygenation
- Anticoagulation
- Hemodynamic stability
- Recovery of lung function

Goals of Nursing Care

Monitor for potential complications

- Cannula dislodgement
- Infection/sepsis
- Air emboli
- Renal failure
- Metabolic changes
- Pressure ulcers
- Hemorrhage
- Neurologic complications
- Vascular complications
- Disseminated intravascular coagulopathy (DIC)


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Nursing Care: Cannula Safety

- Maintain cannula stability
  - Verify surgical security
  - Turn carefully
    - With someone attending to cannulas

- Monitor distal perfusion in cannulated limb
  - Check peripheral pulse hourly
    (capillary refill distal to the cannulae)

Changes in circulation can constitute an emergency
Nursing Care: Bleeding

- Monitor potential bleeding sites regularly
- Closely monitor physical, physiological, and laboratory indicators of disseminated intravascular coagulation
- Transfuse blood products
  - Maintain adequate hematocrit, platelet count
  - Can contribute to increased immune sensitization
    - Can complicate options for lung transplant
Nursing Care: Oxygenation and Ventilation

ECMO circuit corrects pCO₂ and pO₂

- Still need to maintain resting ventilation
  - FiO₂ < 60%
  - Inspiratory pressure < 35 cm H₂O
  - PEEP 10–15 cm H₂O
  - Respiratory rate 6 breaths/min to prevent atelectasis

- Manage secretions to prevent pulmonary infection
**Nursing Care: Neurological Monitoring**

- Assess hourly for intracerebral changes related to potential hemorrhagic or embolic complications
  - Pupils, other cranial nerve function
  - Motor function

- Assess for pain
  - Depending on level of sedation
  - May be subtle if sedated (eg, facial grimacing)
Nursing Care: Other Organ Complications

Renal
- Function may be compromised
  - Reduced blood flow
  - Vasopressor requirements
- If unresponsive to diuretics, initiate chronic renal replacement therapy (CRRT)
  - Separate vascular access (adults)
  - Splice into circuit (pediatrics)

Skin
- Increased risk of pressure ulcer from
  - Limited mobility
  - Altered perfusion
  - Other equipment
Nursing Care: Psychological Risks

Contributors to psychological disruptions
- Sedation, paralysis
- Noise
- Overstimulation
- Lack of mobility
- Sleep deprivation
- Fear
- Understimulation
- Pharmacotherapy

Nursing interventions
- Maintain day/night orientation
- Promote sleep with nonpharmacological interventions (when possible)
- Explain interventions, describe progress
- Re-orient regularly
Nursing Care: The Family’s Experience

Families experience...

Fear  Guilt  Anxiety

Meet family members “where they are”
- Partner to foster understanding
- Help them participate in patient’s care

Stress impacts...
- Comprehension
- Recall
- Appreciation of whole picture
Nursing Care: Progressive Mobility

- Dual lumen cannula
  - Jugular vein access
  - Provides adequate flows
  - Permits increased activity while on ECMO

- Increased activity may include
  - PT and OT
  - Ambulation
Nursing Care: Conclusions

- Critical-care nurses play central role
  - Providing direct patient care
  - Coordinating care among team members

- Optimal patient outcomes depend on carefully monitoring
  - Effectiveness and complications of therapy
Extracorporeal Life Support (ECLS)* Registry Report
International Survival Rates: Inception to January 2013

- **Respiratory patients**: 64% Survived ECLS, 55% Survived to DC or transfer
- **Cardiac patients**: 55% Survived ECLS, 39% Survived to DC or transfer
- **ECPR patients**: 37% Survived ECLS, 28% Survived to DC or transfer

*Provided by the Extracorporeal Life Support Organization (ELSO)
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Summary

- Provides effective cardiopulmonary support to select patients, oxygenating the blood and removing CO₂
- Successful ECMO therapy requires collaborative team of professionals
- Patient management
  - Monitor progress toward goals
  - Assess for potential complications
- Include family in care when possible
- Evolving ECMO technology → increased patient activity
AACN Implementation Tools
Evidence-based resources to support your practice

- **Becoming an ECMO Specialist**
  Training guidelines from Extracorporeal Life Support Organization (ELSO)

- **Frequently Asked Questions About ECMO**
  A family and patient education guide

- **ECMO for ARDS Patients: Discussion Guide**

Find these tools on the ECMO webinar information page at [www.aacn.org](http://www.aacn.org)
Start Managing ECMO Patients and Families Now

1. Download the **Implementation Tools**. Find them on the ECMO webinar information page at [www.aacn.org](http://www.aacn.org)

2. **Discuss** these resources with your colleagues.

3. **Use** them to support your practice.

4. Join the **Webinar Series Learn Network** online discussion forum to continue the conversation.