FROM DETERIORATION TO CANNULATION

Simulation Training for ECMO Escalation

Sophia Moriarty, RN, BSN
MCS Coordinator
Baystate Medical Center

DISCLOSURES

- No Disclosures.

LEARNING OBJECTIVES

01 Discuss the role of simulation-based training in replicating real-world patient deterioration to improve recognition of patients who may be candidates for ECMO support.

02 Explain how simulation of time-sensitive clinical scenarios reinforces timely escalation, team communication, and appropriate activation of ECMO pathways.

WHY THIS MATTERS: GROWTH WITHOUT IMPROVED OUTCOMES

611

ELSO-reporting centers in 2024

280K+ runs completed; up from registry inception

~30%

ECMO survival rate — largely unchanged

Despite 4× growth in education publications

↑

Complication rates remain high

Across ELSO registry despite growth

≠

Variability in training practices remains

the norm across ELSO centers

ELSO Registry International Report 2024.
Moore EA et al. ELSO 2025 Narrative Guideline on ECMO Training and Continuing Education. ASAIO J. 2026;72:274–283.

ELSO 2025: A COMPETENCY-BASED FRAMEWORK

DOES — *Prevents, detects & manages circuit complications at the bedside*

SHOWS — *Demonstrates prevention, detection & management in water-drills / simulation*

KNOWS HOW — *Knows how to prevent, detect & manage circuit-related complications*

KNOWS — *Knows main circuit-related complications*

Miller's Prism of Clinical Competence (ECMO Adapted — ELSO 2025)

ELSO 2025: Minimum Standards

- Four-phase simulation structure: Briefing, Simulation, Debriefing, Assessment
- Quarterly: psychomotor skills and emergency recognition drills
- Biannual: psychomotor and team-based simulation
- Annual: full multidisciplinary team training

Moore EA et al. ASAIO J. 2026;72:274–283.

EVIDENCE FOR SIMULATION-BASED ECMO EDUCATION

Ling et al. - Simul Healthc, 2025

Systematic scoping review of 28 ECMO simulation studies. Consistent improvement in competency scores, team communication, and troubleshooting. Reduced time to critical actions and cannulation.

Zakhary et al. - Crit Care Med, 2017

Randomized controlled trial: high-fidelity simulation for ECMO emergency training in critical care fellows improved management of ECMO emergencies.

Whitmore et al. - Resuscitation, 2019

ECPR simulation training significantly reduced time to ECMO flow in real clinical events. Demonstrating direct transfer from simulation to the bedside.

Han et al. - ATS Scholar, 2022

Scoping review of ECMO education literature: significant growth in educational interventions but persistent variability in curriculum design and competency assessment across centers.

WHERE WE STARTED

🔍 ECMO simulation scenarios for fellows ×

No results found.

(Turns out ELSO published a whole guideline on exactly this in 2025. So we're in good company.)

DEVELOPING OUR SIMULATION CURRICULUM

The Gap We Found

No standardized ECMO simulation scenarios existed for MICU fellows.

A search of available resources returned nothing specific to ECMO escalation decision-making.

Existing materials addressed technical skills, but not the clinical decision process — when to recognize the patient, when to call, and what to do in between.

Our Approach

We built scenarios directly from clinical practice - cases we manage at the bedside, translated into a structured simulation environment.

Each simulation was designed with expected and unexpected action pathways, staged deterioration, and structured debrief questions aligned to specific learning objectives.

The ELSO 2025 guideline now formalizes exactly this approach - reinforcing that bedside-derived, structured simulation is the standard.

SIMULATION PROGRAM: STRUCTURE AND DESIGN

VV ECMO SERIES

1

Escalation to VV ECMO

Recognize severe ARDS, exhaust conventional therapy, initiate timely VV consult

2

Hypoxemia on VV ECMO

Troubleshoot recirculation, high native CO shunting, and oxygen delivery failures

3

Weaning VV ECMO

Identify lung recovery, shift support to vent, coordinate decannulation

VA ECMO SERIES

1

Differentiating Shock → VA ECMO

Recognize cardiogenic shock pattern, interpret limited TTE, escalate VV vs. VA

2

North-South Syndrome

Recognize differential hypoxia, temporize, advocate for VA-V conversion

3

Weaning VA ECMO

Structured flow wean, hemodynamic interpretation, decannulation readiness

VV SIM 1 · ESCALATION TO VV ECMO

Case Scenario

64M admitted to MICU after aspiration and intubation for hypoxemic respiratory failure. On arrival: sinus tachycardia, SBP 88-98, FiO_2 90%, SpO_2 88%, ABG showing P:F ratio < 69.

The team escalates ventilator settings, initiates paralysis, and prones the patient. Despite optimized ARDSNet management, the P:F ratio remains < 0.6. A limited bedside echo is obtained - normal cardiac function.

Path A: Team recognizes ARDS failure criteria, consults CV surgery promptly → VV ECMO cannulated, rest vent settings established.

Path B: Team delays consult → continued decompensation → acidosis → RV dysfunction → PEA arrest.

Learning Objectives

- Calculate P:F ratio and apply ARDS severity criteria
- Sequence adjunctive therapies before ECMO: paralysis, proning, prone-position evaluation
- Use limited echo to differentiate VV vs. VA candidacy
- Recognize when VV ECMO consult is indicated vs. overdue
- Establish rest ventilator settings and initial ECMO goals post-cannulation

VV SIM 2 · HYPOXEMIA ON VV ECMO

Case Scenario

Same patient, VV ECMO Day 3. FiO_2 100%, flow 4 LPM - previously tolerating well. SpO_2 drops to 79%.

Stage 1: Team increases RPMs to 4500; flow goes to 5 LPM. SpO_2 worsens. Pre-oxygenator saturation rises — consistent with recirculation. Team recognizes pattern and returns to prior settings.

Stage 2: Patient is tachycardic, febrile, beginning to wake from sedation. CO is 10.8. Assessment addresses patient-level contribution: wakefulness, fever, high native output reducing ECMO effectiveness.

Stage 3: Vent FiO_2 increased; sedation/paralysis addressed; temperature managed. SpO_2 improves to 94%.

Key Concepts

Recirculation

Increasing RPMs can worsen hypoxia if drainage recirculates to the return cannula - recognized by rising pre-oxygenator saturation and matched cannula colors.

High Native Output / Shunting

Patient wakefulness, fever, and elevated CO dilute ECMO-oxygenated blood. VV ECMO operates in tandem with native lungs - the patient is always part of the equation.

Oxygenator Failure

Considered last after ruling out patient-level and circuit-level recirculation causes. Requires oxygenator swap.

Sin et al. J Thorac Dis 2019 · Brown et al. JMIR Med Educ 2025

VV SIM 3 · WEANING VV ECMO

Case Scenario

Day 5. Patient on low ECMO support: FiO_2 30%, Sweep 1, Flow 3 LPM. Hemodynamics stable without vasopressors. CXR shows resolving bilateral opacities.

Stage 1: Team assesses current ECMO settings and recognizes support is minimal. Vent is adjusted to take on more work at current ECMO settings. Post-adjustment ABG is obtained.

Key decision: ABG post-vent adjustment shows adequate gas exchange with pre-oxygenator saturation rising - lungs are contributing. Team discusses decannulation readiness with CV surgery.

The discussion addresses realistic post-decannulation goals - not targeting pH 7.40 and pCO_2 38, but establishing acceptable parameters appropriate for the patient's trajectory.

Weaning Principles

- Do not explant on high ventilator settings - the lungs need room to take over
- Weaning requires the ventilator to prove gas exchange, not the ECMO
- Rising pre-oxygenator saturation confirms native lung contribution
- Post-decannulation goals are trajectory-based, not absolute - not every patient will live at pH 7.40
- Decannulation too early carries higher re-cannulation mortality than staying on support

VA SIM 1 · DIFFERENTIATING SHOCK → VA ECMO

Case Scenario

64M admitted to MICU with massive saddle PE (CT confirmed bilateral PE, small RML infarct). PERT consulted in ED - IR unavailable, patient relatively stable on arrival. Intubated for hypoxemia, levophed initiated.

Phase 1: BP and O_2 sats drift down. Critical lactate 3.8 reported by lab. Team addresses vitals, orders repeat perfusion labs and ABG. Lactate returns 6.8 → 8.9. LFTs rising.

Phase 2: Persistent hypotension despite increasing vasopressors. Limited TTE performed: severe RV dilation, RV failure, LV EF 5-10% - acute biventricular failure.

Phase 3: Team calls CV surgery for VA ECMO (not VV), providing clear physiologic rationale: perfusion failure + biventricular failure. Any further delay → patient codes.

The Shock Spiral

Rising Lactate

▼

Worsening Acidosis

pH 7.19 → 7.12

▼

Refractory Hypotension

Pressors insufficient

▼

Biventricular Failure (TTE)

RV dilation, LV EF 5-10%

Unexpected: giving fluids → CVP rises, SpO_2 falls, patient worsens · Fixating on vent → perfusion failure continues

VA SIM 2 · NORTH-SOUTH SYNDROME

Case Scenario

Day 4, peripheral femoral-femoral VA ECMO (post-thrombectomy for massive PE). Native cardiac function recovering - milrinone initiated by Heart Failure. ECMO flow 3.5 L/min.

Phase 1: SpO_2 drops to 86%. Right radial ABG: pO_2 50, SaO_2 84%. Post-oxygenator values remain normal. Pulse pressure increasing - native LV recovering.

Phase 2: Team increases vent FiO_2 and PEEP; increases ECMO flow to 4.0 L/min. SpO_2 improves to 92% but falls again - temporizing only.

Phase 3: Persistent hypoxemia despite dual measures → team advocates to CV surgery for conversion to VA-V ECMO, providing clear physiologic rationale for timing and urgency.

The Physiology

Femoral VA ECMO returns oxygenated blood retrograde from below. As native LV recovers (milrinone-assisted), it ejects before ECMO return reaches the arch. That ejected output passes through poorly-oxygenated native lungs - delivering desaturated blood to the coronary and cerebral circulation.

Recognize: Right radial ABG desats; post-oxygenator normal → North-South

Temporize: ↑ Vent FiO_2/PEEP + ↑ ECMO flow — partial and temporary

Define: Persistent right radial pO_2 < 60 after temporizing measures

Convert: VA-V ECMO: venous return limb delivers O_2 to pulmonary circ

VA SIM 3 · WEANING VA ECMO

Case Scenario

Day 6. VA-V ECMO weaned back to VA 48h ago. Cardiac surgeon requests formal weaning assessment. Flow at 3.5 L/min. Pulsatility present on arterial line. Echo shows LVEF 15-20%, improving RV. Stable MAP without vasopressors.

Phase 1: Team performs structured flow reduction: 3.5 → 3.0 → 2.5 → 2.0 L/min. CO/CI and SvO_2 monitored at each step. Filling pressures (CVP, PA) rise modestly — within acceptable limits. LVEF improves on echo to 28-30%.

Phase 2: Team communicates to CV surgery: hemodynamics tolerated wean to 2.0 L/min, lactate 1.1, pulsatility maintained, filling pressures acceptable. Plan: maintain 2.5 L/min, turn off anticoagulation, OR in 2h.

Structured Wean: What to Follow

Flow	MAP	CVP	CO/CI	SvO_2	Assessment
3.5 L/min	100/78 (85)	11	5.4 / 2.7	72%	Baseline
3.0 L/min	98/74 (82)	10	4.9 / 2.5	68%	Tolerating ✓
2.5 L/min	97/69 (78)	10	4.8 / 2.4	66%	Modest ↑PA ✓
2.0 L/min	96/67 (77)	11	4.7 / 2.4	65%	Cardiac Fx on Echo improving ✓

THE DEBRIEF: WHERE THE LEARNING OCCURS

"A strong debriefer is not merely a feedback provider but a learning architect."

— ELSO 2025 Narrative Guideline on ECMO Training (Moore EA et al., ASAIO J 2026)

Recognition Over Fixation

Across both series: teams managed ventilators and ordered tests while perfusion markers deteriorated. Debrief refocuses on what clinical data actually drove the time-sensitive decision.

The Patient as a Variable

In VV Sim 2, teams addressed the circuit before the patient. VV ECMO operates with native lungs - wakefulness, fever, and high cardiac output are all modifiable contributors to hypoxemia.

Structured Communication

Calling CV surgery for VA ECMO or VA-V conversion requires a clear physiologic rationale. Debrief emphasizes SBAR structure and the specific data required for an effective surgical consult.

Timing and the Shock Spiral

Each VA scenario stages deterioration in phases. Debrief maps actions back to the timeline - when was the consult placed relative to when it was indicated? What delayed it?

Duff JP et al. Debriefing methods for simulation in healthcare: systematic review. Simul Healthc 2024;19:S112–S121.

OBSERVATIONS FROM THE SIMULATION SERIES

Vent vs. Perfusion Priority

Across both series, teams spent time optimizing ventilator settings while perfusion markers indicated progressive shock. Simulation created structured time to recognize and reframe that pattern.

Escalation Timing

The ECMO consult was consistently placed later than indicated. Each unexpected action pathway staged the consequence of delay - allowing teams to observe the relationship between timing and outcome in a controlled setting.

Patient-Level vs. Circuit-Level Troubleshooting

In VV management, teams defaulted to circuit and procedure-based interventions before assessing patient-level contributors. Simulation reinforced the integrated physiology of VV ECMO.

Surgical Communication

Consult calls for VA ECMO and VA-V conversion revealed gaps in structured communication. Teams had the correct diagnosis but needed practice assembling and delivering a clinical rationale under pressure.

Weaning Interpretations

Both VV and VA weaning scenarios surfaced the same challenge: interpreting small hemodynamic changes in context. Teams benefited from seeing the full hemodynamic picture at each wean step.

Simulation vs. Didactic

These concepts are teachable in a lecture. But the decision-making, timing, and team dynamics that define ECMO escalation are best practiced in a structured simulation environment with real consequences built into the design.

WHERE DO WE GO FROM HERE: REALISTIC ECMO SIMULATION

ECMO Specialists

Bedside hands-on circuit training - the foundation of everything we build

APPs

Escalation recognition, management protocols, and ECMO consult pathways

Physicians & Surgeons

Multidisciplinary decision-making, cannulation readiness, and team leadership

Fellows - MICU & Cardiac

VA-ECMO and VV-ECMO escalation, consultation, and clinical management

See it

Real cases from our own bedside - complications, decisions, and escalation moments

Know it

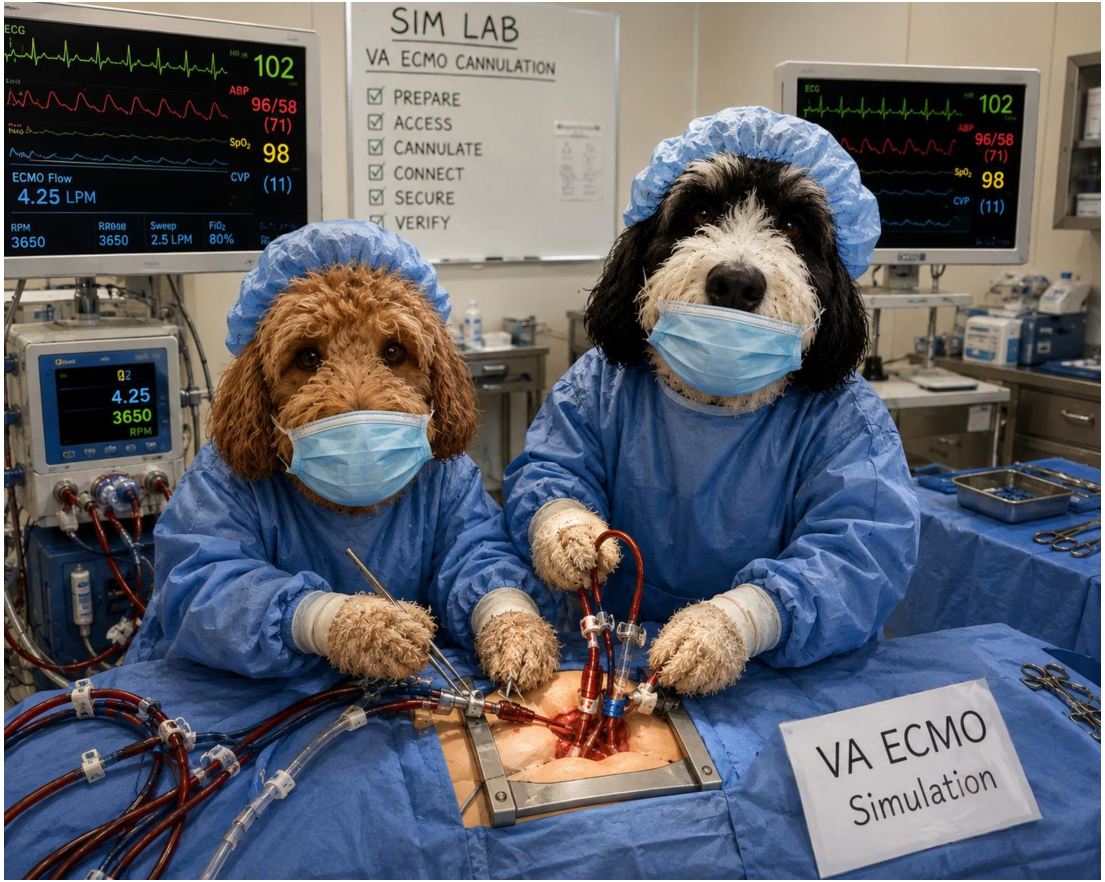
Build the knowledge base: physiology, indications, and circuit troubleshooting

Teach it

Structured simulation with briefing, realistic scenario, debrief, and assessment

Do it

Hands-on practice in dynamic, high-fidelity scenarios across all team levels


SIM LAB
VA ECMO CANNULATION
PREPARE
ACCESS
CANNULATE
CONNECT
SECURE
VERIFY
ECG
102
ABP
96/58
(71)
98
CVP
(11)
ECMO Flow
4.25 LPM
RPM
3650
Sweep
2.5 LPM
80%
4.25
3650
RPM
VA ECMO
Simulation

REFERENCES

1. Moore EA, Han P, Shekar K, et al. ELSO 2025 Narrative Guideline on ECMO Training and Continuing Education. ASAIO J. 2026;72:274–283.

2. Tonna JE, Boonstra PS, MacLaren G, et al. ELSO Registry International Report 2022: 100,000 Survivors. ASAIO J. 2024;70(2):131–143.

3. Ling RR, Milas A, Wang JK, et al. Simulation-based education for ECMO and strategies for implementation: A systematic scoping review. Simul Healthc. 2025;21:57–74.

4. Zakhary BM, Kam LM, Kaufman BS, Felner KJ. High-fidelity simulation for training critical care fellows in ECMO emergency management: RCT. Crit Care Med. 2017;45:1367–1373.

5. Whitmore SP, Gunnerson KJ, Haft JW, et al. Simulation training enables emergency medicine providers to rapidly initiate ECPR. Resuscitation. 2019;138:68–73.

6. Han PK, Purkey NJ, Kuo KW, et al. A scoping review and appraisal of extracorporeal membrane oxygenation education literature. ATS Scholar. 2022;3:468–484.

7. Duff JP, Morse KJ, Seelandt J, et al. Debriefing methods for simulation in healthcare: a systematic review. Simul Healthc. 2024;19:S112–S121.

8. Sin SWC, Ng PY, Ngai WCW, et al. Simulation training for crises during venoarterial ECMO. J Thorac Dis. 2019;11:2144–2152.

9. Brown J, De-Oliveira S, Mitchell C, et al. Barriers to and facilitators of team-based ECMO simulation: exploratory analysis. JMIR Med Educ. 2025;11:e57424.

10. Badulak J, Rubin J, Moore E, et al. Development of the ELSO International Adult ECMO Curriculum via modified Delphi. CHEST Crit Care. 2023;1:100026.