Refractory VF and Double Sequential External Defibrillation (DSED)

Section 1: Case Summary

Scenario Title:	**Refractory VF and Double Sequential External Defibrillation (DSED)**
Keywords:	Refractory VF, electrical storm, DSED, dual sequential defibrillation, cardiac arrest, ACLS
Brief Description of Case:	A 62-year-old male with a history of ischemic cardiomyopathy presents to the Emergency Department in cardiac arrest with refractory ventricular fibrillation. After standard ACLS interventions fail to terminate VF, the team must recognize refractory VF, coordinate DSED per PHC protocol (Document #B-00-12-10201), and manage post-ROSC care.

Goals and Objectives	
Educational Goal:	To practice the recognition and management of refractory ventricular fibrillation using Double Sequential External Defibrillation (DSED) per PHC protocol, with emphasis on team coordination and communication.
Objectives: (Medical and CRM)	**Medical Objectives:** • Manage cardiac arrest using standard ACLS algorithms • Recognize refractory VF (persistent VF after 3 consecutive standard defibrillation attempts) • Initiate DSED per PHC protocol: correct pad placement (anterior-lateral + anterior-posterior), "one person, one finger" sequential shock delivery • Verbalize appropriate post-DSED defibrillator testing and BioMed notification • Initiate appropriate post-ROSC care **CRM Objectives:** • Effectively lead a resuscitation with multiple team members • Demonstrate clear closed-loop communication during DSED ("shock one" / "shock two") • Assign clear roles: equipment lead, defibrillator operator, compressor, timer • Coordinate team during DSED setup to minimize chest compression interruptions
EPAs Assessed:	EPA C1 Resuscitation of the critically ill patient EPA C6 Perform procedures relevant to emergency medicine EPA C7 Communication and collaboration in emergency care of patients

Learners, Setting and Personnel				
Target Learners:	☒ Junior Learners	☒ Senior Learners		☒ Staff
	☒ Physicians	☒ Nurses	☒ RTs	☒ Inter-professional
	☐ Other Learners:			
Location:	☒ Sim Lab	☒ In Situ		☐ Other:
Recommended Number of Facilitators:	Instructors: 1			
	Sim Actors: 1			
	Sim Techs: 1			

Scenario Development	
Date of Development:	February 2026
Scenario Developer(s):	Roxanne Robidoux

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Refractory VF and Double Sequential External Defibrillation (DSED)

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Last Revision Date:	
Revised By:	
Version Number:	1

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Refractory VF and Double Sequential External Defibrillation (DSED)

Section 2A: Initial Patient Information

A. Patient Chart					
Patient Name: Robert Chen			Age:62	Gender: M	Weight: 75 kg
Presenting complaint: Cardiac arrest – witnessed collapse in ED waiting room					
Temp: 36.2°C	HR: 0	BP: 0/0	RR:	O_2Sat: 76%	FiO_2: 1.0
Cap glucose: 6.3 mmol/L			GCS: 3 (E1V1M1)		
Triage note: 62 y/o male presented to triage with chief complaint of substernal chest pressure and diaphoresis for 2 hours. While being registered, patient became unresponsive and collapsed. Bystander (triage nurse) confirmed pulseless – Code Blue called. CPR initiated immediately.					
Allergies: Penicillin (rash)					
Past Medical History: Ischemic cardiomyopathy (EF 35%), prior MI (LAD stent 2021), hypertension, type 2 diabetes, dyslipidemia			Current Medications: ASA 81 mg, ticagrelor 90 mg BID, bisoprolol 5 mg, ramipril 5 mg, atorvastatin 80 mg, metformin 1000 mg BID		

Section 2B: Extra Patient Information

A. Further History

Clinical Vignette – To Read Aloud at Beginning of Case:

"Code Blue, Emergency Department, Resuscitation Bay 1." *A 62-year-old male collapsed in the ED waiting room about 2 minutes ago. The triage nurse confirmed he was pulseless and started CPR. He was brought into the resuscitation bay on a stretcher. He had been complaining of chest pressure for the past 2 hours. CPR is ongoing.*

From Wife (if asked):

- Husband had an MI in 2021, stent placed at SPH
- Recently told by cardiologist his heart function is reduced (EF 35%)
- Was supposed to get an ICD but was still on the waitlist
- No recent illness, no drug use, no toxic ingestion
- She is unsure of his exact medication but says he takes blood thinners and blood pressure pills
- Code Status: Full Code

B. Physical Exam	
General: Unresponsive, pulseless, apneic. Pale, diaphoretic.	
Cardio: No heart sounds. VF on monitor. No pulse with CPR pause.	Neuro: GCS 3. Pupils 6 mm, fixed bilaterally.
Resp: No spontaneous respirations. Bilateral air entry with BVM.	Head & Neck: No trauma. No JVD appreciable.
Abdo: Soft, non-distended.	MSK/skin: Pale, cool, mottles. No scars on chest (no sternotomy scar). Small scar right groin (prior cath).
Other:	

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Section 3: Technical Requirements/Room Vision

A. Patient
☒ Mannequin *(High-fidelity adult mannequin capable of displaying cardiac rhythms and accepting defibrillator pad placement)*
☐ Standardized Patient
☐ Task Trainer
☐ Hybrid

B. Special Equipment Required
• **TWO defibrillators (Zoll R-Series and/or X-Series) – both functional with adequate battery** • **TWO sets of defibrillator pads** • NIBP Cuff, Pulse Oximeter, Temperature Probe • Standard crash cart with ACLS medications, IV Bags/Lines • BVM, oral/nasal airways, intubation equipment (laryngoscope, VL, ETT, LMA) • IV supplies, IO kit • EKG Leads/Wires • Backboard/CPR compression device if available • DSED Infographic (PHC version) – printed and posted in resus bay

C. Required Medications
Epinephrine, Amiodarone, Esmolol, Lidocaine, Magnesium sulfate, Sodium bicarbonate, Normal saline 1L bags (x2)

D. Moulage
Diaphoretic skin (water spray). Small scar right groin (drawn with marker).

E. Monitors at Case Onset
☐ Patient on monitor with vitals displayed
☒ Patient not yet on monitor

F. Patient Reactions and Exam
General: Unresponsive, pulseless, apneic. Pale, diaphoretic. Airway/Breathing: no spontaneous respirations → bilateral air entry if BVM initiated Circulation: absent heart sounds, pulseless Disability: GCS 3 Exposure: euglycemic, normothermic, no visible signs of trauma Once patient is placed on monitors, VF should display. Defibrillator #1 at bedside with pads to be placed in standard anterior-lateral position. Defibrillator #2 available but NOT yet at bedside (must be requested/retrieved).

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Section 4: Sim Actor and Standardized Patients

Sim Actor and Standardized Patient Roles and Scripts	
None	N/A

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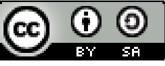
Section 5: Scenario Progression

Scenario States, Modifiers and Triggers				
Patient State/Vitals	Patient Status	Learner Actions, Modifiers & Triggers to Move to Next State		Facilitator Notes
1. Baseline State Rhythm: VF HR: 0 BP: 0/0 RR: 0 O_2SAT: 76% with CPR ETCO2: 21 T: 36.2°C GCS: 3	Unresponsive, pulseless, apneic.	Expected Learner Actions ☐ Confirm pulselessness, initiate/continue high-quality CPR ☐ Attach monitor, confirm VF ☐ Defibrillate at 200J (biphasic) ☐ Establish IV/IO access ☐ Epinephrine 1 mg IV q3-5 min ☐ Amiodarone 300 mg IV after 3rd shock ☐ BVM ventilation ± advanced airway ☐ Consider reversible causes (Hs and Ts) and send for labs ☐ Bedside echo if available	Modifiers - Patient remains in VF regardless of standard defibrillation or medications given. - Rhythm briefly organizes to coarse VF after each shock then returns to fine VF. Triggers - After 3 consecutive defibrillation attempts + amiodarone → **progress to State 2: Refractory VF**	
2. Refractory VF Unchanged	Unchanged. Persistent VF.	Expected Learner Actions ☐ Recognize refractory VF after 3 consecutive shocks → Prepare for DSED → Request 2nd defibrillator to bedside and apply 2nd set of pads ☐ Pad placement: Set 1 anterior-lateral, Set 2 anterior-posterior (preferred) – no overlap ☐ **Assign single operator for both defibrillators ("one person, one finger")**	Modifiers - VF persists until DSED is correctly performed. - If pads placed overlapping, prompt team to readjust Triggers - **The first DSED attempt will NOT achieve ROSC** (VF persists after first DSED, **requiring 2 attempts before ROSC** → after 2 attempts with DSED correctly performed (sequential shocks,	- If learners not yet considering DSED after 4th shock, Facilitatory should bring out infographic on DSED and say *"I just found this info-have you thought about it?"* - After 3 doses of epinephrine (3mg total), consider holding further epinephrine and pivoting to esmolol (see discussion notes for details on epinephrine ceiling dose)



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		☐ At rhythm check: Leader orders energy level (e.g., "200J on each") → charge both → clear patient (visually confirms) ☐ **Deliver Shock 1 → announce "Shock One"→ Immediately deliver Shock 2 → announce "Shock Two"** ☐ Resume CPR immediately after 2nd shock	proper pad placement) → **Progress to State 3: ROSC** - If no DSED after 6 total shocks → **Progress to State 4: Deterioration (Asystole)**	Esmolol: - Loading dose: 500 mcg/kg IV bolus - Infusion: 0–100 mcg/kg/min, titrate to effect - Onset <60 seconds, half-life ~9 minutes - Expected post-ROSC BP effect: hypotension likely; manage with norepinephrine; stop infusion if severe (effects self-resolve in 10–30 min) - If BP is labile: stop infusion (no taper needed), support with vasopressors; short half-life is the safety net - Post-ROSC: may continue low-rate infusion to prevent re-fibrillation; titrate down as patient stabilizes Labs results pending.
3. ROSC Rhythm: Sinus Tach HR: 105 BP: 95/58 RR: 14 (vent) O_2SAT: 94% T: 36.2°C $ETCO_2$: 35	Color improves. Palpable pulse. Remains unresponsive.	Expected Learner Actions ☐ Confirm pulse and BP ☐ 12-lead ECG (and 15-lead) ☐ Intubate if not yet done ☐ Post-intubation CXR ☐ Initiate targeted temperature management ☐ Vasopressors for MAP > 65 (norepinephrine) ☐ Activate cath lab, ICU, CCU	Modifiers - ECG shows anterior STEMI Triggers **- All post-ROSC actions complete OR 15 min elapsed → End of Case ("Cath lab is ready for the patient")** - If time permitting → **optional branch point to 3A. Pseudo-PEA post ROSC**	Labs results available

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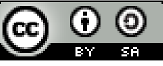
		☐ Sedation and analgesia		
3A. Pseudo-PEA Rhythm: organized	Loss of palpable pulse post-ROSC.	Expected Learner Actions ☐ Perform POCUS to assess for cardiac activity ☐ Use Doppler or arterial lines to detect low-flow state ☐ Distinguish pseudo-PEA (PREM) from true PEA (PRES) ☐ Treat as profound shock with titratable vasopressors rather than epi boluses ☐ Search for reversible causes	Modifiers - If carotid Doppler shows low flow → confirm pseudo-PEA, consider pausing CPR, initiate vasopressor infusion and volume - If echo shows contractions but no Doppler flow → true PEA, continue CPR and aggressively treat reversible causes	**Optional branch after ROSC:** The patient transiently develops an organized rhythm without a palpable pulse post-ROSC.
4. Deterioration *(if DSED not performed)* Rhythm: Asystole HR: 0 BP: 0/0 ETCO2: 5	Non-responsive. No pulse.	Expected Learner Actions ☐ Continue epinephrine 1mg q3-5 min ☐ Consider termination of resuscitation	Modifiers - - - Triggers - -	*End case. Debrief on missed DSED opportunity.*



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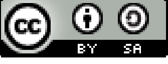
Appendix A: Laboratory Results

CBC	Cardiac/Coags
WBC 12.5 Hgb 142 Plt 225	Trop 450 ng/L D-dimer INR 1.0 aPTT 28
Lytes Na 139 K 4.2 Cl 102 HCO_3 16 Cr 96 Glucose 14.2	Biliary: pending AST ALT GGT ALP Bili Lipase
Extended Lytes Ca 2.25 Mg 0.82 PO_4 1.2 TSH 4	Tox: pending EtOH ASA Tylenol Dig level Osmols
VBG pH 7.18 pCO_2 52 pO_2 45 HCO_3 16 Lactate 8.5	



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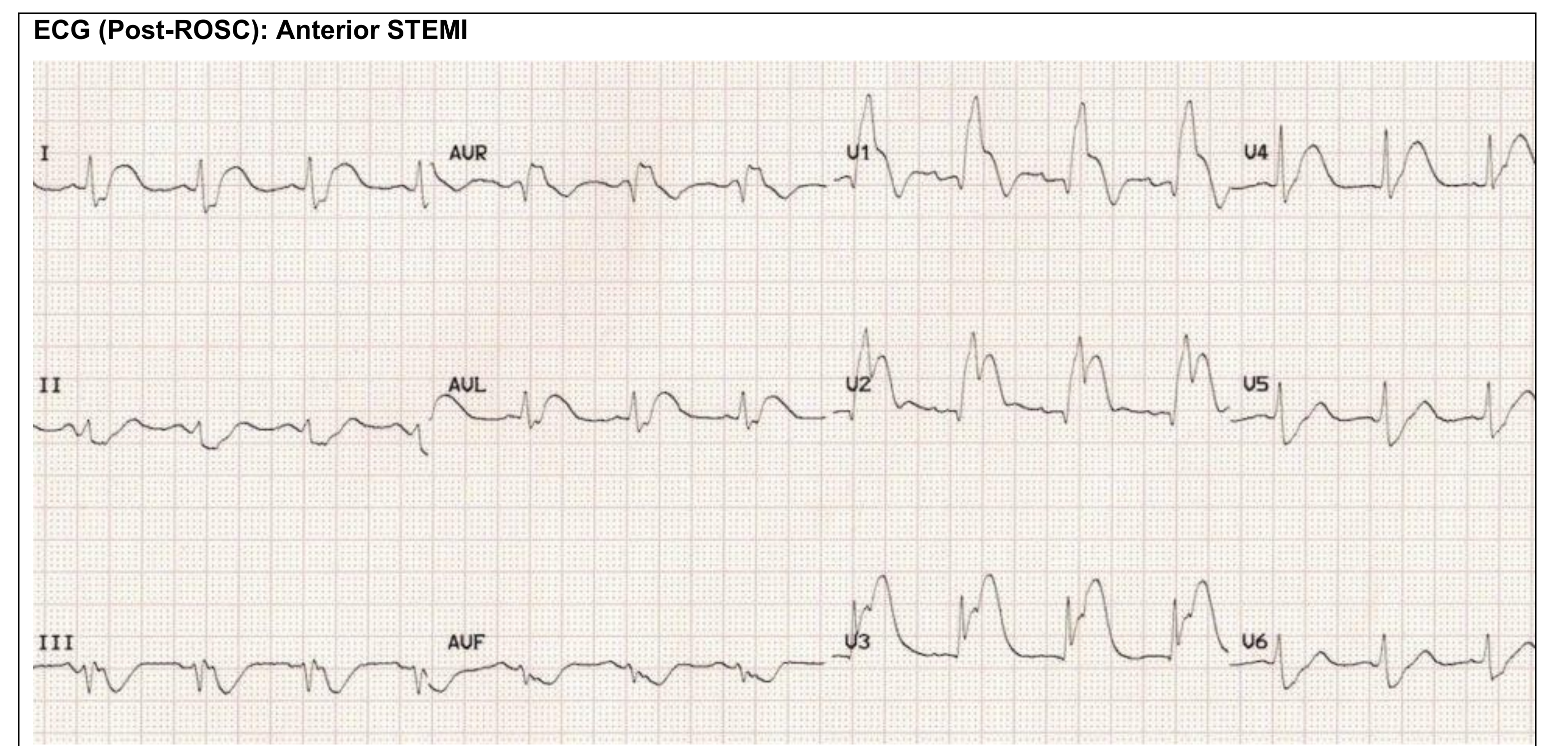
Appendix B: ECGs, X-rays, Ultrasounds and Pictures

ECG (Post-ROSC): Anterior STEMI



Source: https://litfl.com/anterior-myocardial-infarction-ecg-library/ Example 8: https://litfl.com/wp-content/uploads/2018/08/ECG-Ostial-LAD-occlusion-septal-STEMI-2.jpg

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CXR (Post-Intubation): Normal ETT placement, no pneumothorax.

Source: https://emsimcases.com/wp-content/uploads/2015/11/normal-post-intubation-cxr.png

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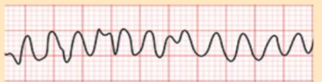
PHC DSED Infographic (Print and have available to provide to a copy to learners during the simulation):

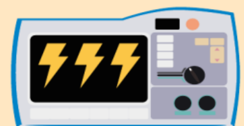
SPH/MSJ

DUAL SEQUENTIAL EXTERNAL DEFIBRILLATION (DSED)

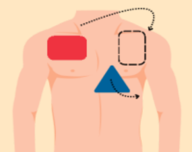
CONSIDER DSED IF:



Cardiac arrest with **refractory ventricular fibrillation**



At least **3 consecutive defibrillation attempts** (with appropriate ACLS medications administered)



Attempted to **change electrical vector** (e.g. consider AP placement if starting with AL placement)

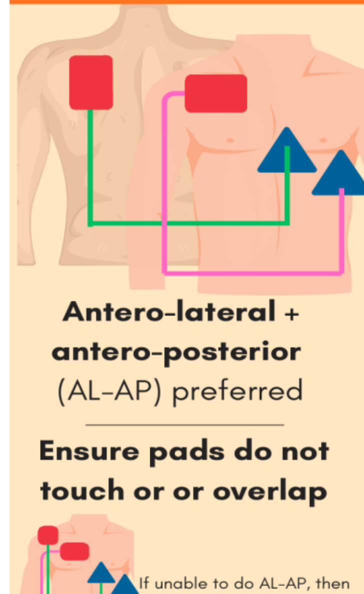
YOU WILL NEED

Two **defibrillators** and two **defibrillator pads**

Either 2 R-Series, 2 X-Series, or a combination of the two

"One person, one finger" for both defibrillators

A second operator is only used if it's not possible to position both defibrillators near each other



Antero-lateral + antero-posterior (AL-AP) preferred

Ensure pads do not touch or or overlap

If unable to do AL-AP, then antero-lateral + antero-lateral is also acceptable.

PROCEDURE

CLEAR PATIENT

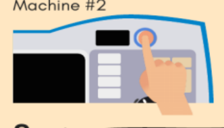
Machine #1

Give first shock

Say: Shock ONE

THEN IMMEDIATELY

Machine #2



Give second shock

Say: Shock TWO

AFTER USE

1. Do a **30J manual test** on each defibrillator.
2. **Visually inspect** each defibrillator for damage.
3. Follow department-specific process to **report defibrillators to BioMed** for additional inspection.

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Appendix C: Facilitator Cheat Sheet & Debriefing Tips

Include key errors to watch for and common challenges with the case. List issues expected to be part of the debriefing discussion. Supplemental information regarding any relevant pathophysiology, guidelines, or management information that may be reviewed during debriefing should be provided for facilitators to have as a reference.

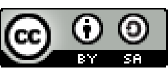
Key Errors to Watch For:
- Delivering simultaneous shocks instead of sequential shocks (must be rapid succession, NOT simultaneous)
- Overlapping defibrillator pads between the two sets
- Using two operators when defibrillators can be positioned side-by-side ("one person, one finger" preferred)
- Failing to verbally clear the patient before DSED shock delivery
- Prolonged chest compression pauses during DSED setup
- Attempting DSED before 3 consecutive standard defibrillation attempts
- Forgetting post-DSED defibrillator testing (manual self-test + visual inspection) and BioMed notification

DSED Quick Reference (per PHC Protocol #B-00-12-10201):
- Indicated for: Refractory VF after 3 consecutive shocks + high-quality CPR + appropriate pharmacotherapy
- Requires: 2 defibrillators, 2 sets of pads, ACLS-trained personnel
- Pad placement: Set 1 = anterior-lateral; Set 2 = anterior-posterior (preferred) or anterior-lateral (alternate). No overlap.
- Operator: Single designated person operates both defibrillators ("one person, one finger")
- Delivery: Shock 1 → "Shock One" → immediately Shock 2 → "Shock Two" → resume CPR

Sample Debriefing Questions:
- When did you first recognize this was refractory VF? What prompted you to consider DSED?
- Walk me through how you set up for DSED. What went well? What would you change?
- How did the team coordinate pad placement while minimizing compression pauses?
- Describe the "one person, one finger" principle. Why is sequential (not simultaneous) delivery important?
- What additional pharmacological strategies exist for refractory VF beyond DSED?
- Walk us through the esmolol dosing you would use. What would you do if the patient's BP dropped after ROSC while on an esmolol infusion?
  - Esmolol in Refractory VF: Evidence Summary.
    - *The following table summarises the key studies and current guideline recommendations for esmolol use in refractory ventricular fibrillation. Evidence remains limited to small retrospective studies and one pilot RCT; larger prospective trials are ongoing.*

Esmolol in Refractory VF: Evidence Summary

Study	Design	Esmolol Dose	Key Findings
Driver et al. 2014 *Resuscitation*	Retrospective, single-centre	500 mcg/kg bolus + 0–100 mcg/kg/min infusion	**Sustained ROSC:** 67% vs 32% **Survival to discharge:** 50% vs 16% **Good neuro outcome:** 50% vs 11%
Lee et al. 2016 *Resuscitation*	Retrospective pre-post, single-centre (Korea)	500 mcg/kg bolus + 0–100 mcg/kg/min infusion	**Sustained ROSC:** 56% vs 16% (p=0.007) **Good neuro outcome:** 19% vs 8% (NS)
Patrick et al. 2022 *JACEP Open*	Retrospective before-and-after, EMS feasibility	0.5 mg/kg single bolus (no infusion)	**Feasibility:** 87% of eligible patients received esmolol **Prehospital ROSC:** 52% vs 44% (NS) **Survival to discharge:** NS



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Stupca et al. 2023 *Am J Emerg Med*	Retrospective multi-centre cohort	40 mg fixed bolus + epi cap 3 mg + vector change (EMS bundle)	**Sustained ROSC:** Lower in bundle group **Neuro-intact survival:** Similar between groups ***Note:*** *Fixed (non-weight-based) esmolol dose may have been inadequate*
BETA-ARREST 2024 *Resuscitation* (Schriefl et al.)	Prospective RCT, double-blind, placebo-controlled (pilot)	Landiolol 20 mg bolus (not esmolol; ultra-short beta-1 blocker)	**First prospective RCT of beta-blockade in refractory VF** No benefit demonstrated for time to ROSC **Key caveats:** different drug (landiolol), no infusion, small pilot study, broader VF definition
REVIVE 2025 *Resusc Plus*	Multi-centre collaborative (UK); pilot RCT planned	Esmolol + de-emphasised adrenaline (protocol in development)	**Ongoing:** 3-phase project (national survey, registry review, pilot RCT) Rationale: combines sympatholysis (esmolol) with reduced catecholamine load

2025 AHA ACLS Guidelines — Beta-Blockers for Refractory VF/pVT

Recommendation: "Use of beta-blockers, bretylium, procainamide, or sotalol for refractory VF/pVT is of uncertain benefit."

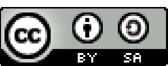
Class of Recommendation: 2b (Weak) | **Level of Evidence:** C-LD (Limited Data)

Clinical implication: *May be considered as a "kitchen sink" adjunct when standard ACLS + amiodarone + DSED have failed. Ultra-short half-life (~9 min) provides a built-in safety net. Larger RCTs (REVIVE) are ongoing.*

Esmolol Quick-Reference Dosing for Refractory VF			
Loading Dose	**Infusion**	**Onset / Half-Life**	**Post-ROSC BP Management**
500 mcg/kg IV bolus *(~37.5 mg for 75 kg)*	**0–100 mcg/kg/min** Titrate to rhythm stability *Some protocols: bolus only (no infusion)*	**Onset: <60 sec** Half-life: ~9 min Steady state: 2 min (with loading dose)	**If hypotensive:** STOP infusion (no taper) Effects resolve in 10–30 min Support with norepinephrine **Labile BP is manageable;** *short t½ is the safety net*

- How many doses of epinephrine were given? At what point, if any, would you consider capping epinephrine? What does the evidence say?
  - Emerging evidence suggests cumulative epi >3 mg is associated with worse neurological outcomes (Garcia et al., Am J Emerg Med, 2024). Current AHA guidelines do not define a formal ceiling but recommend against high-dose epi and note increasing evidence of harm from excessive catecholamine exposure in refractory shockable rhythms.
- What are the post-DSED equipment responsibilities per PHC protocol?
- If after ROSC the patient lost their pulse again with an organized rhythm on the monitor, how would you use POCUS to distinguish pseudo-PEA from true PEA? How would your management differ?
  - Pseudo-PEA / PREM Teaching Points

Pseudo-PEA (PREM) vs. True PEA (PRES): Definitions, Diagnosis & Management		
Feature	**Pseudo-PEA / PREM** *(Pulseless, Rhythm, Echo Motion)*	**True PEA / PRES** *(Pulseless, Rhythm, Echo Standstill)*
Definition	Organized electrical activity on monitor + cardiac contractile activity on POCUS + no palpable pulse. A profound shock state, **NOT** true cardiac arrest.	Organized electrical activity on monitor + **NO** cardiac contractile activity on POCUS + no palpable pulse. **True** electromechanical dissociation.
POCUS Cardiac	Coordinated ventricular contractions visible with LV volume change (organized activity)	Cardiac standstill, or only agonal/disorganized twitching without effective ventricular contraction
Carotid Doppler	Low-flow pulsatile signal detectable (may detect flow at SBP as low as 19 mmHg — Faldaas et al. 2023)	No pulsatile flow detected
Other Indicators	May see: $ETCO_2$ >20 mmHg, SpO_2 waveform present, arterial line pulsations	$ETCO_2$ typically <10 mmHg, no SpO_2 waveform, flat arterial line tracing



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Prognosis	ROSC 70–94%; ~50% good neurological outcome (Prosen et al. 2010)	Survival to discharge 0–6% (Gaspari et al., REASON trial)
Management	**Treat as PROFOUND SHOCK:** • Consider pausing CPR (compressions during contractility may impair output) • IV fluid bolus • Titratable vasopressor: norepinephrine infusion or push-dose epi (10–20 mcg) **— NOT 1 mg epi boluses** • Place arterial line (top priority) • Aggressively treat reversible causes (Hs & Ts) • Reassess frequently with POCUS	**Treat as TRUE CARDIAC ARREST:** • Continue high-quality CPR • Epinephrine 1 mg IV q3–5 min per ACLS • Aggressively search for and treat reversible causes • POCUS: tamponade, RV strain (PE), hypovolemia, pneumothorax • Consider early termination if cardiac standstill persists • Prognosis is poor if no activity found on serial POCUS

Key Concept: The POCUS Pulse Check

Manual pulse palpation is unreliable: up to 45% of providers cannot accurately detect a central pulse during CPR (Eberle et al. 1996). Up to 32% of PEA diagnoses are inaccurate — patients have detectable circulation missed by palpation (Zengin et al. 2018).

POCUS pulse check: Place a linear probe over the carotid (or femoral) artery in short axis. Pulsatile Doppler flow during a pause in compressions indicates cardiac output is present, even if a manual pulse is not palpable. Can be completed accurately in <5 seconds with minimal training (Simard et al., The POCUS Pulse Check).

Decision framework (from EM Cases Ep. 131, Simard & Weingart):

1. POCUS cardiac: Is the heart contracting? → If NO = PRES (true PEA). If YES, proceed to step 2.
2. POCUS pulse (carotid/femoral Doppler): Is there detectable flow? → If YES = PREM (pseudo-PEA). If NO with echo motion = consider true PEA with agonal activity.
3. Corroborate with $ETCO_2$ (>20 mmHg suggests output), SpO_2 waveform, and arterial line if available.

Key Debriefing Moments:

- Recognition of refractory VF and decision to escalate to DSED
- Correct DSED procedure: pad placement, "one person, one finger," sequential shock delivery with verbal announcements
- Team role assignment and closed-loop communication during DSED
- Post-ROSC care: ECG interpretation (STEMI), cath lab activation, TTM initiation

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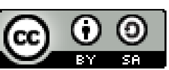

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