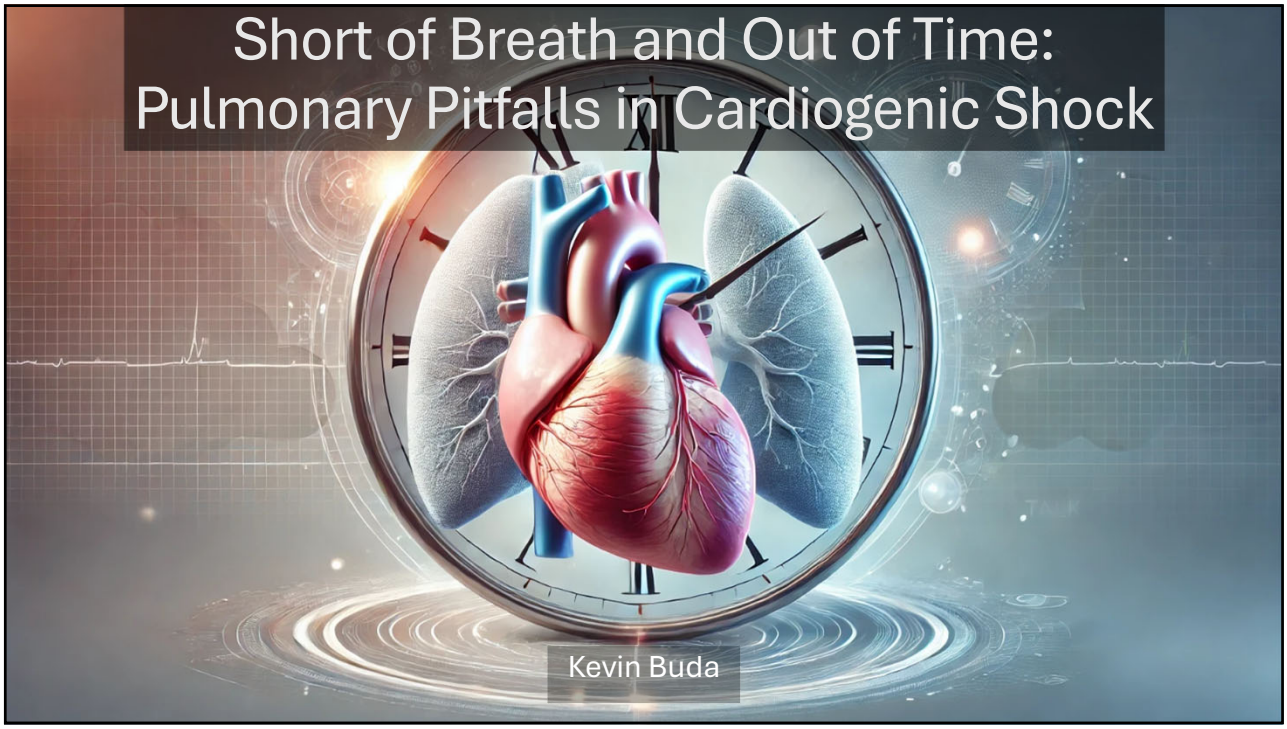
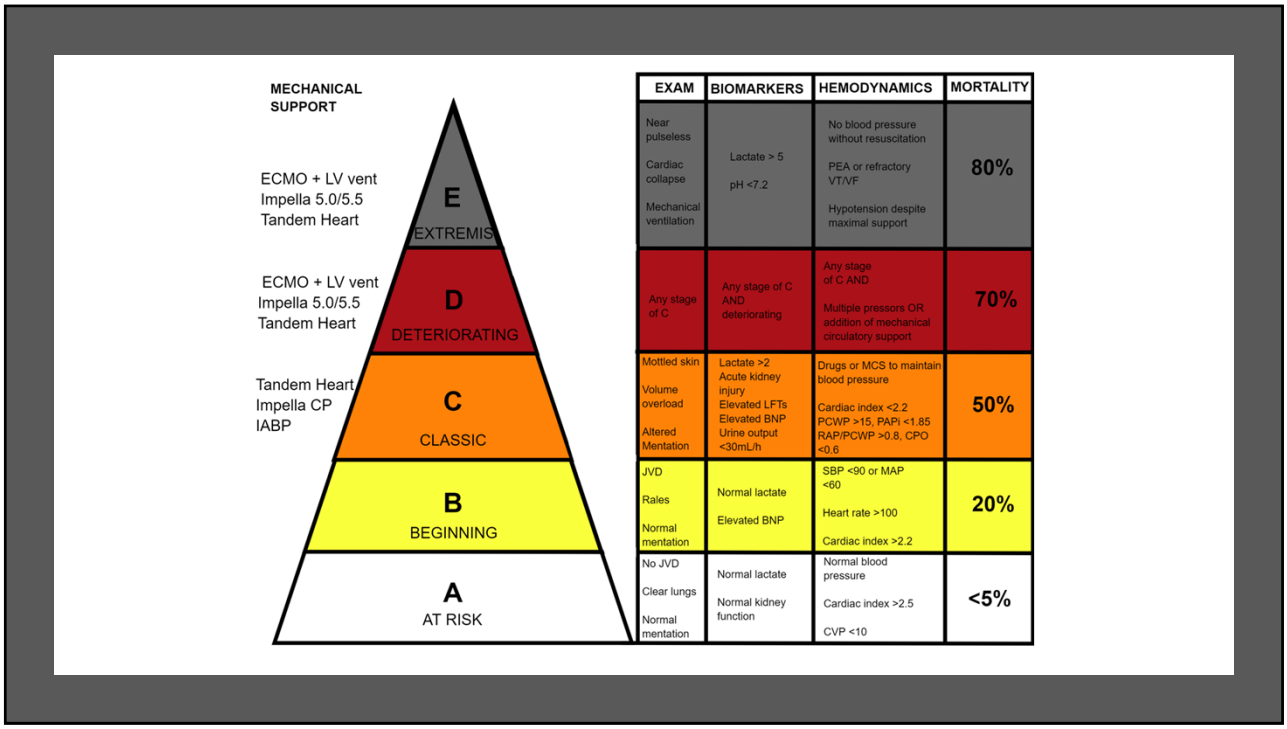

Minneapolis
Heart Institute
Foundation
GRAND ROUNDS

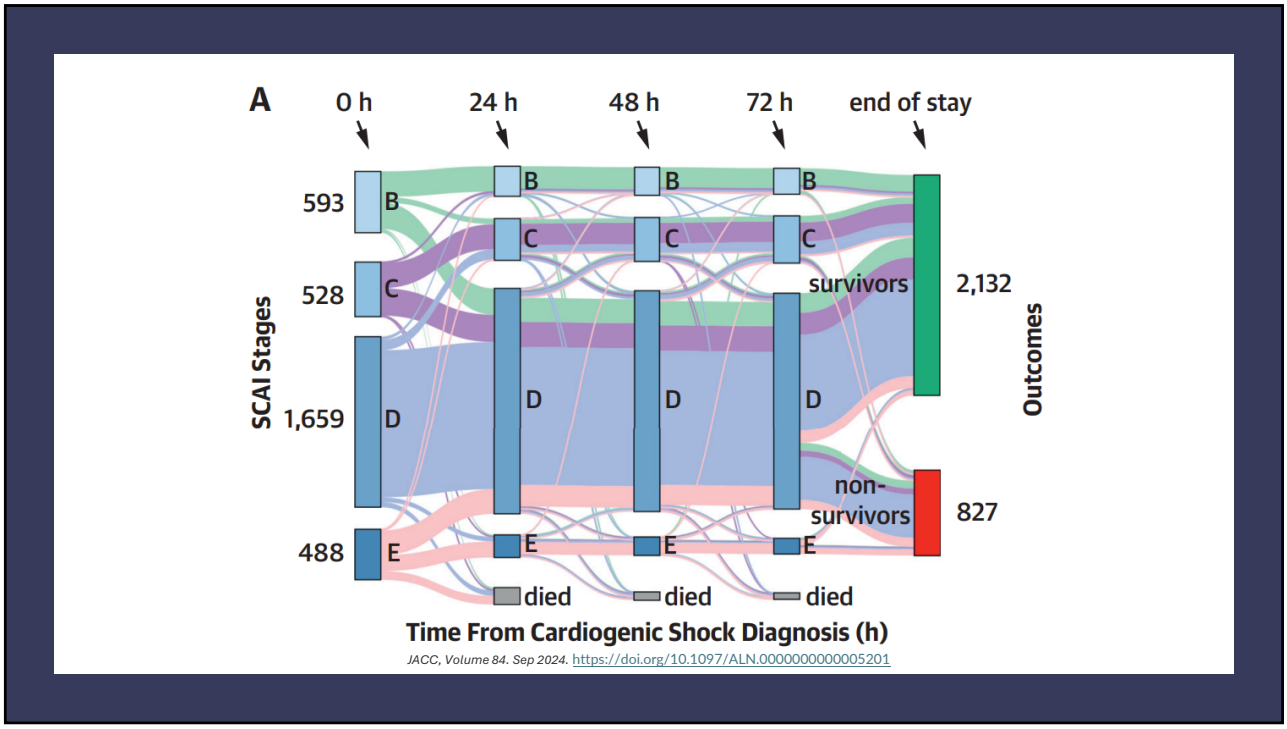
1


Short of Breath and Out of Time:
Pulmonary Pitfalls in Cardiogenic Shock
Kevin Buda

2


MECHANICAL SUPPORT
ECMO + LV vent
Impella 5.0/5.5
Tandem Heart
E
EXTREMIS
ECMO + LV vent
Impella 5.0/5.5
Tandem Heart
D
DETERIORATING
Tandem Heart
Impella CP
IABP
C
CLASSIC
B
BEGINNING
A
AT RISK
EXAM
BIOMARKERS
HEMODYNAMICS
MORTALITY
Near pulseless
Cardiac collapse
Mechanical ventilation
Lactate > 5
pH <7.2
No blood pressure without resuscitation
PEA or refractory VT/VF
Hypotension despite maximal support
80%
Any stage of C
Any stage of C AND deteriorating
Any stage of C AND
Multiple pressors OR addition of mechanical circulatory support
70%
Mottled skin
Volume overload
Altered Mentation
Lactate >2
Acute kidney injury
Elevated LFTs
Elevated BNP
Urine output <30mL/h
Drugs or MCS to maintain blood pressure
Cardiac index <2.2
PCWP >15, PAPi <1.85
RAP/PCWP >0.8, CPO <0.6
50%
JVD
Rales
Normal mentation
Normal lactate
Elevated BNP
SBP <90 or MAP <60
Heart rate >100
Cardiac index >2.2
20%
No JVD
Clear lungs
Normal mentation
Normal lactate
Normal kidney function
Normal blood pressure
Cardiac index >2.5
CVP <10
<5%

3


A
0 h
24 h
48 h
72 h
end of stay
593
528
1,659
488
B
C
D
E
SCAI Stages
survivors
non-survivors
2,132
827
Outcomes
died
Time From Cardiogenic Shock Diagnosis (h)
JACC, Volume 84. Sep 2024. https://doi.org/10.1097/ALN.0000000000005201

4

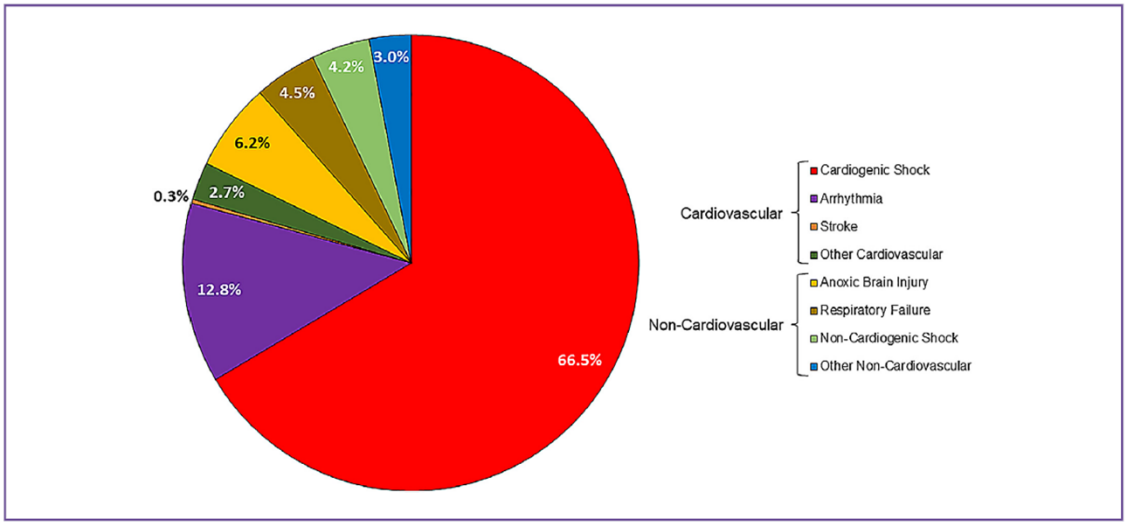


Fig. 1. Modes of in-hospital death in patients with cardiogenic shock ($N = 337$).

J Cardiac Fail, Volume 30. May 2024. https://doi.org/10.1016/j.cardfail.2024.01.012

5

Our V-A ECMO Experience

735 consecutive V-A ECMO runs January 2011 – April 2024

Patient characteristic	Died before decannulation (n=224)	Died after decannulation (n=125)	P value	Survived (n=386)	P value
Age	57	63	<0.001	54	<0.001
Hours on VA-ECMO	72.9	100.5	<0.001	91.4	<0.001
ECMO Indication					
ECPR (%)	36.1	25.6	0.059	22.2	0.508
Cannula Configuration (%)					
Femoral-femoral	79.5	71.4	0.114	79.6	0.074
North-south	2.6	0	0.167	0	•
Central	17.9	28.6	0.029	20.4	0.074
Post-Cardiotomy (%)	27.0	40.7	0.012	41.3	0.989
Impella	52.4	37.9	0.013	48.9	0.041

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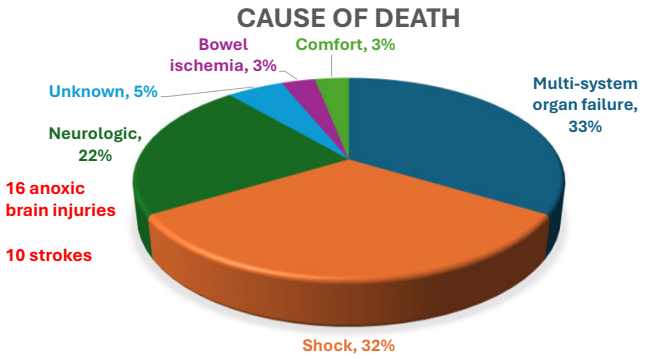
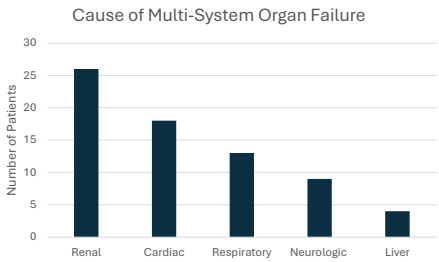
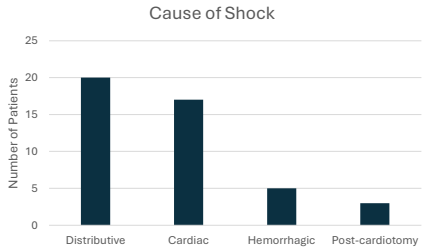
Methods and Results







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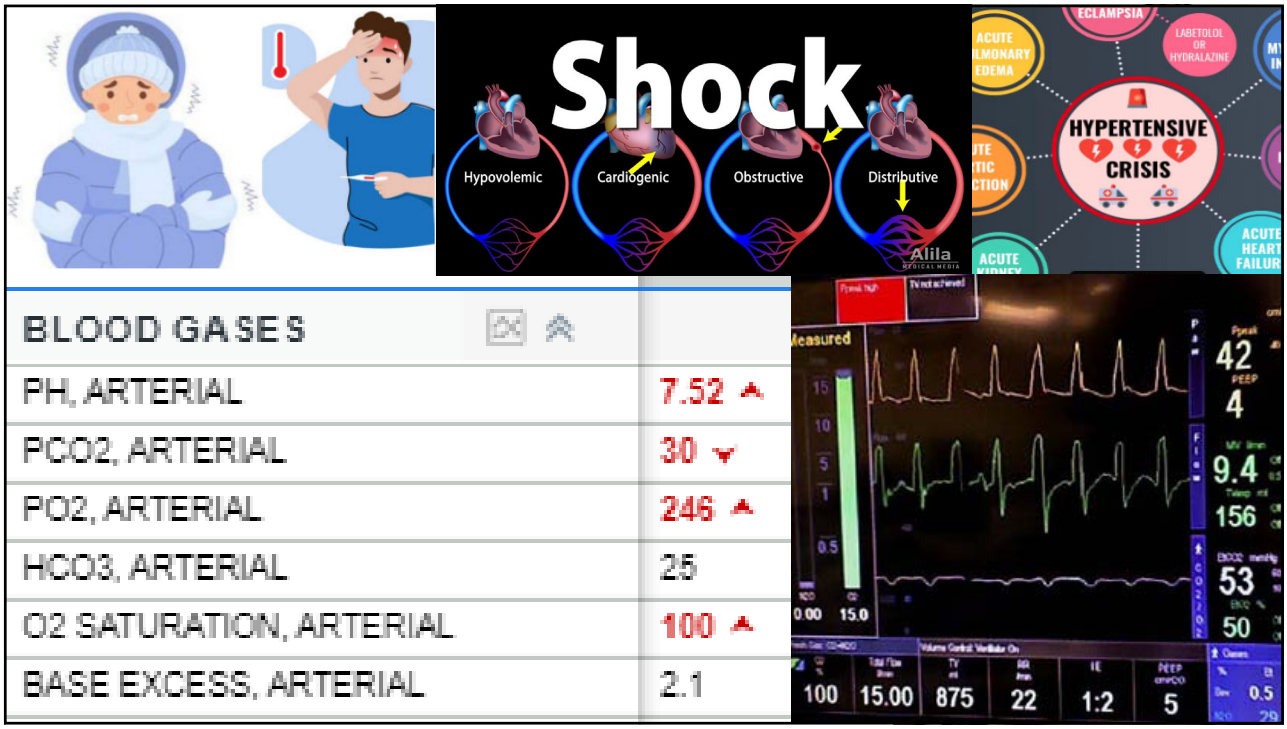

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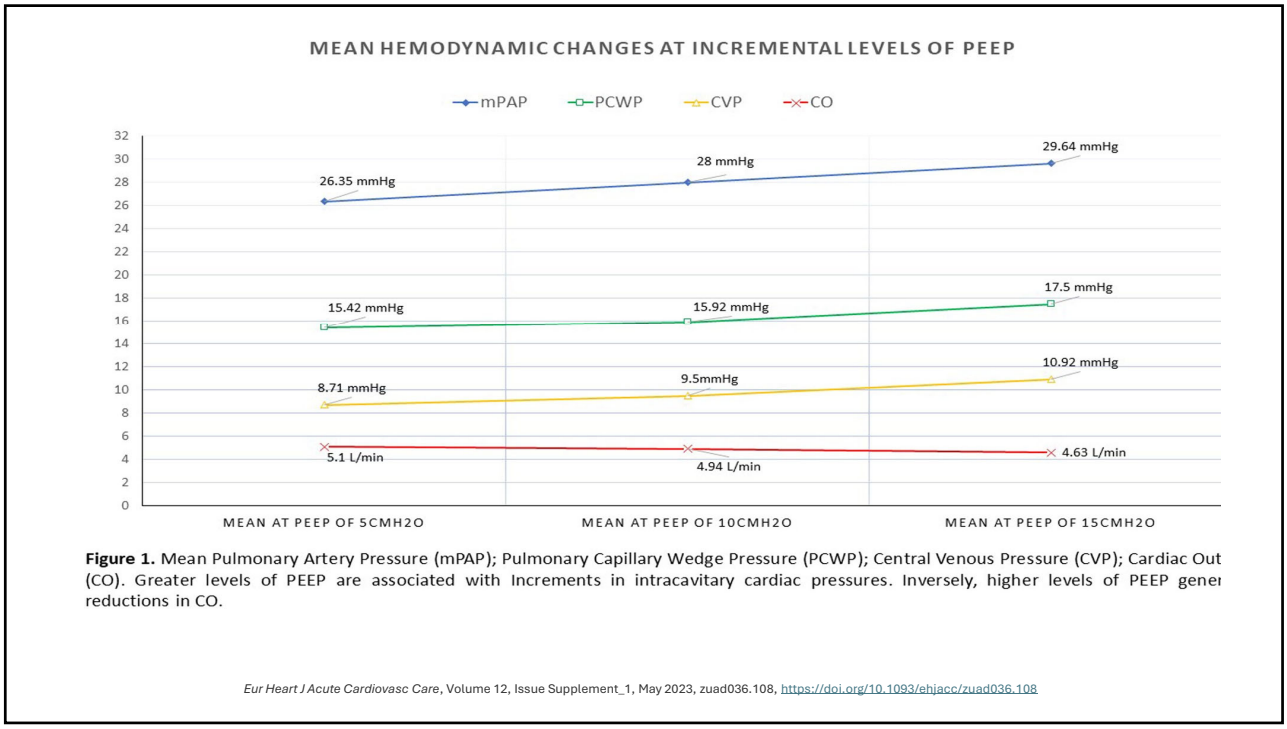
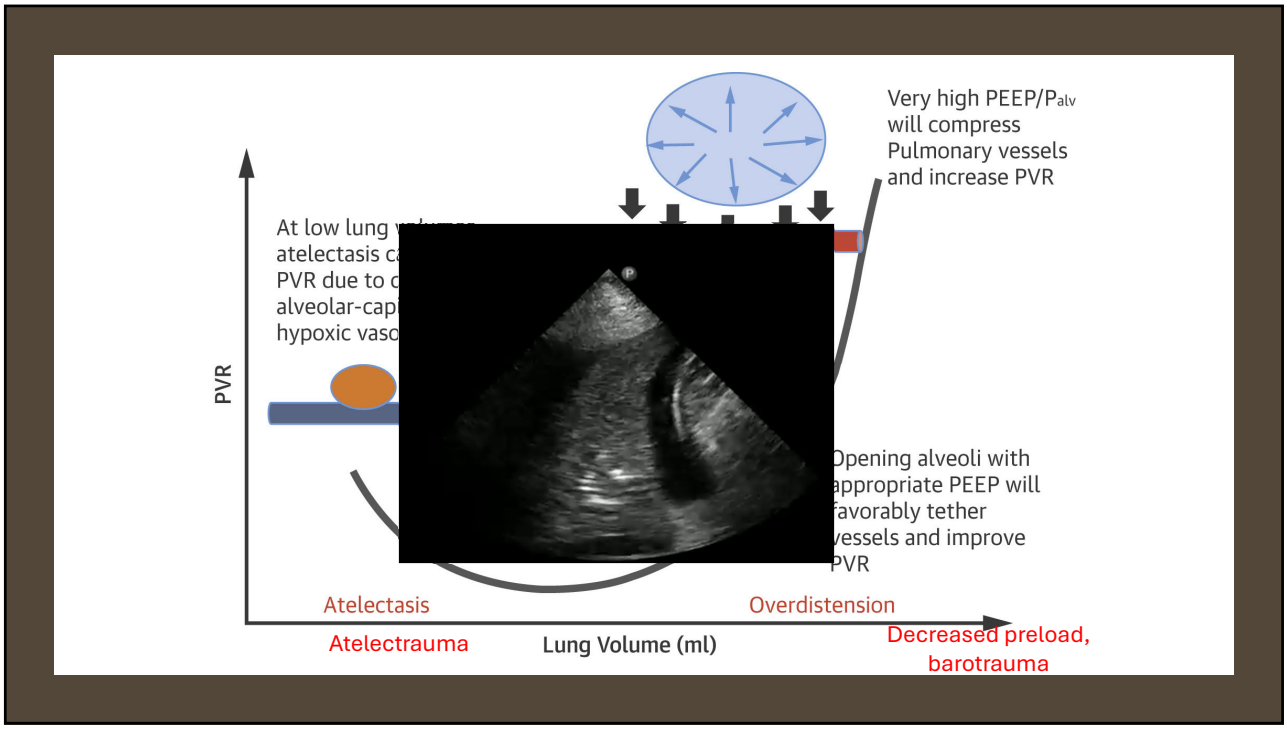


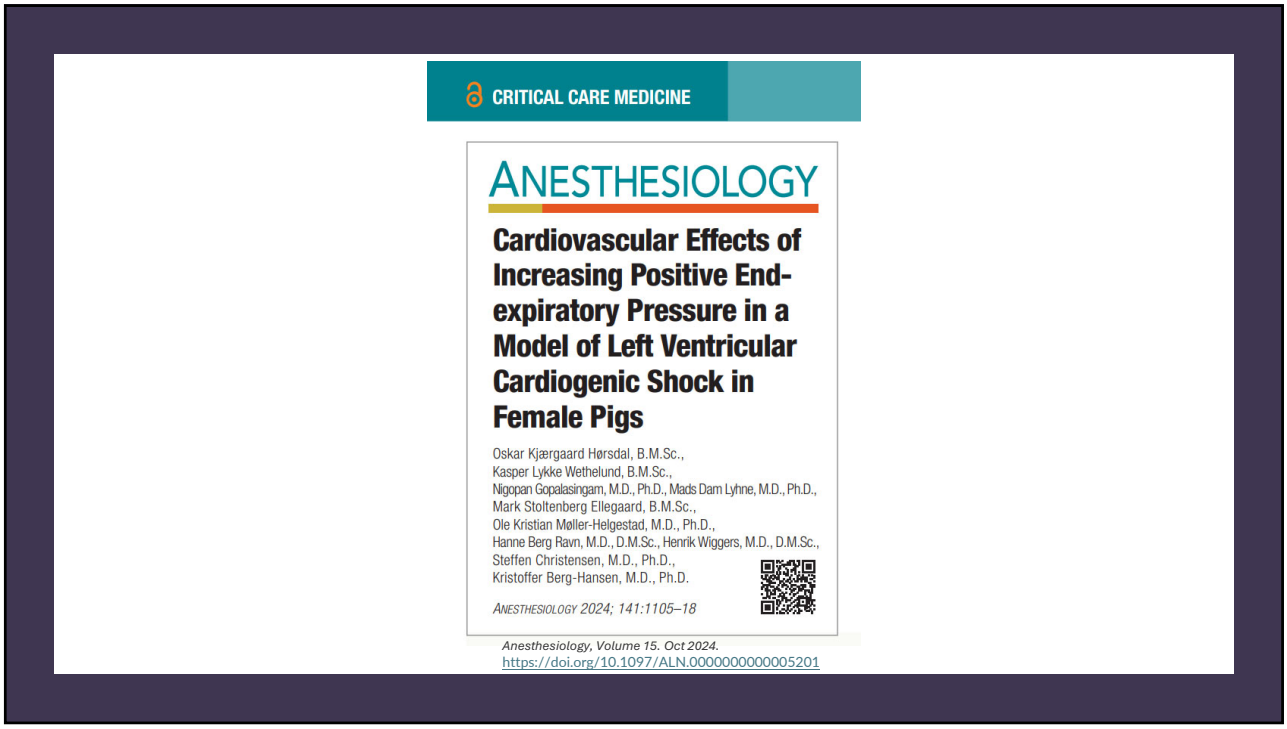
Figure 1. Mean Pulmonary Artery Pressure (mPAP); Pulmonary Capillary Wedge Pressure (PCWP); Central Venous Pressure (CVP); Cardiac Out (CO). Greater levels of PEEP are associated with Increments in intracavitary cardiac pressures. Inversely, higher levels of PEEP gener reductions in CO.

Eur Heart J Acute Cardiovasc Care, Volume 12, Issue Supplement_1, May 2023, zuad036.108, https://doi.org/10.1093/ehjacc/zuad036.108

10


Very high PEEP/Palv will compress Pulmonary vessels and increase PVR
At low lung
atelectasis c
PVR due to c
alveolar-cap
hypoxic vaso
Opening alveoli with appropriate PEEP will favorably tether vessels and improve PVR
PVR
Atelectasis
Atelectrauma
Lung Volume (ml)
Overdistension
Decreased preload, barotrauma

11


CRITICAL CARE MEDICINE
ANESTHESIOLOGY
Cardiovascular Effects of Increasing Positive End-expiratory Pressure in a Model of Left Ventricular Cardiogenic Shock in Female Pigs
Oskar Kjærgaard Hørsdal, B.M.Sc.,
Kasper Lykke Wethelund, B.M.Sc.,
Nigopan Gopalasingam, M.D., Ph.D., Mads Dam Lyhne, M.D., Ph.D.,
Mark Stoltenberg Ellegaard, B.M.Sc.,
Ole Kristian Møller-Helgestad, M.D., Ph.D.,
Hanne Berg Ravn, M.D., D.M.Sc., Henrik Wiggers, M.D., D.M.Sc.,
Steffen Christensen, M.D., Ph.D.,
Kristoffer Berg-Hansen, M.D., Ph.D.
ANESTHESIOLOGY 2024; 141:1105–18
Anesthesiology, Volume 15. Oct 2024.
https://doi.org/10.1097/ALN.0000000000005201

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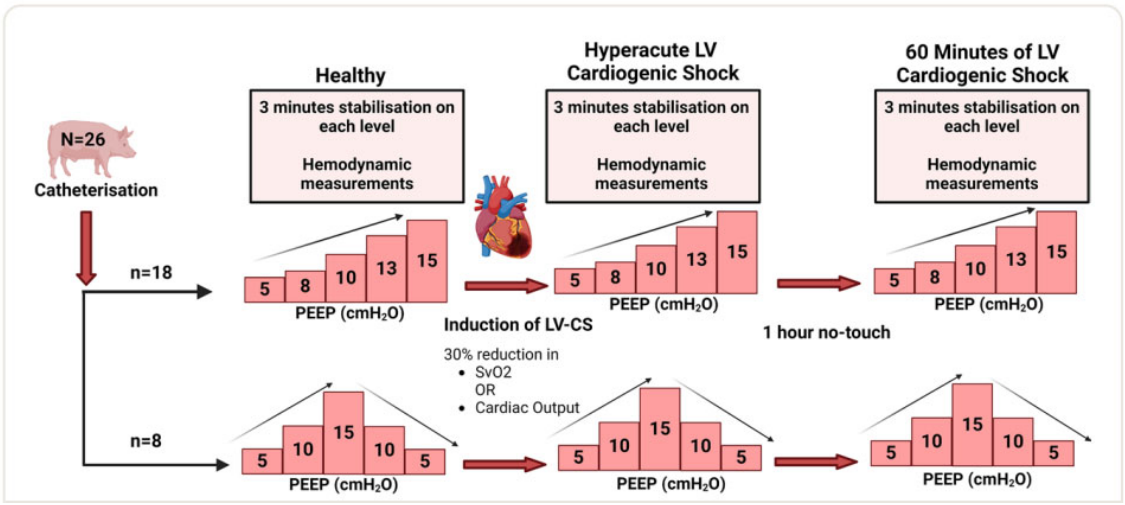

Kjaergaard et al. Anesthesiology, Volume 15. Oct 2024. https://doi.org/10.1097/ALN.0000000000005201

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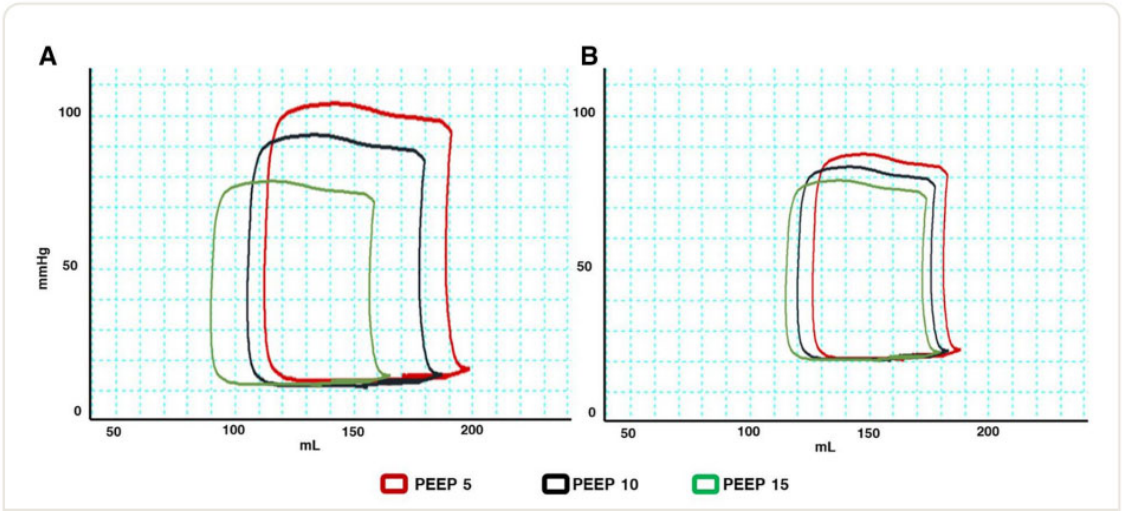

Kjaergaard et al. Anesthesiology, Volume 15. Oct 2024. https://doi.org/10.1097/ALN.0000000000005201

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Table 1. Cardiac Energetic Parameters during Different PEEP Settings

	PEEP				
Parameter	**5 cm H_2O**	**8 cm H_2O**	**10 cm H_2O**	**13 cm H_2O**	**15 cm H_2O**
PVA, mmHg × ml					
Healthy	10,437 ± 3,091	9,749 ± 3,395	8,755 ± 2,999‡	7,325 ± 2,882‡	6,699 ± 2,660‡
LV-CS	7,350 ± 2,798	7,406 ± 3,249	6,714 ± 2,630†	6,889 ± 2,784†	6,083 ± 2,233‡
MPE, mmHg × l/min					
Healthy	665 ± 221	607 ± 227	544 ± 182‡	458 ± 180‡	414 ± 160‡
LV-CS	490 ± 180	462 ± 191	452 ± 161*	448 ± 182*	436 ± 160†
SW, mmHg × ml					
Healthy	6,223 ± 2,167	5,954 ± 2,621	5,365 ± 2,230‡	4,662 ± 2,313‡	4,370 ± 2,005‡
LV-CS	3,572 ± 2,184	3,965 ± 2,322	3,311 ± 1,964*	3,753 ± 2,065	2,994 ± 1,791‡
PE, mmHg × ml					
Healthy	4,214 ± 2,210	3,795 ± 2,154	3,391 ± 1,707‡	2,663 ± 1,360‡	2,329 ± 1,303‡
LV-CS	3,778 ± 1,316	3,442 ± 1,432	3,403 ± 1,364†	3,135 ± 1,194‡	3,089 ± 1,104‡
CE, %					
Healthy	60 ± 14	61 ± 16	61 ± 14	63 ± 15	65 ± 13†
LV-CS	46 ± 13	51 ± 11	48 ± 14	52 ± 11	48 ± 15

Kjaergaard et al. Anesthesiology, Volume 15. Oct 2024. https://doi.org/10.1097/ALN.0000000000005201

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Table 2. Effects of Different PEEP Settings on Hemodynamic Pressure–Volume Parameters

	PEEP				
Parameter	**5 cm H_2O**	**8 cm H_2O**	**10 cm H_2O**	**13 cm H_2O**	**15 cm H_2O**
SV, ml					
Healthy	69 ± 24	67 ± 26	66 ± 23	63 ± 22	64 ± 21*
LV-CS	51 ± 30	57 ± 32	50 ± 27	57 ± 27	48 ± 24*
HR, min^{-1}					
Healthy	64 ± 14	63 ± 12	63 ± 13	63 ± 11	63 ± 12
LV-CS	71 ± 25	65 ± 17	71 ± 24	67 ± 18	75 ± 24*
Ees, mmHg/ml					
Healthy	1.39 ± 0.41	1.50 ± 0.44	1.40 ± 0.41	1.62 ± 0.61†	1.50 ± 0.47
LV-CS	1.00 ± 0.26	1.05 ± 0.27	1.03 ± 0.31	1.05 ± 0.26	1.02 ± 0.26
dP/dt_{max}, mmHg/s					
Healthy	1,729 ± 354	1,698 ± 371	1,551 ± 338†	1,464 ± 463‡	1,297 ± 416‡
LV-CS	1,147 ± 201	1,147 ± 233	1,089 ± 227*	1,128 ± 238*	1,030 ± 221†
LVEF, %					
Healthy	49 ± 15	51 ± 17	51 ± 14	54 ± 17†	55 ± 13‡
LV-CS	36 ± 13	41 ± 11	38 ± 13	42 ± 11	38 ± 14

Kjaergaard et al. Anesthesiology, Volume 15. Oct 2024. https://doi.org/10.1097/ALN.0000000000005201

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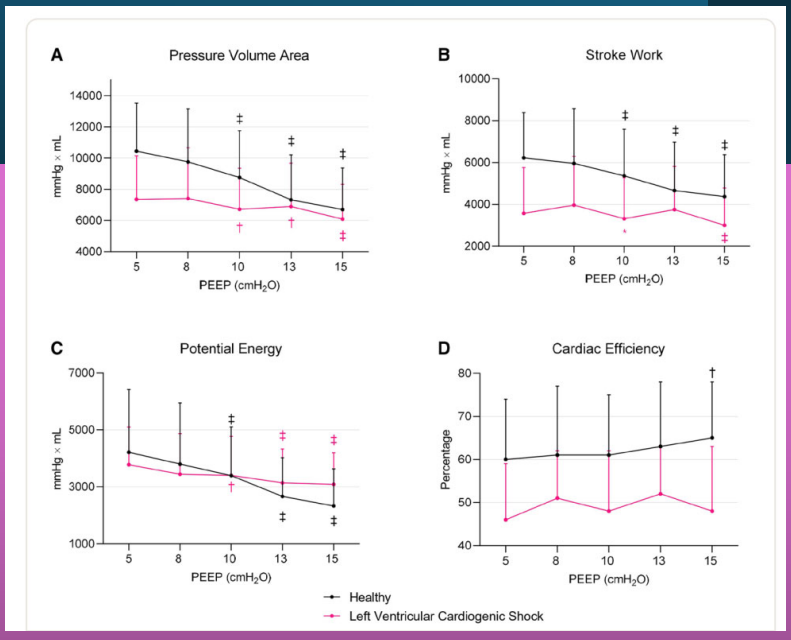
Table 2. Effects of Different PEEP Settings on Hemodynamic Pressure–Volume Parameters

Parameter	PEEP 5 cm H_2O	8 cm H_2O	10 cm H_2O	13 cm H_2O	15 cm H_2O
Afterload parameters					
Ea, mmHg/ml					
Healthy	1.72 ± 0.89	1.67 ± 0.92	1.53 ± 0.77	1.52 ± 0.88*	1.32 ± 0.69‡
LV-CS	2.09 ± 1.10	1.75 ± 1.04	1.89 ± 1.01	1.65 ± 0.99	1.89 ± 1.18
LVESP, mmHg					
Healthy	102 ± 21	99 ± 20	92 ± 19‡	86 ± 21‡	78 ± 18‡
LV-CS	84 ± 15	82 ± 19	81 ± 18*	80 ± 19†	77 ± 17‡
P_{max}, mmHg					
Healthy	104 ± 21	104 ± 19	95 ± 17‡	90 ± 20‡	83 ± 18‡
LV-CS	87 ± 16	87 ± 18	84 ± 18*	84 ± 18*	79 ± 16‡
LV wall stress, mmHg					
Healthy	191 ± 94	179 ± 93	160 ± 73‡	137 ± 67‡	118 ± 55‡
LV-CS	170 ± 63	161 ± 71	154 ± 64†	147 ± 64†	142 ± 50‡
LVESV, ml					
Healthy	108 ± 36	103 ± 39	99 ± 33‡	89 ± 34‡	85 ± 31‡
LV-CS	119 ± 31	114 ± 32	112 ± 33†	107 ± 30†	108 ± 28‡
Preload parameters					
LVEDV, ml					
Healthy	178 ± 36	174 ± 36	169 ± 35‡	157 ± 36‡	153 ± 35‡
LV-CS	172 ± 39	175 ± 44	165 ± 40*	167 ± 38*	159 ± 32‡
LVEDP, mmHg					
Healthy	15 ± 7	17 ± 7	15 ± 7	17 ± 7	15 ± 7
LV-CS	21 ± 10	21 ± 9	20 ± 8	21 ± 8	19 ± 8†

Kjaergaard et al. Anesthesiology, Volume 15. Oct 2024. https://doi.org/10.1097/ALN.0000000000005201

17



Kjaergaard et al. Anesthesiology, Volume 15. Oct 2024. https://doi.org/10.1097/ALN.0000000000005201

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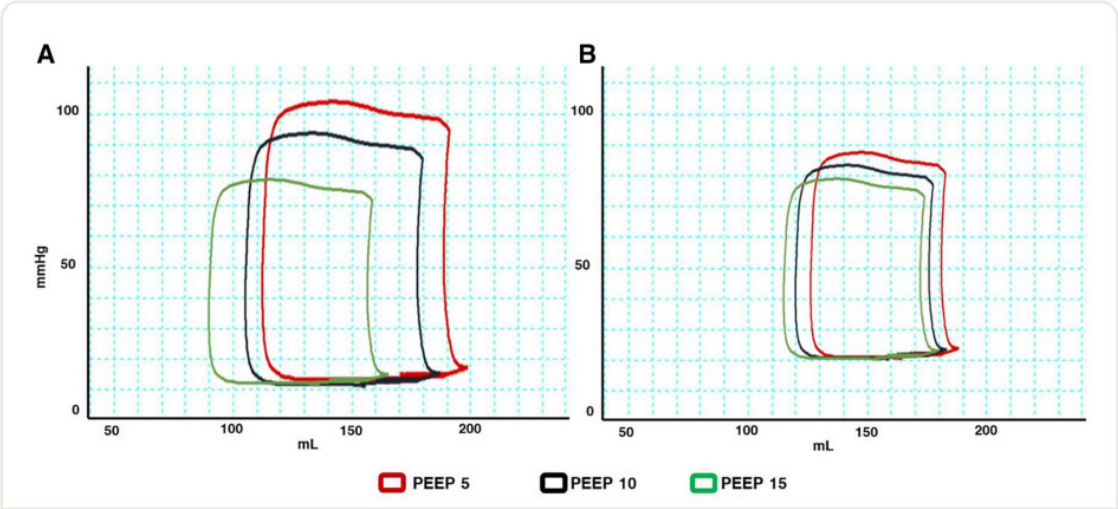

Kjaergaard et al. Anesthesiology, Volume 15. Oct 2024. https://doi.org/10.1097/ALN.0000000000005201

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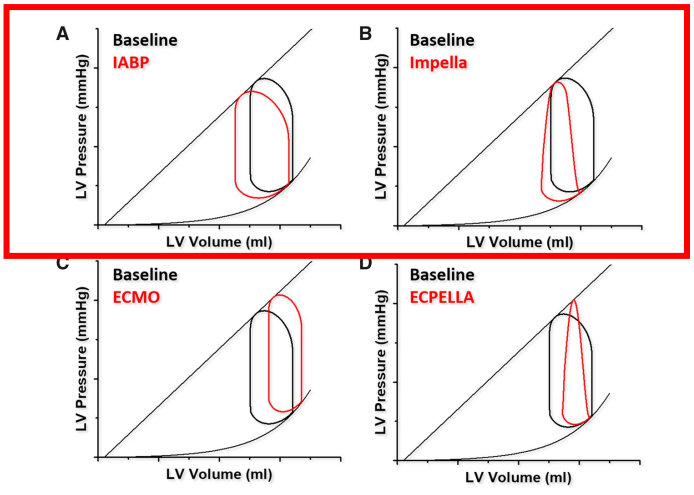

Eur Heart J, Volume 41, Issue 12, 21 March 2020, Pages 1286–1297, https://doi.org/10.1093/eurheartj/ehz552

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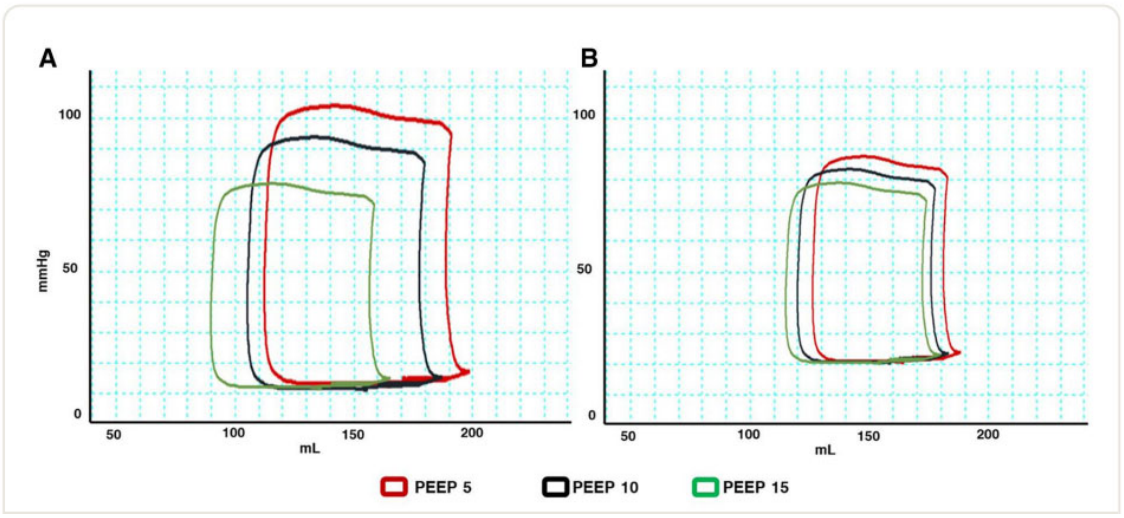

Kjaergaard et al. Anesthesiology, Volume 15. Oct 2024. https://doi.org/10.1097/ALN.0000000000005201

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CENTRAL ILLUSTRATION: Potential Physiological Effects of Positive End-Expiratory Pressure on Ventricular Function and Cardiac Output

Alviar, C.L. et al. J Am Coll Cardiol. 2018;72(13):1532–53.

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But what mode of IMV do I use?

23

24

ELSEVIER

Resuscitation
Volume 127, June 2018, Pages 83-88

Review

Association between intra- and post-arrest hyperoxia on mortality in adults with cardiac arrest: A systematic review and meta-analysis

Jignesh K. Patel [a], Abdo Kataya [a], Puja B. Parikh [b]

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Figure A

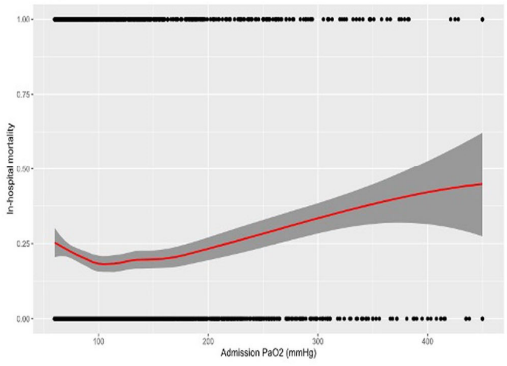
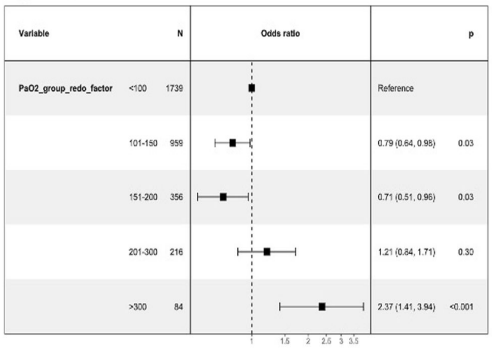
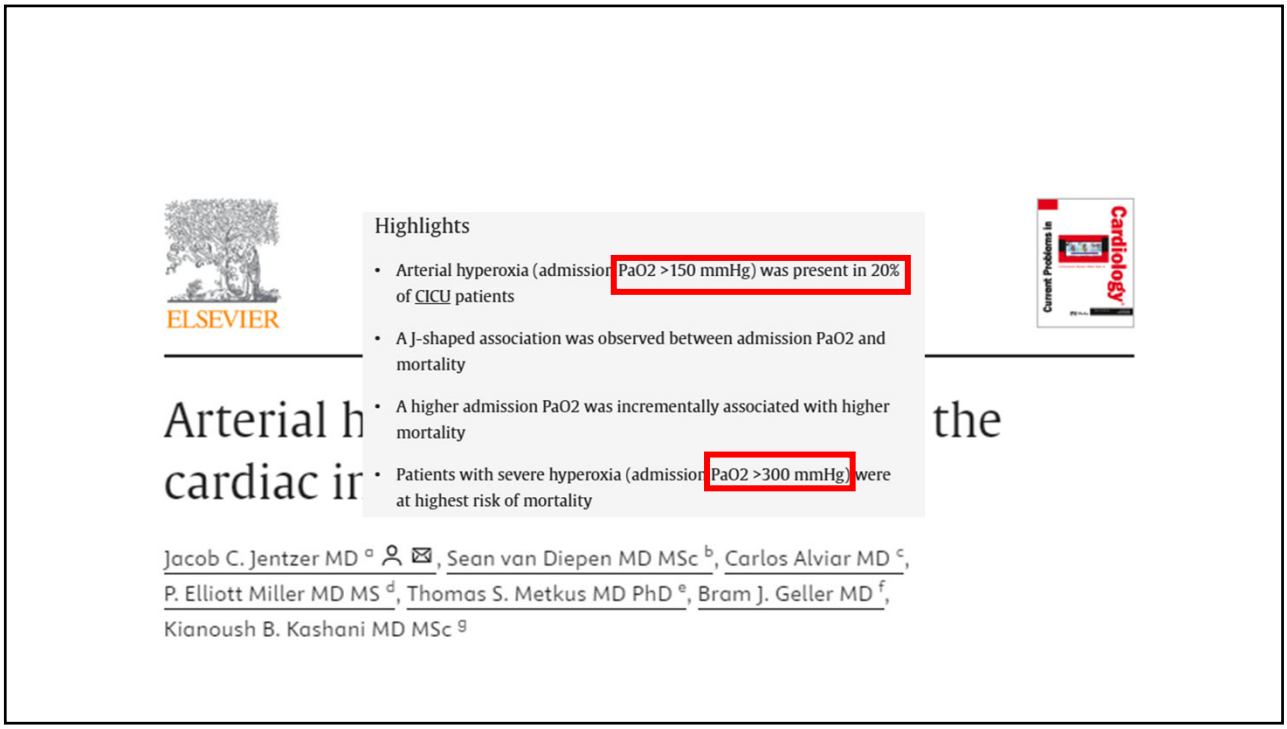


Figure B

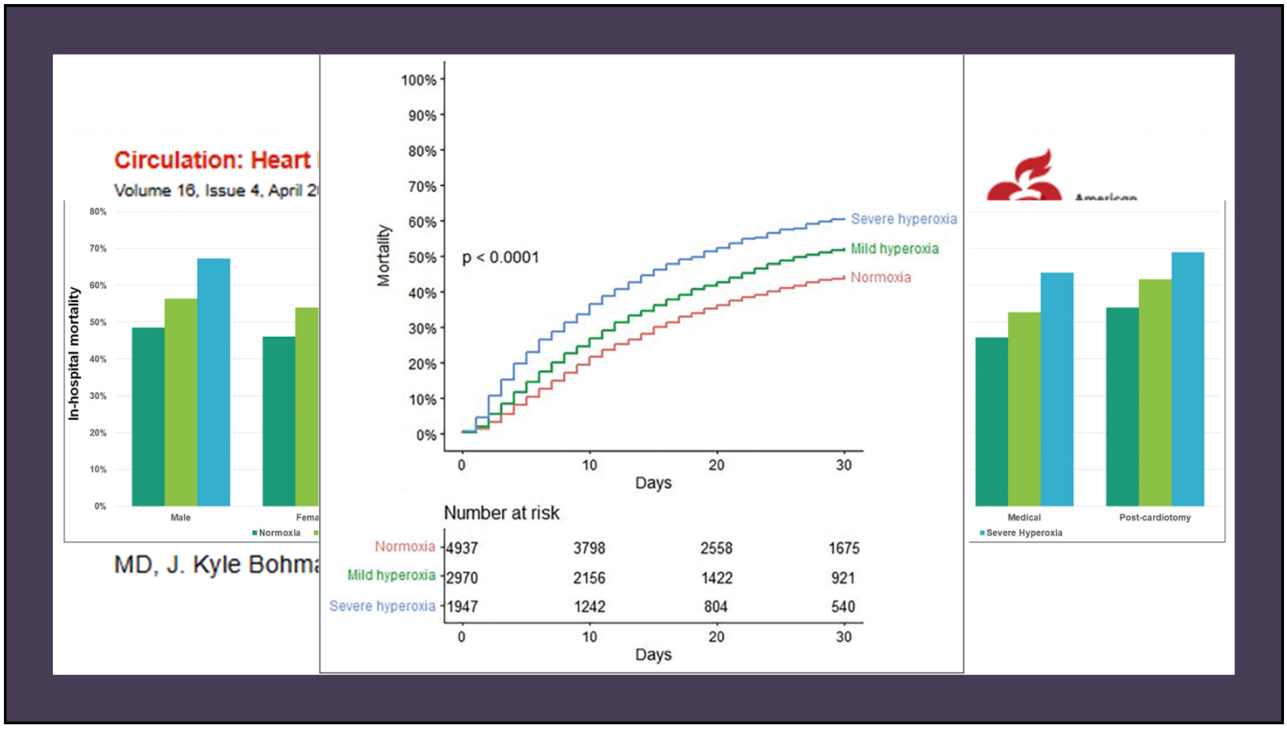


Eur Heart J Acute Cardiovasc Care, Volume 13, Issue Supplement_1, April 2024, zuae036.138,
https://doi.org/10.1093/ehjacc/zuae036.138

26


ELSEVIER
Highlights
• Arterial hyperoxia (admission PaO2 >150 mmHg) was present in 20% of CICU patients
• A J-shaped association was observed between admission PaO2 and mortality
• A higher admission PaO2 was incrementally associated with higher mortality
• Patients with severe hyperoxia (admission PaO2 >300 mmHg) were at highest risk of mortality
Current Problems in Cardiology
Arterial h
the
cardiac ir
Jacob C. Jentzer MD [a], Sean van Diepen MD MSc [b], Carlos Alviar MD [c], P. Elliott Miller MD MS [d], Thomas S. Metkus MD PhD [e], Bram J. Geller MD [f], Kianoush B. Kashani MD MSc [g]

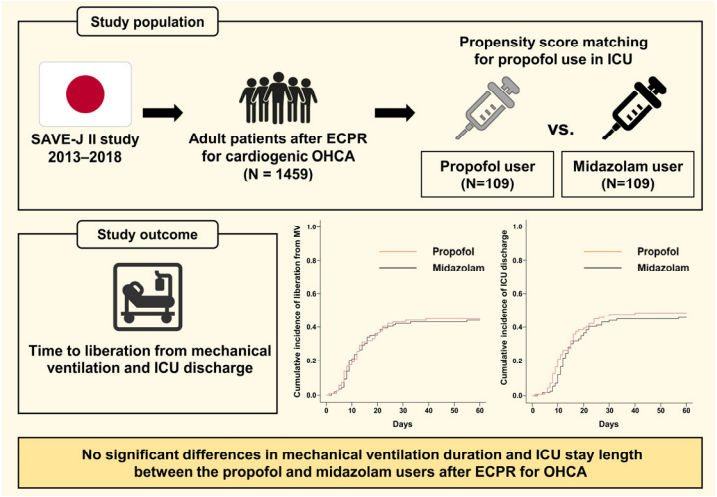
27


Circulation: Heart
Volume 16, Issue 4, April 2
In-hospital mortality
Male
Normoxia
MD, J. Kyle Bohma
Mortality
p < 0.0001
Severe hyperoxia
Mild hyperoxia
Normoxia
Days
Number at risk
Normoxia 4937 3798 2558 1675
Mild hyperoxia 2970 2156 1422 921
Severe hyperoxia 1947 1242 804 540
Medical
Post-cardiotomy
Severe Hyperoxia

28

29

Sedation



Eur Heart J Acute Cardiovasc Care, Volume 12, Issue 4, April 2023, Pages 246–256, https://doi.org/10.1093/ehjacc/zuad009

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Induction Agent

ELSEVIER

American Heart Journal
Volume 272, June 2024, Pages 116-125

AHJ

Clinical Investigations

Propofol vs etomidate for induction prior to invasive mechanical ventilation in patients with acute myocardial infarction

Alexander Thomas MD [a], Soumya Banna MD [b], Andi Shahu MD, MHS [a], Tariq Ali MD, MBA [a], Christopher Schenck MD [c], Bhoumesh Patel MD [d], Andrew Notarianni MD [d], Melinda Phommalinh PA [e], Ajar Kochar MD, MHS [f], Cory Heck PhD, BCCP [e], Sean van Diepen MD, MSc [g], P. Elliott Miller MD, MHS [a]

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TABLE 6 Cardiovascular Effects of Key Agents Used in the Management of PPV in the CICU

Drug Class/ Common Agents	Drug Dosage	Pharmacological Class	Most Frequent Adverse Cardiac Effects	Comments
Sedation/induction agents				All agents can worsen myocardial dysfunction.
Propofol	Bolus: 0.25-2.00 mg/kg IV Infusion: 5-50 μg/kg/min IV	General anesthetic	Hypotension, bradycardia	Hypertension and tachycardia are also possible. Caution if LVEF <50%. Monitor for propofol-related infusion syndrome, a rare but important side effect. Negative inotropic effect, especially when infused as a bolus.
Etomidate	0.3-0.4 mg/kg IV	General anesthetic	Hypotension because of adrenal suppression	Single dose inhibits adrenal steroid production for 6-24 h; hence, need to closely monitor fluid balance in patients with heart failure. May require stress steroids. Concerns for adrenal insufficiency have been raised, but it has not been demonstrated to increase mortality in septic patients. Useful for intubation in RV failure. Consider an alternative agent in patients with sepsis (e.g., ketamine, methohexital).
Dexmedetomidine	Loading: 1 mcg/kg over 10 min IV Infusion: 0.2-0.7 μg/kg/h IV* for 24 h	α2 adrenergic agonist, sedative	Hypotension, bradycardia	Hypotension due to cardiovascular depression and hypertension due to peripheral vasoconstriction (α2B receptor-mediated) have been described during bolus dosing. Hypertension and tachycardia may improve with dose reduction. Caution if pre-existing heart block or bradycardia.
Methohexital	Loading: IV: 0.75-1.00 mg/kg; can re-dose 0.5 mg/kg every 2 to 5 min as needed	General anesthetic (barbiturate derivative)	Hypotension, tachycardia	Hypotension due to cardiovascular depression and tachycardia.
Ketamine	Bolus: 0.1-0.5 mg/kg IV Infusion: 5-20 μg/kg/min IV	General anesthetic	Hypertension, tachycardia	Hypotension may also occur. Reactions may require additional sedation with other agents; use with caution in CAD and catecholamine depletion, such as in states of prolonged illness/hospitalization. Although superiority over other agents has not been demonstrated, ketamine may cause less hypotension by increasing systemic vascular resistance, so careful patient selection and monitoring in patients with LV dysfunction and hypertension is warranted. Useful for intubation in RV failure in patients without [illegible] for catecholamine depletion.

Alviar, C.L. et al. J Am Coll Cardiol. 2018;72(13):1532-53.

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Neuromuscular blockade agents				Ensure adequate sedation and analgesia if using NMB; monitor NMB through stimulation of peripheral nerves (79).
Succinylcholine	Bolus: 1-2 mg/kg IV	Depolarizing neuromuscular blockade	Bradycardia (most often in children); hypotension, hypertension, tachycardia; Arrhythmias because of hyperkalemia	Avoid if severe electrolyte abnormalities including hyperkalemia, muscle disorders, plasma pseudo cholinesterase disorders.
Rocuronium	Bolus: 0.6-1.2 mg/kg IV Infusion: 4-16 μg/kg/min IV	Nondepolarizing neuromuscular blockade	Infrequent side effects (<1%); Anaphylaxis, hypersensitivity reactions; Hypertension, tachycardia	Use with caution in conditions that potentiate or antagonize NMB. Maintenance bolus dosing used in operating room.
Vecuronium	Bolus: 0.08-0.10 mg/kg IV Infusion: 1 μg/kg/min IV	Nondepolarizing neuromuscular blockade	Infrequent side effects (<1%); Hypersensitivity, bradycardia, hypotension; Cross-reactivity with other NMBs	Use with caution in conditions that potentiate or antagonize NMB. Maintenance bolus dosing used in operating room.
Cisatracurium	Bolus: 0.15-0.20 mg/kg IV Infusion: 0.5-10.0 μg/kg/min IV	Nondepolarizing neuromuscular blockade	Infrequent side effects (<1%); Hypersensitivity, bradycardia, hypotension; Cross-reactivity with other NMB	Use with caution in conditions that potentiate or antagonize NMB. Maintenance bolus dosing used in operating room. May be preferred in ARDS.

Alviar, C.L. et al. J Am Coll Cardiol. 2018;72(13):1532-53.

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Reversal agents				
Sugammadex	Bolus: 2-16 mg/kg IV depending on level of block	Selective relaxant binding agent	Anaphylaxis is major side effect, Hypotension, hypertension, bradycardia, tachycardia, QT prolongation	Reverses neuromuscular blockade only for rocuronium and vecuronium, not nonsteroidal neuromuscular blocking agents such as succinylcholine or benzylisoquinolinium compounds.
Naloxone	0.4-2.0 mg IV, can be repeated at 2-3 min intervals to maximum dose 10 mg	Opioid antagonist	Flushing, hypertension, hypotension, arrhythmias	For reversal in chronic use cases, reduce dose and/or dilute in 10 ml 0.9% NaCl. Infuse slowly, to avoid acute opioid withdrawal and catecholamine release that can be very concerning in cardiac patients.
Analgesics				
Fentanyl	Bolus: 25-75 μg q1-2 h IV Infusion: 50-100 mcg/h IV	Anilidopiperidine opioid; general anesthetic	Hypotension, bradycardia	Many other reported adverse reactions. Fentanyl-induced chest wall rigidity (rare complication). Other dose ranges depend on diagnosis and route of administration.
Hydromorphone	Bolus: 0.2-0.6 mg q1-2 h IV Infusion: 0.5-3.0 mg/h IV	Opioid	Hypotension, bradycardia Hypertension, tachycardia	Dose varies depending on route of delivery.
Morphine	Bolus: 2-5 mg q4 h IV for pain Infusion: 2-30 mg/h IV	Opioid	Bradycardia, tachycardia, hypotension; histamine release	Dose varies depending on route of delivery. Has a venodilatory effect so it should be used with caution in preload-dependent states (e.g., RV failure).
Methadone	2.5-10.0 mg q8-12 h IV or 10-40 mg q6-12 h by mouth	Opioid	Hypotension, arrhythmias, QT prolongation	Monitor QT interval; discontinue if significant QT prolongation. Dose varies depending on route of delivery and patient. Half-life variable and very long.
Ketorolac	Bolus: 30 mg IV, then 15-30 mg q6 h up to 5 days	NSAID	Edema, hypertension, hyperkalemia	Adjust dose for weight <50 kg, age ≥65 yrs and renal impairment. Contraindicated in setting of coronary artery bypass surgery.

Alviar, C.L. et al. J Am Coll Cardiol. 2018;72(13):1532-53.

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Anxiolytic agents				
Midazolam	Bolus: 0.01-0.05 mg/kg IV Infusion: 0.02-0.10 mg/kg/h IV†	Anticonvulsant, benzodiazepine	Hypotension, especially in children	
Lorazepam	Bolus: 0.02-0.04 mg/kg (max 2 mg per dose) IV Infusion: 0.01-0.10 mg/kg/h IV†	Anticonvulsant, benzodiazepine	Hypotension	Monitor for propylene glycol toxicity, especially if doses above 0.1 mg/kg/h and/or renal failure.
Antipsychotic/hypnotic agents				
Quetiapine	No intravenous dosing. For ICU delirium: 50 mg by mouth twice daily; may increase to maximum dose 200 mg twice daily‡	Atypical antipsychotic, 2nd generation	Hypotension, hypertension, tachycardia	Monitor QT interval, discontinue if significant QT prolongation.
Haloperidol	Bolus: 0.5-10.0 mg q2-4 h IV Infusion: 0.5-2.0 mg/h IV	Typical antipsychotic, 1st generation	Hypotension, hypertension, arrhythmias	Monitor QT interval, discontinue if significant QT prolongation.

Alviar, C.L. et al. J Am Coll Cardiol. 2018;72(13):1532-53.

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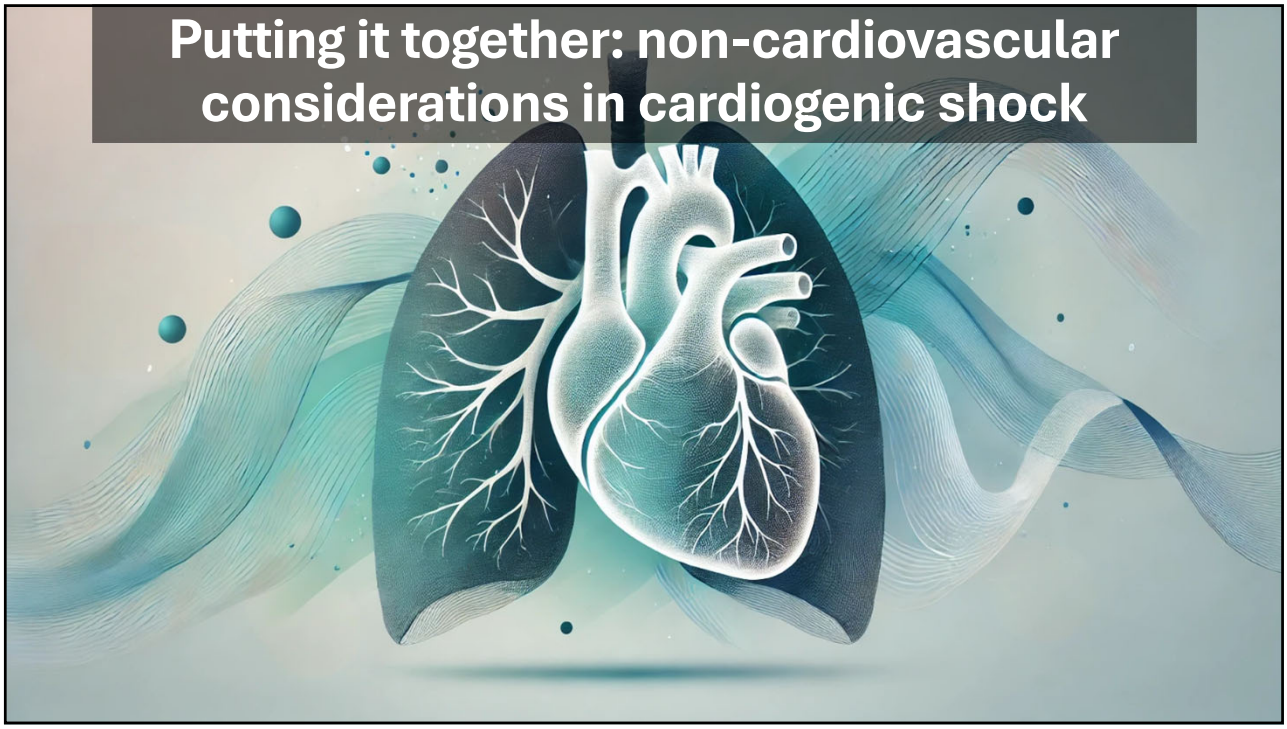
Putting it together: non-cardiovascular considerations in cardiogenic shock



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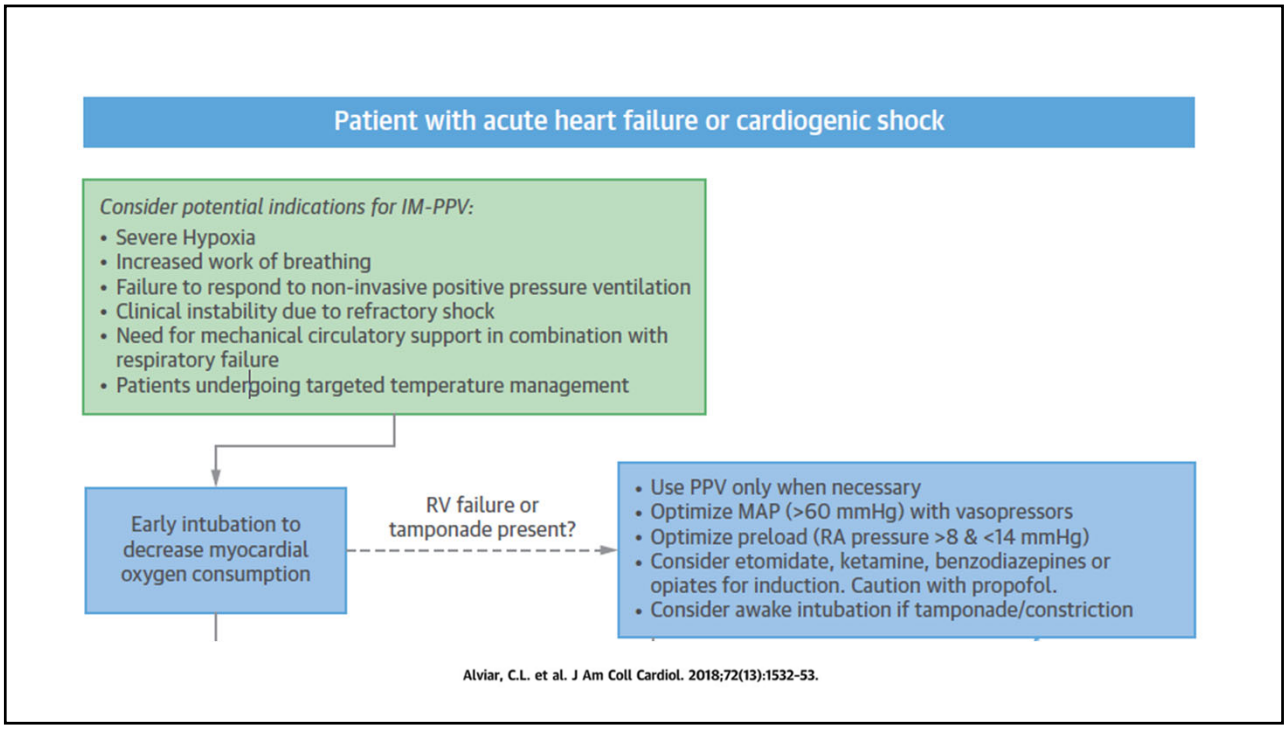
Patient with acute heart failure or cardiogenic shock
Consider potential indications for IM-PPV:
• Severe Hypoxia
• Increased work of breathing
• Failure to respond to non-invasive positive pressure ventilation
• Clinical instability due to refractory shock
• Need for mechanical circulatory support in combination with respiratory failure
• Patients undergoing targeted temperature management
Early intubation to decrease myocardial oxygen consumption
RV failure or tamponade present?
• Use PPV only when necessary
• Optimize MAP (>60 mmHg) with vasopressors
• Optimize preload (RA pressure >8 & <14 mmHg)
• Consider etomidate, ketamine, benzodiazepines or opiates for induction. Caution with propofol.
• Consider awake intubation if tamponade/constriction
Alviar, C.L. et al. J Am Coll Cardiol. 2018;72(13):1532-53.

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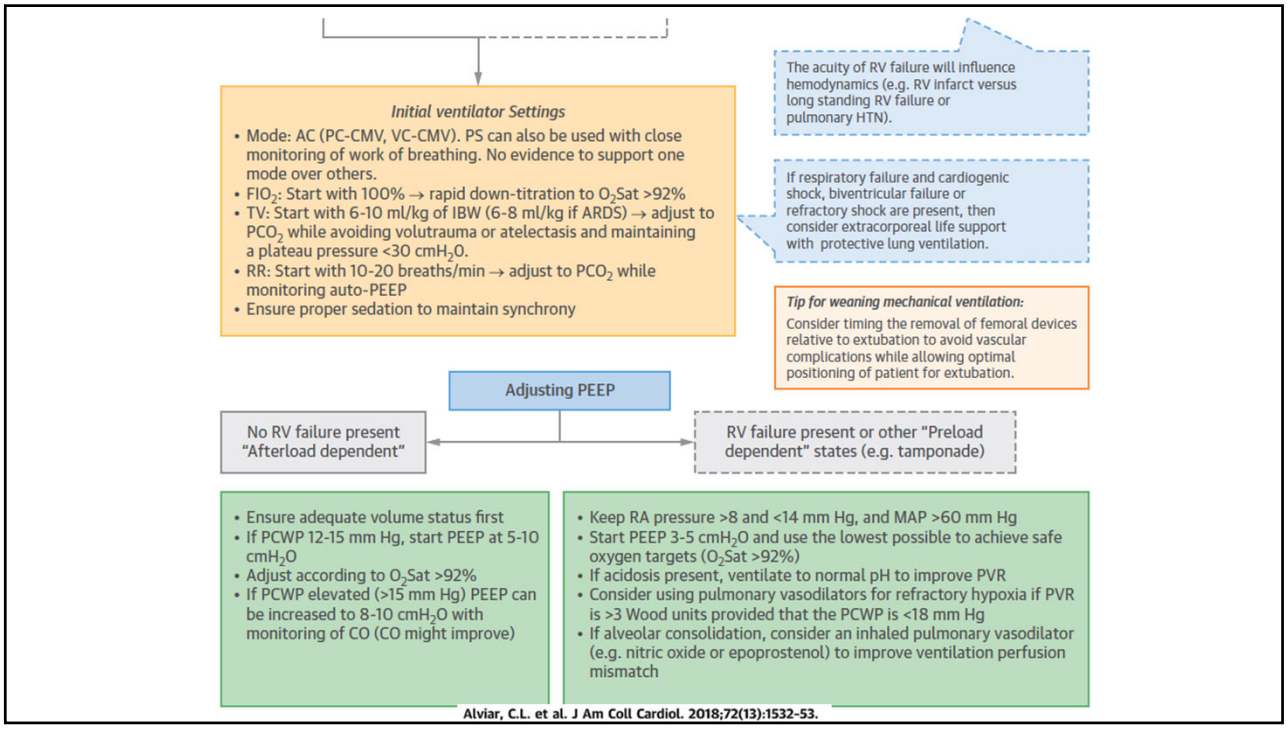
Initial ventilator Settings
• Mode: AC (PC-CMV, VC-CMV). PS can also be used with close monitoring of work of breathing. No evidence to support one mode over others.
• FIO_2: Start with 100% → rapid down-titration to O_2Sat >92%
• TV: Start with 6-10 ml/kg of IBW (6-8 ml/kg if ARDS) → adjust to PCO_2 while avoiding volutrauma or atelectasis and maintaining a plateau pressure <30 cmH_2O.
• RR: Start with 10-20 breaths/min → adjust to PCO_2 while monitoring auto-PEEP
• Ensure proper sedation to maintain synchrony
The acuity of RV failure will influence hemodynamics (e.g. RV infarct versus long standing RV failure or pulmonary HTN).
If respiratory failure and cardiogenic shock, biventricular failure or refractory shock are present, then consider extracorporeal life support with protective lung ventilation.
Tip for weaning mechanical ventilation:
Consider timing the removal of femoral devices relative to extubation to avoid vascular complications while allowing optimal positioning of patient for extubation.
Adjusting PEEP
No RV failure present "Afterload dependent"
RV failure present or other "Preload dependent" states (e.g. tamponade)
• Ensure adequate volume status first
• If PCWP 12-15 mm Hg, start PEEP at 5-10 cmH_2O
• Adjust according to O_2Sat >92%
• If PCWP elevated (>15 mm Hg) PEEP can be increased to 8-10 cmH_2O with monitoring of CO (CO might improve)
• Keep RA pressure >8 and <14 mm Hg, and MAP >60 mm Hg
• Start PEEP 3-5 cmH_2O and use the lowest possible to achieve safe oxygen targets (O_2Sat >92%)
• If acidosis present, ventilate to normal pH to improve PVR
• Consider using pulmonary vasodilators for refractory hypoxia if PVR is >3 Wood units provided that the PCWP is <18 mm Hg
• If alveolar consolidation, consider an inhaled pulmonary vasodilator (e.g. nitric oxide or epoprostenol) to improve ventilation perfusion mismatch
Alviar, C.L. et al. J Am Coll Cardiol. 2018;72(13):1532-53.

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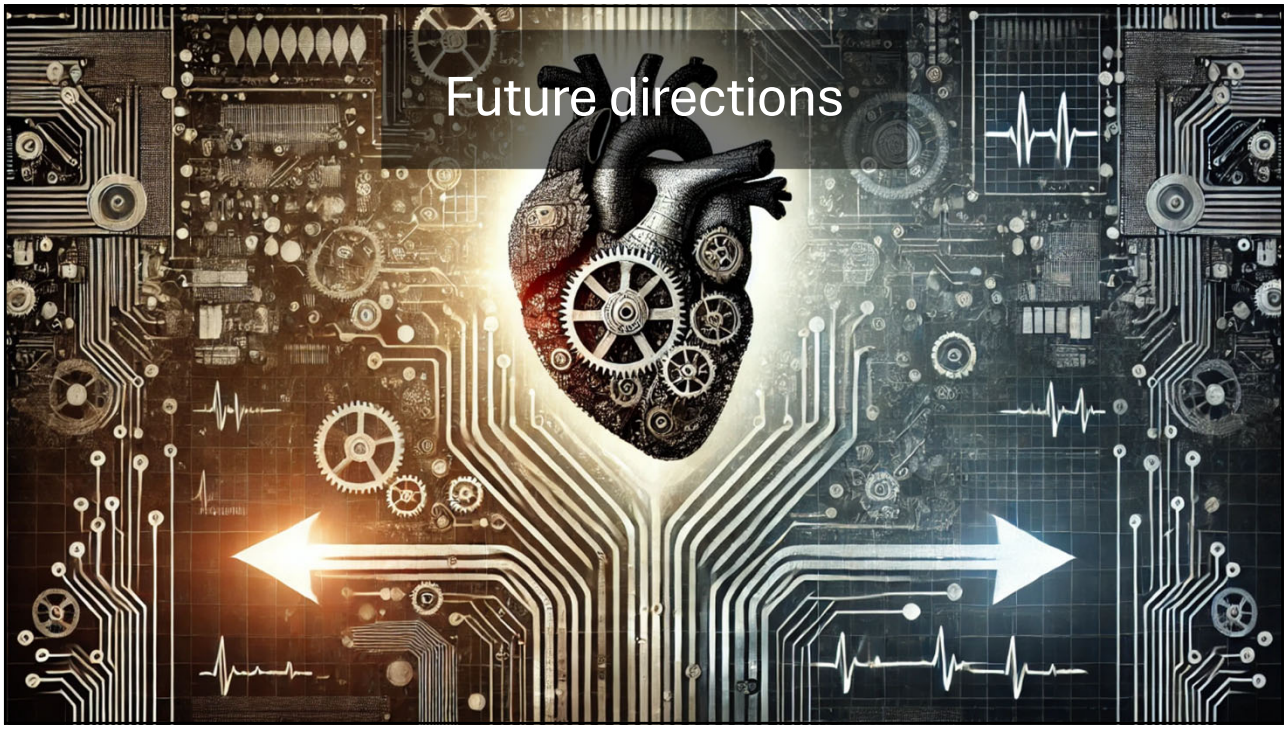
Future directions

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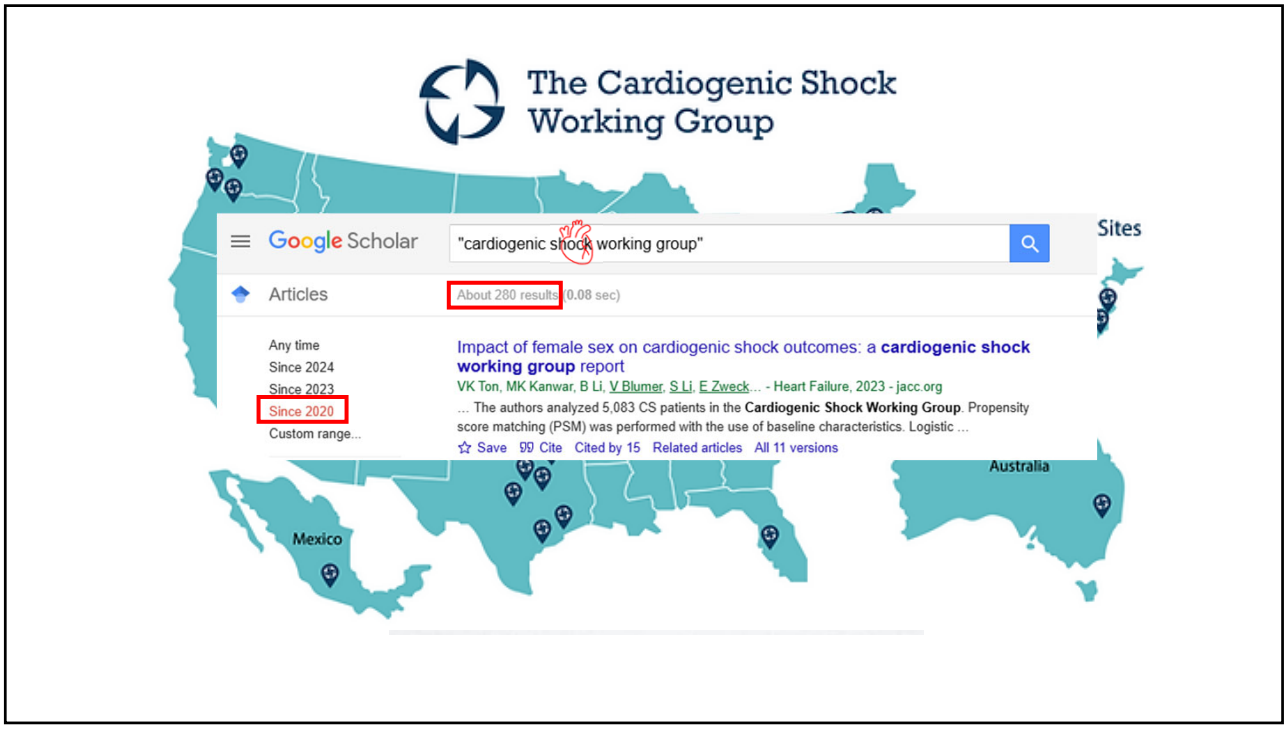
The Cardiogenic Shock Working Group
Google Scholar
"cardiogenic shock working group"
Articles
About 280 results (0.08 sec)
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Since 2024
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Since 2020
Custom range...
Impact of female sex on cardiogenic shock outcomes: a cardiogenic shock working group report
VK Ton, MK Kanwar, B Li, V Blumer, S Li, E Zweck... - Heart Failure, 2023 - jacc.org
... The authors analyzed 5,083 CS patients in the Cardiogenic Shock Working Group. Propensity score matching (PSM) was performed with the use of baseline characteristics. Logistic ...
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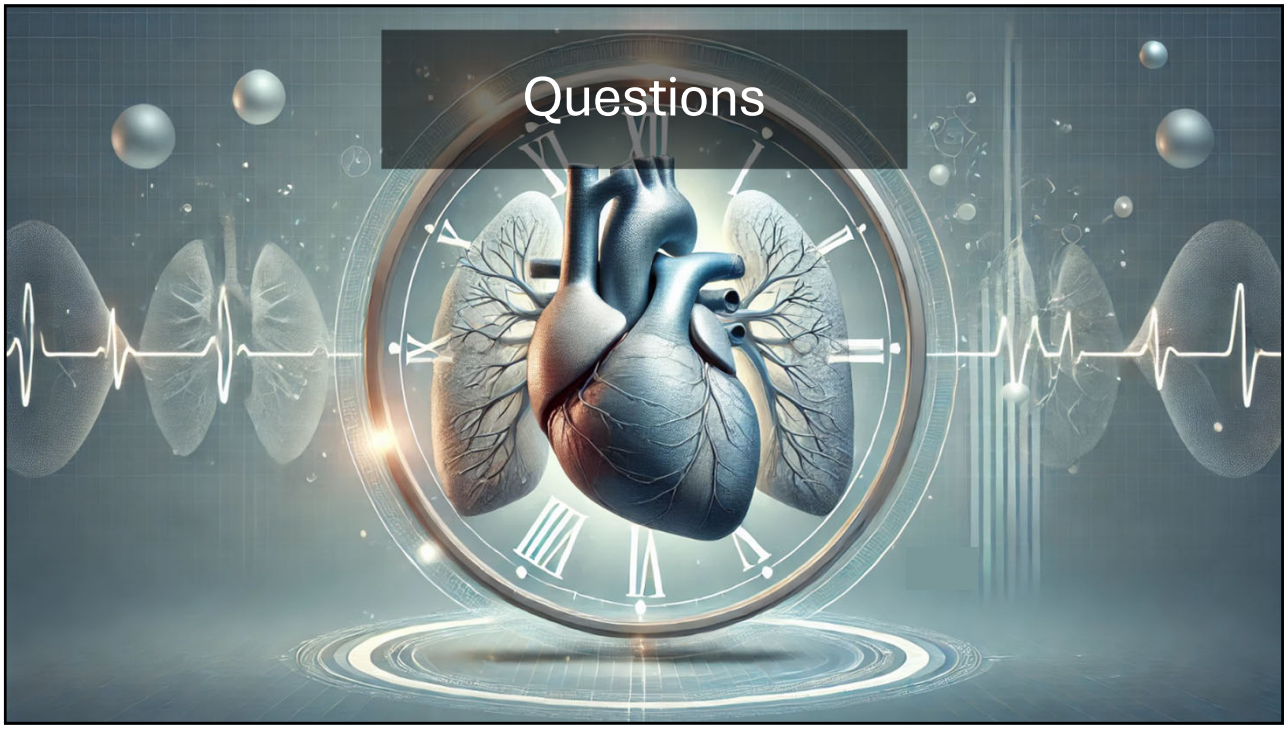
Questions

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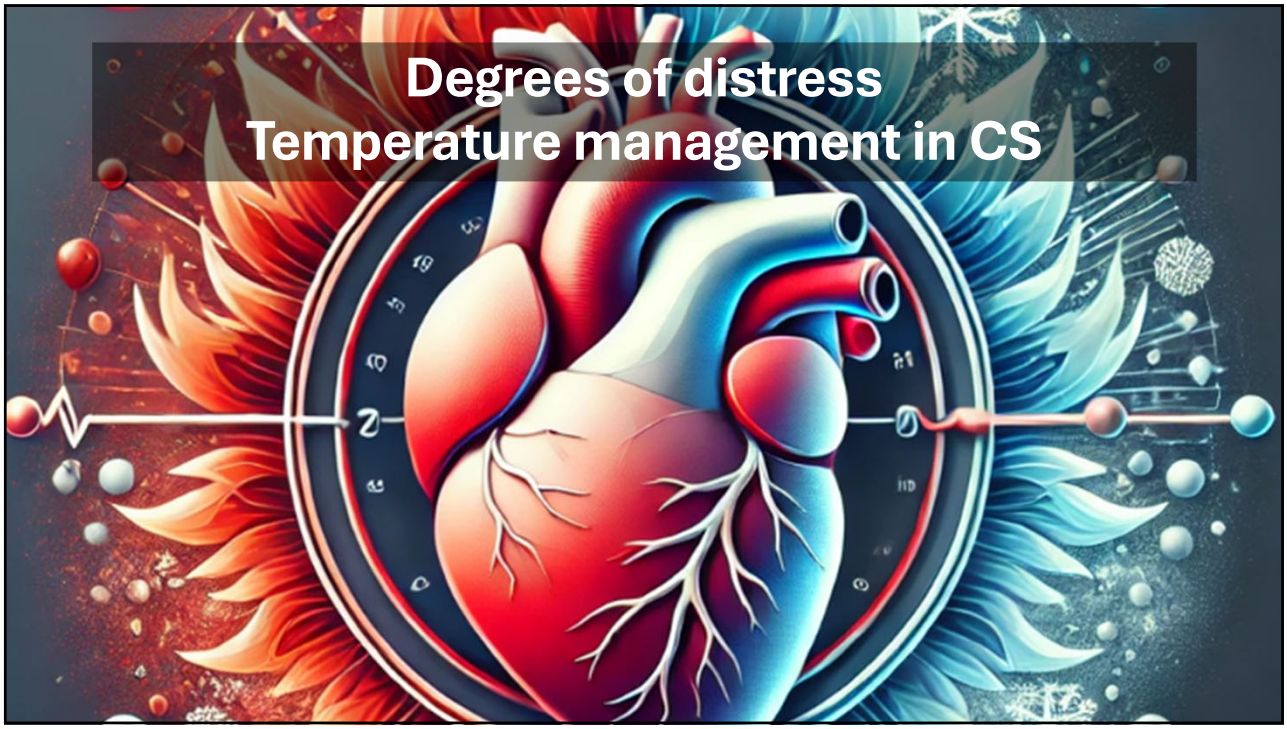
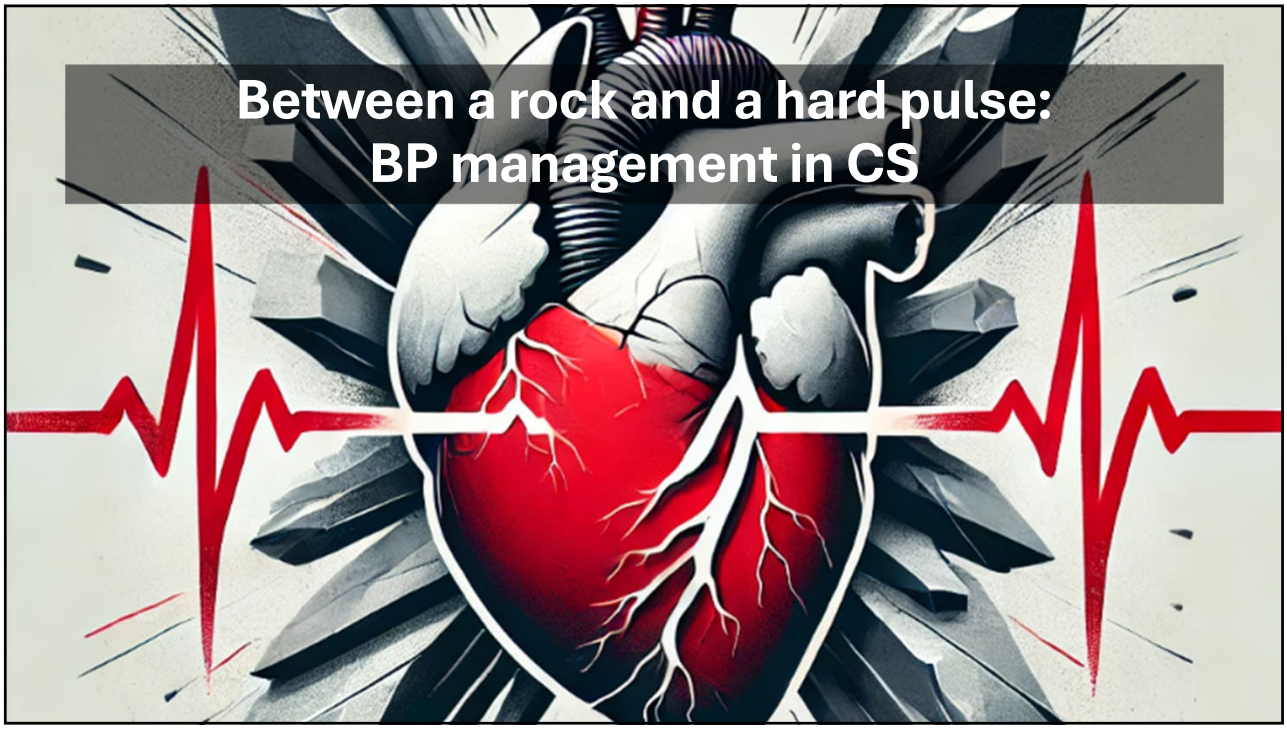

Degrees of distress
Temperature management in CS

42



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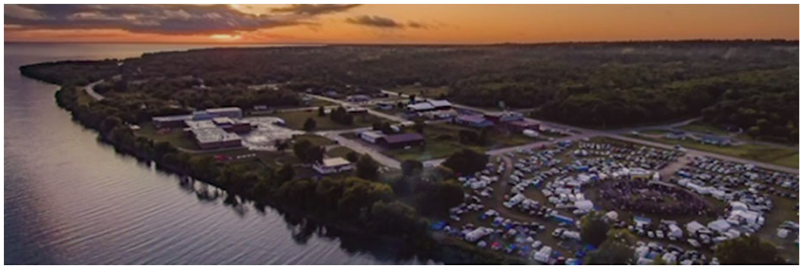
American Indian Cardiovascular Health: Minnesota Focus



Krishna Prabhu, MD, MSc
General Cardiology Fellow
Minneapolis Heart Institute at Abbott Northwestern Hospital
Hennepin County Medical Center
Minneapolis, MN
12/2/24

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Objectives

- Geography of Minnesota's American Indian Reservations
- Disparities in burden of cardiovascular disease among American Indians
- Challenges in prevention and treatment of cardiovascular disease
- Opportunities and assets for care delivery

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"Red Lake Reservation is mostly water. It is a beautiful place, unlike any other in America. For starters, Upper and Lower Red Lake are almost completely undeveloped. Elm, ash, and maple march down to the water's edge.

- David Treuer, *Rez Life*

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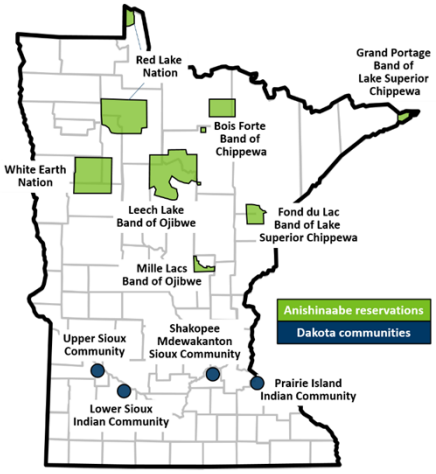

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CARDIOVASCULAR DISEASE BURDEN DISPARITIES

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Cardiovascular disease burden of American Indians

- 1970-1980s notion from available data that American Indians had *lower* rates of cardiovascular disease than other Americans
- All from retrospective data from the Indian Health Service
- Born out of a lack of empirical data was the Strong Heart Study
  - Prospective cohort study 4549 patients from Arizona, Southwestern Oklahoma, North Dakota, South Dakota
  - Baseline exam with EKG, labs (lipids, A1c, albuminuria, obesity measures)
  - Surveilled patients over time to detect new diagnoses

Howard BV, Lee ET, Cowan LD, et al. Rising tide of cardiovascular disease in American Indians: the Strong Heart Study. *Circulation*. 1999;99(18):2389-2395.

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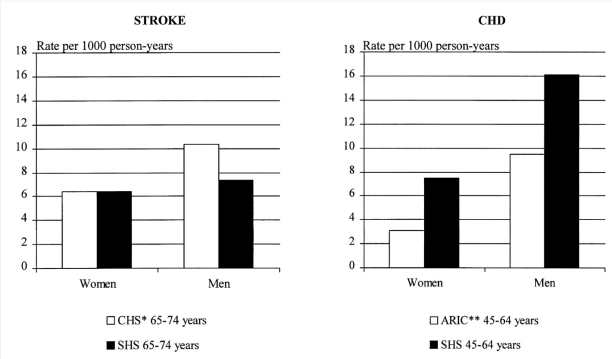
Strong Heart Study



- Strong Heart found men and women had rates of coronary artery disease that were twice that of comparable US general population cohorts
- Risk factors for coronary artery disease include: diabetes, HTN, HLD, macroalbuminuria

Howard BV, Lee ET, Cowan LD, et al. Rising tide of cardiovascular disease in American Indians: the Strong Heart Study. *Circulation*. 1999;99(18):2389-2395.

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Cardiovascular disease burden of American Indians

- Retrospective analysis of Medicare data for self identified American Indian patients between 2015-2019
  - Burden of heart failure 22% amongst Medicare cohort of American Indians vs 14% in comparable cohorts
  - Burden of CAD 37% amongst Medicare cohort of American Indians, vs 27% in comparable cohorts

Eberly LA, et al. Cardiovascular Disease Burden and Outcomes Among American Indian and Alaska Native Medicare Beneficiaries. JAMA Netw Open. 2023 Sep 5;6(9):e2334923.

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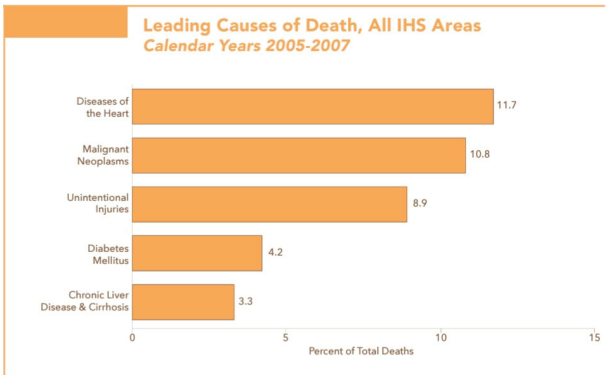
Cardiovascular disease burden of American Indians



Regional Differences in Indian Health, 2012 Edition. U.S. Department of Health and Human Services, Indian Health Service, Office of Public Health Support, Division of Program Statistics

54

Cardiovascular disease burden of American Indians

Source: https://www.ihs.gov/careeropps/where-we-work/

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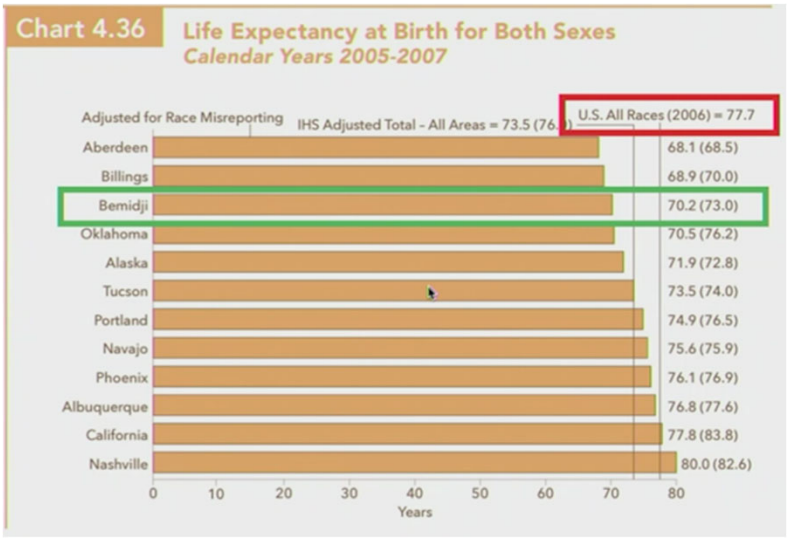

Regional Differences in Indian Health, 2012 Edition. U.S. Department of Health and Human Services, Indian Health Service, Office of Public Health Support, Division of Program Statistics

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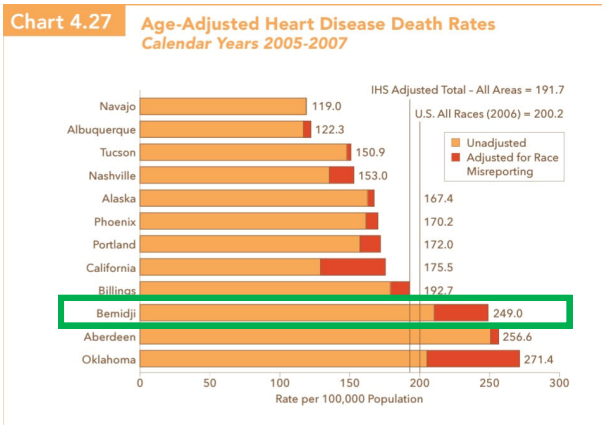
Upper Midwest CV Burden



Regional Differences in Indian Health, 2012 Edition. U.S. Department of Health and Human Services, Indian Health Service, Office of Public Health Support, Division of Program Statistics

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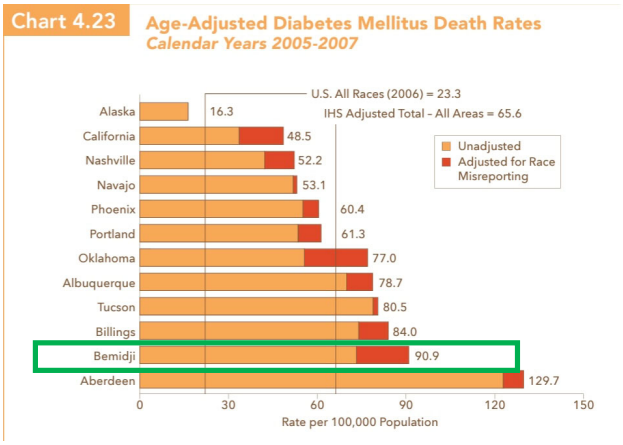
Upper Midwest Comorbidities



- Bemidji Area was found to have higher age adjusted rates of death related to diabetes compared
  1) US population as whole
  2) Other IHS areas

Regional Differences in Indian Health, 2012 Edition. U.S. Department of Health and Human Services, Indian Health Service, Office of Public Health Support, Division of Program Statistics

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Upper Midwest Comorbidities – Inter-Tribal Heart Study 1992-94

Table 2. Prevalence of hypertension and diabetes according to hypertensive and diabetic status: Inter-Tribal Heart Project preliminary data

	Prevalence of Hypertension				Prevalence of Diabetes			
	Total Population		Diabetics		Total Population		Hypertensives	
	%	n	%	n	%	n	%	n
Age								
25–44	16	61	31	8	10	26	21	8
45–64	37	157	49	45	34	93	47	45
65+	62	98	67	37	56	58	61	37
Gender								
Women	29	171	49	51	29	109	44	51
Men	39	146	58	39	27	68	47	39
Total	33	317	52	90	28	177	46	90

- Inter-Tribal Heart Study
  - Surveyed random sample of members of Red Lake Nation, White Earth Reservation, and Menomonie tribal members with detailed survey and physical exam in the 1990s
- Found very high rates of T2DM among patients above 65 (~ 56%) and HTN (62%)

Casper M, et al. Blood pressure, diabetes, and body mass index among Chippewa and Menominee Indians: the Inter-Tribal Heart Project Preliminary Data. Public Health Rep. 1996;111 Suppl 2(Suppl 2):37-9.

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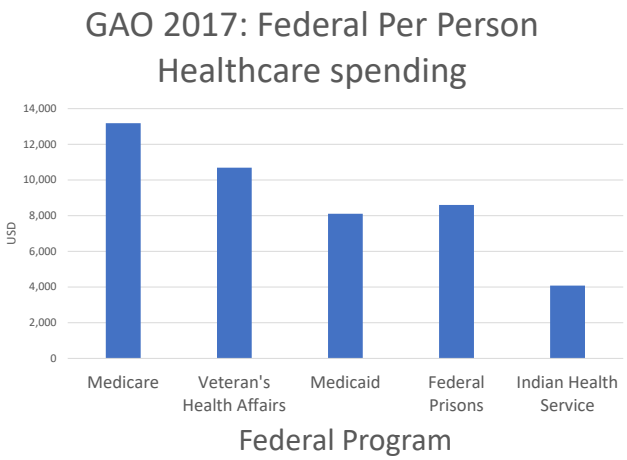
CHALLENGES IN PREVENTION AND TREATMENT OF CARDIOVASCULAR DISEASE

60

Health Care Funding Shortfalls



- Many US government treaties with American Indian tribes stipulated US government provision of health services, previously through Bureau of Indian Affairs
- 1954 Indian Transfer Act established Indian Health Service as vehicle for fulfilling treaty obligations
- Significant differentials in healthcare spending among federal programs

Source: https://www.gao.gov/products/gao-19-74r

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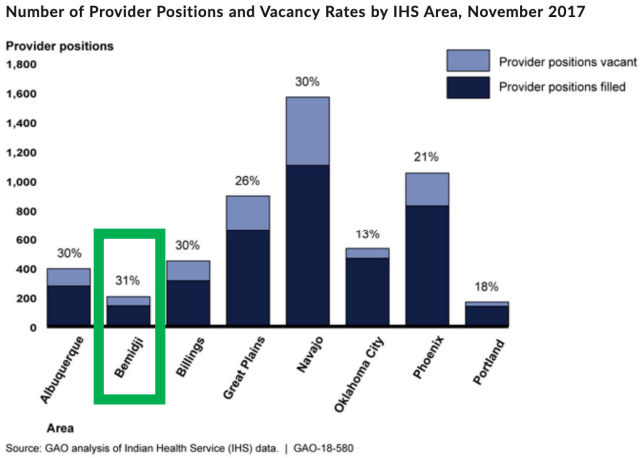
Health Care Workforce Shortage



Source:https://www.gao.gov/products/gao-18-580

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Social Determinants of Health

"Red Lake suffers from some of the most crippling economic conditions of any community in the country. Unemployment stands at 60%. The *average* income at Red Lake is well below the poverty level. High school graduation rates are the lowest in the state."

– David Treuer, *Rez Life*

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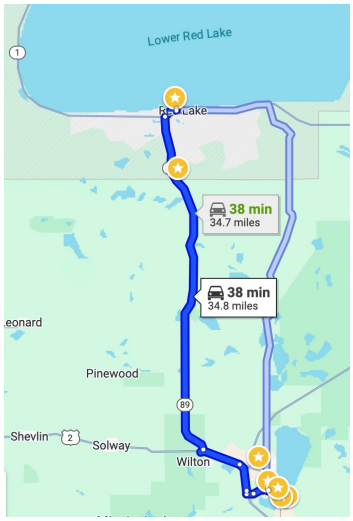
Geography

- One grocery store on Red Lake Reservation
- Bemidji is nearest major town, about 40 minute drive



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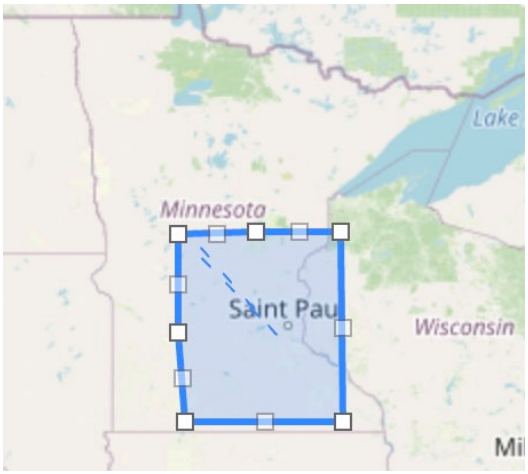
Geography

-“Food insecurity is endemic in many Indigenous communities[40-42]—of the 27 000 square miles of land on the Navajo Nation, the largest US reservation, there are only 13 grocery stores”
- Eberly, et al.



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ASSETS AND OPPORTUNITIES FOR THE FUTURE

66

Asset: Task Shifting

- Task shifting = giving specific tasks to healthcare workers who have not typically done them as part of their scope of practice
- Pharmacist led clinics
  - Experience with PrEP in the Albuquerque IHS
    - Follow up required every 3 months for PrEP
    - Pharmacists with prescriptive authority to order PrEP, labs, lab data interpretation
    - Pharmacy led follow up visits
- Anecdotal experience: Red Lake IHS pharmacists
  - Job satisfaction with greater clinical responsibility

Source: https://www.hiv.gov/blog/pharmacist-led-program-expands-access-prep-indian-health-service

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Asset: Telehealth

Telephone-Based Guideline-Directed Medical Therapy Optimization in Navajo Nation
The Hózhó Randomized Clinical Trial

Lauren A. Eberly, MD, MPH[1,2,3,4,5]; Ada Tennison, CNA[1]; Daniel Mays, MD[1]; et al

- HF patients with EF < 40%, encounter at IHS site in last 12 months
- Randomized to telehealth uptitration of GDMT vs usual care
  - Stepped-wedge-cluster randomized trial
  - Each cluster crossed over into intervention every 30 days

Eberly LA, et al. Telephone-Based Guideline-Directed Medical Therapy Optimization in Navajo Nation: The Hózhó Randomized Clinical Trial. JAMA Intern Med. 2024 Jun 1;184(6):681-690.

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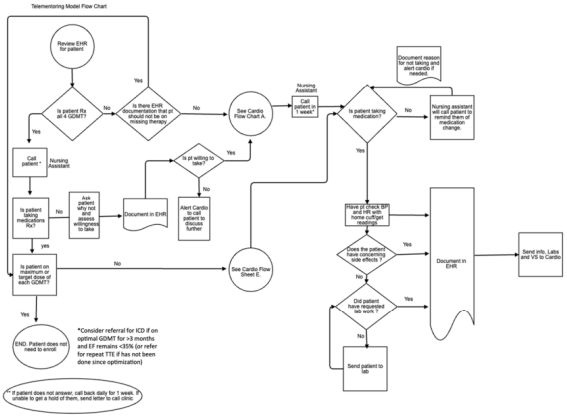
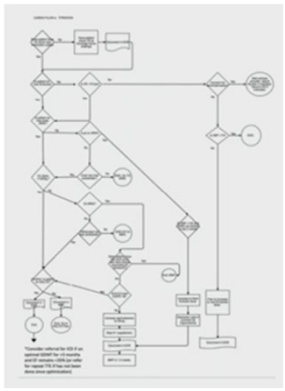
Asset: Telehealth





Eberly LA, et al. Telephone-Based Guideline-Directed Medical Therapy Optimization in Navajo Nation: The Hózhó Randomized Clinical Trial. JAMA Intern Med. 2024 Jun 1;184(6):681-690.

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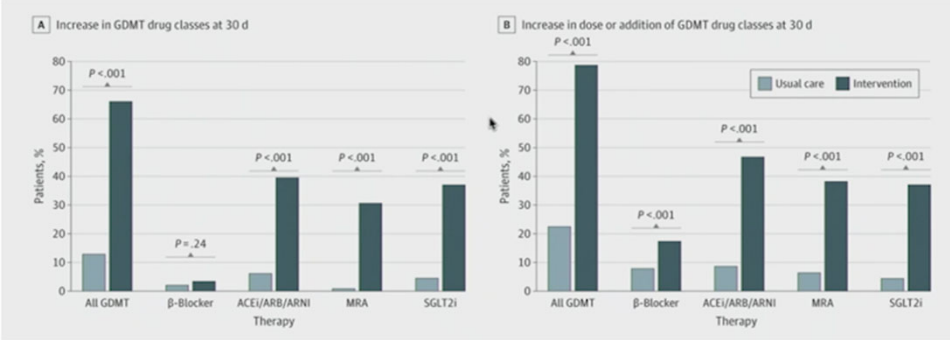
Asset: Telehealth



Eberly LA, et al. Telephone-Based Guideline-Directed Medical Therapy Optimization in Navajo Nation: The Hózhó Randomized Clinical Trial. JAMA Intern Med. 2024 Jun 1;184(6):681-690.

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Asset: Telehealth

- Results
  - By end of the study
    - 96/99 patients on beta blocker (97%)
    - 89/91 patients on RASS inhibitor (98%)
    - 60/77 patients on ARNI (78%)
    - 65/77 patients on SGLT2
    - 60/77 on MRA (78%)
    - 81% on all 4 drug classes

Eberly LA, et al. Telephone-Based Guideline-Directed Medical Therapy Optimization in Navajo Nation: The Hózhó Randomized Clinical Trial. JAMA Intern Med. 2024 Jun 1;184(6):681-690.

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Asset: Tribal Compacting

- 1990s
  - Tribal compacting - budgetary discretion to be flexible in providing services
  - Tribes can choose:
    - Direct health care services by IHS
    - Fund own programs overseen by the tribe
- Flexibility in a complex system
  - COVID-19 vaccination drive
  - Mammogram
  - Community Health Workers

Source: Kruse, et al. The Indian Health Service and American Indian/Alaska Native Heath Outcomes. Annual Review of Public Health 2022

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Opportunities

- Diagnostic innovations
  - Artificial intelligence – EKG, diagnostic imaging
- Therapeutic innovations
  - Inclisiran - longer acting duration may aide with adherence
- Community-led innovations and initiatives

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Opportunities

- Hard work of delivering high quality care consistently for multiple chronic illnesses
  - Diabetes care
  - Hypertension
  - Hyperlipidemia
  - Cardiovascular disease
- Addressing social determinants of health in prevention
  - Food deserts
  - Economic and social factors

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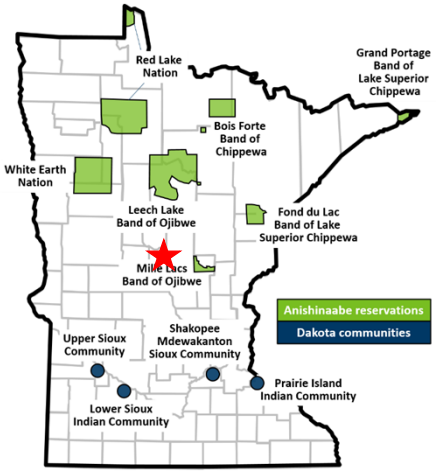
MHI Baxter

- Cardiology specialty care
- Sub-specialty cardiologists
- Diagnostics
  - Cardiac CT
  - Stress Echo
  - Nuclear perfusion



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"Do we see [human disparity] as a human predicament--an inescapable result of frailty of our existence? That would be correct had these sufferings been really inescapable, but they are far from that. Preventable diseases can indeed be prevented, curable ailments can certainly be cured, and controllable maladies call out for control. Rather than lamenting the adversity of nature, we have to look for a better comprehension of the social causes of horror and also of our tolerance of societal abominations." - Amartya Sen

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