Cardiogenic Shock:
Diagnosis and Management

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Disclosures

Speaker – Abbott Laboratories, Inc.

Outline

1. Epidemiology and Definition of Cardiogenic Shock
    1. Incidence and outcomes
2. Overview of Shock Physiology
3. Early Recognition and initial treatment
4. UNMC Shock Program

Objectives

1. Understand the incidence and mortality associated with cardiogenic shock
2. Review diagnosis of cardiogenic shock
3. Explain initial treatment and stabilization of cardiogenic shock

“A momentary pause in the act of death”

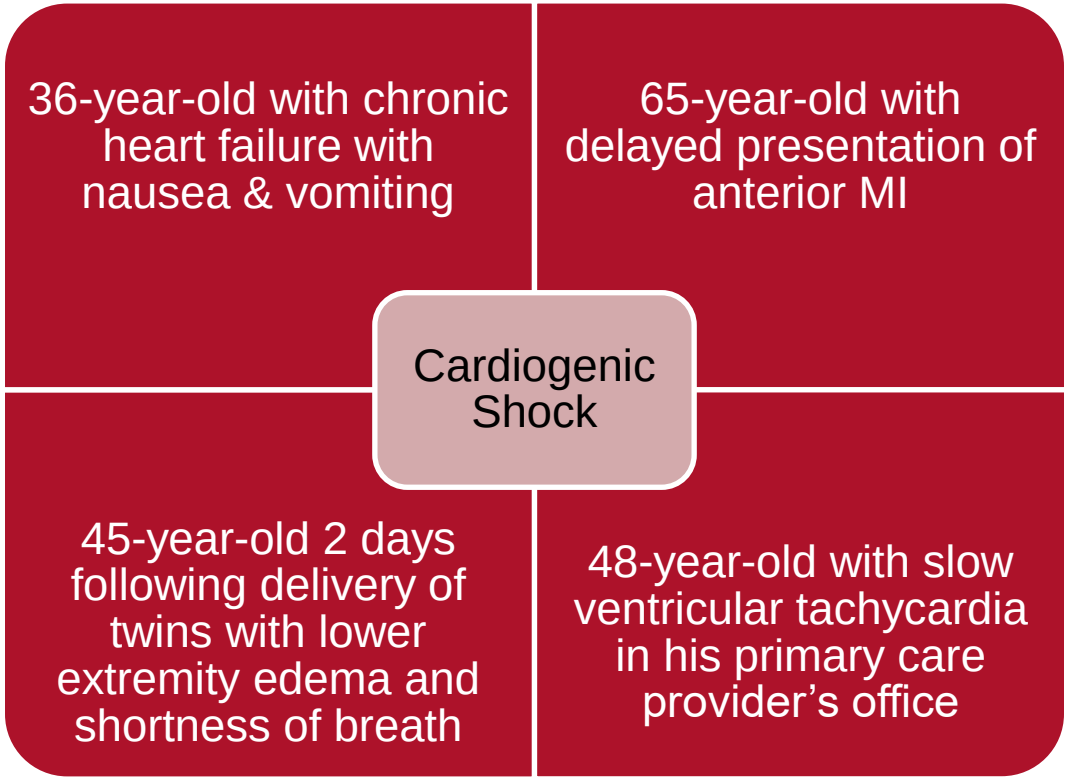
Dr. John Collins Warren

What is Cardiogenic Shock?

-Patients with cardiogenic shock will present in a myriad of ways

-Cardiogenic shock will see you, therefore you should make sure you can see it

-Be cognizant of subtle signs of heart failure/cardiogenic shock



What is Cardiogenic Shock?

<u>Cardiogenic Shock</u>- Shock mediated by the inability of the heart to provide **<u>sufficient cardiac output</u>** despite adequate filling pressures:

-Systolic BP of **<80-90 mmHg OR a SBP 30 mmHg < then baseline** with reduction in **cardiac index (<1.8 L/m/m2 without support OR <2.0-2.2 L/min/m2 with support**) and adequate filling pressures **(LVEDP >18 mmHg** or RVEDP >10-15 mmHg)

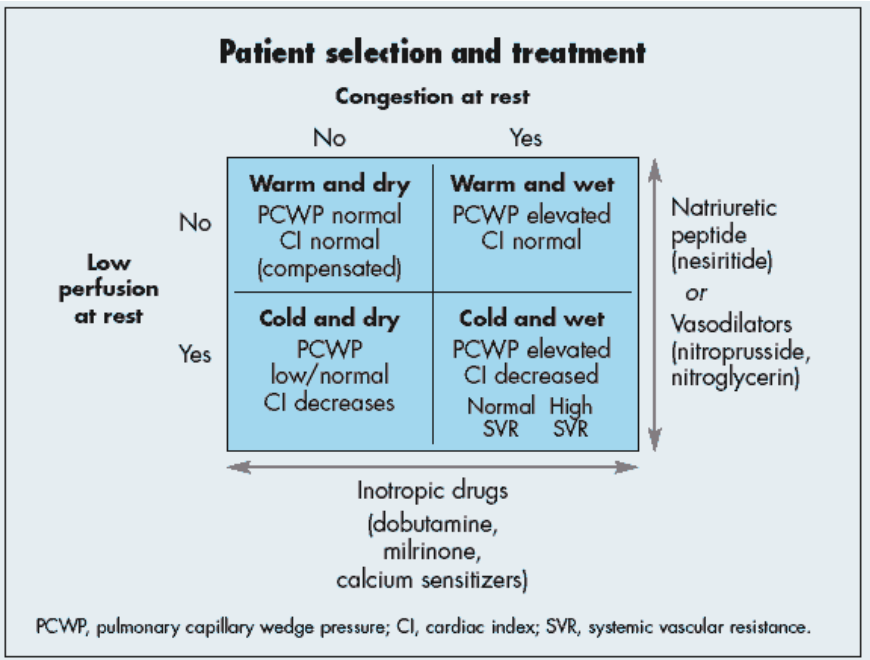
-Acute worsening of chronic disease

-Initial presentation of new onset heart failure

Table 1. Clinical Features of CS as Defined in Contemporary Trials and Guidelines

Clinical Trial/Guideline	CS Criteria
SHOCK Trial (1999)[3]	• SBP <90 mm Hg for >30 min or vasopressor support to maintain SBP >90 mm Hg • Evidence of end-organ damage (UO <30 mL/h or cool extremities) • Hemodynamic criteria: CI <2.2 and PCWP >15 mm Hg
IABP-SHOCK II (2012)[4]	• MAP <70 mm Hg or SBP <100 mm Hg despite adequate fluid resuscitation (at least 1 L of crystalloids or 500 mL of colloids) • Evidence of end-organ damage (AMS, mottled skin, UO <0.5 mL/kg for 1 h, or serum lactate >2 mmol/L)
EHS-PCI (2012)[5]	• SBP <90 mm Hg for 30 min or inotropes use to maintain SBP >90 mm Hg • Evidence of end-organ damage and increased filling pressures
ESC-HF Guidelines (2016)[6]	• SBP <90 mm Hg with appropriate fluid resuscitation with clinical and laboratory evidence of end-organ damage • Clinical: cold extremities, oliguria, AMS, narrow pulse pressure. Laboratory: metabolic acidosis, elevated serum lactate, elevated serum creatinine

What is Cardiogenic Shock?



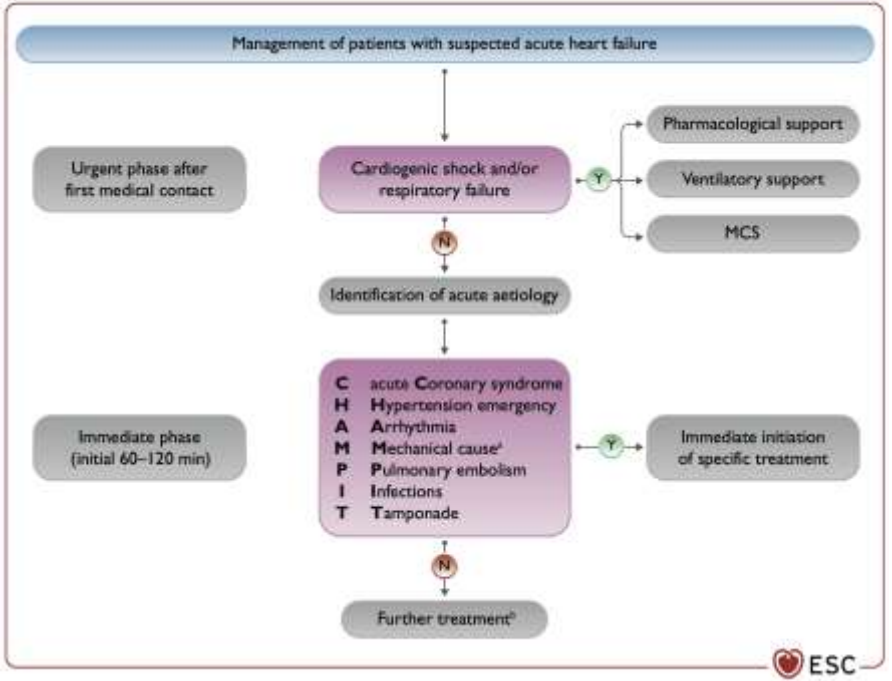
Hypoperfusion
-Low BP/CO
-Elevated Lactate
-Cool Extremities
-End-organ Failure
-Somnolence

Congestion
-Edema
-Abdominal distention
-Renal failure

Forrester, James S., et al. “Medical therapy of acute myocardial infarction by application of hemodynamic subsets.” *New England Journal of Medicine*, vol. 295, no. 24, 9 Dec. 1976, pp. 1356–1362, https://doi.org/10.1056/nejm197612092952406.

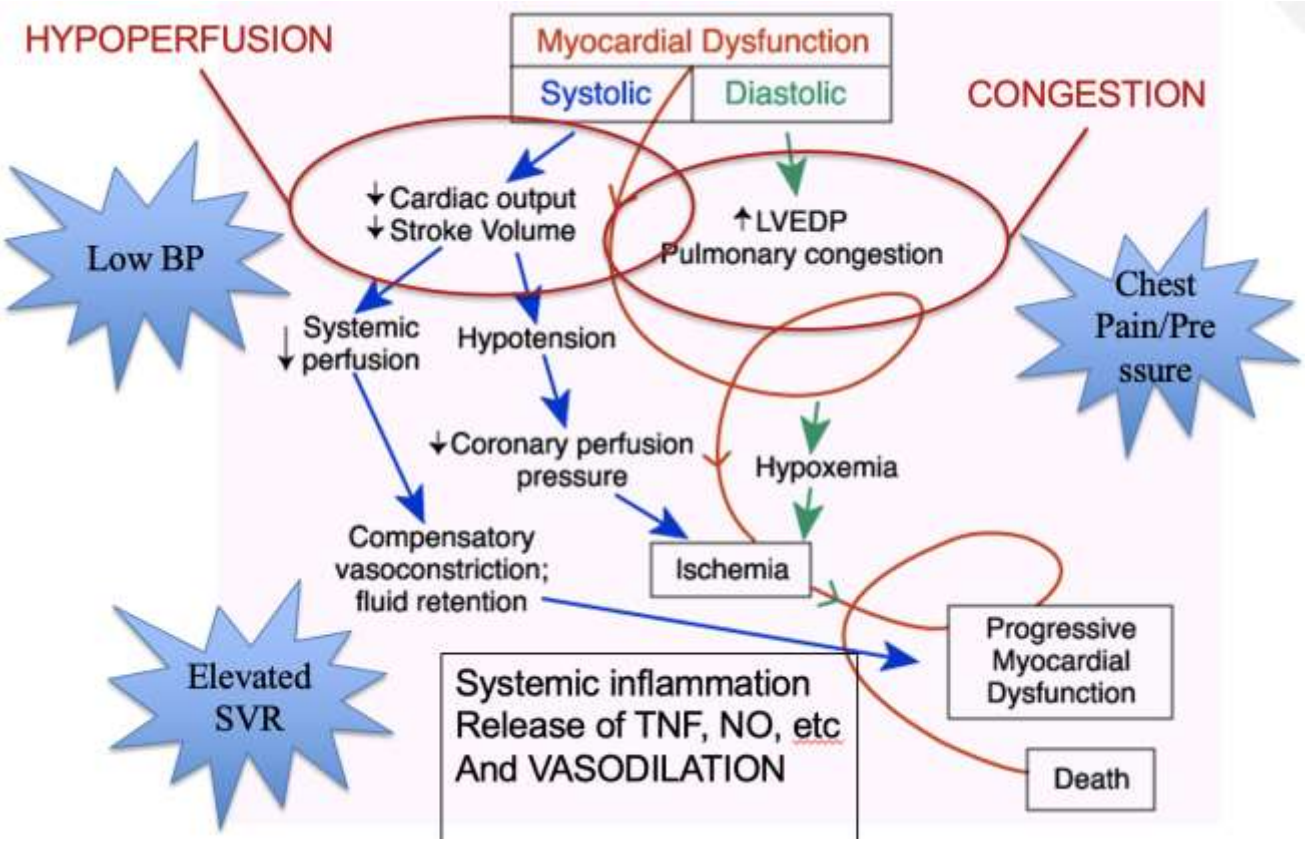
What is Cardiogenic Shock?

C- ACS
H- Hypertension Emergency
A- Arrhythmia
M- Mechanical Cause
P- Pulmonary Embolism
I- Infection
T- Tamponade



McDonagh TA, et al. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. Eur Heart J. 2021 Sep 21;42(36):3599-3726. doi: 10.1093/eurheartj/ehab368. Erratum in: Eur Heart J. 2021 Dec 21;42(48):4901. doi: 10.1093/eurheartj/ehab670. PMID: 34447992.

Pathophysiology of Cardiogenic Shock



Initial Management of Cardiogenic Shock

SCAI Shock Stages

Initial Management of Cardiogenic Shock

ECG
Echocardiogram
ABG/VBG
CMET
Lactate
Troponin
CHF Peptide
Coags
TFTs

Fuernau, G, Desch, S, de Waha-Thiele, S. et al. Arterial Lactate in Cardiogenic Shock: Prognostic Value of Clearance Versus Single Values. *J Am Coll Cardiol Intv.* 2020 Oct, 13 (19) 2208–2216.

Initial Management of Cardiogenic Shock

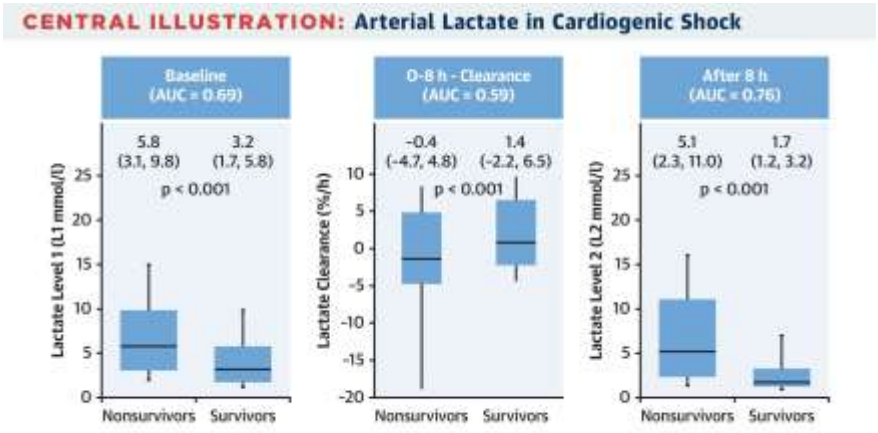
Sub-analysis of the IABP-SHOCK II trial

-Lactate levels were prospectively collected.

-All-cause mortality at 30 days was assessed as primary endpoint.

-Arterial lactate after 8 hours is superior in mortality prediction in comparison with baseline lactate and lactate clearance

-Cutoff value of 3.1 mmol/l for lactate after 8 h showed the best discrimination for assessing early prognosis in cardiogenic shock and may serve as new treatment goal.



Fuernau, G. et al. J Am Coll Cardiol Intv. 2020;13(19):2208–16.

$$LC\left(\%/h\right) = \frac{L1 - L2}{L1 * \Delta t(L1, L2)} * 100$$

Fuernau, G, Desch, S, de Waha-Thiele, S. et al. Arterial Lactate in Cardiogenic Shock: Prognostic Value of Clearance Versus Single Values. *J Am Coll Cardiol Intv.* 2020 Oct, 13 (19) 2208–2216.

Prognosis in Shock

ORBI score
SHOCK score
IABP-SHOCK-II score
} Mortality or Shock post-PCI in AMI

CardShock score
INOVA score
} Mixed Shock

SCAI SHOCK
} Retrospective Analysis Only

CSP (Cardiogenic Shock Prognosis)

Early Prediction of Cardiogenic Shock Using Machine Learning

Yale Chang[1], Corneliu Antonescu[2,3], Shreyas Ravindranath[1], Junzi Dong[1], Mingyu Lu[4], Francesco Vicario[1], Lisa Wondrely[1], Pam Thompson[2], Dennis Swearingen[2,3] and Deepak Acharya[2,3]*

[1] Philips Research North America, Cambridge, MA, United States, [2] Division of Cardiovascular Disease, Banner Health, Tucson, AZ, United States, [3] University of Arizona College of Medicine, Phoenix, AZ, United States, [4] Department of Computer Science, University of Washington, Seattle, WA, United States

-Retrospective machine learning model which runs automatically on patient data from the electronic health record (EHR).
-Trained on 8 years of de-identified data from a large regional healthcare system
-76 data points
-**Older age, male gender, higher troponin level, lower pulse pressure, medium level of immature granulocytes, higher O_2 saturation, and lower bicarbonate**
-Risk factors that with the clinical picture could alert to the increased probability of a lethal spiral of CS

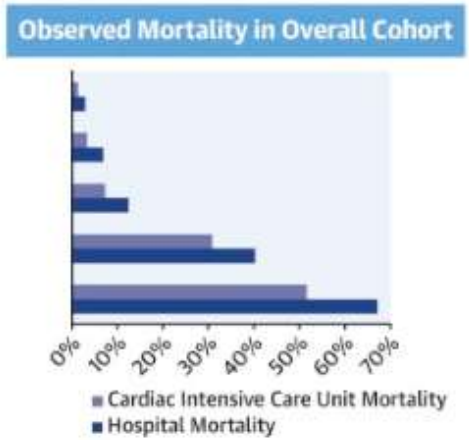
Chang, Yale, et al. “Early prediction of cardiogenic shock using machine learning.” *Frontiers in Cardiovascular Medicine*, vol. 9, 13 July 2022, https://doi.org/10.3389/fcvm.2022.862424.

Prognosis in Shock

Worsening shock stage results in increased risk of mortality

CENTRAL ILLUSTRATION: Definitions of SCAI Shock Stages A Through E, With Associated Cardiac Intensive Care Unit and Hospital Mortality in Each SCAI Shock Stage

Cardiogenic Shock Stage	Study Definition
Stage A ("At risk")	Neither hypotension/tachycardia nor hypoperfusion
Stage B ("Beginning")	Hypotension/tachycardia WITHOUT hypoperfusion
Stage C ("Classic")	Hypoperfusion WITHOUT deterioration
Stage D ("Deteriorating)"	Hypoperfusion WITH deterioration NOT refractory shock
Stage E ("Extremis")	Hypoperfusion WITH deterioration AND refractory shock



Jentzer, J.C. et al. J Am Coll Cardiol. 2019;74(17):2117-28.

Initial Management of Cardiogenic Shock

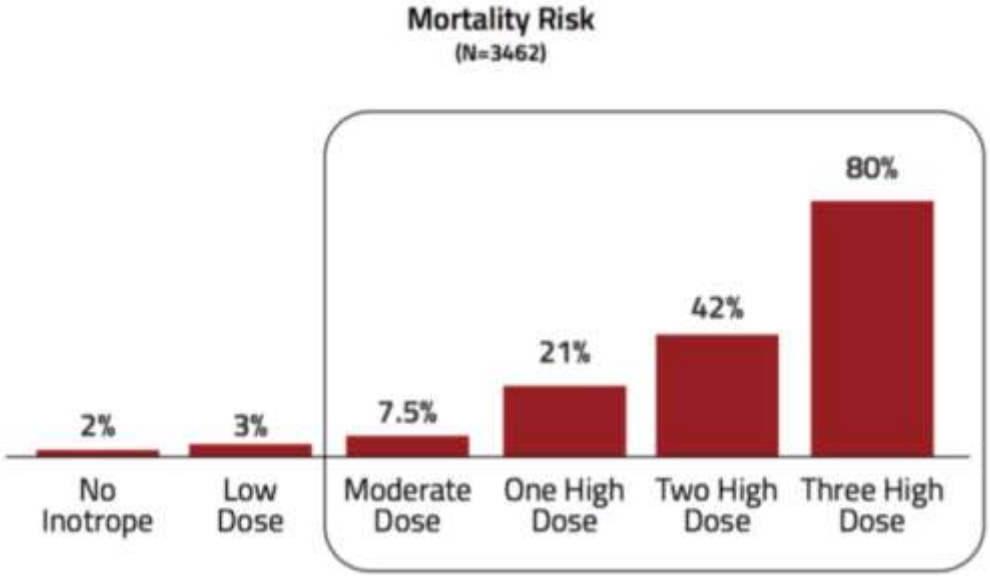
Cardiogenic shock management requires rapid identification and initiation of treatment widely referred to as the **“golden hour”**

Type of first intervention	Number of patients	Percentage (%)
Norepinephrine	2,524	47
Dopamine	1,057	20
Dobutamine	691	13
Epinephrine	642	12
IABP	458	9
Phenylephrine	430	8
Milrinone	385	7
Vasopressin	214	4
VAD	92	2
Impella	70	1
ECMO	18	0

Chang, Yale, et al. “Early prediction of cardiogenic shock using machine learning.” *Frontiers in Cardiovascular Medicine*, vol. 9, 13 July 2022, https://doi.org/10.3389/fcvm.2022.862424.

Initial Management of Cardiogenic Shock

With escalating doses of inotropes & vasopressors, comes escalating risk of mortality

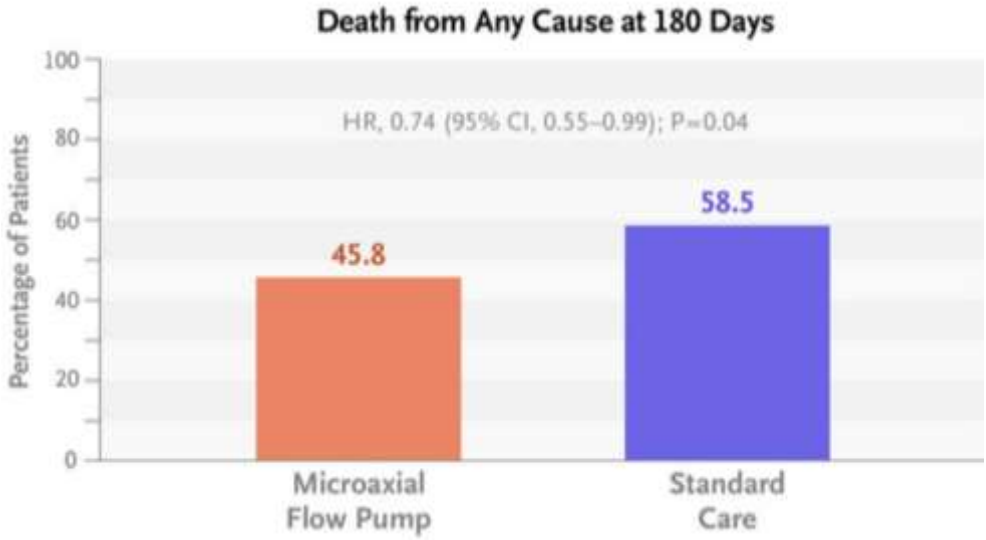


Samuels et al, 1999

MCS and Shock

-Routine implantation of Impella CP + standard care is superior to standard care alone in reducing 6-month mortality among patients presenting with STEMI and cardiogenic shock.

-Risk of complications including bleeding, limb ischemia, need for RRT, and sepsis were all higher with Impella CP. Of note, in >50% of patients, Impella CP was placed prior to revascularization.



"Microaxial flow pump in infarct-related cardiogenic shock." *New England Journal of Medicine*, vol. 390, no. 24, 27 June 2024, pp. 2325–2330, https://doi.org/10.1056/nejmc2406255.

MCS and Shock

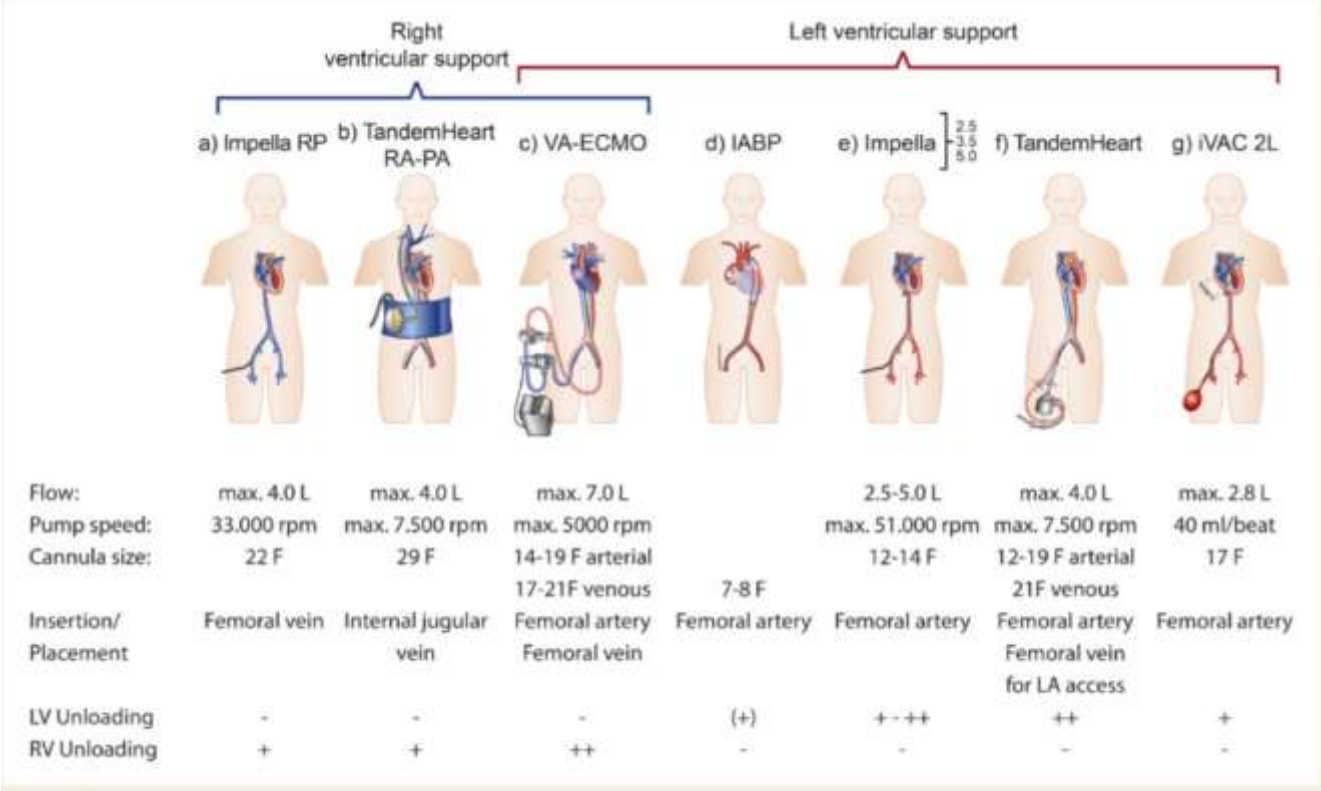
Impella CP®
with SmartAssist®

Impella 5.5®
with SmartAssist®

Impella RP®
with SmartAssist®

RP Flex

MCS and Shock



	a) Impella RP	b) TandemHeart RA-PA	c) VA-ECMO	d) IABP	e) Impella 2.5 3.5 5.0	f) TandemHeart	g) iVAC 2L
Flow:	max. 4.0 L	max. 4.0 L	max. 7.0 L		2.5-5.0 L	max. 4.0 L	max. 2.8 L
Pump speed:	33.000 rpm	max. 7.500 rpm	max. 5000 rpm		max. 51.000 rpm	max. 7.500 rpm	40 ml/beat
Cannula size:	22 F	29 F	14-19 F arterial 17-21F venous	7-8 F	12-14 F	12-19 F arterial 21F venous	17 F
Insertion/ Placement	Femoral vein	Internal jugular vein	Femoral artery Femoral vein	Femoral artery	Femoral artery	Femoral artery Femoral vein for LA access	Femoral artery
LV Unloading	-	-	-	(+)	+ - ++	++	+
RV Unloading	+	+	++	-	-	-	-

Initial Management of Cardiogenic Shock:

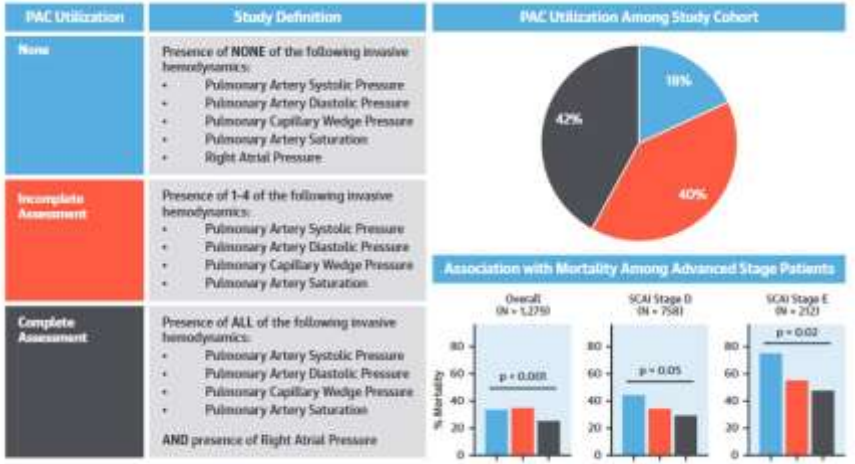
Swan-Ganz Use

RHC/Swan help guide tx decisions

Recent studies show improved outcomes in CS

Improved survival

Decreased 30-day readmits, time to readmit, death during readmit



Garan, A.R. et al. J Am Coll Cardiol HF. 2020;8(11):903-13.

Table 2. Index Admission In-Hospital Outcomes and Therapies

Outcomes	Total, N=236 158	Non-RHC, N=210 316	RHC, N=25 840	*P* value
Death, %	38.0	39.5	25.8	<0.001
Stroke, %	3.9	3.9	3.4	0.018
Need for hemodialysis, %	3.2	2.8	3.8	0.009
Mechanical ventilation, %	48.9	20.0	39.5	<0.001
Length of stay, d	15.3 (16.3)	14.3 (15.1)	22.7 (20.9)	<0.001

RHC indicates right heart catheterization.

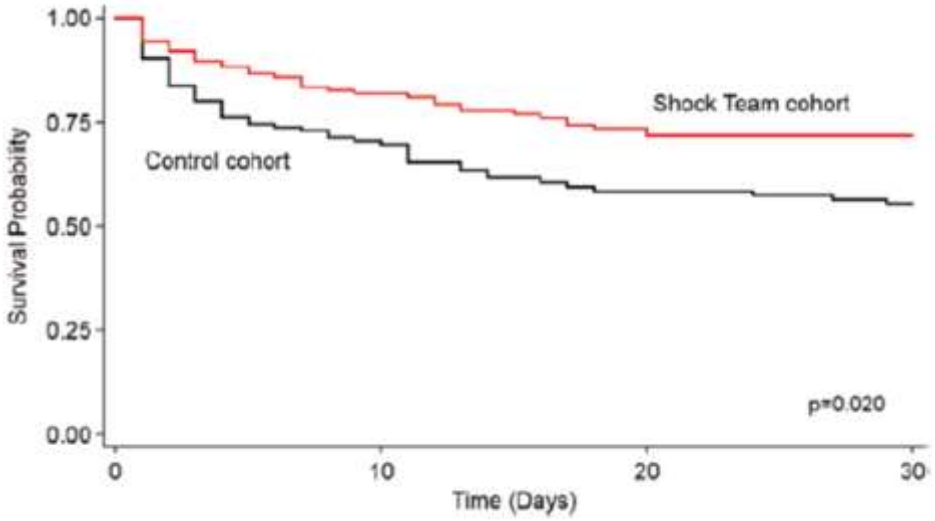
University of Utah Shock Program

Shock Team since 2015

Compared 1st 123 pts with previous 121 pts

Improved 30-day survival

No difference in complication rates or ICU LOS



Ottawa Heart Experience

Shock team started in 2016

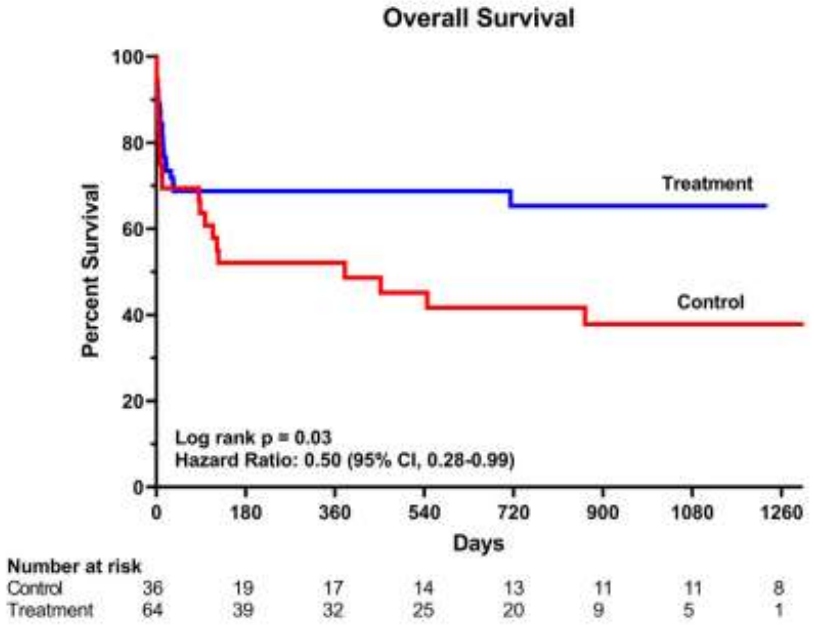
Smartphone-app used to lead online discussion

64 pts vs 36 controls

Improved survival

Lower rates of dialysis

tMCS use



Detroit Cardiogenic shock Initiativr

4 centers in Detroit metro

Focus on AMICS needing PCI

41 pts w/ Impella pre/IP/post-PCI

88% presented w/ STEMI

31/41 pts survived to d/c

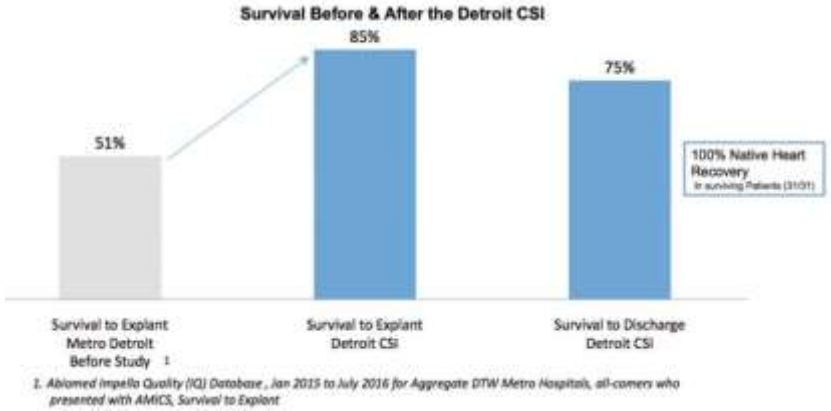
Only 17% didn't have RHC

Inclusion

- Acute Myocardial Infarction (AMI)
  - Ischemic Symptoms of AMI
  - ECG and/or biomarker evidence of STEMI or NSTEMI
- Cardiogenic Shock
  - Systolic blood pressure (SBP) ≤90 mm at baseline or use of inotropes or vasopressors to maintain SBP ≥ 90
  - Evidence of end organ hypoperfusion (cool extremities, oliguria, lactic acidosis)

Exclusion

- Evidence of anoxic brain injury
- Unwitnessed out of hospital cardiac arrest or any cardiac arrest in which ROSC is not achieved in 30 min
- Intra-aortic balloon pump placed prior to mechanical circulatory support
- Septic, anaphylactic, hemorrhagic, and neurologic causes of shock
- Nonischemic causes of shock/hypotension (pulmonary embolism, pneumothorax, myocarditis, pericardial tamponade, etc.)
- Active bleeding
- Mechanical complications of AMI (ventricular septal defect, acute papillary muscle rupture)
- Known left ventricular thrombus
- Patient who did not receive revascularization
- Mechanical aortic prosthetic valve
- Contraindication to intravenous systemic anticoagulation



UNMC Shock Program

UNMC Shock Program

Team Member	Responsibilities of Role
Provider Activating CST	• Providing background & events that led up to activation
HF Attending (On-Call)	• Facilitator, role call – quorum • Documenting Plan of Care in OneChart & executing pathway • Advanced HF therapy considerations
CCA Attending (in-house)	• Airway considerations • Critical care management considerations
CTS Attending (On-Call)	• Surgical candidacy discussion for temp and durable MCS options
IC Attending (On-Call)	• STEMI Plan of Care considerations • Percutaneous options for temp MCS
CVICU Team Lead	• Bed/staff availability • Equipment availability • Awareness/ visibility to plan

UNMC Cardiogenic Shock Team: 2023 Performance Review

2023 – 53 activations

Internal activations: 23
43% of activations were for NMC patients

External activations: 30
57% of activations

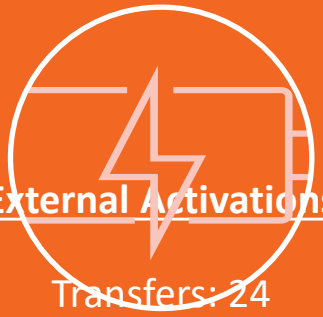
Diagnostics and tMCS Usage

RHC: 23
43% of activations received RHC

temporary MCS: 27
51% of activations managed with temporary MCS

Advanced HF Work Up Summary

Screened & ineligible: 5
Listed & deceased: 1
Heart Transplanted: 4



External Activations

Transfers: 24
80% of external activations transferred

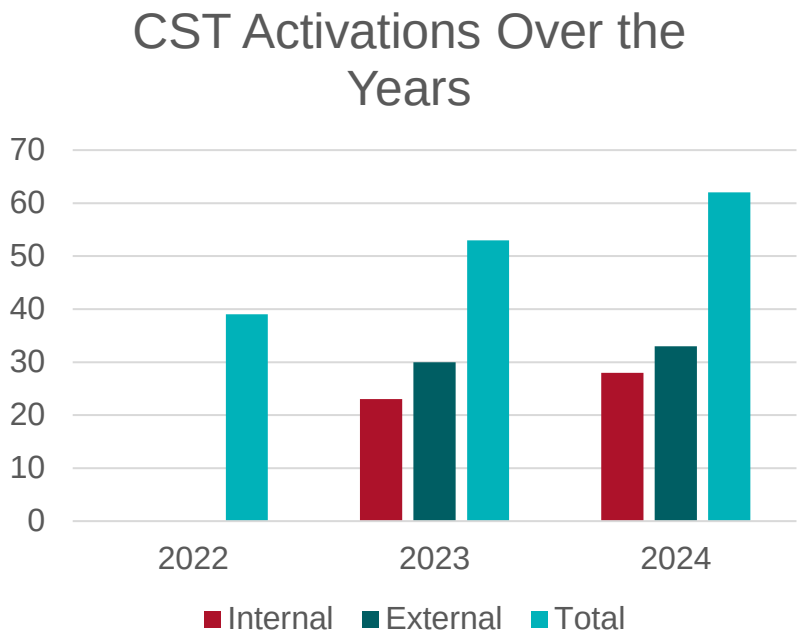
10% of candidates were not advanced therapy candidates and not eligible for transfer

01/01/2023 – 12/31/2023

Data

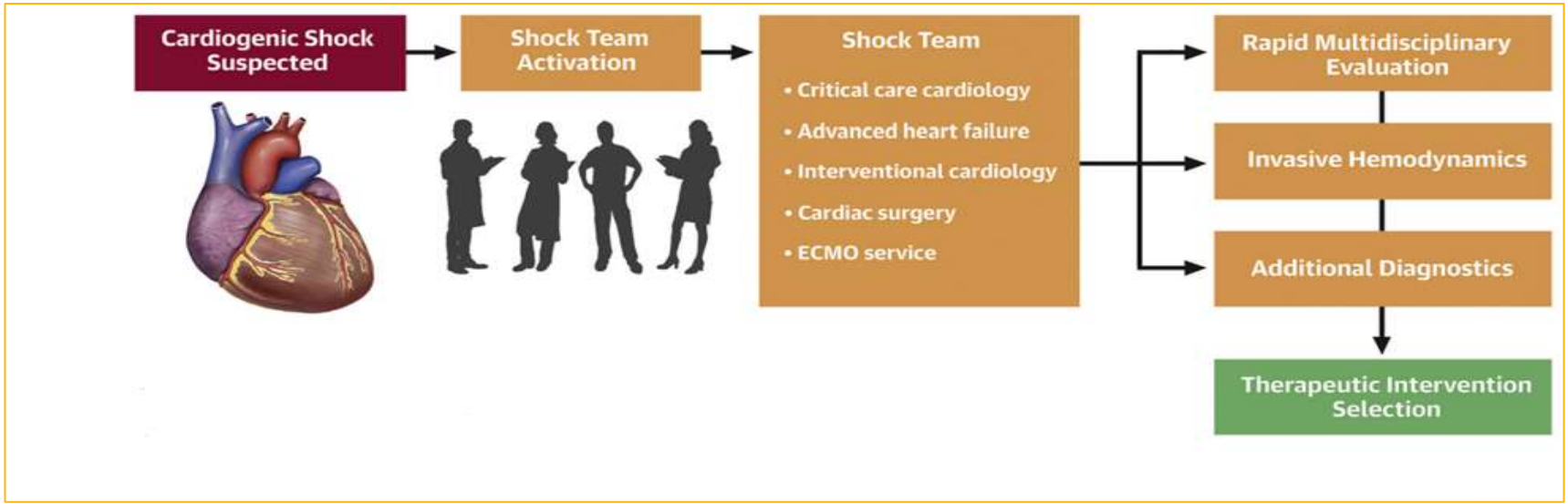
2024 YTD: 62 activations

- 28 internal
- 33 external



Nebraska Medicine Cardiogenic Shock Team

Multidisciplinary team established to evaluate and determine the plan of care for patients in cardiogenic shock



Cardiogenic Shock Team (CST) Activation

Referring Provider recognizes cardiogenic shock and calls the Nebraska Medicine Bed Desk/ Patient Placement Unit (PPU)

Bed Desk notifies the Nebraska Medicine Provider who will activate the CST

Available multidisciplinary Nebraska Medicine team members utilize a ***shared conference line to discuss the patient***

Bed desk conferences in outside physician to participate in call

Team will make a shared decision on next steps

Emergent CST Conference Members

****5-minute internal response time****

Referring Provider	• Provide background & events leading to cardiogenic shock
Heart Failure Attending	• Facilitator • Document plan of care in EMR, execute pathway • Advanced HF therapy consideration
Critical Care Anesthesia	• Airway considerations • Critical care management considerations
Cardiothoracic Surgery	• Surgical candidacy discussion for temporary and durable mechanical circulatory support (MCS) options
Interventional Cardiology	• STEMI plan of care considerations • Percutaneous option for temporary MCS
Bed Desk/CVICU Team Lead	• Bed/staffing • Equipment availability • Awareness and visibility to plan

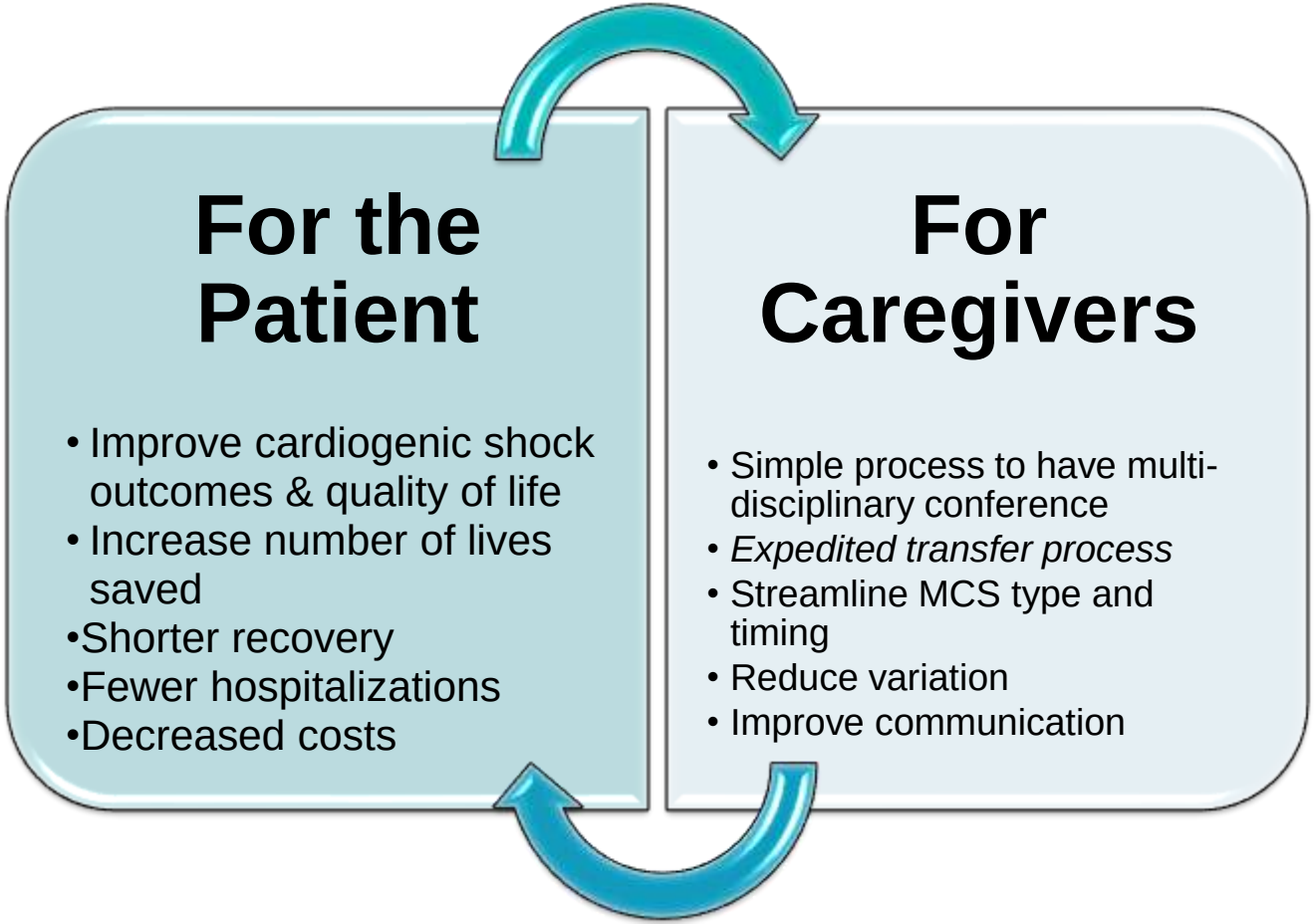
Information Discussed During Conference

Background of patient and events leading up to shock	Pertinent Labs Lactic Acid and VBG)	Hemodynamics (transducing CVC for CVP)	Imaging Results (LHC, RHC, Echo)	Recommendations

Cardiogenic Shock Team Recommendations Could Include:

Invasive recommendations:	Non-invasive recommendations:	Surveillance:
• Temporary MCS • Durable MCS/ Transplant candidacy • Cath Lab Needs	• Drip changes • Vent changes • Additional diagnostics	• Remain in place • Transfer • Official consultation to a specific team

Benefits of Cardiogenic Shock Team



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