Cardiogenic shock

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9.2017

Definitions of shock

- Severe hemodynamic impairment which causes hypoperfusion of vital organs
- Clinical syndrome that results from inadequate tissue perfusion

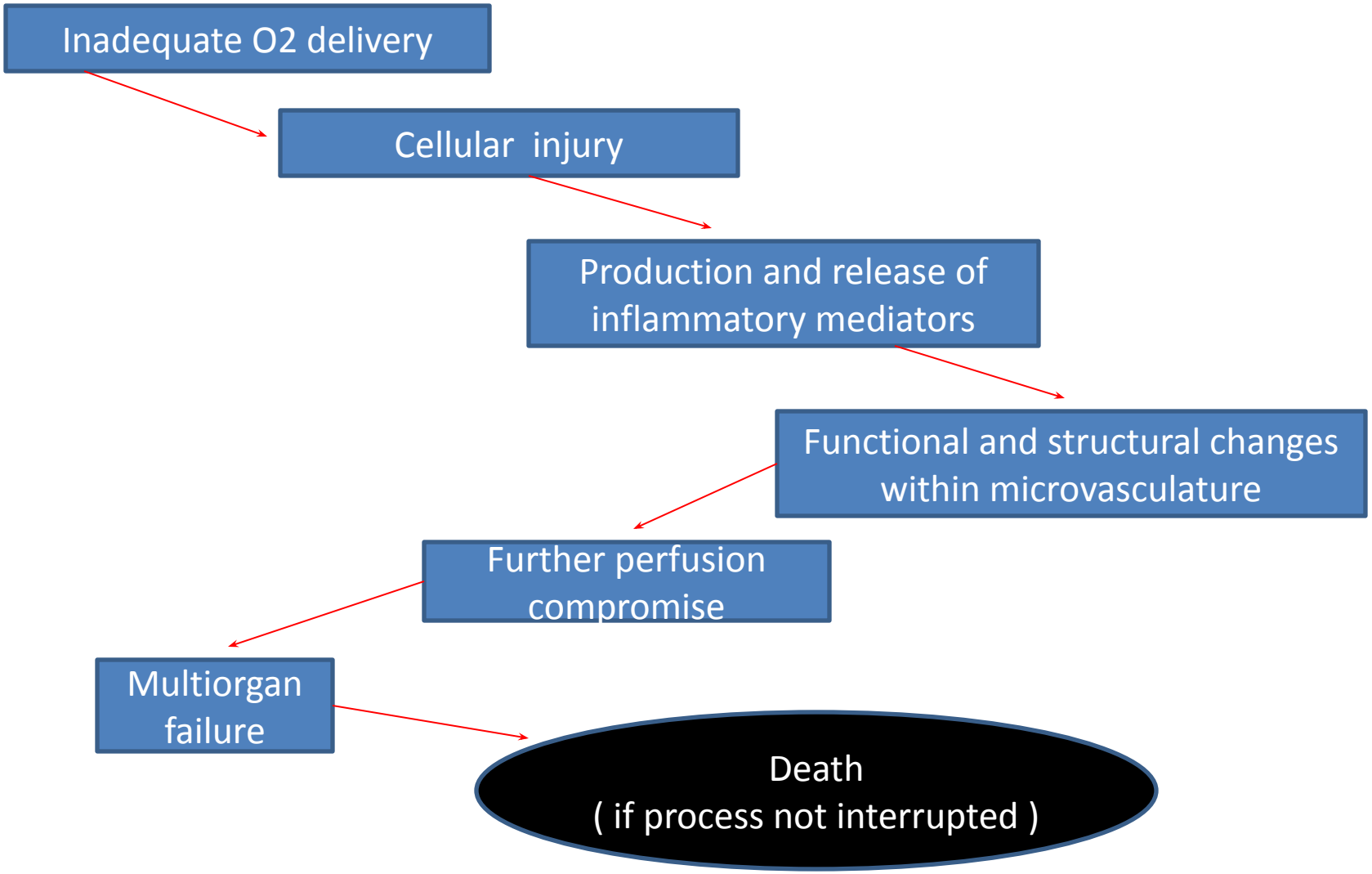
Signs of hypoperfusion

- clouded sensorium
- cool extremities
- oliguria
- acidosis

Cardiogenic shock

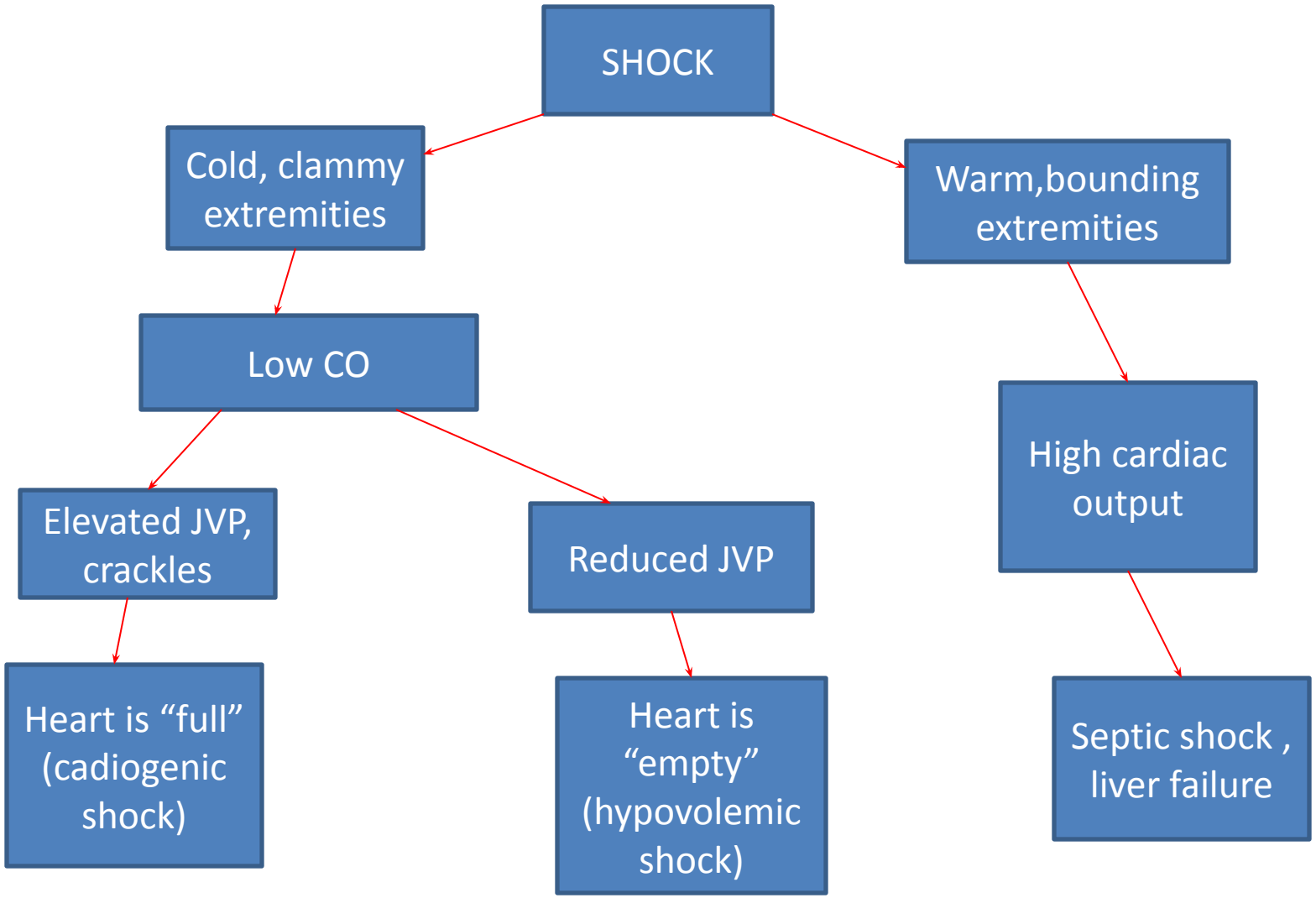
- Hemodynamic criteria
  - persistent (>30 min) hypotension (systolic BP <80 or mean BP<60 mm Hg)
  - cardiac index (CI) < 1.8 L/min/m2
  - pulmonary capillary wedge pressure (PCWP) > 18 mm Hg

Pathogenesis of shock



Types of shock

- Hypovolemic
- Traumatic
- Cardiogenic
- Septic
- Neurogenic
- Hypoadrenal


SHOCK
Cold, clammy extremities
Warm,bounding extremities
Low CO
High cardiac output
Elevated JVP, crackles
Reduced JVP
Heart is “full” (cadiogenic shock)
Heart is “empty” (hypovolemic shock)
Septic shock , liver failure

Causes of cardiogenic shock

- Acute myocardial infarction
  - large MI with extensive LV dysfunction (75%)
  - RV infarction
  - acute severe mitral regurgitation
  - ventricular septum rupture
  - subacute free-wall rupture with tamponade
- Pericardial effusion with cardiac tamponade
- Acute myocarditis
- End stage heart failure (different diseases)

Etiology of cardiogenic shock in SHOCK trial and registry

30-d mortality (%)	Number (%) of patients	Etiology
59.2	(78.5) 1116	Predominant LV failure
55.1	98 (6.9)	Mitral regurgitation
87.3	(3.9) 55	VS rupture
55.0	(2.8) 40	RV failure
55.0	(1.4) 20	tamponade
65.3	(6.7) 95	other
60.1	(100) 1424	OVERALL

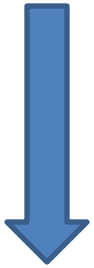
Hochman JS et al. J Am Coll Cardiol 2000; 36:1063-70

Cardiogenic shock
due to RV failure

- Acute dilatation of ischemic RV
- Increase in intrapericardial pressure due to restraining force of pericardium
- Decrease in RV systolic pressure and output
- Decrease in LV preload
- Decrease in LVED dimension and stroke volume

Cardiogenic shock
due to RV failure

- Reduction of RV preload (volume depletion, diuretics, nitrates)
- Decrease of right atrial augmentation (concomitant atrial infarction, loss of atrio-ventricular synchrony)
- Increase in RV afterload (concomitant LV dysfunction)



PROFOUND ADVERSE HEMODYNAMIC EFFECT

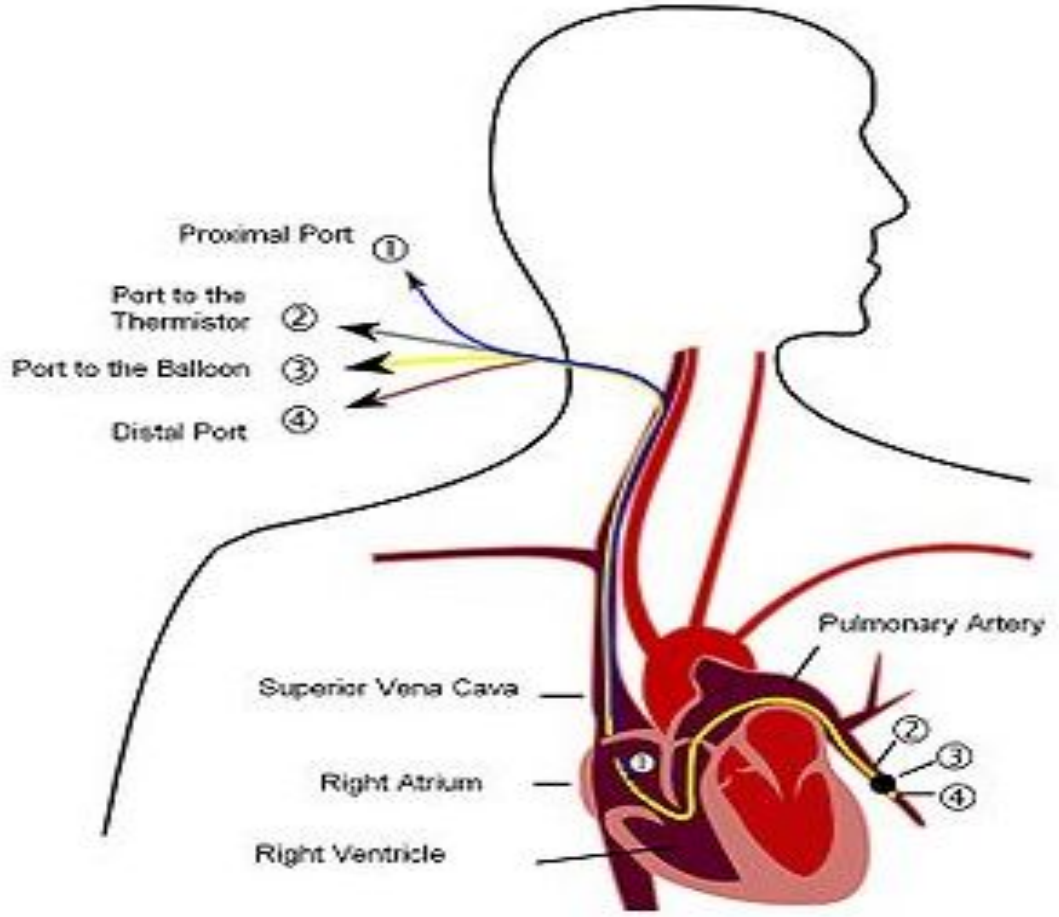
Hemodynamic monitoring

Pulmonary artery catheter

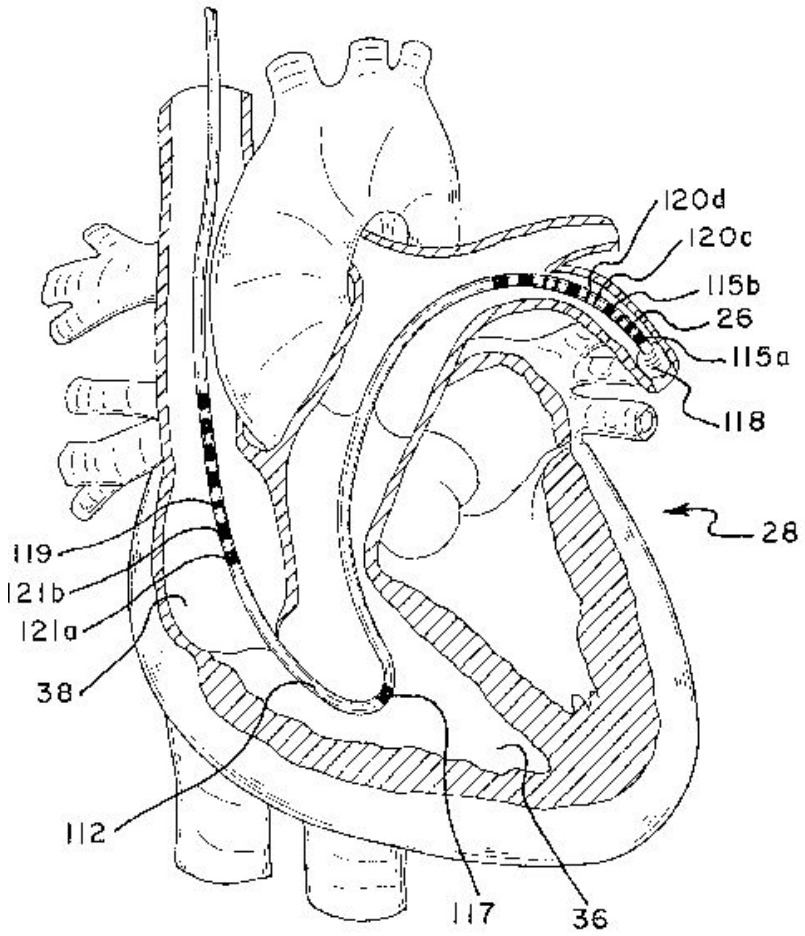
Class IIa

1. **Pulmonary artery catheter monitoring can be useful for the management of STEMI patients with cardiogenic shock.** ***(Level of Evidence: C)***
2. **Early revascularization, either PCI or CABG, is reasonable for selected patients 75 years or older with ST elevation or LBBB who develop shock within 36 hours of MI and who are suitable for revascularization that can be performed within 18 hours of shock. Patients with good prior functional status who agree to invasive care may be selected for such an invasive strategy.** ***(Level of Evidence: B)***

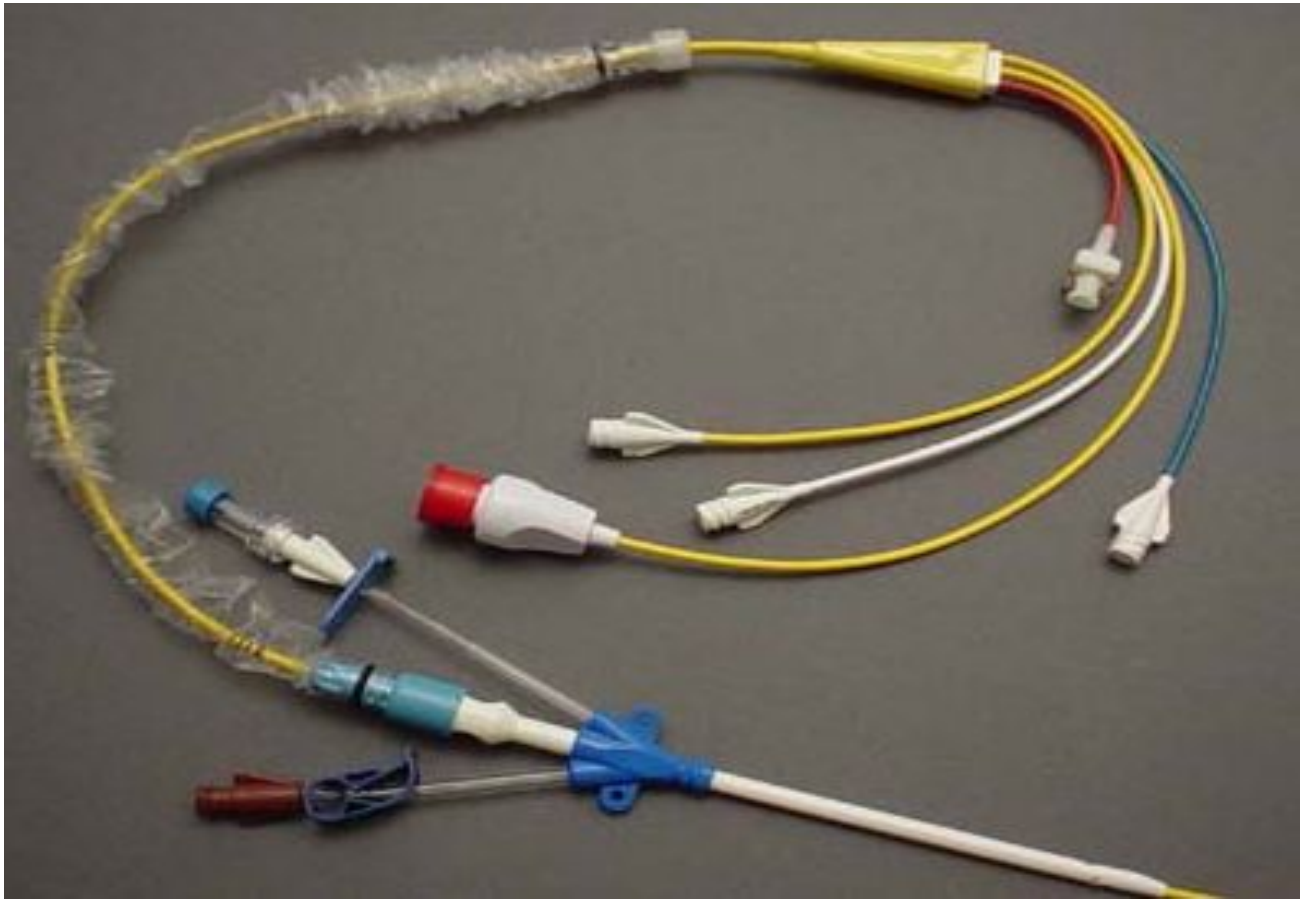
Pulmonary artery catheter



Pulmonary artery catheter

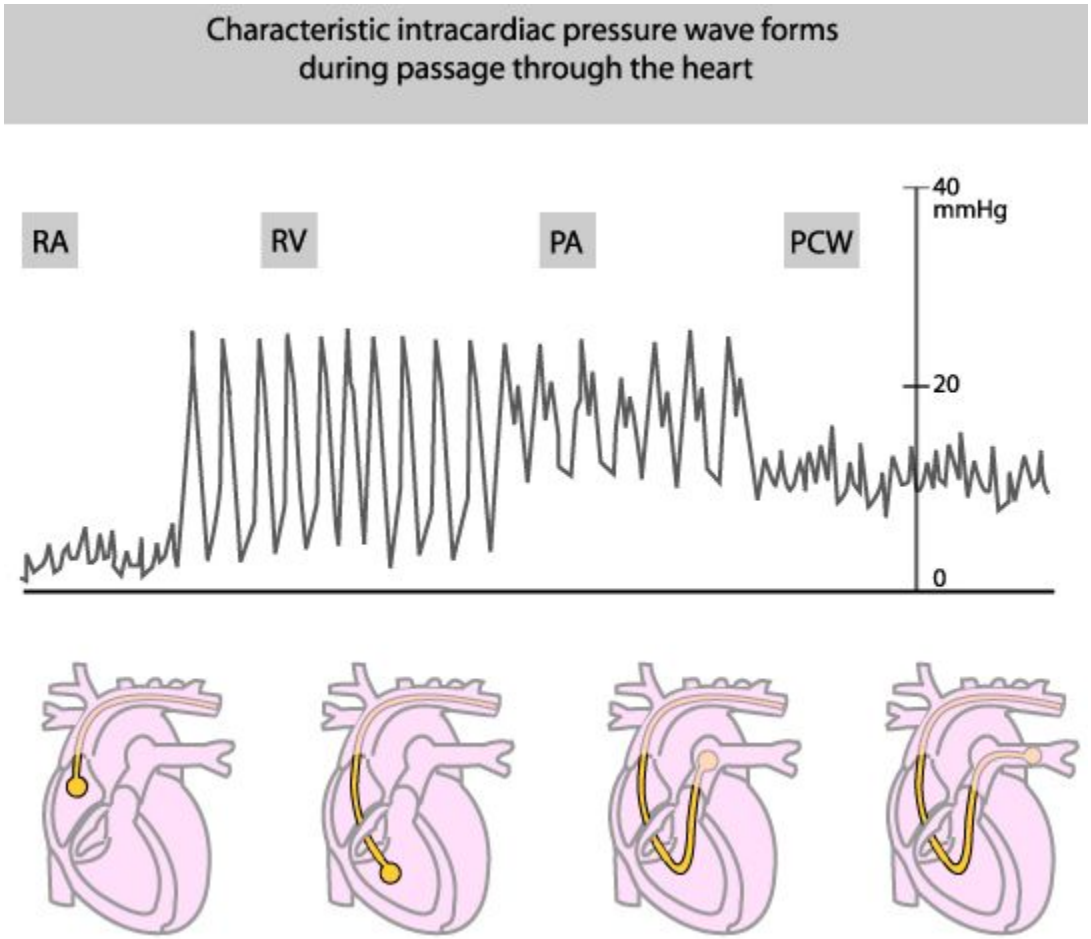


Pulmonary artery catheter



Pulmonary artery catheter

Pulmonary artery catheter



Pulmonary artery catheter

- VASCULAR COMPLICATIONS :

- Accidental arterial puncture
- Pneumothorax
- Braquial plexus lesion
- Horner syndrome
- Phrenic nerve lesion
- Gaseous embolism
- Hemorrhage (when coaggulopathy is anticipated, use right internal jugular, femoral or antecubital)
- Infections

- COMPLICATIONS RELATED TO CATHTER :

- Tachyarrhytmias
- Right bundle branch block (0.05-5%)
- Complete heart block (with preexisting left bundle branch block)
- Cardiac perfuration
- Thrombosis and embolism
- Pulmonary infarction due to persistent wedging (0-1.4%)
- Catheter-related sepsis
- PA rupture (0.2% chance)
- Knotting of the catheter
- Endocarditis, bland and infective
- Pulmonic valve insufficiency
- Balloon fragmentation and embolization

STEMI guidelines
ESC 2017

Haemodynamic assessment with pulmonary artery catheter may be considered for confirming diagnosis or guiding therapy.[433]	IIb	B

Treatment of cardiogenic shock

- Inotropes
- IABP
- Early revascularization (PCI or CABG)
- Surgery for mechanical complications
- Pericardiocentesis (if tamponade is a cause of shock)
- Percutaneous ventricular assist devices

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MARCH 4, 2010 VOL. 362 NO. 9

Comparison of Dopamine and Norepinephrine in the Treatment of Shock

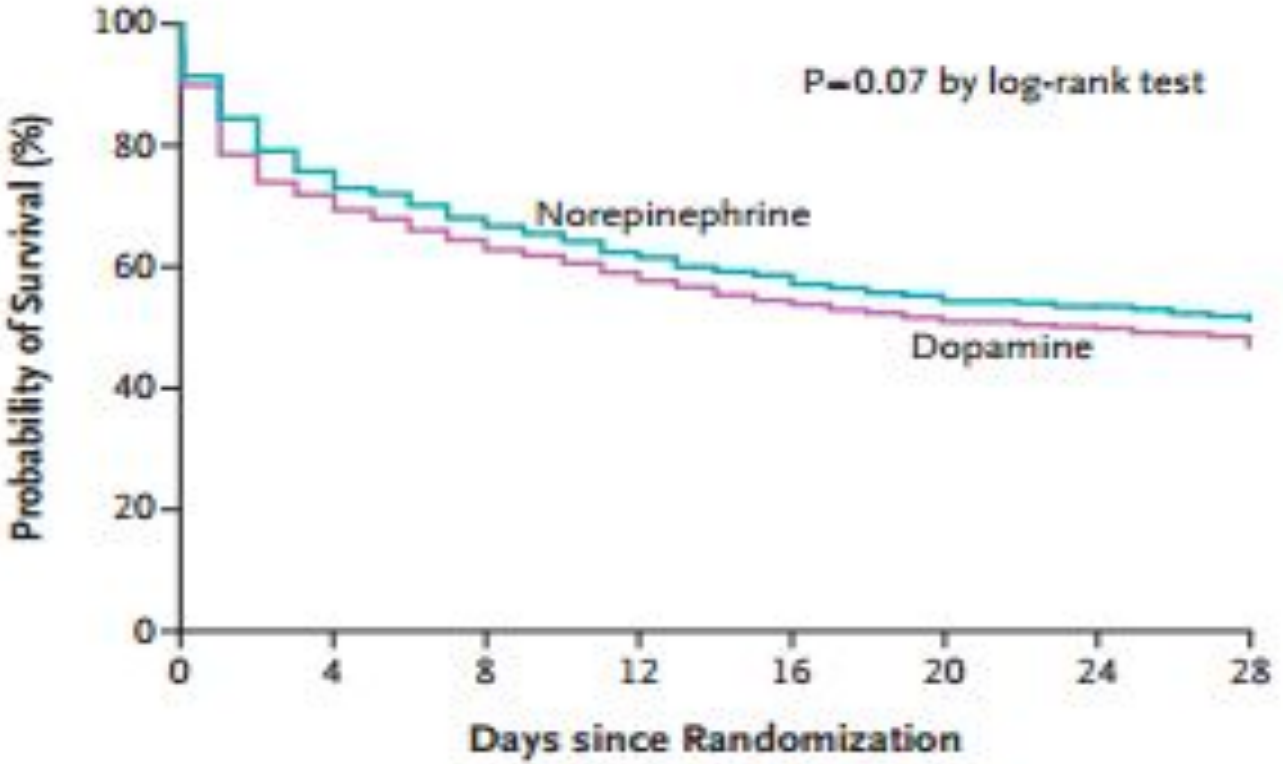
Daniel De Backer, M.D., Ph.D., Patrick Biston, M.D., Jacques Devriendt, M.D., Christian Madl, M.D., Didier Chochrad, M.D., Cesar Aldecoa, M.D., Alexandre Brasseur, M.D., Pierre Defrance, M.D., Philippe Gottignies, M.D., and Jean-Louis Vincent, M.D., Ph.D., for the SOAP II Investigators*

Table 2. Mortality Rates.*

Time Period	Dopamine	Norepinephrine	Odds Ratio (95% CI)†	P Value
	percent mortality			
During stay in intensive care unit	50.2	45.9	1.19 (0.98–1.44)	0.07
During hospital stay	59.4	56.6	1.12 (0.92–1.37)	0.24
At 28 days	52.5	48.5	1.17 (0.97–1.42)	0.10
At 6 mo	63.8	62.9	1.06 (0.86–1.31)	0.71
At 12 mo	65.9	63.0	1.15 (0.91–1.46)	0.34

* Data were available for 1656 patients in the intensive care unit, in the hospital, and at 28 days; for 1443 patients at 6 months; and for 1036 patients at 12 months.

† Odds ratios for death are for the comparison of the dopamine group with the norepinephrine group.



No. at Risk								
Norepinephrine	821	617	553	504	467	432	412	394
Dopamine	858	611	546	494	452	426	407	386

Figure 2. Kaplan–Meier Curves for 28-Day Survival in the Intention-to-Treat Population.

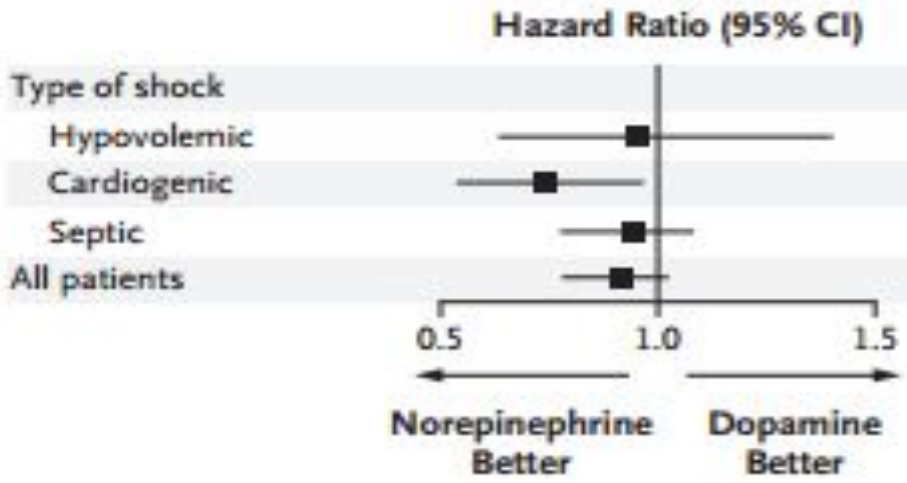


Figure 3. Forest Plot for Predefined Subgroup Analysis According to Type of Shock.

A total of 1044 patients were in septic shock (542 in the dopamine group and 502 in the norepinephrine group), 280 were in cardiogenic shock (135 in the dopamine group and 145 in the norepinephrine group), and 263 were in hypovolemic shock (138 in the dopamine group and 125 in the norepinephrine group). The P value for interaction was 0.87.

STEMI guidelines
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Inotropic/vasopressor agents may be considered for haemodynamic stabilization.	IIb	C

Intra-aortic balloon pump (IABP)

Intra-aortic balloon pump

Intra-aortic balloon pumping

Beneficial effects

- reduces cardiac work by decreasing afterload
- increases coronary blood flow

Basic mechanism

- placed in the thoracic aorta
- balloon inflated during diastole, thus increasing aortic pressure during diastole and increasing coronary blood flow
- balloon deflated prior to and during early left ventricular ejection thus reducing aortic pressure and thus afterload

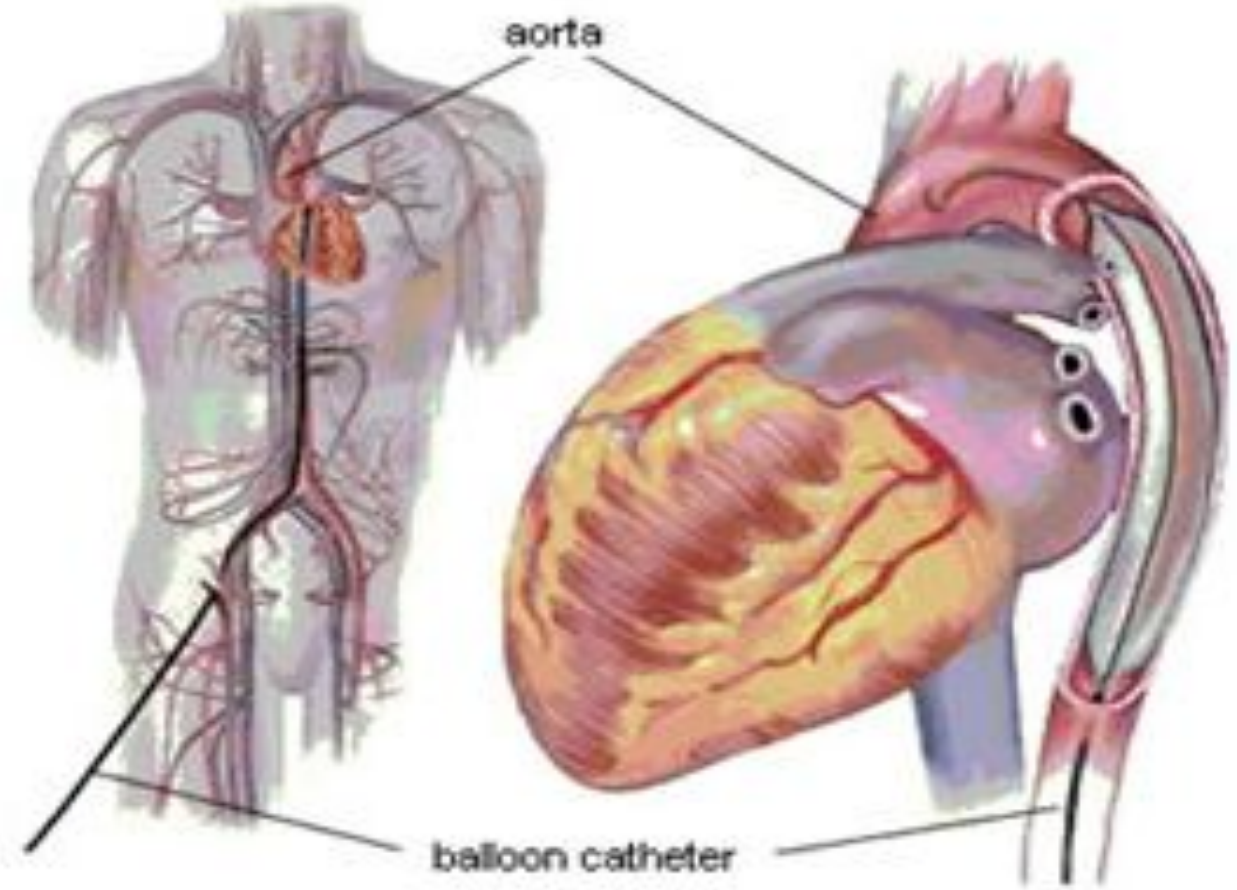
Intra-aortic balloon pump
Contraindications

- Absolute
  - aortic insufficiensy
  - aortic dissection
- Relative
  - significant aortoiliac or ileofemoral disease
  - descending thoracic or abdominal aneurysm
  - recent groin incision
  - morbid obesity

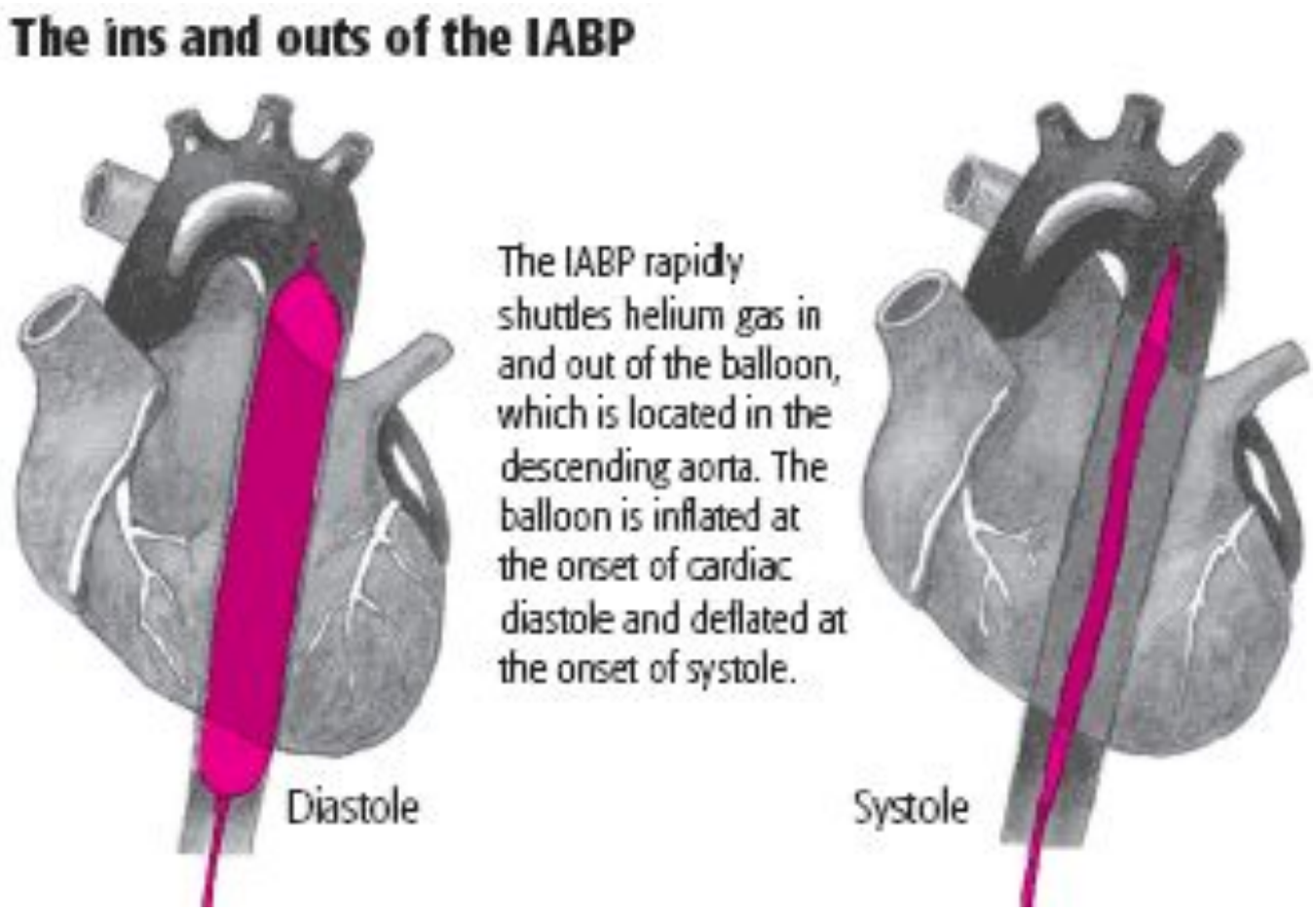
Intra-aortic balloon pump

Intra-aortic balloon

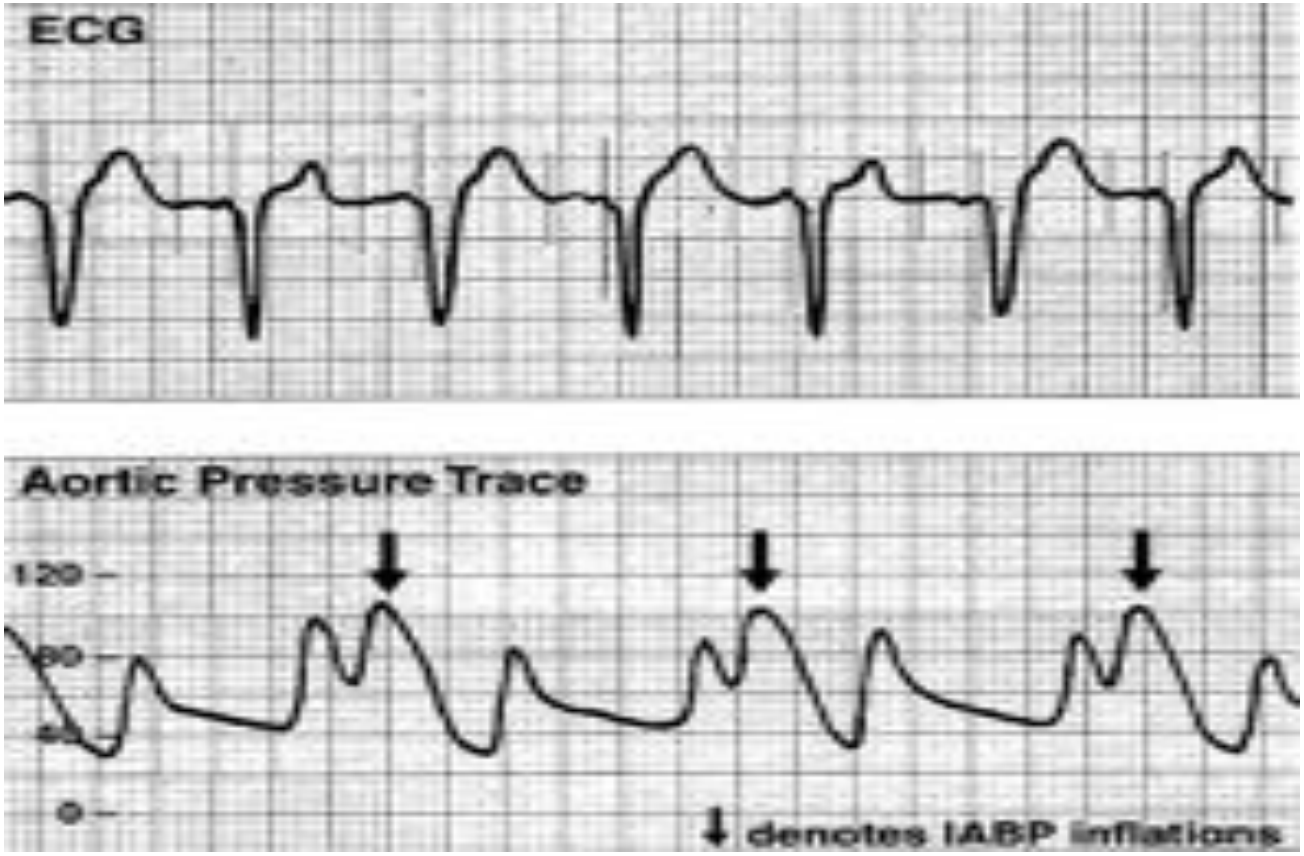
Intra-aortic balloon pump



Intra-aortic balloon pump



Intra-aortic balloon pump



Intra-aortic balloon pump

Class I

1. **Intra-aortic balloon counterpulsation is recommended for STEMI patients when cardiogenic shock is not quickly reversed with pharmacological therapy. The IABP is a stabilizing measure for angiography and prompt revascularization.** ***(Level of Evidence: B)***
2. **Intra-arterial monitoring is recommended for the management of STEMI patients with cardiogenic shock.** ***(Level of Evidence: C)***
3. **Early revascularization, either PCI or CABG, is recommended for patients less than 75 years old with ST elevation or LBBB who develop shock within 36 hours of MI and who are suitable for revascularization that can be performed within 18 hours of shock unless further support is futile because of the patient's wishes or contraindications/unsuitability for further invasive care.** ***(Level of Evidence: A)***
4. **Fibrinolytic therapy should be administered to STEMI patients with cardiogenic shock who are unsuitable for further invasive care and do not have contraindications to fibrinolysis.** ***(Level of Evidence: B)***
5. **Echocardiography should be used to evaluate mechanical complications unless these are assessed by invasive measures.** ***(Level of Evidence: C)***

IABP-SHOCK II Trial

N Engl J Med. 2012 Oct 4;367(14):1287-96. doi: 10.1056/NEJMoa1208410. Epub 2012 Aug 26.

Intraaortic balloon support for myocardial infarction with cardiogenic shock.

Thiele H, Zeymer U, Neumann FJ, Ferenc M, Olbrich HG, Hausleiter J, Richardt G, Hennersdorf M, Empen K, Fuernau G, Desch S, Eitel I, Hambrecht R, Fuhrmann J, Böhm M, Ebelt H, Schneider S, Schuler G, Werdan K; IABP-SHOCK II Trial Investigators.

IABP-SHOCK II Trial

RR, 95% confidence interval, p value	Control n=299 (298)	IABP n=301 (300)	
0.69 ,0.79-1.17 ,0.96	41.3%	39.7%	All cause mortality
0.51	4.4%	3.3%	Major bleeding
0.53	3.4%	4.3%	Periph. vascular complications
0.15	20.5%	15.7%	Sepsis
0.28	&1.7	0.7%	Stroke

IABP-SHOCK II Trial: conclusions

The use of IAB counterpulsation did not significantly reduce 30-day mortality in patients with cardiogenic shock complicating acute myocardial infarction for whom an early revascularization strategy was planned

STEMI guidelines
ESC 2017

Intra-aortic balloon pumping should be considered in patients with haemodynamic instability/cardiogenic shock due to mechanical complications.	IIa	C
Routine intra-aortic balloon pumping is not indicated.[177,437]	III	B

Early revascularization

SHOCK trial

Early revascularization in acute myocardial infarction complicated by cardiogenic shock

J. Hochman et al . NEJM 1999; 341(9):625

- Patients with STEMI, Q-wave MI, a new LBBB, posterior MI with anterior ST depression complicated by shock due predominantly left ventricular dysfunction

SHOCK trial

Shock criteria

Clinical :

- hypotension (SBP<90 mm Hg for at least 30 min or need for supportive measures to maintain a SBP ≥90 mm Hg)
- end-organ hypoperfusion (cool extremities or a urine output < 30 ml/h and heart rate ≥60 beats per minute)

Hemodynamic:

- CI ≤ 2.2 L/min/m2
- PCWP ≥ 15 mm Hg

SHOCK trial

- Timing
  - onset of shock within 36 h of infarction
  - randomization as soon as possible but no more than 12 h after Ds of shock
  - PCI or CABG as soon as possible and within 6 h of randomization (for patient assigned to revascularization)

SHOCK trial

- Exclusion criteria
  - severe systemic illness
  - mechanical or other cause of shock
  - severe valvular disease
  - dilated cardiomyopathy
  - inability of care givers to gain access for catheterization
  - unsuitability for revascularization

SHOCK trial

- End points

  primary : overall mortality 30 days after randomization

  secondary : overall mortality 6 and 12 months after infarction

SHOCK trial

- Results

	revasc (n=152)	medical Rx (n=150)	raltive risk	p value
30-d mortality				
Total	47%	56%	0.83	0.11
Age<75	41%	57%	0.73	0.02
Age ≥75	75%	53%	1.41	0.16
6-mo mortality				
Total	50%	63%	0.80	0.027
Age<75	45%	65%	0.70	0.002
Age≥75	79%	56%	1.41	0.09

SHOCK trial

Hochman JS, Sleeper LA, White HD, et al, for the Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock (SHOCK) Investigators. One-year survival following early revascularization for cardiogenic shock. *JAMA* 2001;285:190-2.

SHOCK trial

1 year survival

- Early revascularization group – 46.7%
- Initial medical stabilization group – 33.6%

p<0.003

- RR of death = 0.72; 95% CI 0.54-0.95
- Treatment benefit was apparent only in patients younger than 75 years

JAMA 2001; 285(2):190-192

SHOCK trial

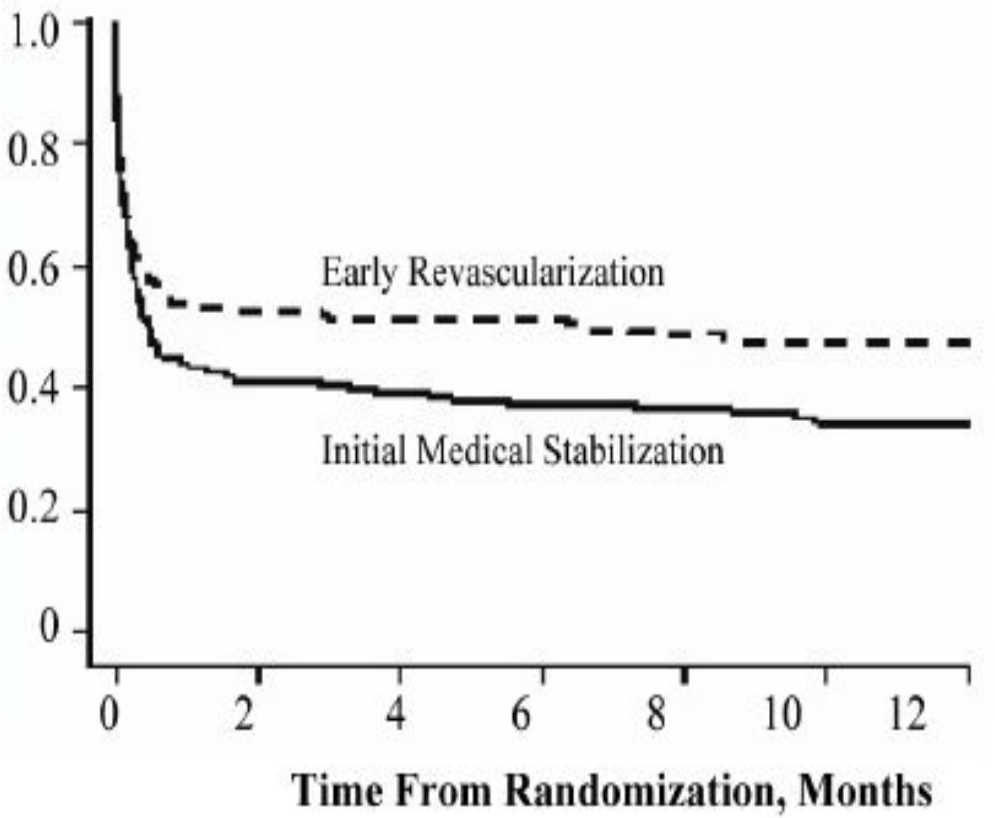


Figure 29. Kaplan-Meier survival of cardiogenic shock after early revascularization curve 1-year postrandomization. Survival estimates for early revascularization (n=152) and initial medical stabilization (n=149) groups. Log-rank test P = 0.04. Reprinted with permission from Hochman et al. JAMA 2001;285:190-2.

Early revascularization and long-term survival in cardiogenic shock complicating acute myocardial infarction

- Overall survival rates at 6 years
  - early revascularization group – 32.8%
  - initial medical stabilization group – 19.6%

Hochman JS et al . JAMA 2006; 295(21):2511-5

STEMI guidelines 2004
Cardiogenic shock

Class I

1. **Intra-aortic balloon counterpulsation is recommended for STEMI patients when cardiogenic shock is not quickly reversed with pharmacological therapy. The IABP is a stabilizing measure for angiography and prompt revascularization.** ***(Level of Evidence: B)***
2. **Intra-arterial monitoring is recommended for the management of STEMI patients with cardiogenic shock.** ***(Level of Evidence: C)***
3. **Early revascularization, either PCI or CABG, is recommended for patients less than 75 years old with ST elevation or LBBB who develop shock within 36 hours of MI and who are suitable for revascularization that can be performed within 18 hours of shock unless further support is futile because of the patient's wishes or contraindications/unsuitability for further invasive care.** ***(Level of Evidence: A)***
4. **Fibrinolytic therapy should be administered to STEMI patients with cardiogenic shock who are unsuitable for further invasive care and do not have contraindications to fibrinolysis.** ***(Level of Evidence: B)***
5. **Echocardiography should be used to evaluate mechanical complications unless these are assessed by invasive measures.** ***(Level of Evidence: C)***

ACCF/AHA STEMI GL 2013

9.1.1. Treatment of Cardiogenic Shock: Recommendations

Class I

1. **Emergency revascularization with either PCI or CABG is recommended in suitable patients with cardiogenic shock due to pump failure after STEMI irrespective of the time delay from MI onset.[212,379,452] (*Level of Evidence: B*)**
2. **In the absence of contraindications, fibrinolytic therapy should be administered to patients with STEMI and cardiogenic shock who are unsuitable candidates for either PCI or CABG.[81,453,454] (*Level of Evidence: B*)**

Class IIa

1. **The use of intra-aortic balloon pump (IABP) coun-ter-pulsation can be useful for patients with cardiogenic shock after STEMI who do not quickly stabilize with pharmacological therapy.[455–459] (*Level of Evidence: B*)**

Class IIb

1. **Alternative LV assist devices for circulatory support may be considered in patients with refractory cardio-genic shock. (*Level of Evidence: C*)**

STEMI guidelines
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Immediate PCI is indicated for patients with cardiogenic shock if coronary anatomy is suitable. If coronary anatomy is not suitable for PCI, or PCI has failed, emergency CABG is recommended.[248]	I	B

STEMI guidelines
ESC 2017

Complete revascularization during the index procedure should be considered in patients presenting with cardiogenic shock.	IIa	C

STEMI guidelines
ESC 2017

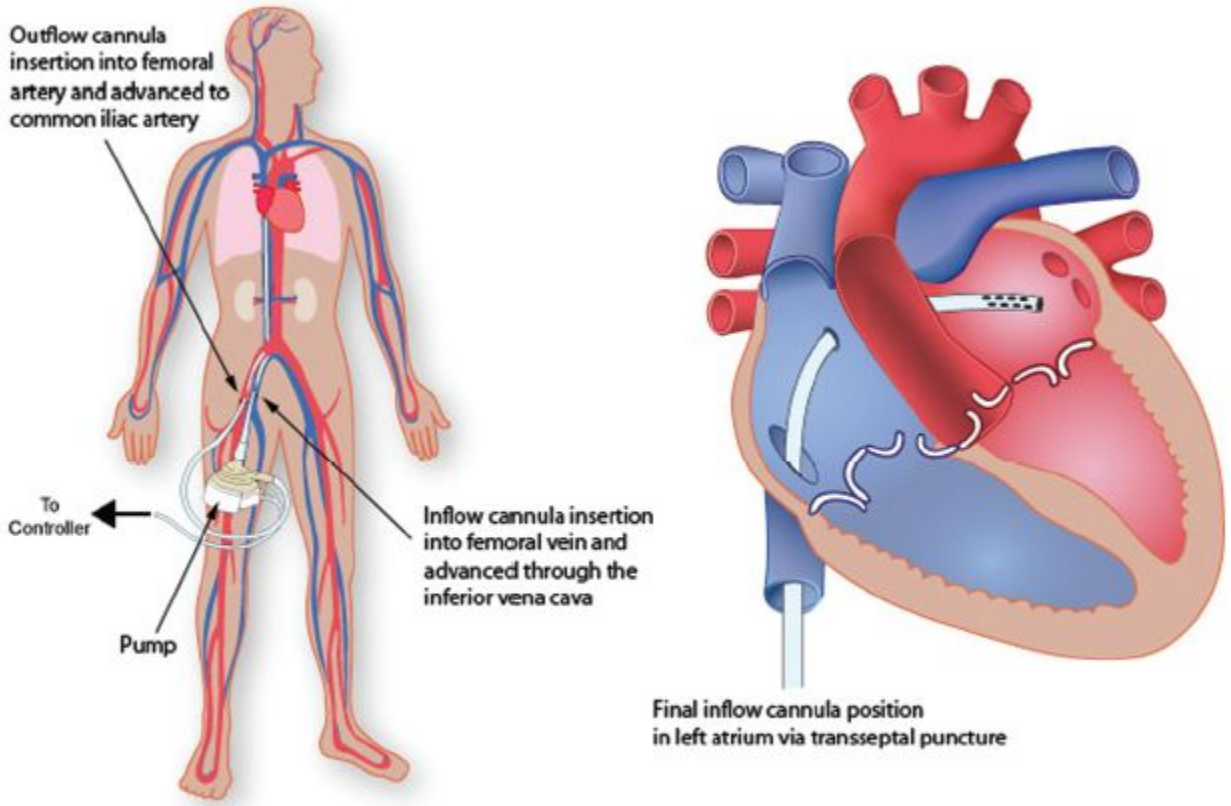
Fibrinolysis should be considered in patients presenting with cardiogenic shock if a primary PCI strategy is not available within 120 min from STEMI diagnosis and mechanical complications have been ruled out.	IIa	C

Percutaneous ventricular assist devices

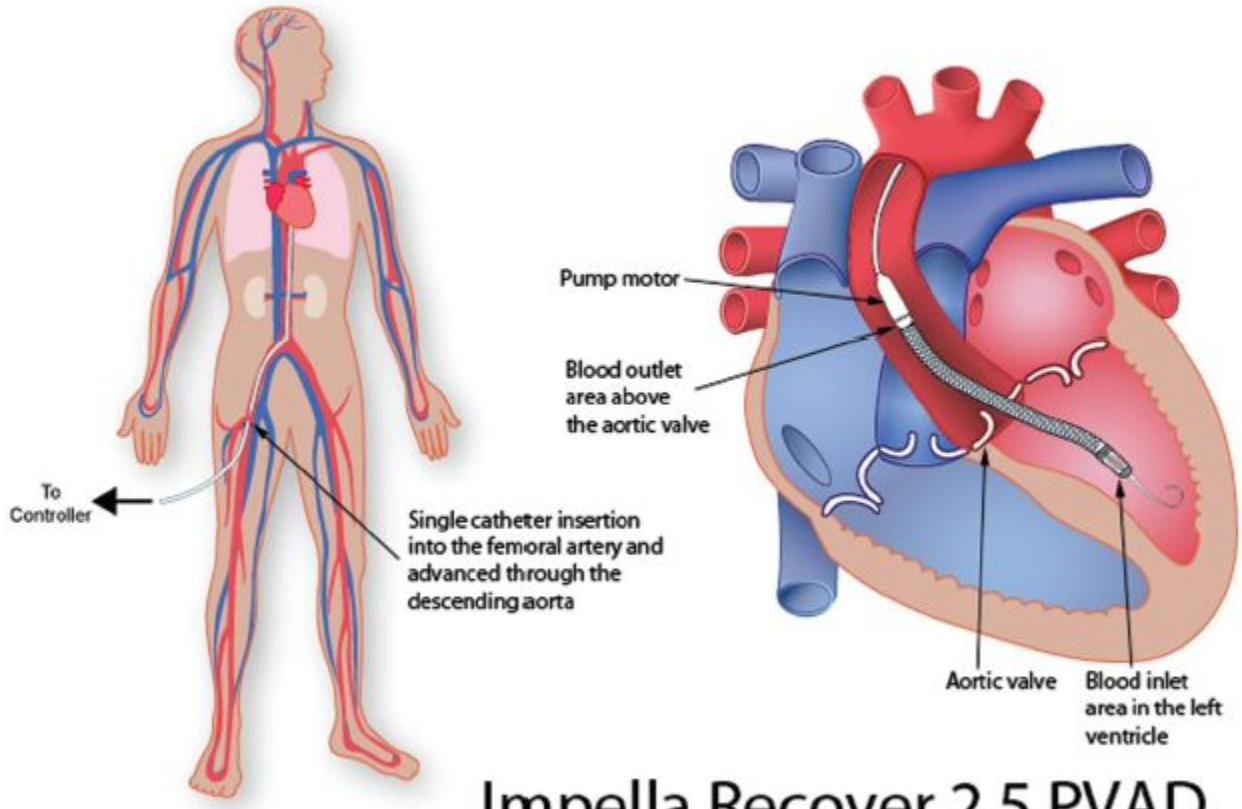
Table 2. Comparison of Currently Available Percutaneous Ventricular Assist Devices

	IABP	TandemHeart	Impella Recover System	ECMO
Pump mechanism	Pneumatic	Centrifugal	Axial	Centrifugal
Insertion	Retrograde 7–9F balloon catheter into the descending aorta via the femoral artery	21F inflow cannula into the left atrium via the femoral vein and transseptal puncture and 15/17F outflow cannula into the femoral artery	12F catheter (13F sheath) retrograde across the aortic valve via the femoral artery	18–31F inflow cannula into the right atrium via the femoral vein and 15–22F outflow cannula into the descending aorta via the femoral artery
Difficulty of insertion	+	++++	+++	++
Degree of circulatory support (with ideal SVR)	+ (Increased CO by 0.5 L/min)	+++ (Increased CO by 3.5–4.5 L/min)	++ (Increased CO by 2.5 L/min)	++++ (Increased CO to ≥4.5 L/min)
Implantation time, min	10	25–65	11–25	10–15
Limb ischemia risk	+	+++	++	+++
Hemolysis	0	++	++++	+++
Bleeding risk	+	+++	++	++++
510k Approval duration, h		6	6	
Evidence of efficacy	Increased CO and coronary and peripheral perfusion; deceased afterload	Increased CO, MAP, Mvo_2, and urine output; decreased lactic acid, creatinine, and PCWP	Increased CO and MAP; decreased lactic acid and PCWP	Increased CO, MAP, and oxygenation

SVR indicates systemic vascular resistance; CO, cardiac output; MAP, mean arterial pressure; Mvo_2, mixed venous oxygen saturation; and PCWP, pulmonary capillary wedge pressure.

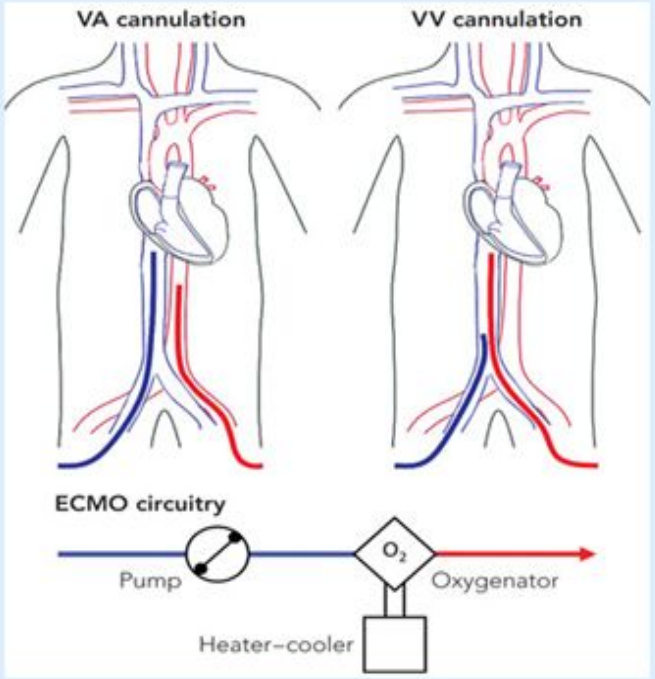


TandemHeart PVAD



Impella Recover 2.5 PVAD

Examples of cannulation for venoarterial (VA) and venovenous (VV) ECMO



In both modalities, blood is drained from the venous system (blue). In VA ECMO it is returned (red) to the arterial system, and in VV ECMO it is returned to the venous system. The direction of blood flow in the ECMO circuit is indicated by the arrow.

Venovenous (VV) modality

- Provides complete or partial support of the lungs when cardiac output is sufficient
- Drainage and return cannulas are positioned in the vena cava
- Vascular cannulas are introduced peripherally via jugular or femoral vessels
- Single double lumen cannula can be used

Venoarterial (VA) modality

- Provides complete or partial cardiac support in addition to gas exchange
- Central cannulation: blood is drained directly from the RA and returned to the proximal ascending aorta
- Peripheral cannulation: blood is drained from the proximal great veins (via a femoral or jugular vein and returned to the aorta via cannulation of carotid, axillary or femoral artery

Photograph showing venous drainage cannula (A), arterial return cannula (B) and a back-perfusion cannula (C) for distal supply of the femoral artery.

Table 2. Comparison of Currently Available Percutaneous Ventricular Assist Devices

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Insertion	Retrograde 7–9F balloon catheter into the descending aorta via the femoral artery	21F inflow cannula into the left atrium via the femoral vein and transseptal puncture and 15/17F outflow cannula into the femoral artery	12F catheter (13F sheath) retrograde across the aortic valve via the femoral artery	18–31F inflow cannula into the right atrium via the femoral vein and 15–22F outflow cannula into the descending aorta via the femoral artery
Difficulty of insertion	+	++++	+++	++
Degree of circulatory support (with ideal SVR)	+ (Increased CO by 0.5 L/min)	+++ (Increased CO by 3.5–4.5 L/min)	++ (Increased CO by 2.5 L/min)	++++ (Increased CO to ≥4.5 L/min)
Implantation time, min	10	25–65	11–25	10–15
Limb ischemia risk	+	+++	++	+++
Hemolysis	0	++	++++	+++
Bleeding risk	+	+++	++	++++
510k Approval duration, h		6	6	
Evidence of efficacy	Increased CO and coronary and peripheral perfusion; deceased afterload	Increased CO, MAP, Mvo_2, and urine output; decreased lactic acid, creatinine, and PCWP	Increased CO and MAP; decreased lactic acid and PCWP	Increased CO, MAP, and oxygenation

SVR indicates systemic vascular resistance; CO, cardiac output; MAP, mean arterial pressure; Mvo_2, mixed venous oxygen saturation; and PCWP, pulmonary capillary wedge pressure.

Prehospital ECMO Team

– 2 senior non-surgeon physicians with expertise in ECMO, 1 nurse, 1 paramedic

– Maquet™ Cardiohelp

– 2 units of packed RBCs and 2 units of FFP

– Sedation

– Therapeutic Hypothermia

Approach

– Seldinger technique with modified cutdown of proximal vessels. They FIRST do a cutdown to expose the femoral vessels. They then insert the needle DISTAL to the femoral cutdown and visualize direct vessel access within the open surgical field. That way, the cannulas are actually placed percutaneous while vessel access can be directly visualized. Lionel says that this approach is actually faster and safer than just blindly stabbing around with the needle as is done with a blind percutaneous method.

Examples of Pre-hospital ECMO*

ECMO at the Louvre

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Short-term mechanical support[c] may be considered in patients in refractory shock.	IIb	C

Thank you for attention

Back up slides

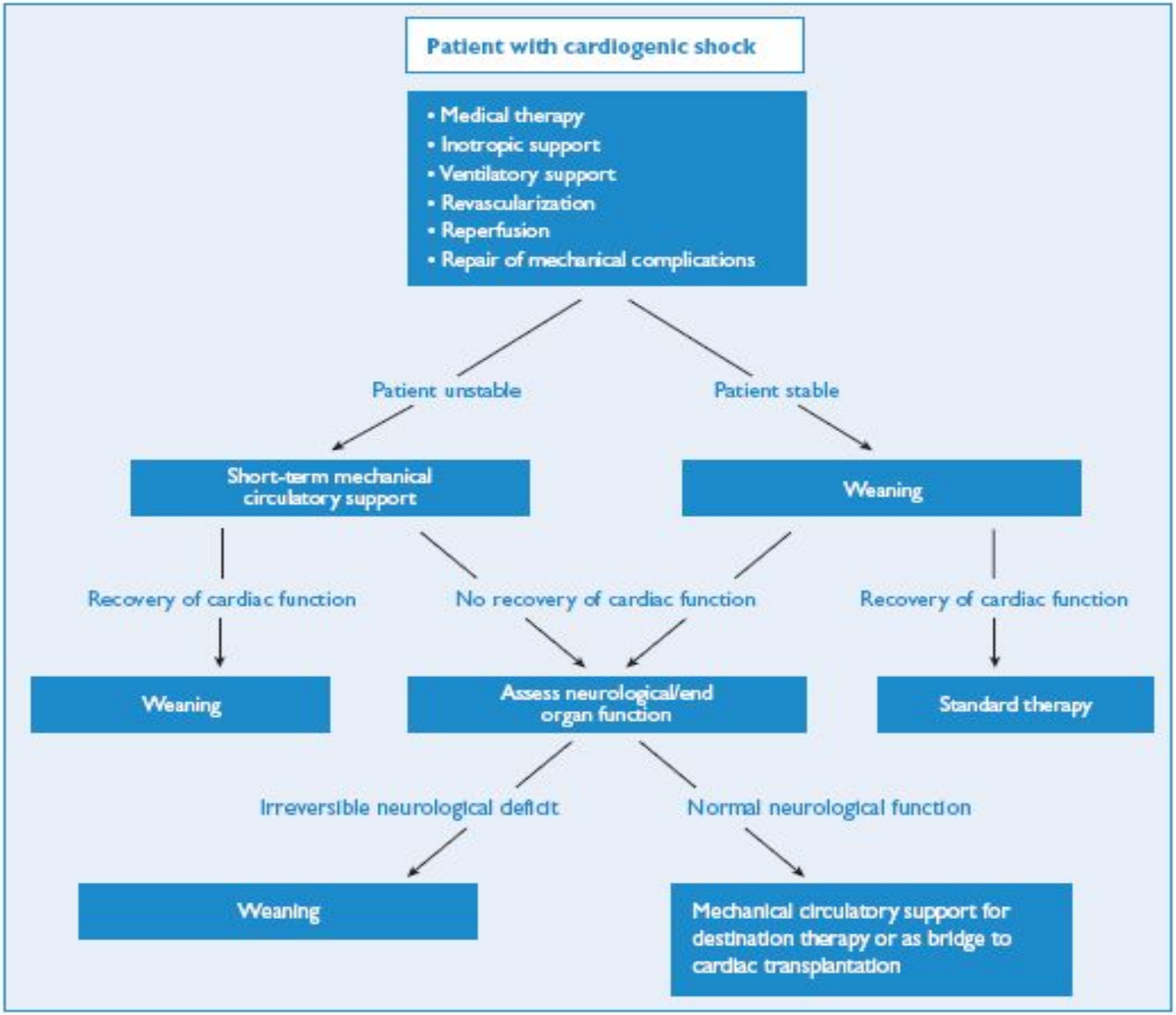
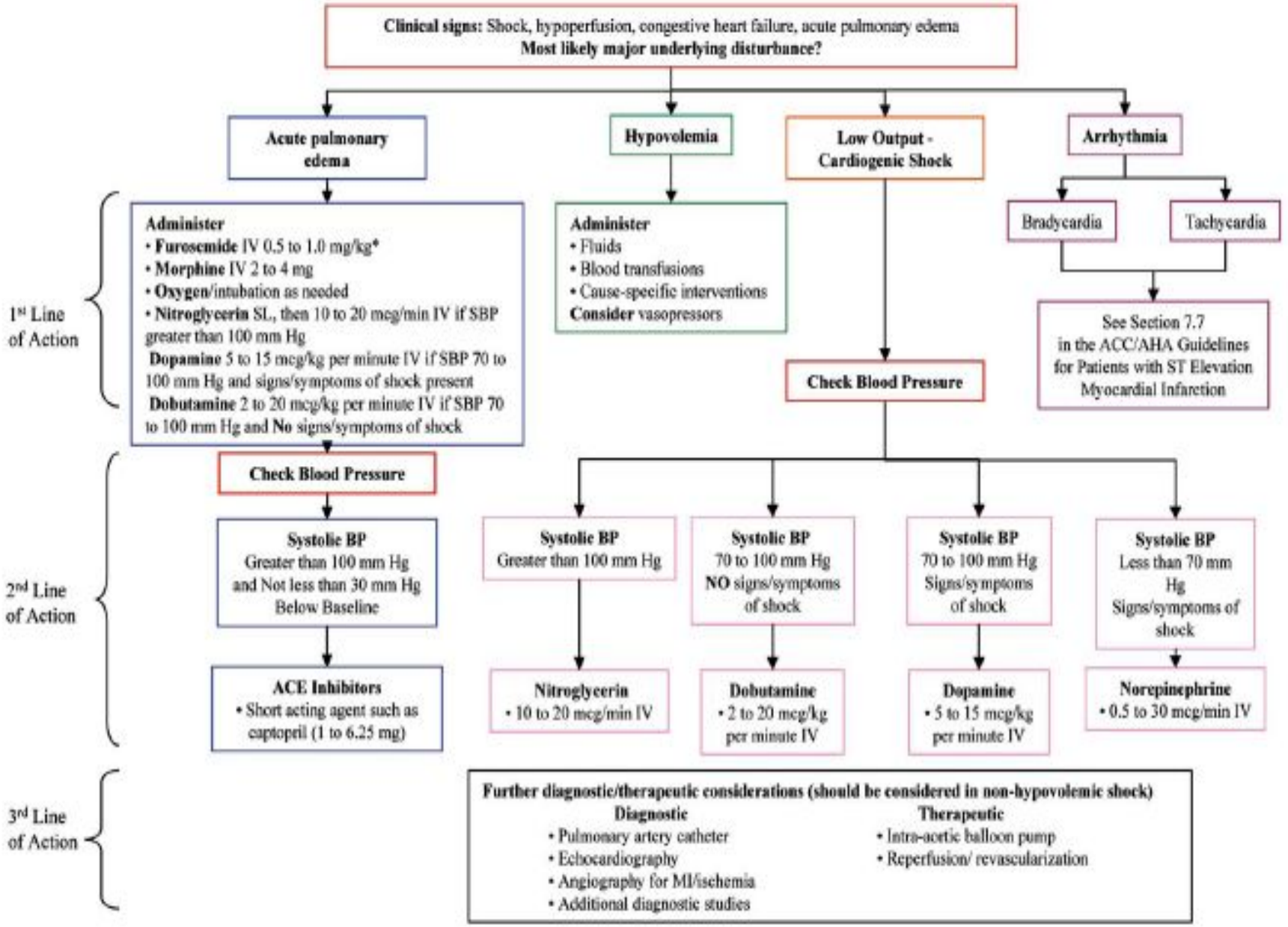


Figure 3 Treatment of patients with cardiogenic shock.

Treatment


Clinical signs: Shock, hypoperfusion, congestive heart failure, acute pulmonary edema
Most likely major underlying disturbance?
Acute pulmonary edema
Hypovolemia
Low Output - Cardiogenic Shock
Arrhythmia
1st Line of Action
Administer
• Furosemide IV 0.5 to 1.0 mg/kg*
• Morphine IV 2 to 4 mg
• Oxygen/intubation as needed
• Nitroglycerin SL, then 10 to 20 mcg/min IV if SBP greater than 100 mm Hg
Dopamine 5 to 15 mcg/kg per minute IV if SBP 70 to 100 mm Hg and signs/symptoms of shock present
Dobutamine 2 to 20 mcg/kg per minute IV if SBP 70 to 100 mm Hg and No signs/symptoms of shock
Administer
• Fluids
• Blood transfusions
• Cause-specific interventions
Consider vasopressors
Bradycardia
Tachycardia
See Section 7.7 in the ACC/AHA Guidelines for Patients with ST Elevation Myocardial Infarction
Check Blood Pressure
2nd Line of Action
Check Blood Pressure
Systolic BP Greater than 100 mm Hg and Not less than 30 mm Hg Below Baseline
ACE Inhibitors
• Short acting agent such as captopril (1 to 6.25 mg)
Systolic BP Greater than 100 mm Hg
Nitroglycerin
• 10 to 20 mcg/min IV
Systolic BP 70 to 100 mm Hg NO signs/symptoms of shock
Dobutamine
• 2 to 20 mcg/kg per minute IV
Systolic BP 70 to 100 mm Hg Signs/symptoms of shock
Dopamine
• 5 to 15 mcg/kg per minute IV
Systolic BP Less than 70 mm Hg Signs/symptoms of shock
Norepinephrine
• 0.5 to 30 mcg/min IV
3rd Line of Action
Further diagnostic/therapeutic considerations (should be considered in non-hypovolemic shock)
Diagnostic
• Pulmonary artery catheter
• Echocardiography
• Angiography for MI/ischemia
• Additional diagnostic studies
Therapeutic
• Intra-aortic balloon pump
• Reperfusion/ revascularization

Treatment of cardiogenic shock (Killip class IV)

Recommendations	Class	Level
Oxygen/mechanical respiratory support is indicated according to blood gasses.	I	C
Urgent echocardiography/Doppler must be performed to detect mechanical complications, assess systolic function and loading conditions.	I	C
High-risk patients must be transferred early to tertiary centres.	I	C
Emergency revascularization with either PCI or CABG in suitable patients must be considered.	I	B
Fibrinolysis should be considered if revascularization is unavailable.	IIa	C
Intra-aortic balloon pumping may be considered.	IIb	B
LV assist devices may be considered for circulatory support in patients in refractory shock.	IIb	C
Haemodynamic assessment with balloon floating catheter may be considered.	IIb	B
Inotropic/vasopressor agents should be considered:		
• Dopamine;	IIa	C
• Dobutamine;	IIa	C
• Norepinephrine (preferred over dopamine when blood pressure is low).	IIb	B

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IABP insertion should be considered in patients with haemodynamic instability/cardiogenic shock due to mechanical complications.	IIa	C	
Routine use of IABP in patients with cardiogenic shock is not recommended.	III	A	332,333