How to manage a life-threatening complication (in a pregnant woman / woman giving birth)

Dr. Antoine Herpain

BAMM
Belgian Analysis system for Maternal Mortality

B.OSS
Belgian Obstetric Surveillance Sytem

How to Manage a Life-threatening Complication (in a Pregnant Woman / Woman Giving Birth)

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BIWAC

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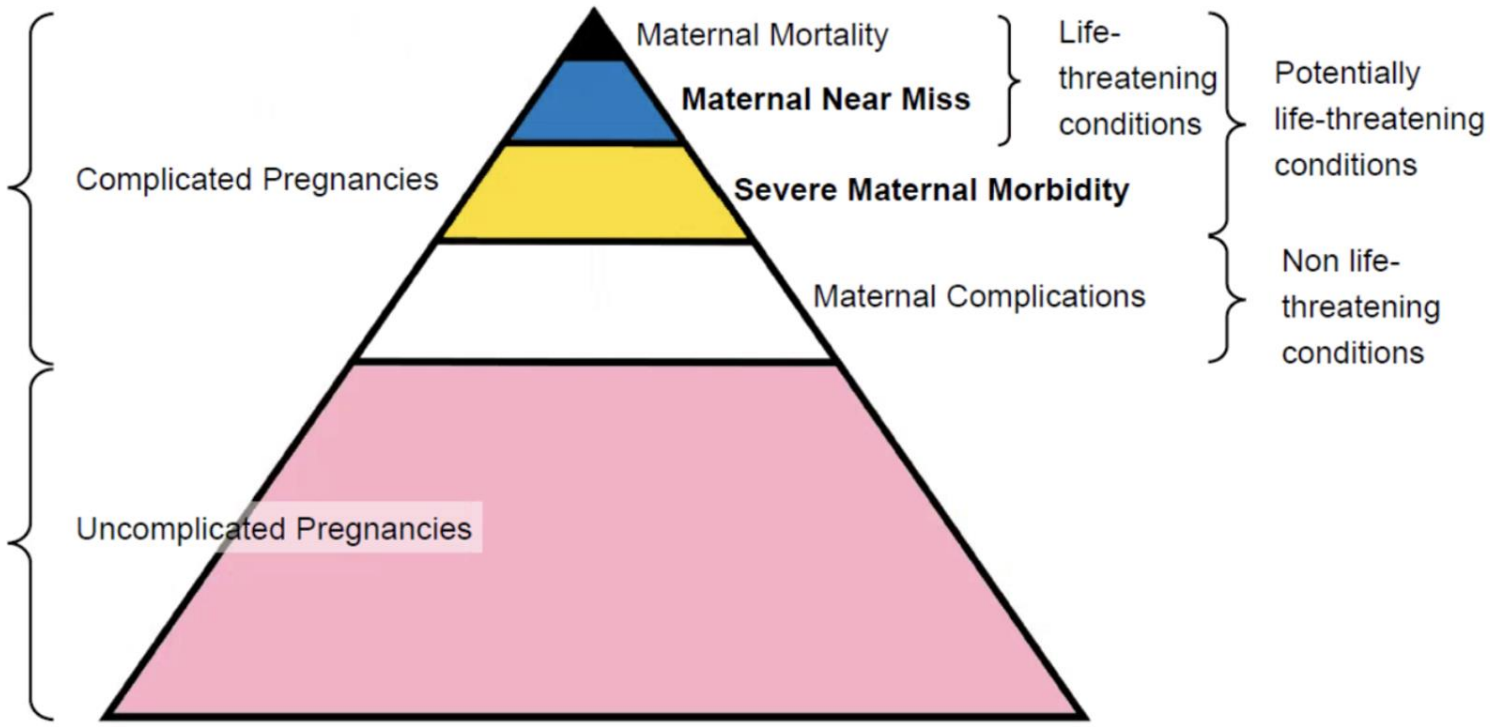
OUTLINE

- **Shock Recognition**
  - Modern view
  - Pitfalls
  - Screening tools
- **Cardiac Arrest**
  - BLS
  - (ALS)
  - ECLS



INTRODUCTION

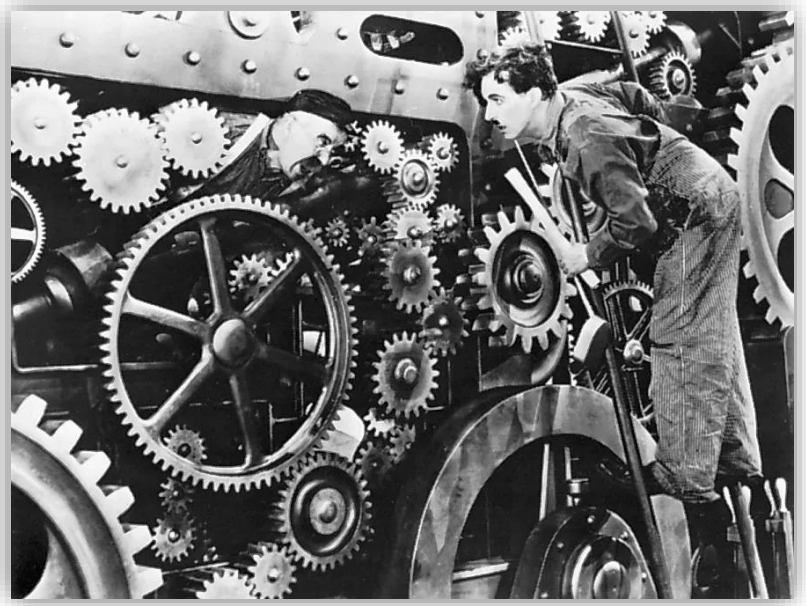
- Maternal Causes of Death

PRE-MODERN TIMES

Sepsis

Dehydration

Hemorrhagic shock



MODERN TIMES

Cardiac diseases

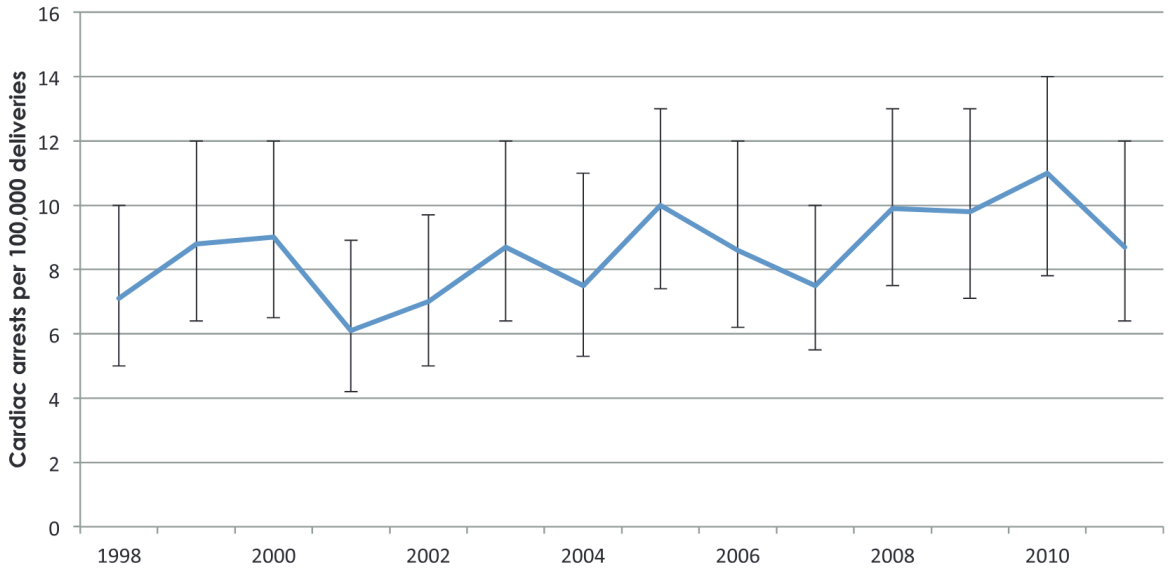
Trauma

Embolism

CARDIAC ARREST DURING DELIVERY

Trends and Medical Conditions

- Nationwide Inpatient Sample
- > 50 million hospitalizations for delivery (1998 to 2011)
- Cardiac arrest in 8.5 per 100,000 hospitalizations



J. Mhyre et al. **Anesthesiology** 2014

PERIOPERATIVE MEDICINE

Cardiac Arrest during Hospitalization for Delivery in the United States, 1998–2011

Jill M. Mhyre, M.D., Lawrence C. Tsen, M.D., Sharon Einav, M.D., Elena V. Kuklina, M.D., Ph.D., Lisa R. Leffert, M.D., Brian T. Bateman, M.D., M.Sc.

	Arrest, N (%)	No Arrest, N (%)	aOR* (99% CI)
Overall			
Age group, yr			
<20	327 (6.8)	6,021,192 (10.6)	0.8 (0.5–1.0)
20–34	3,191 (65.9)	42,762,659 (75.2)	Ref
35–39	965 (19.9)	6,597,067 (11.6)	**1.6 (1.3–2.0)†**
≥40	359 (7.4)	1,483,916 (2.6)	**2.0 (1.5–2.8)**
Race/ethnicity			
White	1,500 (31.0)	23,264,619 (40.9)	Ref
Black	1,191 (24.6)	5,914,624 (10.4)	**2.3 (1.8–3.0)**
Hispanic	879 (18.1)	9,957,035 (17.5)	1.3 (1.0–1.7)
Asian/Pacific Islander	200 (4.1)	2,042,190 (3.6)	1.4 (0.9–2.2)
Other	195 (4.0)	2,366,238 (4.2)	1.2 (0.7–1.9)
Unknown	878 (18.1)	13,350,964 (23.5)	1.1 (0.8–1.4)
Primary payer			
Medicare	83 (1.7)	280,194 (0.5)	2.1 (0.8–5.1)
Medicaid	2,209 (45.7)	22,495,861 (39.6)	**1.3 (1.1–1.6)**
Private insurance	2,221 (45.9)	30,509,870 (53.7)	Ref
Self-pay	195 (4.0)	1,937,426 (3.4)	1.5 (0.9–2.2)
No charge	18 (0.4)	131,388 (0.2)	1.7 (0.7–3.9)
Other	112 (2.3)	1,413,565 (2.5)	1.2 (0.6–2.1)
Maternal medical conditions			
Pulmonary hypertension	92 (1.9)	7,904 (0)	**13.3 (6.0–29.6)**
Malignancy†	38 (0.8)	21,579 (0)	**12.5 (4.7–33.0)**
Ischemic heart disease†	30 (0.6)	6,751 (0)	**7.6 (2.1–27.5)**
Liver disease†	53 (1.1)	54,158 (0.1)	**5.5 (2.3–13.1)**
Congenital heart disease†	48 (1.0)	42,600 (0.1)	**4.2 (1.6–11.0)**
Systemic lupus erythematosus†	60 (1.2)	49,803 (0.1)	**4.1 (1.8–9.8)**
Cardiac valvular disease	179 (3.7)	343,650 (0.6)	**3.8 (2.2–6.3)**
Pre-existing hypertension	457 (9.4)	863,155 (1.5)	**2.7 (1.9–3.7)**
Chronic renal disease	83 (1.7)	110,236 (0.2)	**2.6 (1.2–5.5)**
Sickle cell disease†	38 (0.8)	68,711 (0.1)	**2.6 (1.0–6.4)**
Drug abuse/dependance	153 (3.2)	651,875 (1.1)	**1.8 (1.1–2.9)**
Asthma	258 (5.3)	1,281,158 (2.3)	**1.7 (1.1–2.4)**
Diabetes mellitus	495 (10.2)	3,154,125 (5.5)	1.0 (0.8–1.4)
Maternal obstetrical conditions/procedures			
Stillbirth	386 (8.0)	361,976 (0.6)	**12.9 (9.4–17.7)**
Cesarean delivery	3,758 (77.6)	16,546,570 (29.1)	**6.7 (5.4–8.3)**
Severe preeclampsia/eclampsia	701 (14.5)	682,730 (1.2)	**6.5 (5.0–8.3)**
Placenta previa	257 (5.3)	296,571 (0.5)	**4.4 (2.9–6.5)**
Chorioamnionitis	159 (3.3)	1,013,164 (1.8)	1.3 (0.8–2.0)
Multiple gestation	184 (3.8)	986,535 (1.7)	0.8 (0.5–1.3)

SHOCK RECOGNITION

- **Triage And Early Management**

SHOCK : THE INTENSIVE CARE PERSPECTIVE

ULB

Definition, pathophysiology, features and epidemiology of shock

Definition

Shock is best defined as a life-threatening, generalized form of acute circulatory failure associated with inadequate oxygen utilization by the cells. It is a state in which the circulation is unable to deliver sufficient oxygen to meet the demands of the tissues, resulting in cellular dysfunction. The result is cellular dysoxia, i.e. the loss of the physiological independence between oxygen delivery and oxygen consumption, associated with increased lactate levels. Some clinical symptoms suggest an impaired microcirculation, including mottled skin, acrocyanosis, slow capillary refill time and an increased central-to-toe temperature gradient.

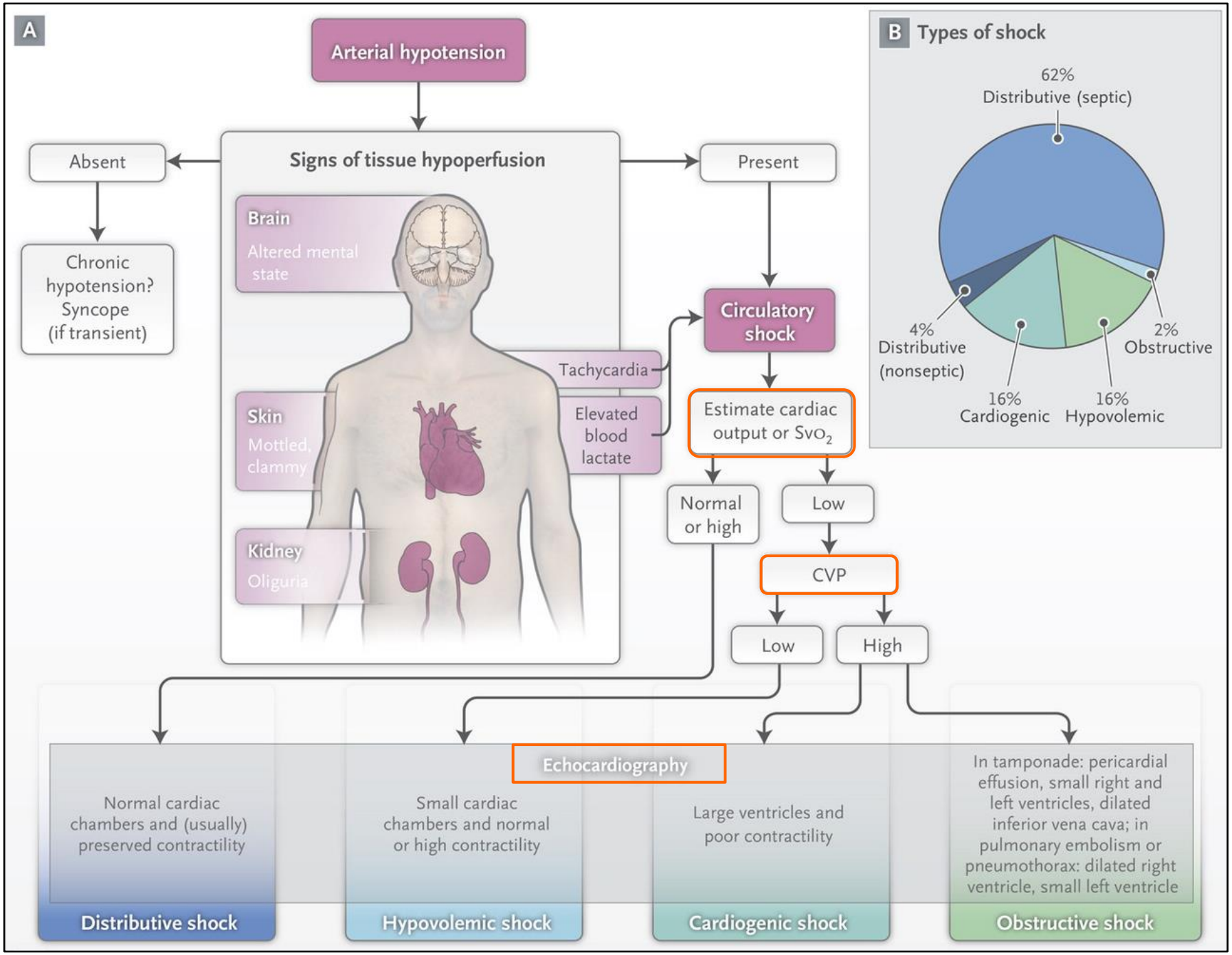
Intensive Care Med (2014) 40:1795–1815
DOI 10.1007/s00134-014-3525-z

CONFERENCE REPORTS AND EXPERT PANEL

Maurizio Cecconi
Daniel De Backer
Massimo Antonelli
Richard Beale
Jan Bakker
Christoph Hofer
Roman Jaeschke
Alexandre Mebazaa
Michael R. Pinsky
Jean Louis Teboul
Jean Louis Vincent
Andrew Rhodes

Consensus on circulatory shock and hemodynamic monitoring. Task force of the European Society of Intensive Care Medicine

" The presence of **low blood pressure** should **not** be a prerequisite for defining shock: **compensatory mechanisms** may preserve blood pressure through vasoconstriction "



Vincent JL. and De Backer D.
New Eng J Med 2013

SEPSIS 3.0

▪ Sepsis and Septic Shock

Box 3. New Terms and Definitions

- Sepsis is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection.
- Organ dysfunction can be identified as an acute change in total SOFA score ≥2 points consequent to the infection.
  - The baseline SOFA score can be assumed to be zero in patients not known to have preexisting organ dysfunction.
- Patients with septic shock can be identified with a clinical construct of sepsis with persisting hypotension requiring vasopressors to maintain MAP ≥65 mm Hg and having a serum lactate level >2 mmol/L (18 mg/dL) despite adequate volume resuscitation.

Special Communication | CARING FOR THE CRITICALLY ILL PATIENT

The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3)

Mervyn Singer, MD, FRCP; Clifford S. Deutschman, MD, MS; Christopher Warren Seymour, MD, MSc; Manu Shankar-Hari, MSc, MD, FFICM; Djillali Annane, MD, PhD; Michael Bauer, MD; Rinaldo Bellomo, MD; Gordon R. Bernard, MD; Jean-Daniel Chiche, MD, PhD; Craig M. Coopersmith, MD; Richard S. Hotchkiss, MD; Mitchell M. Levy, MD; John C. Marshall, MD; Greg S. Martin, MD, MSc; Steven M. Opal, MD; Gordon D. Rubenfeld, MD, MS; Tom van der Poll, MD, PhD; Jean-Louis Vincent, MD, PhD; Derek C. Angus, MD, MPH

Table 1. Sequential [Sepsis-Related] Organ Failure Assessment Score[a]

System	Score 0	1	2	3	4
Respiration					
Pao_2/Fio_2, mm Hg (kPa)	≥400 (53.3)	<400 (53.3)	<300 (40)	<200 (26.7) with respiratory support	<100 (13.3) with respiratory support
Coagulation					
Platelets, $\times 10^3/\mu L$	≥150	<150	<100	<50	<20
Liver					
Bilirubin, mg/dL (μmol/L)	<1.2 (20)	1.2-1.9 (20-32)	2.0-5.9 (33-101)	6.0-11.9 (102-204)	>12.0 (204)
Cardiovascular	MAP ≥70 mm Hg	MAP <70 mm Hg	Dopamine <5 or dobutamine (any dose)[b]	Dopamine 5.1-15 or epinephrine ≤0.1 or norepinephrine ≤0.1[b]	Dopamine >15 or epinephrine >0.1 or norepinephrine >0.1[b]
Central nervous system					
Glasgow Coma Scale score[c]	15	13-14	10-12	6-9	<6
Renal					
Creatinine, mg/dL (μmol/L)	<1.2 (110)	1.2-1.9 (110-170)	2.0-3.4 (171-299)	3.5-4.9 (300-440)	>5.0 (440)
Urine output, mL/d				<500	<200

Abbreviations: Fio_2, fraction of inspired oxygen; MAP, mean arterial pressure; Pao_2, partial pressure of oxygen.

[a] Adapted from Vincent et al.[27]

[b] Catecholamine doses are given as μg/kg/min for at least 1 hour.

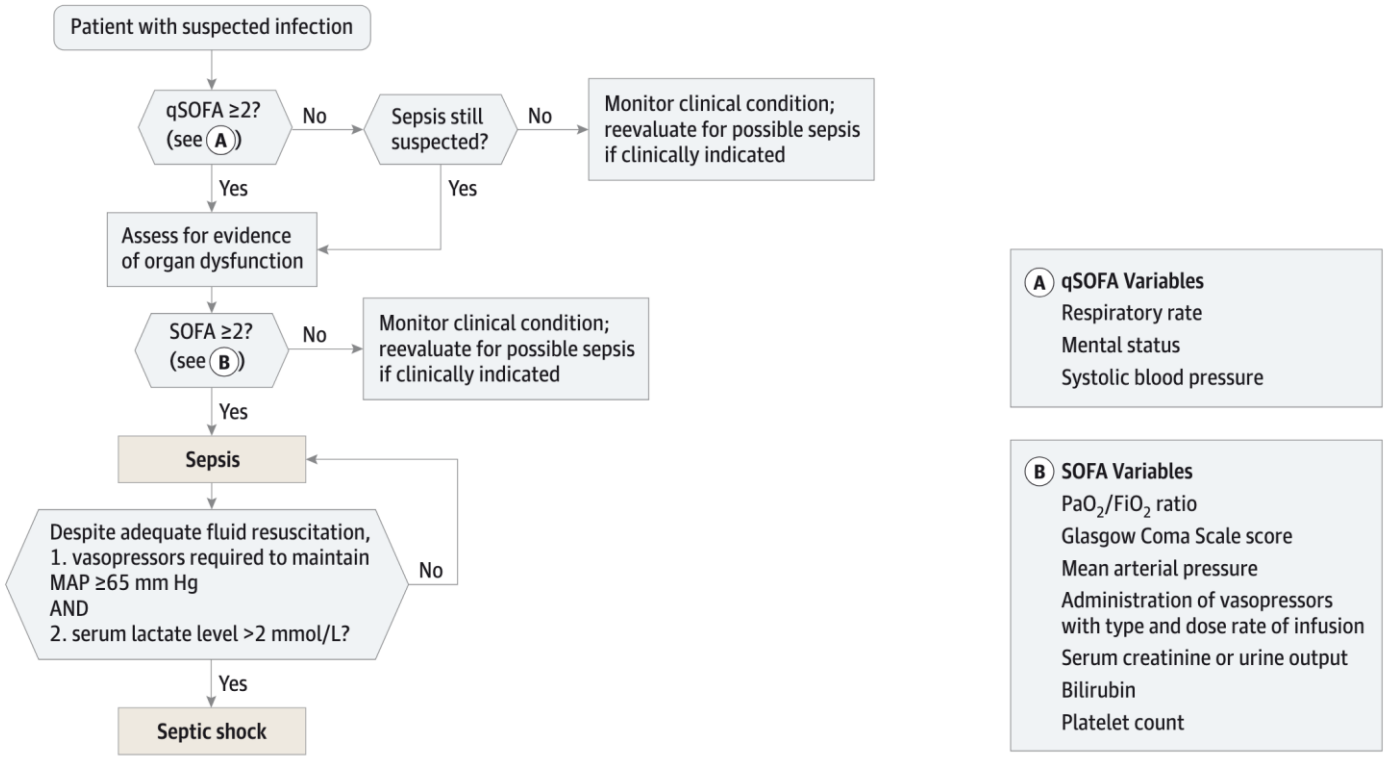
[c] Glasgow Coma Scale scores range from 3-15; higher score indicates better neurological function.

M. Singer et al. **J Am Med Ass.** 2016

SEPSIS 3.0

Sepsis and Septic Shock

Figure. Operationalization of Clinical Criteria Identifying Patients With Sepsis and Septic Shock



The baseline Sequential [Sepsis-related] Organ Failure Assessment (SOFA) score should be assumed to be zero unless the patient is known to have preexisting (acute or chronic) organ dysfunction before the onset of infection. qSOFA indicates quick SOFA; MAP, mean arterial pressure.

Box 4. qSOFA (Quick SOFA) Criteria

Respiratory rate ≥22/min

Altered mentation

Systolic blood pressure ≤100 mm Hg

M. Singer et al. **J Am Med Ass.** 2016

CARDIOVASCULAR DISEASE IN PREGNANCY

- **Anticipation is key**

ESC European Society of Cardiology
European Heart Journal (2018) **39**, 3165–3241
doi:10.1093/eurheartj/ehy340

ESC GUIDELINES

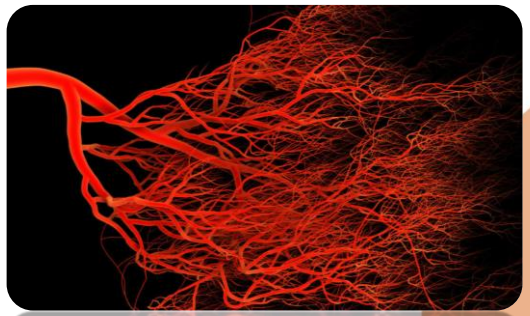
2018 ESC Guidelines for the management of cardiovascular diseases during pregnancy

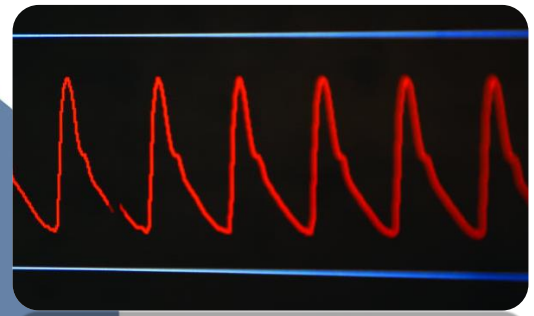
The Task Force for the Management of Cardiovascular Diseases during Pregnancy of the European Society of Cardiology (ESC)

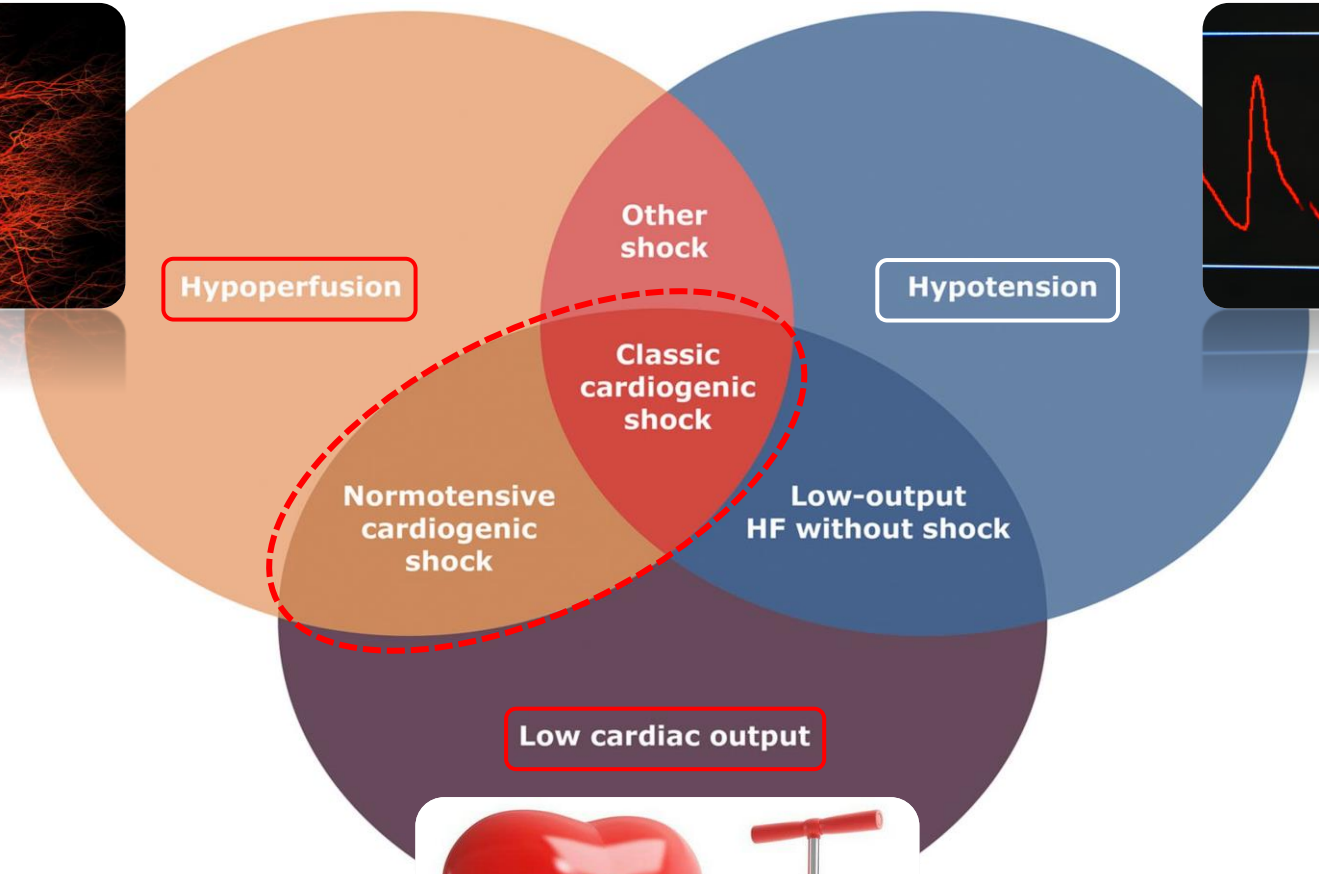
New concepts
Enforcing mWHO classification of maternal risk.
Introduction of the pregnancy heart team.
More attention for assisted reproductive therapy.
Discussion of the use of bromocriptine in PPCM.
Introduction of specific levels of surveillance based on low/medium/high risk for arrhythmia with haemodynamic compromise at delivery.
New information on pharmacokinetics in pregnancy, more detailed information on pharmacodynamics in animal experiments on all drugs (Supplementary Data)
Perimortem caesarean section is discussed.
Advice on contraception and the termination of pregnancy in women with cardiac disease is now provided.

	mWHO I	mWHO II	mWHO II–III	mWHO III	mWHO IV
Diagnosis (if otherwise well and uncomplicated)	Small or mild – pulmonary stenosis – patent ductus arteriosus – mitral valve prolapse Successfully repaired simple lesions (atrial or ventricular septal defect, patent ductus arteriosus, anomalous pulmonary venous drainage) Atrial or ventricular ectopic beats, isolated	Unoperated atrial or ventricular septal defect Repaired tetralogy of Fallot Most arrhythmias (supraventricular arrhythmias) Turner syndrome without aortic dilatation	Mild left ventricular impairment (EF >45%) Hypertrophic cardiomyopathy Native or tissue valve disease not considered WHO I or IV (mild mitral stenosis, moderate aortic stenosis) Marfan or other HTAD syndrome without aortic dilatation Aorta <45 mm in bicuspid aortic valve pathology Repaired coarctation Atrioventricular septal defect	Moderate left ventricular impairment (EF 30–45%) Previous peripartum cardiomyopathy without any residual left ventricular impairment Mechanical valve Systemic right ventricle with good or mildly decreased ventricular function Fontan circulation. If otherwise the patient is well and the cardiac condition uncomplicated Unrepaired cyanotic heart disease Other complex heart disease Moderate mitral stenosis Severe asymptomatic aortic stenosis Moderate aortic dilatation (40–45 mm in Marfan syndrome or other HTAD; 45–50 mm in bicuspid aortic valve, Turner syndrome ASI 20–25 mm/m^2, tetralogy of Fallot <50 mm) Ventricular tachycardia	Pulmonary arterial hypertension Severe systemic ventricular dysfunction (EF <30% or NYHA class III–IV) Previous peripartum cardiomyopathy with any residual left ventricular impairment Severe mitral stenosis Severe symptomatic aortic stenosis Systemic right ventricle with moderate or severely decreased ventricular function Severe aortic dilatation (>45 mm in Marfan syndrome or other HTAD, >50 mm in bicuspid aortic valve, Turner syndrome ASI >25 mm/m^2, tetralogy of Fallot >50 mm) Vascular Ehlers–Danlos Severe (re)coarctation Fontan with any complication
Risk	No detectable increased risk of maternal mortality and no/mild increased risk in morbidity	Small increased risk of maternal mortality or moderate increase in morbidity	Intermediate increased risk of maternal mortality or moderate to severe increase in morbidity	Significantly increased risk of maternal mortality or severe morbidity	Extremely high risk of maternal mortality or severe morbidity
Maternal cardiac event rate	2.5–5%	5.7–10.5%	10–19%	19–27%	40–100%

CARDIOGENIC SHOCK







Adapted from Jenzer J. et al. **Crit Care Med** 2023

CS RECOGNITION

- **RCT's** Inclusion Criteria ***Vs.*** **Real life & Best Practice Recommendations**

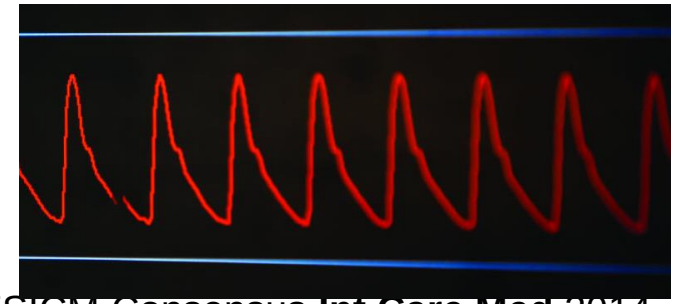
	Year or trial status	Hypotension criteria	Hypoperfusion criteria	Haemodynamic criteria
SHOCK[6]	1999	SBP <90 mm Hg or medical support	Cold extremities or urine output <30 mL/h	Cardiac index ≤2·2 L/min per m² and PAWP ≥15 mm Hg
IABP-SHOCK II[7]	2012	SBP <90 mm Hg or medical support	Altered mental state, cold skin, urine output <30 mL/h, or serum lactate >2·0 mmol/L	..
CULPRIT-SHOCK[8]	2017	SBP <90 mm Hg or medical support	Altered mental state, cold skin, urine output <30 mL/h, or serum lactate >2·0 mmol/L	..
IMPRESS[9]	2017	SBP <90 mm Hg or medical support	..	..
OPTIMACC[10]	2018	SBP <90 mm Hg, MAP <65 mm Hg, or medical support	..	Cardiac index ≤2·2 L/min per m² and PAWP ≥15 mm Hg
EUROSHOCK (NCT03813134)	Ongoing	SBP <90 mm Hg or medical support	Altered mental state, cold skin, urine output <30 mL/h, or serum lactate >2·0 mmol/L	..
ECLS-SHOCK (NCT03637205)	Ongoing	SBP <90 mm Hg or medical support	Altered mental state, cold skin, urine output <30 mL/h, or serum lactate >3·0 mmol/L	..
ANCHOR (NCT04184635)	Ongoing	SBP <90 mm Hg or medical support	Altered mental state, cold skin, urine output <30 mL/h, or serum lactate >2·0 mmol/L	..

M. Arrigo et al. **Lancet Respir Med** 2021

CS RECOGNITION

- **Art Pressure (at ICU admission)**

= Poor value for CS diagnostic guidance :



- Patients can develop tissular hypoperfusion
  without low arterial pressure

Cecconi M. et al. ESICM Consensus **Int Care Med** 2014

- Kept normal despite **overt CS** (baroreflex and ↑SVR)
  = Normotensive CS

Chioncel O. et al. ESC-HFA position statement **Eur J HF** 2020

- Reduced but **well** tolerated ! *(i.e. without hypoperfusion signs)*
  < Reduced afterload preserves CO

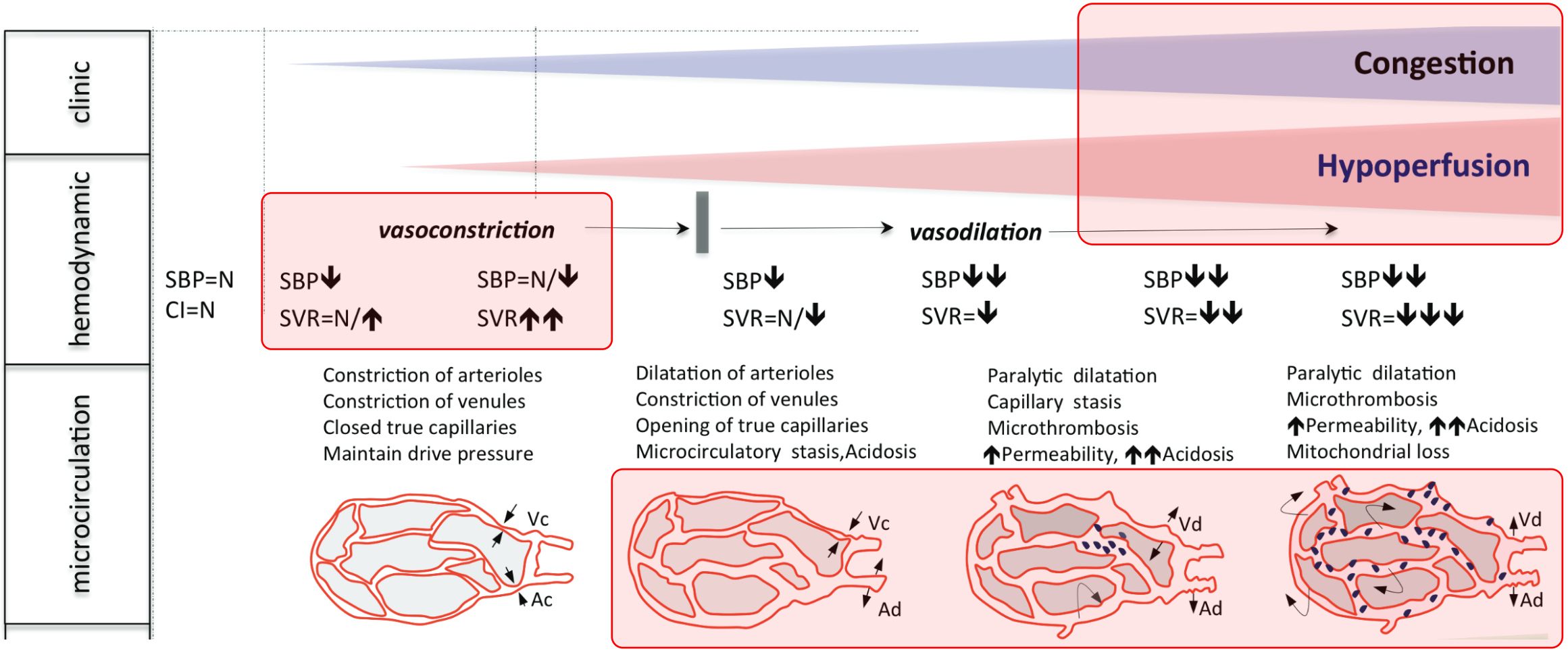
Menon V. et al. SHOCK registry **Am J Med** 2000

- Reduced and **poorly** tolerated …
  ↑ MOF and ↑ 2x mortality

Burstein B. et al. **Crit Care** 2020

CS RECOGNITION

- **Pathophysiologic Continuum**

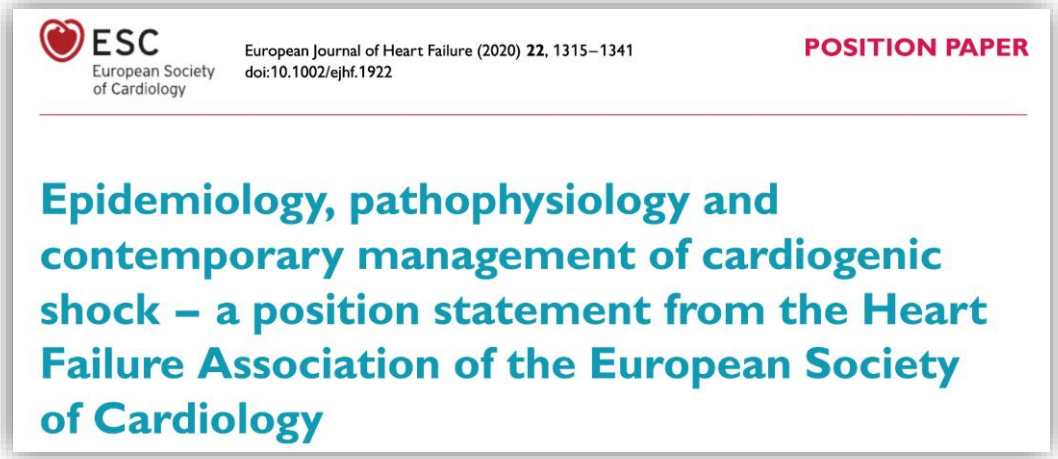


Chioncel O. et al. ESC-HFA position statement **Eur J HF** 2020

CS RECOGNITION

- **CS "definition"**

*« We propose to **define CS** as a **syndrome** caused by a **primary cardiovascular disorder** in which **inadequate CO** results in a life-threatening state of **tissue hypoperfusion** associated with **impairment of tissue oxygen metabolism** and **hyperlactatemia** […] »*



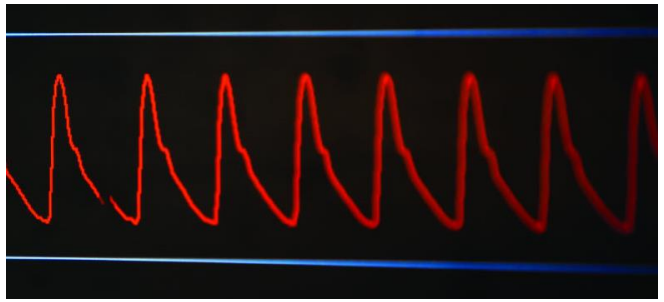
Domain	Gaps in evidence
Definition	• Definition is not unique among RCTs or consensus documents • How many clinical or biological signs of hypoperfusion are required for the definition of CS • The value of hypotension as mandatory criterium for CS definition • Additional value of pulse pressure in normotensive CS patients • Cut-off lactate levels for CS definition in patients with liver disease or diabetic ketoacidosis
Pathophysiology	• Pathophysiology is not well clarified because there are diverse aetiologies and precipitants, and varied baseline cardiac conditions • There is substantial overlapping among the stages of evolution of CS and no clear chronology • The role and time of occurrence of inflammation
Classification	• Recognition of early stages (pre-shock states) • AMI patients at risk for CS (stage A): in-hospital trajectory, monitoring and management • Normotensive CS: prognostic and medical management

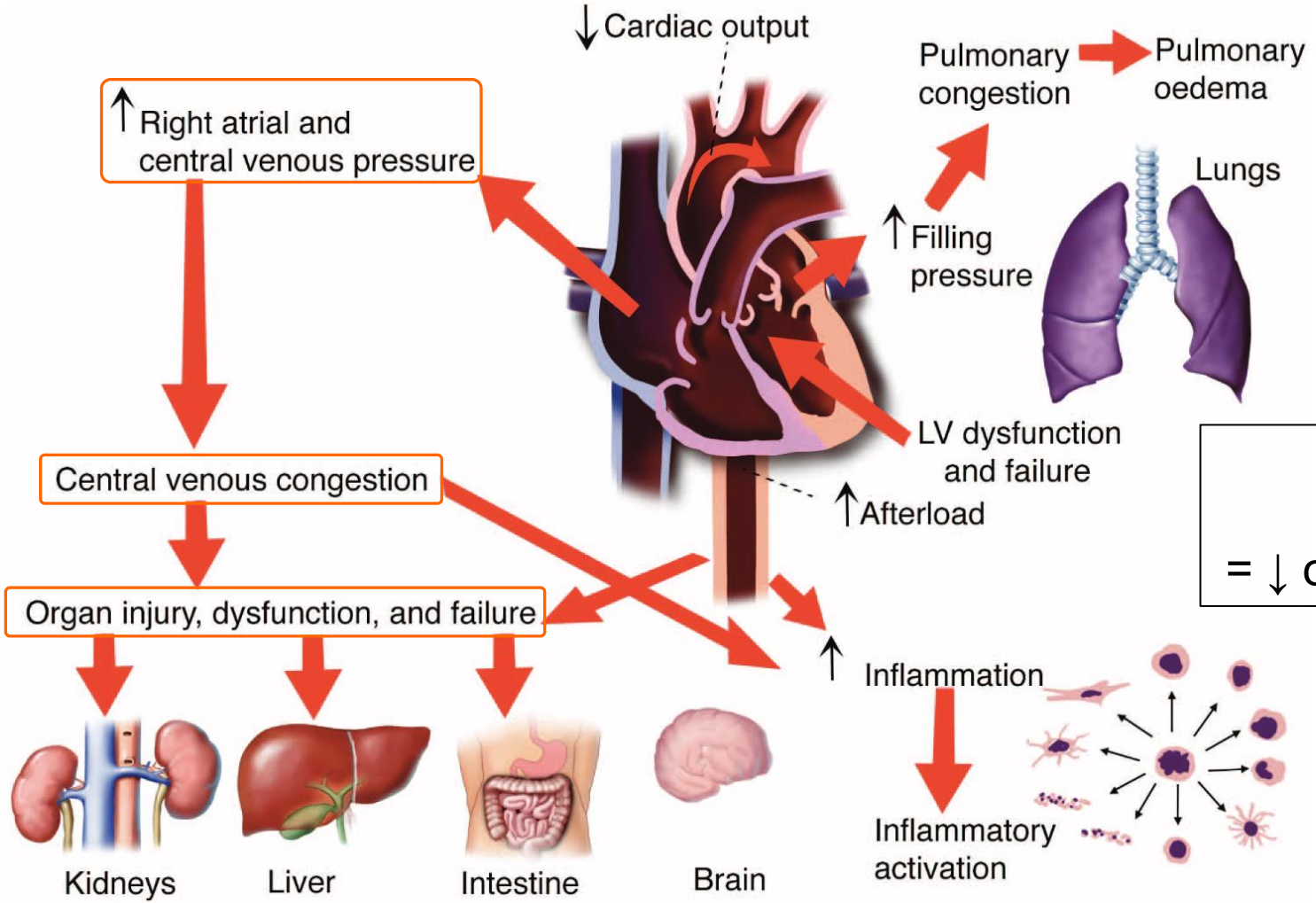
Chioncel O. et al. ESC-HFA position statement **Eur J HF** 2020

CS RECOGNITION

- **Art Pressure (at ICU admission)**

= Poor value for CS diagnostic guidance :





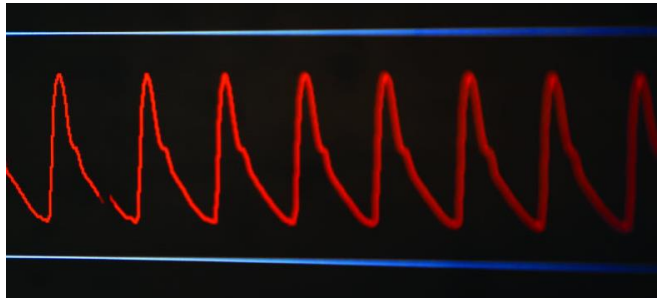
Hypoperfusion depends also from venous congestion
= ↓ organ perfusion pressure gradient

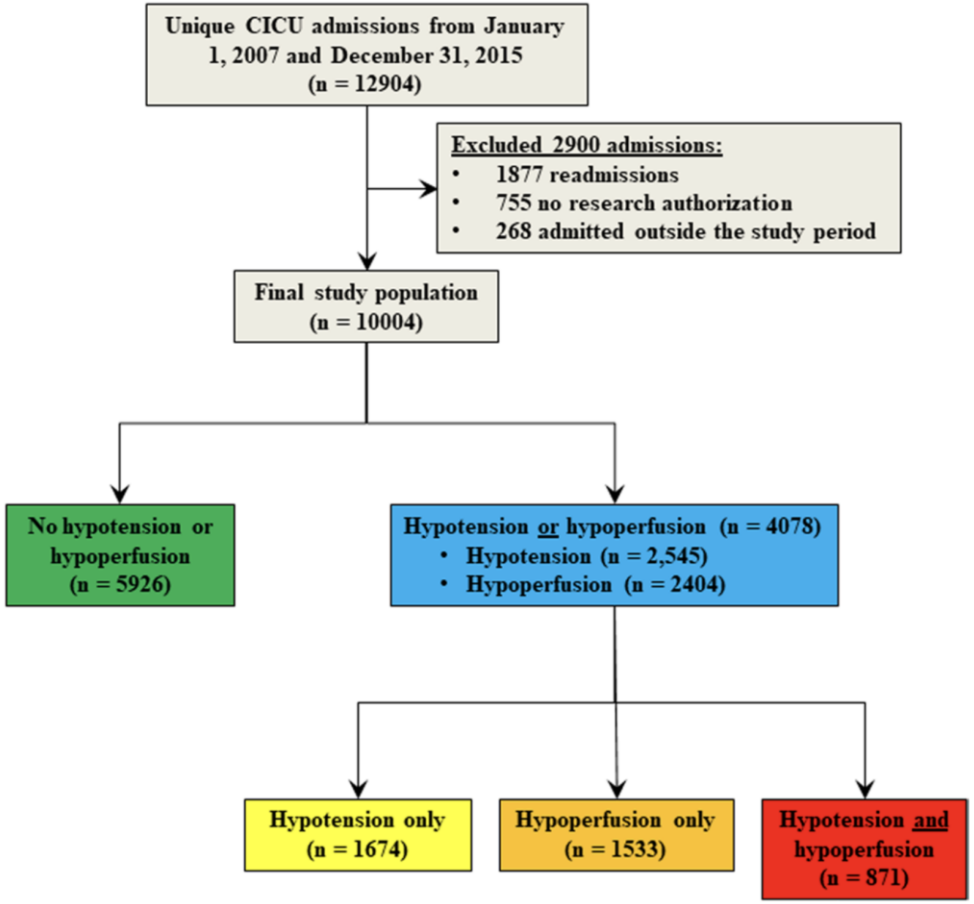
Harjola VP. et al. AHF committee ESC-HFA
Eur Heart J HF 2017

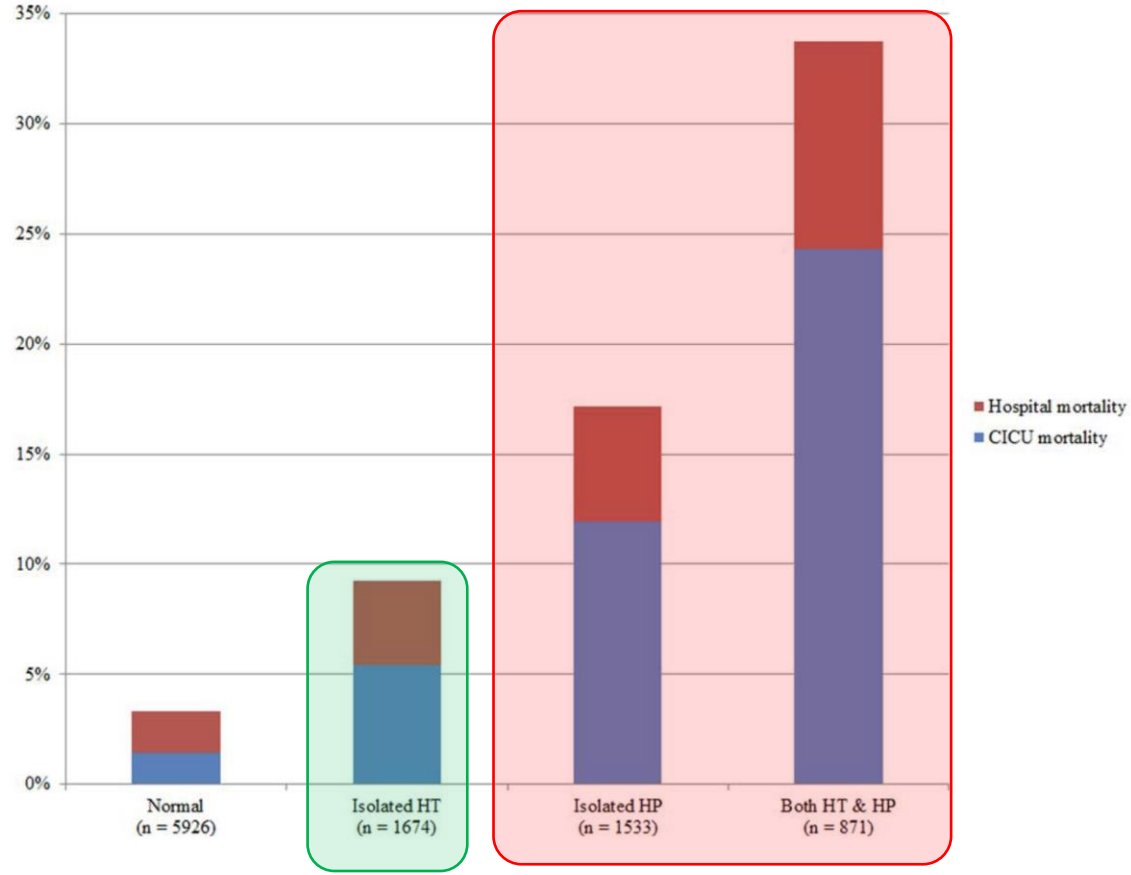
CS RECOGNITION

- **Art Pressure (at ICU admission)**

= Poor value for CS diagnostic guidance :



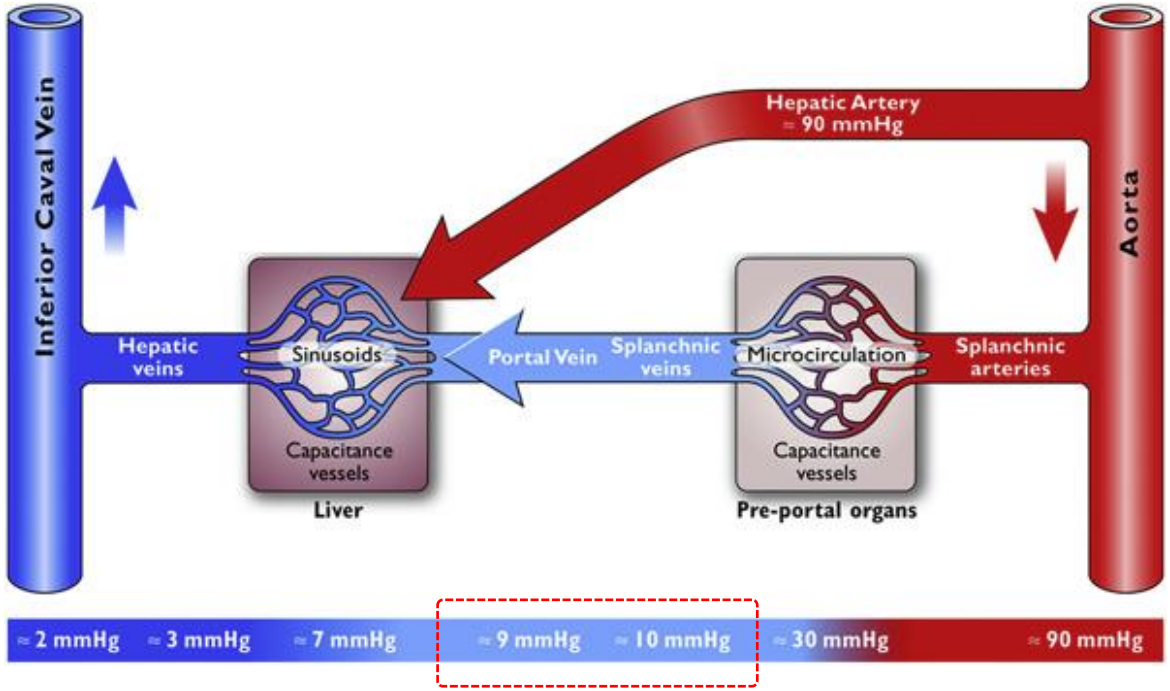


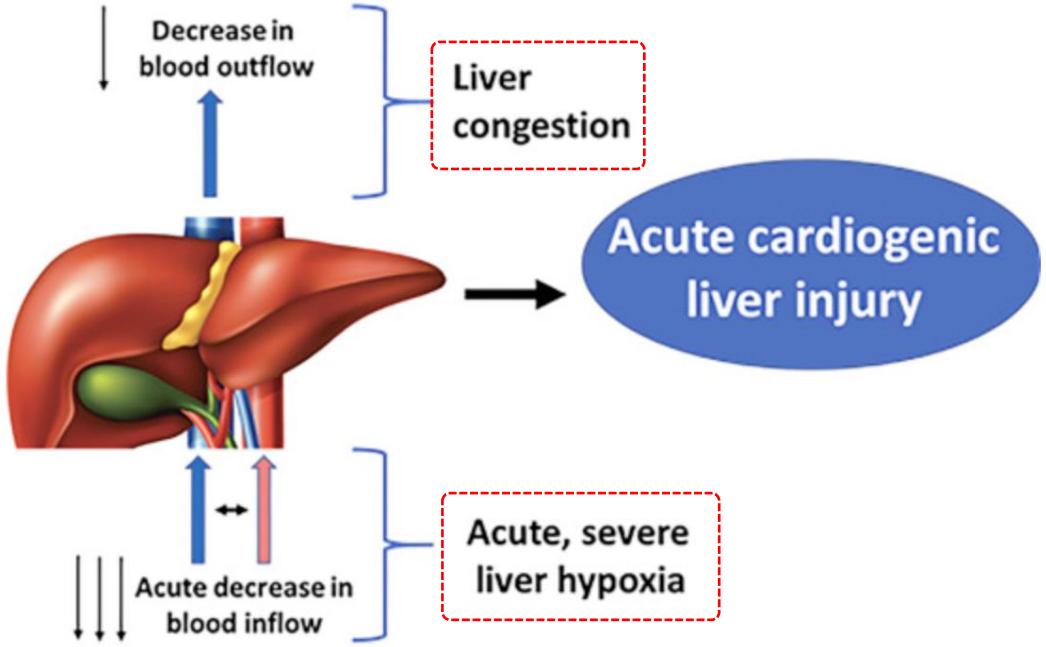


Jentzer J. et al. **Circulation HF** 2021

PITFALL IN PREGNANT WOMEN

- **Hypoxic Hepatitis (" Shock Liver")**
  - Easily mistaken with more common sources of liver enzymes abnormalities
    (e.g. HELLP syndrome, viral hepatitis, etc.)

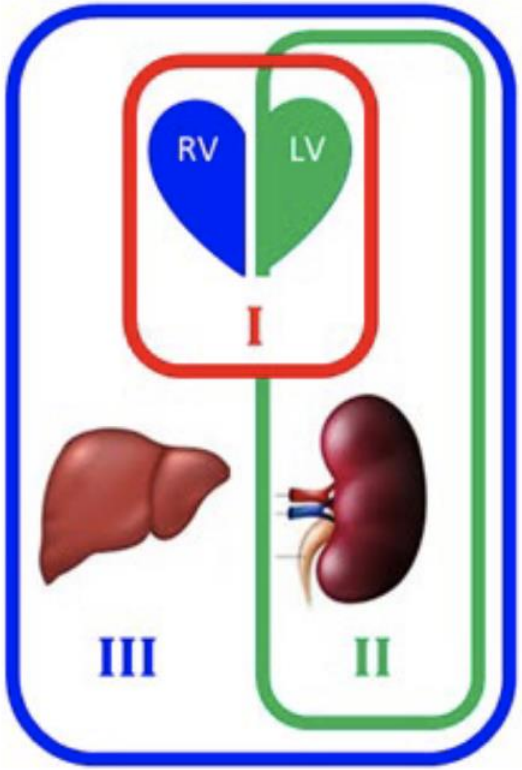


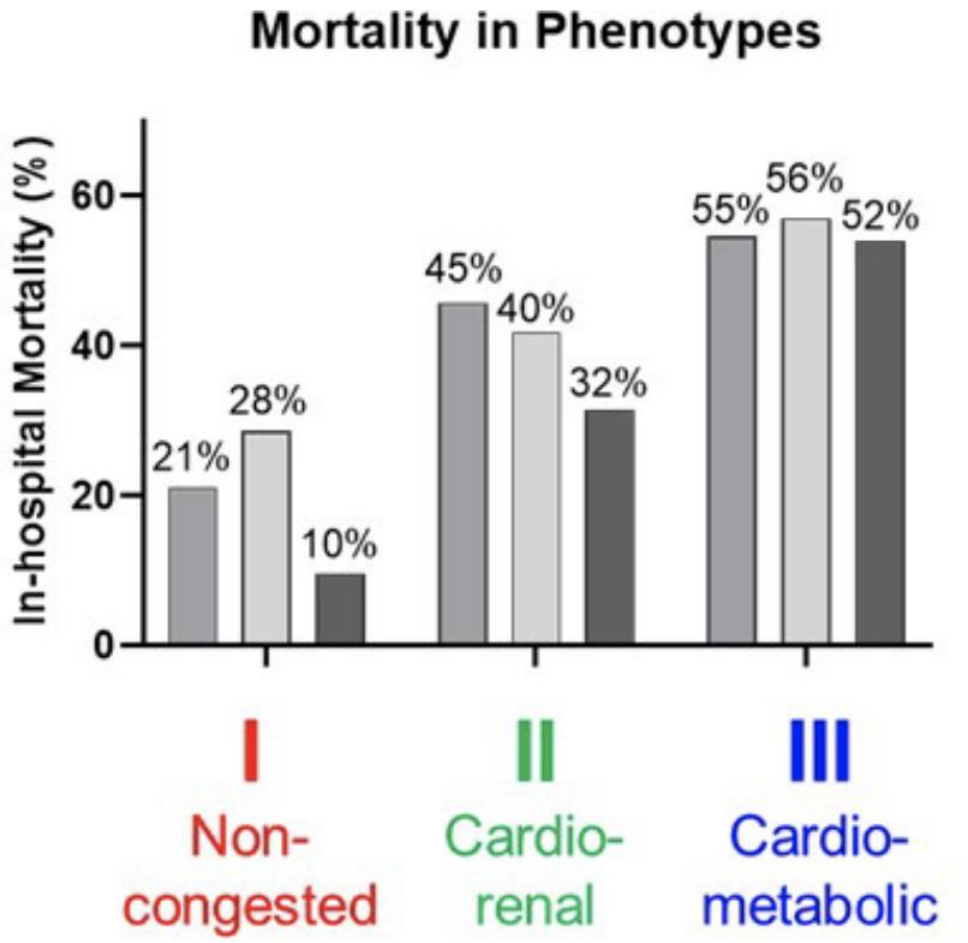


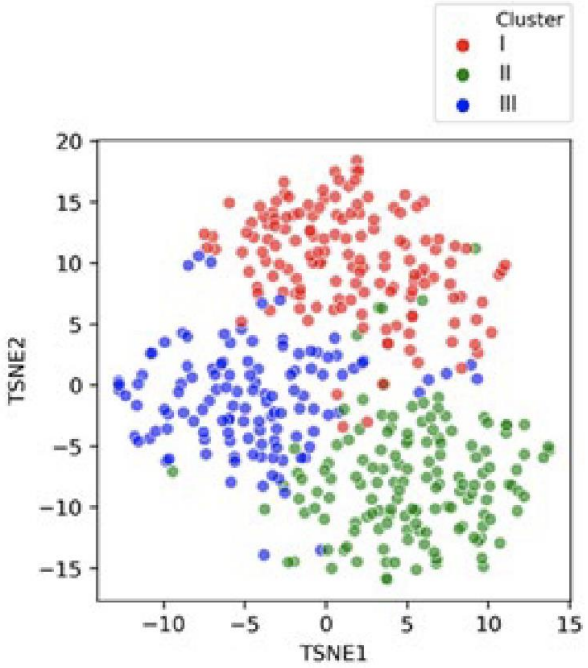
A. Xanthopoulos et al. **J Am Coll Card – Heart Fail** 2018

CS PHENOTYPING

- **Machine Learning derived CS *Phenotypes***





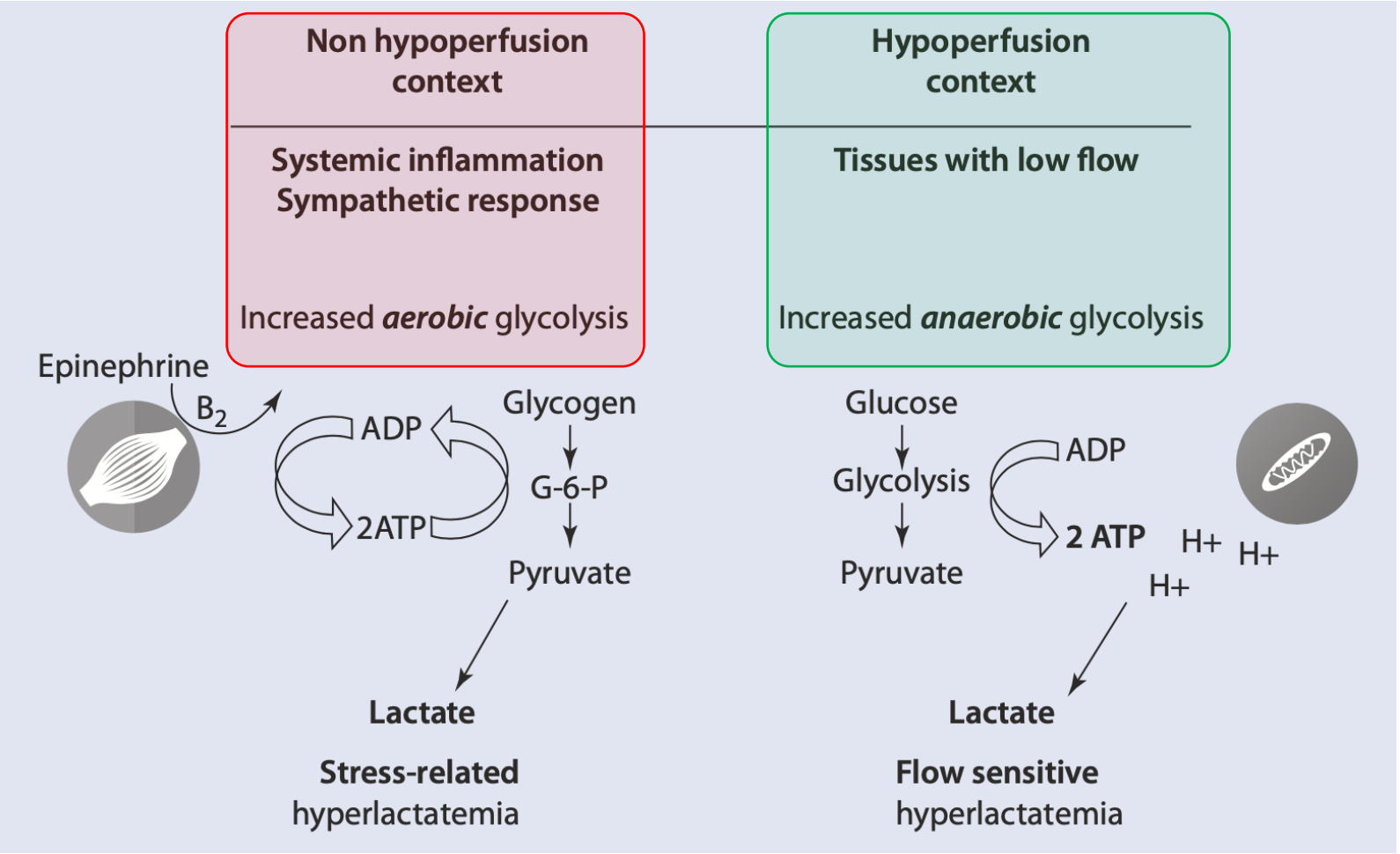


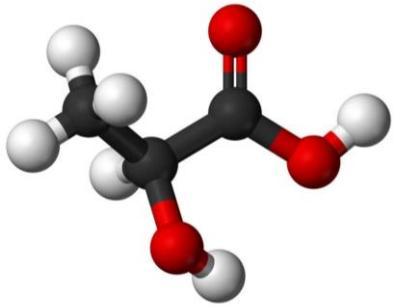
International cohorts
(USA + DK)
n = 1959
→ 3 clusters

Zweck E. et al **J Am Heart Assoc.** 2021

SHOCK RECOGNITION

- **Lactate**





Levy B. et al. **Shock** 2008
Levy B. et al. **Lancet** 2005
Castro R. et al. In « *Hemodynamic Monitoring* » Ed. Pinsky M. – Teboul JL. – Vincent JL. (*Springer)* 2019

SHOCK RECOGNITION

- **Capillary Refill Time (CRT)**

Research

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Effect of a Resuscitation Strategy Targeting Peripheral Perfusion Status vs Serum Lactate Levels on 28-Day Mortality Among Patients With Septic Shock

The ANDROMEDA-SHOCK Randomized Clinical Trial

Hernandez G. et al. **J Am. Med. Ass.** 2019

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American Journal of Respiratory and Critical Care Medicine

Home > American Journal of Respiratory and Critical Care Medicine > List of Issues > Volume 206, Issue 10

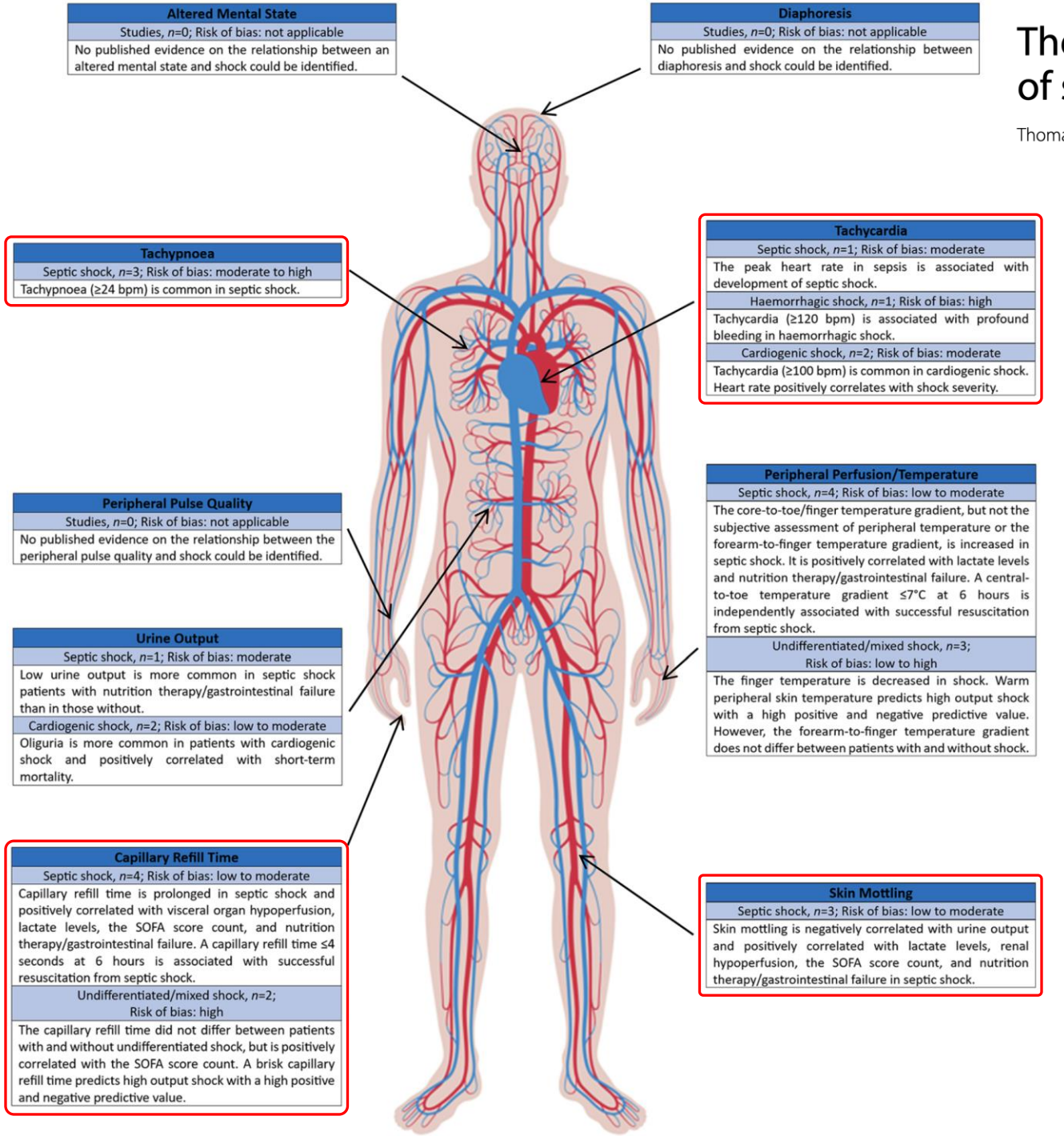
Performance of Early Capillary Refill Time Measurement on Outcomes in Cardiogenic Shock: An Observational, Prospective Multicentric Study

Previous Article

Merdji H. et al. **Am. J. Resp. Crit. Care Med** 2022

The value of clinical signs as indicators of shock

Thomas Tschoellitsch[1], Matthias Noitz[1], Michael Türk[2], Jens Meier[1] and Martin W. Dünser[1*]



Altered Mental State

Studies, *n*=0; Risk of bias: not applicable

No published evidence on the relationship between an altered mental state and shock could be identified.

Diaphoresis

Studies, *n*=0; Risk of bias: not applicable

No published evidence on the relationship between diaphoresis and shock could be identified.

Tachypnoea

Septic shock, *n*=3; Risk of bias: moderate to high

Tachypnoea (≥24 bpm) is common in septic shock.

Tachycardia

Septic shock, *n*=1; Risk of bias: moderate

The peak heart rate in sepsis is associated with development of septic shock.

Haemorrhagic shock, *n*=1; Risk of bias: high

Tachycardia (≥120 bpm) is associated with profound bleeding in haemorrhagic shock.

Cardiogenic shock, *n*=2; Risk of bias: moderate

Tachycardia (≥100 bpm) is common in cardiogenic shock. Heart rate positively correlates with shock severity.

Peripheral Pulse Quality

Studies, *n*=0; Risk of bias: not applicable

No published evidence on the relationship between the peripheral pulse quality and shock could be identified.

Peripheral Perfusion/Temperature

Septic shock, *n*=4; Risk of bias: low to moderate

The core-to-toe/finger temperature gradient, but not the subjective assessment of peripheral temperature or the forearm-to-finger temperature gradient, is increased in septic shock. It is positively correlated with lactate levels and nutrition therapy/gastrointestinal failure. A central-to-toe temperature gradient ≤7°C at 6 hours is independently associated with successful resuscitation from septic shock.

Undifferentiated/mixed shock, *n*=3; Risk of bias: low to high

The finger temperature is decreased in shock. Warm peripheral skin temperature predicts high output shock with a high positive and negative predictive value. However, the forearm-to-finger temperature gradient does not differ between patients with and without shock.

Urine Output

Septic shock, *n*=1; Risk of bias: moderate

Low urine output is more common in septic shock patients with nutrition therapy/gastrointestinal failure than in those without.

Cardiogenic shock, *n*=2; Risk of bias: low to moderate

Oliguria is more common in patients with cardiogenic shock and positively correlated with short-term mortality.

Capillary Refill Time

Septic shock, *n*=4; Risk of bias: low to moderate

Capillary refill time is prolonged in septic shock and positively correlated with visceral organ hypoperfusion, lactate levels, the SOFA score count, and nutrition therapy/gastrointestinal failure. A capillary refill time ≤4 seconds at 6 hours is associated with successful resuscitation from septic shock.

Undifferentiated/mixed shock, *n*=2; Risk of bias: high

The capillary refill time did not differ between patients with and without undifferentiated shock, but is positively correlated with the SOFA score count. A brisk capillary refill time predicts high output shock with a high positive and negative predictive value.

Skin Mottling

Septic shock, *n*=3; Risk of bias: low to moderate

Skin mottling is negatively correlated with urine output and positively correlated with lactate levels, renal hypoperfusion, the SOFA score count, and nutrition therapy/gastrointestinal failure in septic shock.

T. Tschoellitsch et al. **Int Care Med.** 2023

EARLY WARNING SCORE

Date										
Time										
Systolic BP										
<80	3									
80–89	2									
91–139	0									
140–149	1									
150–159	2									
>160	3									
Respiratory rate										
<10	3									
10–17	0									
18–24	1									
25–29	2									
>30	3									
Heart rate										
<60	3									
60–110	0									
111–149	2									
>150	3									
FIO_2 to keep Sat >96%										
Room air	0									
24%–39%	1									
>40%	3									
Temperature										
<34	3									
34.1–35.0	1									
35.1–37.9	0									
38.0–38.9	1									
>39.0	3									
Consciousness										
Alert (GCS=15)	0									
Not alert (<15)	3									

AHA Scientific Statement

Cardiac Arrest in Pregnancy

A Scientific Statement From the American Heart Association

Farida M. Jeejeebhoy, MD, Chair; Carolyn M. Zelop, MD; Steve Lipman, MD; Brendan Carvalho, MD; Jose Joglar, MD; Jill M. Mhyre, MD; Vern L. Katz, MD; Stephen E. Lapinsky, MB BCh, MSc; Sharon Einav, MD; Carole A. Warnes, MD; Richard L. Page, MD; Russell E. Griffin, LP, FP-C; Amish Jain, MD; Katie N. Dainty, PhD; Julie Arafeh, RN, MS; Rory Windrim, MD; Gideon Koren, MD; Clifton W. Callaway, MD, PhD; on behalf of the American Heart Association Emergency Cardiovascular Care Committee, Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation, Council on Cardiovascular Diseases in the Young, and Council on Clinical Cardiology

Score ≥ 6

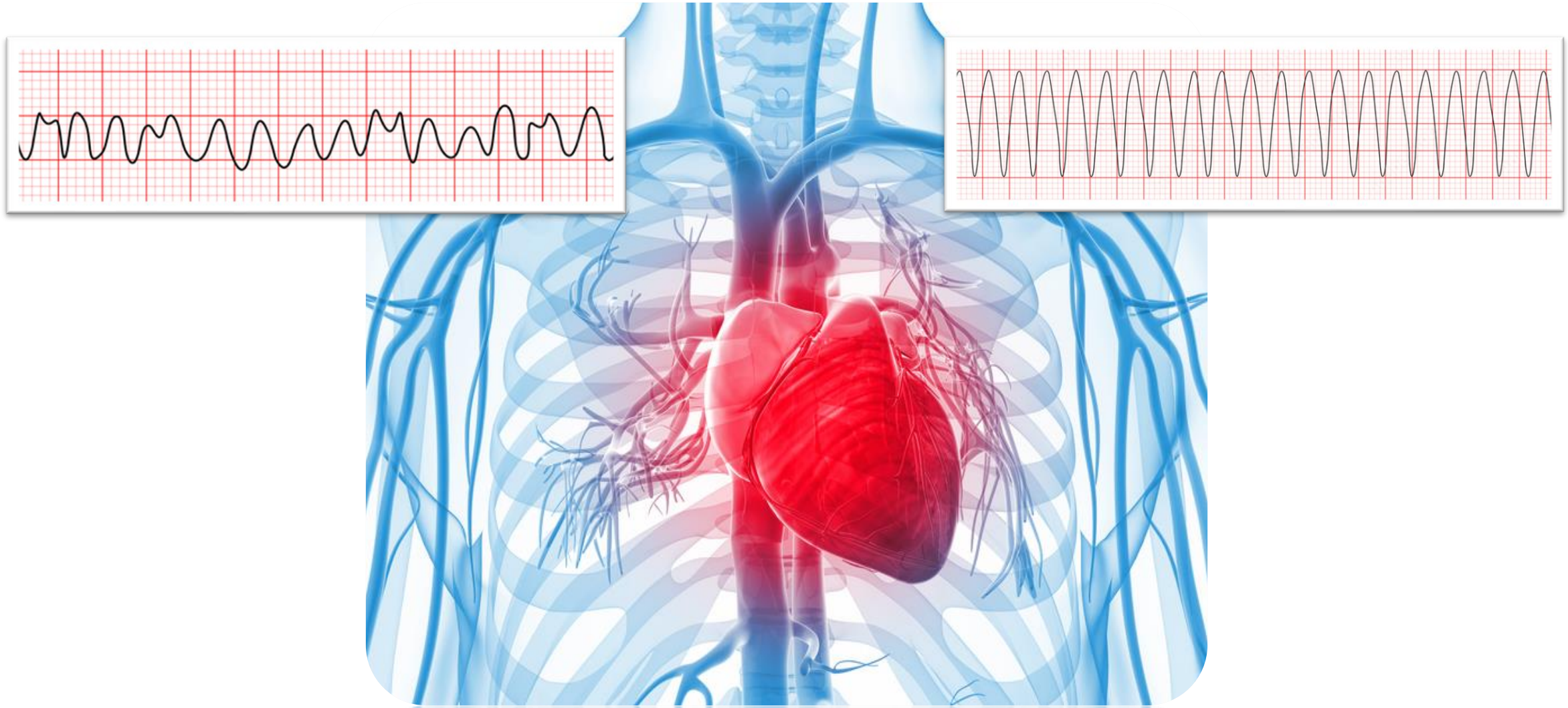
→ call for ICU support or rapid response team

→ initiation of continuous monitoring of vital signs

F. Jeejeebhoy et al. AHA Scientific Statement **Circulation** 2015

C. Carle et al. **Anaesthesia** 2013

CARDIAC ARREST



CHAIN OF SURVIVAL

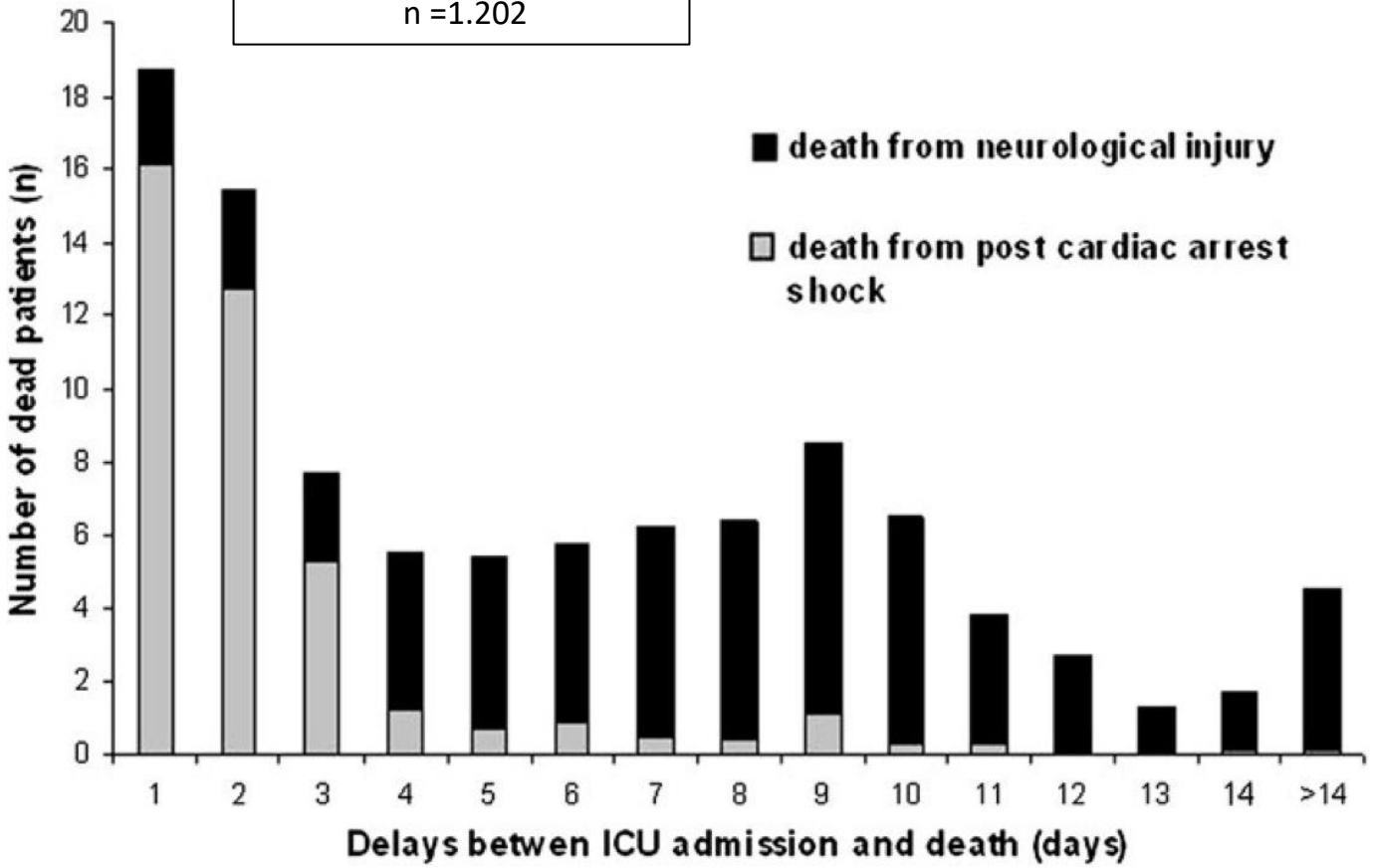
Adult IHCA Chain of Survival

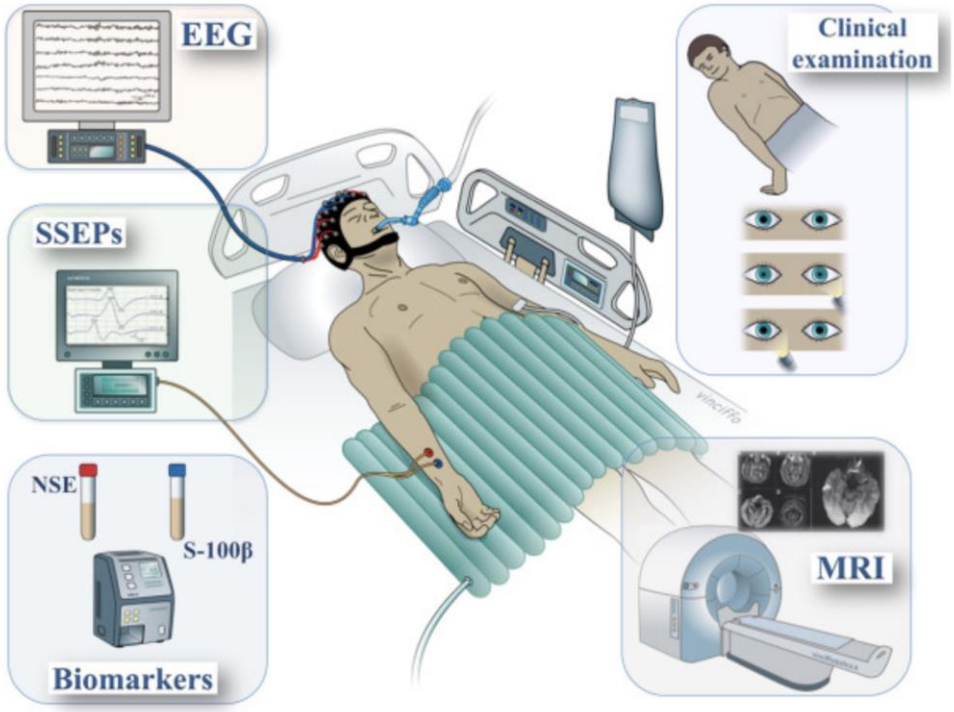
Adult OHCA Chain of Survival

POST-ANOXIC BRAIN INJURY

- **1st cause of death after ROSC (OHCA)**

French registry
OHCA admitted to ICU
n =1.202



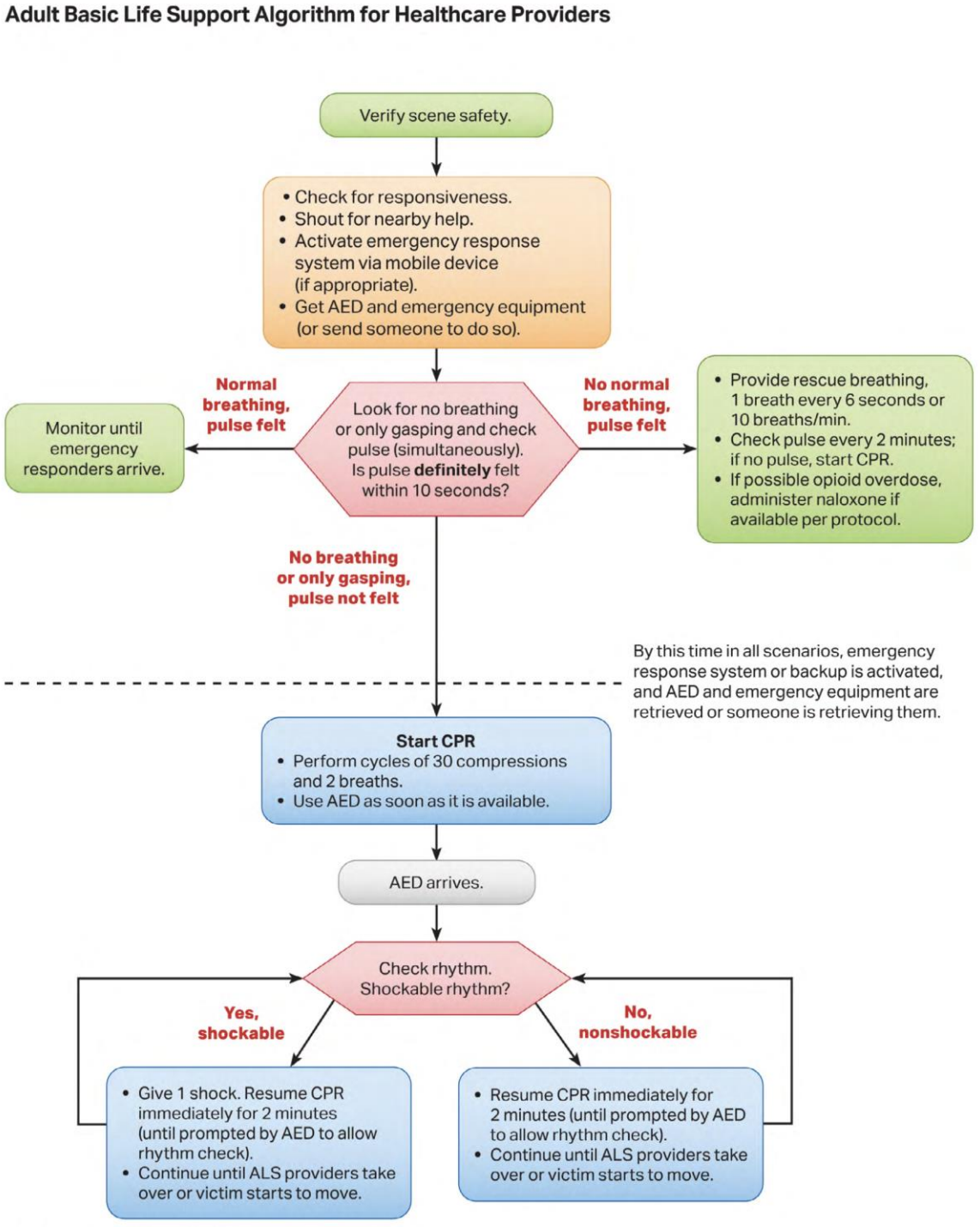


V. Lemiale, A. Cariou et al. **Intensive Care Med** 2013
F. Taccone et al. **Crit Care** 2014

BLS Adult

- **Cardiac Arrest Recognition**
- **Call for help = AED + ALS**
- **Start CPR**

Recommendations for Recognition of Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	C-LD	1. If a victim is unconscious/unresponsive, with absent or abnormal breathing (ie, only gasping), the lay rescuer should assume the victim is in cardiac arrest.
1	C-LD	2. If a victim is unconscious/unresponsive, with absent or abnormal breathing (ie, only gasping), the healthcare provider should check for a pulse for no more than 10 s and, if no definite pulse is felt, should assume the victim is in cardiac arrest.



BLS Adult

- **Cardiac Arrest Recognition**
- **Call for help = AED + ALS**
- **Start CPR**

BASIC LIFE SUPPORT STEP-BY-STEP

EUROPEAN RESUSCITATION COUNCIL GUIDELINES 2021

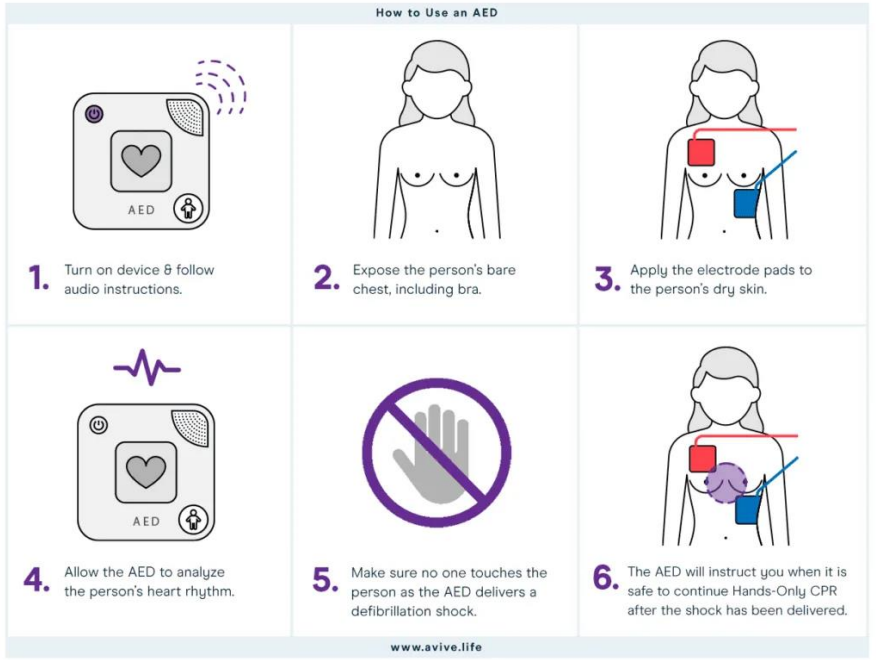
SEQUENCE/ACTION	TECHNICAL DESCRIPTION
SAFETY	• Make sure that you, the victim and any bystanders are safe
RESPONSE Check for a response	• Shake the victim gently by the shoulders and ask loudly: *"Are you all right?"*
AIRWAY Open the airway	• If there is no response, position the victim on their back • With your hand on the forehead and your fingertips under the point of the chin, gently tilt the victim's head backwards, lifting the chin to open the airway
BREATHING Look, listen and feel for breathing	• Look, listen and feel for breathing for **no more** than 10 seconds • A victim who is barely breathing, or taking infrequent, slow and noisy gasps, is not breathing **normally**
ABSENT OR ABNORMAL BREATHING Alert emergency services	• If breathing is absent or abnormal, ask a helper to call the emergency services or call them yourself • Stay with the victim if possible • Activate the speaker function or hands-free option on the telephone so that you can start CPR whilst talking to the dispatcher
SEND FOR AED Send someone to get an AED	• Send someone to find and bring back an AED if available • If you are on your own, **DO NOT** leave the victim, but start CPR
CIRCULATION Start chest compressions	• Kneel by the side of the victim • Place the heel of one hand in the centre of the victim's chest - this is the lower half of the victim's breastbone (sternum) • Place the heel of your other hand on top of the first hand and interlock your fingers • Keep your arms straight • Position yourself vertically above the victim's chest and press down on the sternum at least 5 cm (but not more than 6 cm) • After each compression, release all the pressure on the chest without losing contact between your hands and the sternum • Repeat at a rate of 100-120 min-1

BLS In Pregnant Woman

- **Specificities**

BLS Recommendations (Actions Are Simultaneous, Not Sequential)

1. Rapid notification should be provided to the maternal cardiac arrest response team[29,63–65] (*Class I; Level of Evidence C*).
2. The time when pulselessness was confirmed should be documented[66] (*Class I; Level of Evidence C*).
3. High-quality CPR should be paired with uterine displacement, and a firm backboard should be used[42-45] (*Class I; Level of Evidence C*).
4. Rapid automated defibrillation should be provided whenever it is indicated as appropriate by rhythm analysis[63,65] (*Class I; Level of Evidence C*).
5. Appropriate BLS airway management should be initiated.
   a. A member of the first responder team should perform bag-mask ventilation with 100% oxygen flowing to the bag at a rate of at least 15 L/min (*Class IIb; Level of Evidence C*).
   b. Two-handed bag-mask ventilation is preferred (*Class IIa; Level of Evidence C*).
6. Hospitals need to establish first-responder roles that satisfy all of the requirements for BLS, including modifications recommended during pregnancy. A minimum of 4 staff members should respond for BLS resuscitation of the pregnant patient. All hospital staff should be able to fulfill first-responder roles (*Class I; Level of Evidence C*).



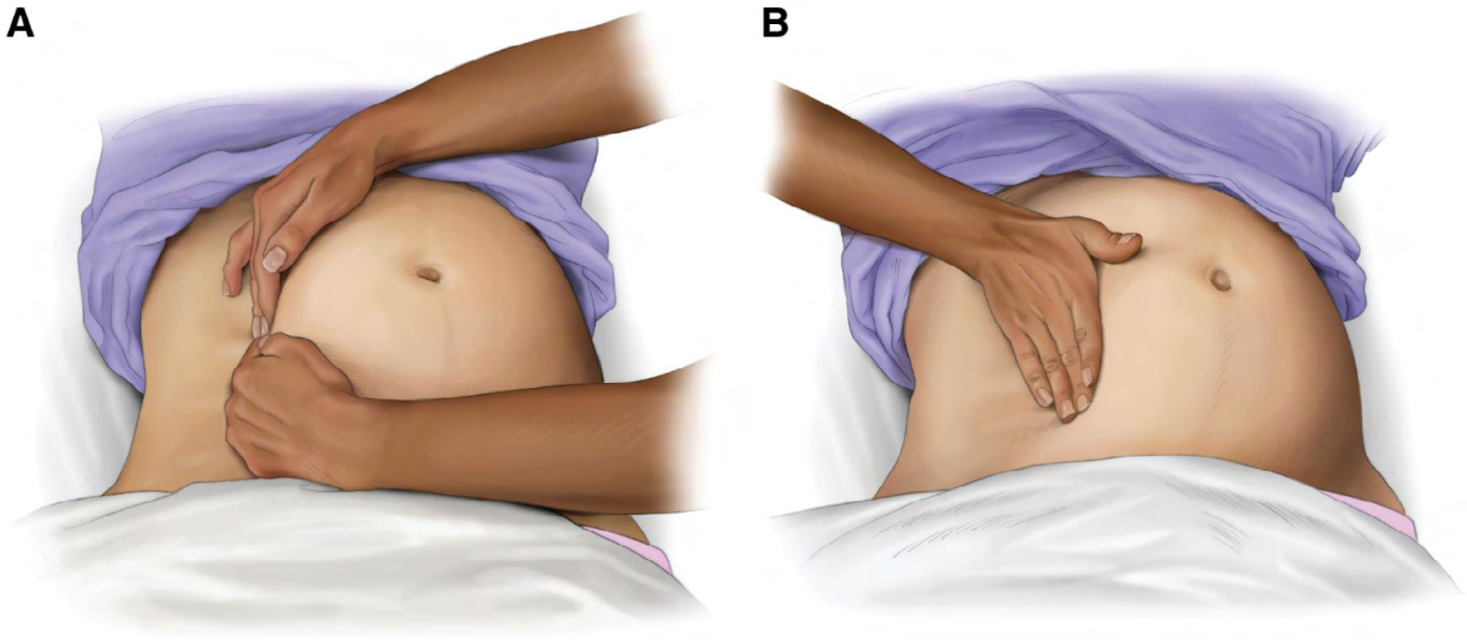
Recommendations[29]

1. The patient should be placed in a full left lateral decubitus position to relieve aortocaval compression (*Class I; Level of Evidence C*).
2. Administration of 100% oxygen by face mask to treat or prevent hypoxemia is recommended (*Class I; Level of Evidence C*).
3. Intravenous access should be established above the diaphragm to ensure that the intravenously administered therapy is not obstructed by the gravid uterus (*Class I; Level of Evidence C*).
4. Precipitating factors should be investigated and treated (*Class I; Level of Evidence C*).

F. Jeejeebhoy et al. AHA Scientific Statement **Circulation** 2015
Panchal et al. AHA Guidelines **Circulation** 2020

CPR IN PREGNANT WOMAN

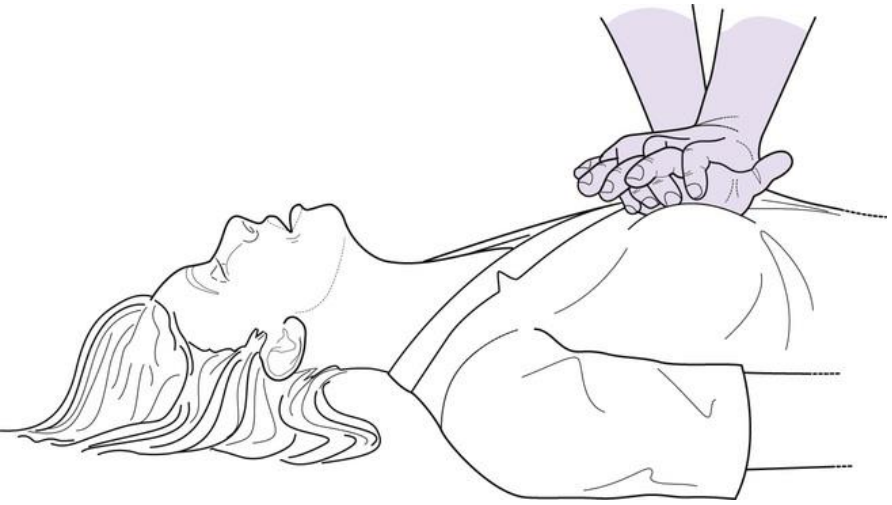
- **Continuous Lateral Uterus Displacement (LUD)**



F. Jeejeebhoy et al. AHA Scientific Statement **Circulation** 2015
Panchal et al. AHA Guidelines **Circulation** 2020

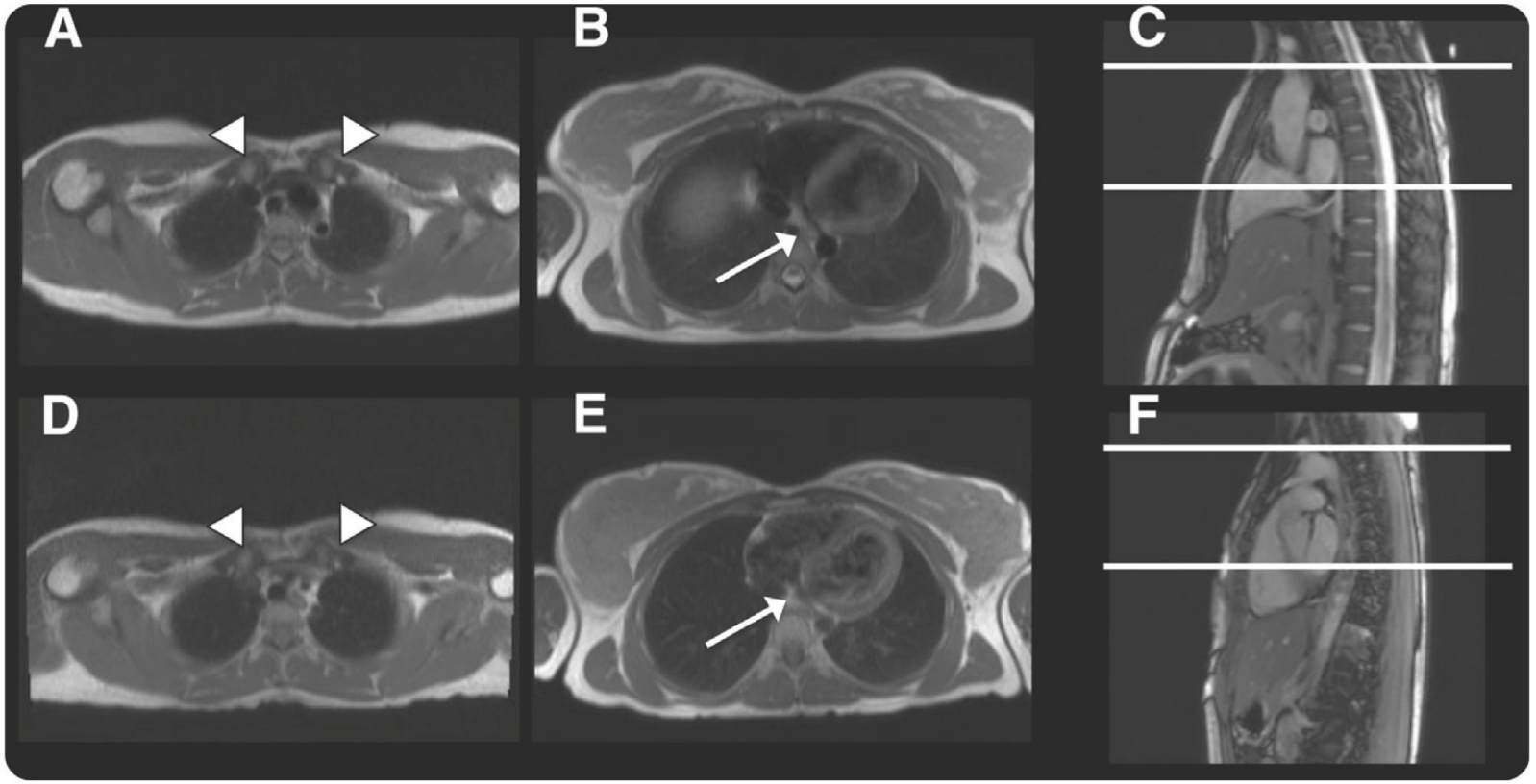
CPR IN PREGNANT WOMAN

- **Chest Compression**



FIGURE

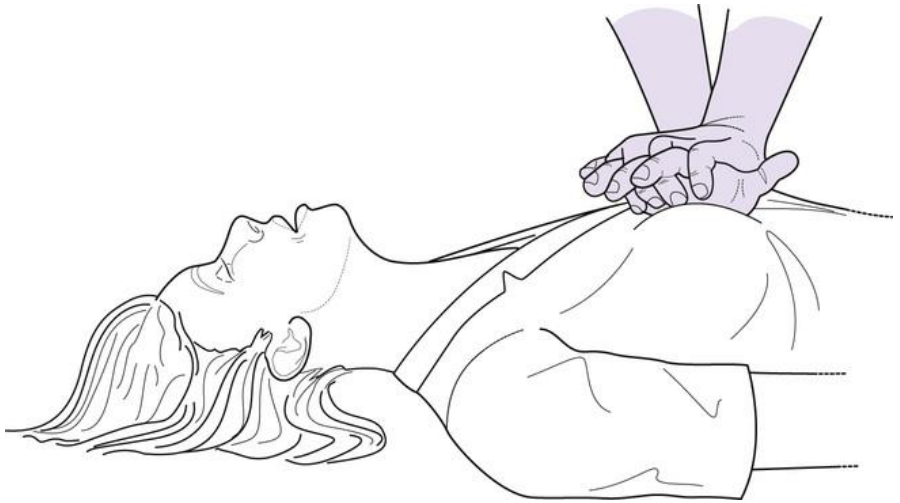
Relative position of the heart



S. Holmes et al. **Am J Obst Gyn** 2015

CPR IN PREGNANT WOMAN

- **Chest Compression**



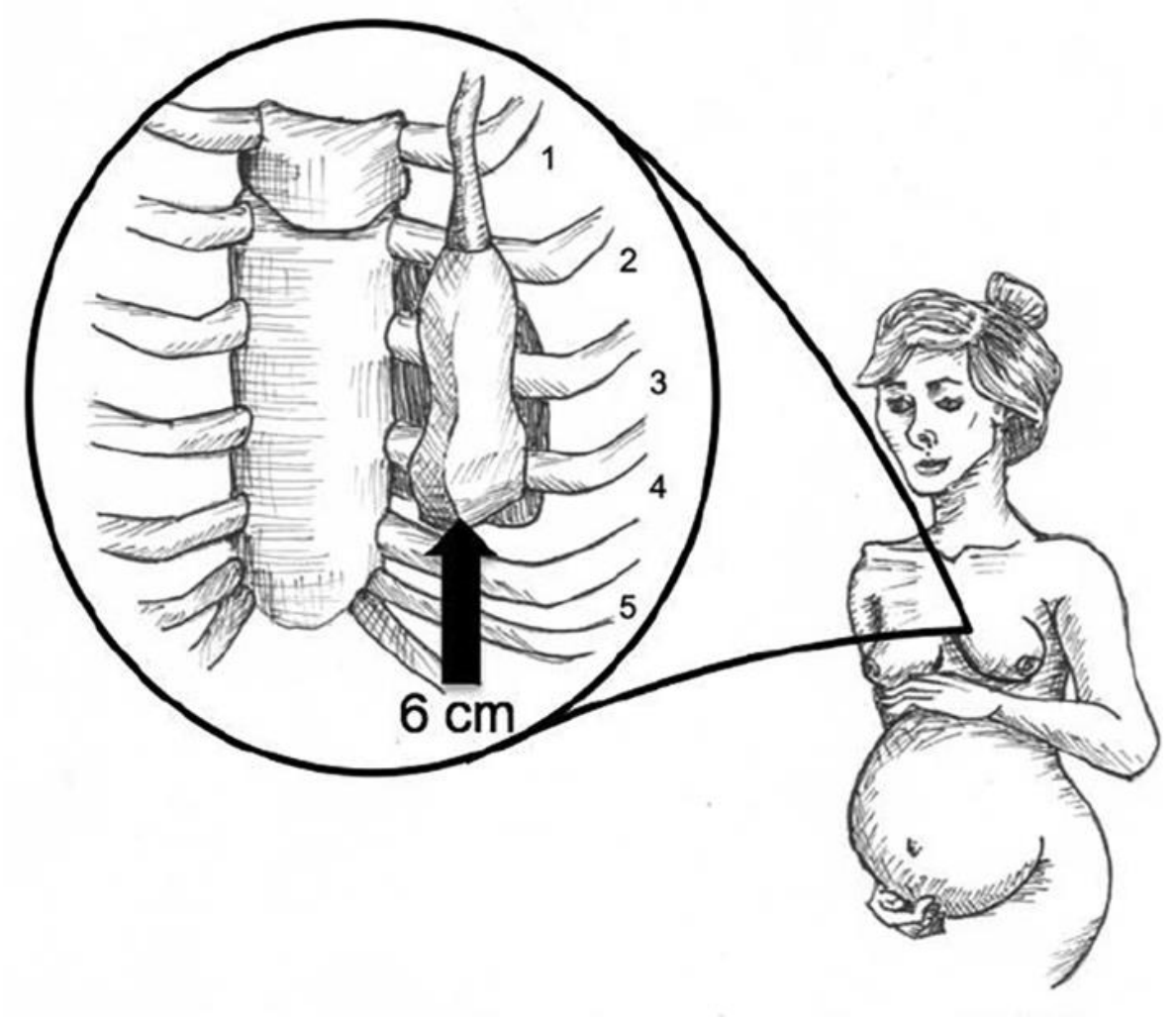


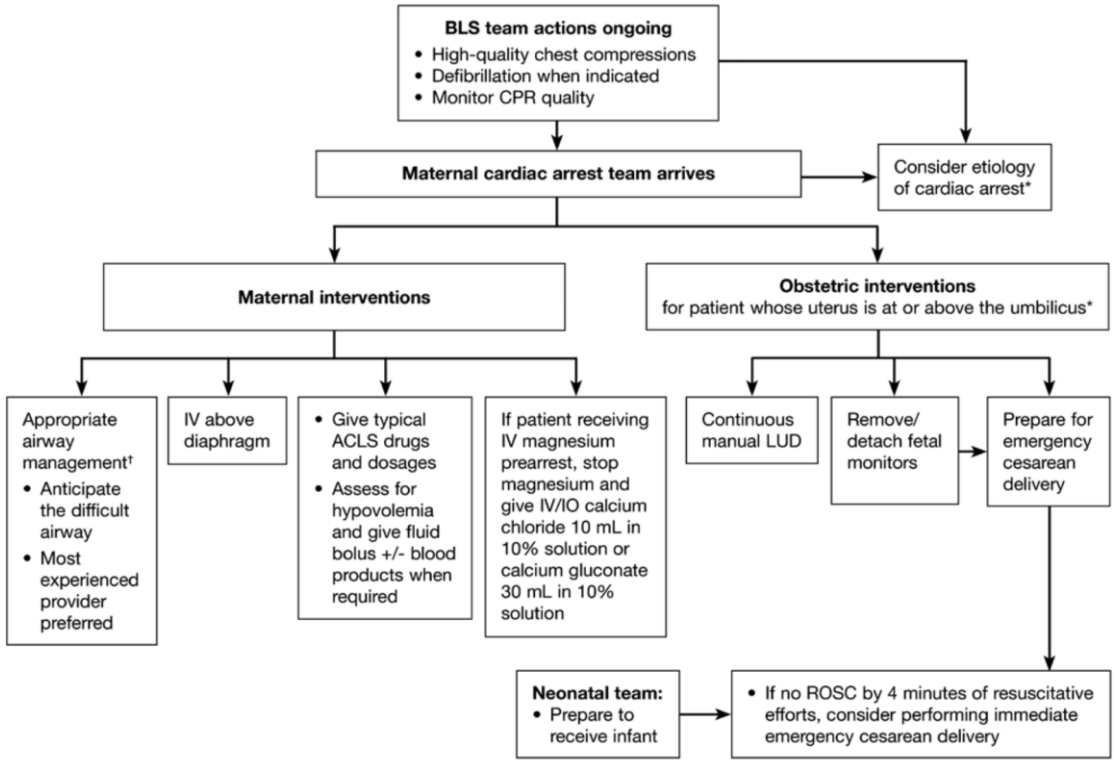
Table 2 Left ventricle position in relation to lower half of sternum (n=20)

Variable	
Cranial displacement, supine (cm)	5.8 (±1.9)
Lateral displacement, supine (cm)	0.1 (±0.7)
Cranial displacement, wedge (left lateral) (cm)	6.1 (±2.0)
Lateral displacement, wedge (left lateral) (cm)	0

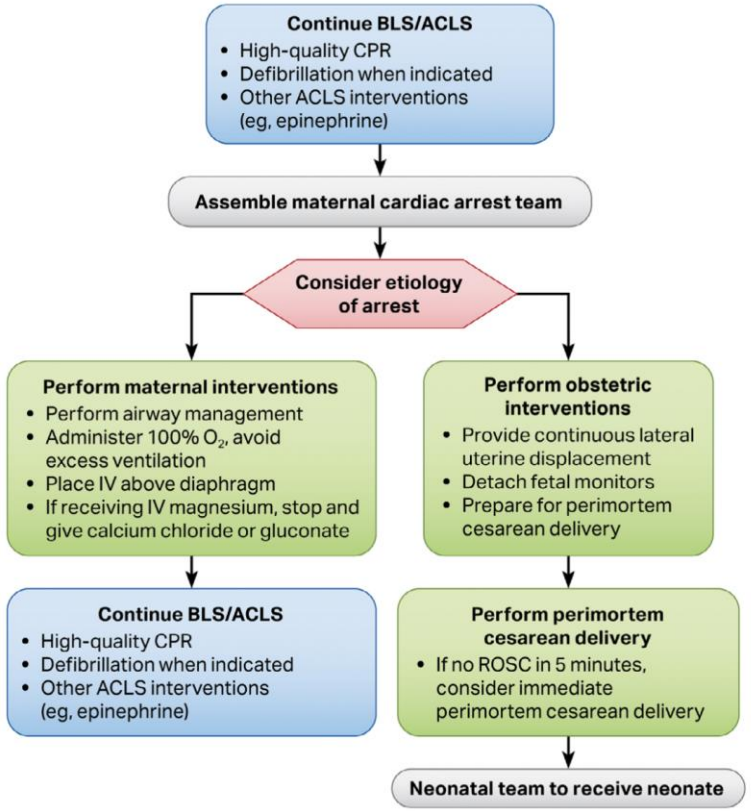
Values expressed as mean (±SD).

C. Delgado et al. **Int J Obst Anest** 2020

ACLS



Cardiac Arrest in Pregnancy In-Hospital ACLS Algorithm



Maternal Cardiac Arrest

- Team planning should be done in collaboration with the obstetric, neonatal, emergency, anesthesiology, intensive care, and cardiac arrest services.
- Priorities for pregnant women in cardiac arrest should include provision of high-quality CPR and relief of aortocaval compression with lateral uterine displacement.
- The goal of perimortem cesarean delivery is to improve maternal and fetal outcomes.
- Ideally, perform perimortem cesarean delivery in 5 minutes, depending on provider resources and skill sets.

Advanced Airway

- In pregnancy, a difficult airway is common. Use the most experienced provider.
- Provide endotracheal intubation or supraglottic advanced airway.
- Perform waveform capnography or capnometry to confirm and monitor ET tube placement.
- Once advanced airway is in place, give 1 breath every 6 seconds (10 breaths/min) with continuous chest compressions.

Potential Etiology of Maternal Cardiac Arrest

A Anesthetic complications
B Bleeding
C Cardiovascular
D Drugs
E Embolic
F Fever
G General nonobstetric causes of cardiac arrest (H's and T's)
H Hypertension

F. Jeejeebhoy et al. AHA Scientific Statement **Circulation** 2015
Panchal et al. AHA Guidelines **Circulation** 2020

CARDIAC ARREST IN PREGNANCY

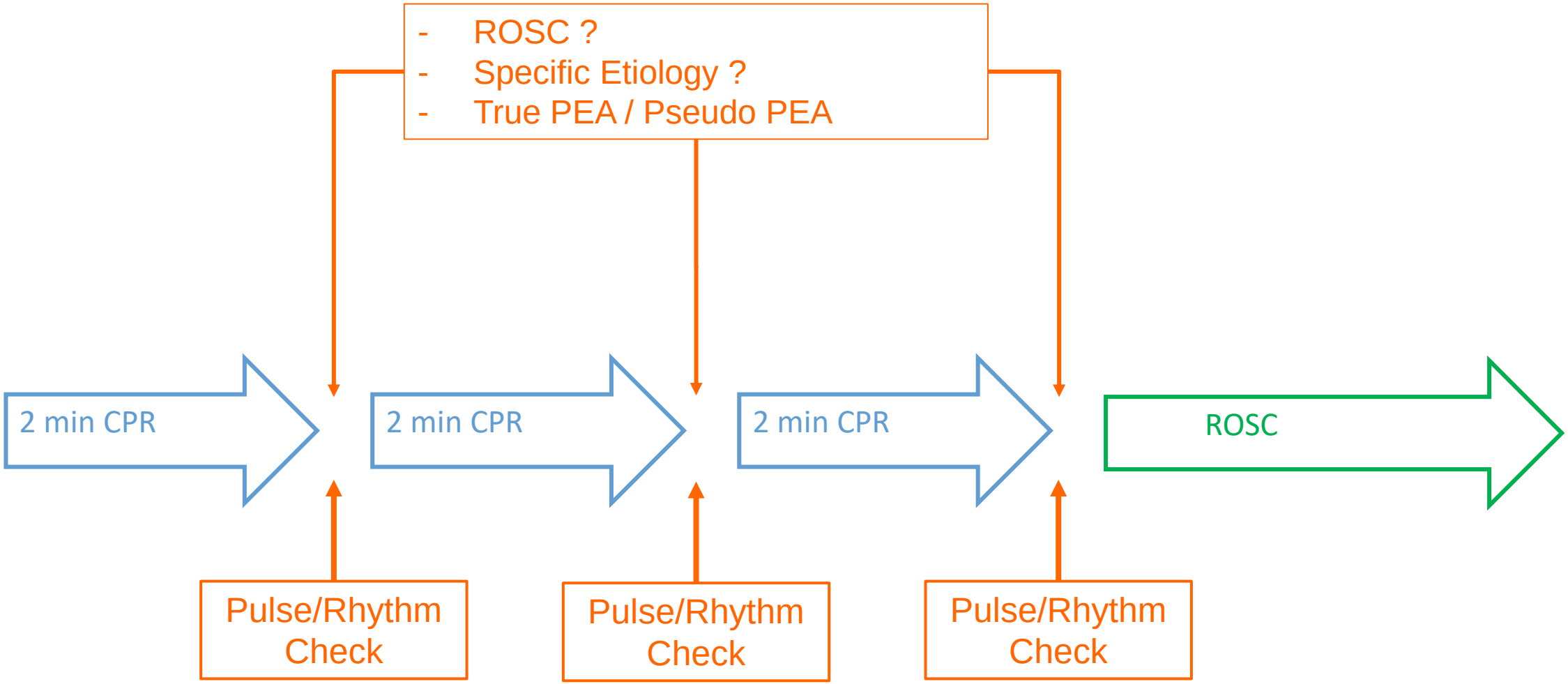
- **Specific Etiologies**

TABLE
Etiologies for cardiac arrest during pregnancy (adapted from American Heart Association)[9]

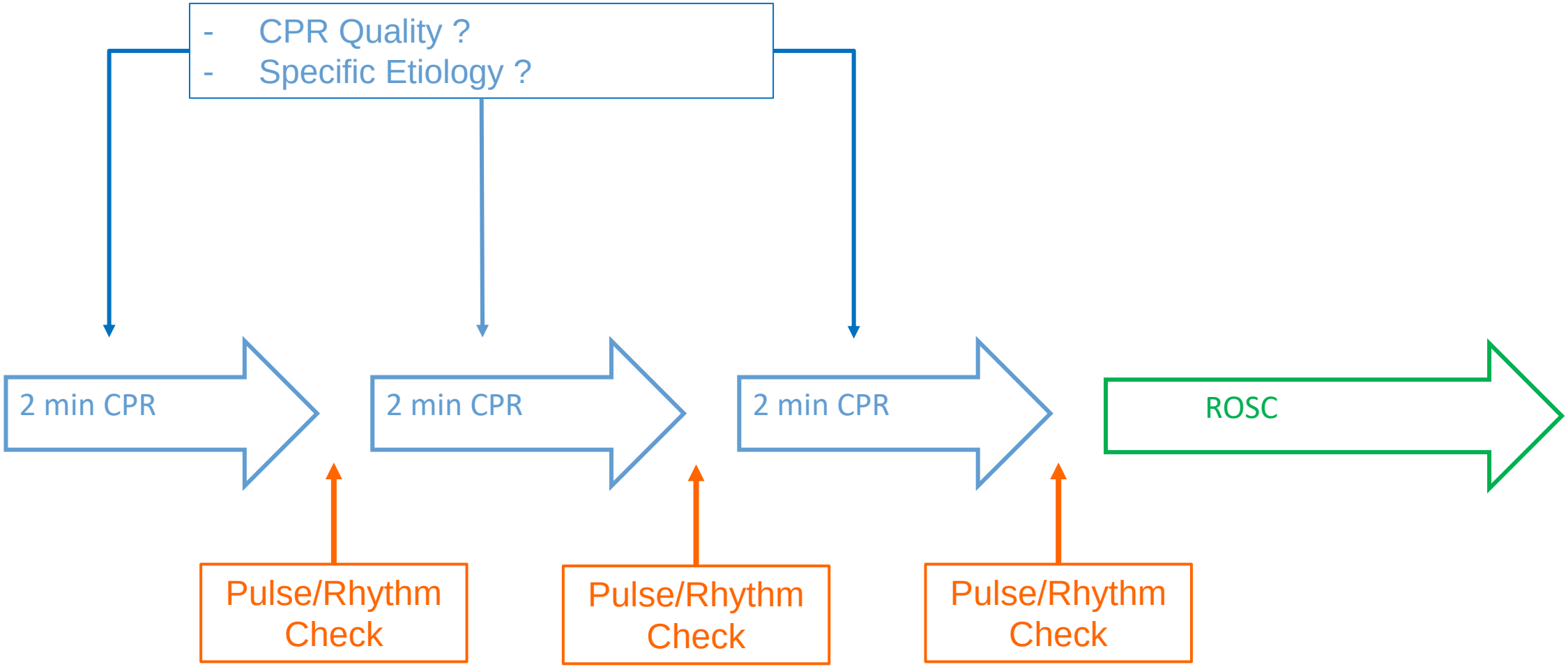
Anesthetic causes	High spinal or epidural
	Intravascular injection of local anesthetic
	Airway complications
	Aspiration
Accidents	Trauma
Bleeding	Uterine atony
	Abnormally adherent placentation
	Coagulopathy
Cardiovascular	Valvular disease
	Congenital cardiac disease
	Ischemia and atherosclerosis
	Arrhythmias
	Rupture of dissection
Drugs	Tocolytic agents
	Illicit drugs leading to overdose
	Anaphylaxis
	Uterotonics
	Magnesium
Embolism	Venous embolism
	Amniotic fluid embolism
Fever	Sepsis
	Necrotizing fasciitis
	Viral syndromes
	Acute respiratory distress syndrome
General	Metabolic abnormalities
	Hypocalcemia or hyperkalemia during massive hemorrhage
Hypertension	Stroke (thrombotic or hemorrhagic)
	Preeclampsia/eclampsia/HELLP

Source: American Heart Association, Inc.

ECHO IN CARDIAC ARREST



ECHO IN CARDIAC ARREST



CPR QUALITY

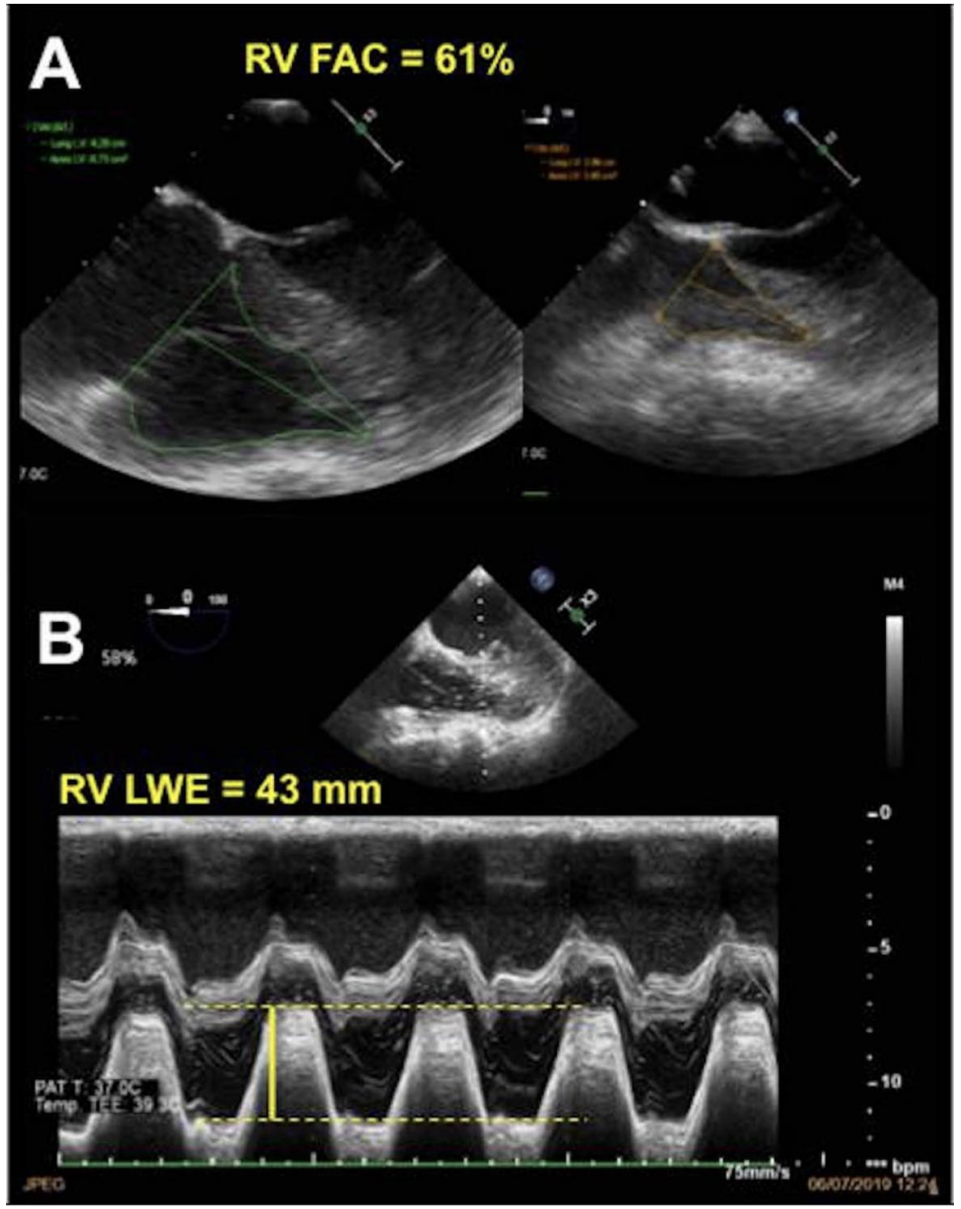
- **Assessment during CPR**

  - **TEE only :**
    Mid-Oeso **Four chambers** view

  - **Check :**
    - **RV/LV cavities compression**

  - **Caveat :**

*Progressive **drift** of the mechanical chest compression device*



Catena E. et al. **J. Echocardiogaphy** 2021

CPR QUALITY

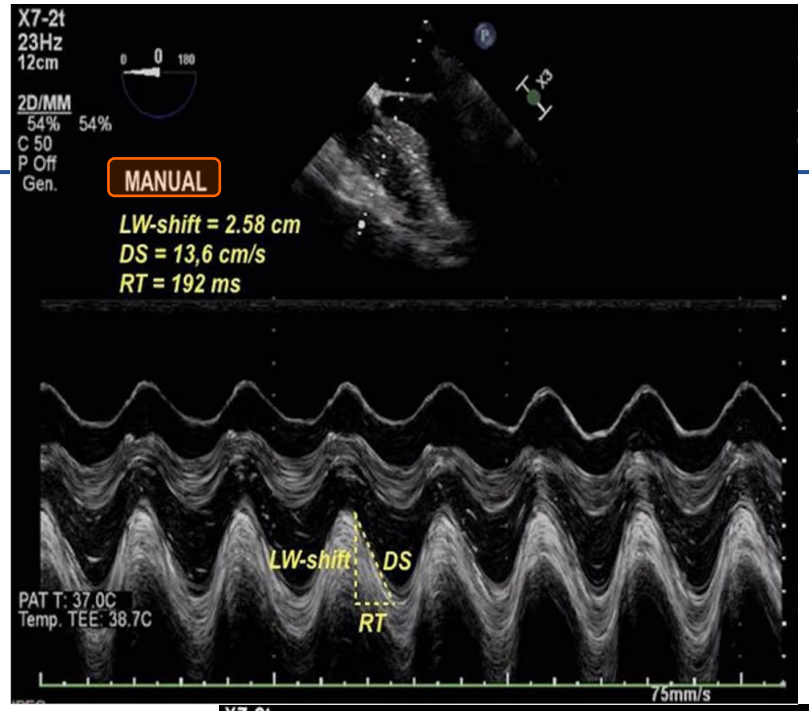
- **Assessment during CPR**

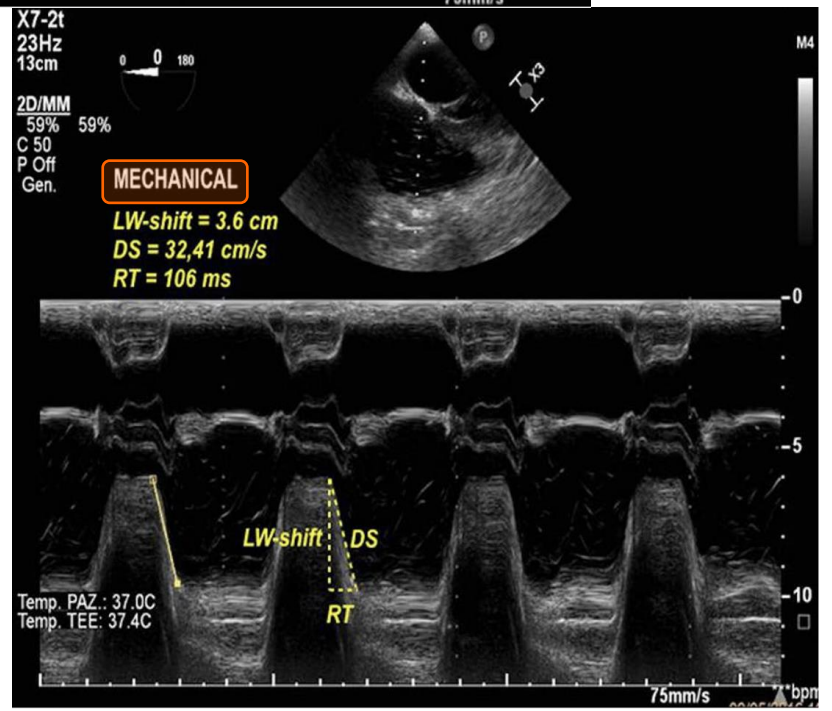
  - **TEE only :**
    Mid-Oeso **Four chambers** view

  - **Check :**
    - RV/LV cavities compression
    - **RV/LV cavities recoil**

  - **Caveat :**

*Progressive **drift** of the mechanical chest compression device*





Catena E. et al. **J. Echocardiogaphy** 2021

CPR QUALITY

- **Assessment during CPR**

• **TEE only :**

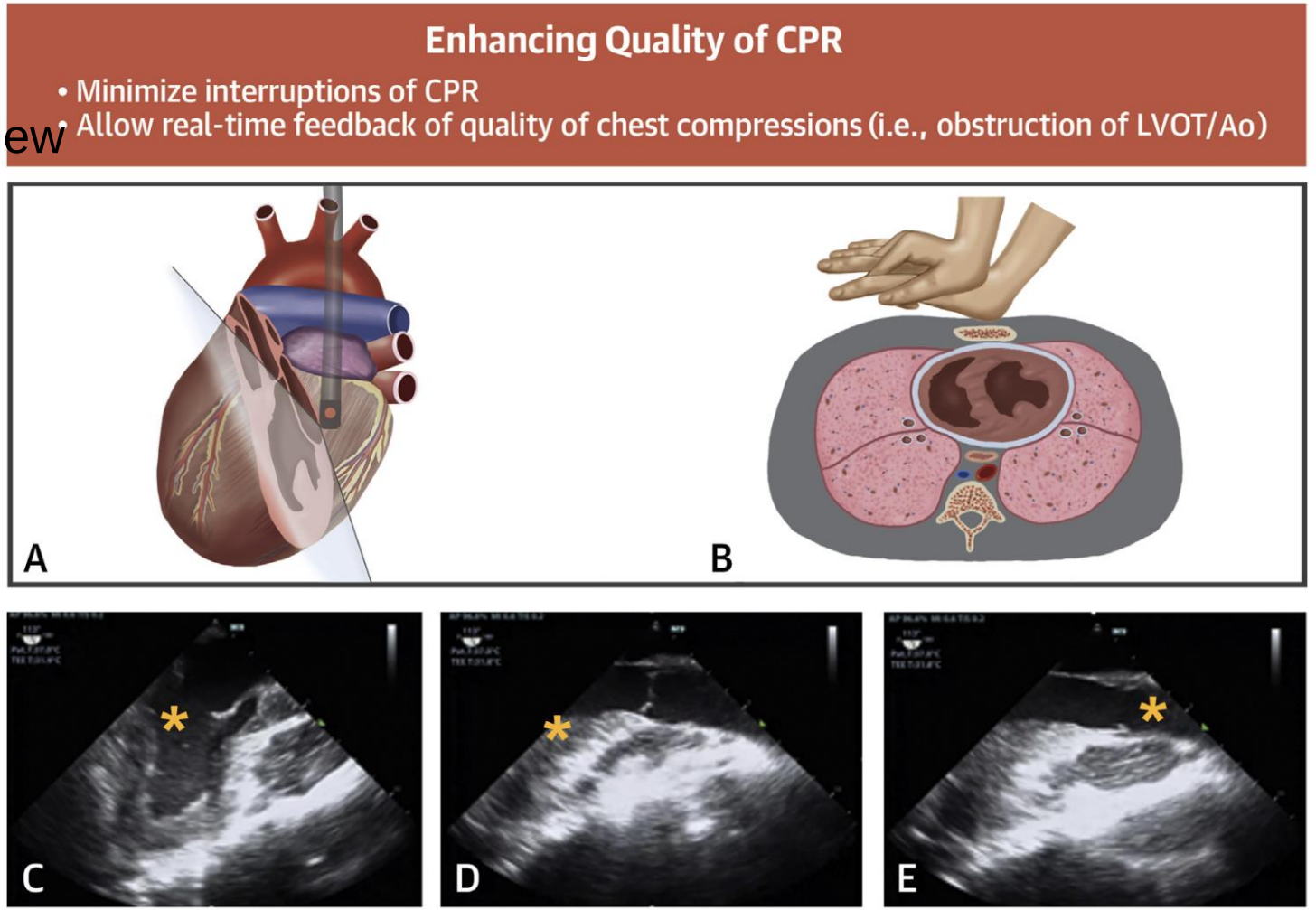
Mid-Oeso **Long Axis** view

• **Check :**

- RV/LV cavities compression
- RV/LV cavities recoil
- **Aortic valve opening**

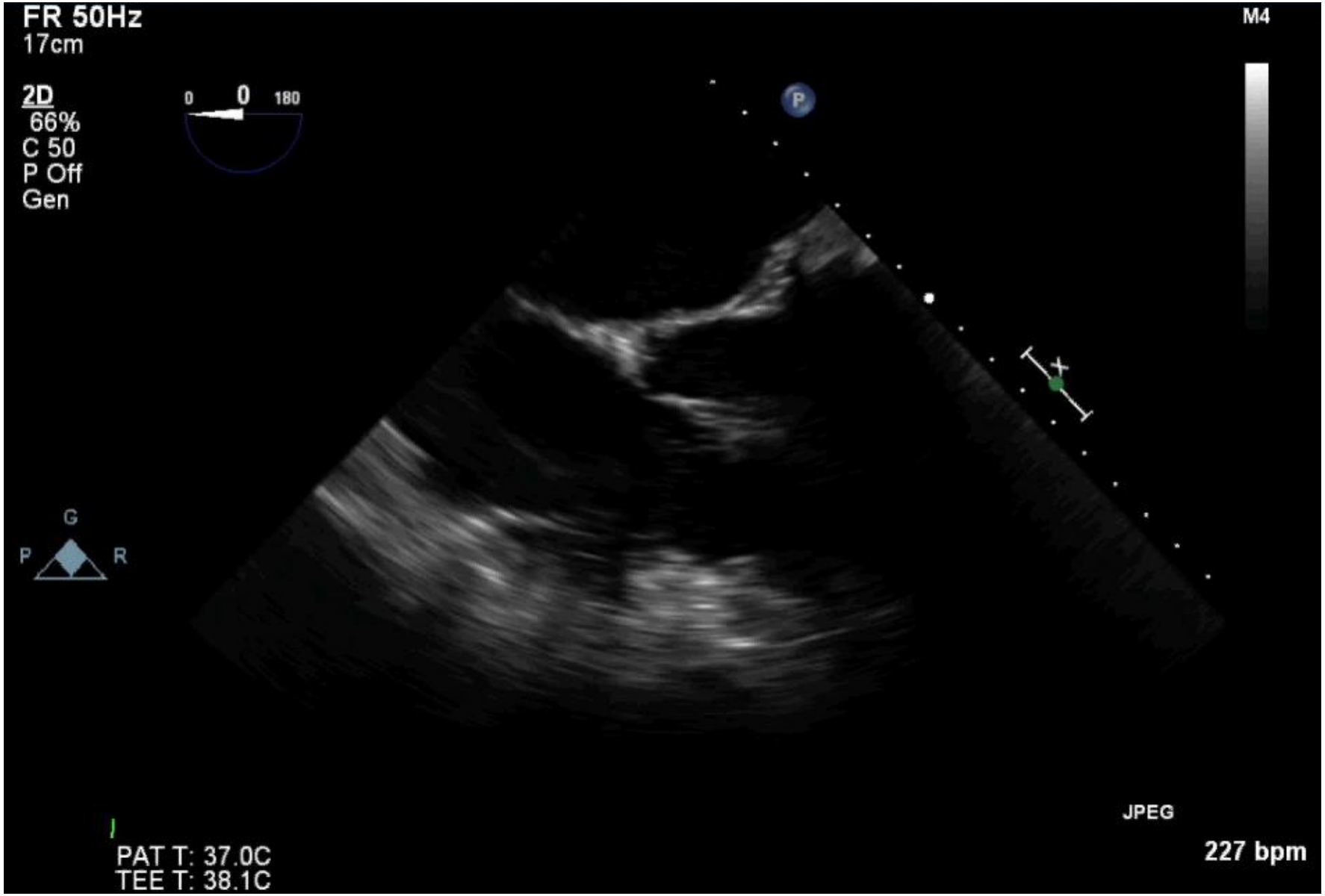
• **Caveat :**

*Progressive **drift** of the mechanical chest compression device*

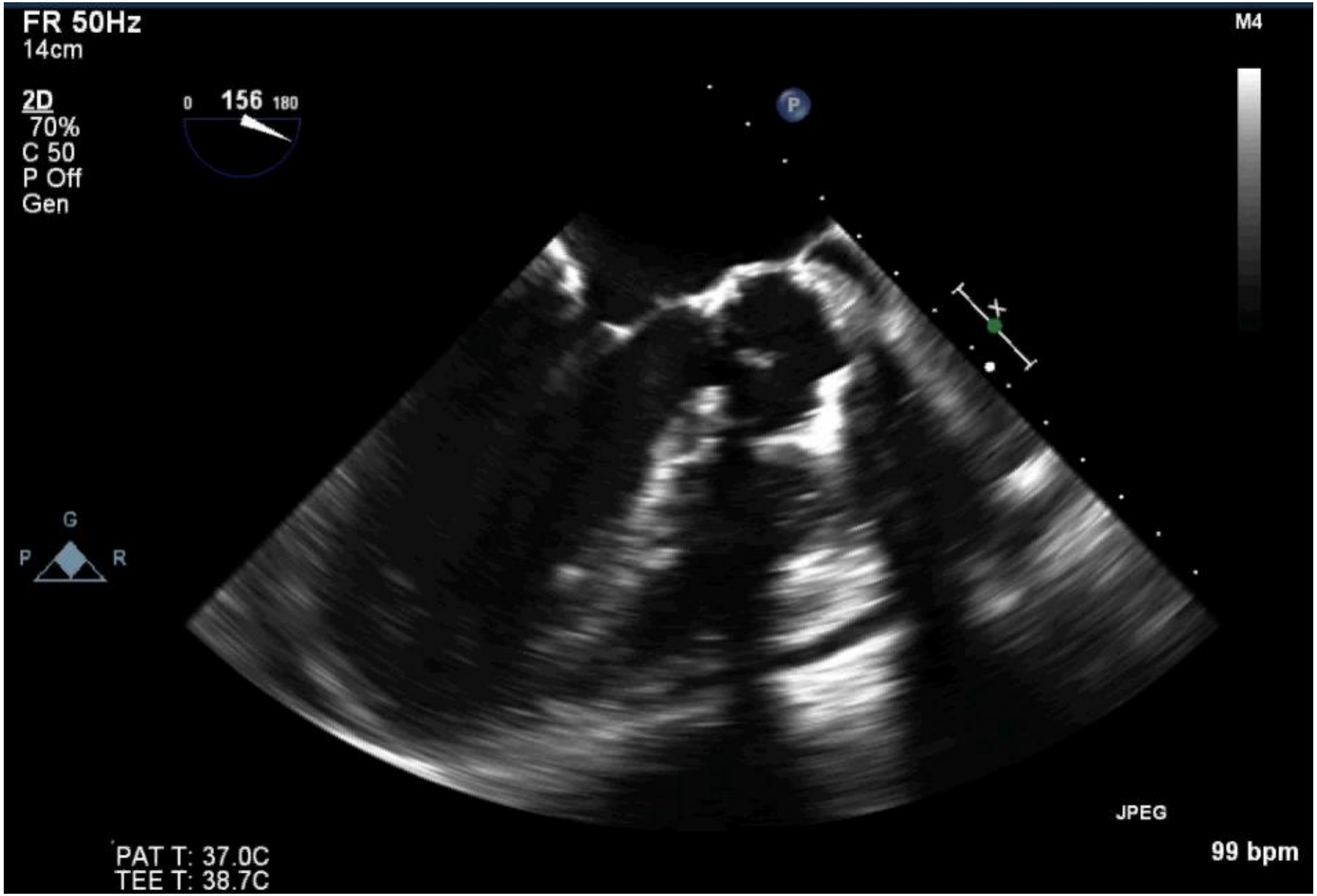


Teran F. et al. **J. Am. Coll. Card.** 2020

CPR QUALITY


FR 50Hz
17cm
2D
66%
C 50
P Off
Gen
0
0
180
M4
G
P
R
JPEG
PAT T: 37.0C
TEE T: 38.1C
227 bpm

CPR QUALITY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C 50
P Off
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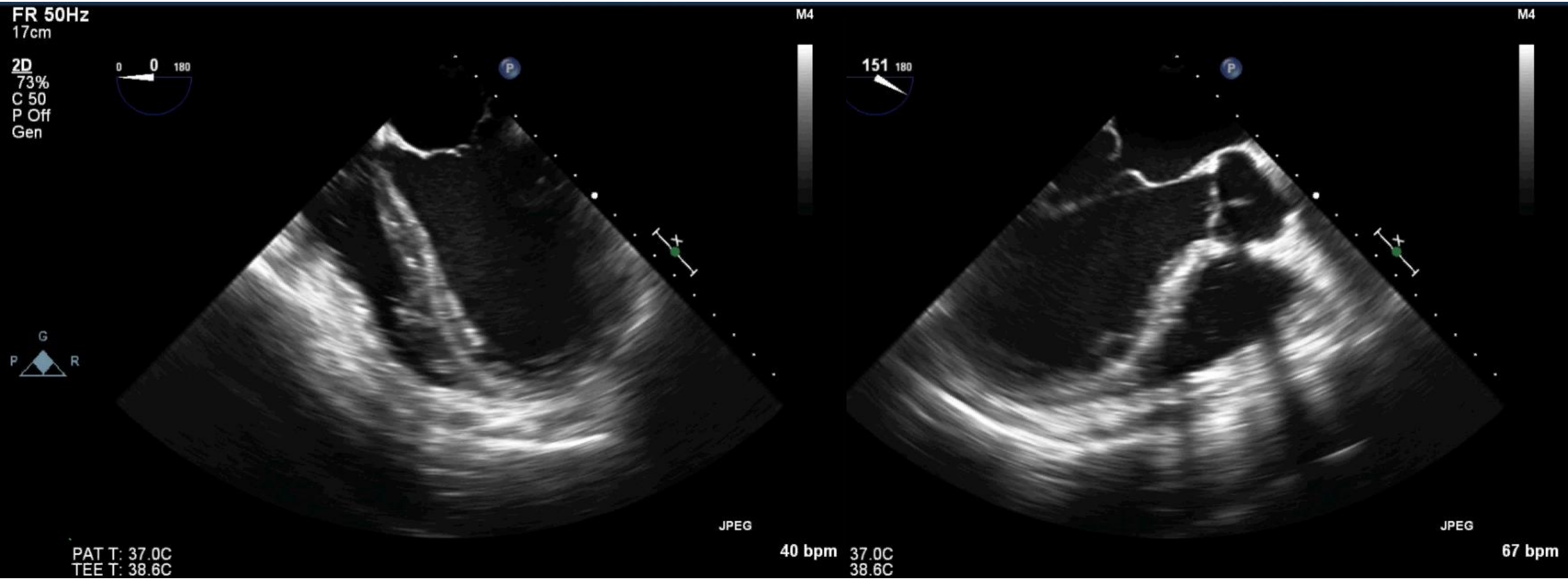
P
R
JPEG
PAT T: 37.0C
TEE T: 38.7C
99 bpm

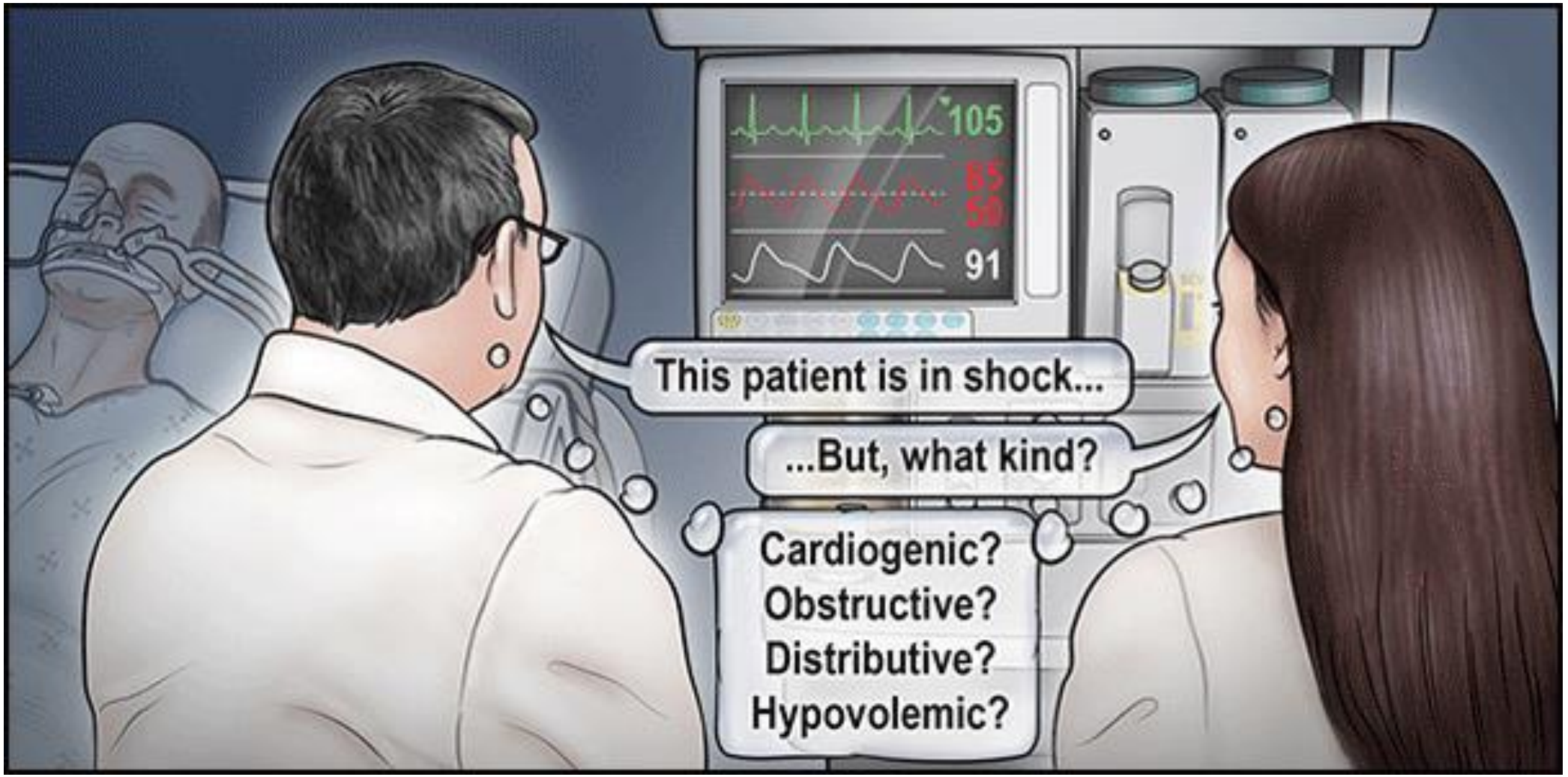
ROSC


FR 50Hz
17cm
2D
73%
C 50
P Off
Gen
0 0 180
M4
JPEG
PAT T: 37.0C
TEE T: 38.6C
40 bpm
151 180
M4
JPEG
37.0C
38.6C
67 bpm

CRITICAL CARE ECHOCARDIOGRAPHY

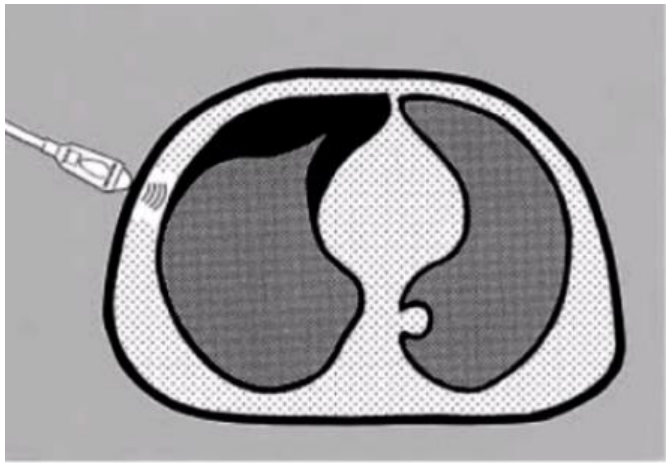
ULB

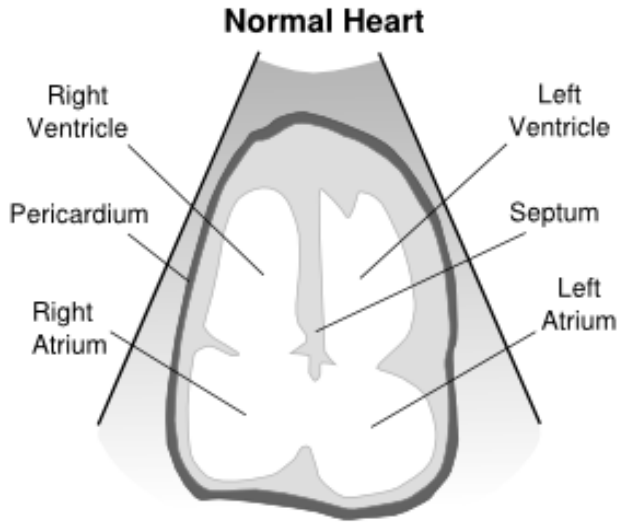
- Circulatory Failure

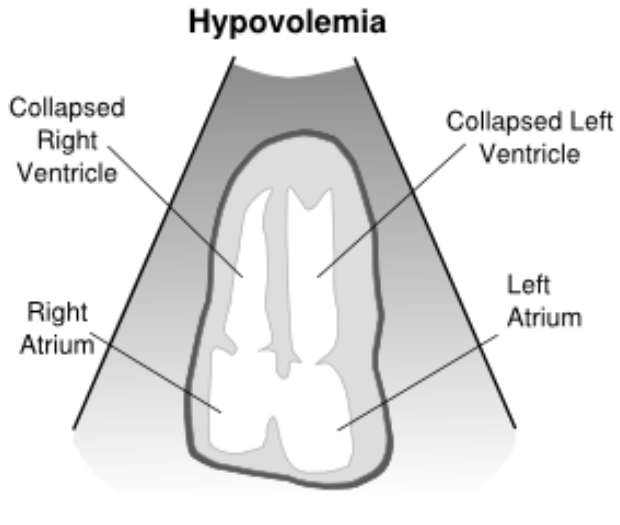


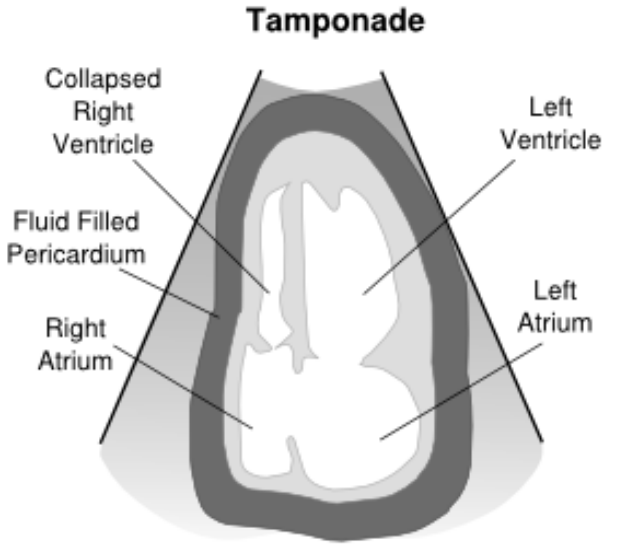
ETIOLOGIES

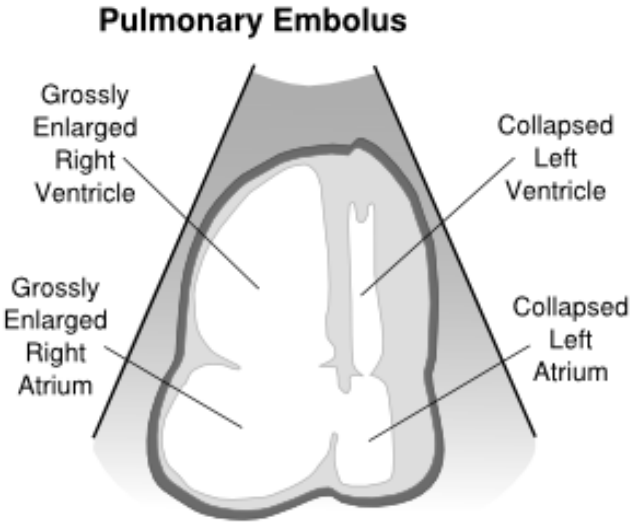
- Immediate Therapeutic Effect
  - **Severe Hypovolemia**
  - **Tamponade**
  - **Pulmonary Embolism**
  - **Pneumothorax**







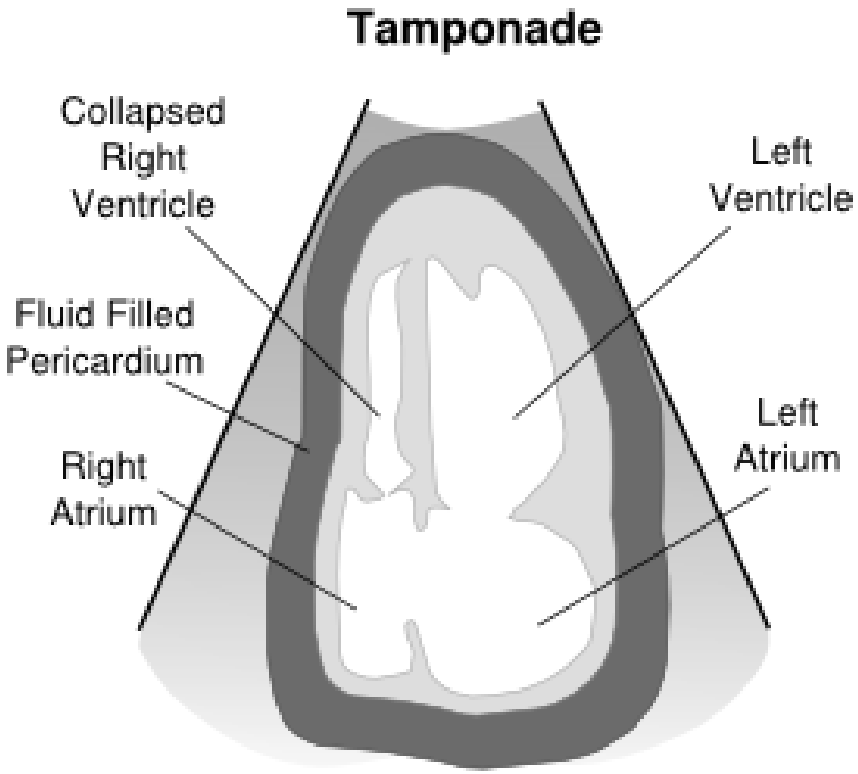


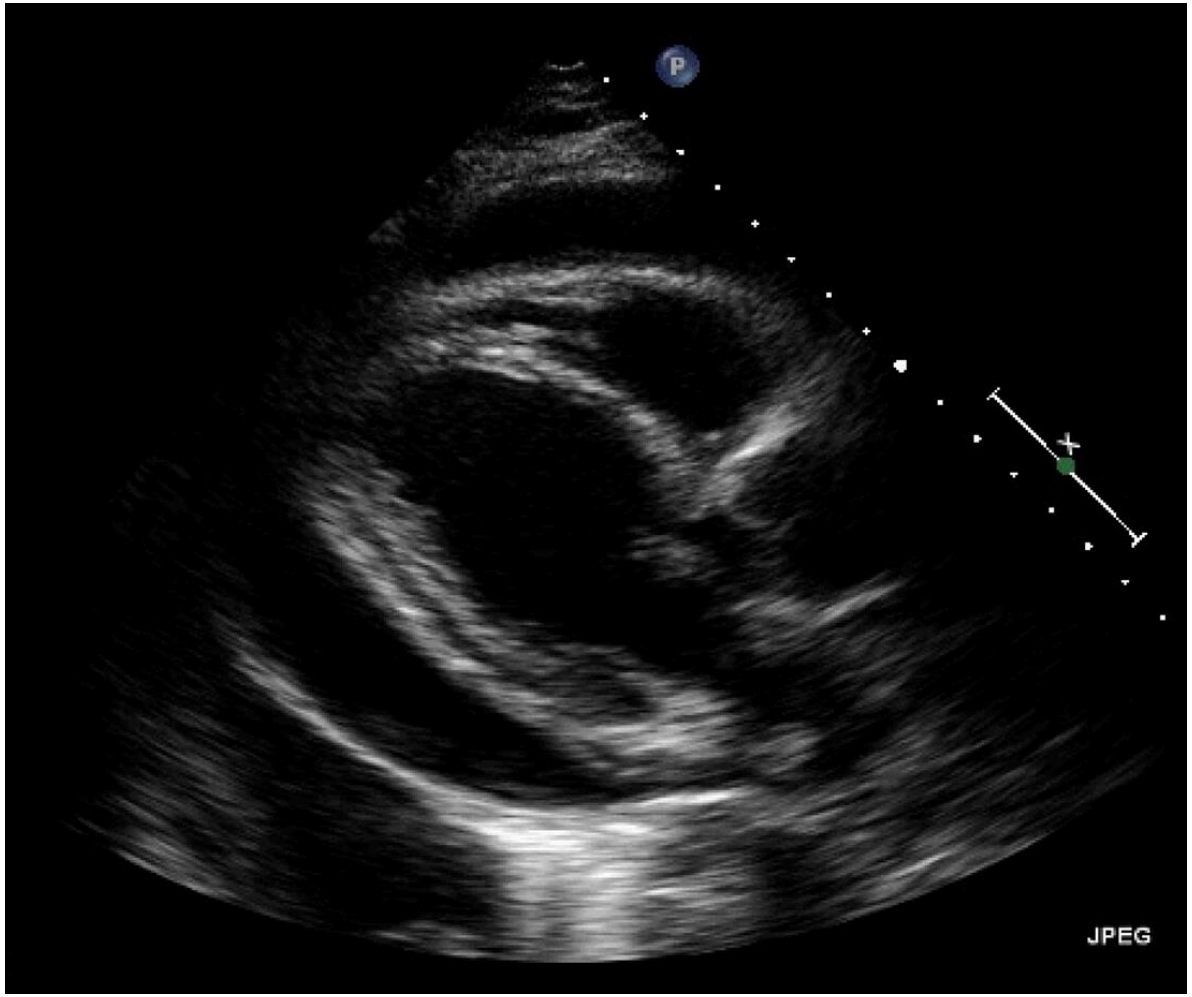


ETIOLOGIES

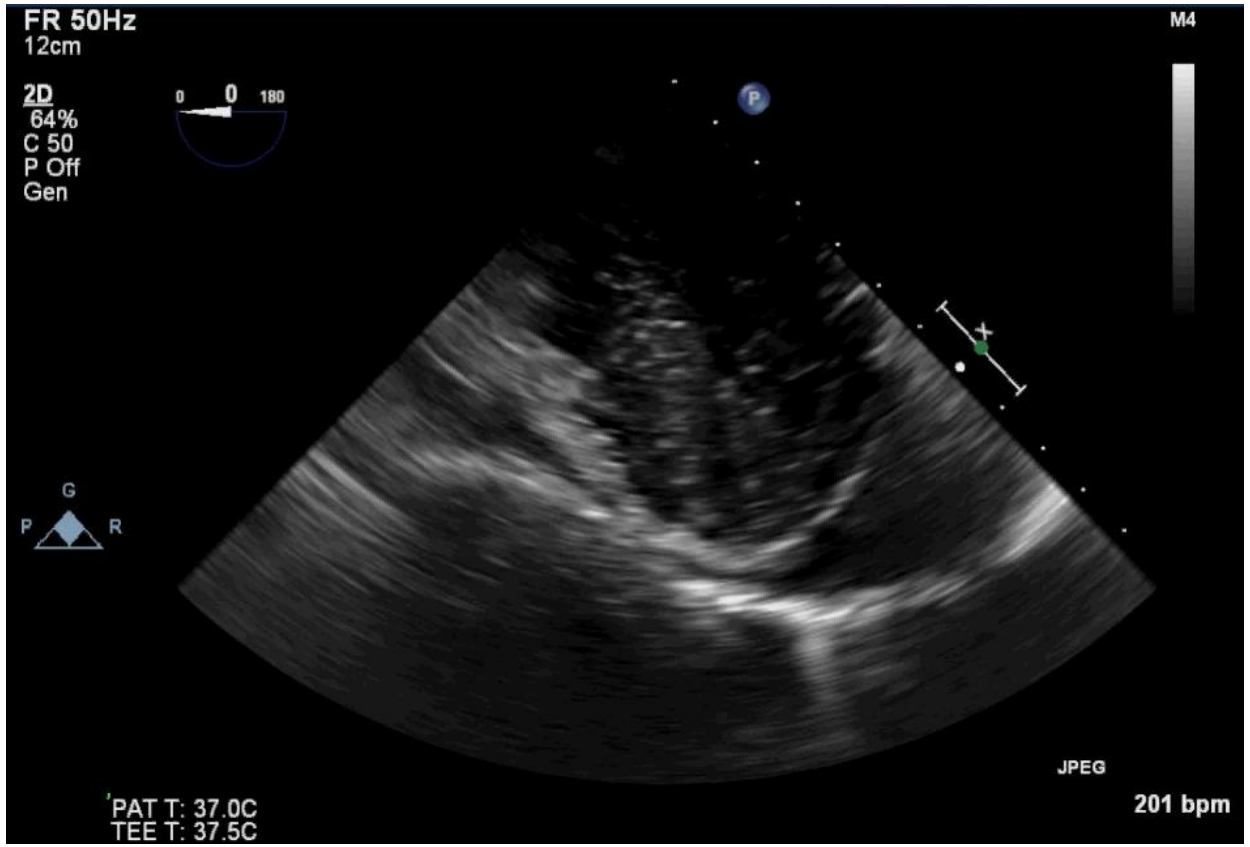
Immediate Therapeutic Consequence during CPR

- **TAMPONADE**





ETIOLOGIES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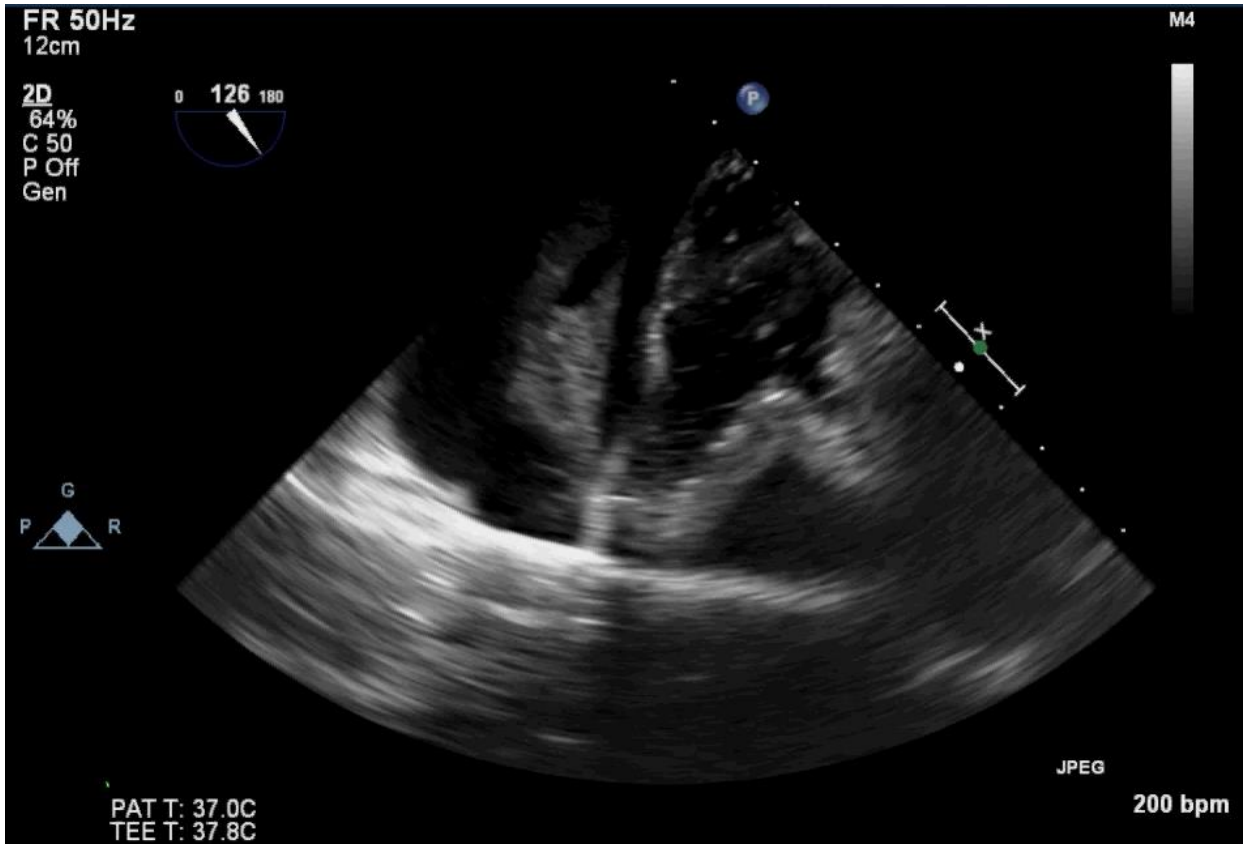
TEE T: 37.5C
201 bpm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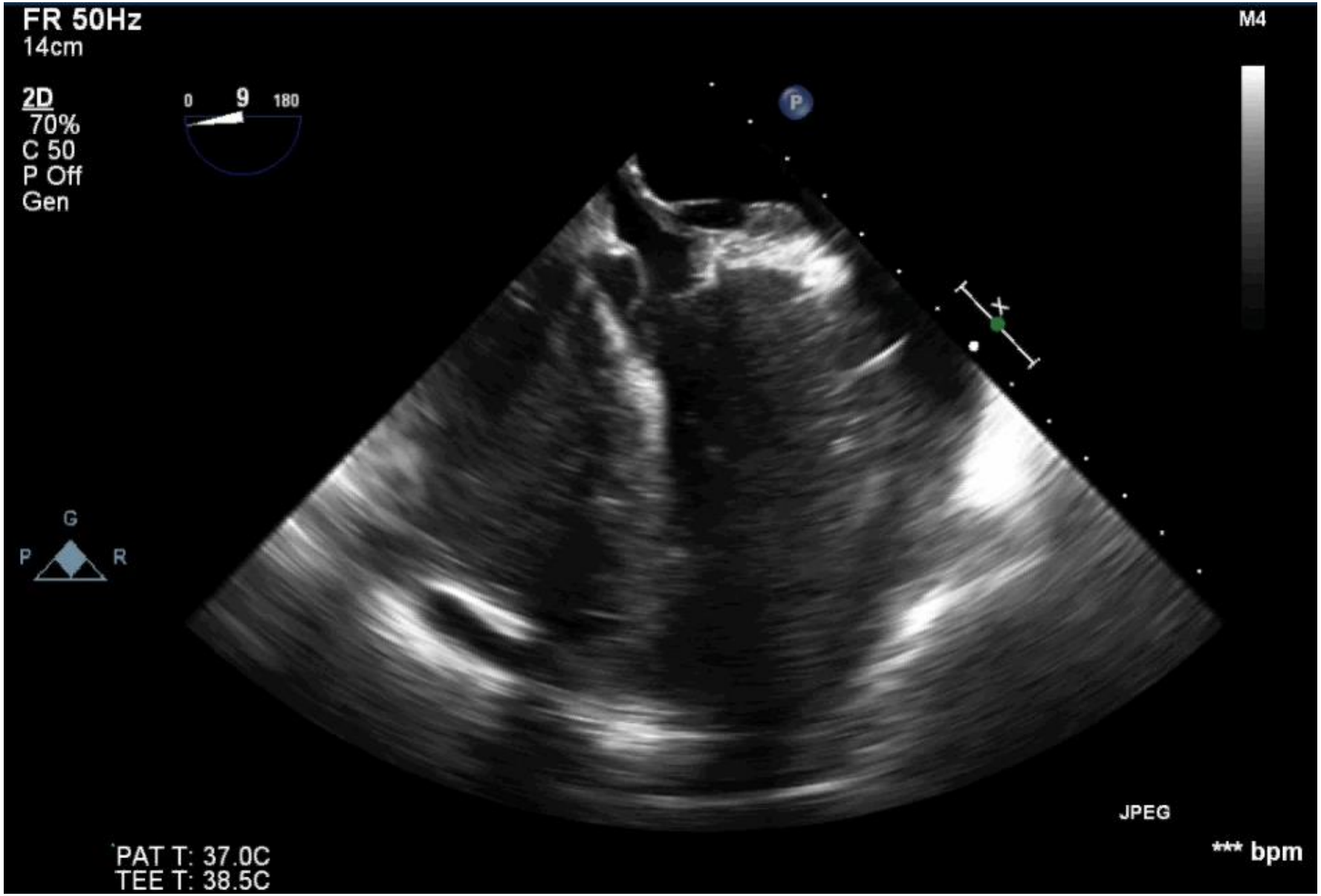
ETIOLOGIES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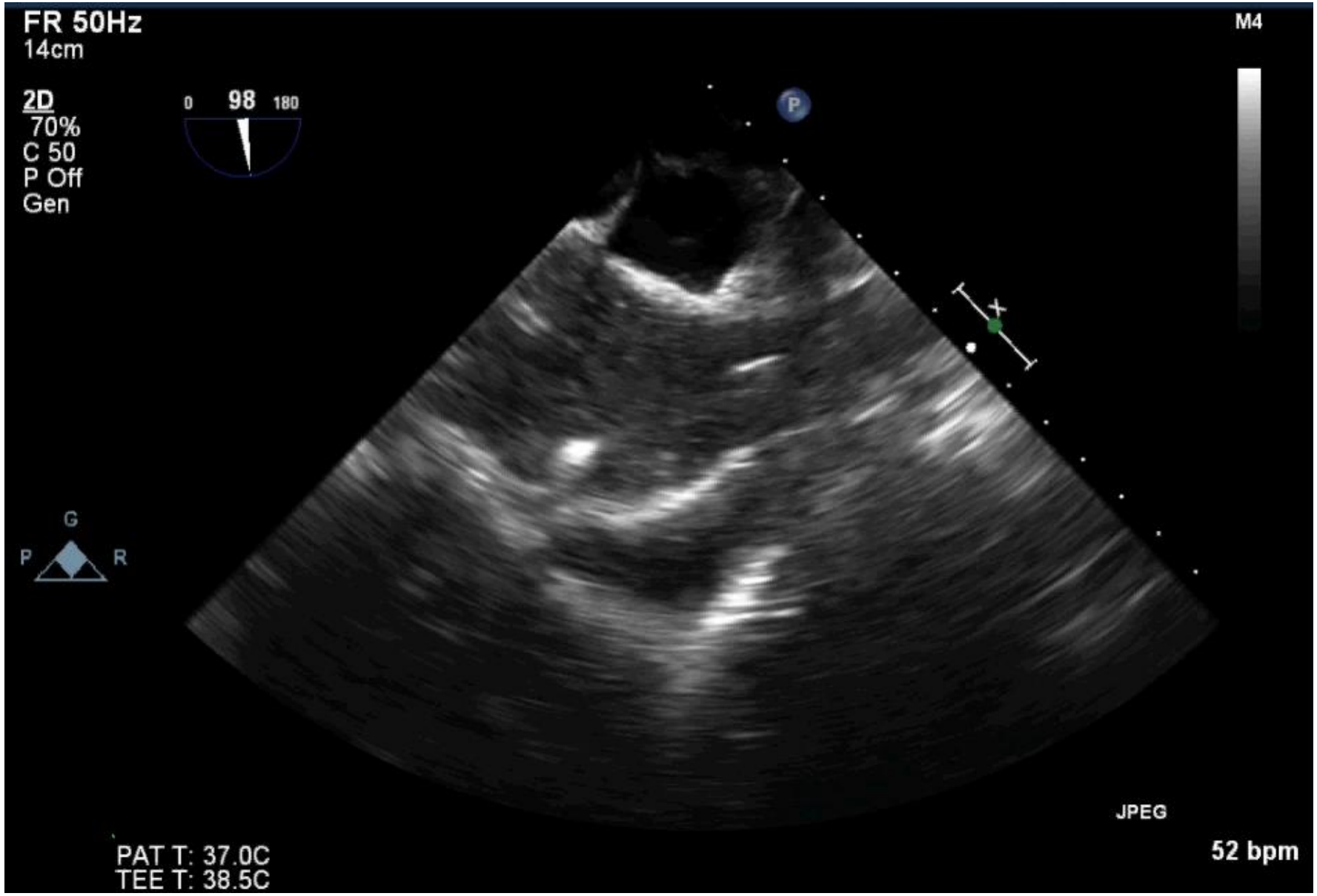
TEE T: 38.5C
*** bpm

ETIOLOGIES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TEE T: 38.5C
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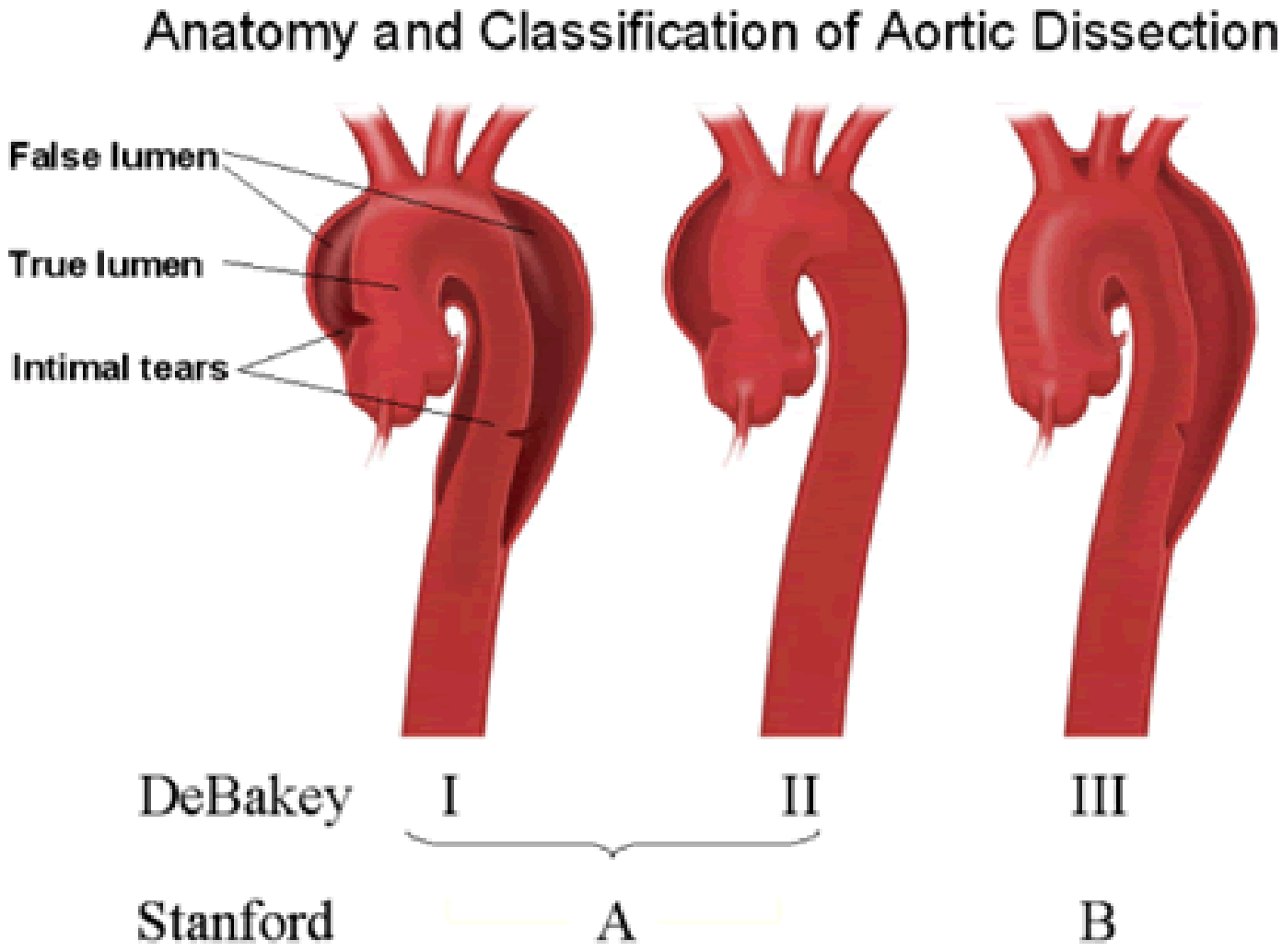
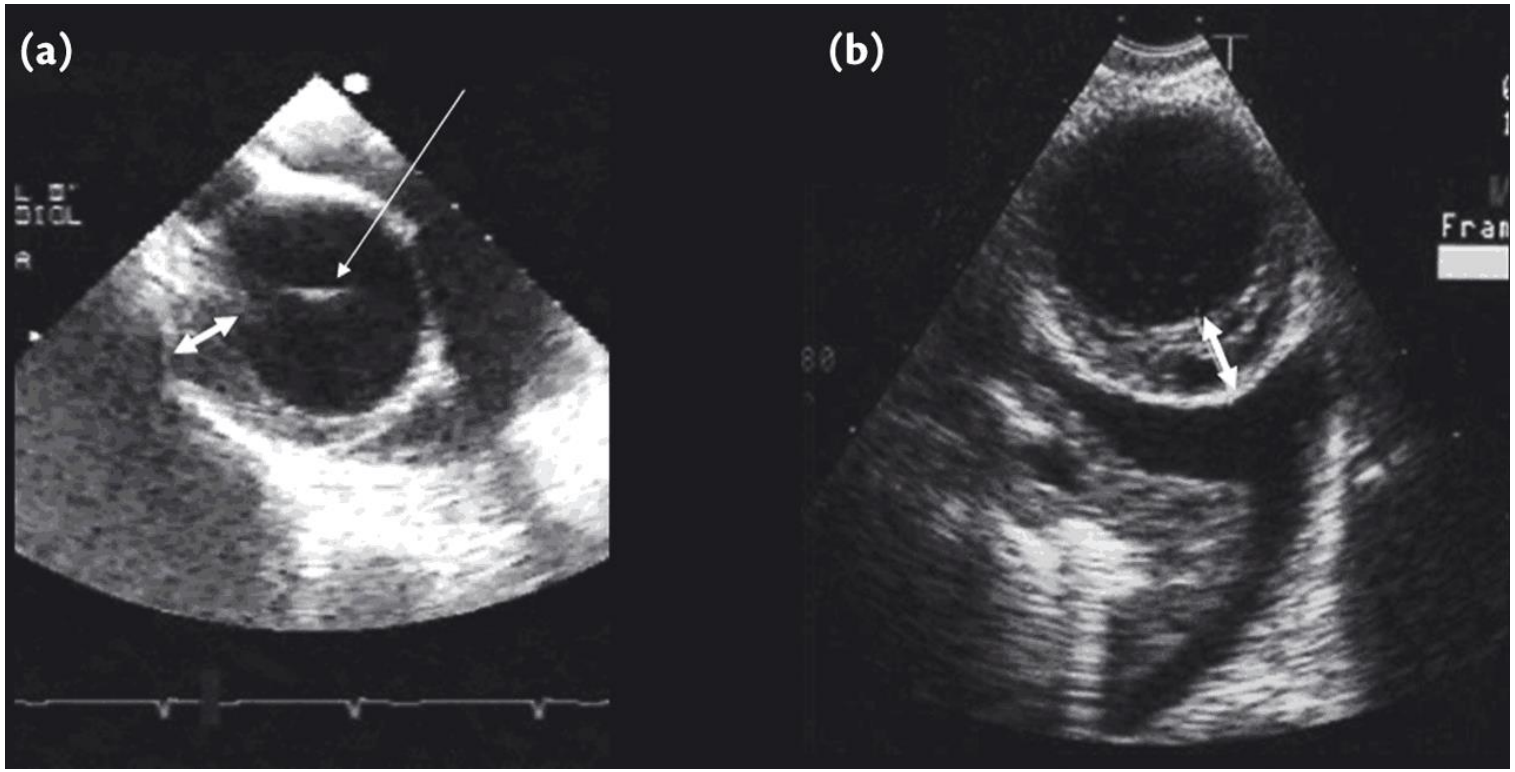
ETIOLOGIES

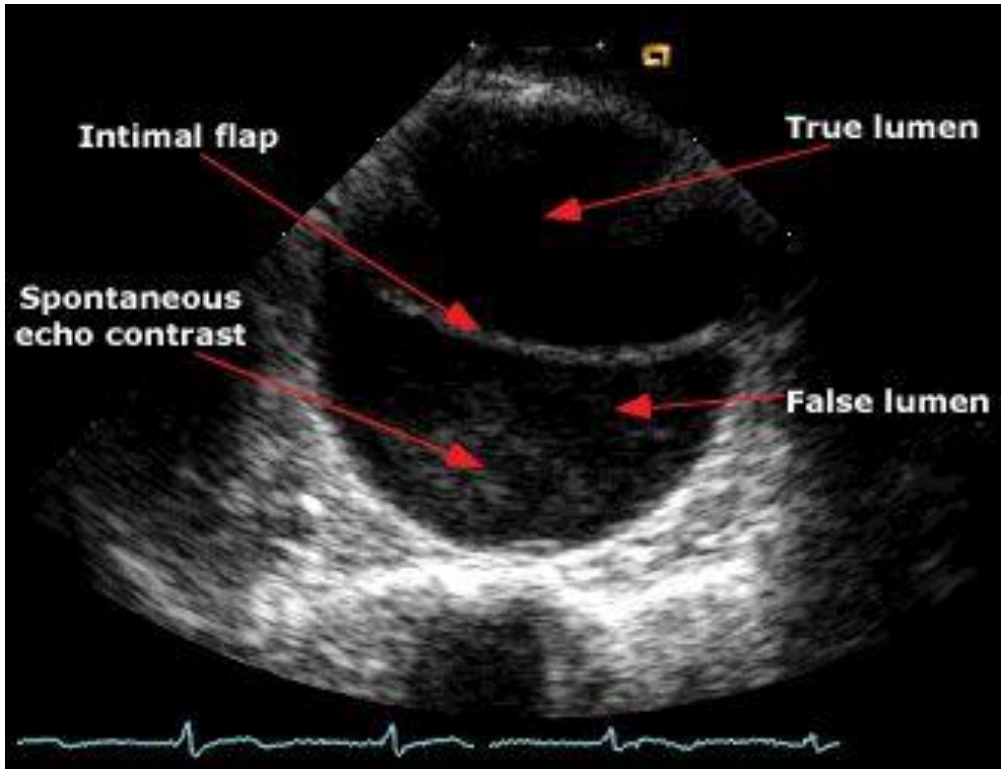
- **AORTIC DISSECTION**



ETIOLOGIES

- **AORTIC DISSECTION :**





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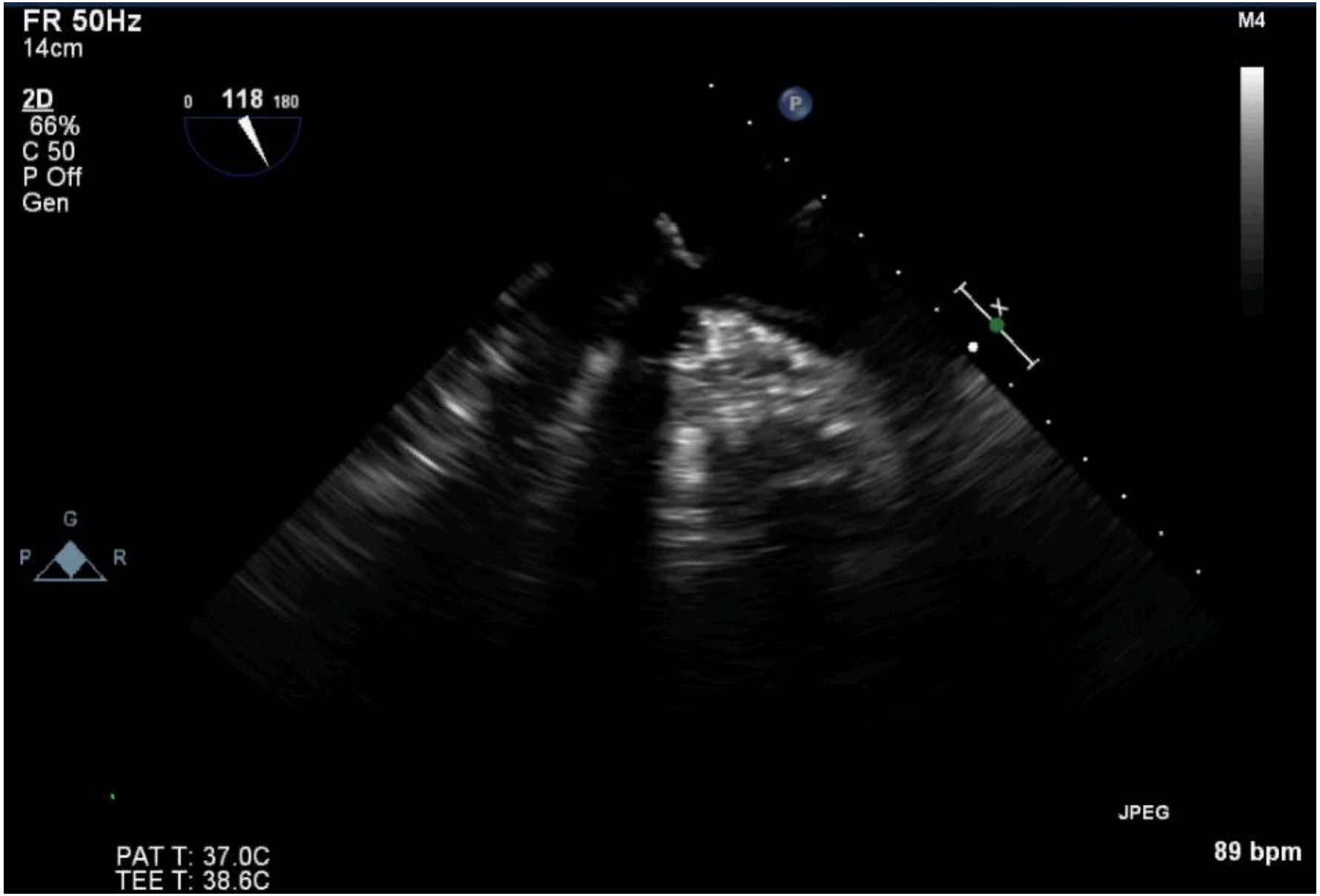
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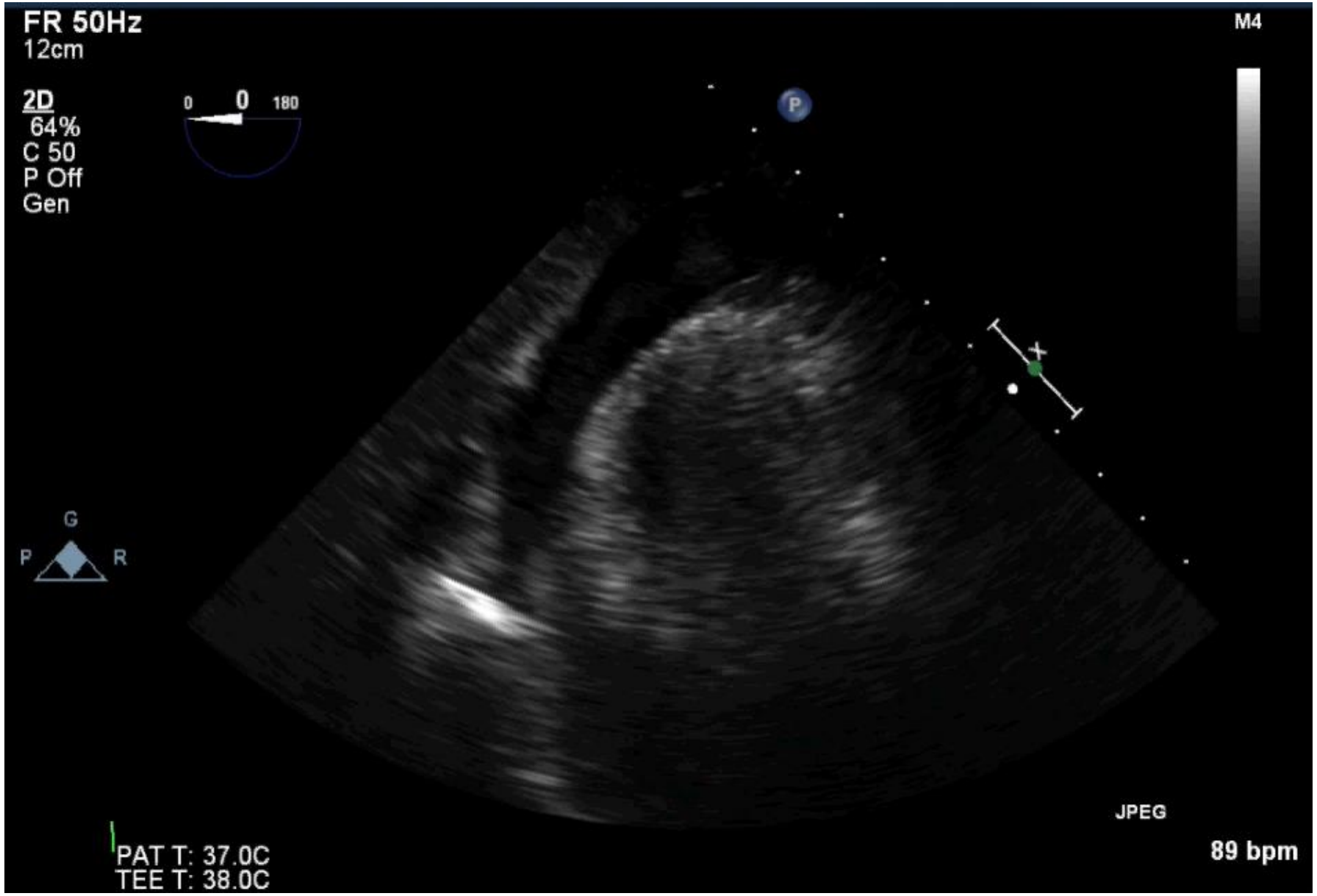
TEE T: 38.6C
89 bpm

ETIOLOGIES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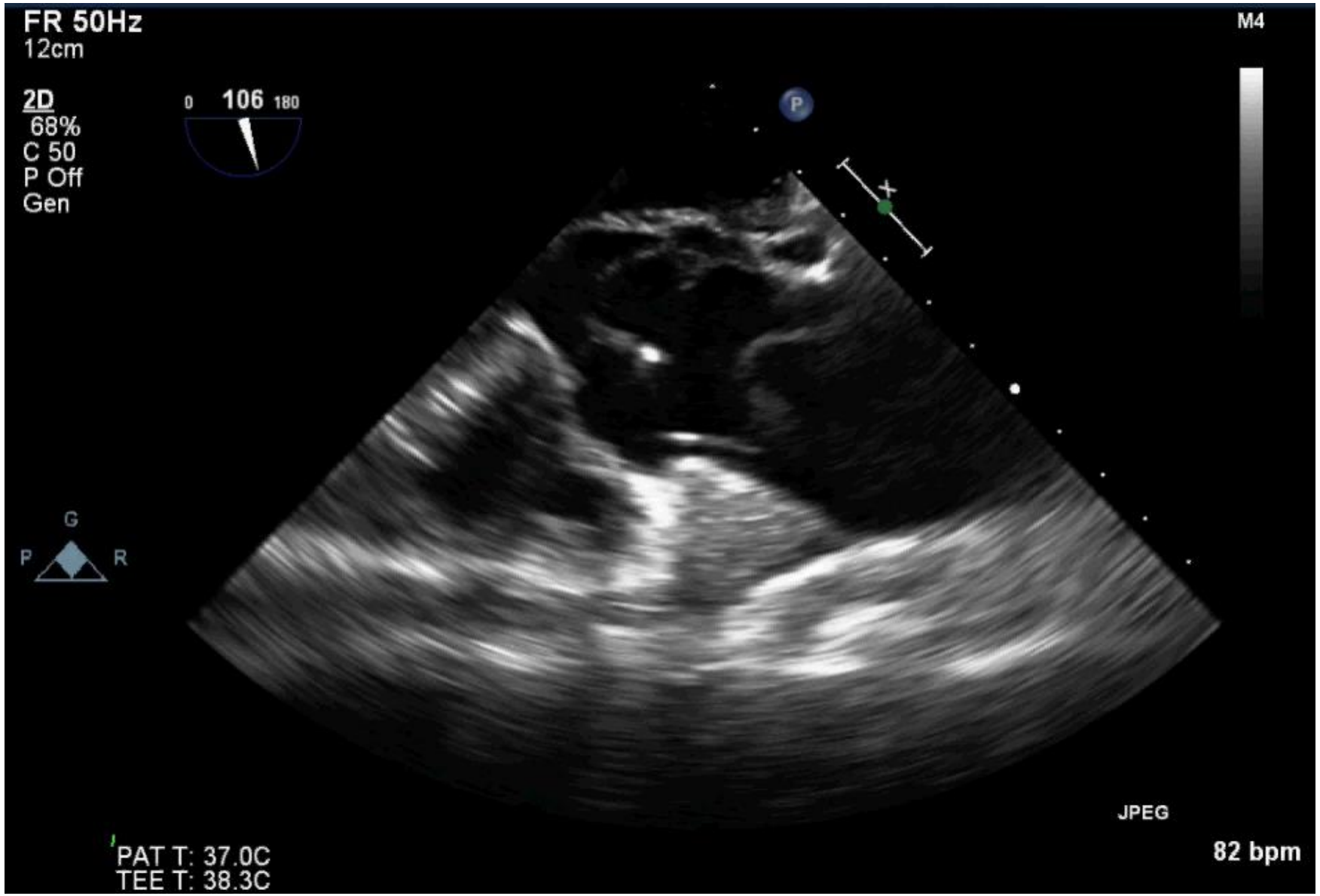
TEE T: 38.0C
89 bpm

ETIOLOGIES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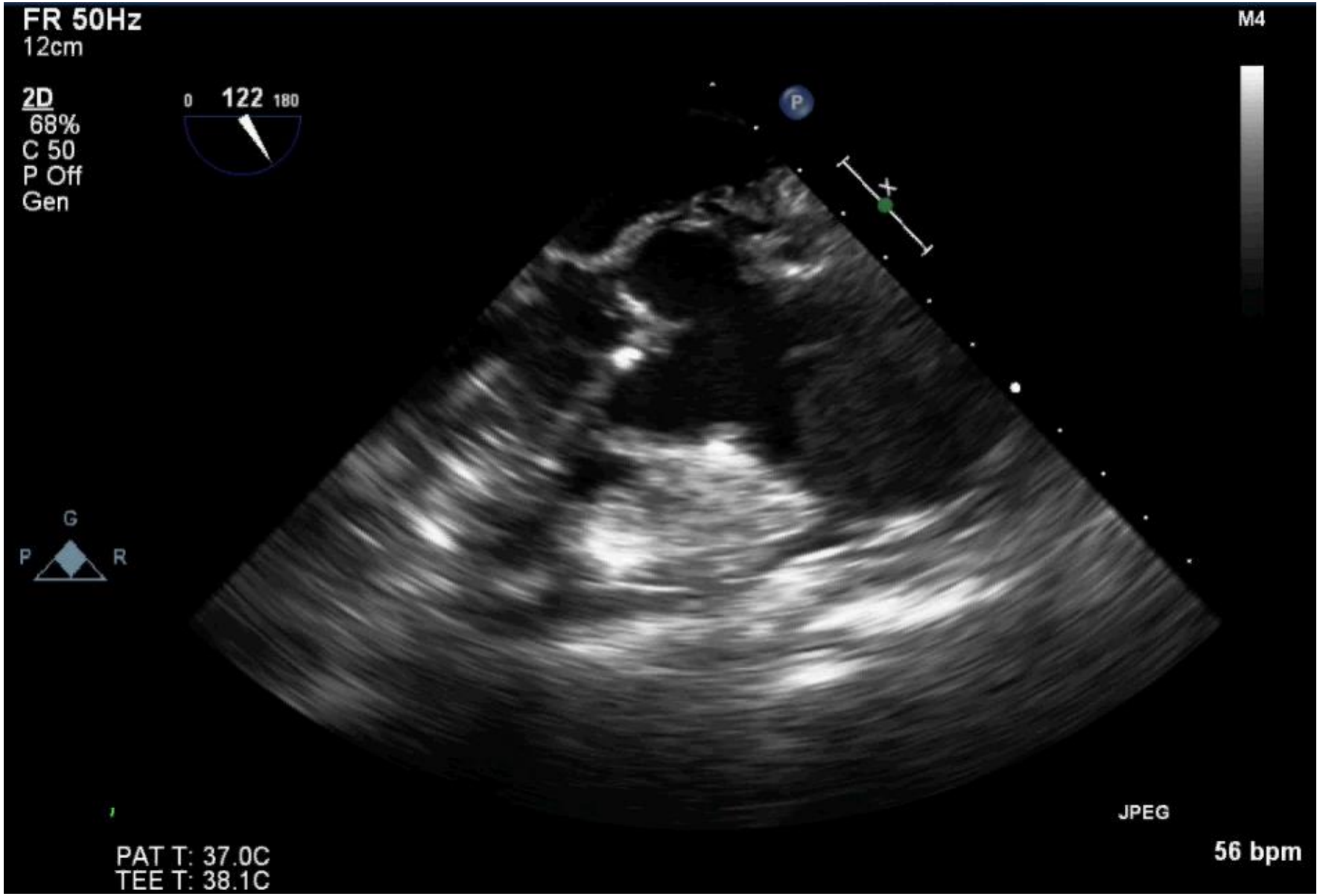
TEE T: 38.3C
82 bpm

ETIOLOGIES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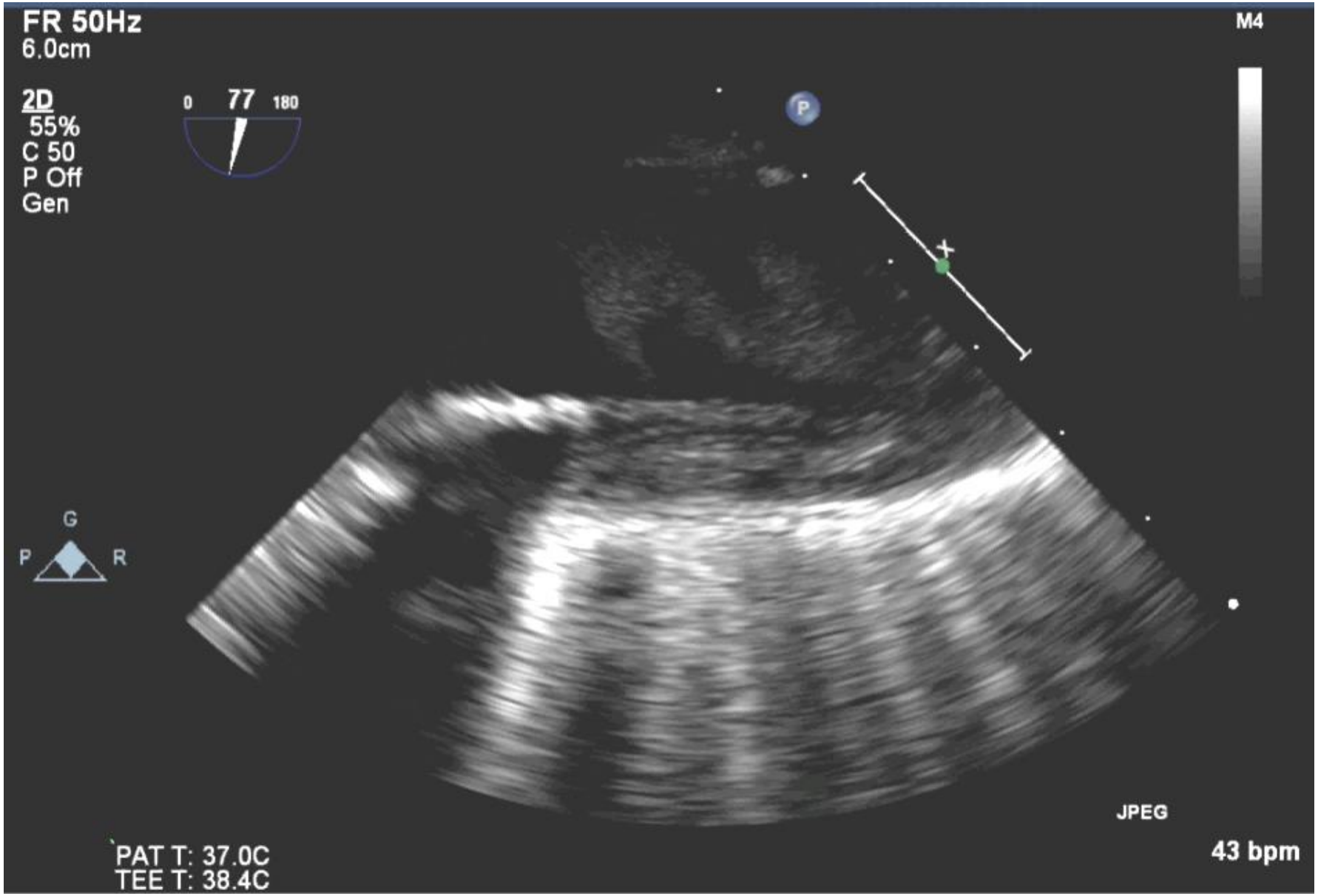
TEE T: 38.1C
56 bpm

ETIOLOGIES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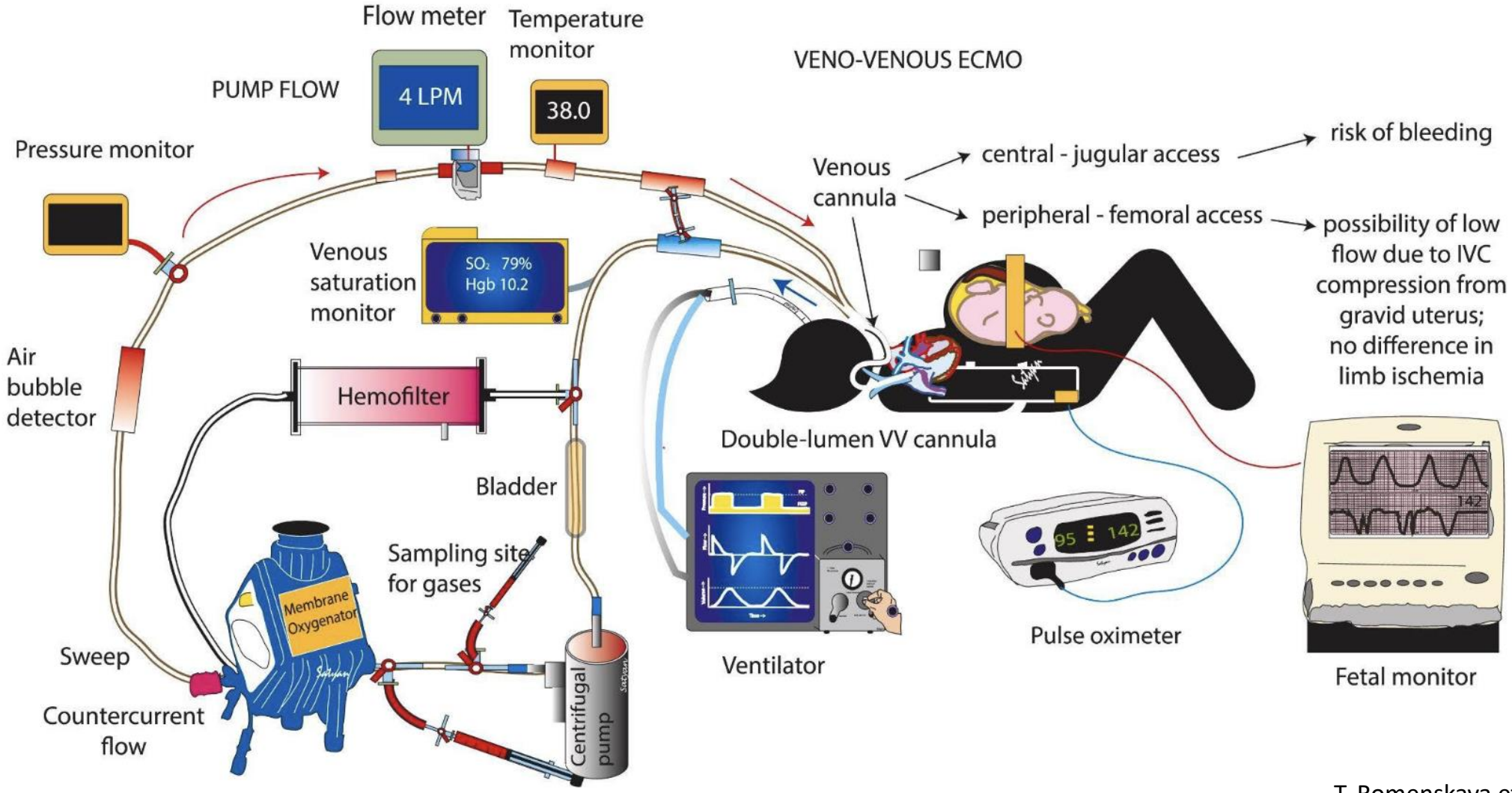
TEE T: 38.4C
43 bpm

ECLS IN PREGNANCY

- **Veno-Venous ECMO**



T. Romenskaya et al. **J Clin Med** 2024

ECLS IN PREGNANCY

- **Veno-Venous ECMO**

JAMA Network Open™

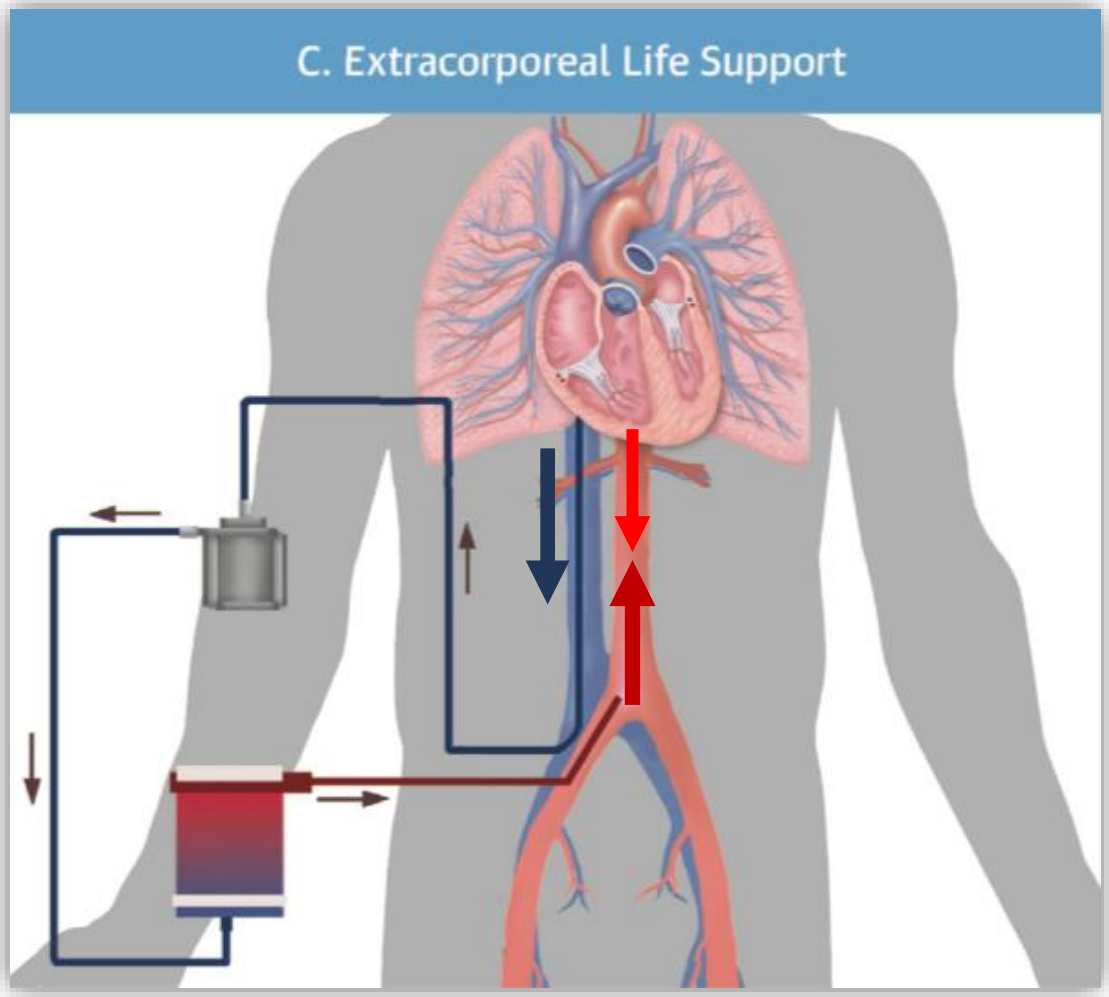
Original Investigation | Obstetrics and Gynecology

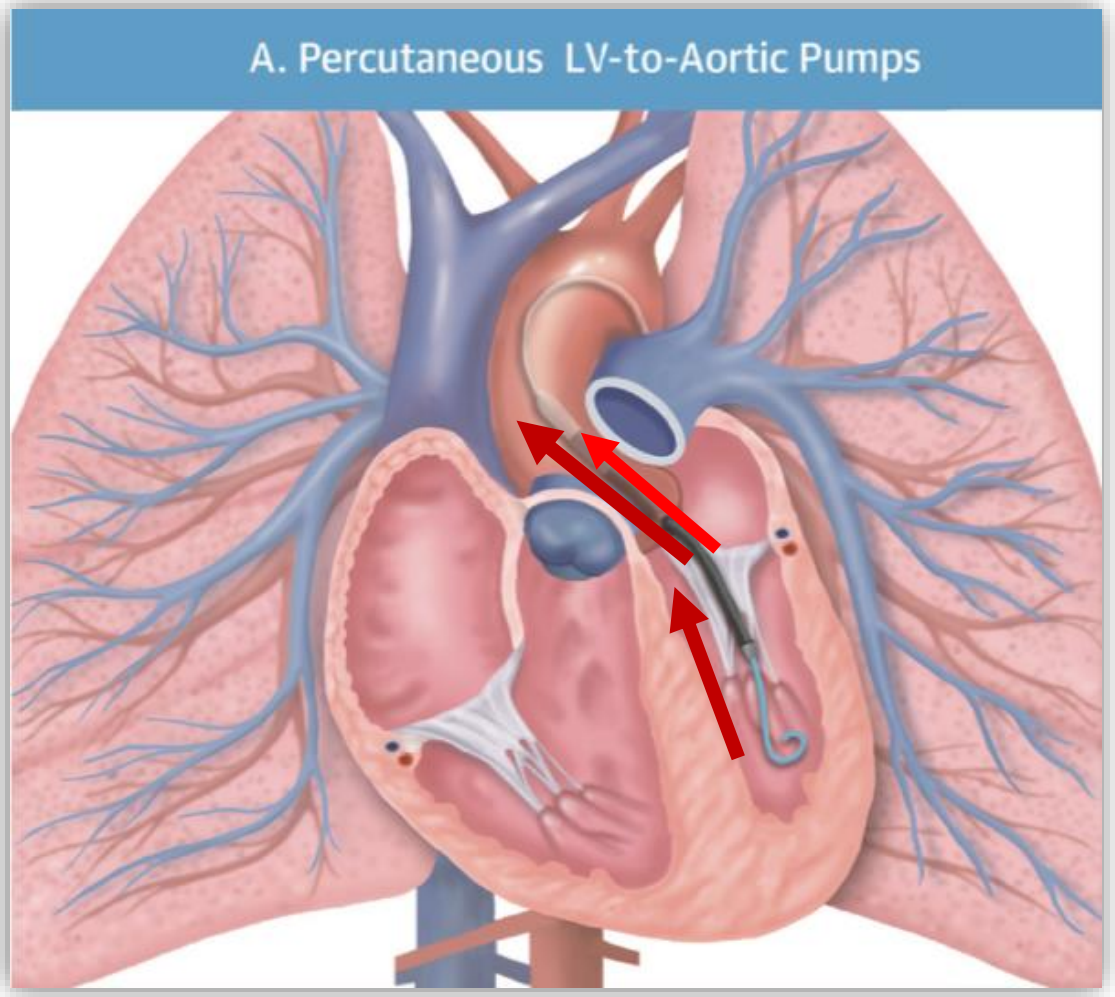
Outcomes Following Extracorporeal Membrane Oxygenation for Severe COVID-19 in Pregnancy or Post Partum

John J. Byrne, MD, MPH; Amir A. Shamshirsaz, MD; Alison G. Cahill, MD, MSCI; Mark A. Turrentine, MD; Angela R. Seasely, MD, MS; Joe Eid, MD; Caroline E. Rouse, MD; Michael Richley, MD; Nandini Raghuraman, MD, MSCI; Mariam Naqvi, MD; Yasser Y. El-Sayed, MD; Martina L. Badell, MD; CeCe Cheng, MD; James Liu, MD; Emily H. Adhikari, MD; Soha S. Patel, MD, MSPH; Erika R. O'Neil, MD; Patrick S. Ramsey, MD, MSPH

VA-ECMO/ECLS *Vs.* $_{P}$VAD (Impella®)

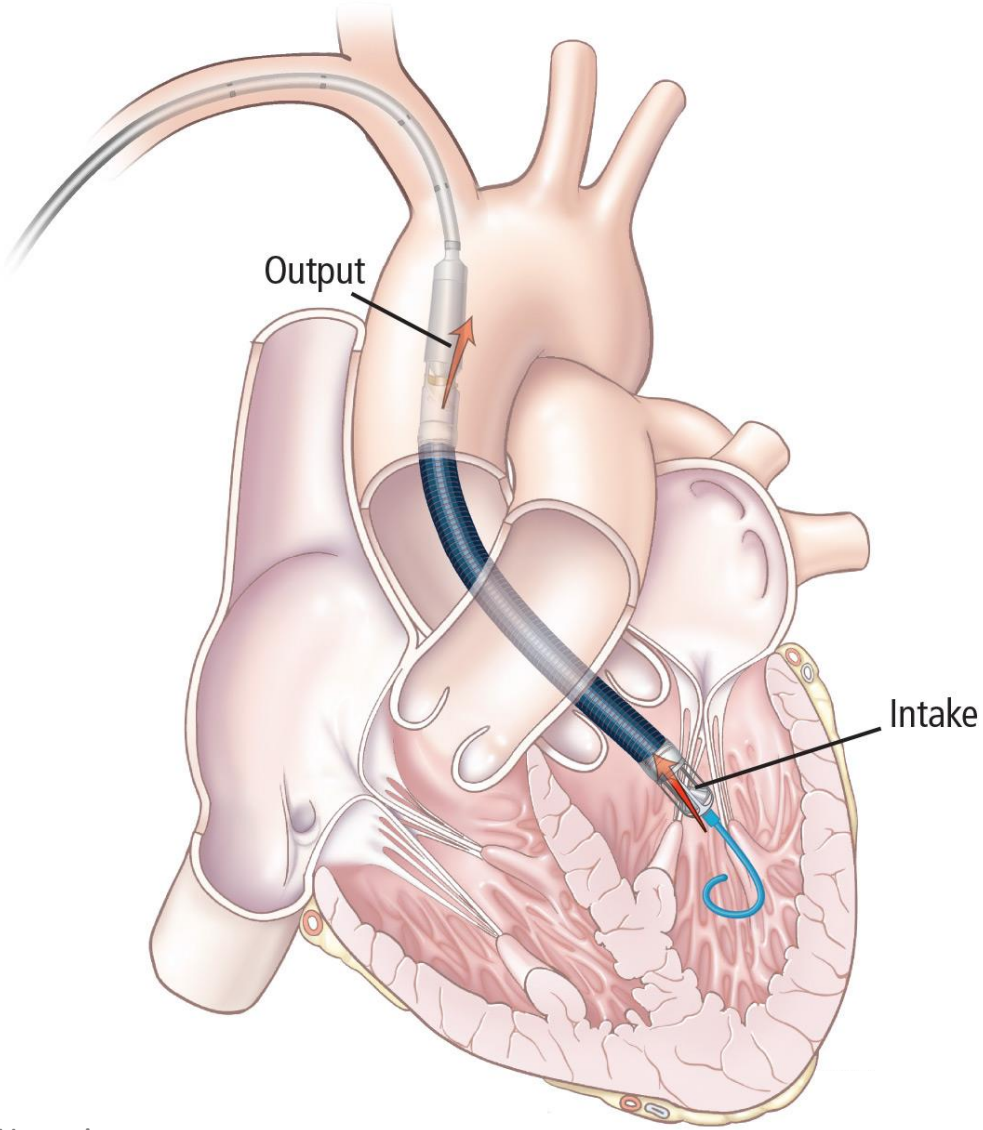
- Most Striking Difference = Reinjection Flow Direction & LV (Un)Loading





Burkhoff D. et al. **J Am Coll Card** 2015

IMPELLA® PHYSIOLOGICAL BACKGROUND



1. **↑ Coronary perfusion gradient**
   → ↑ Myocardial O_2 delivery **(MDO_2)**

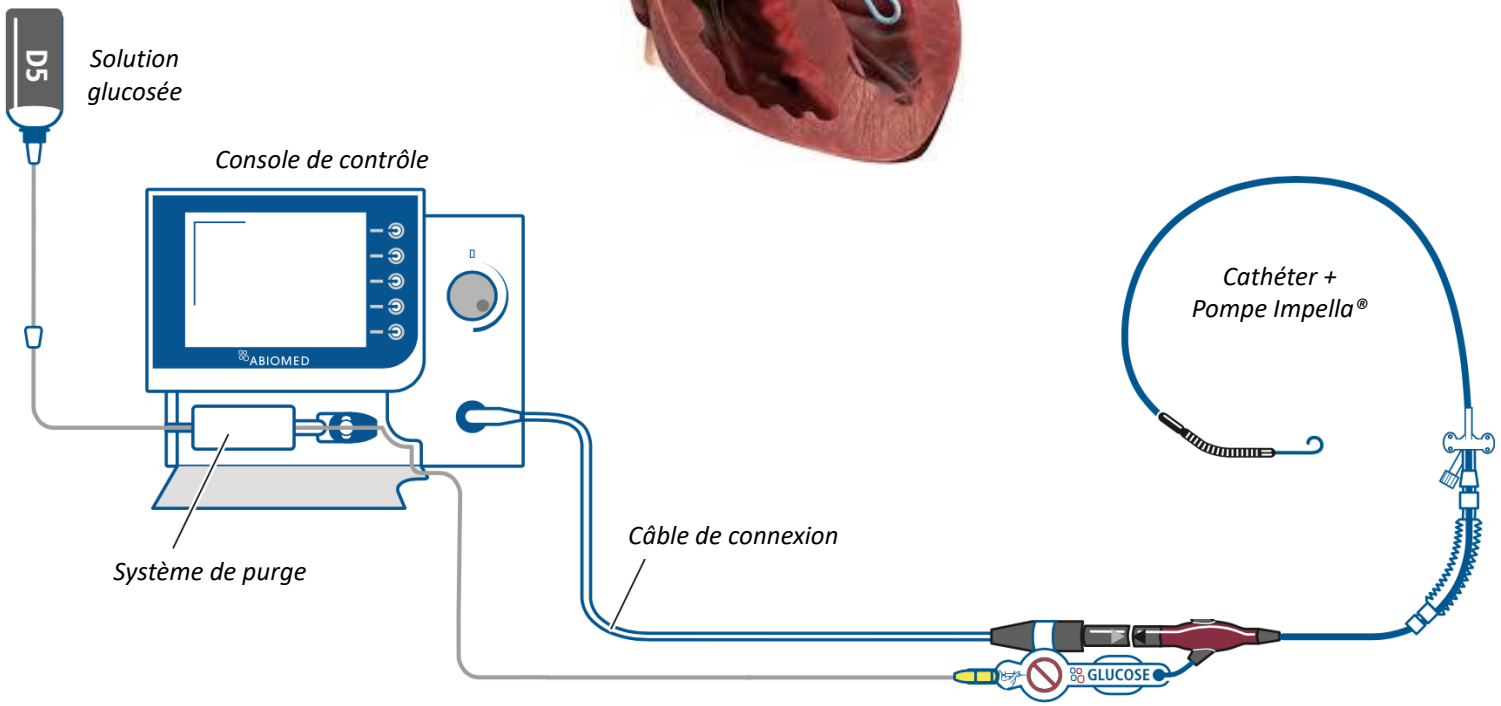
2. **Left Ventricle UNLOADING**
   → ↓ ↓ Myocardial O_2 consumption **(MVO_2)**

3. **Left heart cavities decongestion**
   → Pulmonary decongestion

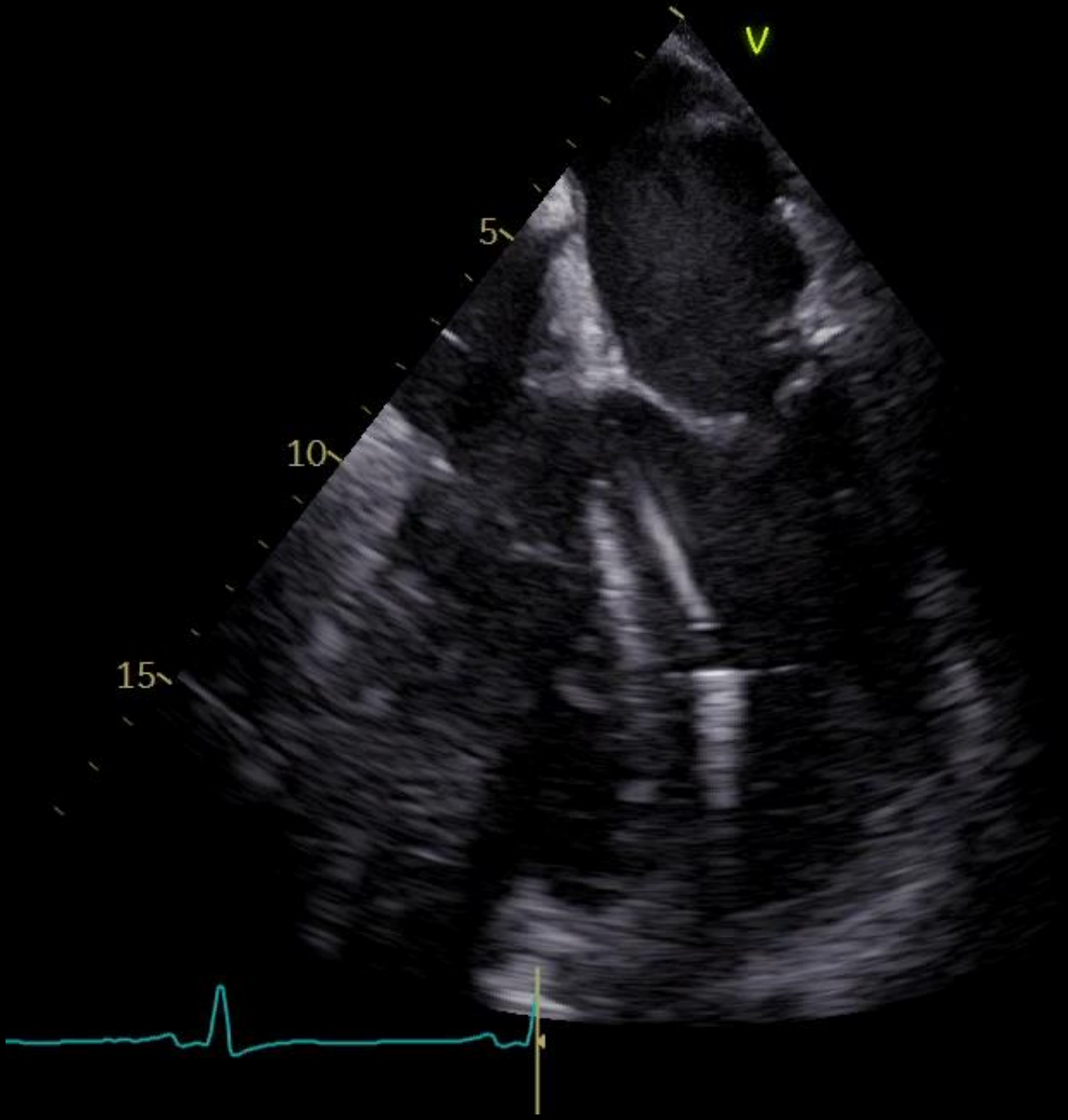
4. **Early awakening and Mobilization**
   (Impella®5.0 > CP)

+ Common advantages as for any MCS

IMPELLA® - CP


D5
Solution glucosée
Console de contrôle
ABIOMED
Système de purge
Câble de connexion
Cathéter + Pompe Impella®
GLUCOSE


Blood Inlet Area
Catheter diameter: 9Fr
Flow rate: up to 3.5 L/m
Blood Outlet Area
14FR Pump Motor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10
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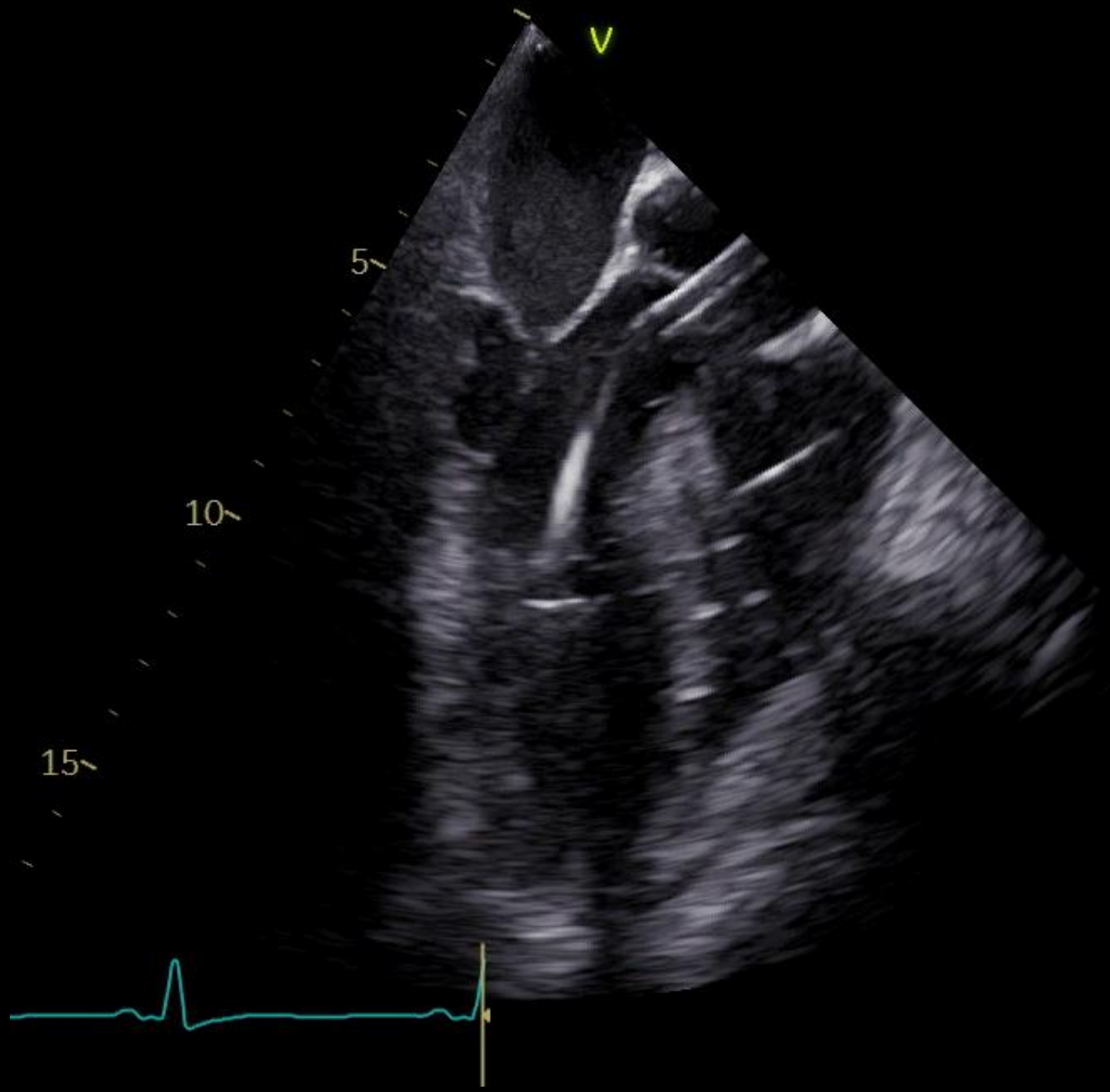
V
5
10
15


TAKE HOME MESSAGES

CONCLUSIONS

1. **Shock Recognition**
   - Doesn't need arterial hypotension
   - Requires organ hypoperfusion
   - Increased burden of CV disaeses
2. **Resuscitation Chain of Survival**
   - **Early BLS**
   - Multidisciplinary team approach
   - **CPR specificities**
3. **New Perspectives**
   - Advanced Echocardiography
   - ECLS - pVAD

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PRAC³ Meeting

Preclinical Research in Acute Cardiac and Critical Care