

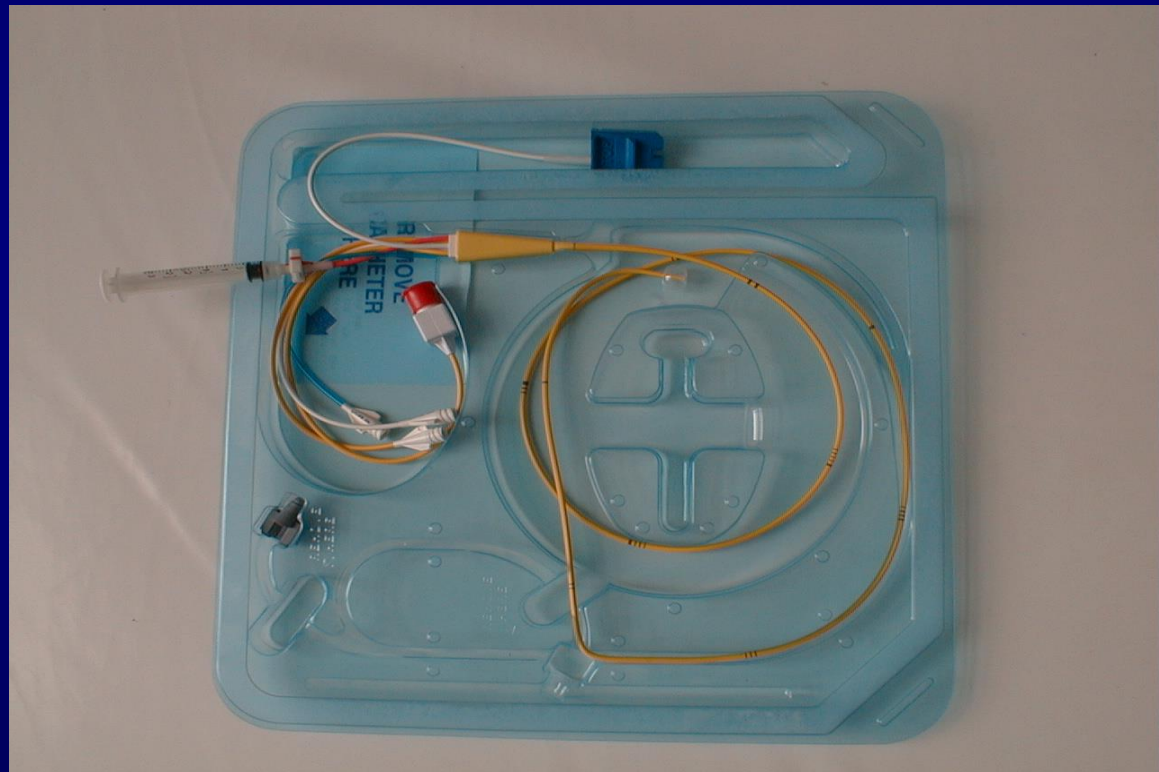


Circulatory failure

Jan Bělohávek, M.D.

CCU

Dept. of Medicine II.



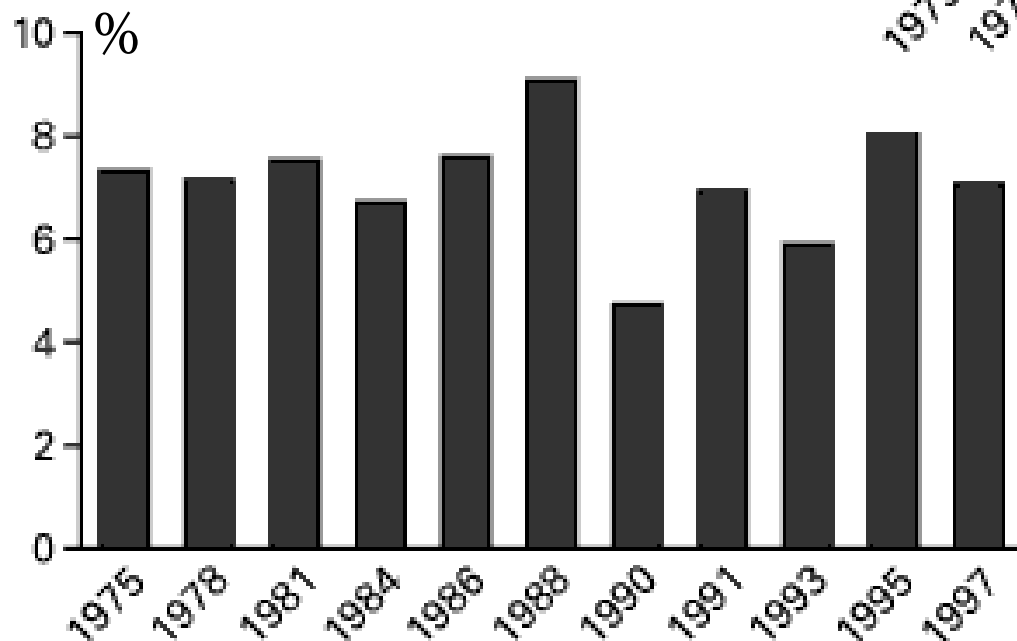
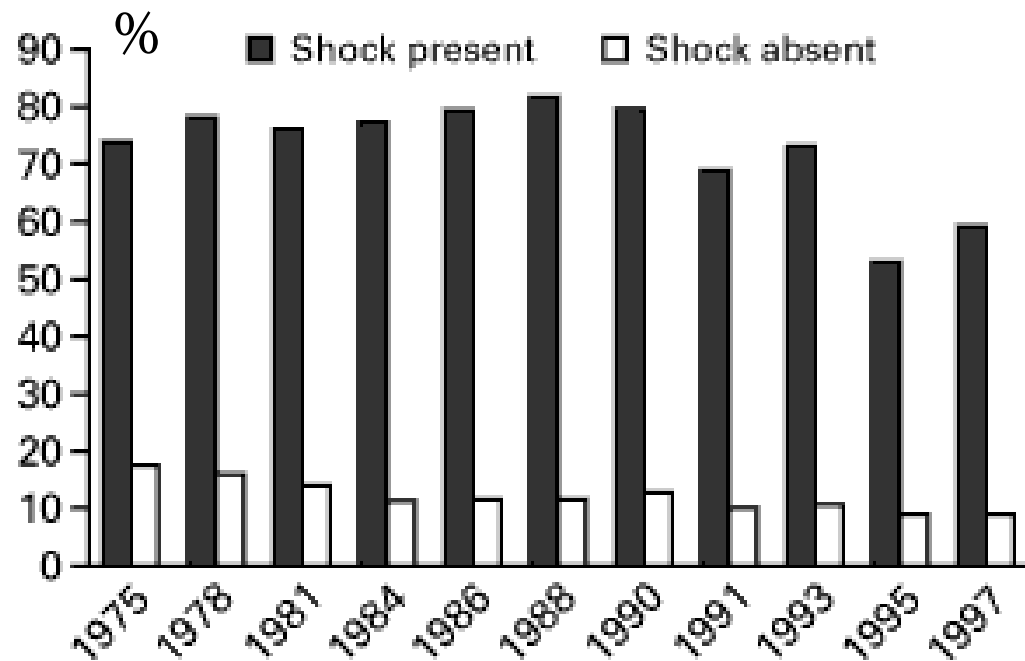


*...MEDICAL CATASTROPHIES
WITH POOR PROGNOSIS...*



Mortality

Incidence



Temporal trends in CS complicating AMI /Goldberg, NEJM, 1999/



Critical illness

Age

hemodynamics

respiration/ventilation

mineral metabolism

acid-base balance

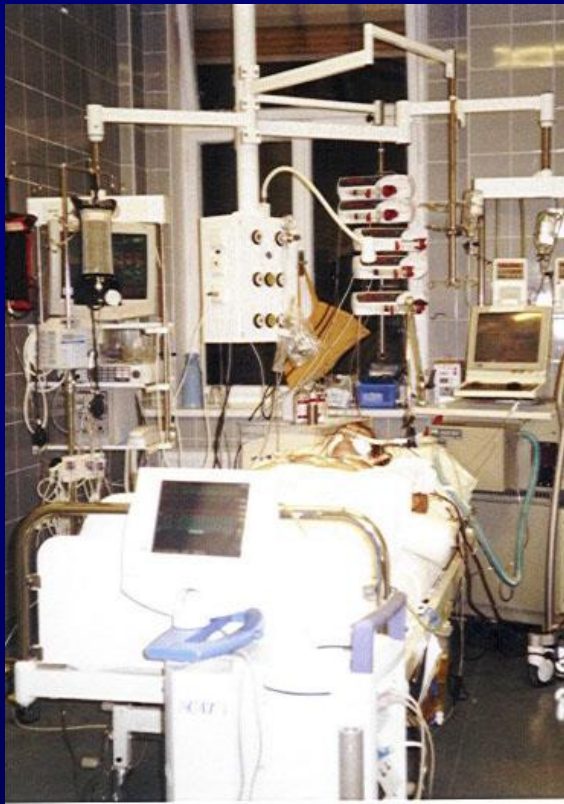
coagulation

immunity

CNS/“psycho“

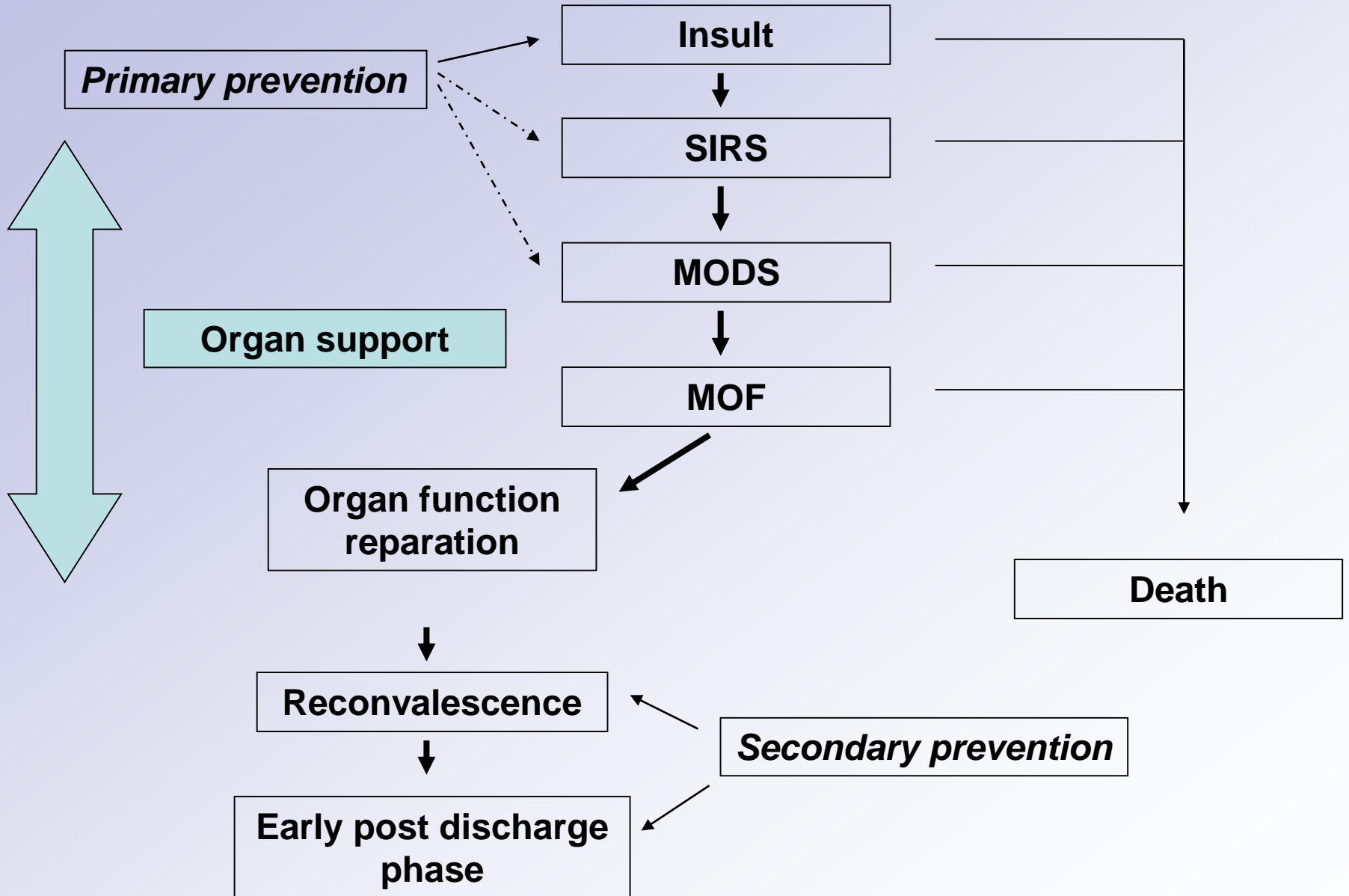
nutrition

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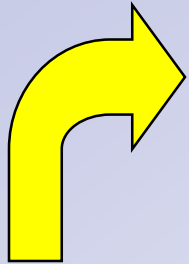
Comorbidities

Critical illness

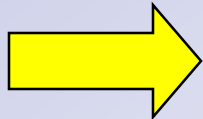


Shock definition

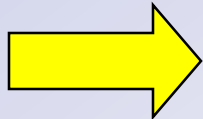
Acute circulatory failure with inadequate distribution and perfusion in relation to metabolic tissue requirements leading to generalized cellular hypoxia



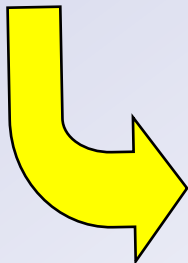
Cardiogenic shock (AMI, myocarditis, contusion, hemodynam. significant arrhythmia, acute valvular dysfunction, hypertension crisis)



Obstructive shock (PE, tamponade)



Hypovolemic shock (bleeding, dehydration)



Distributive shock (septic, SIRS, anaphylactic, neurovasoparalytic)

(Systemic Inflammatory Response Syndrome)

SIRS

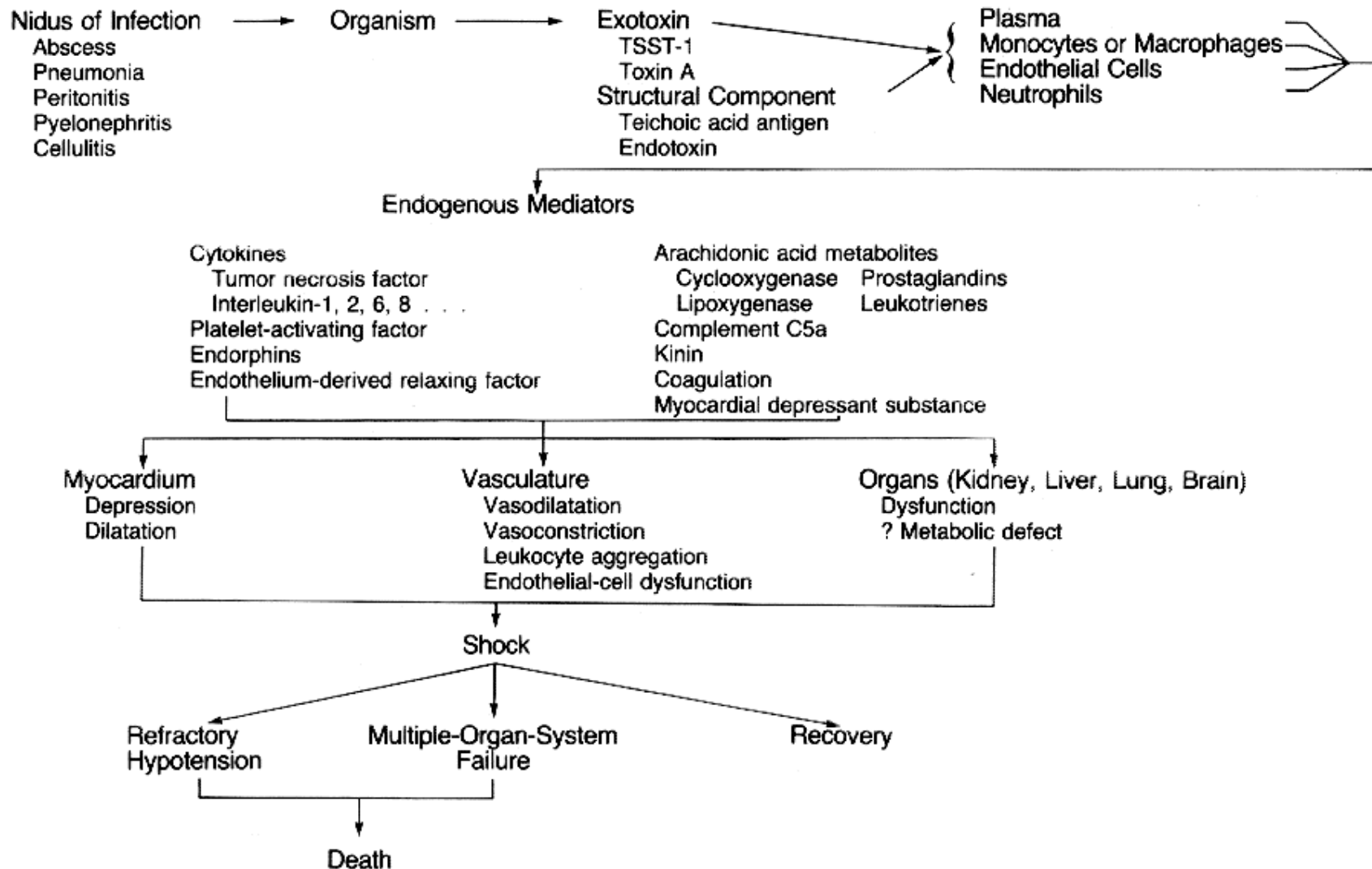
Diagnostic criteria:

- Temp $> 38\text{ }^{\circ}\text{C}$ or $< 36\text{ }^{\circ}\text{C}$
- Tachycardia $> 90/\text{min}$
- Breathing frequency $> 20/\text{min}$ or $\text{PaCO}_2 < 4,3\text{ kPa}$
- Leucocytes $> 12 \times 10^9/\text{l}$ or $< 4 \times 10^9/\text{l}$ nebo
> 10% immature forms of leu

Develops as a reaction to various strong stimuli/insults (bakteriemia, pancreatitis, burns, trauma and large AMI and others jiné), needs 2 or more criteria to fulfill SIRS definition

Pathophysiological sequency

SIRS, MODS





Organ failure

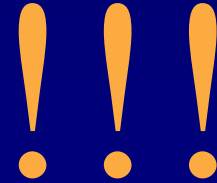
(modified Goris score)

- *lungs* **mechanical ventilation**
- *kidneys* **creatinin > 170, need for (C)RRT**
- *liver* **bilirubin > 100, 3x > AST, ALT**
- *coagulation* **TRC < 50.000, hemorrhagic diatesis**
- *GIT* **GI bleeding**
- *circulatory* **hypotension – volume load, inotropes**
- *CNS* **GCS < 8**



Cardiogenic shock – essentials of dg.

- ✦ decreased urine output
- ✦ impaired mental function
- ✦ cool extremities
- ✦ distended neck veins
- ✦ hypotension with evidence of peripheral and pulmonary venous congestion





Causes of cardiogenic shock

✦ Nonmechanical

✦ Mechanical

bed-side echocardiography

=

the cornerstone of diagnosis

✦ Arrhythmias (brady,
tachy)

✦ critical aortic stenosis
✦ pericardial stenosis



Cardiogenic shock

- ✦ amount of myocardium affected (40-45%)
- ✦ A. compensated hypotension (arterial baroreceptors increase SVR)
- ✦ B. decompensated hypotension (further fall in CO – fall in pressure and tissue perfusion)
- ✦ C. irreversible shock – irreversible myocardial and other organ failure – MODS - MOF



Signs and symptoms

- ✱ Pain – (AMI, UA) – analgesia, sedation
- ✱ pale, anxious, somnole, confused
- ✱ LCO – hypotension (< 90 mmHg)
- ✱ tachycardia – gallop, (S3), bradycardia with decomp.)
- ✱ neck veins distended
- ✱ cool extremities
- ✱ congested, distended liver, tender to palpation
- ✱ rales on lung auscultation
- ✱ oliguria, acidosis



Clinical scenario (pts. with AMI)

- ✦ older
- ✦ history of prior MI od CHF
- ✦ anterior MI or (posterior post CABG, known CAD)
- ✦ prognosis is poor – 70 % mortality
- ✦ usually 3VD, „dominant“ LAD closure
- ✦ thrombotic occlusion of IRA



Pathophysiology

- ✦ vicious cycle – coronary obstruction → myocardial ischemia → decr. contractility and LV function → decr. BP → coronary perfusion → further ischemia and extension of necrosis until not enough myocardium

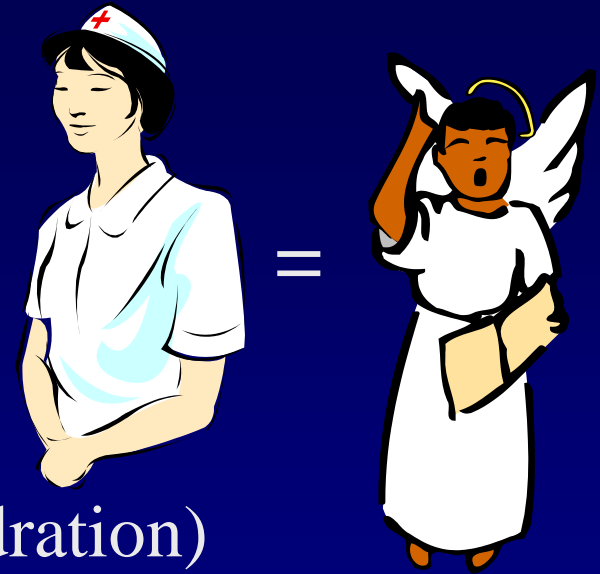


Diagnosis

- ✦ marked prolonged hypotension
- ✦ $CI < 2,2 \text{ l/min/M}^2$
- ✦ elevated left ventricular filling pressures =
PAOP $> 18 \text{ mmHg}$
- ✦ echocardiographic signs of low EF
- ✦ immediate hemodynamic, echocardiographic
and angiographic evaluation
- ✦ exclude mechanical complications



Monitoring



- ✦ Clinical status – vital signs (hydration)
- ✦ ECG
- ✦ Hemodynamics – IBP, CVP, PAOP, CO
- ✦ Respiration, ABGs, pulse oximetry
- ✦ Fluid balance
- ✦ Laboratory (minerals, U, kr, lactate, cardiac enzymes, liver tests, coagulation, total blood count)
- ✦ the best monitor is a **good nurse**



Management

- ✦ general measures – analgesia, sedation (Morphine, Diazepam)
- ✦ + inotropic drugs (dobutamine, dopamine, PDE inhibitors) doses ...
- ✦ vasodilators ?
- ✦ noradrenaline
- ✦ Mechanical circulatory support – IABC, ECMO, LVAD
- ✦ reperfusion strategies – TL, PCI, CABG ?



Cardiogenic shock

Early diagnosis

- History + PE
- ECG
- TTE (TEE)
- Lab
- CXR
- PAC

Initial therapy

- oxygen, ventilation
- i.v. acces
- monitoring
- analgesia, sedation
- hemodynamic support

↓tissue perfusion

↓Catechol. + IABC

Perfusion OK, no
congestion

Perfusion OK, congestion

diuretics, vasodilators, PEEP

Reperfusion

coronarography

TL + IABC

PCI

CABG

persistent shock

improvement



Cardiogenic shock in AMI (1)

- ✦ state of inadequate tissue perfusion caused by cardiac dysfunction
- ✦ in 5-15% patients with AMI
/Califf, NEJM 1994/
- ✦ mortality 50-80%
/Hollenberg, Ann Intern Med 1999/
- ✦ early and long-term survival depends on patency of **infarct related artery**
/Goldberg, NEJM 1999/

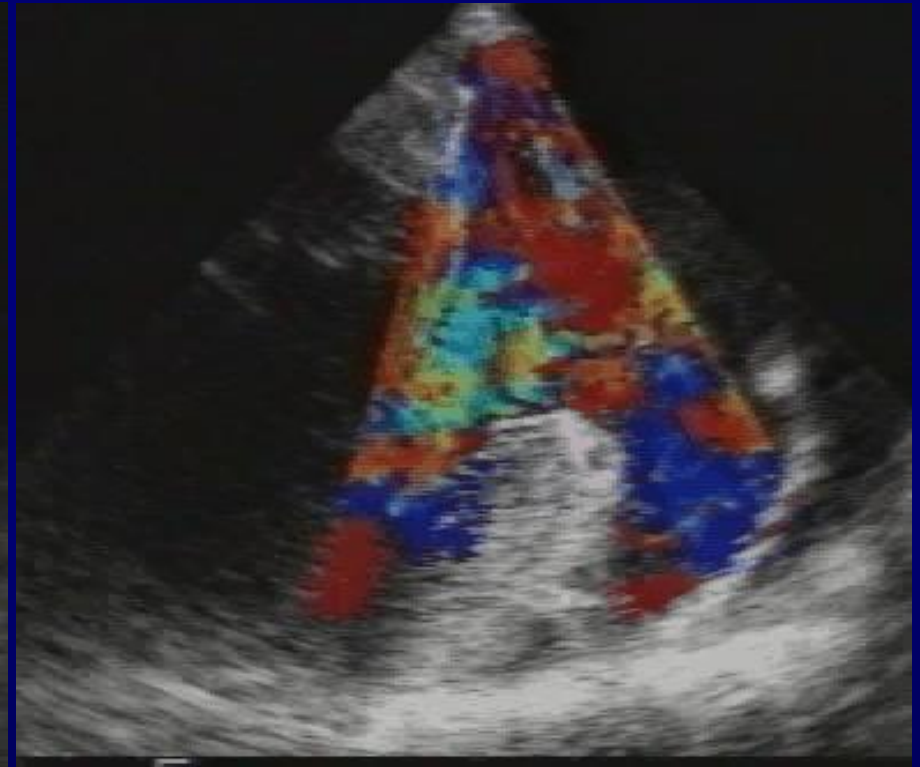


Cardiogenic shock in AMI (2)

- ✦ failure of thrombolysis = increased morbidity and mortality
/Serryus, Eur Heart J 1999/
- ✦ aggressive measures including early revascularization and intraaortic balloon counterpulsation may decrease mortality
/Berger, Circulation 1999/
- ✦ new techniques in PTCA (stenting and platelet IIb/IIIa receptor antagonists) bear additional favourable effect in failing standard PTCA
/Antoniucci, JACC 1999; Tchong, Am J Cardiol 1996/



AMI + cardiogenic shock



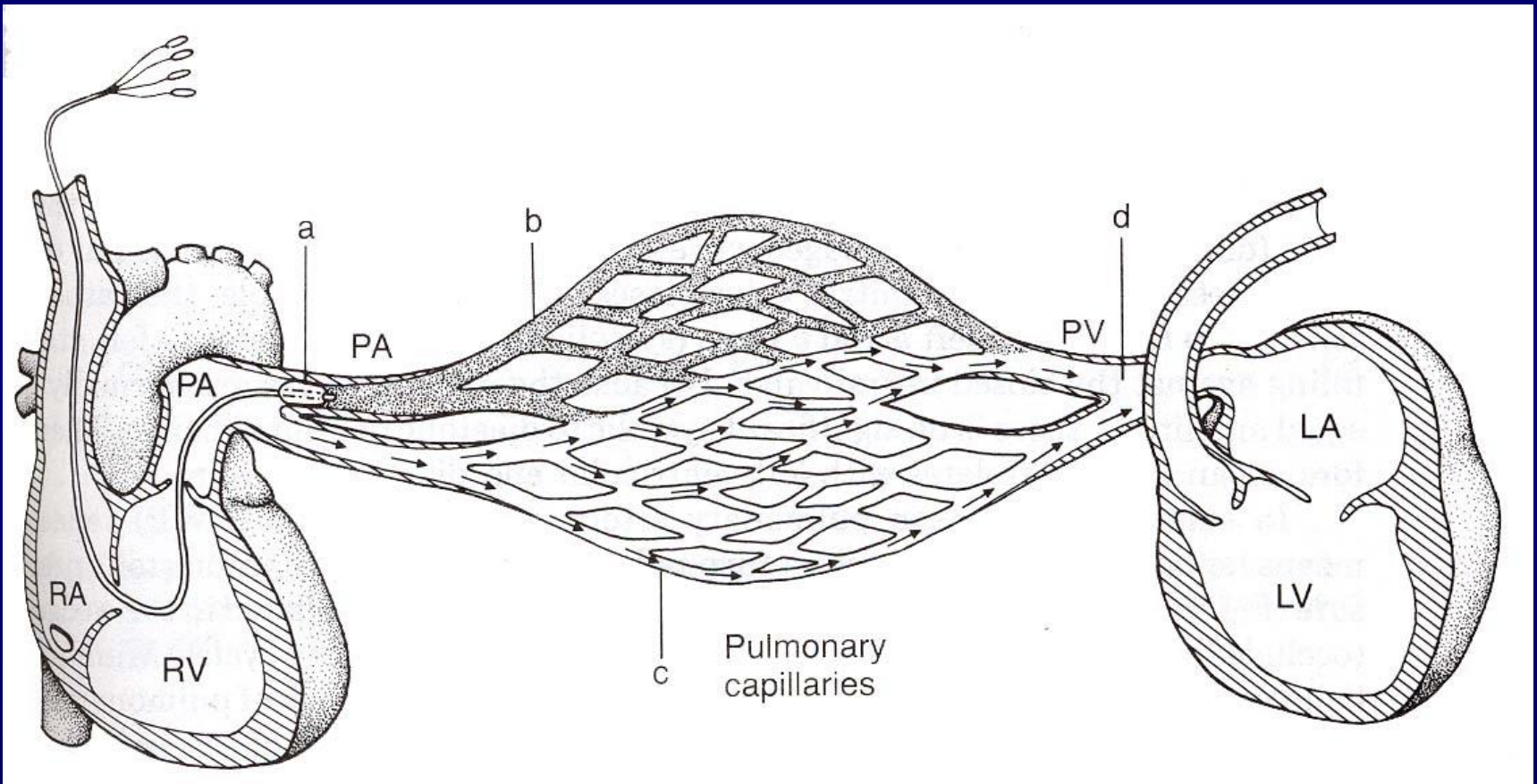


Organ support



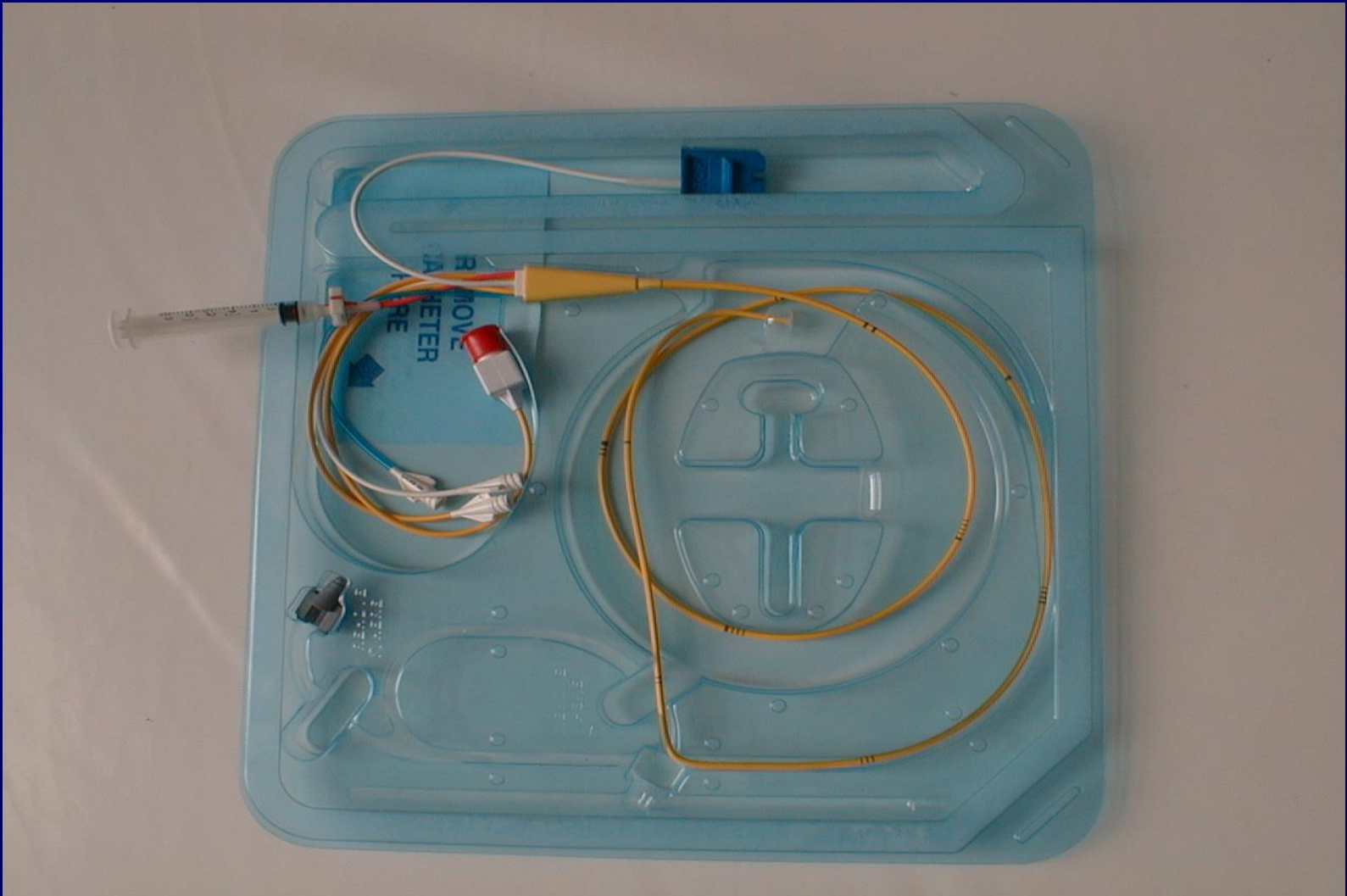


Pulmonary artery catheter (1)





Pulmonary artery catheter (2)





Pulmonary artery tracings

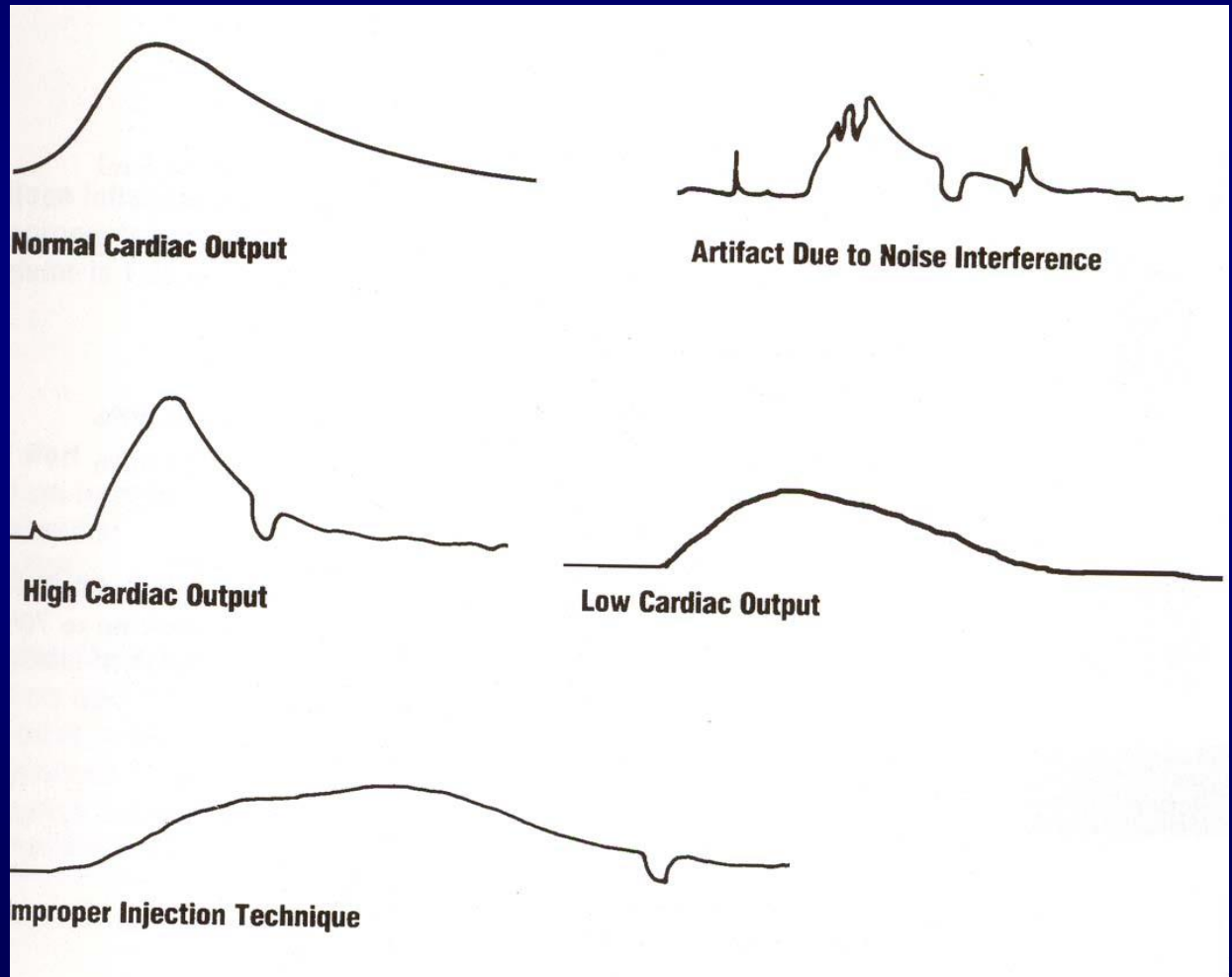


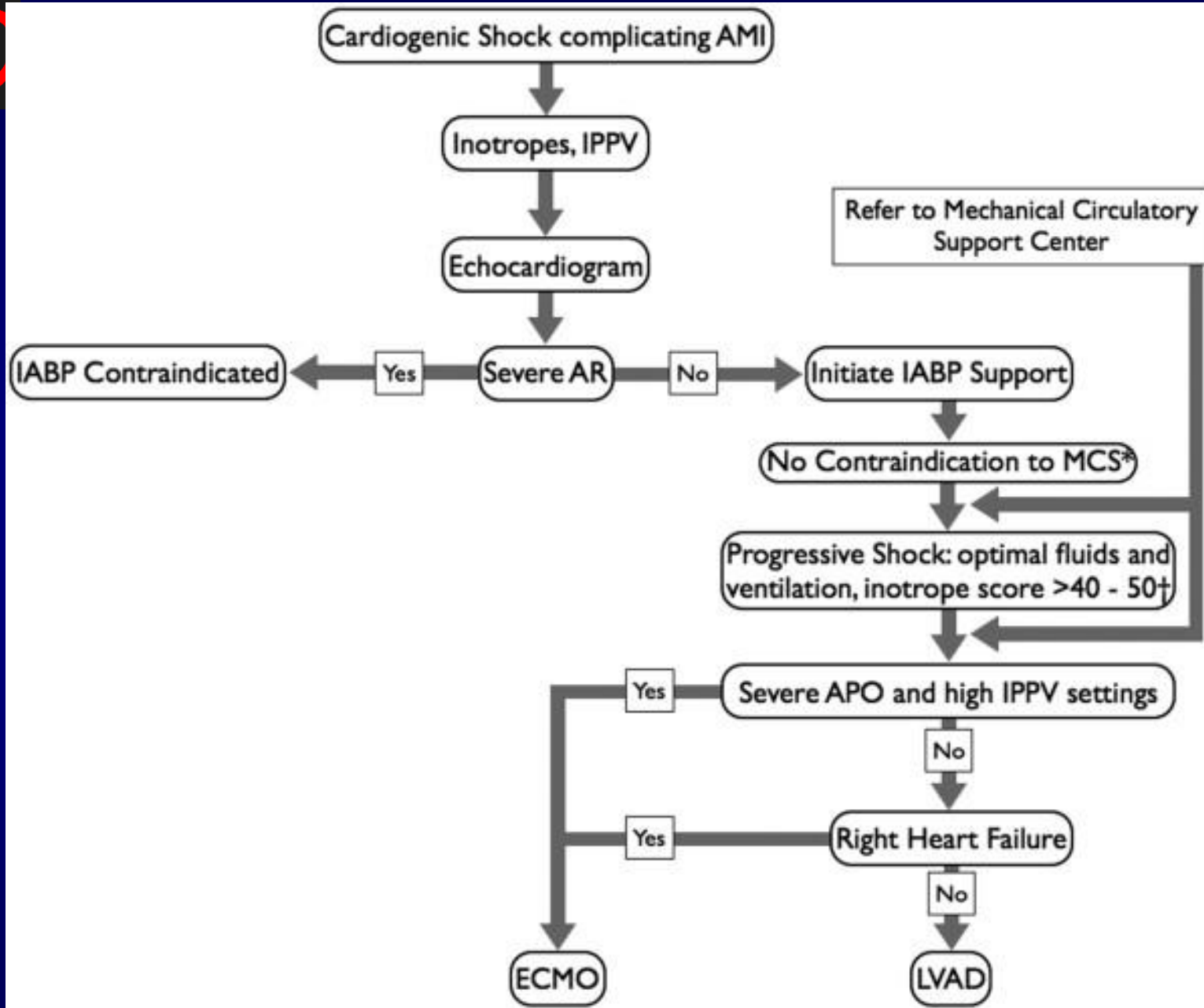


Thermodilution cardiac output

/Swan, Ganz 1970/

$$CO = \frac{V \times (TB - TI)}{A}$$





Number of patients in studies

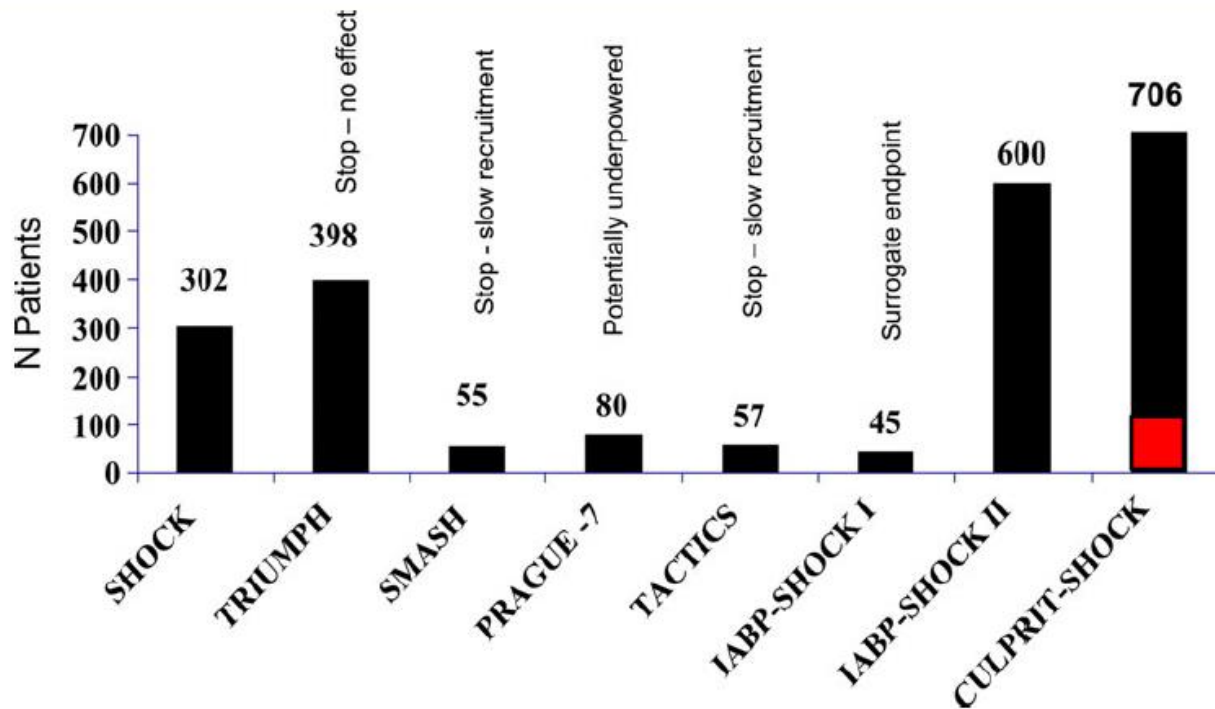


Figure 5 Number of patients included in major randomized cardiogenic shock trials.

ECMO – Cardiogenic Shock trial

Rapidly deteriorating (A) or severe (B) cardiogenic shock:

A. Rapidly deteriorating cardiogenic shock is defined as progressive hemodynamic instability necessitating repeated bolus administration of vasopressors to maintain mean arterial pressure > 50 mmHg + impaired left ventricle systolic function (Left ventricle ejection fraction (LVEF) < 35% or LVEF 35-55% in case of severe mitral regurgitation or aortic stenosis)

or

B. In severe cardiogenic shock all following criteria should be met:

1. Hemodynamic:

Cardiac Index (CI) < 2.2 L/min/m² + norepinephrine dose > 0.1 µg/kg/min + dobutamin dose > 5 µg/kg/min

or Systolic blood pressure < 100 mmHg + norepinephrine dose > 0.2 µg/kg/min + dobutamin dose > 5 µg/kg/min + (LVEF < 35% or LVEF 35-55% + severe mitral regurgitation or aortic stenosis)

2. Metabolic:

Lactate – two consecutive values ≥ 3 mmol/L (with at least 30 min between samples), with non-decreasing trend on steady doses of inotropes and/or vasopressors

or SvO₂ – two consecutive values < 50% (with at least 30 min between measurements), with non-increasing trend on steady doses of inotropes and/or vasopressors

3. Hypovolemia must be excluded:

Central venous pressure > 7 mmHg or pulmonary capillary wedge pressure > 12 mmHg

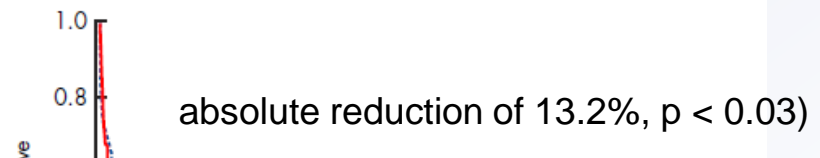
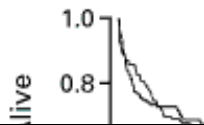
PCI a kardiogenního šok

/ ACC/AHA Guidelines for PCI, JACC, 2001, Menon, V. et al. Heart 2002;88:531-537/

*Early revascularization in AMI complicated by cardiogenic shock -
SHOCK trial /NEJM, 1999/ n = 302 pacientů*

revaskularizace (PTCA +CABG +/- IABK vs. konz. terapie (TL +/- IABK)

- **30-ti denní mortalita** 46,7 vs. 56% (41 vs. 57% u < 75 let, stejná u > 75 let), **celkově obdobná**
- ↓ mortalita revaskularizovaných za 6 měsíců (50 vs. 60%) **i za rok**
/JAMA, 2001/



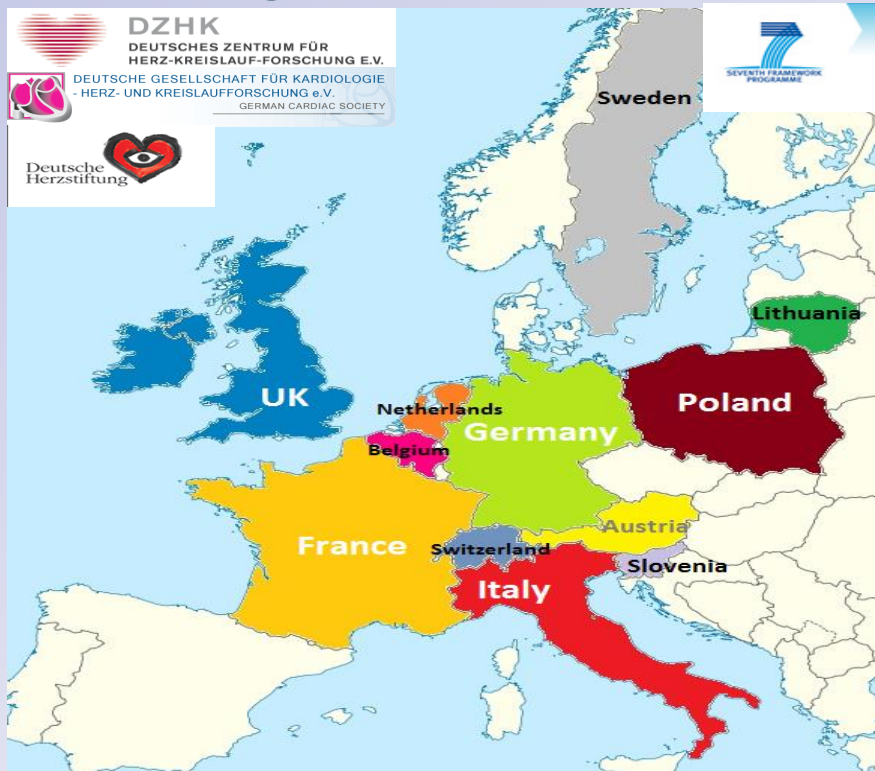
***Koronární stenting u kardiogenního šoku
je nejsilnější předpovědní faktor přežití...***

GRACE registr

PCI Strategies in Patients with Acute Myocardial Infarction and Cardiogenic Shock

H. Thiele, I. Akin, M. Sandri, G. Fuernau, S. de Waha, R. Meyer-Saraei, P. Nordbeck, T. Geisler, U. Landmesser, C. Skurk, A. Fach, H. Lapp, J.J. Piek, M. Noc, T. Goslar, S.B. Felix, L.S. Maier, J. Stepinska, K. Oldroyd, P. Serpytis, G. Montalescot, O. Barthelemy, K. Huber, S. Windecker, S. Savonitto, P. Torremante, C. Vrints, S. Schneider, S. Desch, and U. Zeymer, for the CULPRIT-SHOCK Investigators*

Investigator-initiated European multicenter trial; 1:1 randomization



PI + Coordination:

Holger Thiele

National Coordinators (83 centers):

- Kurt Huber
- Gilles Montalescot
- Jan Piek
- Holger Thiele
- Pranas Serpytis
- Janina Stepinska
- Christiaan Vrints
- Marko Noc
- Keith Oldroyd
- Stefan Windecker
- Stefano Savonitto

Selected demographics

Previous myocardial infarction — no./total no. (%)	60/339 (17.7)	53/335 (15.8)
Previous stroke — no./total no. (%)	29/341 (8.5)	20/336 (6.0)
Known peripheral artery disease — no./total no. (%)	43/341 (12.6)	37/337 (11.0)
Previous PCI — no./total no. (%)	64/339 (18.9)	63/335 (18.8)
Previous coronary-artery bypass grafting — no./total no. (%)	20/341 (5.9)	13/337 (3.9)
Signs of impaired organ perfusion — no./total no. (%)		
Altered mental status	237/341 (69.5)	224/341 (65.7)
Cold, clammy skin and limbs	233/338 (68.9)	236/335 (70.4)
Oliguria	80/334 (24.0)	93/326 (28.5)
Arterial lactate >2.0 mmol/liter	216/334 (64.7)	224/330 (67.9)
Fibrinolysis <24 hr before randomization — no./total no. (%)	19/341 (5.6)	15/341 (4.4)
Resuscitation before randomization — no./total no. (%)	177/341 (51.9)	189/342 (55.3)
ST-segment elevation myocardial infarction — no./total no. (%)	206/335 (61.5)	209/330 (63.3)
Anterior ST-segment elevation myocardial infarction — no./total no. (%)	108/205 (52.7)	114/206 (55.3)
Left bundle-branch block — no./total no. (%)	52/335 (15.5)	47/331 (14.2)

Treatment

Characteristic	Culprit only PCI (n=344)	Multivessel PCI (n=342)	
Femoral access; n/total (%)	287/343 (83.7)	277/342 (81.0)	0.36
Radial access; n/total (%)	61/343 (17.8)	66/342 (19.3)	0.61
Stent implanted in culprit lesion; n/total (%)	326/343 (95.0)	324/342 (94.7)	0.86
Drug-eluting stent in culprit lesion; n/total (%)	305/326 (93.6)	308/324 (95.1)	0.41
TIMI-flow III post PCI of culprit lesion; n/total (%)	289/342 (84.5)	293/338 (86.7)	0.46
Immediate PCI of non-culprit lesions; n/total (%)	43/344 (12.5)	310/342 (90.6)	<0.001
Immediate complete revascularization; n/total (%)	26/344 (7.6)	277/342 (81.2)	<0.001
Total amount of contrast agent (ml); median (IQR)	190 (140-250)	250 (200-350)	<0.001
Staged PCI of non-culprit lesions; n/total (%)	60/344 (17.4)	8/341 (2.3)	<0.001
Staged coronary artery bypass surgery; n/total (%)	1/344 (0.3)	0/341	>0.99
Mechanical circulatory support; n/total (%)	99/344 (28.8)	95/342 (27.8)	0.77
Intraaortic balloon pump; n/total (%)	25/99 (25.3)	26/95 (27.4)	0.74
Impella 2.5; n/total (%)	16/99 (16.2)	18/95 (18.9)	0.61
Impella CP; n/total (%)	30/99 (30.3)	18/95 (18.9)	0.07
TandemHeart; n/total (%)	2/99 (2.0)	0/95	0.50
ECMO; n/total (%)	18/99 (18.2)	27/95 (28.4)	0.09
Mild hypothermia; n/total (%)	111/344 (32.3)	118/340 (34.7)	0.50
Mechanical ventilation; n/total (%)	273/344 (79.4)	282/339 (83.2)	0.20
Duration of mechanical ventilation (days); median (IQR)	3 (1-7)	3 (1-7)	0.97
Duration of intensive care treatment (days); median (IQR)	5 (2-12)	5 (2-11)	0.61

Results

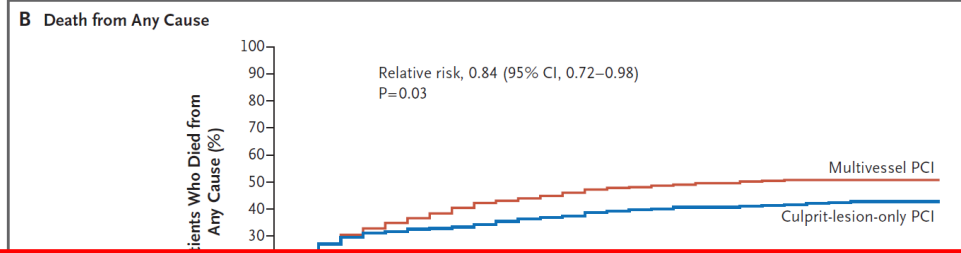
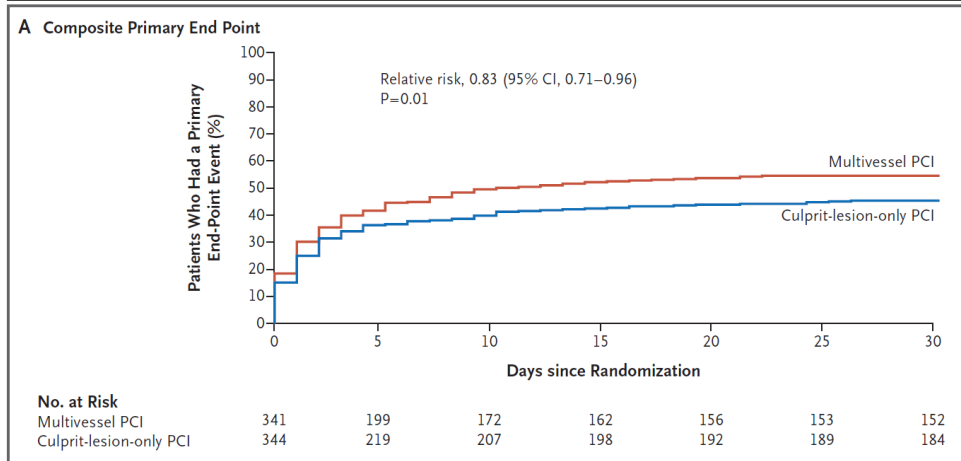
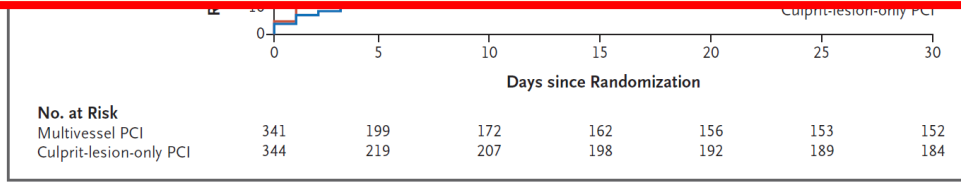
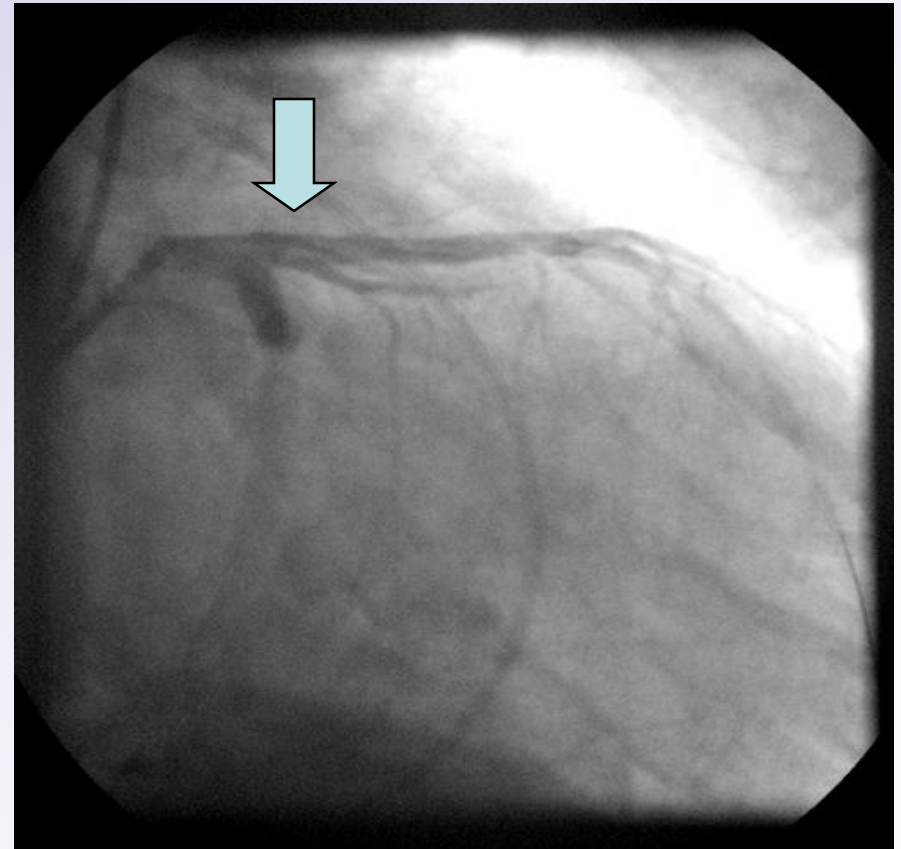
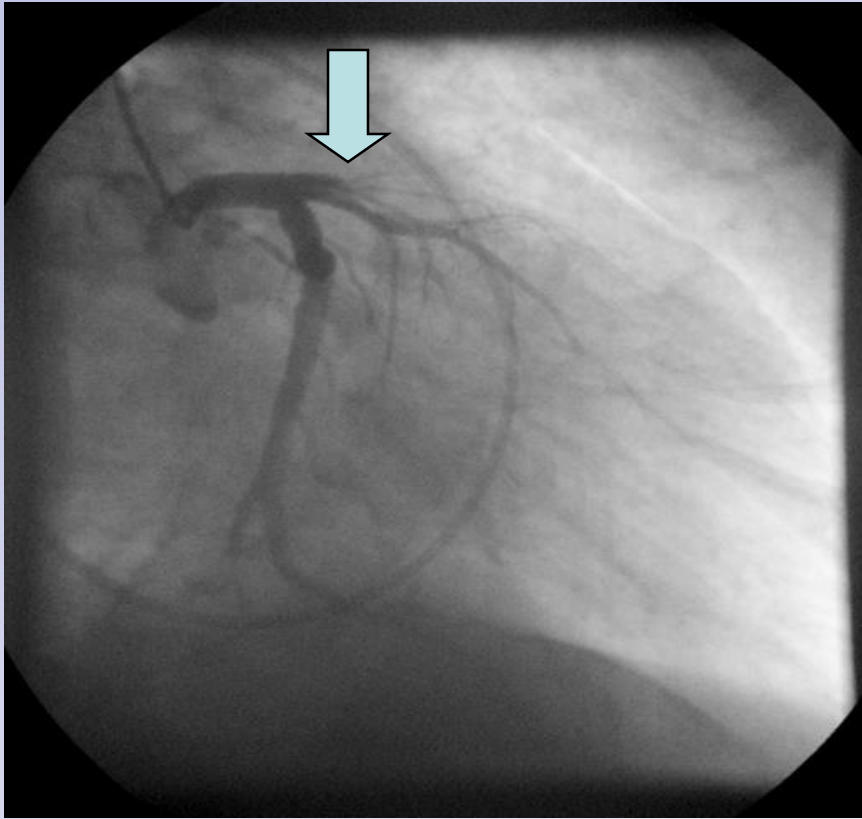
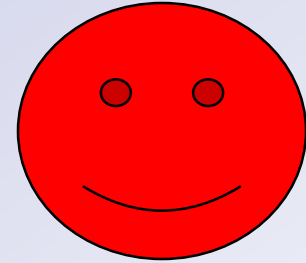


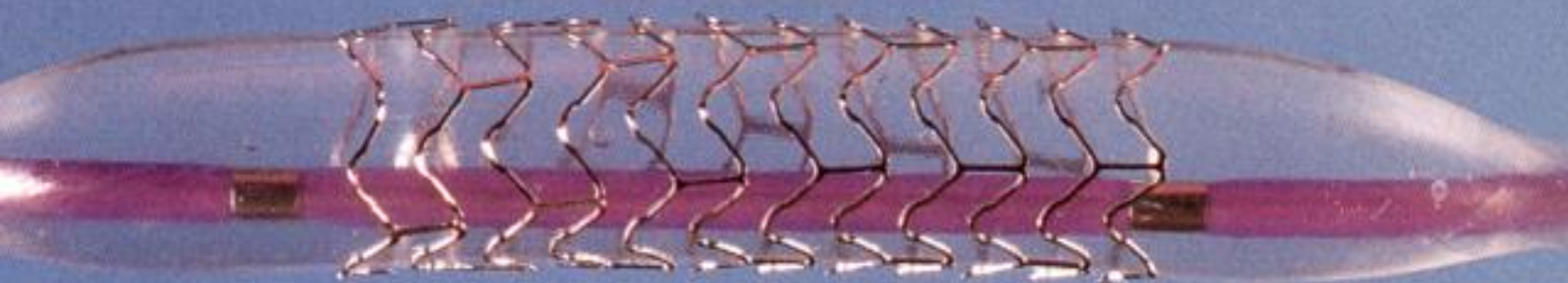
Table 3. Clinical Outcomes at 30 Days.

Outcome	Culprit-Lesion-Only PCI Group (N = 344)	Multivessel PCI Group (N = 341)	Relative Risk (95% CI)	P Value
	<i>no./total no. (%)</i>			
Primary end point: death from any cause or renal-replacement therapy	158/344 (45.9)	189/341 (55.4)	0.83 (0.71–0.96)	0.01
Death from any cause*	149/344 (43.3)	176/341 (51.6)	0.84 (0.72–0.98)	0.03
Renal-replacement therapy	40/344 (11.6)	56/341 (16.4)	0.71 (0.49–1.03)	0.07



Successful PTCA





Mechanical support – IABC - physiological effects

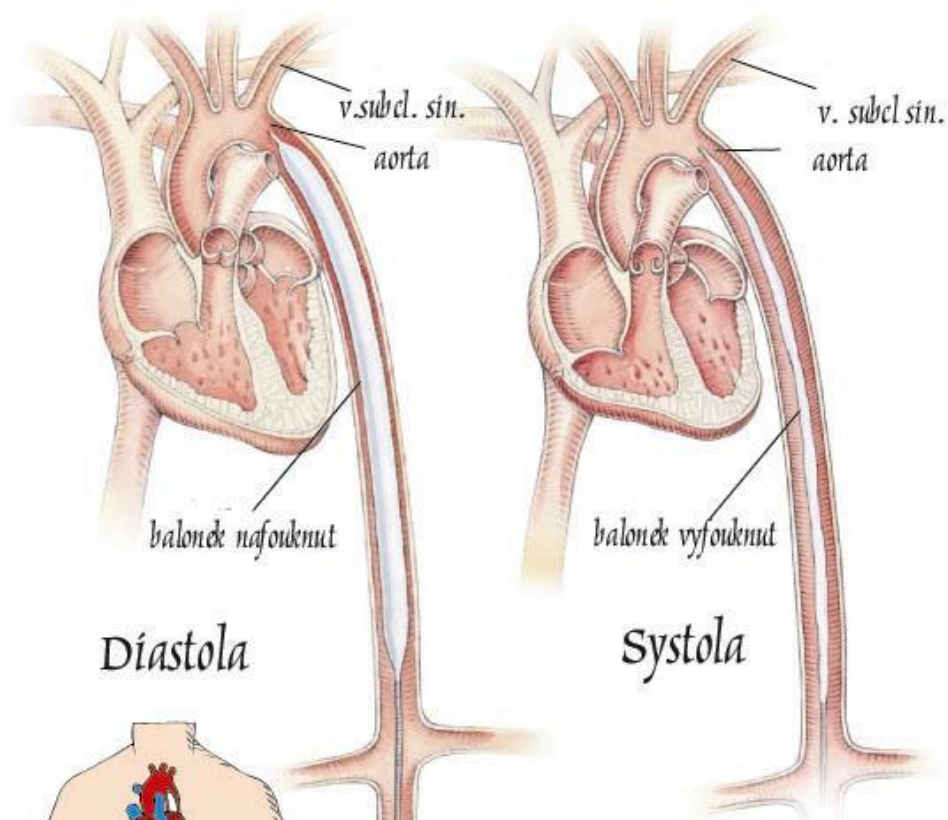
- *Diastole*

- (balloon insufflation)
- increase in dBP
- ↑ coronary perfusion
- ↑ systemic perfusion

- *Systole*

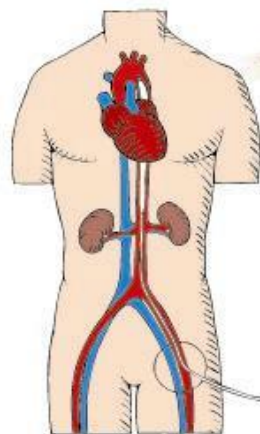
- (balloon desufflation)
- ↓ aortic pressure
- unloading for LV
- ↓ O₂ demand

Pozice intra-aortálního balónku



Diastola

Systola



Koronární jednotka

II. interní klinika VFN

IABC



ORIGINAL ARTICLE

Intraaortic Balloon Support for Myocardial Infarction with Cardiogenic Shock

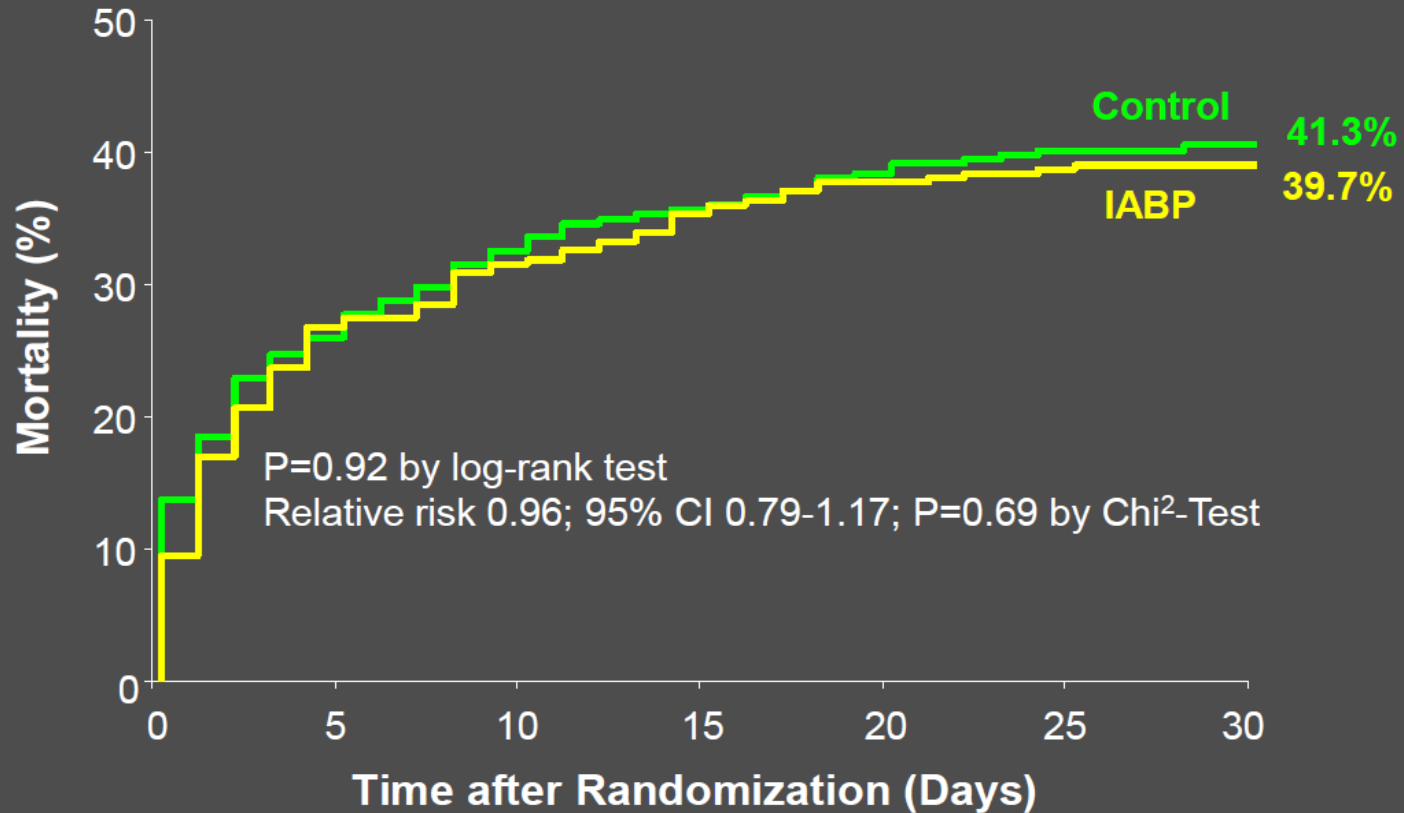
Holger Thiele, M.D., Uwe Zeymer, M.D., Franz-Josef Neumann, M.D., Miroslaw Ferenc, M.D., Hans-Georg Olbrich, M.D., Jörg Hausleiter, M.D., Gert Richardt, M.D., Marcus Hennersdorf, M.D., Klaus Empen, M.D., Georg Fuernau, M.D., Steffen Desch, M.D., Ingo Eitel, M.D., Rainer Hambrecht, M.D., Jörg Fuhrmann, M.D., Michael Böhm, M.D., Henning Ebel, M.D., Steffen Schneider, Ph.D., Gerhard Schuler, M.D., and Karl Werdan, M.D., for the IABP-SHOCK II Trial Investigators*

This article was published on August 27, 2012, at NEJM.org.

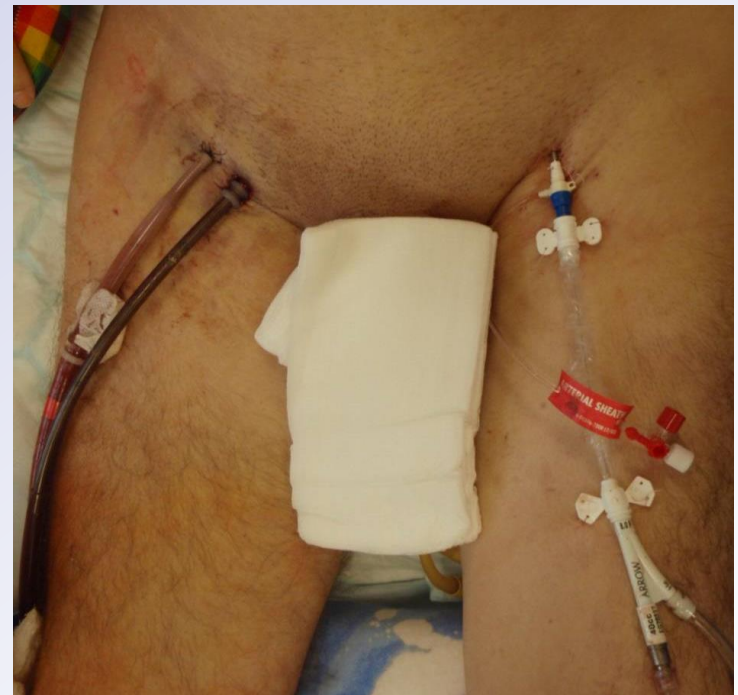
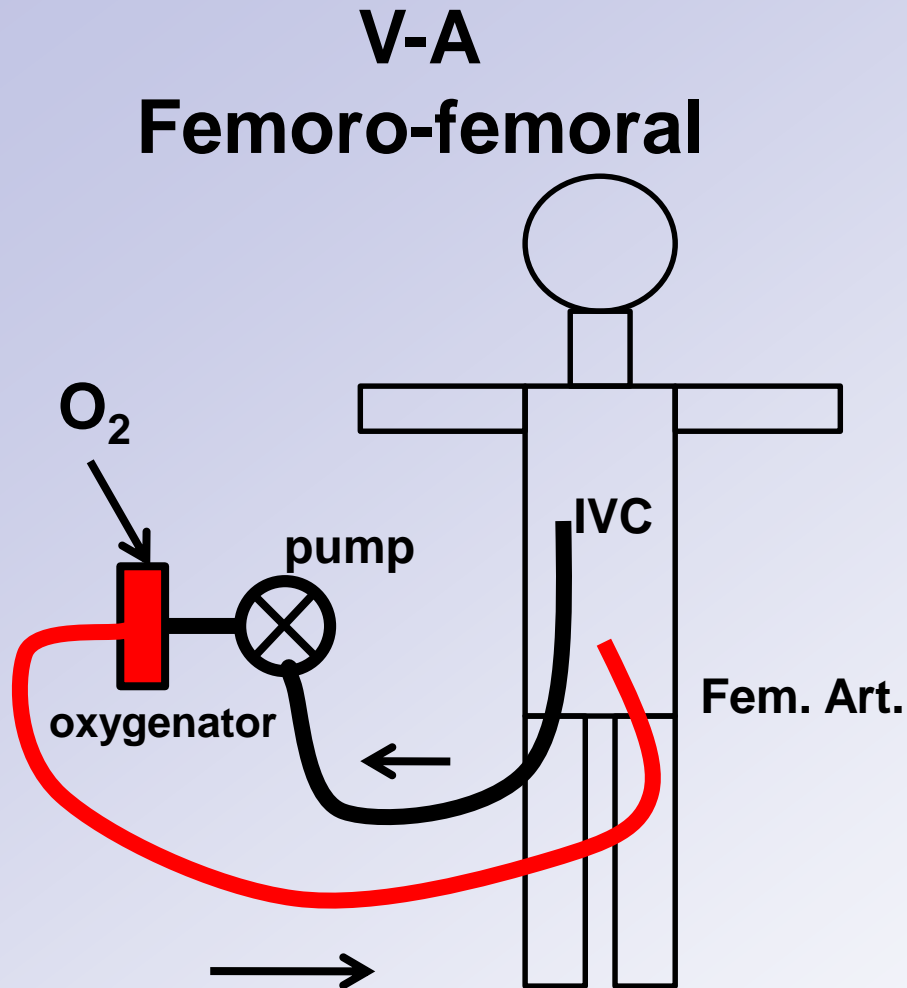
N Engl J Med 2012.

DOI: 10.1056/NEJMoa1208410

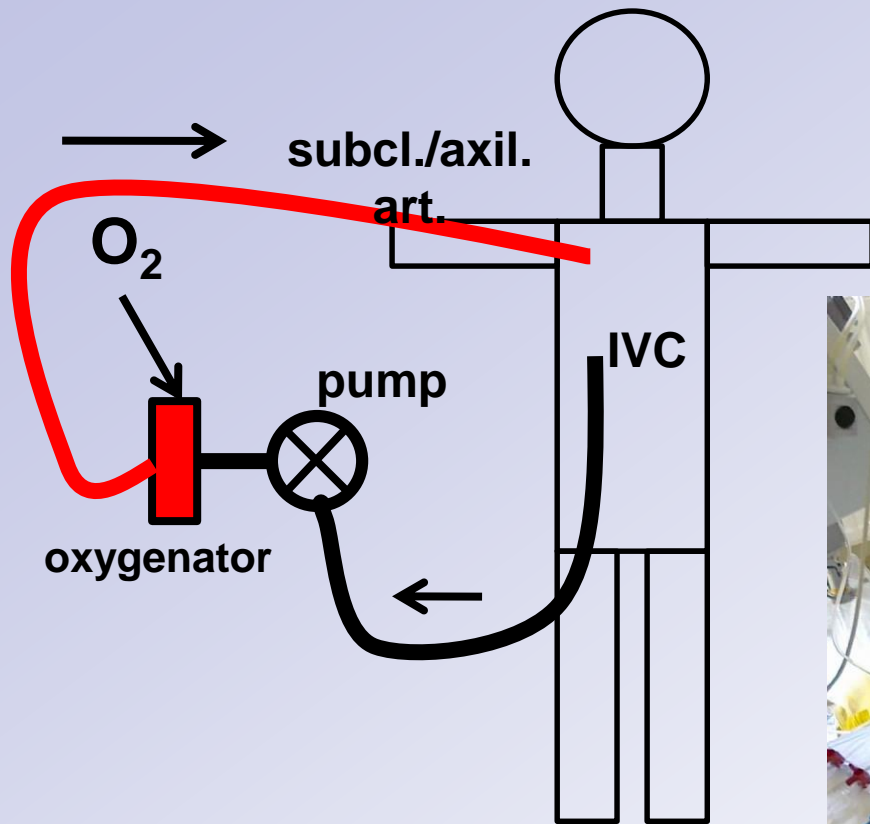
Primary Study Endpoint (30-Day Mortality)



Peripheral ECMO



Peripheral ECMO



V-A
Femoro-
subclavian/axillary



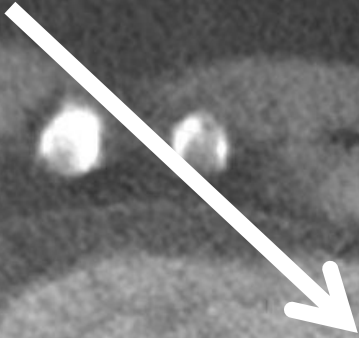
„Awake ECMO“ cardiogenic shock



Immerova Ludmila
*16. 9. 1947, žena 68 let
ID: 475916074
VFN
Acc no. 3142751
20. 6. 2016 12:19:41
MPR, Axial
512*512px XCD

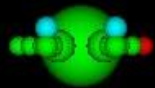
7289 CTA koronarografie
MPR, Axial
Serie 11 / 11
Obrázek 11 / 28
CONTRAST

Postinfarction VSD



2
1
0
-1
-2
cm

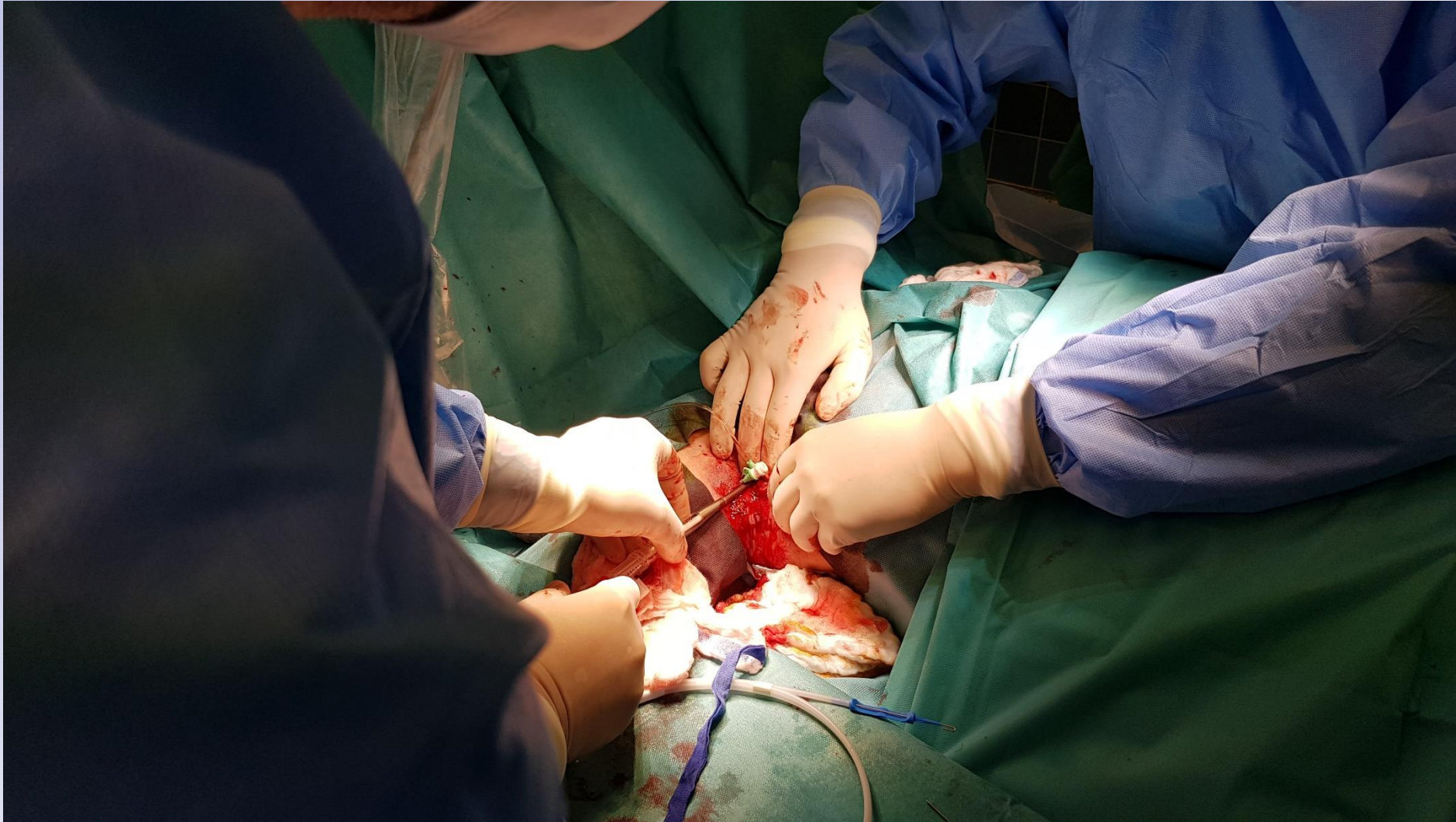
>465
400
300
200
100
0
-100
-200
←-285



7 6 5 4 3 2 1 0 1 2 3 4 5 6 7
cm

KVP 120 kV / 993 mA
Gantry tilt: 0°
Exposure time: 4171 ms
Slice thickness: 4.5 mm
DFOV 19,46 × 19,46 cm
Jas. okno střed: 90; šířka: 750

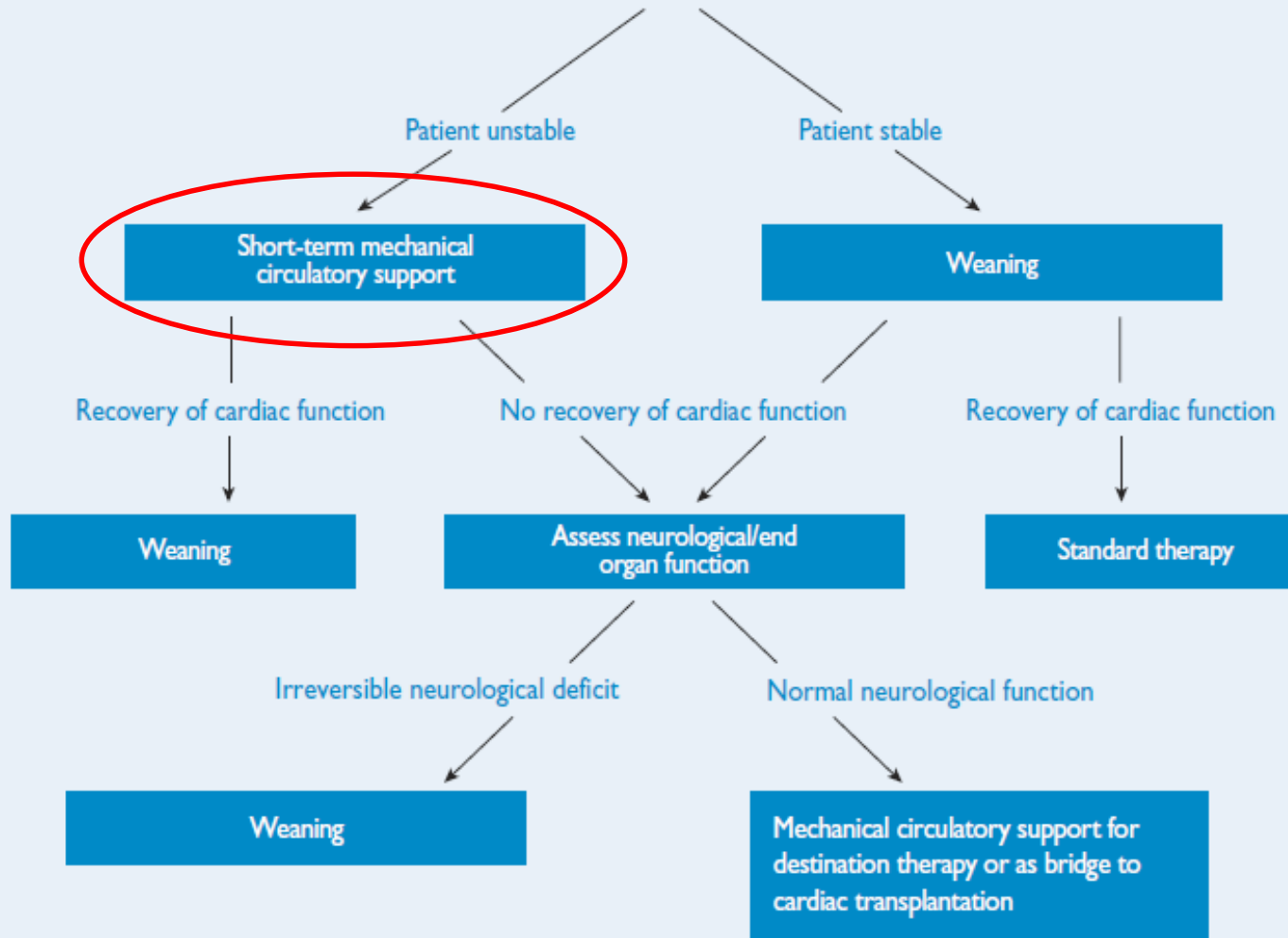
Extremes of mechanical support



Patient with cardiogenic shock

- Medical therapy
- Inotropic support
- Ventilatory support
- Revascularization
- Reperfusion
- Repair of mechanical complications

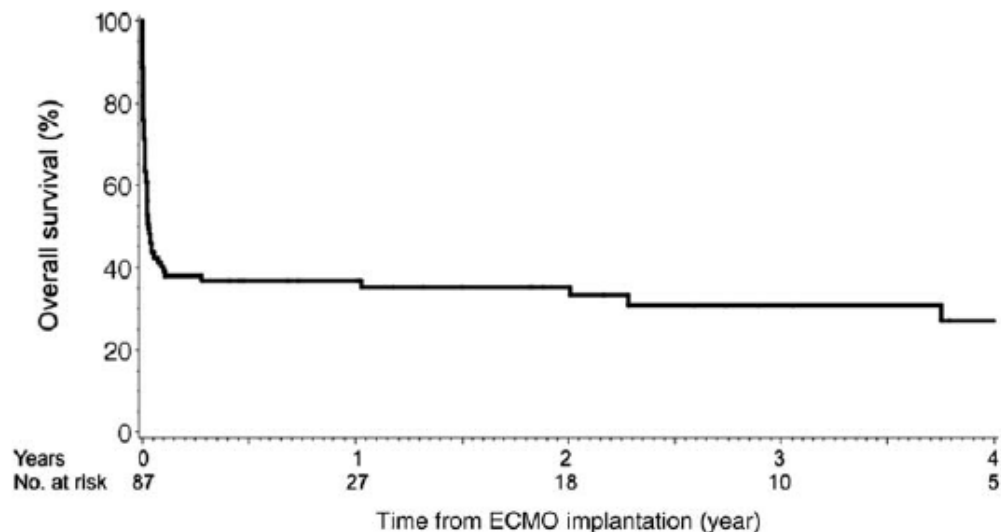
ESC + EACTS
Guidelines Revasc 2014



Emergency circulatory support in refractory cardiogenic shock patients in remote institutions: a pilot study (the cardiac-RESCUE program)

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Therapeutical approach in cardiogenic shock

- antiplatelets (DAPT)
 - ASA, clopidogrel/ticagrelor/prasugrel
- anticoagulation - heparin
- revascularization
- fluids
- vasopressors and inotropes
- complex intensive care
 - mechanical ventilation vs. „**awake ECMO strategy**“
- mechanical circulatory support

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De Backer D, Biston P, Devriendt J, Madl C, Chochrad D, Aldecoa C, Brasseur A, Defrance P, Gottignies P, Vincent JL. Comparison of dopamine and norepinephrine in the treatment of shock. *N Engl J Med* 2010;**362**:779–789.





Have a nice day !!!!

