Casa di Cura SAN MICHELE

ECOCARDIOCHIRURGIA

ECMO nello shock refrattario

Emanuele Catena

La paziente Cecilia Bavolek di 18 anni

1953: John H Gibbon

Utilizzo della prima pompa roller come circuito extracorporeo nella riparazione di un difetto del setto interatriale

1954: Richard De Wall

Invenzione del primo ossigenatore a bolle e primo utilizzo clinico

In 1944, Willem Johan Kolff (1911-2009), the famous artificial organs pioneer scientist from the Netherlands, used a cellophane membrane for hemodialysis as an artificial kidney.

Bramson developed a new disposable oxygenator using silicon-rubber membrane and included a heat exchanger in 1964.

In membrane oxygenators, the gas is separated from the blood by a semi-permeable membrane made of polyurethane or silicon-rubber. Gas exchange is accomplished without direct contact between the gas and the blood, just as it is the case in normal lung. In the absence of direct contact between the gas and the blood, extra-corporeal membrane oxygenation (ECMO) can be carried on for weeks without significant hemolysis or organ deterioration. Membrane oxygenators are safe, efficient and easy to use. For these reasons they are now the most commonly used oxygenators.

Prolonged extracorporeal oxygenation for acute post traumatic respiratory failure (shock lung syndrome). Use of the Bramson membrane Lung

J Donald Hill et al. N Engl J Med 1972;286:629-634.

Bramson developed a new disposable oxygenator using silicon-rubber membrane and included a heat exchanger in 1964.

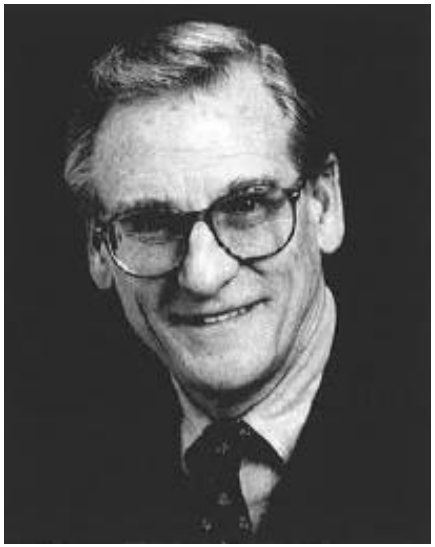
1989: Extracorporeal Life Support Organization (ELSO)

EXTRACORPOREAL LIFE SUPPORT ORGANIZATION
Charter Meeting
October 1-3, 1989 Ann Arbor, Michigan

Table 1-1. Charter Members of First Extracorporeal Life Support Organization Steering Committee, 1989

Members	Location
Robert Bartlett	Ann Arbor, MI
William Kanto	Augusta, GA
Fred Ryckman	Cincinnati, OH
Larry Cook	Louisville, KY
Martin Keszler	Washington, DC
Billie Lou Short	Washington, DC
P. Pearl O'Rourke	Seattle, WA
J. Devn Cornish	San Diego, CA
Charles Stolar	New York, NY
Michael Klein	Detroit, MI
Phyllis McClelland	Ann Arbor, MI
Sandy Snedecor	Ann Arbor, MI

Robert Bartlett



1990 – 2013 ECMO

6225 casi pediatrici (31 gg – 18 aa)

Weaning from ECMO: 65%
Survival to discharge: 49%

Adults: 5000 casi
Survival to hospital discharge:

Cardiac arrest: 27%
Cardiogenic shock: 49%

Le ragioni di un sistema di supporto meccanico al circolo

1) mantenere la perfusione degli organi vitali

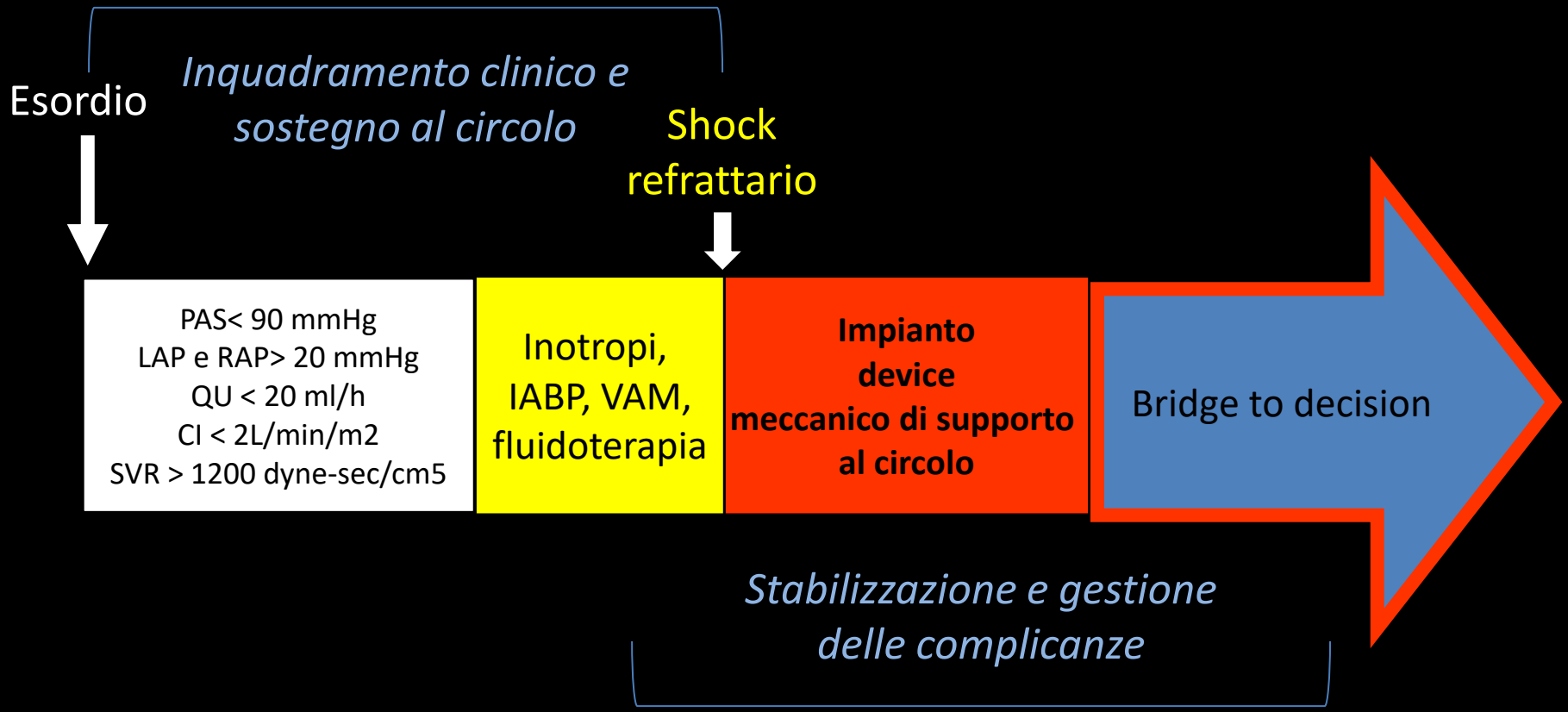
2) ridurre le pressioni di riempimento
   - controllo della congestione polmonare
   - controllo congestione letto venoso sistemico

Prevenire danno d'organo

3) ridurre i volumi ventricolari e lo stress
4) ridurre il consumo di O2
5) favorire la perfusione coronarica
6) ridurre l'area infartuale

Favorire il recupero della funzione

Supporto meccanico al circolo nello shock cardiogeno: quando?



Indicazione precoce alle misure di sostegno al circolo

Monitoraggio stretto per valutare l'adeguatezza del trattamento e il "timing" degli interventi

Prevenzione del danno d'organo e della risposta infiammatoria incontrollabile

Il metodo = MONITORAGGIO

1) diuresi
2) lattati
3) saturazione venosa

MCS

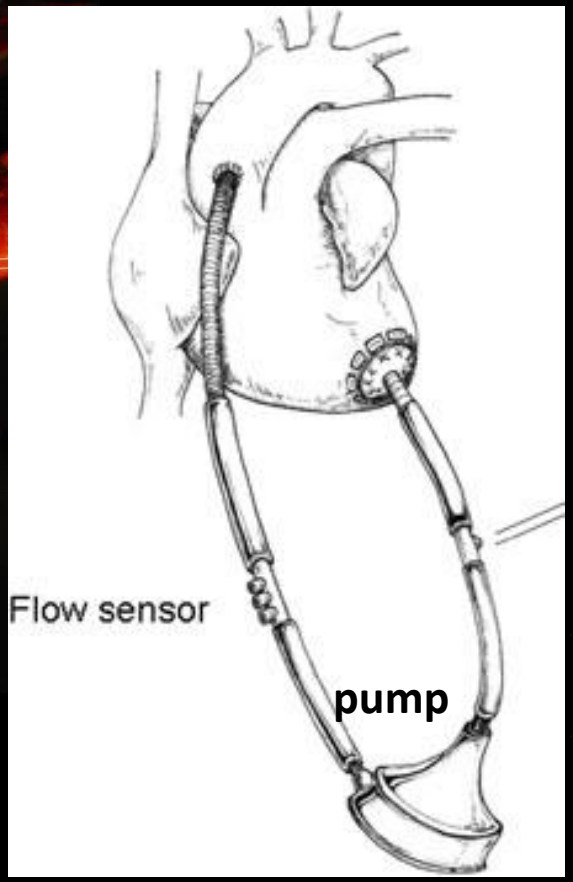
CONTROPULSATORE

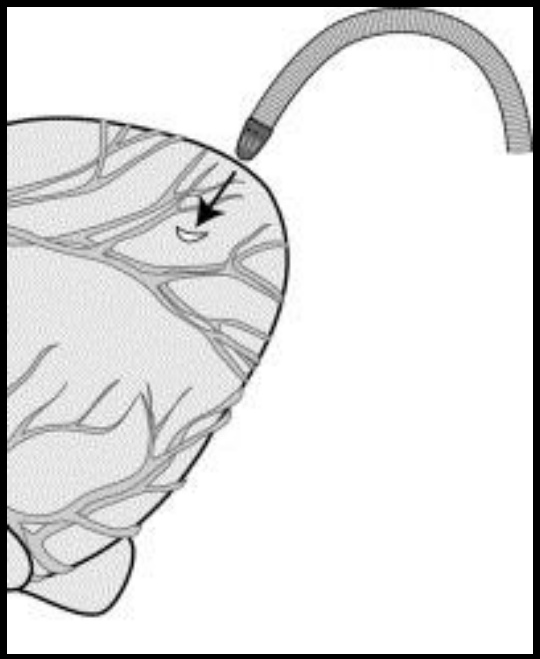
VENTILAZIONE MECCANICA

INOTROPI E FLUIDOTERAPIA

MONITORAGGIO clinico e strumentale (PA, PVC, wedge, eco, ECG)

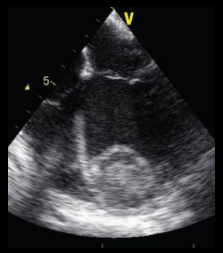
“drenaggio diretto del VS”

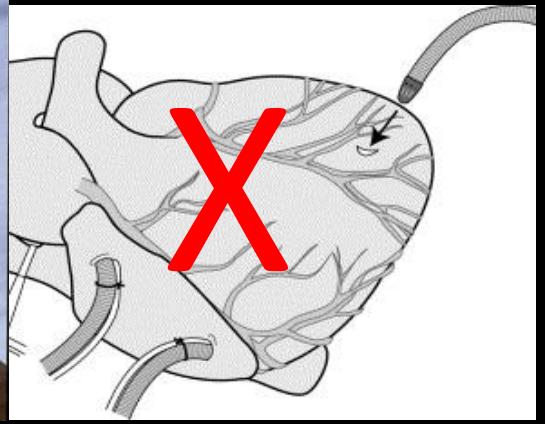




“unloading” efficace

- necessità di avviare il supporto meccanico rapidamente
- necessistà di garantire una possibilità di “recovery” (miocardite)
- insufficienza biventricolare
- insufficienza respiratoria



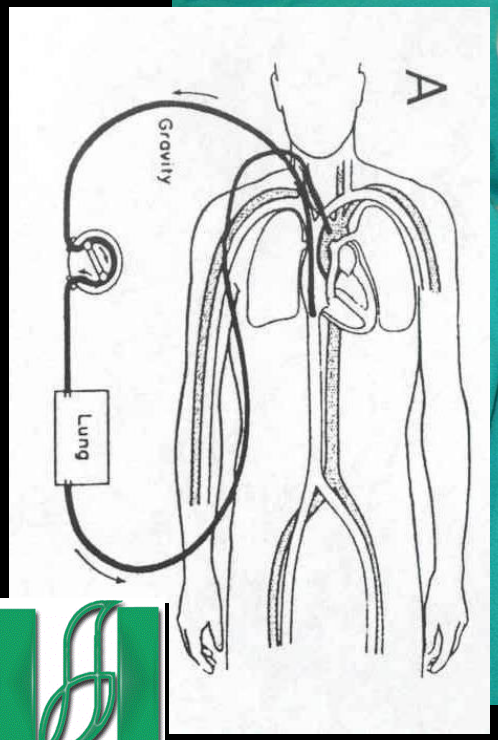


√

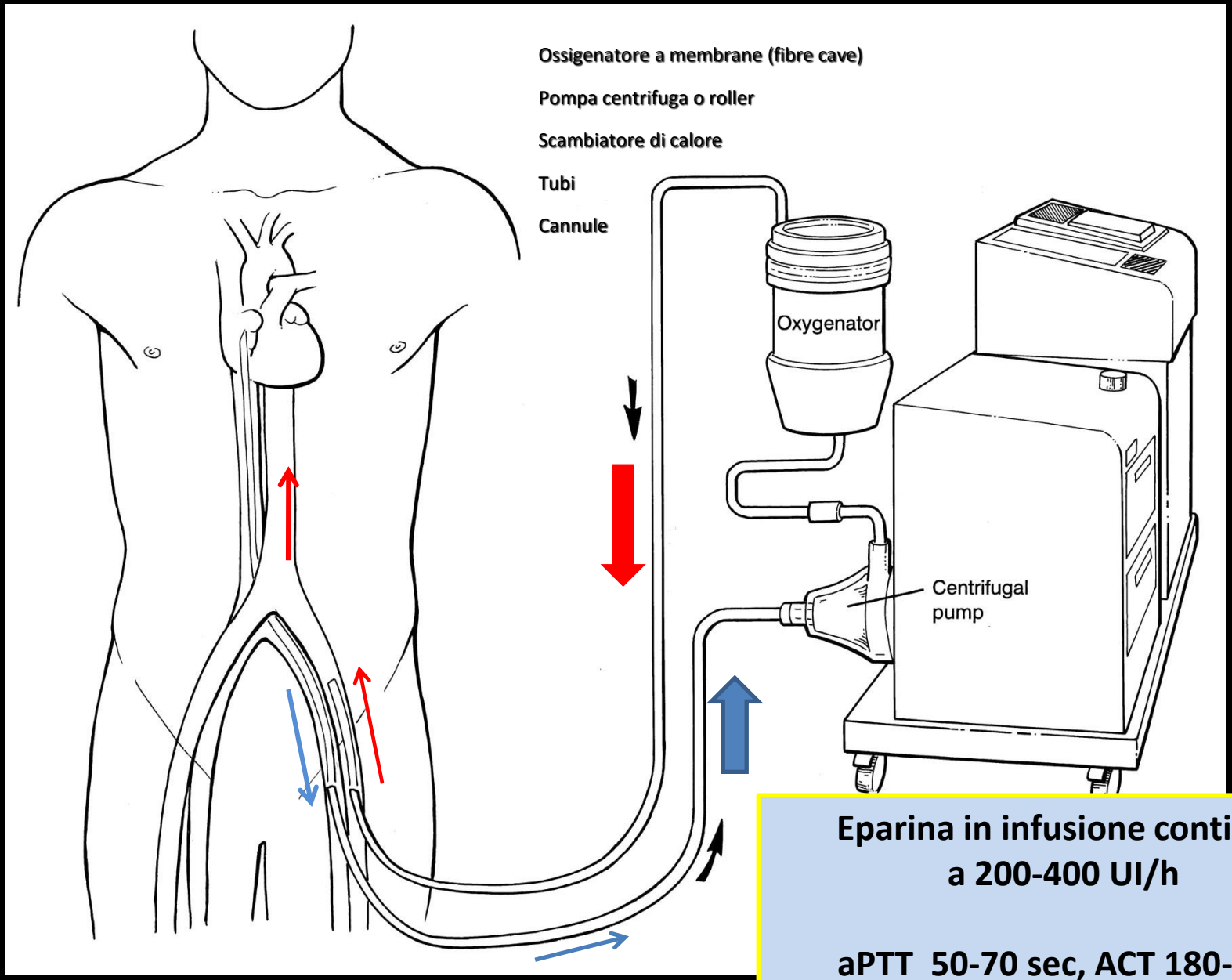
V-A

ECMO

ECMO-VA con cannulazione “centrale”



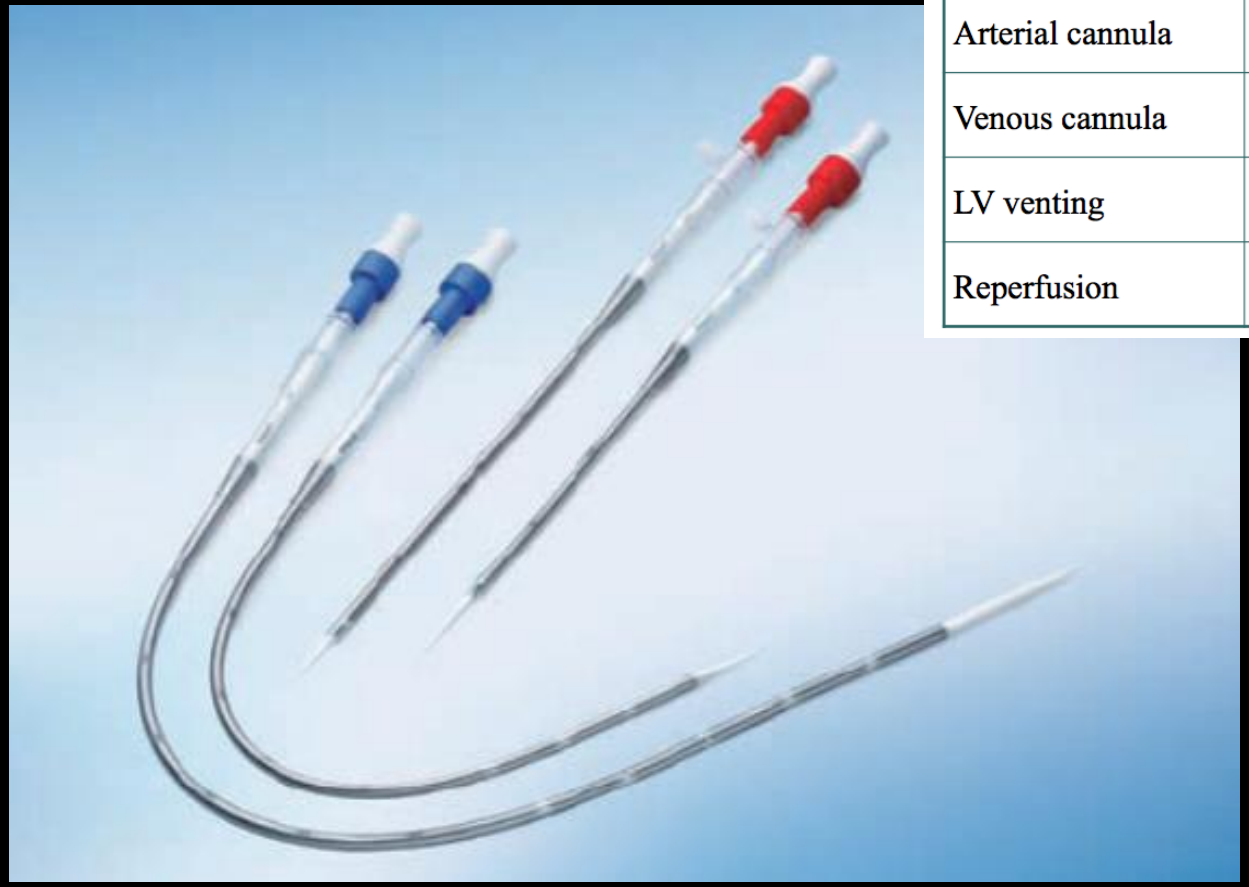
ECMO veno-arterioso “periferico”



Eparina in infusione continua a 200-400 UI/h

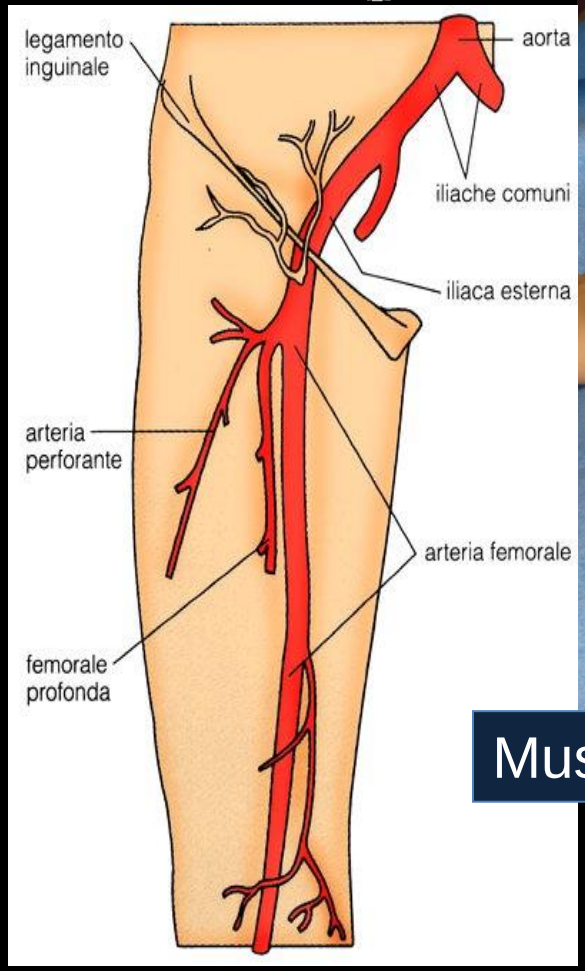
aPTT 50-70 sec, ACT 180-200

Cannule arteriosa e venosa



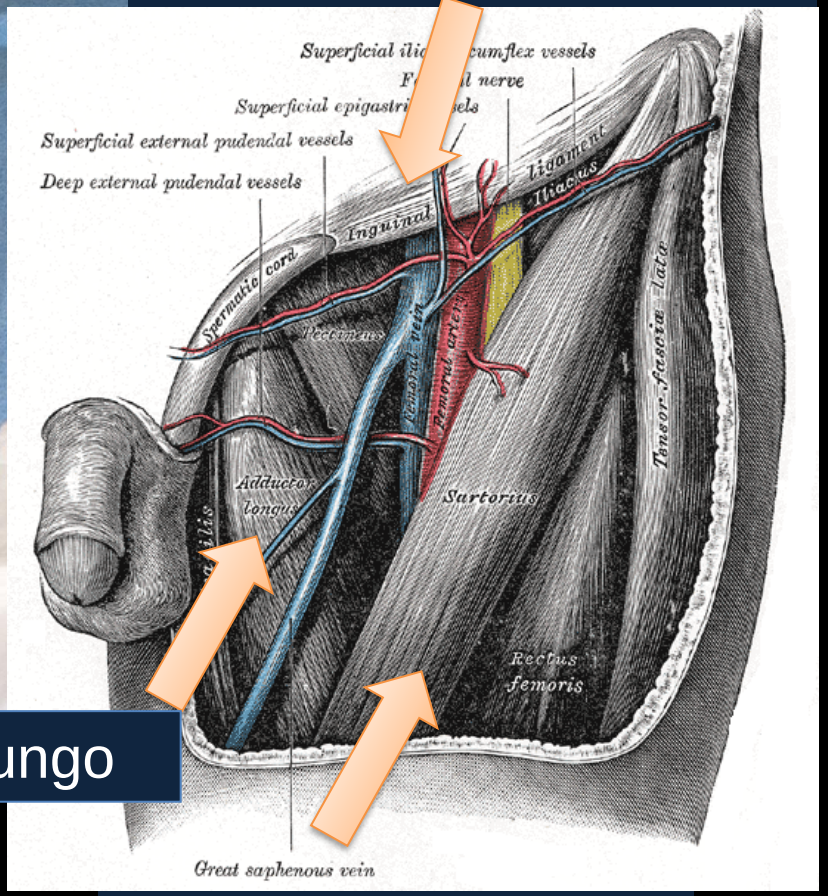
	Peripheral ECMO	Central ECMO
Arterial cannula	17 – 19 F	19F
Venous cannula	21- 23 F	32 F
LV venting	-	24 F
Reperfusion	5 F	-

Ricerca del punto corretto per pungere l’arteria femorale



Muscolo adduttore lungo

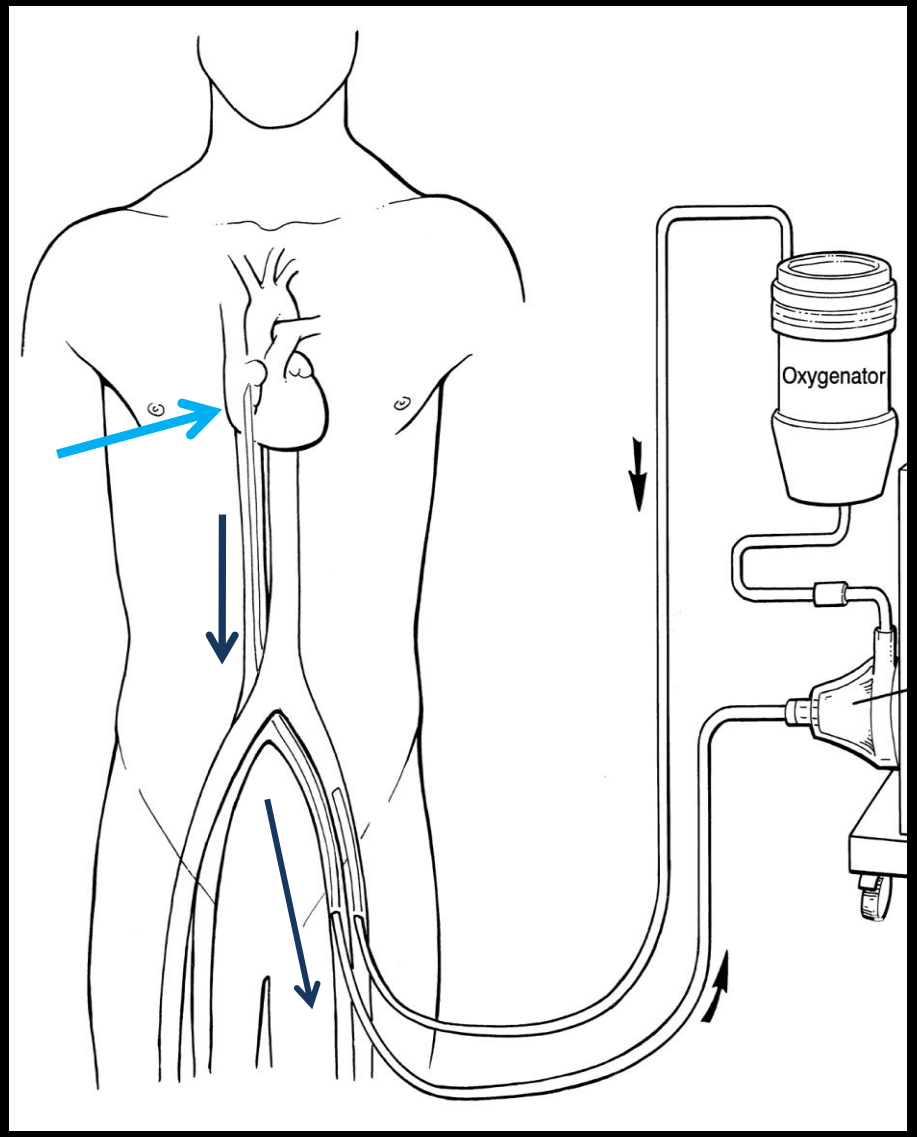
Legamento inguinale



Muscolo sartorio

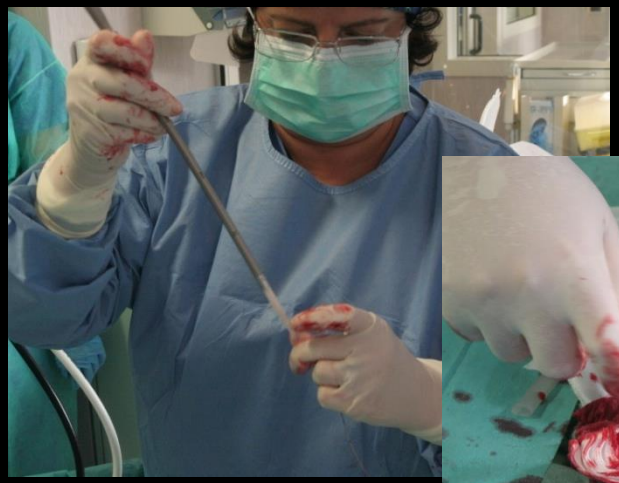
ECMO veno-arterioso “periferico”

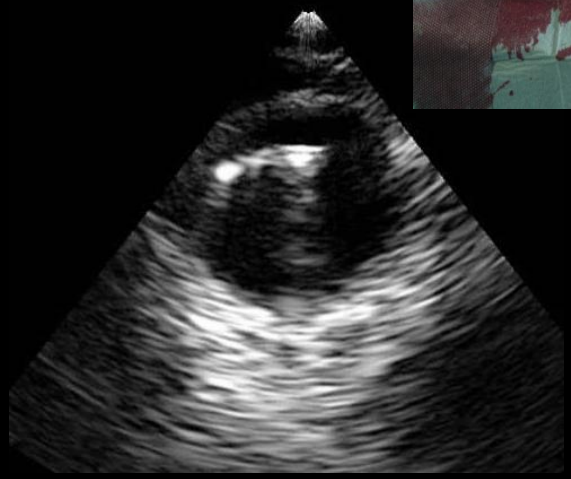
cannula venosa: 21-23 Fr

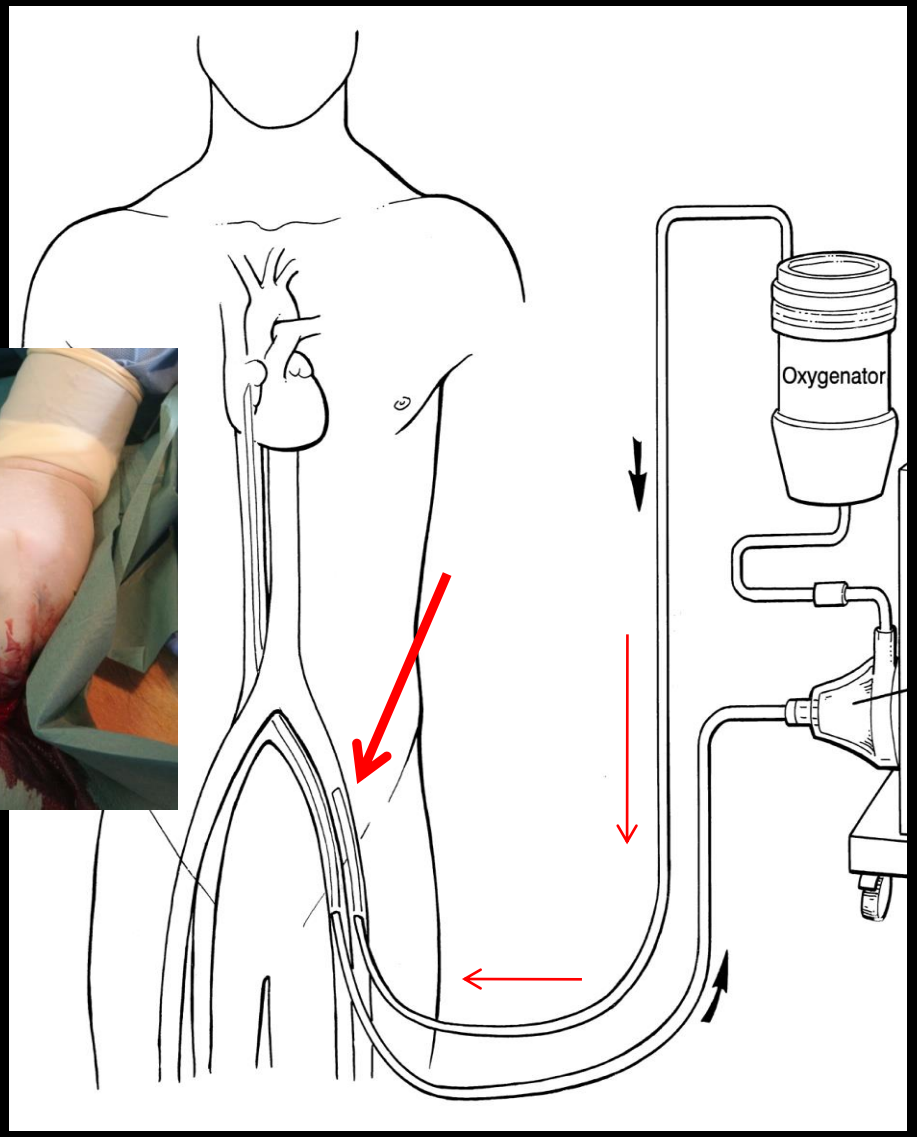


ECMO veno-arterioso “periferico”

cannula arteriosa : 17-19 Fr

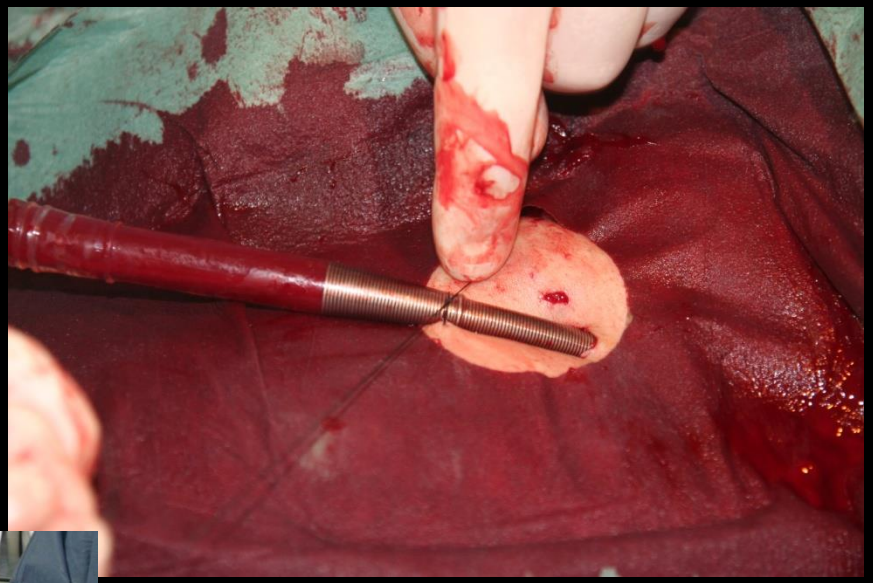


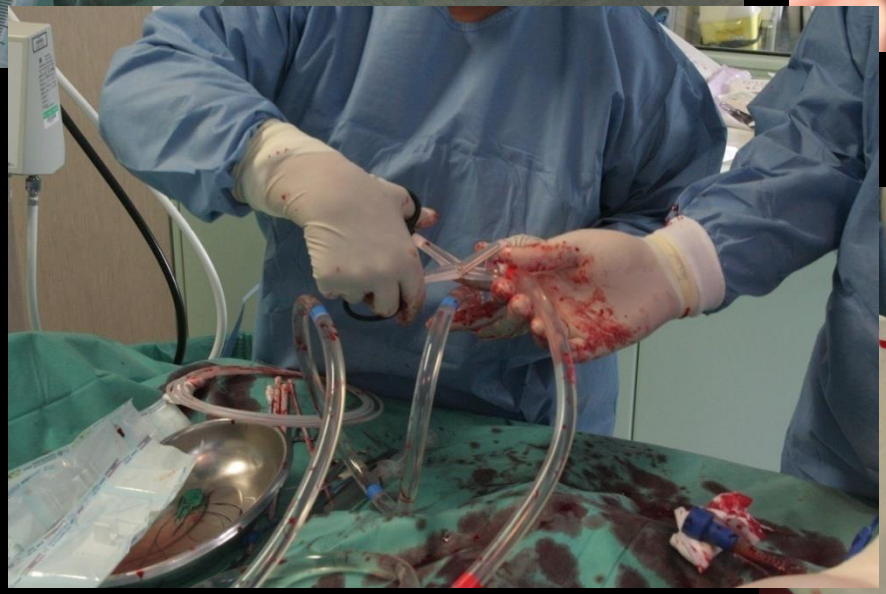




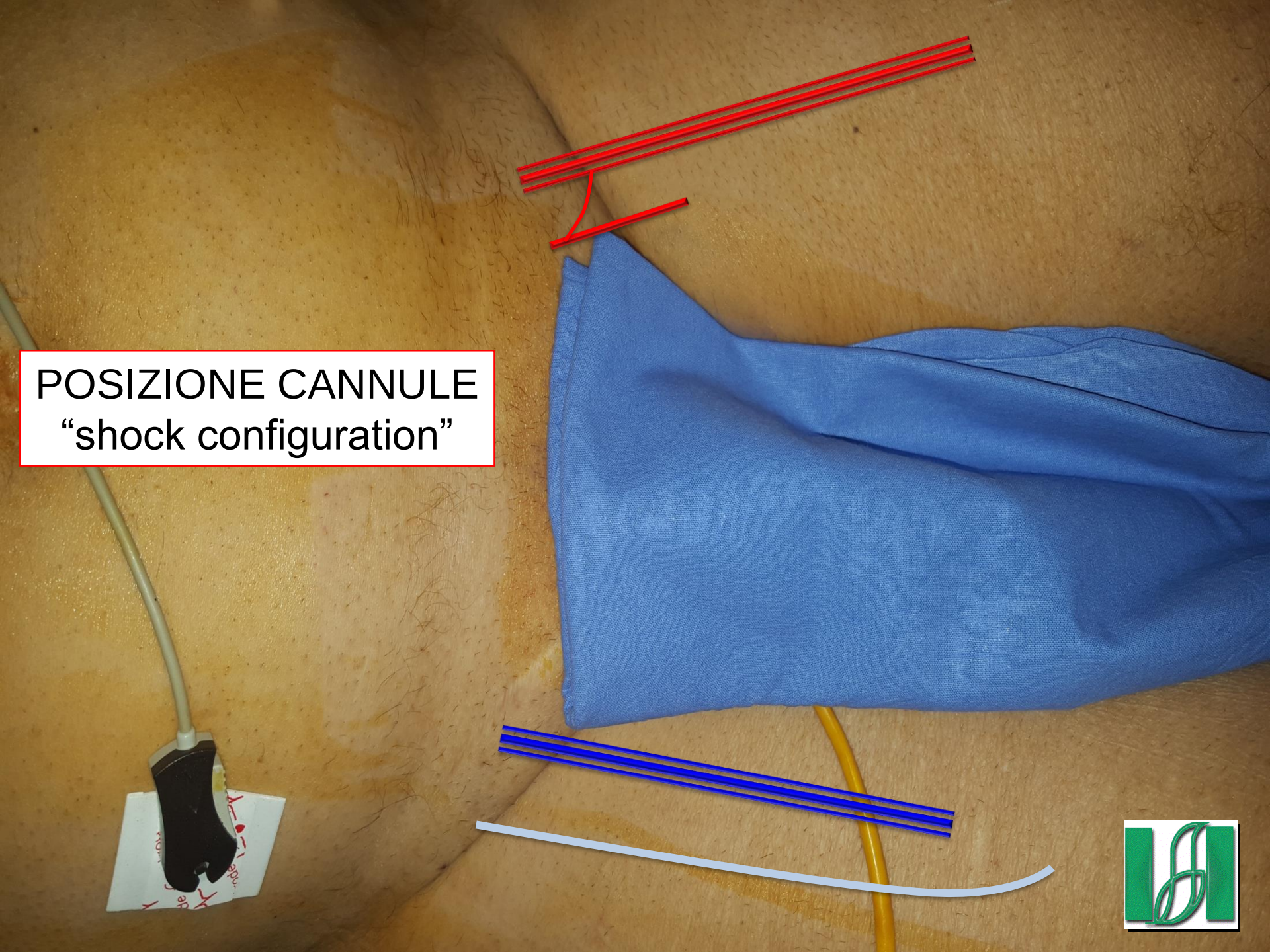
LINEA VENOSA

LINEA ARTERIOSA



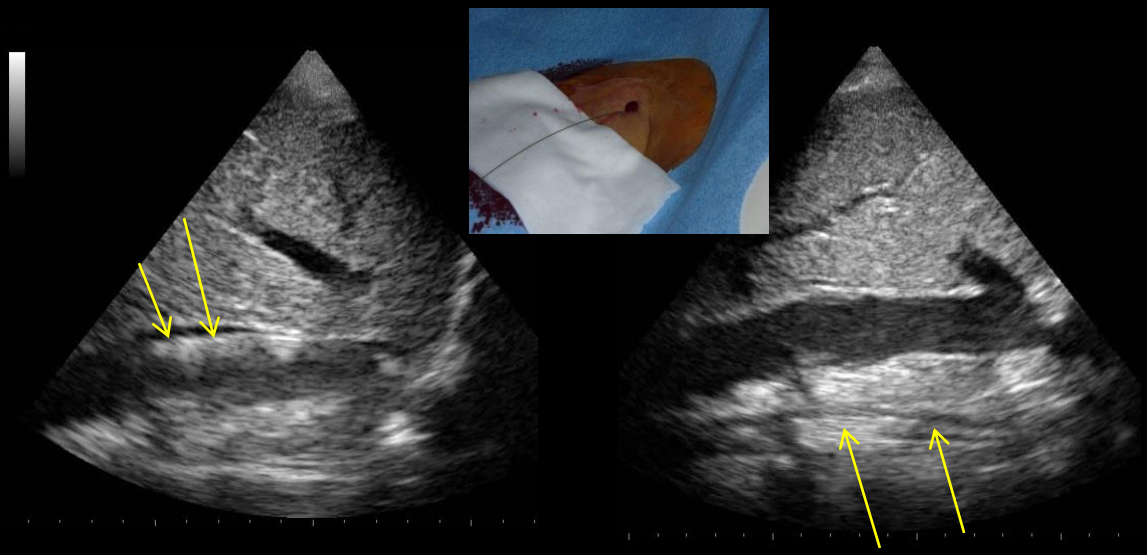



RPM
LPM
3420
4.40
2500
2000
3000
1500
3500
1000
4000
500
4500
0
RPM
5000
LPM
Mode
MAQUET


POSIZIONE CANNULE
“shock configuration”

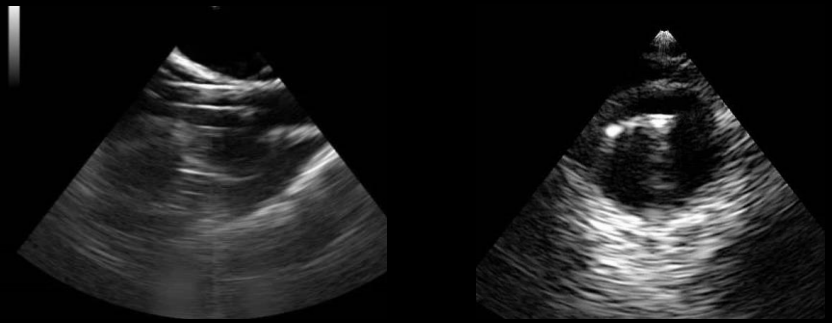
GUIDA ECOCARDIOGRAFICA

1) POSIZIONAMENTO DELLE GUIDE (transtoracico)



2) INTUBAZIONE OROTRACHEALE

3) POSIZIONAMENTO DELLE CANNULE VENOSA E ARTERIOSA (TEE)




PHILIPS
SECHRIST
CARRELLO
VASI CENTRALI
DIOHELP

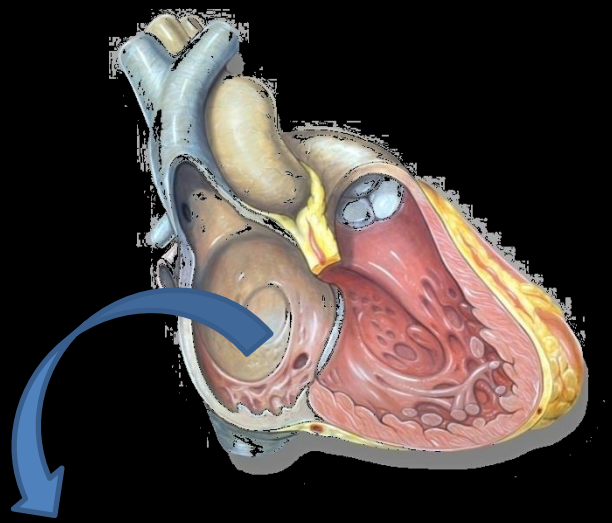
ECMO veno-arterioso

Vantaggi:

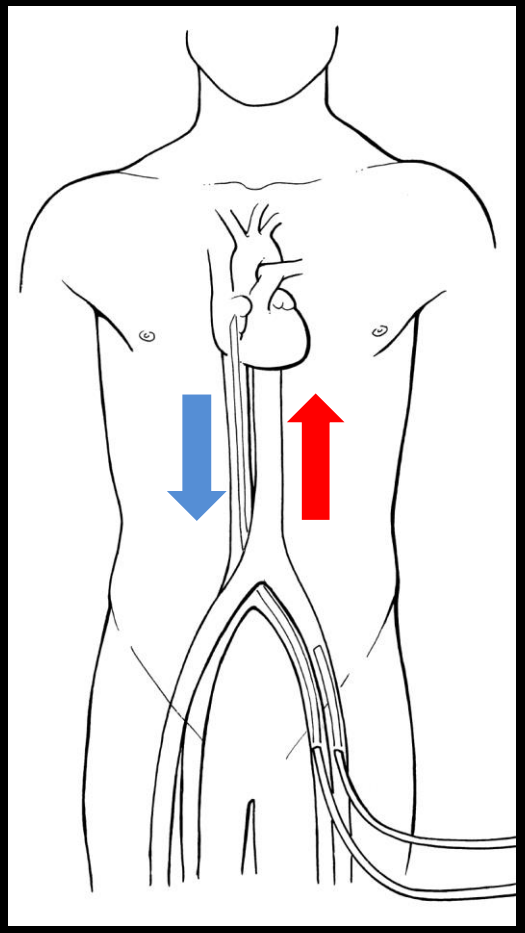
- istituibile anche al di fuori della camera operatoria
- istituibile anche per via percutanea
- l'impianto non richiede di necessità la CEC e la sternotomia
- possibilità di pieno supporto cardiopolmonare
- supporto biventricolare
- non richiede una terapia antitrombotica massimale
- procedura di espianto non complessa, anche fuori dalla sala operatoria
- meno costoso di altri sistemi

ECMO v-a: effetti cardiaci

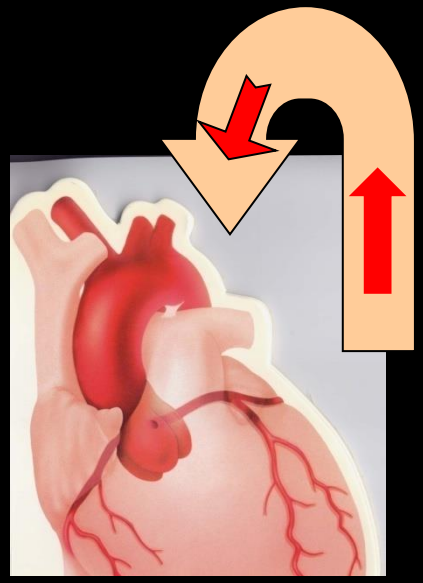
Riduzione del "preload"



Fino al 90% della portata può essere drenata dalla linea venosa -> minimo flusso transpolmonare



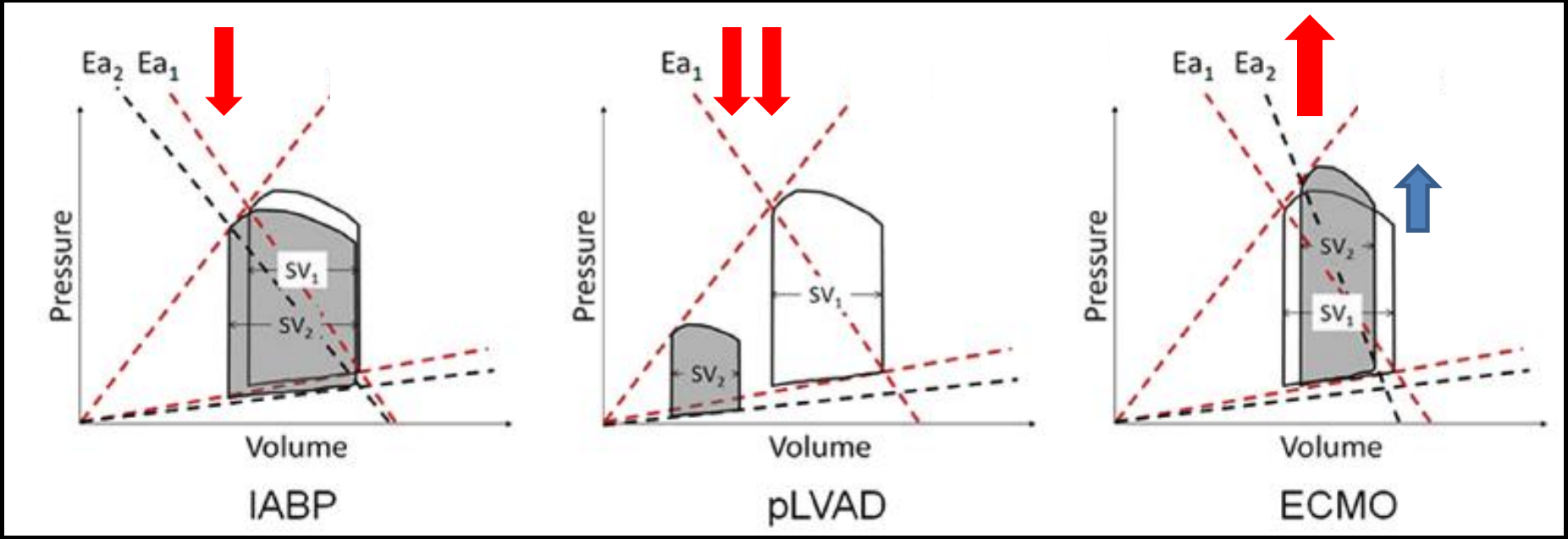
Aumento del "afterload"



Il flusso retrogrado in aorta si oppone all'eiezione del VS

Supporto parziale o completo

ECMO v-a: effetti cardiaci



(FE << 10%)

Ea (ELASTANZA ARTERIOSA) = end-systolic pressure / Stroke volume

una componente dell'afterload !

J Cardiac Fail 2015 vol 21, n 6

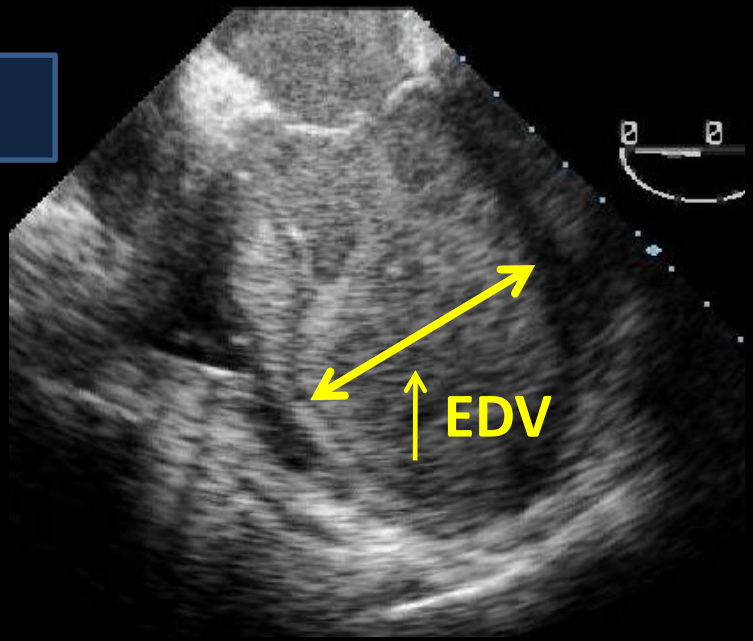
La **circolazione bronchiale** giunge in atrio sinistro e contribuisce all'aumento del volume stagnante

AFTERLOAD

FE << 10%

Eventuale **IAO**

EPA



La pressione sistolica generata dal VS è insufficiente ad aprire la valvola aortica

Il sangue ristagna all'interno del ventricolo sinistro e aumenta il volume ventricolare

LV-EDP

Compromissione del "myocardial recovery"

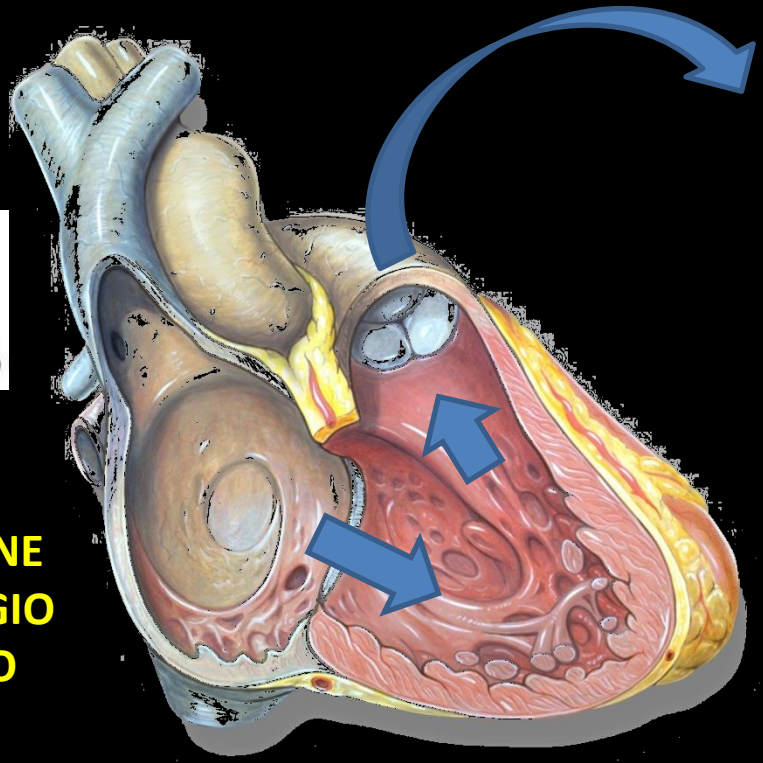
ECMO v-a: ”unloading”

FLUSSO “pieno”: 4.4 L/min

Inotropo “low dose”

IABP o Impella

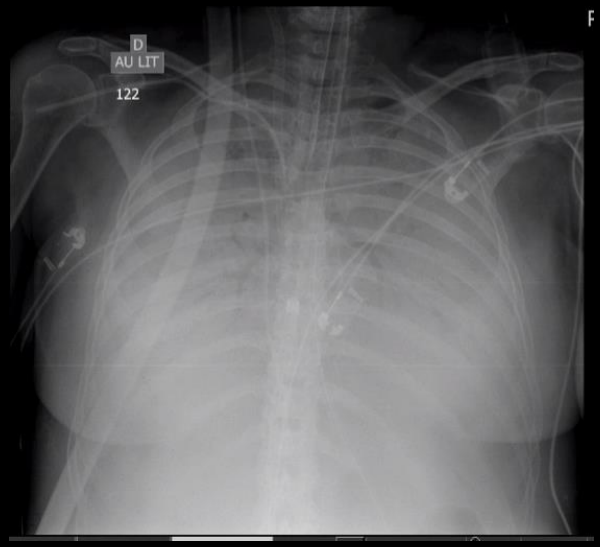
FLUSSO 3.2 L/min



RIDUZIONE DRENAGGIO VENOSO

RIDUZIONE FLUSSO ECMO

AUMENTO FLUSSO TRANSPOLMONARE

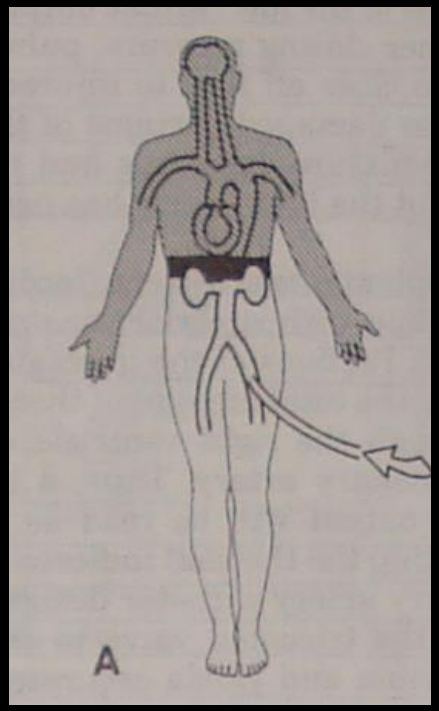


In presenza di patologia del parenchima polmonare, ventilazione meccanica non adeguata, ipossia, il sangue eiettato dal VS risulta desaturato

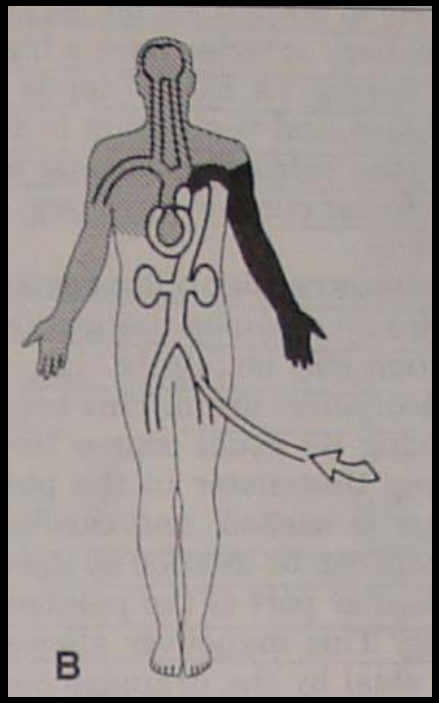
Rischio per la perfusione coronarica

Rischio per la perfusione cerebrale

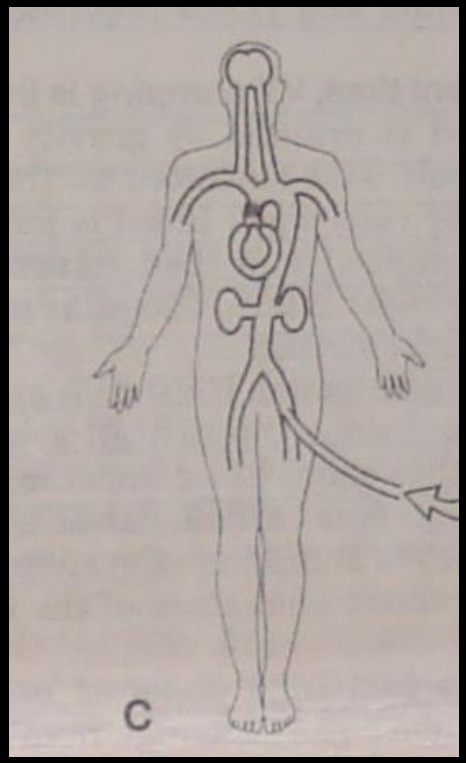
Aree con diversa ossigenazione



MINIMO



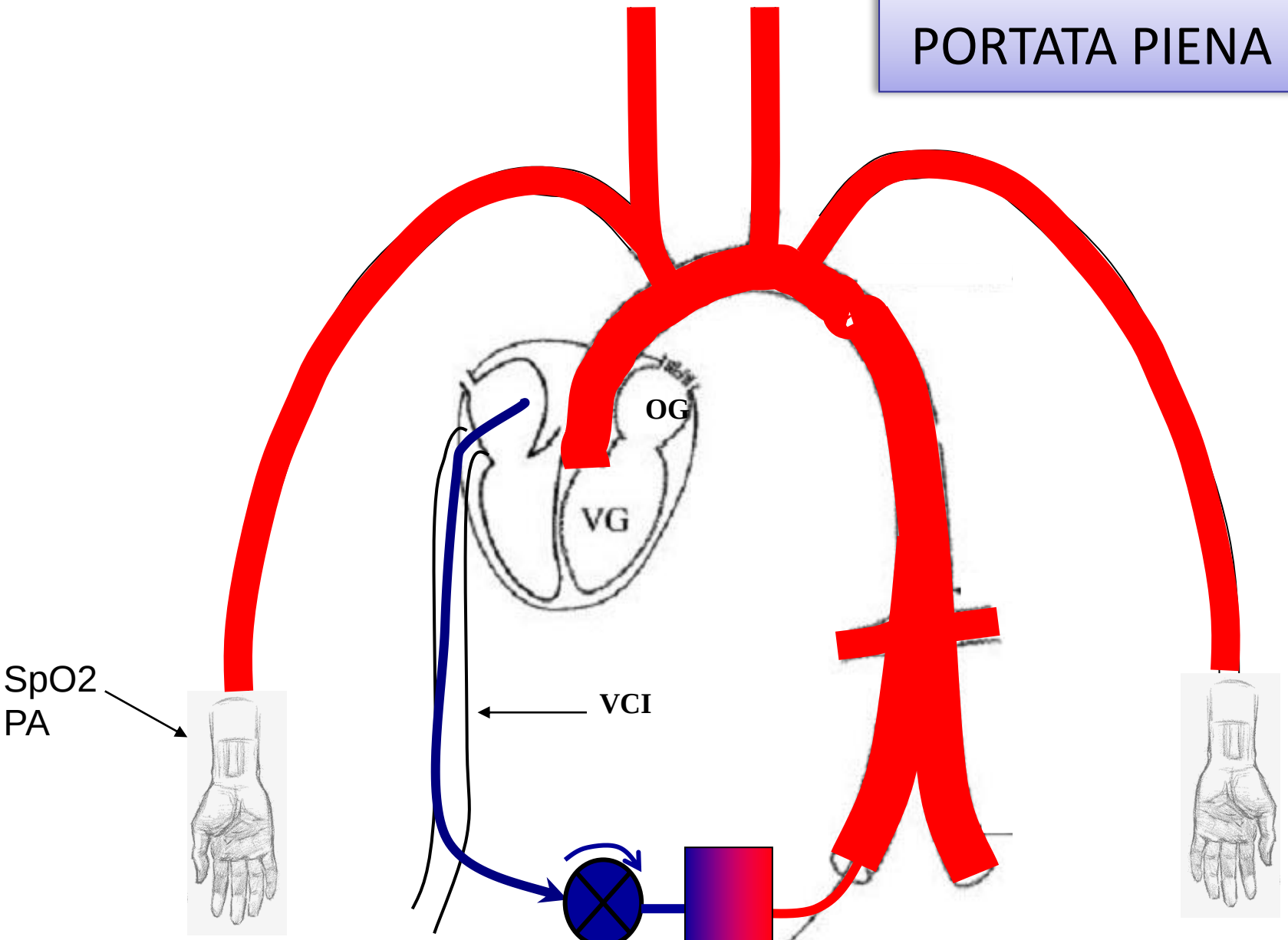
MEDIO



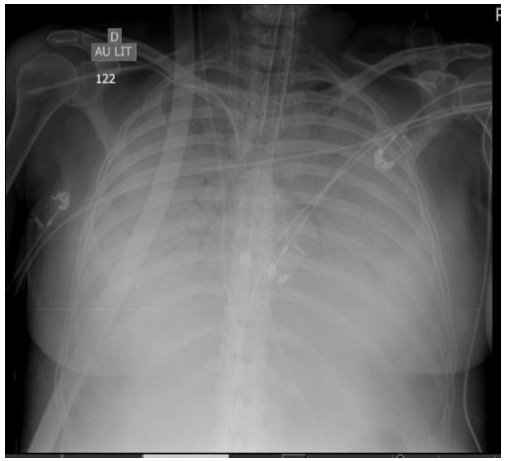
MASSIMO

FLUSSO DELLA POMPA

PORTATA PIENA



RIDUZIONE PORTATA
svezzamento



SVEZZAMENTO

- Ossigenazione adeguata con FiO2 0.50
- Assenza di edema polmonare
- Volemia ottimizzata
- Risoluzione del danno d’organo
- Assenza di febbre
- Anticoagulazione stabile

S. Unai. Artificial Organs 2015

INDICAZIONI

ARRESTO CARDIACO

IN OSPEDALE TESTIMONIATO (WIHCA)

FUORI SPEDALE TESTIMONIATO (WOHCA)

FUORI OSPEDALE NON TESTIMONIATO (NWOHCA)

No flow time ??
LOW flow time ??

~~No flow time~~
LOW flow time ??

ANNEGAMENTO - IPOTERMIA

WIHCA: Witnessed IN hospital Cardiac Arrest

SHOCK CARDIOGENO

Our H

Other H

Cardiogenic shock
- Acute MI
- Fulminant myocarditis
- Acute exacerbation of chronic severe HF
- Acute circulatory failure attributable to intractable arrhythmias
- Postcardiotomy cardiac failure
- Acute HF attributable to drug toxicity

Possible concomitant respiratory failure†
- Severe, refractory hypoxia (PaO_2:FiO_2 ratio < 100)
- Hypercapnic respiratory failure (arterial pH <7.20)
- Severe ARDS‡

INDICAZIONI e sopravvivenza

ARRESTO CARDIACO

IN OSPEDALE TESTIMONIATO (WIHCA)

FUORI SPEDALE TESTIMONIATO (WOHCA)

FUORI OSPEDALE NON TESTIMONIATO (NWOHCA)

No flow time ??
LOW flow time ??

~~No flow time~~
LOW flow time ??

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- Severe ARDS‡

RISULTATI

In Hospital Cardiac Arrest (IHCA)

TESTIMONIATO (Witnessed-IHCA)

Of cardiac origin, excluding intoxication and hypothermia

Authors	Patients *(n)*	No Flow *(min)*	Low Flow *(min)*	Alive *(%)*
Chen, 2003	57	ND	57 ± 13	32 (20-45)
Massetti, 2005	35	ND	105 ± 44	12 (3-27)
Chen, 2008	135	ND	50 [16-150]	34 (26-43)
Vanzetto, 2009	38	0	49 ± 44	11 (3-25)
Thiagarajan, 2009	295	ND	ND	27 (22-32)
Daubin, 2009	7	0	101 ± 55	71 (29-96)
Kagawa, 2010	38	0 [0-1]	25 [21-43]	34 (20-51)
Mateen, 2011	14	ND	ND	29 (8-58)
Shin, 2011	60	ND	39 ± 21	32 (20-45)
Sakamoto, 2012	64	ND	26 ± 22	28 (18-41)
Haneya, 2012	59	ND	40 ± 28	42 (30-56)

(95% CI), median [interquartiles]

INDICAZIONI e sopravvivenza

ARRESTO CARDIACO

IN OSPEDALE TESTIMONIATO (WIHCA)

FUORI SPEDALE TESTIMONIATO (WOHCA)

FUORI OSPEDALE NON TESTIMONIATO (NWOHCA)

No flow time ??
LOW flow time ??

~~No flow time~~
LOW flow time ??

ANNEGAMENTO - IPOTERMIA

WIHCA: Witnessed IN hospital Cardiac Arrest

SHOCK CARDIOGENO

Our H

Other H

Cardiogenic shock
- Acute MI
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Possible concomitant respiratory failure†
- Severe, refractory hypoxia (PaO_2:FiO_2 ratio < 100)
- Hypercapnic respiratory failure (arterial pH <7.20)
- Severe ARDS‡

RISULTATI

Out-of-Hospital Cardiac Arrest (OHCA)

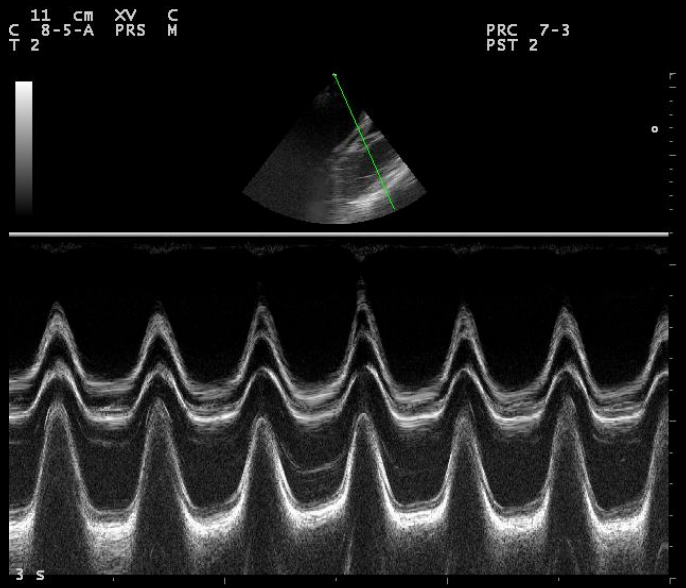
Testimoniato (witnessed-OHCA)

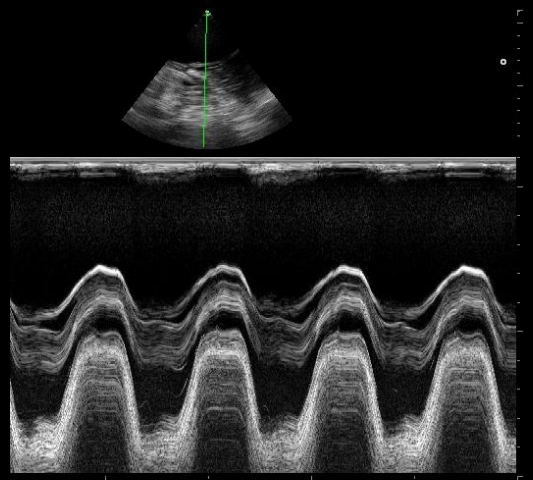
Of cardiac origin, excluding intoxication and hypothermia

Authors	**Patients** *(n)*	**No Flow** *(min)*	**Low Flow** *(min)*	**Alive** *(%)*
Chen, 2008	7	NA	NA	14 (0-58)
Kagawa, 2010	39	1 [1-8]	59 [45-65]	13 (4-27)
Le Guen, 2011	51	3 [1-7]	120 [102-149]	4 (1-13)
Mégarbane, 2011	66	2 [0-6]	155 [120-180]	2 (0-8)
Hashiba, 2012	16	0	27 ± 12	13 (2-38)
Wu, 2012	28	NA	NA	18 (6-37)
Maj, 2012	20	NA	NA	15 (3-38)
Masson, 2012	3	NA	59 ± 11	100 (29-100)
ECLS France	**374**	**0[0-5]**	**80 [70-105]**	**13 (9-16)**

(95% CI), median [interquartiles]

Il massaggio cardiaco...





INDICAZIONI e sopravvivenza

ARRESTO CARDIACO

IN OSPEDALE TESTIMONIATO (WIHCA)

FUORI SPEDALE TESTIMONIATO (WOHCA)

FUORI OSPEDALE NON TESTIMONIATO (NWOHCA)

No flow time ??
LOW flow time ??

~~No flow time~~
LOW flow time ??

ANNEGAMENTO - IPOTERMIA

WIHCA: Witnessed IN hospital Cardiac Arrest

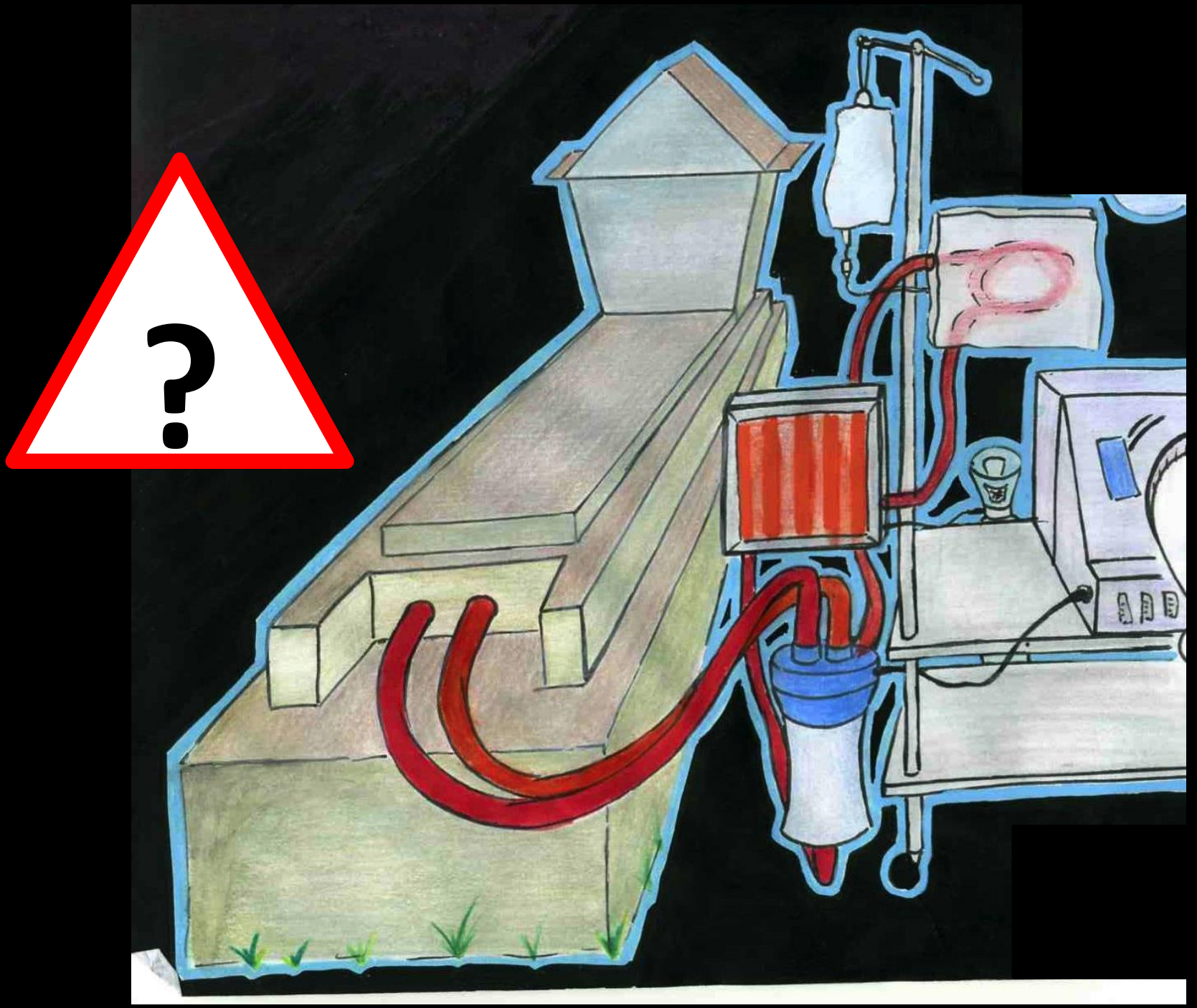
SHOCK CARDIOGENO

Our H

Other H

Cardiogenic shock
- Acute MI
- Fulminant myocarditis
- Acute exacerbation of chronic severe HF
- Acute circulatory failure attributable to intractable arrhythmias
- Postcardiotomy cardiac failure
- Acute HF attributable to drug toxicity

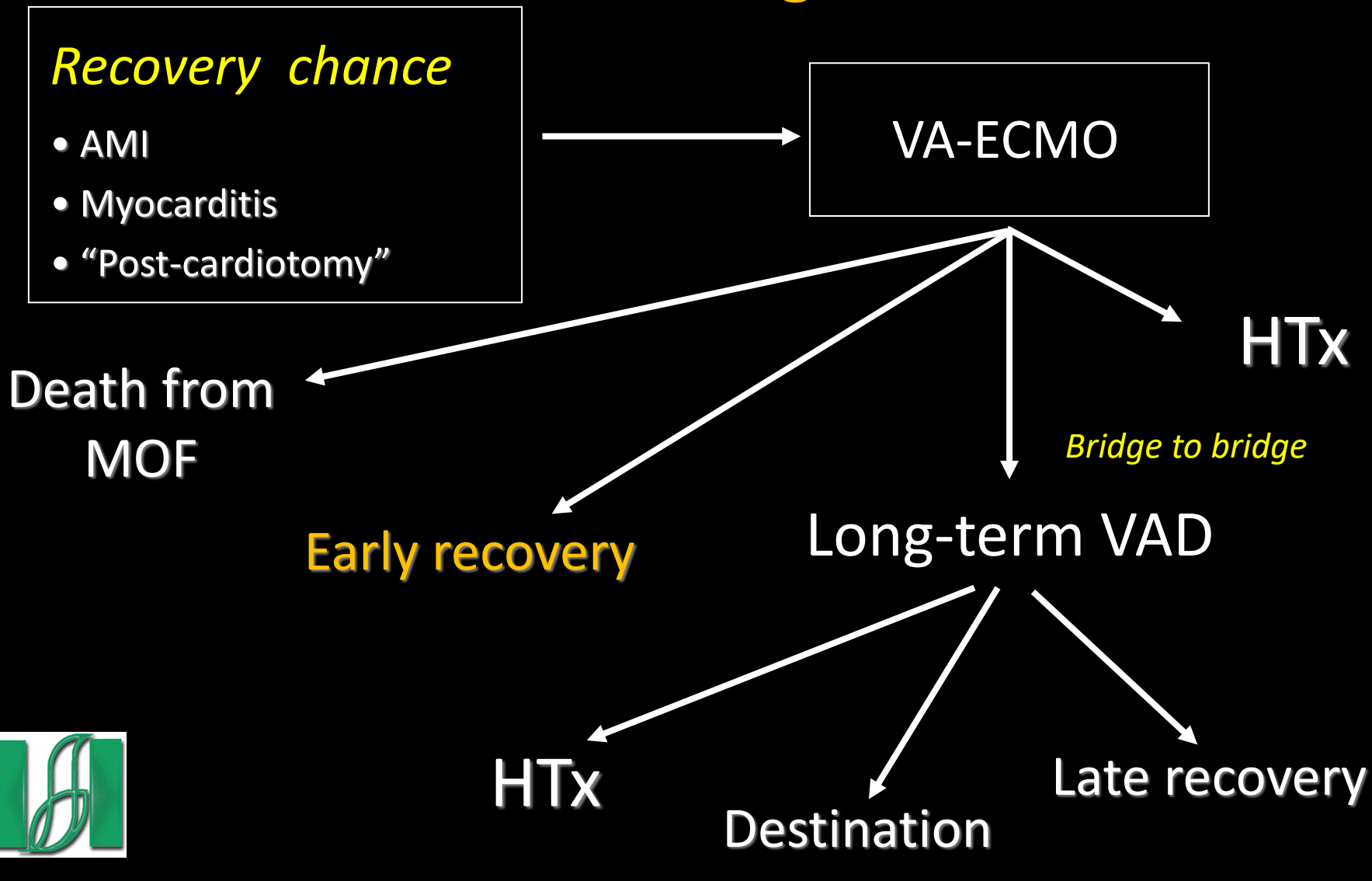
Possible concomitant respiratory failure†
- Severe, refractory hypoxia (PaO_2:FiO_2 ratio < 100)
- Hypercapnic respiratory failure (arterial pH <7.20)
- Severe ARDS‡



PROSPETTIVA DI DONAZIONE ?

ECMO v-a non è una terapia “long term”:

“bridge to decision”



Evoluzione della miocardite fulminante

Presentazione in PS

Shock

Shock refrattario

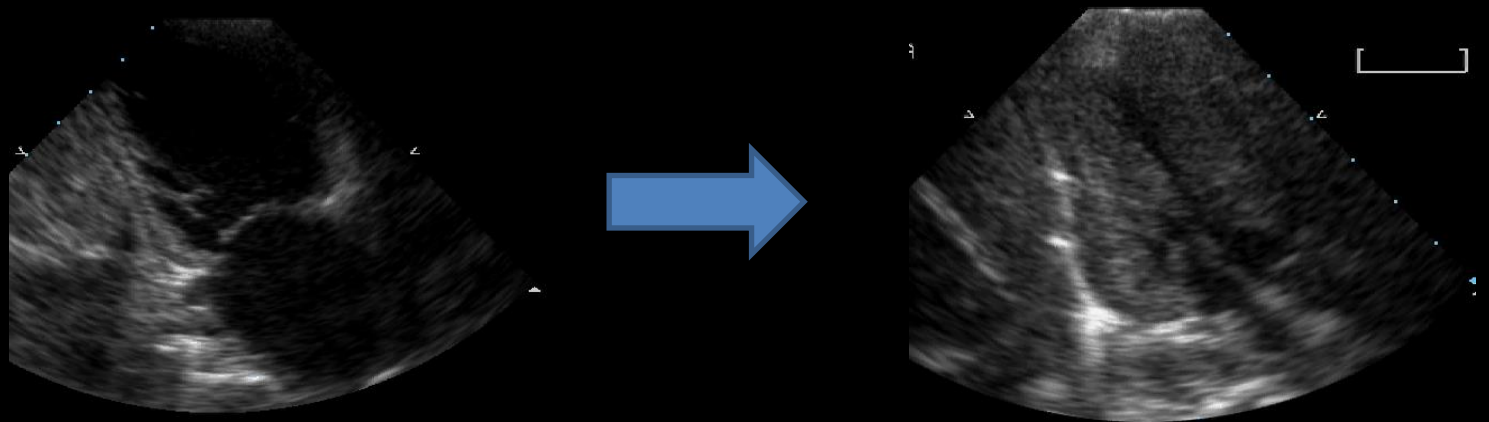
7 – 10 giorni

Tempo medio: 1.5 giorni

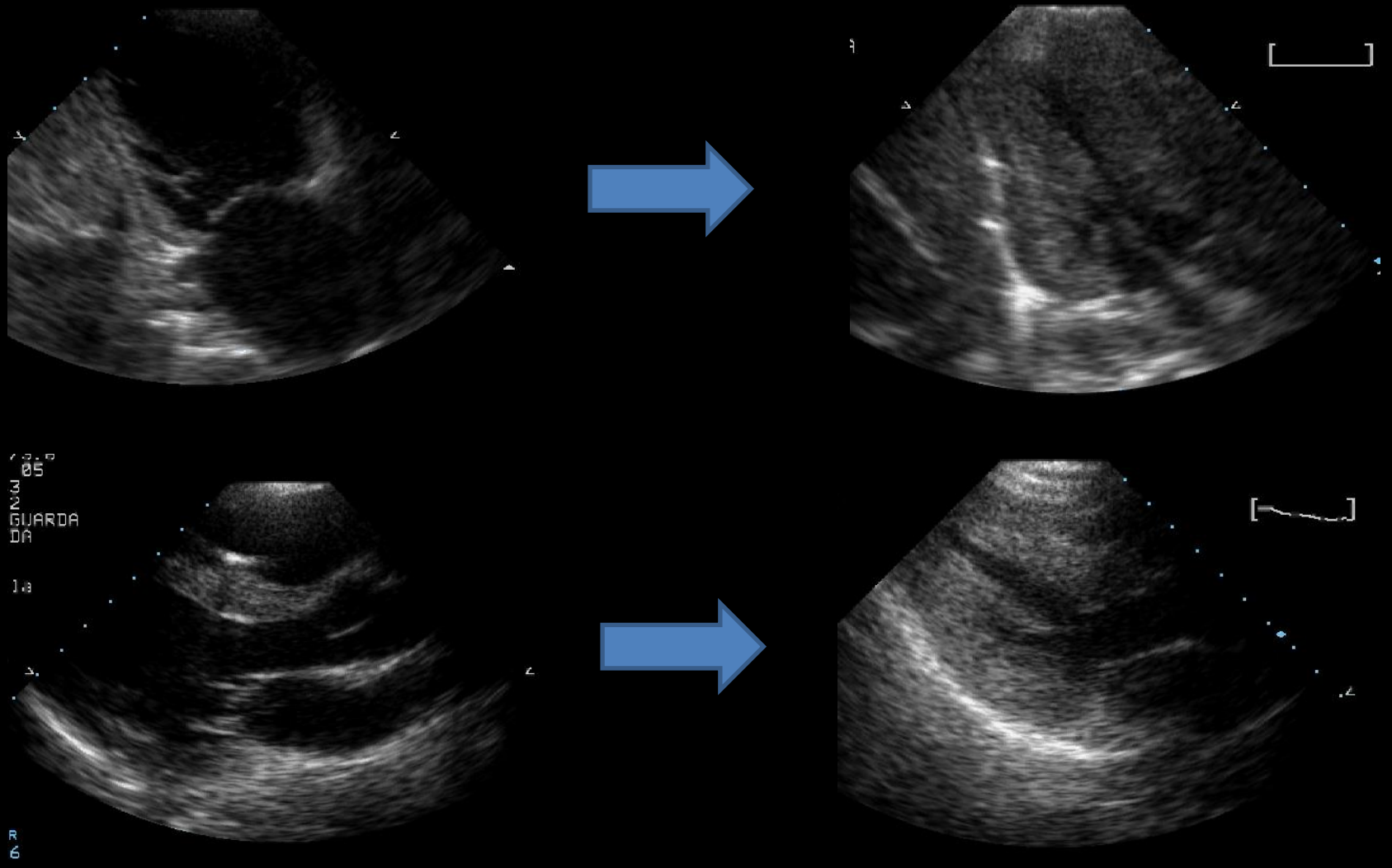
10-12 ore

Impianto MCS

Bridge to RECOVERY



Edema miocardico nella miocardite fulminante



Outcomes and long-term quality-of-life of patients supported by extracorporeal membrane oxygenation for refractory cardiogenic shock*

INSTITUT DE CARDIOLOGIE
Pitié-Salpêtrière
Paris

CARDIOMIOPATIE
STEMI
MIOCARDITI
POST-CARDIOTOMY
TRAPIANTI

ECMO for Acute Cardiogenic Shock
n = 81

38 Deaths under ECMO

9 Deaths after ECMO weaning

34 ICU survivors

42%

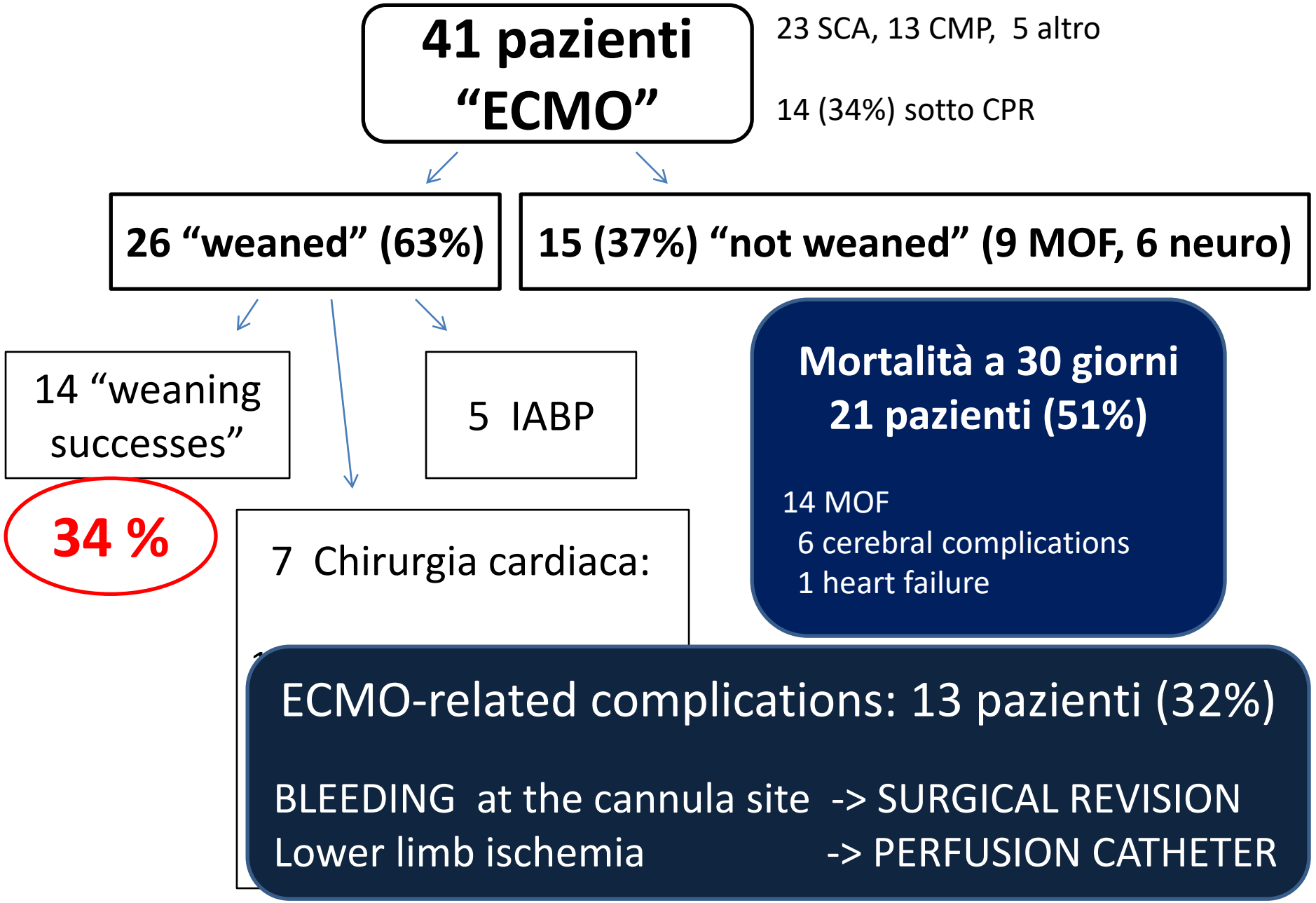
29 Long term survivors

36%

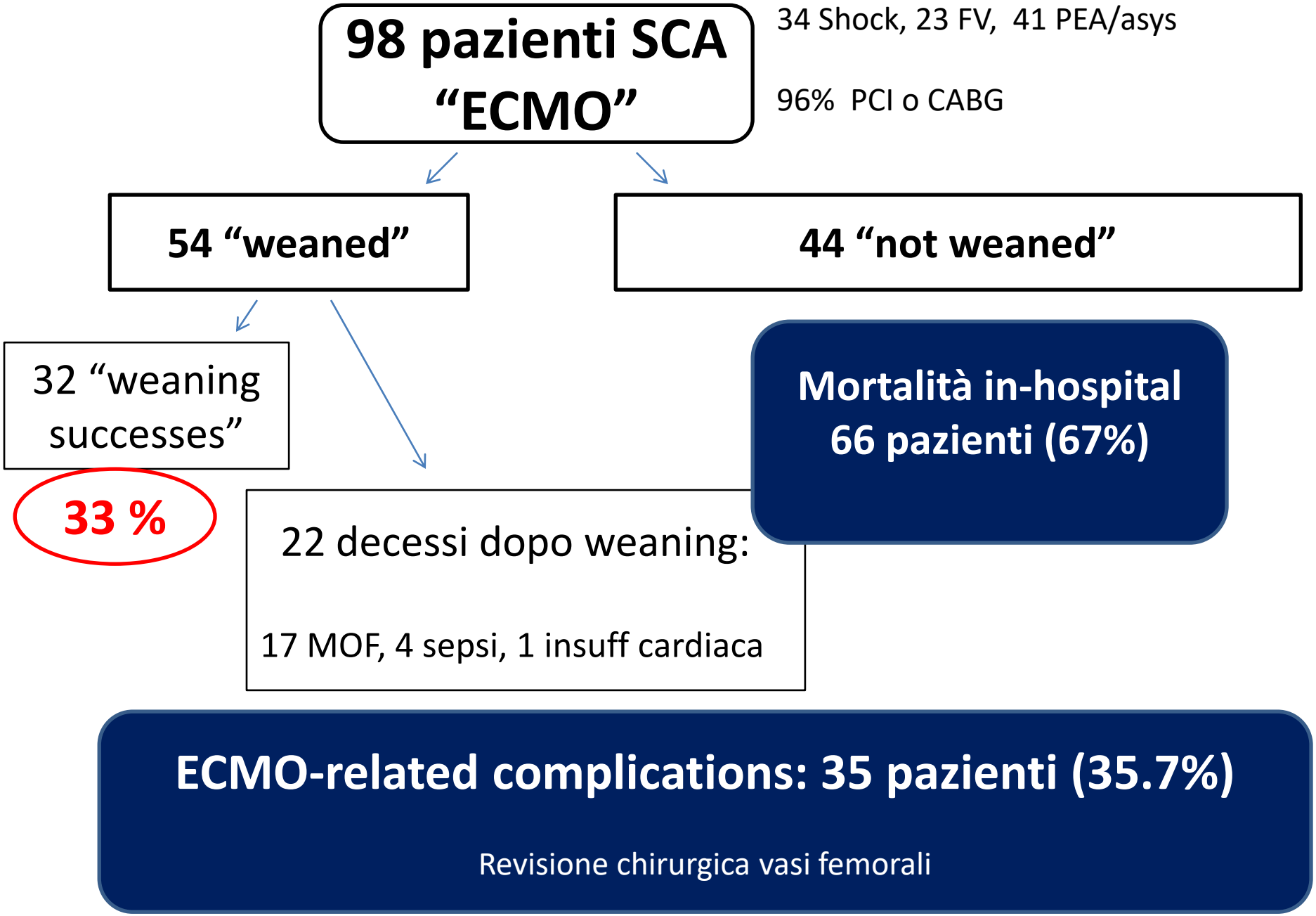
MAJOR COMPLICATIONS : > 50%

Major bleeding:	32% of all patients
Femoral vein thrombosis:	10%
Arterial ischemia:	19%
Vena cava thrombosis:	7%
Stroke:	8%
Infection	17%
Pulmonary edema:	6%

A.Combes, CCM 08



Guenther S, Interactive CardioVascular and Thoracic Surgery 2013 – Munich, Germany



Sakamoto S, Ann Thorac Surg 2012 – Hyogo. Japan

PREDICTORS OF IN-HOSPITAL MORTALITY

Sakamoto S, Ann Thorac Surg 2012 – Hyogo. Japan

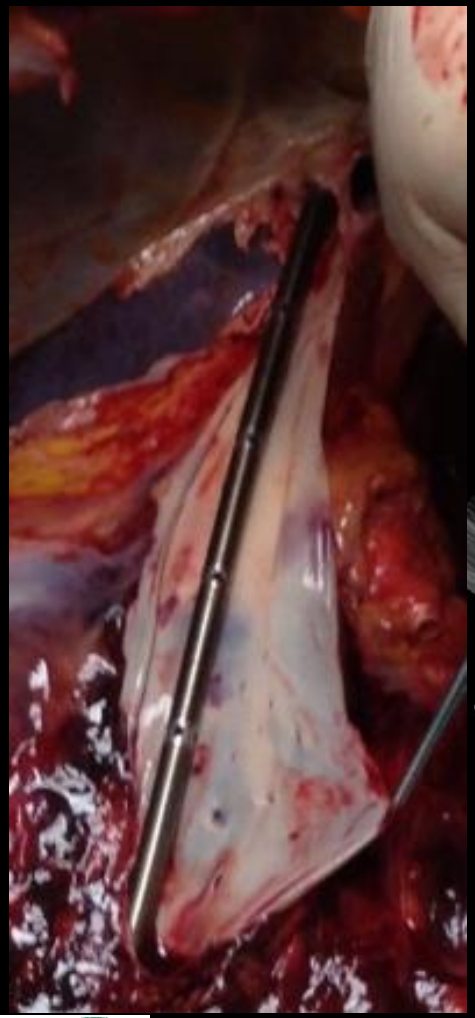
Variables	Total (n = 98)	Survived (n = 32)	Died (n = 66)
Clinical situation of ECLS implantation			
Hospital arrival	44 (44.9)	10 (31.3)	34 (51.5)
During PCI	33 (33.7)	15 (46.9)	18 (27.3)
After PCI	20 (20.4)	7 (21.9)	13 (19.7)
After left ventricular repair	1 (1)	0	1 (1.5)
Circulatory status before ECLS introduction			
Cardiogenic shock	34 (34.7)	14 (43.8)	20 (30.3)
VF/VT	23 (23.5)	13 (40.6)	10 (15.2)
Asystole/PEA	41 (41.8)	5 (15.6)	36 (54.5)
ECLS-related complications	35 (35.7)	5 (15.6)	30 (45.5)
Cannula site complication	23 (23.5)	3 (9.4)	20 (30.3)
Retroperitoneal hemorrhage	4 (4.1)	0	4 (6.1)
Lower limb ischemia	7 (7.1)	1 (3.1)	6 (9.1)
Cerebral hemorrhage	3 (3.1)	1 (3.1)	2 (3)

UNSUCCESSFUL ANGIOPLASTY

DUAL ANTIPLATELET MEDICATIONS

AGE ≥ 75 YEARS WAS NOT PREDICTOR OF IN-HOSPITAL MORTALITY

Trombo a stampo post-rimozione cannula venosa



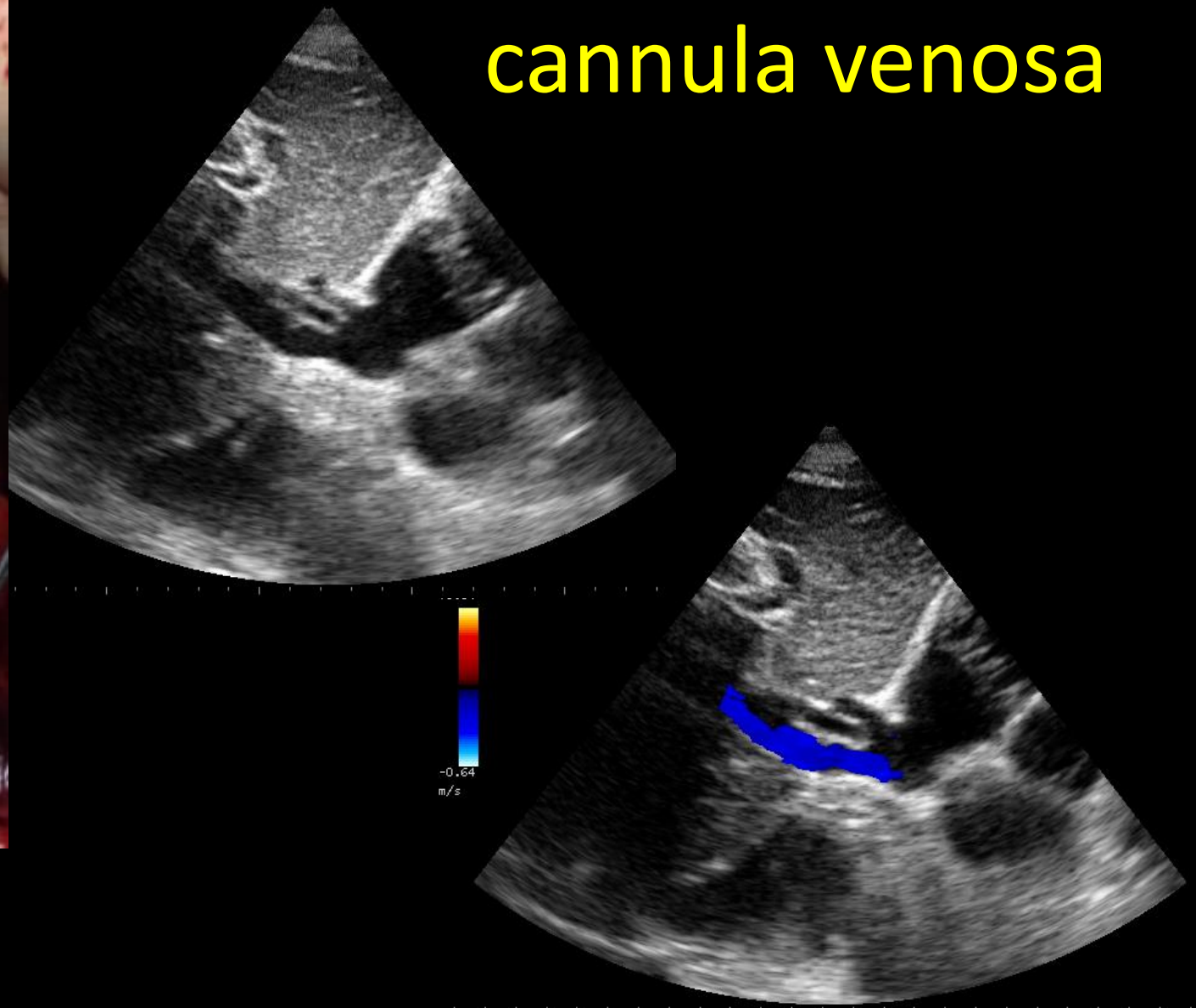


Table 2. Frequent Contraindications for Veno-Arterial Extracorporeal Membrane Oxygenation*

Absolute contraindication
Patients with nonrecoverable cardiac dysfunction who are not candidates for LVAD or transplantation
Relative contraindications
Contraindications to therapeutic-dose anticoagulation†
Severe aortic regurgitation
Aortic dissection
Existent multiorgan failure
Mechanical ventilation >7–10 days

(*Circulation.* 2015;131:676-680.

Table 3 Contraindications to ECMO

Absolute: among these futile treatment without exit strategy in case of

- Unrecoverable heart and not a candidate for transplant or destination therapy of VAD support
- Disseminated malignancy
- Known severe brain injury
- Unwitnessed cardiac arrest
- Prolonged CPR without adequate tissue perfusion
- Unrepaired aortic dissection
- Severe aortic regurgitation
- Severe chronic organ dysfunction (emphysema, cirrhosis, renal failure)
- Compliance (financial, cognitive, psychiatric, or social limitations in patient without social support)
- Peripheral vascular disease is contraindicated in peripheral VA ECMO
- VV ECMO is contraindicated in cardiogenic failure and in Severe chronic pulmonary hypertension (mean pulmonary artery pressure >50 mmHg)

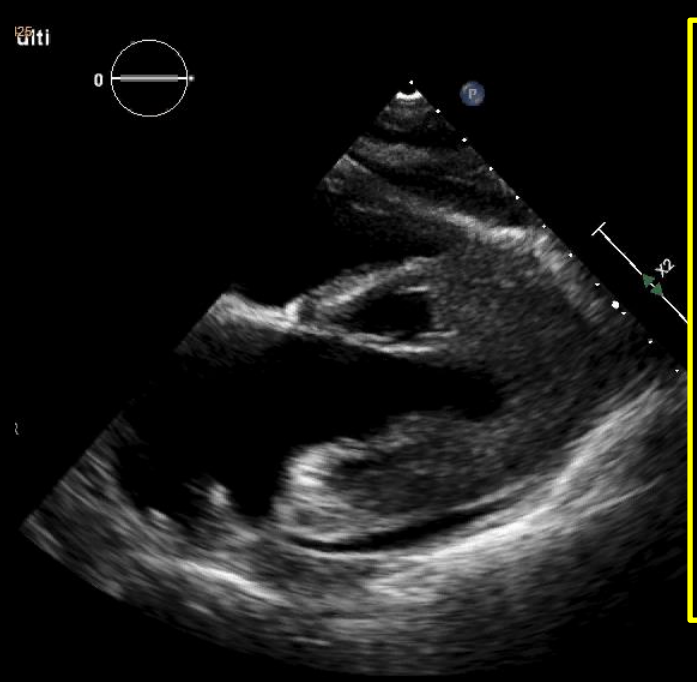
Relative: contraindication for anticoagulation, advanced age, obesity

George Makdisi, I-wen Wang

J Thorac Dis 2015;7(7):E166-E176

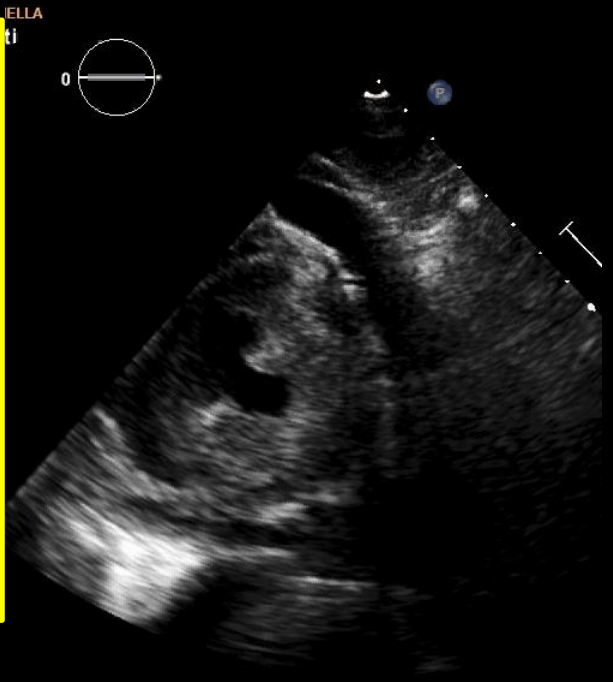
Miocardite eosinofila

24 Aprile 2015 ore 18.30: giunge in PS per dolore toracico e dispnea, febbre da 10 giorni. Storia di poliallergia ed eosinofilia



TRE STADI DELLA MALATTIA

1) Endomiocardite
2) Trombosi endocardica
3) Fibrosi endomiocardica



ore 3.00: shock cardiogeno. PAS 80 mmHg, PVC 15, Fc 160 bpm.
Lattati: 1.9 -> 2.9 -> 3.4 mmol/L
Adrenalina 0.08 mcg/Kg/min + nora 0.1 mcg/Kg/min e CONTROPULSAZIONE AORTICA

Ore 6.00 ECMO veno-arterioso

veno-arterial-ECMO (SAVE)-score

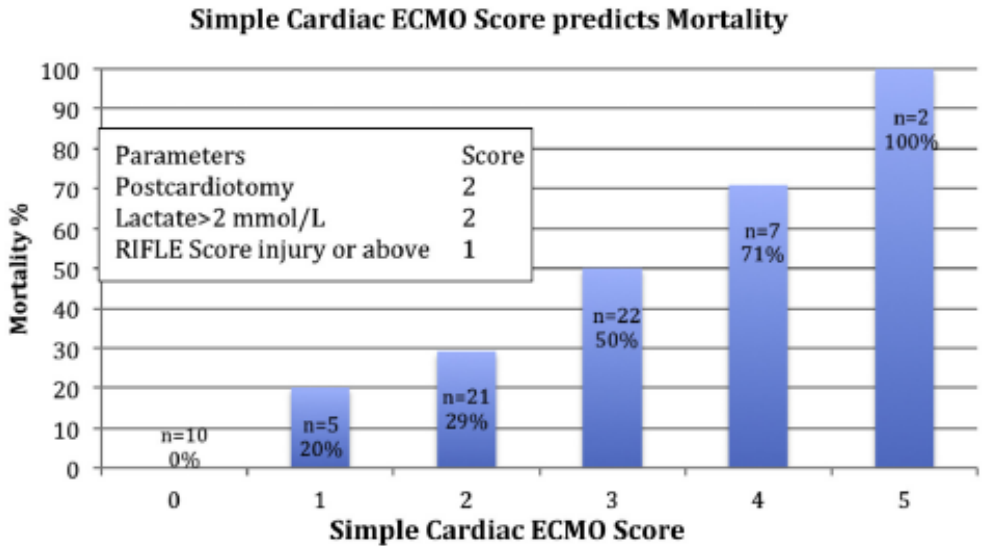
Acute cardiogenic shock diagnosis group (select one or more)		
Myocarditis	3	
Refractory VT/VF	2	
Post heart or lung transplantation	3	
Congenital heart disease	−3	
Other diagnoses leading to cardiogenic shock requiring VA-ECMO	0	
Age (years)		
18–38	7	
39–52	4	
53–62	3	
≥63	0	
Weight (kg)		
≤65	1	
65–89	2	
≥90	0	
Acute pre-ECMO organ failures (select one or more if required)		
Liver failure[a]	−3	
Central nervous system dysfunction[b]	−3	
Renal failure[c]	−3	
Chronic renal failure[d]	−6	
Duration of intubation prior to initiation of ECMO (h)		
≤10	0	
11–29	−2	
≥30	−4	
Peak inspiratory pressure ≤20 cmH_2O	3	
Pre-ECMO cardiac arrest	−2	
Diastolic blood pressure before ECMO ≥40 mmHg[e]	3	
Pulse pressure before ECMO ≤20 mmHg[e]	−2	
HCO_3 before ECMO ≤15 mmol/L[e]	−3	
Constant value to add to all calculations of SAVE-score	−6	
Total score	−35 to 17	
Total SAVE-score	Risk class	Survival (%)
Hospital survival by risk class		
>5	I	75
1–5	II	58
−4 to 0	III	42
−9 to −5	IV	30
≤−10	V	18

European Heart Journal (2015) 36, 2246–2256

Risk score

Simple new risk score model for adult cardiac extracorporeal membrane oxygenation: simple cardiac ECMO score

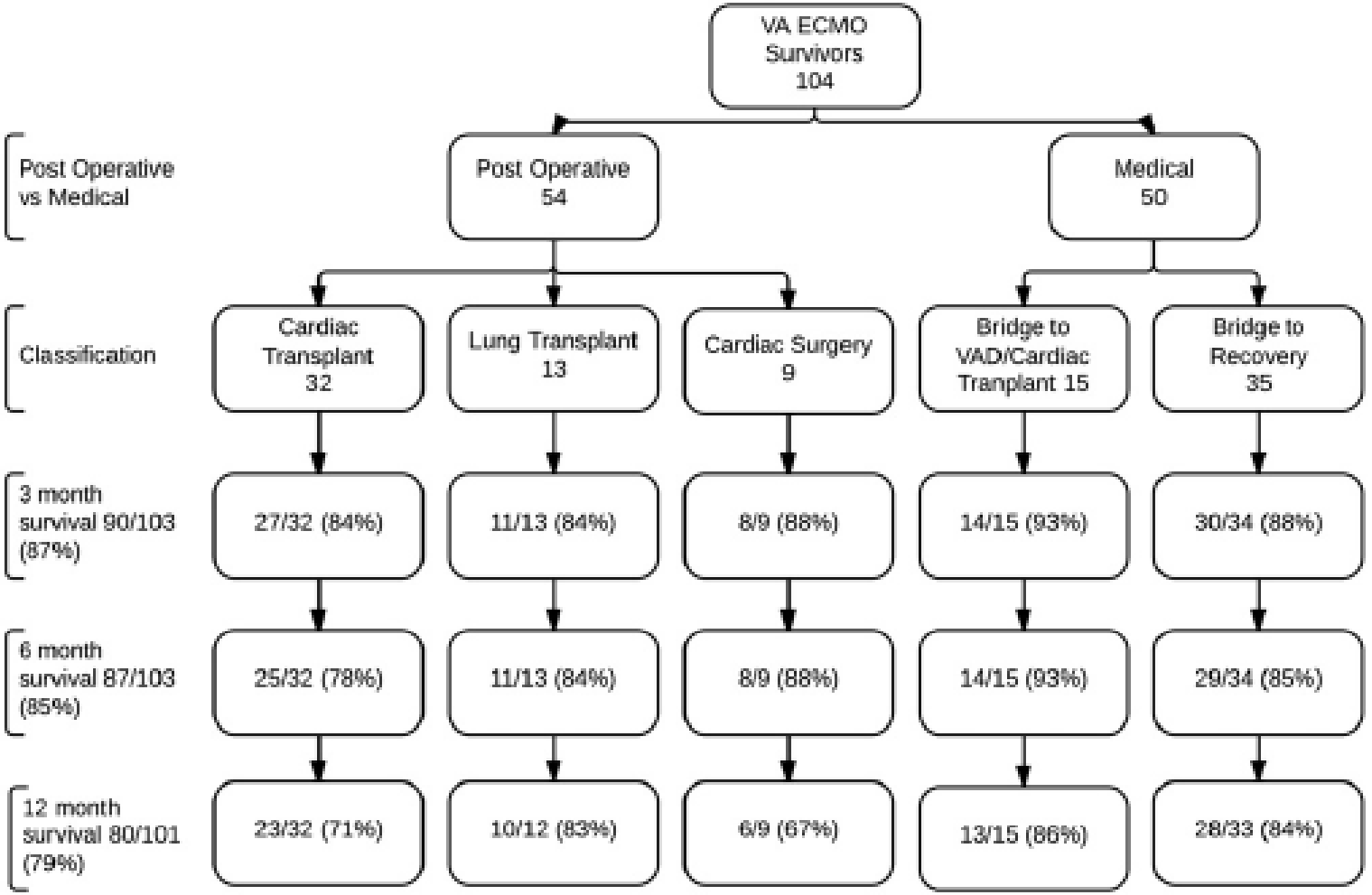
Graham Peigh, BA,[a] Nicholas Cavarocchi, MD,[a] Scott W. Keith, PhD,[b] and Hitoshi Hirose, MD, PhD[a,]*



JOURNAL OF SURGICAL RESEARCH 198 (2015) 273–279

Long-term survival of adults with cardiogenic shock after venoarterial extracorporeal membrane oxygenation☆

Aidan J.C. Burrell, MBBS [a,b,*], Vincent A. Pellegrino, MBBS [a,e], Rory Wolfe, PhD [e], Wen Kai Wong, David Jamie Cooper, MBBS, MD [a,b], David M. Kaye, MBBS, PhD [c,d], David V. Pilcher, MBBS [a,b]



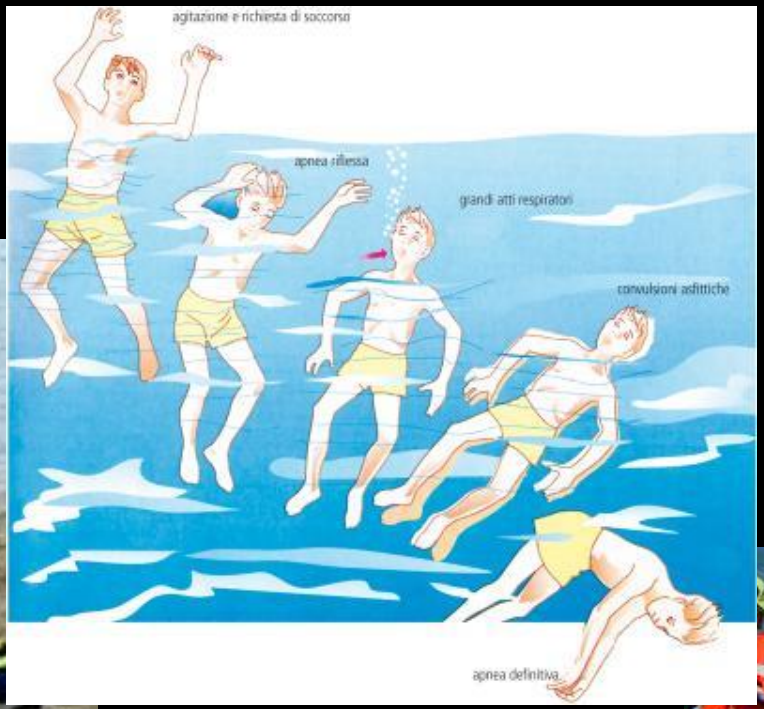
ECMO v-a: conclusioni

- Non è il sistema di supporto ideale per garantire l’”unloading” ventricolare.
- Sistema di supporto rapido da applicare, sostituisce entrambi i ventricoli e la funzione polmonare.

- I risultati nel trattamento dello shock cardiogeno refrattario sono migliori rispetto all’arresto cardiaco. L’ACC intraospedaliero testimoniato è la condizione più favorevole.
- I vantaggi del sistema nell’arresto cardiaco extraospedaliero sono ancora da valutare.
- Le complicanze non sono trascurabili, soprattutto vascolari legate al sito di cannulazione

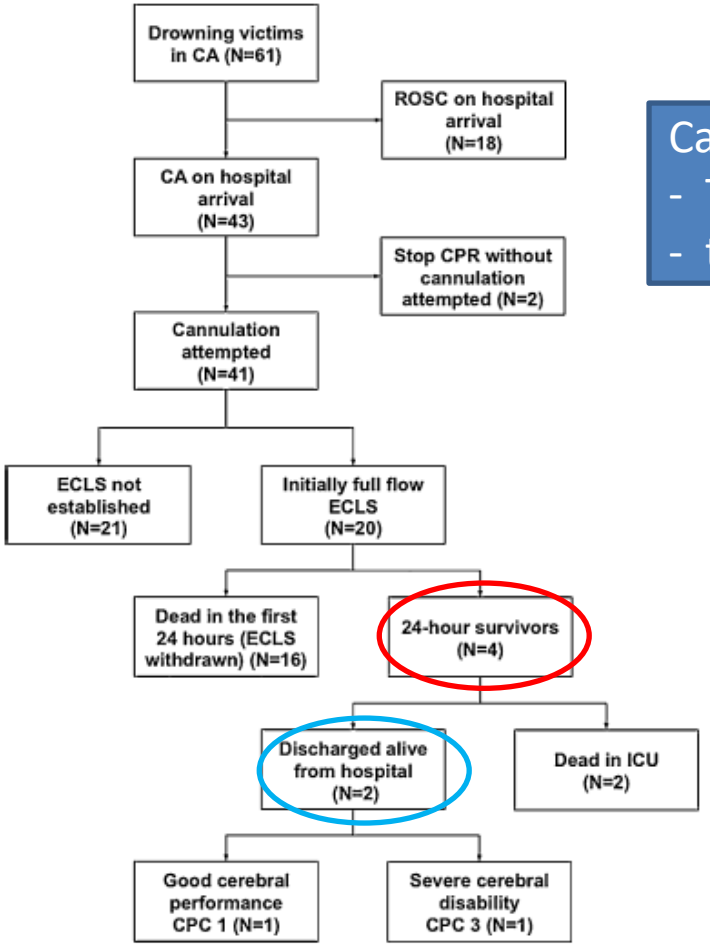
Sommersione - Annegamento

- In Europa 38.000 morti anno
- In Italia 360 morti anno per sole attività ricreative



Ecmo e sommersione

ESPERIENZA FRANCESE



Candidabili a ECMO:
- T < 30°C
- tempo sommersione < 1 h

SOPRAVVIVENZA a 24 ore:
-First hospital T ≤ 26°C
-K < 6 mEq/l

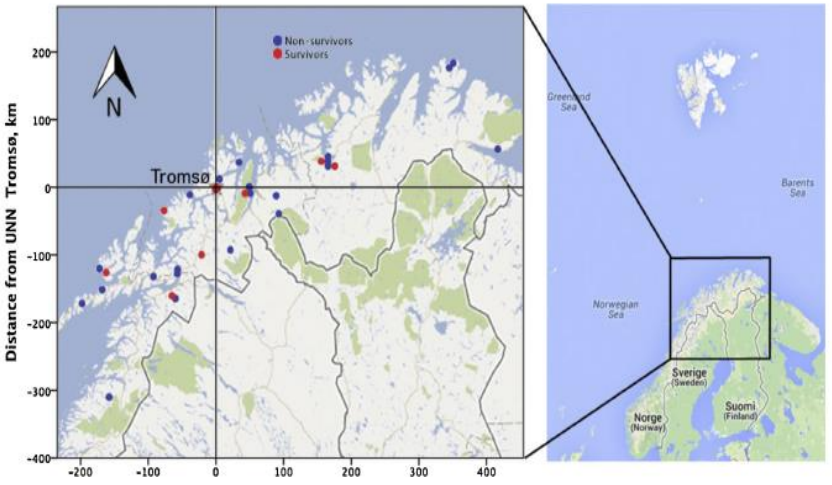
	Patients with successful ECLS implantation (*N* = 20)		*p* Value[a]
	24-h non-survivors (*N* = 16)	24-h survivors (*N* = 4)	
Age (years)	42 (12)	44 (14)	0.84
Male	13 (81%)	2 (50%)	0.25
Seine water temperature (°C)	14 (7)	8 (3)	0.04
Total immersion duration (min)[b]	25 (14–30)	23 (20–25)	0.82
Prehospital first core temperature (°C)	26 (5)	21 (2)	0.07
Prehospital CPR duration (min)	46 (36–60)	35 (30–39)	0.12
First hospital core temperature (°C)	27 (3)	21 (4)	0.004
pH at admission	6.77 (0.19)	6.79 (0.27)	0.92
Potassium level at admission (mM)	5.9 (2.4)	4.8 (0.4)	0.09
Lactate level at admission (mM)	19 (9)	19 (7)	0.90
Total CPR duration (from water recovery to start of ECLS) (min)	103 (83–120)	105 (73–120)	0.95

-First hospital T 21°C
-Immersion duration 23 min

Resuscitation 88 (2015) 126-131

Ecmo e sommersione

ESPERIENZA NORVEGESE



34 PATIENTS --> 9 SURVIVORS

Core Temperature at admission:

- 28°C cooled by snow (survivor 0)
- 22°C cooled by air (survivor 1)
- 24°C cooled by water (survivors 8)

Initial serum [K] was the only predictor of survival

[K] < 12 mmol/L: stop resuscitation

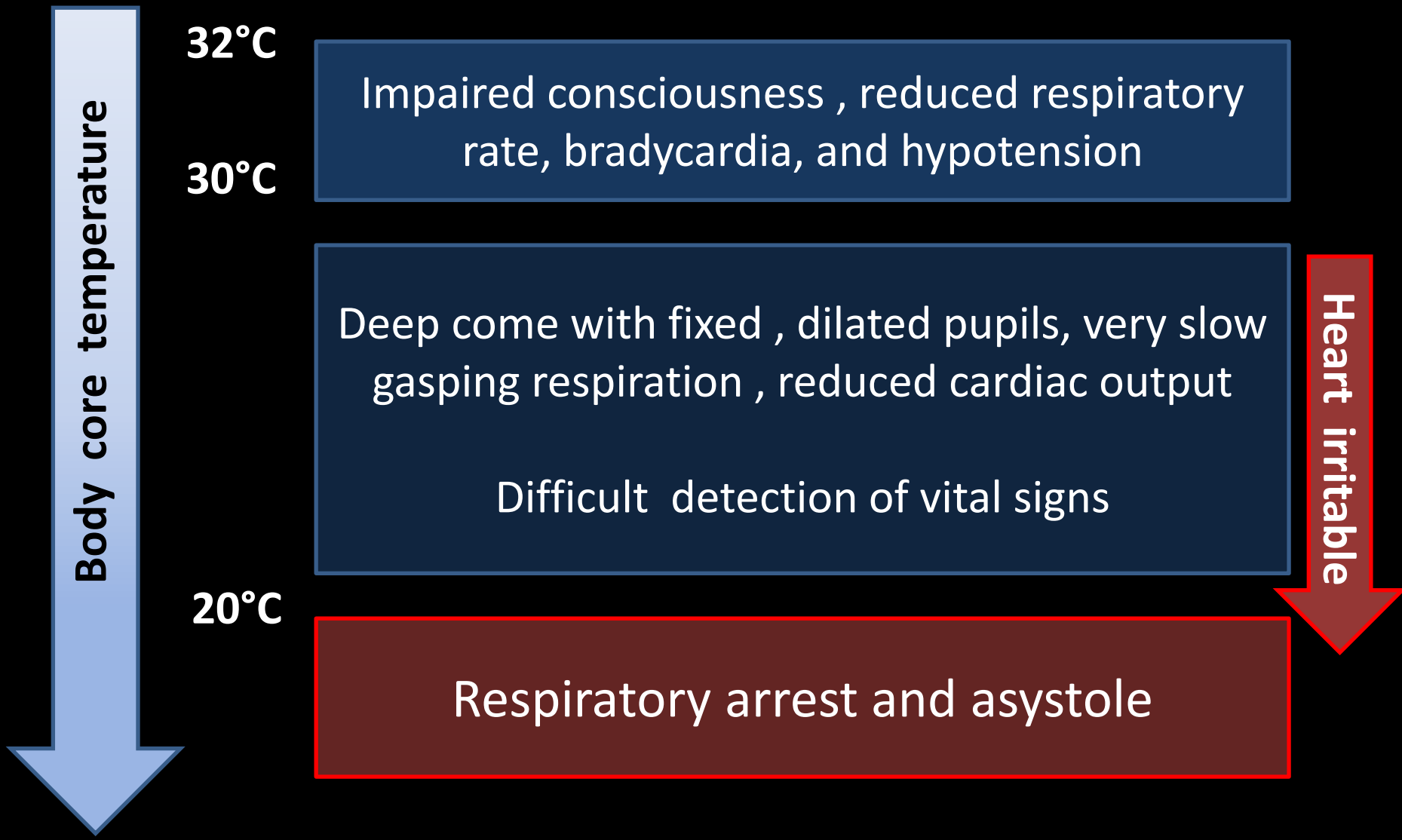
Time in water 32.5 min

Water temperature 2.3 °C

Cooling rate: rapid cooling in cold or icy water can exert some protection against anoxia

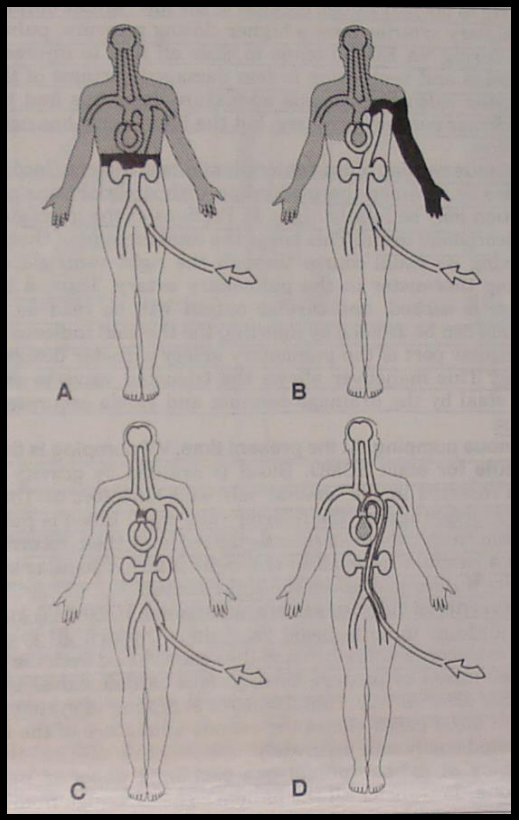
Resuscitation 85 (2014) 1204-1211

ECMO for Severe Accidental Hypothermia



SHOCK TEAM
Ospedale Sacco
Milano

Grazie per l'attenzione!



Coronary perfusion

- Oxygenated blood from the arterial cannula fails to reach the coronary artery.

- Coronary flow is provided by LV only if there is any appreciable ventricular ejection.

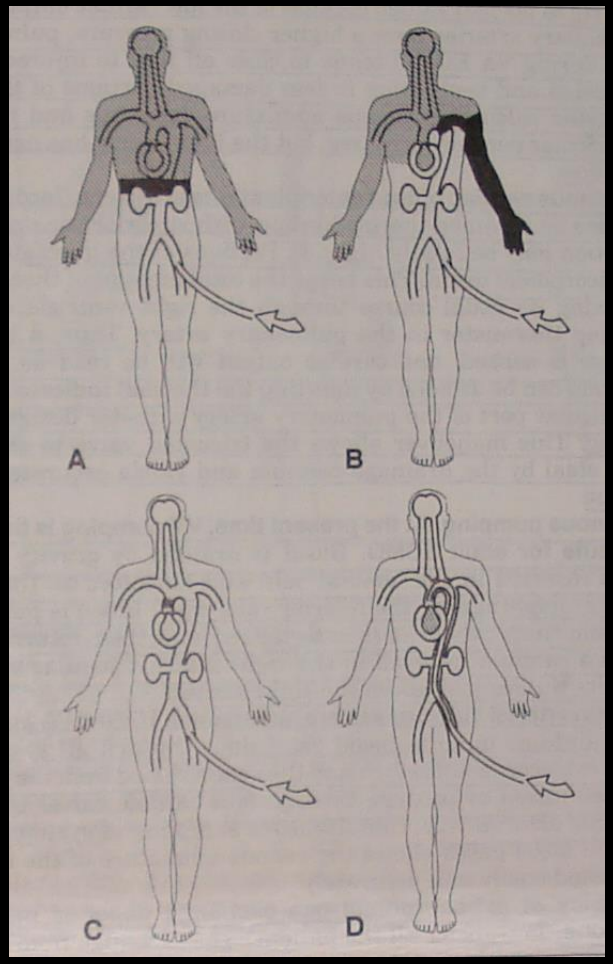
Nowlen et al. 1989; Kato et al. 1996

- If there is significant pulmonary parenchymal disease or inadequate mechanical ventilation during ECMO support , hypoxic blood returning to the LV may provide the sole source of coronary perfusion with deleterious effects on ventricular function and recovery.

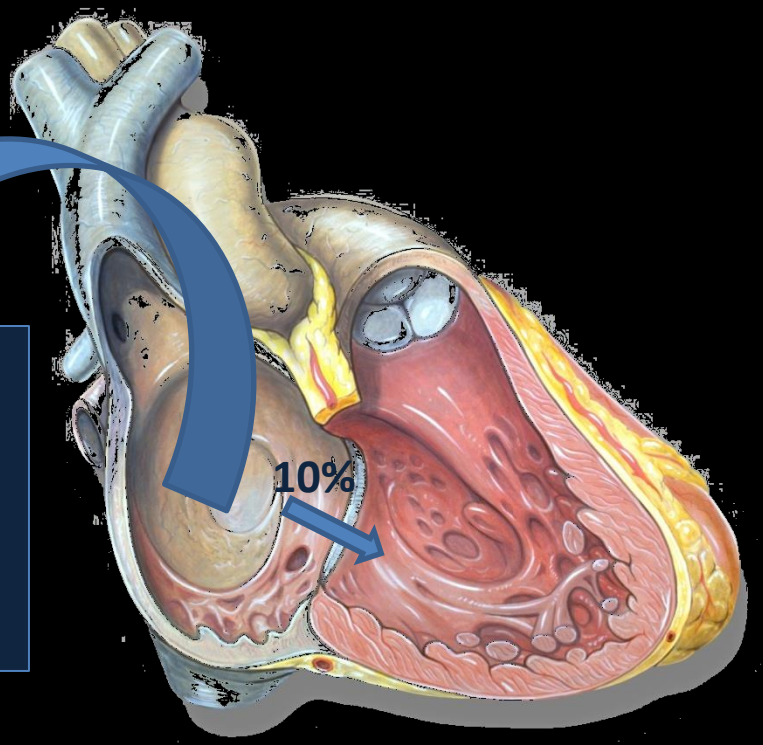
- Concomitant clinical condictions like sepsis, acidosis, or hypoxia may contribute to the decrease in cardiac performance.

Shen et al. 2001

Brain and coronary bed



- Normoxic arterial blood will perfuse the ***brain*** only if the tip of the return cannula lies between the aortic arch and the aortic root
- Normoxic arterial blood will be provided to the ***coronary bed*** only if the tip of the return cannula is placed in the aortic root

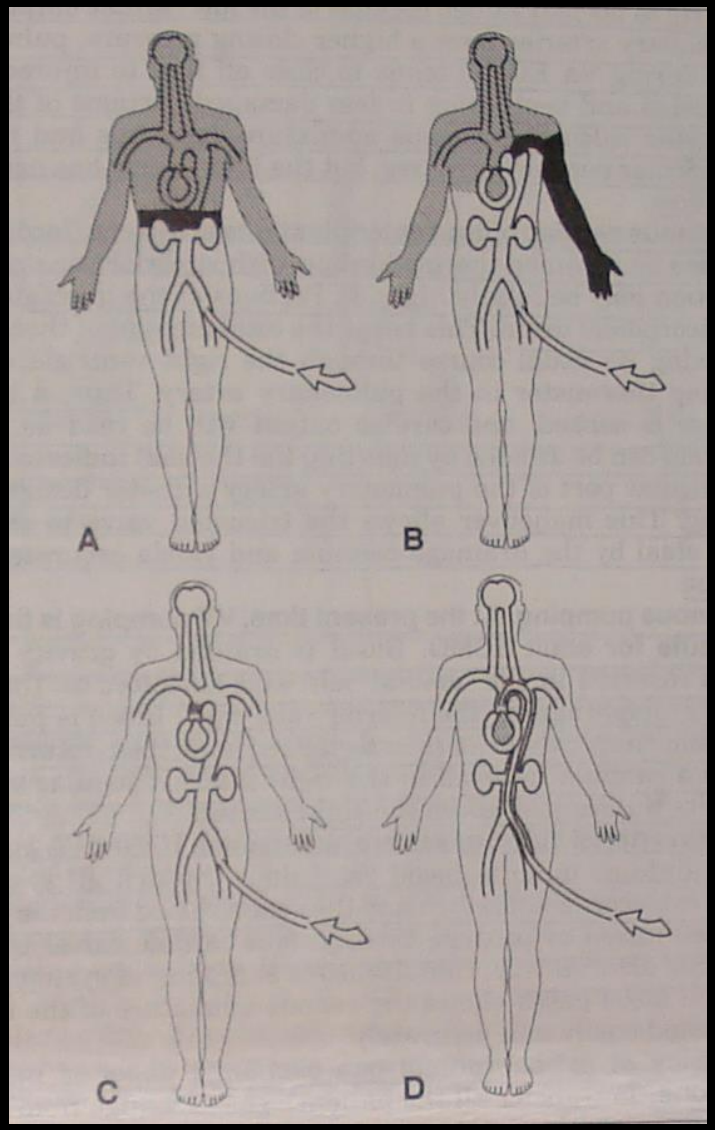


With optimal placement of venous cannula, up to 90 % of the pre-ECMO cardiac output can be diverted to extracorporeal circuit

Only the coronary sinus venous return fails to be drained into the extracorporeal circuit. This flow can become the the major fraction of the RV cardiac output that is pumped into the pulmonary artery.

Pulmonary circulation is perfused by blood at a low flow rate and with low SO2 (10-20%). This hypoxic condition may further damage the lung already injured.

Three regions where the saturation varies widely



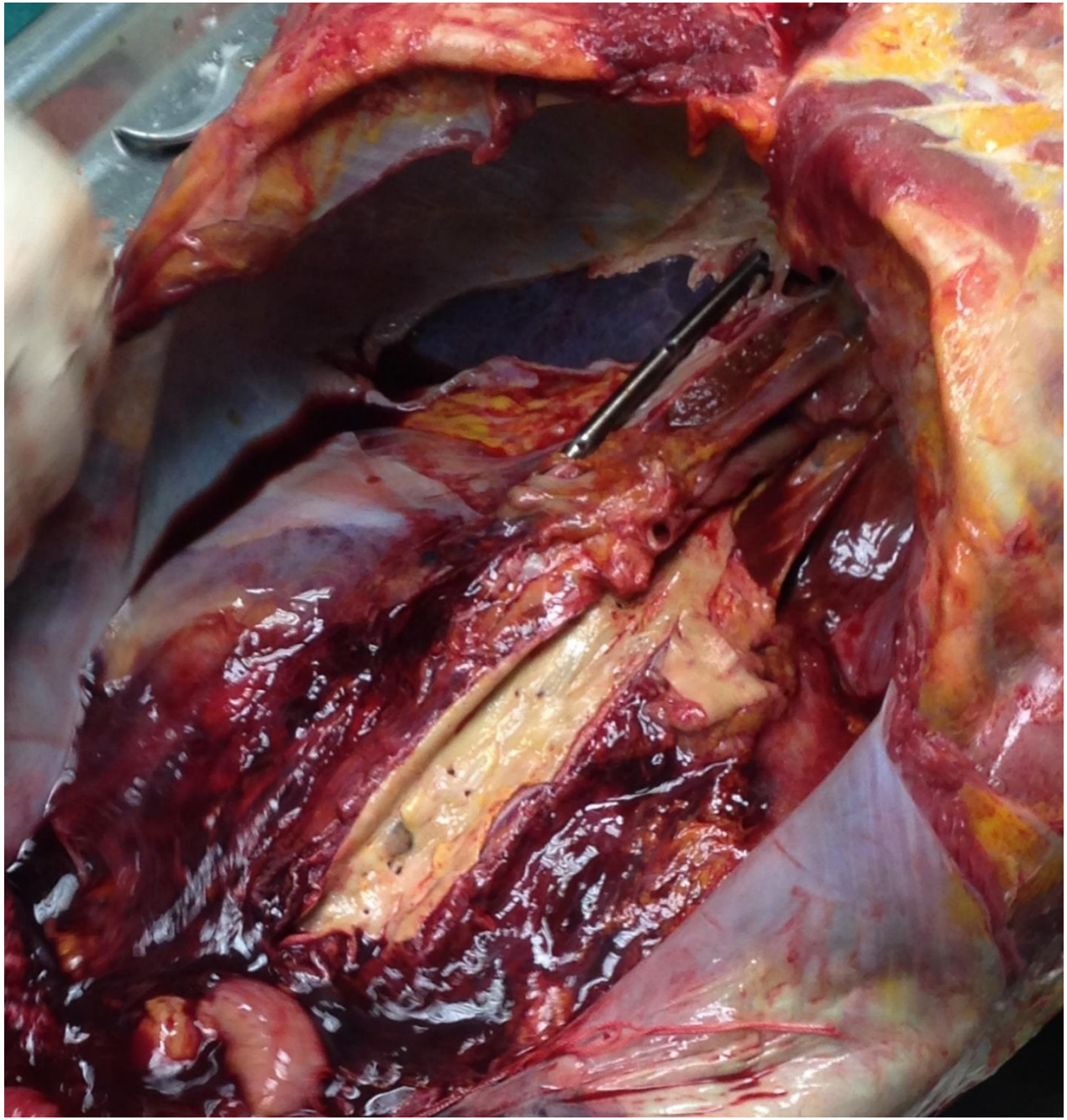
A: low return flows delivered to femoral artery

B: moderate return flows delivered to femoral artery

C: high return flows to the femoral artery

D: high return flow to the aortic root

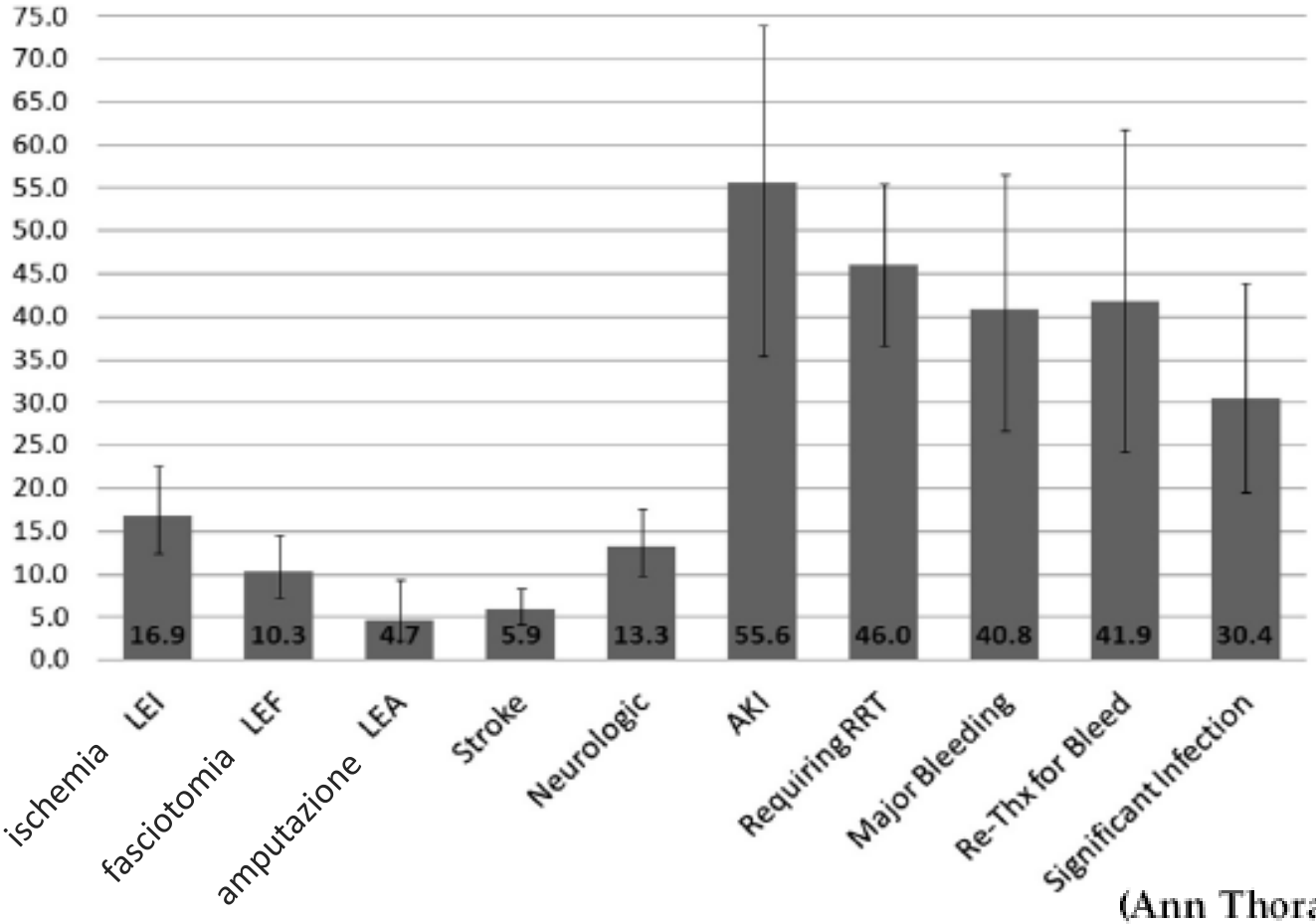
- PaO2 and SpO2 on the right arm



Complications of Extracorporeal Membrane Oxygenation for Treatment of Cardiogenic Shock and Cardiac Arrest: A Meta-Analysis of 1,866 Adult Patients

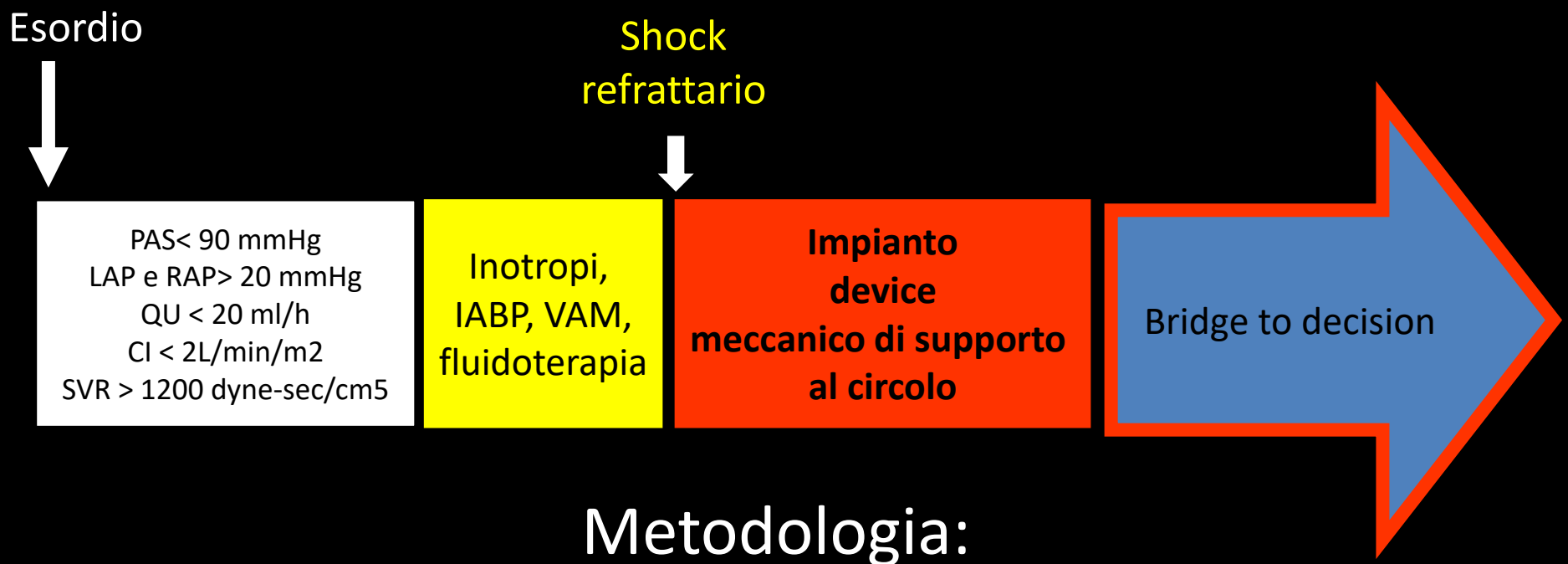
Richard Cheng, MD, Rory Hachamovitch, MD, Michelle Kittleson, MD, PhD, Jignesh Patel, MD, PhD, Francisco Arabia, MD, Jaime Moriguchi, MD, Fardad Esmailian, MD, and Babak Azarbal, MD

Cedars-Sinai Heart Institute, Los Angeles, California, and Department of Cardiovascular Medicine, Heart and Vascular Institute, Cleveland Clinic, Cleveland, Ohio



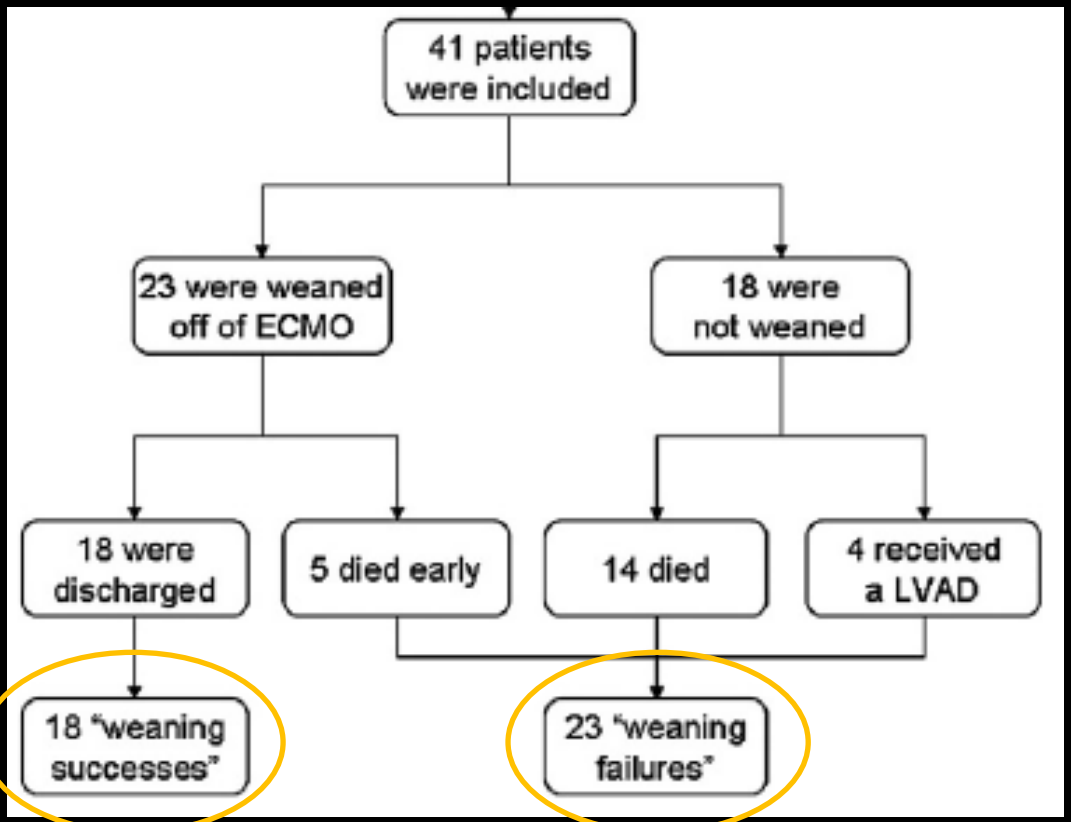
(Ann Thorac Surg 2014;97:610–6)

Shock cardiogeno refrattario



Metodologia:

definire e utilizzare un algoritmo multidisciplinare condiviso



SOPRAVVIVENZA
44 %

Reason for ECMO implantation, n		
Myocarditis	3	4
Myocardial infarction	2	9
Post–open-heart surgery	4	2
Early cardiac graft failure	4	3
Refractory cardiac arrest	2	1
Septic shock	2	2
Refractory rhythm disturbance	1	2

In-hospital mortality
56 %

Luyt CE, J Crit Care 2012
Alain Combes, Parigi

Extracorporeal Membrane Oxygenation Support in Acute Coronary Syndromes Complicated by Cardiogenic Shock

Stephen A. Esper,[1] MD, MBA, Christian Bermudez,[2] MD, Eric J. Dueweke,[2] MD,

Catheterization and Cardiovascular Interventions 86:S45–S50 (2015)

TABLE III. ECMO Complications

Complication	$n = 18$ (%)
Ischemic stroke	1 (6)
Intra-cranial bleed	0 (0)
Limb ischemia	4 (22)
Limb amputation/fasciotomy	0 (0)
Blood transfusion	17 (94)
PRBC	17 (94)
FFP	9 (50)
Platelets	10 (56)
Cryoprecipitate	2 (11)

Percentages shown in parentheses. PRBC = packed red blood cells, FFP = fresh frozen plasma.

The use of ECMO is associated with significant morbidity, mainly requiring blood transfusions and the need for close monitoring for distal limb ischemia. The use of oral dual antiplatelet medications is necessary after PCI, but the use of glycoprotein IIb/IIIa inhibitors is associated with significant bleeding risk.