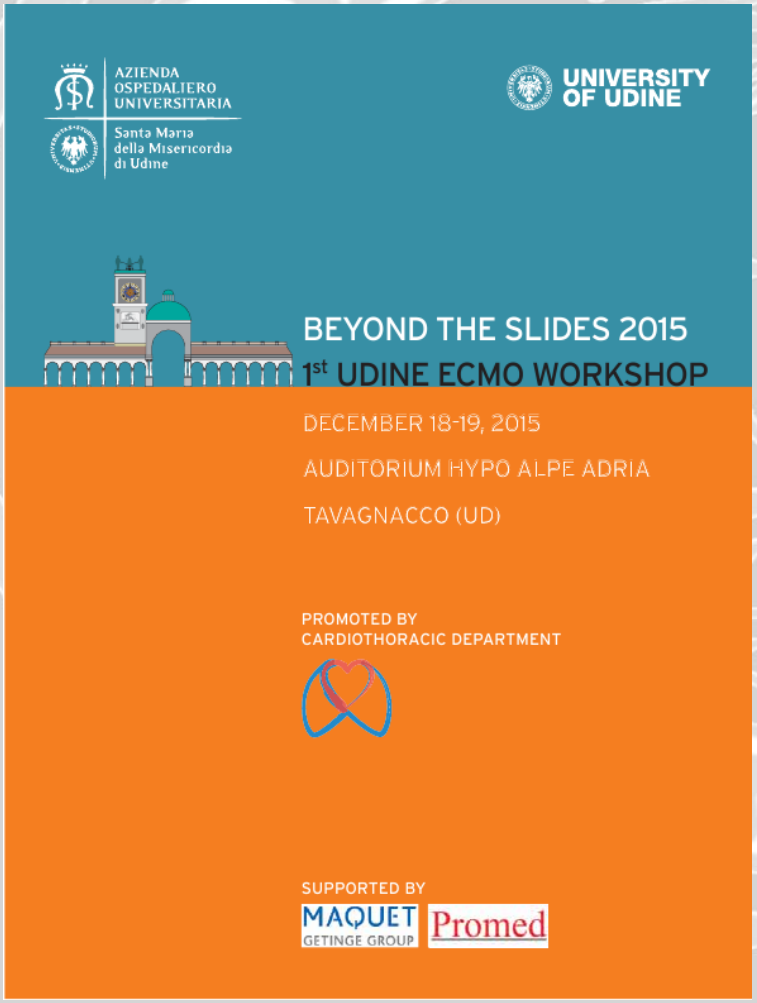
Città della Salute e della Scienza

University of Turin

Division of Cardiac Surgery



TIMING of ECMO IMPLANTATION

Prof. M. Rinaldi

CARDIOGENIC SHOCK
General Considerations

- *Results of conventional therapy*

- *Risks and Benefits of the VA ECMO therapy*

- *no randomized study data available for ECMO/ECLS use in cardiogenic shock*

Refractory Failure and Treatment

«*The ECMO galaxy*»

CARDIOPULMONARY

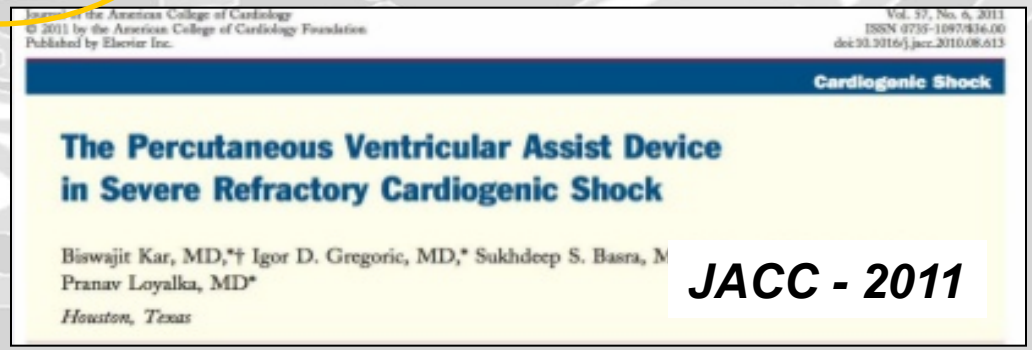
- Pulm+ RV
  - **RA-LA ECMO**
  - **RVAD ECMO**
- Pulm+ BiV or LV
  - **V-A ECMO**

CARDIAC

- BiV
  - **V-A ECMO BiVAD**
- RV
  - **RVAD**
- LV
  - **LVAD**

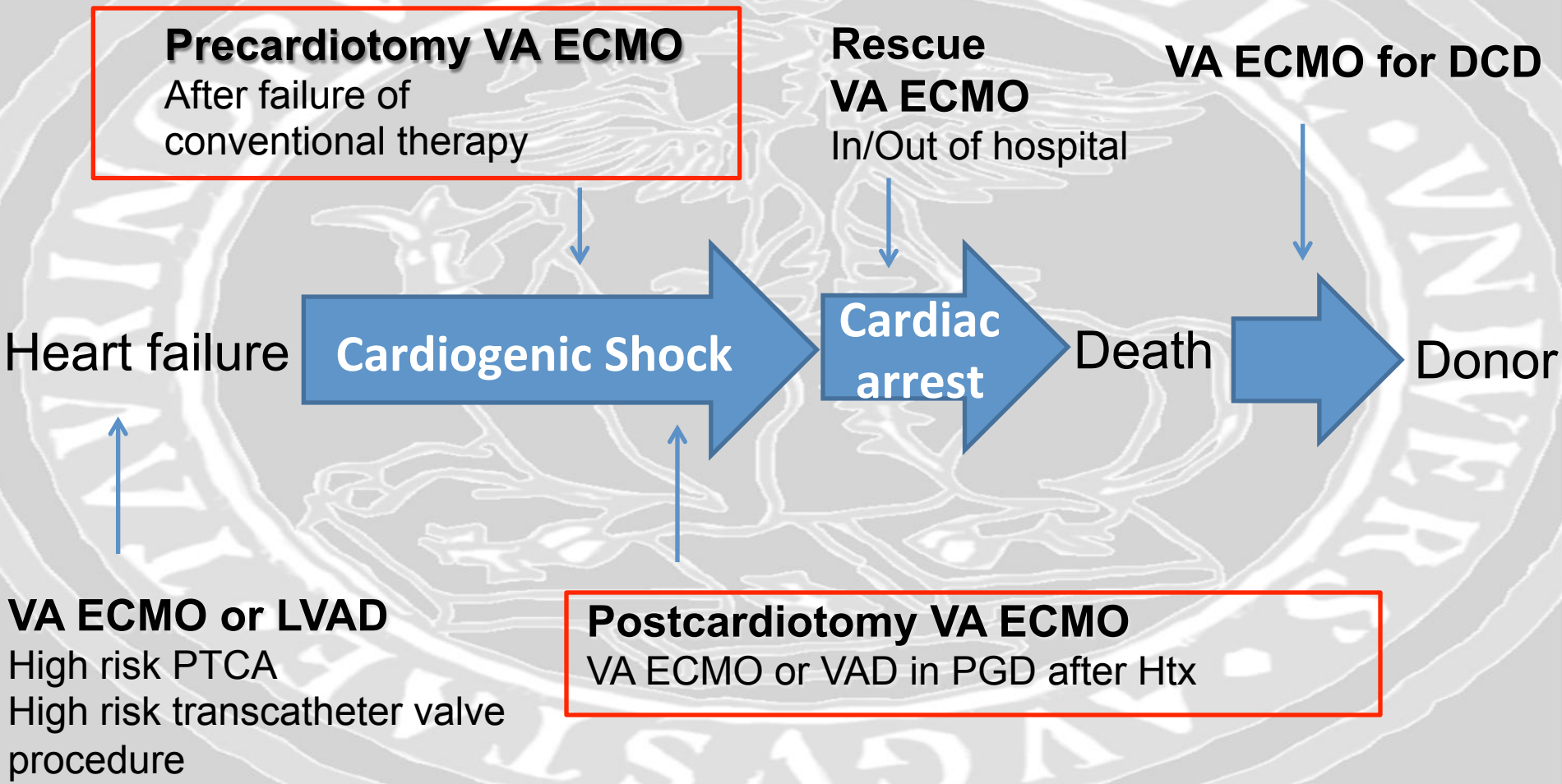
PULMONARY

- **V-V ECMO**



JACC - 2011

Timetable of VA ECMO implantation



Cardiogenic Shock: clinical definition

- **Unresponsive Hypotension**
- Prolonged MAP < 60 mmhg for > 30 min (or decrease in SBP more than 40 mmhg)
- C I < 1,8 l/min/m2 or < 2,2 l/min/m2 with **inotropic support**
- **High filling pressures**
- CVP > 14 mmhg
- Wedge pressure > 16 mmhg
- **Inadequate tissue perfusion**
- SVO2 < 55; Lactate continuously increase (or > 3)
- Alteration in consciousness
- Urine output < 30 cc/h

Journal of Cardiac Failure Vol. 21 No. 6 2015

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ISSN 0735-1097/00/$20.00
PII S0735-1097(00)00879-2

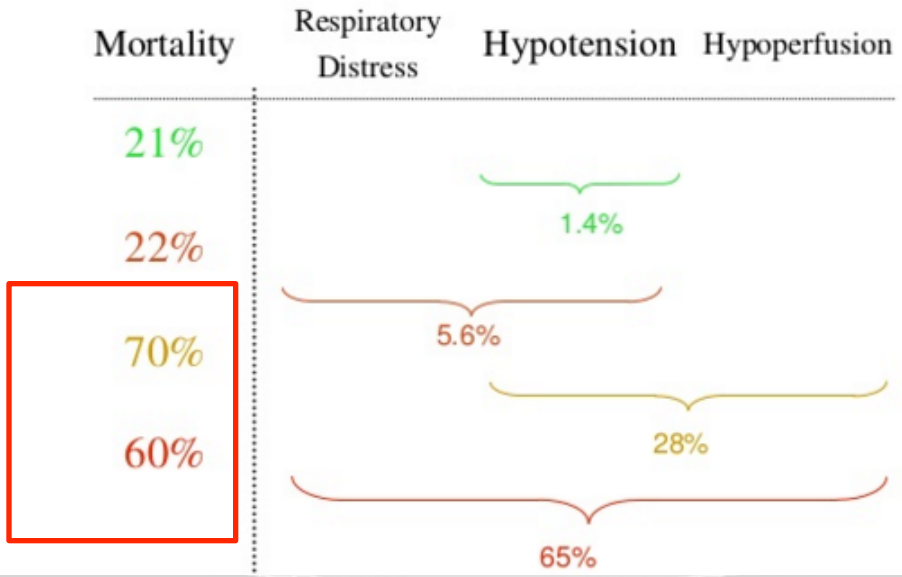
Cardiogenic Shock Complicating Acute Myocardial Infarction—Etiologies, Management and Outcome: A Report from the SHOCK Trial Registry

Judith S. Hochman, MD, FACC,* Christopher E. Buller, MD, FACC,† Lynn A. Sleeper, ScD,‡ Jean Boland, MD,§ Vladimir Dzavik, MD,‖ Timothy A. Sanborn, MD, FACC,¶ Emilie Godfrey, MS, RD,* Harvey D. White, DSc, FACC,# John Lim, BA,‡ Thierry LeJemtel, MD,** for the SHOCK Investigators

New York, New York; Vancouver and Edmonton, Canada; Watertown, Massachusetts; Liege, Belgium; Auckland, New Zealand

SHOCK Registry JACC Sept. 2000, Supp. A

Spectrum of Clinical Presentations



Cardiogenic Shock survival after diagnosis

In-hospital mortality 60- 80%

Long-Term Mortality of Patients With Acute Myocardial Infarction in the United States and Canada

Comparison of Patients Enrolled in Global Utilization of Streptokinase and t-PA for Occluded Coronary Arteries (GUSTO)-I

Padma Kaul, PhD; Paul W. Armstrong, MD; Wei-Ching Chang, PhD; C. David Naylor, MD, DPhil; Christopher B. Granger, MD; Kerry L. Lee, PhD; Eric D. Peterson, MD, MPH; Robert M. Califf, MD; Eric J. Topol, MD; Daniel B. Mark, MD, MPH

- **56% GUSTO I study**

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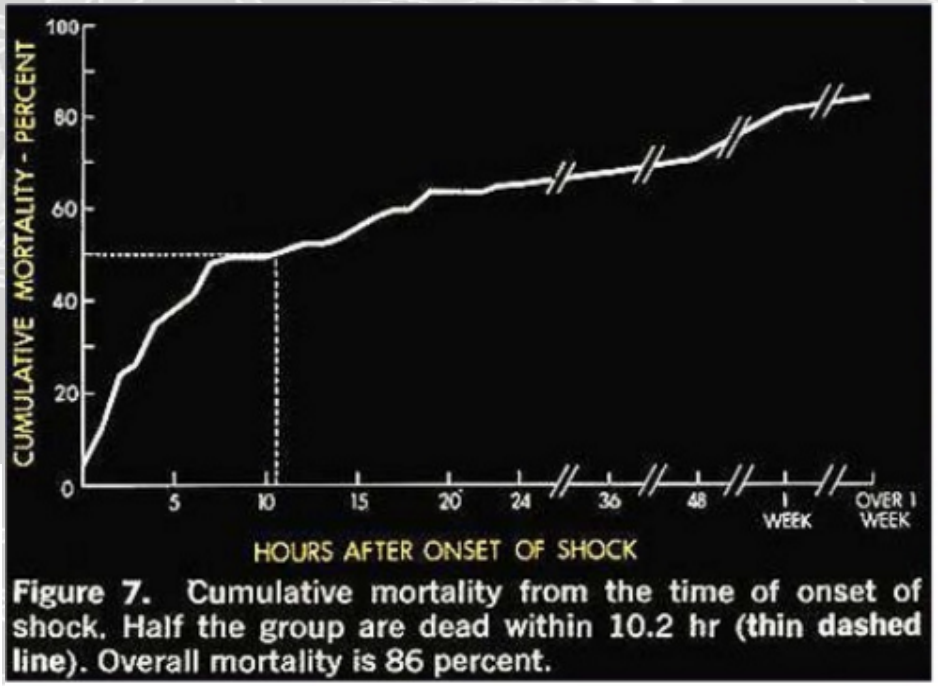


Figure 7. Cumulative mortality from the time of onset of shock. Half the group are dead within 10.2 hr (thin dashed line). Overall mortality is 86 percent.

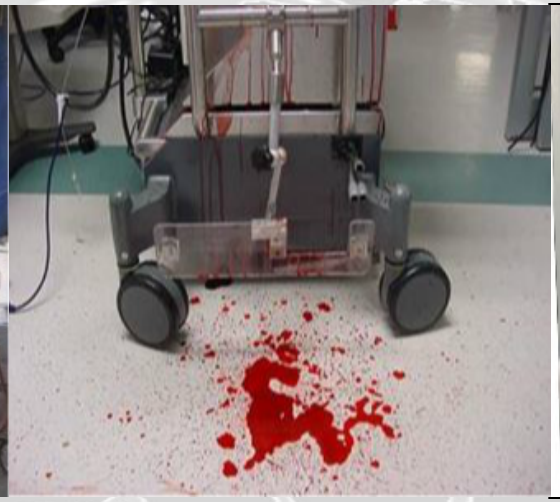
Hasdai et al. JACC 2000;36:687

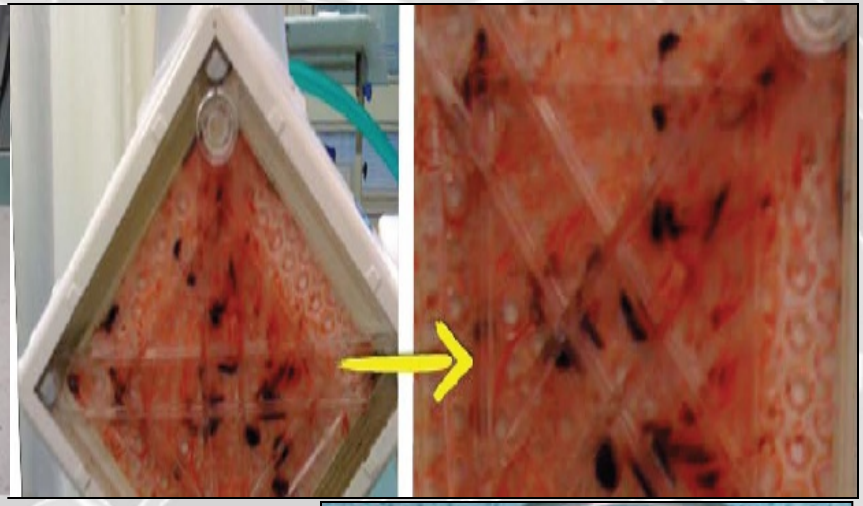
- **67% Shock Trial Registry**

PROFILE-LEVEL	Official Shorthand	General time frame for support
INTERMACS LEVEL 1	"Crash and burn"	Hours
INTERMACS LEVEL 2	"Sliding fast"	Days to week
INTERMACS LEVEL 3	Stable but Dependent	Weeks
INTERMACS LEVEL 4	"Frequent flyer"	Weeks to few months, if baseline restored
INTERMACS LEVEL 5	"Housebound"	Weeks to months
INTERMACS LEVEL 6	"Walking wounded"	Months, if nutrition and activity maintained
INTERMACS LEVEL 7	Advanced Class III	

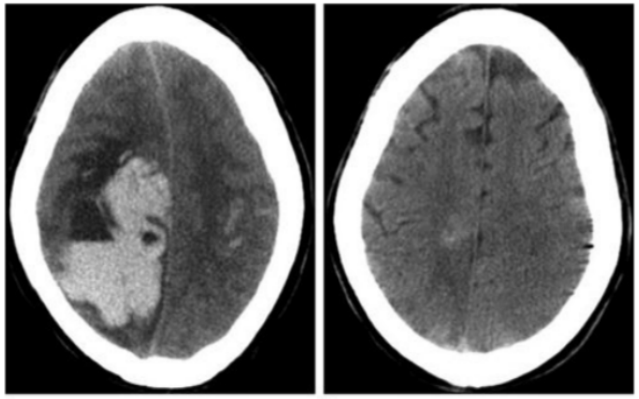
«Science never solves problem without creating ten more…»

George Bernard Shaw

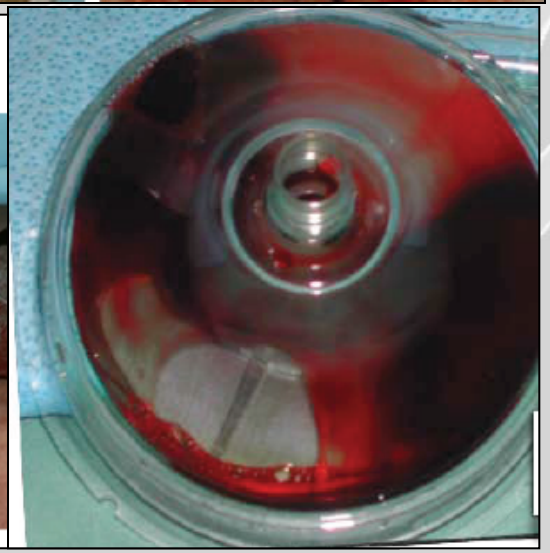




CNS bleeding



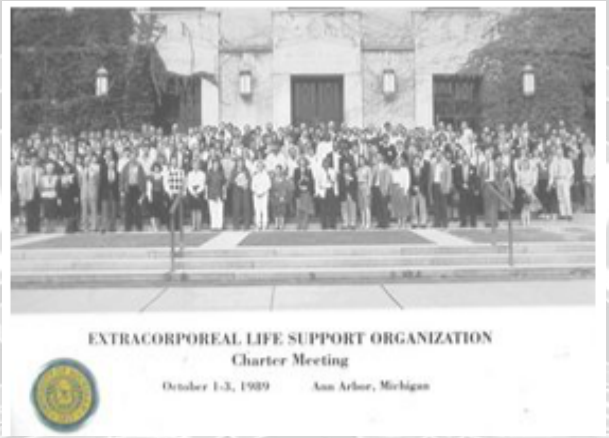
Pulmonary bleeding



V-A ECMO critical issues

- Bleeding and thrombosis
- Aortic flow competition- *Harlequin syndrome*
- Left heart overload
- Pulmonary function impairment
- Emolysis

- Data since 1979
- Charter Meeting 1989
- 230 centers
- International



ELSO: What do we do?

- Registry

	Total	Surv ECLS		Surv to DC	
Neonatal					
Respiratory	27,007	22,782	84%	20,093	74%
Cardiac	5,425	3,339	62%	2,206	41%
ECPR	980	626	64%	388	40%
Pediatric					
Respiratory	6,149	4,034	66%	3,496	57%
Cardiac	6,784	4,443	65%	3,388	50%
ECPR	2,071	1,123	54%	840	41%
Adult					
Respiratory	5,146	3,317	64%	2,905	56%
Cardiac	4,042	2,255	56%	1,636	40%
ECPR	1,238	476	38%	355	29%
Total	58,842	42,395	72%	35,307	60%

ECLS Registry Report

International Summary

January, 2014

Extracorporeal Life Support Organization
2800 Plymouth Road
Building 300, Room 303
Ann Arbor, MI 48109

Overall Outcomes

Mechanical and Patient related Complications

	0–30 Days	31 Days and <1 Year	1 Year and <16 Years	>16 Years
Mechanical				
Oxygenator failure	7.4 (24)	8.1 (29)	9 (43)	15.1 (36)
Tubing rupture	0.3 (25)	0.6 (50)	0.7 (47)	0.2 (0)
Pump malfunction	1.6 (29)	2.1 (35)	2.1 (50)	0.7 (28)
Cannula problems	6.1 (33)	5.6 (38)	6.3 (42)	4.4 (27)
Patient-related				
ICH	11.3 (23)	5.7 (29)	3.8 (21)	1.7 (7)
Cannula site bleeding	10.4 (30)	11.9 (40)	17.6 (52)	20.9 (39)
Surgical site bleeding	31.7 (30)	33 (39)	28.8 (48)	25.5 (34)
Cardiac tamponade	6.1 (27)	5.1 (38)	5.1 (50)	5.7 (27)
Clinical seizures	7.3 (29)	9 (26)	4.5 (21)	2.1 (15)

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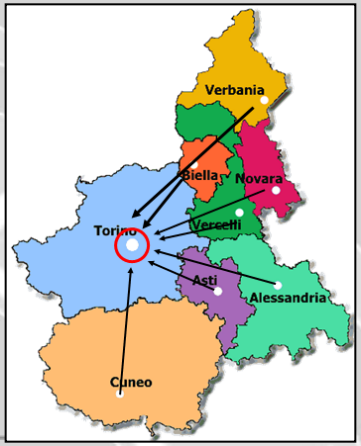
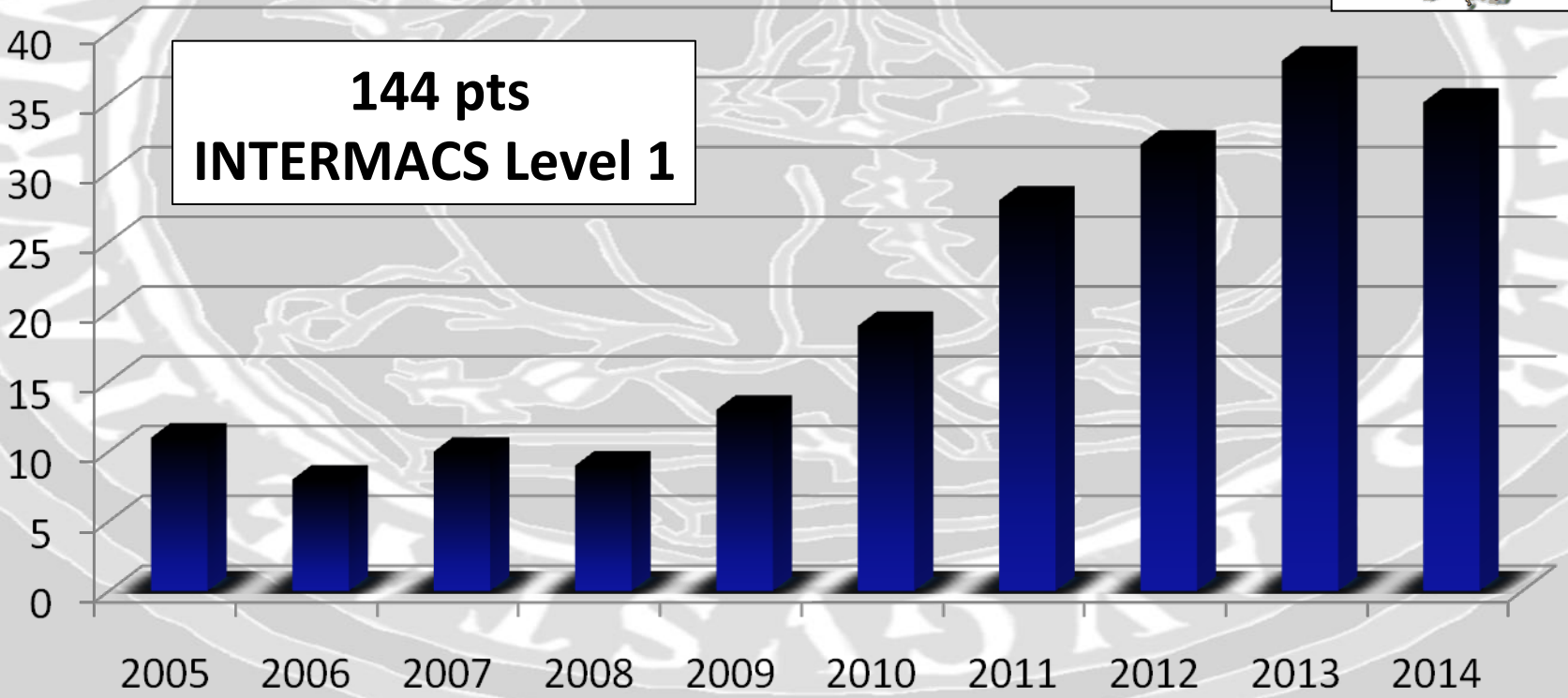
Hub-and-Spoke 2005-2014



Short term VAD/ECMO implants



Mechanical assistance implanted

N= 144 *n cases*

• VA ECMO	113
• VA ECMO to RVAD	5
• RVAD	13
• VA ECMO to LVAD	9
• LVAD	4

VA ECMO in Cadiogenic shock
University of Turin

n= 113 patients INTERMACS level 1

Results

Death	41/113	36%
Recovery	38/113	34%
Bridge to emergency transplant	28/113	25%
Bridge to long term LVAD	6/113	5%
Survival to discharge	59/113	51%

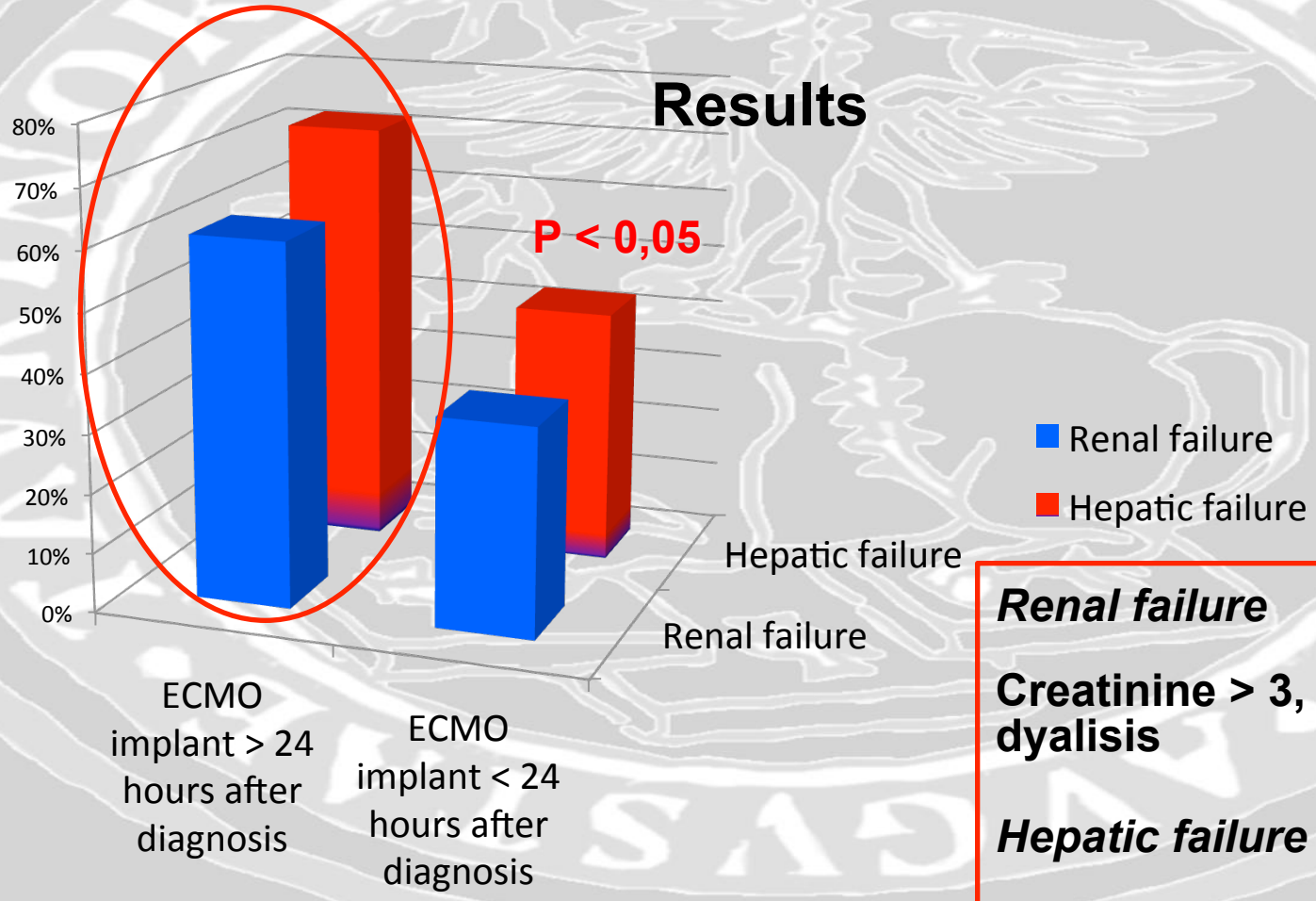
VA ECMO Risk factors for death
University of Turin n= 113 patients

Multivariate analysis for hospital death

Postcardiotomic	**p 0,003**
No left ventricular venting	**p 0,01**
Central approach	**p 0,01**
External ECMO	p 0,22
"Unstable" ECMO	**p 0,02**
Previous cardiac arrest (CPR)	p 0,15
Miocardial infarction	p 0,32
Renal failure (Creatinine > 3, oligo- anuria or dyalisis)	**p 0,04**
Hepatic failure (INR> 1,5; AST or ALT > 3 times)	**p 0,03**

VA ECMO in Cadiogenic shock
University of Turin

n= 113 patients INTERMACS level 1



Renal failure

Creatinine > 3, oligo- anuria or dyalisis

Hepatic failure

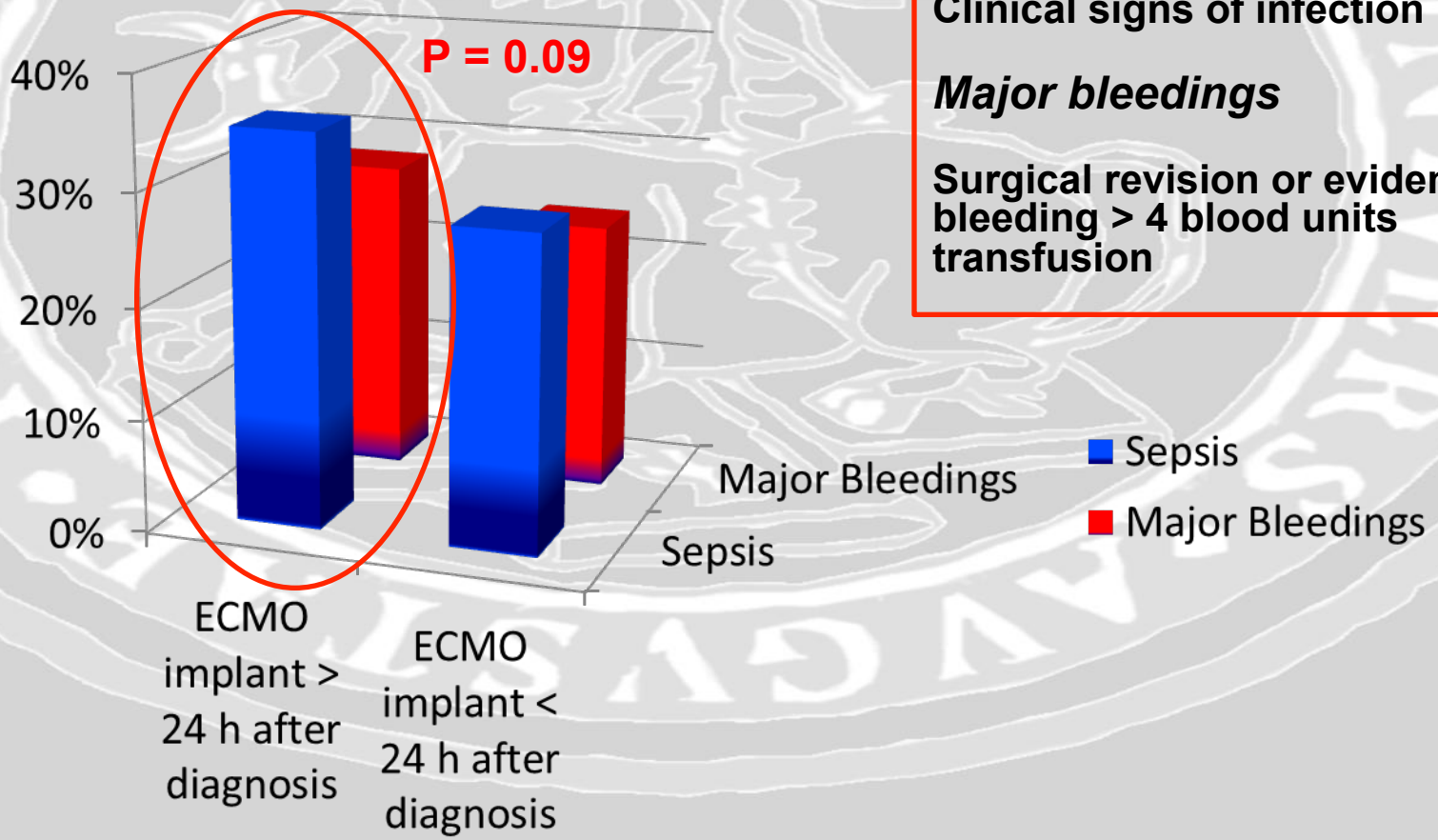
INR> 1,5; AST or ALT > 3 times

VA ECMO in Cadiogenic shock

University of Turin

n= 113 patients INTERMACS level 1

Results



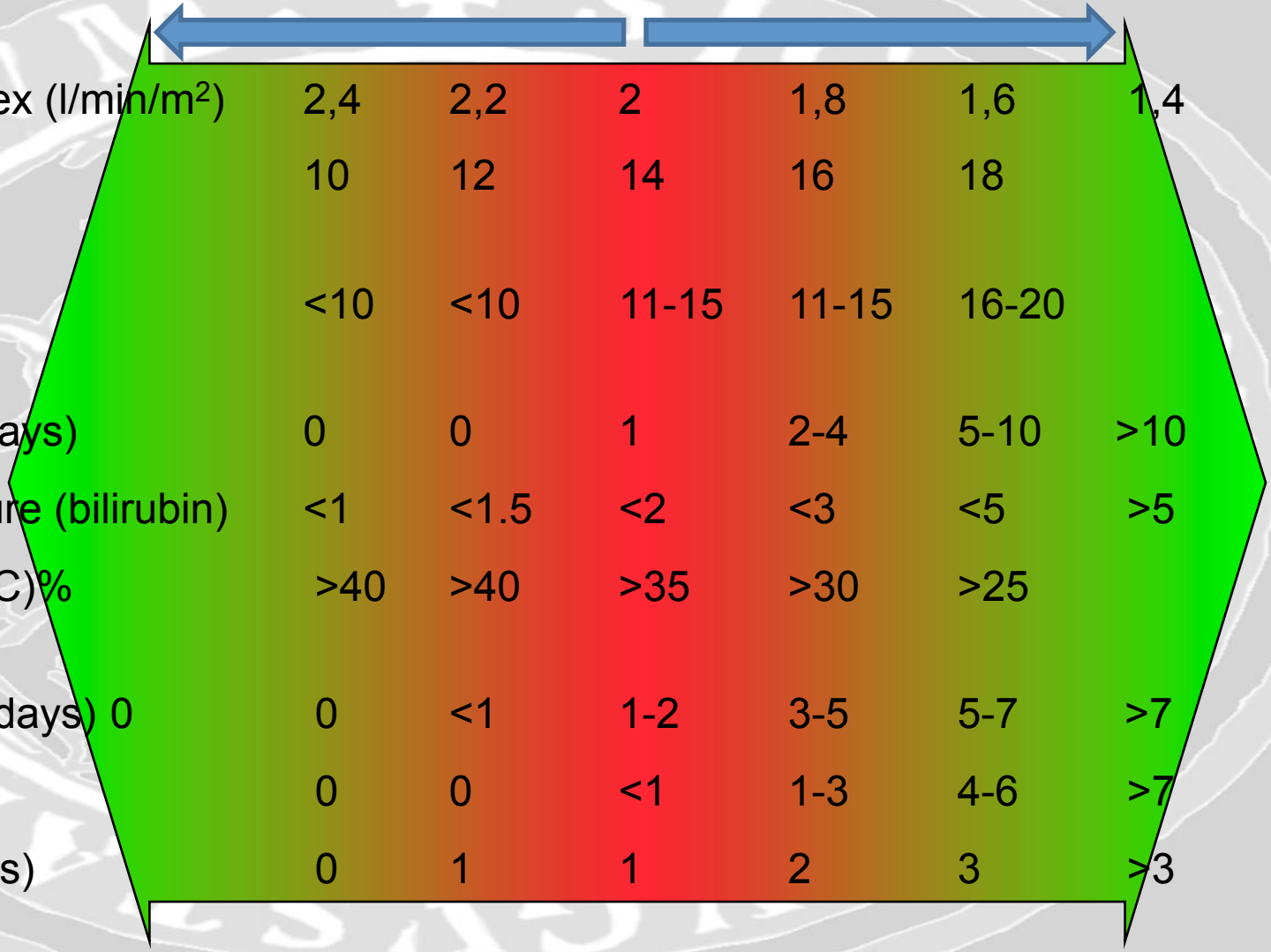
Sepsis

Positive blood cultures and Clinical signs of infection

Major bleedings

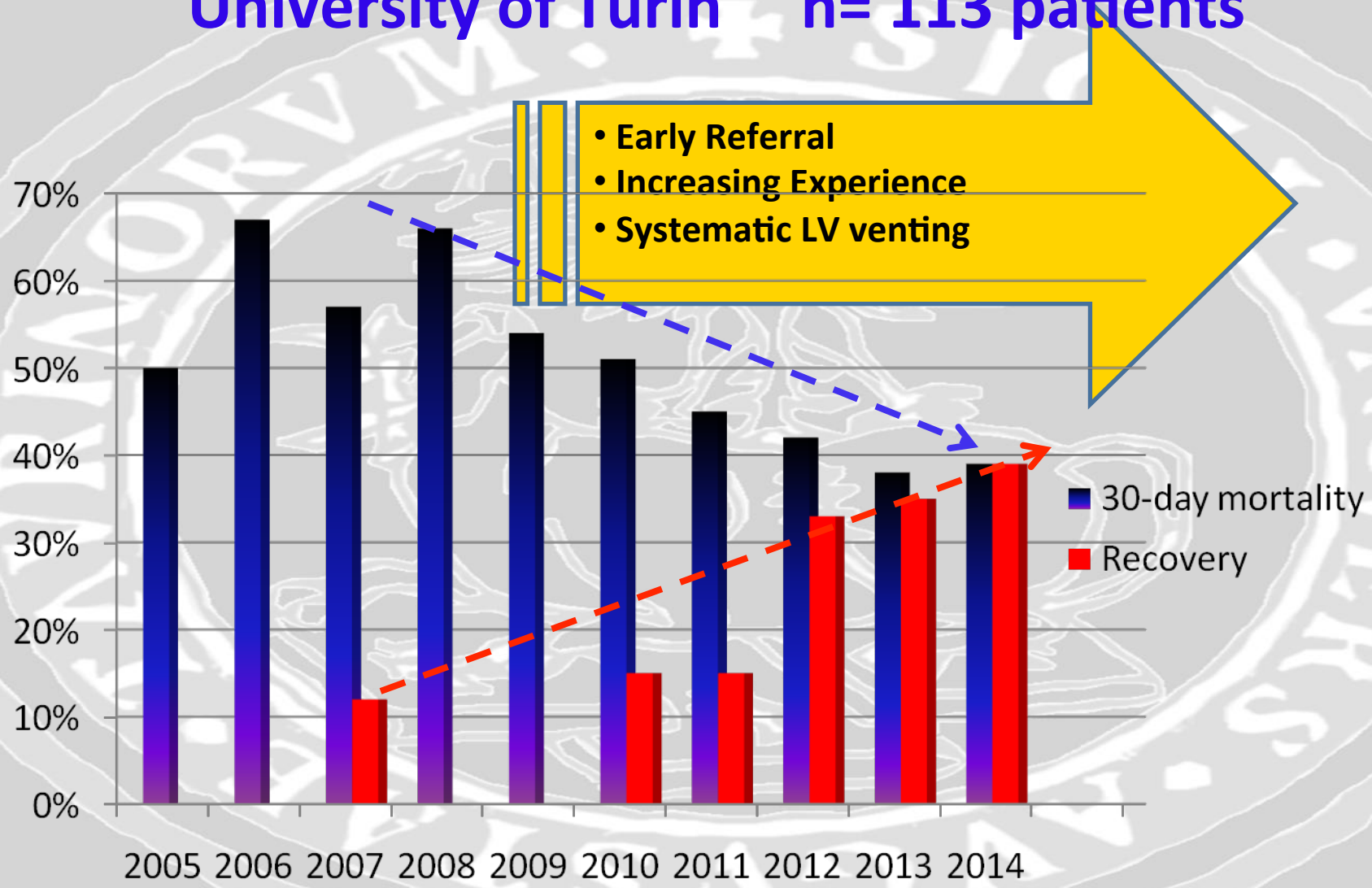
Surgical revision or evidence of bleeding > 4 blood units transfusion

When is too early or too late?



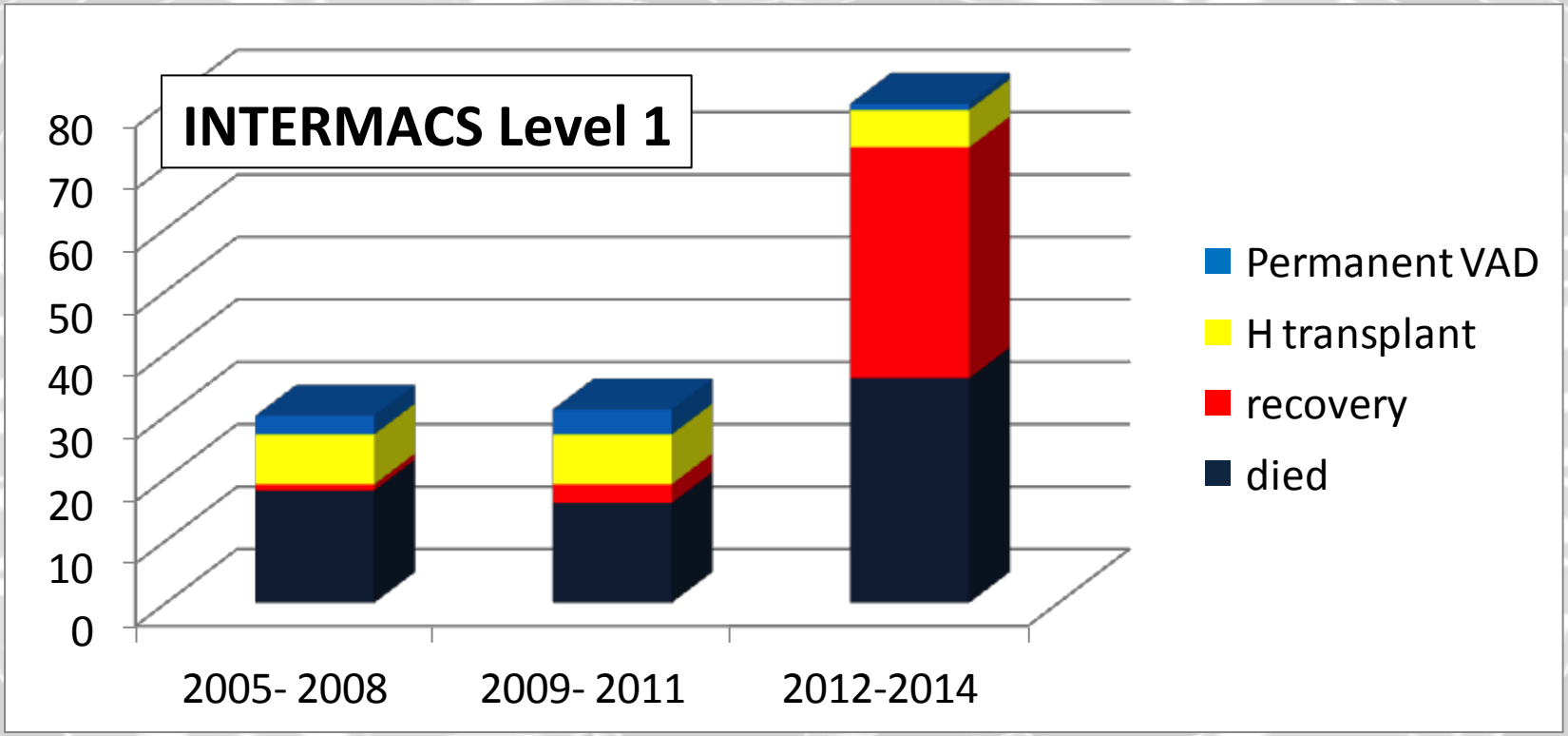
LVEF (%)	35	30	25	20	15	<10
LVEDD (mm) >90	65	70	75	80	85	
Cardiac Index (l/min/m^2)	2,4	2,2	2	1,8	1,6	1,4
CVP tor >20	10	12	14	16	18	
APACHE II >20	<10	<10	11-15	11-15	16-20	
Inotropes (days)	0	0	1	2-4	5-10	>10
Hepatic failure (bilirubin)	<1	<1.5	<2	<3	<5	>5
RVF (RVFAC)% <20	>40	>40	>35	>30	>25	
Ventilation (days) 0	0	<1	1-2	3-5	5-7	>7
MCS (days)	0	0	<1	1-3	4-6	>7
MOF (organs)	0	1	1	2	3	>3

VA ECMO changing outcomes
University of Turin n= 113 patients



INTERMACS Level 1

VADs-ECMO outcomes



30-day mortality 60%	**30-day mortality 52%**	**30-day mortality 44%**

When the Heart kills the Liver and the Kidney

Heart Fail Rev (2012) 17:355–366
DOI 10.1007/s10741-011-9291-x

The cardiorenal syndrome in heart failure: cardiac? renal? syndrome?

Filippos Triposkiadis · Randall C. Starling · Harisios Boudoulas · Gregory Giamouzis · Javed Butler

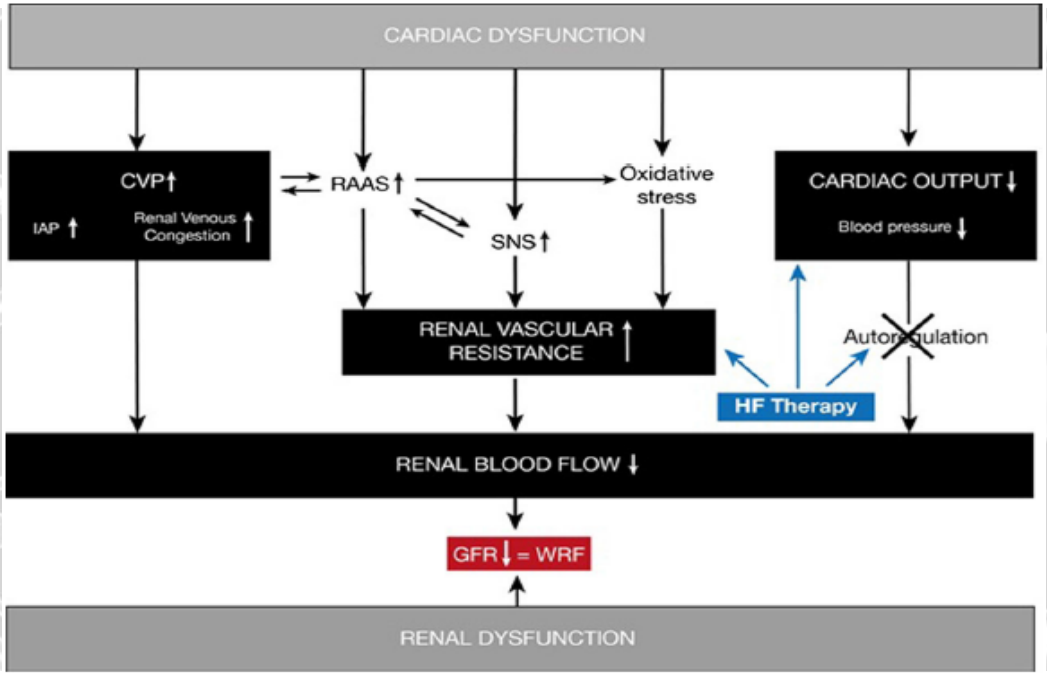


Table 1 Classification of acute kidney injury (AKI)

Stage	Creatinine criteria	Urine output (UO) criteria
Risk or stage 1	Creatinine increase ≥0.3 mg/dl or creatinine ≥150 and <200% than baseline	UO < 0.5 ml/kg/h for 6 h
Injury or stage 2	Creatinine ≥ 200% and < 300% than baseline	UO < 0.5 ml/kg/h for 12 h
Failure or stage 3	Creatinine ≥ 300% than baseline, or ≥ 4.0 mg/dl and increase ≥ 0.5 mg/dl	UO < 0.3 ml/kg/h for 24 h or anuria for 12 h

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Vol. 61, No. 24, 2013
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2013.03.042

STATE-OF-THE-ART PAPER

Cardiohepatic Interactions in Heart Failure

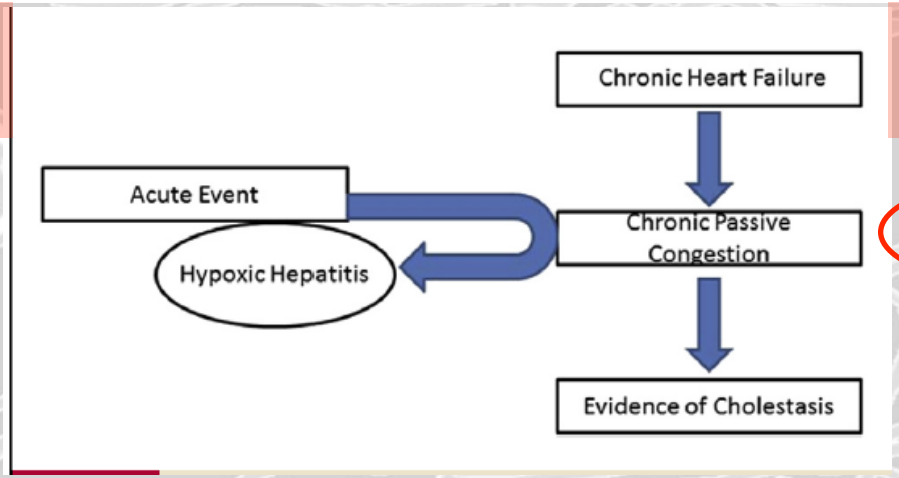
An Overview and Clinical Implications

Marc D. Samsky, MD, Chetan B. Patel, MD, Tracy A. DeWald, PharmD, Alastair D. Smith, MB, ChB, G. Michael Felker, MD, MHS, Joseph G. Rogers, MD, Adrian F. Hernandez, MD, MHS

Durham, North Carolina

Hypoxic Hepatitis
Reversible damage

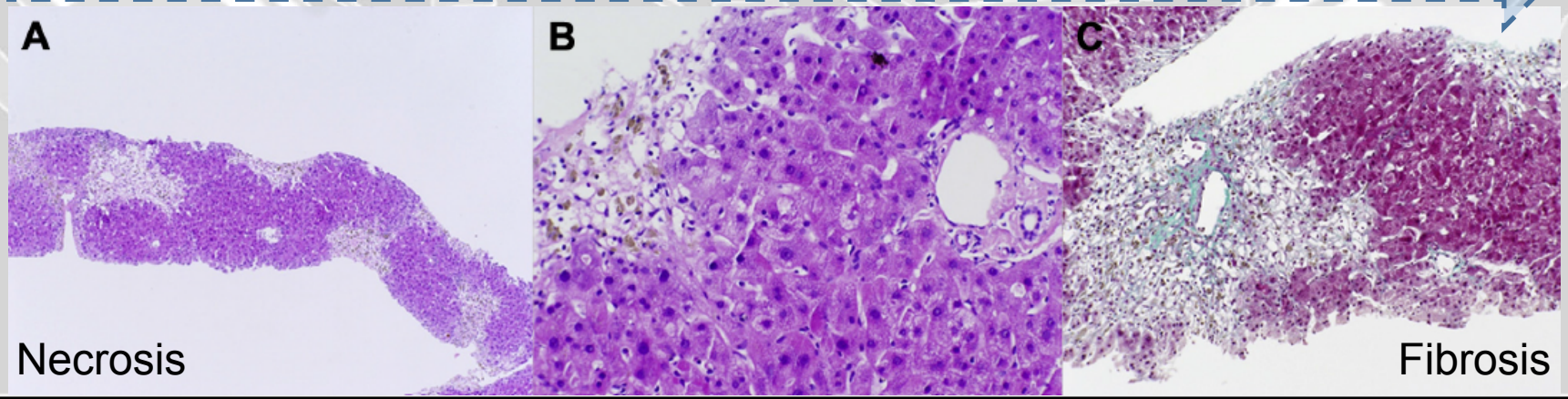
AST, ALT, LDH, INR



Cronic Hepatitis
Irreversible damage

Bilirubin, Albumin, INR

Time hours days weeks



ORIGINAL PAPERS, CLINICAL

Cardiogenic Hepatic Injury-Renal Impairment *J Clin Basic Cardiol 2000; 3: 35*

Cardiogenic Hepatic Injury-Renal Impairment

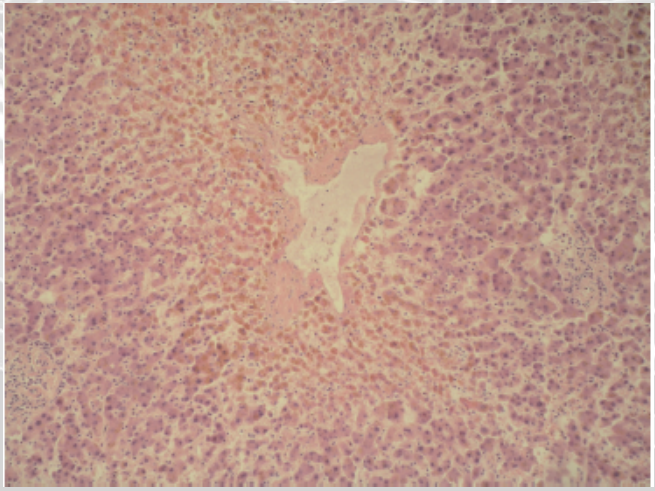
J. E. Naschitz[1], N. Elias[1], E. Zuckerman[1], E. Sabo[2], E. G. Abinader[3], D. Yeshurun[1]

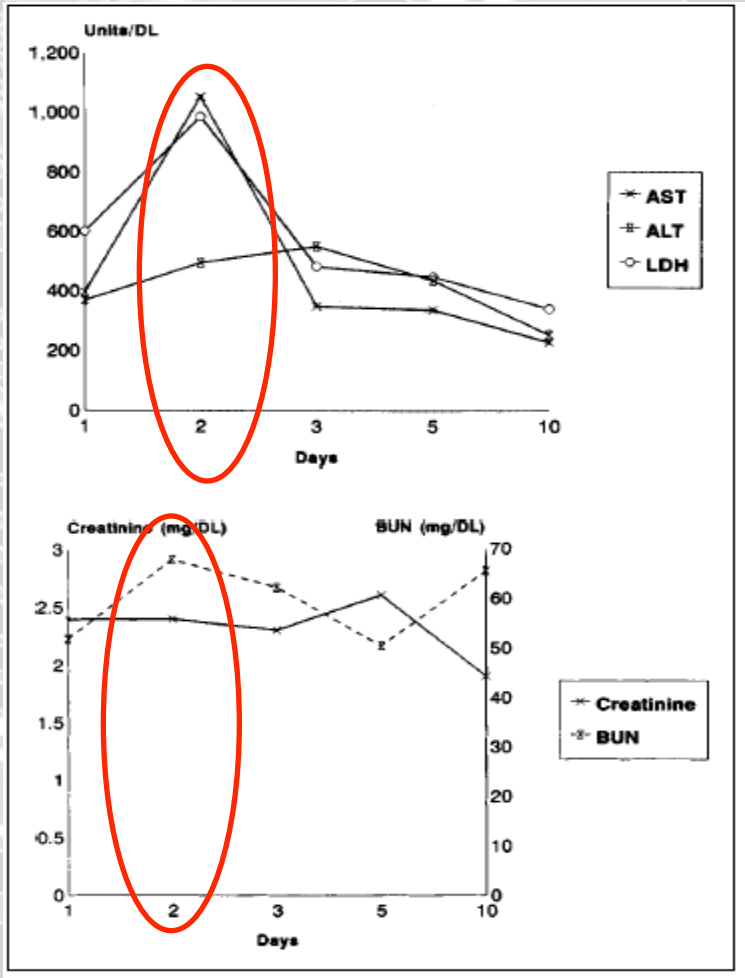
N= 25 in cardiogenic shock in medical therapy

CAHIRI is potentially reversible

CAHIRI (ischemic hepatic and renal failure)
Peak of necrosis within 48 hours

Liver autopsy:
Central necrosis





Short term ECMO/VAD - Indications

SCENARIO

Cardiology – Cardiac Surgery

Precardiotomy

Acute Cardiogenic Shock

Postcardiotomy

Low cardiac output

- **high dose inotropic drugs**

10 units:

10 gamma/kg/min dobutamine

or

0,1 gamma /kg/min adrenaline

Inotropic drugs

IABP

Short-term ECMO/VAD

Persistent Low cardiac output

Check signs of renal

and hepatic injury

Whithin 6 hours

TIMING: ECMO implant before Liver and Kidney Irreversible ischemic Injury

Hepatic function cut-off

- **AST, ALT < 3 times than normal value**
- **LDH < 1,5 times than normal value**
- **INR < 1,5 times than normal value**

- *Bilirubin and Albumin are usually preserved*

Kidney function cut-off

- **Creatinine < 2 times than normal value and BUN< 60**
- **UO > 0,5 ml/kg/h**
- **GF > 40 ml/min/m2**

CARDIOGENIC SHOCK

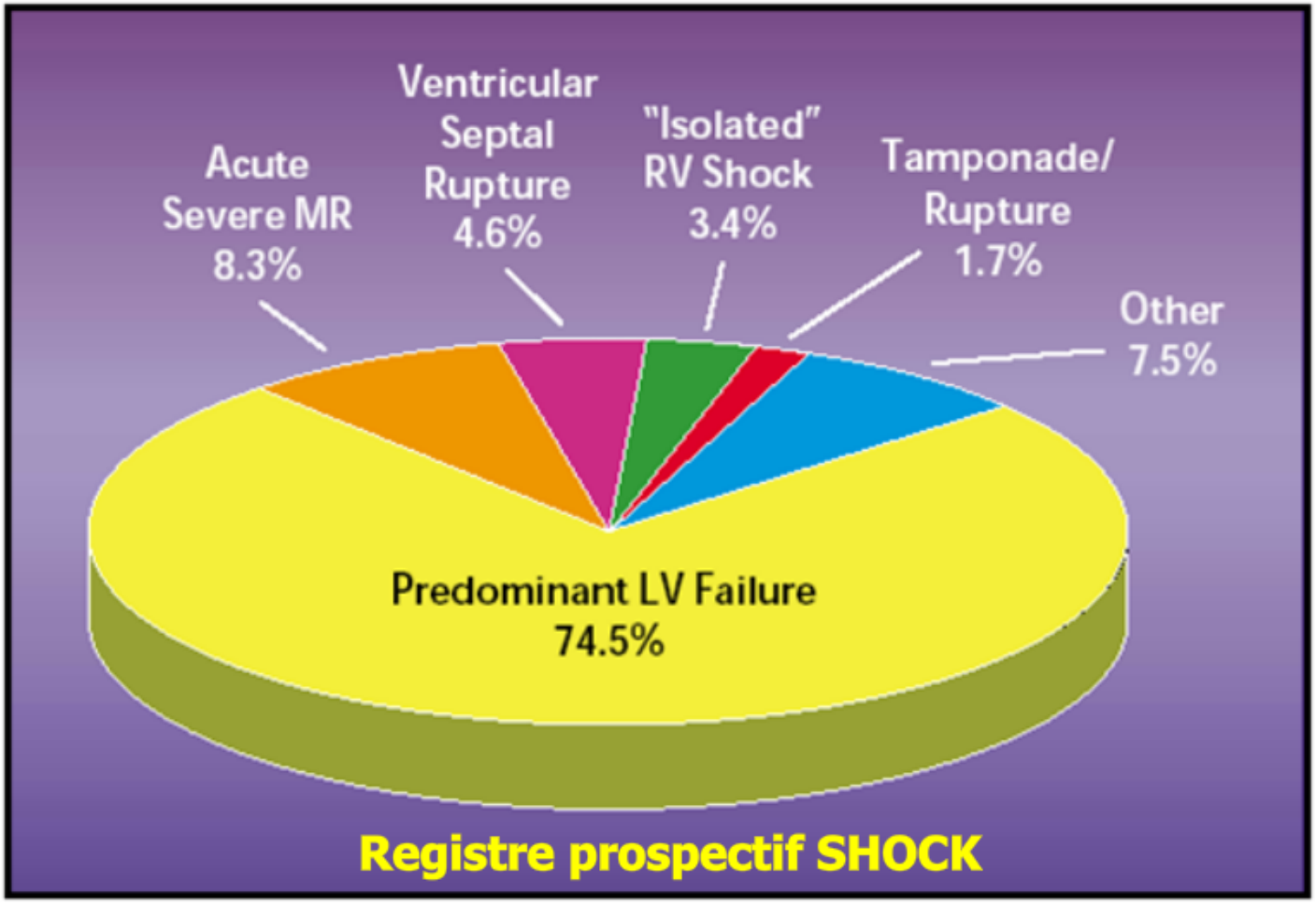
Basic Approach

- **RAPID REPERFUSION** of the myocardium
- **SUPPORT THE HEMODYNAMIC SYSTEM** assuring adequate fluid volume, maintaining adequate cardiac output with drugs or **mechanical assistance**, correcting gas-exchange abnormalities and providing adequate oxygenation
- It is not clear the chance of **RECOVERY**

J Intensive Care Med 2005

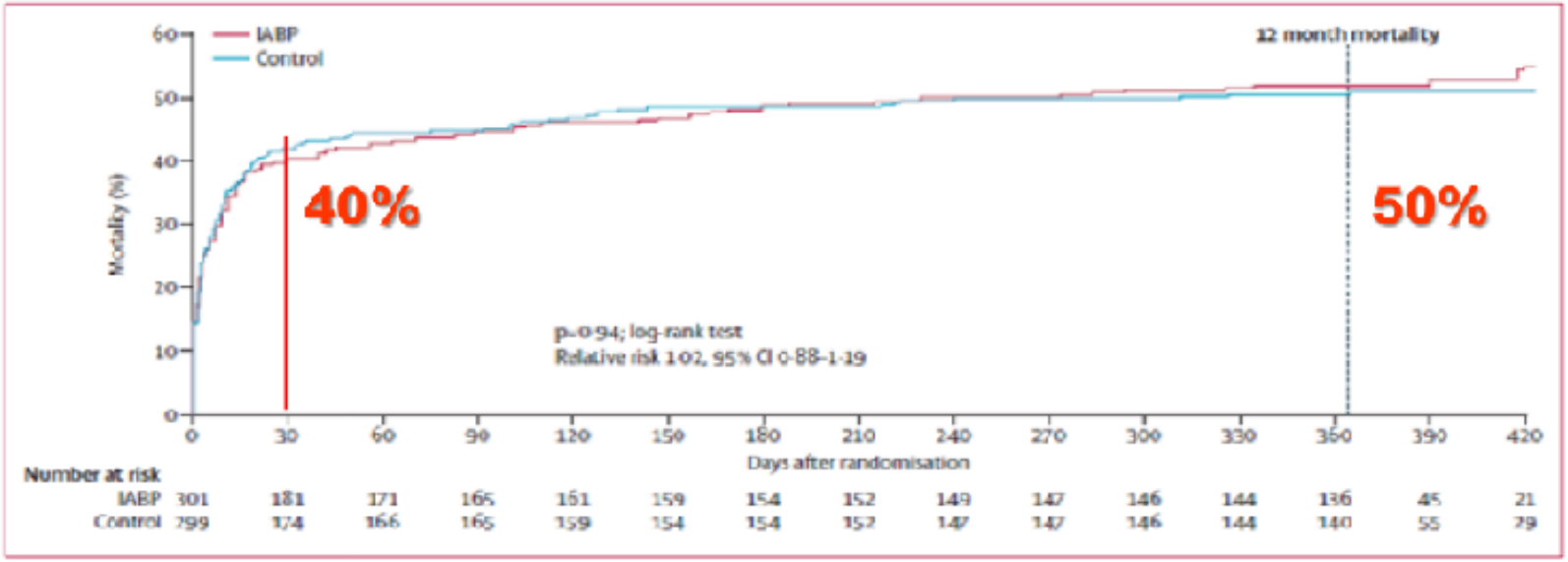
Post-AMI cardiogenic shock

Hochman, Circ, 1995



Intra-aortic balloon counterpulsation in acute myocardial infarction complicated by cardiogenic shock (IABP-SHOCK II): final 12 month results of a randomised, open-label trial

www.thelancet.com Published online September 3, 2013



Consensus Statement

2015 SCAI/ACC/HFSA/STS Clinical Expert Consensus Statement on the Use of Percutaneous Mechanical Circulatory Support Devices in Cardiovascular Care (Endorsed by the American Heart Association, the Cardiological Society of India, and Sociedad Latino Americana de Cardiologia Intervencion; Affirmation of Value by the Canadian Association of Interventional Cardiology–Association Canadienne de Cardiologie d'intervention)*

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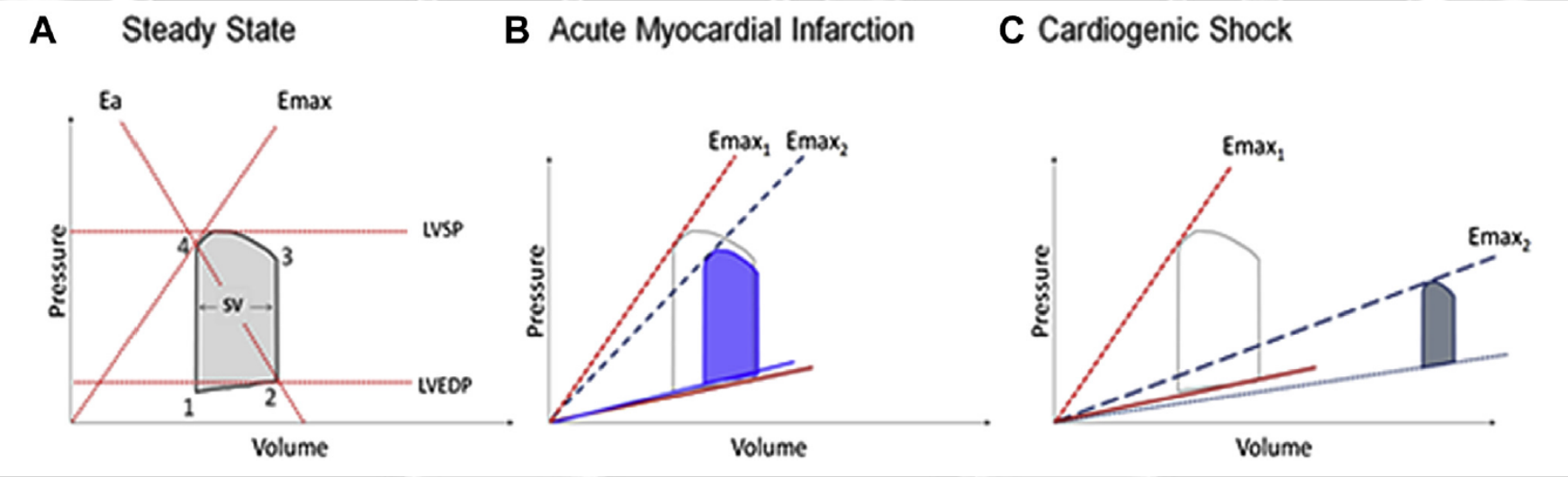

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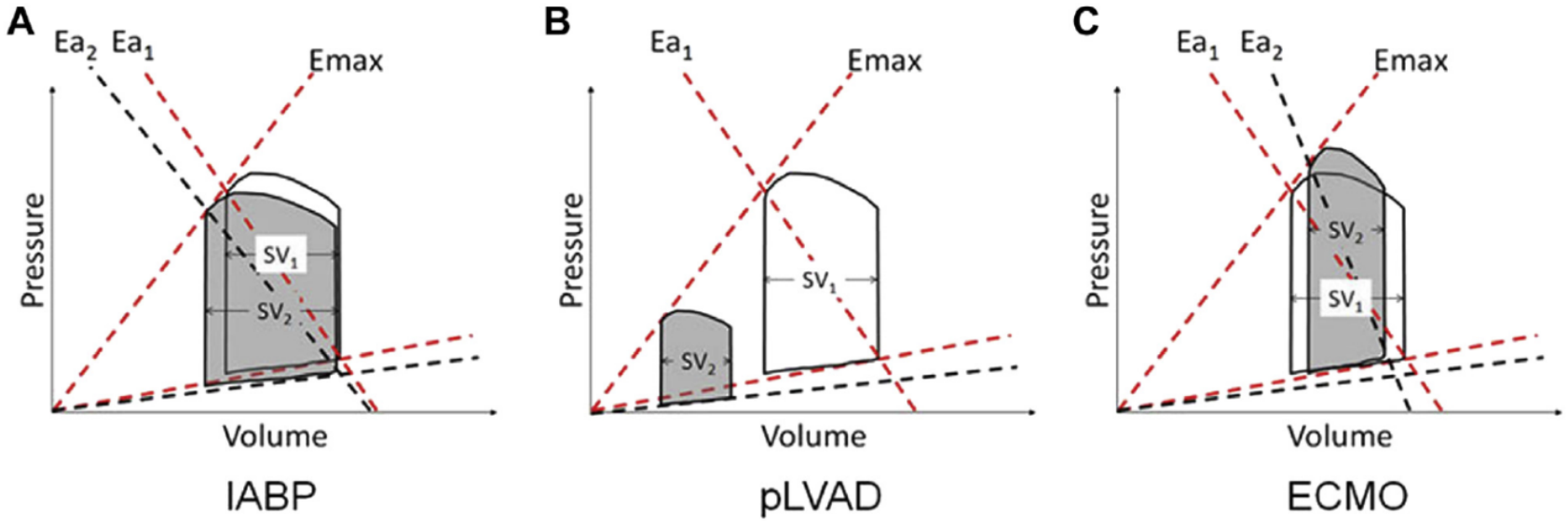
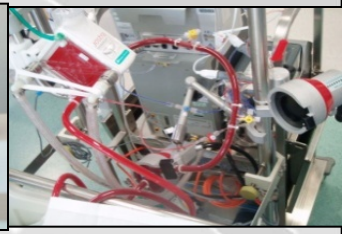
Left ventricular overload on ECMO



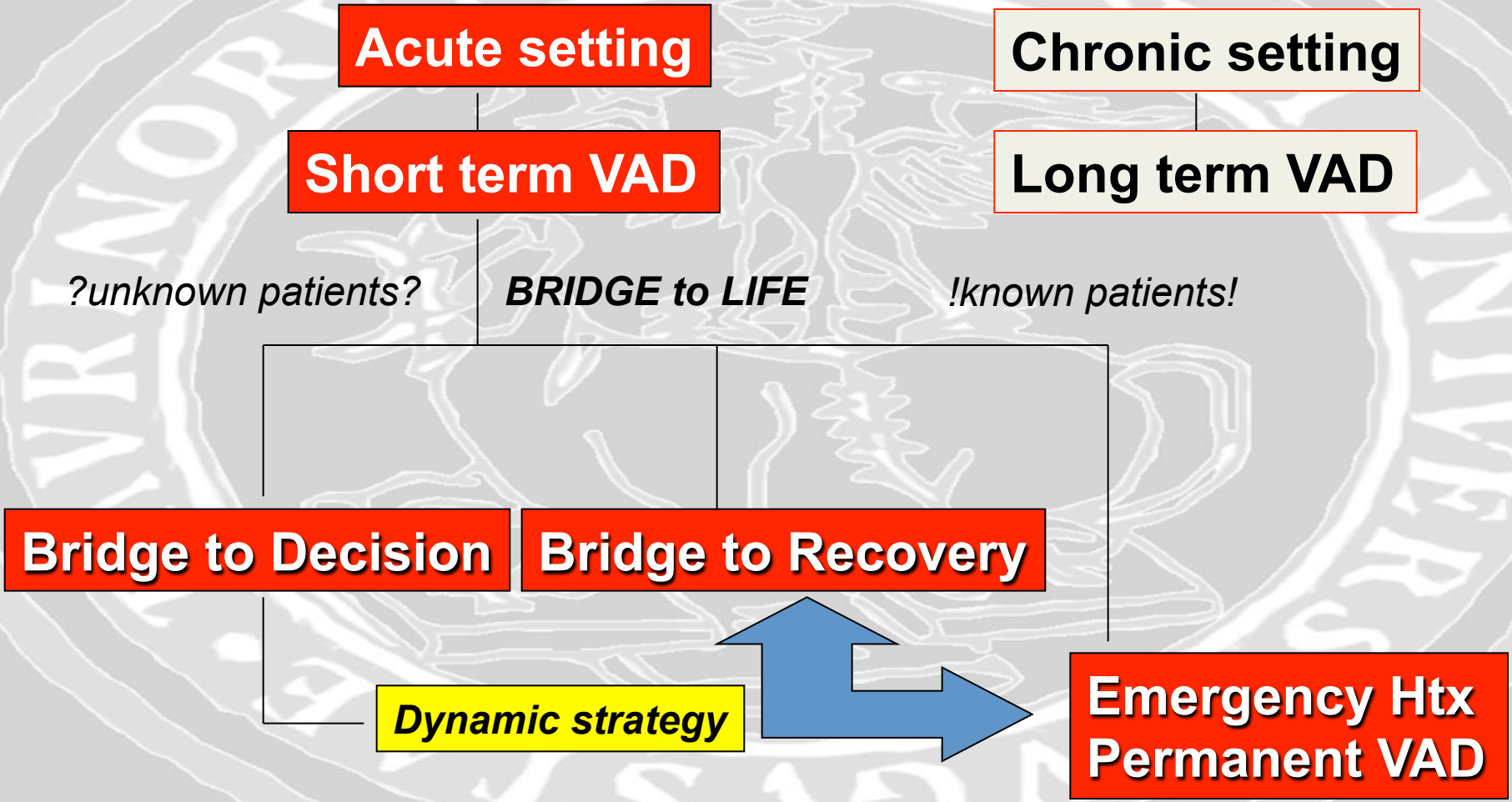
Currently available percutaneous MCS



	iVAC 2L®	TandemHeart™	Impella®5.0	Impella® 2.5	Impella® CP	ECLS (multiple systems)
Catheter size (F)	11 (expandable)	–	9	9	9	
Cannula size (F)	17	21 venous 12–19 arterial	21	12		17–21 venous 16–19 arterial
Flow (L/min)	Max 2.8	Max. 4.0	Max. 5.0	Max. 2.5	3.7–4.0	Max. 7.0
Pump speed (rpm)	Pulsatile, 40 mL/beat	Max. 7500	Max. 33 000	Max. 51 000	Max. 51 000	Max. 5000
Insertion/placement	Percutaneous (femoral artery)	Percutaneous (femoral artery + vein for left atrium)	Peripheral surgical (femoral artery)	Percutaneous (femoral artery)	Percutaneous (femoral artery)	Percutaneous (femoral artery + vein)
LV unloading	+	++	++	+	+	–
Anticoagulation	+	+	+	+	+	+
Recommended duration of use	–21 days	–14 days	10 days	10 days	10 days	–7 days
CE-certification	+	+	+	+	+	+
FDA	–	+	+	+	+	+
Relative costs	++	+++++	++++	+++	++++	+(+)

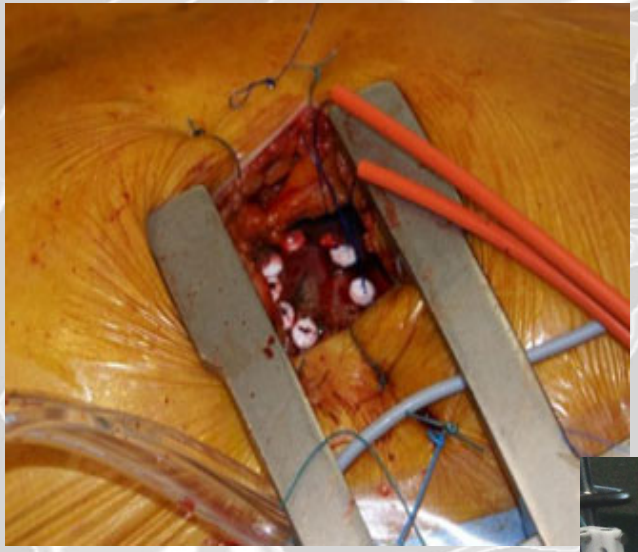
Reproduced from Ref. [57] with permission

MCS Strategy

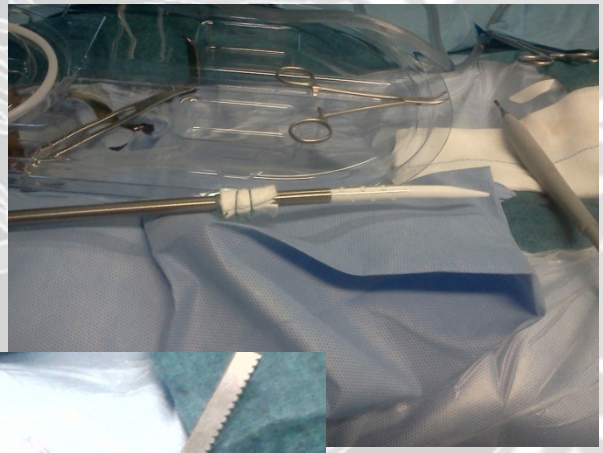


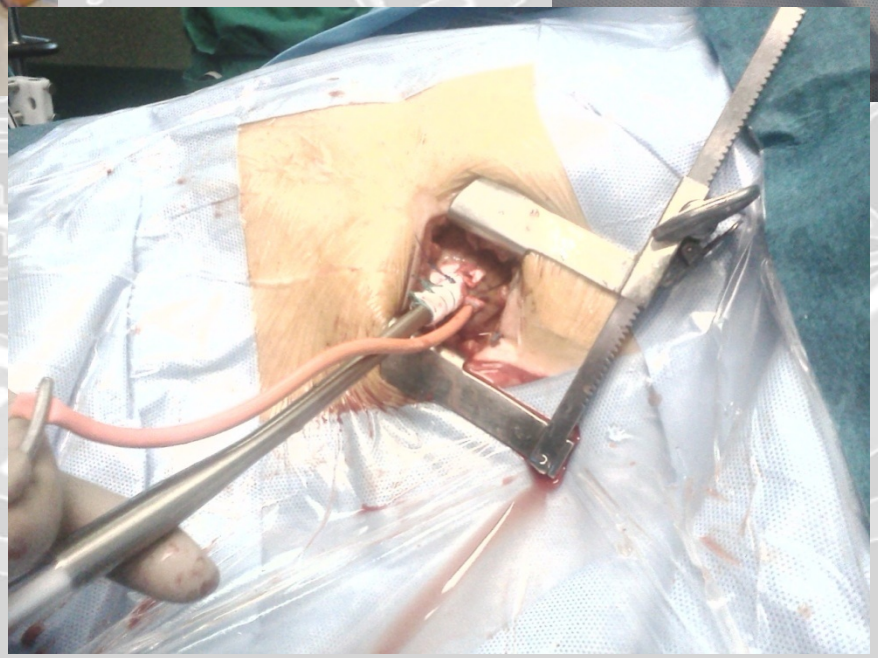
Transapical Left Ventricular Venting

Anterolateral Mini left thoracotomy



Medtronic High flow cannula 21 Fr





Postcardiotomy Heart Failure

the IABP Score for VA ECMO indication

Prognosis After the Implantation of an Intra-Aortic Balloon Pump in Cardiac Surgery Calculated With a New Score

Harald Hausmann, MD; Evgenij V. Potapov, MD; Andreas Koster, MD; Thomas Krabatsch, MD; Julia Stein; Ruhi Yeter, MD; Marian Kukucka, MD; Ralf Sodian, MD; Hermann Kuppe, MD, PhD; Roland Hetzer, MD, PhD

TABLE 3. Results of Multivariate Analysis

Parameter	Odds Ratio (OR)	Range (OR)	*P*
Adrenaline dose >0.5 μg/kg/BW/min	6.6	2.3–18.8	0.0005
Diuresis <100 ml	2.5	1.2–5.4	0.026
SVO_2 <60%	2.5	1.0–6.3	0.048
LAP >15 mm Hg	3.0	1.1–8.5	0.036

Multivariate analysis showed 4 parameters as statistically significant for the prediction of survival or death 1 hour after IABP implantation in patients with cardiac low-output syndrome in cardiac surgery. All other parameters were not significant.

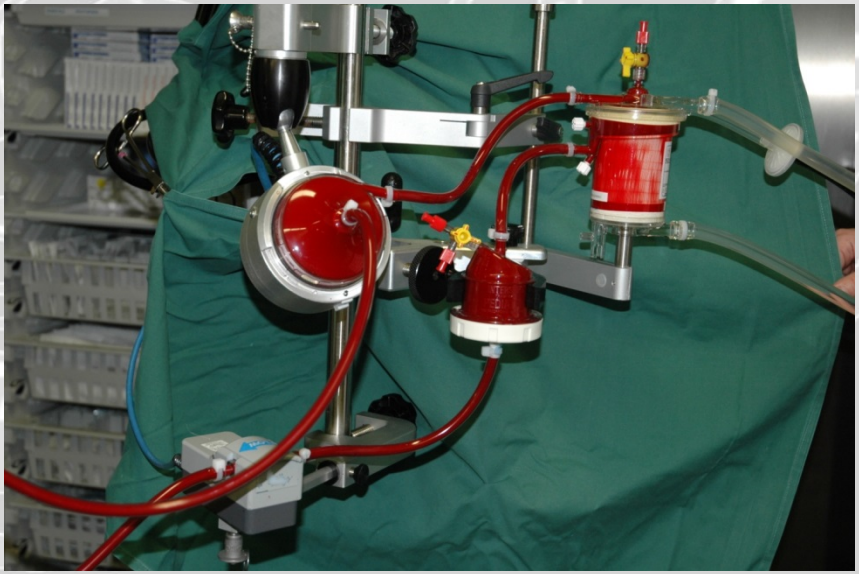
Short term biventricular support *postcardiotomy setting*

ASAIO Journal 2009

Levitronix CentriMag to Berlin Heart Excor: A "Bridge to Bridge" Solution in Refractory Cardiogenic Shock

Antonio Loforte, Evgenij Potapov, Thomas Krabatsch, Michele Musci, Yuguo Weng, Miralem Pasic, and Roland Hetzer

centrifugal pump ± oxigenator (ECMO)



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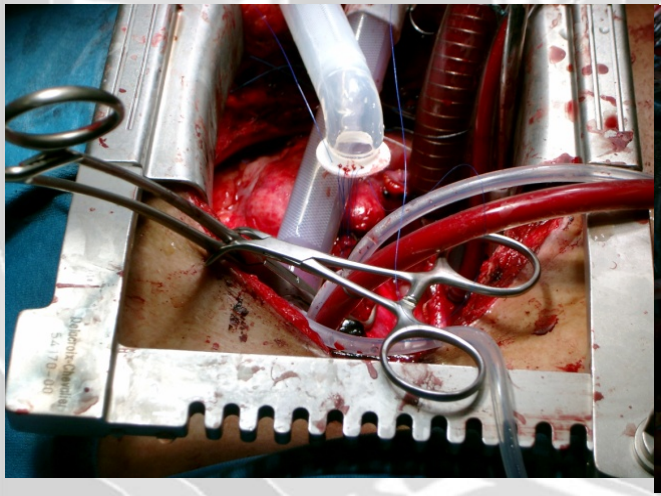
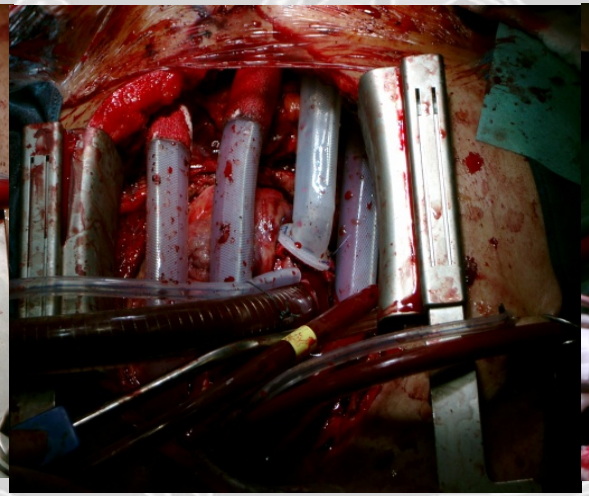
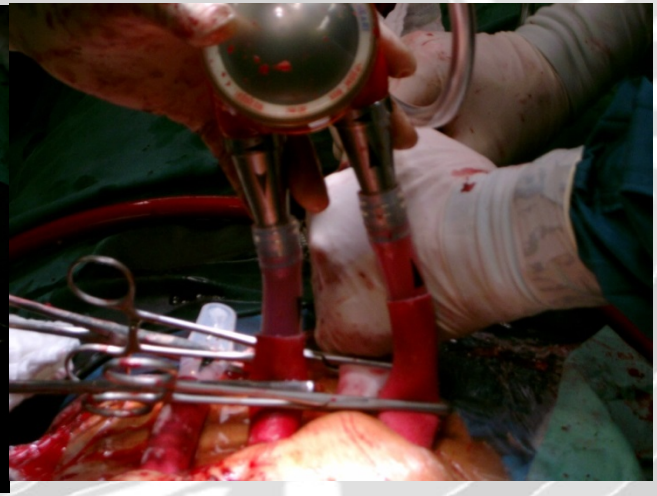




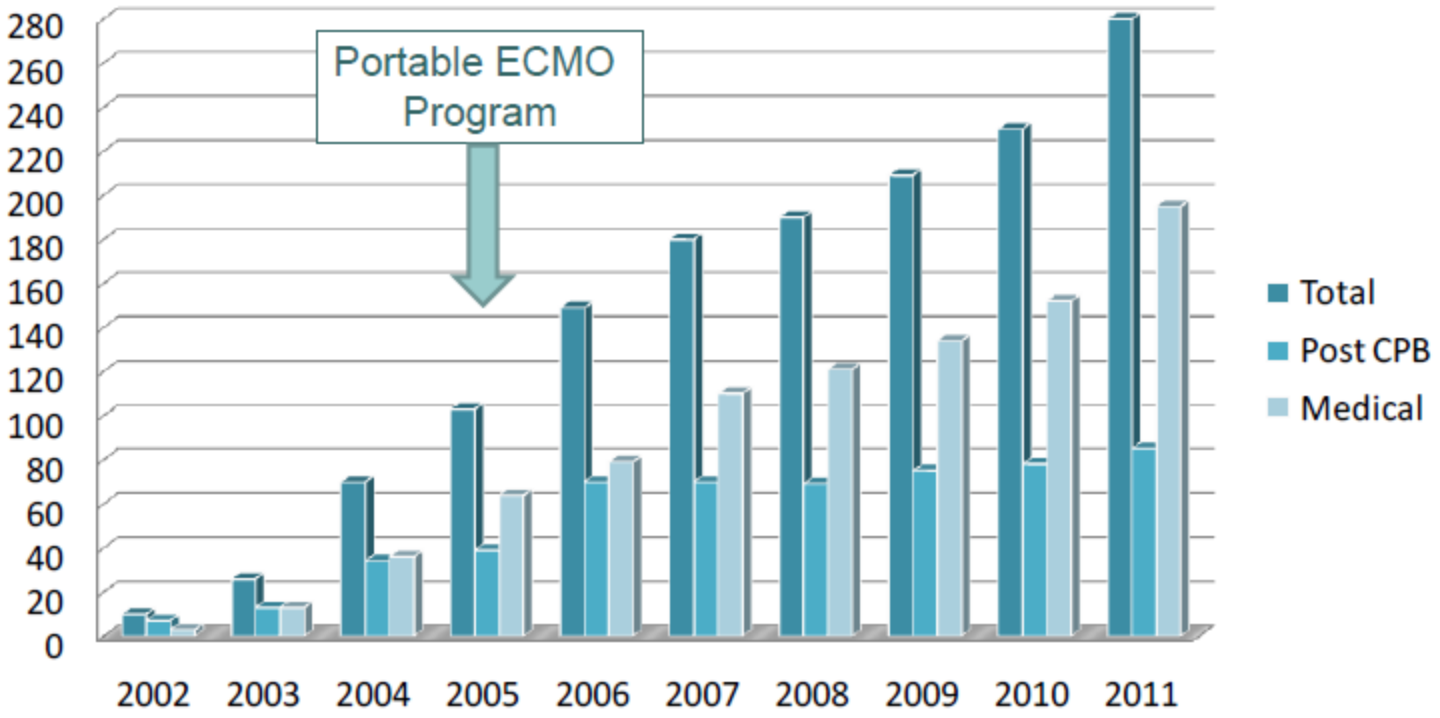


V-A ECMO out of hospital

Out-of-Hospital Resuscitative ECMO

CARDIO HELP- Maquet

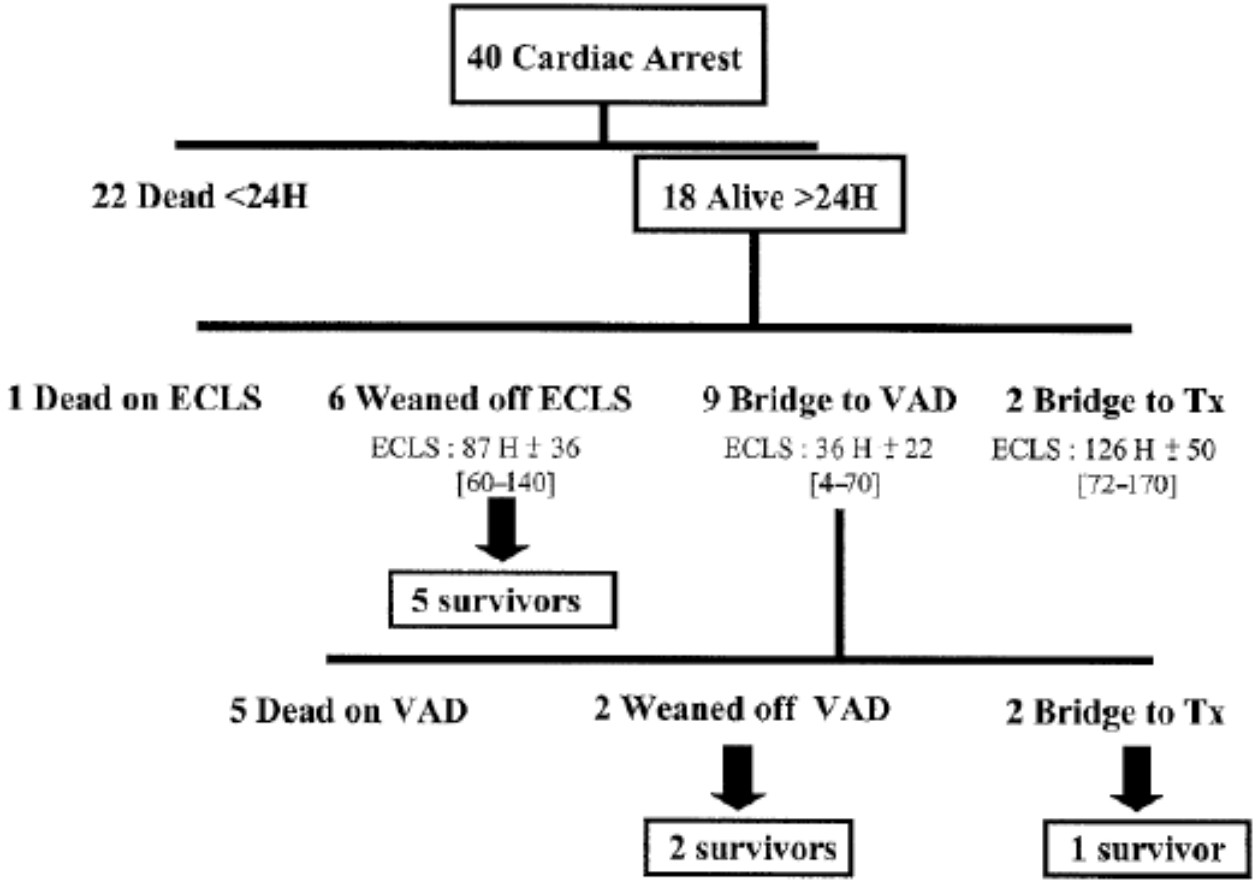
ECMO program at La Pitié, Paris



Back from Irreversibility: Extracorporeal Life Support for Prolonged Cardiac Arrest

Massimo Massetti, MD, Marine Tasle, MD, Olivier Le Page, MD, Ronan Deredec, MD, Gerard Babatasi, MD, Dimitrios Buklas, MD, Sylvain Thuaudet, MD, Pierre Charbonneau, MD, Martial Hamon, MD, Gilles Grollier, MD, Jean Louis Gerard, MD, and André Khayat, MD

Ann Thorac Surg 2005;79:178–84



Extracorporeal life support following out-of-hospital refractory cardiac arrest

Morgan Le Guen[1], Armelle Nicolas-Robin[1], Serge Carreira[1], Mathieu Raux[1], Pascal Leprince[2], Bruno Riou[3*], Olivier Langeron[1]

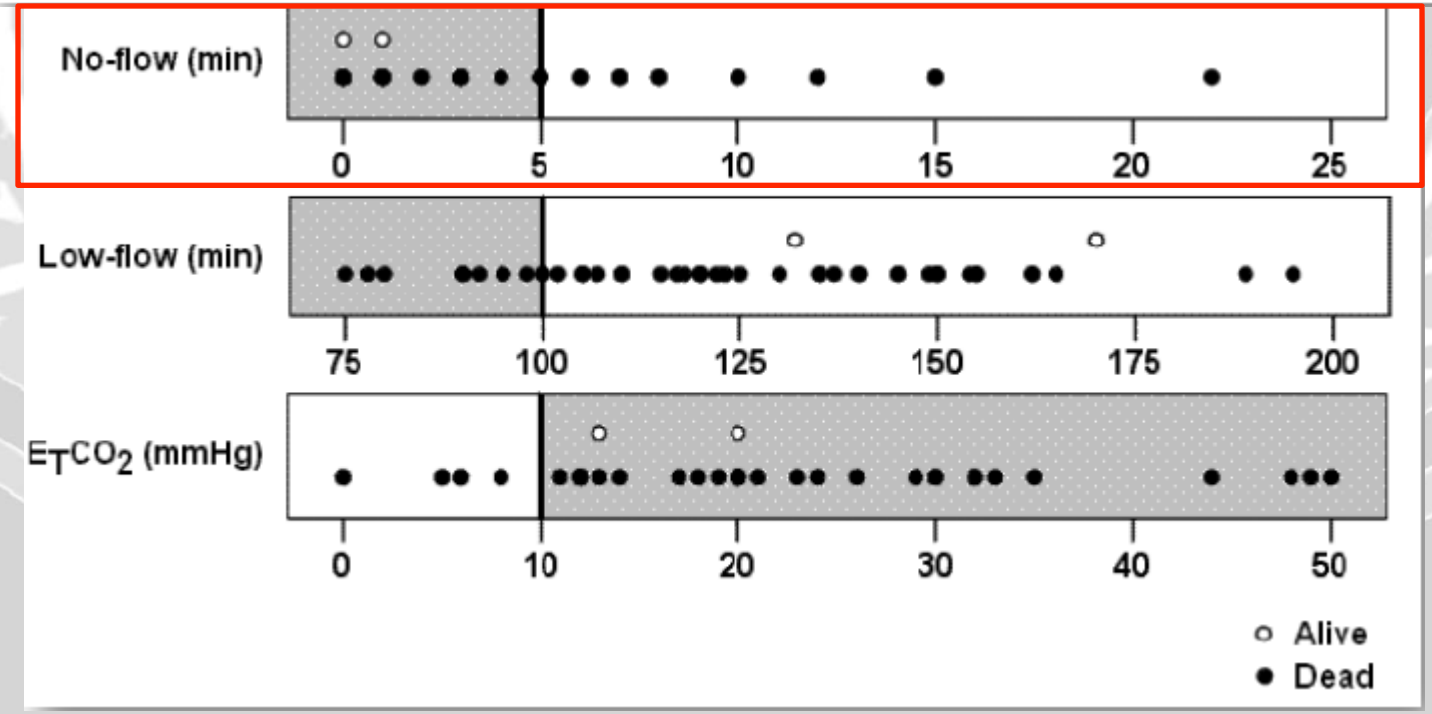
CRITICAL CARE

Critical Care 2011, 15:R29

Abstract

Introduction: Extracorporeal life support (ECLS) has recently shown encouraging results in the resuscitation of in-hospital (IH) refractory cardiac arrest. We assessed the use of ECLS following out-of-hospital (OH) refractory cardiac arrest.

Methods: We evaluated 51 consecutive patients who experienced witnessed OH refractory cardiac arrest and received automated chest compression and ECLS upon arrival in the hospital. Patients with preexisting severe hypothermia who experienced IH cardiac arrest were excluded. A femorofemoral ECLS was set up on admission to the hospital by a mobile cardiothoracic surgical team.



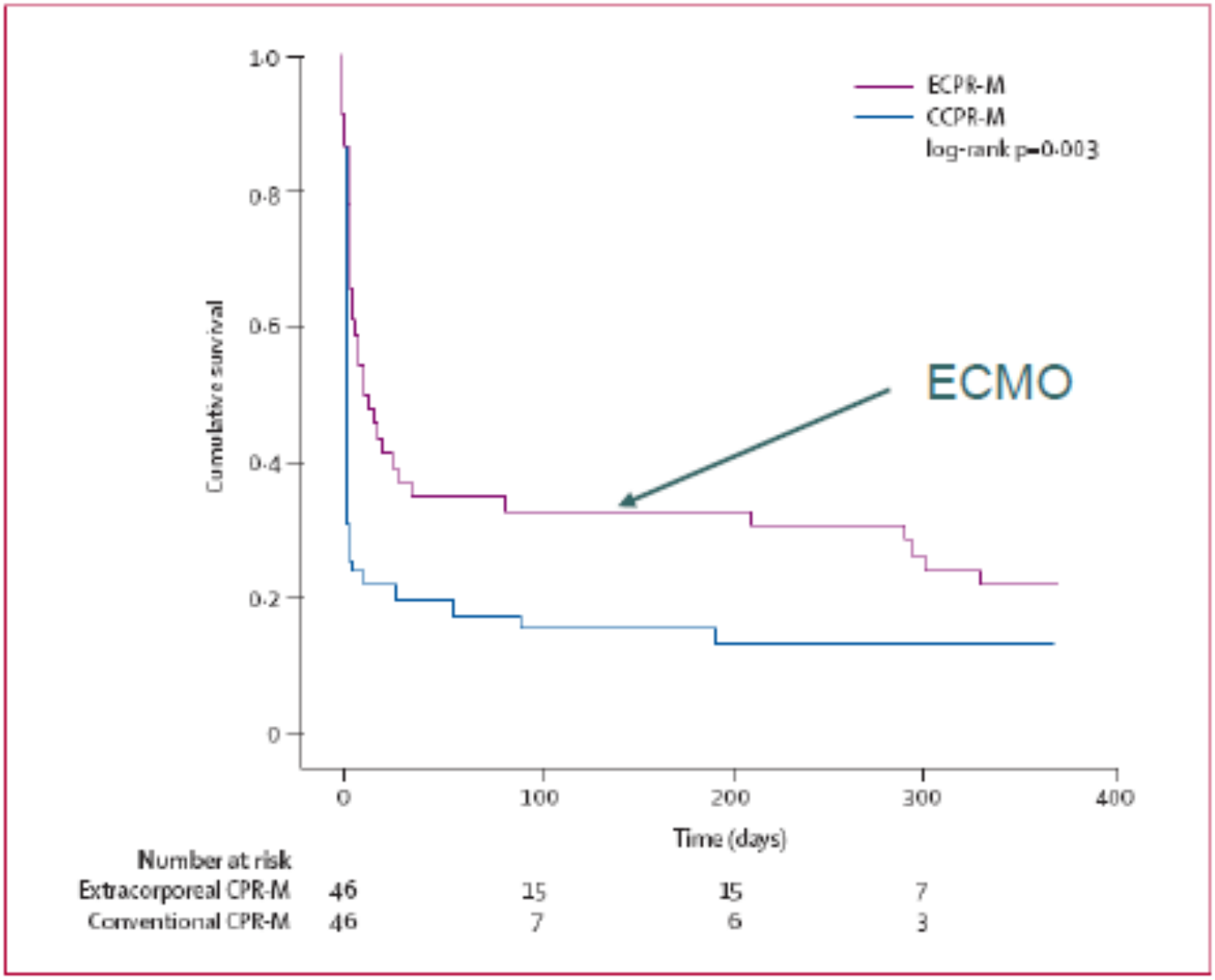


Figure 3: **Kaplan-Meier plot of the survival curves in the extracorporeal CPR-M and conventional CPR-M groups for 1 year**

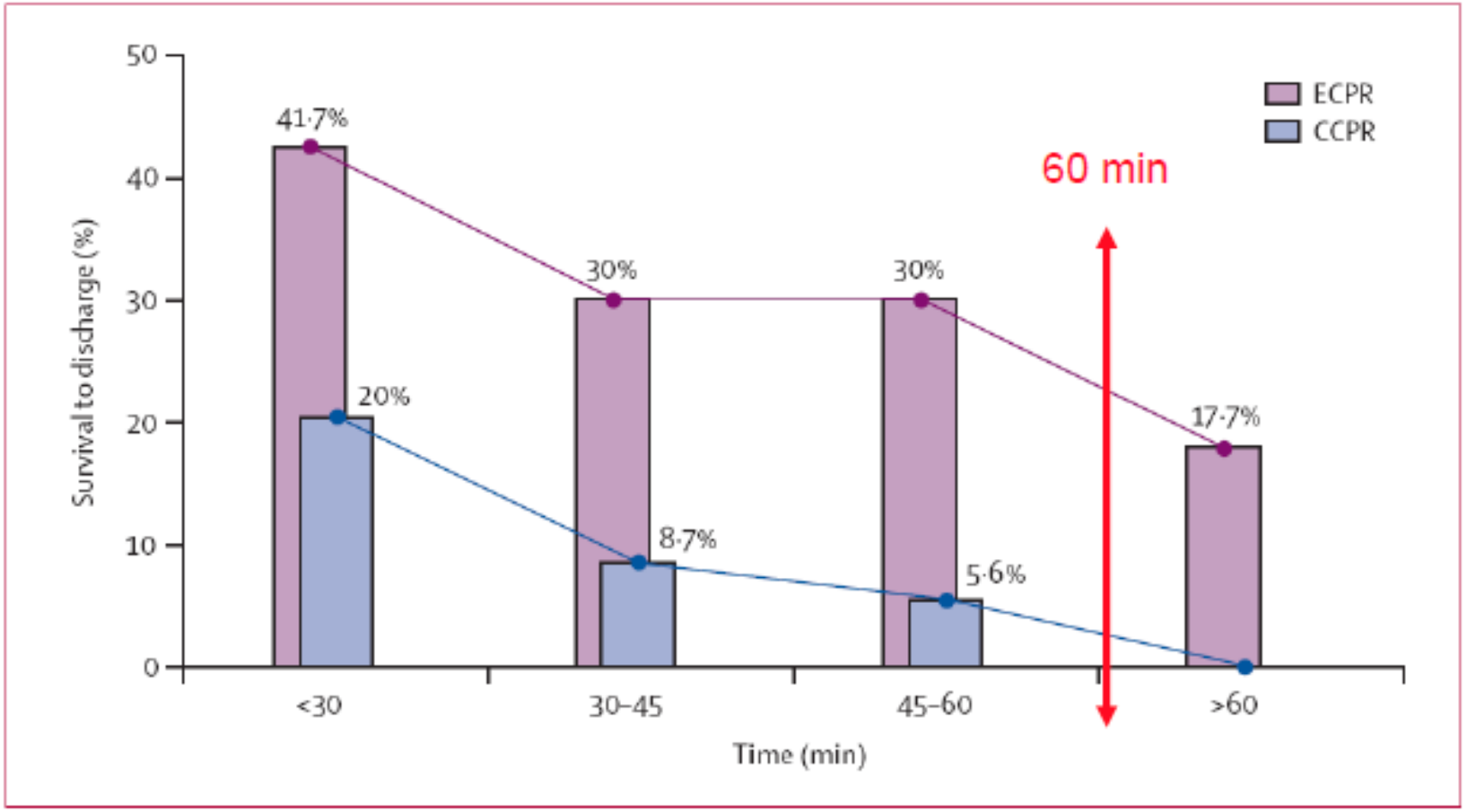
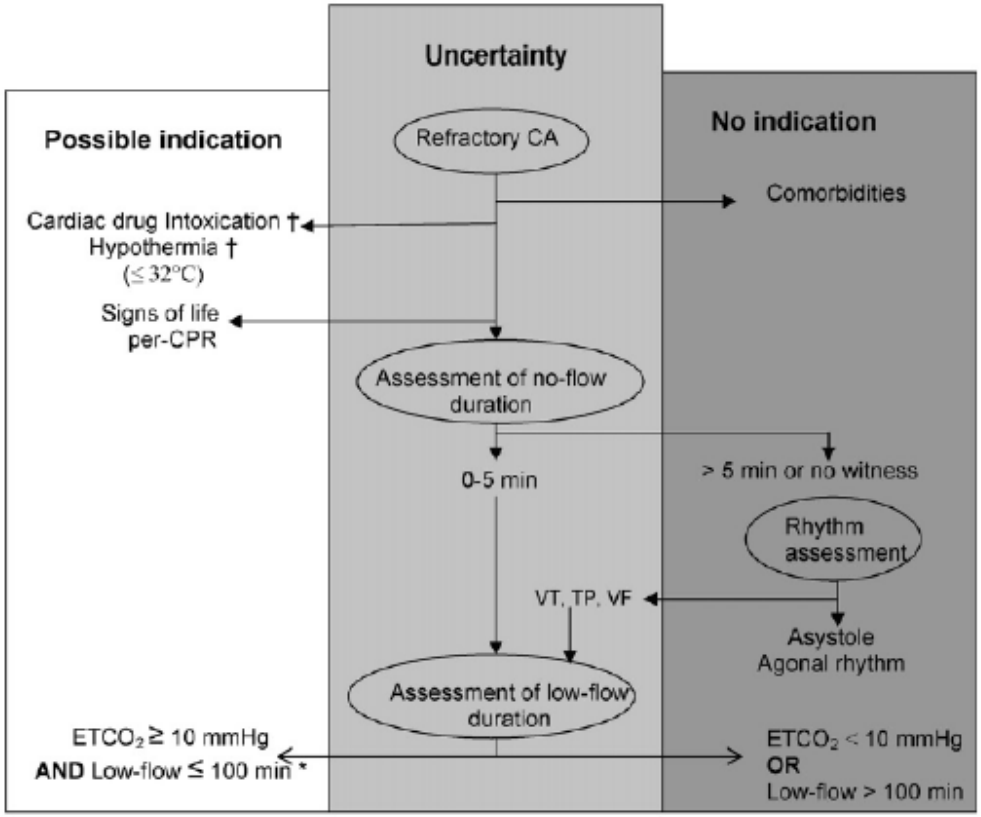


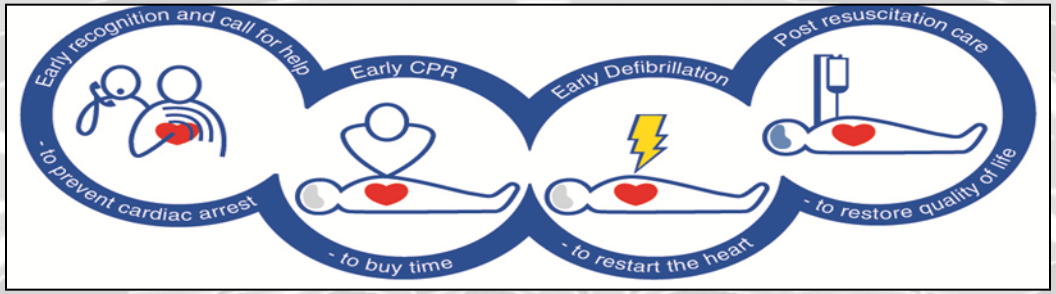
Figure 1: **Relation between CPR duration and the survival rate to discharge**
ECPR=extracorporeal CPR. CCPR=conventional CPR.

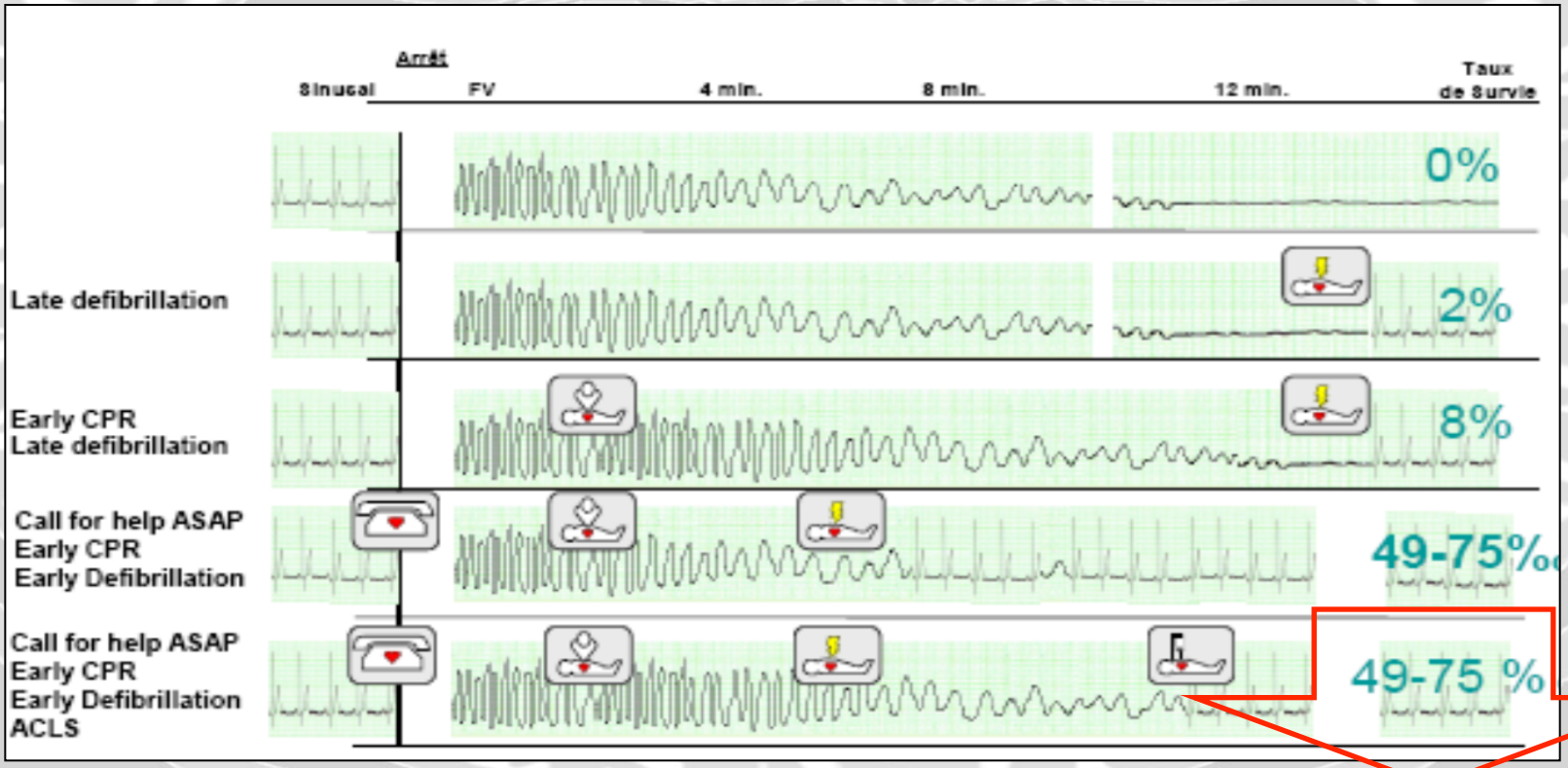
Guidelines for indications for the use of extracorporeal life support in refractory cardiac arrest☆

Annales Françaises d'Anesthésie et de Réanimation 28 (2009) 187–190



Survival Chain





L.Becker, A.H.A. datas

V-A ECMO


SIGIL·VNIVERS·AVGVSTAE·TAVRINORVM·

CONCLUSIONS

- Timing of ECMO implantation is strictly dependent from renal and hepatic function
- The earlier the better: within 6-12 hs after inotropes and IABP if renal and hepatic dysfunction progresses
- Systematic LV apical venting
- In out-of-hospital: only no-flow, low-flow times and ETCO2 drive the timing and indication