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Extracorporeal Membrane Oxygenation in Cardiac Arrest

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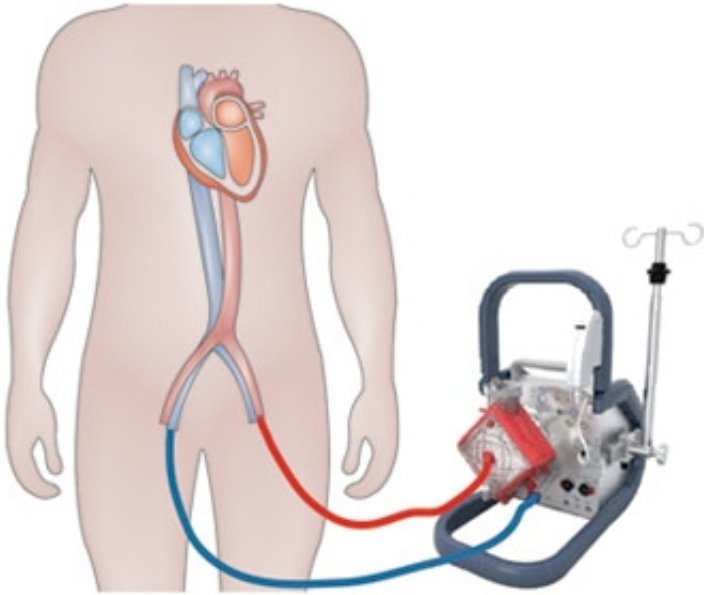
Universitätsklinik für Innere Medizin II
Abteilung für Kardiologie

DECLARATION OF INTEREST

- I have nothing to declare

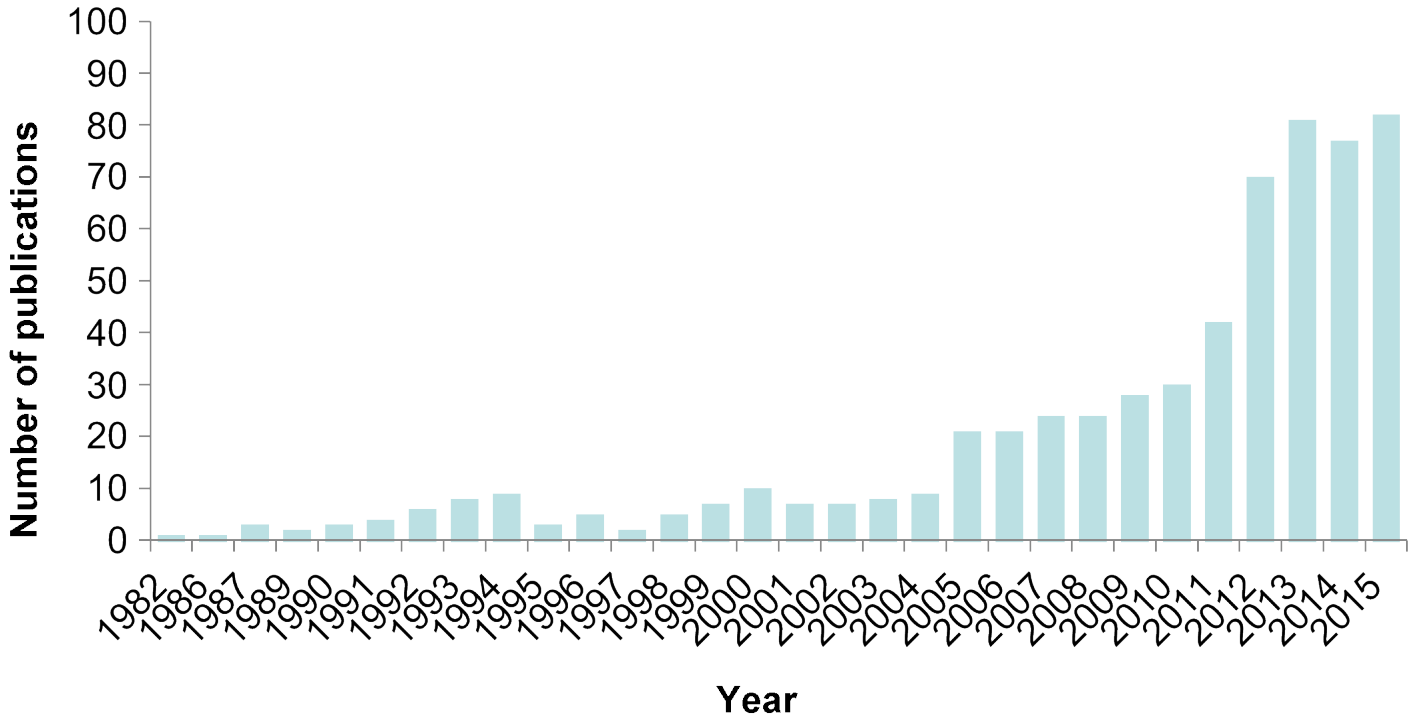
Overview

- Introduction
- Outcomes
- Prognostic factors
- Cannulation
- Post-resuscitation care
- Complications



Publications

Pubmed: extracorporeal and CPR



Definition

ECPR: Extracorporeal cardiopulmonary resuscitation

ECLS: Extracorporeal live support

The rapid deployment of extracorporeal membrane oxygenation (ECMO) to provide immediate cardiovascular support for patients who have cardiac arrest unresponsive to conventional CPR measures.

Morris MC, Crit Care Med. 2004 Apr;32(4):1061-9.

Veno-Arterial ECMO

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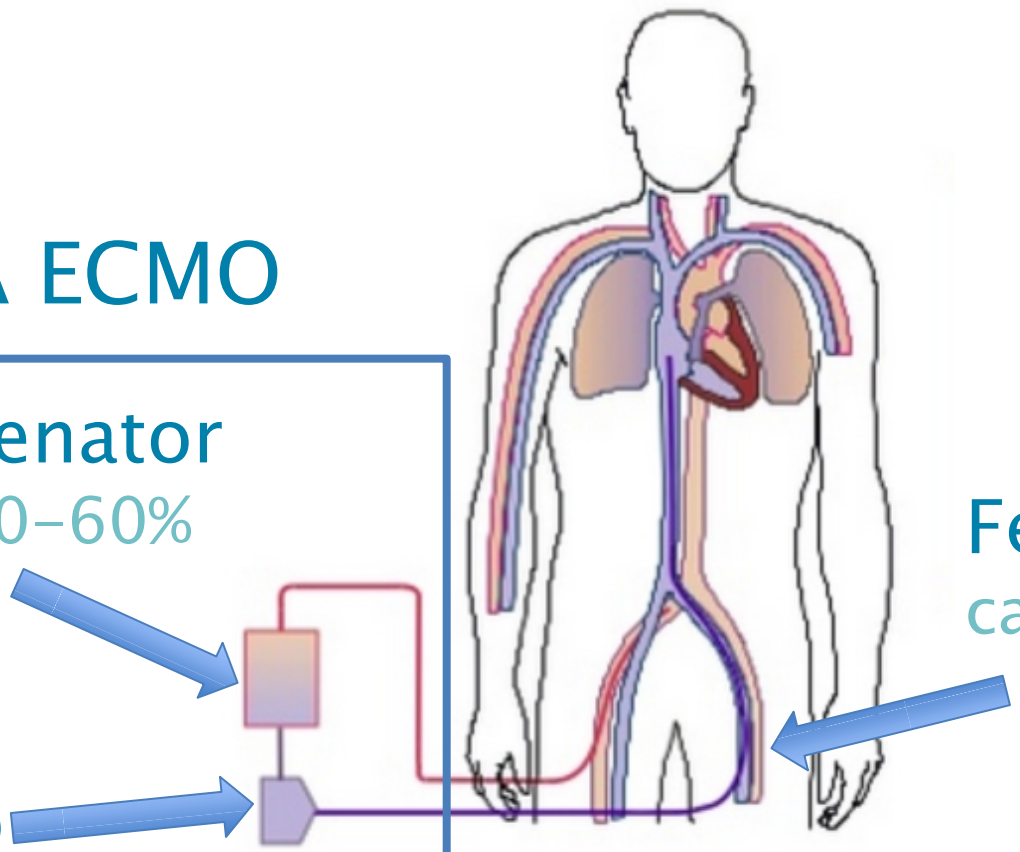
V-A ECMO

Oxygenator
FiO_2 40-60%



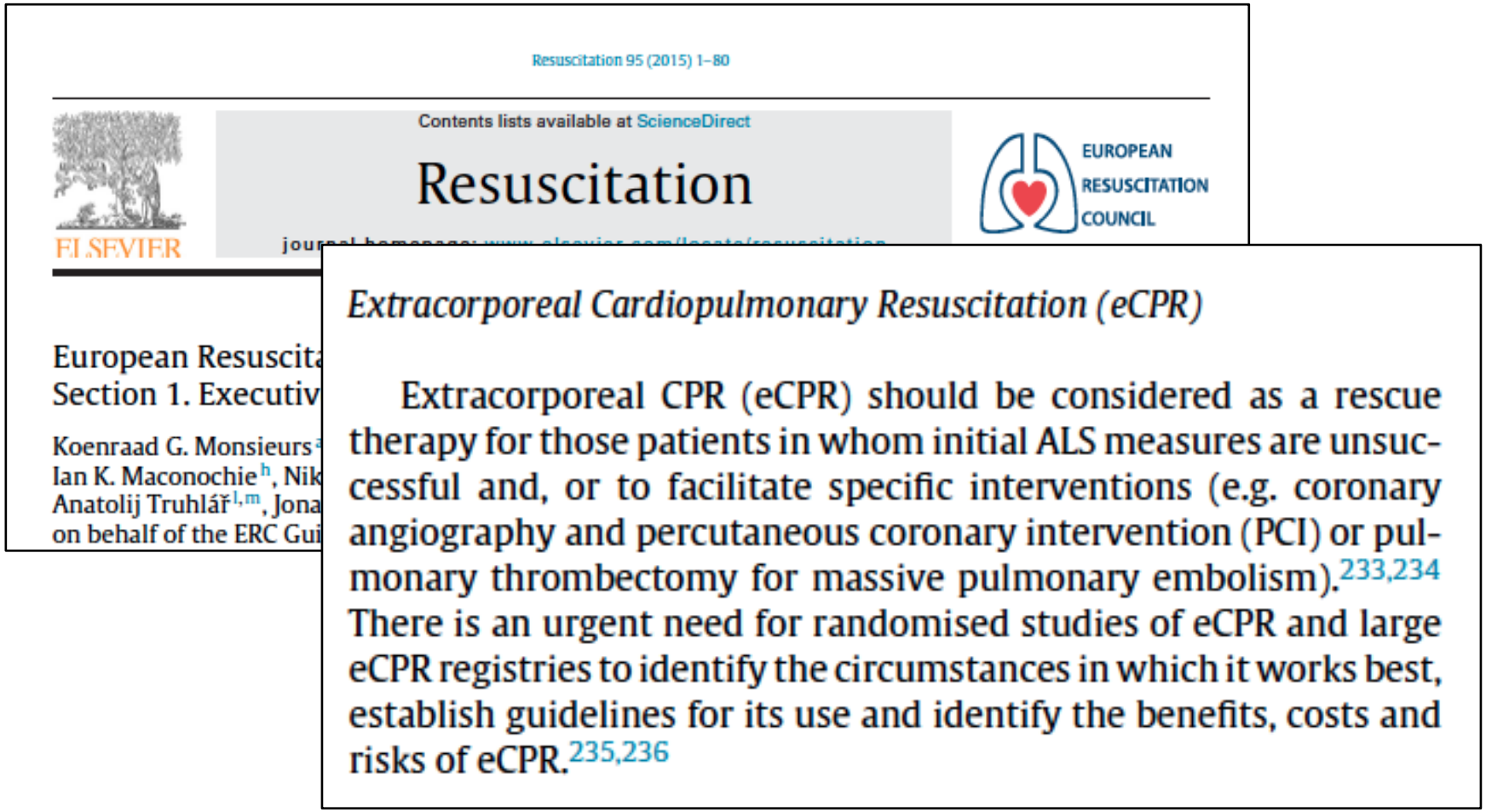
Pump
flow 3-4 l/min

Femoral access
cannulas 15-21F

ECLS
in-hospital and out-of-hospital

Image courtesy of Lamhaut L.

Guidelines



Resuscitation 95 (2015) 1–80

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

ELSEVIER

EUROPEAN RESUSCITATION COUNCIL

European Resuscita
Section 1. Executiv

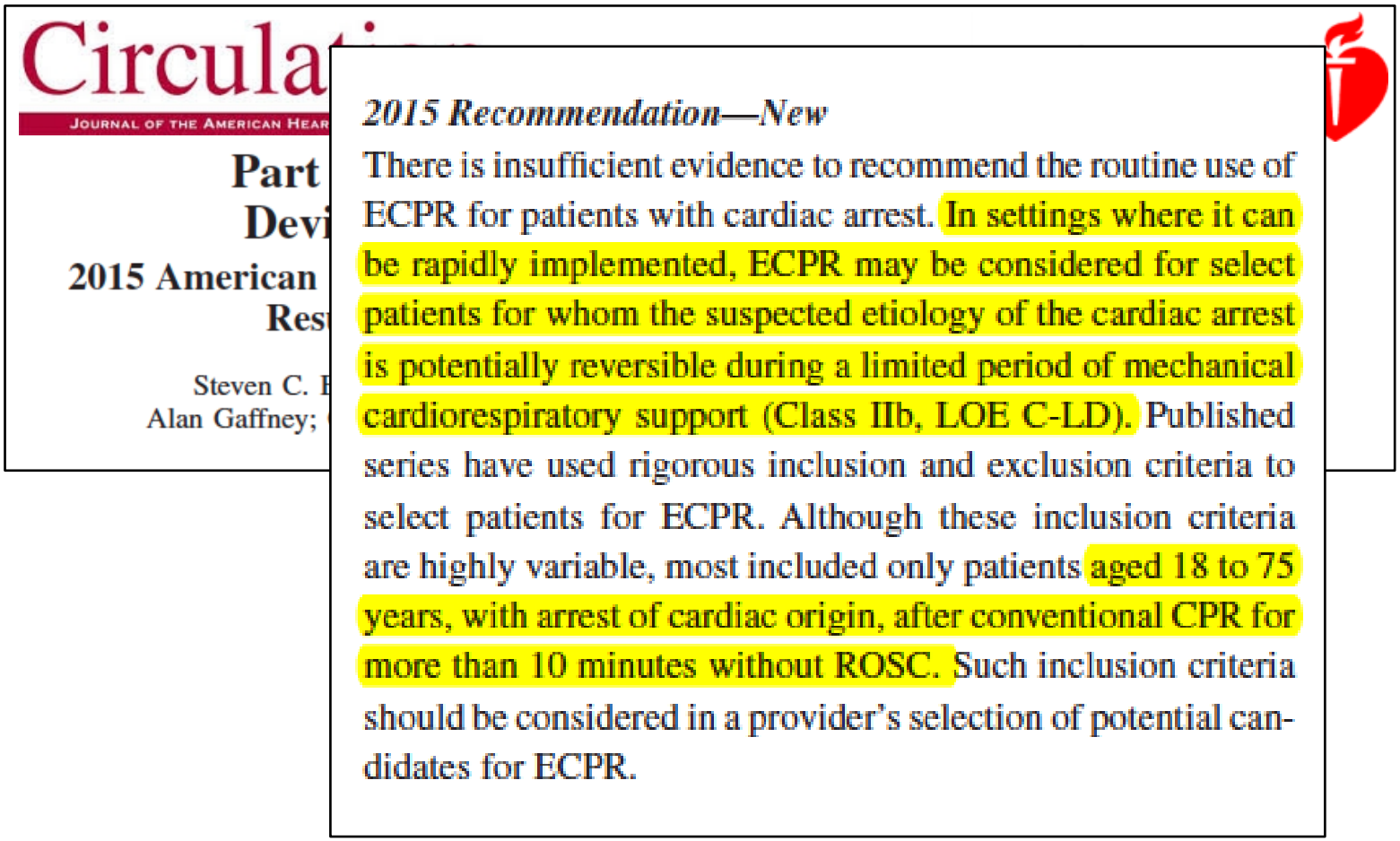
Koenraad G. Monsieurs[a], Ian K. Maconochie[h], Nik
Anatolij Truhlář[l,m], Jona
on behalf of the ERC Gui

Extracorporeal Cardiopulmonary Resuscitation (eCPR)

Extracorporeal CPR (eCPR) should be considered as a rescue therapy for those patients in whom initial ALS measures are unsuccessful and, or to facilitate specific interventions (e.g. coronary angiography and percutaneous coronary intervention (PCI) or pulmonary thrombectomy for massive pulmonary embolism).[233,234] There is an urgent need for randomised studies of eCPR and large eCPR registries to identify the circumstances in which it works best, establish guidelines for its use and identify the benefits, costs and risks of eCPR.[235,236]

K.G. Monsieurs et al. / Resuscitation 95 (2015) 1–80

Guidelines


Circula
JOURNAL OF THE AMERICAN HEAR
Part
Devi
2015 American
Res
Steven C. E
Alan Gaffney;

2015 Recommendation—New

There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support (Class IIb, LOE C-LD). Published series have used rigorous inclusion and exclusion criteria to select patients for ECPR. Although these inclusion criteria are highly variable, most included only patients aged 18 to 75 years, with arrest of cardiac origin, after conventional CPR for more than 10 minutes without ROSC. Such inclusion criteria should be considered in a provider's selection of potential candidates for ECPR.

Brooks SC, Circulation. 2015 Nov 3;132(18 Suppl 2):S436-43

Outcomes
Meta-analysis

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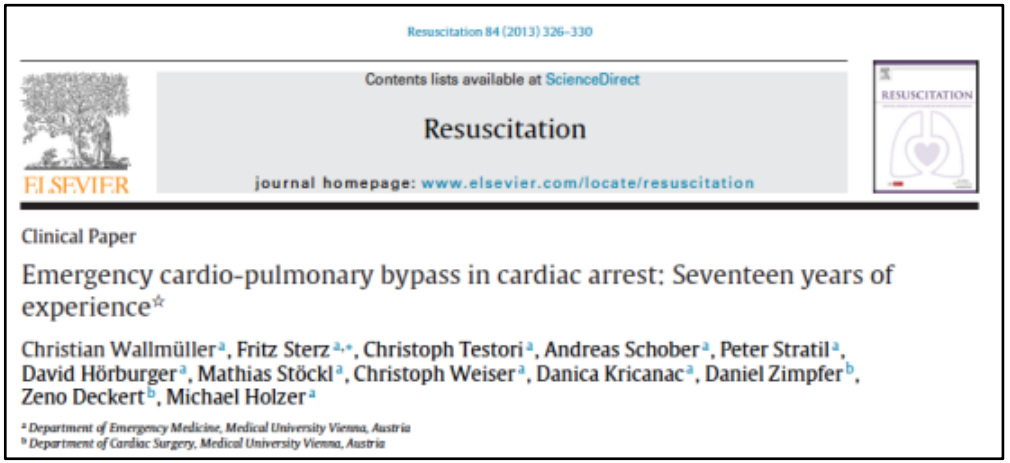
Venoarterial Extracorporeal Membrane Oxygenation for Cardiogenic Shock and Cardiac Arrest: A Meta-Analysis

Ashleigh Xie,*† Kevin Phan, BSc,*¶ Yi-Chin Tsai MBBS,‡ Tristan D. Yan, MD, MS, PhD, FRACS,*§¶ and Paul Forrest, MBChB, FANZCA‖¶

- 8 observational studies after 2000
- 343 patients with cardiac arrest
- Survival to discharge 35.9%

Xie A, J Cardiothorac Vasc Anesth. 2015 Jun;29(3) 637-45

Outcomes
Vienna 1993–2010



Resuscitation 84 (2013) 326–330

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical Paper

Emergency cardio-pulmonary bypass in cardiac arrest: Seventeen years of experience☆

Christian Wallmüller[a], Fritz Sterz[a,*], Christoph Testori[a], Andreas Schober[a], Peter Stratil[a], David Hörburger[a], Mathias Stöckl[a], Christoph Weiser[a], Danica Kricanac[a], Daniel Zimpfer[b], Zeno Deckert[b], Michael Holzer[a]

[a] Department of Emergency Medicine, Medical University Vienna, Austria
[b] Department of Cardiac Surgery, Medical University Vienna, Austria

- 3621 patients with cardiac arrest at the ED
- 55 patients treated with ECPR (2%)
- 60 % out-of-hospital cardiac arrest
- Time till start of canulation 52 min
- Cannulation time 33 min

Wallmüller C, Resuscitation. 2013 Mar;84(3):326-30

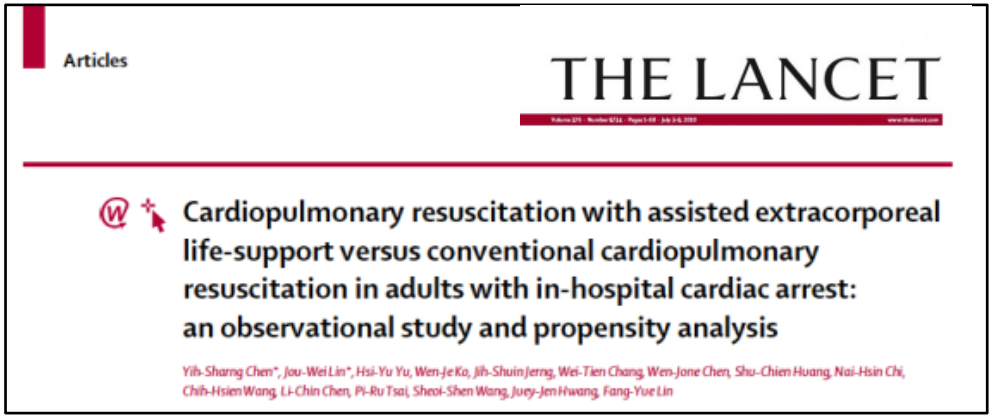
Outcomes

Vienna 1993–2010

• Cardiac	19 (35%)
• Hypothermic	14 (25%)
• Pulmonary	11 (20%)
• Intoxication	8 (15%)
• Diabetic coma	3 (5%)
• Total	55
• Weaning from ECMO	14 (25%)
• 6 month survival	8 (15%)
• CPC-Score 1 or 2	8 (15%)

Wallmüller C, Resuscitation. 2013 Mar;84(3):326-30

Outcomes
In-hospital cardiac arrest


Articles

THE LANCET

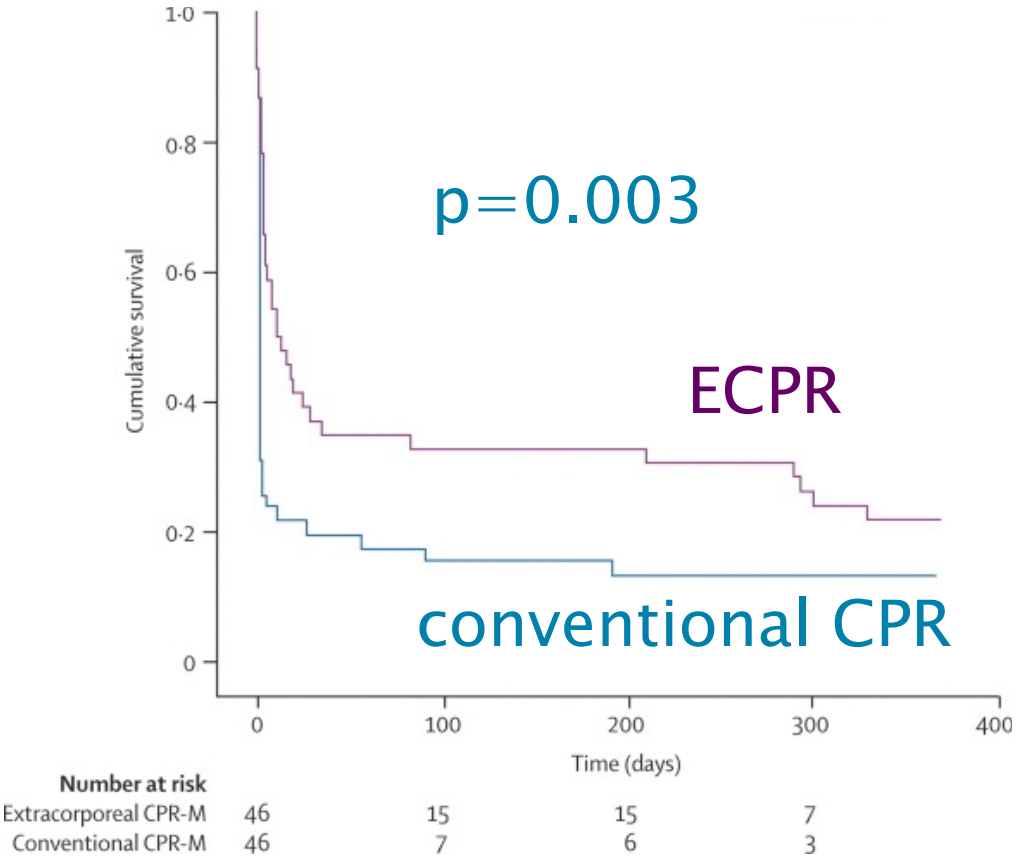
Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis

Yih-Sharng Chen*, Jou-Wei Lin*, Hsi-Yu Yu, Wen-Je Ko, Jih-Shuin Jerng, Wei-Tien Chang, Wen-Jone Chen, Shu-Chien Huang, Nai-Hsin Chi, Chih-Hsien Wang, Li-Chin Chen, Pi-Ru Tsai, Sheai-Shen Wang, Juey-Jen Hwang, Fang-Yue Lin

- 3-year prospective observational study
- ECMO for 59 patients
- Age 18-75 years
- Witnessed in-hospital cardiac arrest of cardiac origin
- Undergoing CPR for >10 minutes
- Propensity-score matched with conventional CPR

Chen YS, Lancet. 2008 Aug 16;372(9638):554-61

Outcomes
In-hospital cardiac arrest



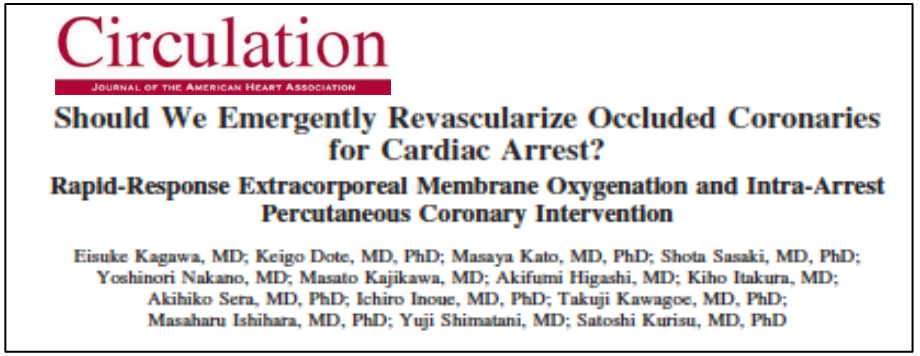
Chen YS, Lancet. 2008 Aug 16;372(9638):554-61

Outcomes
In-hospital cardiac arrest

	ECPR	CCPR
• Weaning from ECMO	49%	
• Survival to discharge	29%	12%
• CPC 1 or 2 at discharge	11%	24%
• CPC 1 or 2 at one year	9%	15%

Chen YS, Lancet. 2008 Aug 16;372(9638):554-61

Outcomes
Cardiac origin


Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

Should We Emergently Revascularize Occluded Coronaries for Cardiac Arrest?

Rapid-Response Extracorporeal Membrane Oxygenation and Intra-Arrest Percutaneous Coronary Intervention

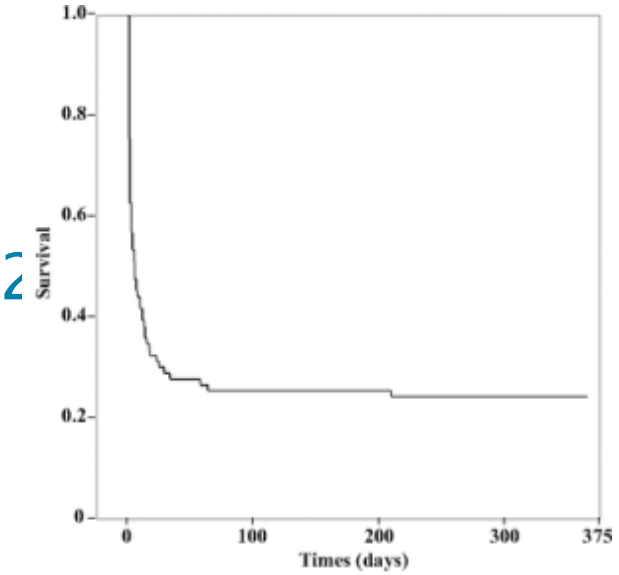
Eisuke Kagawa, MD; Keigo Dote, MD, PhD; Masaya Kato, MD, PhD; Shota Sasaki, MD, PhD; Yoshinori Nakano, MD; Masato Kajikawa, MD; Akifumi Higashi, MD; Kiho Itakura, MD; Akihiko Sera, MD, PhD; Ichiro Inoue, MD, PhD; Takuji Kawagoe, MD, PhD; Masaharu Ishihara, MD, PhD; Yuji Shimatani, MD; Satoshi Kurisu, MD, PhD

- 7-year retrospective study
- ECMO for 86 patients
- Age 18–74 years
- Cardiac arrest of cardiac origin, 49% out-of-hospital
- VF on ECG during CPR
- Undergoing ALS for >20 minutes

Kagawa E, Circulation. 2012 Sep 25;126(13):1605-13

Outcomes
Cardiac origin

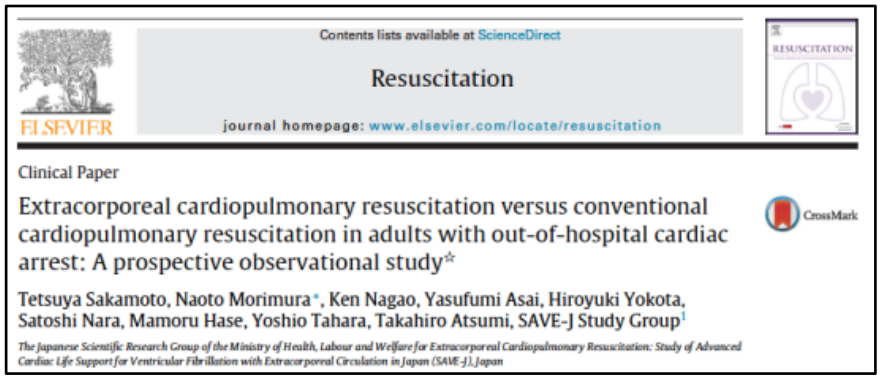
- Weaning from ECMO 50%
- 30-days survival 2
- CPC 1 or 2 at discharge 24%



- Survivors 28% out-of-hospital cardiac arrest
- Non-survivors 57% out-of-hospital cardiac arrest

Kagawa E, Circulation. 2012 Sep 25;126(13):1605-13

Outcomes
Out-of-hospital cardiac arrest



Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical Paper

Extracorporeal cardiopulmonary resuscitation versus conventional cardiopulmonary resuscitation in adults with out-of-hospital cardiac arrest: A prospective observational study☆

Tetsuya Sakamoto, Naoto Morimura*, Ken Nagao, Yasufumi Asai, Hiroyuki Yokota, Satoshi Nara, Mamoru Hase, Yoshio Tahara, Takahiro Atsumi, SAVE-J Study Group[1]

The Japanese Scientific Research Group of the Ministry of Health, Labour and Welfare for Extracorporeal Cardiopulmonary Resuscitation: Study of Advanced Cardiac Life Support for Ventricular Fibrillation with Extracorporeal Circulation in Japan (SAVE-J), Japan

- 3 year prospective study
- 26 hospitals ECPR
  20 hospitals non-ECPR
- VF/VT initial ECG, 20-70 years
- Hospital arrivial within 45min after EMS call

Sakamoto T, Resuscitation. 2014 Jun;85(6):762-8.

Outcomes
Out-of-hospital cardiac arrest

	ECPR	non-ECPR
Number of patients	260	194
Time from EMS call to arrival	29min	30min
CPC 1 or 2 at 6 months	12.4%	3.1%

Sakamoto T, Resuscitation. 2014 Jun;85(6):762-8.

Outcomes
CHEER trial

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical Paper

Refractory cardiac arrest treated with mechanical CPR, hypothermia, ECMO and early reperfusion (the CHEER trial)☆

Dion Stub[c,f,g], Stephen Bernard[a,b,d,*], Vincent Pellegrino[a], Karen Smith[b,d,e], Tony Walker[d], Jayne Sheldrake[a], Lisen Hockings[a], James Shaw[a,b,c], Stephen J. Duffy[a,b,c], Aidan Burrell[a,b], Peter Cameron[a,b], De Villiers Smit[a], David M. Kaye[a,b,c]

- Prospective study
- Age 18–65 years
- Cardiac arrest of cardiac origin
- Initial rhythm ventricular fibrillation
- CPR > 30min
- 26 patients, 11 OHCA, 15 IHCA

Stub D, Resuscitation. 2015 Jan;86:88-94

Outcomes

CHEER trial

- Mechanical chest compression (Autopulse®)
- 2 liter ice-cold saline
- Transfer to the ED, immediate ECMO

• Cardiac arrest to ECMO	56min (40-85min)
• Arrival to ECMO flow	20min (15-30min)
• Weaning from ECMO	54%
• Hospital discharge	54%(IHCA 60%,OHCA 45%)
• CPC 1 of survivors:	100%

Stub D, Resuscitation. 2015 Jan;86:88-94

Patient selection

Accidential Hypothermia

ECPR associated with 6.6-fold survival

Intoxication

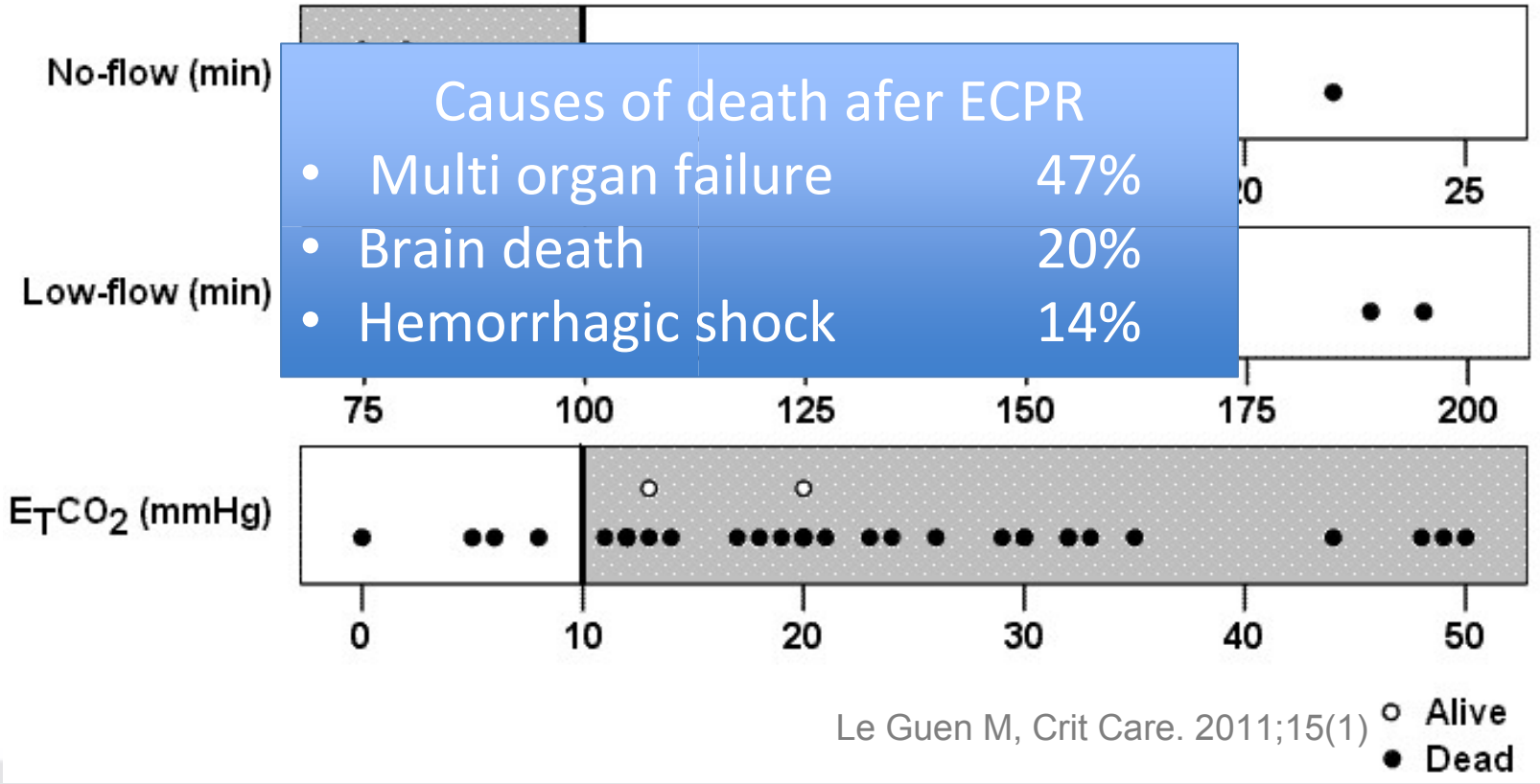
Beta-blockers
Calcium-antagonists
Antiarrhytmics
Tricyclic antidepressants
Benzodiazepines

Case reports with good outcome

Prognostic factors

No flow time

51 consecutive patiens
witnessed OHCA, 2 survivors

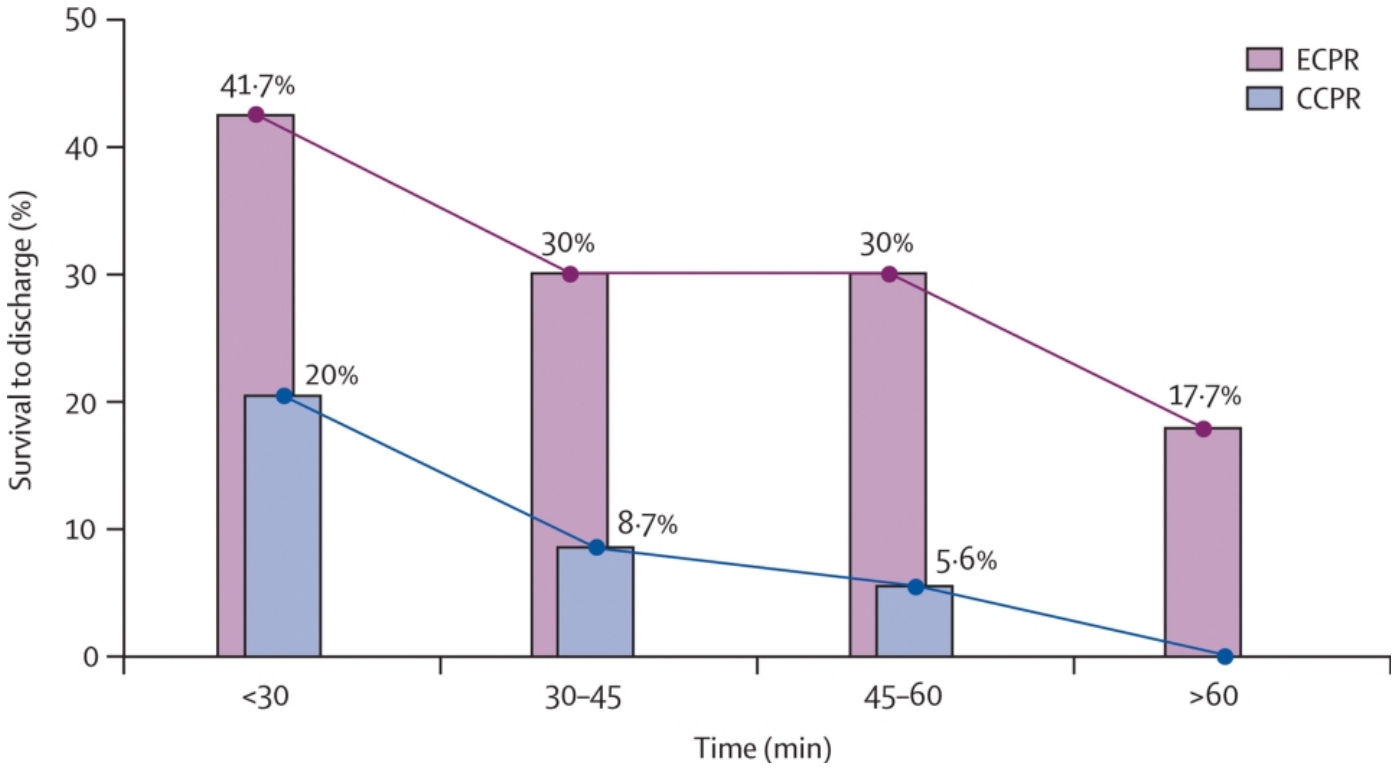


Causes of death afer ECPR

- Multi organ failure 47%
- Brain death 20%
- Hemorrhagic shock 14%

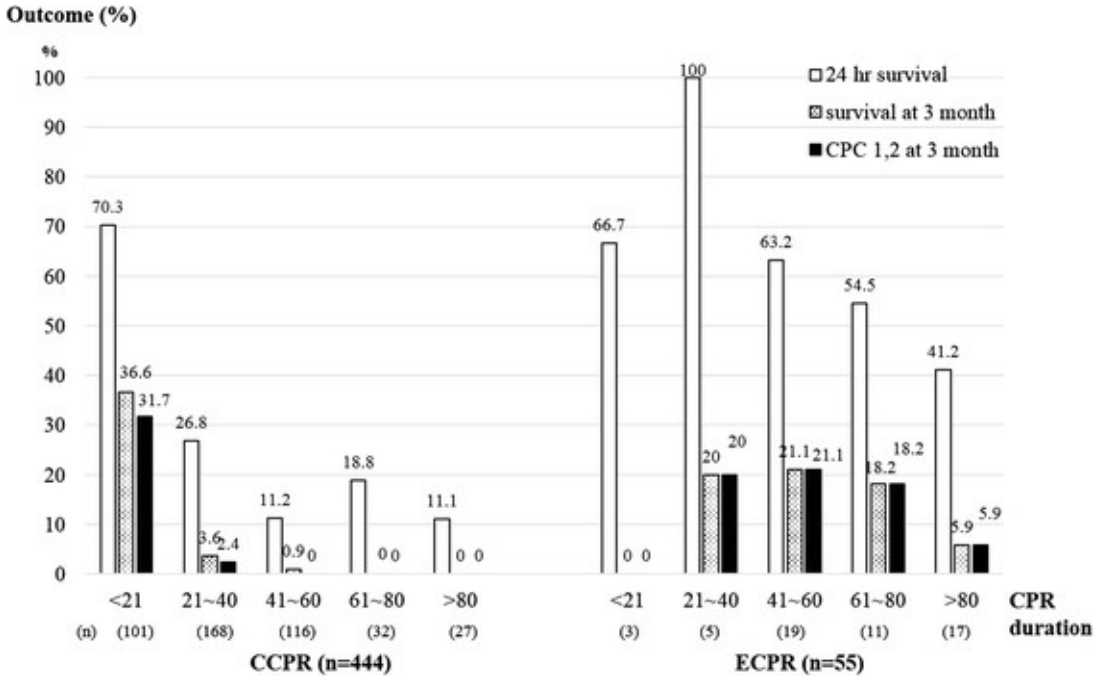
Le Guen M, Crit Care. 2011;15(1)

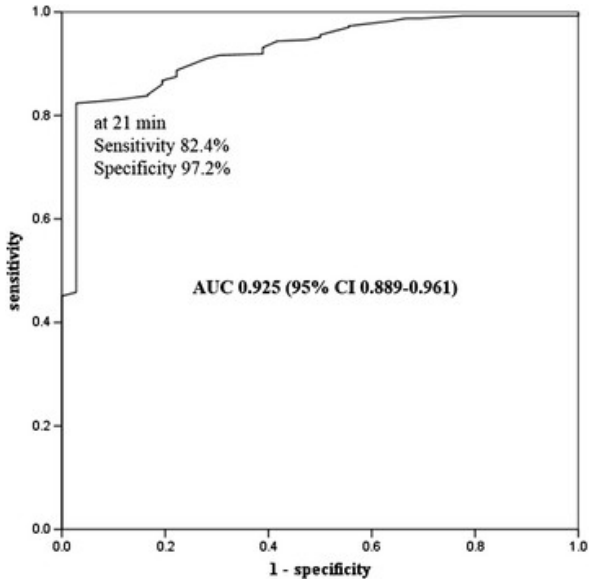
Prognostic factors
Time until ECMO-flow



Chen YS, Lancet. 2008 Aug 16;372(9638):554-61

Prognostic factors
Time of CPR

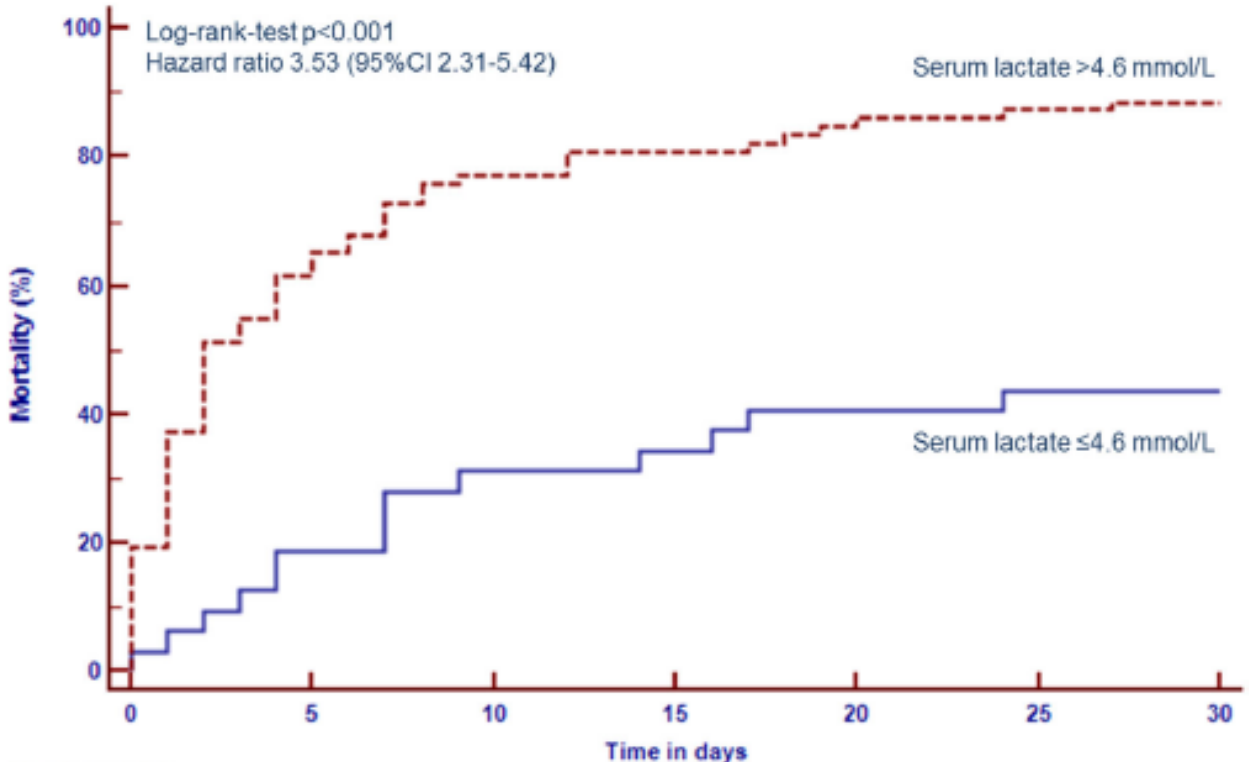




Kim SJ, Crit Care. 2014 Sep 26;18(5):535

Prognostic factors

Serum lactate



117 patients: multivariate analysis only serum lactate

Jung C, Clin Res Cardiol. 2015 Aug 25.

Prognostic factors

- No flow time
- VF/VT at initial ECG
- Cardiac origin
- Signs of live
  movement, respiration, pupillary response
- Time to ECMO flow
  no differences IHCA/OHCA when adjusted for time
- $E_TCO2 > 10$ mmHg
- Lactate levels

Cannulation

- Surgeon
- Emergency physician
- Cardiologist
- Intensivist

Percutaneus

Open

Mixed

Arterial 15-19F

Venous 19-21F

Cannulation
Technique

Percutaneus

- Seldinger technique
- Ultrasound or fluoroscopy to locate wire in V. cava inf. and Ao. desc.
- Risk of failure
- Distal limb perfusion catheter

Cannulation
Technique

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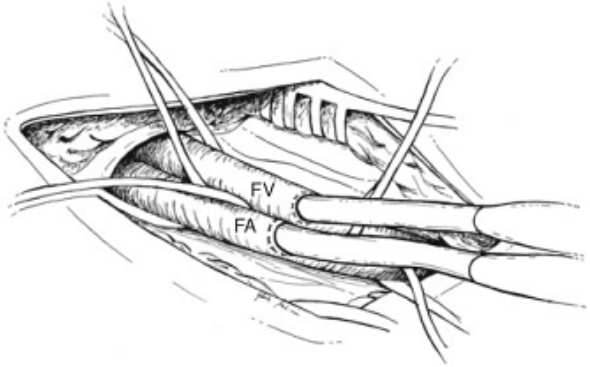
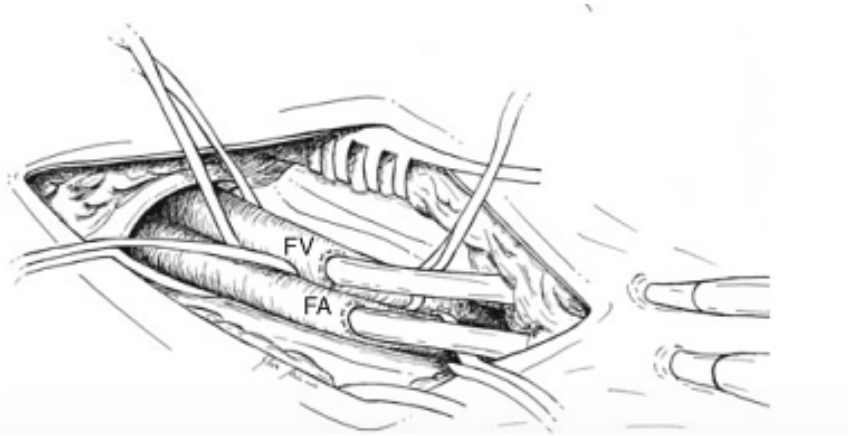
Open



- Needs a Surgeon
- Time consuming
- Not for out of hospital ECMO
- Lowest risk of failure

Cannulation
Technique



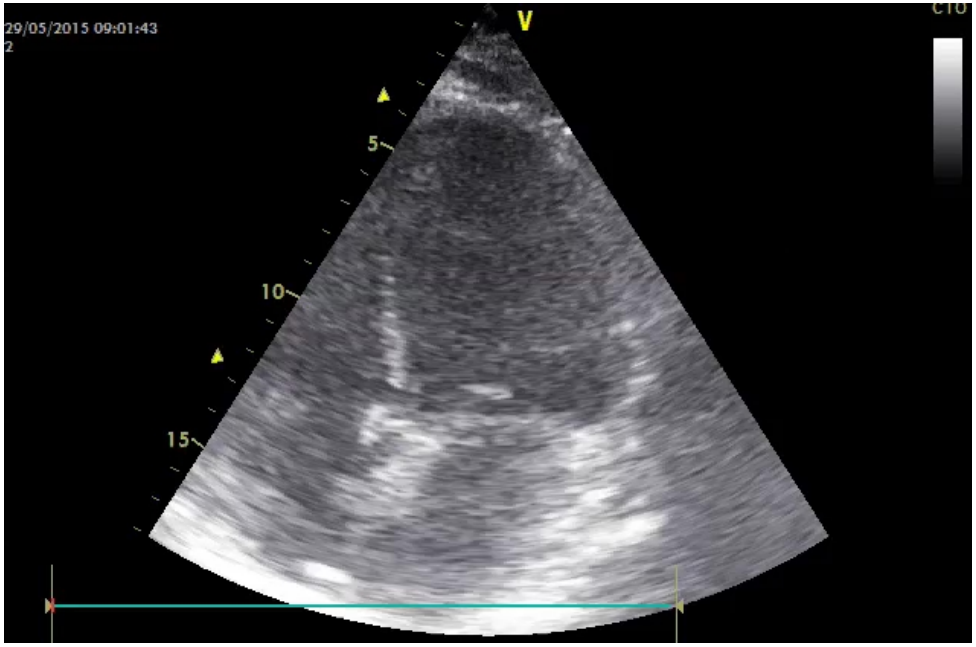
Mixed

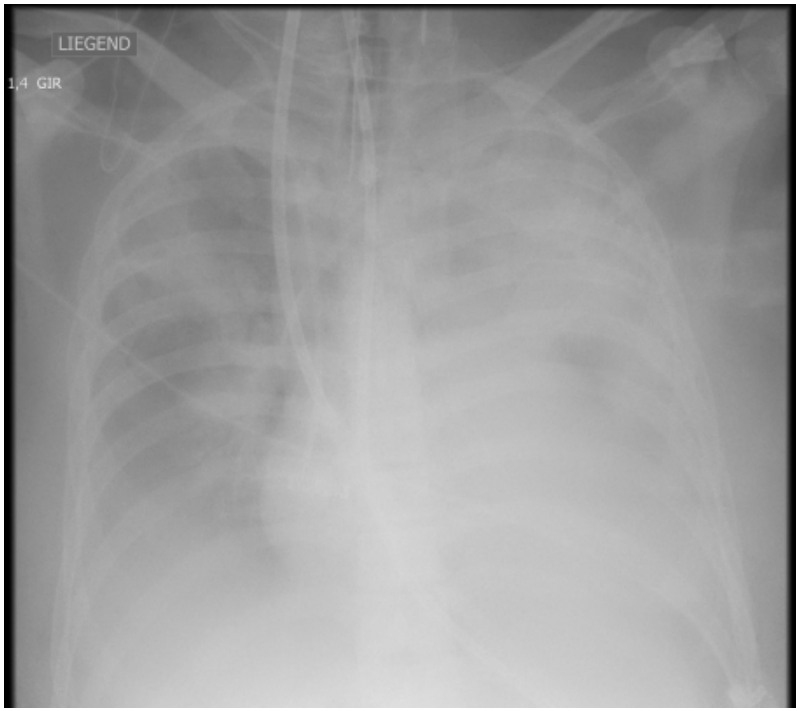
- Incision in the groin
- Insertion of guidewire, dilator and cannula under vision with Seldinger
- Increased bleeding
- Best for out-of-hospital ECMO

Post-resuscitation care

- MAP 60-70 mmHg
- Normoxia, normocapnia
- Ice-cold saline for volume loading and mild hypothermia
- Immediate coronary angiography or CT scan for pulmonary embolism

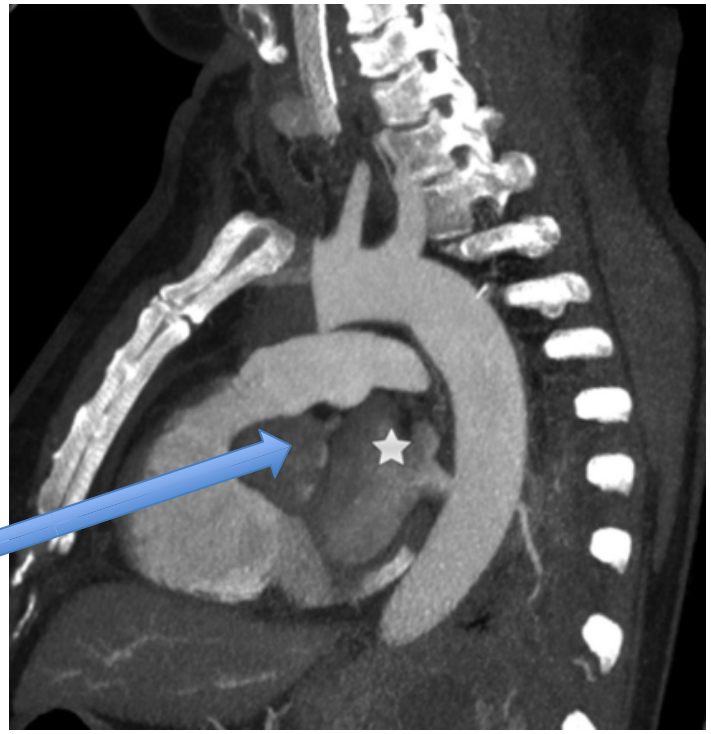
Post-resuscitation care
no flow – pulmonary oedema



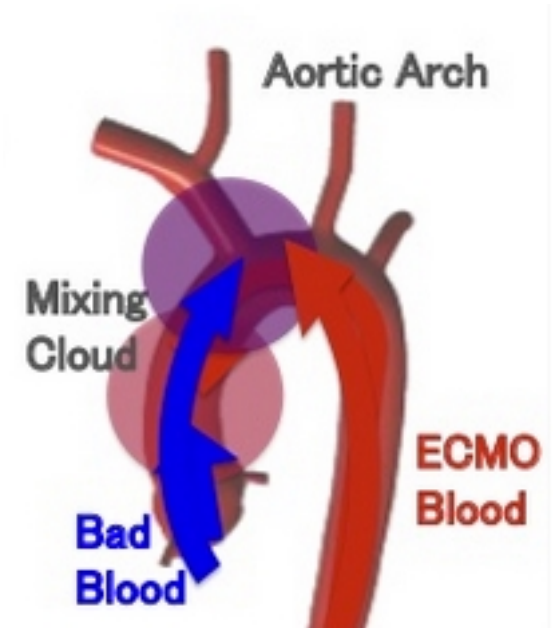


24 hours after ECMO

Post-resuscitation care
no flow – watershed phenomenon



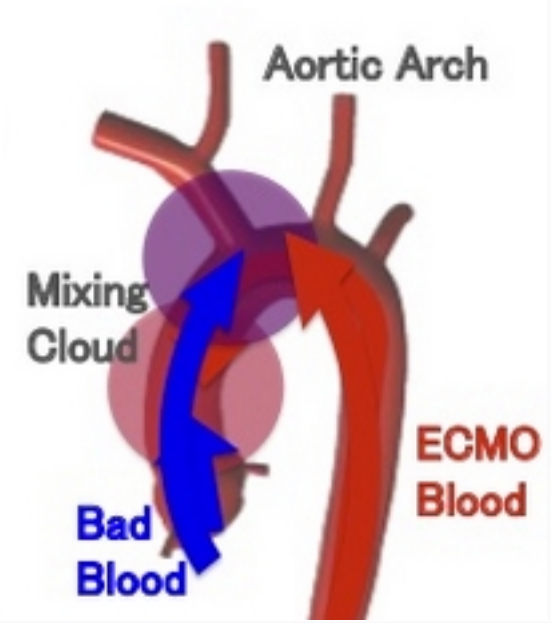
No contrast
in coronaries
and Ao. ascendens



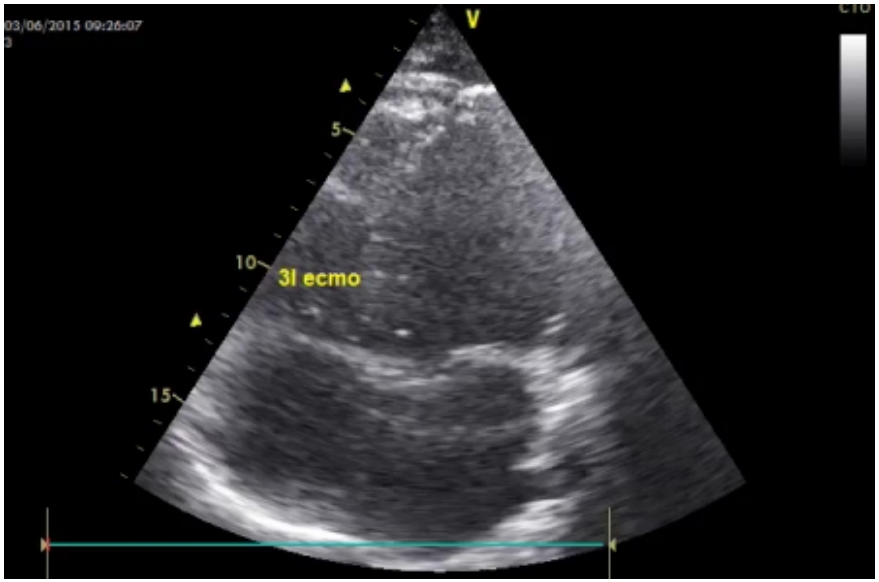
Hoeper MM, Circulation. 2014 Sep 2;130(10):864-5

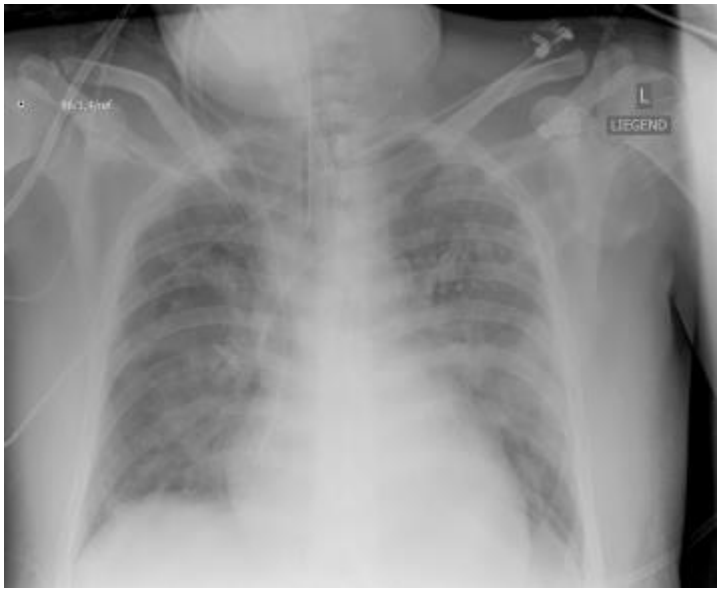
Post-resuscitation care
no flow – myocardial ischemia

- Decrease afterload as much as possible
  low ECMO flow
  MAP 60–70 mmHg
- Use inotropic agents
  dobutamine, levosimendan
- Increase FiO_2 and PEEP at respirator



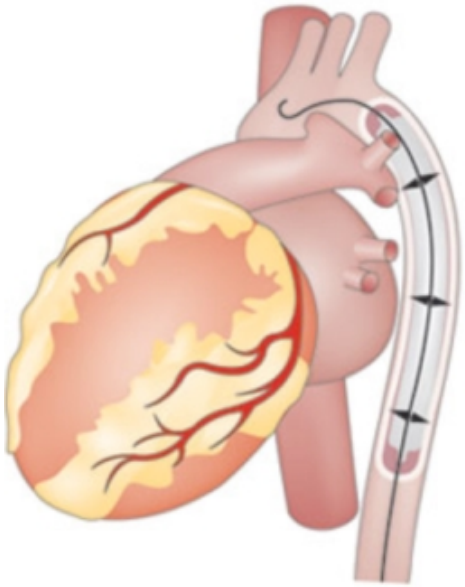
Post-resuscitation care
no flow – pulmonary oedema



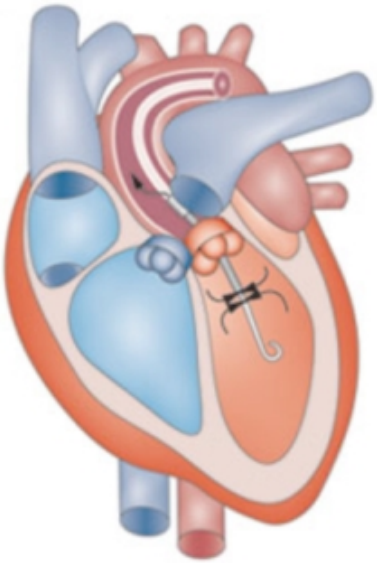


4 days after ECMO

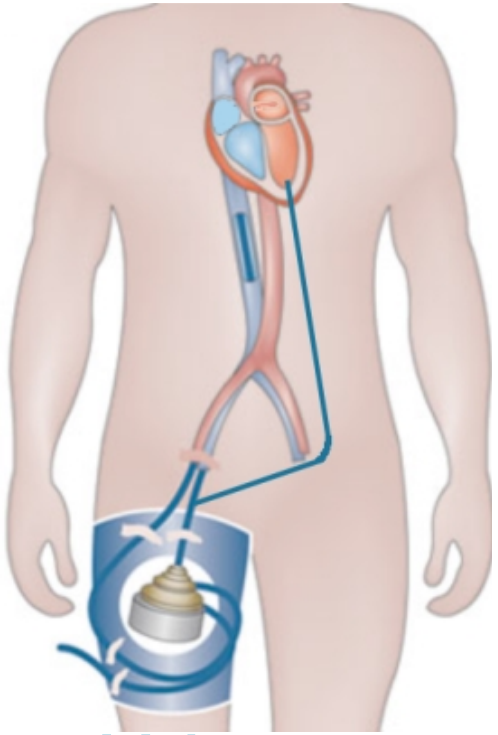
Post-resuscitation care
no flow – pulmonary oedema



IABP



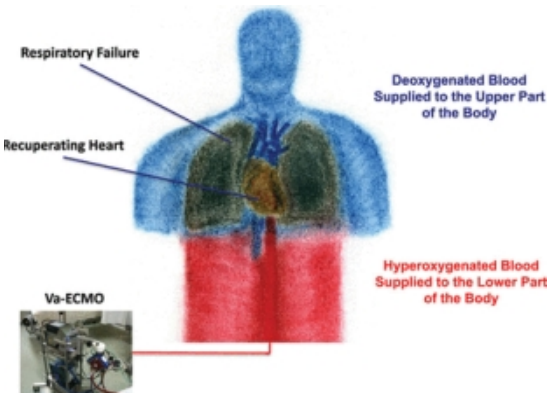
Impella



LV-vent

Complications
Acute setting

- Wrong cannulation
  venous-venous or arterial-arterial
- Bleeding
- Accidental decannulation
- „Harlequin" syndrome



Zangrillo A, Crit Care Resusc. 2013 Sep;15(3):172-8.

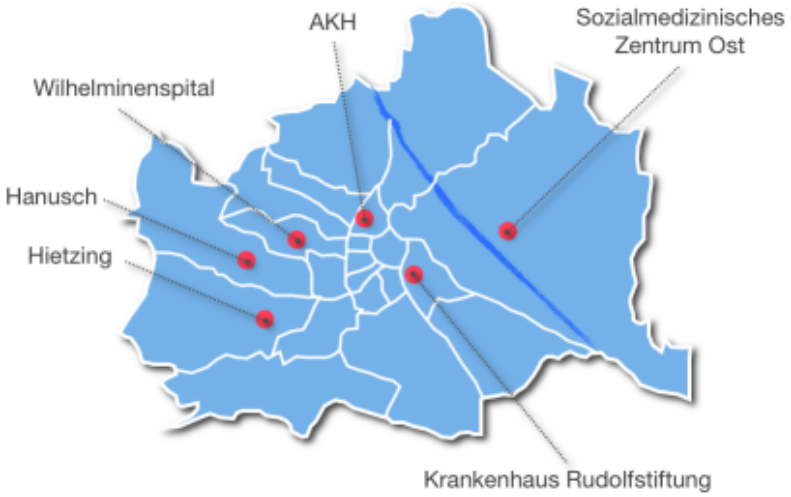
Complications in the ICU

- renal failure requiring haemofiltration 52%
- bacterial pneumonia 33%
- any bleeding 33%
- sepsis 26%
- haemolysis 18%
- central nervous system complications 15%
- liver dysfunction 16%
- leg ischaemia 10%
- venous thrombosis 10%
- gastrointestinal bleeding 7%
- aspiration pneumonia 5%
- disseminated intravascular coagulation 5%

Zangrillo A, Crit Care Resusc. 2013 Sep;15(3):172-8.

Patient selection

Load & Go Criteria Vienna



- Age < 75 years
- Witnessed OHCA
- Basic life support
- Ventricular fibrillation/ventricular tachycardia
- No ROSC within 15 min of advanced-life-support

Poppe M, Resuscitation 91 (2015) 131–136

Patient selection

Load & Go Criteria Vienna

Population 1.8 Million
VICAR Study:
August 1, 2013 to July 31, 2014

	Total	ROSC at the scene	Ongoing CPR on transport	Died on the scene	*p* value
Count (%)	864 (100)	257 (29.7)	96 (11.1)	511 (59.1)	
load&go criteria, *n* (%)					
VF/VT	215 (24.9)	118 (45.9)	37 (38.5)	60 (11.7)	<0.001
Basic life support	514 (59.5)	169 (65.8)	69 (71.9)	276 (54.0)	<0.001
Witnessed collapse	482 (55.8)	172 (66.9)	68 (70.8)	242 (47.4)	<0.001
Age <75 year	574 (66.4)	198 (77.0)	72 (75.0)	304 (59.5)	<0.001
CPR >15 min of ALS	400 (46.3)	94 (36.6)	–	306 (59.9)	<0.001
All “load&go” criteria fulfilled, *n* (%)	55 (6.4)	17 (6.6)	16 (16.7)	22 (4.3)	<0.001

Poppe M, Resuscitation 91 (2015) 131–136

Summary

- Only small non-randomized studies
- Survival in ECPR ranges from 4% to 54%
- Decision for ECMO after 15-20 min
- ECMO should start within 60 min
- Need for efficient ECMO rescue teams for IHCA and OHCA

Thank you!

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