Tempest in The T-Waves

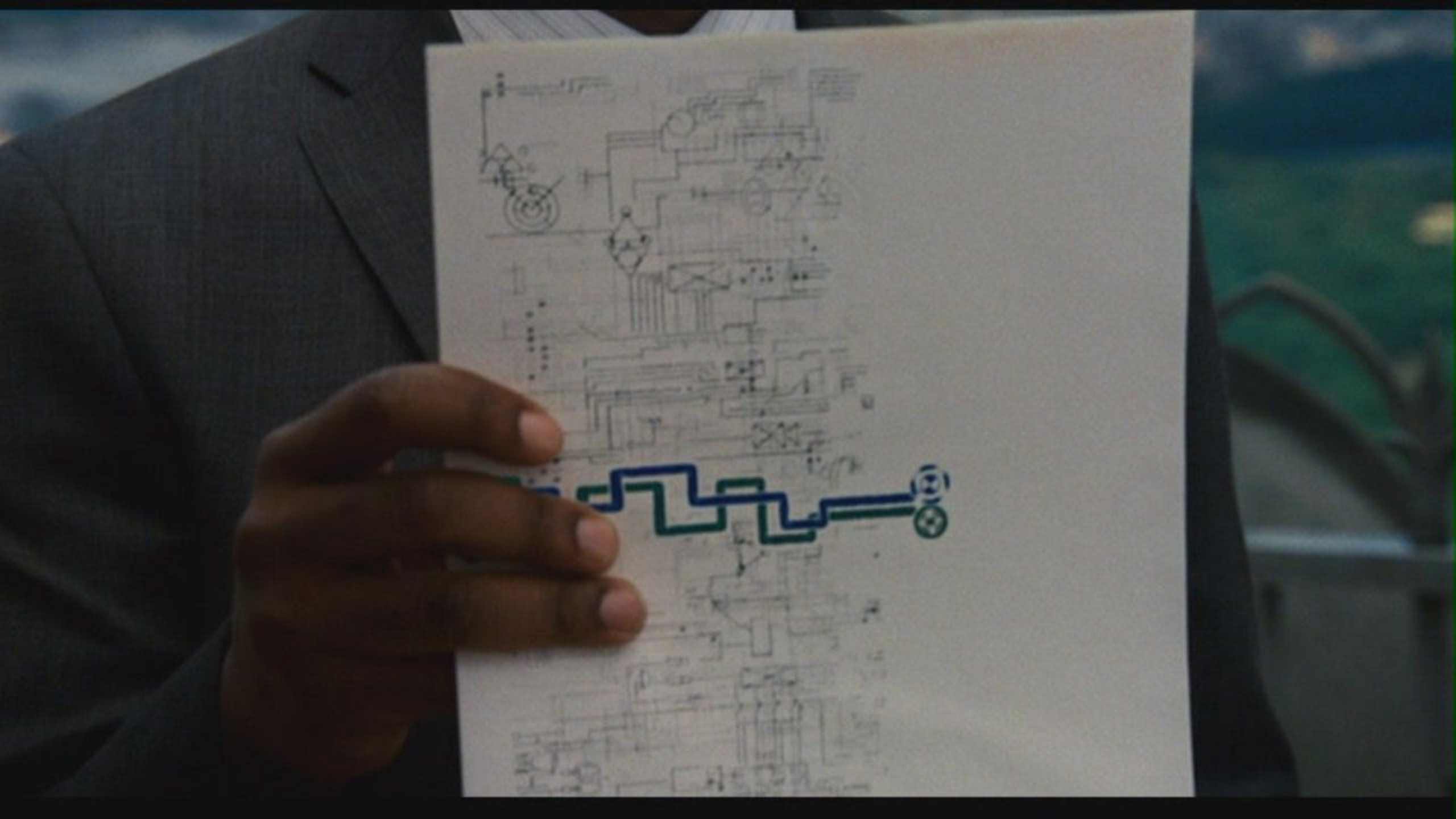
Righting the Ship During a Cardiac Electrical Storm

Scott Gilmore, MD, FACEP, FAEMS

Medical Director

What is Cardiac Electircal Storm?

- A life-threatening syndrome that involves recurrent episodes of ventricular arrhythmias.
- Defined as 3 or more sustained episodes of ventricular tachycardia (VT), ventricular fibrillation (VF), or appropriate implantable cardioverter-defibrillator (ICD) shocks during a 24-hour period.
- In the out-of-hospital setting, this often presents as recurrent VT or VF



So Now What Do We Do?

Beta Blockade?

Treating Electrical Storm

Sympathetic Blockade Versus Advanced Cardiac Life Support–Guided Therapy

Koonlawee Nademanee, MD; Richard Taylor, MD; William E. Bailey, MD;
Daniel E. Rieders, MD; Erol M. Kosar, MD

Beta Blockade?

Resuscitation 85 (2014) 1337–1341

Contents lists available at ScienceDirect

Resuscitation

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

Clinical paper

Use of esmolol after failure of standard cardiopulmonary resuscitation to treat patients with refractory ventricular fibrillation

Brian E. Driver[a,*], Guillaume Debaty[a,b,c], David W. Plummer[a], Stephen W. Smith[a]

[a] Hennepin County Medical Center, Department of Emergency Medicine, 701 Park Ave S, MC 825, Minneapolis, MN 55415, USA
[b] University of Minnesota, Department of Medicine-Cardiovascular Division, Mayo Mail Code 508, 420 Delaware Street SE, Minneapolis, MN 55455, USA
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Table 4
Patient outcomes.

	Esmolol ($n = 6$)	No esmolol ($n = 19$)
Total ED CPR time, min; median (IQR)	39.5 (31, 59)	16 (13, 25)
Total CPR time, min; median (IQR)	63 (57, 83)	57 (39, 66)
Temporary ROSC (%)	4 (66.7)	8 (42.1)
Sustained ROSC (%)	4 (66.7)	6 (31.6)
STEMI (%)	3/5[a] (60)	1/7[a] (14.3)
Emergent cardiac catheterization from the ED (%)	5 (83.3)	3 (15.8)
Survival to ICU admission (%)	4 (66.7)	6 (31.6)
Therapeutic hypothermia (%)	4 (66.7)	5[b] (26.3)
Survival to hospital discharge (%)	3 (50)	3 (15.8)
Survival to discharge with good neurologic outcome[c] (%)	3 (50)	2 (10.5)

Beta Blockade?

- Administration of esmolol may increase the rate of sustained ROSC and ICU survival among patients with RVF in OHCA

- Further larger-scale prospective studies are necessary to determine the effect of esmolol for RVF in OHCA

Resuscitation 107 (2016) 150–155

Contents lists available at ScienceDirect

Resuscitation

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

Clinical paper

Refractory ventricular fibrillation treated with esmolol☆

Young Hwan Lee[a,b], Kui Ja Lee[c], Yong Hun Min[a], Hee Cheol Ahn[a], You Dong Sohn[a], Won Woong Lee[a], Young Taeck Oh[a,b], Gyu Chong Cho[d], Jeong Yeol Seo[e], Dong Hyuk Shin[f], Sang O. Park[g], Seung Min Park[a,*]

Beta Blockade?

American Journal of Emergency Medicine 38 (2020) 1921–1934

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

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

Esmolol in the management of pre-hospital refractory ventricular fibrillation: A systematic review and meta-analysis

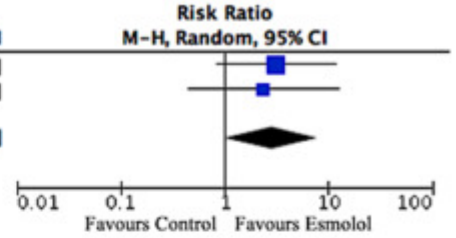
Dennis Miraglia, MD *, Lourdes A. Miguel, MD, MPH, Wilfredo Alonso, MD

Department of Internal Medicine, Good Samaritan Hospital, Aguadilla, PR, United States

Survival to hospital discharge

Study or Subgroup	Esmolol Events	Esmolol Total	No Esmolol Events	No Esmolol Total	Weight	Risk Ratio M-H, Random, 95% CI
Driver et al 2014	3	6	3	19	62.0%	3.17 [0.85, 11.75]
Lee et al 2016	3	16	2	25	38.0%	2.34 [0.44, 12.52]
Total (95% CI)		**22**		**44**	**100.0%**	**2.82 [1.01, 7.93]**
Total events	6		5			

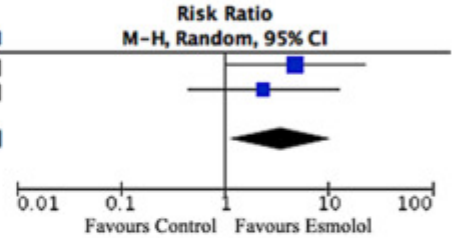
Heterogeneity: Tau² = 0.00; Chi² = 0.08, df = 1 (P = 0.78); I² = 0%
Test for overall effect: Z = 1.97 (P = 0.05)



Neurologically intact survival

Study or Subgroup	Esmolol Events	Esmolol Total	No Esmolol Events	No Esmolol Total	Weight	Risk Ratio M-H, Random, 95% CI
Driver et al 2014	3	6	2	19	54.3%	4.75 [1.02, 22.06]
Lee et al 2016	3	16	2	25	45.7%	2.34 [0.44, 12.52]
Total (95% CI)		**22**		**44**	**100.0%**	**3.44 [1.11, 10.67]**
Total events	6		4			

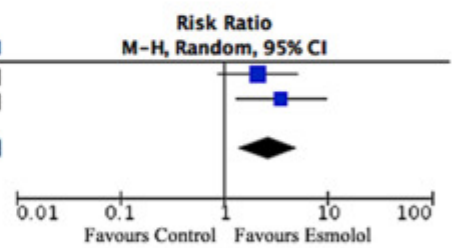
Heterogeneity: Tau² = 0.00; Chi² = 0.38, df = 1 (P = 0.54); I² = 0%
Test for overall effect: Z = 2.14 (P = 0.03)



Return of spontaneous circulation

Study or Subgroup	Esmolol Events	Esmolol Total	No Esmolol Events	No Esmolol Total	Weight	Risk Ratio M-H, Random, 95% CI
Driver et al 2014	4	6	6	19	56.7%	2.11 [0.88, 5.04]
Lee et al 2016	9	16	4	25	43.3%	3.52 [1.30, 9.53]
Total (95% CI)		**22**		**44**	**100.0%**	**2.63 [1.37, 5.07]**
Total events	13		10			

Heterogeneity: Tau² = 0.00; Chi² = 0.62, df = 1 (P = 0.43); I² = 0%
Test for overall effect: Z = 2.89 (P = 0.004)



Survival to ICU/hospital admission

Study or Subgroup	Esmolol Events	Esmolol Total	No Esmolol Events	No Esmolol Total	Weight	Risk Ratio M-H, Random, 95% CI
Driver et al 2014	4	6	6	19	56.7%	2.11 [0.88, 5.04]
Lee et al 2016	9	16	4	25	43.3%	3.52 [1.30, 9.53]
Total (95% CI)		**22**		**44**	**100.0%**	**2.63 [1.37, 5.07]**
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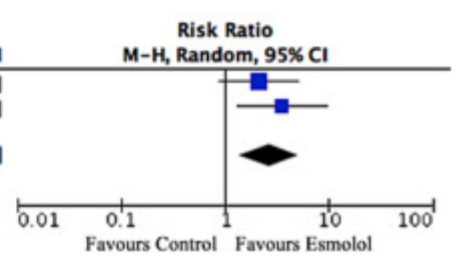
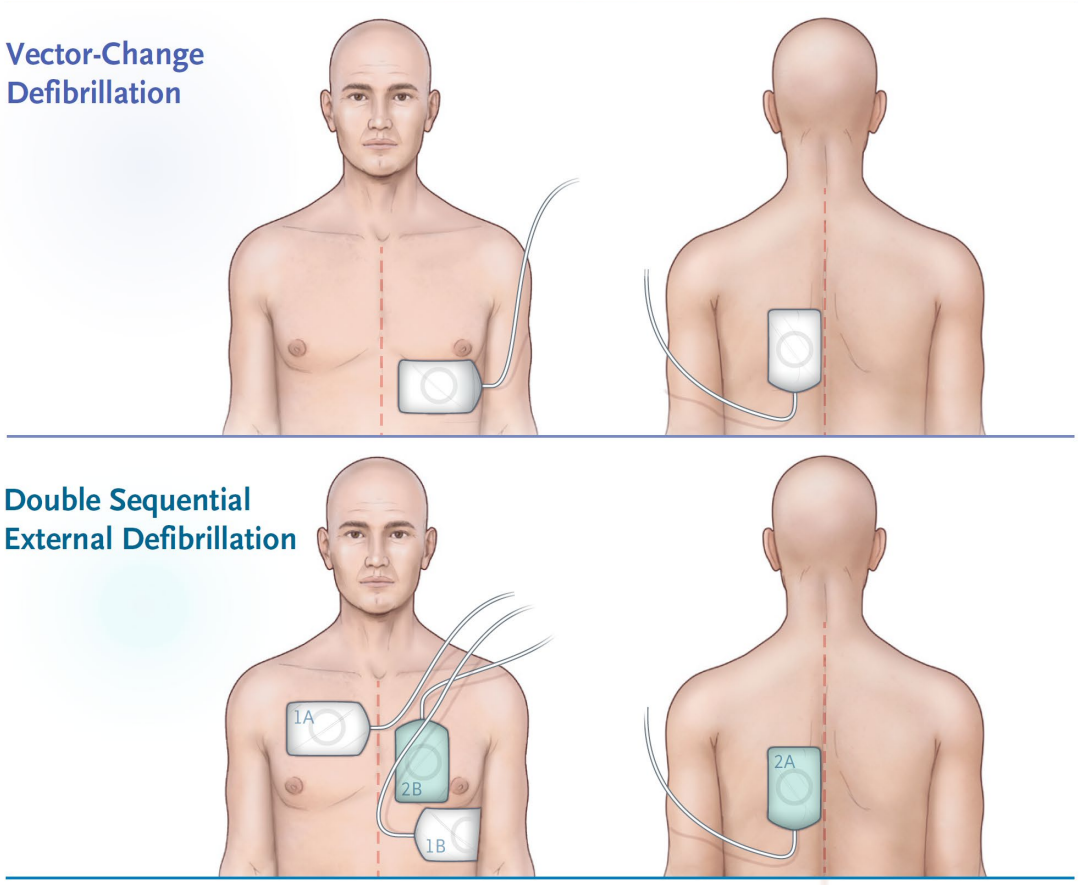


Electrical Considerations?

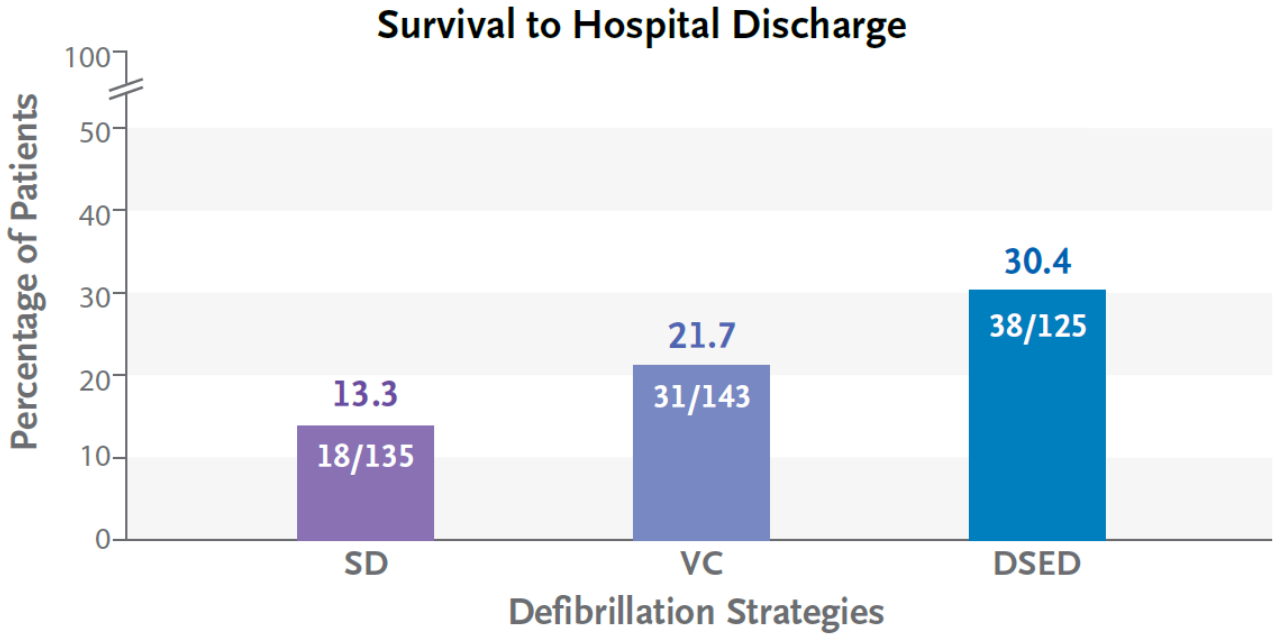


The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Defibrillation Strategies for Refractory Ventricular Fibrillation

Sheldon Cheskes, M.D., P. Richard Verbeek, M.D., Ian R. Drennan, A.C.P., Ph.D., Shelley L. McLeod, Ph.D., Linda Turner, Ph.D., Ruxandra Pinto, Ph.D., Michael Feldman, M.D., Ph.D., Matthew Davis, M.D., Christian Vaillancourt, M.D., Laurie J. Morrison, M.D., Paul Dorian, M.D., and Damon C. Scales, M.D., Ph.D.

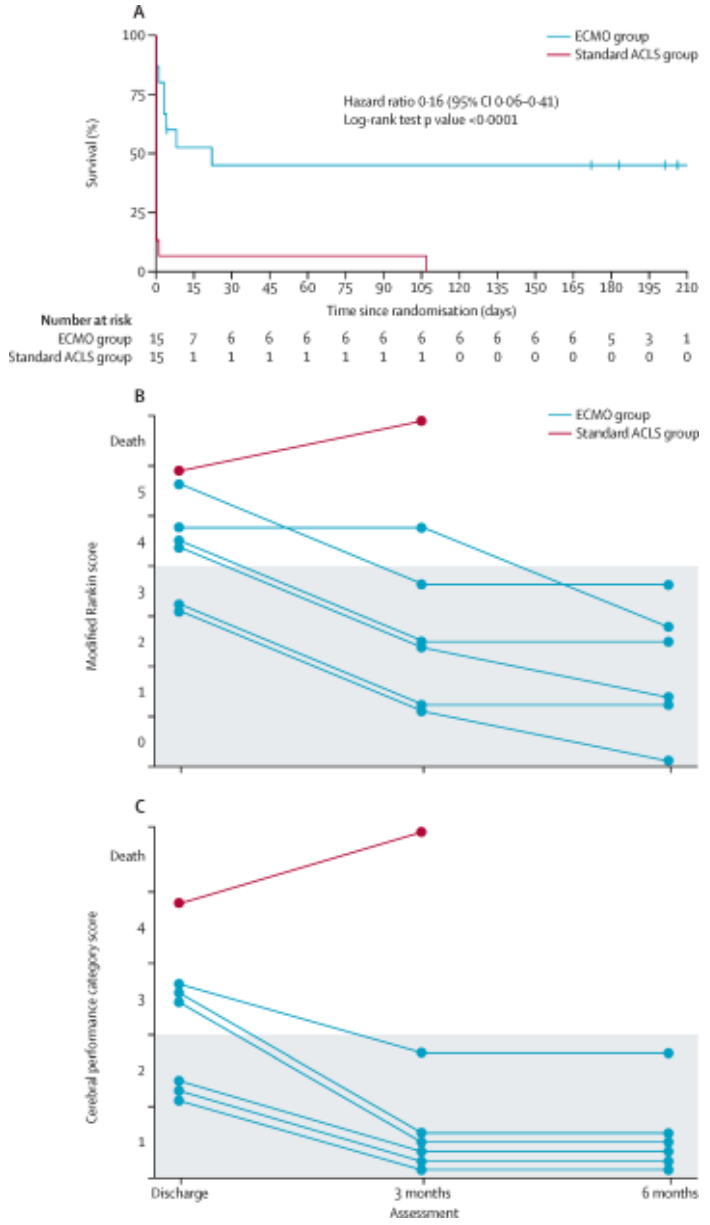


eCPR?

eCPR - ARREST

Advanced reperfusion strategies for patients with out-of-hospital cardiac arrest and refractory ventricular fibrillation (ARREST): a phase 2, single centre, open-label, randomised controlled trial

Demetris Yannopoulos, Jason Bartos, Ganesh Raveendran, Emily Walser, John Connett, Thomas A Murray, Gary Collins, Lin Zhang, Rajat Kalra, Marinos Kosmopoulos, Ranjit John, Andrew Shaffer, R J Frascone, Keith Wesley, Marc Conterato, Michelle Biros, Jakub Tolar, Tom P Aufderheide



eCPR - INCEPTION

Table 4. Survival with Favorable Neurologic Outcome.*

Outcome	Extracorporeal CPR (N=70)	Conventional CPR (N=63)†	Odds Ratio (95% CI)	P Value	Risk Ratio (95% CI)
Primary outcome: 30-day survival with favorable neurologic outcome — no./total no. (%)	14/70 (20)	10/62 (16)‡	1.4 (0.5–3.5)	0.52	1.05 (0.97–1.13)
Secondary outcomes — no./total no. (%)					
3-month survival with favorable neurologic outcome	12/68 (18)	9/63 (14)	1.5 (0.6–3.8)		
6-month survival with favorable neurologic outcome	14/70 (20)	10/63 (16)	1.3 (0.5–3.3)		

* The widths of the confidence intervals have not been adjusted for multiplicity and so should not be used in place of a hypothesis test. A favorable neurologic outcome was defined as a Cerebral Performance Category score of 1 or 2 (normal performance or mild disability with independence) on a scale of 1 to 5, with higher scores indicating more severe disability.
† One patient was not assessed by an independent neurologist and thus was excluded from the primary analysis.
‡ One patient withdrew from the trial before 30 days.

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JANUARY 26, 2023 VOL. 388 NO. 4

Early Extracorporeal CPR for Refractory Out-of-Hospital Cardiac Arrest

M.M. Suverein, T.S.R. Delnoij, R. Lorusso, G.J. Brandon Bravo Bruinsma, L. Otterspoor, C.V. Elzo Kraemer,

eCPR – Prague Study

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Effect of Intra-arrest Transport, Extracorporeal Cardiopulmonary Resuscitation, and Immediate Invasive Assessment and Treatment on Functional Neurologic Outcome in Refractory Out-of-Hospital Cardiac Arrest

A Randomized Clinical Trial

Jan Belohlavek, MD, PhD; Jana Smalcova, MD; Daniel Rob, MD; Ondrej Franek, MD; Ondrej Smid, MD; Milana Pokorna, MD, PhD; Jan Horák, MD; Vratislav Mrazek, MD; Tomas Kovarnik, MD, PhD; David Zemanek, MD, PhD; Ales Kral, MD, PhD; Stepan Havranek, MD, PhD; Petra Kavalkova, PhD; Lucie Kompelentova, MD; Helena Tomková, MD; Alan Mejstrik, MSc; Jaroslav Valasek, MD; David Peran, MSc; Jaroslav Pekara, MSc; Jan Rulisek, MD, PhD; Martin Balik, MD, PhD; Michal Huptych, PhD; Jiri Jarkovsky, PhD; Jan Malik, MD, PhD; Anna Valerianova, MD, PhD; Frantisek Mlejnsky, MSc, PhD; Petr Kolouch, MD; Petra Havrankova, MD, PhD; Dan Romportl, MD; Arnost Komarek, PhD; Ales Linhart, MD, PhD; for the Prague OHCA Study Group

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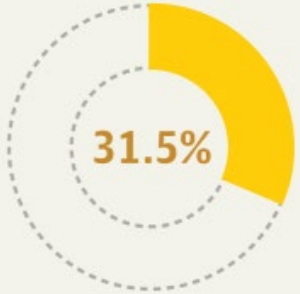
FINDINGS

Survival to 180 days with good neurologic outcome

Invasive strategy
39 of 124 patients



Standard strategy
29 of 132 patients

The between-group difference was not significant:

9.5% (95% CI, -1.3% to 20.1%);

odds ratio, **1.63** (95% CI, 0.93 to 2.85); *P* = .09

eCPR – Pooled Analysis of ARREST and Prague OHCA

Panel A. Modified intention to treat analysis in the whole population of both trials

Outcomes	Invasive (N = 139)	Standard (N = 147)	Absolute difference (CI), %	p value
Primary outcome				
Survival with minimal or no neurologic impairment at 180 days	45 (32.4%)	29 (19.7%)	12.7 (2.6–22.7)	**0.015**
Secondary outcomes				
Survival with minimal or no neurologic impairment at 30 days	44 (31.7%)	24 (16.3%)	15.4 (5.6–25.1)	**0.003**
Cardiac recovery at 30 days	60 (43.2%)	46 (31.3%)	11.9 (0.7–23)	0.05

Intraarrest transport, extracorporeal cardiopulmonary resuscitation, and early invasive management in refractory out-of-hospital cardiac arrest: an individual patient data pooled analysis of two randomised trials

Jan Belohlavek,[a,g,] Demetris Yannopoulos,[b,g] Jana Smalcova,[a] Daniel Rob,[a] Jason Bartos,[b] Michal Huptych,[c] Petra Kavalkova,[a] Rajat Kalra,[b] Brian Grunau,[d] Fabio Silvio Taccone,[e] and Tom P. Aufderheide[f]*

Questions?

gilmorew@stlouis-mo.gov