ECPR – How to Build and Run a Successful Program

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Western Pennsylvania Cardiogenic Shock Initiative Symposium: September 16, 2023

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Disclosures

- American College of Cardiology Clinical Trials Research Grant: Mild hypothermia versus a fever avoidance strategy in cardiac arrest patient rescued with extracorporeal cardiopulmonary resuscitation

- R01 HL160973: Left ventricular physiological effects of veno-arterial ECMO support during cardiogenic shock

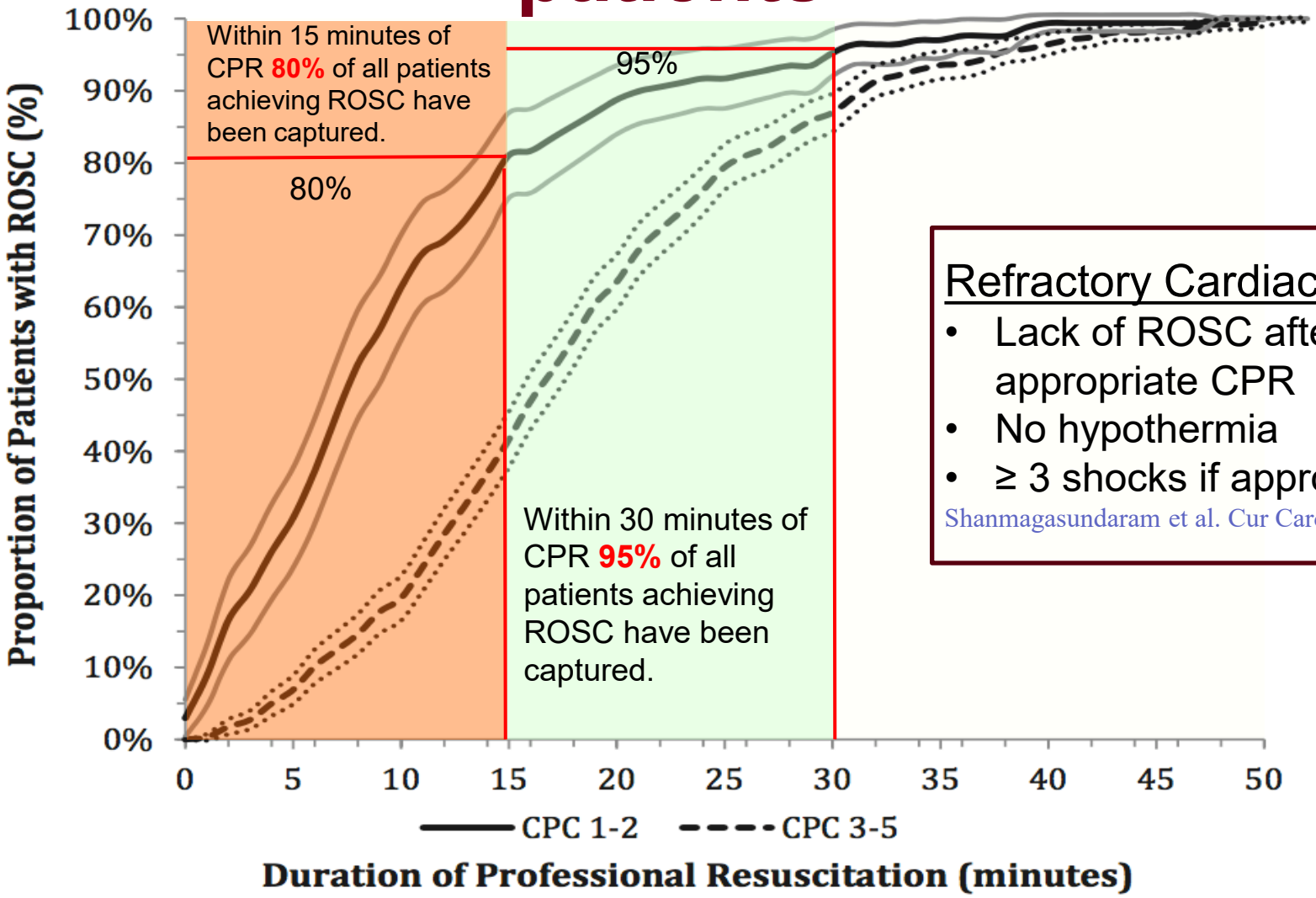
Outline

- ECPR definition
- Local Epidemiology of Cardiac Arrest
- Patient Selection
- Building a Protocol
  - Prehospital Care
  - Cannulation
  - Admission
  - ICU cares
  - Post Arrest Clinic
- Maintenance
- Growth

Extracorporeal Life Support Organization (ELSO) definition of ECPR

Extracorporeal cardiopulmonary resuscitation (ECPR): the application of rapid-deployment **venoarterial extracorporeal membrane oxygenation, VA ECMO,** to provide circulatory support **in patients in whom conventional cardiopulmonary resuscitation (CPR) is unsuccessful in achieving sustained return of spontaneous circulation** (sustained ROSC). **Sustained ROSC** is deemed to have occurred when chest **compressions are not required for 20 consecutive minutes** and signs of circulation persist (Jacobs et al, Cardiac arrest and CPR outcome reports: Utstein templates from ILCOR. Circulation. 2004;110(21):3385-972004).

Duration of CPR and Likelihood of ROSC in VT/VF patients



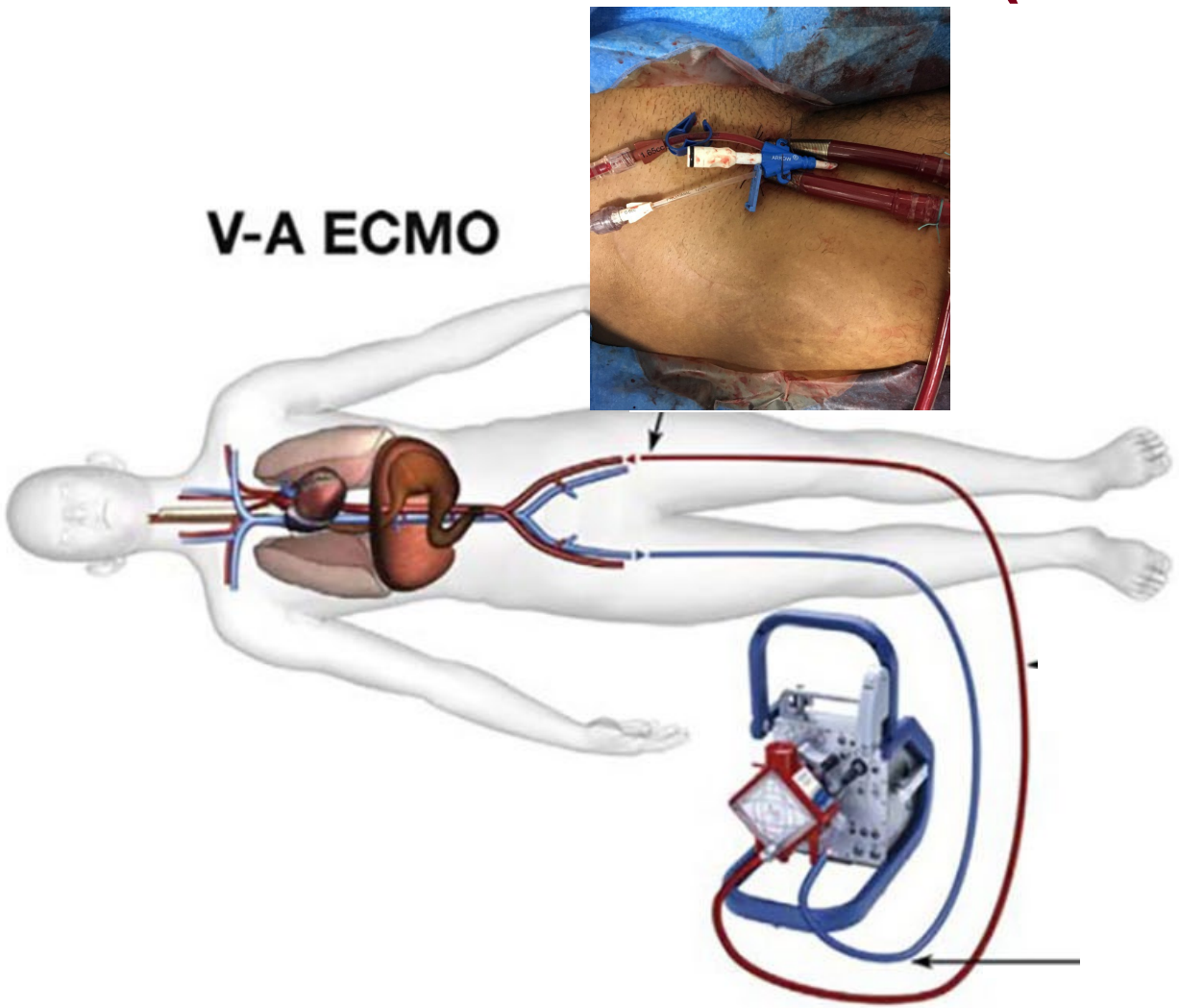
Refractory Cardiac Arrest

- Lack of ROSC after 30 minutes of appropriate CPR
- No hypothermia
- ≥ 3 shocks if appropriate (VT/VF)

Shanmagasundaram et al. Cur Cardiology Reviews, 2018

Grunau et al., Resuscitation, 2016

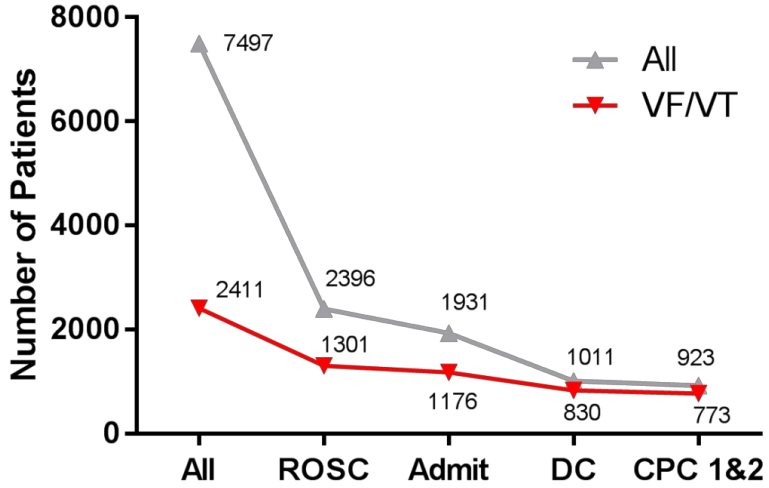
Veno-Arterial Extracorporeal Membranous Oxygenation (VA ECMO):

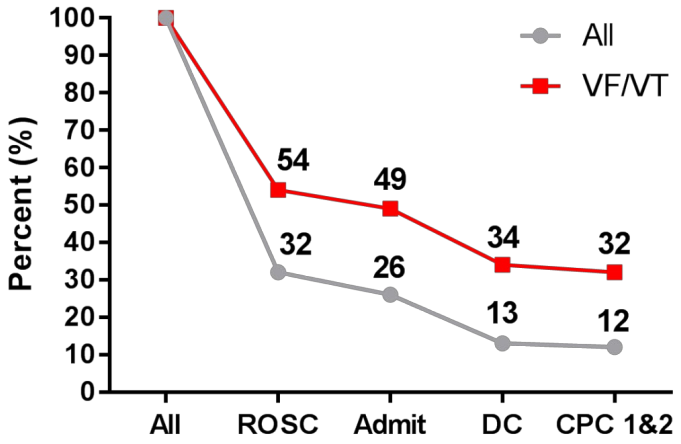


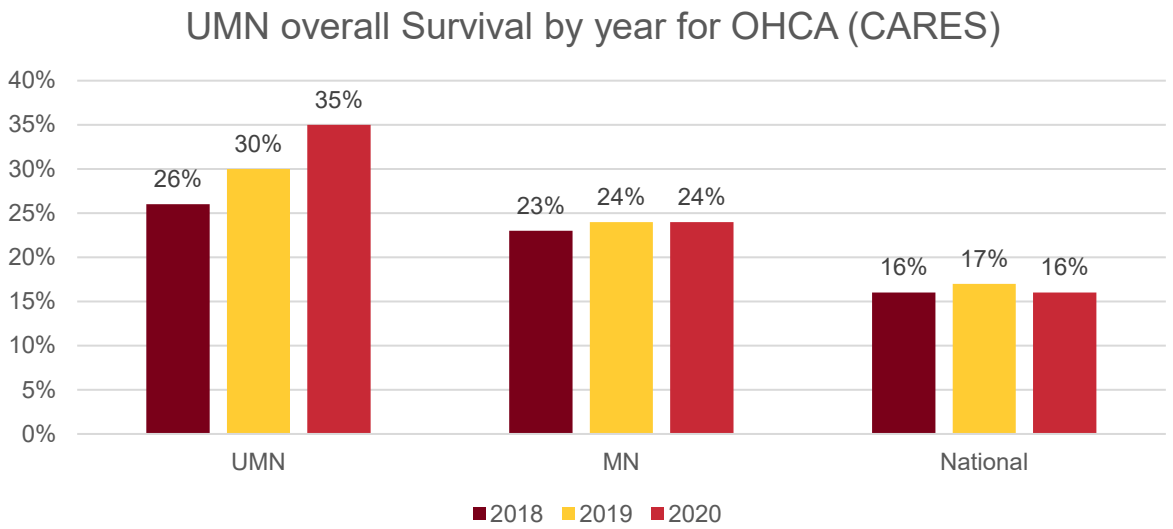
- Peripherally cannulated veno-arterial ECMO
- Provides oxygenation and CO2 removal
- Immediately 3-5L/min blood flow
- Independent of LV and RV function and rhythm

Know Your Data: Local Epidemiology of CA

2011-2015 Minnesota OHCA ages 18-75







Patient Selection: Balancing Act

Strict

Age ≤ 60 yrs
Shockable presenting rhythm
Witnessed arrest
Bystander CPR
Automated CPR in transport
Total CPR time < 60min

Lenient

Age ≤ 75 yrs
Any presenting rhythm
Any CPR
No limit to CPR duration

Surviv

Additional Criteria

Signs
- (
- |
- |

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

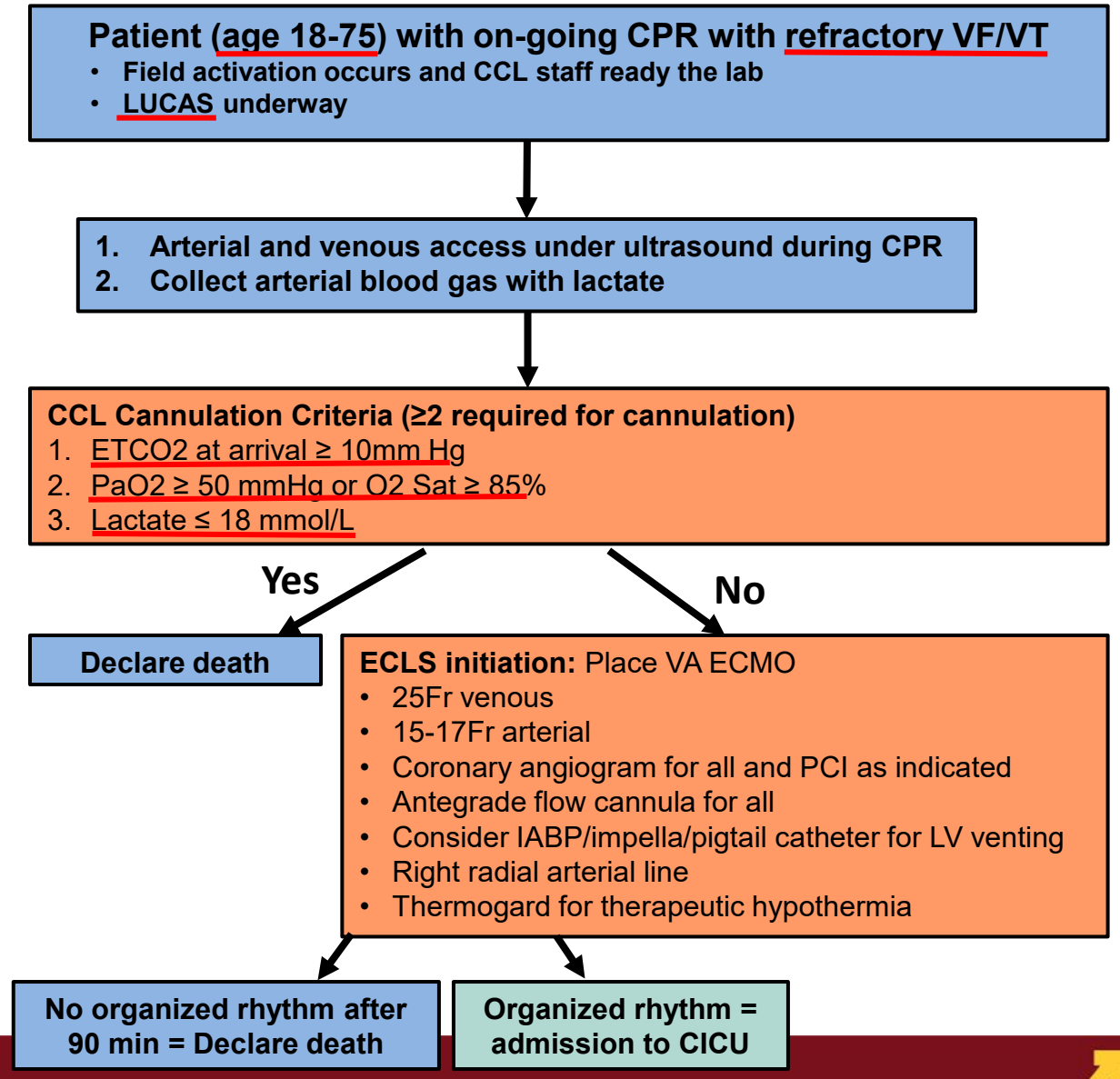
Field Criteria

Inclusion:

- Ages 18-75
- VT/VF as the presenting rhythm
- Refractory cardiac arrest with VT/VF after ≥ 3 EMS-delivered shocks and 300mg of amiodarone or refractory PEA/asystole
- LUCAS CPR
- Estimated transfer time from scene to CCL < 30 min

Exclusion:

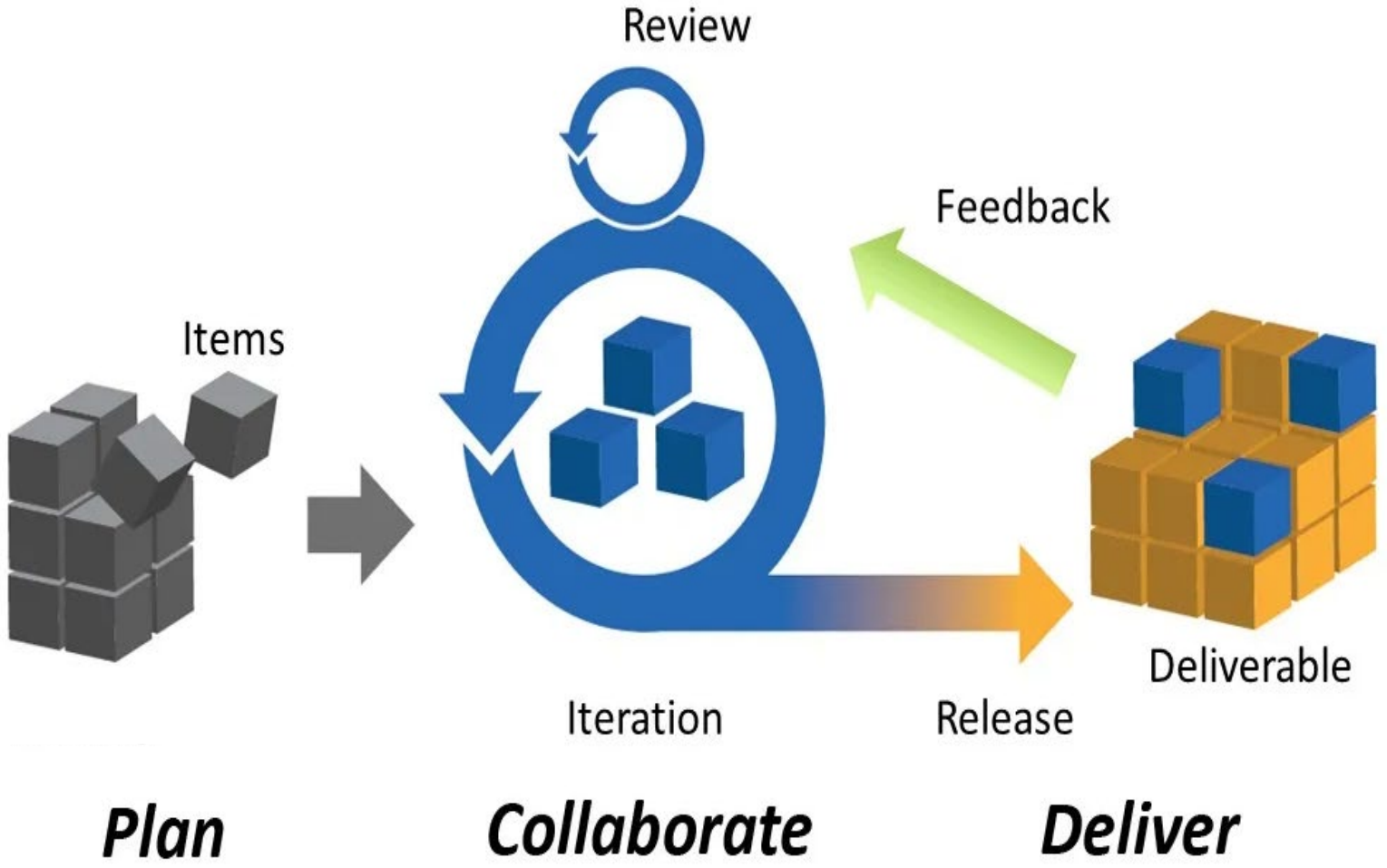
- DNR/DNI status or known terminal illness
- Nursing home residents
- Clear non-cardiac etiology



Yannopoulos, JAHA, 2016
Yannopoulos et al. The Lancet. 2020; 396: 1807-1816

Building a Protocol: System of Care

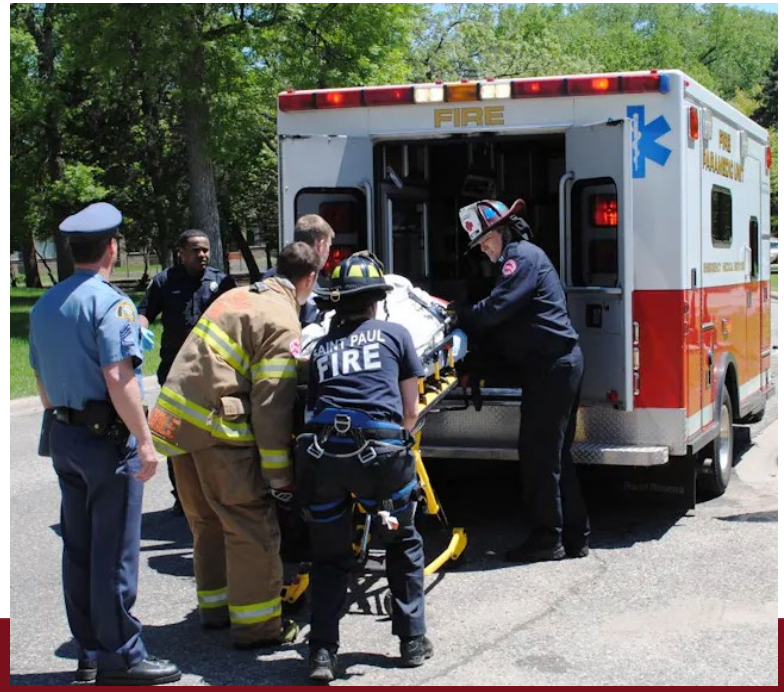
- Building a Protocol
  - Prehospital Care
  - Cannulation
  - Admission
  - ICU cares
  - Post Arrest Clinic



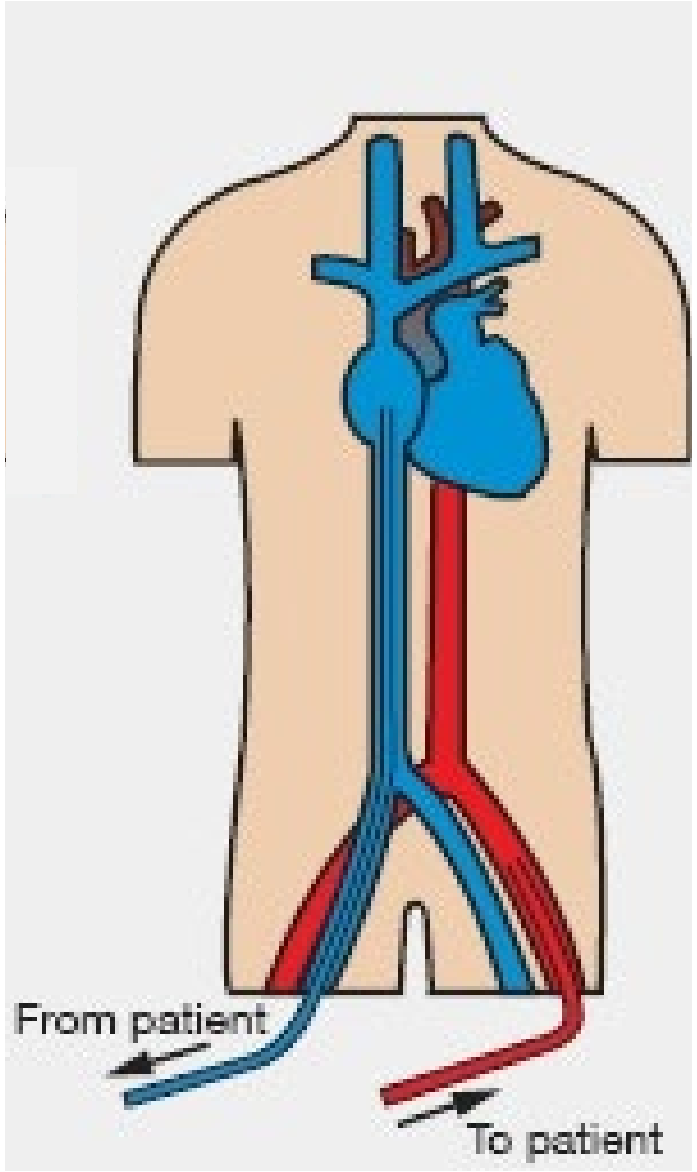
Prehospital Care

- Equipping with first responders
- Knowledge of regional EMS structure
- Patient identification
  - Eligibility and Contraindications
- Transport considerations
  - When to activate and when to move
  - Airway
  - CPR quality and ACLS (ex LUCAS 30:2, ITD, limit total epinephrine)
  - Any prehospital medications/study
  - Others protocols (ex remove clothes)

Continuous outreach

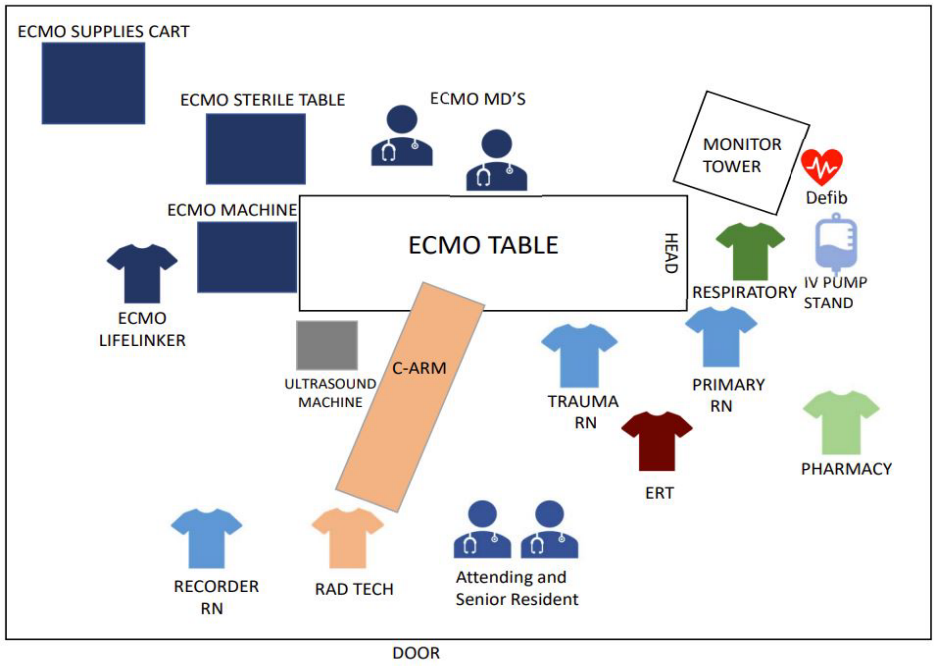


Cannulation : Safe, Effective, and Fast

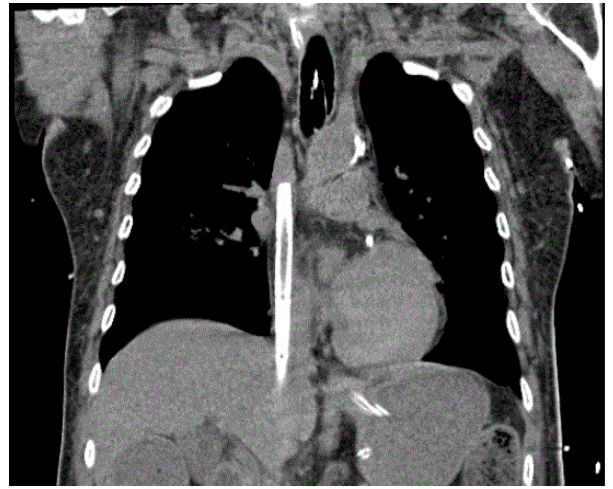


- Cannulation anatomic location(s)
- Standard Supplies, available and monitoring for expiration
- Roles of support staff during cannulation
- Temperature Management
- Minimize bleeding and limb ischemia
- Ultrasound and/or fluoroscopic guidance

UMN: Cannulation Strategy



- Prefer right groin
- Goal needle to ECMO time 4-5 min
- Ultrasound-guided access with fluoro confirmation
- Cannulas:
  - -15-17Fr arterial
  - -25Fr venous
- Venous cannula: SVC/ R atrium
- Arterial Cannula: as close to Ao as possible
- Temperature Control Device(s)
- 10K units heparin on cannulation and ACT goal 180-200 after



UMN strategy: Cath Lab Evaluation for Underlying Etiologies

Coronary Artery Disease in Patients With Out-of-Hospital Refractory Ventricular Fibrillation Cardiac Arrest

Demetris Yannopoulos, MD,[a] Jason A. Bartos, MD, PhD,[a] Ganesh Raveendran, MD,[a] Marc Conterato, MD,[b] Ralph J. Frascone, MD,[c] Alexander Trembley, BS,[b] Ranjit John, MD, PhD,[d] John Connett, PhD,[e] David G. Benditt, MD,[a] Keith G. Lurie, MD,[a] Robert F. Wilson, MD,[a] Tom P. Aufderheide, MD[f]

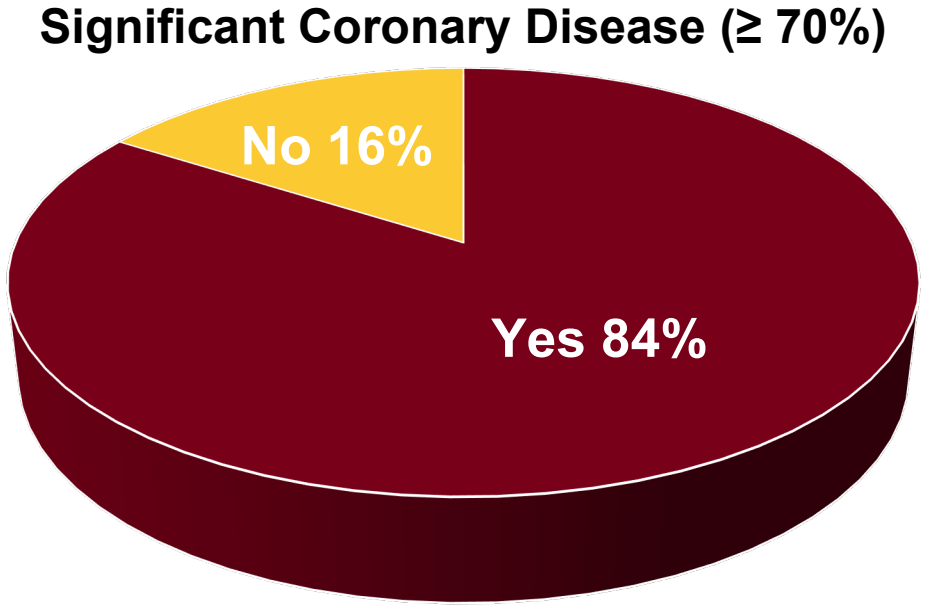
- Coronary angiogram and PCI
- Pulmonary angiogram and intervention

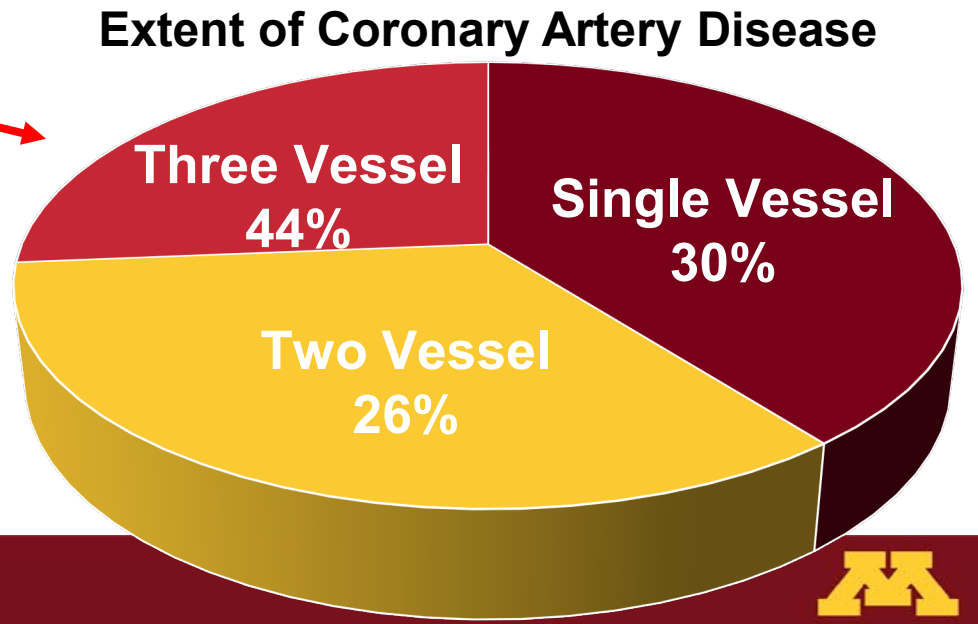
TABLE 2 Angiographic Findings and Procedural Outcomes

Angiographic findings	
Normal or clinically insignificant CAD (≤70% stenosis)	9/55 (16)
Clinically significant CAD (>70% stenosis)	46/55 (84)
Single-vessel disease	14/46 (30)
2-Vessel disease	12/46 (26)
3-Vessel disease	20/46 (44)
Disease location	
Left main	7/46 (15)
LAD	40/46 (87)
LCx	24/46 (52)
RCA	23/46 (50)
Prior coronary artery bypass graft	5/55 (9)
Chronic total occlusion present	18/55 (33)
Patients with acute thrombotic lesions	35/55 (64)
Patients with chronic disease	33/55 (60)
Acute on chronic lesion	23/55 (42)
SYNTAX score	29.4 ± 13.9
Procedural outcomes	
Patients with stent implanted	45/46 (98)
No. of stents/patient	2.7 ± 2.0
Intra-aortic balloon pump inserted	25/55 (45)

Values are n/N (%) or mean ± SD. Coronary angiography was performed in 55 patients, and percutaneous coronary intervention was performed in 46 patients.

CAD = coronary artery disease; LAD = left anterior descending artery; LCx = left circumflex artery; RCA = right coronary artery.





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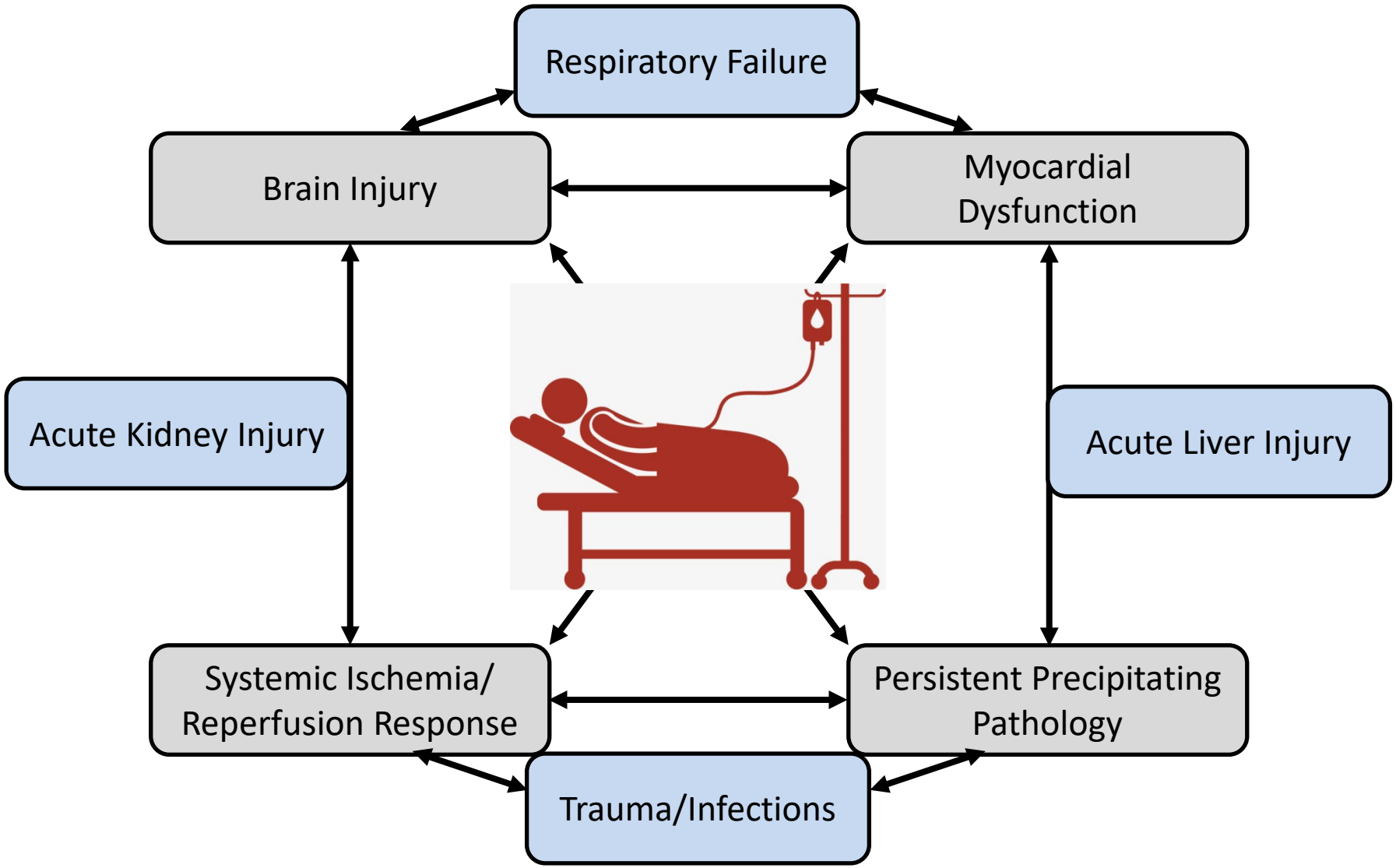
Adapted from Yannopoulos et al, JACC, 2017

Admission and ICU Cares



- Admission order sets
- Competent and available staff: nursing, perfusion, respiratory therapy, physicians etc
- Consulting services familiarity Neurocritical care, surgical teams, Palliative/Hospice, Renal, Transplant etc
- Care protocols TTM, transfusion goals, limb ischemia monitoring, etc
- Assessment for and decannulation protocols

Post Arrest Clinic

- Protocolized follow up
- Gap Management
  - Neuropsych evaluation
  - Psychiatric support of pt and family
  - Evaluation of cannulation site
  - Additional staged PCI assessment
  - Incidental findings follow up
  - Medication Reconciliation
  - GDMT and ICD evaluation
  - Survivor network, support groups
  - Addressing neuropathic pain, PT/OT and speech needs

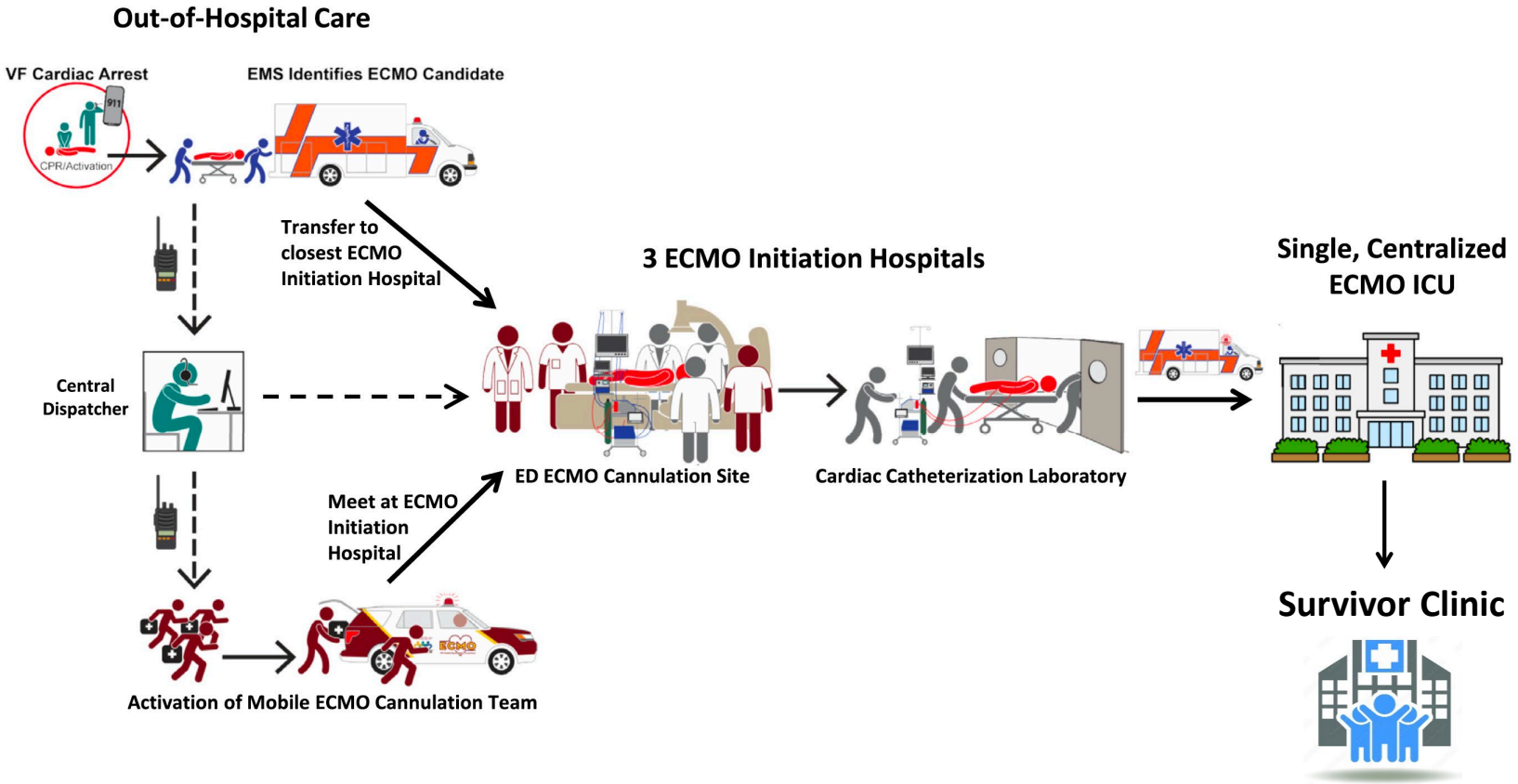




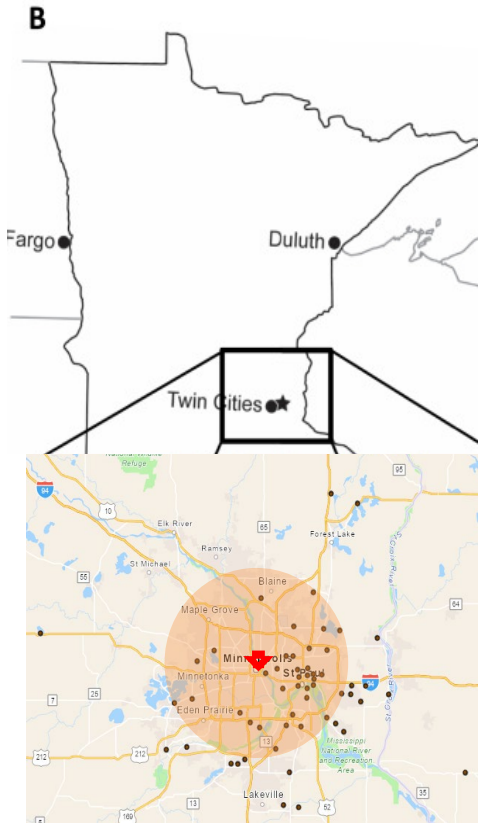


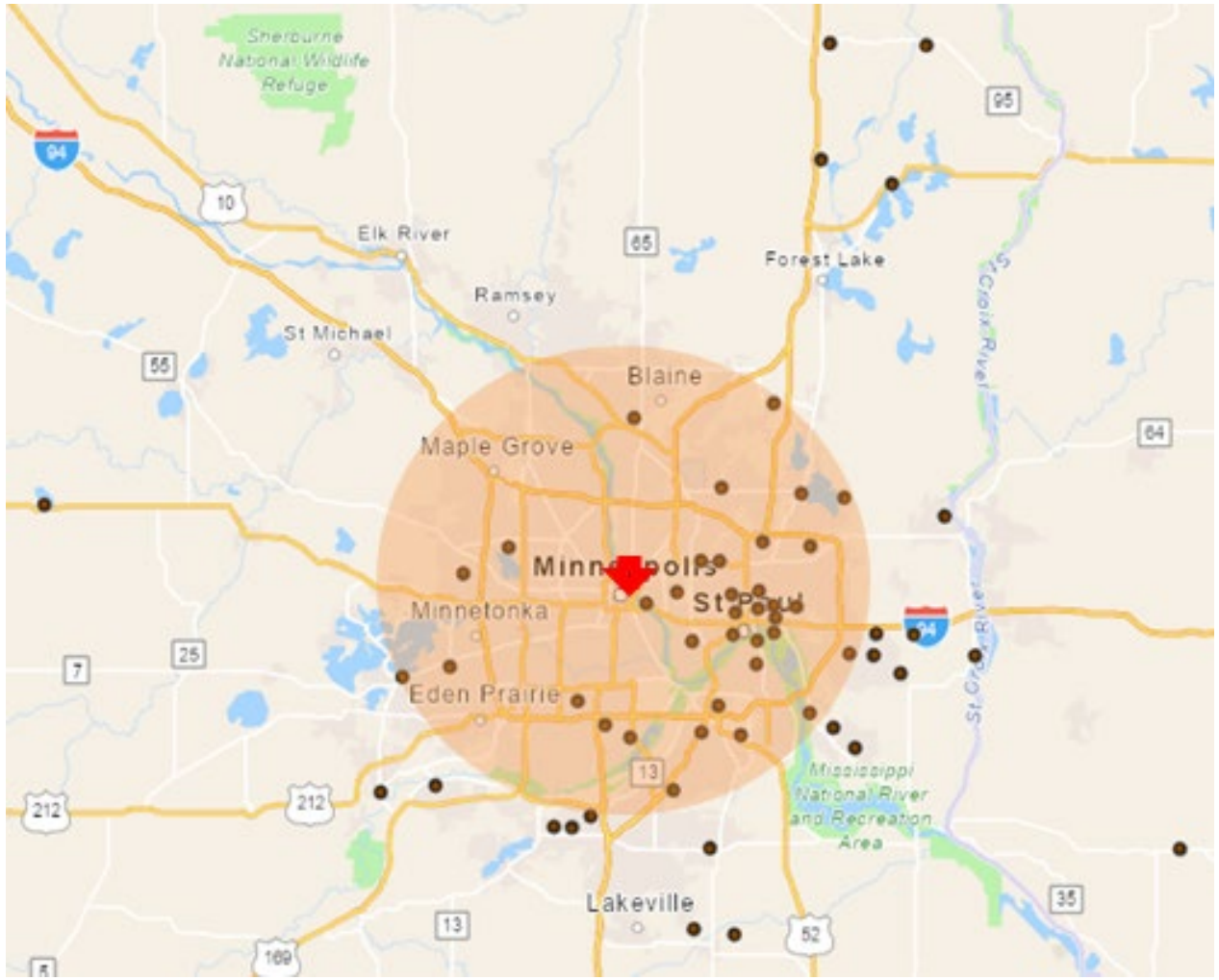
Maintenance

- Data Collection
  - Quality improvement
  - Program management
  - Research
- Order set revision
- Team training
- Team Morale
  - Marathon not a sprint
  - 40% live 60% don't
  - Address burnout for providers



Beginning Small and focused





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Bartos et al, EClinicalMedicine, 2020

Grow: Timeline of ECPR in the Twin Cities

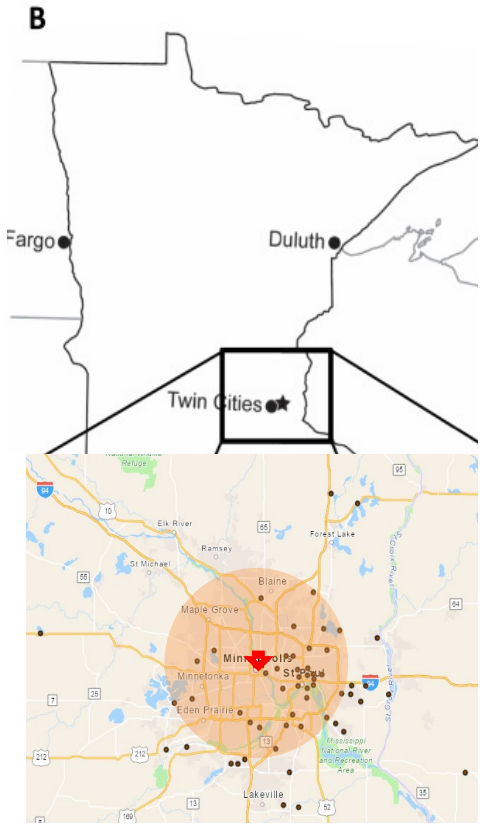
12/2015 UMMC ECPR

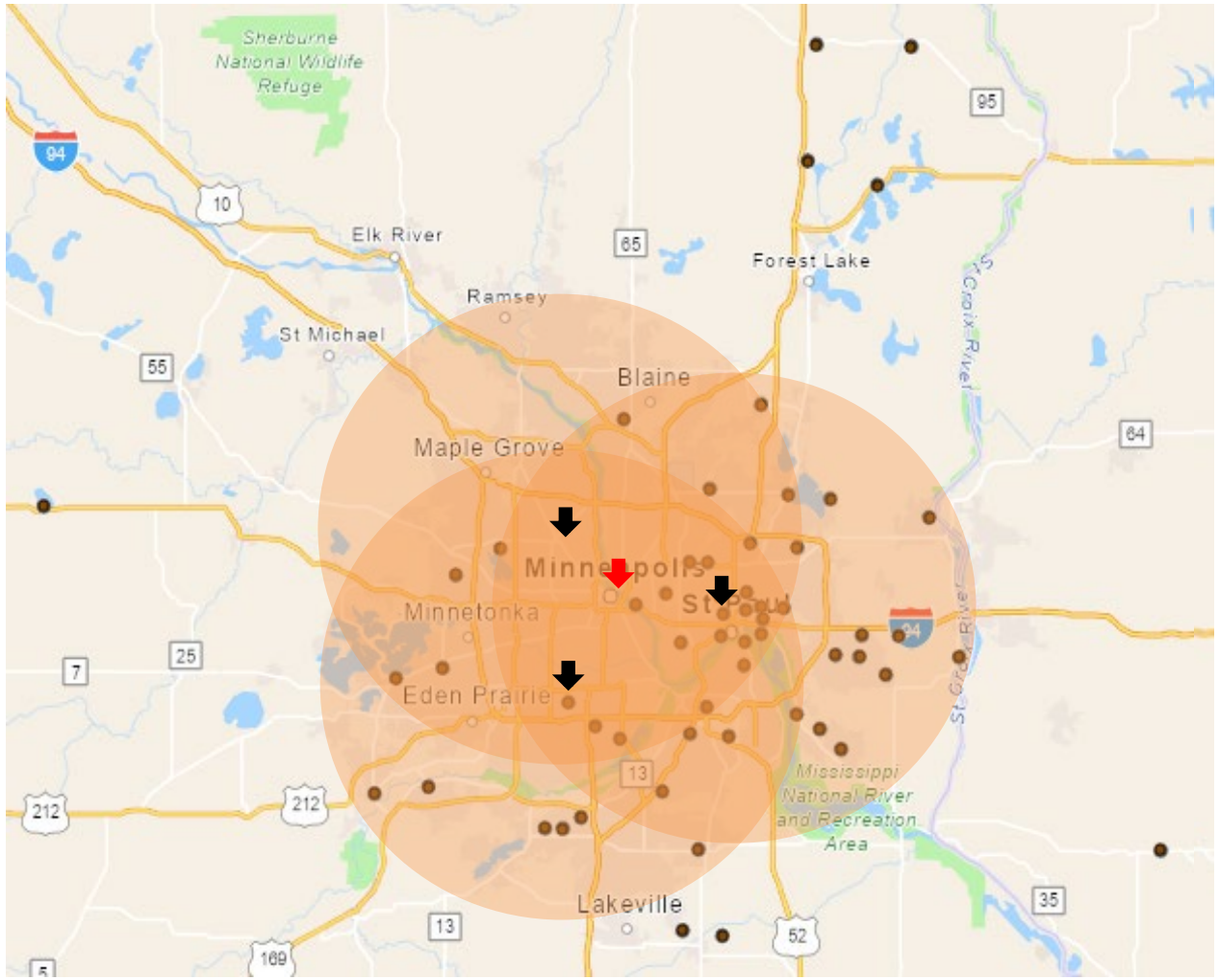
Cath lab
Cannulation

12/2019 Mobile ECMO at Southdale and Regions

ER
cannulation

Growth: Expanding Our Reach





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Bartos et al, EClinicalMedicine, 2020

Grow: Timeline of ECPR in the Twin Cities

12/2015 UMMC ECPR

Cath lab
Cannulation

12/2019 Mobile ECMO at select hospitals within the system

ER
cannulation

4/2020 – 5/2022
Intermittent COVID
Closures

5/2022
Reopen Mobile ECMO
at Southdale and
Regions

7/2022 Mobile ECMO Truck

Bringing the ECMO to the Patient can take many forms

Netherlands

Paris, France

Minneapolis, MN

Building and Maintaining an ECPR program: Summary

- Patient selection is key, time sensitive and dynamic
- ECPR is a **system of care**: all aspects of the system must be preplanned
- Program evaluation and re-evaluation is imperative
- Maintenance of a program is laborious and multifaceted (from stocking supplies to managing burnout)
- Start ‘small’ (build and refine a program) then expand

Thank You

elliotta@umn.edu

Recovery from ECPR

478 Patients Transported by EMS

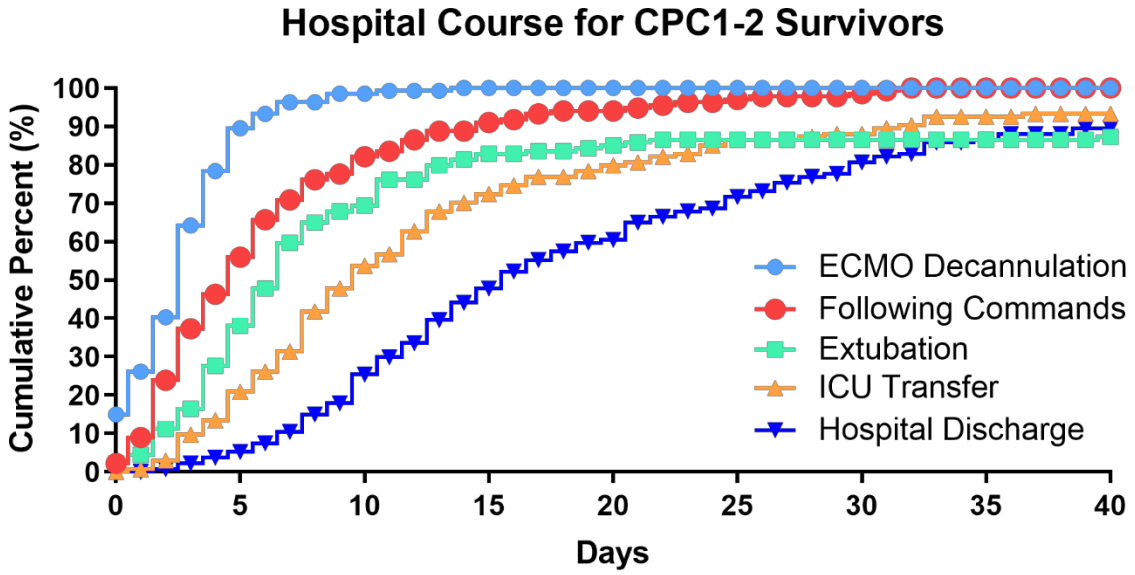
→ 101/478 (21%) Excluded Not Meeting Resuscitation Criteria

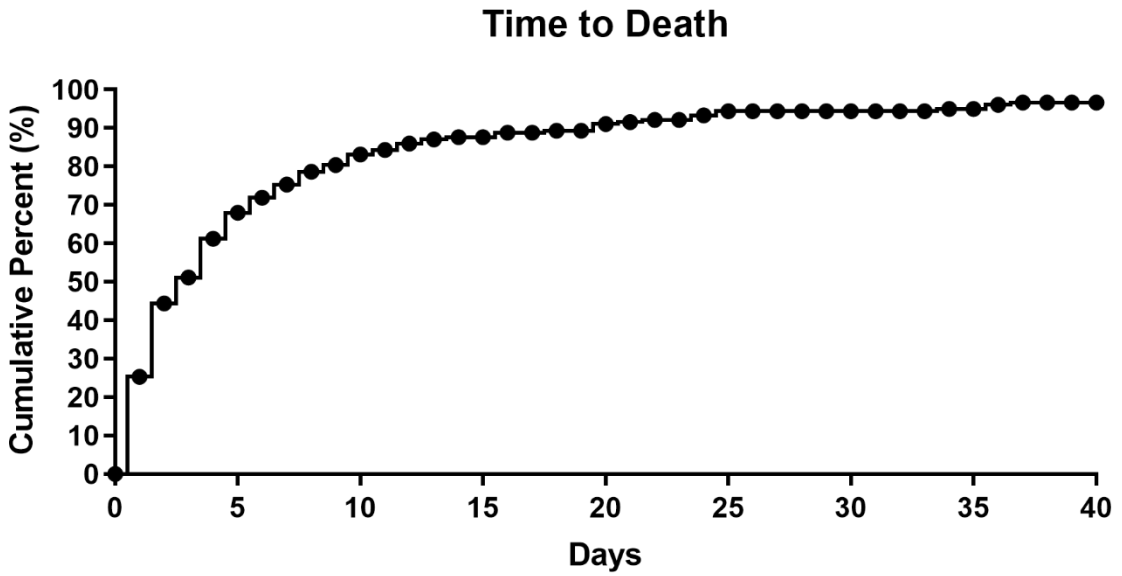
377/478 (79%) Patients Received Full CCL Treatment:

→ 18/478 (4%) Declared Dead with Failure to Achieve Sustained Organized Cardiac Rhythm after 90 Minutes

359/478 (75%) Patients Admitted to CICU

Survival to Discharge with CPC 1-2	
Patients Receiving Full Tx	141/377 (37%)
Patients Admitted to CICU	141/359 (39%)

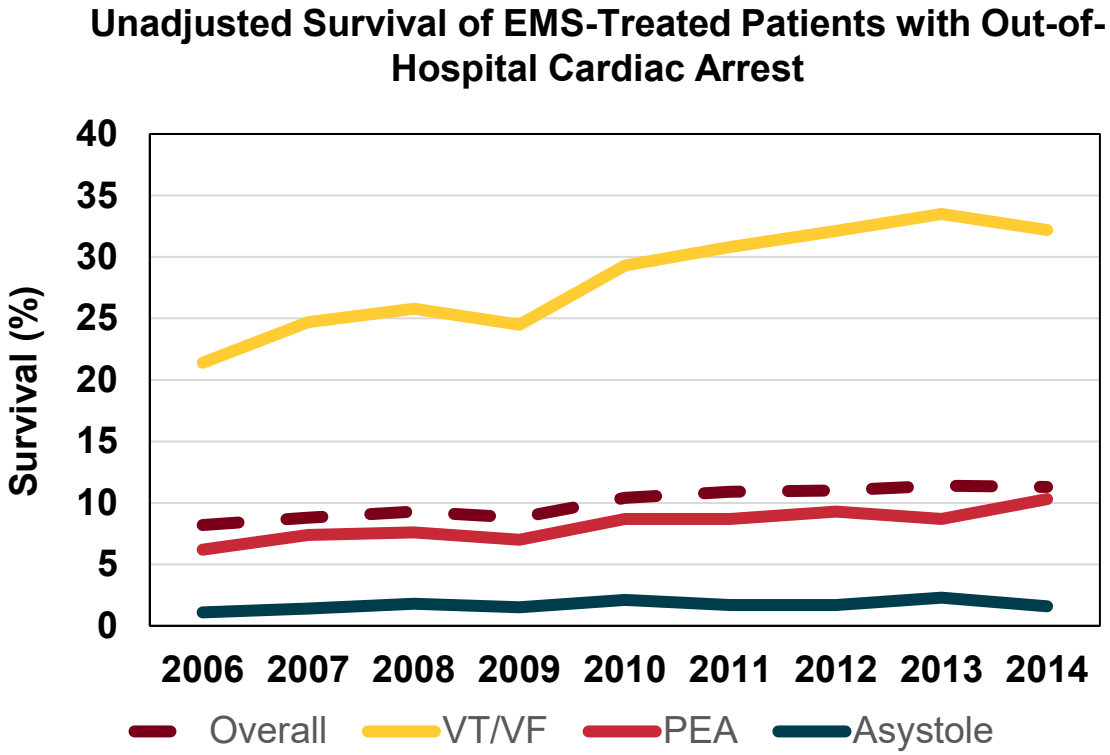




Bartos, unpublished data

Cardiac Arrest: Epidemiology

- 600,000 cardiac arrests in the US each year; 400,000 are OHCA
- 3rd leading cause of death in the US
- 80% of all survivors present with VT/VF
- Of all ACLS therapies, only early CPR and early defibrillation improve survival



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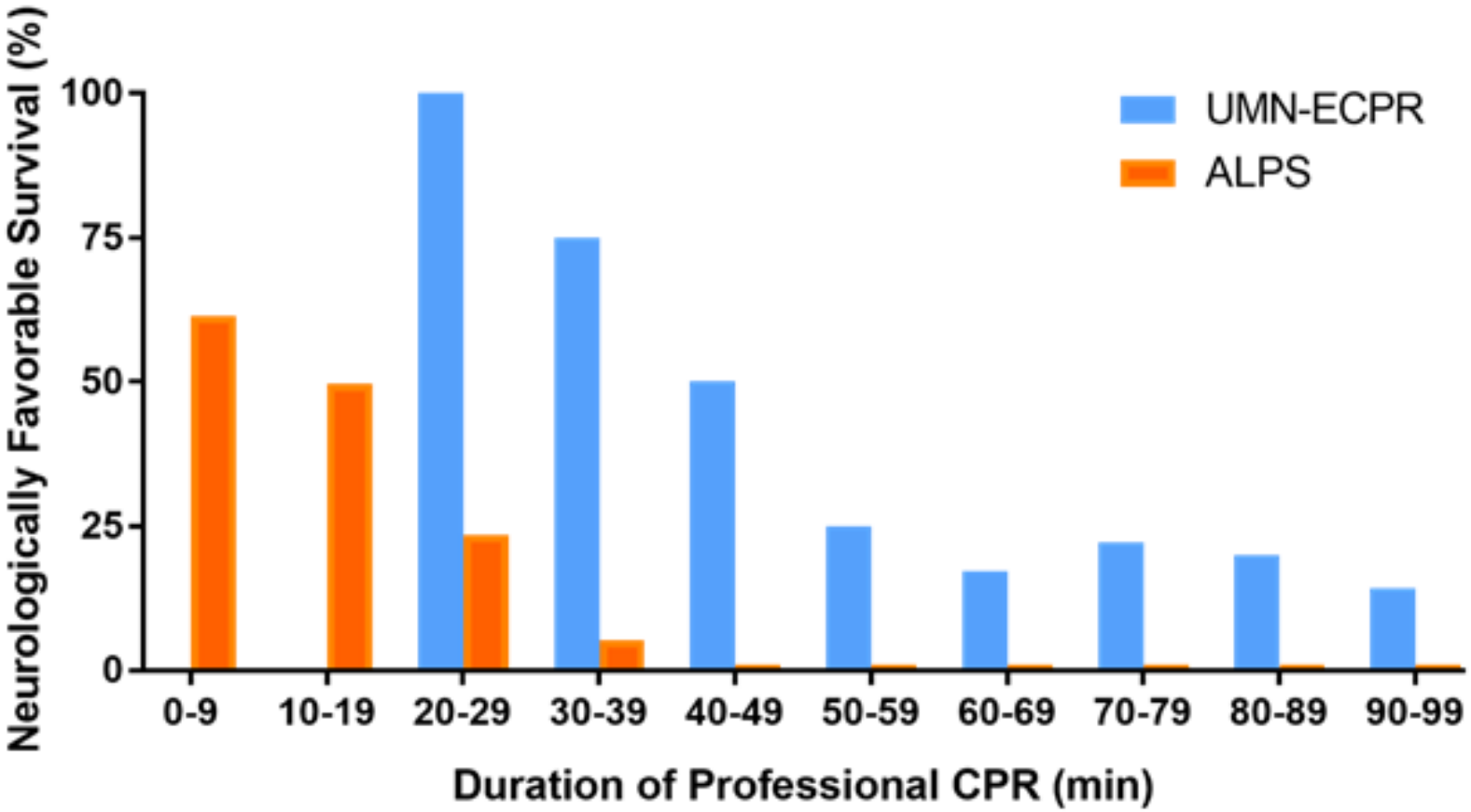
Adapted from Daya et al, Resuscitation, 2015
Zive et al, Resuscitation, 2018

Pre-hospital Optimization: Time is Critical

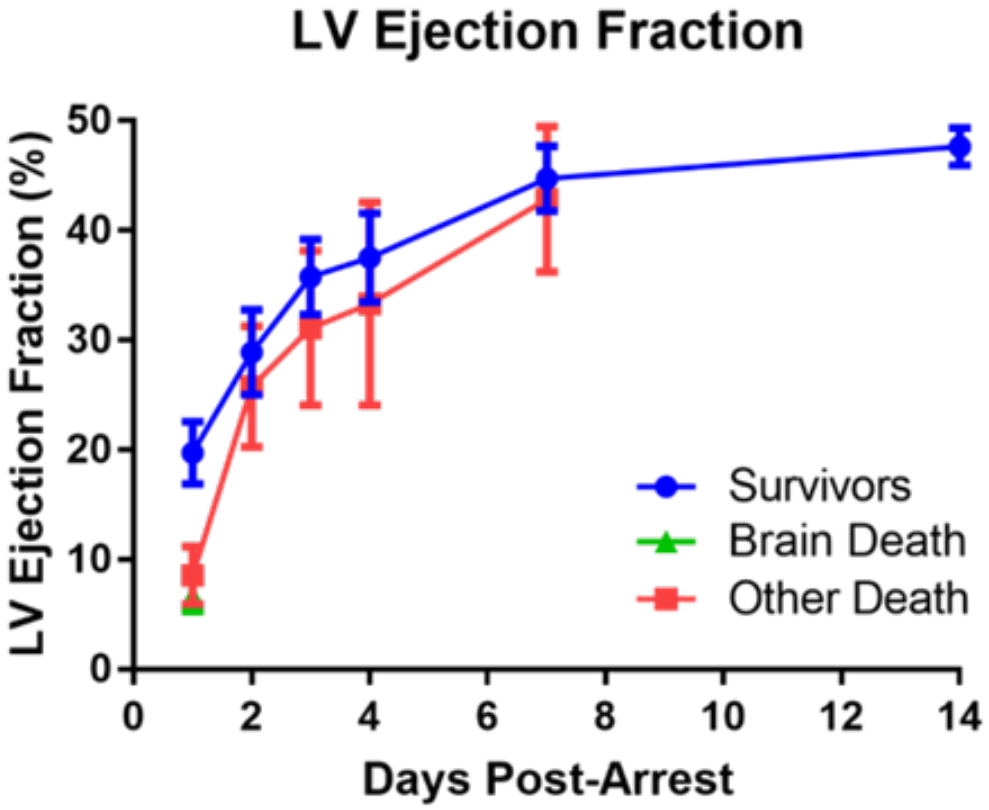


Patients at Risk

Time (min)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	Total
UMN-ECPR	0	0	8	12	20	36	35	27	15	7	160
ALPS	70	151	102	95	99	69	29	11	3	7	636

Bartos et al, Circulation, 2020

Neurologic Outcomes Drive Mortality
(Not the Heart)



Causes of Death (N=75)	N (%)
Recurrent VF Cardiac Arrest	8 (11%)
Brain Death	31 (41%)
Anoxic Brain Injury	21 (28%)
Acute Hemorrhagic Shock Due to Intra-Abdominal Bleeding	2 (2.7%)
Refractory Shock	6 (8%)
Bowel Infarction	3 (4%)
Chronic Aspiration and Severe Pneumonia	1 (1.3%)
Goals of Care	3 (4%)

Bartos et al, Resuscitation, 2018

Mobile ECMO Recovery Characteristics

Time to ECMO Decannulation, days	
Survivors	4.2 ± 1.5
Non-survivors	--
Time to Extubation, days	
Survivors	10.2 ± 7.5
Non-survivors	--
ICU Length of Stay, days	
Survivors	15.1 ± 8.1
Non-survivors	7.0 ± 13
Hospital Length of Stay, days	
Survivors	18.9 ± 8.6
Non-survivors	7.0 ± 13