

Shelter from the (Electrical) Storm: Treatment Strategies for Persistent VF

Marc Conterato, MD, FACEP

Office for the Medical Director, NMHAS

Joint Hennepin County EMS Services





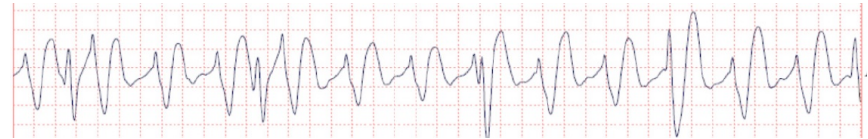
DISCLOSURE STATEMENT

- Board Member, MN Resuscitation Consortium
 - Images of any commercial devices or medications are for illustration purposes only. The inclusion of such images in this presentation does not imply endorsement of any specific device or company.

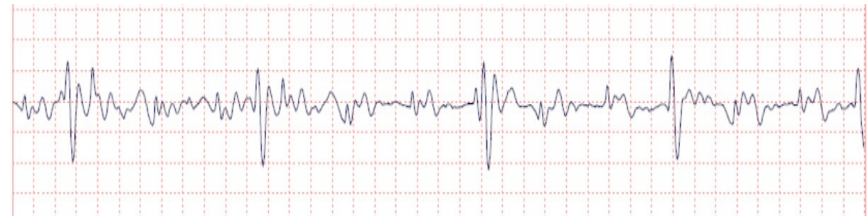
Defining the problem:

What is recurrent versus refractory VF (RVF)?

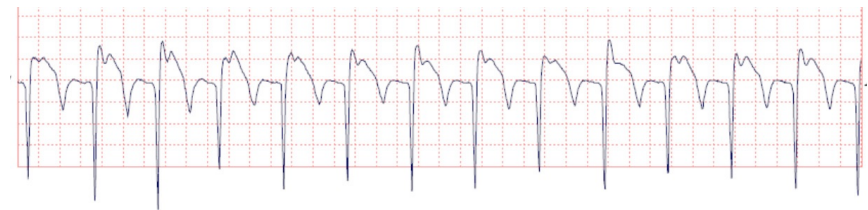
- Recurrent VF is a rhythm that terminates with cardioversion, but then recurs rapidly.
- As CPR is immediately restarted after defibrillation, this may be missed due to CPR artifact.
- This rhythm is amenable to treatment with chemical antidysrhythmics if recognized and treated appropriately.
- (Courtesy of ZOLL Corp.)



ECG with CPR artifact



SeeThruCPR filtered ECG



CPR Acceleration Signal

Defining the problem: What is recurrent versus refractory VF?

- **Refractory VF** is ventricular fibrillation that is thought to be “shock resistant” to standard cardioversion, due to ongoing myocardial ischemia fostering ongoing electrical instability.
- This is the concept of cardiac “Electrical Storm”, where the myocardium is extremely resistant to stabilization.



Current Pre-hospital treatments

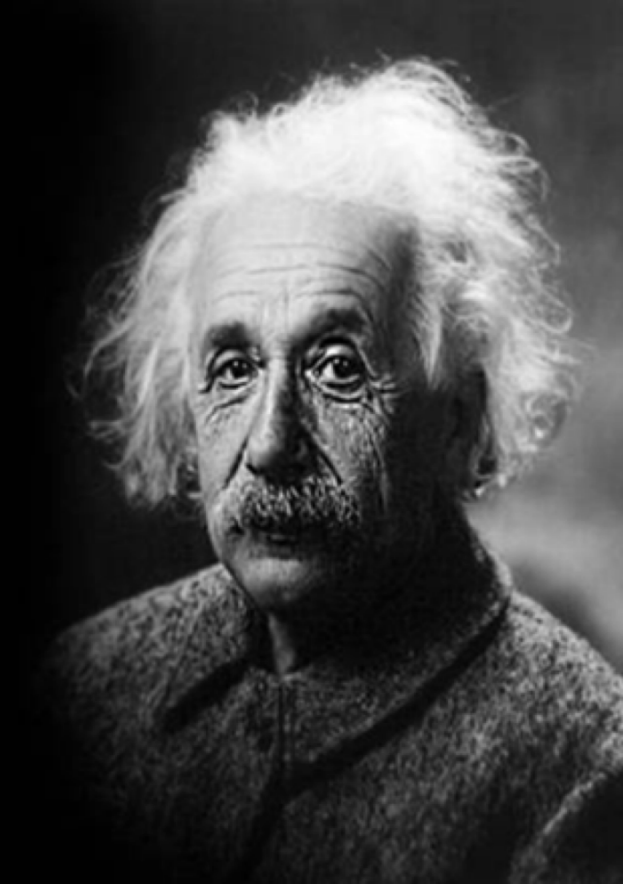
- Current treatments for VF/VT include defibrillation, epinephrine, and amiodarone. If unable to achieve ROSC, current treatments for VF/VT include defibrillation, epinephrine, and amiodarone.
- Amiodarone is used if unable to achieve ROSC.
- *RVF* is the current treatment for VF/VT.

"Insanity: doing the same thing over and over again and expecting different results."

Albert Einstein

Adult Cardiac Arrest

Shout for Help/Activate Emergency Response



CPR Quality

- Push hard (≥ 2 inches [5 cm]) and fast (≥ 100 /min) and allow complete chest recoil
- Minimize interruptions in compressions
- Avoid excessive ventilation
- Rotate compressor every 2 minutes
- If no advanced airway, 30:2 compression-ventilation ratio
- Quantitative waveform capnography
 - If $PETCO_2$ < 10 mm Hg, attempt to improve CPR quality
- Intra-arterial pressure
 - If relaxation phase (diastolic) pressure < 20 mm Hg, attempt to improve CPR quality

Return of Spontaneous Circulation (ROSC)

- Pulse and blood pressure
- Abrupt sustained increase in $PETCO_2$ (typically ≥ 40 mm Hg)
- Spontaneous arterial pressure waves with intra-arterial monitoring

Shock Energy

- **Biphasic:** Manufacturer recommendation (eg, initial dose of 120-200 J; if unknown, use maximum available. Second and subsequent doses should be equivalent, and higher doses may be considered.
- **Monophasic:** 360 J

Drug Therapy

- **Epinephrine IV/IO Dose:** 1 mg every 3-5 minutes
- **Vasopressin IV/IO Dose:** 40 units can replace first or second dose of epinephrine
- **Amiodarone IV/IO Dose:** First dose: 300 mg bolus. Second dose: 150 mg.

Advanced Airway

- Supraglottic advanced airway or endotracheal intubation
- Waveform capnography to confirm and monitor ET tube placement
- 8-10 breaths per minute with continuous chest compressions

Reversible Causes

- Hypovolemia
- Hypoxia
- Hydrogen ion (acidosis)
- Hypo-/hyperkalemia
- Hypothermia
- Tension pneumothorax
- Tamponade, cardiac
- Toxins
- Thrombosis, pulmonary
- Thrombosis, coronary

12

- If no signs of return of spontaneous circulation (ROSC), go to 10 or 11
- If ROSC, go to Post-Cardiac Arrest Care

Go to 5 or 7

© 2010 American Heart Association

Current Pre-hospital treatments

- **How about limiting or eliminating epinephrine?**
 - It has never been shown to improve survival to hospital discharge, and may actually decrease it.
 - Increases oxygen consumption.
 - Increases cerebral and myocardial vasoconstriction, so it impairs critical tissue oxygenation.
 - It is a dysrhythmic catecholamine, so it may actually make RVF harder to break.

Current Pre-hospital treatments

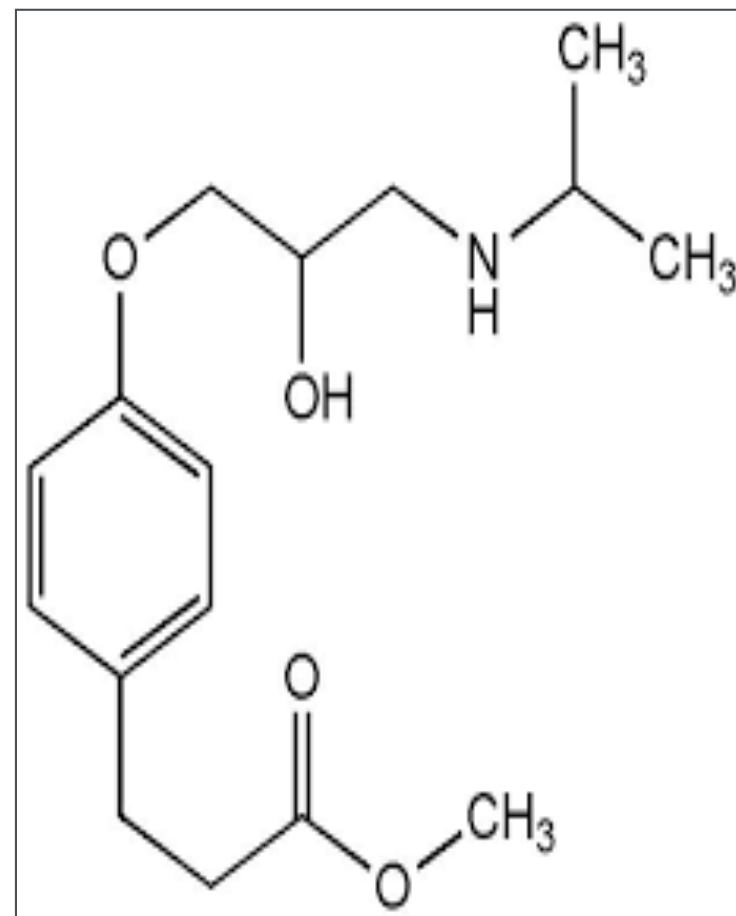
- How about limiting or eliminating epinephrine?
 - Preliminary research shows that lower doses of epinephrine does not impact outcomes.
 - There is a reasonable argument that to decrease the catecholamine surge associated with RVF, epinephrine should be reduced or eliminated in these patients.



Hospital treatment: Other medications for RVF

- **Esmolol**

- Esmolol decreases sympathetic tone and counteracts the catecholamine surge thought to occur during RVF arrest.
- This is the only drug in cardiac arrest management that has been shown to increase the rate of survival to hospital discharge **with** favorable neurologic outcomes.



Hospital treatment: Other medications for RVF

- **Esmolol**

- Blocks beta-adrenergic receptors in the myocardium, thereby blocking the beta effects of the high concentrations of catecholamines.
- This allows RVF to be more responsive to cardioversion.



Hospital treatment: Other medications for RVF

- **INTRA-LIPID EMULSION THERAPY**
 - Recent research has shown that intra-lipids appear to open a different calcium channel into the myocardial conduction cells.
 - This allows the generation of ATP (energy) that can stimulate cardiac conduction and contractility.



Hospital treatment: PCI with automated CPR

- Cardiac catheterization with ongoing automated CPR has been described multiple times in the medical literature.
- It requires well trained staff, rapid transport directly to the CCL, and interventionalists adept at the intricacies of the procedure.



Pre-hospital and hospital treatment: Dual/Double Sequence Defibrillation (DSD)

- This mode of treatment has been around for over thirty years, and has been used mainly by EP cardiologists.
- It is based on the concept that very high doses of energy are needed when RVF is unresponsive to maximum standard defibrillations.
- DSD relies on the current delivered to the patient, and the vector that it goes through in order to maximally capture the fibrillating myocardium.
- In order to successfully defibrillate, ~90% of the myocardium must be depolarized with greater than 14A of current.

Pre-hospital and hospital treatment: Dual/Double Sequence Defibrillation (DSD)

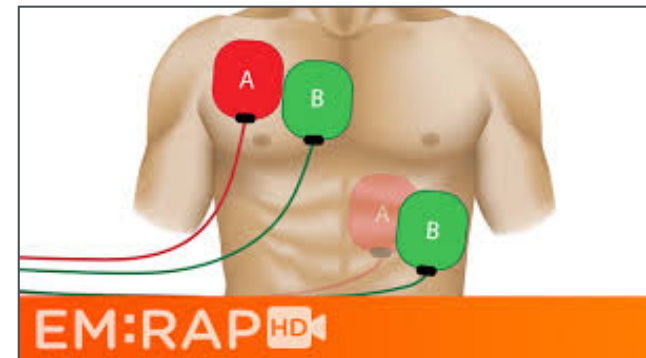
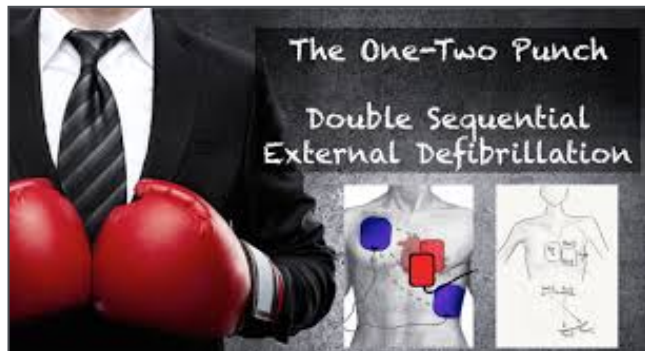
- Current (A)=Energy(J)/Impedance(ohms); with impedance being a function directly related to the patient. The higher the impedance, the less current delivered.
- All current defibrillators measure patient impedance, and increase the delivered energy to increase the current delivered.
- Impedance can be lowered by improving the contact between patient and defibrillator pads by:
 - Cleaning skin prior to pad placement.
 - Removing excess body hair or sweat.
 - Increasing pressure on the pads (gloved hands with dry towels).

Pre-hospital and hospital treatment: Dual/Double Sequence Defibrillation (DSD)

- Shock success depends on a number of factors:
 - Vector of the shock (pad placement) and resulting current shunting (current going to areas other than the heart)
 - Location of the heart (axis deviation or degree of ventricular enlargement placing the myocardium in a suboptimal shock location)
 - Shock strength or size (e.g., more current)
 - Shock waveform (e.g., longer duration)
- Two major determinants of energy (joules)
- The results from this experimental study show that even minor changes in pad placement (< 3 cm) can impact shock success.

Pre-hospital and hospital treatment: Dual/Double Sequence Defibrillation (DSD)

Case Series	Patients	Conversion	DSD Shocks	Survivors
Cabanas	10	7	2	0
Cortez	12	9	2	3
Ross	50	14	unknown	3
Merlin	7	5	2	3
Emmerson	45	17	2.5±2	2
Totals:	129	52	2	11 (8.5%)



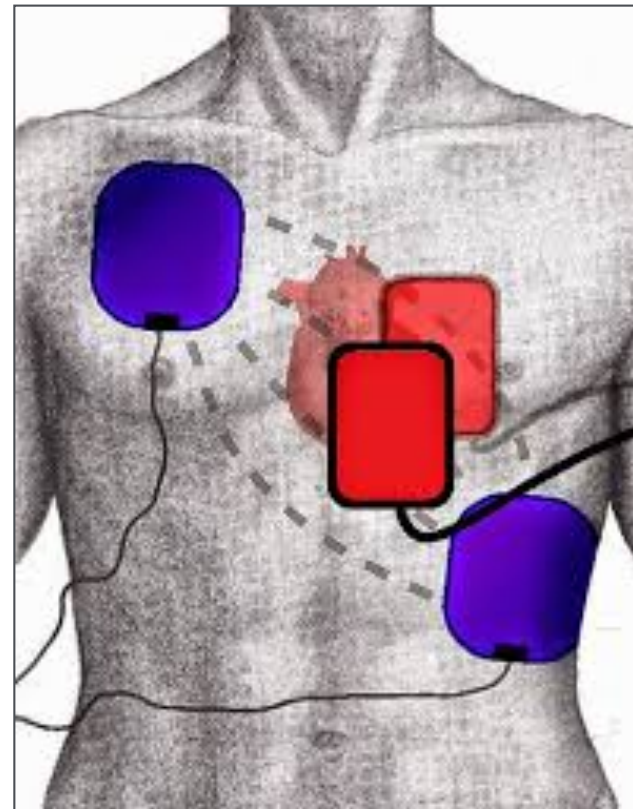
Pre-hospital and hospital treatment: Dual/Double Sequence Defibrillation (DSD)

- All the listed studies attempted DSD after 3-5 standard defibrillation attempts.
- All were given amiodarone prior to DSD.
- Highest CPC 1-2 discharge rate was 28.7% (Merlin).
- Several ongoing studies currently.



Pre-hospital and hospital treatment: Dual/Double Sequence Defibrillation (DSD)

- **Keys to maximizing early defibrillation success**
 - Initial proper angle of Anterior-Lateral pad placement.
 - Maximize pad contact to decrease electrical impedance.
 - If unsuccessful after three attempts, change to Anterior-Posterior position.
 - If still unsuccessful, **and** equipment is available, consider DSD.



The Refractory VF Patient: Take Home Points:

- The current AHA guidelines do not adequately delineate the treatment of this condition.
- Automated CPR has markedly extended the “window of opportunity” for these patients.
- Epinephrine is arrhythmogenic and can worsen RVF, as well as cause cerebral/myocardial ischemia.
 - Limit epinephrine to a total of 3 mg, **OR** eliminate its use altogether in these patients.

The Refractory VF Patient: Take Home Points:

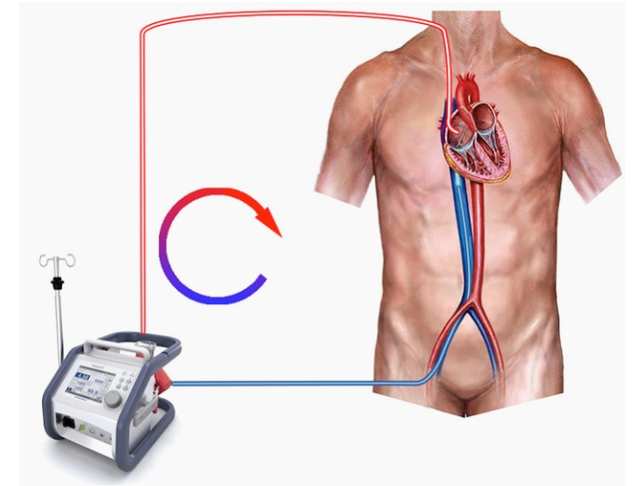
- Have a plan for the RVF patient, including early transport, appropriate destination, and an organized approach when they arrive.
 - Consider Esmolol for decreasing sympathetic tone and counteracting the catecholamine surge.
 - Consider 20% Lipid infusion therapy for restoring energy flow to the myocardial mitochondria and possible associated drug intoxications.
 - PCI with ongoing automated CPR is feasible and extends our “window of opportunity”, but requires skilled practitioners and a prepared CCL.
 - Consider what you need to do to make your cardioversions successful and what your protocols state about DSD use.



- **Special Thanks to:**
Alex L.Trembley, II; NRP, BSM
Paramedic, Quality Supervisor; NMHAS
- **The Minnesota Resuscitation Consortium**
-  **@ConteratoMarc**

2018 EMS STATE OF THE SCIENCE Gathering of Eagles

Trickle Me ECMO! *Starting an ECMO Program for Refractory Ventricular Fibrillation*



THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

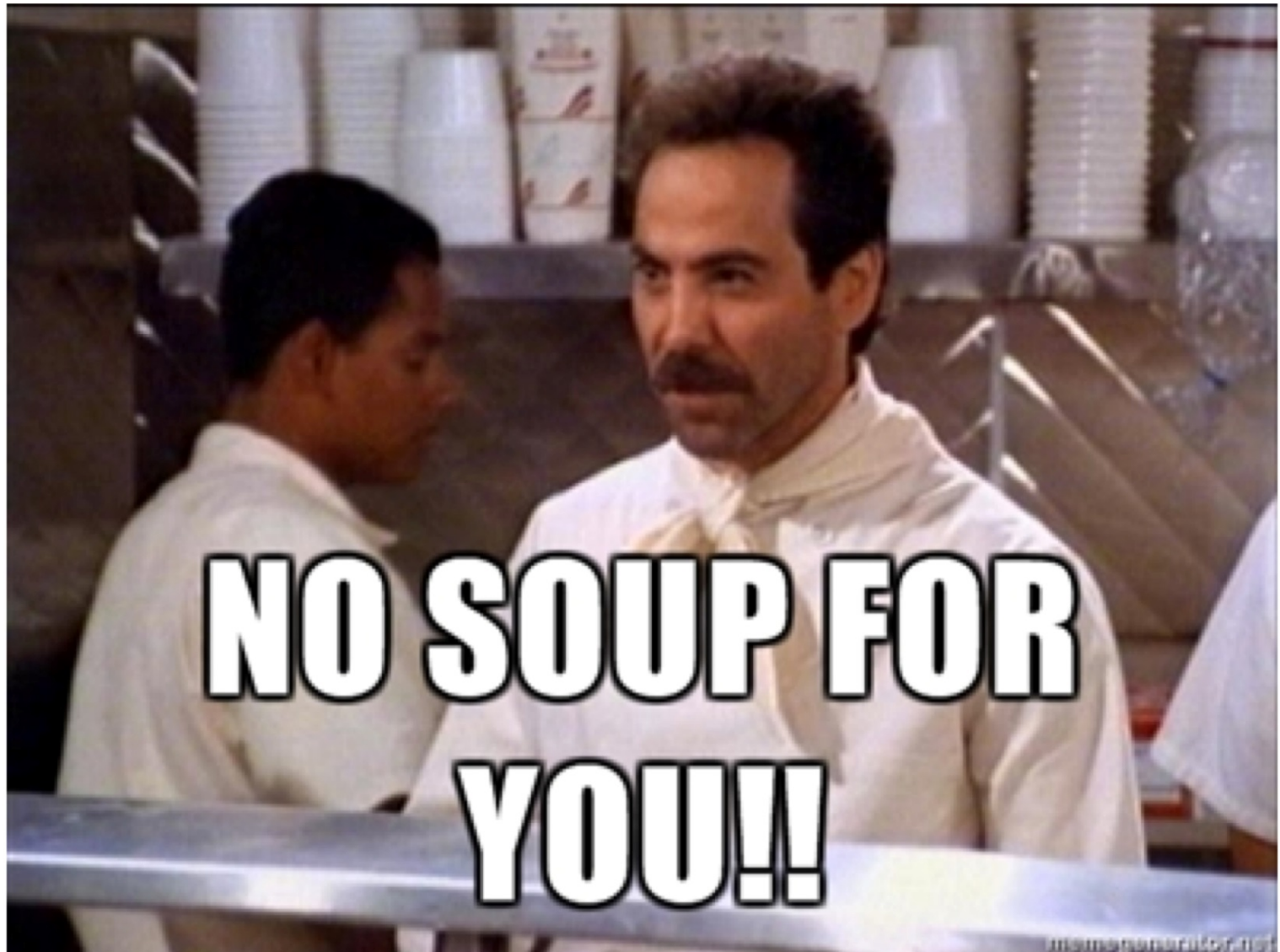
Dr. David P. Keseg M.D. FACEP

Medical Director Columbus Division of Fire

Adjunct Professor Ohio State University Wexner Medical Center



Disclosures



Can survival rates for refractory ventricular fibrillation be favorably impacted by selective transport to the cath lab to be put on ECMO in an urban fire-based EMS system?

Minnesota Resuscitation Consortium's Advanced Perfusion and Reperfusion Cardiac Life Support Strategy for Out-of-Hospital Refractory Ventricular Fibrillation

Demetris Yannopoulos, MD; Jason A. Bartos, MD, PhD; Cindy Martin, MD; Ganesh Raveendran, MD, MPH; Emil Missov, MD, PhD; Marc Conterato, MD; R. J. Frascone, MD; Alexander Trembley, BS; Kevin Sipprell, MD; Ranjit John, MD, PhD; Stephen George, MD, PhD; Kathleen Carlson, MD; Melissa E. Brunsvold, MD; Santiago Garcia, MD; Tom P. Aufderheide, MD

Background—In 2015, the Minnesota Resuscitation Consortium (MRC) implemented an advanced perfusion and reperfusion life support strategy designed to improve outcome for patients with out-of-hospital refractory ventricular fibrillation/ventricular tachycardia (VF/VT). We report the outcomes of the initial 3-month period of operations.

Methods and Results—Three emergency medical services systems serving the Minneapolis–St. Paul metro area participated in the protocol. Inclusion criteria included age 18 to 75 years, body habitus accommodating automated Lund University Cardiac Arrest System (LUCAS) cardiopulmonary resuscitation (CPR), and estimated transfer time from the scene to the cardiac catheterization laboratory of ≤ 30 minutes. Exclusion criteria included known terminal illness, Do Not Resuscitate/Do Not Intubate status, traumatic arrest, and significant bleeding. Refractory VF/VT arrest was defined as failure to achieve sustained return of spontaneous circulation after treatment with 3 direct current shocks and administration of 300 mg of intravenous/intraosseous amiodarone. Patients were transported to the University of Minnesota, where emergent advanced perfusion strategies (extracorporeal membrane oxygenation; ECMO), followed by coronary angiography and primary coronary intervention (PCI), were performed, when appropriate. Over the first 3 months of the protocol, 27 patients were transported with ongoing mechanical CPR. Of these, 18 patients met the inclusion and exclusion criteria. ECMO was placed in 83%. Seventy-eight percent of patients had significant coronary artery disease with a high degree of complexity and 67% received PCI. Seventy-eight percent of patients survived to hospital admission and 55% (10 of 18) survived to hospital discharge, with 50% (9 of 18) achieving good neurological function (cerebral performance categories 1 and 2). No significant ECMO-related complications were encountered.

Conclusions—The MRC refractory VF/VT protocol is feasible and led to a high functionally favorable survival rate with few complications. (*J Am Heart Assoc.* 2016;5:e003732 doi: 10.1161/JAHA.116.003732)

Key Words: Extra-corporeal membrane oxygenation • emergent extracorporeal membrane oxygenation • perfusion • refractory ventricular fibrillation/ventricular tachycardia • resuscitation • ventricular fibrillation

**HEY, I'VE GOT AN IDEA,
HEY...**

**WHERE ARE YOU GUYS GOING? CAN
I COME?**

HISTORY.COM

memegenerator.net

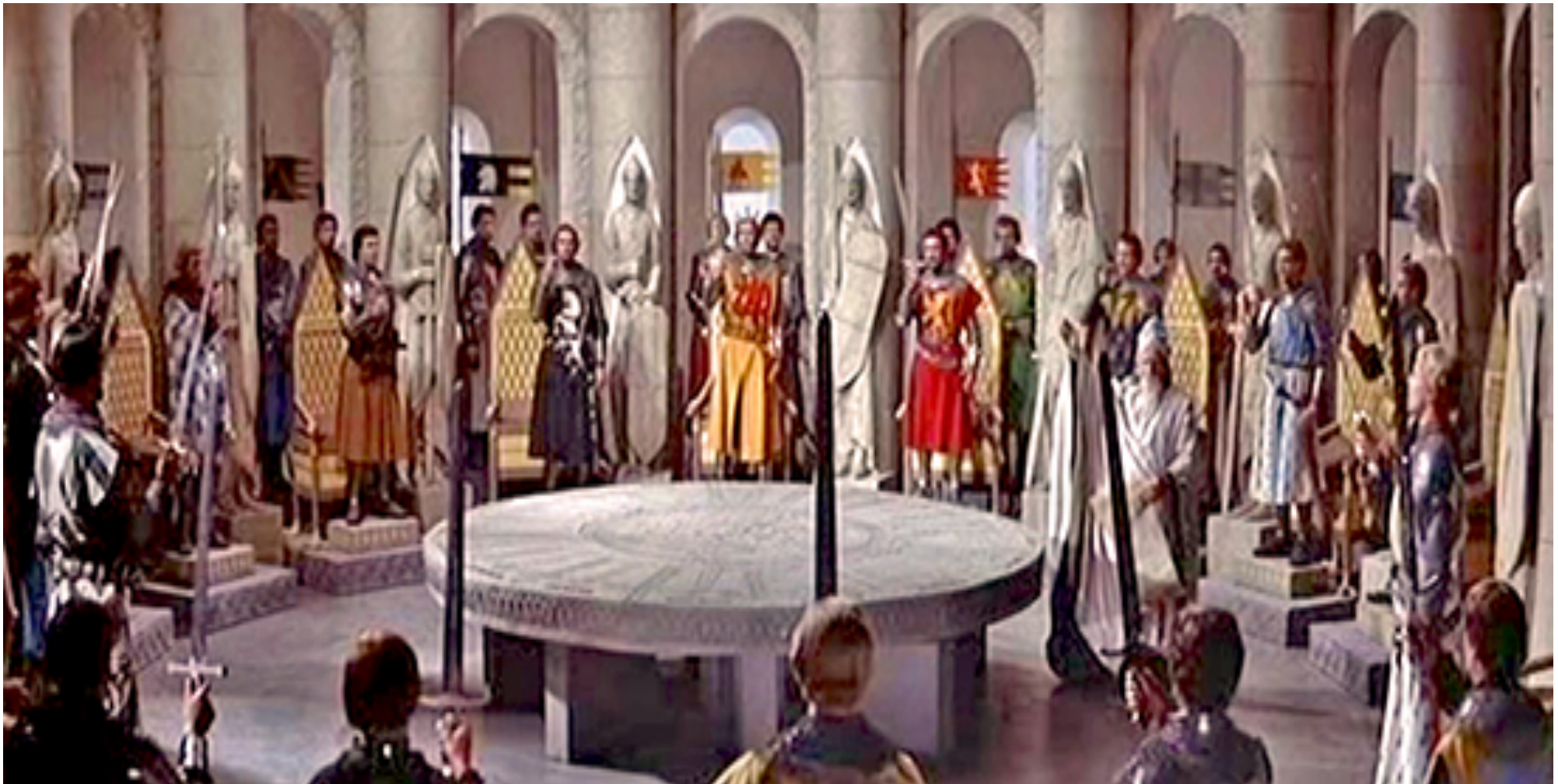


THE OHIO STATE UNIVERSITY

WEXNER MEDICAL CENTER



The Council of Cardiology and ECMO



GOOD
THINGS
TAKE
time







Tuesday, July 18th
0730 am

At the request of the Columbus Fire Department, we have been asked to participate in a dry run for the ECPR initiative. They will be videotaping this dry run for use as an education tool for their EMS units. This will give us the opportunity to run through our processes as well, and to test the paging group. Information re: the planned drill follows:

Tuesday July 18th, 0730: Start of Drill

- **EMS** will radio the Emergency Department (ED) as follows: "ECPR Alert, ETA 10 minutes, THIS IS A DRILL"
- **ED** will call hotline 6-8111 and inform as follows: "ECPR Alert, ETA 10 minutes, THIS IS A DRILL"
- **Transfer Center** will page: "ECPR Alert, ETA 10 minutes, THIS IS A DRILL"
- **ECPR team** (STEMI, OHS, Perfusion) will respond directly to the cardiac cath lab with necessary equipment and prepare to receive the patient. (Please be ready in CL prior to 0740 regardless of page status!)
- **Security** will respond to ED to lock down and hold an elevator for EMS arrival
- **Transfer Center** will send a second identical page which includes a mock MRN
- **At 0740, EMS will arrive** with CPR in progress with a Lucas device on mannequin, and will be met and escorted by security and **ED RN** directly to the cath lab
- EMS will give a **handoff report** on arrival to the ECPR team in cath lab
- The "patient" will be placed onto the cath lab table
- ECPR team will go through a mock of their **secondary screening** for inclusion/exclusion criteria, and will also briefly mock the beginning of the process to establish ECMO.
- **End of drill:** short debriefing on process with EMS will be conducted.

CFD Algorithm

Refractory VT/VF after 3 **unsuccessful** shocks **and patient is still in ventricular fibrillation**



ECPR Field Criteria

Inclusion Criteria

- ☐ 18-65yo
- ☐ Witness arrest
- ☐ Bystander CPR
- ☐ **Mechanical CPR device (Lucas or Autopulse) must be in place while transporting**

Exclusion Criteria

- ☐ DNR



CFD Ventricular Fibrillation protocol should be followed



Radio Call to OSU-ED stating "ECPR Alert"

OSU-ED notifies Transfer Center, ECLS team activated



Transport patient directly to cardiac cath lab





Columbus Fire Department

3639 Parsons Ave Columbus OH 43207 (614)645-7384

Incident Number **17141350**

Patient *** **

Complaint **CARDIAC ARREST**

Case Status **CLOSED**



INCIDENT



PATIENT



DATES/TIMES

Case # **{F3E42314-4D99-4621-B4E8-F439E6023CBD}**
Incident # **17141350**
Case Status **CLOSED**
Incident Type **CA - CARDIAC ARREST**
Urgency To Scn **EMERGENCY**
Address **WICKLOW RD/DEMOREST RD**
City, St., Zip **COLUMBUS, OH 43204**
Loc. Type **PARK**
Agency/Unit **CDF / Medic 12**
Shift/Veh. **1-Unit /**
Skillset **ALS**

Name (First/MI/Last) *** **
Gender **M**
DOB/Age *** **
Race/Lang. **Caucasian /**
Weight **230 lb**
SSN ***

Dispatched **09/15/2017 08:45:17**
Enroute **09/15/2017 08:46:14**
At Scene **09/15/2017 08:51:04**
At Patient **09/15/2017 08:47**
Depart Scene **09/15/2017 09:11:04**
At Destination **09/15/2017 09:25:19**
In Service **09/15/2017 10:29:37**

CREW

Role: Name (Qualification) Emp, Cert, Badge



Hx PRESENT

Subject Description/Details

Cause **UNKNOWN**
Complaint **CARDIORESP ARREST**
Symptom **CARDIAC: CARDIORESP ARREST**

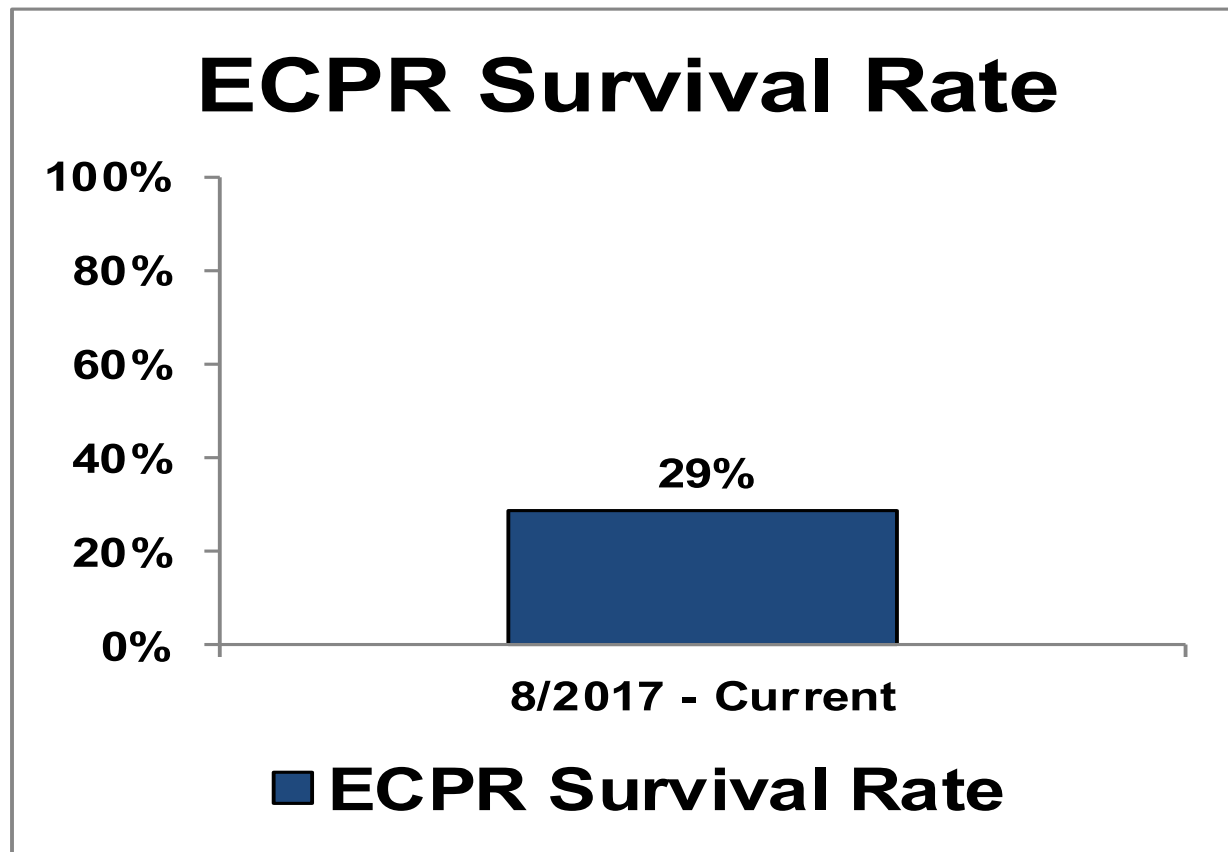
U/A 68 Y/O M LAYING ON BACK IN FULL ARREST W/ CPR BEING PERFORMED BY E12 CREW. E12 HAD OPA, O2, BVM, IV, X2 SHOCKS DELIVERED, AND 30/2 CPR AS NOTED PRIOR TO OUR ARRIVAL. LP15 ATTACHED AS NOTED. INITIAL RHYTHM WAS VFIB. DUAL SEQUENTIAL MANUAL DEFIB AS NOTED AND CONTINUED THROUGHOUT ARREST. EPI AS NOTED. EMS 15 ON SCENE PROVIDED LUCAS AS NOTED. INTUBATION AS NOTED. AMIO 300MG/IVP AS NOTED. EPI CONTINUED THROUGHOUT ARREST AS NOTED. AMIO 150/MG AS NOTED. PT HAD MULTIPLE RHYTHM CHANGES THROUGHOUT ARREST. PT PRESENTED W/ TORSADES, PULSELESS VTACH, VFIB, PEA, WIDE COMPLEX SINUS RHYTHM W/ PULSE. PT CONTINUED TO REVERT TO REFRACTORY VFIB, OSU WAS ALERTED TO ECPR PT. PT WAS MOVED TO COT AND LOADED TO M12 W/O INCIDENT. ET TUBE RECONFIRMED AND CPR CONTINUED. ACLS PROTOCOL CONTINUED. 2GM MAG AS NOTED. BICARB AS NOTED. 2ND IV INITIATED AS NOTED. PT WAS MONITORED DURING TRANSPORT W/ CONTINUED CPR W/O CHANGE. U/A TO OSU WE WERE DIRECTED TO CATH LAB. PT CARE AND REPORT WERE TRANSFERRED TO CATH LAB STAFF. M12 BIS, ALL TIMES ARE APPROXIMATE. NO PT HX OR INFORMATION WAS AVAILABLE OTHER THAN INFO FOUND ON PT ID.



Survival by Activations Since Inception

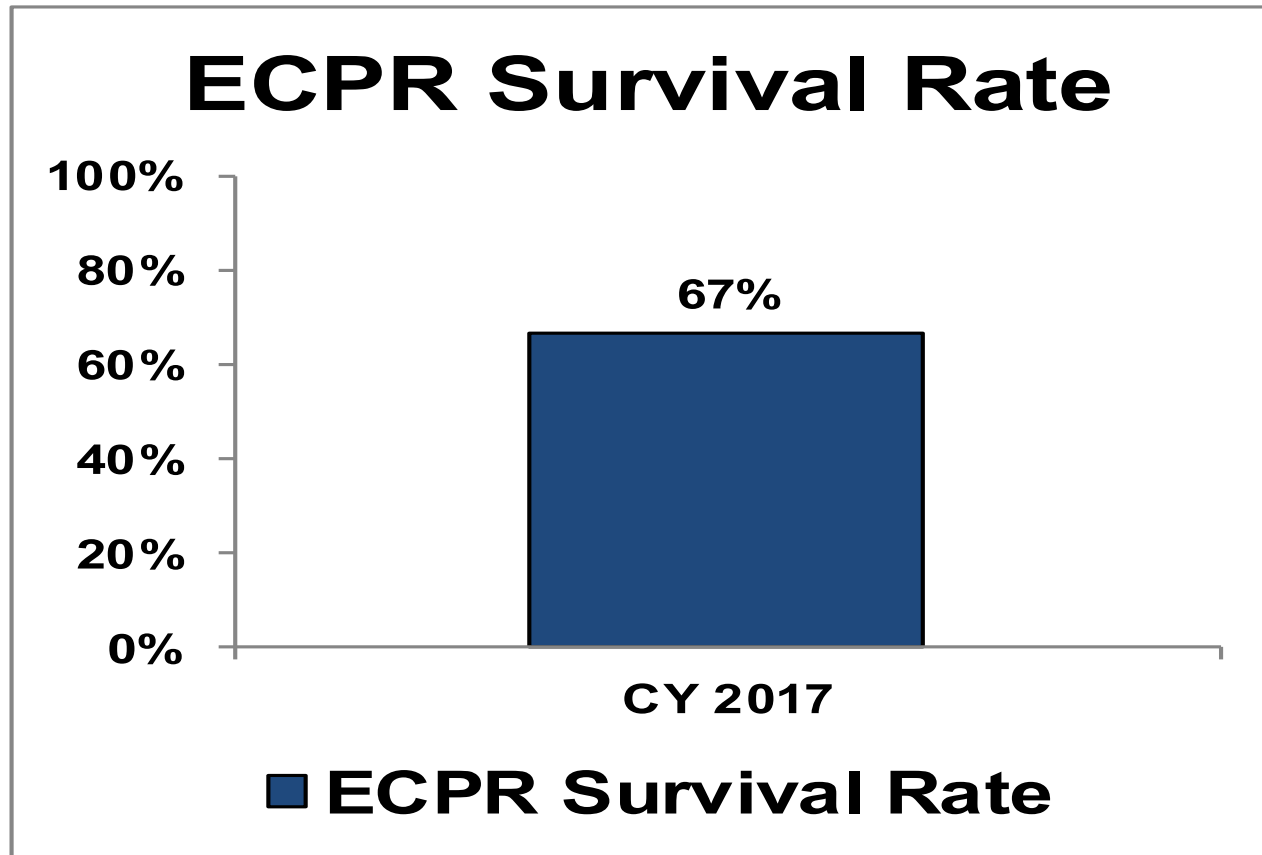
August 2017 - Current

Survival by Activations	8/2017 - Current
Activation Volume	7
Survival Volume	2
ECPR Survival Rate	29%



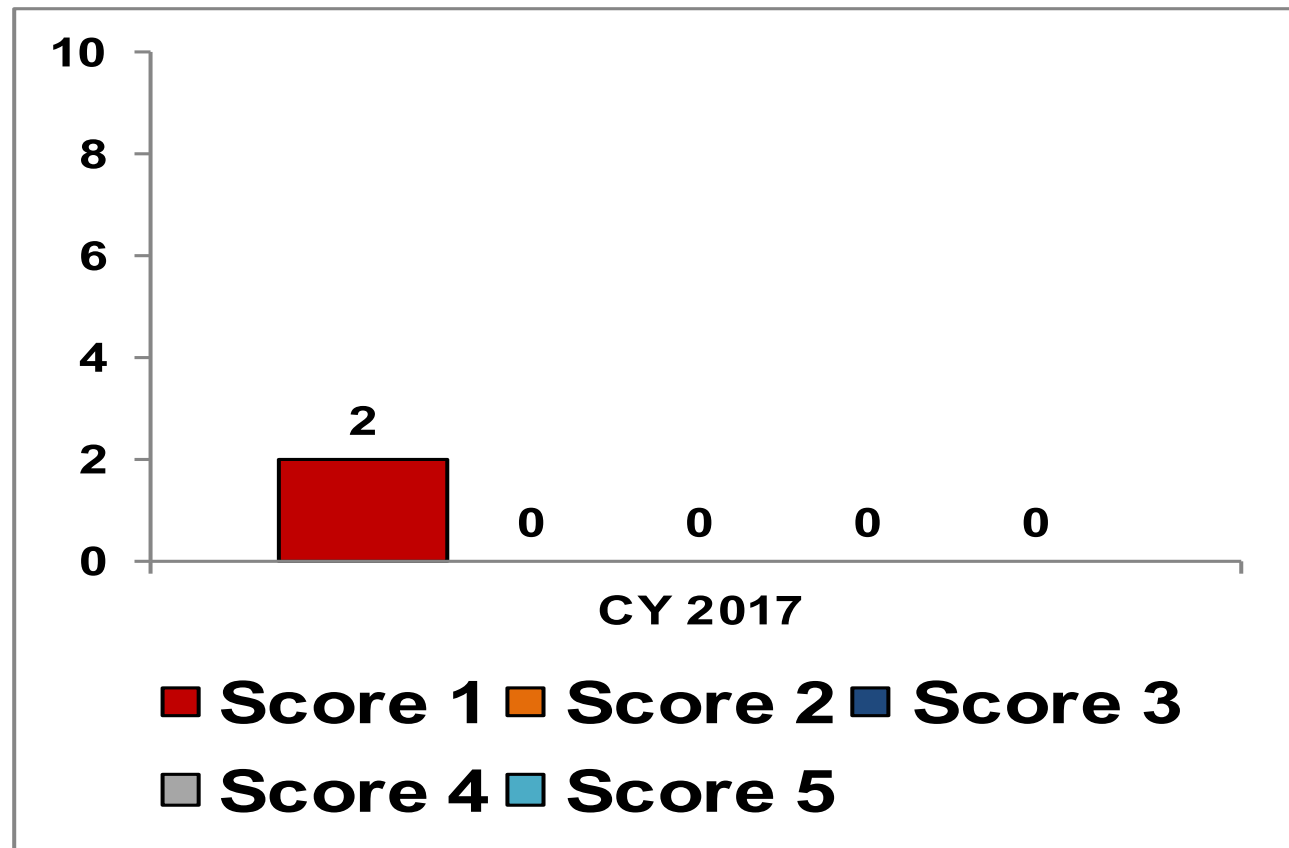
Survived ECLS by Reason for Support

Survived ECLS by Reason for Support	CY 2017
ECPR Volume	3
ECPR Survival	2
ECPR Survival Rate	67%



CPC Score for all Survivors

CPC Score: All Survivors	CY 2017
Score 1	2
Score 2	0
Score 3	0
Score 4	0
Score 5	0



Reasons for Decline

Reasons for Decline	CY 2017
Decline Pt. Volume	3
Metabolic Acidosis < 7.1	3
Lactate > 12	2

*Patients can have multiple reasons for decline

CFD Algorithm

Refractory VT/VF after 3 **unsuccessful** shocks **and**
patient is still in ventricular fibrillation



ECPR Field Criteria

Inclusion Criteria

- ☐ 18-65yo
- ☒ ~~Witness arrest~~
- ☒ ~~Bystander CPR~~
- ☐ **Mechanical CPR device (Lucas or Autopulse) must be in place while transporting**

Exclusion Criteria

- ☐ DNR



CFD Ventricular Fibrillation protocol should be followed



Radio Call to OSU-ED stating “ECPR Alert”

OSU-ED notifies Transfer Center, ECLS team activated



Transport patient directly to cardiac cath lab

New Program Criteria

ORIGINATING BUREAU: Training Bureau
EFFECTIVE DATE: March 1, 2018

The ECLS pilot program that started August 14th of 2017 has been very effective and has resulted in a 67% survival rate (2 out of 3 patients who were entered into the trial). After review of the last six months we have decided to continue the program and expand the parameters for entry. Here are the new ECPR program changes:

- 1) The age range will be increased to 75 years of age
- 2) There will not be requirements for bystander CPR
- 3) Cardiac arrest will not have to be witnessed.

The new ECPR Field Criteria will look like this:

- Patient is in refractory V-fib or pulseless v-tach after 3 consecutive defibrillation attempts.
- Patient age is between 18 – 75 years.
- Patient is on the LUCAS device.
- Patient does not have a DNR.

Annual Incidence of Death

Compiled by Sudden Cardiac Arrest Foundation

www.sca-aware.org

