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Progressive Systemwide Collaboration

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Photo courtesy Physio-Control.

Alameda County (Calif.) EMS coordinates with clinical stakeholders to improve cardiac arrest survival

Every year, more than 400,000 people suffer non-traumatic out-of-hospital cardiac arrest (OHCA) in the United States.[1-4] This represents the third leading cause of death in industrial nations and accounts for eight times as many deaths as caused

by car crashes.[5,6]

Previous decades have seen minimal improvement in survival outcomes,[1] but recently, many systems are improving survival rates among OHCA patients by using a systems-based approach.[7-12]

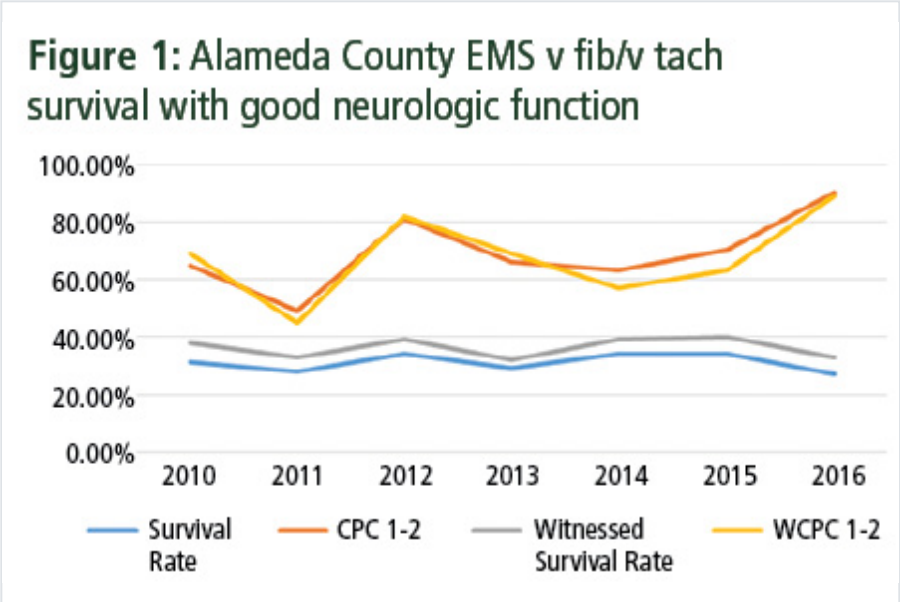
Many successful EMS systems have adopted a number of changes to improve outcomes.[13-16] Alameda County (ALCO) EMS has made a number of sequential changes over the last decade to improve OHCA care. This article addresses those changes and the resulting improvement in cardiac arrest resuscitation.

The endorsed system of care for OHCA by ALCO EMS has been modeled after that of the decade-old and nationally recognized Take Heart America.[16]

All of the changes and system design are based upon recommended evidence-driven treatment strategies, techniques and devices that are consistent with the 2005, 2010 and 2015 American Heart Association (AHA) Guidelines.[17,18]

These have included measures to improve the rate of bystander CPR through CPR-7, a community outreach education program using seventh graders and those they train; use of dispatch-assisted CPR; and the implementation of PulsePoint, a method of crowdsourcing citizen CPR.

We've improved prehospital cardiac arrest treatments from 2005 to the present with annual training on pit-crew CPR, advanced airway placement with the availability of a supraglottic backup airway, intraosseous access and the use of mechanical chest compression devices. The training includes a renewed focus on high-quality CPR that emphasizes the correct compression rate and depth, minimal interruptions, full recoil of the chest wall, and proper use of the impedance threshold device (ITD), which was introduced systemwide in 2009 for both bag-valve mask ventilation as well as with any advanced airway.



In 2009, ALCO EMS started collecting all data elements (dispatch, EMS and hospital) from the Cardiac Arrest Registry to Enhance Survival (CARES) and we continue to work closely with our receiving hospitals to obtain patient outcomes.

After the third complete year of data collection in 2012, a marked increase was noted in both the return of spontaneous circulation (ROSC) and those discharged alive with a cerebral performance category (CPC) score of 1-2 (good neurologic function). Closer scrutiny and analysis of those data was published in *Prehospital Emergency Care* as an EMS systems quality improvement article.[19]

During the study period (2009-2012), patients with ROSC with coma received prehospital surface cooling and were transported to hospitals capable of therapeutic hypothermia, with transport times generally less than 10 minutes.

All receiving hospitals in the study area had surface cooling protocols that included patients with primary ventricular fibrillation (v fib) or ventricular tachycardia (v tach), and a few included primary non-shockable rhythms.

Prior to 2012, mechanical CPR devices were available on approximately 10% of our first responder engines, which are all ALS staffed and equipped. Beginning in 2012, all first responder paramedic engines were equipped with a LUCAS mechanical CPR device and responded to all cardiac arrests.

THE HYPOTHESIS

We hypothesized that the increased use of therapies in 2012 that focused on perfusion during CPR using mechanical adjuncts and protective post-resuscitation care with in-hospital therapeutic hypothermia would improve survival with good neurologic outcome (CPC score of 1 or 2) compared to the lesser use of such therapies in 2009-2011.

Statistical findings on final analysis suggested that multiple strategies for OHCA implemented in our community over time resulted in a significant increase in ROSC (from 29% to 34%) and a 76% relative increase in those patients surviving with good neurologic outcome. (See Figure 1.)

The subgroup that received mechanical CPR and hospital hypothermia had the greatest improvement with a survival rate of 24%. We also found that for those that experience OHCA and not achieving spontaneous circulation promptly following initial EMS effort, optimizing a therapy-specific system of care that focuses on enhanced circulation during CPR and cerebral recovery after ROSC improves survival with favorable neurologic outcome.

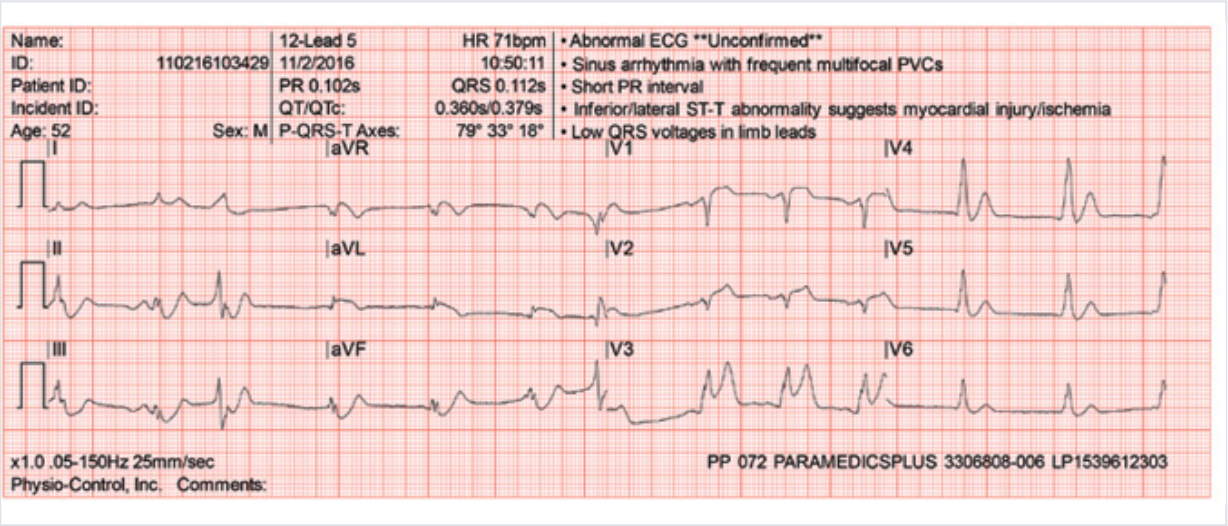
In 2013, ALCO EMS had a fairly mature ST-elevation myocardial infarction (STEMI) receiving center (SRC) program with six of 13 hospitals participating. Those same centers also had three years of therapeutic hypothermia experience managing comatose ROSC patients, hence leading those specialty SRCs to also be designated as cardiac arrest receiving centers (CARCs) for the system.

EMS field protocol directs patient transport to these CARCs if ROSC or a shockable cardiac rhythm is achieved at any time. This allows the patient to be taken to a facility that has the capability and experience in 24/7 emergent cardiac catheterization, targeted temperature management and metabolic support in the ICU, as well as electrophysiology and rehabilitation services.

ALCO EMS established a contractual agreement with all SRCs/CARCs in our system by a memorandum of understanding. This has fostered an instrumental collaboration with system stakeholders regarding ongoing review and revisions of prehospital protocols, as well as in-hospital order sets and treatment pathways based on current scientific evidence. These continuous professional relationships are pivotal to help ensure the continuity of care from dispatch to discharge.

ALCO EMS performance and survival data captured and reported by CARES demonstrates that in 2016, the system demonstrated its highest utilization of prehospital ITD and mechanical chest compression, as well as in-hospital percutaneous coronary intervention (PCI) and targeted temperature management.

Figure 2: 12-lead ECG of 52-year-old male displaying sinus arrhythmia with frequent multiform PVCs



Despite a slight decrease in overall survival (10%) and v fib/v tach survival (27%) from recent years past, the 2016 data reflects the highest overall ROSC rate for the system in the past decade (37%).

And from those patients admitted that survived to hospital discharge, the mass majority (75%) were neurologically intact and an even higher number (89%) for both witnessed and unwitnessed v fib/v tach. (See Figure 1.)

EXTRACORPOREAL CPR

At ALCO SRC/CARC meeting in the second quarter of 2016, shortly after the release of the 2015 AHA Guidelines, the topic of extracorporeal CPR (ECPR) using an extracorporeal membrane oxygenation (ECMO) device for patients experiencing refractory cardiopulmonary arrest (CPA) including OHCA was presented by EMS leadership.

This presentation was prompted by the case of a 15-year-old male that was a witnessed OHCA, received bystander CPR and was found in v fib by EMS on their arrival. Initial ACLS was delivered by EMS according to ALCO-prescribed prehospital protocol and the patient was transported to the nearest SRC/CARC in a shock refractory state.

On arrival at the receiving center, the patient received an additional 90 minutes of gallant and innovative resuscitative effort by the ED staff 120 minutes before the patient was pronounced dead.

With collaborative review of this case, it was clear that the SRC/CARC had no other care in our existing protocol to offer the patient or family by the end of the resuscitation. The only ECMO-capable hospital in Alameda County, currently and at the time of this case, was the local Children's Hospital. ECMO wasn't considered by the adult SRC/CARC at the time of resuscitation, especially for use in refractory

OHCA.

This particular SRC/CARC is very familiar with aggressive resuscitation strategies-two cardiac arrest patients had been taken to the catheterization lab with active mechanical CPR that same year, both of which survived with good neurologic function.

The 2015 AHA Guidelines state that there's insufficient evidence to recommend the routine use of ECPR in cardiac arrest; however, ECPR may be considered for select patients for whom the suspected etiology of the cardiac arrest is potentially reversible (e.g., patients experiencing refractory cardiopulmonary arrest/OHCA) during a limited period of mechanical cardiorespiratory support.

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.

Two recent studies each demonstrated survival-to-hospital discharge greater than 50% with good neurologic function for patients experiencing refractory in-hospital cardiac arrest (IHCA) as well as OHCA with the use of ECPR.[20,21]

FROM CONCEPT TO PRACTICE

In the fourth quarter of 2016, only a few months after first discussion with ALCO's SRC/CARC stakeholders regarding the concept of using mechanical CPR as a bridge to ECMO, one center had their first opportunity to utilize the ECMO option and they did with amazing success!

Oakland Fire Department and Paramedics Plus (Alameda County's largest contracted EMS ambulance transport provider) were dispatched code 3 for a 52-year-old male near fainting.

Upon ambulance arrival, the patient was found sitting on a curb with personnel from the Oakland Fire Department. He was alert and oriented to person, place, time and circumstances (A&Ox4).

The patient stated that four hours prior to EMS activation, he was involved in an argument with a neighbor and began having sudden, acute shortness of breath that brought on chest pain and nausea.

The patient rated his pain seven out of 10 and said he was unable to describe it. He also stated he had no cardiac history.

The patient's pulse was 62 and irregular, with a respiratory rate of 24 and irregular.

His blood pressure was 122/92 mmHg via automated cuff, SpO2 of 100% on room air. His skin was diaphoretic, lung signs normal and pupils were 3 mm and reactive. A 12-lead ECG revealed sinus arrhythmia with frequent multiform premature ventricular contractions (PVCs). (See Figure 2.)

The patient was emergently transported to Highland Hospital, which was advised of a possible STEMI.

During transport, the patient became lethargic and was unwilling to answer further assessment questions. His vital signs were reassessed throughout contact until he was handed over to the hospital's ED staff.

During a brief clinical re-evaluation on arrival in the ED, the patient was found to have a much lower blood pressure than expected. This warranted the administration of pharmacologic support prior to proceeding to the catheterization lab for emergent PCI.

Shortly after arrival in the catheterization lab, the patient went into cardiac arrest and was placed on the hospital's LUCAS mechanical chest compression device as resuscitative efforts were carried out.

At the time of this case, Highland Hospital didn't have the capability to perform ECMO, so they contacted the University of California, San Francisco (UCSF) Medical Center, who agreed to dispatch their ECMO team to initiate ECMO care and transfer the patient to UCSF. The patient was maintained on a LUCAS device in the catheterization lab while waiting for the ECMO team to arrive.

Once UCSF agreed to accept the patient and respond with their ECMO team and equipment, Highland Hospital's catheterization lab director knew that the lab needed to become an OR as well as an ICU until the patient was successfully on ECMO and en route to UCSF.

After the patient started to deteriorate, the ED was called to secure the patient's airway by intubation. Anesthesia was called in to manage oxygenation/ventilation as well the sedation of the patient during the resuscitation efforts.

An OR team came and prepared the catheterization lab for the surgical procedure of large bore arterial/venous cannulation for ECMO. An ICU physician and nurse came to the lab to monitor and manage hemodynamics and metabolic support needed throughout the prolonged resuscitation.

Once the UCSF ECMO team arrived, an additional time challenge was overcome-the emergent granting of clinical privileges for visiting non-Highland faculty.

The ongoing struggle throughout the entire resuscitation was keeping the batteries

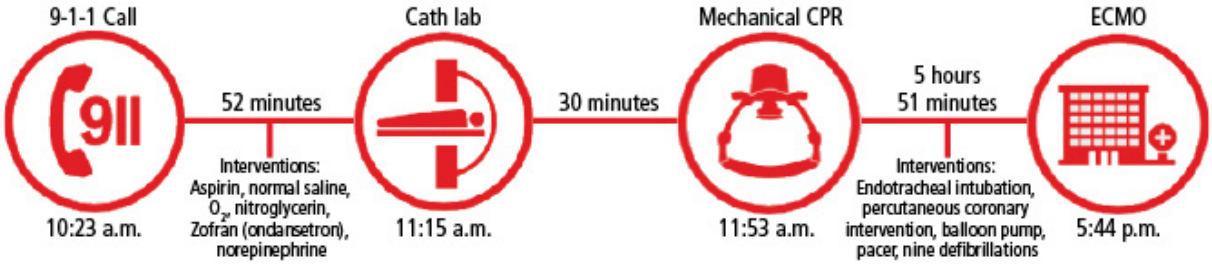
of the LUCAS device charged. The initial power drain from hour after hour of continuous chest compressions wouldn't allow for the batteries to charge, even when plugging the device's AC adapter into a wall outlet.

A request for fully charged batteries went out to the Oakland Fire Department and Paramedics Plus, and they immediately responded and delivered several spare batteries to the hospital to allow for continued operation of the LUCAS throughout the prolonged resuscitation.

After ECMO establishment, the patient was transferred to UCSF via ambulance, where he remained on ECMO for seven days with the intention of continued multisystem support.

After a week on ECMO, the patient was extubated, his sudation was lightened and he was weaned from ECMO. He interacted appropriately and showed good cardiac function. After a brief in-hospital setback, the patient underwent intensive rehabilitation.

Figure 3: Timeline of 52-year-old witnessed cardiac arrest patient using mechanical CPR as a bridge to ECMO



At the time of discharge, the patient presented with good cognitive return in memory, comprehension and social interaction. After improving his strength and endurance from the prescribed course of rehabilitation, he was discharged with no focal neurologic weakness other than a slightly unsteady gait and was able to ambulate without assistive devices.

CONCLUSION

The total time from 9-1-1 call to UCSF transfer was just a little over eight hours! The pieces of this story not documented here are the personal interactions and emotions of those involved with the laborious care of this patient in the cardiac catheterization laboratory.

One week following this case, a multidisciplinary debriefing was conducted including leadership from EMS, ED, catheterization lab, OR and ICU. The insight from the debriefing dialogs made it clear that leadership from the catheterization lab facilitated multiple services within the hospital to come together for the good

of the patient.

Highland Hospital has the reputation of being on the forefront of the most current and cutting-edge medicine with its renowned residency programs.

In 2016, Highland had three patients go to the cardiac catheterization lab for PCI with active resuscitation (i.e., mechanical CPR) that survived to hospital discharge with good neurologic function. This further demonstrates their leadership and commitment as a community champion to improving patient outcomes.

Even though this case may be perceived as an outlier and an exception to the rule, it strongly suggests that it does take a fearless scientific community working together on behalf of the patient to achieve the unexpected. This case exhibits what we may have found to be the next frontier in cardiac arrest resuscitation, prolonged care with mechanical compressions and the application of ECMO.

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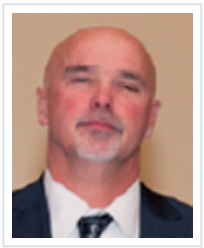

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