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INTRODUCTION:
The Future of Resuscitation

BY KEITH G. LURIE, MD; CHARLES LICK, MD; PAUL E. PEPE, MD, MPH, FACEP & LIONEL LAMHAUT, MD, PHD

This supplement was developed to present the proceedings and recommendations from the International State of the Future of Resuscitation Conference held in September 2018 in Oakland, California.

Together, the authors share a common passion to help improve outcomes after cardiac arrest. Collectively, we established a program in 2015 called Take Heart America: A sudden cardiac arrest initiative that focuses on best practices and successful “bundles of care,” therapeutic interventions proven to improve out-of-hospital cardiac arrest (OHCA) resuscitations. Most importantly, care that results in patients leaving the hospital neurologically intact.

The conference was offered by Take Heart America in collaboration with:
- Alameda County, California;
- Dutch Resuscitation Council;
- Consortium of Metropolitan EMS Directors (the “Eagles” Coalition);
- French Resuscitation Council;
- Minnesota Resuscitation Consortium; and
- JEMS (Journal of Emergency Medical Services).

Experts from around the world, who are now part of a new International Resuscitation Collaborative, discussed a wide range of topics related to advances in resuscitation science and clinical practice.

The goal was to discuss ways to combine the best evidence and experience from the innovative work of the participants to optimize the systems-of-care approach to cardiac arrest.

The International Resuscitation Collaborative identified six areas within an optimal bundle of OHCA care where new interventions have been developed and have been shown to synergistically improve neurologically favorable survival rates.

These areas are:
1. Improved methods to enhance community response or “citizen activation,” so that CPR and defibrillation are provided more rapidly by lay rescuers after cardiac arrest;
2. Improved CPR hemodynamics with technologies that provide significantly greater cerebral and coronary blood flow, and lower intracranial pressure compared with traditional manual CPR;
3. Methods and technologies that provide greater circulation and hemodynamic stability in patients with refractory ventricular fibrillation (v-fib), buying time for more definitive treatments;
4. Improved ways to reduce reperfusion injury;
5. Better diagnostic and therapeutic approaches for cerebral monitoring and neuroprognostication to optimize post-resuscitation care; and

This supplement will provide you with the most up-to-date science and technology, including expert opinions and the latest preclinical and clinical evidence that can be used today and in the future to optimize outcomes after cardiac arrest.

Cardiac arrest is a disease state that’s still a leading cause of death around the world and one that has touched many of us personally. What’s striking is that average national survival rates have barely increased at all over the last 30 years across this country and around the world.

National and international survival rates with good brain function after a cardiac arrest remain around 7%. However, if you have a cardiac arrest today in many places, such as Alameda County, Calif., and are treated with all the new technology that Mike Jacobs, Karl Sporer, MD, James Pointer, MD, and others have introduced over the last 20 years, you would have an overall chance of survival—regardless of your first rhythm—of > 30%, and upwards of 60% for a v-fib rhythm.

So, we know that the concept of a bundle of cardiac arrest care can and does work well. We also know, and do not accept that, when these technologies aren’t used all together, survival rates are at a national average of around 7%.

The bundle of care approach is now used effectively for cardiac arrest resuscitation in Alameda County and Rialto, California; Henry County, Georgia; Palm Beach County, Florida; Anchorage, Alaska; Lucas County, Ohio; Amsterdam, the Netherlands; Paris, France; and widely throughout the Twin Cities of Minneapolis and St. Paul, Minnesota.

You’ll find that this supplement’s content focuses on the current science and recommendations for resuscitative practices for cardiac arrest patients in areas such as the systematic approach to resuscitation using rapid response; mechanical chest compression and impedance threshold devices in the field, as well as in the hospital; high-quality, uninterrupted and controlled, sequential elevation of the head and torso during CPR; REBOA (for traumatic cardiac arrest) and ECMO for refractory v-fib cases.

Over the past four decades, many complex disease states have been treated with a bundle of care. It’s critical to understand that although each element of the bundle of care by itself may not be effective in complex disease states, when used together they’re often lifesaving.

For bios of the authors go to www.jems.com/THA

Save the date for the next International Resuscitation Collaborative State of the Future of Resuscitation Conference:
October 14–16, 2019: Paris, France
Early recognition of cardiac arrest, early effective CPR and early defibrillation are the most effective treatments yielding favorable neurological outcome from out-of-hospital cardiac arrest (OHCA). If CPR is started prior to the arrival of EMS, the patient’s chances for survival dramatically increase.

The data supporting this axiom is extensive but is exemplified by a recent large review. CPR provided by bystanders prior to EMS arrival was studied in a retrospective Swedish cohort of over 31,000 patients spanning a period from 1990–2011, and researchers found that 30-day survival improved from 4% to 10.9%.1

Bystander CPR dramatically improves a number of important OHCA benchmarks for survival. In the United States, current cardiac arrest registry data is readily available through sites participating in the Cardiac Arrest Registry to Enhance Survival (CARES).

The 2017 CARES Annual Report includes 76,215 worked OHCA's from 1,156 participating U.S. sites and 1,304 participating hospitals providing information on events from dispatch to hospital discharge with outcomes. Further review provides a current view into the outcomes associated with CPR provided prior to EMS arrival compared to first responder or EMS-initiated CPR. When one looks at benchmarks of potential resuscitation success of v fib or other shockable rhythms, including sustained return of spontaneous circulation, survival to admission and survival to discharge all strongly favor the provision of bystander CPR (64% vs. 49%; 63% vs. 47%; 49% vs. 28%, respectively).2

The time to first CPR has repeatedly been shown to be critical to outcome in studies since the 1980s. In King County, Wash., researchers examined the outcome in 244 witnessed arrests related to the
times to beginning CPR and to initial defibrillation; mortality increased 3% each minute until CPR was begun and 4% per minute until the first shock was delivered.³

The outsized value of early recognition, early CPR and early defibrillation was powerfully displayed in a recent study of epinephrine.⁴ This emphasizes the importance of these interventions in terms of numbers needed to treat.

The period from the time of dispatch until a first responder is at the patient’s side is subject to many variables, but most EMS systems try to engineer a 6–8 minute response time with a reliability of 90%. The six-minute number likely derives from consideration of the interval of possible survival from OHCA without CPR and trying to have responders arrive in that critical interval. Further build out of EMS to provide faster response to OHCA, a very small part of the overall call volume of EMS systems, isn’t feasible or desirable.

In spring 2014, the Anchorage Fire Department changed its entire dispatch method to a system called Criteria-Based Dispatch from King County, Wash. Despite well-trained dispatchers who adhered to the protocol, meeting the time goals was hampered by the old dispatch method. Among the new changes was a simplified method for interrogating the caller to rapidly receive the answers to two key questions following confirmation of the caller and address. This includes asking the caller, “Is the person awake and alert?” and, “Is (s)he breathing normally?” If the answers to both are “no,” the dispatcher directs the caller to begin CPR. In other words, “No-No: Go to CPR.” This method has provided significantly improved results for this system. Anchorage’s bystander CPR rate also improved with this change.

Telecommunicator CPR (aka dispatcher-assisted CPR and TCPR) has been shown to be an effective intervention when studied in the U.S.⁵,⁶ and in other countries.⁷⁻⁹

Telecommunicator CPR (aka dispatcher-assisted CPR and TCPR) has been shown to be an effective intervention when studied in the U.S.⁵,⁶ and in other countries.⁷⁻⁹

It’s also important to try to provide feedback to the team on the outcomes from the field and hospital. In those situations where a survivor can be introduced to the telecommunicator who initiated the process for his or her survival, the effects are extremely gratifying and can energize an entire dispatch agency.

It should be noted that many dispatch centers across the country have limited resources, are cash-strapped and task saturated. Call-taking and dispatch are often done by the same individual. Provision of TCPR optimally involves the telecommunicator to stay on the phone and to continue encouraging and coaching the rescuer, which could take 10 or 20 minutes or more.

A potential solution to this would be to have regional or national TCPR referral centers. Call transfer could occur very easily using current technologies to a telecommunicator with extensive experience in this technique, much like nurse advice lines. This would allow for even very small and rural agencies to provide the highest quality TCPR while continuing their baseline duties.

The future of TCPR shouldn’t be limited to our current model. The most common place for a cardiac arrest to occur is in a private residence, with 69.9% of events occurring in a home.

Patients with bystander-witnessed OHCA have three times higher likelihood of survival vs. unwitnessed events (16.0% vs. 4.6%, respectively; p < 0.0001). Initial rhythm is another major determinant of outcome and only 18.4% of victims were found in v fib overall, but it was a much higher proportion in witnessed vs. unwitnessed arrest (30.1% vs. 10.0%, respectively, p < 0.0001).²

As we look for ways to improve outcomes, we have to consider earlier detection, better provision of CPR prior to EMS arrival and ways to provide very early defibrillation.

Immediate care for victims of cardiac arrest can be provided by willing members of the community who can be notified when they’re in physical proximity to the OHCA. A significant increase in bystander CPR was demonstrated in Sweden, when volunteers who witnessed a cardiac arrest in their vicinity. The provision of bystander CPR was shown to be an effective intervention when studied in the U.S.⁵,⁶ and in other countries.⁷⁻⁹
There are growing numbers of communities employing crowdsourcing apps to alert lay rescuers of a cardiac arrest in their vicinity, as well as the locations of the nearest AEDs. An example in the U.S. is PulsePoint, and there are numerous other examples across the globe, including the Singapore Civilian Defense Force app, to name just one.

Demonstrations in the U.S. are underway to vet a subset of users as “trusted” and allow them to respond to residences to initiate care. This, coupled with geolocation of nearby AEDs, could completely change the odds of survival for a significant subset of cardiac arrests.

Fundamental enhancements to the public safety communication network may allow new opportunities for leveraging TCPR. FirstNet is an independent authority within the U.S. Department of Commerce authorized by Congress in 2012 to develop, build and operate a nationwide broadband network that equips first responders to save lives and protect U.S. communities. The presence of a dedicated, reliable, high-bandwidth communication channel, along with applications and technologies purposely built to augment public safety activities, may herald a new era.

Currently, at least one application exists that provides the potential for video conferencing between a rescuer and the telecommunicator at dispatch. FirstNet would allow one-push access to dispatch that automatically confirms the user and location foregoing the current 1–2 minutes spent, with videoconferencing to confirm the scene and provide immediate feedback to the caller.

Failure to recognize cardiac arrest in the home is a major problem. The latest Apple Watch can use its accelerometer to detect a likely collapse. The device is also able to detect and record heartbeats, so the ability for a wearable device to detect sudden cardiac arrest is already on the market. It’s not at all inconceivable that there are ways to filter this information and make it available to loved ones, caregivers and even dispatch centers to act preemptively to speed care.

In summary, we look forward to the benefits our communities will reap as we implement a host of state-of-the-art techniques for resuscitation. Public safety access points should be optimized to provide maximal benefit to the communities they serve. In many cases, they’re an untapped, underutilized multiplier of potential for successful resuscitation from sudden cardiac death.

For a complete list of references and a bio of the author, go to www.jems.com/TMA

Electronic Community Alerting & Response

BY RICHARD PRICE, MPA

Public safety agencies are increasingly using mobile apps to engage CPR-trained citizens on nearby out-of-hospital cardiac arrest (OHCA) events occurring in their community. For extremely time sensitive emergencies like cardiac arrest, notifying these “first-first responders” who are in the immediate vicinity of an event—simultaneously with the conventional Fire/EMS response—offers the potential to improve outcomes.

By expanding situational awareness beyond the purview of a traditional witnessed arrest radius, there’s a better opportunity to instantly draw skilled individuals, including off-duty healthcare professionals, enabling critical life-sustaining BLS interventions to begin sooner and more often.

Over the past eight years, government and non-profit organizations have developed mobile app initiatives to bridge the gap between a cardiac arrest event and the arrival of a traditional prehospital response. These apps work effectively to match victims in cardiac arrest with nearby CPR-trained individuals. Some solutions only target vetted healthcare professionals, while others target both professionals and lay rescuers with only basic training.

Rescuer notifications are typically driven by the local jurisdiction’s computer-aided dispatch (CAD) system, the same system used to dispatch emergency responders. If the call-taker-driven emergency medical call protocol determines that a cardiac arrest event has likely occurred, emergency responders and nearby app responders are notified simultaneously.

There are also some solutions that activate responders via a separate app, eliminating the need for a technical interface to the dispatch system.

Responders voluntarily participate in these programs by installing an app on their cellphone. When a responder receives an alert, they can choose to immediately initiate lifesaving treatment prior to the arrival of emergency responders. Currently, most bystanders who provide CPR either witness the event themselves or are directed to do so by a 9-1-1 dispatcher.

Often, friends and family are reluctant to provide CPR and trained citizens who may be nearby are unaware that help is needed. With implementation of this type of mobile technology, the likelihood that a sudden cardiac arrest victim will receive CPR from a trained citizen responder increases.

Many off-duty firefighters, EMS providers and medical professionals are
willing and able to respond to nearby cardiac arrests. At any given time, approximately two-thirds of “24-hour” emergency personnel are off-duty. The value of being able to communicate immediately with these professional responders for off-duty response may considerably expand the reach and quality of early CPR in a community.

Along with the victim’s location, these apps also commonly provide the location of nearby AEDs. Early application of an AED is one of the crucial steps in the chain of survival for a patient who has experienced sudden cardiac arrest. Trained dispatchers will often ask if there’s an AED present when the patient’s condition warrants this lifesaving device; however, it’s entirely plausible that the person on the emergency call is unaware of the location of the closest AED.

There are many benefits to using technology to alert qualified individuals of a citizen/off-duty response in conjunction with community bystander CPR and AED programs. Ultimately, they can improve survival from OHCA in both rural and metropolitan communities and should be widely available and utilized.

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**Technical Innovations: Corti**

**BY A.J. HEIGHTMAN, MPA, EMT-P & LARS MAALØE**

Corti is a digital assistant that helps medical personnel make critical decisions in the heat of the moment. Already in use by EMS in Copenhagen, Denmark, and soon to be implemented in a major United States urban center, Corti represents the early phases of an era where developers are showing how EMS can be augmented by artificial intelligence (AI) to better diagnose patients, reduce uncertainty and eliminate fatal errors.

Corti acts like a second EMS communications specialist and can identify patterns of anomalies or conditions of interest with a high level of speed and accuracy. It’s a real-time, AI-powered decision support system which processes a massive amount of data, identifies important patterns in the ongoing conversation and immediately alerts dispatchers of urgent instances, such as cardiac arrest. Machine learning can recognize agonal breathing in the background as the human dispatcher queries the caller and alert the dispatcher that it has detected agonal breathing – a critical piece of information for the dispatcher and responding first response and EMS crews.

Corti has the potential to reduce the number of undetected out-of-hospital cardiac arrests by more than 50%.

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**Community Response to Cardiac Arrest in the Netherlands**

**BY HANS VAN SCHUPPEN, MD**

In 1767, the Foundation of the Rescue of Drowned Persons was established in the Netherlands because of the high number of people who drowned in Amsterdam’s many canals. The foundation promoted rescue techniques, informing Amsterdam’s citizens that drowned persons could actually be saved by first-aid interventions.

They also gave medals to rescuers.

The foundation exists and is still active today, and it illustrates the proactive Dutch attitude toward community participation to save lives.

Like drowning, the first few minutes of an out-of-hospital cardiac arrest (OHCA) are essential. This is especially true when the arrest is witnessed, caused by a shockable rhythm, and immediately recognized. BLS measures, including the use of an AED, must be implemented quickly.

This poses a great challenge in prehospital care, because most bystanders haven’t been trained to recognize and respond to cardiac arrests. It often takes approximately 10 minutes before the emergency dispatcher recognizes the arrest and an ambulance with trained responders can arrive to defibrillate the heart. These barriers of survival should be overcome to improve OHCA survival.

Today, the Netherlands has a nationwide response system that alerts trained citizens when they’re near someone who’s experiencing an out-of-hospital cardiac arrest (OHCA). The main elements of this system are available trained citizens, available AEDs and a system to alert them that’s used by the dispatch center.

This system has led to an increase in bystander CPR and placement of an AED prior to ambulance arrival. The average age of OHCA patients in the Netherlands is 66 years of age, with 72% being male. Cardiac arrests usually occur at home (69%) and are typically witnessed by at least one person (68%).

The median time from the emergency call to ambulance arrival is nine minutes. BLS is started before ambulance arrival in 84% of cases. An AED (either on-site or delivered on scene by a first responder) is placed before ambulance arrival in 65% of cases.

The overall survival to hospital discharge (of non-traumatic OHCA, all rhythms) is 23%, with a good neurological outcome (CPC1 or CPC2) in 95% of cases. The EuReCa study showed that the Netherlands, at 56% survival, has the highest survival rate in the Utstein comparator group (witnessed arrest with shockable rhythm) in all of Europe.

The use of the nationwide OHCA response...
Reperfusion injury is linked with several pathophysiological pathways leading to cell apoptosis. The metabolic processes associated with reperfusion injury are well described in the setting of a myocardial infarction and CVA and more recently in the setting of cardiac arrest. These processes include pro-apoptotic signaling and inflammatory response.

The mitochondria plays a critical role and mitochondrial transition pore opening and calcium release are important determinant in the apoptosis signaling. Increased no-flow and low-flow duration as well as poor quality of CPR are associated with more severe reperfusion injury.

Return of spontaneous circulation (ROSC) is achieved in 20–40% of out-of-hospital cardiac arrests (OHCA) with resuscitation attempted. For these patients, reperfusion injury is responsible for increased in-hospital mortality, and, consequently, 40–50% of them will survive to be discharged from the hospital. Moreover, survivors frequently have persistent subtle cognitive impairment and some have severe neurological deficit. Some also have persistent heart failure.

Therapeutic strategies developed to improve cardiac arrest survival (e.g., epinephrine use, extracorporeal CPR, etc.) may be successful in terms of increased survival, but are often limited by the increase rate of reperfusion injury associated with prolonged CPR. Several strategies targeting different pathways have been developed in an effort to limit these lesions. First, optimizing CPR quality is a key component in order to limit reperfusion injury. Second, post-resuscitation care that targets normal oxygenation (avoiding hyper or hypoxia), normocapnia, and normal blood pressure post ROSC seem to be of major importance.

Recently, new research has focused on specific therapeutic options to try to limit these injuries. Targeted temperature management is one of the most studied. Its effects are multifactorial and target different pathways, providing an overall decrease in global metabolism proportional with core temperature. Several inhaled gases have also been studied (e.g., xenon, argon, sevoflurane, nitrous oxide), with promising results in preclinical and clinical studies.

Sodium nitroprusside, a potent vasodilator, has also been associated with improvement in survival and a decrease in reperfusion injuries in animal studies. Ischemic post conditioning—using a series of 3–4 short (20–30 seconds), controlled pauses at the very start of CPR is associated with a decrease in myocardial infarction size and increased survival in animal models. The use of a bundle of care to prevent reperfusion injury is associated with survival with an extremely long no-flow duration (17 minutes) in an animal model.

Reperfusion injury protection remains one of the most important challenges in cardiac arrest research. It’s unlikely that one drug or therapy will be able to succeed alone in preventing reperfusion injury. Use of a bundled approach to CPR and post-resuscitation care that includes one or more interventions known to reduce reperfusion injury is essential. At present, therapeutic hypothermia is the most widely used means to reduce perfusion injury and use of this modality should be broadly encouraged.
Head-Up CPR

BY JOHANNA C. MOORE, MD, MS

Head-up CPR is a novel concept in resuscitation that has the potential to improve neurologically intact survival after cardiac arrest.

Inspired by the clinical question of whether patients in cardiac arrest should be transported either head-up or feet-up in a small elevator, an initial animal study was performed in 2014. In this swine model of cardiac arrest, pigs underwent five-minute periods of automated CPR with an impedance threshold device (ITD-16) in the conventional supine position, with a 30-degree whole-body head-up tilt, and then a 30-degree whole-body head-down tilt.

The cerebral blood flow and cerebral perfusion pressures (CerPP) were higher in the whole-body tilt-up group vs. the flat group. Intracranial pressure (ICP) was also lower in the whole-body head-up tilt group. Notably, CerPP and ICP were lower and higher, respectively, in the whole-body head-down tilt.1

Subsequent studies refined the body position over a longer period of CPR, where the head and thorax of the pig was elevated during 22 minutes of active compression-decompression (ACD) CPR plus use of an ITD-16 (ACD+ITD) to reduce venous pooling in the lower extremities during resuscitation. CerPP was higher and sustained over this entire period of time in the ACD+ITD head-up group vs. the flat group.2 (See Figure 1.)

Further studies using a similar protocol for a prolonged period of head-up ACD+ITD CPR showed a doubling of cerebral blood after 15 minutes of CPR and also replicated the finding of higher CerPP pressures seen in previous studies.3

The primary mechanism of benefit behind head-up CPR is the use of gravity to enhance venous drainage not only from the brain and cerebral venous sinuses, but also the paravertebral venous plexus, thereby decreasing ICP and creating potential for the forward flow of blood.1,3,4

A secondary mechanism of benefit is thought to be the concept of decreasing the pressure transmitted to the brain via both the venous and arterial vasculature during CPR, effectively reducing a concussive injury with compression.

A third mechanism involves redistributing blood flow through the lungs in a manner similar to what occurs when patients with heart failure sit upright.

Animal studies show head-up CPR is dependent on circulatory adjuncts during CPR, such as the ITD-16 to drive blood “uphill” to maintain an adequate mean arterial blood pressure during resuscitation. When head-up standard CPR is performed, CerPP during resuscitation has been reported in the range of 7–10% of baseline CerPP values.1,3 This is compared to 50–60% of baseline CerPP values when head-up CPR is performed with circulatory adjuncts, such as ACD+ITD CPR or CPR performed with both the LUCAS mechanical chest compression device combined with use of the ITD-16.1,3

Other important considerations when performing head-up CPR includes: performing CPR flat before elevation, which primes the cardio-cerebral circuit; and to use caution when elevating the entire body over a long CPR effort, as blood likely pools in the lower extremities over time.5,7

The finding of lowered ICP and higher CerPP with head-up CPR has subsequently been replicated in a human cadaver model, the strongest translational evidence to date that head-up CPR is ready to move forward into humans in active cardiac arrest.8

More recent animal studies have focused on the optimal head-up CPR height and timing of head and thorax elevation. To date, no optimal angle has been determined, however a sequence effect has emerged, where animals treated with a controlled progressive elevation after two minutes of “priming”—to a final head height of 22 cm and a heart height of 9 cm—had sustained CerPPs and also higher coronary perfusion pressures > 70% of baseline values after > 15 minutes of ACD+ITD CPR.5,10

Most recently, head-up CPR has been incorporated into bundles of care in Palm Beach County, Fla., and Rialto, Calif.

As part of these bundles, survival rates in these two EMS systems have essentially doubled. Head-up CPR, when applied correctly and as part of a bundle of care, has the potential to improve neurologically intact survival rates after cardiac arrest.9

For a complete list of references and a bio of the author, go to www.jems.com/THA

Click here to learn more about the ElevatedCPR(TM) method
Mechanical CPR

BY CHARLES LICK, MD

Mechanical CPR devices (mCPR) provide automated chest compressions during cardiac arrest. High-performance CPR improves survival, and mechanical CPR has multiple advantages over manual CPR: consistent compressions, “cognitive offloading,” effective CPR during patient transport and crew safety, as well as the ability to provide PCI/ECMO during CPR, the need for less rescuers and decreased CPR pauses.

Published data showing the errors in the performance of CPR are common, and research has shown that proper CPR rate and depth improve survival. At present, there are no mCPR devices that actively decompress the chest during the chest recoil phase—this kind of advancement is needed to further optimize outcomes during CPR.

Multiple trials and systematic reviews have shown that mCPR achieves similar outcomes to manual CPR but isn’t superior. However, none of these trials had implemented a full bundle of care for cardiac arrest.

Cardiac arrest bundles of care that take into account the best tools and techniques are showing that we can maximize survival with telephone CPR instructions; early citizen CPR and defibrillation; high-performance CPR; mCPR that consistently compresses the chest at the correct rate and depth without fatigue, allows for full chest recoil and significantly reduces interruptions in compressions; use of an impedance threshold device; proper ventilation; therapeutic hypothermia; early PCI/ECMO; transport to cardiac arrest centers of excellence; expert ICU care; and data collection and analysis.

Therefore, mCPR devices are essential and critical to improving survival in any bundle of care for cardiac arrest, especially when prolonged CPR or CPR during transport are needed.

For a complete list of references and a bio of the author, go to www.jems.com/THA

At present, there are no mCPR devices that actively decompress the chest during the chest recoil phase—this kind of advancement is needed to further optimize outcomes during CPR.
Supraglottic Airways

BY JOE HOLLEY, MD, FACEP, FAEMS

Supraglottic airways play an important part in the bundle of care for cardiac arrest. However, use of these airway adjuncts remain somewhat controversial.

It was recently reported that SGAs can improve outcomes vs. an ET tube in patients with a cardiac arrest, but another large study from the same time period in Great Britain found no difference when either adjunct was applied early in the treatment of cardiac arrest. Importantly, more than 90% of all patients treated in both studies still died from cardiac arrest, regardless of the type of airway adjunct deployed.

We examined whether different SGAs behave the same way when used clinically. Our work builds on prior studies in pigs suggesting that not all SGAs function the same and that some may cause internal strangulation. Our current work also builds on recent studies that were performed using the human cadaver model to study the physiology of CPR.

This human cadaver model is particularly useful in that we can measure airway pressures as well as intracranial pressures. The airway and intracranial pressures and changes in those pressures are similar to what we’ve observed in animal models and cardiac arrest in humans. More specifically, we previously reported changes in airway pressures in human cadavers that were identical to what we have observed in humans in cardiac arrest.

Because of the importance of the SGA in the bundle of care, as well as the use of the impedance threshold device (ITD), a circulatory adjunct that attaches to the SGA, we assessed in human cadavers the ability of a variety of SGAs to maintain negative intrathoracic pressure during the recoil phase of CPR. Generation of negative intrathoracic pressure with the ITD is associated with superior outcomes.

We studied five different SGAs in seven cadavers, randomizing the order between the five SGAs and an endotracheal (ET) tube. We performed CPR manually, with the LUCAS mechanical chest compression device, and the ACD CPR device called the ResQPUMP, in both the supine position and in the head-up position.

We first identified that when CPR is performed supine with any of these methods of CPR, an ITD was essential to create a negative intrathoracic pressure. With mechanical CPR, there was no vacuum in the absence of the ITD. This is important for those using a mechanical chest compression device, as it shows that it doesn’t work nearly as well alone as with the ITD.

When looking at the generation of negative intrathoracic pressure with the five different airways, three of the SGAs (the LMA, i-gel and AirQ) and the ET tube resulted in the greatest negative intrathoracic pressure during the recoil phase of CPR, suggesting these airways should be used in an optimal bundle of care.

By contrast, the Combitube and King SGA failed to adequately seal the airway consistently during the decompression phase of CPR, and this resulted in an inferior vacuum compared to the other three SGAs.

These findings are similar to pig studies performed with SGAs. Our observations were similar during CPR in a supine position, with both automated CPR and ACD CPR, as well as head-up CPR with both automated CPR and ACD CPR. In all cases, the ITD was essential to generate negative intrathoracic pressure during the chest recoil phase.

In summary, SGAs and the ET tube play an important role in the treatment of cardiac arrest: both of them enable the rescuer to maintain an adequate seal so that an intrathoracic vacuum can be developed during CPR to enhance circulation, especially with the ACD+ITD combination.

But all SGAs aren’t equal. The King and Combitube should be avoided if the goal is to both maintain and allow for the generation of the negative intrathoracic pressure during the recoil phase of CPR.

This is more than an implementation issue, this is a question of what tools will help you to provide the best care for your patients and deliver the best clinical outcomes. We know that generation of a negative intrathoracic pressure is critical, and you’ll get less of this negative intrathoracic pressure that helps drive cardio-cerebral circulation during CPR by using the right SGA.
High-Quality CPR

BY SHELDON CHESKES, MD, CCFP (EM), FCFP

Survival from out-of-hospital cardiac arrest (OHCA) continues to be dismal in many EMS systems around the world. Is this actually true, or is it merely an often-used opening line to thousands of papers published annually on OHCA survival?

Evidence from many communities suggests otherwise. In fact, in many jurisdictions, survival from OHCA has improved dramatically, impacting many lives. So, what’s the difference between some jurisdictions and others when it comes to OHCA survival? Are there common themes that others can learn from in improving their own survival rates?

One of the common themes we see in areas with higher survival rates is a focus on providing high-quality CPR to patients in OHCA. Compression rate, depth, shock pause duration, release velocity and the use of CPR feedback have all been associated with improved outcomes and are highlighted repeatedly in the 2015 AHA/ILCOR guidelines as crucial factors to improving outcomes from OHCA. (See Figure 1.)

Yet surprisingly, many systems around the world still fail to measure these metrics, despite the widespread availability of technology that makes this process both simple and inexpensive. But many systems choose to find any number of reasons, such as cost, workload and failure to have resources to implement these systems, as an excuse not to measure CPR quality, which is truly a shame.

The well-known adage of “if you don’t measure it, you can’t improve it,” has never been more appropriate than it is today. The recommendations from the Take Heart America conference will go a long way in ensuring that every EMS system in North America has the capability to measure CPR quality in all cases of cardiac arrest, while also putting into place quality assurance programs focused on improving CPR quality for all. Focusing on implementing real-time CPR feedback on a global basis will go a long way in attaining this goal.

The future of cardiac arrest research is full of new concepts and research into new strategies focused on improving OHCA survival. Whether we speak about ACD+ITD CPR, ECMO, double sequential external defibrillation, or alternative drug therapies for patients in cardiac arrest of a variety of etiologies, what remains clear is that none are effective without high-quality CPR. The previously demonstrated interaction between interventions and high-quality CPR informs us that without improved CPR quality, even the greatest of ideas will fall flat. So let’s all, as a resuscitation community, increase our focus on improving the quality of CPR around the world. The old adage of “some CPR is better than no CPR at all” must be replaced by “high-quality CPR is the only form of CPR.”

Figure 1: Variations in CPR quality strongly linked to outcomes

Resuscitation Outcome Consortium data showed that wide variations in compression depth and rate limit blood flow and worsens outcomes—even in some of the best EMS systems.

For a complete list of references and a bio of the author, go to www.jems.com/THA
Active Compression-Decompression CPR Plus an Impedance Threshold Device

BY TOM P. AUFDERHEIDE, MD, MS, FACEP, FACC, FAHA

Although conventional closed-chest manual CPR has been the standard of care for over 60 years, its limitations have resulted in new CPR techniques. Conventional, standard CPR provides only about 20–30% of normal blood flow to the heart and brain, which in many cases is insufficient to enable a return of spontaneous circulation (ROSC). In addition, it’s difficult to perform correctly and consistently.

Over the past 25 years, a new method of CPR called “active compression-decompression (ACD) CPR plus an impedance threshold device (ITD)” has been developed as a superior alternative to standard CPR. ACD+ITD CPR has been tested in multiple animal and human studies, and it has been found to provide significantly higher rates of survival with favorable neurological function compared with standard CPR.

ACD+ITD CPR is performed with tools that work synergistically to more than double the blood flow to the heart and brain vs. standard CPR. ACD+ITD CPR relies on a suction cup to actively lift the chest during the recoil phase and an ITD to impede air from rushing into the lungs during the recoil phase. This device combination lowers intrathoracic pressure during the CPR decompression phase, which in turn draws more venous blood back into the heart, refilling it more efficiently than is possible with standard CPR.

Perhaps most importantly, during the active recoil phase, the biophysics of ACD+ITD CPR causes more venous blood flow from the brain to the heart, thereby lower intracranial pressures. This results in less resistance to forward blood flow to the brain and an overall increase in brain flow.

The ACD+ITD CPR device provides guidance to help minimize common errors during CPR, such as compressions that are too fast or too slow, incomplete chest wall recoil, inadequate or too much compression depth, and excessive ventilation rates. (See Figure 1.)

Based upon multiple animal studies and four European studies demonstrating superior hemodynamics and short-term survival rates with ACD+ITD CPR vs. ACD CPR alone or standard CPR, a large NIH-funded trial was performed from 2005–2010. It showed that ACD+ITD CPR was superior to standard CPR when ACD+ITD CPR was started as a BLS therapy and continued for at least 30 minutes or until ROSC. Fifty percent more patients with a non-traumatic cardiac arrest of cardiac etiology were alive and with good neurological function a year after cardiac arrest with ACD+ITD CPR vs. standard CPR controls.

The ACD+ITD CPR combination, called ResQCPR, is the first and only CPR technology ever approved by the FDA that’s indicated to increase the likelihood of survival after a cardiac arrest compared with standard CPR.

Since FDA approval, ACD+ITD CPR has been introduced into a number of different EMS systems and hospitals. Like any new...
Carbon dioxide (CO₂) in the body is a product of metabolism. It’s produced in cells dependent on oxygen supply. During cardiac arrest, oxygen delivery to cells falls, and CO₂ production decreases.

CO₂ levels may be monitored at the airway through CO₂ excretion, and they may be monitored in the cells through peripheral measurement. Peripheral measurement of CO₂ has typically been carried out through arterial or venous analysis. Transcutaneous CO₂ measurement is now a popular and useful method of providing the monitoring of CO₂ levels in critically ill patients, especially pediatric patients.

Variations between the levels of CO₂ excretion at the airway often indicate the state of CO₂ production in the periphery. However, matters affecting venous return—such as ventilation practices and shock—can affect CO₂ excretion at the airway.

This proposition for the future of cardiac arrest resuscitation provides an augmented intelligence-guided method of assessing the state of the patient’s metabolism while guiding both compression and ventilation efforts during resuscitation. It suggests the automated external defibrillator of the future could analyze CO₂ transcutaneously during the resuscitation attempt.

Finally, “smart monitors” might be developed and equipped that could compare the analyses of airway CO₂ and peripheral (transcutaneous) CO₂ during resuscitation to optimize the outcome of these patients.
Epinephrine has been a key component of ALS since the first CPR guidelines were published in the early 1960s, and its use has continued with little change in dose or timings over the past 60 years.

As well as its positive inotropic and chronotropic properties mediated through beta-agonist properties, the demonstration that epinephrine’s alpha-agonist effects increased aortic diastolic pressure to increase both coronary blood flow (associated with an increased chance of return of spontaneous circulation [ROSC]) and cerebral blood flow was also thought to be of benefit.1,2

However, there have been concerns about potentially harmful effects of epinephrine, mediated through reduced cerebral microvascular blood flow, cardiovascular instability after ROSC and adverse metabolic and immunomodulatory effects.

Recent prospective randomized trials concluded that although epinephrine generally increased the rate of ROSC, its use wasn’t associated with neurologically intact survival;3,4 findings supported by large observational studies.5–7

Of additional concern were several large database and registry studies finding that prehospital epinephrine was associated with a decreased chance of neurologically intact survival,8,9 particularly when given > 15–20 minutes after the cardiac arrest occurred, as tends to be the case in out-of-hospital cardiac arrests.10–12

Systematic reviews and meta-analyses of epinephrine in cardiac arrest reinforced concerns about the survival benefits of epinephrine therapy.13–15 This then led to a large prospective randomized trial of epinephrine in out-of-hospital cardiac arrest—the Prehospital Assessment of the Role of Adrenaline: Measuring the Effectiveness of Drug administration In Cardiac arrest (PARAMEDIC-2) trial, which sought to establish whether the use of IV epinephrine, administered in accordance with current ALS guidelines is helpful or harmful.

This recently published study has demonstrated that, although epinephrine increased overall survival to hospital discharge (3.2% vs. 2.4%; unadjusted OR 1.39; p=0.017), there was no difference in neurologically intact survival to hospital discharge between groups (2.2% vs. 1.9%; unadjusted OR 1.18; p=NS). Significantly, survivors given epinephrine were more likely to be neurologically impaired, compared with those given placebo.16

However, much remains unanswered with regards to the optimal dose, dose interval and timing of epinephrine administration, although there are clues from registry and database studies suggesting that smaller doses given earlier and less frequently may be a better strategy.

In its current dosing strategy, epinephrine in cardiac arrest increases the chances of ROSC and survival to hospital discharge, but doesn’t increase neurologically intact survival. Whether epinephrine administration during cardiac arrest should continue in its current format, or whether alternative strategies may be more optimal, needs to be considered in detail. At a minimum, significant caution should be taken when administering epinephrine as currently recommended by ILCOR and AHA Guidelines.

For a complete list of references and a bio of the author, go to www.jems.com/THA

Technical Innovations: FirstPass Quality Enhancement Module

BY A.J. HEIGHTMAN, MPA, EMT-P

FirstPass is an advanced, automated, cloud-based software system created by FirstWatch in Carlsbad, Calif., that scans all patient records to identify key parameters selected by an EMS agency and alerts when a electronic patient care report (ePCR) doesn’t match an agency’s protocols. It’s a QA system that can identify high performers and low performers, as well as areas that can be improved.

The FirstPass Quality Enhancement Module has processed more than 1 million ePCR records, from four different ePCR vendors, and has performed more than 30 million tests for deviations from protocol.

What used to take days or weeks can now be accomplished in minutes, allowing agencies to take immediate action to correct documentation errors or to provide positive feedback and training.

The FirstPass bundle of care includes protocols such as: ACS/STEMI, stroke, trauma, airway management and cardiac arrest. Additional metrics a service might consider include: pain management, patient care aspect, high-risk/low-frequency event or non-transports/patient refusals.
Cerebral Monitoring

BY Kees Polderman, MD, PhD

The overall aims of neuromonitoring are to identify worsening neurological function and secondary cerebral insults that may benefit from specific treatment(s) and improve pathophysiological understanding of cerebral disease in critical illness, to provide clear physiological data to guide and individualize therapy, as well as assist with neuroprognostication. It’s not a novel concept to directly monitor the organ of interest to direct and assess therapies.

The human brain constitutes 2% of the total body weight, yet the energy-consuming processes that enable the brain to function adequately account for about 25% of total body energy expenditure and 20% oxygen consumption of the whole organism.

Noninvasive evaluation of cerebral blood flow (CBF) is possible with transcranial Doppler (TCD), utilizing derived pulsatility index or optic nerve sonography. However, methods for continuous online monitoring of the brain remains primarily invasive.

Intraventricular devices have long been considered the gold standard for measurement of cerebral oxygenation; intraparenchymal devices are particularly useful when intracranial pressure monitoring and drainage is also desirable. Though noninvasive monitoring of cerebral oxygenation exists, there’s little evidence for its usefulness outside of the operating room.

Continuous measurement of CBF is now feasible using a thermal diffusion probe (TDP), which shows good correlation with CBF as measured by xenon-CT.

TCD shows flow velocity rather than flow itself. It combines ultrasound and the Doppler principle to represent erythrocyte flow in the basal cerebral arteries.

As cerebrovascular resistance increases, systolic velocity increases and diastolic velocity decreases. TCD is also used to assess cerebrovascular autoregulation in traumatic brain injury (TBI) and subarachnoid hemorrhage patients. The quality of TCD signal is operator-dependent and correct interpretation requires training. In approximately 10% of patients, transtemporal sonication isn’t feasible.

Brain Tissue Oxygen Monitoring

Arterio-jugular difference in oxygen content (AJDO₂), calculated by the arterial minus the jugular bulb venous pressure, is proportional to CBF and inversely proportional to oxygen consumption (i.e., cerebral metabolic rate for oxygen, CMRO₂). Normal values for jugular bulb oxygen saturation (SjO₂) are about 57% (95% confidence interval 52–62%). This is a global measure and insensitive to small regional changes, and a larger volume of the brain must be under-perfused for a significant abnormality to be detected.

Use of intraparenchymal tissue oxygenation probes (i.e., PbO₂ monitors) involves insertion of a probe into the white matter of the brain and provides a reasonable estimate of global brain oxygenation. However, this isn’t a “surrogate” for ischemia. It varies not only with CBF, but also with changes in arterial oxygen tension.

With brain tissue oxygenation (PbtO₂), xenon-enhanced CT scanning and SPECT, threshold values vary slightly, depending on what type of PbtO₂ monitor is used, but values < 20 mmHg should be treated. The quantity, duration and intensity of brain hypoxic episodes (PbtO₂ < 15 mmHg) and any PbtO₂ values ≤ 5 mmHg are associated with poor outcomes after TBI.

Near infrared spectroscopy utilizes the property that oxyhemoglobin, deoxyhemoglobin and oxidized cytochrome oxidase absorb specific portions of the light spectra. This is correlated to the relative proportions of oxyhemoglobin and deoxyhemoglobin (HbO₂/Hb) and oxidized cytochrome oxidase in the tissue. This is made noninvasively and works continuously. However, baseline normal values vary.
Aortic Interventions for Resuscitation

BY JAMES E. MANNING, MD

REBOA

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) involves the use of an aortic balloon catheter to limit blood loss caudal to the inflated balloon in patients with severe, uncontrolled truncal and junctional hemorrhage.

Initially described during the Korean War, aortic balloon occlusion for hemorrhage control in trauma was reported sporadically over the ensuing decades without general adoption into clinical practice. This has changed in the past decade in response to injury patterns observed in the combat theaters of the Middle East. Preclinical studies in U.S. military research labs characterized the physiological effects and limitations associated with aortic balloon occlusion in laboratory models of severe non-compressible torso hemorrhage. This laid the scientific foundation for a 2011 report defining REBOA and the subsequent translation into clinical practice in recent years.

Several aortic balloon catheters are now commercially available, and reports of clinical experience are increasing rapidly along with growing data reported to multi-institutional REBOA registries.

Aortic occlusion of the thoracic aorta (Zone I) for sub-diaphragmatic hemorrhage and infrarenal aorta (Zone III) for isolated hemorrhage are utilized near-infrequently over the ensuing years, for hemorrhage control in trauma was reported sporadically over the ensuing Korean War, aortic balloon occlusion involves the use of an aortic balloon catheter to limit blood loss caudal to the inflated balloon in patients with severe, uncontrolled truncal and junctional hemorrhage.

Initially described during the Korean War, aortic balloon occlusion for hemorrhage control in trauma was reported sporadically over the ensuing years, for hemorrhage control in trauma was reported sporadically over the ensuing years. For hemorrhage control in trauma was reported sporadically over the ensuing years, for hemorrhage control in trauma was reported sporadically over the ensuing years.
pelvic and junctional hemorrhage have been reported in-hospital and in combat theaters. Prehospital Zone III REBOA has been reported and implementation of prehospital Zone I REBOA is forthcoming.

The use of REBOA for hemorrhage control in nontraumatic conditions, such as severe peripartum obstetrical hemorrhage, has also been increasing with favorable outcomes reported. Strategies for intermittent and graded partial aortic occlusion are maturing and offer the prospect of extending aortic balloon hemorrhage control while limiting distal ischemia.

The use of aortic balloon occlusion to augment coronary perfusion pressure during CPR chest compressions has been studied in laboratory models and evidence of increased coronary perfusion pressure has been reported. Clinical trials to investigate REBOA in medical cardiac arrest are being pursued.

Figure 1: Selective aortic arch perfusion (SAAP) data from pig studies shows potential.

Selective Aortic Arch Perfusion (SAAP)

Selective Aortic Arch Perfusion (SAAP) involves the use of a large-lumen thoracic aortic balloon catheter to provide relatively isolated perfusion to the heart and brain during cardiac arrest. The perfusate is initially an exogenous oxygen carrier, such as allogeneic blood or a hemoglobin-based oxygen carrier (HBOC), but autologous blood can subsequently be used, if needed, in a manner similar to extracorporeal life support (ECMO/ECLS).

SAAP was initially described in 1992 as a resuscitation technique for treating nontraumatic/medical cardiac arrest with the prehospital setting in mind. Preclinical studies in models of ventricular fibrillation demonstrated improved rates of return of spontaneous circulation (ROSC) compared to standard resuscitation therapies. The physiologic effects of SAAP were characterized and perfusion parameters were optimized.

The potential for SAAP balloon hemorrhage control in trauma and rapid volume repletion in hemorrhage-induced hypovolemia was also recognized. In a 2001 preclinical report, SAAP with oxygenated HBOC-201 showed consistent ROSC in a model of liver trauma with exsanguination-induced cardiac arrest. (See Figure 1.)

Subsequently, SAAP with allogeneic whole blood and red blood cells, have been studied given the lack of a commercially approved non-blood oxygen carrier. Translation into clinical use is presently being pursued with clinical trial preparations underway to investigate blood product and HBOC perfusates in both hemorrhage-induced traumatic cardiac arrest and non-traumatic/medical cardiac arrest.

At the current time, data are limited for the use of SAAP and REBOA in humans in cardiac arrest. In the future, this therapeutic approach may play a vital role in the treatment of traumatic and refractory cardiac arrest.
The Minnesota Resuscitation Consortium (MRC) initiated the Advanced Perfusion and Reperfusion Cardiac Life Support Strategy for Out-of-Hospital Refractory Ventricular Fibrillation (v fib) in December 2015, in an effort to improve survival outcomes for patients suffering refractory v fib arrest.

Extracorporeal life support (ECLS) provides two critical advantages to the care of patients with refractory cardiac arrest. First, it provides near complete replacement of cardiac function with flows of 4–5 L/min. Second, the hemodynamic stability it provides enables the underlying causes of arrest to be addressed. Importantly, the primary etiology of refractory v fib is coronary artery disease, with 84% of refractory v fib patients presenting with severe coronary lesions. Further, these coronary lesions are highly complex with high syntax scores and a high rate of chronic total occlusions.

Three Key Components

The MRC ECPR program has three key components: prehospital, stabilization and recovery. First, the prehospital care is highly coordinated and the paramedics involved have been highly trained to provide rapid assessment on scene and rapid transport, in the case of refractory cardiac arrest, to the cardiac catheterization laboratory (CCL) at the University of Minnesota for initiation of ECLS. Transport is performed with mechanical CPR and ITD and ongoing ACLS.

Patients are screened by paramedics using the following field criteria. Inclusion criteria include the following: 1) age 18–75; 2) OHCA of presumed cardiac etiology; 3) initial cardiac arrest rhythm of v fib, v tach; 4) received three defibrillation shocks without return of spontaneous circulation; 5) received IV amiodarone 300 mg; 6) body habitus accommodating a LUCAS automated CPR device; and 7) estimated transfer time to the CCL of < 30 minutes. Exclusion criteria include: DNR/DNI, live in a nursing home, or have a clear non-cardiac etiology to the arrest.

Second, the stabilization stage begins upon arrival in the CCL, with immediate assessment of the patient for resuscitation termination criteria including: 1) end-tidal carbon dioxide < 10 mmHg; 2) PaO₂ < 50 mmHg; and 3) lactic acid < 18 mmol/L.

Figure 1: Refractory cardiac arrest due to v fib/v tach and the University of Minnesota ECLS/PCI protocol

If none of these criteria are met, resuscitation continues with placement of ECLS within 6–8 minutes of arrival in the CCL. Ultrasound-guided percutaneous access is used for cannulation. Medical therapy is then provided to achieve hemodynamic stability.

Once hemodynamically stable, coronary angiography and PCI are performed as needed. Pulmonary angiography or laboratory testing may be performed as well. A distal perfusion cannula, IV cooling catheter, and right radial arterial line are placed, and LV venting is considered.

As the patient is transferred to the cardiovascular ICU, a CT scan of the head, chest, abdomen, and pelvis is performed to evaluate for trauma. Traumatic injuries are then addressed as needed. Importantly, all patients are considered viable and all procedures are considered if needed until a patient is declared dead.

The last stage is recovery in the cardiovascular ICU, cardiac telemetry floor, and after discharge. Recovery is limited by severe multisystem organ failure, which is ubiquitous in this patient population. Although most organ systems will recover, including the heart, neurologic recovery limits survival in most patients. Recovery is delayed in most patients with mean time to ECMO decannulation of four days, following commands at six days, and hospital discharge at 21 days.

Importantly, prognostication efforts must be delayed, as patients who have neither followed commands nor been declared dead have a 35% chance of surviving at one week and 20% chance of surviving at two weeks post-arrest.

Anoxic brain injury or brain edema on CT scan at the time of cardiovascular ICU admission, decreasing near-infrared spectroscopy over the first 48 hours, severely elevated neuron-specific enolase, and nonconvulsive status epilepticus on EEG are associated with poor outcomes, but no single test can be used to determine prognosis.

Using these selection criteria and protocols, a 43% rate of neurologically intact survival can be achieved. This is compared to a 5% rate of survival for this population prior to initiation of this protocol.

Importantly, post-discharge care is also critical for complete rehabilitation of this patient population. Psychological consequences including post-traumatic stress disorder, anxiety, and depression are common.

Short-term memory deficits and personality changes are common immediately following the hospital stay. These deficits typically resolve with appropriate therapy. Patients are encouraged to seek physical therapy, psychological therapy, neuropsychologist evaluation and genetic counseling if a clear etiology of the cardiac arrest isn’t discovered. Follow-up cardiology care is also provided.

Overall, care for this patient population is highly specialized and time intensive. However, with these protocols, neurologically favorable survival can be improved substantially.

For a complete list of references and bios of the authors, go to www.jems.com/THA
For decades, extracorporeal life support (commonly referred to as extracorporeal membrane oxygenation, or ECMO) was used in the operating room (OR) and ICU to treat refractory shock, typically after surgery. More recently, ECMO has been used to treat refractory cardiac arrest; in this indication, it takes the name “ECPR.” Today, ECPR is used in many places.

Although there are published case reports, series and after/before studies, there have been no randomized controlled trials to illustrate its effectiveness in the resuscitation of out-of-hospital cardiac arrest (OHCA) patients.

However, ECPR is now recommended by international guidelines in the management of refractory OHCA of suspected reversible cause, such as acute myocardial infarction, refractory cardiac arrest of suspected reversible cause, pulmonary embolism and intoxication. The 2015 American Heart Association Guidelines recommend ECPR could be considered in refractory cardiac arrest of suspected reversible cause.

ECPR is the second line of treatment for OHCA not responding to usual BLS and ALS treatments (e.g., cardiac compressions/massage, ventilation, defibrillation, drug administration, etc.). ECPR brings respiratory and circulatory support, ensuring sufficient blood and oxygen supply to the whole body, especially the brain.

The ECPR response team in Paris implements ECMO on scene to restore blood flow to the body and limit ischemic consequences to the brain and coronary arteries. Since 2011, the ECPR response team in Paris may implement ECMO on scene to restore blood flow to the body and limit ischemic consequences to the brain and coronary arteries.

ECPR is a neuroprotective treatment. Neuroprotective treatments are therapies that block the cellular, biochemical and metabolic elaboration of injury during or after exposure to ischemia and have a potential role in ameliorating brain injury in patients with acute ischemic stroke.

Patients with neuroprotection need to be cannulated. These patients include neuroprotected patients, the low flow time can be very long (e.g., five hours of hypothermia).

For neuroprotected patients, the low flow time can be very long (e.g., five hours of hypothermia).

The quality of the CPR is crucial, as is the quality of care after ECPR.

**Who and Where?**

Today surgeons, intensivists, cardiologists and emergency physicians can perform ECPR. However, new ECMO devices may enable highly trained prehospital clinical specialists to perform ECMO in the field.

The objective of ECPR is to get the patient on ECMO within 60 minutes of an OHCA. If a patient has some persistent signs of life, they can undergo ECPR at any time. For neuroprotected patients, the low flow time can be very long (e.g., five hours of hypothermia).

The location to initiate ECPR insertion is usually the OR, ICU or ED, and insertion can be done by surgical technique, percutaneous under ultrasound control or by a hybrid technique. The location for ECPR needs to be selected based on the site most advantageous to reduce the low-flow time. Since 2011, some teams in Europe have started to do prehospital ECPR with good results, in order to reduce the low-flow time.

**Recommendation**

In 2018, all communities should have a pre-established protocol of ECPR for selected refractory cardiac arrest patients. This protocol needs to describe the selection criteria, the technique of insertion and the site of insertion. This protocol should try to reduce the period of low flow. Prehospital ECPR can be done effectively and should be considered when adequately trained medical personnel are available. This protocol needs to be collaborative with EMS, ED, ICU and cardiologists. ECPR has the potential to significantly increase survival rates when incorporated into an optimal OHCA bundle of care.
Targeted Temperature Management

BY BRIAN J. O’NEIL, MD, FACEP, FAHA

Hypothermia has a number of potential neuroprotective effects; however, they can be broken down into two main properties: metabolic and neuronal protection.

When mammals hibernate, they experience acidosis both from lactate and carbon dioxide, resulting in hypoxia and hypoglycemia. These conditions are not unlike those that occur post-cardiac arrest: Hypothermia decreases metabolic rate by about 6% per 1 degree C reduction in brain temperature. If blood flow and demand are coupled, it’s possible to see a 50% decline in cerebral metabolic after cooling the brain to 32 degrees C.

The protective effects occur via reduction in the early rise of calcium, decreased release of excitatory amino acids, improved cell survival signaling processes, inhibited cytochrome c release from mitochondria, decreases in free radical production and propagation, decreased lipolysis that causes salutary changes in glutamate receptor composition and signaling.

The 2015 AHA Guidelines and 2015 ERC Guidelines recommend targeted temperature management (TTM) for comatose adult patients with return of spontaneous circulation (ROSC) after cardiac arrest for all rhythms and all locations of cardiac arrest.1,2

Further, they recommend selecting and maintaining a constant temperature between 32 degrees C and 36 degrees C during TTM. Absolute contraindications to TTM are an awake and responsive patient, DNR, active non-compressible bleeding and the need for immediate surgery. Relative contraindications for TTM are trauma/exsanguination, intracranial hemorrhage, recent surgery, pregnancy and suspected sepsis.1,2

Examining the Evidence

The recommendations from these guidelines are based primarily on three major studies. The first was conducted with 136 patients who were in v-fib arrest, comatose, had stable hemodynamics, and used a number of external cooling device. Eight hours was the median time to reach the target temperature of 32–34 degrees C, and the cooling continued for a mean of 24 hours.

A total of 75 (55%) patients were in the hypothermia group and 54 (39%) of the patients fell into the normothermia group. The risk ratio was 1.40 (95% CI 1.08-1.81) for a favorable outcome in the hypothermic group. The number needed to treat (NNT) to improve neurological outcome was six patients; NNT to prevent one death was seven patients; and NNT to harm was 14 patients.

In a study on comatose survivors of cardiac arrest, a total of 77 patients were externally cooled after v-fib arrest. An external cooling device and ice bags were initiated by EMS at ROSC.

The patient’s temperature was brought to 33.5 degrees C within two hours of ROSC and were cooled for 12 hours. The outcome results showed a good neurologic outcome in 49% in the hypothermia vs. 26% in the normothermic.4

The TTM Trial was the largest and best trial design to date. The study was a randomized controlled trial that included out-of-hospital cardiac arrest (OHCA) patients with all initial rhythms, and the cooling target was set at 33 degrees C vs. 36 degrees C. The primary outcome was the neurological performance of the cerebral performance category (CPC).

The patient population was different than previous trials, in that 90% of the episodes were witnessed, 73% had bystander CPR and 80% of the cases had a shockable rhythm. The average time down until BLS arrival was 1 minute and 10 minutes for ACLS; and 40% of these cases were STEMI and two-thirds had a corneal reflex and three-quarters had a pupillary reflex. Overall, there was no difference in adverse events.5

COOL-ARREST was a multicenter, prospective, single arm, observational pilot trial enrolled patients at eight U.S. hospitals between July 28, 2014, and July 24, 2015. Adult OHCA subjects of presumed cardiac etiology who achieved ROSC were considered for inclusion. This trial utilized the latest ZOLL Intravascular Temperature Management method, which has significantly more cooling power than previous devices. This study showed that patients achieved target temperature more quickly than in the TTM trial (median 89 minutes [IQR 42-155] vs. 210 minutes [IQR 180]) and there were fewer deviations from set temperature.6

In my practice, I cool to 33 degrees C. Some is good, but more is better. It also takes less sedation, and I’m a believer in the effect on metabolism, event greater with intact autoregulation. I’m also a believer in the effect on cell signaling, which truly turns off the bad and turns on the good. For neuroprognostication, wait 72-plus hours for normothermia.

The ILCOR and AHA Guidelines came to the right conclusions based upon the current evidence. Remember that hypothermia is the platform, not the end. It’s important to build upon growth factors like insulin and IGF-1 and mitochondrial modulators like photomodulation of cytochrome oxidase.+

For a complete list of references and a bio of the author, go to www.jems.com/THA
Active Intrathoracic Pressure Regulation During Resuscitation

BY NICOLAS SEGAL, MD, PhD

Active intrathoracic pressure regulation (aIPR) is a novel therapy approved for the treatment of low blood flow states, such as cardiac arrest. This therapy is delivered with a device called the CirQPOD that’s inserted into a standard respiratory circuit between the patient and a means to provide positive pressure ventilation (e.g., bag-valve balloon or mechanical ventilator). Between each positive pressure ventilation, aIPR decrease intrathoracic pressure to subatmospheric levels, which subsequently enhances blood return to the heart and increases stoke volume, cardiac output, arterial blood pressures and coronary perfusion pressures. It also simultaneously decreases intracranial pressure and improves cerebral perfusion pressure and cerebral blood flow. The physiology has been confirmed in multiple animal studies and several human studies, during CPR and in the post-resuscitation phase. Intrathoracic pressure regulation relies on similar physiological principles of the impedance threshold device. Overall, aIPR therapy has significant potential to improve outcomes in patients in cardiac arrest, especially when used as part of an overall bundle of care.

For a complete list of references and a bio of the author, go to www.jems.com/THA

Technical Innovations: Pulsara
BY A.J. HEIGHTMAN, MPA, EMT-P

Built on a cloud-based platform, Pulsara applications provide secure access to telecommunications services via smart devices, allows for transmission of ECG images, medication lists, etc., to the hospital, as well as enabling EMS to alert or inform key staff and get the quick answers needed—when they’re needed.

Pulsara increases the speed and efficiency of care for patients with time-critical medical needs by facilitating coordination among care team members, providing quick and coordinated treatment to patients that can dramatically improve their chances for resuscitation and recovery.

Transesophageal Echocardiography During Cardiac Arrest

BY SCOTT T. YOUNGQUIST, MD, MS, FAHA, FACEP, FAEMS

Transthoracic echocardiography (TTE) has been endorsed by international guidelines as a potentially useful diagnostic modality for the evaluation of patients in cardiac arrest. Echocardiography can identify organized cardiac activity vs. standstill, predict the likelihood of survival, and may be used to establish the cause of the arrest and guide treatment, such as in the case of pericardial tamponade or massive pulmonary embolus.

However, the process of TTE image acquisition has been observed to cause prolonged pauses in the delivery of vital chest compressions and reduce hands-on time. A structured protocol and quality assurance process may reduce these times.

Nonetheless, TTE remains particularly challenging in patients who are obese, have gastric distention from air insufflation, or are barrel chested. In approximately one-third of patients, an adequate cardiac window cannot be obtained for interpretation during resuscitation.
Transesophageal echocardiography (TEE), by contrast, offers several advantages over TTE in the setting of cardiac arrest. Cardiac windows can be obtained once the probe has been correctly positioned during CPR, offering continuous images during CPR. Image quality is superior to TTE as the transducer is placed directly behind the heart without significant intervening tissue.

In our own ED, pauses in CPR were shorter with TEE vs. TTE, when performed by emergency physicians, since image acquisition was continuous. Mean pauses were 9 seconds (95% CI 9–12) for TEE and 19 seconds (95% CI 16–22) for TTE, a difference that was statistically significant. By comparison, the use of manual palpation to check for a pulse while a verbal countdown was performed resulted in an average pause of 11 (95% CI 8–14) seconds. (This data was presented at AHA 2017 and is unpublished data under review.)

Emergency physicians are able to obtain adequate images 98% of the time and findings impacted therapeutic decisions in 31–67% of cases.6,10 TEE can be used to identify the cause of arrest with sensitivity of 93% and specificity of 50%.10 It’s also been used to assess the adequacy of chest compressions, as well as direct the positioning of hands (or mechanical piston) to improve subjective assessment of flow.

There are known limitations of TEE. The modality requires that the patient be endotracheally intubated for airway protection before examination. Supraglottic airways create an obstruction to passage of the probe into the esophagus and, thus, can’t be in place during placement. TEE probes have come down in cost over time, but they remain relatively expensive. Additionally, probes require the same level of decontamination and cleaning as endoscopes before reuse.

Finally, no study has demonstrated superior outcomes using TTE or TEE to guide resuscitation. The existing evidence arises from case reports and case series, making it difficult to determine whether a patient-oriented benefit exists. When trained personnel are available, TEE can play an important role in the overall bundle of care by facilitating more accurate diagnosis of a number of disease states that can cause cardiac arrest.+

For a complete list of references and a bio of the author, go to www.jems.com/THA

Pediatric Resuscitation

BY PETER ANTEVY, MD

Data from the American Heart Association and the Pediatric Advanced Life Support (PALS) guidelines consistently report neurologically intact survival from pediatric cardiac arrest to be 3% for infants and 10% for children. This pediatric survival data has remained unchanged for decades without a clear vision or path to improved survival statistics.

Change is needed, and we recommend focusing on the following three pillars in order to achieve success in pediatric cardiac arrest: 1) bystander CPR; 2) telecommunicator CPR (TCPR); and 3) on-scene EMS resuscitation. Using a different lens to evaluate these links in the chain of survival may provide a different perspective, and inform the way forward.

In the United States today, children in cardiac arrest have less than a 50% likelihood of receiving bystander CPR. The solution to this dilemma has remained elusive, proving to be a difficult problem to solve; yet correcting it may yield the biggest impact on survival. Resolution of this problem is beyond the scope of this write-up.

Often called the “first first responders,” call-takers are critically important to the survival of those found in cardiac arrest. Time-to-recognition of cardiac arrest and time to hands-on-chest are of critical importance to survival, yet call-taker
performance isn’t being currently measured by these two key performance indicators. The AHA recently released guidelines targeting two minutes for arrest recognition and three minutes for hands-on-chest in high-performing systems, yet EMS agencies have yet to incorporate these metrics into their cardiac arrest CQI processes. Furthermore, call-takers are “gun-shy” in both the initiation and continuation of CPR in children, for reasons that remain elusive, and which require further study.

Like adults, children who don’t receive CPR prior to arrival of EMS have significantly decreased odds of survival. We therefore advocate that EMS leadership and their communication center counterparts review all pediatric arrest calls within 72 hours to better understand and correct issues that may exist. Every call should, at a minimum, have the two KPIs listed above consistently reported as quality metrics to both EMS and communication center leadership. Additionally, resuscitation-specific education must be provided to call-takers in order to emphasize the rapid initiation of CPR, as well as a sustained commitment to continuation, even when distracting information has been obtained.

The practice of “load and go” remains pervasive in the prehospital environment and the reasons for it are deeply rooted and complex. High-performance CPR is as much a regimented physical process as it is a mental one, with the later strongly linked to on-scene performance. The goal of every resuscitation should be getting each provider to closure, something that can only be accomplished by perfecting the pre-arrival and on-scene sequences.

**Pre-Arrival Discussion Is Critical**

A deliberate pre-arrival discussion is crucial in pediatrics and differs from the adult call, which is primarily non-verbal (due to standardized dosing and equipment sizing). This mental readiness impacts the confidence of EMS professionals prior to arrival on scene and ultimately impacts their ability to initiate high-performance CPR in the presence of family and onlookers. A mandatory pre-arrival discussion for pediatric calls arms EMS providers with critical information such as equipment sizing, epinephrine dosing and electrical values and signals team members to, not only stay on scene, but to also stay in their lanes.

When performed this way, on-scene care can finally resemble that of an adult, therefore minimizing the urge to rush off the scene with a pulseless child. An immediate post-incident review with the medical director, including a review of the 9-1-1 audio, strengthens the message of high-performance on-scene care, while simultaneously providing a case-by-case evaluation of bystander and telephone CPR. A quarterly report evaluating the three pillars outlined above (i.e., bystander, telecommunicator, EMS) will provide a clear view of where the disparities exist and highlight areas for improvement within a given community.

“If treating kids like we treat adults” is still considered blasphemy, mainly due to the medical sub-specialization that’s occurred in the house of medicine, but particularly in pediatrics. The unchanged pediatric survival statistics are a cry for help, calling out to the lay public and prehospital professionals for change. Pediatric resuscitative care desperately needs to realign with its adult counterpart, and this will require a foundational adjustment. Beyond the more difficult bystander issue, telephone CPR and EMS care are the low-hanging fruit and can be easily be “nudged” into alignment.

A large Florida fire department recently reported sustained survival rates of 35% since implementing enhanced TCPR, pre-arrival planning of dosing and equipment, and high-performance on-scene care, a change from 0% the two years prior. Kids in cardiac arrest are no different than adults in cardiac arrest. There, we said it ... now let’s get to work!

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For a complete list of references and a bio of the author, go to www.jems.com/THA

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**Alameda County EMS Improves Cardiac Arrest Survival**

**BY MICHAEL J. JACOBS, EMT-P & KARL A. SPORER, MD, FACEP, FACP**

Alameda County is approximately 750 square miles with a population of 1.6 million and is marked by demographic and socioeconomic diversity. The county consists of urban, suburban, as well as rural areas. Alameda County Emergency Medical Services (ALCO EMS) runs approximately 170,000 emergency 9-1-1 calls and 120,000 transports annually, responding to approximately 1,300 cardiac arrests (attempting resuscitation about 1,100 times a year), and has maintained a survival rate of around 10% for the last half a decade.

ALCO EMS has made several 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 the 9-1-1-1 audio, strengthens the message of high-performance on-scene care, while simultaneously providing a case-by-case evaluation of bystander and telephone CPR. The endorsed system of care for OHCA by ALCO EMS has been modeled after the 9-1-1-1 audio, strengthens the message of high-performance on-scene care, while simultaneously providing a case-by-case evaluation of bystander and telephone CPR.

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For a complete list of references and a bio of the author, go to www.jems.com/THA
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 (i.e., good neurologic function). Closer scrutiny and analysis of those data was published in Prehospital Emergency Care.5

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 staffed and equipped for ALS. Beginning in 2012, all first responder paramedic engines were equipped with a LUCAS mechanical CPR device and responded to all cardiac arrests.

Resuscitation Hypothesis

We hypothesized that the increased use of therapies in 2012 that focused on perfusion during CPR using mechanical adjunets 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.

The subgroup that received mechanical CPR with an ITD 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 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

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### Year & Intervention Details

<table>
<thead>
<tr>
<th>Year</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Adopted 2005 AHA Guidelines; implemented intraosseous (EZ-IO)</td>
</tr>
<tr>
<td>2007</td>
<td>EtCO2 monitoring, dispatch-assisted CPR, comprehensive data collection based on CARES</td>
</tr>
<tr>
<td>2008</td>
<td>Advanced airway training for all EMS</td>
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<tr>
<td>2009</td>
<td>Impedance threshold device (ITD)</td>
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<tr>
<td>2010</td>
<td>Hospital therapeutic hypothermia; EMS pit crew CPR; EMS hypothermia; CPR training in all schools</td>
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<tr>
<td>2011</td>
<td>ITD retraining</td>
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<tr>
<td>2012</td>
<td>Electronic medical record (EMR) implementation; PulsePoint activated</td>
</tr>
<tr>
<td>2013</td>
<td>OHCA transported to cardiac arrest centers</td>
</tr>
<tr>
<td>2014</td>
<td>Discontinued prehospital therapeutic hypothermia</td>
</tr>
<tr>
<td>2015</td>
<td>Adopted 2015 AHA guidelines for CPR</td>
</tr>
</tbody>
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# Figure 1: Alameda County EMS v fib/v tach with good neurologic survival

![Figure 1](image-url)

**Figure 1:** Alameda County EMS v fib/v tach with good neurologic survival
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.

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.)

At an 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 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 bystand CPR and was found in v fib by EMS on 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.

From Concept to Practice

In the fourth quarter of 2016, only a few months after the 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!

In the fourth quarter of 2016, only a few months after the 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!

At the time of this case, Highland Hospital didn’t have the capability to perform ECMO, and received an otherwise healthy 52-year-old male who presented with left coronary artery occlusion, arrested in the catheterization lab, and was unable to achieve ROSC after an hour of resuscitation. The cath lab 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 cath lab while waiting for the ECMO team to arrive.

The total time from 9-1-1 call to UCSF transfer was just a little over eight hours, and during that time the patient received nearly six hour of continuous mechanical CPR until being placed on ECMO for seven days. The patient was discharged alive, with good neurologic function, three weeks after admission.

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.

In January 2017, ALCO EMS designated the seventh SRC/CARC in the system (out of 12 adult hospitals in the county). Even though 2017 CARES data demonstrates an increase in ROSC compared to 2016 (42% vs. 37%)—virtually the same survival rate (10.4% vs. 10.1%)—there was a slightly lower neurologically intact survival rate (7.3% vs. 7.6%). According to 2017 CARES data, ITD and mechanical CPR use were at an all-time high (81% and 78%, respectively), as well as hospital admission (46%), but coronary angiography was significantly lower compared to the 2016 data (15% vs. 23%). EMS transports and those that received targeted temperature management remained about the same.

As of 2019, Alameda County still doesn’t have an ECMO-capable adult hospital.

Resuscitation Goals

In 2019, the ALCO EMS system goals to improve neurologically intact survival from OHCA include: working closer with dispatch to improve time to first compression; capping the cumulative maximum dose of epinephrine to three within 30 minutes and prolonging dosing frequency to q 10 minutes in EMS ACLS protocol; implementing head-up CPR feasibility study; selecting a new supraglottic airway to replace the King LT; coordinate with county SRC/CARC’s to better standardize inclusion criteria for both cardiac angiography and TTM, as well as become ECMO-capable, or at minimum to establish a formal agreement with an “ECMO-to-go” hospital in the bay area.

For complete references and bios, go to www.jems.com/THA
The Rialto, Calif., Fire Department (RFD) changed the way we view cardiac arrest. Our goal was to transform from the way we’ve “always done it,” which was resulting in 77% of our cardiac arrest patients never regaining a pulse, to a progressive bundle of care approach that utilizes the synergy of multiple small improvements for significant improvements in return of spontaneous circulation (ROSC)—eventually tripling of our survival to hospital discharge.

The RFD bundle of care, which we call our “resuscitation toolbox,” was implemented on the vision that survival from cardiac arrest should be the rule, not the exception. The toolbox leverages contemporary research and has forced us to “unlearn” our previous treatment paradigm, which resulted in a high cardiac arrest fatality rate.

Think about that: cardiac arrest shouldn’t be an almost uniformly fatal condition, and if any treatment for any condition is predominantly fatal, you should stop doing it, even if it’s the way you’ve always done it, or it’s the way everybody does it.

We can’t continue to view prehospital medicine this way. We must innovate. Using common and novel practices, we’ve found there’s no one silver bullet—the bundle is the key. We’ve expanded our understanding of who can survive cardiac arrest, with more than 20% of asystolic patients surviving to discharge in 2018.

How we do it is more important than what we do, and the quality of CPR can vary greatly throughout the country and the world. There are four components of CPR: 1) compression rate; 2) compression depth; 3) adequate recoil; and 4) limiting pauses. All four are required to perform high-quality CPR. This can only be accomplished with real-time CPR performance feedback.

Additionally, you must define, in writing, what your acceptable pauses in compressions are for your agency. If you don’t define the acceptable pauses there will be more of them than are acceptable. The four acceptable pauses in CPR in the city of Rialto are:

1. Place a feedback device = one-second pause;
2. Place a posterior defibrillation pad = five-second maximum pause;
3. Place a mechanical CPR device = five-second maximum pause; and
4. Start mechanical CPR device = five-second maximum pause.

Acceptable pauses in your agency may be different, but they must be defined in writing as a beginning to changing the pervasive poor quality of CPR throughout the EMS system. This is just one example of the theory, “It’s not what you do, it’s how you do it,” but the quality of what we do must be continually evaluated and improved.

RFD implemented a “wheel of survival,” which outlines what we do and the order in which we do it. Each cog on the wheel is placed in an order consistent with the clinical evidence, which our data supports, suggesting the order in which we do things matters.

Promising Results

These tools, the quality of what we do, and the order in which we do it in, has resulted in ROSC rates in the city of Rialto averaging 51% for the past three years (2016–2018), regardless of the rhythm the patient was found in, if the arrest was witnessed, or if CPR was applied prior to arrival.

The RFD’s survival using the Utstein criteria is 44%. Survival to hospital discharge has ranged from 12–14% in all patients that received our bundle of care again regardless of rhythm, CPR prior to arrival, or downtime.

There’s still significant room for improvement in both our ROSC rates and our survival to discharge rate, and we’re sure 50% of what, how or when we’re doing it is wrong, we just don’t know which 50%.

We still don’t accept that over 80% of our cardiac arrest patients won’t survive to hospital discharge. We’ll continue to challenge our own assumptions, push the envelope and crunch the data to find the answers.

For more on the Rialto Resuscitation Toolkit, go to www.jems.com/rialto.

For a complete list of references, a bio of the author and a downloadable PDF containing the RFD Wheel of Survival and Adult Non-Traumatic Cardiac Arrest Resuscitation Algorithm, go to www.jems.com/THA
Palm Beach County, Florida, Bundle of Care

BY KENNETH A. SCHEPPKE, MD

Palm Beach County, Florida, is home to 1.4 million residents and is host to many more visitors each year as a major tourist destination. It’s a sprawling, multicultural and diverse socioeconomic demographic with extremes of age.

In 2015, based upon disappointing resuscitation rates, the bundle of care approach was instituted by the county’s new EMS medical directors. Within three months, resuscitation rates improved dramatically, and in the ensuing years, have remained at over double their prior level. How did this occur, and what are the implications for enhancing cardiac arrest survival across other jurisdictions?

In 2011, according to Florida EMSTARS (EMS Tracking and Reporting System), the odds that any EMS agency in the state would get return of spontaneous circulation (ROSC) for an adult with out-of-hospital cardiac arrest (OHCA) was a meager 6%. However, after widespread adoption of the 2010 American Heart Association ACLS guidelines, which emphasized compressions over ventilations, the statewide ROSC rate jumped to 17%.

This change provided an important clue into where the state’s EMS systems could find further improvement. Based upon root cause analysis, if an arrest is due to sudden loss of the cardiac “pump,” then efforts to restore or replace the function of the pump must be the focus of any resuscitative efforts. Specifically, it was hypothesized that further improvement could be made by concentrating on therapies aimed at enhancing the flow of blood to the heart and brain using the thoracic pump theory of CPR.

Included in our bundle of care was passive ventilation, delayed positive pressure ventilation, use of an impedance threshold device (ITD), a renewed focus on continuous chest compressions with early transition to mechanical CPR with the LUCAS device, and transport with the head and thorax in an elevated position to allow a drop in intracranial pressure and a potential improvement in cerebral perfusion.

Among 1,304 consecutive OHCA cases in 2014–2015, survival rates were fairly constant in 2014 (17.4% mean, range 15–20%) but rose steadily during the implementation of the bundle of care, with an ensuing sustained doubling of survival (36.0%; range 35–37%). Outcomes improved across subgroups while response intervals, indications for initiating CPR and bystander CPR rates were unchanged. Regionally, in 2015, hospital admission rates were found to remain proportional to neurologically intact discharge.

We’ve continued to monitor success rates over the ensuing years and found that these results were maintained through all of 2016, indicating there is more than simply a Hawthorne effect (i.e., the observer effect) to the flow-focused bundles of care.

Hospital outcomes weren’t consistently available during the study period, which limits the generalization that improved ROSC rates alone will equate to improved survival to hospital discharge. However, the immediate and sustained dramatic increase in ROSC suggests the need for further efforts to evaluate and enhance the flow-focused bundle of care approach.

Figure 1: Percent of OHCA patients surviving by quarter 2014–2015

Community outreach in Palm Beach County includes teaching the public hands-only CPR.

PHOTO COURTESY PALM BEACH COUNTY FIRE RESCUE
Whatcom County, Washington, is the furthermost northwest county in the continental United States. The county covers over 2,200 square miles and has a population of approximately 250,000 people, of which 150,000 are within the city of Bellingham. Whatcom County is the state’s 12th largest county, part of which is only accessible by land through Canada.

Whatcom County's ALS program began in 1974. Over the years, the manner in which care has been delivered has steadily improved.

In 1996, all BLS response units were equipped with an AED and a strong community effort to provide CPR training was initiated. Then, in 2006, a BLS transport system was created comprising of 49 potential response units divided along fire district/city lines. Today, all BLS providers are AED-equipped and trained in high-performance CPR.

Prior to 2006, we estimated the return of spontaneous circulation rate was 16%. We subsequently participated in the ResQTrial, a study of active compression-decompression (ACD) CPR with the use of an impedance threshold device (ITD-16). During this time, our overall survival to hospital discharge rate with favorable neurological function was > 12%.

Currently we deploy ACD+ITD-16 CPR as well as LUCAS devices, which are used during transport. Data is now collected for each ALS agency and from our one receiving hospital. This data is then put into the Cardiac Arrest Registry to Enhance Survival (CARES). We’re also moving toward an effective electronic health record (EHR) that will cover our entire ALS and BLS system.

As we all know, EMS response isn’t instantaneous, and therefore can’t succeed without an exceptional dispatch team. All of our dispatchers are trained as EMTs and are Priority Dispatch-certified. Hospital prearrival instructions and telephone CPR are both mandated and reviewed. EMS dispatch has both administrative and—unique for Washington state—physician oversight.

Whatcom County has a community hospital that’s a Level 1 cardiac and a Level 2 trauma center. The next nearest Level 1 cardiac center is over 70 miles away. Progressively, EMS and the hospital have worked to provide immediate response for cath codes (STEMI) and select post-arrest patients 24/7. In addition, in the past several years, we’ve selectively taken patients with signs of life, but refractory rhythm, directly to the cath lab. Some have had percutaneous coronary intervention (PCI) with ongoing mechanical CPR, a few have been transitioned to mechanical support (Impella or ECMO).

In 2008, we began a post-arrest targeted temperature management program. Initially, we were using topical blankets and now are using an esophageal temperature management device. To date we have cooled over 820 patients. The survival to hospital discharge rates are between 48% and 52% with modified Rankin scale (mRS) scores of 2 or less. One confounder to our data remains the number of patients presenting with cardiac arrest who may have drug use as the inciting cause.

Although all of this has promise, we have several significant areas of weakness, particularly with our public response. In 2013, with the help of enlightened legislators, we created a mandatory CPR requirement for all high school students in both the eighth and 12th grade. We’ve found, however, that this doesn’t cover the majority of our community. To try and correct this, we’re focusing on holding more CPR classes provided by fire agencies, social clubs, at public events, and in certain industries. However, this is far from sufficient where community response is concerned.

An electronic community response system, PulsePoint, has been implemented, but due to insufficient education and publicity, is not yet achieving its goals. Not enough people are signing up, nor are they responding. Along those same lines, we’re only in the early stages of documenting the location of all the AEDs in the county. What we really need is for our medical community to move forward with supporting CPR training for staff—a concept not yet universally accepted.

We will continue to deploy our comprehensive bundle of care for patients in cardiac arrest, which we expect to continue to enhance survival rates, even though the population of Whatcom County is growing at a rate of 10% per year.

In 2016, Whatcom County passed a levy to support and help build upon the countywide EMS system. The funds will provide for much-needed new paramedic training, a universal electronic health record, and upgraded professional dispatch, including review of all telephone CPR calls. In addition to other administrative and medical review, we’ve hired a full-time data analyst. We hope to add an administrative educator and community EMS planner in the near future.

For a bio of the author, go to www.jems.com/THA
The Lifeline ARM

Automated Chest Compression (ACC) Device for Professionals

Precise operation of the Lifeline ARM helps to ensure high-quality and continuous cardiopulmonary resuscitation (CPR) associated with better survival for victims of sudden cardiac arrest (SCA).\(^1\) Be it on the ground, in an ambulance cot, a moving vehicle, or intra-hospital transport, the Lifeline ARM is your solution for uninterrupted CPR.