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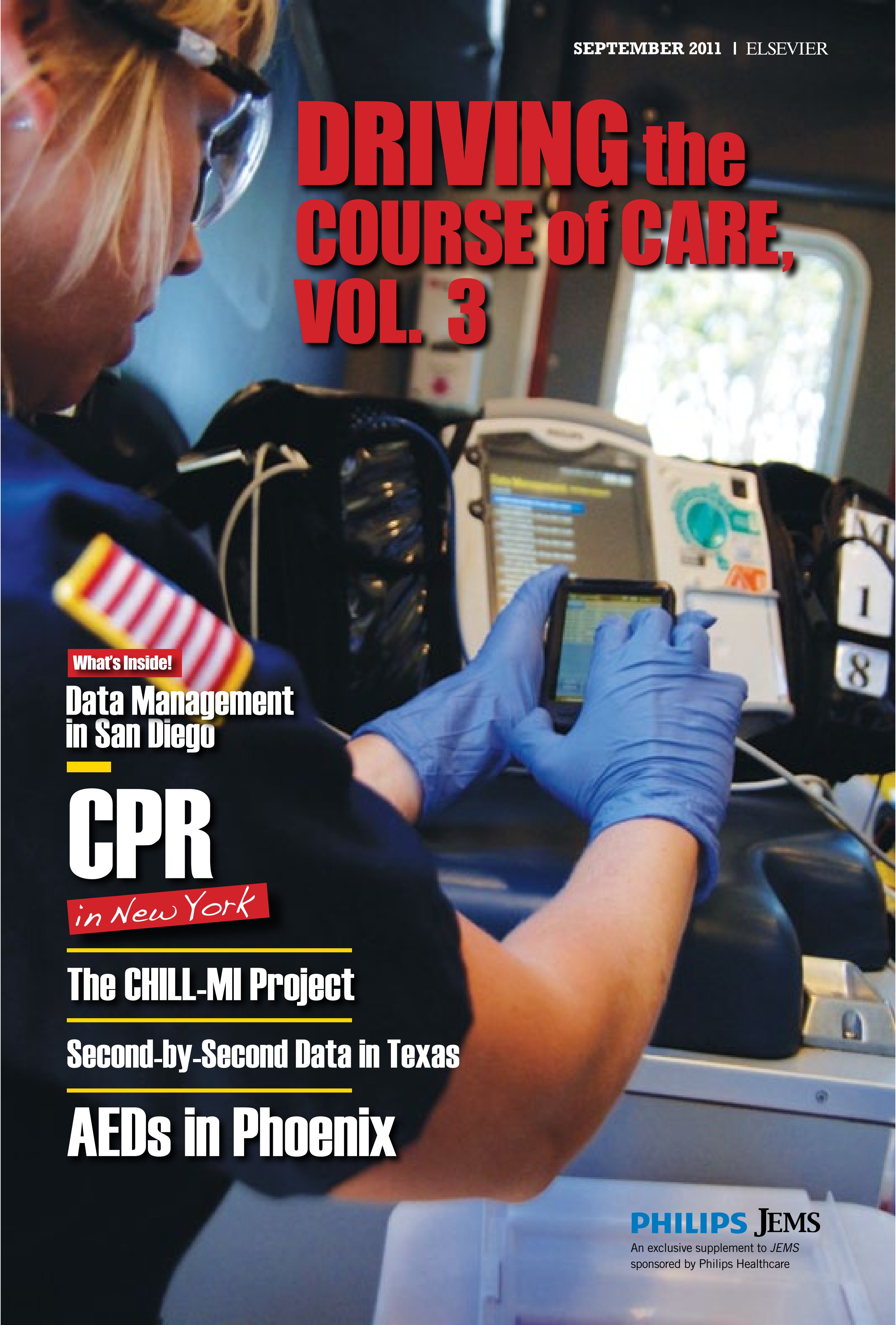
DRIVING the COURSE of CARE, VOL. 3



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PHILIPS JEMS
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Seamless Care Becoming a Reality

By A.J. Heightman

This editorial supplement shows how advances in technology are linking prehospital and hospital teams in an unprecedented, seamless manner. The result: better coordination of care, better resuscitation results and better evaluation and validation of what we are doing for our patients.

In "Where's My Tricorder?," a San Diego Fire-Rescue Department administrator explains how his agency, in concert with multiple hospitals and technology companies, is linking its electronic patient care record system with hospital data systems. This will allow the hospitals to see what is occurring in the field—as it is occurring—and reciprocate by allowing the prehospital sector to later see what was done for their patient, as well as the patient's final discharge diagnosis. This pioneering effort could pave the way for improved systems and cooperation between EMS and hospital providers nationwide.

In "Second-by-Second Data," Montgomery County (Texas) Hospital District officials explain how making the switch to the monitoring, analysis and transmission of data on a second-by-second basis has enabled them to see trends, take faster corrective treatment action and continuously evaluate and improve their system.

In "Surviving SCA at Sky Harbor," we look at how the Phoenix Fire Department has achieved an incredible 75% survival rate for cardiac arrests through coordinated AED deployment, training and increased bystander participation in sudden cardiac arrest resuscitations.

In "Resuscitation in the City," Fire Department of New York (FDNY) EMS Medical Director John Freese, MD, discusses the five key aspects his system has focused on to improve its resuscitations in the field. He also points out how, through use of the HeartStart MRx, the department's quality-CPR technology and the Event Review Pro software, the FDNY is now able to review these important parameters for each resuscitation and rapidly make changes when necessary.

And finally, with therapeutic hypothermic (TH) being shown to be effective and safe when used in post-arrest settings, "Chilled to the Bone," takes a look at a study underway that's evaluating the effect of TH and endovascular cooling before reperfusion in patients suffering ST-elevated myocardial infarction (STEMI).

If the study finds that cooling can reduce heart damage in STEMI patients, it could chart the course for future prehospital cooling therapy, further allowing field care to continue to drive the course of care for cardiac patients.

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Where's My Tricorder?

The San Diego EMS technology experience | **By Roger Fisher, EMT-P**

I'm no Trekkie, however, like many other EMS administrators who have assumed the responsibility for review, deployment and maintenance of technology-related items, I can identify with the highly respected title of "techno geek." The San Diego Fire-Rescue Department, San Diego Medical Services and our partners in the city of San Diego's EMS system have had the wonderful opportunity to envision and develop many advanced tools to improve our delivery of prehospital emergency care.

San Diego's backyard houses such wireless giants as Qualcomm Inc. and an ever-growing host of smaller medical technology companies that are working to make their mark on EMS. We have the luxury of a tight working relationship among first responders, transport medics and hospitals, and, although funding is always a consideration, we have EMS leadership that understands how investments in technology can result in better patient care and workflow. Yet again, in an environment that fosters forward progress, the elusive **tricorder** remains somewhere on the horizon.

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Visit **jems.com/special-2011-course-of-care** for a glossary of boldface terms used in this article.

PHOTO CHRIS SWABB

EMS providers in San Diego get feedback on all cardiac arrest calls, which are monitored for quality assurance purposes.

We're using the *Star Trek* word "tricorder" as an analogy here because it's a useful point of comparison for what many of you might expect in an EMS technology discussion. Today, we expect our systems to collect data, turn it into useful information, move it to the right places and produce it—all in real time. Because of the nature of our work environment, we also expect our tools to be small, rugged and preferably combined into one, easy-to-carry device. Our proposed EMS tricorder is truthfully many "things" and "systems" of hardware and software, and unfortunately these things don't always work well together.

Electronic Patient Care Records

The electronic patient care record (ePCR) has become a standard in our industry. San Diego developed its own ePCR system in 2000, basing the system on the original PalmPilot platform. Although ePCR systems for EMS were virtually nonexistent in the early 2000s, we were tapping away. Ours was a rapid entry tool that rarely crashed and had minimal delay to input. Also, because it was a homegrown product, we had the luxury of making changes to the software at will. We coined the system "TapChart" because of its stylus-driven input. The charting was straightforward, records were transferred between devices by infrared "beaming," and printing of charts was easily performed on infrared printers.

As well as the TapChart system performed, we still had a continual need to keep up with the handheld device changes and looming wireless technologies that surrounded our homegrown effort. We watched from the sidelines as others attempted development of handheld ePCR systems. Some were successful; some were not.

Used to documenting on small handhelds our crews carried on their hips, we were puzzled at the growing trend of placing ePCR systems on ruggedized laptops, wondering what EMT would ever lug such a thing to a patient's side for documentation. As time went on, we realized that technology was racing forward, making our venerable TapChart obsolete.

The writing was on the wall when we realized the Palm device and the Palm operating system we were using were headed for retirement. San Diego then decided to place years of homegrown software development into the hands of professionals who had entered the market well after us. Although we resolved to no longer be our own software company, we were reluctant to simply turn over what had worked so well for our EMS providers. We were looking for partners to redevelop our TapChart system, and we found that spirit in a well-established company, ImageTrend Inc.

Today, even with a decade of experience with handheld ePCRs in San Diego, we have a long way to go with this part of our tricorder. There's an explosion of devices that will fit the bill for ePCR collection, from smartphones to tablets to slates. So what should an agency strive for in this complicated and growing selection of products? The best ePCR systems should strive toward **platform independence**. Our Achilles' heel in San Diego was the reliance on software tied to companies, operating systems and specific devices. Choose a system that's bold enough to give you a choice of devices and is built on broad standards to future-proof your investment.

Monitor Technology

The data you collect in patient care doesn't start with tapping on a screen or keyboard. Cardiac monitors have become a central part of data collection, gathering a wide variety of vital sign parameters and saving the information for subsequent transfer to analysis software packages. The days of running a paper ECG strip and taping it to your paper medical record have transformed into saving all vital signs to a memory card and selecting what to do with all that information.

San Diego's experience has aimed at forging a stronger link between the monitor and the ePCR system. The monitor has become as much a tool for the field practitioner as it is for our quality assurance (QA) department. San Diego was an early (and unique) adopter of voice recording through our cardiac monitors. A continuous voice recording has become a valuable part of our QA review process, providing information on cases that involve high risk.

In San Diego, a 100% audit of cardiac arrest is performed by a full-time QA analyst, and our goal is for feedback to be returned to crews within a few days. Audio aids in the confirmation that clinical expectations are met and protocols followed. Direct feedback is provided in a constructive manner as close to the incident date as possible, so it's meaningful and educational for the crews.

San Diego's use of voice recording data is now a matter of practice. However, this also adds a layer of complexity to data management and transmission. Although typical ECG and vital sign data are small in file sizes, the addition of voice creates a significant increase in file size. Only recently have new technologies begun to be incorporated into cardiac monitors, allowing for bulk uploads of large data files to back-end systems for archiving and later analysis. Transmission speeds over slow **serial ports** have been upgraded to local area network speeds, and we are now able to cut the cable in favor of wireless offload of monitor data.

Manufacturers of EMS cardiac monitors are well aware of the potential benefits of linking the monitor data to the ePCR to the receiving hospital or medical control center. Performing this wirelessly will be an expectation and requirement rather than an interesting experiment. Today, in San Diego, the first glimpses of these capabilities are being realized.

The current version of our TapChart program runs on an HTC HD2 Windows Mobile Smartphone via the T-Mobile 3G network. Smartphones are paired with Philips HeartStart MRx cardiac monitors via Bluetooth. Resident on the smartphone is a small application that's responsible for the integration of data into the ePCR record or passage over the 3G network to the Philips Telemedicine server for further processing and transmission (fax or e-mail). Our paramedics can now bring live **computer-aided dispatch (CAD) incident data** into their TapChart record, avoiding duplication of effort, input time and incident information already obtained by the dispatch center. Paramedics can quickly input data at the patient's side via the touch screen while using the full TapChart system on their smartphone.

The touchscreen buttons are large and easy to see, and the user interface is designed to facilitate rapid entry. Monitor data can be imported directly from the Philips MRx to the TapChart ePCR on the smartphone. When it's time to transfer the record, the engine or ladder company first responder simply releases the record to a server, where it becomes available for continuation by the ambulance crew. On completion of the ePCR, the patient chart can be automatically sent to the receiving hospital, fax machine or to a secure link that can be accessed only by staff with proper credentials. All records are housed in a **secure data server**, which serves the needs of all stakeholders, from billing to quality assurance.

At the end of their shift, our crews upload the entire day's worth of cardiac monitor data, including voice data, via an Ethernet-based **batch LAN data transfer** to a central file server. Monitor data is matched to the ePCR and available to QA staff directly from the ePCR system.

The QA staff, however, isn't the only end-stakeholder of ePCR and cardiac monitor data. San Diego has been at work tying in "the last mile"—the hospital system.

The Last Mile

That last mile is the need for data to follow the patient into the hospital system and allow EMS to become a part of the continuum of care and learn final discharge diagnosis for each patient. Through the University of California at San Diego (UCSD), San Diego County was the recipient of a Healthcare Information Technology (HIT) grant through the Recovery Act Beacon Community Program in 2010. Although many Beacon Community grants are in effect across the nation, San Diego is unique because it will incorporate EMS data into the overall HIT strategy.

The grant will allow for the realization of a total San Diego Health Information Exchange (HIE), which includes the ePCR and monitor data for all EMS encounters. Currently, data from our CAD system, cardiac monitors and ePCRs is entering a greater developing HIE planned to link clinics and hospitals throughout San Diego.

The efficiencies to be proved include such items as:

- Faster transfer of information for decision-making in medical control, such as 12-lead ECG transmission to cardiologists. Future interest in alternative diagnostic tools, such as ultrasound;
- Other non-traditional data transmission, such as digital images or documents that can be used to guide patient care;
- Direct sharing of the appropriate data back to the field practitioner based on records within the HIE;
- Full incorporation of the prehospital ePCR into the receiving center's medical records system;
- Sharing of historical prehospital data across hospitals and clinics as patients move through the area;
- Provision of outcome data back to the EMS agencies to guide in QA efforts; and
- Management of high-frequency EMS system users and abusers, allowing for better use of social resources outside EMS.

As San Diego's Beacon program fully develops and provides a well-integrated HIE, the future possibilities for EMS are astounding.

The Future Ahead: What's Your Tricorder?

San Diego is unique in many ways. But its technology experience probably isn't different from your system's—at least from the perspective of your overall needs. Our EMS professionals are demanding of our tools and equipment. The equipment must work flawlessly without failure lest it negatively affect patient care. EMS technology manufacturers, of both documentation and monitoring systems, are aware of the trends and desires from EMS, but the perfect device and system to fit everyone's needs is difficult to obtain.

If there's sage advice to offer based on many years of testing these types of technologies, you should consider the following four points before starting your own trek into comprehensive electronic patient care data management:

1. ***Demand standards:*** Incredible progress has been made on a national scale with the National EMS Information System (NEMSIS) data standard. A common underlying data standard is essential to any downstream processes that depend on data. Although a majority of vendors and manufacturers may abide by standards, such as NEMSIS, other innovations will benefit from standardization of national requirements. Efforts toward standardization of QA and system performance measures can have a major effect on benchmarking;
2. ***Demand platform flexibility and choice:*** Although San Diego moved in the direction of smaller handheld smartphones, this doesn't suggest that a ruggedized, large laptop isn't the right fit for your system. The playing field has expanded to offer devices of all sizes and prices. The suppliers should strive toward software development that can take advantage of the variety of platforms available;
3. ***One system doesn't fit all, so demand connectivity:*** As stated earlier, many systems don't always work well together. Moving into a new documentation system or cardiac monitor shouldn't require you to change your billing software, CAD or QA platform. Vendors offering solutions for everything from CAD to billing may be attractive for a system starting from scratch. However, the reality is that your system can't afford wholesale change and depends on those legacy system pieces. Look for vendors with experience making connections and a track record of working well with others; and
4. ***Work toward fixing the funding model:*** At least in San Diego, the funding model is upside down. There's little incentive for the EMS agency to adopt new technology, especially when a return on investment is difficult to prove. Who truly benefits when a 12-lead is sent directly to the cardiologist who will open that catheterization lab at 3 a.m.? Although we can all agree that, in the name of excellent patient care, these advances will benefit the patient, it would be a stretch to say EMS should fund technology based on better patient care alone.

> **Choose a system that is bold enough to give you a choice of devices & is built on broad standards to future-proof your investment. —Roger Fisher, EMT-P**

Truth be told, with the current billing structures, EMS has minimal incentive to invest. However, other winners exist when we improve our prehospital technologies, and those winners are the hospital systems. When prehospital care is improved and when hospitals are aware of prehospital data, hospital costs are reduced.

Summary

Although proud of the road we've travelled and the distance we've come, the trip isn't complete. Technology is an evolving animal. It is, by definition, always new. And to remain new, it must continually change. How your system works with this change can be a positive or negative experience. Fall behind technology and you may lose market share or be considered irrelevant. Pace too close to evolving technology and you may wind up as an unintentional test, learning hard lessons for others. ■

GO Online

Check out the March 2011 *JEMS* article "Data Transfers: Sharing patient information in the electronic age" on **jems.com** for more about SDFD's homegrown data management solution.

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Resuscitation in the City

How technology helps maintain quality CPR in New York | **By John Freese, MD**

It's been more than 50 years since the first report of successful resuscitation using "closed chest massage." In describing the early success of this thing called cardiopulmonary resuscitation (CPR), the authors noted that "anyone anywhere can now initiate cardiac resuscitative procedures. All that is needed are two hands."[1]

Little has changed with regard to CPR technique in the past half century, but our understanding of the importance of quality CPR has taken center stage in recent years. Beginning with the "push hard, push fast" approach in the 2005 American Heart Association (AHA) Guidelines for CPR and continuing with such new areas of emphasis as the compressions, airway, breathing (CAB) approach to initial resuscitation described in the 2010 Guidelines, it seems we're beginning to appreciate the link between quality CPR and survival. Now the challenge becomes finding ways to ensure that such quality is provided during every resuscitation.

PHOTO COURTESY JOHN FREESE

Compressions might be the most important, and difficult, part of resuscitation.

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Learn more about quality CPR in "CPR Performance Counts" at **jems.com/special/cpr-december-2010** and watch "CPR Quality Improves Survival" at **jems.com/webcasts**.

Scope of the Problem

Only a few months before the release of the 2005 Guidelines, a landmark study published in *JAMA* sought to describe the performance of CPR in the out-of-hospital setting in three major European cities.[2] They did so after providing updated ACLS training for all the providers and informing them that their CPR performance was the subject of the study. This made its results all the more remarkable.

Very few patients received CPR that met the standard of care at the time. The 2000 Guidelines called for a specific target rate of 100 compressions per minute. The compression rate during CPR typically exceeded 120 compressions per minute, and no compressions were being performed nearly half of the time. These factors combined to yield a net compression rate of just 64 compressions per minute.

Even the compressions that were delivered were of questionable quality. More than 60% of the compressions provided were too shallow. And when you combine adequate depth with complete chest-wall recoil, barely one in four compressions met this definition.

Merging all this information together, despite the fact that providers had just been retrained in standard resuscitation practices and knew that their CPR was being measured, the net result was that patients received adequate chest compressions at a rate of not even 18 per minute. You can imagine what their CPR performance might have been when more removed from their training and without the knowledge that their CPR was being monitored. Both of these were likely the case for most of us in the field … until now.

Defining Quality CPR

"All that is needed are two hands." Seemingly an oversimplification, this remains true to a great degree today. Mechanical CPR devices currently available in the U.S. haven't been proven to work better than manual CPR. If performing CPR were simple, however, its delivery would be much better than what we've seen in studies, such as the one we just described—or what many of us have witnessed in real life. Put simply, if it's to make a difference, quality CPR requires attention to the details.

Rendering effective chest compressions involves the optimal performance of five key aspects: ensuring the correct compression rate, allowing for complete chest-wall recoil, pressing to the correct depth, minimizing interruptions and maintaining an appropriate duty cycle. Let's take a moment to look at each of these facets of quality compressions.

Not too fast, not too slow, but just right: Just right seems easy enough to define. We simply need to find a rate that achieves the best possible forward flow of blood while allowing the heart to fill between compressions. Too fast and the heart won't fill sufficiently, and there will be no blood to move forward. Too slow and the heart will fill but won't move that blood sufficiently to maintain effective circulation. So we need a rate that's just right.

Over the past two decades, numerous studies have sought to define the correct rate for chest compressions during CPR. The worksheets that review these studies and form the basis of the 2010 AHA Guidelines support the recommendation that compressions be delivered at a rate of "at least 100/minute."[3] But they also support the concept that compressions can be too fast and probably shouldn't exceed 120 per minute. And so our "just right" rate falls within that range of 100–120 compressions per minute.

Don't lean on the chest, just press on it: Remember that generating blood flow during CPR requires both compression and relaxation of the chest wall. It's during this latter phase, as a result of the slightly negative resting intrathoracic pressure, that blood is pulled back into the chest, filling the heart prior to the next compression.

It turns out that even the slightest bit of leaning on the chest between compressions can result in positive pressures that eliminate this natural "pull." To put it in perspective, keep in mind that the negative intrathoracic pressure at rest is only ~4 cm H_2O. And although this may not mean much, consider that each of us usually generates nearly 20 times that amount of pressure in our abdomen when we urinate. So it is, in fact, a miniscule amount of pressure—any leaning on the chest—that will prevent chest-wall recoil, eliminate that negative resting pressure and prevent blood return to the chest. We have to allow the chest wall to fully recoil after each compression.

Just deep enough: Ensuring the correct compression depth is difficult, as the *JAMA* study mentioned above highlights with more than half the compressions failing to do so. And similar to compression rate, it's important to deliver compressions that are neither too deep nor too shallow. Compressions that are too deep increase the risk of injury (e.g., rib fractures, pneuomothorax, liver or splenic lacerations), and compressions that are too shallow will result in inadequate blood flow.

The 2010 AHA Guidelines recommend that compressions be delivered at a depth of "at least 2 inches." And reviewing the aforementioned worksheets, it's clear that the depth should probably not exceed 2.5 inches.

Don't stop: Only half of the resuscitation time in the *JAMA* study was spent actually performing compressions, and the reasons for this are all too common.

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Get the EMS implications of the 2010 AHA Guidelines for CPR at **jems.com/special/evolution-resuscitation**.

As was likely the cause in that study, compressions are frequently "held" for airway management, pulse checks, rhythm interpretation and patient movement, as well as to change provider roles, charge the defibrillator and defibrillate. But we know that interruption of chest compressions reduces perfusion and survival.[4,5] This means we must limit the interruption of chest compressions, ideally to no more than 10 seconds.

One and two and … : The use of a cadence like this isn't coincidental. It accomplishes an important final goal of delivering chest compressions with the appropriate rhythm, maintaining the appropriate duty cycle, which is the percentage of time spent pressing downward during each compression. Said another way, it's the percentage of time you spend applying pressure to the chest in order to deliver the compressions. Ideally that percentage will fall between 40–50% of the compression time, and the use of a cadence (out loud or in your head) will help achieve that percentage. However, many providers might not need the cadence because delivering 100–120 compressions per minute actually produces a natural duty cycle of ~50%. So attention to one aspect of compressions (rate) may actually help to define quality in this area as well.

Bringing It All Together

It turns out that you *do* need just "two hands" to deliver effective compressions and to meet the recommendations set forth in the 2010 AHA Guidelines. These two hands must provide compressions at an appropriate rate, allow for complete chest-wall recoil, deliver compressions of sufficient depth, not stop for more than 10 seconds at a time and maintain a rhythm that ensures the ideal duty cycle. And knowing how hard it can be to get all of those things right, we need to look for a way to measure our performance and improve on it.

Reality (Quality) Check

Chest compressions may actually be the most difficult part of resuscitation. They require attention to all the details described above, and they're essential for maintaining circulation. Without them, the rest of the resuscitation becomes pointless. But most providers have difficulty achieving those goals, as described in the *JAMA* article.

Here's where two other important recommendations from the 2010 AHA Guidelines come into play—quality improvement and the potential benefits of real-time CPR prompting and feedback. In fact, it was recognition of these important items that contributed to the decision by the Fire Department of New York (FDNY) to adopt a new ALS monitor—the Philips HeartStart MRx and its Q-CPR technology.

Inherent to efforts to improve on the quality of the CPR being delivered within a system is the ability to accurately measure and review the various aspects of the chest compressions described above. Via the HeartStart MRx, its Q-CPR technology and the Event Review Pro software, the FDNY is now able to review all these compression parameters for every resuscitation in which our paramedics are involved.

Looking at the resuscitation data after the event is important, but perhaps an even more valuable tool is the ability to measure the CPR performance in real time, to provide feedback to the providers and to guide their resuscitation efforts. And although the AHA Guidelines appropriately note that "there are no studies to date that demonstrate a significant improvement in patient survival related to the use of CPR feedback devices during actual cardiac arrest events … real-time CPR feedback technology, such as visual and auditory prompting devices, can improve the quality of CPR."

2010 Guidelines & the FDNY

During the past several years, the New York City 9-1-1 system has implemented a number of initiatives to improve cardiac arrest survival throughout the five boroughs. The result of these changes and initiatives has been a significant increase in the number of patients who have survived following out-of-hospital cardiac arrest.

The most recent of these initiatives was the decision to introduce the Philips HeartStart MRx with the Q-CPR feature. We believed this technology would provide us with the data necessary to appropriately oversee the resuscitations by our providers, deliver real-time feedback to those providers to optimize each resuscitation effort and collectively develop a data set that would allow us to define CPR benchmarks for a "quality" resuscitation effort.

Quality Improvement Efforts

In my opinion, one of the most impressive parts of the 2010 AHA Guidelines was the specific mention of the need for quality improvement measures. "This process of quality improvement consists of … (1) systematic evaluation of resuscitation care and outcome, (2) benchmarking with stakeholder feedback, and (3) strategic efforts to address identified deficiencies."

As a result of the introduction of the Philips MRx within the FDNY, combined with our interest in improving cardiac arrest outcomes, these principles are becoming part of our ongoing quality assurance (QA) and quality improvement (QI) efforts.

In New York City, cardiac arrest patients are transported only to cardiac arrest centers, which are hospitals that have partnered with the FDNY to provide therapeutic hypothermia and are required to provide outcomes and other data points for all cardiac arrest patients. This data is added to prehospital data and can now be combined with the CPR performance data derived from the Q-CPR feature. This master data set will allow us to analyze the various aspects of CPR performance to establish benchmarks that reflect "quality CPR" and that are defined by their likelihood to improve cardiac arrest outcomes. We will then be able to measure performance during each resuscitation against these benchmarks.

This has been done by others in other systems. In 2010, Ahamed H. Idris, MD, and his Resuscitation Outcome Consortium (ROC) colleagues reported that a 60% flow time should be considered a minimum standard for CPR performance to improve survival.[3] We look forward to validating such statements and hope to address other aspects of CPR performance, such as compression depth, compression rate, duty cycle, incomplete chest-wall recoil, and CPR pauses before and after defibrillation. All of these are measured by the MRx and reported for each resuscitation in the Q-CPR report. The Q-CPR data also allows for close attention to the details of the resuscitation by providing a large data set for every 30-second interval. Interruptions that result from airway management, patient movement and rhythm check can be identified and used to discuss the resuscitation with the providers involved as part of a thorough QA review.

Finally, we plan to address the issue of deficiencies and successes by providing these reports to the field providers, including the EMTs, paramedics, firefighters and EMS officers. Because this data is aggregated from the entire resuscitation, it won't identify specific individuals or times in which less-effective CPR was delivered. But we believe that it will help reinforce the concept of the resuscitation team by making all the providers on the scene responsible for the overall quality of the CPR being provided during the resuscitation.

Summary

Central to any effective resuscitation is the delivery of quality CPR, including adequate rate, depth, chest-wall recoil, duty cycle and limited interruptions. Technologies, such as the Philips MRx with Q-CPR, allow for both real-time feedback to the providers and post-hoc QA and QI efforts, which are central to overseeing a resuscitation system. This dual approach to resuscitation oversight was one of the reasons that the FDNY chose to implement this device this past year. And these types of technologies mean any EMS system can implement similar oversight mechanisms to help ensure the best possible care for their patients. After all, that report from more than 50 years ago appears to have been correct when it stated, "All that is needed is two hands."[2] Or perhaps two hands and a way to make sure those hands do what they're supposed to do. ■

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Chilled to the Bone

New study to evaluate hypothermia for STEMI patients | **By Cynthia Kincaid**

Hypothermia has been gaining steady ground as a standard of care for cardiac arrest patients. A new clinical study in Europe being sponsored by Philips Healthcare is taking a look at rapidly induced hypothermia by infusion of cold saline and endovascular cooling before reperfusion in patients suffering ST-elevated myocardial infarction (STEMI). It is hoped the study will determine whether hypothermia can make an even bigger difference in reducing heart damage in these patients.

"STEMIs are large heart attacks where a lot of heart tissue is at risk for permanent damage, which can lead to subsequent heart attacks, congestive heart failure and other comorbidities," says Brad Klos, vice president of marketing for Philips Healthcare's InnerCool business unit. "If you can prevent this myocardial damage, you will have a stronger, healthier heart that can possibly lead to less heart-related issues in the future." The new study will concentrate on what Klos calls "the next frontier" for hypothermia, which is to preserve myocardium in the heart.

Study Parameters

The CHILL-MI trial started in June and is being led by Professor David Erlinge, principal investigator and head of the department of cardiology at Lund University Hospital in Sweden. It's anticipated that the study will take about a year to enroll 120 patients at 10 centers in four countries: Sweden, Denmark, Germany and Austria. Half of the patients in the study will be cooled in the experimental group, and the other half in the control group will not. In addition, cardiac MRIs will be used to measure heart damage. Results are expected sometime next year.

The EMS industry will be closely watching the trial's results. In past STEMI hypothermia studies, results were inconclusive. However, those studies revealed some promising insights. "There were subgroups within each study that showed patients whose core body temperature was below 35° Celsius at the time a balloon angioplasty was done saw a significant reduction in heart damage," says Klos.

Deepak L. Bhatt, MD, MPH, a researcher and chief of cardiology at VA Boston Healthcare System, acknowledges the provocative data coming out of hypothermia studies and notes a range of uses with respect to stroke, cardiac arrest and STEMI. But he stresses the need for clinical proof.

"Whether hypothermia works in preserving heart muscle seems quite logical, but the only way to know for sure is to do a clinical study," he says. "Things that have been shown to prevent heart attacks, or reduce the size of heart attacks or myocardial infarctions, that have been promising in animal models or small

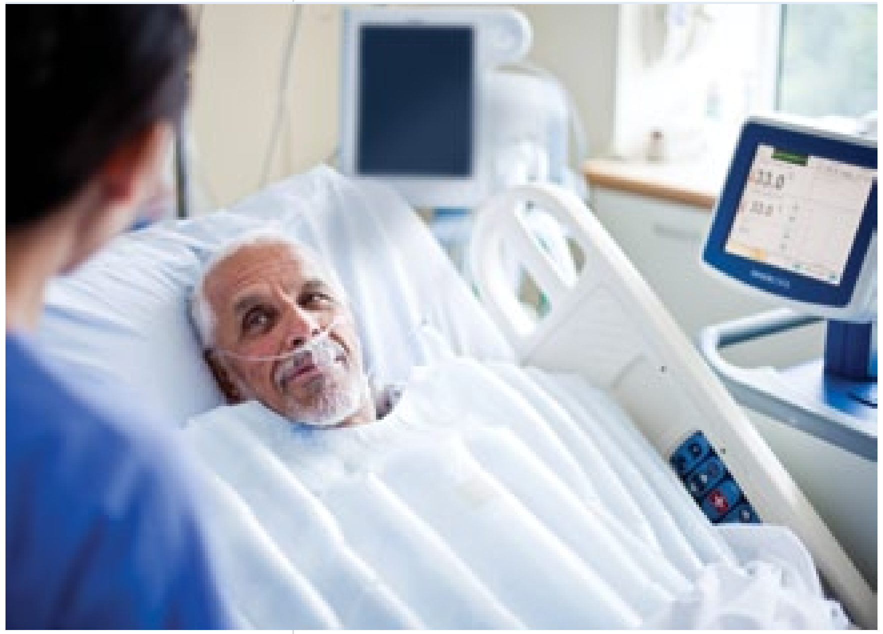

PHOTO INNERCOOL

A new study, called CHILL-MI, will look at hypothermia's effect on reducing heart damage in STEMI patients.

human studies, don't always pan out in large human studies, so we need to see what the data from CHILL-MI show."

One of the challenges in this study, and indeed in treating STEMI patients with hypothermia, is the "awake" factor. "The challenges in cooling an awake or conscious patient versus a paralyzed patient are quite different," says Klos. "Surface cooling systems induce shivering quickly in conscious patients and can't provide the fast cooling required to cool STEMI patients prior to angioplasty. Most STEMI patients, unlike cardiac arrest patients, are not intubated and, therefore, cannot be paralyzed."

Klos adds that time is another factor. STEMI patients in the CHILL-MI trial are cooled through endovascular means for only one hour. Most cardiac arrest cooling protocols require 24 hours of cooling. The CHILL-MI trial is addressing reperfusion injury in the heart unlike cardiac arrest patients where the focus is on reperfusion injury in the brain.

But the cooling is impactful. "Previous human studies, animal studies and a recently published pilot study called RapidMI-ICE have shown that if STEMI patients can be cooled to less than 35° Celsius before the angioplasty, 40% of the heart muscle at risk can be salvaged, which is a significant amount," Klos says. "If the patients are not at this temperature or lower, we are not seeing this level of reduction in heart tissue damage."

Hopeful Signs

Because of the many lifesaving features of hypothermic cooling for cardiac arrest patients, the U.S. has seen a significant uptick in this therapy in the past few years with EMS agencies starting the cooling process in the field. Many hospitals are now using hypothermia in their facilities for cardiac arrest patients. But more needs to be done in hypothermia with STEMI patients.

Bhatt acknowledges that hypothermia has had a somewhat checkered past because of the level of complexity of heart attack treatment. "Important factors are identifying and opening blocked arteries, which needs to be done quickly—in less than 90 minutes. Initiating hypothermia too late in that cycle will probably not yield much benefit because once the artery is open, reperfusion injury can occur," he said. Many drugs have attempted to reduce this injury, but none have yet been successful, so a major issue with hypothermia is making sure the procedure gets initiated in a timely way. "Without doing that, I think the chance of it succeeding is much more slim," says Bhatt.

> 'Whether hypothermia works in preserving heart muscle seems quite logical, but the only way to know for sure is to do a clinical study.' —Deepak L. Bhatt, MD, MPH

Getting personnel properly trained and in place to treat the patient adds another level of complexity to the process. "You don't want to delay the primary therapy for any add-on therapies and certainly for experimental therapies as they are being evaluated, so for ongoing and future trials of hypothermia it will be important that any incremental delay not be more than just a few minutes," Bhatt says. "These will be factors that the CHILL-MI investigators will have thought out."

Bhatt stresses, however, that if the data from this study are strong, and there's a significant reduction in the amount of heart muscle damage using hypothermia, then the treatment should be used, "even if it adds a bit of complexity to the overall procedure and care of the patient," he says. "I don't think it would be an inordinate amount of complexity; however, it wouldn't be a trivial add-on either."

Continuity of care will also be a factor in future successful treatment of hypothermia. EMS personnel, emergency department physicians, the cardiac cath lab, the intensive care unit and the nursing staff all currently care for cardiac arrest patients being treated with hypothermia. "You've got to get all these specialties on the same page," says Klos. "It's hard to get doctors within one specialty to agree, let alone three specialties and nursing as well." Patient treatment in the CHILL-MI trial will occur in the cath lab, which means the decision to treat will rest primarily with the interventional cardiologist.

"Whenever you are tinkering with the care of heart attack patients, it involves system-level approaches and figuring out who is going to initiate hypothermia," Klos says. "There are potential challenges. But if the data are strong [in this study], I don't think the challenges will be viewed as a major obstacle for adoption. If the data aren't strong, the point is moot."

GO Online

Read why the researchers of the CHILL-MI study feel the U.S. environment for ST-evaluation trials is hurting American patients at **jems.com/special-2011-course-of-care**.

Summary

Clearly, a need exists to continue to improve heart attack therapies, given the 500,000 or so patients who suffer a myocardial infarction or STEMI in the U.S. every year. Hypothermia is showing itself to be an important contributor in that regard.

Bhatt acknowledges that hypothermia has resulted in a lot of hope and disappointment, especially in finding the Holy Grail combination of effective drug therapies and cooling processes. But he notes several reasons to be optimistic. "Scientifically, this approach seems very sound, with a fair amount of clinical data supporting it," he says. "Finding a drug that reduces heart attack size in patients undergoing angioplasty and stenting procedures for heart attacks, while cooling them down, seems like it should be complementary. If that potential is realized, it would be a major event."

And this new study just may reveal that potential. ■

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Second-by-Second Data

Analysis is only a few clicks away in Montgomery County, Texas

By Allen J. Sims, EMT-P, & Kelly Curry, RN, EMT-P

How important is data to the success of your system and the outcome of the patient care you deliver? At Montgomery County (Texas) Hospital District (MCHD), we consider data one of our most valuable resources. Being able to measure something gives us the ability to understand and manage it. Without data, we're in the dark about our performance, which means we can't improve it.

So if having data is so important, how much do you need to make informed clinical decisions? You need exactly as much data as required to accurately reflect reality of what you're looking at. When changes occur slowly, the data frequency requirement is low—and vice versa.

The right measure of performance is critical for balancing the amount of data with the process you're measuring. EMS examples of appropriate matching include measuring dispatch process times in seconds, vital signs every few minutes and hospital length of stay in days. Using the wrong unit of measure could lead to an inability to draw meaningful results.

With the most critical of patients, most notably those in whom we're immediately affecting pulse, respirations and blood pressure, how much data is needed? Many EMS protocols call for vital signs every five minutes in the sickest of patients. Although this may have been acceptable in the past, we believe the bar has been raised.

MCHD records, trends and analyzes every second of vital sign data to properly assess vital human physiologic parameters. Only through the retrospective review of this data have we come to fully understand how the care we provide affects patients; the National Association of EMS Physicians (NAEMSP) agrees.[1]

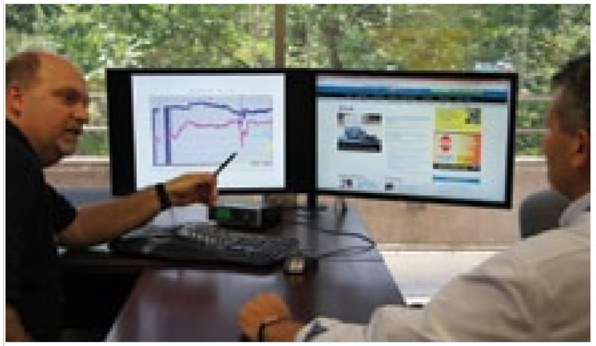


PHOTO MONTGOMERY COUNTY HOSPITAL DISTRICT

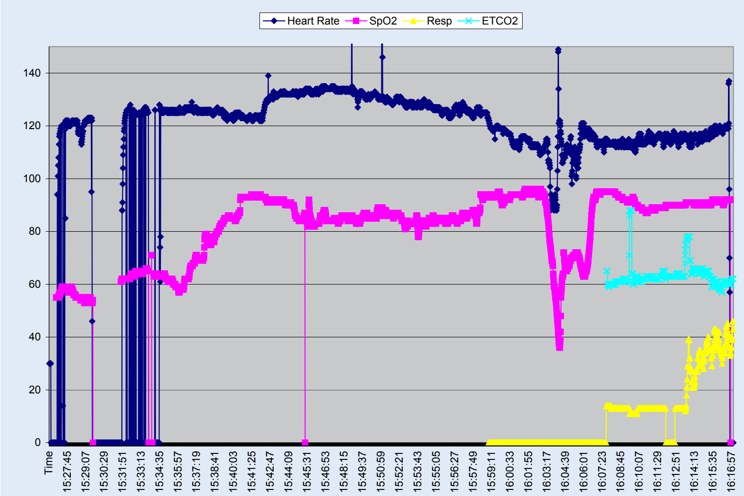
Field providers and administrators routinely use second-by-second vital signs to assess physiologic parameters.

How we got there is a bit of a journey, so let us explain.

How It Started

In 2003, researchers in San Diego began presenting and publishing the results of their landmark trial of paramedic rapid sequence intubation (RSI) in patients with severe traumatic brain injury. Although we, like many other agencies, were surprised that the study concluded, "paramedic RSI protocols to facilitate intubation of head-injured patients were associated with an increase in mortality and a decrease in good outcomes," we were fascinated by the details.[2]

Figure 1: Before Six Sigma



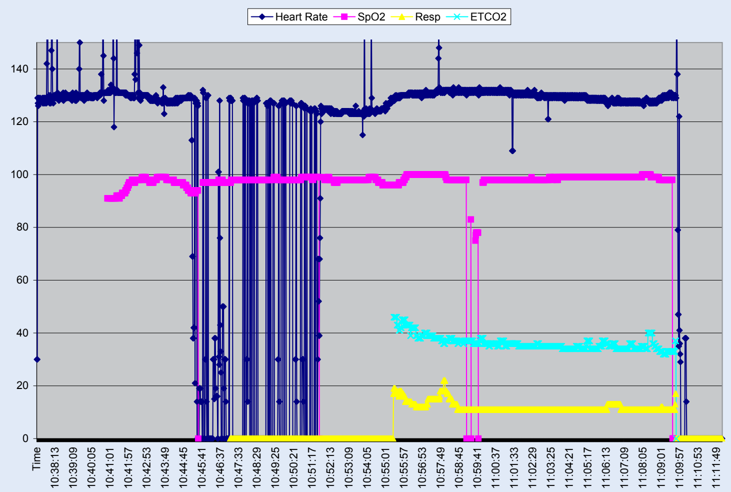
A typical case with initial hypoxia partially resolved by oxygen administration, then multiple intubation attempts with resulting hypoxia with SpO_2 falling from 94 to 37. Ventilator use is apparent until arrival at the hospital, where profound hyperventilation is obvious with respiratory rates climbing above 40 per minute.

We had an opportunity to see James V. Dunford, MD, FACEP, present on the researchers' findings, where Dunford demonstrated that there were events happening that hadn't been previously reported. Dunford used recordings of RSI cases containing high-resolution data to show transient periods of hypoxia occurring during intubation.

These hypoxic episodes were going unnoticed by the paramedics doing the intubation. Traditional, "once every five minutes" vital signs were missing these episodes as well. During debriefing sessions immediately after the cases, paramedics consistently described the intubations as easy, and none noted the hypoxia occurring.

Our immediate reaction to learning

Figure 2: **After Six Sigma**



After implementation of the Six Sigma feedback process, more cases looked like this—with no hypoxia during intubation, with well-controlled ventilations and $EtCO_2$.

about this situation was to ask ourselves, "Do we have that problem in our service?" To find out, we had to ask whether we had the data and whether we could measure similar cases in the same way. Fortunately, and unfortunately, the answer to both questions was "yes."

The monitors that we used at the time recorded discrete readings of heart rate, SpO_2, respirations and $EtCO_2$ every second. Through a somewhat cumbersome and time-consuming process, we were able to create graphs that showed us this critical trend data at a one-second sample rate. We used the published definitions and methodology as our standard to benchmark our process.

After developing a process to create graphs of this second-by-second trend data, we were able to identify that we did indeed have a similar issue to the one uncovered in San Diego. More than 50% of our RSI patients were experiencing hypoxic episodes, with duration and depth at comparable rates to those published in their series of articles on the subject.[2–4] A finding that should concern every EMS physician was that even though our number of paramedics was smaller and our intubation success rate higher, the extent of the problem was eerily similar (see Figure 1, p. 11).

By this point, Dunford and Daniel P. Davis, MD, had also shown that hyperventilation was perhaps an even larger issue than hypoxia. We quickly confirmed once again that the ability to measure our performance in this newfound way showed us a problem we had that we weren't aware of. Our paramedics and firefighters were hyperventilating our patients. The muscle memory of most providers caused them to squeeze the BVM up to 30 times per minute.

Immediately after discovering the problem, we started a journey toward improvement. It wasn't easy because our first, second and even third attempts failed. We initially did what we had been trained to do, and that meant looking away from individual providers as the root cause of the problem. We focused tremendous energy on training, equipment and protocol issues. We had some sort of airway training at every quarterly mandatory training session for a long time.

We continued to show graphs of hypoxia and hyperventilation. Crews would ask, "Was that one of my patients?" We didn't want to embarrass anyone by singling them out as having a problem because it was happening across the system. The effect was that everyone reached the same conclusion: Everyone else had a problem, not them.

They continued to see graphs of different situations, and although they found them interesting and informative, no one really changed their behavior. In our attempt to address this as a system issue, we weren't identifying specifics. This meant our message wasn't effective, and we weren't learning from our mistakes. It took a while, but we finally found a process to improve the rates of hypoxia and hyperventilation.

A New Workflow

Ultimately, we had to find a way to use this information to get better. We looked at how the best agencies enhanced their processes, and we formally adopted Six Sigma as our improvement methodology. Using this tried-and-true, quality process, we were able to develop a process that ultimately proved effective.

We created a workflow to make and analyze the graphical representation of the one-second trend data as soon as possible after each critical patient care encounter. Our goal after that was to get this information in front of the staff that had cared for the patient by their next shift. Our plan was to share the right information at the right time with the right people. This would allow us to turn our data into information, so that the staff could gain knowledge about their performance.

It worked. This knowledge, when provided to the staff immediately after a critical airway incident, allowed them to gain wisdom about the effect of their interventions. After learning how their decisions and actions affected the patient, crews changed their treatment plans on the next call to better manage the situation. They finally put those lessons we'd been providing during that airway continuing education to use. Such things as "first attempt equals best attempt," bag-valve mask (BVM) application prior to intubation, gum elastic bougie use and getting the patient off of the floor to intubate finally started to pay off (see Figure 2, above).

After literally years of minimal improvement, we developed a method to drastically reduce the hypoxia and hyperventilation associated with airway procedures. It was time to celebrate!

We learned many lessons from this technique. By analyzing the cases in such high resolution, we were able to identify additional trends and uncover multiple other details about our care.

We learned about the impatience of paramedics and how they were quick to attempt intubation when SpO_2 didn't immediately rise with BVM ventilations. We were able to show how it can take 45 seconds or longer to see increased oxygenation using a fingertip SpO_2 sensor.

Another critical improvement came when our paramedics witnessed clear feedback that use of a transport ventilator allowed much more consistent control of respirations. This, in turn, allowed improved management of $EtCO_2$. We also witnessed the hyperdynamic phase following cardiac arrest, as well as subsequent cardiovascular collapse—something we had read about but didn't fully appreciate until seeing the phenomenon in our patients (go online for Figure 3).

Beyond the Noise

One of the most interesting cases we identified involved the successful decompression of a tension pneumothorax. The particular hemodynamic footprint of this case is unique: It includes tachycardia, low amplitude ECG, low SpO_2, tachypnea and unexpectedly *high* $EtCO_2$ (more than 99 mgHg). Go online for Figure 4, which clearly illustrates the dramatic improvement of all physiologic parameters following chest decompression.

One thing you'll note is the frequency of the data points can sometimes give a noisy or messy appearance. We initially considered trying to smooth these lines out, or somehow reduce the number of readings, thereby lowering the resolution of the information. Thankfully, we decided early on not to reduce or filter that data in any way. In much the same way that researchers didn't initially realize that aberrant readings in ozone levels were telling them about a hole in the ozone layer of the atmosphere, we found that there's information within this noise.

The fact that some lines appear thick or fuzzy shows us there's inherent irregularity in the parameter being measured. Rapidly fluctuating readings indicate the device may be searching for an accurate reading and that the data may not be 100% accurate. Our ultimate conclusion is clear: More data equals higher resolution, which equals more information, which equals more learning, ultimately equaling improved patient care.

The NAEMSP stated in its 2003 Position Paper on Uniform Reporting of Data from Out of Hospital Airway Management that oxygen saturation should be recorded within five minutes before intubation and again within five minutes after intubation. That could leave up to a 10-minute gap in what happened *during* intubation. Now, combining information from San Diego with our own experience, we know that what happens during these critical few minutes is of the utmost importance.

The NAEMSP discusses drug-assisted intubation (DAI) in its most recent position paper. It now states in Drug-Assisted Intubation in the Prehospital Setting Position that all agencies should have "resources for continuous monitoring and recording of heart rate and rhythm, oxygen saturation and $EtCO_2$ before, during, and after DAI." This is exactly what we're demonstrating here. To be considered state of the art, you must have and use this data.

If you publish research on airway management, your data is incomplete if you don't demonstrate exactly what's happening during intubation attempts. How many patients experience hypoxia, to what extent and for how long? How many are hyperventilated and for how long? At MCHD, we believe this standard should apply not only to EMS agencies, but also hospital emergency department quality and research efforts as well.

It should come as no surprise that when the time came to replace our cardiac monitors, one of our essential requirements was the ability to monitor and record data at one-second intervals.

At the time, only one major monitor manufacturer included this feature on its devices. However, once we explained our desire for this feature and demonstrated the value of this data, Philips was convinced and changed the software in its device. The company's willingness to make this change, along with our staff's positive field trial of the Philips HeartStart MRx, made it our winning bidder. In March 2011, MCHD became the first agency to record and analyze one-second data using a Philips device.

Summary

Today, using the Philips monitors and software provided by ESO Solutions, we're only a few clicks and seconds away from graphical analysis of a wide variety of cases.

One-second trend analysis should be an industry standard that's available to every provider on every call, directly from the monitor. "Vital signs trend" analysis in real time should be available during the care of the patient and printed, analyzed and discussed by the providers after each call. ■

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Visit **jems.com/special-2011-course-of-care** for a video of this process.

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Surviving SCA at Sky Harbor

Airport AED program boasts 75% survival rates | By Richard Huff, EMT-B

Phoenix Sky Harbor International Airport may be one of the best public places in the country to survive a sudden cardiac arrest (SCA). Indeed, thanks to an innovative public AED program initiated 10 years ago at the airport, the rate of people surviving witnessed cardiac arrests and being released from a hospital neurologically intact is a stunning 75%.

"If you want to have your heart stop beating, have it [occur] at the Phoenix Sky Harbor airport," says Debbie Thomas, RN, a paramedic training coordinator for the Phoenix Fire Department.

The pioneering public-access-defibrillation program in place at the airport was the brain child of Phoenix Fire Department EMS Medical Director John V. Gallagher, MD, FAAEM, FACEP, and Chief Bob Khan.

"The success rate has been astounding," Gallagher says, "greater than my highest expectations."

The program to outfit the airport with AEDs began in 2001 when Gallagher and Khan lobbied the Phoenix City Council to strategically place the devices throughout the city-owned facility. The airport was an ideal location because millions of people travel through there annually.

However, getting the program going took some work on the part of Gallagher and his team. "In the beginning there were some administrators at the airport who thought the liability of having AEDs out there would be too great," Gallagher says. "We found that to be totally not true."

Gallagher viewed the Sky Harbor International Airport as a small city—and one that could benefit from an intense AED and CPR training program. The airport, which sits on 3,000 acres, has three terminals. An estimated 100,000 passengers travel through the facility every day. Add to that another 125,000 of their friends, families and drivers, and employees, and you have one busy airport. In fact, Phoenix Sky Harbor International Airport had more than 38.5 million passengers in 2010, according to the city's aviation department.

The facility has its own police unit, a cadre of volunteers and fire department units staffed by paramedics. Add in bystanders willing to do CPR and use an AED, and the likelihood that some medical professionals would be passing through, and Sky Harbor seemed like a perfect incubator for the program.

The Inspiration

Gallagher got the inspiration for the Sky Harbor International Airport program after reading a study of AED usage for cardiac arrest patients in Nevada casinos conducted by Terence D. Valenzuela, MD, MPH.

Valenzuela's study, conducted in the late 1990s and described in the *New England Journal of Medicine* in 2001, tracked casino security guards who were trained to use AEDs. The guards observed nearly 150 cases of SCA and used AEDs on 105 that had ventricular fibrillation. More than half of those patients survived to hospital discharge.

AEDs are located throughout public places in Phoenix, including the airport, stadium, gyms and government offices.

Valenzuela maintained that if more AEDs were available and more non-medical personnel were trained to use them, an increased number of people would survive cardiac arrests.

"Both the size of the study and the clarity of its conclusions suggest an urgent, immediate course of action," Valenzuela noted in a prepared statement issued at the time of the casino study. "We all should work to ensure that each community has a targeted first responder defibrillator program that makes AEDs more easily and quickly available. AEDs should be as handy as fire extinguishers in all public places."

Valenzuela's research also found those who were defibrillated within three minutes had a 75% survival rate, while only about half of those who got it after three minutes survived.

Gallagher took Valenzuela's research to heart.

"I hoped we could get something close to the casino study," Gallagher says. "Something between 50% and 60% would have been a good result. This result [75%] is better than I could have expected."

Gallagher's research counts only SCAs witnessed on the ground in the airport, not those that happened on airplanes aloft that land there.

As in the casinos, the thinking at the Sky Harbor International Airport was that getting nonprofessional rescuers involved as the key first link in the chain of survival was critical to success. Even under the best circumstances, the response time of professional rescuers reduces the ability to successfully resuscitate SCA victims.

"We have an average response time of four to six minutes," says Thomas. "Hopefully that person is defibrillated before we get there."

Thomas says the push toward hands-only CPR also helps in getting people to assist when they might otherwise not.

"It's the early intervention that helps," she says.

> 'In the beginning there were some administrators at the airport who thought the liability of having AEDs out there would be too great. We found that to be totally not true.' —John V. Gallagher, MD, FAAEM, FACEP

Take Off

The program started with 55 AEDs at Sky Harbor. Today, 90 devices are strategically located throughout the facility. Each is mounted in a large, white box with a glass front and a heart with a lightning bolt through it. Each unit is only about a two-minute walk from the next.

Since the program started, 34 incidents of witnessed v-fib SCAs have happened at the airport, with 26 of those patients surviving and being released from the hospital without neurological deficits. There were two AED uses alone in April, according to Gallagher.

"All of our police officers there have been trained in CPR and how to use the AED," Gallagher says. "And the nice thing is, in all of the cardiac arrests that have been witnessed we've had bystander CPR100% of the time, and [they have] used the AED."

In each of the cases, the patient had an AED attached within four minutes of the arrest, according to Gallagher.

"The biggest part is the bystanders," he says. "Usually there are one or two healthcare providers around. Plus, the police officers and the aviation staff are trained."

At the airport alone, more than 2,000 people, some volunteers, have been trained to use the AEDs and perform CPR. In one save, an off-duty paramedic was standing in line behind one of the people who collapsed while suffering SCA. The paramedic and an emergency medicine resident started CPR on the patient, who was neurologically intact on discharge from the hospital.

Extending the Reach

Since the airport project started, the public access AED program has been extended to five public golf courses, as well as all city senior centers and office buildings.

The fire department has 350 Philips HeartStart AED units in service in Phoenix, counting those in the airport, public facilities and on-board fire apparatus and ambulances.

Members of the Phoenix Fire Department maintain the publicly mounted AEDs on a monthly basis. Some of those units, according to Gallagher, were put into service a decade ago and are still functional.

When an AED is used in the airport, Gallagher's team is notified and he tracks each patient. He has also personally interviewed all but one of the survivors since the program started.

Just a few months after one of the resuscitations in 2006, Gallagher was invited to the patient's birthday party. "They were all very grateful," Gallagher says. "Otherwise, they wouldn't be around."

When Gallagher recalls how he and Khan approached the Phoenix officials in 2001 to start the program, and how council members trusted him and Khan, he realizes the bet paid off with the successes they've produced.

"When I see these people, it's another person who is alive because of those efforts by the fire chief and others involved, and seeing that result is a tremendous personal satisfaction," Gallagher says. "The biggest thing is to see them interact with their families. Often they're going back to work, whatever it is, and there definitely is a significant reward."

Summary

The cost of the AED program and maintenance is covered as part of the Phoenix Fire Department's annual budget. The initial expense is about $2,000 per unit, but given that some have been in place for a decade already, Gallagher sees that as a small price over time.

"For each person we've saved, obviously, it's priceless," he says. "But it's an investment. If your city is looking to improve survival rates from cardiac arrests, it's worth it."

He also gets a level of personal satisfaction out of the program. "Personally," he says, "I see this as kind of the goal we should have for all of our cities."

Because of the Sky Harbor International Airport experience, Gallagher can't walk through another airport or public place without looking for the positioning of AEDs.

"I'm always looking," Gallagher says. "If someone goes down, I want to know where [the AEDs] are." ■

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Disclosure: **The author has reported no conflicts of interest with the sponsors of this supplement.**


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