The Art and Science of Resuscitation

A GUIDE TO IMPROVE COMMUNITY CARDIAC ARREST SURVIVAL

RESUSCITATION ACADEMY

FIRST EDITION
BROUGHT TO YOU BY
THE RESUSCITATION ACADEMY

The Art and Science of Resuscitation

A GUIDE TO IMPROVE COMMUNITY CARDIAC ARREST SURVIVAL

The Resuscitation Academy logo is symbolic in several ways. The red background depicts a heart, the four stars denote the original four links in the chain of survival (911, CPR, defibrillation, advanced cardiac life support), and the 10 branches in the tree of knowledge symbolize the 10 steps to improve survival.

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Preface

A Note from the Editors

Collectively the authors of this guide have over 300 years of experience treating and studying out-of-hospital cardiac arrest. Many directly supervise EMS services in Seattle and King County. We are lucky to work with them and consider each a remarkable colleague. Every program and new innovation we have instituted over the past decades has been a collaborative effort. And these efforts have paid off – survival has continued to rise such that it now consistently exceeds 50% for witnessed cases of ventricular fibrillation in Settle and King County.

Such survival is the result of hundreds of EMTs, paramedics, telecommunicators, and police officers – they comprise the front line that literally snatches life from the jaws of death. Your community can also achieve 50% survival. It won't happen overnight but with effort, buy-in, training, quality improvement, and leadership it will happen.

This guide describes the art and science behind the key interventions in cardiac arrest.

Since the time interval from collapse to the beginning of treatment is so critical, we focus on ways to start CPR as quickly as possible. Thus, we provide great detail about Telephone CPR (T-CPR – also called telecommunicator-CPR) and Rapid Dispatch programs. Speed is critical but quality is equally critical. Therefore, we also provide great detail about performing letter perfect CPR, namely High-Performance CPR (HP-CPR). This guide next covers defibrillation, including how to manage refractory and recurrent fibrillation. We then model the response to cardiac arrest to explain low, average, and high performing EMS systems. Last, we describe some practical ways to improve your system.

What we don't cover in any detail is advanced cardiac life support encompassing medications and advanced airways. These certainly are important and comprise a large body of knowledge in and of themselves. However, this guide focuses on the first 10 minutes or so of out-of-hospital cardiac arrest – a period when the challenge of resuscitation is largely won or lost. Emphasis is on bystanders and first responders including law enforcement officers and emergency medical personnel.

This guide directly stems from 12 years of involvement with the Resuscitation Academy (resuscitationacademy.org). If ever there is a nirvana of committed professionals, we have found it with the faculty, EMS personnel, research assistants, and the Resuscitation Academy staff.

The RA has blossomed in the past decade and pointed many communities in the direction of improved cardiac arrest survival. Our work is oriented at both the micro and macro levels of EMS. We constantly strive to assist other EMS agencies and we offer two Academies a year – at no cost to attendees thanks to generous support from our sponsors. We also work at the larger policy level. Nationally, our faculty played a large role in three important reports: The Institute of Medicine report on cardiac arrest, the AHA report on program and performance standards on T-CPR and the NHTSA report T-CPR and HP-CPR. Internationally, our faculty played large roles in the development of the Global Resuscitation Alliance.

This guide is evidence of our commitment to improving cardiac arrest survival. We want this guide to be informative as well as useful. For the science of each program (T-CPR, HP-CPR, rapid dispatch, and defibrillation) we briefly summarize what is known and provide references to key scientific articles. For the art of each program, the guide provides relevant performance standards and protocols issued by national organizations. We thank our colleagues who contributed to the authorship of this guide for their massive commitment to helping save lives.

We are fortunate for having been awarded numerous federal and other research grants over the past four decades. These have supported over twenty major research studies in cardiac arrest and emergency medical services in Seattle and King County. All have helped define and improve resuscitation science and practices.

We are deeply appreciative of the American Heart Association and Laerdal Medical who have partnered with the Resuscitation Academy to help spread our educational mission to improve cardiac arrest survival. Since 2018 RQI Partners (a collaboration of Laerdal and the AHA) has been a strong supporter of the Resuscitation Academy

Special Note about References

We did not wish to overwhelm the reader with references but rather selected key references for the science topics. Please note that the URL following each citation leads directly (assuming you are connected to the web) to the abstract or full text of the article.

A Word about the Resuscitation Academy

In 2008, faculty from the University of Washington along with leaders in King County EMS and Seattle Medic One formed the Resuscitation Academy. Its formative stimulus was the recognition of overall low cardiac arrest survival rates and the outrageous disparity in survival from community to community. Since the first class, over 1,500 EMS leaders from throughout the nation and world have attended the free two-day Academy held twice a year in Seattle. Each Academy is limited to 50 attendees, most of whom are EMS chiefs, EMS training officers, telecommunication center directors, and medical directors. All of us involved in the effort are pleased to see local Academies spread to over 25 other states. The Global Resuscitation Alliance began to help spread the message in other countries. So far 9 nations have conducted Resuscitation Academies. Most importantly, survival rates have increased among the various communities.

Cardiac arrest is a public health problem and we are committed to the public health model of education and service. In 2016 with support from Laerdal Medical and the American Heart Association we established the Resuscitation Academy Foundation with Ann Doll as the Executive Director. The Foundation allowed us to expand and ensure quality and consistent instruction. Collaborating with leading EMS program directors from throughout the world, we collectively established the Global Resuscitation Alliance in 2017.

This document comprises what we consider to be Core Material of the Resuscitation Academy. Along with 10 Steps to Improve Cardiac Arrest Survival, the Art and Science of Resuscitation is foundational material for improving cardiac arrest survival.

PREFACE

In Appreciation

We offer huge thanks to the following organizations and institutions who have supported us over the years, continue to support us, and allow us to provide the highest educational material at no cost - including free attendance at the Resuscitation Academy: University of Washington, King County Emergency Medical Services, Seattle Fire Department, Seattle Medic One, Medic One Foundation, Physio Foundation, Philips Medical, Stryker Corporation, Zoll Medical Corporation, Medtronic HeartRescue Program, Hillsdale Foundation, Laerdal Foundation for Acute Medicine, and American Heart Association.

Change Agents

One of the Resuscitation Academy's mantras is "It takes a system to save a victim." You, the readers of this guide, comprise the system as well as the agents to improve the system. It staggers the imagination when one considers the complexity and team of professionals responding to and treating cardiac arrest in the community. While the challenges are massive, the rewards are even more so.

QUESTIONS

A wise sage of resuscitation was asked how to improve resuscitation survival rates in her community. She replied: Ask yourself these 4 simple questions:

1. **If not me, who?**
2. **If not here, where?**
3. **If not now, when?**
4. **If not improved, why?**

We welcome feedback and/or questions. Write to Mickey Eisenberg: gingy@uw.edu

Introduction

Resuscitation is ultimately life affirming. It is an ennobling act that reveals much about our society's values – namely that human life has value.

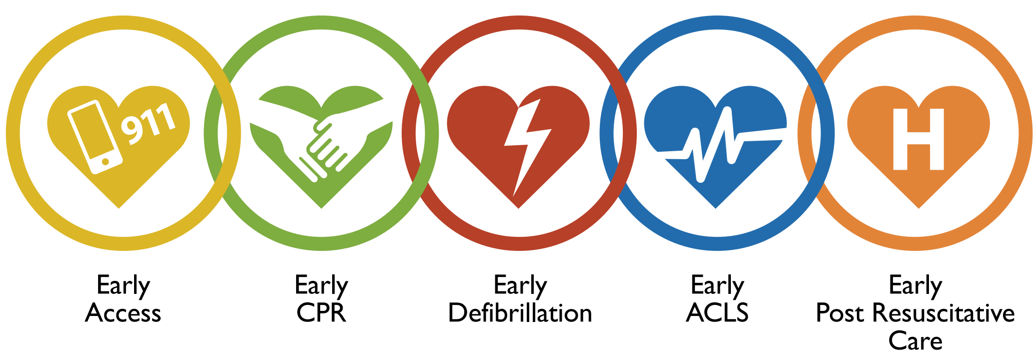
The past 50 years have seen considerable advances in the science of resuscitation. Defibrillation is now pretty straightforward, and professional CPR has become so good in the hands of well-trained responders that the dying process is virtually suspended and thus can provide time for other interventions to succeed (such as defibrillation, oxygenation of the heart and other organs). And lay CPR (as a result of telecommunicator assistance or from previous training) can double or triple the likelihood of survival compared to no CPR.

Yet over the course of 50 years we have not seen considerable advances in the art of CPR. What do we mean by the art of CPR? We refer to implementation and fidelity to the science of CPR. In other words, the science is only half the challenge – the other half is the art of ensuring that the science is implemented with high fidelity. The latter includes training and quality improvement, accountability, and leadership (both at the community level and at the agency level).

Chain of Survival – The Science

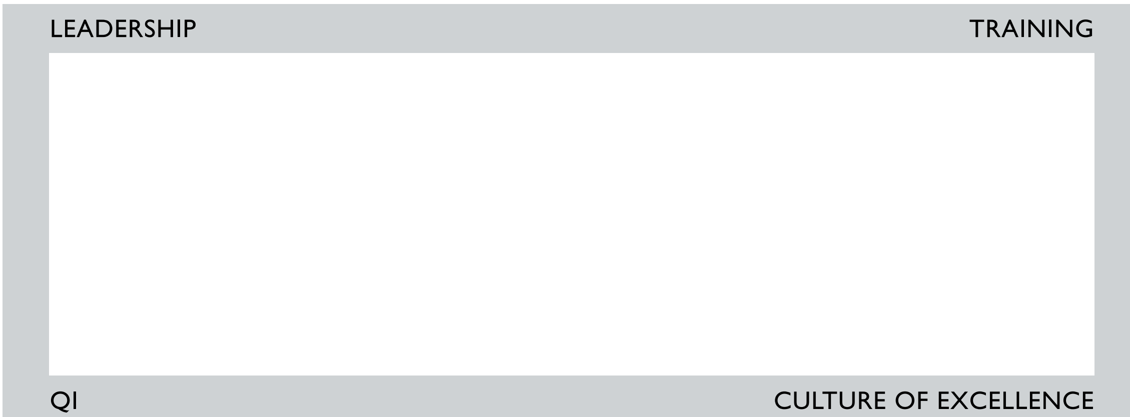
A graphical way to convey this concept of art and science is the chain of survival. The typical chain denotes the specific sequence of interventions in treating cardiac arrest. The metrics of each link are well defined and comprise the science of CPR.

But the various links in the chain of survival are unlikely to be effective unless they can be provided quickly and with fidelity to what that link is trying to achieve. As an example of achieving early CPR, many EMS telecommunication centers claim: "We have a telephone CPR program." But upon closer scrutiny, it is apparent many do not measure their performance, have no idea of how often instructions are provided or whether they are meeting performance standards, provide no feedback to the telecommunicators, and have little or no ongoing training. In short, they may have a "program" in T-CPR, but it is not very effective.



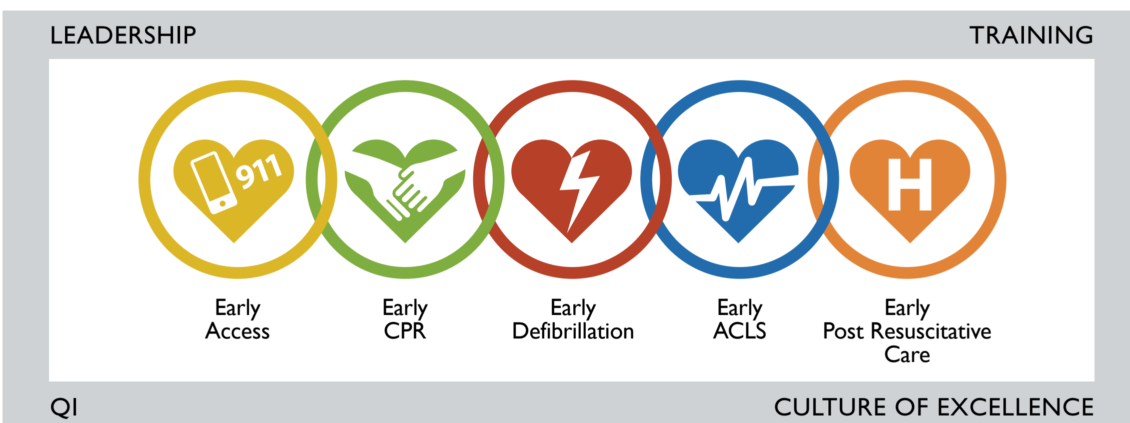
Frame of Survival – The Art

The frame of survival contains continuous quality improvement, training, leadership, and a culture of excellence. These qualities are more subjective compared to the metrics of the chain and may be thought of as the art. They are vital if each link will be provided properly.

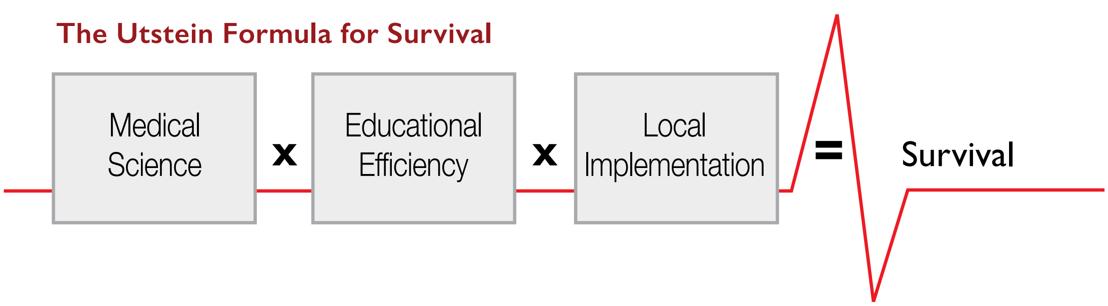


Chain and Frame Together

Together the chain and frame provide a complete picture of a high-functioning EMS program for the treatment of sudden cardiac arrest. Timely, high quality interventions are the secret to success.



The Utstein Formula for Survival



Another way to convey the interaction of art and science is with a simple formula (shown on the previous page).

High survival requires good performance in each of the three variables. Great science without great education and implementation can only achieve a modest survival rate. High performance in all three is required for high survival. Of the three elements we consider educational efficiency and local implementation to comprise the art of resuscitation. At the core of the art of resuscitation is ongoing quality improvement - perhaps the best tool to achieve educational efficiency and local implementation.

What this Guide Covers

This guide emphasizes the primary importance of T-CPR and HP-CPR and does not consider the role of advanced cardiac life support (ACLS) care. ACLS covers such topics as airway control and emergency medications. The exclusion is not to minimize the importance of medications and airway management but rather to stress that these interventions must be built on the solid foundation provided by HP-CPR in order to be effective. Thus, the goal here is to emphasize the role of telecommunicators, EMS and other first responders. The skills they bring to a resuscitation are foundational and critical. Without rapid and quality interventions by telecommunicators, bystanders, initial EMS providers and other responders there is little likelihood that paramedics or doctors with their quiver loaded with advanced cardiac life support measures can make much of a difference in the outcome. The battle to snatch life from the jaws of death is won or lost in the first few minutes following a patient's collapse.

There is another reason paramedic procedures, such as advanced airway and pharmacologic management, are not emphasized. First, they are more specialized skills and require considerably more training than EMTs or first responders typically have and are outside the EMT scope of practice, and second, there have not been many dramatic improvements in airway or pharmacological care for many decades. While the past 25 years have seen T-CPR and HP-CPR catalyze resuscitation, there have not been equally dramatic improvements in airway or pharmacologic therapy. There is one exception involving laryngeal mask airways (LMAs), a procedure slowly entering the realm of EMT and first responders. The safety and utility of LMAs are still to be defined.

Emphasis on Ventricular Fibrillation (VF)

This guide emphasizes treatment for VF. VF is the most survivable rhythm associated with sudden cardiac arrest. Among witnessed cardiac arrest events, VF is also the most common rhythm. Some communities can achieve 60% or higher rates of survival from VF. Asystole (flat line rhythm) has almost no chance of survival and the rhythm of pulseless electrical activity has a small but appreciable likelihood of survival – in some communities as high as 15%. Pulseless ventricular tachycardia represents only 1% of cardiac arrests and, since the therapy is identical to that of VF, is lumped together with VF.

The Utstein Metric

During the early years of emergency medical services, researchers recognized the need for a common metric to compare cardiac arrest survival rates across different systems. In other words, it was necessary to compare apples to apples. In 1989 an international group of researchers and EMS leaders convened in the Utstein Abbey located near Stavanger, Norway. The conference unanimously recommended that witnessed cases of VF be the standard metric for reporting community survival rates. The reasoning was simply that in order to better understand differences in survival rates, there had to be a universal metric of what defined a case. This universal metric came to be known as the Utstein metric.

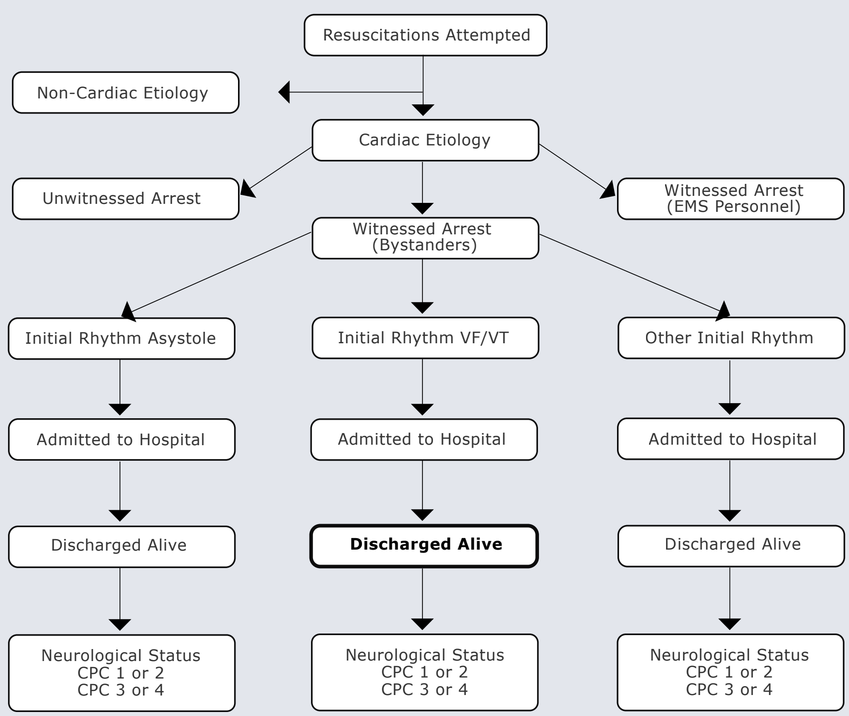

UTSTEIN ABBEY, NORWAY

Recommended guidelines for uniform reporting of data from out-of-hospital cardiac arrest: the Utstein Style. Cummins RO, Chamberlain DA, Abramson NS, Allen M, Baskett PJ, Becker L, Bossaert L, Delooz HH, Dick WF, Eisenberg MS, et al; Circulation.1991;84:960-75.Perkins GD, Jacobs IG, Nadkarni VM, et al; Circulation. 2015;132:1286-300.
➔ **https://www.ahajournals.org/doi/10.1161/01.CIR.84.2.960**

Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest: Perkins GD, Jacobs IG, Nadkarni VM, Berg RA et al. Circulation. 2015 Sep 29;132(13):1286-300
➔ **https://www.ahajournals.org/doi/epub/10.1161/CIR.0000000000000144**

Utstein Survival Report

The figure to the right shows the key elements of the Utstein report. The main metric is the discharged alive box in the center column. This number divided by the "initial rhythm VF/VT" gives the community survival rate from witnessed cardiac arrests in ventricular fibrillation. This survival rate is considered the Utstein survival rate, also referred to as the Utstein metric.



Chapter 1: Overview

Emergency Medical Services 50 years ago

When it comes to emergency medical services, the dark ages were only 50 years ago. In 1970:

- There were no emergency medical technicians.
- There were no paramedics.
- Portable defibrillators were as rare as a hen's tooth. The few that were available weighed 35 lbs.
- CPR had been invented in 1960 but initially only doctors and nurses were trained.
- 911 services covered only part of the nation.
- The bottom line: mortality from sudden cardiac arrest was virtually 100%.

Fast forward to now:

- Virtually every community is served by emergency medical technicians and paramedics – equipped with defibrillators.
- Paramedics administer medications, intravenous fluids, and can provide advanced airways.
- Many millions are trained in CPR.
- 911 telecommunicators can assist callers with CPR instructions.
- Many cities equip police with automatic external defibrillators.
- Public access defibrillators are all over public places.
- The bottom line: Based on CARES national data, about 30% of patients in VF survive. CARES is a cardiac arrest registry comprising approximately 30% of the US population (mycares.org).

So, what's the problem? Isn't 30% cause to celebrate when it used to be zero 50 years ago? The short answer is NO! It is not cause to celebrate because:

- 30% is the average. Many communities are at 10%.
- We understand the reasons high performing communities succeed.
- Why shouldn't every community be at 50%?
- Where you live should not determine if you live.
- Accepting such disparity is wrong in light of the ability to improve.

To understand these differences, one might assume they are due to structural causes such as differences in response times or better staffing of EMS vehicles. If only it could be explained so easily! The disparity in survival is primarily due to differences in the performance of key interventions. EMS programs that embrace both the art and the science of resuscitation can become high performing and achieve high survival rates.

The Resuscitation Academy Mantras

The tagline of the Academy is: A foundation committed to improving cardiac arrest survival rates. The Academy put forth a series of mantras as teaching tools.

- One of them is, "If you've seen one EMS system, you've seen one EMS system". The variation among EMS programs is astounding. No two are alike and each has its strengths and weaknesses. The wide variation in EMS programs mandates that improvements be custom tailored to the local circumstances.
- "Measure and improve" is another mantra. Measurement of cardiac arrest is foundational. Without a registry of cardiac arrest, it is impossible to determine if improvement is occurring.
- A third mantra, "It takes a system to save a victim," was mentioned in the Preface but is worthy of reemphasizing. EMS systems are intricate and complex organizations. All elements from dispatching to first responders to paramedics, not to mention training and quality improvement, must be functioning harmoniously at high capacity to successfully resuscitate a victim of cardiac arrest.

10 STEPS
to Improving Cardic Arrest Survival

The Resuscitation Academy strongly promotes 10 steps toward improving cardiac arrest survival.

1. Establish a cardiac arrest registry
2. Provide telecommunicator-CPR instructions with ongoing training and quality improvement
3. Provide high-performance CPR with ongoing training and quality improvement
4. Use rapid dispatch
5. Measure resuscitation performance using defibrillator recording
6. Begin an AED program for first responders, including police officers, guards, and other security personnel
7. Use smart technologies to notify volunteer bystanders when there is a nearby cardiac arrest so they can respond to provide early CPR and defibrillation
8. Make CPR and AED training mandatory in schools and communities
9. Be accountable – issue annual reports
10. Provide a culture of excellence

The first four steps are considered low hanging fruit and the other six are considered high hanging. While all the steps are important, some are more important than others.

We consider the lower hanging steps the most important and likely to have the greatest impact on survival. We also believe them to be readily attainable at modest cost. The first step is "Establish a Cardiac Arrest Registry." This is foundational to all the other steps since without measurement it is impossible to determine if the other steps are succeeding. While crucial to all EMS systems, a cardiac arrest registry is a topic unto itself and will not be covered here.

The other lower hanging fruit are core to ensuring quality intervention during the early minutes of a cardiac arrest. The step of "Telecommunicator CPR" (the term "Telephone CPR" is synonymous) achieves provision of CPR within a few minutes of collapse. The step of "High-performance CPR" dramatically slows the dying process and allows defibrillation to succeed. And the step of "Rapid Dispatch" allows EMS providers to arrive sooner at the scene.

The remaining 6 steps each contribute to a highly effective EMS system, but they do not have the impact of the first four steps. For this reason, they are not highlighted in this guide. Furthermore, this guide does not discuss hospital-based elements of resuscitation such as cooling, cardiac catheterization, or extracorporeal membrane oxygenation. Instead there is focus on the rapid delivery of bystander CPR through delivery of telephone CPR and the provision of HP-CPR. Rapid dispatch ensures EMS personnel arrive at the scene as quickly as possible, and thus the delivery of HP-CPR (as well as defibrillation) occurs as rapidly as possible.

Do the Steps Improve Survival?

This guide has a lot to say about the art and science of resuscitation and advocates 10 very concrete steps to improve survival. Do the steps really work? The short answer is: yes, they really do. In this guide we focus on the initial phase of EMS care, namely steps 2 (Telephone CPR), 3 (Rapid Dispatch), and 4 (High-performance CPR). We also discuss defibrillation as a separate topic since it is so integral to the care provided by first responders.

Since the first Resuscitation Academy (RA) in 2008 we have measured the impact of the Academy itself. Do the RA attendees improve the survival rates in their own community? Do the programs work? YES, THEY DO. First, survey data from attendees show improvements. Following are changes in resuscitation programs taken before and one year after attending a Resuscitation Academy:

- Cardiac arrest registry: 31% to 85%
- QI for T-CPR: 46% to 83%
- QI for HP-CPR: 17% to 76%
- QI for cardiac arrests: 40% to 86%
- Police AED: 34% to 48%
- Public access AED program: 58% to 76%
- Public CPR training: 77% to 91%

More importantly, three counties in Washington State saw an average increase in witnessed VF survival by 60%. We have recently undertaken a longitudinal study to better quantify the improvements in survival and the programs most responsible.

In additions to survey data, scientific peer-reviewed studies show improvements in survival. The most recent study came from Chicago. Chicago medical directors and EMS leaders attended Resuscitation Academies and from 2013-2016 instituted several of the RA programs, specifically telephone CPR, high-performance CPR, team-based training, case review, and community CPR training. The results of a study published in 2019, evaluating the impact of these programs, showed dramatic improvements. Bystander CPR rates and survival rates improved dramatically. The survival rate for witnessed VF doubled from 16% to 35%. Densely populated urban areas face considerable challenges, so it is very gratifying to see such dramatic improvements in Chicago.

Large urban center improves out-of-hospital cardiac arrest survival. Del Rios M, Weber J, Pugach O, Nguyen H, Campbell T, Islam S, Stein Spencer L, Markul E, Bunney EB, Vanden Hoek; Resuscitation.2019;139:234-240.

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(19)30136-4/abstract**

i

The Growing Science of Resuscitation

The science of resuscitation has grown considerably in the last 5 decades. We now know the elements of effective CPR and why high-performance CPR is so important. We know more about the science of defibrillation. We also have a pretty good idea about the characteristics of high-performing, medium-performing, and under-performing EMS systems in terms of cardiac arrest survival.

Cardiac arrest is a singular event – one person whose life hangs in the balance. People live in communities and since emergency care must be rushed to the patient the relevant question we seek to answer is: Why do some communities achieve high survival rates from cardiac arrest and others do not? This guide provides an answer, but more importantly, shows a way to improve survival from SCA.

Spoiler alert: The simple answer to the question is that the best performing agencies provide CPR quickly (through T-CPR, rapid dispatch and community training in CPR) and provide high-performance CPR by EMS providers. They also work to achieve defibrillation as rapidly as possible. Understanding the art and science of CPR and defibrillation, and the critical role they play in survival from cardiac arrest, is the goal of this book. As mentioned previously, this guide does not discuss the important role of paramedics and advanced life support. Our emphasis here is on the key early steps in resuscitation – those provided by telecommunicators and emergency medical technicians.

Chapter 2: Cardiac Arrest

What is Sudden Cardiac Arrest?

Simply put, sudden cardiac arrest is the cessation (it happens very quickly – thus the term "sudden") of the heart's pumping activity. It is distinguished from "circulatory arrest" (which can arise from other conditions such as exsanguination in which the heart continues to beat but receives little or no blood to pump) in that the heart's pumping ability is itself abruptly compromised. SCA is a pretty dramatic event. A person previously active and fully alert sudden collapses because the heart stops pumping blood. There are several abnormal heart rhythms associated with SCA. One of the most common is ventricular fibrillation (an ineffective quivering of the heart). The only way to stop this rhythm is to electrically shock the heart (called defibrillation). Think of this as rebooting the heart.

At the moment of cardiac arrest, the person loses consciousness and there is no pulse or blood pressure. Abnormal respirations (called agonal respirations) may be present for the first couple of minutes, as can seizure-like activity, but they soon cease. The person is clinically dead (meaning no signs of life). There is a narrow window of about 10 minutes when life can resume if the heart can be restarted. Without some intervention, beyond 10 minutes clinical death morphs into biological death (death at the cellular level) with no chance of recovery. As will be discussed later, the 10-minute window of opportunity can be extended with good quality CPR.

CPR and defibrillation work best together. That is, CPR does not reboot a defibrillating heart, but it buys time until a defibrillator can arrive to restart a normal rhythm. In this manner CPR actually enhances the effectiveness of defibrillation.

What Causes Cardiac Arrest?

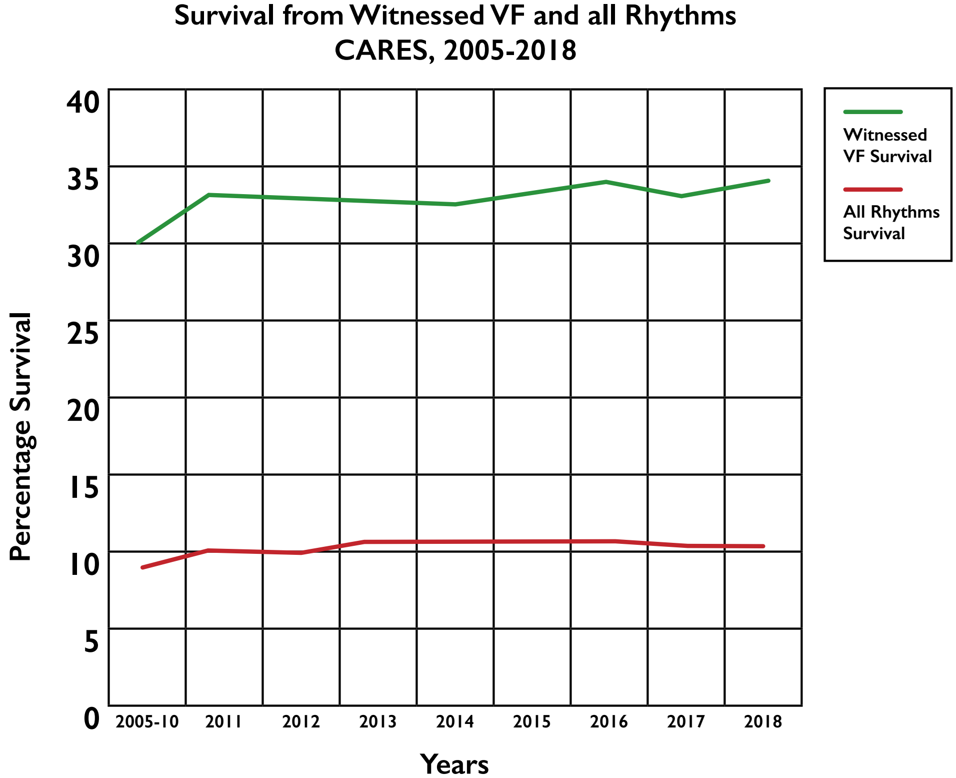
The causes are many but the most common is underlying coronary artery disease. Because of narrowing of a coronary artery, a portion of the heart may become infarcted or ischemic (damaged or not getting enough blood) which in turn may lead to ventricular fibrillation.

Facts About Cardiac Arrest
Sudden cardiac arrest is a leading cause of death in adults.
The annual incidence in the US is approximately 250,000 or 1.3 events for every 1,000 people per year.
The gender ratio is M:F of 2:1.
The median age for men is 64.
The median age for women is 69.
About 75% of SCAs occur in homes.
25% are in public locations and assisted care facilities.
About 50% of all cardiac arrests are unwitnessed and the remainder are witnessed by a bystander 3/4th of the time by bystanders and 1/4th by EMS personnel.
There are three common heart rhythms associated with SCA: ventricular fibrillation (VF), electrical mechanical dissociation, and asystole (flat line). Of the three rhythms, VF is the easiest to convert with defibrillation to a normal rhythm and has the best prognosis. Pulseless ventricular tachycardia also responds to defibrillation but it only accounts for one or two percent of all arrests. Pulseless Electrical Activity has an intermediate prognosis. Asystole has the worst prognosis.
VF is the most common rhythm among witnessed cardiac arrest.
A bystander performs CPR prior to arrival of EMS about 70% of the time in high performing EMS agencies.

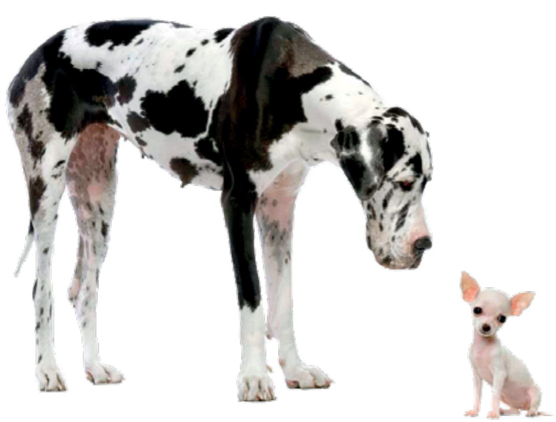
While the causes of sudden cardiac arrest are multiple, by far the most common cause is underlying heart disease, specifically ischemic heart disease and heart failure. Cardiac arrests in young people (fortunately fairly uncommon) are mostly the result of a genetic predisposition to heart rhythm abnormalities or unsuspected structural heart disease.

So, How Are We Doing?

The short answer is not so well. Data from CARES (a cardiac arrest registry comprising approximately 30% of the US population – mycares.org) show that there has been no improvement in the survival from all rhythms or ventricular fibrillations over the past 14 years. *(see chart below)*



In addition to low survival there is remarkable diversity in community survival rates. The range of survival following VF cardiac arrest varies from single digits to over 60%.



Disparity

All rhythm survival

(commmunities with over 100 arrests annually)

3% to 30%

10 fold disparity

VF witnessed

(commmunities with over 20 witnessed VF arrests)

4% to 62%

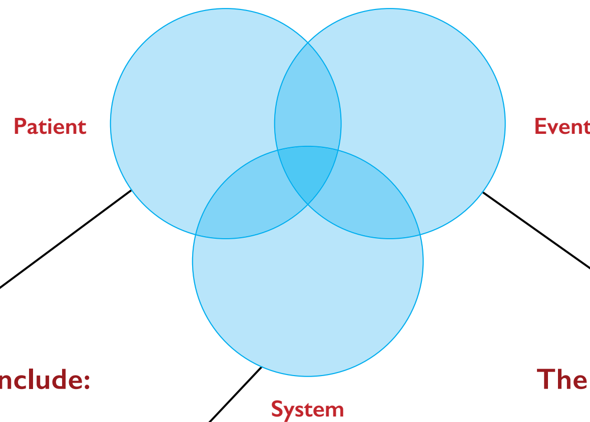
15 fold disparity

Thus, we have the unenviable situation of overall low survival combined with very large differences in survival from community to community. The community in which you live predicts to a significant degree whether or not you will live. Another way to say this, with a touch of urgency, is "Where you live should not determine if you live".

Why Do Some People Survive SCA and Others Do Not?

Surviving cardiac arrest is associated with multiple factors. These can be grouped into event, patient, and system factors. It is not an exaggeration to say that survival is a function of patient, event, and EMS system factors.

Factors Which Determine Survival
Following Cardiac Arrest



The patient factors include:

- Age
- Co-morbidity
- Gender

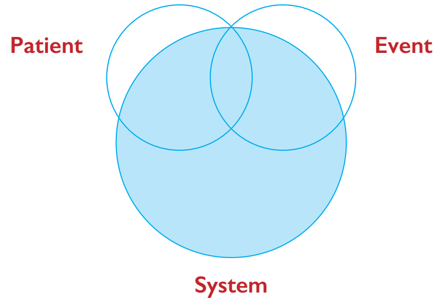
The event factors include:

- The rhythm associated with cardiac arrest
- Location of cardiac arrest: Home versus public arrest
- Whether the collapse was witnessed.

The system factors include:

- Bystander CPR (either by a previously trained person or by telephone CPR)
- HP-CPR by first responders
- Rapid dispatch
- Level of response (it is assumed in this guide that EMS care consists of basic life support and advanced life support). In most communities, basic life support is provided by EMT trained fire fighters or EMS responders. Advanced life support is provided – typically arriving after basic life support – by paramedic trained fire fighters or EMS responders. Relatively few communities, most of them rural, have EMT only care (meaning they have no paramedic response). Some communities have a single tiered system with the responders trained in both basic and advanced life support. There is no single model of response for cardiac arrest. Remember the mantra, "If you've seen one EMS system, you've seen one EMS system." Since EMTs are trained to defibrillate (usually using automated external defibrillators), they provide HP-CPR as well as defibrillation. Paramedics provide advanced airway management, medications, and additional shocks if needed.

Factors Which Determine Survival
From Cardiac Arrest

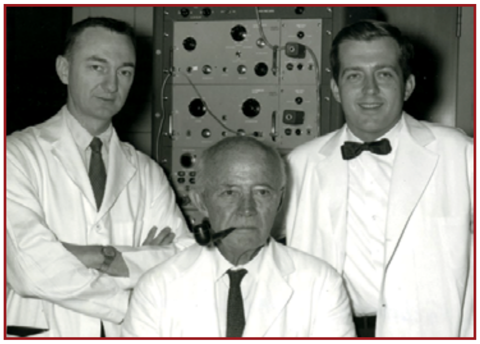


In the graphic above we purposely enlarge the system circle to emphasize both its importance in determining survival as well as to stress it is the category most influenced by community decisions. It should be obvious that patient and event factors, as predictive of survival as they may be, are difficult to alter. Witnessed collapse, and the rhythm associated with the cardiac arrest can be regarded as factors of fate and not influenced by the EMS system. Even the community in which a person lives is largely a matter of circumstances – one is not likely to choose a community because of good or poor EMS services (though one could argue the merits of such a decision). But the system factors are by definition directly related to the type of system and details of the care provided by the responding personnel. This includes training, specific programs (T-CPR, HP-CPR, rapid dispatch), supervision, quality improvement, and yes, leadership, culture, and accountability.

Chapter 3: The Science of CPR

The Evolution of CPR

It has taken decades to work out the science of CPR. The actual discovery of CPR in 1960 was an accident. Prior to CPR there were lots of "resuscitation" methods and most were geared at helping victims of drowning or smoke inhalation. There was no specific therapy for cardiac arrest except opening the chest and manually squeezing the heart. The accidental discovery of CPR occurred during experiments on defibrillation in dogs. William Kouwenhoven, along with two colleagues, James Jude and Guy Knickerbocker, observed that pressing the defibrillator paddles on the chest led to a small rise in arterial pressure. Fairly quickly they worked out that direct hand pressure could achieve the same rise in pressure. From the laboratory the technique of hands directly compressing the chest wall was tried in the hospital on patients with cardiac arrest. They reported great success. Thus, CPR was born.



James Jude, William Kouwenhoven & Guy Knickerbocker

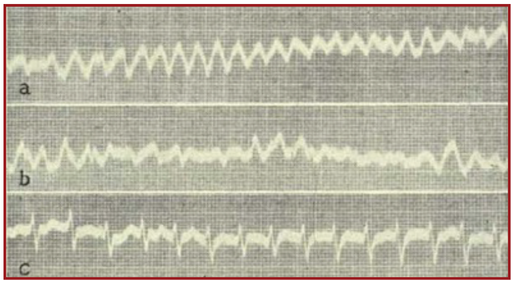
Initially it was believed that chest compression squeezed the heart against the spine and led to forward flow of blood. It took two decades to work out that this was not the case. Forward flow results from intrathoracic pressure changes and the presence of valves in the large veins preventing backward flow. For the last thirty years researchers have been defining the science of CPR and refining the technique of CPR. It is fair to say that the dynamics of CPR have largely been worked out and it is possible for science to define the highest quality CPR.

In the decades from the late 70s until 2015 the American Heart Association (AHA) in conjunction with the International Liaison Committee on Resuscitation (ILCOR) convened approximately every five years. They invited a group of clinicians, researchers, and scientists to evaluate the science of resuscitation and offer updated guidelines on the best practices of CPR and resuscitation therapy. These guidelines defined the clinical practice for management of cardiac arrest and were adopted by virtually all clinical practitioners. In 2017 the AHA and ILCOR began moving toward an ongoing process of scientific review.

One cringes a little looking at prior guidelines. For example, during the era when stacked defibrillatory shocks were recommended, there could be up to several minutes without CPR as the rhythm was repeatedly analyzed, the defibrillator charged, and the shock delivered – three times in a row. There was an assumption that defibrillation as soon as possible and as often as possible was optimal. The slogan at the time was shock fast and shock often. Regrettably it was not appreciated at the time how deleterious pauses in CPR were. It's not that anyone was ignoring the science, but rather detailed granular data about every element of CPR were not available.

Fortunately, science has advanced such that the dynamics of CPR and the optimal way to perform CPR emerged. Though there is still much to learn, science can now define quality CPR. My colleagues in Seattle and King County were actively involved in the guideline process as well as producing some of the science, which informs the current standards. The term we have applied to this science-based CPR is High Performance CPR (HP-CPR).

The first human to be successfully defibrillated occurred in 1947. Dr. Claude Beck, a cardiothoracic surgeon at Case Western University in Cleveland was operating on a 14-year-old boy for severe congenital funnel chest. The boy's sternum was only one inch from the spine. Dr. Beck was closing the chest after the defect was repaired and the boy's heart suddenly stopped. Dr. Beck reopened the chest and saw the fibrillating heart. He began manual massage and told his associate to run to his research lab and bring back an experimental defibrillator. Dr. Beck had been doing research with defibrillators at that time – how fortunate for the boy. The associate returned and after a gap of 45 minutes Dr. Beck successfully defibrillated the boy on the second shock. The boy fully recovered.

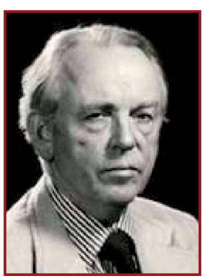


Rhythm from the first successful human defibrillation in 1947. First two panels show ventricular fibrillation and the third panel shows an organized rhythm after the second shock. (Beck C; JAMA; 135:985-986, 1947)

This historical account dramatically makes two points: First, the heart (and thus the rest of the body) can be kept alive for a period of time with manual open-heart massage and second, ventricular fibrillation can only be treated with a defibrillator.

Fast forward to 1960 when closed chest massage was first demonstrated to be clinically effective. This occurred at Johns Hopkins Hospital in Baltimore when Dr. James Jude used the technique on a patient with anesthesia-related cardiac arrest. Dr. Jude was a research associate with Drs. Kowenhoven and Knickerbocker and saw first-hand the effectiveness of closed chest compression. Soon other patients were saved with closed chest massage and word spread quickly. For most of the 1960s, closed massage was performed exclusively by doctors and occasional nurses in hospitals and there were many in-hospital successful applications of this technique.

By 1962, medical organizations endorsed the technique of closed chest massage for persons in cardiac arrest. Chest compression replaced the old Boy Scout technique of repetitive pressing on the back "out goes the bad air, in comes the good air."



Dr. Frank Pantridge

Defibrillators used exclusively in hospitals during the 1960s were large ungainly devices wheeled to the scene of the cardiac arrest. Dr. Frank Pantridge and his associate Dr. James Geddes, both working at the Royal Victoria Hospital in Belfast, believed mobile intensive care (including a defibrillator) could be rushed to the scene of cardiac arrests. In a landmark study published in 1967 in the international medical journal, The Lancet, they demonstrated the life-saving potential of mobile intensive care units.

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A mobile intensive-care unit in the management of myocardial infarction. Pantridge JF, Geddes JS. Lancet. 1967 Aug 5;2:271-3.

➔ **Abstract only: https://www.sciencedirect.com/science/article/pii/S0140673667901109**

It was appreciated soon after CPR was discovered that the earlier CPR began, the better the outcome. Since the emergency response system took minutes to arrive at the scene, truly rapid onset of CPR was largely the result of bystander-initiated CPR. Data from EMS systems came from studies in Seattle and King County. The studies also demonstrated that there was a narrow window of effectiveness. When CPR was delayed beyond 4-6 minutes its lifesaving potential diminished considerably.

Survival of out-of-hospital cardiac arrest with early initiation of cardiopulmonary resuscitation. Cummins RO, Eisenberg MS, Hallstrom AP, Litwin PE, Am J Emerg Med. 1985;3:114-9

➔ **Abstract only: https://www.ajemjournal.com/article/0735-6757(85)90032-4/fulltext**

It was also appreciated by the early 1990s that the physiological cause for patients without CPR faring poorer compared to those with CPR was potentially due to depletion of adenosine triphosphate (ATP) in the myocardial cells. CPR helps preserve cellular ATP by providing the perfusion needed for its replenishment. ATP can be thought of as the fuel for cellular function and the heart's ability to generate both electrical impulses and muscle contraction.

Estimation of myocardial ischemic injury during ventricular fibrillation with total circulatory arrest using high-energy phosphates and lactate as metabolic markers. Neumar RW, Brown GC, Van Ligten P, Hoekstra J, Altschuld RA, Baker P. Ann Emerg Med. 1991;20:222-9.

➔ **Abstract only: https://www.annemergmed.com/article/S0196-0644(05)80927-8/pdf**

The Science of Telephone CPR

Telephone CPR was born from the appreciation that most cardiac arrests did not have bystander CPR. Thanks to federal research grants, the King County Emergency Medical Services Division of the health department developed the nation's first program in Telephone CPR. With vigorous testing, investigators at King County EMS and the University of Washington demonstrated that CPR instructions could be provided over the telephone to a caller reporting a cardiac arrest. The instructions were improved over the years.

The first scientific study to demonstrate the feasibility of Telephone CPR occurred in King County, Washington in 1984 (it was called dispatcher-assisted CPR at the time).

Development and implementation of emergency CPR instruction via telephone. Carter WB, Eisenberg MS, Hallstrom A, Schaeffer S. Ann Emerg Med 1984; 13:695-700

➔ **Abstract only: https://www.annemergmed.com/article/S0196-0644(84)80730-1/pdf**

Emergency CPR instruction via telephone. Eisenberg M, Hallstrom A, Carter W, et al: Am J Pub Health 1985; 75:47-50.

→ **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1646147/**

Over the next few years, survival with T-CPR compared favorably to bystander CPR without T-CPR. In a study from King County, survival in patients with bystander CPR without T-CPR was 69% higher than patients with no CPR and in patients with T-CPR survival was 45% higher compared to patients with no CPR. The take home message is that T-CPR was almost as good as CPR from previously trained individuals. And both were far better than no CPR.

Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. Rea TD, Eisenberg, MS, Culley LL, Becker L, Circulation. 2001; 20:104:2513-6

→ **https://www.ahajournals.org/doi/pdf/10.1161/hc4601.099468**

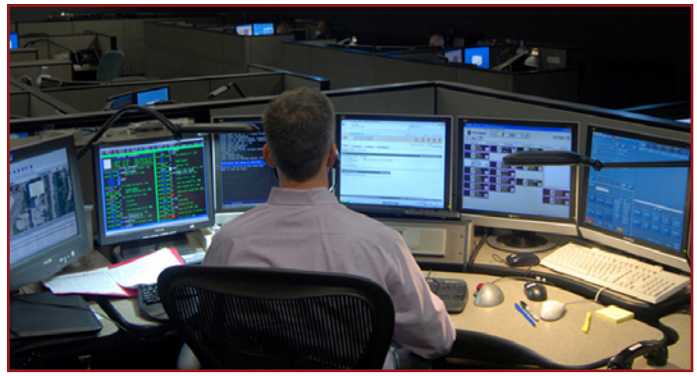
T-CPR has been shown in many articles to improve survival. A large study from Arizona demonstrated that T-CPR improved survival and functional outcomes.

Telephone cardiopulmonary resuscitation is independently associated with improved survival and improved functional outcome after out-of-hospital cardiac arrest. Wu Z, Panzyk, M Spaite DW, Hu C, Fukushima H, Langlais B, Sutter J, Bobrow BJ Resuscitation. 2018;122:135-140.

→ **https://www.resuscitationjournal.com/article/S0300-9572(17)30297-6/fulltext**

CHAPTER 3

Performance recommendations should be based on real data whenever possible. A good example of using real times come from a study of T-CPR which looked at both the time to identify cardiac arrest and the time to perform the first chest compression.



Dispatcher-assisted cardiopulmonary resuscitation: time to identify cardiac arrest and deliver chest compression instructions. Lewis M, Stubbs BA, Eisenberg MS Circulation. 2013; 128:1522-30.

➔ **https://www.annemergmed.com/article/S0196-0644(84)80730-1/fulltext**

Dispatcher-assisted bystander cardiopulmonary resuscitation in a metropolitan city: a before-after population-based study. Song KJ, Shin SD, Park CB, Kim JY, Kim DK, Kim CH, Ha SY, Eng Hock Ong M, Bobrow BJ, McNally B, Resuscitation, 2014; 85:34-41.

➔ **https://www.resuscitationjournal.com/article/S0300-9572(13)00311-0/fulltext**

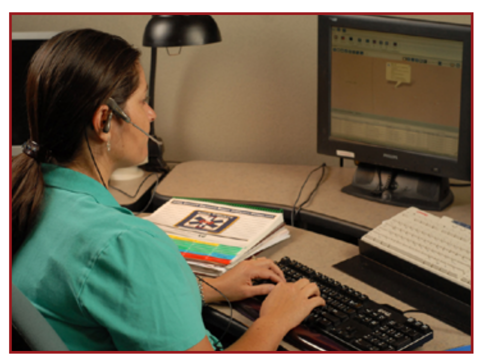
Dispatch-assisted cardiopulmonary resuscitation: the anchor link in the chain of survival. Bobrow BJ, Panczyk M, Subido C. Curr Opin Crit Care. 2012;18:228-33

➔ **Abstract only: https://pubmed.ncbi.nlm.nih.gov/22334216**

Implementation of a Regional Telephone Cardiopulmonary Resuscitation Program and Outcomes after Out-of-Hospital Cardiac Arrest. Bobrow BJ, Spaite DW, Vadeboncoeur TF, Hu C, Mullins T, Tormala W, Dameff C, Gallagher J, Smith G, Panczyk M. JAMA cardiology, 2016; 1:1:294-302

➔ **Abstract only: https://jamanetwork.com/journals/jamacardiology/fullarticle/2518761**

The telephone instructions have been improved and honed over the past three decades to be both effective and as succinct as possible. The goal is to begin the compressions as quickly as possible. "Bare the chest" and using the nipples as a landmark were part of early instructions. A study demonstrated that the time to bare the chest did not result in better hand position. Thus, wording of "baring the chest" and "right between the nipples" were eliminated and the instructions for proper position now are simply "in the center of the chest."



Abstract: Should dispatchers instruct lay bystanders to undress patients before performing CPR? A randomized simulation study. Chavez D, Meischke H, Painter I, Rea T. Resuscitation, 2013, 84; 979-981.

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(12)00945-8/pdf**

The Science of Rapid Dispatch

Rapid dispatch is a means to send an EMS unit to the scene as quickly as possible. It basically short cuts the usual dispatching procedures and can save 30-60 seconds or more. One could easily make the point that rapid dispatch should be part of T-CPR. If the telecommunicator rapidly identifies cardiac arrest, then it follows that the dispatch should rapidly occur. The reality is more complicated. Many dispatch centers have specific protocols for what information must be obtained prior to dispatching. The whole point of rapid dispatch is to short cut any questions that could delay dispatch and focus on sending the responding unit(s) ASAP. Rapid dispatch also requires separate training from T-CPR and has its own performance standards. Therefore, we treat it separately.

In a tiered system of EMT and paramedic responding units, rapid dispatch should focus on getting the EMT unit dispatched as quickly as possible. This means once the address is verified and the symptom suggests cardiac arrest, the EMT unit should be dispatched. The T-CPR protocol uses two key questions to help identify cardiac arrest (Is the patient conscious? Is the patient breathing normally?). Once the dispatcher receives this information it is OK to go with the rapid dispatch. Simply put, when there is a high suspicion of cardiac arrest, the EMT and paramedic unit should simultaneously be dispatched. If additional information is obtained suggesting it is not a cardiac arrest the level of response can be downgraded.

The first step to achieve rapid dispatch is to have written protocols in place and to train all telecommunicators. Some CAD systems have symptom-driven shortcuts that allow for abbreviated interviewing in order to rapidly send a unit. It is vital to measure the current dispatch times for cardiac arrest prior to beginning rapid dispatch. This should be the time interval from call pick up to the dispatch (tone-out) of the first-in vehicle.

There is an inherent logic in rapid dispatch. Shouldn't all-time critical conditions receive rapid dispatch? We believe they should. In King County the rapid dispatch protocols apply to active seizures, respiratory difficulty, stroke, decreased level of consciousness, chest pain, major trauma, and, of course, cardiac arrest.

Research from Seattle Medic One demonstrated, using actual dispatch times (called activation times in the article) from 2,600 patients in cardiac arrest, that shorter time intervals were strongly associated with improved survival.

There are no national protocols for instituting rapid dispatch. Proprietary dispatch operating systems take different approaches in trying to achieve rapid dispatch.

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Briefer activation time is associated with better outcomes after out-of-hospital cardiac arrest. Nichol G, Cobb LA, Yin L, Maynard C, Olsufka M, Larsen J, McCoy AM, Sayre MR. Resuscitation. 2016; 107:139-44.

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(16)30148-4/fulltext**

The Science of High-Performance CPR

High-Performance CPR is a highly refined, choreographed cardiac arrest evolution centered on evidence-based performance metrics. HP-CPR incorporates both individual and team performance metrics that are measurable and evaluated for programmatic compliance. HP-CPR is literally letter-perfect CPR.

HP-CPR metrics involve proper rate and depth of compression, and full recoil after each compression. Correct ventilation is crucial. It is a team-based endeavor with no long pauses in CPR. Thus, when rhythm assessment occurs or a defibrillatory shock is delivered, there is no pause in CPR greater than 10 seconds.

The specific elements of HP-CPR are:

- Compression rate of 100-120 compressions per minute (use of audible assistance with a metronome is recommended)
- Compression depth of 2-2.4 inches (50-60 mm)
- Full recoil (no leaning on the chest)
- Compression fraction greater than 80%
- No pause greater than 10 seconds (including peri shock pause)
- Avoid excessive ventilation (proper volume - just enough to see initial chest rise - and rate of about 10/minute)
- Assigned roles and teamwork

Observers who see HP-CPR in action are struck by several things:

- The resuscitation is quiet (because the team is well trained in individual roles, and know what to do and when to do it such that little talking is needed)
- The rotation between CPR performers appears like a choreographed ballet (because of quarterly practices and feedback following every real resuscitation)
- The manual defibrillator is pre-charged to further eliminate hands off chest time for charging
- The chest barely rises with each ventilation
- Intubation occurs without stopping compressions (because the paramedics practice making this happen)
- The EMTs are in charge of HP-CPR quality (EMTs "own" CPR) thus allowing the paramedics to focus on medications and airway control.
- Feedback devices (such as metronomes or "puck" devices) are used to ensure proper performance

Because pauses in chest compression are minimized, a new metric called the "compression fraction" (also called the compression ratio) is used to determine quality performance. This fraction should be at least 80% - meaning chest compression occurs 80% of the time the person is in cardiac arrest.

HP-CPR is very effective and the choreography (movement and flow) is efficient. It may be only a slight exaggeration to say that HP-CPR virtually suspends the dying process. Clearly it will not stop ventricular fibrillation since only defibrillation can accomplish that, but it can "buy" valuable time for other interventions such as airway management and CPR to help increase tissue oxygenation and ATP in the heart muscle and maybe decrease toxins. Thus, changing the milieu of the heart may allow a shock to successfully change VF to a normal rhythm.

Rate

The optimal rate of HP-CPR is 100-120 compressions per minute. If the rates are slower or faster, then both return of spontaneous circulation and survival decrease. The study cited below involved over 3,000 patients and compared outcomes to the rate of CPR compressions.

Relationship between chest compression rates and outcomes from cardiac arrest. Idris AH, Guffey D, Aufderheide TP, Brown S, Morrison LJ, Nichols P, Powell J, Daya M, Bigham BL, Atkins DL, Berg R, Davis D, Stiell I, Sopko G, Nichol G; Resuscitation Outcomes Consortium (ROC) Investigators. Circulation. 2012;125:3004-12.

➔ **https://www.ahajournals.org/doi/epub/10.1161/CIRCULATIONAHA.111.059535**

Chest compression rates and survival following out-of-hospital cardiac arrest. Idris AH, Guffey D, Pepe PE, Brown SP, Brooks SC, Callaway CW, Christenson J, Davis DP, Daya MR, Gray R, Kudenchuk PJ, Larsen J, Lin S, Menegazzi JJ, Sheehan K, Sopko G, Stiell I, Nichol G, Aufderheide TP; Resuscitation Outcomes Consortium Investigators. Crit Care Med, 2015;43:840-8.

➔ **https://journals.lww.com/ccmjournal/Abstract/2015/04000/Chest_Compression_Rates_and_Survival_Following.15.aspx**

Depth

Proper depth of 2-2.4 inches (50-60 mm) is important to achieve the maximum output of blood. In the early years of CPR, the proper depth was difficult to precisely measure. But as soon as it became possible to accurately measure cardiac output during CPR using "puck-like" tools, as with chest compression rate, an important association was found between chest compression depth and survival.

Cardiopulmonary resuscitation: improving cardiac resuscitation outcomes both inside and outside the hospital: a consensus statement from the American Heart Association. Meaney PA, Bobrow BJ, Mancini ME, Christenson J, de Caen AR, Bhanji F, Abella BS, Kleinman ME, Edelson DP, Berg RA, Aufderheide TP, Menon V, Leary M; CPR Quality Summit Investigators, the American Heart Association Emergency Cardiovascular Care Committee, and the Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. Circulation. 2013;128:417-35.

➔ **https://www.ahajournals.org/doi/epub/10.1161/CIR.0b013e31829d8654**

What is the role of chest compression depth during out-of-hospital cardiac arrest resuscitation? Stiell IG, Brown SP, Christenson J, Cheskes S, Nichol G, Powell J, Bigham B, Morrison LJ, Larsen J, Hess E, Vaillancourt C, Davis DP, Callaway CW; Resuscitation Outcomes Consortium (ROC) Investigators. Crit Care Med. 2012;1192–1198.

➔ **https://journals.lww.com/ccmjournal/Abstract/2012/04000/What_is_the_role_of_chest_compression_depth_during.20.aspx**

Full Recoil

Full recoil following each chest compression is important in order to allow the ventricles of the heart to refill with blood. Leaning on the chest following each downward compression (meaning maintaining some degree of weight or pressure on the chest) causes a fall in coronary perfusion pressure as well as cerebral perfusion pressure. In other words, the brain and heart are receiving less blood when full recoil does not occur. Training is important because it is so natural to rest on the chest, especially when fatigue sets in following minutes of chest compressions.

Effects of incomplete chest wall decompression during cardiopulmonary resuscitation on coronary and cerebral perfusion pressures in a porcine model of cardiac arrest. Yannopoulos D, McKnite SD, Aufderheide TP, Sigurdsson G, Pirrallo RG, Benditt D, Lurie KG. Resuscitation. 2005;64:363-72.

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(04)00414-9/fulltext**

Incomplete chest wall decompression: a clinical evaluation of CPR performance by trained laypersons and an assessment of alternative manual chest compression-decompression techniques. Aufderheide TP, Pirrallo RG, Yannopoulos D, Klein JP, von Briesen C, Sparks CW, Deja KA, Kitscha DJ, Provo TA, Lurie KG. Resuscitation. 2006;71:341-51

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(06)00197-3/fulltext**

Minimal Peri-Shock Pauses

During the era of "shock fast and shock often" it was assumed that shocking took priority over CPR. Today we teach that one of the pillars of high-performance CPR is that there be no pause greater than 10 seconds and that the manual defibrillator be pre-charged prior to rhythm assessment in order to minimize charging time. If the AED does not allow pre-charging with ongoing CPR, then we train to perform chest compression during AED charging.

A study from King County in 2006 revealed that long pauses in CPR were associated with worse outcomes compared to infrequent pauses of minimal duration. This finding, along with other accumulating evidence, led to a major change in CPR recommendations and helped contribute to the current science of CPR.

Increasing use of cardiopulmonary resuscitation during out-of-hospital ventricular fibrillation arrest: survival implications of guideline changes. Rea TD, Helbock M, Perry S, Carcia M, Becker L Cloyd D, Eisenberg M, Circulation. 2006;114:2760-5.

➔ **https://www.ahajournals.org/doi/epub/10.1161/CIRCULATIONAHA.106.654715**

Effects of Interrupting Precordial Compressions on the Calculated Probability of Defibrillation Success During Out-of-Hospital Cardiac Arrest Trygve Eftestøl; Kjetil Sunde,; Petter Andreas Steen, Circulation. 2002; 105:2270-2273.

➔ **https://www.ahajournals.org/doi/epub/10.1161/01.CIR.0000016362.42586.FE**

Perishock pause: An independent predictor of survival from out of hospital shockable cardiac arrest. Cheskes S, et al. Circulation 2011; 124:58-66.

➔ https://www.ahajournals.org/doi/epub/10.1161/CIRCULATIONAHA.110.010736

Compression fractions (time spent doing chest compression compared to total time of CPR) should be greater than 80%. In addition, peri-shock pauses should be as brief as possible. The higher the compression fraction and briefer the peri-shock pauses, the higher the survival rate. Pauses can also occur for other reasons such as rotation in roles or stopping CPR for endotracheal intubation, all of which can contribute to worse resuscitation outcome. However, with proper training it is possible to perform endotracheal intubation without stopping chest compression. The bottom line: the fewer the pauses the better.

Association between chest compression interruptions and clinical outcomes of ventricular fibrillation out of hospital cardiac arrest. Brouwer TF et al. Circulation 2015; 132:1030-7.

➔ https://www.ahajournals.org/doi/epub/10.1161/CIRCULATIONAHA.115.014016

Chest compression fraction determines survival in patients with out-of-hospital ventricular fibrillation. Christenson J, Andrusiek D, Everson-Stewart S, Kudenchuk P, Hostler D, Powell J Callaway CW, Bishop D, Vaillancourt C, Davis D, Aufderheide TP, Idris A, Stouffer JA, Stiell I, Berg R; Resuscitation Outcomes Consortium Investigators. Circulation. 2009;120:1241-7.

➔ https://www.ahajournals.org/doi/epub/10.1161/CIRCULATIONAHA.109.852202

The impact of peri-shock pause on survival from out-of-hospital shockable cardiac arrest during the Resuscitation Outcomes Consortium PRIMED trial. Cheskes S, Schmicker RH, Verbeek PR, Salcido DD, Brown SP, Brooks S, Menegazzi JJ, Vaillancourt C, Powell J, May S, Berg RA, Sell R, Idris A, Schmidt T, Christenson J; Resuscitation Outcomes Consortium (ROC) investigators. Resuscitation. 2014;85:336-42.

➔ https://www.resuscitationjournal.com/article/S0300-9572(13)00814-9/fulltext

Precountershock cardiopulmonary resuscitation improves initial response to defibrillation from prolonged ventricular fibrillation: a randomized, controlled swine study. Berg RA, Hilwig RW, Ewy GA, Kern KB. Crit Care Med. 2004;32:1352-7.

➔ https://journals.lww.com/ccmjournal/Abstract/2004/06000/Precountershock_cardiopulmonary_resuscitation.19.aspx

Avoid Excessive Ventilation

Excessive ventilation may seem like a good thing (doesn't the body need as much oxygen as possible?). But in fact, it can be harmful. Too much ventilation serves to over inflate the lungs and thus preclude proper filling of the large vessels in the chest. The bottom line is that too much ventilation volume will reduce cardiac output. During HP-CPR, consider a lower tidal volume that produces only a minimal rise in the chest wall – just enough to visibly see the chest rise (350-500 ccs). In addition to ventilation volume there is also the issue of ventilation rate. Neither the volume nor the rate should be excessive.

Arterial blood-gases with 500- versus 1000-ml tidal volumes during out-of-hospital CPR. Langhelle A, Sunde K, Wik L, Steen PA. Resuscitation. 2000;45:27–33.

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(00)00162-3/fulltext**

Available ventilation monitoring methods during pre-hospital cardiopulmonary resuscitation. Terndrup TE, Rhee J. Resuscitation. 2006;71:10–18.

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(06)00103-1/pdf**

Death by hyperventilation: A common and life-threatening problem during resuscitation. Aufderheide TP et al. Crit Care Med 2004;32:S345-51.

➔ **https://journals.lww.com/ccmjournal/Abstract/2004/09001/Death_by_hyperventilation__A_common_and.2.aspx**

Choreography

Predefined roles prior to arrival at the patient's side helps to make the chorography of the cardiac arrest scenario both efficient and effective. Each provider knows and understands their individual role and its importance as a team function. Furthermore, the EMT or paramedic knows each of their colleagues' positions as well and can perform that task at the same high level as needed. Quarterly training in HP-CPR enables EMS providers to hone both individual and team performance, allows for equipment familiarity, and promotes a high-level operation during an actual cardiac arrest event.

Continuous Chest Compression Versus 30:2 Compressions

There is agency-to-agency variation in how EMS providers perform HP-CPR. Most agencies use 30:2 compressions and others use continuous chest compressions with interspersed ventilations (with no pause in compression). Which is better? The short answer is they are equivalent. In a large multi-community randomized trial there was no difference in survival among patients receiving either form of CPR.

Trial of Continuous or Interrupted Chest Compressions during CPR. Nichol G, Leroux B, Wang H, Callaway CW, Sopko G, Weisfeldt M, Stiell I, Morrison LJ, Aufderheide TP, Cheskes S, Christenson J, Kudenchuk P, Vaillancourt C, Rea TD, Idris AH, Colella R, Isaacs M, Straight R, Stephens S, Richardson J, Condle J, Schmicker RH, Egan D, May S, Ornato JP; ROC Investigators. N Engl J Med. 2015;373:2203-14.

➔ **https://www.nejm.org/doi/full/10.1056/NEJMoa1509139?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%20%200pubmed**

2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Andrew H. Travers Thomas D. Rea, Bentley J. Bobrow et al 2010;122:S676–S684

➔ **https://pubmed.ncbi.nlm.nih.gov/20956220/**

Manual versus Mechanical Chest Compressions

A number of randomized trials as well as observational studies have compared manual with mechanical chest compression. Perhaps the best review comparing this issue was performed by the Cochrane Database. The Cochrane group is an international group of research scientists who undertake systematic reviews of the literature on important and/or controversial topics. Their review of manual versus mechanical chest compressions was conducted in 2017 and included 11 trials representing almost 13,000 patients with in-hospital or out-of-hospital arrest. Their conclusion was that mechanical chest compressions using a chest compression device was not superior to manual chest compression. They did state that mechanical compressors may be useful in special circumstances, such as for long transport time or in a moving ambulance. They cautioned that systems incorporating devices should be closely monitored because some articles suggest harm with the devices. And they stress the wise advice that "special attention should be paid to minimizing time without compression and delays to defibrillation during device deployment".

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Mechanical versus manual chest compressions for cardiac arrest. Wang PL, Brooks SC. Cochrane Database Syst Rev. 2018;Aug 20;8.

→ **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6953326/**

Table 1. Summary of Key BLS Components for Adults, Children and Infants

	Recommendations		
Component	Adults	Children	Infants
Recognition	Unresponsive (for all ages)		
	No breathing, not breathing normally (eg, only gasping)	No breathing or only gasping	
	No pulse palpated within 10 seconds (HCP Only)		
CPR Sequence	CAB	CAB	CAB
Compression Rate	At least 100/min		
Compression Depth	At least 2 inches (5 cm)	At least 1/3 AP Depth About 2 12 inches (5 cm)	At least 1/3 AP Depth About 1 12 inches (4 cm)
Chest Wall Recoil	Allow Complete Recoil Between Compressions HCPs Rotate Compressors Every 2 minutes		
Compression Interruptions	Minimize Interruptions in Chest Compressions Attempt to limit interruptions to less than 10 seconds		
Airway	Head tilt-chin lift (HCP suspected trauma: jaw thrust)		
Compression to Ventilation Ratio (until advanced airway placed)	30:2 (1 or 2 rescuers)	30:2 Single Rescuer 15:2 2 HCP Rescuers	30:2 Single Rescuer 15:2 2 HCP Rescuers
Ventilations: When rescuer Untrained or Trained and Not Proficient	Compressions Only		
Ventilations with advanced airway (HCP)	1 breath every 6-8 seconds (8-10 breaths/min) Asynchronous with chest compressions About 1 second per breath Visible Chest Rise		
Defribillation	Attach and use AED as soon as available. Minimize interruptions in chest compressions before and after shock, resume CPR beginning with compressions immediately after each shock		

Chapter 4: The Art of CPR

Art versus Science

In the science/art synergy, science is the easier of the two to define and measure. Art on the other hand is somewhat fuzzier and more subjective. But that may be simply due to the fact that science is based on numbers and concrete measurements. It is reproducible. Art is more subjective and cannot be quantified with numbers or measurements. As a result, science is perceived to be hard and objective; art as soft and subjective. While there is some truth to this dichotomy it is also true that many complex phenomena require both science and art to be fully understood. CPR, as provided by EMS, specifically requires this dual description. In this chapter we will emphasize the programmatic, training, and quality improvement aspects of HP-CPR.

The Art of Telephone CPR

The Resuscitation Academy played, and continues to play, a large educational and advocacy role in the mission to advance the importance of T-CPR and HP-CPR. We have worked hard to place these interventions as key to improving survival on the national radar screen. We are extremely pleased to see our efforts and those of many other leaders in the field of resuscitation lead to forward progress. In the past two years national organizations, specifically the American Heart Association (AHA) and the National Highway Traffic and Safety Administration (NHTSA), have issued standards for T-CPR and HP-CPR. In 2018 the American Heart Association issued program and performance standards for T-CPR. The standards are very detailed and are listed in the following pages. The detailed report may be found at the following site:

➔ **https://cpr.heart.org/AHAECC/CPRAndECC/ResuscitationScience/UCM_477526_CPR-Emergency-Medical-Dispatcher-CPR-Instructions.jsp#collapse_AHAC51E6A71EF6029B_3**

AHA Telephone-CPR (T-CPR) Program Recommendations and Performance Measures

1. **Commitment to T-CPR**
   - The emergency communications center will commit to providing effective T-CPR.
   - The dispatch center director must provide leadership and hold the staff accountable for implementation.
2. **Train and Provide Continuing Education in T-CPR for all Telecommunicators**
   - Require initial training for 100% of call takers and dispatchers. Initial training will require an estimated 3-4 hours.
   - Require ongoing continuing education. This will require 2-3 hours annually.
3. **Conduct Ongoing Quality Improvement (QI) for all Calls in which a Cardiac Arrest is Confirmed by EMS Personnel and in which Resuscitation is Attempted**
   - 100% of calls in which resuscitation is attempted must have the dispatch call audited for QI purposes.

- The QI must collect key time intervals and reasons for non-recognition of cardiac arrest and reasons for delays.
- Individual QI review of every cardiac arrest call provided by the supervisor (or designated QI person) including helpful feedback.
- QI reports must be summarized annually, and secular trends reported.
- QI reports should be used to identify training needs.

4. Connection to EMS Agency
   - Close engagement with the EMS agency is required to link data from dispatch audio with EMS run report data.
   - Linkage with EMS is required to identify the denominator of total cardiac arrest cases and the percentage of all cardiac arrests which are recognized as cardiac arrest by the telecommunicator/dispatcher.

5. Designated Medical Director
   - There must be a designated communications center medical director who shall issue the dispatch protocols for T-CPR and be able to work closely with the EMS agency. Ideally there should be a combined medical director for the dispatch center and EMS agency.

6. Recognition for Outstanding Performance
   - Telecommunicator recognition program for outstanding performance in the recognition of cardiac arrest and delivery of T-CPR instructions.

AHA Performance Recommendations

Summary of performance recommendations:

- Percentage of total OHCA Cases Correctly Identified by Telecommunicators
- Percentage of OHCA Cases Correctly Identified by Telecommunicators that were recognizable
- Percentage of Telecommunicator-Recognized OHCA Receiving T-CPR
- Median Time Interval Between 9-1-1 Call and OHCA Recognition
- Median Time Interval Between 9-1-1 Call and First T-CPR Directed Compression

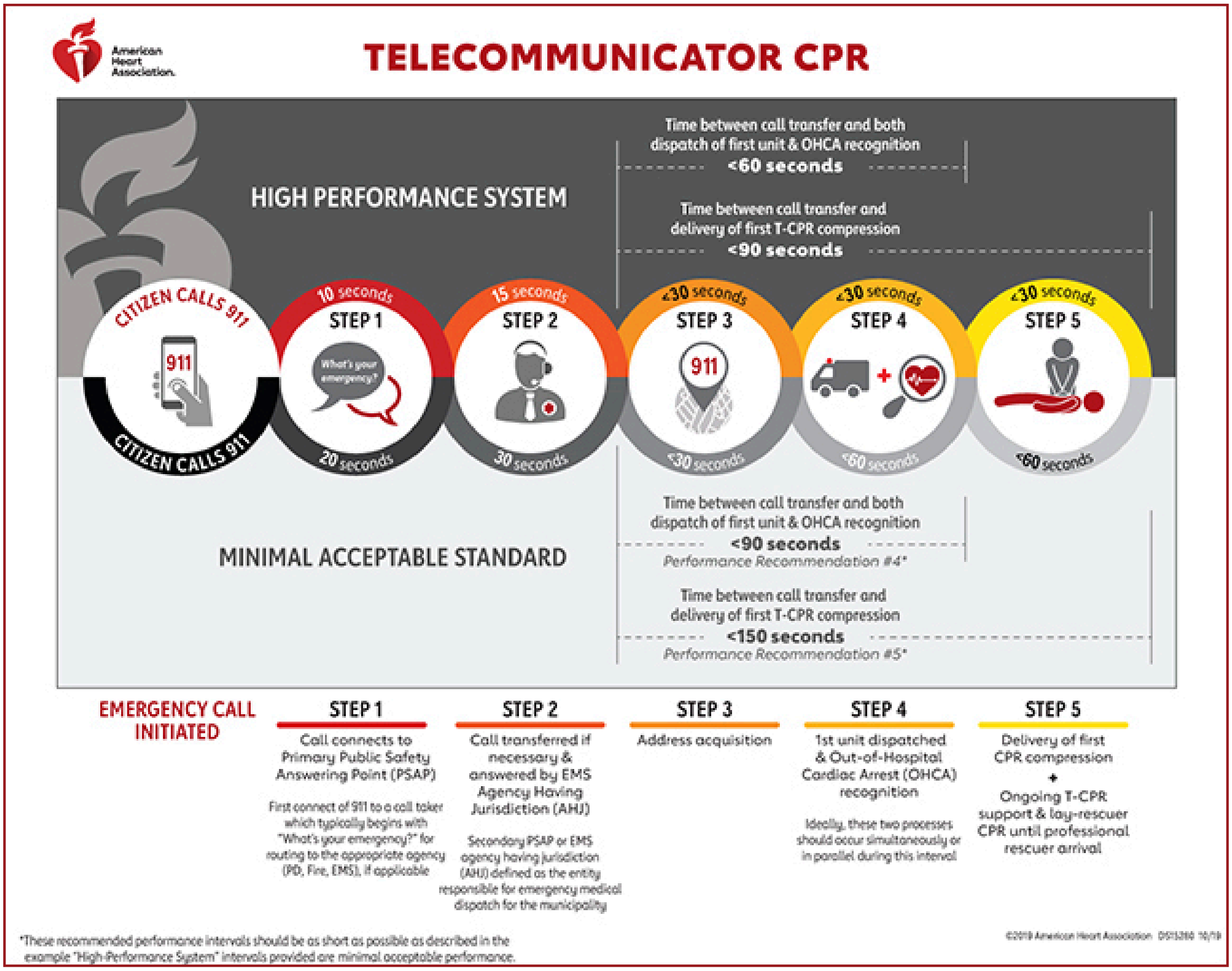
Details of Performance Measures

1. **Percentage of Total Out-of-Hospital Cardiac Arrest (OHCA) Cases Correctly Identified by Telecommunicators**
    - Definition: telecommunicator recognized / total OHCA (confirmed by EMS impression)
    - Numerator: # of QI reviewed EMS confirmed OHCA with recognition noted
    - Denominator: EMS confirmed OHCA
    - Performance Goal: 75%
2. **Percentage of OHCA Cases Correctly Identified by Telecommunicators that were Recognizable**
    - Definition: telecommunicator recognized / number of cases deemed identifiable
    - Numerator: number of QI reviewed EMS confirmed OHCA with recognition noted
    - Denominator: number of QI reviewed EMS confirmed OHCA deemed identifiable by supervisor
    - Exclusions from denominator:
        - 3rd party calls
        - Hang up
        - Hysteria
        - CPR in progress
        - Language barrier
        - Other circumstances supervisor deems "unidentifiable"
    - Performance Goal: 95%
3. **Percentage of Telecommunicator-Recognized OHCA Receiving T-CPR**
    - Definition: number of telecommunicator recognized OHCA cases receiving call-taker directed T-CPR / number of call-taker recognized OHCA cases
    - Numerator: number of QI reviewed EMS confirmed OHCA with recognition noted where call-taker directed T-CPR is preformed
    - Denominator: number of QI reviewed EMS confirmed OHCA with recognition noted

- Exclusions from denominator:
  - CPR is already in progress by bystander
  - Caller is unable to physically perform CPR (ie, call being made from alternative location to OHCA)
  - Caller is unable to get patient into appropriate position for CPR (ie, can't move patient from bed to floor)
  - Call-taker refuses
  - For safety, T-CPR instructions are not given (eg, traumatic cause, disaster scenario, etc.)
  - Hang up
  - Other circumstances supervisor deems T-CPR could not be performed
- Performance Goal: 75%

4. **Median Time between 911 Call and OHCA Recognition**
   - Definition: median amount of time in seconds between 911 call connected and OHCA recognition
   - Benchmark: < 90 seconds (less than 60 seconds from address acquisition to telecommunicator recognition of OHCA)
   - We acknowledge:
     - This performance goal may be challenging to meet in the short-term due to PSAP call transfer protocols that may lie outside the authority of the PSAP responsible for EMS dispatch.
     - Measurement of intervals prior to call transfer to the PSAP responsible for dispatching EMS should be included, however where impractical, the minimal acceptable performance recommendation should revert to less than 60 seconds from address acquisition to telecommunicator recognition of OHCA.

5. **Median Time between 911 Call and First T-CPR Directed Compression**
   - Definition: median amount of time in seconds between 911 call connected and first CPR compression directed by telecommunicator
     - Benchmark: < 150 seconds (less than 120 seconds from address acquisition to first CPR compression directed by telecommunicator)
   - We acknowledge:
     - This performance goal may be challenging to meet in the short-term due to PSAP call transfer protocols that may lie outside the authority of the PSAP responsible for EMS dispatch.
     - Measurement of intervals prior to call transfer to the PSAP responsible for dispatching EMS should be included, however where impractical, the minimal acceptable performance recommendation should revert to less than 120 seconds from address acquisition to first telecommunicator directed T-CPR compression.



NHTSA Standards

In 2019, NHTSA issued performance standards for T-CPR and HP-CPR. The emphasis is on how EMS and telecommunications can work together to ensure rapid delivery of telephone CPR and high-performance CPR by EMS responders. NHTSA calls the program CPR LifeLinks.

There is a wealth of useful information in the accompanying toolkit, which may be found at:

➔ **https://www.911.gov/project_cprlifelinks/CPR_LifeLinks_Toolkit_Final.pdf**

A recent document from the American Heart Association provides useful educational strategies to help implement new resuscitation programs.

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Resuscitation Education Science: Educational Strategies to Improve Outcomes from Cardiac Attest: A Scientific Statement from the American Heart Association. Cheng A, Nadkarni VM, Mancini MB, et al. Circulation. 2018 Aug 7;138(6)

➔ **https://www.ahajournals.org/doi/epub/10.1161/CIR.0000000000000583**

CHAPTER 4

The above guidelines and standards issued by the AHA and NHTSA go a long way toward promoting T-CPR and HP-CPR as the standard of care. But the science of CPR without the art of CPR will not result in much of a boost in survival rates. What do we mean by the art of HP-CPR?

The art of HP-CPR entails ensuring the quality of the intervention. It means ongoing quality improvement and ongoing training to maintain the fidelity to the procedure. It will be very easy for any telecommunication center or any EMS agency to claim adherence to the standards of T-CPR and HP-CPR. It is very easy to issue new policies and even to document initial training. But without follow through with ongoing training and ongoing quality improvement (QI), the telecommunicators and EMS providers will come away thinking this is just another change in CPR, which historically occurred every 5 years.

Without ongoing training and ongoing quality improvement for both T-CPR and HP-CPR, policies issued by management will be only empty gestures. And this brings us back to the mantra of "measure and improve." Measurement is the core of quality improvement. The only way to ensure fidelity to T-CPR and HP-CPR is through ongoing quality improvement.

Ongoing Training

Ongoing training is essential. Both T-CPR and HP-CPR will infrequently be performed by telecommunicators and EMS personnel on an annual basis. Remember the incidence of cardiac arrest – only one case per year for every 1,000 people in the community. Divide the number of cases by the number of EMTs/paramedics or telecommunicators and you reveal the infrequency of the event per person. Thus, ongoing training is vital. Each program should have quarterly review with hands-on practice for the EMS provider and simulated training for the telecommunicator.

An example of training based on identifying obstructions to good performance involved an analysis of hundreds of real T-CPR episodes.

Factors impeding dispatcher-assisted telephone cardiopulmonary resuscitation. Hauff SR, Rea TD, Culley LL, Kerry F, Becker L, Eisenberg MS. Ann Emerg Med. 2003;42:731-7.

➔ **https://www.annemergmed.com/article/S0196-0644(03)00423-2/fulltext**

The concept of low-dose, high-frequency training is very relevant to T-CPR and HP-CPR. Frequent but short retraining is more likely to achieve sustained performance.

Ongoing Quality Improvement

Ongoing quality improvement is an art. First there has to be support from the top and an appreciation of how important (and difficult) QI can be. There has to be dedicated personnel for ongoing QI. And there has to be a means to gather performance metrics for each cardiac arrest. For the telecommunicator agency this means recordings of the call must be reviewed. For the EMS agency it means the actual resuscitation is being recorded. There are various means to accomplish this through both the machine itself which captures CPR metrics and rhythm data, as well as through defibrillatory shocks and the response to each shock.

Thus, quality improvement requires that every cardiac arrest be reviewed, and detailed information abstracted. For T-CPR this means listening to the dispatch recording and abstracting data which in turn are shared with the telecommunicator. For HP-CPR it means reviewing all defibrillator machine downloads and reviewing that information with the individual EMT involved.

QI reviews should never be used for punitive purposes. The sole purpose of ongoing QI is to improve so the intervention will be provided with more fidelity at the next opportunity.

A study from Japan demonstrated the benefits of continuous quality improvement for T-CPR. Both the incidence of T-CPR and overall bystander CPR improved from 42% to 62% and 41% to 56% respectively. Survival improved by 81%. The authors concluded that continuous QI was vital to augmenting the effects of T-CPR. This study provides a lovely example of how the art of continuous QI improves the implementation of T-CPR and thereby increases survival.

The continuous quality improvement project for telephone-assisted instruction of cardiopulmonary resuscitation increased the incidence of bystander CPR and improved the outcomes of out-of-hospital cardiac arrests. Tanaka Y, Taniguchi J, Wato Y, Yoshida Y, Inaba H. Resuscitation. 2012; 83:1235-41.

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(12)00108-6/fulltext**

The Art of Positive Reinforcement

Alarm centers and EMS agencies should practice positive reinforcement. The outcome of the cardiac arrest should be shared with the telecommunicators. Outstanding performance should be recognized and honored in public.

For patients resuscitated at the scene and admitted to hospital, the best positive reinforcement is feedback about the hospital outcome. When telecommunicators and EMS personnel learn of surviving patients, such information is the greatest reinforcement of a job well done.

Focus on the Patient

Quality improvement (QI) should always have a positive spin. Occasionally listening to dispatch recordings may reveal performance that is less than stellar. When this occurs, remember that quality improvement information should never be used punitively. QI information is intended to improve patient care and never to discipline an EMT, paramedic, or telecommunicator.

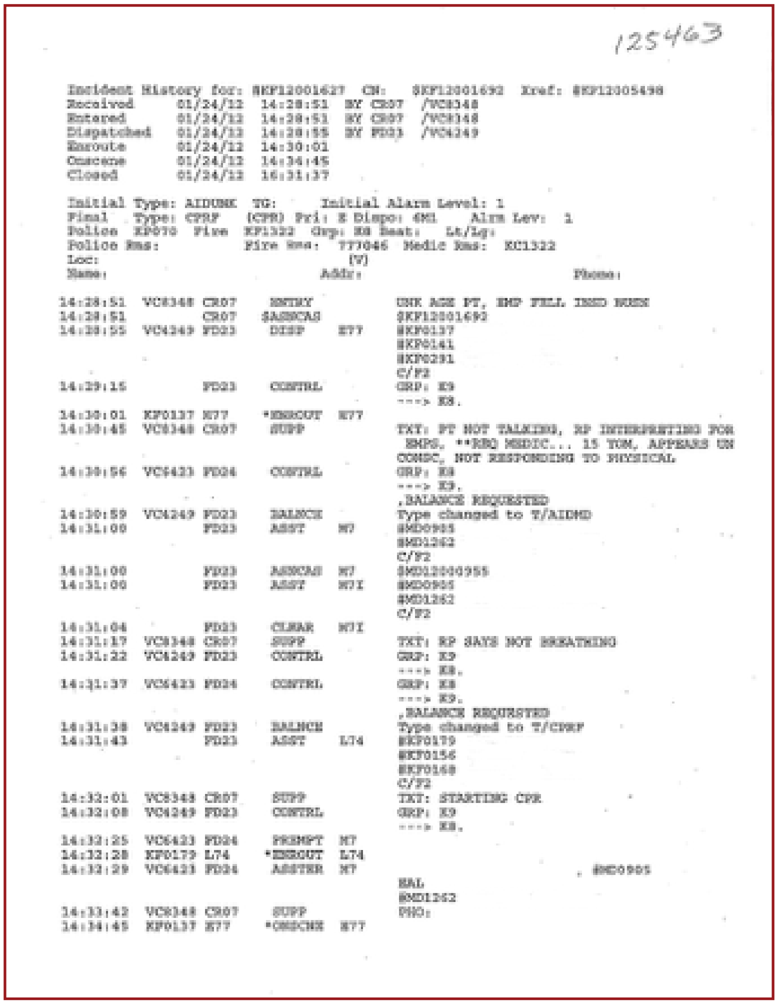
The best way to provide feedback for challenging cases is to focus on the patient, not the EMS personnel. The relevant phrase is "How can we do better to help the patient next time?" If this advice is followed, EMTs and paramedics will feel secure and forthcoming with challenging cases or situations where things went astray. A trust will be built on the foundation that we are all professionals in a challenging job, and we want to do what is best for the patient. Always focus on the patient.

The Art of Rapid Dispatch

We include the art of rapid dispatch in this chapter as it is fundamentally a means to achieve professional CPR and defibrillation as quickly as possible. However, the art as it relates to training and quality improvement are identical to those of telephone-CPR. Telecommunicators should receive training in the rationale of rapid dispatch.

A telecommunication center (ideally with medical direction) should decide which conditions warrant rapid dispatch. In addition to suspected cardiac arrest, medical conditions which could benefit from rapid dispatch include shortness of breath, ongoing seizures, stroke symptoms, diabetic hypoglycemia, and chest pain. There should be a performance goal for the percentage of times rapid dispatch is provided. The time to dispatch of the first-in unit should be collected for these conditions with feedback to the telecommunicators. The findings of ongoing QI of the conditions should be shared with the telecommunicators.

Figure: An actual telecommunication center summary record of a telephone CPR call. Data are abstracted from this report and become part of the file for every resuscitation as well as the actual voice recording of the call. Feedback is provided to the telecommunication center.



```
                                                                      125463

Incident History for: #KP12001627  CN:   $KP12001692  Xref: #KP12005498
Received      01/24/12  14:28:51  BY CR07  /VC8348
Entered       01/24/12  14:28:51  BY CR07  /VC8348
Dispatched    01/24/12  14:28:55  BY FD23  /VC4249
Enroute       01/24/12  14:30:01
Onscene       01/24/12  14:34:45
Closed        01/24/12  16:31:37

Initial Type: AIDUNK  TG:      Initial Alarm Level: 1
Final   Type: CPRF   (CPR) Pri: E Dispo: 4M1    Alrm Lev:  1
Police  KP070  Fire   KF1322  Grp: E8 Beat:    Lt/Lg:
Police Rms:           Fire Rms:  777046  Medic Rms:  KC1322
Loc:                              (V)
Name:                         Addr:                              Phone:

14:28:51  VC8348 CR07    ENTRY            UNK AGE PT, EMP FELL IN BUSH
14:28:51         CR07   $ASSNCAS          $KP12001692
14:28:55  VC4249 FD23    DISP      E77    #KP0137
                                          #KP0141
                                          #KP0291
                                          C/F2
14:29:15         FD23    CONTRL           GRP: E9
                                          ---> E8.
14:30:01  KP0137 E77    *ENROUT    E77
14:30:45  VC8348 CR07    SUPP             TXT: PT NOT TALKING, RP INTERPRETING FOR
                                           EMPS. **REQ MEDIC... 15 YOM, APPEARS UN
                                          CONSC, NOT RESPONDING TO PHYSICAL
14:30:56  VC6423 FD24    CONTRL           GRP: E8
                                          ---> E9.
                                          ,BALANCE REQUESTED
14:30:59  VC4249 FD23    BALNCE           Type changed to T/AIDMD
14:31:00         FD23    ASST      M7     #MD0905
                                          #MD1262
                                          C/F2
14:31:00         FD23    ASSNCAS   M7     $MD12000955
14:31:00         FD23    ASST      M7I    #MD0905
                                          #MD1262
                                          C/F2
14:31:04         FD23    CLEAR     M7I
14:31:17  VC8348 CR07    SUPP             TXT: RP SAYS NOT BREATHING
14:31:22  VC4249 FD23    CONTRL           GRP: E9
                                          ---> E8.
14:31:37  VC6423 FD24    CONTRL           GRP: E8
                                          ---> E9.
                                          ,BALANCE REQUESTED
14:31:38  VC4249 FD23    BALNCE           Type changed to T/CPRF
14:31:43         FD23    ASST      L74    #KF0179
                                          #KF0156
                                          #KF0168
                                          C/F2
14:32:01  VC8348 CR07    SUPP             TXT: STARTING CPR
14:32:08  VC4249 FD23    CONTRL           GRP: E9
                                          ---> E8.
14:32:25  VC6423 FD24    PREMPT    M7
14:32:28  KF0179 L74    *ENROUT    L74
14:32:29  VC6423 FD24    ASSTER    M7                           , #MD0905
                                          BAL
                                          #MD1262
14:33:42  VC8348 CR07    SUPP             PHO:
14:34:45  KP0137 E77    *ONSCNE    E77
```

The Art of High-Performance CPR Performance Recommendations

The performance metrics of HP-CPR are the individual components of CPR. These are rate, depth, full recoil, minimizing peri-shock pauses, high compression fraction, and no excessive ventilation. These metrics MUST be measured to validate physician-directed performance and to identify gaps during both individual and team performance. The use of an instrumented manikin is required for this type of training and team feedback.

Ongoing Training - Low-Dose, High-Frequency

The concept of low dose, high frequency training is very relevant to T-CPR and HP-CPR. Frequent but short retraining is more likely to achieve sustained performance. The art of HP-CPR training and education for EMS professionals should instill the concept that the measured, high-level performance achieved during training will extend that level of performance to an actual cardiac arrest scenario. Inherently, all EMS providers will strive toward excellence when asked to perform a required task or skill. The art of HP-CPR training is to 'plant the seed' that once mastery-level HP-CPR has been achieved (during training), field performance will also increase with the overall goal of increasing survival from cardiac arrest. In King County training in HP-CPR is provided quarterly.

Quality Improvement

Quality improvement involves measurement of the metrics of HP-CPR and feedback to all EMS personnel involved. The best means to obtain good data is through the use of recording defibrillators. Most AEDs and defibrillators have the ability to collect key metrics of CPR. The rate of compression and the pauses in chest compression can easily be determined. In addition, the compression faction is usually automatically calculated. Some manufacturers offer devices – often called pucks – to collect depth of compression and to determine recoil.

Quality improvement also includes review of the entire resuscitation with feedback to the EMS crews as well as the telecommunicator. Following is a case review. Such reviews are sent following all VF cardiac arrests including the outcome. The review goes to all the EMTs and paramedics who provided care to the patient. The case review is usually posted within a week of the event and for admitted patients there is information about the outcome.

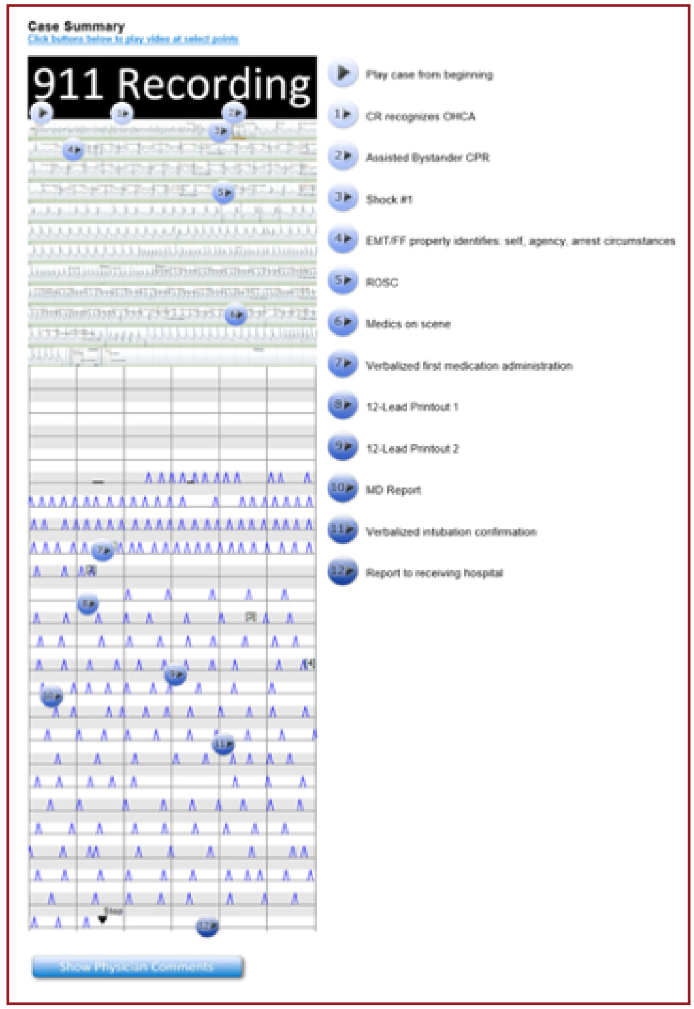


Figure: Actual case review which is sent to all crew members involved in the resuscitation. This is approximately 30 minutes in length and records the telecommunicator providing telephone CPR instructions (numbers 1-2), followed by the EMT crew's shock (3) of the patient and then the medics arrival at the scene (6) and arrival at the hospital (12). The blue "tents" are pulse CO2 readings. Not shown is the 12 lead ECG which is also sent with the review and the outcome following hospitalization (in this case the patient was discharged 7 days later with a full neurological recovery).

In addition, detailed feedback is provided to the EMT and paramedic crews. Following are portions of the report from Dr. Rea (King County EMS Medical Director) to the individuals involved in the resuscitation:

SUMMARY: Very good care from beginning to end of the prehospital. You can appreciate why the "system" works. The bystanders were engaged and willing, the call-receiver was very good at quickly recognizing the arrest and then navigating the relay between caller and rescuer to get chest compressions started, and EMS did their thing. This is the system that can save lives and provides the best chance in this specific case.

BLS – overall excellent – see the detailed review for the high praise. For constructive criticism please consider:

1. Early application of the puck if possible. I could not tell when compressions started/stopped or the quality of the individual compressions.
2. Proactive timekeeper who announces times at the 1 minute and 1:45 mark
3. Chest compressor who counts out the terminal portion of each set of 30 so the airway person can anticipate the 2 breaths (I heard this once).
   ALS is also very good – again see the detailed comments for high praise - but please consider:
4. When you report at the hospital that the patient never woke up.....please make sure the physician knows you gave a big slug of rocuronium so he has no chance to show signs of brain function. Importantly before he received the roc, he was breathing spontaneously which indicates his brainstem is functioning – a very good prognostic sign.

Details:

Dispatch: Call taker really did do a good job. Recognized arrest at 1:45 seconds, started instruction at 2:10, and started compressions at 3 minutes. Great job navigating the bike crash and determining this was an arrest. My only comment would be to confirm the restart of CPR after they had moved the patient.

Communication, Scene and Teamwork: Scene was well-controlled. Communication was very good. Good initial report. Thanks for narrating ALS interventions.

Patient and Arrest Etiology: Presents with VF. ECG shows anterior (septal) STEMI. Not much doubt in this case what caused the arrest as you note in your physician report.

CPR: Solid as best as I can tell. Puck, timer, and compressor count out terminal compressions are all asks on my part. Appears 30:2 good. Nice work to interface with the AED to limit perishock CPR interruption.

Airway / Ventilation: 30:2 before pulses and then excellent work to assist the patient's native ventilations after pulses and before intubation. After intubation correct approach to go with about 10 breaths per minutes. Nice work not to hyperventilate (which can be tempting once pulses return.)

Good work to transition the mindset for intubation AFTER a pulse has returned. Monitor oximetry and use RSI. The intubation was flawless. Placement was confirmed with ETCO2 soon after. Generally, ventilation rate was 10-12 throughout – really nice.

ALS airway: ~13 minutes after paramedic arrival (very appropriate given ROSC)

ACLS management and medications:

Overall this is well done. Intubation was "routine" and expert. Thank you for giving sedation after the robust dose of rocuronium – appreciate this patient will likely be paralyzed for 30+ minutes so important to provide sedation in case he does wake up. And again, to alert the hospital that he is paralyzed currently so not to expect any responses. Once a pulse returns, I think it is quite reasonable to check a blood sugar so nice work. Understand that the heart does not need sugar to contract so that BS check and glucose do not have a role DURING resuscitation, but certainly low blood sugar could affect brain function and awakening so good to check at some point after ROSC.

Post ROSC

Repeat Vitals: Yes. Thank you for your close monitoring.

12 lead: Yes. Repeated. Important and I appreciate you proactively alerting the ED that this is a STEMI that needs the cath lab.

Total time from final ROSC to enroute: ~13 minutes. Very appropriate. Clearly there was a goal to move toward the hospital in an efficient manner. Excellent effort all around.

Thank you.
Tom Rea MD
Medical Director
King County EMS

The Choreography of High-Performance CPR

Training in HP-CPR involves individual roles within the responding team. We highly recommend practicing as a team – in fact, make HP-CPR a true team event!

Agencies that fail to train as a team in HP-CPR often fail in a number of performance metrics: (pre-shock, post-shock and peri-shock pauses). Additionally, the efficiency of movement (rotations) by EMS personnel is often lost without a team approach to training.

There are three roles often described in terms of a triangle. The top of the triangle is the ventilator who positions him/herself at the head of the patient. The sides of the triangle are for the chest compressor and the timer/defibrillator. Every two minutes the compressor and ventilator should change position. In general, at the beginning of the cardiac arrest event, the person managing the defibrillator should be in charge and run the resuscitation providing key times and when to stop for rhythm checks. A key attitudinal concept we teach is that the EMTs own the quality of CPR. They are in charge of the compressions and ventilation portion of the arrest. Additionally, the EMTs are in charge of crew rotations freeing the paramedics to perform advanced airway techniques and IV/IO access along with any pharmacological interventions.

One of the skills that must be mastered during HP-CPR is the transition between the EMT use of an AED and that of a manual defibrillator used by paramedics. Pre-shock and post-shock pauses must be kept to a minimum (less than 3 seconds). The routine incorporation of team training will identify performance gaps to eliminate any excessive pauses.

The Art of Positive Reinforcement

For patients resuscitated at the scene and admitted to hospital, the best positive reinforcement is feedback about the hospital outcome. When EMTs learn of surviving patients, such information is the greatest reinforcement of a job well done.

Focus on the Patient

Similar to telephone CPR, HP-CPR should always have a positive spin. QI information, obtained from the case, is intended to improve patient care and never to discipline an EMT or paramedic.

Chapter 5: The Science of Defibrillation

Along with CPR, defibrillation is our most potent weapon against sudden cardiac arrest. As with any weapon, it needs to be used thoughtfully, safely and effectively. Here are potential suggestions to optimize such use:

When to Defibrillate?

A sudden witnessed collapse is more likely due to ventricular fibrillation than to other rhythm causes, and the patient should be defibrillated as soon as possible. If a defibrillator is not immediately available, CPR should be initiated and continued until its arrival. As noted in the section on HP-CPR, when CPR is in progress a shock should be administered with as little a pause as possible between the last chest compression and the shock, and CPR should be resumed immediately afterward.

Effects of cardiopulmonary resuscitation on predictors of ventricular fibrillation defibrillation success during out-of-hospital cardiac arrest. Eftestol T, Wik L, Sunde K, Steen PA. Circulation. 2004; 110:10–15.

➔ **https://www.ahajournals.org/doi/epub/10.1161/01.CIR.0000133323.15565.75**

When a cardiac arrest due to ventricular fibrillation is not witnessed or has likely been ongoing for at least a few minutes before discovery, there is evidence to suggest that a period of CPR may be beneficial prior to the first shock. In such circumstances, the ideal duration of CPR before the first rhythm analysis and shock, and whether this might also apply to both shockable and non-shockable presentations of cardiac arrest, was recently evaluated in a large randomized clinical trial. The trial found that survival, regardless of the presenting rhythm, was similar whether the first rhythm analysis was preceded by a relatively short (30-60 seconds) or longer (180 seconds) period of CPR. The important take-away message is that a period of CPR is advisable before first application of a defibrillator (CPR can be performed while the defibrillator is readied for use), but its actual duration (30-180 seconds) is less important than its actual performance.

Influence of cardiopulmonary resuscitation prior to defibrillation in patients with out of hospital ventricular fibrillation. Cobb LA, et al, JAMA 1999; 281:1182-8.

➔ **https://jamanetwork.com/journals/jama/fullarticle/189314**

Resuscitation Outcomes Consortium (ROC) PRIMED cardiac arrest trial methods part 2: rationale and methodology for "Analyze Later vs. Analyze Early" protocol. Stiell IG, Callaway C, Davis D, Terndrup T, Powell J, Cook A, Kudenchuk PJ, Daya M, Kerber R, Idris A, Morrison LJ, Aufderheide T. Resuscitation. 2008;78:186–195.

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(08)00114-7/fulltext**

Delaying defibrillation to give basic cardiopulmonary resuscitation to patients with out-of-hospital ventricular fibrillation: a randomized trial. Wik L, Hansen TB, Fylling F, Steen T, Vaagenes P, Auestad BH, Steen PA. JAMA. 2003; 289:1389–1

➔ **https://jamanetwork.com/journals/jama/fullarticle/196200**

Defibrillation or cardiopulmonary resuscitation first for patients with out-of-hospital cardiac arrests found by paramedics to be in ventricular fibrillation? A randomised control trial. Baker PW, Conway J, Cotton C, Ashby DT, Smyth J, Woodman RJ, Grantham H. Resuscitation. 2008;79:424–431.

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(08)00607-2/fulltext**

Pad Placement

Defibrillator pads (electrodes) should be placed without interrupting CPR. The recommended location for the sternal pad is just to the right of the upper sternal border below the right clavicle; the apical pad is located to the left of the nipple with the center of the electrode in the midaxillary line. While other pad locations are also acceptable (such as placing a posterior patch in the left or right infrascapular area, and an anterior patch to the left of the sternum) placing both patches anteriorly, as suggested, is preferred as the initial approach to care because it avoids interruption of CPR.

How Much Energy?

While all defibrillators require selection of a shock energy (measured in Joules or watt-seconds), the electrical resistance created by the skin, bone, muscle, and lung air lying between the two the defibrillator electrodes dissipate much of this energy when the shock is administered. Ultimately, it is current (measured in amperes) that reaches and defibrillates the heart. Modern-day defibrillators measure this electrical resistance and automatically alter the energy delivered to the patches in order to achieve the desired current. Given the expected resistance of human tissue, biphasic defibrillators typically deliver energy ranging from 120 to 360 J, depending on the manufacturer. Based on the manufacturer's recommendations for the device being used, defibrillation energy is initially selected at 120, 150 or 200 J, and may be incremented upward to 360 J if required for shock-resistant arrhythmias, depending on the device's capabilities.

Understanding the relationship between energy, resistance and current underscores the importance of the "small details" entailed in successful defibrillation. For example, poor electrical contact of patches with skin can result in a lower than successful defibrillation current reaching the heart, which can be easily remedied by closer attention to the patch-skin interface. Conversely, excessive shock energies that result in high currents can actually damage the heart and provoke recurrent ventricular fibrillation.

Energy, current and success in defibrillation and cardioversion. Kerber RE, et al. Circulation 1988;77:1038-46.

➔ **https://www.ahajournals.org/doi/pdf/10.1161/01.CIR.77.5.1038**

Low-energy biphasic waveform defibrillation: Evidence-based review applied to ECC guidelines. Cummins RO, Hazinski MF, Kudenchuk P, Kerber RE, Becker L, Nichols G, Malanga B, Stapleton E, Aufderheide T, Kern K, Ornato J, Sanders A, Valenzuela T, Eisenberg M. Circulation 1998; 97:1654-67.

➔ **https://www.ahajournals.org/doi/epub/10.1161/01.CIR.97.16.1654**

Automatic versus Manual Defibrillation by EMTs

In the early 1980s, King County EMS demonstrated that EMTs could be trained in VF recognition and could properly deliver a shock after identifying VF on a defibrillator. At that time AEDs had not been invented and so the EMTs were trained in manual recognition of VF on a manual defibrillator.

AEDs are certainly easier to operate than manual defibrillators. However, some AEDs require hands-off time for the device to be charged (our experience demonstrated that this time could be 30 or more seconds), suggesting that manual defibrillation is quicker and perhaps better. A small animal study by Berg and colleagues from 2003 demonstrated that the extra time for AEDs to defibrillate compared to manual defibrillation led to a worse survival rate.

Automated external defibrillation versus manual defibrillation for prolonged ventricular fibrillation: lethal delays of chest compressions before and after countershocks. Berg RA, Hilwig RW, Kern KB, Sanders AB, Xavier LC, Ewy GA. Ann Emerg Med. 2003;42:458-67.

➔ **Abstract only: https://www.annemergmed.com/article/S0196-0644(03)00525-0/fulltext**

Since this study, AEDs have improved with faster detection algorithms and shorter charge times than in the past. Thus, two of the reasons for manual defibrillation have been mitigated. Given the issue of safety (such as shocking a patient who is not in VF) and ease of use, automatic external defibrillators (AEDs) have gained near universal acceptance as the preferred method of defibrillation for EMTs who are not formally trained in rhythm recognition.

Double Sequential Defibrillation

In the early era of defibrillation, some physicians advocated higher than usual energy for defibrillation - up to 500 joules or even higher. However, evidence at the time demonstrated that the high energy was not beneficial, may be harmful, and moreover made the size and weight of "high energy defibrillators" impractical for use. Although the idea of a "high energy defibrillator" was abandoned, this did not preclude the occasional use of two standard defibrillators to simultaneously shock patients with refractory arrhythmias, the risk of "shock toxicity" notwithstanding. These challenges underscore some of the limitations of then-current "monophasic shock" waveform. The now-current defibrillation standard, biphasic waveform defibrillation, provides comparable or better defibrillation efficacy than the older monophasic waveform defibrillation technology, but with lower energy requirements and greater safety from the potentially harmful effects of high energy shock. Questionable procedures have a way or recycling, and in the past few years some physicians have advocated a return to double defibrillation (also called double sequential defibrillation or dual defibrillation) using biphasic defibrillators for shock resistant VF. This requires two biphasic defibrillators, each set to maximum energy, and a double set of defibrillator patches. Each defibrillator is discharged simultaneously, sequentially or with some degree of overlap, in a generally uncontrolled fashion with respect to either the timing of shocks or patch location. Although initial case reports cited some successes, a recent series observed no benefit and potential harm from double biphasic defibrillation. This technique also risks substantial damage to the defibrillator devices themselves. At present, use of this technique raises the same concerns as in the past and is in need of further study before clinical adoption.

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Effectiveness of prehospital dual sequential defibrillation for refractory ventricular fibrillation and ventricular tachycardia cardiac arrest. Beck LR et al; Prehosp Emerg Care 2019; DOI: 10.1080/10903127.2019.1584256

➔ **Abstract only: https://www.tandfonline.com/doi/full/10.1080/10903127.2019.1584256**

Shocking insights on double defibrillation: How, when and why not? Kudenchuk, PJ. Resuscitation 2019; 10.1016/j.resuscitation.2019.05.022

➔ **https://www.resuscitationjournal.com/article/S0300-9572(19)30191-1/fulltext**

Recurrent/Resistant VF

Under current resuscitation guidelines, resumption of chest compressions is recommended immediately after a defibrillation shock. Such an approach affords a survival advantage in providing ongoing circulatory support because of minimally interrupted CPR before and after the heart receives a shock. However, immediate resumption of CPR after shock also obscures the ECG, making it difficult to determine whether VF actually terminated or not. When VF is still seen on the subsequent rhythm analysis (2 minutes later) it is often presumed that the rhythm is "shock refractory".

However, in studies that formally analyzed defibrillator recordings from clinical resuscitations, it was observed that the vast majority of VF/VT episodes were successfully terminated by shock but recurred during the ensuing period of CPR. Put another way, VF that is often deemed "shock-refractory" is far more likely to be "recurrent" after shock than truly "resistant" to it. Recognizing this difference is critical since the recurrence of VF/VT after a successful shock does not mean the shock failed, nor the need for more power (such as double defibrillation), but should rather direct providers to other avenues of therapy such as use of antiarrhythmic medications.

In instances where VF is truly shock-refractory, the culprit more often than not is high resistance, not insufficient defibrillator energy. This can potentially be improved by ensuring appropriate patch-skin contact – which may require putting pressure on the pads themselves (using a dry folded or rolled towel) analogous to how defibrillator "paddles" were used in the past. Adding pressure to pads can reduce resistance at this level, improve current flow to the heart and result in greater likelihood of successful defibrillation. Another consideration is to ensure patches are properly placed – as often the anterior apical patch is placed too medially (toward the sternum) whereas the center of that electrode should lie more laterally in the midaxillary line. In some cases, replacing the patches in an entirely different location (such as anterior-posterior) may shock the heart "from a different angle" and achieve greater success.

Transthoracic incremental monophasic versus biphasic defibrillation by emergency responders (TIMBER). Kudenchuk PJ, Cobb LA, Copass MK, Olsufka M, Maynard C, Nichol G. Circulation 2006; 114:2010-18.

➔ **https://www.ahajournals.org/doi/epub/10.1161/CIRCULATIONAHA.106.636506**

A prospective, randomized and blinded comparison of first shock success of monophasic and biphasic waveforms in out-of-hospital cardiac arrest. Van Alem AP, Chapman FW, Lank P, Hart AA, Koster RW. Resuscitation. 2003;58:17-24.

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(03)00106-0/fulltext**

We recommend the following sequence for dealing with recurrent/resistant ventricular fibrillation. When encountering so-called "shock refractory" VF, consider the following:

1. Is the VF truly shock-refractory, or just recurrent? Playing the odds, the VF is most likely recurrent, in which case a change in shock energy (or resorting to double defibrillation) is unlikely to be helpful. Such patients may benefit by other rhythm-stabilizing medical interventions.

2. Are defibrillator pads positioned appropriately? A common mistake is to place the anterior apical patch too medially (just below the nipple), whereas it is recommended that it be located with the center of the electrode in the midaxillary line.

3. Can resistance be minimized at the defibrillator pad-skin interface? Applying manual pressure to pads can help lower resistance at the electrode pad-skin interface. This can be accomplished by (using gloved hands) pressing a folded or rolled dry towel on one or both pads during shock delivery. This can substantially reduce pad resistance, increase current delivery to the heart and improve defibrillation success.

4. Should defibrillator pads be relocated? Changing the patch configuration from antero-lateral to anterior-posterior might improve current flow across the heart and achieve greater success.

5. Is this a circumstance in which the patient is best transported to hospital for acute cardiac catheterization? Recurrent and shock-refractory forms of VF can be signs of ongoing acute myocardial ischemia and infarction, which may only be correctable by emergent revascularization, if this is available.

Chapter 6: The Art of Defibrillation

Performance Metrics

Similar to high performance CPR, defibrillation is no less a choreographed dance. Think of it this way: there are separate finely tuned dances around the patient - two principals performing the CPR "dance of chest compression and ventilation" and another principal performing the "dance of defibrillation." In the dance of defibrillation, the following sequence should be undertaken:

1. Defibrillator pads should be placed during ongoing CPR. They should be optimally positioned to ensure the heart is captured (sandwiched) between the pads.
2. Resistance at the pad-skin interface should be minimized.
3. Minimize pauses surrounding defibrillation. Defibrillators should be pre-charged prior to a rhythm/pulse check, affording a rapidly administered shock if a shockable rhythm is subsequently identified.
4. Stick to 2-minute intervals between formal pauses in CPR for rhythm analysis. This gives you 2 minutes to "think thru" your strategy for the next scheduled pause.
5. Announce an upcoming pause for rhythm analysis 30 seconds in advance. This affords time to pre-charge the defibrillator and organize other activities that might be required surrounding the upcoming pause (such as switching compressors, ensuring there is no motion of the patient during the pause that might obscure the rhythm analysis, and preparing to evaluate the rhythm during the pause itself).

Quality Improvement

Unlike T-CPR and HP-CPR, there are no nationally recommended performance standards for defibrillation. The above list provides a sequence we believe to be reasonable and clinically tested. A review of the event using downloaded recordings from the defibrillator should allow for general statements about the quality of defibrillation (and CPR) during a resuscitation. We recommend, in addition, that EMS systems consider voice recording of the resuscitation. Voice recording is available as an accessory to most standard pre-hospital paramedic defibrillators and EMT automated external defibrillators. Though there is a cost involved and sometimes challenging issues with transmission of the recording to the base station or EMS office, we believe the information collected to be extremely worthwhile.

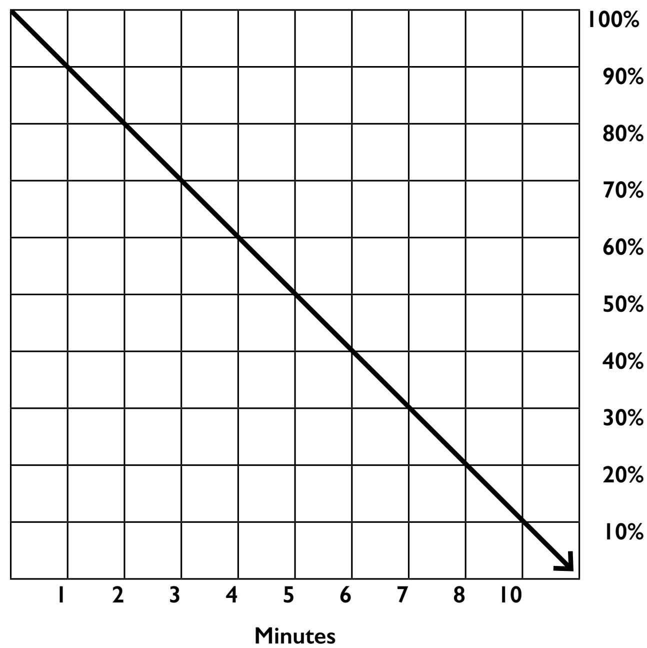
Seattle and King County have been using defibrillator and AED voice recordings almost from the inception of the programs. Each recording is downloaded, data are abstracted, and results of the resuscitation shared with the responding team. The information provided to the team is extremely detailed with comments from the medical director or his/her associate. As with CPR QI, all comments are positive and always focused on how to provide the best care for the patient.

Chapter 7: The Slope of Death

Understanding Why the Lower Hanging Fruits Are So Critical

A cardiac arrest registry (Step 1) is crucial as it is the only way to measure how a system is performing. It is the foundation upon which the other steps are built. The importance of Step 2 (Telephone CPR), Step 3 (High Performance CPR) and Step 4 (Rapid Dispatch) are also crucial as they directly stem the dying process. A convenient way to understand the importance of these interventions is to use the graphical display of the slope of death. At the moment of cardiac arrest, the slope begins and by 10 minutes it reaches zero. Interventions along these 10 minutes can alter the slope and thereby improve the likelihood of survival. This is admittedly a graphical representation of a complex process, but it is a fair approximation of what actually occurs.

The Slope of Death



The slope of death conveys an important concept in understanding why some EMS systems achieve high survival rates and others do not. It also provides a graphical explanation for the factors contributing to underperforming, average performing, and high performing EMS systems.

Predicting survival from out-of-hospital cardiac arrest: A graphic model. Larsen MP, Eisenberg, MS, Cummins RO, Hallstrom AP, Ann Emerg Med 1993;22:1652-8.

→ **Abstract only: https://www.annemergmed.com/article/S0196-0644(05)81302-2/fulltext**

The first article to document the decrease in likelihood of survival with each passing minute without therapy was documented almost 30 years ago. The actual relationship is more nuanced than shown in the above graph as there is a strong interaction between CPR and the time to defibrillation. If defibrillation is provided very early, CPR may not be necessary in some instances. And the longer the delay to CPR the more difficult it becomes to achieve successful defibrillation. Plus, as will be shown in subsequent pages, the quality of the CPR is another important determinant of survival.

Some clarification about CPR and the slope of death:

1. Bystander CPR and T-CPR slow the dying process until defibrillation occurs.

2. High Performance CPR virtually suspends the dying process until defibrillation occurs.

3. Defibrillation is definitive therapy for ventricular fibrillation.

4. The sooner CPR begins the better. Without CPR death is almost inevitable when defibrillation occurs after 10 minutes

With the slope of death serving as a template, we can model differences in various EMS systems to understand survival rates. The underlying assumption is that the time intervals from 911 call to the various interventions determine the survival rate.

Modeling EMS Systems

The following 3 graphs model the reasons why EMS systems achieve low, average, and high performance. Low (or under) performing communities achieve 10% survival rate. Average performing communities achieve 30% survival rate. High performing communities achieve 50% survival rate. High performing agencies define best practices.

For each of the models the following assumptions apply:

Assumptions	
Dispatch time:	2 minutes
Turnout time:	1 minute
Travel time to scene:	4 minutes
Scene to patient and start of HP-CPR:	1.5 minutes
HP-CPR to defibrillation:	1.5 minutes
Defibrillation is definitive therapy	

Are these times realistic? The times are based on actual measurements from King County Washington. What distinguishes under, average, and high performance (best practices) communities? The Seattle Medic One program measured time intervals of at scene to at patient side of 2.4 minutes. Thus, the above assumptions are likely to be even longer. In this model the T-CPR is equivalent to bystander CPR.

The impact of first responder turnout and curb-to-care intervals on survival from out-of-hospital cardiac arrest. DeRuyter NP, Husain S, Yin L, Olsufka M, McCoy AM, Maynard C, Cobb LA, Rea TD, Sayre MR. Resuscitation. 2017;113:51-55.

➔ **Abstract only: https://www.resuscitationjournal.com/article/S0300-9572(17)30027-8/fulltext**

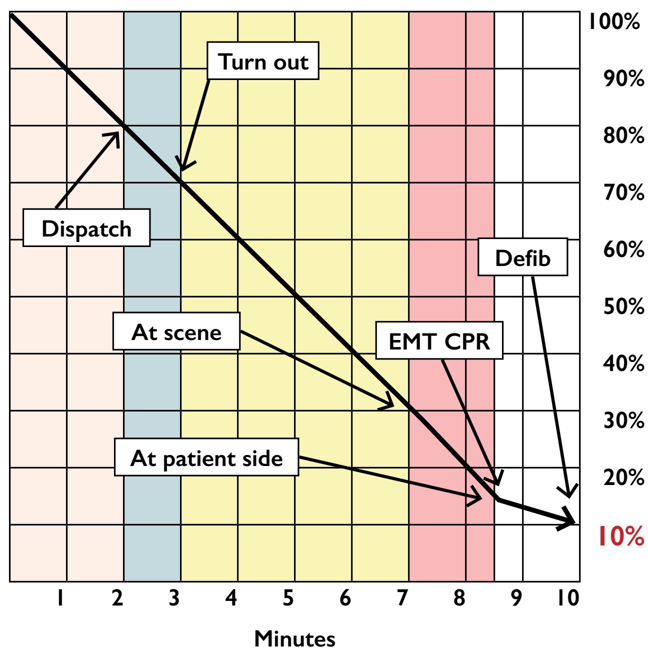
Characteristics of Under-performing Communities

The following three graphical displays show why T-CPR, HP-CPR and rapid dispatch are crucial. Each of these interventions alters the slope of death so that when defibrillation occurs there is a higher likelihood of survival. Rapid dispatch is effective because it allows EMTs to arrive sooner and begin HP-CPR sooner. In the example above we have kept the turn-out time, the drive time and the time to reach the patient the same.

Under-performing communities have the following characteristics of their EMS system:

- 10% survival from VF
- No HP-CPR
- Almost no T-CPR/bystander CPR
- No rapid dispatch

Under Performing: No T-CPR, no HP-CPR, no Rapid Dispatch

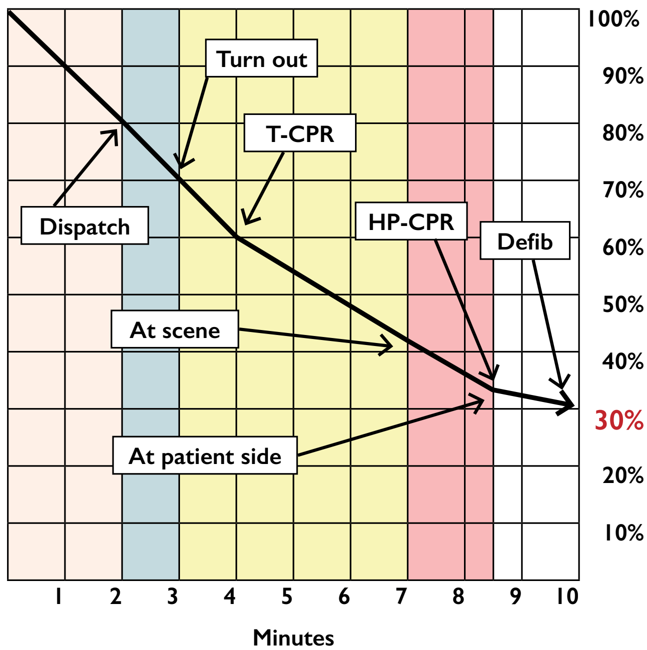


Characteristics of Average-performing Communities:

Average-performing communities have the following characteristics of their EMS system:

- 30% survival from VF
- HP-CPR
- Late T-CPR
- No rapid dispatch

Average Performing: delay in T-CPR, no Rapid Dispatch

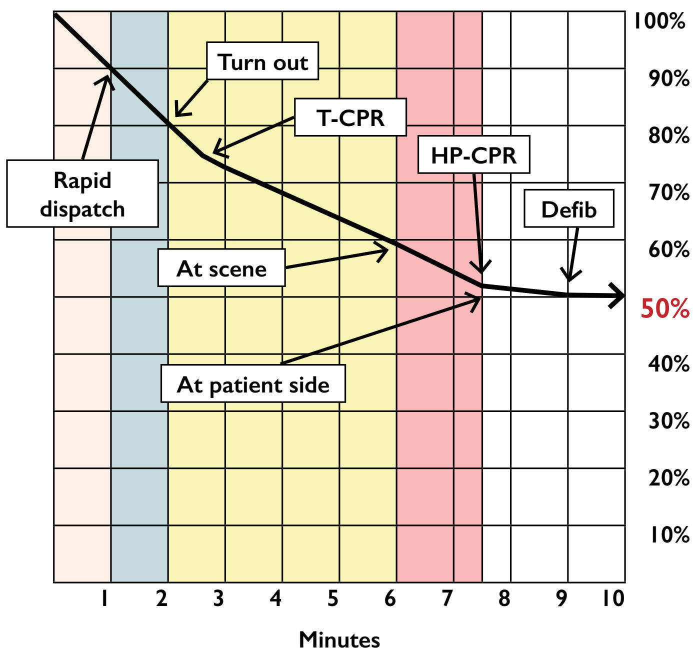


Characteristics of High-performing (best practices) Communities

High-performing communities (which we consider to embody best practices) have the following characteristics of their EMS system:

- 50% survival from VF
- 100% HP-CPR
- 75% T-CPR
- Rapid dispatch

Best Practices: Rapid Dispatch, T-CPR, HP-CPR



The above models only take into account the influence of T-CPR, HP-CPR and rapid dispatch. Of course, there are other interventions occurring in cardiac arrests. For example, the models do not factor in bystander CPR (without telephone assistance). It is true that high rates of bystander CPR would raise the survival rate, but as a model the intervention of T-CPR could stand in for bystander CPR. The reality is that even when bystander CPR is in progress at the time of the 911 call, there are opportunities for telephone assistance and instant refresher training as well as rate correction.

Another factor not taken into account is the use of AEDs by police or first responders (such as security guards). Currently, police AED is very uncommon and when it occurs it would tend to raise the slope of the curve. Also not included are smart apps to alert individuals of a nearby cardiac arrest. Currently in the US such apps are not activated for cardiac arrest in private homes (where most cardiac arrests occur) and while AEDs are mapped on the app they are seldom retrieved. Thus, the impact is small.

Chapter 8: Improvement is Possible

The Challenge of Implementation

> We would tear our department apart and rebuild it step by step, if we thought we were losing 4 to 6 citizens per year that should have been rescued from fires. So, when we know that we can save 4 to 6 additional people every year from cardiac arrest – are we as an agency going to step up and put the same energy into saving these CPR patients? Whether it is a person dying in a house fire or a person dying from cardiac arrest – to the family – dead it dead, and equally tragic, so why should we spend any less effort saving these patients?
>
> Russ McCallion, Asst. Chief,
> East Pierce Fire and Rescue

Assistant Chief McCallion gets it: he would tear his department apart and rebuild it step by step if he thought he could save a few more citizens per year from cardiac arrest. (And actually, he did exactly that after attending a Resuscitation Academy. After training all his EMTs in HP-CPR he measured an immediate improvement in survival in his district.)

Within three years of the Resuscitation Academy's inaugural class we felt something was missing from the program. We believed the 10 steps were being well communicated and we believed each class came away highly motivated to improve their system. But through follow up with the attendees we realized new knowledge and high motivation were not enough. Many attendees encountered a wall of inertia and status quo. It was very difficult to create change in their agency's management of cardiac arrest. They encountered problems across the spectrum: a disinterested telecommunication director, a medical director too busy to take on new programs, a training chief wondering where the mandate was for change, an EMS battalion chief not having the resources for additional training, and on and on. The challenge was not with the science, the challenge was with the art. It was difficult to motivate leadership to take on more training and more quality improvement. Where was the mandate? Where were the funds? Who is forcing us to change? And on and on.

Even when the agency's medical director or fire chief attended the RA similar problems arose upon returning to his/her agency. Why change? Will the mayor approve more funds? Is there enough political capital to take this on? And on and on.

Lest we sound too pessimistic there have been dozens of communities that embraced change and made meaningful improvements to their system. In some instances, the improvement in survival from VF was dramatic. But we'd have to say that for every agency which improved its survival rate, there were two that did not. Why?

To address this issue, we have added considerable material on implementation and have made the challenges of implementation a major part of the program. We are slowly learning some hard lessons.

1. The first is that implementation of new programs or even enhancements to existing programs are very difficult to achieve.

2. Before any change can occur, the community must determine its cardiac arrest survival rate (the Utstein metric). One would think every community had this information, but such is not the case. CARES, as mentioned in Chapter 2, covers only 30% of the US population. Thus, the vast majority of communities do not have a clue of how they are performing.

3. Assess your system. Once a community has determined its survival rate, they should assess their system. The Resuscitation Academy offers a free system assessment. *(Resuscitationacademy.org)* This assessment provides suggestions for improvement. It also provides comparison with national averages for various programs such as T-CPR, HP-CPR, community programs, and cardiac arrest registry.

4. The data from step 3 (system assessment) provide the facts needed to know where to start.

5. Start small, perhaps with a pilot program. We know of several communities that decided to start HP-CPR with the EMTs in one fire station. They wisely worked closely with a local champion among the firefighters. After some initial successes word got around the department and soon other stations asked to get on board and within a year the entire department was trained.

6. Form an advisory group. This can be formal or informal. Obviously defining a shared vision is important – it can be as general as "Improving survival from Sudden Cardiac Arrest". The advisory group should be broadly comprised – ideally with the fire chief, EMS director, EMS medical director, EMS training chief, telecommunications director, mayor (or head of city council or both), representative from the main hospital(s) and/or emergency department, perhaps the local newspaper publisher, head of the local Kiwanis or Rotary club, and other local appropriate person(s). Better to start with a very small group – perhaps only 3 or 4 people – and then grow from there once you are all on the same page. Just like no two EMS agencies are the same, no two advisory groups should be the same. Once you have a group, even if it only has three members, begin to define your goals and decide the best strategy for accomplishing them. Meet regularly and try to set accomplishable goals.

The Challenge of Accountability

Accountability occurs on all levels within an EMS agency. The agency should be accountable to the mayor/elected officials and/or administrative head of EMS such as the fire chief. But accountability also means sharing vital information with the community served by EMS. An annual report is the best way to declare accountability.

Most EMS agencies do not publish annual reports, and certainly not with sensitive information such as cardiac arrest survival rates. But why hide the information? Doesn't an EMS agency exist solely to serve the inhabitants within that community?

Following are suggested elements to include in an annual report card to the community. Most of these elements are available in the CARES registry so it would not take too much effort to collate them into a report.

a. Total number of worked cardiac arrests

b. Utstein survival (discharged survival from witnessed VF)

c. Survival from all rhythms

d. Percent of witnessed cardiac arrests

e. Percent of bystander CPR

f. Percent of bystander CPR due to telecommunicator CPR

The Challenge of Leadership

Confronting the reality that one's EMS system is not performing well is never pleasant. Typically, such harsh awareness occurs when one learns that the community's VF survival rate is only 10% when the national survival rate is 30% and that some communities reach 50%. What do you do with such information? Rationalizing it is probably the best response but there is always the nagging doubt of "can we do better?" Thus, begins the journey of finding the reasons for low survival, learning how to embark on new programs, leading the effort or finding good people to lead it, then seeing the effort to completion, and last celebrating success. From realization to improvement is a multi-year journey in most instances. Not a job for a short-termer. Nevertheless, a leader, if worthy of that name, accepts the challenge of improvement and guides the organization on that journey.

Leadership also entails responding to individual resuscitations – both those that go well and those that go less than well. For the "good" resuscitations feedback is easy. Personal notes or phone calls, letters to supervisors, and even award ceremonies are always appreciated. But remember to honor the entire team of responders including the telecommunicator. For the "less than good" resuscitations feedback should always focus on the patient. "How can we improve?" Disciplinary actions are rarely productive. In our system no data, especially voice recordings, are ever used for disciplinary reasons. Our operative ethic is: "How can we do better for the patient on the next resuscitation?"

Focusing on the patient is another aspect of leadership. QI for cardiac arrest often becomes mired in statistics and numbers. Percent survival rates are abstract and lose sight of the fact that the numbers represent real people. It is fine to note and celebrate rising survival rates, but even better is to draw attention to people. In discussing survival rates, it is always appropriate to translate percentages to people. "Last year we saved 25 lives" has real impact and resonates better than, "our survival rate is 18%."

10 Questions Every EMS Leader Should Ask

1. What is our Utstein VF survival rate? (Remember to also translate percentages to number of lives saved.)
2. What is our bystander CPR rate?
3. Do we have ongoing training and QI for T-CPR?
4. What is the median call to cardiac arrest recognition time?
5. What is the median call to cardiac arrest chest compression time?
6. Do we have rapid dispatch for cardiac arrest?
7. What is our time from tone out (alarm in the station) to wheels rolling?
8. What is our time from arrival at scene to arrival at patient's side?
9. Do we have ongoing QI and documented performance training for HP-CPR?
10. Is our current HP-CPR training meeting performance metrics?

10 Questions Every Citizen Should Ask

1. Do we have a cardiac arrest registry?
2. What is the VF survival rate in my community?
3. What is the bystander CPR rate in my community?
4. How long does it take from my call to 911 for an EMT unit to arrive at my doorstep?
5. Do telecommunicators send the first-in unit ASAP when cardiac arrest is suspected?
6. Are all EMTs who respond to medical emergencies trained in HP-CPR?
7. Are all telecommunicators trained in T-CPR?
8. How long do telecommunicators take to recognize cardiac arrest?
9. How long do telecommunicators take to "provide" the first chest compression?
10. Is there mandatory CPR training in my community?

We believe the journey to improvement starts with asking key questions. When the answers disappoint, establish ongoing measurement and ongoing quality improvement. Measure and improve is the best way we know to improve survival rates. And remember to celebrate successes.

Final Words

We offer our congratulations if you have reached these final words. You clearly care about improving cardiac arrest survival in your community and we honor you in this quest. Improvement is difficult – in fact we have a Resuscitation Academy mantra just to describe this challenging quest -- "Change occurs iteratively" – but it is possible. We also have a mantra to describe the first step of any change – "First do a pilot." Piloting affords the opportunity to see what works and what is challenging, and most importantly, how to get buy-in from the telecommunicators, EMTs, and paramedics.

But, however small the steps and however long it may take, you will find nothing more gratifying in your career. Our last mantra describes it perfectly. Resuscitation is "snatching life from the jaws of death". And that is pretty amazing.

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