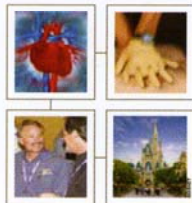
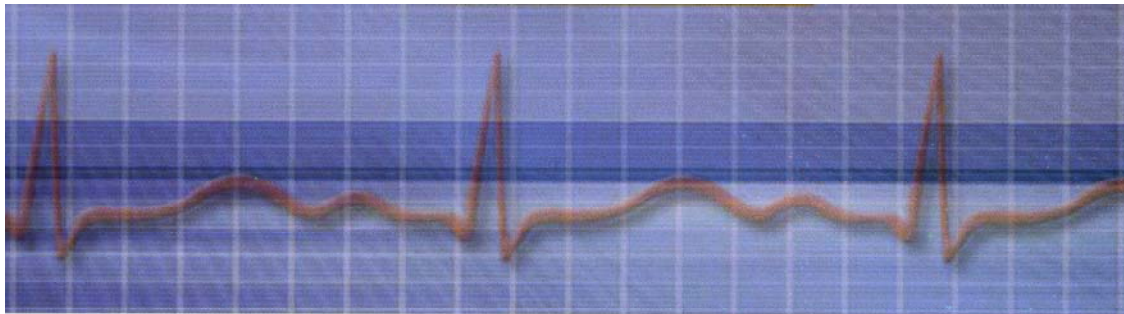


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Building and Understanding a Community Survival Curve ©

According to the 1982 Farmington Study, every 29 seconds, someone in the United States suffers a heart attack and every minute someone dies from one. Sudden Cardiac Death (SCD) is one of the leading causes of death and a major public health problem, representing 30% of all non-traumatic and 50% of all coronary artery disease related deaths. In the United States, approximately 300,000 to 400,000 sudden deaths occur annually, and about two thirds of these victims are above the age of 65 years¹. Unfortunately, survival from cardiac arrest remains relatively low.

Today, the probability for a patient's survival is determined mainly by the interval between the patient's collapse and the delivery of the first defibrillatory shock. Research has informed us that a patient defibrillated within the first minute or two after their collapse has more than a 90 percent chance to be discharged from the hospital^{2,3}. For each minute of sudden cardiac arrest, the likelihood of surviving the event decreases by approximately 2% to 10% per minute^{4,5}. The shorter the time from collapse to defibrillation, the better the chances of survival⁶.

Figure 1 is referred to as the Patient's Survival Curve, where minutes are represented on the "x" axis and the percentage probability of a patient's survival is represented on the "y" axis. As the curve moves out and away from the patient's time of collapse, the probability of the patient surviving the event lessens. This depressing statistic means that if we have not managed to defibrillate a patient within 10 minutes of their collapse, the probability of surviving the event approaches zero.

According to the American Heart Association (AHA), clinical and epidemiological studies have confirmed two observations:

- Almost every adult (over 90% in most studies) who survives sudden non-traumatic cardiac arrest is resuscitated from Ventricular Fibrillation (VF)
- The success of defibrillation is remarkably time-dependent.

The Patient Survival Curve is quite graphic and easily understood by the reader; however, can we apply this same approach to understanding a community's delivery of early defibrillation? Can we describe the community's survival based upon the Community's Survival Curve? Can we measure the benefit of providing lay public, BLS and ALS defibrillation? The answer is "yes" to all, and quite persuasively!

Building the Community Survival Curve ©

Pinellas County EMS is considered a national model of excellence. It is a single tier, all Advanced Life Support (ALS/Paramedic) dual response system where the average response time to deliver a paramedic to an emergency scene is 4.2 minutes. Typically, the system manages between 900 and 1,000 sudden cardiac arrests (SCA) annually. In 2003, the system managed 973 events where 260 patients (27 %) presented in VF/VT. From the 260 VF/VT events, 159 or (61%) had valid shock information for analysis and inclusion in the Community Survival Curve. This number was further reduced by 10 to 149 for the events that were witnessed by EMS (These cases were excluded from the response calculations, as their inclusion would distort the overall response performance measures). 34.5% of the SCA patients had Return of Spontaneous Circulation (ROSC) with an Utstein Template survival of 19%.

Figure 2 represents Pinellas County EMS's latest Community Survival Curve. Several important factors need to be understood prior to accurate interpretation of this curve. First, in order to parallel the Utstein Style Template's strict definitions⁷, the curve actually starts at the time of the patient's collapse, not at the time of the 9-1-1 call for assistance. It makes sense that the patient's survival clock begins ticking at the moment of arrest. Determining this time is an extremely difficult task in most situations; bystanders and family members tend not to carry a stopwatch to mark the beginning of the interval. Most "down times" offered by families are subjective, as confirmed by interviews with our SCA survivors and their families. From these discussions, we estimate that the average time from discovery of a person in cardiac arrest to dialing 9-1-1 may be as long as two minutes.

Although the specific time of an individual arrest can sometimes be heard or visibly witnessed and plotted specifically, for the purpose of the Community Survival Curve, we assume a two minute collapse to 9-1-1 call interval. Even though the two minute estimate may be on the long side, it is probably more desirable for the purpose of building the Community Survival Curve and taking from it lessons for community improvement to underestimate community performance rather than overestimate it. Leaving out the consideration of time from recognition to 9-1-1 call altogether will always provide overestimates.

The "call received" (first ring at 9-1-1) time is much more reliably identified. This time is a classic EMS performance data point used in the determination of several important system measurements, including "response time". Pinellas County EMS's VF/VT cardiac arrest-specific interval from 9-1-1 call receipt to "at patient" (Pinellas County's definition of "response time") is 5 minutes and 58 seconds (4 minutes and 40 seconds to arrive on scene plus 1 minute and 18 seconds to arrive "at patient"); therefore, the collapse to "at patient" interval for these patients is just shy of 8 minutes. All of these time intervals, including arrest recognition to 9-1-1 call and receipt of 9-1-1 call to emergency unit arrival with the patient are subject to on-going improvement efforts through community education, improvement of technology, vehicle maintenance programs, and other quality assurance activities.

The final time interval of interest is the time to first defibrillatory shock for the VF/VT SCA patient. Actions included in the interval from “at patient” to “first shock” need to be specifically studied and documented in order to optimize performance in this phase. These actions include turning on the device, applying the pads, performing the initial rhythm analysis, and shock delivery if advised. This analysis can be applied to both professional rescuer and public access (PAD) defibrillation. (A full discussion of effective PAD programs is beyond the scope of this article.) Pinellas County EMS personnel advise dispatch of both “at patient” and “first shock” times; the system’s goal is to achieve “first shock” within ninety seconds (indicated by the blue zone on Figure 2).

The Community Survival Curve in Figure 2 includes histograms reflecting system “first shock” performance. One hundred twenty of one hundred forty nine shocks, or 88%, were delivered at eight to twelve minutes from time of collapse, with the average first shock occurring at ninety-six seconds after arrival “at patient”. With the likelihood of survival decaying by 2 to 10%^{4,5} per minute after cardiac arrest, it is clear that making first defibrillation available on average at nine minutes and thirty-four seconds along the Survival Curve is not the optimum answer to achieving cardiac arrest survival.

What can we learn from a Community Survival Curve?

Understanding and examining all of the elements of the Community Survival Curve can assist a community in developing multiple strategies to improve its SCA survival rates. As previously noted, the EMS system can focus on improvements in community education, technology, medical education, measurement and reinforcement of key performance indicators, vehicle safety and response capabilities and other quality assurance activities. Where BLS response times are consistently shorter than ALS response times, the addition of automated or semi-automated external defibrillators can contribute to shifting the community’s place on the survival curve to the left.

Perhaps even more importantly for the community, the Survival Curve graphically illustrates the potential contribution of public access defibrillation (PAD) programs. If first defibrillation is the defined end-point of the Community Survival Curve, enhancing the community’s ability to furnish that first shock with automated external defibrillators (AEDs) prior to EMS arrival will likely have the most significant impact of all. The time period used to construct the Pinellas County Community Survival Curve happens not to have included any occasions of PAD AED use; however, with 361 AEDs registered with the county as being available during that time and over 475 devices now registered, it is probably only a matter of time before the influence of the PAD programs appears on the curve. That positive impact is made more probable by a county ordinance requiring AED registration and tracking, with the availability of AED location information to Emergency Medical Dispatch (EMD) providers.

Other applications for the Community Survival Curve?

Several newer studies^{8,9} have recommended the initial withholding of EMS defibrillation when response time is longer than three minutes in favor of performing two to three minutes of CPR prior to defibrillation. Applying this information to the Pinellas County Community Survival Curve, it is clear that the majority of patients treated by EMS, with its five minute and fifty-eight second time from call received to “at patient”, would be subject to CPR prior to defibrillation. It is likely that the only way to consistently intervene within the window of time prior to the requirement for CPR will be to get an AED to the patient within three to five minutes of patient collapse, thus increasing the importance of PAD programs.

Conclusion:

Pinellas County EMS has applied the Patient Survival Curve concept in a way never considered during its development. The initial intended application of the Patient Survival Curve was purely educational, distinctly tying together duration of a patient’s collapse with their probability of survival. However, the same concept can clearly be used to illustrate a Community Survival Curve that plots the comprehensive effect of many interventions, including both public and professional and lay and trained rescuers. Factors influencing each segment of the continuum can be identified, dissected, addressed, and remeasured. The Community Survival Curve also clearly indicates that the responsibility for improving cardiac arrest survival truly does lie at the community level, with many opportunities for improved partnerships between local EMS agencies, community groups, governmental jurisdictions and other healthcare providers.

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Figure 1

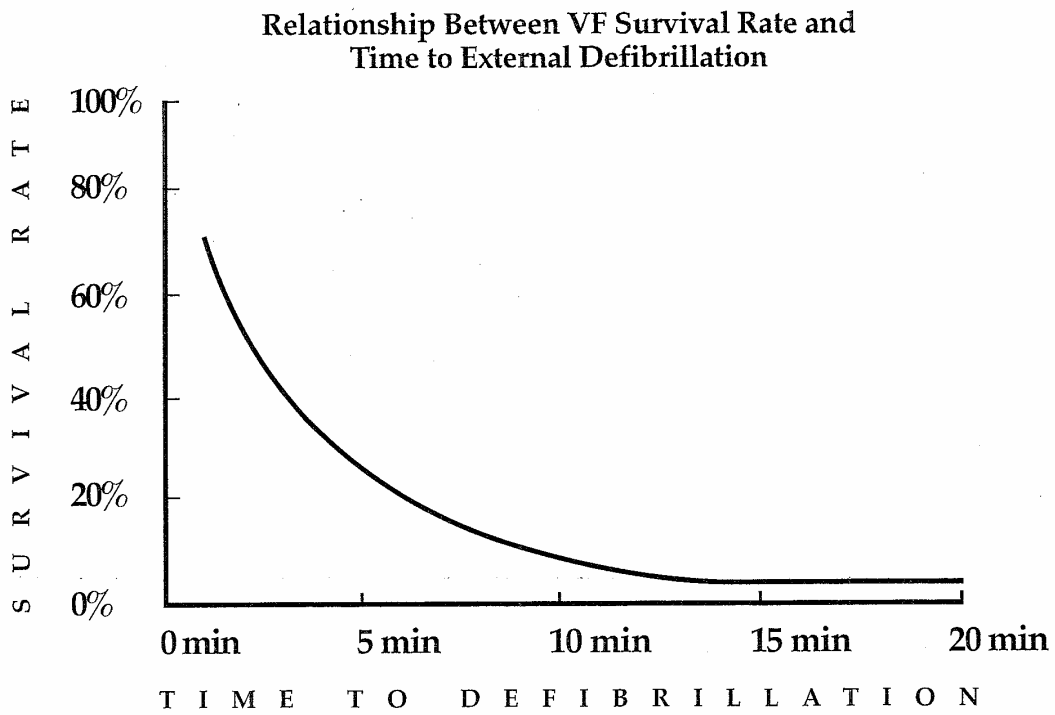
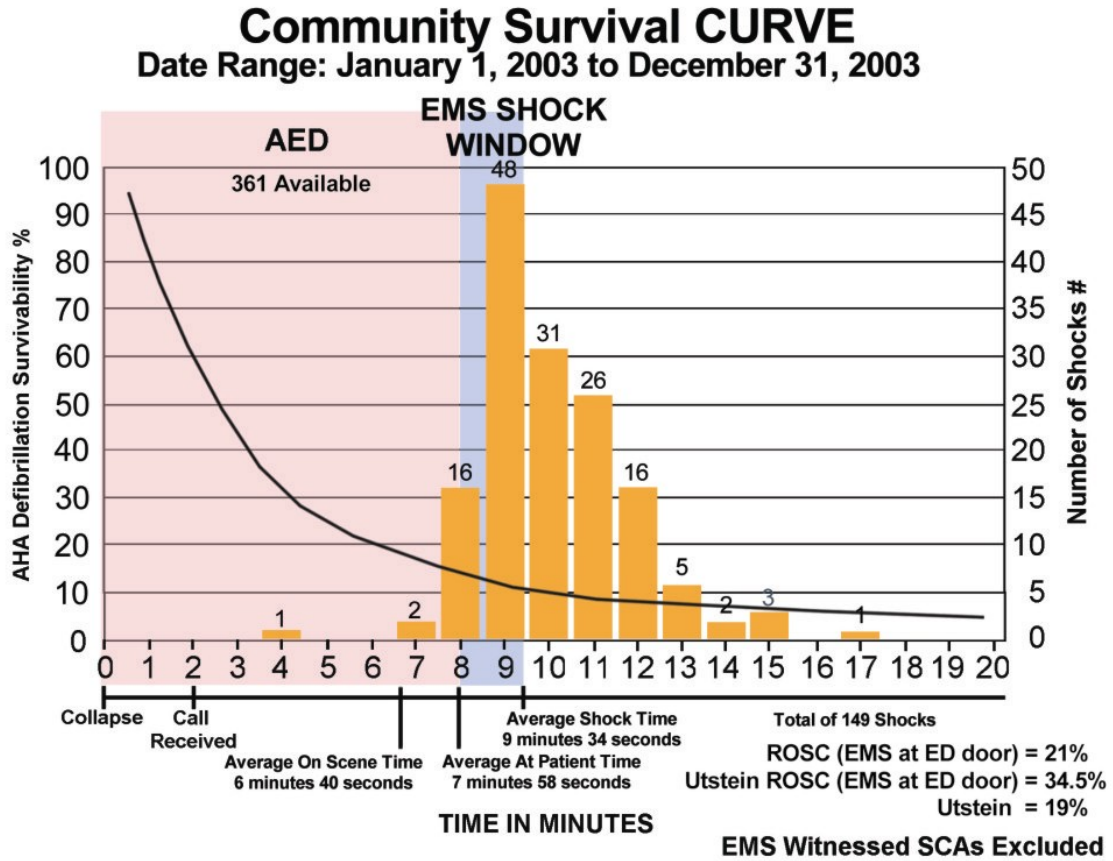


Figure 2



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