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Evaluation of Time-to-Defibrillation and its Impact on Survivability from Sudden Cardiac Arrest

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Sudden Cardiac Arrest and its Treatments

Sudden cardiac arrest (SCA) refers to the sudden and unexpected stopping of the heart, a problem that disables the supply of blood to the brain and other vital organs. Ventricular fibrillation (VF), in which the ventricles (heart's lower chambers) lose their normal rhythm, is the most common way that SCA manifests itself.[1] Ventricular tachycardia (VT), another form of SCA characterized by fast, irregular heartbeats is less common but is also highly time-sensitive. SCA is brought about by many factors including ischemic heart disease, intense physical stress, lifestyle-related problems that may alter heart structure, and various hereditary disorders.[2]

Without quick intervention, SCA typically leads to death within minutes. Fewer than 11% of people who experience SCA survive to hospital discharge[3] and it is one of the leading killers in the USA.

Importance of Time-to-Defibrillation

According to statistics from the American Heart Association, out-of-hospital SCA took the lives of 356,000 people in 2018.[4] During SCA, electrical defibrillation, a process that involves sending a special kind of electric "shock" through the heart, is the most effective way to reestablish normal rhythmic heartbeat. In the absence of a defibrillator, cardiopulmonary resuscitation (CPR) can help to increase the odds of resuscitation and should be applied immediately.[5]

Time-to-defibrillation refers to the length of time between the onset of an SCA in a patient and the first attempt at defibrillation. Time-to-defibrillation is essentially a measure of how quick and effective EMS and other first responders are in attending to SCA emergencies with the right equipment. Early defibrillation is a critical determinant of the success rate in revitalizing heart function, particularly in VF-related SCA. It is identified as the most crucial link in the "chain of survival" which involves a series of four steps that are needed for successful SCA resuscitation.[6] With defibrillation being the most effective treatment for VF cardiac arrest, the longer a patient has to wait for the procedure, the lower the chances of survival. Although cardiologists say that CPR can prolong the neurological viability of a patient in VF for as long as ten minutes using mechanical CPR alone, the procedure is incapable of fully restoring normal rhythm without defibrillation.[7]

Automated External Defibrillators Decrease Time-to-Defibrillation

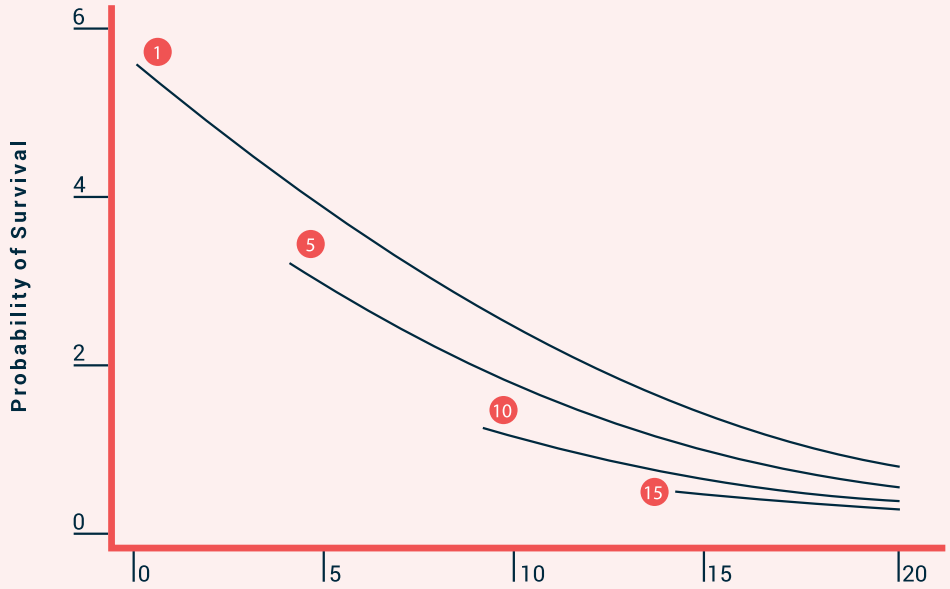
Automated External Defibrillators (AED) are small, portable defibrillators designed mainly for out-of-hospital settings. The device, which was developed in 1973, consists of computer circuitry, batteries, and capacitors that enable it to measure cardiac rhythm as well as its primary function of delivering shock therapy.[8] AEDs are often placed in public places such as malls, swimming pools, police cruisers, airplanes and homes for use by both EMS personnel and medical laypersons.[9] Different AEDs have varying levels of capability. These range from pure shock-inducing AEDs, semi-automatic varieties, to fully automated systems that diagnose the heart rhythm and deliver the shock automatically if needed. Commonly, the time-to-defibrillation is dependent on how quickly EMS personnel can get to the scene of the emergency and use their advanced equipment. With an AED at hand, first responders, such as firefighters and police officers, or even minimally trained bystanders and family members can administer therapy thus improving the prognosis of the patient.[10] Aside from their simplicity, AEDs are designed with safety in mind, so that even errors in an application do not result in harm to the patient or person administering the shock.

Increasing the number of AEDs that are available publicly has been one of the recommendations/ requirements that many health authorities in the industrialized world have instituted.[11] In the United States, over 200,000 AEDs are sold every year.[12] In many of the areas where AEDs have been made available, there has been a significant reduction in the time-to-defibrillation and, thus, an improvement in survival rates. A study of casinos where security personnel and on-ground medical personnel had AEDs found that the mean time to the first defibrillation was 2.9 minutes whereas paramedics take an average of 9.8 minutes to arrive.[13]

Time-to-Defibrillation and SCA Survival Rates

Improved response time is associated with higher chances of survival and is highly critical in remote places where EMS response time is extended due toeen survival rates from SCA and the use of AEDs.

Medical experts recommend that defibrillation be attempted as quickly as possible after a cardiac arrest and survival of out-of-hospital cardiac arrest due to VF is determined primarily by the length of time from onset of VF to the time of electrical defibrillation.[14] According to the American Heart Association,[15] the survival rate from SCA decreases between 7 and 10 percent for every minute that the patient has to wait for defibrillation.

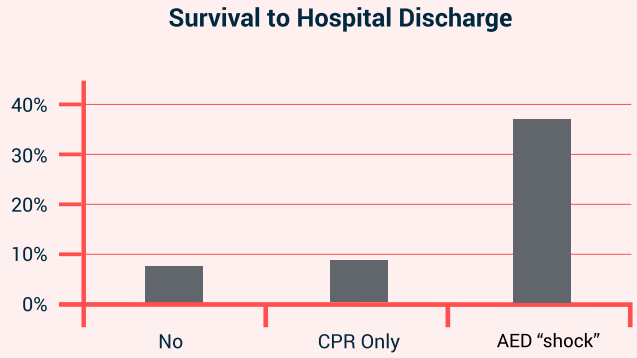


"Relation of collapse to CPR and defibrillation to survival: simplified model. Graphical representation of simplified (includes collapse to CPR and collapse to defibrillation only) predictive model of survival after witnessed, out-of-hospital cardiac arrest due to VF. Each curve represents change in probability of survival as delay (minutes) to defibrillation increases for a given collapse-to-CPR interval (minutes)."

- Valenzuela TD, Et al.

Out-of-Hospital SCA

A study involving 13,769 out-of-hospital cardiac arrests found that survival rates to hospital discharge were 7% with no form of resuscitation attempt, 9% when only CPR was performed and 38% when AED shock therapy was given.[17]



Another study of 105 patients whose initial rhythm was VF, the survival rate was 74% for those who received their first defibrillation no later than three minutes after the witnessed collapse and 49% for those who received their first defibrillation after three minutes of the witnessed collapse.[18]

In a closely related experimental study conducted in the Piacenza region of Italy, researchers provided 1285 lay volunteers with 39 AEDs.[19] The volunteers, who had no traditional training in CPR responded to all reported cases of SCA alongside regular EMS over a period of 22 months during which important metrics were recorded. The volunteers handled 143 SCA cases, including un-witnessed and non-shockable SCA, registering an average arrival time of 4.8 minutes compared to 6.2 minutes for regular EMS. More importantly, the survival to hospital discharge rate for patients attended to by the volunteers was three times higher than with EMS intervention (10.5% versus 3.3%).[20]

Setting	Overall Defibrillation	Early Defibrillation
Airport (public AED use)[1]	56% overall rate of survival in all cases	67% rate of survival with defibrillation in < 5 minutes
Police Response (with AED) vs. Traditional EMS[1]	EMS avg. response time of 7.64 minutes led to a 9% rate of survival	Police with an avg. response time of 4.88 minutes led to 17.2% rate of survival
Casino (security officer AED use)[1]	49% rate of survival with defibrillation in > 3 minutes	74% rate of survival with defibrillation in < 3 minutes
Sporting Grounds[1]	No data available	71% hospital discharge <5 minutes
Italy: Bystander response vs. Traditional EMS[1]	EMS avg. response time of 6.2 minutes led to a 3.3% rate of survival	Bystander avg. response time of 4.8 minutes led to a 10.5% rate of survival

"The survival rate from SCA decreases between 7 and 10 percent for every minute that the patient has to wait for defibrillation"

Endnotes

1 American Heart Association, “What Is an Automated External Defibrillator?”, Heart.Org, accessed 16 February 2019, https://www.heart.org/-/media/data-import/downloadables/pe-abh-what-is-an-automated-external-defibrillator-ucm_300340.pdf.

2 John P. Marenco et al., “Improving Survival from Sudden Cardiac Arrest”, JAMA 285, no. 9 (2001): 1193, doi:10.1001/jama.285.9.1193.

3 The American Heart Association. “The Heart Disease and Stroke Statistics - 2013 Update” January 31, 2018. Circulation. 2018;137:e67–e492.

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5 American Heart Association, “Part 4: The Automated External Defibrillator. Key Link In The Chain Of Survival”, Circulation 102, no. 1 (2000): I-60-I-76, doi:10.1161/01.cir.102.suppl_1.i-60.

6 Rea and Page, “Community Approaches to Improve Resuscitation After Out-Of-Hospital Sudden Cardiac Arrest.”.

7 American Heart Association, “What is an Automated External Defibrillator?”

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14 Valenzuela TD, Roe DJ, Cretin S, Spaite DW, Larsen MP. Estimating effectiveness of cardiac arrest interventions: a logistic regression survival model. Circulation1997;96:3308-3313

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17 Weisfeldt et al., “Survival After Application of Automatic External Defibrillators Before Arrival of the Emergency Medical System.”

18 Terence D. Valenzuela, M.D., M.P.H. et al., “Outcomes of Rapid Defibrillation by Security Officers after Cardiac Arrest in Casinos” N Engl J Med 2000; 343:1206-1209

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20 Cappuci, Aschieri and Piepoli, “Tripling Survival from Sudden Cardiac Arrest Via Early Defibrillation Without Traditional Education in Cardiopulmonary Resuscitation.”