ORIGINAL CONTRIBUTION
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Cardiac Arrest and Resuscitation: A Tale of 29 Cities

Published reports of out-of-hospital cardiac arrest give widely varying results. The variation in survival rates within each type of system is due, in part, to variation in definitions. To determine other reasons for differences in survival rates, we reviewed published studies conducted from 1967 to 1988 on 39 emergency medical services programs from 29 different locations. These programs could be grouped into five types of prehospital systems based on the personnel who deliver CPR, defibrillation, medications, and endotracheal intubation; the five systems were three types of single-response systems (basic emergency medical technician [EMT], EMT-defibrillation [EMT-D], and paramedic) and two double-response systems (EMT/paramedic and EMT-D/paramedic). Reported discharge rates ranged from 2% to 25% for all cardiac rhythms and from 3% to 33% for ventricular fibrillation. The lowest survival rates occurred in single-response systems and the highest rates in double-response systems, although there was considerable variation within each type of system. Hypothetical survival curves suggest that the ability to resuscitate is a function of time, type, and sequence of therapy. Survival appears to be highest in double-response systems because CPR is started early. We speculate that early CPR permits definitive procedures, including defibrillation, medications, and intubation, to be more effective. [Eisenberg MS, Horwood BT, Cummins RO, Reynolds-Haertle R, Hearne TR: Cardiac arrest and resuscitation: A tale of 29 cities. Ann Emerg Med February 1990;19:179-186.]

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INTRODUCTION

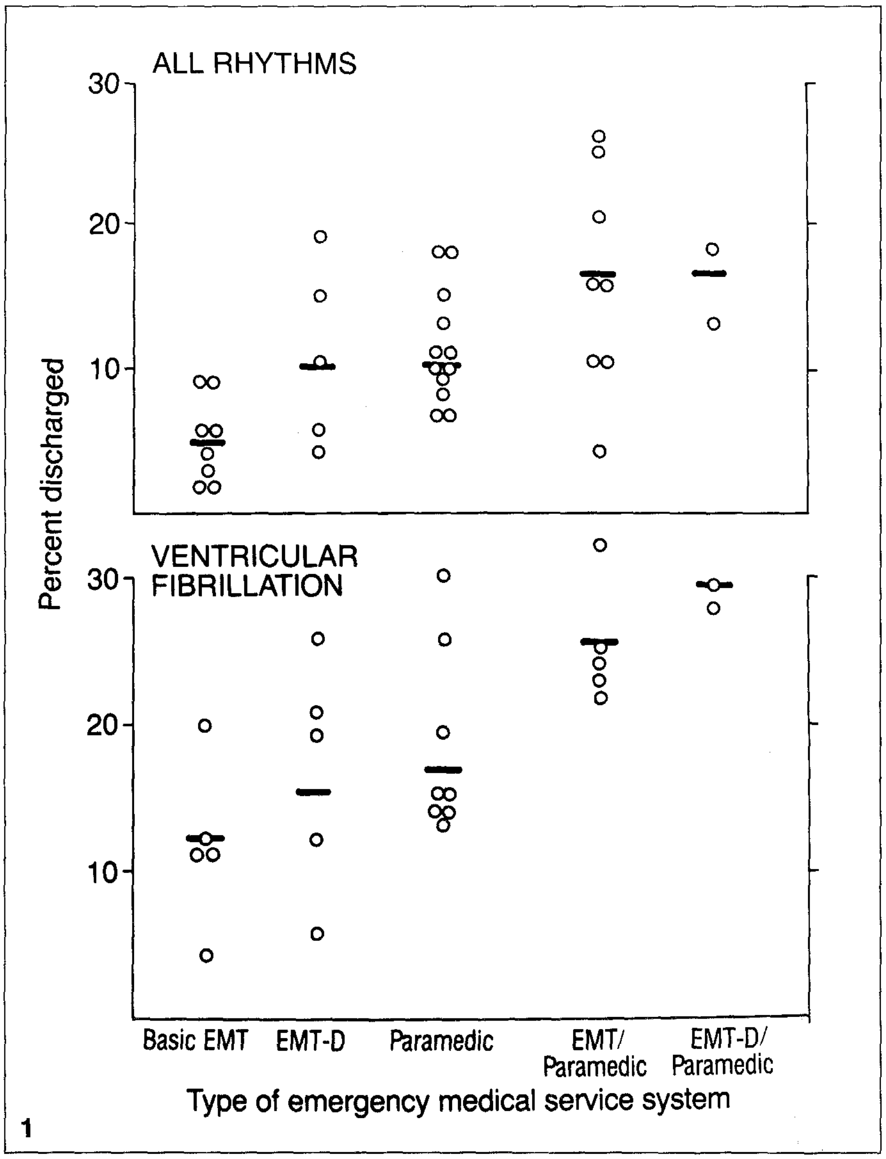
Published survival rates for out-of-hospital cardiac arrest vary widely. More than two decades have passed since Pantridge introduced the mobile intensive care unit (MICU) in Belfast, Ireland.[1,2] Since then, prehospital emergency care programs have spread rapidly throughout the world. Ten years ago, we reviewed the scientific literature for articles that described the success of paramedic systems in resuscitating patients with cardiac arrest.[3] In the past ten years, additional types of emergency systems have developed. The published experiences of 29 communities with out-of-hospital cardiac arrest are described. From this review, five types of emergency medical services (EMS) systems are defined and their success rates compared. The way characteristics of a particular system may explain differences in survival rates also is indicated.

METHODS

Peer-reviewed articles published between January 1967 and December 1988 that reported survival rates for patients with out-of-hospital cardiac arrest were selected for review. Thirty-four articles[4-38] selected for evaluation met two criteria. First, they reported outcome data on a minimum of 100 cases. Second, they provided enough information to characterize the prehospital system.

All published studies could be classified into one of five types of EMS systems. These types are basic emergency medical technician (EMT) (ambulance or response unit staffed with personnel trained in basic cardiac life support [BCLS]), EMT-defibrillation (EMT-D) (basic EMTs also trained in the use of defibrillators), paramedic (personnel trained in advanced cardiac life support [ACLS] and able to provide definitive care [defibrillation, medi-

FIGURE 1. *Percentage discharged from out-of-hospital cardiac arrest in all rhythms* (top panel) *and ventricular fibrillation* (bottom panel) *from five EMS systems. Circles represent the percentage discharged from individual communities, and horizontal line represents the weighted mean discharge rate.*



cation, endotracheal intubation]), basic EMT/paramedic (a double-response system with the first-responder unit being a basic EMT unit and the second-responder unit being a paramedic unit), and EMT-D/paramedic (a double-response system with the first-responder unit being an EMT-D unit and the second-responder unit being a paramedic unit). Units primarily staffed with paramedics but assisted by a physician or nurse were placed under the paramedic classification.[11,18] Systems with prehospital emergency care units staffed by only physicians or nurses were excluded.

Often several reports provided information about the same EMS system. To have a single set of information and to prevent double counting, the study that reported the largest number of cases was, in general, chosen. There were several exceptions to this criterion. Data from one community were updated with unpublished data (personal communication used with permission, AJ Gray and AD Redmond, Stockport, England) that represented a more fully implemented system.[15] In one instance, two articles that reported data over different times were combined to give a more accurate representation of that type of system.[9,10] For King County, Washington, unpublished data describing our experience with EMT-D/paramedic services for the years 1982 through 1987 were added to previously published data for the years 1979 through 1982.[12] Some community reports were of more than one type of system.

In addition to information about the type of system and survival rates, data were also recorded, when available, on average age, percent male, percent cardiac arrest witnessed, average EMT response time, average paramedic response time, percent bystander CPR, and percentage of patients found in ventricular fibrillation (VF). Summary discharge rates were calculated for each of the five systems.

RESULTS

Thirty-four articles on 39 EMS programs in 29 communities met the study criteria.[4-38] Seven communities reported experience with two or more systems. The 29 locations were dispersed throughout eight countries: Australia,[29] Canada,[32-34] England,[15,23] Iceland,[16] Israel,[11] New Zealand,[6] Sweden,[18,19] and the United States.[4,5,8-10,12-14,17,20-22,24-28,30,31,35-38] The settings varied from rural to urban.

Information gathered on the 39 programs is summarized (Table). These were eight basic EMT programs,[5,9,10,16,18,31,32,34,38] five EMT-D programs,[10,15,19,31,35] 14 paramedic programs,[4-6,8,11,14,17,20,21,23,24,27,28,33] ten basic EMT/paramedic programs,[7,13,18,22,25,26,29,30,34,36] and two EMT-D/paramedic programs.[12,37]

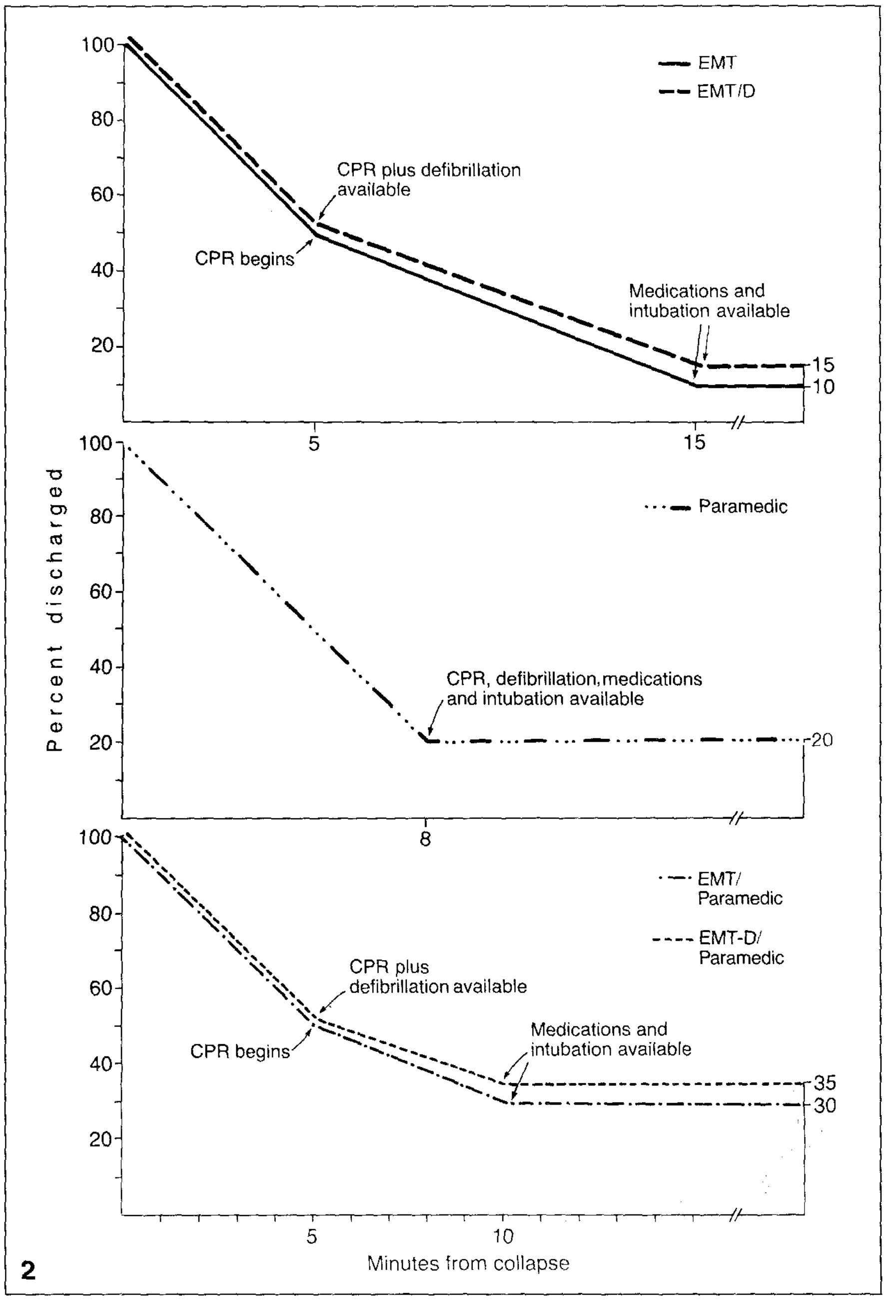
There were variations in case definitions and other variables. Fourteen EMS programs used cardiac arrest due to cardiac etiology as the case definition,[5,7,9-13,17,24,28,29,31] eight reported all etiologies,[6,8,19,21,32-34] three reported only ischemic heart disease cases,[18,22] four excluded trauma cases,[14,16,30,36] and two excluded cases with trauma and previous treatment by physicians before EMS personnel arrival.[25,38] The remaining eight programs did not

TABLE. *Patient characteristics and survival from out-of-hospital cardiac arrest**

Type of EMS System and Location	No. of Attempted Resus-citations	Average Age (yr)	% Male Patients	% Witnessed	Average EMT Response Time in Minutes	Average Paramedic Response Time in Minutes	% With Bystander CPR	No. in All Rhythms Discharged (%)	No. in VF (%)	No. in VF Discharged (%)
Basic EMT										
Durham[38]	126			47†	6.5		35†	11 (9)	61 (48)†‡	7 (11)†
Goteborg[18]	189			100				3 (2)†	23 (12)	
Iowa[31]	52	64	69	73	7		31	1 (2)	31 (60)	1 (3)
King County[9,10]	323	64†	68†	51†	4.3†		19†	19 (6)†	147 (57)†	18 (12)†
Minnesota[5]	118		79†	100			37†	3 (3)		
Reykjavik[16]	222	63	75†		7.3			21 (9)	90 (41)†	18 (20)
Vancouver[34]	110						16†	6 (6)†		
Winnipeg[32]	849							33 (4)	226 (27)‡	24 (11)
EMT-D										
Iowa[31]	110	68	75	70	5.7		20	12 (11)	64 (58)	12 (19)
King County[10]	54	62	89	79	4.3		22	10 (19)	38 (70)	10 (26)
Minnesota[35]	100	70	73†	70	10 (84%)		50†	6 (6)	51 (51)	6 (12)
Stockholm[19]	307							11 (4)†	144 (47)†‡	9 (6)†
Stockport[15]	103							15 (15)	70 (68)	15 (21)
Paramedic										
Auckland[6]	405		75				55	72 (18)†		
Brighton[23]	356							39 (11)		
Charleston[24]	100	56	72†			7	19	7 (7)		
Cincinnati[20]	147		74†					22 (15)		
Israel[11]	2,995	68	71	82		6	8	210 (7)	839 (28)	126 (15)
Los Angeles[17]	300	65	68	41		5	35†	30 (10)	135 (45)	19 (14)
Lucas/Kent[14]	2,171					4.7		169 (8)		
Miami[21]	301	63	75			4 (80%)			301 (100)	42 (14)†
Minnesota[5]	46		80†	100			48†	5 (11)	26 (57)	5 (19)
N Westminister[33]	227							21 (9)†	116 (51)†	15 (13)†
Oregon[27]	210							38 (18)†		
Pittsburgh[28]	187	68†				6	19†	18 (10)†	98 (52)†‡	15 (15)
Tampa[4]	296	58				5 (87%)			296 (100)	68 (23)
Torrance[8]	120		82†			4 (70%)		16 (13)	50 (42)†	15 (30)†
EMT/Paramedic										
Columbus[22]	129				3	5		32 (25)		
Durham[25]	168				6.5§	8.7		7 (4)		
Goteborg[18]	176					5		19 (11)	87 (49)†	
King County[7]	1,297	65†	78†	100	4.4	9.1†	45†	344 (26)†	947 (73)†	312 (33)
Milwaukee[30]	1,905			100	2	5	31†	303 (16)	779 (52)‖†	183 (23)
Minneapolis[26]	514							83 (16)		
New S Wales[29]	434			55†			30	91 (21)	369 (85)	81 (22)
Seattle[36]	725			67	3	6.5§	40		725 (100)	181 (25)
Vancouver[34]	244						12†	28 (11)†		. . . (24)
York Adams[13]	1,066	67	69	79				68 (6)†	454 (43)†	51 (11)†
EMT-D/Paramedic										
Seattle[37]	687	65	81	79	3.6	8.8	36	98 (14)†	276 (40)	83 (30)
King County[12]	4,068	66	75	55	4.2	10	54	741 (18)	2,117 (52)	615 (29)

*EMT, emergency medical technician; EMT-D, emergency medical technician-defibrillation.
†Calculated from available data.
‡Includes VF and ventricular tachycardia.
§Estimated from available data.
‖Includes coarse VF only.

FIGURE 2. *Hypothetical survival curves for out-of-hospital cardiac arrest treated by five types of EMS systems. Basic EMT and EMT-D services are depicted in the top panel, paramedic services in the middle panel, and EMT/paramedic and EMT-D/paramedic services in the bottom panel.*



provide a definition.[4,15,20,23,26,27,35,37]

In 13 programs, emergency personnel were allowed to withhold treatment where resuscitation was considered impossible, but the criteria for "impossible resuscitation" were not defined.[5,8,14,16,19,24,25,28,32,34,38] In the remaining programs, either the emergency personnel were required to treat all patients in cardiac arrest or information on this issue was not provided.

Twenty-one locations reported the percentage of cases receiving bystander CPR before the arrival of an EMT or paramedic unit.[5-7,9-13,17,24,28-30,31,34,36,38] The range for the percentage of patients receiving bystander CPR was 8%[11] to 55%.[6] When reporting bystander CPR, the majority of programs reported CPR by nonprofessionals;[3,5,6,9-11,13,17,28,30,31,36,38] however, in several locations, both professional and laypersons were included.[7,24,29,34,35]

Eighteen locations reported the percentage of cardiac arrests that were witnessed. Five recorded witnessed events only,[5,7,18,30] and 13 others reported witnessed and nonwitnessed events.[9-13,17,29,31,35,36-38] The percentage of patients with a witnessed arrest ranged from 41%[17] to 82%.[11]

The average EMT response time reported for 14 communities[7,9,10,12,16,22,25,30,31,35-38] ranged from two[30] to 7.3 minutes.[16] The response time was defined in three communities[7,16,31] as the interval from receipt of the call by the emergency dispatcher to the arrival of the emergency unit near the scene. Time of actual arrival of the personnel at the patient's side was not recorded. The average paramedic response time was reported in 16 programs[4,7,8,11,12,14,17,18,21,22,24,25,28,30,36,37] and ranged from a minimum response time of four minutes (or less in 70% of cases),[8,21] to a maximum response time of 9.1 minutes.[7]

Twenty-seven locations had information on the percentage of patients who initially were found to be in VF.[4-13,15-19,21,28-33,35-38] In three instances, only patients in VF were reported.[4,21,36] In 24 programs, the percentage of patients found in VF ranged from 12%[18] to 85%.[29] In reporting VF cases, four programs included ventricular tachycardia in the VF group[19,28,32,38] and one reported coarse VF.[30]

The percentage of patients resuscitated from cardiac arrest in all rhythms and discharged from hospital alive is shown (Table). The eight basic EMT programs had a discharge rate varying from 2%[18,31] to 9%.[16,38] Discharge ranged from 4%[19] to 19%[10] for the five EMT-D programs. In the 14 paramedic programs, the discharge percentage ranged from 7%[11,24] to 18%.[6,27] The ten basic EMT/paramedic programs recorded a range from 4%[25] to 26%.[7] The two EMT-D/paramedic programs reported discharge rates of 13% and 18%.[12,37] The range of discharge rates for each type of system is shown (Figure 1).

Also included is a summary discharge rate calculated by weighting each system in proportion to the square root of the number of cases. The square root of the number of cases was selected as an adjustment factor to take into account the widely varying number of cases in each program as well as to reduce the effect of programs that reported large numbers on the summary rate. The summary discharge rates for the EMT, EMT-D, paramedic, EMT/paramedic, and EMT-D/paramedic systems for all cardiac arrests are 5% (95% confidence intervals, 3% to 7%), 10% (6% to 16%), 10% (9% to 13%), 16% (10% to 19%), and 17% (13% to 19%), respectively. Confining the analysis to the 26 US locations reveals summary discharge rates of 5%, 11%, 11%, 16%, and 18%, respectively.

The percentage of patients discharged from the hospital alive who were initially found in VF is summarized (Table). In the five basic EMT programs that reported survival from VF, the percentage discharged ranged from 3%[31] to 20%.[16] In five EMT-D programs, the survival rates ranged from 6%[19] to 26%.[10] Of the eight paramedic programs reporting survival from VF, the range varied from 13%[33] to 30%.[8] The range for the six EMT-D/paramedic programs was 11%[13] to 33%.[7] In the two EMT-D/paramedic programs, the discharge rates were 29%[12] and 30%.[37]

The range of discharge rates for patients in VF in each system is shown (Figure 1). Adjusted discharge rates for VF for the five types of systems were calculated weighting each discharge rate based on the square root of the number of cases. The adjusted discharge rates for VF for the five systems are 12% (95% confidence intervals, 6% to 16%), 16% (10% to 23%), 17% (14% to 21%), 24% (17% to 27%), and 29% (29% to 30%). For US locations, the discharge rates are 10%, 18%, 18%, 24%, and 29%, respectively.

DISCUSSION

The survival rates for the 29 communities and 39 programs vary widely. Not only are there large differences among the five EMS systems, but there also are large variations within each system.

Previous Research

Previous research has demonstrated that shorter time from collapse to the start of CPR and the time from collapse to definitive care are associated with improved survival from cardiac arrest.[32,34,36,39-45] To be effective, CPR must be initiated within four to six minutes from the time of collapse.[7] We have suggested previously that early initiation of CPR prolongs the duration of VF and prevents the deterioration of coarse VF to fine VF. This increases the likelihood that VF will last longer and that the response to defibrillation will be positive.[7] When CPR is delayed or the time to defibrillation is more than ten to 12 minutes after the start of CPR, it is more likely the patient will be in fine VF and will convert to asystole.[46]

Time to definitive care also is recognized as a major factor associated with survival from cardiac arrest.[43] Most studies use the term "definitive care" to encapsulate all ACLS interventions, including defibrillation, IV medications, and endotracheal intubation. While studies have demonstrated the independent benefit of defibrillation, there have been no studies that quantitate the benefits of individual medications or intubation. In large part, such studies are impossible because it has become the standard of care for these advanced procedures to be used. Intubation allows better oxygenation, and administration of medications stabilizes electrical conduction and inhibits recurrence of VF. An awareness of the therapeutic interventions provides a basis for understanding differences in survival rates among systems.

Differences in Survival Among Systems

The variability in survival among the five EMS systems conceivably could be explained solely by differences in methodologies and inconsistencies in terminology and case definitions. These differences and their effects on survival rates are difficult to quantify but must be acknowledged as a partial explanation for the variance in survival rates. However, the upward trend in survival among the five EMS systems suggests that the type of system correlates with survival. As seen (Figure 1), a general improvement in survival occurs as the type of EMS system increases in sophistication with the largest increase occurring between single- and double-response systems.

Although such improvement was expected, what is the explanation? To answer this question, the specific therapies brought to a resuscitation must be considered: CPR, defibrillation, IV medications, and endotracheal intubation. The most obvious differences among the systems are the times required to provide these therapies because each system delivers different elements from this menu of interventions at different times. Conceptually, these therapeutic interventions can be considered to alter the survival curve after cardiac arrest. Most survival curves are defined in months or years; however, the survival curve for cardiac arrest is defined in minutes. It can be argued that the natural history of cardiac arrest without any intervention is biologic death within ten minutes.

The cardiac arrest survival curves of the five EMS systems (Figure 2) are hypothetical models that display the effect of various therapeutic interventions on survival. They are a means to explain intersystem survival differences. The discharge rates of the models are based on the adjusted observed discharge rates for the five systems.

The survival curves, while hypothetical, propose that the ability to resuscitate is a function of time, type, and sequence of therapy. The curves display a sequence of interventions occurring at different times: CPR, defibrillation, intubation, and medication. It is not self-evident, however, whether other sequences could result in higher survival rates. For example, would intubation performed by basic EMTs improve survival compared with an EMT/paramedic or an EMT-D/paramedic system? In a tiered-response system, is early intubation preferable to early defibrillation? The curves, while unable to provide an answer to these questions, suggest a theoretical framework to understand resuscitations in which sequentially applied interventions occur.

The Five Systems

Several assumptions are made in portraying survival curves for the five EMS systems. The probability of survival after cardiac arrest falls linearly with time and varies depending on the therapeutic intervention. The slope of the survival curve is steepest without any intervention; the probability of survival is zero after ten minutes without CPR. In all systems, the survival curve starts at 100% because at the moment of collapse there is a theoretical 100% chance of resuscitation. The slope of the survival curve improves after CPR and defibrillation and stabilizes after medication and intubation are provided (medication and intubation are considered simultaneous interventions).

The average interval from collapse to CPR is five minutes in systems with EMTs and EMT-Ds. The average interval to paramedic care is eight minutes in a single-response paramedic system and ten minutes in a double-response system.

EMT System

The hypothetical survival curves and sequence of events during resuscitation in the five types of EMS systems are portrayed graphically (Figure 2). With each passing minute without CPR, the probability of survival falls steeply toward zero probability at ten minutes. When CPR is initiated by the EMTs (at an average interval of five minutes), the survival curve improves. Survival probability continues to fall but at a slower rate. The ultimate result, however, is still poor because of the long time to reach the hospital, which is where definitive care can begin. The few lives that are saved are those with rapid response times and short drives to the hospital.

EMT-D System

The EMT-D system demonstrates the benefit of early CPR combined with early defibrillation. The probability of survival initially falls, the same as in the EMT system (Figure 2). In an EMT-D system, however, CPR and defibrillation are brought to the patient simultaneously. The survival curve is shifted with a flatter slope than exists with CPR alone. The slope still continues downward because medications are not available at the scene and cannot be given until arrival at the hospital. Results from King County demonstrate the opportunity to save almost 20% of all patients with out-of-hospital cardiac arrest with an EMT-D system.[10]

Paramedic System

Generally, paramedic systems have slower average response times than EMT systems. In EMT systems, vehicles are staffed with EMTs who often respond from local stations. A given geographic area will be covered by a relatively large number of stations. In King County, Washington, for example, EMT-Ds already trained as firefighters are located in 96 different fire stations. Such a system, layered on an existing fire suppression service, does not incur significant extra personnel costs. Paramedic systems use specially trained individuals who generally are not able to serve in a dual capacity. Because of these extra costs, the number of paramedic vehicles is less than the number found in an EMT system. Thus, a given geographic area will be covered by much fewer units. In King County, for example, eight paramedic stations cover the same area allocated by the 96 fire stations.

In single-response paramedic systems, the interval from collapse to care is eight minutes on the average. CPR is administered later and defibrillation is delayed compared with EMT-D systems. While this should theoretically decrease the survival rates, in fact they are often equal to or better than those of EMT-D systems. This is most likely secondary to the early medications and intubation that paramedics provide. The probability of survival in a paramedic system is depicted (Figure 2). Compared with basic EMT and EMT-D systems, the probability of survival initially falls more sharply (owing to the longer response time). However, once the paramedics arrive, all therapies (CPR, defibrillation, medication, and intubation) are available at the scene. Then, survival is stabilized.

It should be pointed out that these graphic representations are slightly deceptive. If a victim had no CPR for eight minutes, there would be little chance of survival. We display average response times – individual times will be less than eight minutes 50% of the time. The low discharge rate of 7% in Charleston, South Carolina, with a response time of seven minutes, emphasizes the importance of early CPR.[24] On the other hand, Torrance, California, with a VF survival rate of 30%, demonstrates the potential for success when CPR and definitive care are provided early; 70% of the victims were reached within four minutes after the call for help.[8]

EMT/Paramedic System

The basic EMT/paramedic system uses EMT units to provide early CPR, which helps delay rhythm deterioration until the paramedic unit can arrive to administer defibrillation and medications. In a basic EMT/paramedic system, initiation of CPR by the EMT unit increases the chance of survival compared with a system without EMT care. The probability of survival is twice that of a paramedic system (Figure 2). The probability of survival is stabilized when the paramedic unit arrives to deliver defibrillation, medication, and intubation. Survival from VF in EMT/paramedic systems consistently approaches 25% (one system reported a 33% survival rate).[7]

EMT-D/Paramedic System

The best therapeutic situation is provided by an EMT-D/paramedic system. On arrival, a unit staffed with EMT-Ds can provide both CPR and defibrillation. When paramedics arrive several minutes later, medications, intubation, and additional defibrillation can be provided. The probability of survival initially is similar to that of an EMT-D system (Figure 2). However, because paramedics can provide the same therapy as a hospital, survival is stabilized at arrival of paramedics. To date, very few studies have been done on this type of system. Information available from Seattle and King County demonstrates the potential benefit of this system. The discharge rates for VF patients were 29% for King County and 30% for Seattle.[12,37]

Differences in Survival Within Systems

The above models may explain differences in survival among the five systems, but they do not explain the wide variation in discharge rates within each system. For example, survival within the basic EMT system for VF ranges from 3% to 20%.

There are several possible explanations for the wide intrasystem variations in discharge rates. One explanation may lie in physiologic variations among populations. It is conceivable that a patient with a cardiac arrest in Reykjavik, Iceland, is physiologically different and more easily resuscitated than a cardiac arrest patient in Los

Angeles. While intriguing, this possibility cannot be measured easily.

A second explanation may lie in the quality of the program. A resuscitation is a complex, dynamic process with many interventions. Systematic problems or deficiencies in performing CPR, paddle placement in defibrillation,[47] rhythm recognition, or sequence of medications[48] could affect overall survival rates. It is possible that some communities have better EMS programs because of these quality factors. Quality, while undoubtedly important, is difficult to measure. Local pride may stimulate some locations to claim high-quality EMTs or paramedics. It is just as likely that all communities have some extremely competent and some less-than-competent personnel, suggesting that the quality factor may neutralize itself.

A third explanation may lie in the demographic and program characteristics of each community. Predictive scores relating the probability of discharge to characteristics such as age, witnessed collapse, percentage of patients in VF, and response time of emergency personnel demonstrate the importance of a variety of factors.[49] Much intrasystem variation can be explained by variations in these factors. For example, a low resuscitation rate in Durham may be explained by older patients, fewer witnessed arrests, less bystander CPR, and longer response times. Other explanations for variations in survival rates may be improved in-hospital care during the past decade or system differences in thresholds for initiation of CPR. There often is no clear demarcation between someone "dead on arrival (DOA)" and someone who potentially can be resuscitated. A system selecting a disproportionate number of DOAs will have a lower survival rate.

It is difficult to quantify the role of these demographic and program factors because few programs report such variables and variation exists in terminology. The term "response time," for example, may involve all or some of the following: recognition time, decision-to-call time, calling time, dispatch interview time, dispatching time, time from station to arrival at scene, and time from scene to arrival at patient's side.

In addition to response time, variations in definitions exist for such basic terms as cardiac arrest, bystander CPR, witnessed arrest, VF, and admission. Rather than this Babel of resuscitation terminology, there should be common definitions and a common format for reporting outcomes from out-of-hospital cardiac arrest.[3] If most systems used a common reporting format, observed differences in survival rates would have more meaning. In addition, it would be possible to address issues such as quality assurance and optimal therapeutic interventions. Quality assurance means that objective goals are set for an EMS system.[50] The average success recorded for various system configurations is shown (Figure 1). By using such data, both national and international organizations can compare their program's cardiac arrest survival rate with that recorded for similarly configured programs. Major discrepancies can serve as a stimulus for refinement and reorganization.

Additional Determinants of Survival

The survival rates for the five types of EMS systems appear to reflect how rapidly and effectively the system can provide CPR, defibrillation, medication, and intubation. There are additional factors that affect the performance of an EMS system. One major determinant is bystander CPR before EMT or paramedic arrival. High rates of bystander CPR permit earlier initiation of CPR. Frequent bystander CPR can occur as a result of widespread CPR training or as a result of dispatcher-assisted telephone CPR programs.

A second factor is for defibrillation to occur before EMT or paramedic arrival. The use of automatic defibrillators by laypersons has the potential to bring defibrillation even quicker to the individual in cardiac arrest. Although these devices are not widespread at the moment, pilot projects have occurred for high-risk patients[51-54] and in community locations such as airplanes, community centers, office buildings, senior centers, and fairgrounds.[55-58]

Are Higher Survival Rates Possible?

Our presentation and discussion of each type of system have focused on the range of survival rates. It appears, however, that as one moves from the basic EMT system to the more advanced double-response systems, the survival rates appear to plateau at approximately 25% to 30% for witnessed arrests in VF. Can higher survival rates be obtained, or is this the maximum percentage of victims who can be saved? Have the systems of today reached a theoretical ceiling for survival rates, or can fine tuning of the systems produce greater survival? Can new techniques and treatment be developed that will increase survival from out-of-hospital cardiac arrest? A community survival rate of 30% for witnessed adult cardiac arrests in VF should be the standard of excellence given current technology and unchangeable variables such as the percentage of witnessed cases, percentage of cases in VF, and realistic response times.

The success of the five EMS systems, as measured by discharge rates, appears directly related to the ability of each to rapidly provide CPR, defibrillation, medications, and intubation. An awareness of these factors and the strengths and weaknesses of each system can allow other communities to rationally build EMS systems and allocate resources.

CONCLUSION

Prehospital programs for out-of-hospital cardiac arrest can be grouped into five systems based on the personnel who deliver CPR, defibrillation, medications, and endotracheal intubation. Reported discharge rates ranged from 2% to 25% for all cardiac rhythms and from 3% to 33% for VF. Although there was considerable variation within each type of system, survival appeared to be highest in the systems that combined EMT or EMT-D with paramedic services. The combined response allows CPR to be started early, which permits definitive procedures, including defibrillation, medications, and intubation, to be more effective.

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