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Long-term survival after successful inhospital cardiac arrest resuscitation

Heather L. Bloom, MD, Irfan Shukrullah, MBBS, Jose R. Cuellar, MD, Michael S. Lloyd, MD, Samuel C. Dudley Jr, MD, PhD, and A. Maziar Zafari, MD, PhD

Atlanta Veterans Affairs Medical Center, Decatur, GA, and Division of Cardiology, Emory University School of Medicine, Atlanta, GA

Abstract

Background—Little is known about long-term outcomes of patients who survive inhospital cardiac arrest.

Methods—We examined long-term survival after inhospital cardiac arrest and whether procedural changes that improved survival to discharge impacted long-term survival. Consecutive inhospital arrests in the Atlanta Veterans Affairs Medical Center (Atlanta, GA) from 1995 to 2004 (n = 732) were retrospectively analyzed. Data regarding the arrest was obtained, including age, left ventricular ejection fraction, medications, and comorbidities, presenting rhythm, location of arrest, code duration, and outcomes. Long-term mortality data was obtained based on chart and Social Security Death Index reviews. Further data was gathered on internal cardioverter-defibrillator presence and use in survivors.

Results—Overall, 49 subjects (6.6%) survived to discharge. Univariate analysis found that ventricular tachycardia/ventricular fibrillation and the use of β -blockers, angiotensin-converting enzyme inhibitors, and antiarrhythmics at the time of arrest were associated with increased survival, whereas advancing age and comorbidities were associated with a higher risk of mortality. Multivariate analysis determined that age, rhythm, and comorbidities independently affected survival. Implementation of a resuscitation program previously documented to improve survival to discharge did not translate to durable long-term survival. Three-year survival rate after discharge was only 41%. Alternatively, subjects with internal cardioverter-defibrillator showed a 36% improvement in 3-year survival rate to 77% ($P = .001$).

Conclusions—Subjects with inhospital cardiac arrest have poor long-term prognoses. A strategy that improved inhospital survival did not alter long-term mortality rate. Thus, survival to discharge may not be a sufficient end point for future resuscitation trials.

Sudden cardiac death accounts for approximately 450000 deaths per year in the United States. Cardiopulmonary resuscitation has been used for >45 years in an attempt to intervene in this process.¹ Nevertheless, outcomes from cardiac arrest remain poor even when the arrest occurs in the hospital setting, where necessary equipment and adequately trained personnel are readily available. Reported survival rates are 3% to 10%,^{2,3} although the increasing availability of early defibrillation improves these rates.⁴ It is well established that patients who had out-of-hospital cardiac arrest are at high risk for recurrent arrhythmic events and sudden death.^{5,6} Based on this observation, secondary prevention strategies have been developed, and long-term outcomes have been assessed.^{7,8} In contrast, less is known about the long-term outcomes of patients who had inhospital cardiac arrest.

Among other limitations, research concerning interventions for in-hospital arrest has been hampered by the lack of a universally accepted assessment and outcome criteria. In 1997, a task force published the “Utstein style” guidelines, standardizing data recording and reporting for in-hospital arrest.⁹ The availability of standardized assessment and outcome criteria facilitated the development of the National Registry of Cardiopulmonary Resuscitation (NRCPR), sponsored by the American Heart Association. *Cardiac arrest* is defined as the sudden cessation of effective cardiac pumping function as a result of either ventricular asystole (electrical or mechanical) or pulseless ventricular tachycardia or ventricular fibrillation (VT/VF).¹⁰ The NRCPR defines a cardiopulmonary arrest event eligible for inclusion in their database as (1) an individual experiencing a resuscitation event defined as cardiopulmonary assistance requiring either chest compressions and/or defibrillation of VF or pulseless VT and (2) the event elicits an emergency response by an acute facility resuscitation team.¹¹ We have used these definitions in our current retrospective analysis.

Adoption of the Utstein criteria and establishment of the NRCPR has led to a better understanding of the risks and outcomes of patients who had in-hospital cardiac arrest.¹² Outcomes are frequently discussed in terms of survival to discharge, an end point available in the NRCPR database. Nevertheless, this database does not contain long-term outcomes after discharge; thus, long-term outcomes of in-hospital cardiac arrest survivors remain unclear.

In a previous report, we compared the outcome of survival to discharge in subjects who had an arrest in the hospital before and after the institution of a cardiac resuscitation improvement program. The program consisted of enhanced education to all allied health and physician staff and use of biphasic waveform defibrillators functioning in automatic external defibrillator mode. The initial report showed a 2.6-fold increased survival to discharge in patients with in-hospital cardiopulmonary arrest after program implementation.¹³ This survival benefit appeared to be primarily among patients presenting with VT/VF. Now, we report our observations regarding long-term outcomes in in-hospital cardiac arrest survivors at our hospital.

Methods

With approval of the Emory University Institutional Review Board (Atlanta, GA), demographic and outcome data were gathered on 732 consecutive patients who had in-hospital cardiopulmonary arrest and in whom resuscitation was attempted at the Atlanta Veterans Affairs Medical Center (Atlanta, GA) between January 1, 1995, and June 30, 2004. The current database expands our previous data set for an additional 24 months.¹³ Demographic and clinical variables obtained at the time of arrest included age; left ventricular ejection fraction (LVEF); baseline cardiovascular drug use before arrest; antiarrhythmic use during arrest; presence of coronary artery disease (CAD); acute myocardial infarction (AMI) (as defined by cardiac enzyme rise and chest pain or electrocardiographic changes); and a numeric comorbidity score computed from a list of defined illnesses including heart failure, myocardial ischemia/infarction, arrhythmia, hypotension, respiratory insufficiency, renal insufficiency, hepatic insufficiency, metabolic or electrolyte abnormality, diabetes mellitus, toxicologic problem, baseline depression in central nervous system function, acute stroke, acute central nervous system nonstroke event, pneumonia, sepsis, infection, trauma, malignancy, and hypertension.¹⁴ Cerebral performance scores (CPSs), using the NRCPR definition, were compared pre- and postarrest based on patient assessment in the hospitalization chart notes for all patients (CPS 1, good cerebral performance—conscious, alert, able to work, may have mild neurologic or psychologic deficit; CPS 2, moderate cerebral disability—conscious, sufficient cerebral

function for independent activities of daily life; CPS 3, severe cerebral disability—conscious, dependent on others for daily support because of impaired brain function; CPS 4, coma or vegetative state—any degree of coma without the presence of all brain death criteria; CPS 5, brain death—apnea, areflexia, electroencephalogram silence).¹⁵

Long-term survival rates were obtained from the permanent medical record. Patients were considered alive if they had an inpatient or outpatient visit within 1 month of data collection. For patients whose status could not be ascertained, a search through the Social Security Death Index was performed. Presence or absence of internal cardioverter-defibrillator (ICD) during the follow-up period was examined. Whether a patient had an ICD implanted was determined by examining computerized electronic medical record for implantation and follow-up device clinic notes. Device follow-up notes were reviewed to determine whether they had received appropriate arrhythmic therapies for VT or VF. Appropriate therapy was considered a shock or antitachycardia pacing event for a confirmed ventricular arrhythmia. Appropriateness was adjudicated by a clinician unaffiliated with the current study. There was no review of ICD programing other than to confirm that all devices were appropriately programed with active therapies.

Statistical analysis

Survival was analyzed as the numbers of days after discharge and the absolute survival rates at 6, 12, 24, and 36 months postdischarge. Statistical tests were implemented by SPSS (version 13.0 and 14.0, SPSS, Chicago, IL) and included χ^2 test for categorical variables, unpaired 2-sided *t* test for continuous variables, and a multiple logistic regression model for variables associated with survival for inhospital arrest.

Results

The demographic and outcome features of cardiac arrest patients who did and did not survive to discharge are compared in Table I. Ventricular tachycardia or VF arrest (odds ratio [OR] 3.4, 95% CI 1.9–6.3, *P* = .02), β -blocker use (OR 4.2, 95% CI 1.9–9.6, *P* < .01), angiotensin-converting enzyme inhibitor (OR 2.7, 95% CI 1.3–6.0, *P* = .01), and antiarrhythmic use (OR 2.9, 95% CI 1.1–8.2, *P* = .05) were associated with survival to discharge. Increasing comorbidity score was associated with an OR for survival of 0.39 (95% CI 0.12–0.69, *P* = .02), consistent with the idea that increasing illness burden resulted in reduced longevity. Also, advancing age was associated with reduced survival (OR 0.91, 95% CI 0.82–0.96, *P* = .001) (Figure 1). Multivariate analysis determined that advanced age, rhythm, and comorbidities independently affected survival. Advanced age and comorbidities decreased survival, whereas VT/VF as presenting rhythm increased survival.

We considered the possibility that improved absolute survival may come with diminished cognitive performance; thus, we examined CPS in survivors. Cerebral performance scores did not vary significantly pre- to postarrest in survivors. Overall, 2 patients had a 1-point decrease in CPS. Average pre- and postarrest CPSs were 1.9 and 2.2, respectively (*P* = not significant).

Despite survival to discharge, arrest survivors showed poor long-term survival. One-year survival rate was 68% (or an absolute survival rate of 5.2%) for all arrest nonsurvivors. Three-year survival rate declined to 41% (a 3.0% absolute survival rate). We previously had instituted a program to improve inhospital resuscitation survival rates and reported that this program resulted in a 2.6-fold improvement in survival to discharge.¹³ To examine the sustainability of this effect, we broke down the survivors into preprogram and postprogram groups. The resulting 1-year survival rates were 67% and 71%, and the 3-year survival rates were 43% and 39%, respectively (*P* = not significant). Relative survival trends over time for

both groups were virtually identical (Kaplan-Meier log-rank 0.26, $P = .6$) (Figure 2), suggesting that successful in-hospital interventions may not be sufficient to alter long-term survival rates.

Our data agree with other studies that arrest patients are more likely to survive if their presenting rhythm is VT/VF.^{16,17} It is known that select patient populations at high risk for VT/VF have benefited from ICD placement.^{18,19} Therefore, we compared in-hospital arrest survivors who underwent ICD implantation with arrest survivors without ICDs (Table II). Of our 49 survivors, only 9 (18.4%) underwent ICD placement. The average age, comorbidity score, duration of resuscitation attempt, CPS, presence of CAD, rhythm (VT, VF, or other), presence of AMI, and LVEF were not statistically different between ICD and non-ICD recipients. There were, however, trends for a lower LVEF and higher likelihood of presentation with VT/VF in the subjects receiving ICDs. The only factor that was significant was location of the arrest; 67% of the arrests in the ICD recipients occurred in an intensive care unit (ICU) setting, whereas only 30% of the non-ICD recipient's arrests occurred in an ICU ($P = .04$). Implantation of ICD improved long-term survival compared with those patients without a device (Figure 3). Subjects with ICDs had a 3-year survival rate of 77% ($P = .03$, OR 2.0, 95% CI 1.1–3.5), a twofold higher 3-year survival rate compared with that of our patients who did not receive an ICD (77% vs 41%).

Discussion

The purpose of this investigation was to evaluate the relationship of survival to discharge after in-hospital arrest with long-term survival. We examined records of 732 consecutive in-hospital arrest patients. Among all subjects surviving to discharge, the 1-year survival rate of 68% was similar to that of other reported series and suggested a continued elevated risk for death in this population.^{20–22} Initiation of a program to improve immediate resuscitation outcomes resulted in increased survival to discharge, which allowed us to assess the relationship between survival to discharge and long-term survival. Our data show that our intervention, clearly shown to improve survival to discharge, did not affect long-term survival rates. For those who did survive, we found that the survival rate did not come at the expense of decreased cognitive performance; CPS did not vary significantly comparing pre- to postarrest, validating the contention that survival does not come at the expense of decreased quality of mental life. A similar lack of significant cognitive decline in VF cardiac arrest survivors has been documented previously in out-of-hospital arrest survivors in Olmsted County, Minnesota.²³

The mortality rate of arrest survivors in our study was comparable to that of out-of-hospital cardiac arrest patients.^{24–29} In the case of out-of-hospital cardiac arrest survivors, ICD implantation is a highly effective secondary prevention strategy for this high-risk group. Our data suggest that a similar strategy may be effective for in-hospital arrest survivors. Patients in our study group who received ICDs had a 1-year survival rate of 77%, which compares favorably with the 3-year survival rate in the AVID trial of 75% in ICD patients; AVID compared ICDs to antiarrhythmic medication in out-of-hospital arrest patients.^{30–32}

The overall rate of use of an ICD for arrest survivors was quite low in our population. The reason for this is unclear, but it appears that this is in part due to the fact that many patients were considered to have a “reversible” cause for their arrest and thus were not felt to qualify for secondary prevention indications for ICD placement. We examined our patients to see how many of them would be good candidates for ICDs. Of the 40 survivors without an implanted device, 9 were poor candidates for ICD therapy based on an expected survival of <1 year, mental status, or active drug abuse. The remaining 31 patients had no contraindications to ICD placement. We suggest that this population of patients should be

considered under secondary prevention guidelines and may benefit from ICD placement. This observation recapitulates the data for out-of-hospital cardiac arrest patients in the AVID trial registry,³³ wherein the survival in patients with out-of-hospital cardiac arrest attributed to reversible causes was not statistically different from the survival in subjects thought to have had an arrest in the absence of reversible causes.

The limitations of our study include its observational nature and retrospective analysis originating from a single medical center. Moreover, our patient population may not be representative of the average hospital patient. Veterans' hospitals traditionally have a larger proportion of older men with significant comorbidities compared with that of patients admitted to community hospitals.³⁴ In addition, ICD implantation was relatively uncommon in our patient cohort, which is in part because of the prior lack of published data and guidelines regarding ICD placement. Also, because this was a retrospective study, we cannot rule out that some of the improvement in survival seen in the patients receiving an ICD was not the result of selection or subsequent treatment biases, where the device was placed in the candidates deemed to have the best survival or that other medical therapies may have differed between the groups. Finally, because of the observational nature of our analysis and the lack of a controlled and randomized assignment to ICD therapy, our conclusions regarding increased survival as observed with ICD therapy in inhospital cardiac arrest survivors may have limited implications. Nevertheless, future studies to define which patients may benefit from an ICD seem warranted.

In conclusion, inhospital arrest patients carry poor long-term survival rates. This reduced long-term survival rate is not favorably influenced by inhospital interventions documented to improve initial resuscitation efficacy. Thus, survival to discharge may not be an inclusive end point for trials that intend to demonstrate improvement in long-term resuscitation outcomes. Future studies and registries such as NRCPR should consider collecting long-term clinical and ICD data in inhospital cardiac arrest survivors to evaluate durability of resuscitation performance and long-term outcomes.

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Figure 1. Odds ratios for survival by significant clinical characteristics between survivors to discharge and nonsurvivors of in-hospital cardiac arrest. Error bars represent 95% CIs.

Figure 2. Kaplan-Meier survival curves comparing survival of subjects before (solid line) and after (dashed line) the implementation of a program designed to improve survival to discharge. Despite improvement in absolute survival rates after program implementation, survival trends are identical.

Figure 3. Kaplan-Meier survival curves comparing long-term survival of in-hospital cardiac arrest survivors with (solid line) and without (dashed line) ICDs. Recipients of ICD have significantly improved survival rates.

Table I

Characteristics of nonsurvivors and survivors of cardiac arrest

Variable	Nonsurvivors	Survivors	<i>P</i> *
No. of subjects	683	49	
Age at arrest (y)	66 ± 12	59 ± 12	<.01
Comorbidity score upon discharge	3.0 ± 1.5	2.6 ± 1.6	.03
Duration of resuscitation attempt (min)	22.6 ± 13	19.9 ± 18	.58
Ejection fraction (%)	42 ± 18	42 ± 18	.67
VT/VF	122 (18)	25 (52)	<.01
Medication use			
ACE-I/ARB	270 (40)	30 (67)	.01
β-Blocker	217 (31)	27 (56)	<.01
Antiarrhythmic	50 (8)	10 (20)	.05
CCB	216 (32)	19 (39)	.62

Data are presented as mean ± SD or as number (percentage). *ACE-I*, Angiotensin-converting enzyme inhibitor; *ARB*, angiotensin receptor blocker; *CCB*, calcium-channel blocker.

* *P* value contrasting the 2 categories.

Table II

Comparison of cardiac arrest survivors with and without ICDs

Variable	Without ICD	With ICD	<i>P</i> [*]
No. of subjects	40	9	
Age (y)	59 ± 12	59 ± 9	.21
Comorbidity score	2.6 ± 1.6	2.8 ± 1.6	.38
Duration of resuscitation attempt (min)	20 ± 15	22 ± 12	.83
Ejection fraction (%)	41 ± 13	32 ± 17	.08
CPS	2.2 ± 0.5	1.9 ± 0.7	.27
CAD	17 (43)	5 (55)	.15
AMI [†]	6 (15)	0	.27
Presenting rhythm			
VT/VF	18 (45)	6 (67)	.06
VT	10 (25)	3 (33)	.27
VF	8 (20)	3 (33)	.24
Other	22 (55)	3 (33)	.15
Location of arrest			
ICU	12 (30)	6 (67)	.04
Non-ICU	28 (70)	3 (33)	
Medication use			
ACE-I/ARB	25 (62)	5 (56)	.14
β-Blocker	22 (55)	5 (56)	.13
Antiarrhythmic	8 (20)	2 (22)	.34
CCB	16 (40)	3 (33)	.22

Data are presented as mean ± SD or as number (percentage).

* *P* value contrasting the 2 categories.[†] Perievent AMI as documented by cardiac enzyme rise and chest pain or electrocardiographic changes.