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Determinants of Long-Term Neurological Recovery Patterns Relative to Hospital Discharge among Cardiac Arrest Survivors

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Abstract

Objective—To explore factors associated with neurological recovery at one year relative to hospital discharge after cardiac arrest (CA).

Design—Observational, retrospective review of a prospectively collected cohort.

Setting—Medical or surgical intensive care units in a single tertiary care center.

Patients—>18 years of age, resuscitated following either in-hospital or out-of-hospital CA, and considered for targeted temperature management between 2007 and 2013.

Interventions—None.

Measurements—Logistic regressions to determine factors associated with a poor recovery pattern after one year, defined as persistent Cerebral Performance Category Score (CPC) 3–4 or any worsening of CPC relative to discharge status.

Main Results—30% (117/385) of patients survived to hospital discharge; among those discharged with CPC 1, 2, 3 & 4, good recovery pattern was seen in 54.5%, 48.4%, 39.5%, and 0%, respectively. Significant variables showing trends in associations with a poor recovery pattern (62.5%) in a multivariate model were age>70 years (odds ratio (OR):4, 95% Confidence intervals (C.I) 1.1–15; p=0.04), Hispanic ethnicity (OR:4, C.I 1.2–13; p=0.02), and discharge disposition (home needing out-patient services (OR:1), home requiring no additional services (OR:0.15, C.I 0.03–0.8; p=0.02), acute rehabilitation (OR: 0.23, C.I 0.06–0.9; p=0.04).

Conclusions—Patients discharged with mild or moderate cerebral dysfunction sustained their risk of neurological worsening within one year of cardiac arrest. Old age, Hispanic ethnicity, and discharge disposition of home with out-patient services may be associated with a poor one year neurological recovery pattern after hospital discharge from cardiac arrest.

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Keywords

cardiac arrest; clinical outcomes; neurological recovery; Cerebral Performance Category score; targeted temperature management

Introduction

There are 630,000 cardiac arrest (CA) patients per year in the United States, of which 12% of out-of-hospital patients and up to 24.8% of in-hospital patients survive to hospital discharge.¹ Survival does not necessarily entail a good neurological outcome, as impaired physical and cognitive function is common.² There is some support for the notion that the recovery process after resuscitation is dynamic and may continue for months following the arrest.³ The predictive nature of factors present on admission, including age, gender, initial rhythm, presence of bystander cardio-pulmonary resuscitation (CPR), time to return of spontaneous circulation (ROSC), preexisting functional status, and administration of Targeted Temperature Management (TTM) on survival and neurological status at discharge is well known.^{4–7} Similar associations of neurological status at the time of hospital discharge and pre-arrest functional status have been reported with 6–12 month cognitive status and quality of life.^{8,9} There is, however, an absence of studies focusing on the long-term neurological recovery attained by the survivors in relation to hospital discharge status.

We aim to describe the long-term patterns of neurological recovery among CA survivors, and further explore factors that are associated with the evolution of their neurological recovery at one year relative to their outcomes at hospital discharge.

Materials and Methods

Participants and procedures

Clinical data from 385 consecutive CA patients >18 years of age, resuscitated following either in-hospital or out-of-hospital CA between 8/2007–7/2013 at a single, high volume, tertiary-care referral facility were collected retrospectively. Those who survived to hospital discharge were then followed until 7/2016 and included in the analysis. The study was approved by the Columbia University institutional review board, and participants gave written or verbal informed consent.

Clinical Data Collection

Patients demographics and arrest-related variables following Utstein guidelines¹⁰, including pre-existing medical conditions, cumulative Charlson comorbidity index (CCI)¹¹, pre-arrest cerebral performance category scale (CPC)¹², living environment, income, insurance, hospital complications, and discharge dispositions, were collected via chart review. Cooling protocol is attached (Supplemental File 1). Neuron specific enolase was collected from day 1 to day 3 post-arrest.

Outcome measures

A single reviewer (AR) determined the CPC score at discharge after a thorough chart review focusing on occupational therapy, physical therapy, and attending physical medicine and rehabilitation notes prior to discharge; this score was independently confirmed by another reviewer (EM). One-year post-arrest CPC was determined by two independent primary reviewers (AP & WR), blinded to discharge CPCs, following administration of a one-year follow-up case-report form by telephone interview. If any of the two primary raters disagreed on a score, a third rater (SA) made the final decision. Outcomes were obtained directly from the patients or from surrogates if patients were unavailable to participate. All reviewers utilized a CPC rubric (Supplemental File 2). The Kappa statistic between two independent reviewers was 0.92 for CPC measurement at discharge and 0.96 (p value <0.001) with 97% agreement at one year.

Patients were categorized as having a “poor recovery pattern” if they had any worsening of CPC score at one year compared to their discharge score. In the case that there was no change in a patient’s CPC score at one year compared to discharge and their discharge CPC was 3 or 4, they were also categorized as having a poor recovery pattern. The remaining patients who either had an reduction in CPC score at one year compared to discharge or maintained their discharge CPC score of 1 or 2 at one year were categorized as having a “good recovery pattern”.

Discharge disposition was collected from psychiatry and social work notes and classified into four categories: (A) home without services, (B) home with services (PT/OT/speech therapy), (C) acute rehabilitation facility or long-term acute care facility, and (D) skilled nursing facility or hospice. According to institutional protocol, all patients are seen prior to discharge by physical, occupational and speech therapists, followed by a psychiatrist-based recommendation on discharge disposition. The eligibility for acute rehabilitation followed Medicare rules, which requires patients to be capable of undergoing intensive physical or occupational rehabilitation (at least three hours per day, five days per week) and at least one additional type of therapy, such as speech-language therapy or occupational therapy.

Statistical analyses

The two groups, “poor recovery pattern” and “good recovery pattern”, were compared using Chi-square and Wilcoxon Rank Sum test for categorical and continuous clinical characteristics, respectively. We used multivariable logistic regression models to estimate odds ratios (OR) and 95% Confidence Intervals (CI) for associations between demographics, comorbidities, arrest related and post-hospital discharge variables, and poor recovery patterns at one year (Table 3). Stepwise selection of variables included in the final model was based on a statistical significance of $p < 0.05$. After adjustment for multiple comparisons using Bonferroni correction, a p-value of 0.01 was considered statistically significant for determinants of one-year neurological recovery patterns. CPC at discharge was dichotomized into poor (CPC 3–4) and good (CPC 1–2) outcomes. Calculations were carried out using STATA software (StataCorp, College Station, TX).

Results

Admission Characteristics

30% of CA patients (117 of 385) admitted after resuscitation survived until discharge and had significantly lower mean age, higher pre-arrest functional and neurological status, lower rates of out of hospital arrests, lower CCI, higher rates of ventricular tachycardia/fibrillation (VT/Vfib), CPR, and defibrillation with medical personnel present, and less time to ROSC, compared to non-survivors (Table 1).

Discharge Characteristics

Good outcomes (CPC 1–2) at discharge were seen in 47% (55/117) of cases; compared to poor outcomes (CPC >2), they were relatively younger, were predominantly men, and had lower CCI. Further, they were mostly living at home with no assistance required and with a CPC of 1 before the arrest. Patients discharged with good outcomes had more witnessed arrests, shorter ROSC times, predominantly VT/Vfib as initial rhythm, higher rates of bystander defibrillation, were more likely to have day 3 neuron specific enolase (NSE) levels <33, and had lower rates of TTM and pneumonia. Lastly, significantly more patients with a CPC of 1 were discharged home (Table 2).

One-Year Findings

At one year, out of 117 discharged, there were 34 (29%) additional deaths; 5 (4%) patients were lost to follow up (1, 2, and 2 from CPC 1, 2, and 3 respectively). Among the 78 (65%) survivors evaluated at one-year, 27 (34.6%) had a CPC of 1, 21 (27%) had a CPC of 2, 20 (25.6%) had a CPC of 3, and 10 (12.8%) had a CPC of 4. Overall good outcome at one year was observed in 41% (48/112) of patients.

Figure 1 illustrates the evolution of patients' neurological status as they transitioned from hospital discharge to one year. Among all discharges with a CPC of 1 (n=23), there were 3 deaths (2 due to re-arrests and 1 had pre-existing non-small cell carcinoma of lung) and 54.5% (12/22) of patients maintained a CPC of 1 at one year.

Among discharges with a CPC of 2 (n=33), there were 7 deaths (2 due to re-arrests, 1 to pre-existing liver cirrhosis, 1 to pulmonary hypertension, and 1 to chronic heart failure leading to DNR orders and 2 due to unknown causes). 48.4% (n=15/31) of patients improved either to CPC 1 (8/31; 25.8%) or remained with CPC of 2 (7/31; 22.6%) at one year.

Of those discharged with a CPC of 3 (n=38), there were 11 deaths (5 due re-arrests, 2 had cancer as a pre-existing condition, and 4 due to unknown causes). Interestingly, 41.6% (15/36) of patients improved to a CPC 1 (7/36; 19.4%) or CPC 2 (8/36; 22%) at one year.

Among patients discharged with a CPC of 4 (n=23), there were 13 deaths; the majority were due to sepsis or re-arrests, and were associated with multiple hospitalizations and readmissions. None of these patients showed any improvement in their neurological status at one year and 10 patients remained in a comatose or persistent vegetative state.

Recovery Patterns after One Year

As shown in Table 3, patients in the poor recovery pattern group (70/112; 61.4%), when compared to good recovery pattern patients, were significantly older (mean age > 70), had higher CCI, were more likely to be women, black, or Hispanic, to have lived at home with assistance at the time of the event, and to be discharged home with out-patient services required. There were no significant differences found between groups for location of arrest, ROSC, bystander CPR, rates of defibrillation, or administration of TTM.

Of note, the poor recovery pattern group included 8.7% (n=6) of patients who had worsened functional status from CPC 1 to CPC 2.

Determinants of One-year Neurological Recovery Patterns

Variables mentioned in Table 3, including demographics (age, gender, race), various comorbidities, CCI on admission, arrest related variables (location of arrest, witnessed/unwitnessed, bystander CPR, ROSC, initial rhythm), presence of TTM, defibrillation, pneumonia, type of insurance, annual income, discharge disposition, and NSE levels on day 3, were analyzed in univariate models to determine the correlations associated with poor recovery pattern after one year.

Significant trends in associations with a poor recovery pattern at one year relative to discharge status were found in a multivariate model with age >70 years (OR: 4, C.I 1.1–15; p=0.04), Hispanic race (OR: 4, C.I 1.2–13; p=0.02), and discharge disposition (home needing out-patient services (OR:1), home requiring no additional services (OR: 0.15, C.I 0.03–0.8; p=0.02), acute rehabilitation (OR: 0.23, C.I 0.06–0.9; p=0.04) (Table 4).

CPC at discharge or CCI on admission were not statistically significant in the multivariate model (Table 4). Sensitivity analysis showed that association with CPC at discharge in the univariate analysis was mostly driven by patients with CPC of 4 (who invariably continued to have a poor outcome at one year follow-up as shown in Figure 1).

Subgroup analysis based on Arrest Site

Among In-hospital arrests, patients with poor recovery patterns were older and had greater CCI scores, compared to the good recovery pattern group. For Out-of-hospital arrests, the two recovery pattern groups were significantly different in pre-arrest living environment and discharge dispositions after survival and there was a trend that patients with good recovery patterns had higher rates of Ventricular tachycardia/fibrillation as initial rhythm (Supplemental File 3).

Discussion

The current study highlights the dynamic and varying outcomes of CA survivors, and identifies factors associated with the evolution of neurological status within the first year of the event after hospital discharge.

There was significant variability in the recovery patterns among patients discharged with mild to moderate cerebral dysfunction. An early good outcome at discharge did not

necessarily maintain neurological status over one year. The neurological status of approximately half of the patients with a discharge CPC of 1 or 2 deteriorated by one year (Figure 1). Factors associated with this apparent worsening in neurological status remain to be elucidated. Neurocognitive and psychosocial sequelae from hypoxic-ischemic injury remain a potential confounder.^{13,14} Previous studies have reported that as many as 50% of survivors discharged with a good CPC suffer from cognitive deficits,¹⁵ 14–45% from depression, 13–61% from anxiety, and 19–27% exhibit symptoms of posttraumatic stress disorder.¹⁵ Similar findings have been reported in patients after stroke, in which depression is not only common but also has been linked to cognitive impairment,¹⁶ worse functional outcomes, and increased mortality, even when controlling for other variables.^{17–20} Thus, routine cognitive and psychiatric screening at discharge followed by a long-term follow-up could potentially help determine what continues to impact long-term outcomes among patients with mild-moderate cerebral dysfunction.

In contrast to recent evidence,^{21–23} our study reports improvement in functional status in 40% of patients discharged with severe disability. A discharge CPC of 3 did not always dictate a poor long-term outcome. As reported previously, the range of discharge dispositions for patients with CPC of 3 can include home, long-term acute care, or hospice.²³ Given that patients experience the most neurological improvement in the first 6 months post-discharge after CA,³ combined with our findings, we believe that severe cerebral disability at discharge should not preclude intensive physical and cognitive rehabilitation, and may potentially benefit a sub-group of these patients.

None of the patients discharged in coma or persistent vegetative state (PVS) improved sufficiently to change their CPC score at one year. The majority either died or remained in a sub-acute nursing facility. This is in concordance with a recent study that reported a 0% survival rate of in-hospital CA patients discharged with a CPC of 4 within 6 months, and an extremely poor survival rate among out-of-hospital CA patients at one year.²² These findings have increased pertinence, given that current health-care infrastructures demand a prioritized system of resource allocation and utilization. Nonetheless, cases have been reported in which patients discharged in minimally conscious states (MCS) awoke one month and three months after hospital discharge,²⁴ though CPC is not an appropriate tool to differentiate between PVS and MCS patients.

The proportion of patients in our cohort with poor neurological status at discharge is very large (>50%) compared to studies from Europe,^{2,8} but comparable to another high-volume, tertiary care referral center in the United States, where it is around 63%.⁴ This discrepancy can be explained by the pre-morbid health and neurological status of our survivors as described in Table 1. Finally, the large number of survivors with a CPC of 4 in our study can be explained by lower rates of withdrawal of care due to neurological reasons (17%).²⁵

It is plausible to assume that patients being discharged home with planned out-patient services have relatively fewer needs and are in better functional status compared to those deemed appropriate for acute rehabilitation in order to regain their independence long-term. Contrary to this assumption, acute rehabilitation was associated with significantly better neurological recovery. This finding may partially be explained by the amount of

deterioration observed at one year in patients discharged with a CPC of 1, as 45% of them were discharged home with services, compared to the 50% of patients with a CPC of 3 who went to an acute rehabilitation and showed significant improvement. Elmer et. al⁴ recently reported no significant differences in hazard of death between patients discharged home or to acute rehabilitation. It is increasingly believed that survival alone cannot be considered a success for these patients.²⁶ Newer guidelines should emphasize the need to include multiple impairment and disability measures with longer-term endpoints among survivors.²⁷ In light of these findings, we suggest that special attention needs to be paid to occupational therapy recommendations for discharge dispositions, which focus more on a patient's ability to function at home and cognitive capabilities required to reintegrate back into society.

Overall, our study showed significant variability in long-term recovery patterns among cardiac arrest survivors. A good discharge status does not necessarily lead to a good recovery pattern at one year, and an early poor discharge status does not guarantee poor recovery at one year. Most of the traditional arrest related predictors of survival to hospital discharge were not associated with long-term recovery patterns. We noticed that factors found to be associated with recovery patterns may have had a variable effect, depending on the site of the arrest, which warrants further investigation in a larger cohort. Discharge disposition of home with out-patient services and Hispanic ethnicity showed trending associations with a poor one year neurological recovery pattern after hospital discharge from cardiac arrest.

Our study has several limitations. The small number of patients in each CPC category might limit reliability of the results; however, our study is one of the biggest cohorts of survivors being followed for neurological outcomes at one year, with very few patients lost to follow-up. We acknowledge that CPC at discharge was determined based on chart review which potentially creates inaccuracies in spite of judicious use of a rubric. Though CPC is a validated and widely utilized tool, it cannot detect mild cognitive problems¹⁵ and has not been shown to correlate with other functional outcomes as assessed by validated functional status and quality of life scales.^{28,29} However, since CPC was determined at both hospital discharge and one year follow-up, it should not affect the internal validity of our results.

Lastly, the association between patients discharged home with additional out-patient services and worse poor recovery patterns at one year, compared to patients sent to acute rehabilitation, needs to be validated in prospective studies. This was an observational study, not designed to answer that specific question. There could be some inherent differences in patients that were discharged home with services versus acute rehabilitation that is difficult to ascertain in a retrospective study.

The primary outcome in this study was not CPC at discharge or at one year, but an evolution of neurological recovery i.e. how much recovery or worsening patients experienced by one year, relative to their discharge status. Other studies^{4,5,6,7,30} have focused on admission characteristics but not factors at discharge that predict long-term recovery. Future studies conducted in a prospective manner with more sophisticated neuropsychological testing at multiple time points are warranted to confirm some of these hypotheses.

Conclusions

Patients discharged with mild to moderate cerebral dysfunction had varying long-term recovery patterns and could develop worsening neurological status within one year. Conversely, patients with severe cerebral disability at discharge had potential to develop good long-term recovery. Other than old age, traditional factors associated with survival to hospital discharge did not correlate with long-term recovery patterns. Old age, Hispanic ethnicity, and the discharge disposition of home with out-patient services may be associated with a poor one year neurological recovery pattern after hospital discharge from cardiac arrest.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Mozaffarian D, Benjamin EJ, Go AS, et al. Heart disease and stroke statistics-2015 Update. *Circulation*. 2015; 131:00–00.
2. Lilja G, Friberg H, Horn J, et al. Cognitive function in survivors of out-of-hospital cardiac arrest after target temperature management at 33°C versus 36°C. *Circulation*. 2015; 131(15):1340–9. [PubMed: 25681466]
3. Raina KD, Rittenberger JC, Holm MB, et al. Functional outcomes: One year after a cardiac arrest. *BioMed Research International*. 2015; 2015(8):1–8.
4. Elmer J, Rittenberger JC, Coppler PJ, et al. Long-term survival benefit from treatment at a specialty center after cardiac arrest. *Resuscitation*. 2016; 108:48–53. [PubMed: 27650862]
5. Aguila A, Funderburk M, Guler A, et al. Clinical predictors of survival in patients treated with therapeutic hypothermia following cardiac arrest. *Resuscitation*. 2010; 81(12):1621–1626. [PubMed: 20708328]
6. Kutsogiannis DJ, Bagshaw SM, Laing B, et al. Predictors of survival after cardiac or respiratory arrest in critical care units. *CMAJ*. 2011; 183(14):1589–95. [PubMed: 21844108]
7. Iqbal MB, Al-Hussaini A, Rosser G, et al. Predictors of survival and favorable functional outcomes after an out-of-hospital cardiac arrest in patients systematically brought to a dedicated heart attack center (from the Harefield Cardiac Arrest Study). *Am J Cardiol*. 2015; 115(6):730–737. [PubMed: 25644852]
8. Beeseems SG, Wittebrood KM, de Haan RJ, et al. Cognitive function and quality of life after successful resuscitation from cardiac arrest. *Resuscitation*. 2014; 85(9):1269–74. [PubMed: 24909366]
9. Pachys G, Kaufman N, Bdolah-Abram T, et al. Predictors of long-term survival after out-of-hospital cardiac arrest: The impact of Activities of Daily Living and Cerebral Performance Category scores. *Resuscitation*. 2014; 85(8):1052–1058. [PubMed: 24727137]
10. Perkins GD, Jacobs IG, Nadkarni VM, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: Update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest: A statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian and New Zealand Council on Resuscitation, Heart and Stroke Foundation of

Canada, InterAmerican Heart Foundation, Resuscitation Council of Southern Africa, Resuscitation Council of Asia); and the American Heart Association Emergency Cardiovascular Care Committee and the Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. Resuscitation. 2014

11. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987; 40(5):373–83. [PubMed: 3558716]
12. Safar, P. Resuscitation after Brain Ischemia. In: Grenvik, A., Safar, P., editors. *Brain Failure and Resuscitation.* 1981. p. 155–184.
13. Sabedra AR, Kristan J, Raina K, et al. Neurocognitive outcomes following successful resuscitation from cardiac arrest. *Resuscitation.* 2015; 90:67–72. [PubMed: 25737082]
14. Moulart VR, Verbunt JA, van Heugten CM, et al. Cognitive impairments in survivors of out-of-hospital cardiac arrest: a systematic review. *Resuscitation.* 2009; 80:297–305. DOI: 10.1016/j.resuscitation.2008.10.034 [PubMed: 19117659]
15. Green CR, Botha JA, Tiruvoipati R. Cognitive function, quality of life and mental health in survivors of out-of-hospital cardiac arrest: a review. *Anaesth Intensive Care.* 2015; 43(5):568–76. [PubMed: 26310406]
16. Kauhanen M, Korpelainen JT, Hiltunen P, et al. Poststroke depression correlates with cognitive impairment and neurological deficits. *Stroke.* 1999; 30:1875–1880. [PubMed: 10471439]
17. Sinyor D, Amato P, Kaloupek DG, et al. Post-stroke depression: relationships to functional impairment, coping strategies and rehabilitation outcome. *Stroke.* 1986; 17:1102–1107. [PubMed: 3810708]
18. Parikh RM, Robinson RG, Lipsey JR, et al. The impact of poststroke depression on recovery in activities of daily living over a 2-year follow-up. *Arch Neurol.* 1990; 47:785–789. [PubMed: 2357159]
19. Morris PLP, Raphael B, Robinson RG. Clinical depression is associated with impaired recovery from stroke. *Med J Aust.* 1992; 157:239–242. [PubMed: 1435438]
20. Ramasubbu R, Robinson RG, Flint AJ, et al. Functional impairment associated with acute poststroke depression: the Stroke Data Bank Study. *J Neuropsychiatry Clin Neurosci.* 1998; 10:26–33. [PubMed: 9547463]
21. Daubin C, Quentin C, Allouche S, et al. Serum neuron-specific enolase as predictor of outcome in comatose cardiac-arrest survivors: a prospective cohort study. *BMC Cardiovascular Disorders.* 2011; 11:48.doi: 10.1186/1471-2261-11-48 [PubMed: 21824428]
22. Hsu CH, Jiagi L, Cinousis MJ, et al. Cerebral performance category at hospital discharge predicts long-term survival of cardiac arrest survivors receiving targeted temperature management. *Critical Care Medicine.* 2014; 42(12):2575–2581. [PubMed: 25072759]
23. Rittenberger JC, Raina K, Holm MB, et al. Association between Cerebral Performance Category, Modified Rankin Scale, and discharge disposition after cardiac arrest. *Resuscitation.* 2011; 82:1036–1040. [PubMed: 21524837]
24. Fischer C, Luauté J, Némaz C, et al. Improved prediction of awakening or nonawakening from severe anoxic coma using tree-based classification analysis. *Critical Care Medicine.* 2006; 34(5): 1520–1524. [PubMed: 16557163]
25. Matthews EA, Magid-Bernstein J, Presciutti A, et al. Categorization of survival and death after cardiac arrest. *Resuscitation.* 2017 Mar 6.114:79–82. [PubMed: 28279695]
26. Neumar RW, Nolan JP, Adrie C, et al. Post-cardiac arrest syndrome: epidemiology, pathophysiology, treatment, and prognostication. A consensus statement from the International Liaison Committee on Resuscitation; the American Heart Association Emergency Cardiovascular Care Committee; the Council on Cardiovascular Surgery and Anesthesia; the Council on Cardiopulmonary, Perioperative, and Critical Care; the Council on Clinical Cardiology; and the Stroke Council. *Circulation.* 2008 Dec 2; 118(23):2452–8. [PubMed: 18948368]
27. Becker LB, Aufderheide TP, Geocadin RG, et al. Primary outcomes for resuscitation science studies: a consensus statement from the American heart association. *Circulation.* 2011; 124(19): 2158–2177. [PubMed: 21969010]

28. Stiell IG, Nesbitt LP, Nichol G, et al. Comparison of the Cerebral Performance Category score and the Health Utilities Index for survivors of cardiac arrest. *Ann Emerg Med.* 2009; 53:241–248. [PubMed: 18450329]
29. Hsu JW, Madsen CD, Callahan ML. Quality-of-life and formal functional testing of survivors of out-of-hospital cardiac arrest correlates poorly with traditional neurologic outcome scales. *Ann Emerg Med.* 1996; 28(6):597–605. [PubMed: 8953946]
30. Kim YJ, Ahn S, Sohn CH, et al. Long-term neurological outcomes in patients after out-of-hospital cardiac arrest. *Resuscitation.* 2016; 101:1–5. [PubMed: 26826564]

Figure 1.
Distribution of Cerebral Performance Category (CPC) at One year Relative to CPC at Discharge

Table 1

Admission characteristics for all 385 patients

Characteristics	Survivors to Discharge 30.4 (n = 117)	Nonsurvivors 69.6 (n = 268)	<i>p</i> value
Age, mean±SD	60±15	67±18	0.001 *
Male % (n)	52 (140)	56 (66)	0.5
Pre-arrest comorbidities			
-BMI, mean±SD	29±7.5	29.5±7.4	0.48
-Hypertension, % (n)	54 (63)	63 (168)	0.39
-Myocardial infarction, % (n)	18 (21)	19 (51)	0.46
-Congestive heart failure, % (n)	29 (24.8)	88 (33)	0.12
-Diabetes mellitus, % (n)	29 (34)	35.8 (96)	0.45
-Cerebrovascular disease, % (n)	12 (14)	13.4 (36)	0.74
-Renal disease, % (n)	22.2 (26)	24.6 (66)	0.7
-Liver disease, % (n)	8 (6.9)	5.2 (14)	0.63
Smoking status, % (n)			0.9
-Current smoker	22.5 (25)	21 (48)	
-Past smoker	33 (37)	36 (81)	
-Never smoker	44 (49)	43 (97)	
Pre-arrest CPC, % (n)			<0.001 *
-CPC 1	74(86)	46 (112)	
-CPC 2	15 (17)	24 (63)	
-CPC 3	10 (12)	28 (74)	
-CPC 4	0.9 (1)	2 (4)	
Out of hospital cardiac arrest, % (n)	63 (74)	77 (206)	0.009
Initial Rhythm, % (n)			<0.001 *
-Ventricular Fibrillation	44 (46)	14 (34)	
-Pulseless electrical activity	42 (44)	50 (126)	
-Asystole	14 (15)	37 (92)	
Bystander CPR, % (n)			0.007
-No CPR	30 (35)	44 (118)	
-Yes, by a bystander	21 (25)	24 (63)	
-Yes, with medical personnel	49 (57)	33 (87)	
Bystander Defibrillation, % (n)			0.003
-No defibrillation	50 (59)	67 (179)	
-Yes, by a bystander	3 (4)	1 (2)	
-Yes, with medical personnel	46 (54)	33 (87)	
Time to ROSC, mean±SD	17±13	27±19	<0.001 *
Therapeutic Temperature Management	77 (90)	75 (199)	0.79

Characteristics	Survivors to Discharge 30.4 (n = 117)	Nonsurvivors 69.6 (n = 268)	<i>p</i> value
ICU Length of stay, median (IQR)	12 (6.5–22)	4 (2–7)	<0.001 [*]
Hospital Length of stay, median (IQR)	23 (13–33)	4 (2–8)	<0.001 [*]

^{*} BMI = body mass index

[†] CPC = cerebral performance score,

[‡] CPR = cardiopulmonary resuscitation,

[§] OOH = out-of-hospital

Table 2

Characteristics based on Discharge Cerebral Performance Category scores (N=117)

Characteristics	CPC 1	CPC 2	CPC 3	CPC 4
% (N)	19(22)	28(33)	33(38)	21(24)
Age (mean±SD)	54±15	58±12	66±17	60±16
BMI (mean±SD)	27±8	26±5	29±8	31±9
Men	59 (13)	70 (23)	53 (20)	42 (10)
Race				
Caucasian	32 (7)	45 (15)	47 (18)	17 (4)
Black	233 (5)	24 (8)	21 (8)	46 (11)
Hispanic	41 (9)	30 (10)	32 (12)	38 (9)
Asian	5 (1)	0 (0)	0(0)	0 (0)
Pre-arrest comorbidities				
Hypertension	36 (8)	55 (18)	63 (24)	54 (13)
Heart Failure	23 (5)	27 (9)	24 (9)	25 (6)
Myocardial infarction	5 (1)	30 (10)	21 (8)	8. (2)
Diabetes mellitus	27 (6)	21 (7)	34 (13)	33 (8)
COPD	9 (2)	18 (6)	13 (5)	22 (5)
Cerebrovascular disease	5 (1)	6 (2)	18 (7)	17 (4)
Renal disease	14 (3)	21 (7)	24 (9)	29 (7)
Liver disease	0 (0)	6 (2)	13 (5)	4 (1)
Dementia	0 (0)	12 (4)	13 (5)	8 (2)
Malignancy	0 (0)	3 (1)	13 (5)	0.00 (0)
Smoking status				
Never smoker	50 (11)	35 (11)	49 (17)	43 (10)
Past smoker	23 (5)	23 (7)	40 (14)	48(11)
Current smoker	27 (6)	42 (13)	11 (4)	9 (2)
Living Environment				
Home, unassisted	86 (19)	79 (26)	68 (26)	52 (12)
Home, assisted with ADLs	14 (3)	15 (5)	21 (8)	35 (8)
Institutionalized, partially dependent ADLs	0 (0)	3 (1)	3 (1)	4 (1)
Institutionalized, fully dependent ADLs	0.00 (0)	3 (1)	8 (3)	9 (2)
Pre-arrest CPC				
CPC 1	95 (21)	76 (25)	63 (24)	65(15)
CPC 2	5 (1)	15 (5)	21 (8)	13 (3)
CPC 3	0 (0)	6 (2)	16 (6)	17 (4)
CPC 4	0 (0)	0 (0)	0 (0)	4 (1)
Out of hospital cardiac arrest	82 (18)	42 (14)	50 (19)	96 (23)
Witnessed cardiac arrest, % (n)	95 (21)	91 (30)	84 (32)	71 (17)
Time to ROSC, (mean±SD)	14±8	15±16	17±14	20±12

Characteristics	CPC 1	CPC 2	CPC 3	CPC 4
Initial Rhythm Initial Rhythm, % (n)				
Ventricular Fibrillation	70 (14)	41 (12)	46 (17)	17 (4)
Pulseless electrical activity	20 (4)	41 (12)	46 (17)	61 (14)
Asystole	10 (2)	17 (5)	8 (3)	22 (5)
TTM	64 (14)	73 (24)	79 (30)	92 (22)
Percutaneous Angioplasty, % (n)	29 (6)	33 (11)	13 (5)	5 (1)
Pneumonia	41 (9)	45 (15)	47 (18)	65 (15)
Out of Hospital arrests Only, % (n)				
Bystander CPR	36 (8)	12 (4)	18 (7)	25 (6)
Defibrillation	68 (15)	48 (16)	46 (17)	17 (4)
Insurance				
None	14 (3)	15 (5)	13 (5)	8 (2)
Medicare	5 (1)	21 (7)	34 (13)	17 (4)
Medicaid	27 (6)	15 (5)	11 (4)	25 (6)
Medicare + Medicaid	9 (2)	24 (8)	24 (9)	33 (8)
Private	45 (10)	24 (8)	18 (7)	17 (4)
Annual Income (\$)				
<45,000	59 (13)	58 (19)	45 (17)	58 (14)
>45,000	41 (9)	42 (14)	55 (21)	42 (10)
Neuron Specific Enolase-Day 3				
<33	88 (7)	87 (13)	86 (12)	43 (6)
>33	13 (1)	13 (2)	14 (2)	57 (8)
Disposition				
Home without services	36 (8)	27 (9)	11 (4)	0 (0)
Home with services	45 (10)	12 (4)	0 (0)	0 (0)
Acute Rehabilitation	14 (3)	42 (14)	50 (19)	13 (3)
Sub-acute facility	5 (1)	18 (6)	39 (15)	87 (21)
ICU Length of stay, median (IQR)	6 (5–8)	12.5 (7–17.5)	19 (9–30)	14 (11–28)
Hospital Length of stay, median (IQR)	13 (11–19)	23 (17–34)	28 (20–37)	24 (15–31)

* BMI: body mass index (kg/m²)

[†] COPD: chronic obstructive pulmonary disease

[‡] ADL: Activity of daily living

[§] CPC: cerebral performance category score

^{||} ROSC: return of spontaneous circulation

[#] TTM: targeted temperature management

Table 3

Comparing Patients Characteristics of Poor Recovery with Good Recovery pattern groups

Characteristics of Survivors	Poor Recovery Pattern, % (n) 62.5% (n=70)	Good Recovery Pattern, % (n) 37.5% (n=42)	p-value
Age >70 years	40 (28)	17 (7)	0.002
BMI, (mean±SD)	28±7	28±8	0.88
Men	49 (34)	74 (31)	0.02
Race			0.01
Caucasian	30 (21)	55 (23)	
Black	29 (20)	19 (8)	
Hispanic	40 (28)	26 (11)	
Asian	1 (1)	0 (0)	
Pre-arrest comorbidities			
Hypertension	53 (37)	55 (23)	0.94
Heart Failure	26 (18)	21 (9)	0.66
Myocardial infarction	20 (14)	14 (6)	0.48
Diabetes mellitus	30 (21)	24 (10)	0.2
COPD	16 (11)	12 (5)	0.2
Cerebrovascular disease	13 (9)	12 (5)	0.92
Renal disease	23 (16)	21 (9)	0.92
Liver disease	7 (5)	5 (2)	0.64
Dementia	10 (7)	10 (4)	0.63
Malignancy	7 (5)	2 (1)	0.29
Cumulative Charlson Index, median (IQR)	3 (1–5)	4 (2–7)	0.01
Smoking status			0.21
Never smoker	44 (31)	38 (16)	
Past smoker	36 (25)	31 (13)	
Current smoker	20 (14)	31 (13)	
Pre-event Living Environment			0.008
Home, unassisted	60 (42)	86 (36)	
Home, assisted with ADLs	30 (21)	10 (4)	
Institutionalized, partially dependent ADLs	1 (1)	5 (2)	
Institutionalized, fully dependent ADLs	9 (6)	0 (0)	
Pre-arrest CPC			0.36
CPC 1	71 (50)	74 (31)	
CPC 2	13 (9)	19 (8)	
CPC 3	14 (10)	5 (2)	
CPC 4	1 (1)	0 (0)	

Characteristics of Survivors	Poor Recovery Pattern, % (n) 62.5% (n=70)	Good Recovery Pattern, % (n) 37.5% (n=42)	p-value
Arrest Site			0.63
Out of hospital cardiac arrest	63 (44)	67 (28)	
In-hospital cardiac arrest	37 (26)	33 (14)	
Witnessed cardiac arrest	86 (60)	86 (36)	0.87
Bystander CPR	19 (13)	26 (11)	0.86
Time to ROSC, (mean±SD)	19±15	14±10	0.14
Initial Rhythm			
Initial Rhythm, % (n)			0.21
Ventricular Fibrillation	37 (26)	50 (21)	
Pulseless electrical activity	43 (30)	33 (14)	
Asystole	16 (11)	10 (4)	
Unknown rhythm	4 (3)	4 (3)	
TTM	83 (58)	69 (29)	0.34
Defibrillation	39 (27)	60 (25)	0.13
Pneumonia	51 (36)	45 (19)	0.9
Insurance			0.35
Self-pay	11 (8)	12 (5)	
Medicare	23 (16)	21 (9)	
Medicaid	21 (15)	14 (6)	
Medicare + Medicaid	26 (18)	19 (8)	
Private	19 (13)	33 (14)	
Discharge disposition			<0.001
Home with no services	6 (4)	27 (12)	
Home with services	17 (12)	13 (6)	
Acute Rehabilitation Program	26 (18)	47 (21)	
Sub-acute Nursing Facility	51 (35)	13 (6)	
Annual Income in dollars			0.64
<45,000	57 (40)	48 (20)	
>45,000	43 (30)	52 (22)	
Neuron Specific Enolase-Day3 (ng/mL)			0.9
<33	64 (21)	89 (16)	
>33	36 (11)	11 (2)	
ICU Length of stay, median (IQR) Hospital Length of stay, median (IQR)	8.5 (6–20)	13.5 (8–26)	0.07
Hospital Length of stay, median (IQR)	20 (13–27)	24.5 (13.5–34)	0.2

* BMI: body mass index (kg/m²)

† COPD: chronic obstructive pulmonary disease

‡ ADL: Activity of daily living

[§]CPC: cerebral performance category score

//ROSC: return of spontaneous circulation

[#]TTM: targeted temperature management

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Table 4

Associations with Poor Recovery Pattern within One Year of Cardiac Arrest (n=112)

Poor Recovery Pattern	Univariate Odds Ratio (95% C.I)	p-value	Multivariate Odds Ratio (95% C.I)	p-value
<u>Disposition</u>				
Home with services	1		1	
Home without services	0.15 (0.04–0.7)	0.01	0.15(0.03–0.8)	0.02
Acute Rehabilitation	0.3 (0.1–0.9)	0.04	0.23 (0.06–0.9)	0.04
Subacute nursing facility	2.9 (0.8–10)	0.1	3.3 (0.7–13.2)	0.77
<u>Race</u>				
Caucasian	1		1	
Black	3.0 (1.1–7.7)	0.03	2.0 (0.5–8)	0.3
Hispanic	4.8 (1.8–12.0)	0.001	4 (1.2–13)	0.02
Age > 70 years	3.8 (1.5–9.7)	0.005	4 (1.1–15)	0.04
Poor CPC at Discharge	4.8 (2–10)	0.001	1.6 (0.5–5.7)	0.4
Charlson Cumulative index	1.2 (1.03–1.4)	0.01	1 (0.85–1.3)	0.7

* CPC- Cerebral Performance Category score. Poor CPC was defined as score 3 or 4