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ORIGINAL RESEARCH

# A Population-Level Analysis of 5620 Recipients of Multiple In-Hospital Cardiopulmonary Resuscitation Attempts

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**BACKGROUND:** There is a paucity of data examining the epidemiology of recipients of multiple in-hospital cardiopulmonary resuscitation (CPR) attempts, and their outcomes.

**METHODS:** Data source: Nationwide Inpatient Sample, 2000 to 2009. Patient characteristics, survival to discharge, discharge disposition, and cost of hospitalization of patients who had 1 versus multiple (>1) CPR attempts were compared using bivariate and multivariate methods.

**RESULTS:** Of 166,519 hospitalized CPR recipients, 3.4% had multiple CPR attempts. Compared with 1-time CPR recipients, those undergoing multiple CPR were younger (age <65 years; 37.3% vs 42.5%, respectively), more often nonwhite (34.2% vs 41.4%), and commonly treated in nonteaching hospitals (58.0% vs 64.5%; all $P < 0.001$). Survival to discharge decreased by >40% for each additional CPR attempt (23.4% vs 11.9%, and 6.7% for 1, 2, and ≥3 CPR attempts, respectively; $P < 0.001$). After multivariate adjustment, multiple CPR was independently associated with a lower survival to discharge (odds ratio: 0.41, 95% confidence interval: 0.37-0.44, $P < 0.001$). Recipients of multiple CPR were more likely to be discharged to destinations other than home (80.7% vs 70.1%, $P < 0.001$); 1 in 15 survivors of multiple CPR were discharged to hospice (6.8%), compared with 1 in 23 patients (4.3%) who had 1 CPR ($P = 0.002$). The average cost per day of hospitalization was higher for patients who had multiple CPR versus 1 CPR ($4484.60 vs $3581.40, $P < 0.001$).

**CONCLUSIONS:** Recipients of multiple in-hospital CPR attempts are more likely to be younger, nonwhite, and treated in nonteaching hospitals. Survival to discharge is significantly worse, and the cost of hospitalization is considerably higher for these patients. *Journal of Hospital Medicine* 2014;9:29–34. © 2013 Society of Hospital Medicine

Cardiopulmonary resuscitation (CPR) is a potentially lifesaving intervention associated with intense resource utilization and poor outcomes.[1–3] CPR is the default intervention for hospitalized patients in cardiopulmonary arrest in the United States. The most common measure of successful in-hospital CPR reported in the literature is survival to (hospital) discharge, with most estimates between 13% and 37%.[3–6] Poor rates of survival to discharge may be explained by use of CPR in patients for whom it was not originally intended, such as the very elderly with multiple illnesses or the terminally ill.[7,8] Use of CPR in patients unlikely to benefit may be due to a physician's inability to estimate the probability of survival, desire to offer hope to patients, fear of litigation, and poor communication with patients about goals of care.[7–10]

The general public has overly optimistic expectations about CPR; surveys have reported perceived survival after CPR of up to 90%.[11–13] Although objective information substantially affects patient preferences for resuscitation,[14] prognosis is rarely discussed during code status encounters[15,16]; physician estimates of prognosis also are often inaccurate.[9,17] With a scarcity of data describing the characteristics of patients undergoing multiple CPR attempts, and their outcomes, patients and their families could have false expectations about the likely outcomes from multiple CPR attempts, because physician counsel is not well-informed.

In this study, we examine the epidemiology of in-hospital CPR recipients stratified by the number of occurrences of CPR during a single hospitalization, along with their outcomes. We hypothesize that recipients of multiple CPR during a single hospitalization are an epidemiologically distinct group compared with those who receive CPR once during their hospitalization, and that their outcomes are worse.

## METHODS

### Data Source

We used unweighted data for the years 2000 to 2009 from the Healthcare Cost and Utilization Project–Nationwide Inpatient Sample (HCUP-NIS). The NIS is the largest all-payer inpatient-care database in the United States, containing nationally representative information regarding up to 8 million hospital stays per year. Each year, NIS data consist of a 20% stratified sample of hospital discharges involving up to

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1100 nonfederal hospitals from up to 44 states. The NIS utilizes International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes to capture up to 25 diagnoses and 15 procedures associated with the index hospitalization.[18]

### Demographic, Clinical, and Hospital Characteristics of Cardiopulmonary Resuscitation Recipients

Adults (age ≥18 years) who underwent CPR (ICD-9 procedure code 99.60) during their hospitalization were abstracted; this ICD-9 code has been used previously to explore CPR epidemiology and outcomes.[3,19,20] Patients were divided into 2 groups, those who had 1 CPR attempt and those who had multiple (>1) CPR attempts, based on the number of times the ICD-9 code for CPR was included in their hospitalization data. Patients who had cardiopulmonary arrest (ICD-9 code 427.5 or 799.1) as a presenting diagnosis were excluded, as these indicate an out-of-hospital event.

Demographic variables included patient age, sex, race, median household income as defined annually in the NIS dataset, insurance status, admission source (skilled nursing facility or not; emergency room vs not), and type (elective vs nonelective; trauma vs nontrauma). Clinical variables included patient comorbidity as assessed by using the enhanced Charlson Comorbidity Index (CCI).[21] Rates of in-hospital dialysis (ICD-9 codes 39.95, V451, V561), tracheostomy (ICD-9 codes 31.1, 31.2), in-hospital neurologic compromise (coma, ICD-9 code 780.01; semi-coma, ICD-9 code 780.09; persistent vegetative state, ICD-9 code 780.03; anoxic brain injury, ICD-9 code 348.1; and brain damage, ICD-9 code 997.01), ventilator support (ICD-9 code 967.0–2); and artificial nutrition (total parenteral nutrition, ICD-9 code 99.15; enteral infusion of nutritional substances, ICD-9 code 96.6) were assessed as potential indicators of clinical debilitation and/or intense healthcare resource utilization. Hospital variables were region in the United States (Northeast, Midwest, West, and South), location (urban vs nonurban), teaching status, and bed size (small, medium, and large), as defined annually in the NIS.[18]

### Outcomes

Outcomes of interest were survival to discharge, discharge disposition, and cost of hospitalization.

### Statistical Analysis

Sensitivity analyses were done to validate the use of the number of occurrences of CPR code 99.60 as a marker of multiple CPR, as well the association between multiple CPR and outcome. We computed the interval (in days) between the first and last CPR such that a result would not be computed if either value were missing. We found that 80.2% of patients who had CPR multiple times also had valid interval data between the first and last CPR. This was slightly higher than the 75.9% of patients with 1 CPR code who also had valid data for the interval (in days) between admission and CPR, indicating the reliability of using the number of CPR codes as a marker of multiple CPR attempts.

Bivariate analyses comparing characteristics and outcomes of interest for recipients of 1 CPR versus multiple CPR were performed using the $\chi^2$ test for categorical variables and Student *t* test for continuous variables; differences in age and CCI score (analyzed as continuous variables) were assessed using the Mann-Whitney *U* test because the distribution of data for these was not normal. Hospital length of stay and cost were natural log transformed to normalize distribution. Cost was calculated using HCUP-NIS–adjusted, hospital-specific cost-to-charge ratios; costs were adjusted for inflation, converting all costs to year 2009 dollar values using rates from the US Bureau of Labor Statistics.[22] Cost-to-charge ratios were first made available in the NIS datasets in year 2001; therefore, data for the year 2000 were excluded from all cost analyses. The aggregate cost of hospitalization at a population-level was estimated using the discharge weight variable included in the NIS.

Separate multivariate logistic regression models were constructed to assess (1) factors independently associated with occurrence of multiple CPR, and (2) whether multiple CPR is independently associated with survival to discharge. Generalized estimating equations were used to account for hospital clustering. Odds ratios (OR) with 95% confidence intervals (CI) were computed for the final multivariate models. All *P* values <0.05 were considered significant; all tests were 2-sided.

Data management and analysis were performed using SAS statistical software, version 9.3 (SAS Institute Inc, Cary, NC), and SPSS for Windows, version 18.0 (SPSS Inc, Chicago, IL). The HCUP-NIS is a public database with no personally identifying information. This study was deemed exempt from institutional review board approval at our institution.

## RESULTS

Of a total of 65,308,185 adults hospitalized between the years 2000 and 2009, there were 166,519 CPR recipients, yielding a CPR incidence of 2.5 per 1000 hospitalizations. Among CPR recipients, 96.6% (n = 166,899) had 1 CPR and 3.4% (n = 5620) had multiple CPR during their hospitalization (range, 1–11 CPR). When further stratified, 3% had 2 CPR attempts (n = 4949) and 0.4% (n = 671) had ≥3 CPR attempts.

Compared with patients who had 1 CPR, those who had multiple CPR were more often younger (median age, 71 vs 67 years), nonwhite, and in a low-income quartile (all $P < 0.001$; Table 1). Rates of admission from a nursing facility (3.3% for the 1-CPR group vs 3.1% for the multiple-CPR group,

**TABLE 1.** Demographic Characteristics of In-Hospital CPR Recipients Stratified by Number of CPR Attempts, NIS (2000–2009), N = 166,519

| Characteristic | 1 CPR (n = 160,899), % | Multiple CPRs (n = 5,620), % | *P* Value |
|---|---|---|---|
| Sex, F | 45.6 | 47.2 | 0.02 |
| Age, y, <65 | 37.3 | 42.5 | <0.001 |
| Race | | | <0.001 |
| White | 65.8 | 58.7 | |
| Black | 18.7 | 21.6 | |
| Other | 15.5 | 19.8 | |
| Income quartile | | | <0.001 |
| Low | 24.1 | 27.8 | |
| Medium-low | 24.9 | 24.7 | |
| Medium | 23.2 | 22.9 | |
| High | 25.2 | 22.2 | |
| Unknown | 2.5 | 2.4 | |
| Insurance | | | <0.001 |
| Medicare | 65.1 | 61.8 | |
| Medicaid | 9.4 | 12.4 | |
| Private | 18.4 | 17.7 | |
| Other | 7.1 | 8.1 | |
| Admission source, ER | 67.9 | 72.0 | <0.001 |
| Admission type, elective | 10.0 | 7.1 | <0.001 |

NOTE: Percentages were rounded and may not add up to 100. **Abbreviations:** CPR, cardiopulmonary resuscitation; ER, emergency room; F, female; NIS, Nationwide Inpatient Sample.

**TABLE 2.** Clinical and Hospital Characteristics of In-Hospital CPR Recipients Stratified by Number of CPR Attempts, NIS (2000–2009), N = 166,519

| Characteristic | 1 CPR (n = 160,899), % | Multiple CPRs (n = 5,620), % | *P* Value |
|---|---|---|---|
| Clinical | | | |
| Charlson score ≥4 | 25.4 | 27.2 | 0.002 |
| MI | 24.9 | 28.5 | <0.001 |
| CHF | 38.3 | 43.3 | <0.001 |
| Cerebrovascular event | 8.5 | 7.1 | <0.001 |
| Metastatic malignancy | 10.6 | 8.7 | <0.001 |
| COPD | 26.0 | 26.0 | 0.945 |
| Neurologic impairment | 13.8 | 21.1 | <0.001 |
| Supplemental nutrition | 7.2 | 8.3 | 0.002 |
| Mechanical ventilator | 57.4 | 83.1 | <0.001 |
| Cardiac surgery | 2.6 | 2.0 | 0.007 |
| Hospital | | | |
| Location, urban | 90.1 | 92.1 | <0.001 |
| Teaching status, no | 58.0 | 64.5 | <0.001 |
| Region | | | <0.001 |
| Northeast | 19.0 | 15.2 | |
| Midwest | 18.6 | 15.7 | |
| South | 37.4 | 37.1 | |
| West | 25.0 | 32.0 | |
| Bed size | | | 0.715 |
| Small | 10.2 | 9.8 | |
| Medium | 25.5 | 25.3 | |
| Large | 64.3 | 64.9 | |

NOTE: Percentages were rounded and may not add up to 100. **Abbreviations:** CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CPR, cardiopulmonary resuscitation; MI, myocardial infarction; NIS, Nationwide Inpatient Sample.

$P = 0.65$) or as a trauma (0.3% for the 1-CPR group and 0.4% for the multiple-CPR group, $P = 0.34$) were similar.

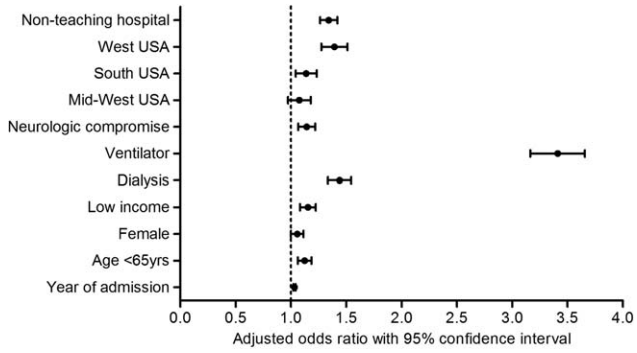


**FIG. 1.** Factors independently associated with the likelihood of multiple in-hospital CPR attempts, NIS (2000–2009). Multivariate model adjusted for age, sex, race, income, elective versus nonelective admission, admission from nursing facility, dialysis, tracheostomy, artificial nutrition, ventilator use during hospitalization, cardiac surgery, CCI score, hospital region, location (urban vs rural), and teaching status. Referents: Age, ≥ 65 years; sex, male; race, white; income, not low; year of admission, continuous variable; hospital region, Northeast; all other referents, no/none. Abbreviations: CCI, Charlson Comorbidity Index; CI, confidence interval; NIS, Nationwide Inpatient Sample.

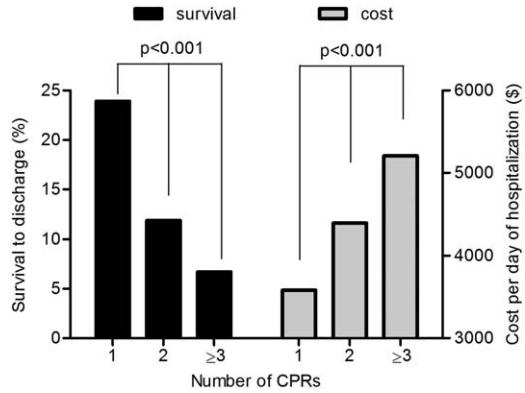


**FIG. 2.** Survival to discharge and cost per day of hospitalization of CPR recipients, stratified by number of CPR attempts, NIS (2000–2009). Abbreviations: CPR, cardiopulmonary resuscitation; NIS, Nationwide Inpatient Sample.

Patients who had multiple CPR had slightly higher mean CCI scores (2.7 vs 2.6, $P = 0.02$). They had higher rates of neurologic compromise and aggressive interventions; they were also more commonly treated in nonteaching hospitals, and in the western region of the United States (Table 2). After multivariate analysis, several patient, clinical, and hospital factors were independently associated with occurrence of multiple CPR (Figure 1).

In bivariate analysis of survival, patients who had multiple CPR had lower rates of survival to discharge (11.3% vs 23.4%, $P < 0.001$). Results were similar (11.6% for multiple CPR vs 22.5% for 1 CPR, $P < 0.001$) when all patients who had CPR but did not have valid timing data were excluded in sensitivity analyses. Further stratification showed that survival to discharge decreased by >40% for each increase in CPR attempt (23.4%, 11.9%, and 6.7% for 1, 2, and ≥3 CPR attempts, respectively, $P < 0.001$; Figure 2). After adjustment, multiple CPR versus 1 CPR during a hospitalization was independently associated with a

**TABLE 3.** Multivariate Analysis Assessing the Independent Effect of Multiple CPR Attempts on Survival to Discharge, NIS (2000–2009)

| Characteristic* | OR | 95% CI | | *P* Value |
|---|---|---|---|---|
| | | Lower | Upper | |
| Demographic | | | | |
| Age <65 years | 1.339 | 1.304 | 1.375 | <0.001 |
| Sex, F | 1.128 | 1.099 | 1.157 | <0.001 |
| Race, nonwhite | 0.781 | 0.758 | 0.804 | <0.001 |
| Low income quartile | 0.887 | 0.858 | 0.915 | <0.001 |
| Year of admission | 1.051 | 1.046 | 1.056 | <0.001 |
| Clinical | | | | |
| Multiple CPR | 0.406 | 0.371 | 0.445 | <0.001 |
| CCI score | 0.939 | 0.933 | 0.944 | <0.001 |
| Cardiac surgery | 1.785 | 1.720 | 1.853 | <0.001 |
| Hospital | | | | |
| Region, Midwest | 1.472 | 1.405 | 1.543 | <0.001 |
| Region, South | 1.262 | 1.218 | 1.309 | 0.008 |
| Region, West | 1.452 | 1.398 | 1.509 | <0.001 |
| Location, urban | 0.876 | 0.837 | 0.917 | <0.001 |

NOTE: Multivariate regression model adjusted for age, sex, race, income, elective vs nonelective admission, admission from nursing facility, cardiac surgery, CCI score, hospital region, location (urban vs not urban), teaching status, bed size, and hospital clustering. **Abbreviations:** CCI, Charlson Comorbidity Index; CI, confidence interval; CPR, cardiopulmonary resuscitation; F, female; M, male; NIS, Nationwide Inpatient Sample; OR, odds ratio.

*Referents: age, ≥65 y; sex, M; race, white; income, not low; year of admission, continuous variable; no. of CPRs, 1; CCI score, continuous variable; hospital region, Northeast; all other referents, no/none.

lower likelihood of survival to discharge (adjusted OR: 0.41, 95% CI: 0.37-0.44, $P < 0.001$; Table 3).

Survivors with multiple CPR were less likely to be discharged home compared with survivors with 1 CPR (19.3% vs 29.9%, respectively, $P < 0.001$); 1 in 15 survivors of multiple CPR were discharged to a hospice (6.8%) versus 1 in 23 1-CPR survivors (4.3%; $P = 0.002$). Mean length of stay was 5.8 versus 5.5 days for patients who had multiple CPR versus 1 CPR, respectively ($P < 0.001$), and 16.0 versus 10.5 days for discharged survivors of multiple CPR versus 1 CPR ($P < 0.001$). The average cost per day of hospitalization was higher for recipients of multiple CPR versus 1 CPR ($4484.60 vs $3581.40, $P < 0.001$). The aggregate cost of hospitalization for 1-time CPR recipients doubled between the years 2001 and 2009 (from $1.3 billion to $2.9 billion); that of recipients of multiple CPR attempts quadrupled in the same time frame (from $38.6 million to $160.7 million).

## DISCUSSION

A number of studies have investigated the epidemiology of patients in whom CPR is attempted.[2,3,5,20,23,24] Several pre-, intra-, and post-resuscitation factors have been shown to affect the survival of resuscitated patients.[6,7,25,26] To our knowledge, neither the epidemiology of hospitalized patients in whom resuscitation is attempted multiple times nor the prognostic value of multiple CPR attempts has been investigated. In this study, we found that multiple resuscitations are more commonly performed on younger, generally sicker patients; their outcomes are significantly compromised compared with patients who are resuscitated once during their hospitalization.

There was a steep decline in survival based on the number of resuscitation events. In multivariate analysis, patients who had multiple CPR were 2.5-fold less likely to survive their hospitalization; survivors of multiple CPR also were more likely to be discharged to a hospice. Overall, this is indicative of clinical deterioration and prolongation of dying should a patient suffer multiple cardiopulmonary arrests during a hospitalization. The robust inverse relationship between multiple CPR and survival to discharge has implications for the development of prognostic models of outcomes following CPR, as previously designed prediction models of CPR outcomes such as the Cardiac Arrest Survival Post-Resuscitation In-hospital (CASPRI) score,[25] Pre-Arrest Morbidity (PAM) score,[27] and Prognosis After Resuscitation (PAR) score[28] do not include multiple resuscitations as a variable of interest.

In-hospital factors were found to be more important than patient factors, such as comorbidities or race, in determining the likelihood of multiple CPR attempts. Hospital teaching status and region remained significantly associated with likelihood of multiple CPR attempts. This is in agreement with studies that have described demographic and regional variation in utilization of do-not-resuscitate orders.[29,30] These findings suggest substantial heterogeneity in the clinical culture and hospital practices across the United States regarding preemptive discussions about resuscitation. This means that where a patient receives care is a significant determinant of their probability of undergoing multiple CPR.

It is known that older patients are more likely to have advance directive orders[30,31] and possibly document their wishes with regard to further resuscitation efforts. There also may be an inclination toward more aggressive care for younger adults compared with those of an advanced age. Uncertainty about a patient's goals of care likely feeds into an increased possibility of multiple resuscitation attempts; this may explain why neurologic compromise and being on ventilator support were independently associated with likelihood of multiple CPR, as these patients often have lost their ability to actively participate in decision-making. The results of this study highlight the importance of engaging patients with a plausible risk of cardiopulmonary arrest about their goals for care and advance directives in a timely manner, regardless of age.

We found that the care of patients who undergo multiple resuscitations is associated with a higher cost of hospitalization than for patients in whom resuscitation is attempted once during their hospitalization. In addition, there was an exponential increase in

aggregate cost over time for multiple CPR recipients compared with 1-time CPR recipients. In a prior study, Ebell and Kruse showed an exponential inverse relationship between cost per surviving patient and rate of survival to discharge.[32] Considering that 93.3% of patients who had ≥3 resuscitation attempts died during their hospitalization, and that hospital-level factors appear to play a significant role in likelihood of multiple CPR, consensus guidelines regarding the appropriateness of ≥3 resuscitation attempts during a single hospitalization may be relevant to aid the care of these patients.

Although the NIS is well-validated,[18] there are some limitations. Whereas CPR incidence in this study (2.5 per 1000 hospitalizations) is within estimates (1–5 arrests per 1000 hospitalizations) reported in previous studies,[3,5] potential undercoding of multiple CPR may explain why the multiple-CPR rate in this study is lower than re-arrest estimates provided in published studies.[2,33] Indeed, accurate calculation of re-arrest rates requires data on do-not-resuscitate orders instituted after successful resuscitation, which are not provided in the NIS. Information on patient-provider discussions about CPR or prognosis is not included. Data regarding the underlying cause and type of arrest rhythm, rates of return to spontaneous circulation, length of code, patient location, critical-care resources and length of critical-care stay, availability of rapid-response/code teams, time to defibrillation, use of therapeutic hypothermia, adherence to resuscitation guidelines, quality of CPR, and long-term follow-up are not included in the database. Presenting rhythms were not assessed, as there are no ICD-9 codes for asystole and pulseless electrical activity. The NIS is de-identified; therefore, chart review to assess the validity of codes is impossible. However, our sensitivity analyses indicate the reliability of using the number of occurrences of the CPR code as a marker of multiple CPR. The strength of our study lies in the use of data that provide a population-level insight into the epidemiology of patients resuscitated multiple times during their hospitalization, and their outcomes.

Decision-making about CPR is at the center of a complex debate that incorporates often divergent clinical, economic, ethical, and personal issues. As debate continues regarding when to not resuscitate,[34–37] studies that explore the public perspective of survival thresholds for the provision of multiple resuscitations will be crucial. As competition for finite healthcare dollars escalates, stratified analyses of the cost implications of resuscitation care are essential. Studies are needed to examine the impact of a history of successful resuscitation in a previous hospitalization on outcomes following CPR in a subsequent hospitalization. Overall, our study fills an important knowledge gap in resuscitation practice and outcomes in the United States and highlights the importance of discussing resuscitation options between a patient and his or her family on hospital admission and, if needed, again after the first successful resuscitation attempt.

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