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Cardiopulmonary resuscitation among mechanically ventilated patients

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Abstract

Purpose—To evaluate the outcomes, including long term survival, after CPR in mechanically ventilated patients.

Methods—We analyzed Medicare data from 1994-2005 to identify beneficiaries who underwent in-hospital CPR. We then identified a subgroup receiving CPR one or more days after mechanical ventilation was initiated (defined by ICD-9 procedure code for intubation [96.04] or mechanical ventilation [96.7x] one or more days prior to procedure code for CPR [99.60 or 99.63]).

Results—We identified 471,962 patients who received in-hospital CPR with an overall survival to hospital discharge of 18.4% (95% confidence interval [CI] 18.3-18.5%). Of those, 42,163 received CPR one or more days after mechanical ventilation initiation. Survival to hospital discharge after CPR in ventilated patients was 10.1% (95% CI 9.8%-10.4%), compared to 19.2% (95% CI 19.1%-19.3%) in non-ventilated patients ($p<0.001$). Among this group, older age, race other than white, higher burden of chronic illness, and admission from a nursing facility were associated with decreased survival in multivariable analyses. Among all CPR recipients, those who were ventilated had 52% lower odds of survival (OR 0.48, 95% CI 0.46-0.49, $p<0.001$). Median long term survival in ventilated patients receiving CPR who survived to hospital discharge was 6.0 months (95% CI 5.3-6.8 months), compared to 19.0 months (95% CI 18.6-19.5 months) among the non-ventilated survivors ($p=<0.001$ by logrank test). Of all patients receiving CPR while ventilated, only 4.1% were alive at one year.

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Conclusions—Survival after in-hospital CPR is decreased among ventilated patients compared to those who are not ventilated. This information is important for clinicians, patients, and family members when discussing CPR in critically ill patients.

Keywords

Cardiopulmonary arrest; Outcome; Predictors; Survival; Quality of life

Introduction

Cardiopulmonary resuscitation (CPR) is an emergent procedure used during cardiopulmonary arrest (CPA) to restore partial flow of oxygenated blood to the brain and heart. It was initially developed in the 1960s for use during the postoperative period after cardiac surgery [1, 2], but over time it has become a default procedure administered to everyone experiencing CPA unless he or she has opted out in advance. Prior studies have examined pre-resuscitation factors and outcomes after CPR such as mortality [3] to better understand its burdens and benefits. However, few studies investigate outcomes after CPR in mechanically ventilated critically ill patients, and there are very limited data on long term survival in this patient population. This information is important for patients, families, and ICU clinicians to have while making decisions about CPR preferences. We therefore conducted an epidemiologic study of CPR among patients receiving mechanical ventilation by analyzing 12 years of Medicare Medical Provider Analysis and Review (MedPAR) claims data.

Methods

Data Sources and Study Population

MedPAR files contain data from claims for inpatient hospital services provided to Medicare beneficiaries and include information on demographics, diagnoses, days of care, and procedures with associated dates. We analyzed MedPAR inpatient claims data from January 1, 1994 to December 31, 2005 to identify beneficiaries who underwent in-hospital CPR, defined by the presence of either of two procedure codes in the International Classification of Diseases, Ninth Revision (ICD-9): 99.60 (Cardiopulmonary resuscitation, not otherwise specified) or 99.63 (Closed chest cardiac massage). We then identified a subgroup who received CPR one or more days after mechanical ventilation was initiated (defined as the presence of either ICD-9 procedure code 96.04 for endotracheal tube insertion or 96.7x for invasive mechanical ventilation one or more days prior to a CPR procedure code). Because we aimed to investigate patients who were already mechanically ventilated at the time of their CPA, we excluded patients whose ICD-9 codes for intubation/mechanical ventilation and CPR occurred on the same date to avoid including patients intubated during the CPR episode. For patients with more than one CPR event following mechanical ventilation, we only analyzed the first occurrence. Those patients for whom the date of CPR was missing were analyzed as not having been ventilated prior to CPR. We included participants receiving Medicare through the Old Age & Survivors Insurance program and the End-Stage Renal Disease program. We excluded individuals co-enrolled in a health maintenance organization (HMO) for whom CPR claims data were likely to be incomplete as is common practice when using MedPAR data to avoid introducing bias [4-6].

Our primary outcome was survival to hospital discharge. Additional outcomes included discharge destination and long term survival after hospital discharge. Predictors of interest selected *a priori* included age, race, sex, chronic comorbid illness, zip-code median income as a marker of socioeconomic status, admission from a skilled nursing facility (SNF), hospital size, hospital rurality, and hospital teaching status. We reduced the 22 discharge destination codes within MedPAR into the following 4 categories: home, another hospital, SNF, or hospice. Vital status after hospital discharge was obtained by linking MedPAR data with Social Security Administration data. Designation of race within MedPAR other than white or black is commonly inaccurate, so we categorized race as white, black, or other [7]. We used the Quan modification of the Deyo-Charlson index to assess the burden of chronic illness. This index uses ICD codes to define the overall comorbidity score and predict mortality (the higher the score, the more severe the burden of comorbidity) and is not a measure of severity of illness [8]. Median household income in 1999 dollars was determined from the 2000 US Census using beneficiary zip code. Given the strong positive correlation between median income using beneficiary zip code and median income using hospital zip code, we used hospital zip code median income for 11,573 individuals who were missing data for median income at the beneficiary zip code but not the hospital zip code level. Data on hospital size is contained in MedPAR as the number of patient beds, and hospital teaching status was determined by the presence of trainees in MedPAR as indicated by the hospital's receipt of graduate medical education funds. Hospital location was determined using hospital zip code and the Rural-Urban Commuting Area Codes approximation, version 2.0, dichotomized as metropolitan and non-metropolitan [9].

The institutional review board of the University of Vermont approved this study. The funding organizations had no role in the design and conduct of the study; in collection, management, analysis, or interpretation of the data; or in preparation, review, or approval of the manuscript.

Statistical Analysis

Crude differences in patient and hospital characteristics and outcomes were analyzed using t, Wilcoxon rank sum, and chi square tests for linear, non-parametric, and categorical data, respectively. Associations between patient and hospital characteristics and both survival to hospital discharge among ventilated patients receiving CPR and discharge destination among CPR survivors were analyzed using logistic regression with robust standard error estimates. Since duration of mechanical ventilation cannot be known from these data (extubation is not captured within administrative data), we carried out a sensitivity analysis evaluating hospital survival in the subset of patients who received CPR 1-3 days after initiation of mechanical ventilation. We were also interested in the association of receiving mechanical ventilation at the time of CPR with hospital discharge survival; to answer this question, a separate multivariable model was created with mechanical ventilation coded as a binary variable. All of our regression models were carried out using complete case analysis. Of the 21,451 participants (4.5%) with one or more missing variables of interest; 19,914 were missing information about hospital rurality. We examined long term survival with time-to event analyses, with censoring on December 31, 2005. Given the nature of administrative data, there were discrepancies in vital status. To avoid biasing the results of our survival analyses, we excluded participants whose coded discharge destination was "death" but whose date of death was recorded as greater than or equal to one day after the date of hospital discharge (n=7159). Similarly, we also excluded participants who were recorded as alive at the time of hospital discharge but who had a recorded date of death greater than or equal to one day before the date of hospital discharge (n=6910). Stata/SE version 11.1 (StataCorp, College Station, TX) was used for all statistical analyses.

Results

We identified 471,962 patients who received in-hospital CPR during the 12-year study period with an overall survival to hospital discharge of 18.4% (95% confidence interval [CI] 18.3-18.5%). Of these, 42,163 received CPR one or more days after mechanical ventilation was initiated; 72% of these received CPR within 1 week of initiation of ventilation. Compared to those who were not ventilated, patients receiving CPR while ventilated were significantly more likely to be younger (73.3±11.9 vs. 75.0±11.4 years, p<0.001), men (52.3% vs. 51.6%, p=0.006), of black race (21.7% vs. 16.4%, p<0.001), and admitted from a SNF (3.4% vs. 2.3%, p<0.001). Burden of chronic illness was not different between the ventilated and non-ventilated groups (Quan modification of the Deyo-Charlson score 2.4±1.9 vs. 2.4±1.9, p=0.22) (Table1). Survival to hospital discharge after CPR in ventilated patients was 10.1% (95% CI 9.8%-10.4%), compared to 19.2% (95% CI 19.1%-19.3%) in non-ventilated patients, p<0.001. Among those receiving CPR 1-3 days after the initiation of ventilation, 8.45% survived to hospital discharge (95% CI 8.1%-8.8%); among those receiving CPR 1 or 2 days after the initiation of ventilation, 8.0 % survived to hospital discharge (95% CI 7.6-8.3%). We also investigated discharge destination in patients who survived to hospital discharge. Among patients ventilated while receiving CPR who survived to hospital discharge, 30.3% were discharged to a skilled nursing facility, compared with 22.0% of non-ventilated patients (Table2). Ventilated patients who survived to hospital discharge were also significantly less likely to be discharged home (26.2%) than non-ventilated patients (44.5%), p<0.001. There were no significant changes in survival to hospital discharge from 1994 to 2005 among all patients, patients who were ventilated prior to CPR, and patients who were not ventilated prior to CPR (p =0.22 when adjusted for mechanical ventilation). However, the proportion of patients receiving CPR while ventilated among all CPR recipients has significantly increased over time, from 5.3% in 1994 to 11.3% in 2005 (p <0.001).

Perhaps the most important results from this research regard long term survival of ventilated and non-ventilated patients, as depicted in Figure 1. Median survival among the 4,273 ventilated CPR recipients who survived to hospital discharge was 6.0 months (95% CI 5.3-6.8 months), compared to 19.0 months (95% CI 18.6-19.5 months) among the 82,502 non-ventilated survivors (p=<0.001 by logrank test) (Figure 1). At 1 year, 4.1% of those who received CPR while ventilated were alive, compared to 10.9% of those who received CPR while not ventilated. During the study period, there were no temporal changes in long-

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term survival after hospital discharge between patients who received CPR with and without mechanical ventilation.

In our multivariable model of survival to hospital discharge in all patients receiving CPR, mechanical ventilation was associated with a 52% lower odds of survival to hospital discharge (OR 0.48 95% CI 0.46-0.49, p<0.001) compared to non-ventilated patients. Other predictors associated with hospital discharge survival in multivariable analyses among ventilated patients who received CPR are shown in Table 3. In multivariable Cox proportional hazards regression, mechanical ventilation was associated with a significantly increased risk of death among those who survived to hospital discharge (hazard ratio 1.55, 95% CI 1.49-1.60, p<0.001).

Discussion

Our study found a hospital survival rate of 10.1 % in ventilated patients receiving CPR compared to 19.2% in non-ventilated patients, and ventilated patients had 52% lower odds of survival than non-ventilated patients. Prior studies on outcomes after in-hospital CPR among critically ill patients receiving mechanical ventilation are limited. A 2010 study included 49,656 critically ill patients from the National Registry of Cardiopulmonary Resuscitation (NRCPR). Among those, 24,522 were mechanically ventilated and had an 11.2% survival rate to hospital discharge and odds of survival of 0.60 compared with non-ventilated patients, which is similar to our results [10]. Our study is larger and may be more generalizable than prior studies, as the NRCPR is a quality improvement initiative in select participating US hospitals. In addition, our study includes interesting and important data on long term survival.

The CPAs in our ventilated group presumably occurred in intensive care units where nurse-to-patient ratio is high and patients are monitored extremely closely. Multiple prior studies have suggested that survival after in-hospital CPR is higher when CPR is received in monitored settings [11-14]. Our findings of worse outcomes in monitored ventilated patients can be fully explained by the fact that these prior studies did not restrict their analyses to ventilated patients, who have a much higher severity of illness than non-ventilated patients. While we found no difference in the burden of chronic illness (by the Quan modification of the Deyo Charlson score) between our ventilated and non-ventilated patients, this score does not measure severity of acute illness such as the Acute Physiology and Chronic Health Evaluation (APACHE) or the Simplified Acute Physiology Score (SAPS) [15].

We found that only 26.2% of patients who received CPR while ventilated and survived to hospital discharge were discharged home, compared to 44.5% in the non-ventilated group. These figures are different from the prior NRCPR study which found that half of critically ill patients receiving CPR and surviving to hospital discharge were discharged to an extended care facility or rehab rather than to home, but their population included ICU patients not requiring mechanical ventilation [10]. Understanding this outcome may be very important information for patients, families, and providers to consider while discussing goals, as patients and families often consider functional status and quality of life to be a key component of their decision-making process [16,17].

Our findings with regard to long term survival may also be important information for patients and clinicians. Ventilated patients who receive CPR and survive to hospital discharge have a median survival of only 6 months, which is less than one-third that of non-ventilated patients (19.1 months). This foreshortened lifespan, in combination with a high likelihood of spending some of that time in a care facility, may prompt many patients and families to forgo CPR. In contrast to our results, a recent study utilizing NRCPR Data found that survival after CPR improved between 2000 and 2009 [18]. However, because these data are from a quality-improvement initiative where participating hospitals receive feedback on their performance, it is perhaps not surprising that an increase in survival after CPR would be observed over time. Thus, our population-based study may be more generalizable.

Our multivariable analyses found associations between lower hospital discharge survival and older age, male sex, black race and race other than white, higher chronic illness burden, and admission from a SNF. Several prior studies have similarly found lower survival after CPR in black patients compared to white [10,19-22], and reasons may include more heart disease [21], less control of heart disease risk factors [21], less access to clinical care [10], receipt of lower quality care [23], a lower prevalence of ventricular fibrillation as the initial cardiac rhythm [10,24], and delayed defibrillation in the hospital [10]. Additionally, black and Hispanic patients may prefer more aggressive life-sustaining treatment than whites and therefore are more likely to receive CPR before death [25], less likely to choose DNR orders [26-28], and less likely to complete any advance directives [29]. Our finding that the proportion of participants receiving CPR while ventilated significantly increased from 5.3% in 1994 to 11.3 % in 2005, p value <0.001, is interesting and perhaps reflects the increasing severity of illness and the higher proportion of critically ill patients seen in hospitals throughout the US during the study period.

The main strengths of our study are its very large sample size, generalizability to a broad population of older adults receiving CPR, and new information about long term survival after hospital discharge. There are also several limitations to this research. First, because we utilized Medicare data, we have relied on ICD codes to define CPR and mechanical ventilation. This definition of CPR within Medicare data has not been validated and short of a long and expensive prospective study cannot be validated. We are reassured that our definition is reasonably accurate as our overall survival among all patients receiving CPR was 18.4%, a figure similar to several prior studies [10,12,13,19,30,31]. Additionally, our finding that 10.1% of ventilated patients receiving CPR survive to hospital discharge is almost similar to the prior NRCPR study [10], again indicating that our definition within Medicare data is adequate. Second, as with all administrative data, Medicare data contains errors, which may have biased our sample. We have tried to avoid bias by excluding patients with obvious discrepancies. Third, we did not want to include patients in this study who were intubated during cardiopulmonary arrest. It is impossible within Medicare data to discern which procedures occurring on any given date happened first. Therefore, we excluded patients with CPR and mechanical ventilation initiation codes on the same date. Because this process may have excluded extremely ill participants who had CPA within hours of being placed on mechanical ventilation, our results may be biased, but we would expect this approach to have biased our results toward the null. Fourth, as mentioned above, Medicare data does not contain a measure of severity of acute illness, nor does it contain a measure of functional status or information about do-not-resuscitate orders. We have tried to approximate functional status with discharge destination. Fifth, Medicare data also does not include potential confounding factors which could impact outcomes such as reason for ICU admission [32,33], type of ICU (CCU, General ICU, Cardiovascular surgical ICU), indication for intubation, cause of arrest [34], and use of vasopressors [10]. Sixth, MedPAR data used in this study are from 1994-2005, and due to our data use agreement we did not have access to more recent data. We have shown that outcomes after CPR did not change between 1992 and 2005 [35], but there are more recent data suggesting that survival to hospital discharge after CPR improved between 2000 and 2009 in select US hospitals participating in NRCPR [18]. Thus, we cannot be certain that outcomes in Medicare beneficiaries have not also improved since 2005. Finally, we do not know the initial arrest rhythm, which is an important variable associated with survival [34], as survival rates are highest among patients with ventricular tachycardia or fibrillation [11-13,16,30,31,34,36-38].

In summary, we found that compared to non-ventilated patients, patients who receive CPR while already mechanically ventilated have reduced survival to hospital discharge, decreased long term survival, and are more likely to be discharged to a SNF and less likely to be discharged home. Factors associated with lower survival include older age, male sex, chronic disease burden, and non-white race. These findings are important for clinicians, patients, and family members when discussing and making decisions about CPR in critically ill mechanically ventilated patients. Our results help inform advanced care planning while addressing the prognosis, efficacy and long term outcomes after CPR.

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Abbreviation List

CPA	Cardiopulmonary arrest
CPR	Cardiopulmonary resuscitation
ICD-9	International Classification of Diseases, Ninth Revision
ICU	Intensive Care Unit
SNF	skilled nursing facility

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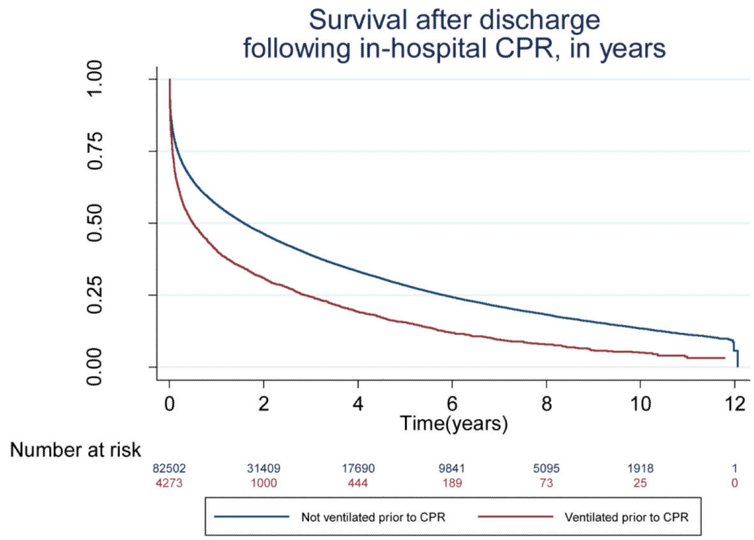

Figure 1.

Long term survival after CPR is significantly shorter in mechanically ventilated patients (p<0.001 by logrank test). These data were censored on December 31, 2005.

Table 1

Survival to Hospital Discharge According to Patient and Hospital Characteristics*

Variable	Intubated Patients		Non-intubated patients	
	Number (%)	Surviving number (%)	Number (%)	Surviving number (%)
Patient characteristics				
Sex				
Male	22,075 (52.3)	2,073 (48.5)	221,877 (51.6)	40,592 (49.2)
Female	20,088 (47.7)	2,200 (51.5)	207,922 (48.4)	41910 (50.8)
Age (yr)				
Mean	73.3±11.9		75.0±11.4	
18- <65	6,866 (16.3)	828 (19.4)	54,222 (12.6)	12,730 (15.4)
65-69	6,133 (14.6)	645 (15.1)	56,021 (13.0)	12,733 (15.4)
70-74	7,625 (18.1)	868 (20.3)	73,587 (17.1)	15,640 (19.0)
75-79	8,039 (19.1)	795 (18.6)	85,478 (19.9)	16,539 (20.1)
80-84	7,041 (16.7)	630 (14.7)	78,708 (18.3)	13,496 (16.4)
85-89	4,330 (10.3)	381 (8.9)	53,252 (12.4)	7,950 (9.6)
≥90	2,128 (5.9)	125 (2.9)	28,494(6.6)	3,377 (4.1)
Race				
White	29,830 (70.8)	3,219 (75.3)	335,403 (78.0)	67,013 (81.2)
Black	9,136 (21.7)	803 (18.8)	70,406 (16.4)	11,212 (13.6)
Other	3,197 (7.6)	251 (5.9)	23,990 (5.6)	4,277 (5.2)
Quan (Chronic illness index) Score				
Mean	2.4±1.9		2.4±1.9	
0	4360 (10.4)	453 (10.6)	50029 (11.6)	10,299 (12.5)
1	10,290 (24.4)	1,067 (25.0)	109,459 (25.5)	22,284 (27.0)
2	11,620 (27.6)	1,279 (29.9)	111,382 (25.9)	22,036 (26.7)
≥3	15,893 (37.7)	1,474 (34.5)	158929(37.0)	27,883 (33.8)
Admitted from a skilled nursing facility				
Yes	1,424 (3.4)	106 (2.5)	9,788 (2.3)	1,241 (1.5)
No	40,739(96.6)	4,167 (97.5)	420,011 (97.7)	81,261 (98.5)
Zip-code median annual income				
<$15,000	1,357 (3.2)	59 (1.4)	9,301 (2.2)	789 (1.0)
$15,000-$29,999	9,686 (23.1)	939 (22.0)	89,873 (21.0)	16,170 (19.7)
$30,000-$44,999	18,374 (43.9)	1,994 (46.9)	197,446 (46.2)	39,365 (48.0)
$45,000-$59,999	7,738 (18.5)	798 (18.8)	82,169 (19.2)	16,372 (20.0)
$60,000-$74,999	3,145 (7.5)	312 (7.3)	32,358 (7.6)	6,303 (7.7)
≥$75,000	1,602 (3.8)	152 (3.6)	15,709 (3.7)	3,045 (3.7)
Hospital characteristics				
Number of beds				

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Variable	**Intubated Patients**		**Non-intubated patients**	
<250	13,657 (32.5)	1,619 (38.2)	153,336 (36.1)	30,475 (37.6)
250-499	14,460 (34.4)	1,385 (32.7)	142,694 (33.6)	26,886 (33.1)
≥450	13,926 (33.1)	1,236 (29.2)	128,356 (30.2)	23,804 (29.3)
Location				
Metropolitan	36,697 (91.0)	3,685 (88.6)	343,352 (83.4)	64,966(81.4)
Nonmetropolitan	3,640 (9.0)	474 (11.4)	68,388 (16.6)	14,894 (18.7)
Teaching status				
Teaching Hospital	16,185 (38.5)	1,454 (34.3)	144,266 (34.0)	26,869(33.1)
Non-teaching Hospital	25,858 (61.5)	2,786 (65.7)	280,120 (66.0)	54,296(66.9)

* p<0.001 for all comparisons of survival between ventilated patients and non-ventilated patients, except male sex (52.3% vs. 51.6%, p=0.006), and Quan (Chronic illness index) Score (2.4 ±1.9 vs. 2.4 ±1.9, p=0.22).

Table 2

Unadjusted outcomes among participants who received CPR while already receiving and not receiving mechanical ventilation*

	Intubated Patients	Nonintubated patients
Survival to Hospital Discharge, n (%)	4,273(10.1)	82,502 (19.2)
Median Long Term Survival in months (IQR)†	6 (5.3-6.8)	19.0 (18.6-19.5)
Discharge Destination, n (%)		
Skilled Nursing Facility	1,296 (30.3)	18,165 (22.0)
Home	1,119 (26.2)	36,710 (44.5)
Other Hospital	1,739 (40.7)	26,076 (31.6)
Hospice	119 (2.8)	1,551 (1.9)

*p<0.001 for all comparisons between groups

†Interquartile range

Table 3

Multivariable analyses of survival to hospital discharge among mechanically ventilated patients receiving CPR *

	Odds Ratio (95%CI)	**P Value**
Age (each one year increase)	0.99 (0.98-0.99)	<0.001
Male	0.82 (0.77-0.87)	<0.001
Race		
White	Reference	
Black	0.77 (0.70-0.83)	<0.001
Other	0.74 (0.64-0.85)	<0.001
Quan (Chronic illness index) Score (each integer increase)	0.93 (0.92-0.95)	<0.001
Skilled nursing facility residence	0.73 (0.59-0.89)	0.002
Median income (per each10K increase)	0.98 (0.96-1.01)	0.14
Nonmetropolitan	1.10 (0.99-1.24)	0.07
Teaching	0.97 (0.90-1.05)	0.44
Number of beds (per each 100 bed increase)	0.95 (0.93-0.96)	<0.001

* Multivariable logistic regression