## Title

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**Journal**
Cardiology, 97(1)

**ISSN**
1422-9528

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**Publication Date**
2002

**DOI**
10.1159/000047412

Peer reviewed

General Cardiology

CARDIOLOGY

Cardiology 2002;97:6–11

Received: September 30, 2001
Accepted: October 14, 2001

# Outcome and Cost-Effectiveness of Cardiopulmonary Resuscitation after In-Hospital Cardiac Arrest in Octogenarians

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**Key Words**
Cardiac arrest · Cardiopulmonary resuscitation · Cost-effectiveness · Octogenarians · Geriatrics

**Abstract**
***Context:*** Octogenarians are the fastest growing segment of the population and little is known about the results of cardiopulmonary resuscitation (CPR) after in-hospital cardiac arrest in this population. ***Objective:*** We sought to investigate the clinical benefit and cost-effectiveness of CPR after in-hospital cardiac arrest in octogenarians. ***Main Outcome Measure:*** Years of life saved. ***Design:*** Effectiveness data were obtained from a review of 91,372 hospital discharges from January 1st, 1993 until June 30th, 1996. Cardiac arrest was reported in 956 patients. The study group consisted of 474 patients ≥80 years old. CPR costs included equipment and training, physician and nursing time and medications. Post-CPR expenses included in-hospital true cost, repeat hospitalizations, physician office visits, nursing home, rehabilitation, and chronic care hospital costs. Life expectancy of the patients who were still alive at the end of the study was estimated from census data. A utility of 0.8 was used to calculate quality-adjusted-life years saved (QALYS). We used a societal perspective for analysis. ***Results:*** The study population was 86 ± 4.8 years old (range 80–103), and 42% were male. Fifty-four patients (11%) were discharged alive, 35 to a chronic care facility and 19 to their home. Assuming that a cardiac arrest without CPR has 100% mortality, 12 octogenarians required treatment with CPR in order to save one life to hospital discharge. Similarly, 29 octogenarian patients with cardiac arrest have to be treated with CPR to net one long-term survivor (mean survival 21 months, with a range from 9 to 48 months). The cost-effectiveness ratio, after estimating the life expectancy of octogenarian survivors, was USD 50,412 per year of life saved, and USD 63,015 per QALYS. However, a utility of 0.5 yielded a cost of USD 100,825 per QALYS. ***Conclusion:*** In comparison with other life-saving strategies, CPR in octogenarians is effective. The favorable cost-effectiveness ratio is highly dependent on the patients' preference for quality rather than quantity of life, as expressed by the utility assumptions.



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0008–6312/02/0971–0006$18.50/0

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## Introduction

Since the introduction of external cardiopulmonary resuscitation (CPR) in 1960 [1] for patients who sustained cardiac arrest following acute myocardial infarction, this intervention has become the standard of care. In the 1980s, 2 reports noted that approximately 30% of the patients who die in the hospital received CPR [2, 3]. At present, CPR is such a universal standard of care that it is often performed on patients for whom the likelihood of survival is very small, such as those with multiorgan failure, septic shock, and advanced malignancies.

Advanced age is not a contraindication for the use of CPR [4, 5]. Nevertheless, in a cost-containment era where the resources are limited, it is essential to understand the cost-effectiveness of medical procedures that are used among the elderly population, such as performing CPR in octogenarians.

Most studies of outcome of in-hospital CPR have focussed on patients younger than 80 years of age and were published over a decade ago [2]. The practice of medicine has changed since that time due to the available technology and the widespread teaching of advanced cardiac life support to the medical profession. The purpose of the present study is to assess the clinical outcomes and cost-effectiveness of CPR in octogenarians who experienced in-hospital cardiac arrest.

## Methods

*Patient Population*

The study cohort was identified from a retrospective review of 91,372 consecutive hospital discharges at Mount Sinai Medical Center (Miami Beach, Fla., USA) from January 1st, 1993 to July 6th, 1996. All patients with the International Classification of Disease version 9, code 427.5 denoting cardiac arrest were studied. Patients who experienced cardiac arrest in the emergency department, surgical recovery unit or in the operating room were excluded from the analysis. Cardiac arrest was reported in 956 patients. The 474 patients who were 80 years of age or older will be referred to as octogenarians.

*Follow-Up*

Vital status of patients discharged alive was obtained from direct telephone calls to the patients, relatives, nursing homes and other residential facilities, from physicians' offices and from the Medicare Online Registry. Vital status of all patients was known until final assessment on February 28th, 1998.

*Economic Analysis*

The cost of in-hospital CPR includes the cost of the procedure itself (medications, nurses, resident physicians, technologists, and equipment, such as crash carts, defibrillator, laryngoscopes, the costs of routine crash cart checks) and also the cost derived from teaching basic and advanced life support to hospital personnel. The cost of attending physicians were not included because they are not part of the CPR team, and the cost of lost work by the persons receiving instruction in CPR was not considered because these classes are an extracurricular activity in our hospital. The unit costs included in this analysis are shown in the appendix.

Post-CPR hospital charges and charge-to-cost ratio for each patient's admission were available for analysis and did not include the CPR cost. The expenses generated by surviving patients were collected using hospital chart abstraction, physicians' records, direct telephone calls to patients and family. These expenses included: the daily hospital cost multiplied by the length of stay, the cost of chronic care facilities such as nursing home, rehabilitation services, chronic care hospital with ventilatory capabilities, medications, physicians' office visits, laboratory tests, any medical intervention such as cardiac catheterization, dialysis, surgeries, endoscopies, biopsies, radiological tests, emergency department visits and repeat hospitalizations. All medical care of the patients took place at our hospital. The cost of medications was based on the unit wholesale price. The cost for physicians' office visits corresponded to the Medicare reimbursement for a complex office visit. The expenses for repeat hospitalizations were calculated based on the mean hospital day cost multiplied by the length of stay. We did not include indirect costs such as wages lost, assuming that most of the patients were retired. Time spent by family members dedicated to the care of the patients was not included in the analysis. The cost of home health services and hospice was not available for the present study.

We used a lifetime horizon in the calculations to estimate the years of life saved (YOLS). The life expectancy of those patients who were still alive at the end of follow-up was calculated based on information from the United States Department of Commerce Bureau of the Census [6, 7] and from the probability of surviving for 5 years for those who are older than 85 years [8].

The cost-effectiveness ratio was estimated according to the following formula: Total cost of CPR and post-CPR care/quality-adjusted-life years saved (QALYS). In order to calculate QALYS, we used utilities reported in the literature for hospitalized patients of 80 years or older with an expected 6-month mortality of 50% [9]. A health-utility is a measure of the value a patient assigns to his or her current state of health. Health-utilities can be measured by the time trade-off method, where the value placed on current health is expressed in terms of the willingness to give up time in one's current state of health to have perfect health. For example, if a person prefers to live 9 months in perfect health instead of 12 months in the current state of health, the utility will be 0.75 (9/12 months).

To assess the most influential variables in the cost-effectiveness ratio, a sensitivity analysis was performed assigning each variable listed in the appendix a value twice and half its true cost. The cost-effectiveness analysis was conducted from a societal perspective. Discounting was not applied because most of the costs occurred during the first year after CPR.

*Statistical Analysis*

Demographic characteristics, length of stay, diagnostic-related groups (DRGs), survival, and cost were analyzed in the octogenarian group and compared with that of the younger population (<80 years of age) during the in-hospital period.

Comparisons between groups (octogenarians versus younger persons) were performed using an unpaired t test for continuous vari-

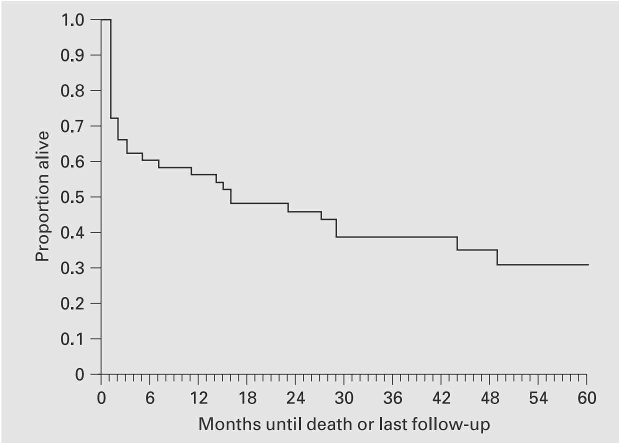


**Fig. 1.** Survival of 50 octogenarians discharged from the hospital following inpatient cardiac arrest and successful CPR.

**Table 1.** Baseline characteristics of 474 octogenarians who suffered in-hospital cardiac arrest

| | |
|---|---|
| Age, years | 86 ± 4.8 |
| Gender (women), % | 58 |
| Cardiovascular DRG, % | 40.1 |
| Respiratory DRG, % | 8.6 |
| Gastrointestinal DRG, % | 7.2 |
| Neurological DRG, % | 7.4 |
| Other DRG, % | 36.7 |
| Length of hospital stay, days | 8.3 ± 8.7 |

ables and the $\chi^2$ statistic for categorical variables. A multiple logistic regression model was constructed using variables that were significant predictors of in-hospital death in the univariate analyses. Results included odds ratios (OR) and 95% confidence intervals (CI). Life tables were used to show time-dependent survival of those octogenarians who were discharged alive from the hospital. Data were analyzed using SPSS software for Windows version 7.5, Chicago, Ill., USA, 1997. A value of $p \leq 0.05$ was considered to be statistically significant.

## Results

*Baseline Characteristics*

The total population who experienced in-hospital cardiac arrest and received CPR consisted of 956 patients. There were 482 patients younger than 80 years and 474 who were 80 years of age or older. The mean age of the total population was 76 ± 15 years, 49% were males. The mean age of the octogenarian population was 86 ± 4.8 years (range 80–103 years, table 1). The distribution of DRGs was cardiovascular 40.1%, respiratory 8.6%, gastrointestinal 7.2%, neurological 7.4%, and other 36.7%. Octogenarians and younger patients were similar in their distribution of DRGs and length of hospital stay. The mean length of stay of the octogenarian group was 8.3 ± 8.7 days compared with the younger group 9.09 ± 9.56 days ($p = 0.18$).

*Survival*

Hospital survival for patients younger than 80 years was 23.8 versus 11% for those 80 years and older ($p < 0.001$). Four of the octogenarians died in hospice. Fifty octogenarian patients were discharged alive from the hospital: 10 (20%) were transferred to a chronic care hospital with ventilatory capabilities, 19 (38%) were discharged home, 9 (18%) were placed in a skilled nursing home and 12 (24%) were admitted to a rehabilitation or psychiatric facility. After discharge from the hospital, 20% died within a week. The death rate was highest among those who were transferred to a chronic care hospital (7 out of 10 died during the first week). At the end of the first month, 34% of the octogenarian survivors had died and at the end of 6 months, 46% of the survivors had expired (fig. 1).

The octogenarian patients who were still alive on the date of the last follow-up (February 28th, 1998) had survived from 9 to 48 months. They represented 36% of all survivors and 3.5% of all who received CPR in this age group.

Variables significantly associated with mortality in both the bivariate and multivariate analyses include age, length of stay in the hospital, cardiovascular, gastrointestinal and respiratory DRG. The independent predictors of in-hospital mortality were: absence of a cardiovascular DRG (OR 3.13, $p = 0.001$); a respiratory DRG (OR 3.55, $p = 0.03$); a gastrointestinal DRG (OR 5.43, $p = 0.02$), and age (OR 1.02 for each year, $p = 0.0001$).

*Cost Analyses*

The daily cost in US dollars in 1988 for nursing homes, chronic care hospitals, and rehabilitation/geriatric facilities was USD 130, USD 800 and USD 730 per person per day, respectively. The total cost of CPR including teaching expenses was USD 480,991 per year per hospital. The true cost of hospitalization was USD 3,869,993 overall. The cost of repeat hospitalizations, physicians' office visits, procedures and medications for survivors was USD 665,405. The cost-effectiveness ratio of CPR in octogenarians was USD 50,412/YOLS. Sensitivity analysis showed that cost-effectiveness ratio is very sensitive to small changes in the health utilities. The quality-adjusted cost-effectiveness ratio was USD 63,015 with a utility of 0.8 and USD 100,825 using a utility of 0.5.

## Discussion

The clinical quandary of whom to resuscitate is a daily issue for physicians. These clinical and ethical dilemmas have led to practices as unusual as the oxymoron 'slow code' [10], which is a superficial attempt to resuscitate a patient whose chance for survival as estimated by the treating physician is nil. However, some patients who sustain cardiac arrest and receive CPR live to be discharged from the hospital and enjoy prolonged survival. The reported rate of survival varies significantly and is likely to be based on patients' underlying clinical condition. Kouwenhoven et al. [1] reported a success rate of 70% (14 of 20 patients), a very high rate which is inconsistent with more recent reports. Indeed, more recent studies have reported rates of survival following in-hospital CPR that vary from 5 to 23% [4, 11]. In our study, the in-hospital survival rate for octogenarians was 11% and for younger patients 21%, indicating that octogenarians have half the probability of surviving an in-hospital cardiac arrest when compared to younger patients.

The association between age and outcome of CPR is variable. Bedell et al. [2], in their prospective study of 294 consecutive CPRs performed at the Beth Israel Hospital in Boston in 1983, reported that age was not a predictor of outcome. Brymer et al. [5] studied 264 coronary care unit patients who underwent CPR in a Canadian tertiary-care teaching hospital. Survival to discharge after CPR was 17.2% for patients 70 years of age or older and 17% for patients younger than 70 years. In contrast, Tresch et al. [12] studied 214 consecutive patients who experienced out of hospital cardiac arrest and received CPR by paramedics. They reported that patients 70 years of age or older had a higher in-hospital mortality than those younger than 70 (71 versus 51%). In the present study, the predicted risk of death as estimated from the multivariate model rose by 2% per incremental year of age.

Overall, the medical community believes that older patients are less likely to survive in-hospital cardiac arrest. Boyd et al. [14] studied 6,103 patients from the Mortality Probability Database to determine whether there is a relationship between age and 'do-not-resuscitate' (DNR) orders in the intensive care unit. They found that after adjusting for severity of illness, older patients ($\geq$75 years old) are more likely to have DNR orders than younger persons. These findings suggest clinical acquiescence to the futility of resuscitative measures in the very old, tacit age discrimination, discouraging the performance of CPR in the elderly or elderly patients' true preferences regarding CPR. Hakim et al. [15], based on data from SUPPORT (study to understand prognoses and preferences for outcomes and risks of treatment), found that DNR orders were written earlier for patients older than 75 years, regardless of prognosis. This may imply that in the absence of risk stratification data, age alone is likely to be used by clinicians to determine the aggressiveness of therapy.

The total number of patients needed to treat to prevent one adverse outcome is an index used to determine which interventions are efficacious. It is calculated dividing 1 by the absolute risk reduction (absolute difference in event rates of adverse outcomes for two groups, usually the treated versus the nontreated group). According to our study, and assuming that a cardiac arrest without CPR has 100% mortality, in the overall population, 12 octogenarians required treatment with CPR in order to save one life to hospital discharge. This value is within the range of other interventions considered efficacious. For example, it is necessary to treat 9 patients with compression stockings to prevent 1 episode of venous thromboembolism. In patients suffering an acute myocardial infarction, it is necessary to treat 20 patients with aspirin and streptokinase to prevent 1 vascular death by the 5-week follow-up [16]. The use of lipid-lowering agents after myocardial infarction compared to placebo has an absolute risk reduction for fatal coronary events or nonfatal myocardial infarction of 3%. Therefore, it is necessary to treat 33 patients to prevent 1 adverse outcome [17]. Similarly, 29 octogenarian patients have to be treated with CPR for in-hospital cardiac arrest to net 1 long-term survivor (mean survival 21 months, with a range from 9 to 48 months).

### *Cost-Effectiveness*

In order to interpret a cost-effectiveness analysis, it is necessary to have benchmark ratios that can be used to judge the new cost-effectiveness ratio. These benchmarks are typically derived from previous cost-effectiveness studies. Many analyses now use a benchmark of USD 50,000/YOLS to differentiate therapies that are clearly cost-effective from those that are uncertain, and a threshold of USD 100,000 to identify therapies that are clearly not economically attractive [18]. Nonetheless, the decision of whether an intervention is or is not desirable based on cost is a societal, and not a clinical one.

According to our study, the cost-effectiveness ratio of performing CPR after in-hospital cardiac arrest in octogenarians is USD 50,412/YOLS. The use of lovastatin for secondary prevention of vascular events costs USD 17,800/YOLS. The use of aspirin during acute myocardial infarction costs USD 2,800/YOLS. The use of captopril after myocardial infarction costs from 3,700 to USD 10,400/YOLS. Finally, admission to the coronary care unit for patients with 5–20% probability of acute myocardial infarction costs from 78,000 to USD 328,500/YOLS [19]. Therefore, in our study, the cost of resuscitating octogenarians is well within the range of what is considered cost-effective. Moreover, if we exclude from the equation the fixed cost (which includes the equipment to perform CPR and the expenses of teaching CPR), the cost-effectiveness ratio becomes slightly more favorable (USD 49,208/YOLS). A sensitivity analysis of our data showed that hospital true cost and health utilities are the most influential variables.

The present study suffers from some methodological limitations which will limit its broad applicability. The study is from a single-center community hospital with university affiliation that may not represent the typical hospital. Furthermore, cardiac arrests that occurred during surgery or in the emergency department were excluded. The retrospective nature of this study may have failed to take into account all costs; however, we believe that the main expenses were taken into consideration. Missing costs, if any, should be small and without a significant effect on the final cost-effectiveness ratio. The retrospective nature of this study prevented us from obtaining prospective information regarding the health-related quality of life of survivors. Thus, we had to assume an overly broad range for the sensitivity analyses.

In conclusion, CPR after in-hospital cardiac arrest in octogenarians has a favorable cost-effectiveness ratio comparable to that of other life-saving medical interventions. Further studies are needed to clarify the most important predictors of successful CPR in octogenarians to maximize the effectiveness of this intervention.

**Appendix:** Costs

| **a** Cost of CPR event | Hour wage, USD | No. | Hours |
|---|---|---|---|
| Resident | 14 | 3 | 1 |
| Nurses/technologists | 20 | 6 | 1 |
| Medications | 18 | – | – |
| Crash cart check, per day | 14 | – | 2 |
| **b** Cost of CPR teaching program per year, USD | | | |
| Basic life support | | 50,352 | |
| Advance cardiac life support | | 33,903 | |
| Equipment for teaching | | 6,000 | |
| **c** Cost of CPR equipment per year, USD | | | |
| Crash cart (n = 42) | | 640 | |
| Defibrillator (n = 48) | | 6,312 | |
| **d** Cost of hospitalization during CPR | | | |
| Days | | 290 | |
| Daily cost, USD | | 1,628 | |
| **e** Cost of outpatient follow-up, USD | | | |
| Physician office visit (n = 378) | | 100 | |
| Medication | Cost/day, USD | Days | |
| Digoxin | 0.77 | 31,740 | |
| Aspirin | 0.08 | 31,740 | |
| Lasix | 0.23 | 31,740 | |
| ACE inhibitors | 1.05 | 31,740 | |
| **f** Cost of chronic care facilities/day, USD | | | |
| Nursing home | | 130 | |
| Chronic hospital with ventilatory capacities | | 800 | |
| Rehabilitation | | 730 | |
| **g** Cost of repeat hospitalization | | | |
| Days | | 343 | |
| Daily cost, USD | | 1,628 | |
| **h** Projected cost of patients who were still alive at the end of follow-up, USD | | | |
| Physicians' visits (n = 325) | | 100 | |
| Long-term medication | Days | Cost, USD | |
| Digoxin | 16,516 | 0.77 | |
| Aspirin | 16,516 | 0.08 | |
| Lasix | 16,516 | 0.23 | |
| ACE inhibitors | 16,516 | 0.05 | |

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