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# Characterization of cardiac arrest in the emergency department of a Brazilian University Reference Hospital: A prospective study

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***Background & objectives*: Sudden cardiac arrest (CA) represents one of the greatest challenges for medicine due to the vast number of cases and its social and economic impact. Despite advances in cardiopulmonary resuscitation (CPR) techniques, mortality rates have not significantly decreased over decades. This study was undertaken to characterize patients that have suffered CA and to identify factors related to mortality.**

***Methods*: This prospective study was conducted at Emergency Department of São Paulo Hospital, Brazil. Two hundred and eighty five patients were followed for one year after treatment for CA. The mean age was 66.3±17.2 yr, and they were predominantly male (55.8%) and Caucasian (71.9%). Mortality rate and factors associated with mortality were the primary and secondary outcome measures. Data were collected using an in-hospital Utstein-style report. A logistic regression analysis was used to determine which variables were related to mortality.**

***Results*: Regarding the characteristics of CPR, 76.5 per cent occurred in hospital, respiratory failure was the most common presumed immediate cause of CA (30.8%) and pulseless electrical activity was the most frequent initial rhythm (58.7%). All attempts at CPR utilized chest compressions and ventilation and the most utilized interventions were epinephrine (97.2%) and intubation (68.5%). Of all patients treated, 95.4 per cent died. Patients with pulseless electrical activity had a higher risk of death than those patients with ventricular fibrillation.**

***Interpretation & conclusions*: The findings of the study highlighted that the mortality rate among CA patients was high. The variable that best explained mortality was the initial CA rhythm.**

**Key words** Cardiac arrest - cardiopulmonary resuscitation - emergency medical services - epidemiology - mortality - survival

Sudden cardiac arrest (CA) represents one of the greatest challenges for medicine due to the vast number of cases and its social and economic impact[1]. In-hospital CA has been shown to be associated with a mortality rate of 80 per cent[2]. Jones *et al*[3] have described antecedent physiological instability, abnormal vital signs and outcomes of CA. It is estimated that each year, 359,400 and 275,000 individuals with CA are admitted to emergency departments in the United States and Europe, respectively[2,4]. In Brazil, 200,000 cases of CA are reported, half of which occur in hospital[5,6].

Successful cardiopulmonary resuscitation (CPR) and its effect on quality of life depend on the availability of basic and advanced life support systems, the ability to immediately defibrillate the heart and the quality of the CPR[7]. Ventricular fibrillation is the most common initial condition associated with sudden CA out-of-hospital and early defibrillation is the most effective treatment in this situation. Moreover, the success of the treatment is related to the interval between the first shock and collapse[6]. Studies have shown an increased survival rate when early defibrillation and CPR are performed[8,9]. In addition, the education and training in basic life support of health professionals and caregivers[10], and immediate access to an automatic external defibrillator (AED) can both contribute to reducing mortality. However, training and education programmes in CPR in Brazil, especially for caregivers, are still developing and despite laws that AEDs should be available in public places, these are rarely found[11].

Despite advances in CPR techniques, mortality rates have not significantly decreased over decades[12,13]. Spontaneous circulation can be restored in 20-50 per cent of patients although many of these patients die in the post-CA phase due to brain injury, haemodynamic instability and multi-organ failure[2]. The survival rates at discharge following out-of-hospital and in-hospital CA are estimated at 9.5 and 24.2 per cent, respectively[2]. In addition, of the survivors, 40-50 per cent of the survivors are discharged with deficits in cognitive function such as memory, attention and intellectual performance[2].

In Brazil, available epidemiological data on CA mortality are scarce[5,6], so this study was carried out to characterize patients treated for CA at one of the major Brazilian public hospitals and to identify factors associated with mortality.

## Material & Methods

This prospective study was conducted in the Emergency Department of São Paulo Hospital, São Paulo, Brazil. The patients sample was obtained by convenience and consisted of 285 patients who were diagnosed with CA. Patients were selected consecutively during the period from February 2011 to January 2012 and were followed for one year after enrolment in the study. There was no loss to follow up.

The inclusion criteria consisted of individuals with CA that had occurred in an out-of-hospital or in-hospital setting and who were treated in the Clinical Emergency Department of São Paulo Hospital. In our population, patients were selected from their admission to the emergency department, and significant data in CA were collected in out-of-patient cases from family members and by the team of nursing professionals (pre-hospital care). Individuals who suffered CA in other hospital departments were excluded from the study.

The mean age of patients was 66.3±17.2 (17-101) years (n=285), and they were predominantly male (55.8%) and Caucasian (71.9%). Regarding clinical characteristics of the patients on admission to the emergency department, 140 (50%) had cerebral performance category (CPC) pre-polymerase chain reaction 2, *i.e*., they were independent for activities of daily living, 182 (63.8%) were conscious, 199 (69.8%) breathing and 212 (74.3%) had pulse on admission.

*Data collection*: Data collection was performed by trained nurses using the Recommended Guidelines for Reviewing, Reporting, and Conducting Research on In-hospital Resuscitation (Utstein Style Report)[14] and consisted of four stages.

First stage: The variables collected were gender, age and skin colour; pre-arrest CPC score; the location of occurrence of the CA; whether the CA was witnessed; the presumed immediate cause; initial rhythm; if CPR was attempted; basic and advanced life support manoeuvres performed during treatment; the interval between initiation of CPR and the first shock, and securing an advanced airway, and the first dose of epinephrine; the interval between the initiation and end of CPR and the return of spontaneous circulation or death and the cause of death.

Second, third and fourth stages: In the second stage, data collection (identical to the first stage) was performed at hospital discharge. In the third (after six months) and fourth (after one year) stages, data

were collected through telephone calls. The variables collected included the occurrence and cause of death.

This study was approved by the Ethics and Research Committee of the Federal University of São Paulo (protocol - 0030/2011). Due to the observational nature of the data collection and the severity of the patients' condition, the study was granted release from consent term.

*Statistical analysis*: Data analysis was performed using IBM SPSS Statistics for Windows Version 19.0 (Armonk, NY: IBM Corp). Chi-square test and Fisher's exact test were used to compare mortality and the categorical variables. ANOVA and Mann-Whitney test were used to compare mortality and the continuous variables. If a patient experienced more than one episode of CA, statistical analysis was performed considering only the first event because the inferences were made regarding the variables of individuals and not those of CA.

A logistic regression analysis was employed to determine which variables explained mortality. Initially, a simple logistic regression was performed which analyzed the relationship between each independent variable and the dependent variable individually. After the simple logistic regression analysis, all independent variables were considered together, and the variables that best explained patient mortality were selected using the forward method. The measure of the strength of the association between variables was expressed as an odds ratio (OR) *i.e.*, as the obtained value increased, the chance of death also increased.

## Results

The characteristics of CA *i.e.*, location (out-of-hospital and in-hospital), witnessed (yes or no), immediate cause (lethal arrhythmia, hypotension, respiratory failure, metabolic disorder, ischaemia or myocardial infarction and others), initial rhythm (ventricular fibrillation, ventricular tachycardia, asystole and pulseless electrical activity), interventions performed (ventilations and chest compressions), defibrillation (yes or no), intubation (yes or no) and epinephrine administration (yes or no) are given in Table I.

Regarding the characteristics of CA, 218 (76.5%) occurred in the hospital and 253 (88.7%) were witnessed by the health team. In CA that occurred out-of-hospital (n=67, 23.5%), there was no attendance

**Table I.** Characteristics of the cardiac arrest episodes of the study population

| Characteristics | Death | | Total |
|---|---|---|---|
| | Yes, n (%) | No, n (%) | |
| Location | | | |
| Out-of-hospital | 66 (98.5) | 1 (1.5) | 67 |
| In-hospital | 205 (94.0) | 13 (6.0) | 218 |
| Total | 271 (95.1) | 14 (4.9) | 285 |
| Witnessed | | | |
| Yes | 239 (94.5) | 14 (5.5) | 253 |
| No | 32 (100) | 0 | 32 |
| Total | 271 (95.1) | 14 (4.9) | 285 |
| Immediate cause | | | |
| Lethal arrhythmia | 10 (83.3) | 2 (16.7) | 12 |
| Hypotension | 49 (94.2) | 3 (5.8) | 52 |
| Respiratory failure | 80 (97.6) | 2 (2.4) | 82 |
| Metabolic disorder | 49 (100) | 0 | 49 |
| Ischaemia or myocardial infarction | 42 (85.7) | 7 (14.3) | 49 |
| Others | 22 (100) | 0 | 22 |
| Total | 252 (94.7) | 14 (5.3) | 266 |
| Initial rhythm | | | |
| Ventricular fibrillation | 11 (68.8) | 5 (31.3) | 16 |
| Ventricular tachycardia | 5 (100) | 0 | 5 |
| Asystole | 76 (100) | 0 | 76 |
| Pulseless electrical activity | 130 (94.2) | 8 (5.8) | 138 |
| Total | 222 (94.5) | 13 (5.5) | 235 |
| Interventions performed | | | |
| Ventilations and chest compressions | 202 (93.5) | 14 (6.5) | 216 |
| Total | 202 (93.5) | 14 (6.5) | 216 |
| Defibrillation | | | |
| No | 163 (94.8) | 9 (5.2) | 172 |
| Yes | 39 (88.6) | 5 (11.4) | 44 |
| Total | 202 (93.5) | 14 (6.5) | 216 |
| Intubation | | | |
| No | 63 (92.6) | 5 (7.4) | 68 |
| Yes | 139 (93.9) | 9 (6.1) | 148 |
| Total | 202 (93.5) | 14 (6.5) | 216 |
| Epinephrine | | | |
| No | 3 (50.0) | 3 (50.0) | 6 |
| Yes | 199 (94.8) | 11 (5.2) | 210 |
| Total | 202 (93.5) | 14 (6.5) | 216 |

**Table II.** Intervals during cardiopulmonary resuscitation

| Intervals (min) | Death | | Total |
|---|---|---|---|
| | Yes | No | |
| Initiation of CPR until first shock | | | |
| Mean (SD) | 10.6 (11.8) | 2.9 (1.8) | 10.0 (11.5) |
| Median (minimum-maximum) | 5.5 (0-55) | 3.0 (0-5) | 5.0 (0-55) |
| Total | 39 | 5 | 44 |
| Initiation of CPR until intubation | | | |
| Mean (SD) | 7.3 (7.9) | 3.33 (2.4) | 7.05 (7.7) |
| Median (minimum-maximum) | 5.0 (0-48) | 3.0 (0-8) | 4.0 (0-48) |
| Total | 126 | 9 | 135 |
| Initiation of CPR until first epinephrine | | | |
| Mean (SD) | 3.6 (5.9) | 1.0 (1.3) | 3.5 (5.7) |
| Median (minimum-maximum) | 1.0 (0-33) | 1.0 (0-5) | 1.0 (0-33) |
| Total | 195 | 12 | 207 |
| Initiation of CPR until end of CPR | | | |
| Mean (SD) | 20.1 (13.6) | 7.1 (4.1) | 19.2 (13.5) |
| Median (minimum-maximum) | 18.0 (2-76) | 6.5 (2-15) | 17.0 (2-76) |
| Total | 197 | 14 | 211 |

CPR, cardiopulmonary resuscitation; SD, standard deviation

performed by a layperson. Respiratory failure was the most common presumed immediate cause of CA (82, 30.8%), and pulseless electrical activity was the most frequent initial rhythm (138, 58.7%). Compressions and ventilations were performed in all cases (n=216), whereas 44 (20.3%) patients required defibrillation (all cases of ventricular fibrillation and ventricular tachycardia), 148 (68.5%) intubation and the others (137, 31.5%) were already intubated before the CA or CPR efforts were suspended before intubation and 210 (97.2%) received epinephrine.

The time intervals (min) during CA treatment *i.e*., initiation of CPR until first shock, initiation of CPR until intubation, initiation of CPR until first epinephrine administration and initiation of CPR until the end of CPR are shown in Table II.

In the cases of in-hospital CA, witnessed, CPR with compressions and ventilations were initiated immediately. The interval time between the CPR initiation until the first shock was 10.0 (median: 5; 0-55), the interval time between the CPR initiation until intubation was 7.0 (median: 4; 0-48), the interval time between CPR initiation until first epinephrine dose was 3.5 (median: 1, 0-33) and finally the interval time between the CPR initiation until CPR end was 19.2 (median: 17.0; 2-76).

Following admission into hospital, 216 (75.8%) were submitted to CPR; 103 (47.7%) died during the treatment, 25 (11.5%) maintained spontaneous circulation over a period ≤20 min, 53 (24.5%) over a period >20 min and ≤24 h and 35 (16.2%) over a period >24 h.

*Outcomes of CA treatment*: Of all patients treated, 269 (94.4%) died during hospitalization, 16 (5.6%) were discharged following treatment and 13 (4.5%) survived after six months and one year of follow up. Of the patients who died before the end of follow up (n=272), 85 (31.1%) died of infections, 56 (20.5%) of heart disease, 16 (5.8%) of neoplasms and 115 (42.2%) died of other causes. The most common other causes of death included respiratory failure (59, 51.3%), stroke (20, 17.4%), hypovolemic shock (15, 13.0%), pulmonary thromboembolism (8, 7.0%), multiple organ failure (6, 5.2%), acute abdomen (2, 1.7%), liver failure (2, 1.7%), metabolic acidosis, kidney failure and acute pancreatitis in one each (1, 0.9%).

*Prognosis of death from CA*: In the 285 patients evaluated, pre-CA CPC, presumed immediate cause of CA, initial CA rhythm and the use of epinephrine during treatment were identified as prognostic factors for mortality (Table III). Patients with a pre-CA CPC

**Table III.** Prognostic factors for patient mortality

| Prognostic factors | Death | | Total | *P* |
|---|---|---|---|---|
| | Yes, n (%) | No, n (%) | | |
| Pre-cardiac arrest cerebral performance category | | | | |
| 1 | 66 (89.2) | 8 (10.8) | 74 | 0.010† |
| 2 | 134 (95.7) | 6 (4.3) | 140 | |
| 3 | 61 (100) | 0 | 61 | |
| 4 and 5 | 5 (100) | 0 | 5 | |
| Total | 266 (95.0) | 14 (5.0) | 280 | |
| Immediate cause of the event | | | | |
| Lethal arrhythmia | 10 (83.3) | 2 (16.7) | 12 | 0.004† |
| Hypotension | 49 (94.2) | 3 (5.8) | 52 | |
| Respiratory failure | 80 (97.6) | 2 (2.4) | 82 | |
| Metabolic disorder | 49 (100) | 0 | 49 | |
| Ischaemia or acute myocardial infarction | 42 (85.7) | 7 (14.3) | 49 | |
| Other | 22 (100) | 0 | 22 | |
| Total | 252 (94.7) | 14 (5.3) | 266 | |
| Initial rhythm of the event | | | | |
| Ventricular fibrillation | 11 (68.8) | 5 (31.3) | 16 | <0.001† |
| Ventricular tachycardia | 5 (100) | 0 | 5 | |
| Asystole | 76 (100) | 0 | 76 | |
| Pulseless electrical activity | 130 (94.2) | 8 (5.8) | 138 | |
| Total | 222 (94.5) | 13 (5.5) | 235 | |
| Epinephrine | | | | |
| No | 3 (50.0) | 3 (50.0) | 6 | 0.003† |
| Yes | 199 (94.8) | 11 (5.2) | 210 | |
| Total | 202 (93.5) | 14 (6.5) | 216 | |
| Intervals (minutes) | | | | |
| Initiation of CPR until first epinephrine | | | | |
| Mean (SD) | 3.6 (5.9) | 1.0 (1.3) | 3.5 (5.7) | 0.040ǂ |
| Median (minimum-maximum) | 1.0 (0-33) | 1.0 (0-5) | 1.0 (0-33) | |
| Total | 195 | 12 | 207 | |
| Initiation of CPR until end of CPR | | | | |
| Mean (SD) | 20.1 (13.6) | 7.1 (4.1) | 19.2 (13.5) | <0.001ǂ |
| Median (minimum-maximum) | 18.0 (2-76) | 6.5 (2-15) | 17.0 (2-76) | |
| Total | 197 | 14 | 211 | |

CPR, cardiopulmonary resuscitation; †Chi-square test and Fisher's exact; ǂANOVA and Mann-Whitney test; SD, standard deviation

3, 4 or 5 (66, 23.5%) had a 100 per cent mortality rate, whereas this percentage dropped to 89.0 per cent for patients with a CPC 1 (74, 26.4%) (*P*=0.010). Patients with a pre-CA CPC 2 had a 96 per cent mortality rate.

Those patients with metabolic disorders (49, 18.4%) had a mortality rate of 100 per cent, whereas patients with ischaemia or an acute myocardial infarction (49, 18.4%) and lethal arrhythmias (12, 4.5%) had a mortality rate of <90 per cent. Patients with asystole (76, 32.3%) had a mortality rate of 100 per cent, whereas patients with ventricular fibrillation (16, 6.8%) exhibited a mortality rate of 69 per cent. Those patients who received epinephrine during CPR (210, 97.2%) had a higher mortality rate than patients who did not receive it (6, 2.7%). There was an increased

**Table IV.** Logistic regression analysis of variables related to mortality

| Variables | Estimate | OR (95% CI) | *P* |
|---|---|---|---|
| Simple logistic regression | | | |
| Pre-cardiac arrest cerebral performance category* | | | |
| CPC†2 | 1.2 | 3.3 (1.0-10.5) | 0.030 |
| CPC 3 | 19.4 | 16.1 (0.9-290.5) | 0.990 |
| CPC 4 and 5 | 19.4 | 0.9 (0.04-20.7) | 0.990 |
| Initial rhythm‡ | | | |
| VT | 20.4 | 5.2 (0.2-113.1) | 0.990 |
| Asystole | 20.4 | 317.5 (0.6-171, 266.9) | 0.990 |
| PEA | 1.9 | 6.8 (1.9-24.4) | 0.003 |
| Multiple logistic regression | | | |
| Initial rhythm‡ | | | |
| VT | 20.4 | 5.2 (0.2-113.1) | 0.990 |
| Asystole | 20.4 | 317.5 (0.6-171, 266.9) | 0.990 |
| PEA | 1.9 | 6.8 (1.9-24.4) | 0.003 |

*Reference category, cerebral performance category Glasgow-Pittsburgh 1; †CPC, cerebral performance category Glasgow-Pittsburgh; ‡Reference category, ventricular fibrillation; VT, ventricular tachycardia; PEA, pulseless electrical activity; OR, odds ratio; CI, confidence interval

chance of death as the interval between the initiation of CPR and the administration of the first dose of epinephrine increased and also as the interval between the initiation and end of CPR increased.

*Prediction of death in CA*: Following the simple logistic regression analysis, the variables that showed some influence on mortality were the pre-CA CPC and the initial CA rhythm. In patients with a pre-CA CPC 2, the odds of death were 3.3 times higher (*P*=0.030) than in those with a pre-CA CPC 1. For patients with pulseless electrical activity as their initial CA rhythm, the odds of death were 6.8 times higher (*P*=0.003) than those patients with ventricular fibrillation. Following the multiple logistic regression analysis, the variable that best explained mortality was the initial CA rhythm. In patients with pulseless electrical activity, the odds of death were 6.8 times higher than in those with ventricular fibrillation [OR: 6.8, 95% confidence interval (CI): 1.9 to 24, *P*=0.003] (Table IV).

## Discussion

CA is a major public health problem. Survival after a CA is low, and it is a leading cause of death in the United States and Europe[15,16]. In this study, a 95.4 per cent mortality rate was observed after CA, and the following variables significantly influenced the mortality rate: pre-CA CPC, presumed immediate cause and initial CA rhythm; use of epinephrine during CPR, interval between the initiation of CPR and administration of the first dose of epinephrine and the duration of CPR. Patients with a pre-CA CPC 2 had a higher mortality rate compared to patients with a pre-CA CPC 1. Our results were in accordance with the literature which showed that regardless of individual characteristics, patients with lower CPC values were more likely to survive than those with higher CPC values[17,18].

Patients with metabolic changes exhibited higher odds of death (100%) compared to those with ischaemia or acute myocardial infarction and lethal arrhythmias (90%). Of these metabolic changes, potassium disorders are the most common causes of CA. Epidemiological studies have provided descriptive data on the metabolic causes of CA, but there has been no detectable association between these changes and patient mortality[19,20].

In this study, the variable that was most associated with mortality was the initial CA rhythm. The mortality rate was 6.8 times higher in patients with an initial CA rhythm of pulseless electrical activity compared to those with ventricular fibrillation. In previous studies, ventricular fibrillation has been identified as the initial CA rhythm most likely to result in the return of spontaneous circulation[21-23].

A study conducted with eighty patients showed return of spontaneous circulation following in-hospital

CA in 55 (69%) cases, with a survival rate to hospital discharge of 33 per cent. Moreover, the mortality rate was lower in patients who had ventricular fibrillation and ventricular tachycardia as the initial CA rhythm in comparison with those presenting with asystole and pulseless electrical activity[24]. Our findings were consistent with the literature, as an initial CA rhythm of ventricular fibrillation appeared to be the best prognostic factor for CA patients[25,26].

The mortality rate was significantly higher in patients who received epinephrine during CPR. A randomized clinical trial aimed at determining the effect of epinephrine on survival to hospital discharge among out-of-hospital CA patients showed that patients who received epinephrine were more likely to achieve return of spontaneous circulation than the placebo group; however, when survival to hospital discharge was compared between the two groups, there was no significant difference[27]. Although the use of epinephrine during CPR did not significantly improve survival to discharge and might be associated with higher mortality rates, current CA guidelines recommend its use during CPR to improve coronary blood flow, thus facilitating return of spontaneous circulation[12].

The mortality rate was higher in those patients where the interval between the initiation of CPR and the first dose of epinephrine was higher. This result may be related to the potential of this drug to facilitate the return of spontaneous circulation, and a delay in its administration can mean a prolonged tissue hypoxia and increased chances of death and persistent heart damage[27].

As the duration of CPR decreases, there is an increased likelihood of survival[28,29]. In the present study, the median duration of CPR was 17.0 min, and patients with a longer CPR duration had a higher mortality rate. Some literature data corroborate the findings of this study, as prolonged CPR increases the length of tissue hypoxia and risk of death[12,29].

The positive aspects of this study were the sample size and the fact that the study was conducted in a reference hospital. Moreover, this was a longitudinal study with a one year follow up period and no loss to follow up. The main limitations were the lack of data regarding pre-hospital care of CA and the lack of an institutional protocol for post-CA care.

In conclusion, our results showed that the mortality rate among CA patients was extremely high. The variables associated with mortality included the pre-CA CPC, the presumed immediate cause and initial CA rhythm, the use of epinephrine during CPR, the interval between the initiation of CPR and administration of the first dose of epinephrine and the duration of CPR. However, the initial CA rhythm was the variable best explained the occurrence of death in this population.

***Conflicts of Interest*:** None.

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