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Clinical outcomes of witnessed and monitored cases of in-hospital cardiac arrest in the general ward of a university hospital in Korea

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Abstract

Background: To investigate the clinical outcomes of witnessed and/or monitored cases of in-hospital cardiac arrest (IHCA) that occurred on the general ward of a university hospital in Korea.

Methods: We prospectively gathered data on all IHCA events that occurred on the general ward of the Asan Medical Center (Seoul, South Korea) and were recorded by medical emergency team records between March 2008 and February 2010. The main outcomes included survival to hospital discharge, incidence of IHCA, and prognostic factors related to hospital mortality. In addition, we also investigated preventable cases.

Results: In total, 238 index cases of IHCA were identified. The average estimated incidence of IHCA was 0.145 events per 1000 patient admissions. Survival to hospital discharge was 19% (46 cases). Of these IHCA cases, 66% were due to non-cardiac causes, and 77% were due to medical illnesses. Besides the most common first documented rhythm was pulseless electrical activity (38%). Two hundred and three cases (85.3%) of IHCA were witnessed at the event; 135 cases (56.7%) were monitored at the event. Non-witnessed cases, monitored cases, night onset, medical illness, metastatic cancer, intubation, and long duration of cardiopulmonary resuscitation were significantly associated with hospital mortality according to logistic regression model. We identified 91 preventable cases (38%) in this study. Respiratory insufficiency (37 cases; 41%) was one of major causes of preventable cases.

Conclusions: Witnessed cases of IHCA that occur on the general ward demonstrate a higher rate of survival to hospital discharge; however, monitored cases demonstrate a lower rate of survival to hospital discharge. Respiratory insufficiency was a major preventable cause leading to cardiac arrest. In consideration of the preventable cases of

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IHCA, further studies should be performed on the monitoring practices that are implemented on general wards.

Keywords: In-hospital cardiac arrest; general ward; hospital mortality; monitoring; witnessed.

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Background

The majority of cases of in-hospital cardiac arrest (IHCA) are cardiac in origin, similar to out-of-hospital cardiac arrest (OHCA).[1,2] Many studies have reported survival to discharge rates of 15–20% for IHCA, which are much lower than the rates for OHCA.[1,3–7] A few studies report higher survival-to-discharge rates of up to 45% by the medical emergency team (MET) activities.[8–10] In addition, the incidence of IHCA has been reported as 1–4 arrests per 1000 patient admissions.[4,11,12] However, there are few studies on the epidemiologic characteristics and clinical outcomes of IHCA cases that occur on the general ward. Also, the response to IHCA on the general ward is expected to be less efficient than in the intensive care unit (ICU) because of delayed diagnosis, poor monitoring, and the lack of equipment and well-trained staffs.[3,12–14]

A recently published paper by Brady et al. report that patients who are witnessed and/or monitored at the time of cardiac arrest demonstrate a significantly higher rate of survival to hospital discharge compared with patients who are neither monitored nor witnessed.[15] However, we hypothesized that survival to hospital discharge after IHCA would be significantly different for patients on general wards than those in ICUs. Hence, we investigated the clinical outcomes of IHCA cases that occurred on the general ward of a university hospital and were either witnessed and/or monitored. In addition, we further investigated cases that could have been prevented in this setting. We believe this study provides valuable information regarding monitoring strategies that could be used to reduce the occurrence of IHCA on the general ward.

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Methods

In March 2008, we structured the MET system at Asan Medical Center to include crisis conditions and IHCA cases that occurred on the general ward. All MET members screened for abnormal signs in all in-patients according to the MET screening criteria. The screening criteria for MET activation are shown in Supplementary Table and were modified from the Medical Emergency Response Improvement Team (MERIT) study criteria.[16] We prospectively gathered data on all IHCA events that occurred on the general ward of Asan Medical Center between March 2008 and February 2010 and were recorded by the MET activity records. IHCA events were recorded in the electronic medical records according to the Utstein template reporting guidelines for IHCA.[17] Also, IHCA events were detail described according to the 2007 operating definitions by the American Heart Association (Supplementary file). All data were documented by the MET regular nurses. This study was approved by the ethics committee of Asan Medical Center, which waived the requirement for written informed consent because it is a prospective observational study.

Hospital

Asan Medical Center is affiliated with the University of Ulsan, the tertiary referral hospital of Seoul, and its in-patient sites admit a wide range of adult medical and surgical patients. In 2008, a total of 2406 beds were available for approximately 774,000 admissions, 2200 in-patients per day, and 5600 highly difficult surgical procedures were performed. In 2009, approximately 2740 beds were available for approximately 871,000 admissions per year, 2400 in-patients per day, and 5700 highly difficult surgical procedures were performed.

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Data collection

All patients aged 18 years or older who experienced a cardiac arrest on the general ward and required cardiopulmonary resuscitation (CPR) or defibrillation were included in this analysis. Only index cases were included. An index case was defined as the first cardiac arrest of a patient who experienced more than one cardiac arrest during the same hospitalization. Exclusion criteria included all cardiac arrests for which resuscitation was initiated outside of the hospital prior to arrival at the emergency department and events that involved defibrillation, ventricular fibrillation, or pulseless ventricular tachycardia and were treated using only an implantable cardioverter-defibrillator. We also excluded all cardiac arrests that occurred in any critical care area (e.g., the ICU, operating rooms, emergency department).

We reviewed the electronic medical records (EMR) of the 238 identified cases in order to extract relevant information regarding IHCA (i.e., immediate causes associated with the event and preventable cases). In our study, a preventable case was defined as a missed predictable events plus potentially avoidable events. Missed predictable events were defined as a missed objective or clear evidence of patient deterioration within the 8 hours before cardiac arrest. Potentially avoidable events included the following: 1) failure to adhere to established hospital patient care policy; 2) delay dealing with patient needs, including at least 20 minutes delay in activating MET; 3) inadequate monitoring or surveillance; 4) procedural or surgical complications that were coincident with IHCA; and 5) do not attempt resuscitation (DNAR) issues.[18]

Statistical analysis

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Data are expressed as the means ± standard deviations (SDs), and non-normally distributed data are expressed as the median and interquartile range (IQR). Nominal variables were compared using the Chi-square test or Fisher exact test, and the mean values of the two groups were compared using the student *t* test. Non-normally distributed continuous variables were compared using the Mann-Whitney U test. We used multivariate logistic regression modeling to determine the prognostic factors that were associated with hospital mortality after adjusting for confounders. Backward elimination was performed using the likelihood ratio method. Model adequacy was assessed using the Hosmer-Lemeshow goodness-of-fit test. Data are presented as the odds ratios (ORs) with 95% confidence intervals (CIs). Significance was defined as a 2-sided p value < 0.05. SPSS 17.0 statistical software package (SPSS Inc., Chicago, IL) was used to perform all statistical analyses.

Results

In total, 238 index cases of IHCA were identified between March 2008 and February 2010. The average estimated incidence of IHCA was 0.145 events per 1000 patient admissions.

Of these identified IHCA cases, 66% were due to non-cardiac causes and 77% were due to medical illnesses. The mean age of these patients was 61.3 ± 15.2 years, and 60% were male. The most common underlying disease was malignancy (114 cases; 48%). Pulseless electrical activity (PEA) was the most common first documented rhythm (38%). Two hundred and three cases (85.3%) of IHCA were witnessed events, among them 128 cases (63.1%) were monitored. All monitored cases at events were 135

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cases (56.7%). The median arrival of the MET time was 1 (0.5–2) minute. The median duration of CPR was 14 (5–32) minutes. One hundred and fifty-one cases (63%) achieved return of spontaneous circulation (ROSC). The median time of ROSC was 12 (5–21) minutes. Survival to hospital discharge was 19% (46 cases). DNAR status prior to the event was only identified in 11 cases (4.6%).

We compared witnessed and non-witnessed cases of IHCA. Witnessed cases occurred more frequently during the daytime (153 cases; 75.4%) than non-witnessed cases. Taking into account preexisting conditions, the witnessed cases were more significantly associated with respiratory insufficiency (56 cases; 27.6%) than the non-witnessed cases (2 cases; 5.6%). The witnessed cases required significantly more frequent oxygen supplementation (130 cases; 64%), electrocardiographic monitoring (121 cases; 59.9%), and invasive airway interventions (36 cases; 17.7%) than the non-witnessed cases (oxygen supplementation: 16 cases, 45.7%; ECG monitoring: 5 cases, 14.3%; and invasive airway interventions: 1 case, 2.9%) before the IHCA event.

The baseline characteristics of the IHCA incidents are shown in Table 1. The witnessed cases demonstrated PEA as the first documented rhythm, and the non-witnessed group demonstrated asystole as the first documented rhythm. The witnessed group consisted of significantly more monitored cases (128 cases; 63.1%) than the non-witnessed group (7 cases; 20%).

The IHCA characteristics are detailed in Table 2 which also shows the immediate causes related to IHCA. Of these immediate causes, 158 (66%) are defined as non-cardiac causes. The most common non-cardiac cause was acute respiratory insufficiency (40 cases; 16.7%). The most common cardiac cause was pulseless ventricular tachycardia/fibrillation (VT/VF) (29 cases; 12.2%). The witnessed group

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consisted of significantly more patients who achieved ROSC (134 cases; 66%) and demonstrated a significantly higher rate of survival to hospital discharge (44 cases; 21.7%) than the non-witnessed group (achieved ROSC: 17 cases, 48.6%; and survival to hospital discharge: 2 cases, 5.7%).

The clinical outcomes of IHCA are detailed in Table 3. The monitored cases did not show a benefit in terms of survival to hospital discharge. These cases are detailed in the Supplementary Tables.

Using multivariate logistic regression model, we identified five significant independent variables that are associated with ROSC: surgical illness, non-metastatic cancer as a preexisting condition, VT/VF as initially recorded rhythm, intubation, and short duration of CPR (Table 4). We also identified seven significant independent factors that are associated with hospital mortality: night onset, medical illness, metastatic cancer as a preexisting condition, non-witnessed case, monitored case, intubation, and long duration of CPR (Table 5).

We identified 91 (38%) preventable cases in this study. Of these preventable cases, missed predictable events were 24 (26%) and potentially avoidable events were 67 (74%). The characteristics of the preventable IHCA cases are detailed in Table 6. Respiratory insufficiency (37 cases; 41%), metastatic cancer (33 cases; 36%), metabolic/electrolyte abnormalities (24 cases; 26%), and acute mental changes (19, 21%) represent the majority of these preventable cases. In contrast, congestive heart failure (1 case; 1%) and arrhythmia (7 cases; 8%) represent the minority of the preventable cases. Preventable cases of IHCA according to preexisting conditions are detailed in the Supplementary Tables.

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Discussion

Although the monitored cases identified in this study did not demonstrate any improvement in survival to hospital discharge compared with the results presented previously by Brady et al.,[15] the witnessed events demonstrated a higher rate of achieving ROSC and a higher rate of survival to hospital discharge. Also, witnessed event was a significant prognostic factor associated with hospital mortality according to the multivariate logistic regression model. In this study, non-cardiac causes resulted in the majority of the IHCA cases that occurred on the general ward of our hospital. Also, the majority of the preventable cases were the result of respiratory insufficiency or metastatic cancer. Considering all of these results, additional monitoring for respiratory insufficiency could reduce the occurrence of IHCA on the general ward, so further studies need to be performed on this issue.

Our data demonstrate a high proportion (85.3%) of witnessed cases in comparison with previous studies (61–77%; 48.6%), excluding IHCA that occurred in critical care areas.[19,20] Witnessed cases typically demonstrate a good prognosis in term of mortality.[15,21] Although previous studies about the National Registry of Cardiopulmonary Resuscitation (NRCPR) included IHCA cases that occurred in the ICU, their results are consistent with the results of our study under the relatively higher proportion of witnessed cases.[15,21] There is also indirect evidence that the higher proportion of witnessed cases that occur on the general ward may be due to the MET screening system through the EMR in our hospital.

Recently, Brady et al. reported that monitored and/or witnessed cases of cardiac arrest demonstrate a significantly higher rate of survival to discharge compared with

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patients who were neither monitored nor witnessed.[15] Also, their study reported that cardiac monitoring conferred no additional benefits over the direct observation of patients suffering IHCA. In contrast, our present results demonstrate that monitored case is paradoxically associated with increased hospital mortality. In our study, monitored cases present with significantly more non-cardiac preexisting conditions (e.g., respiratory insufficiency, hypotension, hepatic insufficiency, metabolic abnormality) and interventions before the event (e.g., vascular access, oxygen supplementation, invasive airway management, the administration of intravenous opioids, mechanical ventilation) than non-monitored cases. These findings suggest that monitored cases could be more severe than non-monitored cases, although we did not measure severity score in this study.

Evidence of deterioration within the 8 hours prior to arrest has been reported in up to 84% of cases. The most common findings include respiratory problems, deterioration of mental status, and hemodynamic instability.[22–25] In our current study, the preexisting conditions of IHCA were found to be similar to previously reported above studies except metastatic cancer. Neither a previously reported study nor this study has reported any benefits of cardiac monitoring on mortality.[15] We believe that the early application of monitoring systems, especially those that identify respiratory insufficiency in high-risk patients currently admitted on the general ward, may reduce the incidence of cardiac arrest on the general ward.

In cases of metastatic cancer, most patients presented with DNAR issues and highly significant preventable cases. This explains why metastatic cancer is one of the most common causes of preventable events. Until recently, there were few guidelines on advanced medical directives, including DNAR directives, in South Korea. In the future,

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formal guidelines should be drafted in consensus meetings.

We find that the survival to hospital discharge rate can demonstrate large variations depending on the center and the inclusion of critical care areas.[1,3–7,19,20,26] Based on our current findings, the majority of causes of IHCA that occur on the general ward are non-cardiac. There are several possible explanations for differences in the survival to hospital discharge rate that follow the occurrence of IHCA on the general ward. First, these differences may be due to racial or national characteristics. Merchant et al. reported that hospitals with higher proportions of black patients demonstrate higher rates of case-mix adjusted IHCA,[27] and Chan et al. reported that black patients who present with IHCA are significantly less likely to survive to discharge than white patients.[28] Second, this may be partly due to the quality of care provided by the hospital. Skrifvars et al. reported that a locally implemented, strong, in-hospital chain of survival is probably the only way to improve clinical outcomes following IHCA.[29] MET implementation may have allowed better survival to hospital discharge rate in our hospital. In addition, the differences in the survival to hospital discharge rate between this study and the study by Chakravarthy et al.[26] could be attributed to the higher proportion of non-cardiac causes and non-cardiac preexisting conditions that presented in our data. Third, Neiman et al. indicated that DNAR decisions affect the survival rate: when they excluded DNAR patients from their study, a 15% increase in the survival to hospital discharge rate was noted.[30] Despite the very low proportion of DNAR patients in this study, we are still able to demonstrate a relatively good survival to hospital discharge rate maybe because of MET.

PEA was the most common first documented rhythm in this study, followed by unknown, asystole and VT/VF. This low proportion of VT/VF is similar to studies

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performed in critical care areas.[19,26] Hypoxia and hypotension as the precipitating causes of IHCA, which are more likely to induce PEA or asystole than VT/VF.[1,22] High proportion of non-cardiac causes in this study supported the results of previous studies. Another possible explanation for the low proportion of VT/VF is the relatively smaller amount of monitoring that was performed in our current study relative to the NRCPR study because we only included the general ward and excluded critical care areas.[1]

There are notable limitations to our current study. First, we did not measure CPR quality according to advanced cardiac life support guidelines provided by the American Heart Association.[31] However, according to the high rates of ROSC and survival and the relatively short amount of time spent performing CPR, we believe that the quality of CPR we observed in this study was quite good. Second, we did not measure the Cerebral Performance Category score[32] and therefore could not assess functional outcomes following IHCA.

Conclusions

We have determined that witnessed IHCA cases that occur on the general ward demonstrate a significantly higher rate of survival to hospital discharge whereas monitored cases demonstrated lower rates of survival to hospital discharge. Non-cardiac causes resulted in the majority of the IHCA cases that presented on the general ward in this study. The most common preventable cause of IHCA was respiratory insufficiency. After considering these results, we believe that monitoring for respiratory insufficiency could reduce the occurrence of IHCA on the general ward, but further studies should be done on this issue. In addition, the role of advanced medical directives in hospital policy,

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including DNAR directives, should be further discussed and clarified.

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Table 1 Comparison of the baseline characteristics of witnessed and non-witnessed cases of in-hospital cardiac arrest

	Witnessed (n = 203)	Non-witnessed (n = 35)	Total (n = 238)	*p*
Age, y	61.9 ± 15.1	57.4 ± 15.7	61.3 ± 15.2	0.117
Sex, male	120 (59.1)	22 (62.9)	142 (59.7)	0.677
Onset of event, daytime (7AM–11PM)	153 (75.4)	17 (48.6)	170 (71.4)	0.001
Illness category				
Medical illness	156 (76.8)	27 (77.1)	183 (76.9)	0.969
Preexisting conditions				
Malignancy	101 (49.8)	16 (45.7)	117 (49.2)	0.659
Metastasis	48 (23.6)	9 (25.7)	57 (23.9)	0.791
ACS prior	26 (12.8)	8 (22.9)	34 (14.3)	0.117
ACS present	9 (4.4)	3 (8.6)	12 (5)	0.392
Arrhythmia	29 (14.3)	5 (14.3)	34 (14.3)	1.000
Non-stroke	30 (14.8)	1 (2.9)	31 (13)	0.058
Stroke	7 (3.4)	1 (2.9)	8 (3.4)	1.000
CHF prior	18 (8.9)	5 (14.3)	23 (9.7)	0.350
CHF present	18 (8.9)	4 (11.4)	22 (9.2)	0.542
Hypotension	45 (22.2)	3 (8.6)	48 (20.2)	0.064
Vasopressor	29 (14.3)	3 (8.6)	32 (13.4)	0.590
Hypertension	80 (39.4)	18 (51.4)	98 (41.2)	0.182
DM	63 (31)	14 (40)	77 (32.4)	0.295
Hepatic insufficiency	37 (18.2)	2 (5.7)	39 (16.4)	0.065

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Pneumonia	22 (10.8)	4 (11.4)	26 (10.9)	1.000
Respiratory insufficiency	56 (27.6)	2 (5.7)	58 (24.4)	0.005
Septicemia	17 (8.4)	2 (5.7)	19 (8)	1.000
Renal insufficiency	60 (29.6)	7 (20)	67 (28.2)	0.246
Metabolic abnormality	31 (15.3)	2 (5.7)	33 (13.9)	0.185
HIV infection	0 (0)	1 (2.9)	1 (0.4)	0.147
Interventions in place before the event				
Vascular access	183 (90.1)	33 (94.3)	216 (90.8)	0.751
Oxygen supplementation	130 (64)	16 (45.7)	146 (61.3)	0.040
ECG monitoring	121 (59.9)	5 (14.3)	126 (53.2)	< 0.001
Pulse oximetry	2 (1)	0 (0)	2 (0.8)	1.000
IV vasoactive agent	33 (16.3)	6 (17.1)	39 (16.4)	0.896
Invasive airway*	36 (17.7)	1 (2.9)	37 (15.5)	0.025
IV opioid agents	33 (16.3)	3 (8.6)	36 (15.1)	0.241
Mechanical ventilation	15 (7.4)	0 (0)	15 (6.3)	0.136
Intraarterial catheter	9 (4.4)	0 (0)	9 (3.8)	0.363
Chest tube	5 (2.5)	0 (0)	5 (2.1)	1.000
IV antiarrhythmic agent	4 (2)	0 (0)	4 (1.7)	1.000
PCA	1 (0.5)	2 (5.7)	3 (1.3)	0.057
Pacemaker, internal	2 (1)	0 (0)	2 (0.8)	1.000
ICD	2 (1)	0 (0)	2 (0.8)	1.000

Data are presented as n (%).

ACS, acute coronary syndrome; CHF, congestive heart failure; CVA, cerebrovascular accidents; DM, diabetes mellitus; ECG, electrocardiography; HIV, human

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immunodeficiency virus; ICD, implantable cardioverter-defibrillator; IV, intravenous; PCA, patient-controlled analgesia.

*Invasive airway: a tracheostomy was performed on 12 patients and an endotracheal intubation on 25 patients.

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Table 2 Comparison of the characteristics of witnessed and non-witnessed cases of in-hospital cardiac arrest

	Witnessed (n = 203)	Non-witnessed (n = 35)	Total (n = 238)	*p*
First documented rhythm				0.001
Pulseless VT/VF	31 (15.3)	3 (8.6)	34 (14.3)	
PEA	85 (41.9)	6 (17.1)	91 (38.2)	
Asystole	35 (17.2)	15 (42.9)	50 (21)	
Unknown	52 (25.6)	11 (31.4)	63 (26.5)	
Discovery status of event				
Monitored	128 (63.1)	7 (20)	135 (56.7)	< 0.001
ECG monitoring only	8	3	11	
Pulse oximetery only	32	3	35	
Both monitoring	88	1	89	
Immediate cause of the event				0.927
Cardiac	68 (33.5)	12 (34.3)	80 (33.6)	
Pulseless VT/VF	27 (13.3)	2 (5.7)	29 (12.2)	
Acute coronary syndrome	10 (4.9)	4 (11.4)	14 (5.9)	
Acute pulmonary edema	10 (4.9)	4 (11.4)	14 (5.9)	
Acute pulmonary embolism	8 (3.9)	1 (2.9)	9 (3.8)	
Other*	12 (5.9)	0 (0)	12 (5)	
Unknown	1 (0.5)	1 (2.9)	2 (0.8)	
Noncardiac	135 (66.5)	23 (65.7)	158 (66.4)	
Cerebrovascular	4 (2)	2 (5.7)	6 (2.5)	
Asphyxia/Airway problem	29 (14.3)	8 (22.9)	37 (15.5)	
Hypovolemic shock	32 (15.8)	3 (8.6)	35 (14.7)	
Septic shock	25 (12.3)	2 (5.7)	27 (11.3)	
Acute respiratory insufficiency	34 (16.7)	7 (20)	41 (17.2)	
Anaphylaxis	9 (4.4)	0 (0)	9 (3.8)	
Other†	2 (1)	1 (2.9)	3 (1.3)	
Arrived time of MET, min	1 (0.5–2)	1 (0.5–2)	1 (0.5–2)	0.485
Duration of CPR, min	12 (5–30)	20 (10–38)	14 (5–32)	0.096

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Duration of CPR, min				0.201
0–15	112 (55.2)	14 (40)	126 (52.9)	
15–35	50 (24.6)	10 (28.6)	60 (25.2)	
> 35	41 (20.2)	11 (31.4)	52 (21.8)	
ROSC, min	11 (5–20)	16 (6.25–27.5)	12 (5–21)	0.188

Data are presented as n (%).

[*]Other causes: aortic dissection in 3 patients, ruptured aneurysm in 2 patients, air embolism in 2 patients, other type of arrhythmia in 2 patients, casues related to the procedure in 1 patient, and progression to aortic stenosis in 1 patient.

[†]Other causes: metabolic acidosis in 2 patients and hypoglycemia in 1 patient.

CPR, cardiopulmonary resuscitation; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation; and VT/VF, ventricular tachycardia/ventricular fibrillation.

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Table 3 Comparison of the clinical outcomes of witnessed and non-witnessed cases of in-hospital cardiac arrest

	Witnessed (n = 203)	Non-witnessed (n = 35)	Total (n = 238)	*p*
ROSC achieved	134 (66)	17 (48.6)	151 (63.4)	0.048
Survival to hospital discharge	44 (21.7)	2 (5.7)	46 (19.3)	0.027

Data are presented as n (%).

ROSC, return of spontaneous circulation.

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Table 4 Prognostic factors associated with the return of spontaneous circulation according to the multivariate logistic regression model

Variable	Odds ratio (95% confidence interval)	*p*
Medical illness	0.333 (0.118–0.934)	0.037
Preexisting metastatic cancer	0.189 (0.073–0.492)	0.001
Initial recorded rhythm, non-VT/VF	0.219 (0.049–0.979)	0.047
Intubation	3.888 (1.507–10.032)	0.005
Duration of CPR, min		< 0.001
0–15	1.0	
15–35	0.194 (0.076–0.495)	
> 35	0.009 (0.002–0.036)	

Variables included in the logistic regression model: time of onset, age, illness (medical/surgical), chronic liver disease as the underlying disease, preexisting malignancy, preexisting metastatic cancer, witnessed case, monitored case, initial recorded rhythm (VT/VF vs. non-VT/VF), defibrillation, intubation, vascular access, immediate cause (cardiac/non-cardiac), atropine use, and duration of CPR.

CPR, cardiopulmonary resuscitation; VT/VF, ventricular tachycardia/ventricular fibrillation.

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Table 5 Prognostic factors associated with hospital mortality according to the multivariate logistic regression model

Variable	Odds ratio (95% confidence interval)	*p*
Nighttime onset (11PM–7AM)	6.311 (1.449–27.473)	0.014
Medical illness	4.712 (1.753–12.668)	0.002
Preexisting metastatic cancer	7.424 (1.221–45.159)	0.003
Witnessed case	0.138 (0.021–0.909)	0.039
Monitored case	3.604 (1.301–9.988)	0.014
Intubation	2.769 (1.061–7.223)	0.037
Duration of CPR, min		0.007
0–15	1.0	
15–35	2.579 (0.765–8.698)	
> 35	13.01 (1.703–99.366)	

Variables included in the logistic regression model: time of onset, age, illness (medical/surgical), malignancy as underlying disease, chronic liver disease as underlying disease, chronic kidney disease as underlying disease, preexisting malignancy, preexisting metastatic cancer, witnessed case, monitored case, initial recorded rhythm (VT/VF vs. non-VT/VF), defibrillation, intubation, vascular access, vasoactive infusion, time of arrival of MET, immediate cause (cardiac/non-cardiac), preventable case, and duration of CPR.

CPR, cardiopulmonary resuscitation; MET, medical emergency team; VT/VF, ventricular tachycardia/ventricular fibrillation.

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Table 6 Characteristics of the preventable cases of in-hospital cardiac arrest identified in this study (n = 91).

Missed predictable event	24 (26)
Potentially avoidable event	67 (74)
Failure to adhere to established hospital patient care policy	5 (5)
Delay dealing with patient needs	6 (7)
Inadequate monitoring/surveillance	9 (10)
Procedure/surgical complication	2 (2)
DNAR issue	45 (50)

Data are presented as n (%)

DNAR, do not attempt resuscitation.