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Evaluation of the blue code system established in the health campus of a university hospital

Arzu Topeli^{1*}, Banu Cakir²

¹Department of Internal Medicine, Division of Intensive Care Medicine, Faculty of Medicine, Hacettepe University, ²Department of Public Health, Faculty of Medicine, Hacettepe University, Ankara, Turkey
*Corresponding author

Abstract:

OBJECTIVE: We report the hospital outcomes after implementing the blue code system in our hospital and health campus. We also aimed to determine factors related to mortality.

METHODS: This is a retrospective observational study of the patients who received cardiopulmonary resuscitation (CPR). All blue code calls for all age groups between March 15, 2013, and April 30, 2015 were analyzed. Logistic regression analysis was performed to find independent predictors of in-hospital mortality.

RESULTS: A total of 155 patients from the blue code calls were evaluated. Return of spontaneous circulation was achieved in 45.5% of patients, and 54.8% of the patients had died at the end of the CPR. The hospital discharge rate was 20%. Of all patients, 65% were adults with a survival rate of 7.9%, whereas pediatric patients had a 44.2% survival rate. Asystole and pulseless electrical activity were the predominant electrocardiography rhythms in 92.4% of patients. The comparison of survivors and nonsurvivors revealed that nonsurvivors were older, had more cancer as the comorbidity, had a more cardiac arrest, and sepsis as the underlying cause and had >20 min of CPR. The logistic regression analysis demonstrated the independent risk factors for mortality as arrest at a hospital ward, and sepsis as the underlying cause and being adult patient.

CONCLUSION: The performance of the blue code system should be evaluated periodically. Every effort should be made to prevent unexpected cardiac arrests and increase hospital discharge with good neurologic outcomes.

Keywords:

Cardiac arrest, cardiopulmonary resuscitation, medical emergency team, mortality, survival

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ORCID:

AT: 0000 0002 5874 9087
BC: 0000 0001 6645 6527

Address for correspondence:

Prof. Arzu Topeli,
Hacettepe University
Faculty of Medicine,
Medical Intensive Care
Unit, Ankara, Turkey.
E-mail: atopeli@
hacettepe.edu.tr

Introduction

Sudden cardiac arrest (SCA) is a devastating problem, reported to occur in about 60% of all deaths from cardiovascular diseases and affects 40–100 people per 100,000 population.^[1] Cardiopulmonary resuscitation (CPR) was established in 1960 to reverse arrest cases, and CPR techniques are updated frequently worldwide.^[2] Even

though applied efficiently, SCA patients' successful outcome has been reported to range from 17% to 32%.^[3,4] In an Australian study, where the survival rate was reported to be relatively higher, there was extensive use of automatic external defibrillators, a dedicated team was established with nurses' active involvement, and standardized CPR education was provided systematically and frequently.^[4]

A successful outcome of CPR is defined as discharge with full neurological wellbeing. Although spontaneous circulation returns

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Box-ED

What is already known on the study topic?

Sudden cardiac arrest (SCA) is a devastating problem with poor outcomes.

What is the conflict on the issue? Is it important for readers?

After establishing a blue code system, it is crucial to evaluate hospital outcomes and determine factors related to mortality for quality improvement purposes, which would help analyze, determine the failing components, and improve the process to increase patient safety.

How is this study structured?

This study was a single-center, retrospective cohort study.

What does this study tell us?

Overall, the hospital discharge rate was 20%.

Adult patients, arrest occurring in patients followed in hospital wards, and sepsis as the underlying cause of arrest were found to be independent risk factors for mortality.

in one-third of patients in out-of-hospital cardiac arrests, only 10% of patients could be discharged with full neurological recovery.^[5,6] There are many factors related to a poor outcome such as age, comorbidity, the first rhythm detected during the CPR, being a witnessed arrest, or CPR duration.^[4,7-9] Besides, the occurrence of SCA in out-of-working hours decreases survival.^[7,10,11] On the contrary, the presence of medical emergency teams (METs) decreases SCA occurrence and increases survival.^[12,13] Therefore, an in-hospital MET for SCA termed as “blue code” is very important to increase patients’ survival.

We report and evaluate the hospital outcomes after the implementation of the blue code system in our hospital and health campus with the study. We also aimed to determine factors related to mortality. This was a quality improvement project which would help to analyze, determine the failing components, and improve the process to increase patient safety.

Methods

Target population, place and time of the study

The study was performed in the Health Campus of a University Hospital, located on an area of approximately 200,000 m². This area includes the faculties of medicine, health sciences, administrative areas, and four hospitals. Blue code system was revised and improved to cover all health campus and four hospitals between December 27, 2011 and March 15, 2013, where the details of this process were reported in a published thesis.^[14] Mainly, there were six teams composed of physicians working in internal medicine (2 teams), cardiology, anesthesiology,

emergency medicine and pediatrics departments, nurses, and other health-care personnel, which worked 7 days a week, 24 h a day covering the whole campus. The codes were pursued through a pager system. All blue code calls in all age groups between March 15, 2013, and April 30, 2015 were analyzed. Due to its retrospective nature, informed consent was not taken, but local ethical committee approval was obtained on April 29, 2015 (GO 15/300-04).

Study design and variables

This retrospective observational study was performed to analyze patients who received CPR after the blue code call and determine the hospital survival rate for the same period. The variables recorded on standard CPR forms and retrieved from the charts were as follows: which included age, sex, comorbidities (cancer, neurological diseases such as cerebrovascular event or neuromuscular disease, chronic lung diseases such as chronic obstructive pulmonary disease or interstitial lung disease, diabetes mellitus, chronic heart diseases such as congestive heart failure, chronic rhythm disturbances, cardiovascular disease, the place of arrest, type of arrest (cardiac, respiratory), cause of arrest (sepsis, cardiac problems, respiratory failure), first electrocardiography rhythm (ventricular fibrillation [VF]/pulseless ventricular tachycardia [PVT], asystole/pulseless electrical activity [PEA]), access time to the scene, CPR duration, and hospital outcome (discharge, death).

Statistical analysis

Variables were summarized with counts (n), percentages (%), medians (interquartile range [IQR]: 25–75 percentile), odds ratios and 95% confidence intervals (CI). The comparison of survivors and nonsurvivors was performed using Chi-square, Fisher’s exact, and Mann–Whitney U tests where appropriate. For advanced analysis of the data, we conducted multivariate logistic regression modeling. In constructing the model, all factors associated with hospital mortality (i.e., the dependent variable) in binary analyses, at $P < 0.20$, were included in the full model. In modeling, we aimed to investigate significant predictors of hospital mortality, with no specified exposure variable.

Given that, there is no established effect modifier for hospital mortality in previous literature, and none was detected in our stratified analyses, we did not use any interaction term in the model. Enter method was used to create the final model. Age was the only continuous variable, with no outlier, and categorized in the analysis into two groups: adults (18 years and above) and children (<18 years old). The correlation matrix was checked for multicollinearity; all correlation coefficients were <0.40. The Hosmer–Lemeshow Goodness of Fit test was used

to assess the model's adequacy at predicting hospital mortality (Chi-square test = 7.818, d. f. = 8, $P = 0.451$). Nagelkerke R square test revealed that the model could explain 58.7% (Cox and Snell R square = 0.346) of the variation in the dependent variable. Regression coefficients and relevant 95% CI obtained from the final multivariate regression model are provided.

The Statistical Package for the Social Sciences (SPSS) version 22 was used for statistical analysis (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). The accepted type 1 error in this study was 5%.

Results

During the study period (25 months, 15 days), 1395 calls were detected through the hospital pager system. Out of all calls, 205 (14.7%) were test calls, 9 (0.6%) were practice applications by the hospital administration, and 777 (55.7%) were unjustified calls for curiosity, self-need of help, or performed by mistake by the health-care personnel. In 166 (11.9%) calls, there were no CPR forms, and hence, they could not be evaluated, and 82 (5.9%) calls were for patients without arrest. In one case, the hospital outcome was missing. Therefore, the final study population was 155 (11.1%) patients.

The access duration to the scene was recorded in 89 forms, and the median access duration was 1.0 min (IQR: 1.0–2.5). Return of spontaneous circulation (ROSC) was achieved in 71 patients (45.5%), 70 patients (45.2%) survived the CPR, and 31 patients (20%) survived to hospital discharge. All patients with a CPR duration of >38 min were lost. The survival rates of adult ($n = 103$, 66.5%) and pediatric patients ($n = 52$, 33.5%) were 7.8% and 44.2%, respectively. Comparison of survivor and nonsurvivors is shown in Table 1.

As shown in Table 2, adult patients (as compared to pediatric), arrest occurring in patients followed in hospital wards (as compared to other areas), and sepsis as the underlying cause of arrest (as compared to cardiac causes and respiratory failure) were found to be independent risk factors for mortality when the model is adjusted for gender (male vs. female), underlying neurological disease (yes vs. no), underlying malignancy (yes vs. no), type of arrest (respiratory vs. cardiac), and CPR duration (>20 min vs. less).

Discussion

In about 2 years, blue code system implementation in a large health-care campus resulted in an in-hospital survival of 20% in all age groups. Adults comprised two-thirds of the study population with a survival rate

of 7.8%, whereas pediatric patients had a 44.2% survival. Although, adults; patients with cancer, cardiac arrest, sepsis as the underlying cause of arrest and patients receiving CPR >20 min had higher hospital mortality; adults, patients hospitalized in wards and patients with sepsis as the underlying cause of arrest were the only independent predictors of mortality in the multivariate analysis.

Our hospital survival is similar to the survival rate reported by Cooper and Jade,^[3] who also included the pediatric age group. However, our survival rate in the adult population is about 8%, which is lower than that reported by Cohn *et al.*,^[4] who included only adult patients with a hospital survival of 21%. In their patient population, 17% had sepsis, 13% had cancer, 81% had asystole/PEA, whereas, in our study, 47% had sepsis, 41% had cancer, and 92.4% had asystole/PEA, which has a poorer prognosis. Therefore, our patient population comprised of very severely ill patients.

In this study, pediatric patients' survival is higher than that reported in a Turkish study, which was 24%, including in-hospital and out-of-hospital arrests.^[15]

Studies about blue code are mainly from developed countries where patient safety and health-care quality cultures are more advanced. Besides, they have do-not-resuscitate (DNR) orders, so patients with DNR orders are mostly not included in their studies. These factors might explain their better survival rates. Our finding that none of the patients having CPR more than 38 min had survived together with their poor prior disease states suggests that some of our patients' CPR attempts were futile. In a UK study,^[16] survival was 45% in patients who received CPR ≤ 20 min, whereas it was 18% if CPR duration was >20 min.

Sepsis has a high mortality rate of about 30%–50%, and it comprises 20% of all deaths worldwide.^[17] For the last two decades, in addition to blue code teams, METs or rapid response teams (RRT) mainly led by intensivists (intensive/critical care physician) have started to be established because it has been demonstrated that 6–8 h before SCA, vital signs have started to deteriorate in about 80% of the patients.^[18,19] Therefore, early warning scores have been suggested to be used in hospitals.^[20,21] Several studies have shown decreased mortality rates by establishing MET or RRT.^[22–24] There were 404 calls for patient deterioration in our study, and 322 were for arrest cases (80%). However, in 167 patients, forms were not adequate, so 155 patients were included. Remainder 82 calls (20%) were not due to arrest but patient deterioration. This finding necessitates the use of early warning scores and MET or RRT for nonarrest patients, too.

Table 1: Comparison of survivor and non-survivors

	All patients (n=155)	Survivors (n=31)	Nonsurvivors (n=124)	P
Age, median (IQR)	54.0 (11.0-70.0)	3.0 (1.0-52.0)	58.0 (24.2-70.7)	<0.001
Adults, n (%)	103 (66.4)	8 (25.8)	95 (76.6)	<0.001
Female, n (%)	72 (46.4)	19 (61.3)	53 (42.7)	0.064
Co-morbidities, n (%)*				
Cancer	63 (40.6)	3 (9.7)	60 (48.4)	<0.001
Neurologic	19 (12.3)	8 (25.8)	11 (8.9)	0.010
Chronic lung disease	11 (7.1)	2 (6.4)	9 (7.2)	1.000
Chronic heart disease	9 (5.8)	3 (9.7)	6 (4.8)	0.385
Diabetes mellitus	9 (5.8)	1 (3.2)	8 (6.4)	0.688
Arrest type, n (%)				
Cardiac	128 (82.6)	13 (41.9)	115 (92.7)	<0.001
Respiratory	27 (17.4)	18 (58.1)	9 (7.3)	
Arrest causes, n (%)	n=137	n=24	n=113	
Sepsis	64 (46.7)	3 (12.5)	61 (54.0)	<0.001
Respiratory failure	37 (27.0)	15 (62.5)	22 (19.5)	
Cardiac causes	36 (26.3)	6 (25.0)	30 (26.5)	
Arrest place as wards, n (%)	141 (91.0)	26 (83.9)	115 (92.7)	0.157
First ECG rhythm, n (%)	n=145	n=22	n=123	
Asystole/PEA	134 (92.4)	21 (95.4)	113 (91.9)	1.000
VF/PVT	11 (7.6)	1 (0.6)	10 (8.1)	
CPR duration	n=145	n=28	n=117	
>20 min, n (%)	96 (66.2)	8 (28.6)	88 (75.2)	<0.001

*The total does not make 155 (100%) because of the absence of co-morbidities and/or missing data. IQR: Interquartile range, ECG: Electrocardiography, PEA: Pulseless electrical activity, CPR: Cardiopulmonary resuscitation, VF: Ventricular fibrillation, PVT: Pulseless ventricular tachycardia

Table 2: Multivariate analysis of risk factors associated with hospital mortality

	B coefficient	Standard error	Wald statistic	P	Odds ratio	95% CI
Constant	-5.42	1.51	12.84	<0.001	0.004	
Age group (adult vs. pediatric)	1.95	0.95	4.23	0.040	7.01	1.09-44.85
Cause of arrest			5.98		0.05	
Cardiac versus respiratory	1.49	1.06	1.99	0.158	4.44	0.56-35.19
Sepsis versus respiratory	2.06	0.87	5.67	0.017	7.87	1.44-43.02
Place of arrest (hospital ward vs. other)	3.06	1.14	7.18	0.007	21.40	2.28-201.06

The model is adjusted for gender (male vs. female), underlying neurological disease, underlying cancer, type of arrest (cardiac vs. respiratory), and CPR duration (>20 min vs. less). CPR: Cardiopulmonary resuscitation, CI: Confidence interval

We tried to establish a blue code system within the hospital and within the campus. However, the majority of the patients are within the hospital. This is normal since the prevalence of out-of-hospital arrests is not that high, and besides, in some cases, 112 could have been called depending on the location.

In 50%–75% of SCA patients, initial rhythm is asystole or PEA, which carries a poor prognosis.^[8,25,26] Nolan *et al.*^[16] reported hospital survival to be 49% in patients with VF/PVT as the initial rhythm, whereas survival dropped to 10% if the initial rhythm was asystole/PEA. In our study, in >90% of patients, the initial rhythm was asystole/PEA, which was another reason for high mortality. According to the CPR forms, the median access time to the scene was 1 min, which was self-reported in 57% of the CPR forms. However, this is questionable due to the high ratio of asystole/PEA compared to VF/PVT. Another reason for the high rate of asystole/PEA could be a lack of starting by-stander basic life support.

Therefore, this part should be reformed so that instead of self-reporting, electronic systems can be used. Basic and advanced life support educations should be increased both in health-care personnel and laypeople.

Turkish Ministry of Health established the blue code system as a mandatory service in state hospitals in 2009. Since then, there are some studies published from state hospitals. In most studies, rather than hospital discharge, just ROSC was given. In a Turkish study,^[27] spontaneous circulation was returned in 46% of patients, similar to our study. However, cancer was seen in only 18% of their patients instead of our study, where cancer was present in 41% of the patients. In another study from Turkey,^[28] the hospital survival rate was 7.1% after CPR, and 20% of their calls were for nonarrest cases. The hospital survival rate of 9.7% was found in a study,^[29] where 60% of the patients were in intensive care units (ICU); however, in our study ICU were not included at all, because, CPR could readily be done in ICUs without necessitating separate teams.

This study is important since there is a paucity of data in university hospitals in Turkey. It is difficult to establish such systems in university hospitals since all physicians are either residents or academic physicians. Due to the absence of nonacademic staff physicians, it is impossible to establish blue code teams from fixed specialist physicians. Therefore, we had to establish our teams from experienced senior residents in rotation. Frequent physician changes might be a limiting factor for the standardization of CPR.

Limitations

The major limitation of this study is its retrospective nature. The variables could only be gathered through CPR forms, which were not detailed and not completed by the CPR respondents thoroughly. Therefore, data analysis was limited, though several more patient and process-related factors could influence the outcome. The second major limitation is the absence of the control group. Although there was a hospital limited blue code in the hospital before the study period, there were no medical records, and hence, it was impossible to make a before-after comparison. This is a single-center study limiting generalization of the results; however, since the blue code system might vary according to hospital type, size, personnel, etc., making multi-center studies on this topic could not be accessible even be impossible. Besides, periodic local epidemiological studies are quite crucial in improving the quality of care, patient safety, and generating hypotheses for further studies.

Conclusion

Blue code and METs or RRT should be fundamental in hospitals, and their performance should be evaluated periodically. Every effort should be made to prevent unexpected cardiac arrests and increase hospital discharge with good neurologic outcomes.

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Author contributions statement

AT conceived, designed the project and gathered the data and wrote the manuscript; AT, BC analyzed and interpreted the data.

Conflicts of interest

None declared.

Ethical Approval

Hacettepe University Ethical Committee approval was obtained on 29.4.2015 (GO 15/300-04).

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