Original Article

Analysis of functioning and efficiency of a code blue system in a tertiary care hospital

ABSTRACT

Background: "Code blue" (CB) is a popular hospital emergency code, which is used by hospitals to alert their emergency response team of any cardiorespiratory arrest. The factors affecting the outcomes of emergencies are related to both the patient and the nature of the event. The primary objective was to analyze the survival rate and factors associated with survival and also practical problems related to functioning of a CB system (CBS).

Materials and Methods: After the approval of hospital ethics committee, an analysis and audit was conducted of all patients on whom a CB had been called in our tertiary care hospital over 24 months. Data collected were demographic data, diagnosis, time of cardiac arrest and activation of CBS, time taken by CBS to reach the patient, presenting rhythm on arrival of CB team, details of cardiopulmonary resuscitation (CPR) such as duration and drugs given, and finally, events and outcomes. Chi-square test and logistic regression analysis were used to analyze the data.

Results: A total of 720 CB calls were initiated during the period. After excluding 24 patients, 694 calls were studied and analyzed. Six hundred and twenty were true calls and 74 were falls calls. Of the 620, 422 were cardiac arrests and 198 were medical emergencies. Overall survival was 26%. Survival in patients with cardiac arrests was 11.13%. Factors such as age, presenting rhythm, and duration of CPR were found to have a significant effect on survival. Problems encountered were personnel and equipment related.

Conclusion: A CBS is effective in improving the resuscitation efforts and survival rates after inhospital cardiac arrests. Age, presenting rhythm at the time of arrest, and duration of CPR have significant effect on survival of the patient after a cardiac arrest. Technical and staff-related problems need to be considered and improved upon.

Key words: Cardiac arrest; cardiopulmonary resuscitation; code blue

Introduction

Medical emergencies are commonly encountered in the hospital setting. "Emergency codes" are being used in modern health-care establishments during these emergency situations; the purpose of which is to provide a message to the specialized hospital staff during emergency situations without creating panic in and around the hospital. Numerous guidelines for unifying the codes internationally exist.

"Code blue" (CB) is a popular hospital emergency code, which is used by hospitals to alert their emergency response team of any cardiorespiratory arrest. The term was first used in the Bethany Medical Center in the State of Kansas

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in the early 1990s.[1] The aim of CB is to ensure that trained resuscitators are despatched to the victim in the shortest possible time, without disturbing the normal functioning of the rest of the hospital.[2,3]

Most victims of cardiopulmonary arrest tend to survive if the intervention is early, in terms of cardiopulmonary resuscitation (CPR), defibrillation, and advance care.[4] The incidence of in-hospital cardio-respiratory arrest has been estimated to be 1–5 events per 1000 annual hospital admissions,[5] but survival to hospital discharge rate is a mere 0.42%.[6] This shows the effect of numerous factors in the ultimate outcome of resuscitation.[7] These factors affecting the outcome are related to both the patient and the nature of the event.[5]

The development of a CB system (CBS) and the types of services need to be regularly analyzed and audited. Furthermore, the cost benefits have to be evaluated to make productive use of a CBS. It is essential to have formal quality assurance programs to regularly evaluate the effectiveness of a CBS.[1,8,9] The current study was intended to critically analyze the protocols and procedures of the CBS and identify variables associated with survival at our tertiary care hospital.

The primary objective was to assess outcome of CB activation and CPR in patients of cardiac arrest and other emergencies, in terms of survival. Secondary objectives were to identify the patient and system variables associated with a favorable outcome and identify the practical problems associated with establishment and functioning of a CBS.

Materials and Methods

After the approval of hospital ethics committee, an analysis and audit was conducted of all patients on whom a "CB" had been called in our tertiary care hospital over 24 months. This was done using the standardized CB audit form, maintained by the department of anesthesiology. The primary objective was to analyze the survival rate and also factors associated with survival.

Inclusion criteria included all patients who were resuscitated by the CB team of the hospital. Exclusion criteria included pediatric patients aged <12 years and patients referred to outside hospitals from accident and emergency (A and E). Data was collected according to a CB audit form. This included demographic data, diagnosis, time of cardiac arrest and activation of CBS, time taken by CBS to reach the place, presenting rhythm on arrival of CB team, details of CPR such as duration and drugs given, and finally, events and outcomes.

The CBS in our hospital was in place 1 year before the commencement of this study. In it, the emergency code is dialed through the CB-enabled telephone extension in the hospital to activate the CBS. This is enabled at different places in hospital where emergencies are expected such as wards, departments, and critical areas. The three components of the CBS include the communication system, trained workforce, and the resuscitation equipment.

The communication system in the CBS has three parts. The first is the afferent limb, which consists of input response from the area of emergency to the central processing unit (CPU) through enabled telephone extension. The second part is the CPU in the department of anesthesia, which analyzes the call and identifies the area of emergency and then gives the output response through the efferent limb, which is the last part. The analyzed message from CPU is delivered through the efferent limb by audio alert through speakers in Intensive Care Unit (ICU), operation theater (OT), and A and E and through a message containing location of the activated area to the on-duty resident. The CB team in this hospital comprises of an intensivist, anesthesia resident, and OT technician. The resuscitation equipment is carried to the place of emergency in a CB bag and box containing emergency drugs, airway equipment, laryngoscope, breathing circuits, etc.

Various areas where emergencies could potentially occur were classified into acute areas and others. Acute areas were those areas of the hospital where continuous monitoring facilities were available for the patients. False CB calls were those which were initiated either unintentionally by mistake when there was no emergency or misinterpretation of patient's status or due to system failure.

Variables collected were analyzed by Chi-square test and logistic regression analysis using SPSS (Released 2009. PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc.) to derive a formula to predict the likelihood of survival. $P < 0.05$ was considered significant.

Results

Data from all CB calls in a period of 2 years were considered. A total of 720 CB calls were initiated during the period. However, 24 patients of age <12 years and 2 referred to other hospitals were excluded, leaving 694 calls to be studied and analyzed. A total of 74 calls were false CBs during the study period. The 620 "true CBs" cardiac arrests on arrival or after arrival of the team were seen in 422 patients, the rest having only "emergency events" [Figure 1].

Interventions during code blue calls

Tracheal intubation, CPR with chest compressions, or requiring defibrillation and administration of emergency drugs in concordance with advanced cardiac life support guidelines. Outcome of CB included either shifting to ICU, OT, or continued care in ward [Table 1].

The overall survival rate was 26.5% in the 2 years studied as the patient sample group included those who had a cardiac arrest on arrival of the CB team and also when the team was called to tackle emergency situations. However, in the subgroup of patients who had a cardiac arrest during or soon after the CB activation, the survival rate was 11.13% [Table 2].

Age, gender, and presenting rhythm on arrival

The mean age of the patients was 56.06 years. The survival in patients <60 years was significantly more compared to those above 60 years of age. There was no statistically significant difference in survival between males and females. The rhythms noted on arrival were bradycardia (32), asystole (371), ventricular tachycardia (VT)/ventricular fibrillation (VF) (11), or normal sinus rhythm (206). Asystole had lowest survival rates as compared to other two rhythms [Table 3].

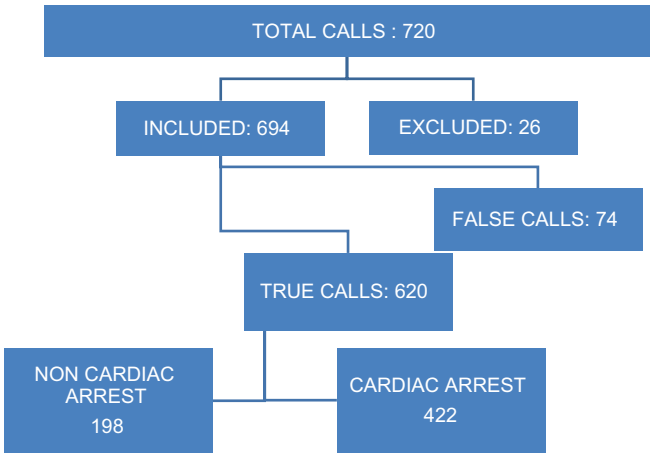

Figure 1: Analysis of total code blue calls

Table 1: Summary of all interventions and outcomes

Parameter	*n* (%)
Interventions (*n*=694)	
Tracheal intubation	443 (63.8)
Cardiopulmonary resuscitation	481 (69.3)
Defibrillation	59 (8.5)
No intervention	123 (17.7)
Outcome of code blue calls (*n*=620)	
Shifted to ICU	256 (41.2)
Declared dead in ward	264 (42.5)
Continued care in the ward	98 (15.8)
Shifted to OT	2 (0.3)

ICU: Intensive Care Unit; OT: Operation theater

Table 2: Overall survival rates

Parameter	Total	Survived	Expired	Survival (%)
True CB calls	620	164	456	26.45
Cardiac arrests	422	47	375	11.3
Noncardiac arrests	198	177	81	59

CB: Code blue

Timing and location code blue and duration of cardiopulmonary resuscitation

There was significant difference between the survival during and off working hours and also between acute and nonacute areas. A and E department was excluded from the analysis since patients were received directly from community, and the holding time was minimal. The mean duration of CPR in the 422 cardiac arrest patients was found to be 15.6 min. Survival was significantly higher in patients with CPR duration <15 min [Table 4].

Multivariate analysis of all the factors

Age, presenting rhythm, and duration of CPR had a $P < 0.05$ indicating statistically significant effect on the survival. The odds ratio was highest in case of VT/VF indicating the highest effect on survival [Table 5]. Problems encounter in maintaining and functioning of the CBS are summarized in Table 6.

Discussion

Studies have reported on different outcomes of survival after cardiac arrest such as return of spontaneous circulation, survival at 24 h, discharge from ICU, and outcome at 28 days. In our study, we have taken the primary outcome as survival to discharge from ICU. The overall survival rate in our study was 26.45%, which is higher than that reported in literature. This is because all the "CBs" in this study were not only for cardiac/respiratory arrest but also for medical emergencies such as sudden dip in sensorium, sudden hypotension, desaturation, anaphylaxis, vasovagal syncope, and seizures. However, when patients who had a cardiac arrest at the time of CB were considered, the survival rate dropped to 11.13%. This is a more realistic figure since most other comparative studies in literature report figures on patients who had a cardiac arrest.[10-12] This figure is again less compared to other studies as the predominant presenting rhythm in most patients of cardiac arrest in this study was asystole, which has been shown to have the least survival as compared to VT/VF.[13-15]

It is prudent to mention that the survival rate alone cannot be taken as sole indicator for the effectiveness of a CBS because the survival is not only effected by the resuscitation but also by patient-related factors. In the current study, we found a better chance of successful resuscitation in those

Table 3: Survival based on age, gender, and cardiac rhythm

Parameter	Total	Survived	Expired	*P**
Age (*n*=620)				
>60 years	288	59	229	0.0017
<60 years	332	105	227	
Gender (*n*=620)				
Male	414	101	313	0.099
Female	206	63	143	
Presenting rhythm (*n*=414)				
Bradycardia	32	17	15	<0.001
Asystole	371	34	337	
VT/VF	11	6	5	

*Chi-square test, *P*<0.05 significant. VT: Ventricular tachycardia; VF: Ventricular fibrillation

Table 4: Survival with other factors

Parameter	Total	Survived	Expired	*P**
Time of day (*n*=620)				
Working hours	294	96	198	<0.001
Off working hours	326	68	258	
Location of CB# (*n*=484)				
Acute areas	162	57	105	0.045
Other areas	322	85	237	
Duration of CPR$ (*n*=422)				
<15 min	116	38	78	<0.001
>15 min	306	7	299	

*Chi-square test, *P*<0.05 significant; #Accident and emergency calls not included; $All cardiac arrest cases. CPR: Cardiopulmonary resuscitation; CB: Code blue

Table 5: Analysis of all variables after applying logistic regression

Variable	χ^2	*P*	OR
Age	−0.026	0.047	0.975
Gender	0.071	0.878	1.074
Place of arrest	−0.437	0.203	0.646
Other areas	1.232	0.495	0.784
A and E		0.502	
Presenting rhythm	0.045	0.006	1.046
Bradycardia	0.174	0.961	0.977
Normal sinus rhythm	0.313	0.885	3.427
VT/VF		0.007	
Time of cardiac arrest	−0.321	0.414	0.725
Duration of CPR	−0.171	0	0.843

P<0.05: Significant. CPR: Cardiopulmonary resuscitation; VT: Ventricular tachycardia; VF: Ventricular fibrillation; A and E: Accident and emergency; OR: Odds ratio

Table 6: Summary of problems associated with maintenance of code blue system

Problems (*n*=250)	*n* (%)
Technical	23 (9.20)
Equipment	114 (45.60)
Crash cart	25 (10)
Staff	88 (35.20)

below 60 years of age. This is corroborated by Paniagua *et al*., who found a significantly low survival rates in patients aged over 80 years than in younger ones,[16] and Rafati *et al*., who found the survival rate after cardiac arrest to be significantly lower in patients of age >60 years.[17] However, there are other independent studies by Brindley *et al*. and Herlitz *et al*. which stated that age is not an independent factor for survival.[18,19] There was no significant effect of gender on the survival rate in this study. Studies by Bolandparvaz *et al*. and Brindley *et al*. also reported similar findings[7,19] although Herlitz *et al*. reported that gender was an independent predictor for survival to discharge after cardiac arrest.[18] The survival rate found was higher for VT/VF and bradycardia and least for asystole. The presenting rhythm thus significantly affects the survival of the patient after cardiopulmonary arrest. Similar results have been reported in literature.[19-22]

In the present study, the survival was better during working hours than off working hours. We could attribute this to the better staffing and probably better detection and more aggressive management. The findings are in keeping with studies by Peberdy *et al*. who reported that survival rates from inhospital cardiac arrest are lower during nights and weekends,[23] and Rafati *et al*.[17] Masoud *et al*. also concluded that more invasive procedures are done in day shifts, and successful CPR on working days was significantly higher than on holidays.[12]

In the current study, survival rates were higher in patients who had received CPR <15 min as compared to >15 min. In the study by Rafati *et al*. and Sandroni *et al*., patients having shorter periods of cardiac arrest or who were revived after a short duration of CPR have a good outcome because it is mostly due to rapidly treatable causes. After long period of arrest, there are more chances of generalized tissue hypoperfusion and hypoxic damage.[5,17]

Limitations

All the CB calls analyzed in this study were not strictly codes (respiratory or cardiac arrest). Hence, the overall survival rate in our study was seemingly higher than that reported in literature. However, our survival rates are comparable to that in literature when the group which had a cardiac arrest was taken. This study has taken only patients of age >12 years. Hence, the survival pattern adult versus pediatric age group could not be studied. Furthermore, resuscitation done in the ICU was not considered. Effectiveness of chest compression during CPR and other parameters such as delays in airway control could not be analyzed. We were unable to analyze the effect of both the primary diagnosis and comorbidities on the survival.

Conclusion

It was concluded that a CBS is effective in improving the resuscitation efforts and survival rates after inhospital cardiac arrests. Age, presenting rhythm at the time of arrest, and duration of CPR have significant effect on survival of the patient after a cardiac arrest. Problems related to working of an effective CBS such as technical problems, problems with equipment, crash cart, and staff-related problems need to be considered and improved upon.

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Conflicts of interest
There are no conflicts of interest.

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