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 in hospital 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.
in the early 1990s. 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.

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

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. 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 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
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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. $P < 0.05$
is 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].

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

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**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
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 CPR1 (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; 1All cardiac arrest cases. CPR: Cardiopulmonary resuscitation; CB: Code blue

Table 5: Analysis of all variables after applying logistic regression

| Variable           | $\chi^2$ | P     | OR   |
|--------------------|----------|-------|------|
| Age                | -0.026   | 0.975 |      |
| Gender             | 0.071    | 1.074 |      |
| Place of arrest     | -0.437   | 0.203 | 0.646|
| Other areas        | 1.232    | 0.495 | 0.784|
| A and E            |          |       |      |
| Presenting rhythm  | 0.045    | 0.006 | 1.046|
| Bradycardia        | 0.174    | 0.961 | 0.977|
| Normal sinus rhythm | 0.313   | 0.889 | 3.427|
| VT/VF              |          |       |      |
| 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) |

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, and Rafati et al. also reported that survival rates were 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.

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.

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.

aged over 80 years than in younger ones and Rafati et al., who found the survival rate after cardiac arrest to be significantly lower in patients of age >60 years. 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. 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 although Herlitz et al. reported that gender was an independent predictor for survival to discharge after cardiac arrest. 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.
Conclusion

It was concluded that a CBS is effective in improving the resuscitation efforts and survival rates after in-hospital 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.

References

1. Zafari AM, Zarter SK, Heggen V, Wilson P, Taylor RA, Reddy K, et al. A program encouraging early defibrillation results in improved in-hospital resuscitation efficacy. J Am Coll Cardiol 2004;44:846-52.
2. Al-Aboud KM, Al-Aboud DM. Hospital emergency codes. An appraisal. Saudi Med J 2010;31:1377.
3. Barbetti J, Lee G. Medical emergency team: A review of the literature. Nurs Crit Care 2008;13:80-5.
4. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: The “chain of survival” concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. Circulation 1991;83:1832-47.
5. Sandroni C, Nolan J, Cavallaro F, Antonelli M. In-hospital cardiac arrest: Incidence, prognosis and possible measures to improve survival. Intensive Care Med 2007;33:237-45.
6. Abe T, Tokuda Y, Ishimatsu S; SOS-KANTO study group. Predictors for good cerebral performance among adult survivors of out-of-hospital cardiac arrest. Resuscitation 2009;78:431-6.
7. Bolandparvaz SH, Mohammadzadeh A, Amini A, Abbasil HR, Ahmadi MM, Ghaffaripour S. Cardiopulmonary resuscitation outcome in Nemazee hospital, Southern Iran. IRMJ 2009;11:437-4.
8. Spearpoint KG, Gruber PC, Brett SJ. Impact of the immediate life support course on the incidence and outcome of in-hospital cardiac arrest calls: An observational study over 6 years. Resuscitation 2009;80:638-43.
9. Garcia-Hejl C, Chianéa D, Dedome E, Sanmartin N, Bugier S, Linard C, et al. Internal audit in medical laboratory: What means of control for an effective audit process? Ann Biol Clin (Paris) 2013;71:615-24.
10. Ebell MH, Becker LA, Barry HC, Hagen M. Survival after in-hospital cardiopulmonary resuscitation. A meta-analysis. J Gen Intern Med 1998;13:805-16.
11. Nadkarni VM, Larkin GL, Peberdy MA, Carey SM, Kaye W, Mancini ME, et al. First documented rhythm and clinical outcome from in-hospital cardiac arrest among children and adults. JAMA 2006;295:50-7.
12. Saghafinia M, Motamedi MH, Piraye M, Rafati H, Saghafinia M, Jalali A, et al. Survival after in-hospital cardiopulmonary resuscitation in a major referral center. Saudi J Anaesth 2010;4:68-71.
13. Sandroni C, Ferro G, Santangelo S, Tortora F, Mistura L, Cavallaro F, et al. In-hospital cardiac arrest: Survival depends mainly on the effectiveness of the emergency response. Resuscitation 2004;62:291-7.
14. Peberdy MA, Kaye W, Ornato JP, Larkin GL, Nadkarni V, Mancini ME, et al. Cardiopulmonary resuscitation of adults in the hospital: A report of 14720 cardiac arrests from the national registry of cardiopulmonary resuscitation. Resuscitation 2003;58:297-308.
15. Skrifvars MB, Rosenberg PH, Finne P, Halonen S, Hautamäki R, Kuosa R, et al. Evaluation of the in-hospital utstein template in cardiopulmonary resuscitation in secondary hospitals. Resuscitation 2003;56:275-82.
16. Paniagua D, Lopez-Jimenez F, Londoño JC, Mangione CM, Fleischmann K, Lamas GA, et al. Outcome and cost-effectiveness of cardiopulmonary resuscitation after in-hospital cardiac arrest in octogenarians. Cardiology 2002;97:6-11.
17. Rafati H, Saghafinia M, Saghafinia M, Panahi F, Hoseinpour M. Survival after in-hospital cardiopulmonary resuscitation in a major referral center during 2001-2008. Iran J Med Sci 2011;36:50-3.
18. Herlitz J, Rundqvist S, Bång A, Aune S, Lundström G, Ekström L, et al. Is there a difference between women and men in characteristics and outcome after in hospital cardiac arrest? Resuscitation 2001;49:15-23.
19. Brindle PG, Markland DM, Mayers I, Kutsogiannis DJ. Predictors of survival following in-hospital adult cardiopulmonary resuscitation. CMAJ 2002;167:343-8.
20. Cummins RO, Chamberlain DA, Abramson NS, Allen M, Baskett PJ, Becker L, et al. Recommended guidelines for uniform reporting of data from out-of-hospital cardiac arrest: The Utstein Style. A statement for health professionals from a task force of the American Heart Association, the European Resuscitation Council, the Heart and Stroke Foundation of Canada, and the Australian Resuscitation Council. Circulation 1991;84:960-75.
21. Meaney PA, Nadkarni VM, Kern KB, Indik JH, Halperin HR, Berg RA, et al. Rhythms and outcomes of adult in-hospital cardiac arrest. Crit Care Med 2010;38:101-8.
22. Cohn AC, Wilson WM, Yan B, Joshi SB, Heily M, Morley P, et al. Analysis of clinical outcomes following in-hospital adult cardiac arrest. Intern Med J 2004;34:398-402.
23. Peberdy MA, Ornato JP, Larkin GL, Braithwaite RS, Kashner TM, Carey SM, et al. Survival from in-hospital cardiac arrest during nights and weekends. JAMA 2008;299:785-92.