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ORIGINAL ARTICLE

Institutional resuscitation protocols: do they affect cardiopulmonary resuscitation outcomes? A 6-year study in a single tertiary-care centre

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Abstract
Purpose Despite advances in cardiopulmonary resuscitation and widespread life-support trainings, the outcomes of resuscitation are variable. There is a definitive need for organizational inputs to strengthen the resuscitation process. Our hospital authorities introduced certain changes at the organizational level in our in-house resuscitation protocol. We aimed to study the impact of these changes on the outcomes of resuscitation.
Methods The hospital code blue committee decided to reformulate the resuscitation protocols and reframe the code blue team. Various initiatives were taken in the form of infrastructural changes, procurement of equipment, organising certified training programs, conduct of mock code and simulation drills etc. A prospective and retrospective observational study was made over 6 years: a pre-intervention period, which included all cardiac arrests from January 2007 to December 2009, before the implementation of the program, and a post-intervention period from January 2010 to December 2012, after the implementation of the program. The outcomes of interest were response time, immediate survival, day/night survival and survival to discharge ratio.
Results 2,164 in-hospital cardiac arrests were included in the study, 1,042 during the pre-intervention period and 1,122 during the post-intervention period. The survival percentage increased from 26.7 to 40.8 % ($p < 0.05$), and the survival to discharge ratio increased from 23.4 to 66.6 % ($p < 0.05$). Both day- and night-time survival improved ($p < 0.05$) and response time improved from 4 to 1.5 min.
Conclusions A strong hospital-based resuscitation policy with well-defined protocols and infrastructure has potential synergistic effect and plays a big role in improving the outcomes of resuscitation.

Keywords Cardiopulmonary resuscitation · Code blue · Institutional protocols · Cardiac arrest · BLS/ACLS training

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Introduction

Over the last 60 years since cardiopulmonary resuscitation (CPR) for in-hospital cardiac arrest was first reported, there has been considerable research on resuscitation [1]. Formal guideline-based life-support training programs for basic life-support (BLS) and advanced cardiac life-support (ACLS) are becoming increasingly popular in hospital settings. However, the effectiveness of these training programs has not been firmly established [2–5]. The major reason cited is that despite trained personnel, successful cardiopulmonary resuscitation can be hindered by multiple variables such as ineffective communication, lack of promptness in responding to codes, stressful environment, lack of functioning equipment, variable team dynamics and an unfamiliar environment [6]. The literature contains numerous proposals including a dedicated in-house

resuscitation policy, documentation of code blue and post-code analysis and summarization, attitude and behavioural changes in resuscitation providers, refresher courses, and innovative training methods to improve survival rates [7–11]. In an effort to strengthen the resuscitation services and maximize the likelihood of successful resuscitation, our hospital authorities introduced certain changes at the organizational level in our in-house resuscitation protocol. We aimed to study the impact of these changes on the outcomes of resuscitation.

Material and methods

Clinical setting

Our hospital is a 350-bed multi-speciality tertiary-care hospital in India. All healthcare professionals are provided with in-hospital basic life-support training. They initiate CPR whenever there is a cardiac arrest in the hospital and continue until the arrival of the code blue team. The hospital has a designated code blue team that responds to all in-hospital cardiac arrest alarms, announced through the public address system. The code blue team consists of an anesthesiology registrar, medicine registrar, on-duty resident medical officer, attending staff nurse and nursing supervisor of the shift. The hospital policy is to always initiate CPR in a cardiac arrest victim. The "do not resuscitate" (DNR) policy is not legal in India. A code blue running sheet is filled in by a record-keeper during the course of CPR. The hospital has a code blue committee which meets at regular intervals and monitors the code blue data from time to time. This committee is also responsible for the formulation and change of in-hospital resuscitation policy.

Background

Upon review of resuscitation data over 2 years (2007–2008) at our institution, the code blue committee observed that the overall survival rate after CPR was low and most of the patients surviving cardiac arrest could not be discharged from the hospital. Night-time resuscitation was poorer and the response time of the code blue team was also delayed. On retrospective analysis of the overall situation, several factors were held responsible for the poor CPR outcomes, including lack of adequately trained staff for performing CPR, delays/discrepancies in announcements and attending of code blues, non-availability of crash carts and defibrillators at various places, inefficiency in using defibrillators, non-acquaintance of staff with CPR guidelines etc. These discrepancies in hospital resuscitation prompted a comprehensive need assessment that was used

Table 1 Interventions at the organizational level

American Heart Association (AHA) certified BLS and ACLS courses were planned and held. First certified training was conducted in October 2009 and, up to the end of 2012, 7 certified ACLS courses had been done. In each course, 30–35 healthcare professionals were certified and to date there are 68 doctors and 41 nurses as AHA-certified BLS and ACLS providers (after attrition). During these courses, emphasis was laid on:
- Code team concept
- Team dynamics
- Sensitization for immediate response to code
- CPR skills
- Training on use of defibrillators
In-house BLS training was strengthened. BLS training and certification was made mandatory for all hospital employees. A module was prepared for uniformity in training. BLS training included:
- Classroom theoretical teaching
- Hands-on trainings on mannequins
- Town hall meetings
- Role plays for contractual staff
- Assessing BLS quality using pocket CPR
- Training on choking mannequin
- Bilingual pocket BLS cards for all the staff
- Training nursing staff in use of defibrillators
Refresher courses were done on a regular basis (every 3 months). Post-refresher course, a skill test was conducted
Conduct of mock codes and simulation drills in different areas; at least 1 in each area every half-yearly and post-code summarization
Infrastucture was strengthened by procuring:
- BLS mannequins
- ACLS simulator
- Airway trainer
- Choking trainer
- Infant mannequin
- Airway equipment
Resuscitation skill labs were established for hands-on practice
Defibrillators were stationed on all floors. The staff was trained in use of defibrillators
Crash cart placement was ensured in each ward. Before the commencement of the program, crash carts were shared by different areas and even floors
Reframing of the code blue team was done. At least one certified ACLS provider was made mandatory in the team, with round the clock coverage. Shifts of ACLS providers were adjusted accordingly
BLS and ACLS algorithms were hung alongside the crash carts and displayed on walls in critical areas for reference
Modification of code blue sheets for better documentation of codes and post-code analysis
Sessions with communiqué staff for more efficient public address system
Formulation of a post-resuscitation care protocol by the end of year 2011

Table 2 Organisational differences between the study periods

	Pre-intervention period	Post-intervention period
AHA certified BLS and ACLS training sessions	0	7
Number of certified ACLS providers	3	109
Certified doctors	3	68
Certified nurses	0	41
BLS training mannequins	1	4
Airway mannequin	0	1
ACLS simulator	0	1
Choking trainer	0	1
Infant mannequin	0	3
Resuscitation skills lab	0	2
Defibrillators	8	27
Monophasic	2	6
Biphasic	6	21
Crash carts	8	32
Simulation drills	0	8
Mock codes	0	22

by the hospital code blue committee to design and implement a customized pan-hospital resuscitation program and to formally reformulate the resuscitation protocols and reframe the code blue team. A code blue renewal program was launched by the code blue committee at our hospitals in mid-2009. A plan was laid out after discussions between the code blue committee members, administrative staff, human resource department and quality assurance department.

Initiatives taken

Various initiatives were taken at the organizational level in the form of infrastructural changes, procurement of equipment, organising certified training programs, etc., which are listed in Table 1.

American Heart Association (AHA) certified BLS and ACLS and in-house BLS training sessions were held for both doctors and nursing professionals. The code blue team was reframed with mandatory inclusion of at least one ACLS-certified team member round the clock. The code blue team members were trained in immediate response to the code. Regular mock codes, simulation drills in different areas of the hospital and refresher courses were conducted. The hospital communiqué team was reoriented so as to improve the code announcement system. Defibrillators were placed in different areas throughout the hospital. The nursing staff was trained to use defibrillators. Well-equipped crash carts, with photographic display of their contents, were placed in each nursing area of the hospital. The contents of the crash cart were modified from time to time according to the feedback. Code blue sheets were modified and reviewed on a quarterly basis. All these changes were in place by the end of 2009. This study was designed to assess the impact of this dedicated initiative on outcomes of cardiopulmonary resuscitation.

Table 2 shows the organisational differences between the pre-intervention and post-intervention periods.

Methods

The hospital ethics committee approved the study protocol. It was a prospective and retrospective observational study. For the study purposes, two periods were identified—a retrospective pre-intervention period, which included all cardiac arrests from January 2007 to December 2009, i.e., before the implementation of the program, and a prospective post-intervention period from January 2010 to December 2012, after the implementation of the program. We identified all cases of first-time in-hospital cardiac arrest in adults (>14 years of age) that occurred over a 6-year period between January 2007 and December 2012. Data regarding each cardiac arrest were collected from code blue running sheets. A comparative analysis of these two periods was undertaken.

Patients on whom CPR was started outside the hospital or on arrival in the emergency ward were not included in the study. When a patient suffered several cardiac arrests in the hospital, only the first episode was included in the analysis, to avoid a falsely elevated rate of successful CPR, or a falsely reduced rate of survival to hospital discharge.

Data entry consisted of patient demographic data, time of arrest, area where cardiac arrest occurred, response time (i.e. from the announcement of code blue to the time when the first member of the code blue team arrived) and the outcomes of CPR.

To objectively assess the impact of our project, the outcomes of interest were:

1. Response time.
2. Immediate survival, which was defined as the return of spontaneous circulation (ROSC) for more than 20 min.
3. Day/night survival (day shift was considered from 8 a.m. to 8 p.m. and night shift from 8 p.m. to 8 a.m.).
4. Survival to discharge ratio (the percentage of patients discharged from hospital after successful resuscitation, i.e. ROSC).

Table 3 CPR outcomes during the study periods

	Pre-intervention period	Post-intervention period	*p* value
Total patients (*n*)	1,042	1,122	
Survival [*n*, (%)]	278 (26.7 %)	458 (40.8 %)	<0.05
Non-survival [*n*, (%)]	764 (73.3 %)	664 (59.2 %)	
Day-time codes (*n*)	389	469	
Day-time survival [*n*, (%)]	120 (30.8 %)	215 (45.8 %)	<0.05
Day-time non-survival [*n*, (%)]	269 (69.2 %)	254 (44.2 %)	
Night-time codes (*n*)	653	653	
Night-time survival [*n*, (%)]	158 (24.2 %)	243 (37.2 %)	<0.05
Night-time non-survival [*n*, (%)]	495 (75.8 %)	410 (62.8 %)	
Survival to discharge [*n*, (%)]	65 (23.4 %)	305 (66.6 %)	<0.05
Response time (min)	4	1.5	<0.05

Statistical analysis

Statistical analysis was performed using SPSS software, version 17. Patient characteristics were summarized using proportions or means and standard deviations (SDs) as appropriate. The outcomes of interest were analysed statistically using the chi-square test to compare clinical variables between the pre-intervention and post-intervention groups. A *p* value of <0.05 was considered statistically significant.

Results

A total of 2,164 adult in-hospital cardiac arrests were included in the study, of which 1,042 cardiac arrests occurred during the pre-intervention period and 1,122 during the post-intervention period. The demographic profile in the two study groups was similar. There was no statistical difference in the area-wise distribution, type of arrest or first documented rhythm between the two periods. The outcomes of cardiac arrests during the two study periods are shown in Table 3.

In the pre-intervention period, 278 patients were revived (26.7 %), compared to 458 patients in the post-intervention period (40.8 %), which was statistically significant ($p < 0.05$). The year-wise survival percentage is shown in Fig. 1.

Day- and night-time survival during the two periods is shown in Fig. 2. In the pre-intervention period, 389 codes occurred during the day, of which 120 patients had ROSC. During the post-intervention period, there were 469 codes during the day, of which 215 survived. Thus the day-time survival increased from 30.8 to 45.8 %, which was statistically significant ($p < 0.05$). 653 cardiac arrests occurred during the night-time in the pre-intervention period, of which 158 survived, while of 653 cardiac arrests occurring during the night-time in the post-intervention period, 243 patients survived. This increase in night-time survival, from 24.2 to 37.2 %, was also statistically significant ($p < 0.05$).

Of 278 patients who survived cardiac arrest during pre-intervention, 65 (23.4 %) could be discharged home, while, of 458 cardiac arrests during post-intervention, 305 patients

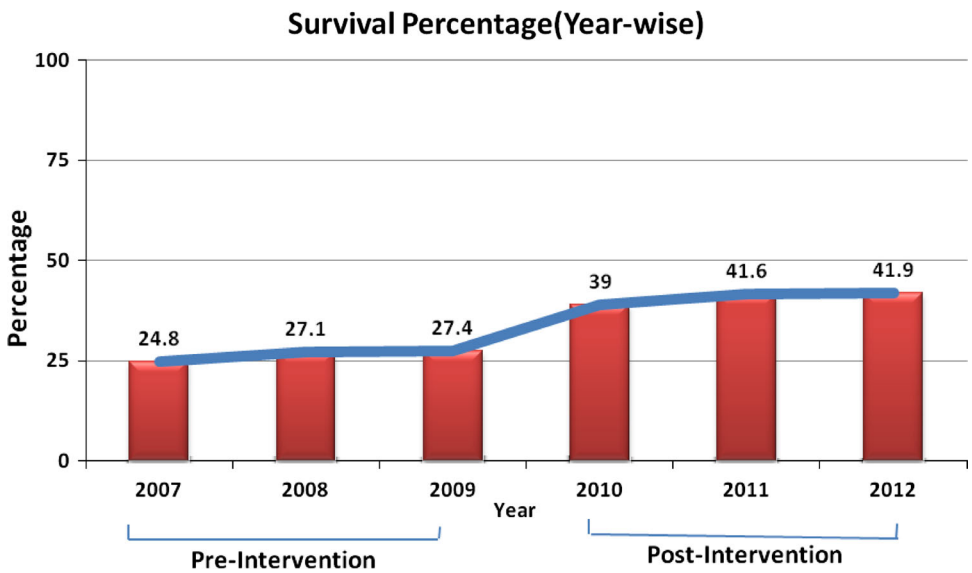

Fig. 1 Survival percentage (year-wise)

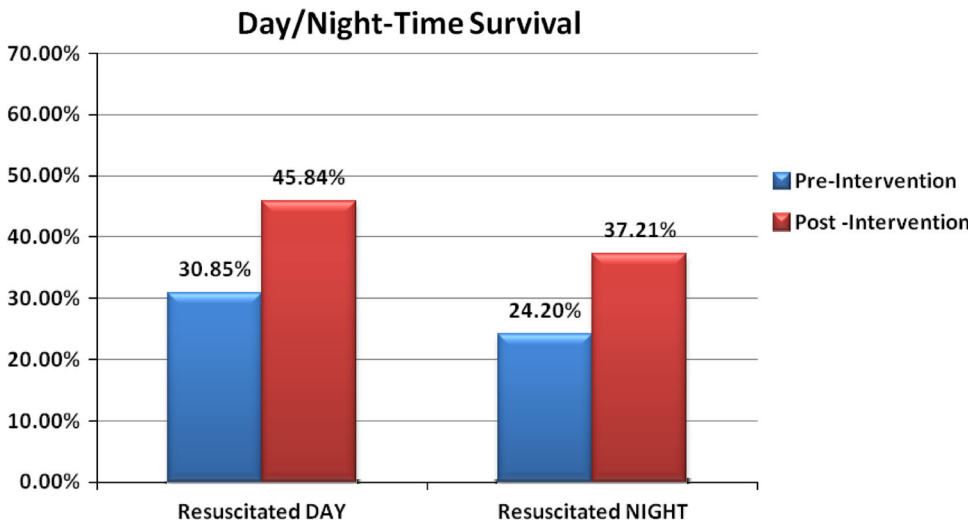

Fig. 2 Day-/night-time survival

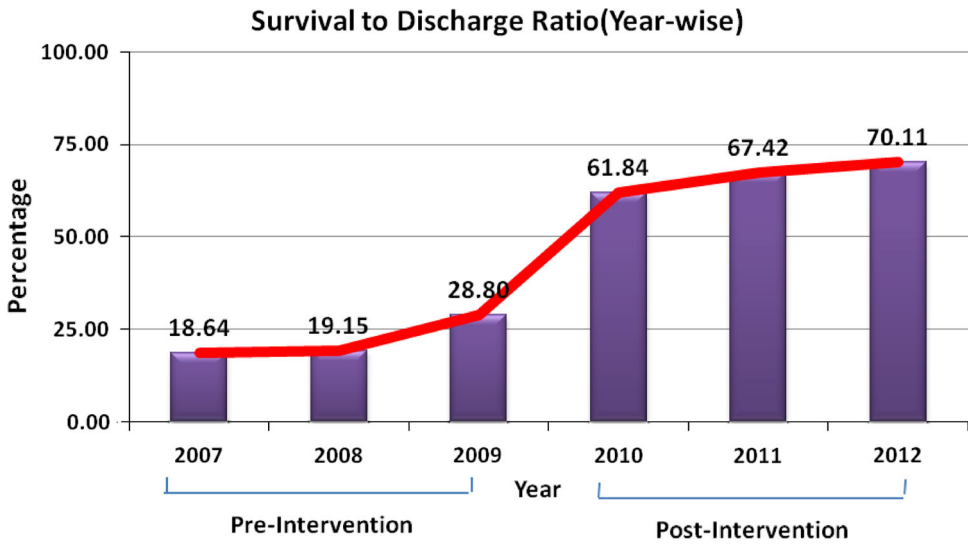

Fig. 3 Survival to discharge ratio (year-wise)

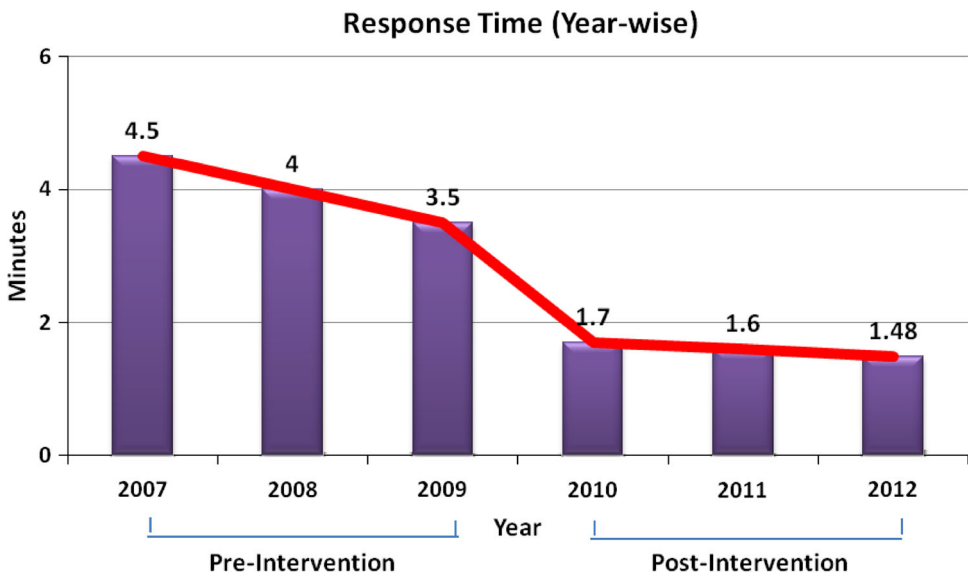

Fig. 4 Response time (year-wise)

Fig. 5 Response to codes shift-wise

(66.6 %) could be discharged home. This increase in survival to discharge was statistically significant ($p < 0.05$). Year-wise survival to discharge ratio is shown in Fig. 3.

The response time to code blue calls decreased from an average of 4 min during the pre-intervention period to around 1.5 min in the post-intervention period. The response time throughout the study period is shown in Fig. 4. The response time decreased from 3.2 to 1.1 min for day-time codes while it decreased from 4.7 to 1.9 min during night-time codes during the two study periods (Fig. 5).

Discussion

During the present study, we modified our institutional resuscitation policy by the introduction of different manoeuvres at various levels and studied the impact of these changes on the hospital resuscitation outcomes. The study results clearly show a statistically significant improvement in the CPR outcomes after the intervention. Survival rates increased significantly ($p < 0.05$) and the response time to code blue decreased from 4 to 1.5 min. This improved response of the code blue team members may be a major factor contributing towards the better immediate survival. Villamaria et al. [12] also showed an improvement in the response time of code blue teams using high-fidelity simulations.

The literature reports lower rates of successful resuscitation during night-time [13]. We also found that the night-time survival during the two study periods was lower than the day-time survival. However, our results show improved survival rates during both the day and night shifts during the post-intervention period. This can be attributed to the uniformity in code-blue team during the post-intervention period, wherein at least one certified ACLS provider was mandatory in the code blue team around the clock. Various studies also confirm improved survival with the participation of certified providers in resuscitation. Moretti et al. [14] in a multicentre cohort study showed that the presence of at least one ACLS-trained member at in-hospital resuscitation efforts increases both short- and long-term survival following cardiac arrest. Dane et al. [15] concluded that patients discovered by an ACLS-trained nurse were about four times more likely to survive than were patients discovered by a nurse without ACLS training. Sanders et al. [16] also showed improvement in immediate resuscitation for patients with ventricular fibrillation/tachycardia after institution of an ACLS-provider course in a rural community hospital. Although Camp et al. [17] could observe a significant increase in resuscitation efforts and reversal of death events after ACLS training and code-team re-organisation in a rural hospital, they could not find an increase in overall survival ($p > 0.3$).

We also observed an overall significant improvement in survival to discharge ratio ($p < 0.05$). Similar findings were observed by Dane et al. [15]. However, Sanders and Lowenstein could not find a significant difference in survival to discharge following ACLS training for in-hospital rescue teams [5, 16]. In our study, we observed a consistent and steady increase in survival to discharge over 3 years during the post-intervention period. This highlights that, besides regular certified ACLS courses, periodical retraining, refresher courses and continued simulations and mock codes can lead to better CPR outcomes.

Restructuring of the hospital resuscitation policy and its effects have been supported by the literature in different forms. At our institution, BLS and ACLS mannequins, airway and choking trainers, defibrillators and crash carts were procured during the post-intervention period and we observed the overall improvement in CPR outcomes. In a review of hospital organization of CPR, Gómez-Arnua et al. in 1999 stressed that hospital CPR should be

supported by an organized plan rather than by the skills of individual health care personnel [18]. In a review of the literature over 10 years, Hamilton concluded that resuscitation training should be based on in-hospital scenarios and current evidence-based guidelines, including recognition of sick patients, and should be taught using simulations of a variety of cardiac arrest scenarios [19]. We also followed a similar protocol and conducted multiple simulation drills at our institution. Dorney, in a university teaching hospital, described an institution's initiative to address multidisciplinary code blue education using a creative acronym coupled with multilevel didactic and simulation exercises [20]. Since most studies assessing the impact of life-support training have reported a deterioration in individual skills with time, remedial and refresher training must be provided, as was done at our hospital [2, 19, 21]. Farah et al. showed that surprise resuscitation drills are the key to improvement of functioning during actual emergency resuscitation. They showed an improvement in calling the doctor, staff work, CPR knowledge and defibrillation ($p < 0.05$) after conducting mock codes [22], but they could not observe any improvement in reaction time or CPR skills. Huseman also had similar findings after 3 months of mock code blue drills. The response times for start of chest compressions and epinephrine administration improved significantly, although the response time to defibrillation did not improve after mock drills [23]. Studies confirm that resuscitation training equipment should be made available at ward/unit level to allow self-study and practice to prevent deterioration between updates [19]. The resuscitation skills labs begun during the post-intervention period catered to the need for hands-on practice for skills refinement of trained personnel.

Keys et al. [24], in an effort to improve resuscitation skills in nursing staff, described a code carnival with a series of learning activities with hands-on practice to enhance the staff's familiarity with emergency equipment and subsequent random unannounced code drills. Similar to our findings, Källestedt recently described the clinical impact of a systematic education of all health care professionals in cardiopulmonary resuscitation and the implementation of 18 automated external defibrillators within one single hospital [7]. The proportion of survivors to hospital discharge improved from 26 % before to 32 % after the intervention, although it was not statistically significant ($p = 0.51$) [7]. Hagyard–Wiebe [11], in a review of the literature, concluded that evidence supports the need for ACLS training for critical care nurses but organized ongoing refresher courses, multidisciplinary mock code blue practice using technologically advanced simulator mannequins, and videotaped reviews to prevent knowledge and skill degradation are required for effective resuscitation efforts.

The importance of prompt defibrillation for in-hospital survival is well documented [9, 12, 18]. In most of the hospital settings, defibrillation may be possible but not readily available as defibrillators are usually placed in critical care areas and mostly only physicians or trained personnel are allowed to use them [19]. Valuable time is thus lost waiting for the defibrillator or the trained physician to use it. By locating defibrillators in different areas throughout the hospital and training appropriate nursing staff to use them, our resuscitation success rates might have improved with early and effective defibrillation. We also ensured the placement of well-equipped crash carts in all areas and the contents of the crash cart were modified from time to time according to feedback. Code blue sheets were modified for better analysis and these were reviewed on a quarterly basis. The effects of the post-resuscitation protocol which was started from January 2012 could not be assessed as only three patients underwent induced hypothermia during the study period.

Our study results confirm that the institutional protocols have a big role to play in the outcomes of resuscitation. This change in organisational policy and strengthening of the infrastructure is especially important in the healthcare scenario in third-world countries, who lack this insight. The multifaceted efforts undertaken by our hospital authorities could potentially show a synergistic effect and help sustain the improved outcomes. Apart from CPR training and strengthening of infrastructure, we reoriented our communiqué team to improve the code announcement system and the code blue team members were trained in immediate response to the code. American Heart Association certified training for the doctors and nurses might have improved the knowledge and skills of the code team members. The conduct of mock codes, simulation drills and refresher courses would have further refined the CPR skills. Reframing of the code blue team with mandatory inclusion of at least one ACLS certified team member might have improved our overall outcomes with better resuscitation skills and more efficient CPR.

Conclusion

We conclude that certified BLS and ACLS training programs along with refresher courses, conduct of mock codes and simulation drills allow teaching/learning, practice, evaluation and refining of the resuscitation skills and can be an aid to development of team concept, orientation to urgently respond to codes, and better recognition and management of peri-arrest scenarios, thereby improving the overall CPR outcomes. Infrastructural changes such as the rapid availability of defibrillators and crash carts may lead to more efficient, responsive and confident

resuscitators, in more comfortable environments during codes. Thus a strong hospital-based resuscitation policy with well-defined protocols is probably the best way to improve CPR outcomes in hospitals. Multidisciplinary hospital-based efforts that reinforce and strengthen the resuscitation protocols may contribute to the improvement in survival of cardiac arrest patients.

Limitations

Several limitations of our study should be acknowledged. This is a single-centre, retrospective, nonrandomized, observational study, so external validity is relative and uncertain. Other multicentre studies are thus required to ascertain the validity. We were unable to identify which interventions were directly associated with improvements in survival as the interventions were individually implemented almost during the same time frame. We were unable to fully adjust for the effects of changes in the overall case mixture, staffing or hospital environment. Our results might be biased because of increased attention on resuscitation during the post-training period. The results of this study may not be applicable to other hospitals in other regions since our study was based on the data from a single tertiary-care hospital in India.

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Conflict of interest The authors declare that they have no competing interests.

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