

Research Article

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Study of compliance of crash carts to standards in the emergency of a tertiary care teaching hospital

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ABSTRACT

Background: The successful management of cardiopulmonary emergencies revolves around the optimum utilization of the golden hour, so that the patient gets the best possible advantage at survival. Aim of the study was to perform gap analysis of crash carts in the emergency of a tertiary care teaching hospital by comparing the salient parameters with standards listed by Resuscitation Council UK (for equipment) and National Accreditation Board of Hospitals and health care providers (for management of medication). Further, to assess the improvement in compliance with the simple intervention of educating staff regarding protocols.

Methods: A descriptive, quantitative, observational study, supplemented in the second phase by an intervention to increase awareness of staff in achieving standardization, followed further by assessing the level of improvement in compliance to standards in terms of content, labeling, documentation and functionality of the contents of the carts.

Results: The root causes of non-adherence to standardization were design of the area and of the cart, amount of workload which led to neglect of labelling, documentation protocols resulting in decreased accountability and inefficient monitoring. This impacted the adequate provision of content and functionality of the items in the crash carts. Human factor engineering in the form of customization of crash carts for cognitive ergonomic design, clarity and awareness of guidelines among the nursing staff i.e. 'first responder' went a long way in improving compliance to standards.

Conclusions: Human factor engineering supplemented by usage of sub-trolleys, along with increasing sensitivity and awareness to standard protocols, can help achieve maximum compliance in terms of the effective functioning of crash carts in the emergency.

Keywords: Crash cart, Resuscitation, Standardization, Customization, Human factor engineering

INTRODUCTION

The successful management of cardiopulmonary emergencies revolves around the optimum utilization of the golden hour, so that the patient gets the best possible advantage at survival.

For achieving this and to improve the response time in management of cardiopulmonary resuscitation (CPR), mobile stocking systems, crash carts/ resuscitation trolleys are used for which a rigorous organization of the

teams and materials is required.¹⁻¹⁰ Studies have highlighted the importance of availability of appropriate equipment, consumables, drugs to successfully manage emergencies along with awareness of staff regarding its location and content; however, it is found that availability of necessary equipment varies from hospital to hospital.¹¹⁻¹³

The layout of the trolley should be standardised throughout the institution including the location and monitoring protocols which should be undertaken on a

daily basis, preferably with storage of adequate disposable and non-disposable medical equipment and drugs.^{14,15}

The Resuscitation Council, UK made recommendations which are considered as the Gold Standard for stocking of relevant resuscitation equipment in crash carts.¹⁶ The National Accreditation Board of Hospitals and Health care providers (NABH), provides standards and warrants mandatory guidelines for effective access to emergency medication including adequate storage of medication in a uniform manner throughout the organization (although the quantity can differ).¹⁷ It also recommends a system of daily checks for ensuring adequate stock levels, monitoring of expiry dates, documentation to set accountability for staff and locking mechanism to prevent theft.¹⁸ There is emphasis on standardization, as it increases the familiarization of the staff using these crash carts and reduces chances of errors and confusion during an emergency.¹⁹

The National Patient Safety Agency (2008:8), UK reported a number of incidents that involved missing or broken equipment, including non-functioning defibrillators due to poor care and maintenance leading to delay in instituting CPR.²⁰ Inadequate training and failure of operators to perform daily checks lead to poor familiarity with the equipment and a failure to identify component failure or damaged devices.²¹ Missing or out dated supplies or equipment due to unavailability of the supply list, has been reported in many studies from around the world.¹⁸

Human error has been identified as one of the major causes for delayed CPR attempts (inadequate knowledge, checking and maintenance) which lead to unfortunate consequences.²² Reports have identified issues such as missing items, empty oxygen tanks, and drained batteries of equipment contributing to human error. So, three factors of clinical emergency preparedness have been identified:

- rapid access to functioning equipment and up-to-date supplies;
- knowledgeable and trained staff to manage the emergency;
- once systems are in place, monitoring those systems¹¹

The study on compliance of crash carts based on requirement of standards was undertaken in a super-specialty tertiary care teaching institute having~1100 beds. The four areas of study were medical emergency, surgical emergency, paediatric emergency and screening areas, of the emergency department which were divided as such for the purpose of better management.

The clinical management of the area was semi-closed type as the administrative control was with the emergency department and the clinical management was

done by specialist chief medical officers, supported by hospital administration and nursing administrators.

The management of the carts is a clinico-administrative issue; standardization of the carts is expected in all areas of the emergency. The total number of beds in the emergency area was about 100, wherein paediatric area, surgical area, medical emergency, had 6, 36, 58 beds respectively. Screening was being used as a transient triaging area.

A total of about 600-700 patients/day availed the emergency services of the institute and among them, approximately 20% patients required resuscitation per day. The approximate average number of emergencies handled in the medical, surgical, paediatric emergency was 90, 30 and 10 per month respectively.

The emergency department was designed in such a way that the areas, though varying in their scope, were administratively managed centrally for close co-ordination and better management.

Objectives

To ensure ready availability of functionally viable crash carts in the emergency, three objectives were identified:

- To perform a gap analysis of the crash carts in the emergency with respect to standard guidelines by the Resuscitation Council UK and National Accreditation Board of Hospitals and Health Care providers.
- To achieve standardization for maintenance of the crash carts.
- To study the effect of awareness on maintenance of standardization of crash carts.

METHODS

It was a descriptive, quantitative, observational study which was conducted at the emergency department of a tertiary care teaching hospital for a period of three months from April 2015 to June 2015 to do a gap analysis of the crash carts. Current medical literature was thoroughly reviewed to identify relevant standards pertaining to the crash carts. As medications are an important part of the crash cart, the relevant objective elements pertaining to the management of medications were also taken into consideration.

Based on these parameters, a check-list was devised which was pre-tested through a pilot study. The modified check-list was then used to carry out a gap analysis of the crash carts.

The crash carts were mainly evaluated on the following parameters: Content; Labelling; Functionality of the equipment; and Documentation.

Interventional phase

Based on the gaps identified, standard operating procedures were discussed with the clinical nursing team. The staff members were made aware regarding the standards.

Descriptive and observational

After implementation of the standards, review audits were conducted for the next three months from July 2015 to September 2015 to assess the level of improvement in compliance to standards.

Study area

The area was selected because of the mandate to handle patients pertaining to medical/ surgical/ paediatric emergency for which crash cart are a prime requisite to efficiently handle initial resuscitation and management of emergencies, thereby ensuring optimum opportunity to improve the clinical outcome for the patient.

Data collection methods

Data was collected through simple random sampling technique. 15 random observations per crash cart were made in the pre and post intervention phases each over a period of 3 months from (July 2015 to September, 2015), with a total of 180 observations made, covering all three duty shifts, as the emergency department should be ready 24 x 7.

Analysis

The data was tabulated using SPSS 1.7 format. Data was analysed using statistical software Stata version 11.0. T-test was used to compare difference in the variables in the pre and post-test phases.

RESULTS

Observations were made with respect to 6 carts in the pre and post intervention phase (3 in medical emergency (including 2 mayo's carts), 2 in surgical emergency (including 1 disaster cart) and 1 in paediatric emergency) with special emphasis on detailing any improvements in the parameters studied in the post intervention phase (Table 1), as follows:

Content of the carts

There was availability of crash carts in each of the three areas of emergency but variation in design was noted wherein out of total 6 carts, 2 were designer, 2 were Mayo's trolleys and the rest were fixed carts. Regarding location, all of the carts were located close to/ inside the resuscitation areas. The designer carts had similar designs with a top shelf, a stand with seventeen containers for keeping drugs, and at the bottom, five

drawers to keep other consumables. The content of the carts had been defined by the stakeholders, with regard to number of items, in contrast to the quantity of each item which varied as per the past utilization of each area. Disaster cart was separately managed as it was meant to be used only during internal or external disasters. Post intervention, significant improvement in compliance regarding defining of stock, reduction in gap between current and defined stock was observed in fixed and designer carts only (which were functionally fixed) due to initiation of the system of documentation. Significant reduction in mixing of drugs was noted in all the carts including Mayo's trolley even despite absence of designed compartments due to proper labelling. The storage of drugs was not as per the ACLS protocol, so, no improvement was noticed in this parameter. However, as regards standardization, it was already being maintained by similar storage pattern of items, drugs including equipment customized locally.

Paucity of space was found to be a major impediment to the proper storage of drugs and availability of sterile packs in the crash carts in paediatric emergency. This was mitigated with continuous training of the staff to increase their awareness regarding location of the packs which were maintained at the nursing counters. Availability of other small sized, critical equipment, like glucose monitor, stethoscope increased significantly in all areas, including the Mayo's trolley, which was frequently shifted from one place to another due to its high usage.

Significant improvement was noted in compliance to standards performed by technical staff like functionality of equipment, by improved documentation, visibility of checklist and amending the reporting protocol to senior nursing staff. Non-significant improvement was observed in securing the carts with lock and key due to overload of patients except in disaster carts where already a robust system was being followed.

Labelling

Although labelling for drawers, drug containers with name and expiry dates was already being done in the fixed carts, improvement to achieve standardization was noticed in the other carts as well except the drawers of the Mayo's trolley, being used as a mobile cart.

Functionality of the equipment

The functionality of equipment inside the cart whether fixed or mobile was being maintained as it was in direct control of nursing staff.

The compliance of parameters regarding additional vital equipment like oxygen cylinder, i.e. its availability, volume of gas present, availability of key which is present outside the cart, improved significantly in all the areas due to proper documentation leading to more accountability.

Documentation

The documentation was initiated for display of the checklists and registers being maintained with signatures of the senior staff. This parameter was complied with in

all the areas, and standardization was achieved for checking stock levels, expiry dates, functionality of equipment including defibrillator and oxygen cylinder, post- intervention.

Table 1: Number of compliant readings against each parameter for each crash cart.

Parameters	Medical emergency			Surgical emergency		Paediatric emergency
	Cart No. 1	Cart No. 2	Cart No. 3	Cart No. 1	Cart No. 2	Cart No. 1
Availability	Present	Present	Present	Present	Present	Present
Type of cart	Mobile (Functionally fixed)	Mobile	Mobile	Fixed	Fixed	Mobile (Functionally fixed)
Design of the cart	Top shelf having emergency drugs stand with bottom 5 drawers	Two shelved Mayo's trolley	Two shelved Mayo's trolley	Open rack embedded in the wall	Closed, lockable cupboard embedded in the wall (Disaster cart)	Top shelf having emergency drugs stand with bottom 5 drawers
Location	In the resuscitation area	No fixed area	No fixed area	Near the resuscitation area	In the resuscitation area	In front of the resuscitation
Content	Pre 0	0	0	0	15	0
Drugs: Emergency: Arranged as per ACLS protocol-area	Post 0	0	0	0	15	0
Drugs: Emergency: Stock defined	Pre 0	0	0	15	15	0
Drugs: Emergency: Gap between the stock defined and current stock	Post 15 (p < 0.05)	0	0	15	15	15 (p < 0.05)
Drugs: Emergency: Gap between the stock defined and current stock	Pre 13	0	0	13	15	13
Drugs: Emergency: Look alike, sound alike drugs not found together	Post 0 (p < 0.05)	0	0	14	15	0 (p < 0.05)
Drugs: Emergency: Look alike, sound alike drugs not found together	Pre 13	13	13	12	15	3
Drugs: Emergency: Look alike, sound alike drugs not found together	Post 12	11	12	15	15	15
Drugs: Emergency: Incidence of mixing of drugs	Pre 12	15	13	15	Nil	14
Drugs: Emergency: Incidence of mixing of drugs	Post 3 (p < 0.05)	8 (p<0.05)	6 (p<0.05)	2 (p < 0.05)	Nil	2 (p < 0.05)
Countable injectable: Stock defined	Pre NA	NA	NA	NA	NA	0
Countable injectable: Stock defined	Post NA	NA	NA	NA	NA	14 (p < 0.05)
Countable injectable: Gap between the defined stock and current stock	Pre NA	NA	NA	NA	NA	15
Countable injectable: Gap between the defined stock and current stock	Post NA	NA	NA	NA	NA	8 (p < 0.05)
Countable injectable: Incidence of mixing of drugs	Pre NA	NA	NA	NA	NA	14
Countable injectable: Incidence of mixing of drugs	Post NA	NA	NA	NA	NA	4 (p < 0.05)

Equipment: Availability of airway, breathing	Pre	10	2	2	10	15	13
	Post	15 (p <0.05)	14 (p<0.05)	14 (p<0.05)	15 (p <0.05)	15	15
Equipment: Availability of stethoscope	Pre	2	0	0	0	15	0
	Post	12 (p<0.05)	8(p<0.05)	8(p<0.05)	7 (p<0.05)	15	10 (p <0.05)
Glucose monitor: Location	Pre	At nursing counter	At nursing counter	At nursing counter	At nursing counter	In the cart	At nursing counter
	Post	In the cart	In the cart	In the cart	In the cart	In the cart	In the cart
Glucose monitor: Availability	Pre	15	0	0	10	15	4
	Post	15	7 (p<0.05)	8 (p<0.05)	15 (p<0.05)	15	15 (p<0.05)
Equipment: Circulation-Availability	Pre	15	15	15	12	15	4
	Post	15	15	15	15	15	15 (p<0.05)
Defibrillator : Location	Pre	Near to cart, but not on the cart	Not on the cart	Not on the cart	Near to cart, but not on the cart	Near to cart, but not on the cart	Near to cart, but not on the cart
	Post	Near to cart, but not on the cart	Not on the cart	Not on the cart	Near to cart, but not on the cart	Near to cart, but not on the cart	Near to cart, but not on the cart
Defibrillator : ECG machine functionality	Pre	15	13	13	14	15	8
	Post	15	15	15	15	15	15 (p <0.05)
Defibrillator : ECG electrodes availability	Pre	5	2	3	3	15	0
	Post	15	15 (p<0.05)	15 (p<0.05)	15	15	15 (p<0.05)
Sterile packs: Location	Pre	At the nursing counter	At the nursing counter	At the nursing counter	At the nursing counter	In the cart	At the nursing counter
	Post	At the nursing counter	At the nursing counter	At the nursing counter	In the cart	In the cart	At the nursing counter
Sterile packs: Availability	Pre	0	Nil	Nil	0	15	0
	Post	7 (p <0.05)	Nil	Nil	15 (p <0.05)	15	3
Lock: Availability	Pre	0	NA	NA	NA	15	0
	Post	2	NA	NA	NA	15	3
Lock: Numbered	Pre	0	NA	NA	NA	15	0
	Post	2	NA	NA	NA	15	2
Oxygen cylinder: Location	Pre	Near to the cart	Away from the cart	Away from the cart	Near to the cart	NA (as bed head panels available)	Away from the cart
	Post	Near to the cart	Away from the cart	Away from the cart	Near to the cart	NA (as bed head panels available)	Away from the cart but in easy access
Oxygen cylinder: Availability	Pre	0	0	0	0	NA	0
	Post	15 (p <0.05)	0	0	10 (p <0.05)	NA	15 (p <0.05)
Labeling: drawers	Pre	4	Nil	Nil	12	15	2
	Post	15 (p <0.05)	Nil	Nil	15	15	15 (p <0.05)
Labeling: Name: For drug containers	Pre	3	12	12	10	15	4
	Post	15 (p <0.05)	15	15	15 (p <0.05)	15	15 (p <0.05)
Labeling Expiry date: For drug containers	Pre	15	11	11	0	15	0
	Post	15	15	15	15 (p <0.05)	15	13 (p <0.05)

Labeling:	Pre	9	9	9	4	15	3
Defibrillator:	Post	15 (p <0.05)	15 (p <0.05)	15 (p <0.05)	15 (p <0.05)	15	15 (p <0.05)
Through defined parameters							
Labeling:	Pre	15	12	12	15	15	13
Defibrillator:	Post	15	15	15	15	15	15
Frequency of checking (once a day)							
Functionality :	Pre	15	13	13	15	15	12
Airway, Breathing; Laryngoscopes	Post	15	15	15	15	15	15
Functionality Bag mask	Pre	3	15	15	8	15	3
	Post	15 (p <0.05)	15	15	15 (p <0.05)	15	15 (p <0.05)
Functionality: Oxygen cylinder: Functionality	Pre	5	NA	NA	7	15	4
	Post	14 (p <0.05)	NA	NA	14 (p <0.05)	15	14 (p <0.05)
Functionality: Oxygen cylinder: Availability of key	Pre	3	NA	NA	15	15	2
	Post	12 (p <0.05)	NA	NA	15	15	15 (p <0.05)
Documentation: For emergency drugs: Frequency of checking (every shift)	Pre	3	10	10	13	15	12
	Post	15 (p <0.05)	15 (p <0.05)	15 (p <0.05)	15	15	15
Documentation: For emergency drugs: Expiry check	Pre	0	Nil	Nil	10	15	3
	Post	8 (p <0.05)	15 (p <0.05)	13 (p <0.05)	15 (p <0.05)	15	15 (p <0.05)
Documentation: For emergency drugs: Quantity check	Pre	5	Nil	Nil	3	15	5
	Post	15 (p <0.05)	15 (p <0.05)	13 (p <0.05)	13 (p <0.05)	15	15 (p <0.05)
Documentation: For emergency drugs: Stock register properly maintained with signatures of senior nursing staff	Pre	3	Nil	Nil	2	15	0
	Post	13 (p <0.05)	Nil	Nil	14 (p <0.05)	15	15 (p <0.05)
Documentation: For equipment: Stock register properly maintained with signatures of senior nursing staff	Pre	3	Nil	Nil	12	15	3
	Post	15 (p <0.05)	Nil	Nil	15	15	13 (p <0.05)
Documentation: Defibrillator: Checklist Displayed	Pre	Nil	Nil	Nil	4	15	Nil
	Post	13 (p <0.05)	13 (p <0.05)	13 (p <0.05)	14 (p <0.05)	15	13 (p <0.05)

DISCUSSION

The study conducted in the emergency department of a Super-specialty Teaching Institute provides us with valuable insight into the maintenance and upkeep of the

crash carts, level of standardization possible according to the design of the area, improved awareness and institution of monitoring mechanisms. The present study showed that with 8-10 CPR's/ day in a particular area which is considered as a heavy workload in addition to

other patient load, sufficient amount of necessary resuscitation drugs can be accommodated in a standard crash cart with daily replenishment to administer effective Advanced Life Support.²³

It was seen that the quantity of items were customized as per the requirement of the stakeholders of individual areas due to current available space, design of the trolley and its mobility, as suggested by NABH MOM 3(e) and Nursing practice educator.²⁴

Initially, due to absence of defined stock levels, daily checking and monitoring practices, stock out situations were observed. This practice was significantly improved by initiating documentation in proper registers with signatures of the concerned staff and counter checking by the senior staff as shown in the study which reduced instances of stock outs and ensured ready availability of items in the carts.

Is customization the way forward?

The concept of mobile sub-trolleys, i.e. Mayo's trolley, in the heavily occupied and congested area like medical emergency served as a boon for managing emergencies where mobile, typical designer carts could actually not be moved. This refutes the concept of standardization where the space and workload of the area became a major bottleneck for standardization.

However, customization was supported by initiating the concept of human factor engineering. Rousek and Hallbeck in 2011 observed that this leads to better visibility, grouping, organization and usability, by saving valuable time in emergency carts.²⁵

It was achieved by instituting appropriate signages, standardized labelling, documentation protocols with regular training of staff.^{18,26} The role of nursing staff who is present in-house and is in the capacity of "First responder" has been highlighted to a large extent in the study.²⁴ In the present study too, the increased compliance and significant improvement in ready availability of properly functional equipment was observed when the reporting shifting to in-house staff with proper documentation and regular inventory checks (as per NABH 3(g) and 3(f)).

Although the storage of drugs needs to be uniformly done as per the ACLS protocol, but it was pointed out clearly in the study that more than following ACLS protocol, the focus should be on a locally customizable but similar pattern of storage for swift location and correct retrieval of item.^{18,27}

Also, avoiding mixing of items should be stressed upon to reduce chances of errors. However, standardization was already being followed in the pattern of storage of items in similar type of carts except in the Mayo's trolley where there was absence of compartmentalization. To

avoid mixing of drugs, proper labelling of containers was done. The recommendation by NABH MOM 3(e), to keep only emergency drugs in the crash carts could not be complied with in the paediatric area, due to paucity of space.²⁷

The standard protocol of locking of the carts to keep the contents safe also depended upon the workload and design of the cart to a large extent. The 100% compliance of locking mechanism with proper system of numbering of keys was observed only in the disaster cart. The other protocols of maintaining the content, labelling, documentation, functionality of equipment were fully complied with in the disaster cart due to its selective usage and fixed, wall embedded cupboard type design.

The frequency of checks initiated were also customized but similar in all the areas of the emergency.²⁸ In this study, the compliance to a system of regular checks of functionality of equipment, as shown in various studies was successfully implemented by proper, supervised documentation.^{27,29,30}

However, it needs to be stressed through this study, that the technical staff responsible for the functionality of equipment is generally posted on on-call basis, but this parameter should be implemented through the local senior nursing staff of the area who are stationed in the area itself. The protocol for displaying standard checklist with a list of compulsory equipment and drugs to be displayed on the trolley to assist in "systematic, visual and functional testing" improved significantly post-intervention.²⁹

CONCLUSION

Emergencies do occur and being prepared for them requires an investment of time, effort and resources to organize and plan their response. In the study undertaken, it can be concluded that, to manage emergencies in an efficient manner, standardization in the crash carts, can be completely implemented in terms of labelling and documentation protocols to increase visibility and accountability of the staff.

Though the customization of quantity of contents, storage protocols have been mentioned, some level of standardization for these in terms of storage pattern should be maintained to aid in familiarity of the staff.

The importance of signages, awareness of staff with regular training signifying the role of end user cannot be refuted. The similarities in design of area and presence of dedicated resuscitation areas have been considered as major bottleneck to achieve standardization. This is especially important for large hospitals, especially preferably public sector entities with heavy workload and older designs of buildings. The concept of mobile sub-trolleys with fixed master carts can be successfully implemented in hospitals facing the above mentioned

bottlenecks, but not without the safety check of labelling and proper documentation. The fact that attempts have been made by the staff to follow various guidelines in the study, cannot be refuted. It has to be accepted that with continuous sensitization and administrative support, maximum compliance can be achieved even with the current workload being handled in the department.

The fact that an improvement in compliance was registered with very small intervention indicates that the objective of having comprehensive, reliable system of crash cart management may be reached by sustained effective daily checking and replenishing of all items on the carts.

Minimising the complexity of the emergency trolley, standardizing the equipment, standardizing the checklist, enhancing nurses' knowledge levels, identifying deficits and immediate replacement of emergency equipment would reduce time delays and errors during CPR.

Recommendations

Improvements in CPR outcomes might be achieved by the standardization of crash carts. Standardized checklists can be used for uniform maintenance of standards, ensuring well stocked and fully functional carts. Developing Standard Operating Procedures with provision of regular audits and inclusion of crash cart maintenance protocols in the in-service education could improve the system.

Audits of missing, faulty or expired equipment or medications during an arrest should be routinely undertaken.

The outcome of the audits should be recorded for future comparative purposes and should be reported to the administration, so that remedial actions can be instituted. Finally, analysing or conducting a post-review after an actual emergency situation, can ensure that all staff provide inputs regarding target areas for improvement.

Limitations

- The study findings are limited to the emergency area of the hospital which cannot be generalized to the other areas considering the scope of service, process flow and amount of load.
- The post intervention audit needs to be extended over a period of atleast 12 more months so that the long term effect of the intervention in this stressful area can be measured.

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