

Review Article

The Emergency Department Crash Cart: A systematic review and suggested contents

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BACKGROUND: As the field of Emergency Medicine grows worldwide, the importance of an Emergency Department Crash Cart (EDCC) has long been recognized. Yet, there is paucity of relevant peer-reviewed literature specifically discussing EDCCs or proposing detailed features for an EDCC suitable for both adult and pediatric patients.

METHODS: The authors performed a systematic review of EDCC-specific literature indexed in Pubmed and Embase on December 20, 2016. In addition, the authors reviewed the 2015 American Heart Association (AHA) guidelines for cardiopulmonary resuscitation and emergency cardiovascular care, the 2015 European Resuscitation Council (ERC) guidelines for resuscitation, and the 2013 American College of Surgeons (ACS) Advanced Trauma Life Support (ATLS) 9th edition.

RESULTS: There were a total of 277 results, with 192 unique results and 85 duplicates. After careful review by two independent reviewers, all but four references were excluded. None of the four included articles described comprehensive contents of equipment and medications for both the adult and pediatric populations. This article describes in detail the final four articles specific to EDCC, and proposes a set of suggested contents for the EDCC.

CONCLUSION: Our systematic review shows the striking paucity of such a high impact indispensable item in the ED. We hope that our EDCC content suggestions help enhance the level of response of EDs in the resuscitation of adult and pediatric populations, and encourage the implementation of and adherence to the latest evidence-based resuscitation guidelines.

KEY WORDS: Resuscitation; Crash cart; Emergency department

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INTRODUCTION

According to 2006 statistics, there are 4,800 operating emergency departments (EDs) in the United States, 3,900 of which receive and care for pediatric patients.^[1] During that same year, about 6 million patients were triaged into the “immediate category”, which required them to be seen by a physician within one minute of arrival due to the severity of their illness.^[2] For patients with such life-threatening conditions presenting to the ED, crash carts have become essential tools for

resuscitation. For instance, in cardiac arrest situations, every minute’s delay in resuscitation can lead to a drop in successful outcomes by 7%–10%.^[3] Thus, timely access to a defibrillator, resuscitation medications, supplies, and equipment should be fast and easy, and crash carts need to be carefully equipped, organized, and maintained.^[4]

Several references recommend having a consistent approach to the organization of the medication drawers in crash carts in order to reduce the likelihood of medication errors and medication retrieval time,^[4,5] and

to ensure correct medication labeling in accordance with The Joint Commission (TJC) medication management standard 4.30.^[6] Few publications have described crash carts specific to the pediatric population, without being specific to the ED,^[7–11] while other publications described “crash cart” or “resuscitation cart” contents in the general and adult populations, without being specific to the ED.^[4–6,12–15]

Around the world, EDs rely on “intrinsic experience” and “best practices” for the layout and content of their crash carts. Many ED nurses and physicians seek guidance when putting together a resuscitation cart for their ED. This article aims at performing a systematic review for articles describing comprehensive crash cart contents—both equipment and medications—specifically in the ED for pediatric or adult populations. In addition, the article aims at proposing a set of suggestions specific for the ED crash cart (EDCC) that encompasses adult and pediatric population needs, based on the 2015 American Heart Association (AHA) recommendations for cardiopulmonary resuscitation and emergency cardiovascular care; the 2015 European Resuscitation Council (ERC) guidelines for resuscitation; and the 2013 American College of Surgeons (ACS) Advanced Trauma Life Support (ATLS) 9th edition, in addition to other clinical guidelines.^[16–20] Additional suggestions are made regarding an EDCC for use in resource-limited settings.

METHODS

On December 20, 2016, the authors performed a systematic review of literature indexed in Pubmed and Embase. Search terms included several crash cart terms (e.g., crash cart, resuscitation cart, code cart); the full search strategy and terms are included in Figure 1. The search was limited to English language only, but not limited by date, clinical setting, or study type. All applicable controlled vocabulary terms were included

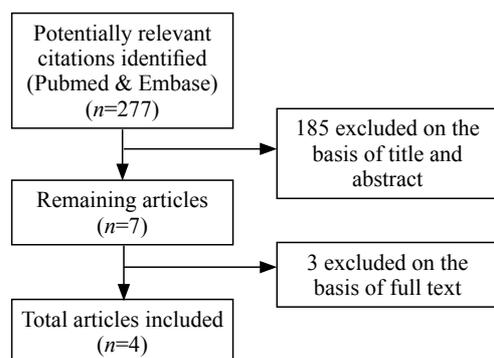


Figure 1. Search protocol.

in the search. Two reviewers independently reviewed all unique titles and selected for abstract review those articles that met the inclusion criteria listed above and whose titles suggested possible emergency department crash cart material. A third reviewer acted as an arbitrator and reviewed any discrepancies to make a final decision. The same 2-step process was performed for the abstract review, and again for the final full article review.

RESULTS

The search yielded a total of 277 results, with 192 unique results and 85 duplicates. After title and abstract review, 185 articles were eliminated because they were not specific to Emergency Departments (EDs) or did not describe crash cart contents. Of the remaining seven articles that underwent full article review, three articles were excluded, because they either did not contain information regarding the contents of the cart, or were not specific to the ED.

Four articles were selected after the final review because they described actual contents of the crash cart, specifically in the ED. However, none of the four articles described comprehensive contents of equipment and medications in both the adult and pediatric populations. Two articles^[21,22] listed equipment for both pediatric and adult populations but none of the medications. One article was specific to pediatric crash carts in the ED,^[8] and another was specific to toxicological emergencies and described the optimal setup for a “Tox” crash cart.^[23] Three articles were written by nurses,^[8,22,23] while the remaining article was written by a surgeon.^[21]

The first article to mention the EDCC was published in 1972 in *Injury* and is entitled “A resuscitation trolley for the emergency and accident department”. It narrates that the “trolley” was being used at the Emergency and Accident Department at the Royal Infirmary in Lancashire, England since 1963. The purpose of the “trolley” was cited as follows: “This trolley has been designed to overcome delays which often arise when a seriously ill or injured patient is... and has been found to be indispensable in the initial management of all types of serious conditions.” It describes the “trolley” as follows: “It measures 40×36×18 inch, has a folding for monitoring the central venous pressure. A shelf 18 inch long at one end, and carries a complete plastic drawer unit on the lower shelf holds drugs, set of intubation apparatus, together with an cross-matching bottles, and needles. Disposable appropriate selection of drugs, intravenous syringes, intravenous solutions, and a transfusion fluids,

and giving sets.” The article does not specify the name of any medication or the size of any equipment listed but has two large pictures of the “trolley” and its contents without labels.

In 1974, a nursing officer at the Northwick park Hospital in Harrow, England described a crash cart that is uniquely shaped like a house with a “roof”,^[22] which is able to hold a full set of adult airway equipment including bronchoscopy on one side, while the other side holds equipment needed for children and infants. These sides can open up revealing a compartment that can support equipment required for ventilation, oxygenation and suctioning. Below the “roof” are two shelves; the top shelf holds intravenous administration sets and fluids for adult and pediatric patients, while the lower shelf holds syringes of all sizes, bandages and splints. An oxygen tank can be fitted on the side of the cart as well.

Twenty years later, in 1994, a registered nurse in Centerville, Massachusetts, described a crash cart for pediatric resuscitations.^[8] The cart had nine drawers that were color coded in coordination with the Broselow® tape, to separate the different pediatric age groups. The drawers were removable to help facilitate running multiple pediatric resuscitations simultaneously. Drugs used in resuscitation were stored in a separate drawer. The cart was checked and replenished after every use, and was checked completely once every 24 hours by a specifically trained nurse.

The final article, from 1995, focused on a crash cart designed for toxicological emergencies.^[23] This cart is a mobile cart that can be used in the ED or on the ambulance ramp. It is made of two drawers; it has a full set of airway equipment found on the top of the cart, along with gastric lavage supplies, pH paper and various blood tubes and specimen containers. Forty-two antidotes are maintained in the two drawers of the cart. It is checked daily and audited monthly. In addition, it includes quick reference guides, common normograms and numbers for the local poison control centers.

DISCUSSION

Our systematic review demonstrated a paucity of literature on articles describing the contents of EDCCs; in addition, the articles found were very old and outdated with the most recent being more than twenty years ago. This shows the potential lack of credibility of these resources and the need for future studies regarding this highly important topic. Most of the equipment and medications used in resuscitation

algorithms have been updated and modified, however there remain certain medications and equipment that all emergency providers use, that should be readily available and were not clearly outlined in the articles reviewed. After reviewing the articles and latest resuscitation guidelines, the authors would like to put forth suggestions that are meant to augment the ad-hoc and heuristic approach to EDCCs.

Suggestions for the Emergency Department Crash Cart (EDCC)

The EDCC is kept in an easily accessible location in the main ED resuscitation area, where it is most commonly used. The cart is mobile on wheels so that it can be moved to another location in the ED if needed. The suggested design for the EDCC is a tall, five-drawer cart. The top three drawers are relatively small and of equal size, the fourth drawer from the top is larger, and the fifth/bottom drawer is largest. A clearly visible content list with expiration dates is attached to the cart. In addition, a laminated alphabetical list of the contents of each drawer is mounted directly on the front of each drawer.

External contents

On top of the EDCC is a biphasic defibrillator with adult paddles and adult multipurpose (defibrillation/c Cardioversion/pacing) pads. Infant paddles with cable and infant pads are placed next to the defibrillator in a transparent bag.

On the EDCC we suggest placing: on one side, one adult (1,000 mL) Ambu-bag with two facemasks (sizes 3 and 4), and one oxygen tube connector in a transparent bag; in a separate transparent bag, one infant (250 mL) and one child (500 mL) Ambu-bag with two facemasks (sizes 1 and 2), and one oxygen tube connector; on the other side, one compressed oxygen tank; on the back of the cart, a hard cardiopulmonary resuscitation (CPR) backboard and a laminated length-based pediatric resuscitation tape, such as a Broselow®.

Internal contents

The top two drawers of the EDCC contain essential resuscitation medications. These drawers are divided into compartments allowing medications to be stored separately and visibly. In addition, each box is labeled with the medication name. The medications in the first two drawers are organized in a systematic way, wherein those with comparable general purpose are grouped in the same rows, and those with more urgency are put

in the front rows. In order to reduce medication error, medications with similar names should be marked clearly and separated by at least one other medication. Several of these medications require protection from excessive light exposure.^[24]

First drawer (Table 1)

The first row of the first drawer contains all the medications used in a cardiac arrest (epinephrine, amiodarone, sodium bicarbonate, and calcium). Vasopressin has been dropped from the 2015 ACLS guidelines in shockable rhythms due to lack of benefit.^[25]

The second row contains Rapid Sequence Induction (RSI) medications needed for intubation, as well as medications for bradycardia. Note that certain medications used in RSI need to be stored in proxy locations (e.g., ketamine in the controlled substances area). Vecuronium is one paralytic that can be placed in the EDCC because it can be stored at room temperature, unlike succinylcholine and rocuronium that require refrigeration. Etomidate is the only sedative suggested for placement in the EDCC for RSI as it has a lower potential for substance abuse compared to other agents. Of note, RSI drugs need not be extensive in areas where intubation is not practiced due to lack of ventilation or subsequent ICU care.

The third row includes medications predominantly used in tachyarrhythmias with a pulse. Some medications can be interchanged with others from the same class with comparable characteristics depending on availability. For instance, Metoprolol might be used as a representative of other beta-blockers.

The fourth row has intravenous medications needed for hypotensive emergencies and for patients with low cardiac output. Hydrocortisone is included for its use in refractory hypotension and suspected adrenal crisis.

Second drawer (Table 2)

The first row in the second drawer is predominantly

stocked with medications for hypertensive emergencies, and decreased mental status due to hypoglycemia and opioid overdose.

The second row contains intravenous and inhaled medications for acute exacerbations of respiratory diseases (asthma, chronic obstructive pulmonary disease, and upper airway edema), as well as medications for allergic reactions.

The third row contains mainly antiepileptic agents in addition to a diuretic. Of note, phenytoin can be stored at room temperature, and hence, is included in the EDCC, while fosphenytoin requires refrigeration and needs to be stored in a proxy location. Naloxone is also kept in this drawer.

The fourth row contains miscellaneous medications such as thiamine to treat Wernicke-Korsakoff syndrome, and glucagon to treat beta-blocker overdose.

Third drawer

The third drawer is reserved mainly for materials to establish peripheral intravenous (PIV) access, and contains some other miscellaneous items as well. The drawer includes: angiocatheters (14, 16, 18, 20, 22, 24 G) for emergent decompression of tension pneumothorax. For PIV access, contents include needles (16, 18, 21, 25 G), alcohol wipes, syringes (1, 3, 5, 10, 20, 30 cc), long spinal needles (Peds: 20, 22 G; Adults: 18 G) for emergency pericardiocentesis, scalpel blades (10, 11, 15), sutures (Nylon 2.0, 3.0, 4.0; Prolene 2.0), radial and femoral arterial line catheters (Peds: 22, 24 G; Adults: 20 G), nasal packs and balloons (unilateral and bilateral) for severe nose bleeding, and a magnet to reset malfunctioning pacemakers/defibrillators.

Fourth drawer (Table 3)

The fourth drawer is designed to store respiratory equipment and supplies for both adults and pediatric patients. The front half of the drawer can be divided into two detachable compartments (pediatric and adult) one

Table 1. Medication contents of the 1st drawer of the EDCC

Norepinephrine	Dobutamine	Vacant	Phenylephrine	Hydrocortisone
Adenosine	Metoprolol [†]	Verapamil	Procainamide	Magnesium
Vecuronium [†]	Etomidate	Vacant	Isoproterenol	Atropine
Epinephrine	Amiodarone	Vacant	Sodium Bicarbonate	Calcium Chloride

[†]: representative drug that may be substituted with another from same class; [‡]: stored at room temperature in powder form.

Table 2. Medication contents of the 2nd drawer of the EDCC

Glucagon	Thyroxine	Oxytocin	Thiamine	Optional
Valproate	Levetiracetam	Phenytoin	Pyridoxine	Furosemide
Albuterol	Ipratropium	Racemic Epinephrine	Dexamethasone	Diphenhydramine
Labetalol	Nicardipine	Hydralazine	Naloxone	Glucose

of which can be removed and placed at the head of the bed during resuscitation, depending on the age group of the patient.

The back half will contain the rest of the supplies: Compact surgical airway set (cricothyroidotomy), batteries and light bulbs for the laryngoscope, tape, endotracheal tube holders, CO₂ detector, and xylocaine spray.

Fifth drawer

The 5th drawer is reserved for larger instruments and supplies needed for special procedures. The contents of this drawer will include: Central venous catheters (3-7 F/ single and triple lumen); intraosseous kit; cut-down tray; umbilical catheterization set (3.5 & 5 F); chest tubes (sizes 10-42); thoracostomy kit; thoracotomy kit; suture set; delivery set; trauma tourniquets; pericardiocentesis kit; sterile stapler; burr hole manual drill kit.

Safety features, expiration dates, and restocking

It is very important for the EDCC to have breakaway plastic locks for safety and to comply with TJC guidelines.^[6] Following each use, the entire crash cart, minus the defibrillator and its external accessories, must be immediately restocked.

Qualified personnel should periodically perform routine inspection of all cart contents. The defibrillator should also be tested on a regular basis. A detailed printed checklist with complete contents and clear expiration dates accompanies the cart. Medication expiration dates should also be checked on a monthly basis by a pharmacy staff member, and replaced accordingly.

Resource-limited settings

Emergency department patient epidemiology in resource-limited settings has not been widely reported, however the most common ED complaints involve infection/sepsis (43.4%) and trauma (28%) in Uganda, and infection (63.7%) in Tanzania.^[26,27] A recent ED epidemiology study in India found the most common

chief complaints to be infectious (21.5%), genitourinary (7.3%), and pulmonary (6.9%).^[28] There is also a paucity of articles that address caring for patients with sepsis,^[29,30] stroke,^[31] and respiratory distress^[31,32] in resource-limited settings. Using this limited data, the EDCC may be modified in resource-limited settings to focus on the suggestions from these articles. The authors recommend that drugs and equipment pertinent to the care of patients with sepsis and acute respiratory conditions be prioritized in their presence and location.

Limitations

This study was limited by the fact that there is a paucity of published literature on EDCC contents, for both high-resource and low-resource settings. Additionally, the search was limited to articles in English so it is possible that articles written in other languages may have been missed in our review.

CONCLUSION

In conclusion, our systematic review highlights a striking paucity of literature describing the contents of a comprehensive EDCC that can be applicable to critical scenarios in both the pediatric and adult populations.

We hope that our suggestions for the EDCC contents help enhance the level of response of EDs in the resuscitation of adult and pediatric populations, and encourage the implementation of and adherence to the latest evidence-based resuscitation guidelines.

As resuscitation guidelines change and technologies advance, the EDCC contents will also require modification. We hope that patient care areas other than the EDs would also benefit from these suggestions, and can customize their crash carts according to their needs.

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Contributors: GJ proposed the study, analyzed the data and wrote the first drafts. All authors contributed to the design and interpretation of the study and to further drafts.

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Table 3. Contents of the 4th drawer of the EDCC

Item	Pediatric sizes	Adult sizes
Oral airway	0, 1, 2	3, 4, 5
Laryngoscope handle	Small	Large
Laryngoscope blade	Straight 0, 1, 2 Curved 2	Straight 3, 4 Curved 3, 4
Endotracheal tube	2.5 to 6.5	7 to 9.5
Stylet	3, 6	14, 16
Nasal trumpet	12-22 F	24-34 F
Laryngeal mask airway	1, 2	3, 4, 5
Tracheostomy tube	2.5-6.5	7-10
Nasogastric tube	8-12	14-18
Bougie	10 F	15 F

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