

Assessment of emergency trolley drugs in a children's hospital. Before and after study on an educational intervention

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ABSTRACT

Introduction. The approach to pediatric emergencies requires specialized resources, and medication errors are common.

Objectives. To describe the contents of emergency trolleys (ETs) in a children's hospital and compare them after an educational intervention.

Methods. The ETs from 9 hospitalization wards were included. A checklist of 30 drugs was developed. ETs were assessed by determining whether drugs were present or absent and their amount. An educational intervention was conducted and assessments were repeated 30 and 90 days after the intervention.

Results. The baseline measurement indicated an overall ratio of adequate drugs of 43.9 % (95 % confidence interval [CI]: 38.4-49.4) with a variation among ETs from 29 % to 54.8 %, and from 15 % to 85 % among drug groups. At 30 days, the adequate ratio reached 70.3 % (95 % CI: 65.2-75.4), with a wide variation among the different ETs and drug groups (from 51.6 % to 93.5 % and from 50 % to 95 %, respectively). At 90 days, the percentages were similar. The comparison between the first and second measurement showed an improvement in all ETs (range: 3.2 %-45.1 %), odds ratio: 3.73 (95 % CI: 2.5-5.6), $p < 0.001$. Results were similar between the second and third measurement.

Conclusions. The baseline measurement showed a low level of adequate ET drugs. After the intervention, this improved significantly and was maintained during the studied period.

Key words: instrumentation, medical emergencies, pediatrics, cardiopulmonary resuscitation.

<http://dx.doi.org/10.5546/aap.2020.eng.234>

To cite: Fernández Achával MI, Mammi LF, Fortini Cabarcos N, Guiñazú GG, et al. Assessment of emergency trolley drugs in a children's hospital. Before and after study on an educational intervention. *Arch Argent Pediatr* 2020;118(4):234-239.

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Funding:
None.

Conflict of interest:
None.

Received: 5-24-2019
Accepted: 12-23-2019

INTRODUCTION

Emergencies that require resuscitation with drugs are uncommon in pediatrics. One of such emergencies is cardiorespiratory arrest (CRA), which has an important morbidity and mortality. In the USA, it accounts for an incidence of 8-20/100 000 children per year and 2-5.5 % of admissions to pediatric intensive care units. It has been estimated that less than 8% of children seen due to a CRA outside of a hospital setting will survive the event, whereas up to 27 % will survive if it occurs within a hospital. In recent years, survival among these patients has improved, partly due to regular updates and the wide dissemination of advanced cardiopulmonary resuscitation (CPR) guidelines.

The approach to pediatric emergencies requires specialized resources, including equipment, drugs, and trained staff.¹ Material- and medication-related errors during CPR are common and may have an impact on patients' morbidity and mortality.^{5,6} For this reason, its use should be based on an organized, effective system.⁶ Health care facilities should have the necessary equipment available and adequately trained health care providers. In this context, an indispensable health care component is the emergency trolley (ET). This type of cart helps to organize the material used during an emergency and is placed in the hospital areas where an emergency is most likely to occur. It should be reserved for use in the situations established in emergency protocols

and use, replacement, and maintenance procedures should be implemented.⁷⁻⁹

In 1995, the American Academy of Pediatrics published guidelines that established the facility characteristics necessary for pediatric emergency care. These guidelines defined the importance of resource organization to provide an optimal and timely response and achieve adequate health care levels for critically-ill patients.¹ In 2003, a new recommendation was published indicating that drugs routinely used in emergency situations should be accessible and clearly labeled based on some sort of visual reference to estimate the drug dose according to weight and/or height. All health care providers should know where every element needed for emergency care is located; and ongoing education is very important for a correct ET use.^{9,10}

Although international guidelines provide recommendations on the desirable ET equipment, in our setting, ET contents are not homogeneous. Sometimes, materials correspond to other requirements, in addition to typical CPR or other emergency needs, resulting from the activities performed where the ET is located.¹¹ Occasionally, it is not clearly defined who is responsible for the replacement and maintenance of its contents. At the hospital where we carried out this study there is no checklist for an adequate drug provision during an emergency. For these reasons, it is important to conduct a study to describe the current situation of ETs and, thus, evidence the problem in our setting and propose possible solutions.

OBJECTIVES

The primary objective of this study was to do an initial descriptive analysis of ET contents in different areas of a children's hospital by comparing them against a previously designed checklist. The secondary objective was to assess the effectiveness of an educational intervention provided to the staff responsible for ET supply and maintenance and compare its contents after 30 and 90 days.

POPULATION AND METHODS

An analytical, prospective, quasi-experimental, non-controlled (before and after) study was conducted in the clinical hospitalization wards dependent on the Department of Medicine of a tertiary care children's hospital in the Autonomous City of Buenos Aires between August 2018 and March 2019.

Based on different publications, drugs considered indispensable in an ET were determined and their minimum amount was defined.¹⁻³ To this end, the possibility of performing advanced CPR for 30 minutes according to current protocols was considered, together with the necessary drug amounts for other emergencies, which was agreed upon with the hospital's departments of pharmacy and nursing and based on drug availability. A checklist was developed based on this information (*Table 1*). All wards where there was an ET were included. The neurosurgery ward was excluded because it was being remodeled. Units where emergencies were managed in a standardized manner, such as the intensive care unit, the intermediate care unit, and the outpatient emergency room, were also excluded.

First of all, 4 trained investigators examined the ETs from 9 hospitalization wards, with the authorization of the Department of Medicine, but not informing the heads of Nursing and Clinical Medicine of each ward: 4 Clinical Pediatrics wards and 5 specialty wards (Hepatology, Pulmonology, Nephrology, and Infectious Diseases [2]), using the previously designed checklist. Each ward had a single ET, whose preparation, maintenance, and verification were the responsibility of nurse managers. For each ET, the presence or absence of drugs was determined. If present, drug's expiry date or sufficient/insufficient amount were also checked.

Once the initial data were collected, the staff responsible for the ET at each of the assessed wards was trained. Training consisted in 2 face-to-face sessions that lasted 1 hour each, during which the importance of having the corresponding material to perform basic and advanced high-quality CPR and other emergencies was described. The checklist was delivered and staff were trained on how to use it. At 30 and 90 days after the intervention, all ETs were reviewed again at a similar time as the first assessment. Visits were not reported in advance to the medical staff or the nurses of each ward so as to prevent outcome bias.


Before data collection, a standard operating procedure manual was developed. The manual detailed checklist coding, adequate data input, and how to note absent or inaccurate information. Drugs were divided into 9 categories for analysis (*Table 2*). Two trained, blinded operators were in charge of double data entry. Input data were compared and no differences were observed.

A descriptive analysis was performed in the first place. For each hospitalization ward and for each of the three measurements, the percentage of adequate items was determined, together with the 95 % confidence interval (CI), and the reasons for items being considered inadequate. Measurements were then compared and the McNemar test for paired data was done to estimate effect sizes and the level of significance

of observed differences. The statistical software package R was used.

Before the conduct of this study, authorization was requested to the heads of the participating units, the Head of the Department of Medicine, and the hospital's Ethics Committee and Research and Teaching Committee. In addition, the confidentiality of all data collected in the data collection sheets was warranted.

TABLE 1. Emergency trolley drug checklist



**HOSPITAL DE NIÑOS
RICARDO GUTIÉRREZ**

EMERGENCY TROLLEY DRUG CHECKLIST

UNIT/DEPARTMENT:			
DATE OF REVIEW:			
SEAL No./CODE:			
<i>The expiry date of each vial should be checked. Those that have expired and/or will expire in the next month should be discarded.</i>			
Drugs	Minimum required amount	Expiry date	Checked
Adenosine	2 vials		
Amiodarone	2 vials		
Adrenaline	10 vials		
Atropine	3 vials		
Sodium bicarbonate	100 mEq x 2		
Neuromuscular blocking agents (vecuronium)	10 mg		
Potassium chloride 3 M	4 vials		
Dopamine	5 vials		
Phenytoin = diphenylhydantoin	15 vials		
Calcium gluconate 10%	2 vials		
Lidocaine	3 vials		
Naloxone	5 vials		
Magnesium sulphate 25%	2 vials		
Fentanyl	2 vials		
Diazepam	2 vials		
Diphenhydramine	2 vials		
Intravenous antipyretic agents: dipyron/ibuprofen	2 vials		
Flumazenil	2 vials		
Furosemide	5 vials		
Haloperidol	2 vials		
Hydrocortisone or dexamethasone or methylprednisolone	2 vials		
Insulin	1 vial REFRIGERATED		
Ketamine	1 vial		
Lorazepam	4 vials REFRIGERATED		
Midazolam	3 vials		
Dextrose solution	2 sachets		
Saline solution 500 mL	2 sachets		
Saline solution	10 vials		
Distilled water	10 vials		

To develop the checklist, indispensable ET drugs were determined and the minimum required amount was defined. It was based on the bibliography and agreed upon with the hospital's departments of pharmacy and nursing based on drug availability and accessibility.
mEq: milliequivalent; mL: milliliter; M: molar.

RESULTS

The first measurement showed a low overall ratio of adequate drugs (i.e., not expired or

insufficient or absent) of 43.9 % (95 % CI: 38.4-49.4), with a variation among ETs from 29 % to 54.8 %, and from 15 % (diuretics) to 85 % (antidotes) when drug groups were considered (Figure 1). The second measurement after 30 days showed an adequate ratio of 70.3 % (95 % CI: 65.2-75.4), with an even greater variation among ETs (from 51.6 % to 93.5 %) and from 50 % (vasopressors) to 95 % (antidotes) among drug groups. The third measurement after 90 days showed similar results to the second one: an adequate ratio of 69.4 % (95 % CI: 64.3-74.5), also with a similar variation among ETs (from 51.6 % to 93.5 %) and, among drug groups, from 45 % (antiarrhythmics) to 90 % (antidotes). The reasons why items were considered inadequate at the three measurements are shown in Table 3.

TABLE 2. Emergency trolley drug grouping based on their use in an emergency

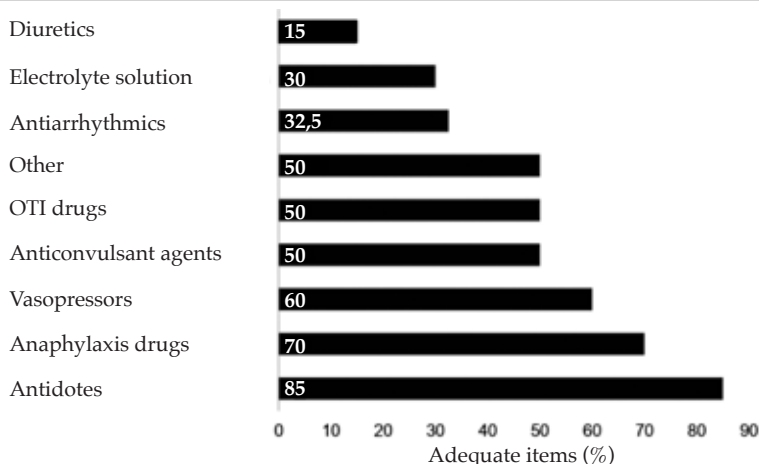
Group	Drug
Antiarrhythmics	Amiodarone
	Atropine
	Lidocaine
Anticonvulsant agents	Diazepam
	Diphenylhydantoin
	Phenobarbital
	Lorazepam
Antidotes	Flumazenil
	Naloxone
Diuretics	Furosemide
	Mannitol
Anaphylaxis drugs	Diphenhydramine
	Hydrocortisone
	dexamethasone
OTI drugs	Fentanyl
	Ketamine
	Midazolam
	Vecuronium
Electrolyte solution	Bicarbonate
	Potassium chloride
	Calcium gluconate
	Magnesium soleplate
	Saline solution vials
	Distilled water vials
	Ringer's lactate solution
	Saline solution x 500 mL
Vasopressors	Adrenaline
	Dopamine
Other	Dipyrene
	Insulin
	Dextrose solution

OTI: oro-tracheal intubation.

The comparison between the first and second measurement showed an improvement in all ETs (range: 3.2 %-45.1 %), with a statistically significant difference between both: odds ratio (OR): 3.73 (95 % CI: 2.5-5.6), $p < 0.001$. We also assessed whether ETs with a greater initial ratio of adequate items had a higher improvement proportion based on the correlation between the ratio of adequate items and the size of change, and Spearman's coefficient r was observed to be -0.29.

The comparison between the second and the third measurement showed similar results: OR: 1.1 (95 % CI: 0.7-1.8), $p = 0.71$, with a reduction in adequate items in 3 ETs (range: 3.2 %-9.7 %), no changes in 1, and improvement in the other 5 (range: 3.2 %-22.6 %). The assessment between the first and third measurement showed a significant and sustained improvement during the study period: 1 ET remained stable and the

FIGURE 1. Assessment of adequate items in the first measurement. Percentage of adequate drugs by category



OTI: oro-tracheal intubation.

rest improved (range: 19.4 %-61.3 %), OR: 3.55 (95 % CI: 2.4-5.3), $p < 0.001$ (Figure 2).

DISCUSSION

According to the USA Agency for Healthcare Research and Quality, improvements in health care quality are reached through systematic thinking, data analysis, and team work to achieve better results and processes and reduce errors that may affect patients and their families.^{12,13} One of the domains of quality is safety, defined as the reduction of risk of unnecessary harm to an acceptable minimum.¹⁴

Several studies tried to analyze the most common errors occurred during emergencies.^{6,16-19} It is evident that, in a stressful situation, as a CRA,

drug administration errors may occur, and an inadequate supply may be the first link in the chain of errors. For this reason, a standardized approach generates a safer environment, especially if the user is not familiarized with the management.¹⁹ This study evidenced a considerable overall improvement in ET drugs after an educational intervention. All ETs in the studied wards showed a significant improvement, although results were not homogeneous among the different hospitalization wards. It is worth noting that the assessment results were sustained in the study period, and no significant differences were observed between the second and third measurement. In addition, the wards with the higher ratios of adequate drugs were the ones that changed their initial contents the least.

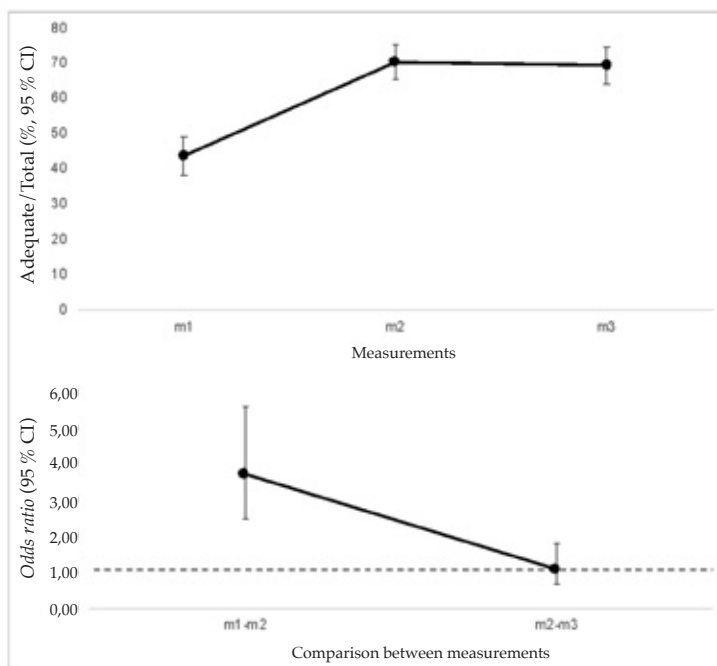
Fierro Rosón et al., assessed ET contents and functioning in a Spanish hospital and described deficiencies that may have compromised or hindered CPR effectiveness, and only a minority of ETs were adequately equipped.¹² Errors in the management of emergencies, such as CPR, caused by resource use problems may lead to a sentinel event (defined as that causing a severe adverse event).¹³⁻¹⁵ This type of event evidences a system weakness that requires immediate analysis and resolution. Because of this, it is important to

TABLE 3. Classification of inadequate items. Differences among the three measurements for inadequate items classified as absent, insufficient, and expired

	Baseline measurement n (%)	30 days n (%)	90 days n (%)
Absent	107 (62.6)	38 (46.3)	24 (43.6)
Insufficient	37 (21.6)	25 (30.5)	27 (49.1)
Expired	27 (15.8)	19 (23.2)	4 (7.3)
Total	171 (100)	82 (100)	55 (100)

n: number of measurements.

FIGURE 2. Comparison among the three measurements. Adequate item ratio over the total for the three measurements. Odds ratio for the difference between the first and second measurement and between the second and third measurement



CI: confidence interval; m: measurement.

implement interventions targeted at this problem in our setting.

In addition, it is worth noting that it is critical for health care services to have their staff trained regularly, even in units where the frequency of CPR or other emergencies is low. According to international recommendations, one of the steps in survival improvement consists in the possibility of having continuously trained staff available because skills deteriorate months after being acquired.²

This study had certain weaknesses. ET contents were analyzed exclusively in relation to drugs. Multiple other materials, such as the devices necessary for airway management or defibrillators, are also a critical part of ETs. These items were not analyzed because, given the format of our ETs (small cases or trolleys with few drawers and open racks), many of them are found in procedure rooms or next to the ETs, not precisely in the ETs. We intend to include them in future measurements. In addition, given ET heterogeneity, it was not possible to assess drug distribution inside the corresponding compartments.

It is known that the protocols for ET equipment vary among the different public and private facilities in the Autonomous City of Buenos Aires, and that there are no regulations in relation to them. This may weaken the external validity of our study. In addition, the areas where CPR is more common, like the emergency department, the intensive care unit or the intermediate care unit, were excluded from this analysis because of structural differences with the other wards.

One of the strengths of this study is that it detected a major deficiency in health care activities, such as an inadequate ET equipment. In addition, it has been demonstrated that establishing an ET protocol together with an educational intervention may help to achieve significant and sustained improvements. We propose to continue making measurements over time and to extend interventions to other hospital areas to try and standardize ET contents.

CONCLUSIONS

The baseline measurement showed a low level of adequate ET drugs. Such level was heterogeneous among the different hospitalization wards. After the intervention, the ratio of adequate drugs improved significantly and was maintained during the studied period. ■

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