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ORIGINAL ARTICLE

Rapid response team led by pediatricians: Experience at a Latin American Tertiary Care Hospital

Equipo de respuesta rápida liderado por pediatras: Experiencia en un hospital terciario de Latinoamérica

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What do we know about the subject matter of this study?

Rapid response teams aim to detect a patient's clinical deterioration and implement timely treatment, avoiding cardiopulmonary arrest and mortality. In high-income countries, the team leader is the pediatric intensivist, anesthesiologist, or pediatric emergency physician.

What does this study contribute to what is already known?

The experience of the rapid response team led by the pediatrician in a high-complexity hospital, including hospitalized patients with different diagnoses, is described. Most interventions were of low complexity. The number of cardiopulmonary arrests decreased in hospitalized children during the years evaluated by the study.

Abstract

Pediatric rapid response teams (PRRT) aim to detect the clinical deterioration of a patient and implement timely treatment, avoiding cardiopulmonary arrests (CPA) and in-hospital mortality. **Objective:** To describe the experience with PRRT led by the pediatrician in a high-complexity hospital. **Patients and Methods:** Descriptive, retrospective, longitudinal study. Hospitalized children under 18 years of age who had a PRRT activation between August 2015 and May 2022 were included. Patients who simultaneously had an activation of the emergency system (suspected CPA) were excluded. Demographic and clinical variables were analyzed through a descriptive analysis. **Results:** We analyzed 225 PRRT events with an activation rate of 17 per 1,000 admissions. Activations were more common in children under two years of age (50%), oncology patients (35%), general hospitalization (88%), the night shift (44%), and respiratory compromise (48%). Most evaluations occurred within the first five minutes (74%). The most frequent interventions were oxygen administration (45%), fluid bolus (43%), laboratory tests (40%), and X-rays (34%). Admission to the pediatric intensive care unit was 45%. The decrease in inpatient CRP was progressive during the time of the study. **Conclusions:** With the implementation of the PRRT, we found a tendency toward fewer CPA events in hospital wards. Most of the therapeutic interventions derived from the PRRT were of low or medium complexity, which supports the pediatrician as the team leader.

Keywords:
Pediatric Rapid Response Team;
Cardiopulmonary Resuscitation;
Cardiac Arrest;
Pediatrics

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Introduction

Hospitalized children may present with deterioration of their condition that, if not detected on time, could progress to cardiopulmonary arrest (CPA). CPA in children is frequently preceded by abnormal vital signs and changes in clinical status hours before the event occurs.[1] Pediatric rapid response teams (PRRTs) are comprised of healthcare professionals who respond when a patient has a clinical deterioration in hospital wards and implement treatments early to prevent CPA, unplanned admissions to the pediatric intensive care unit (PICU), and hospital mortality[2–6]. However, some studies have failed to demonstrate these benefits[7–9].

The implementation of RRTs is fairly widespread in high-income countries but has been more limited in middle- to low-income countries, with few published studies, mainly in adult and oncology populations[6,10–12]. A multicenter study in children with cancer in 32 hospitals in Latin America found that the implementation of the Pediatric Early Warning System (PEWS), reduced hospital mortality and mortality from clinical deterioration events, as well as the need for cardiopulmonary resuscitation[6].

Some barriers detected for its implementation are the perceived shortage of personnel for its conformation and the consideration of requiring the participation of a pediatric intensivist, pediatric emergency specialist, or anesthesiologist as part of the team, which may generate higher costs[13]. The correct functioning of this strategy requires the training of team members, who should be trained in the recognition of the clinically deteriorating and critically ill patient, as well as in initial stabilization. Failure to do so could increase the number of ineffective team calls, the number of unjustified transfers to the PICU, and possibly the costs of health care.

The objective of this study was to describe the experience of the PRRT led by a pediatric hospitalist in a tertiary hospital in Colombia.

Patients and Method

Study design

Retrospective longitudinal descriptive study. All patients younger than 18 years admitted to pediatric hospital wards who had a PRRT activated during hospitalization between August 2015 and May 2022 were included. Patients who had the emergency system activated due to CPA at the same time as the PRRT activation were excluded. Multiple activations in the same patient were analyzed as independent events.

Data were collected from the institutional database and demographic and clinical variables related to PRRT activation were analyzed. The 2020 Pediatric Advanced Life Support guidelines were used as a reference for the classification of vital signs[14]. Blood pressure was classified as normal, hypertension, or hypotension. Heart rate was classified as normal, bradycardia, or tachycardia. Respiratory rate was classified as normal, bradypnea, or tachypnea. Axillary temperature was measured according to institutional protocols, classified as normal between 36°C-37.9°C; hypothermia for temperatures below 36°C and fever above 38°C. The 2007 American Academy of Pediatrics guidelines were used for the diagnosis of arterial hypertension[15].

Other variables were analyzed, such as PRRT response time, the time of day when the PRRT was activated, the involved system that triggered the activation, such as the respiratory one (respiratory distress, desaturation, or cyanosis), the circulatory one (hypotension, tachycardia, slow capillary filling, or thermal gradient), and clinical outcomes (death or admission to the PICU). In addition, we analyzed the treating specialty, the unit in which the patient was hospitalized when the event occurred, comorbidities, interventions performed, the number of CPAs in hospital wards and PICU, and the total number of PRRT activations during the study period.

Definitions

Emergency system activation

Loudspeaker call to the emergency team in case a patient does not respond when called or is not breathing.

PRRT activation

Alert by nursing staff to the pediatrician of a ward to warn of a change in a patient's condition that requires priority evaluation. This alert can be verbal or via telephone, depending on the presence or absence of the pediatrician in the unit where the patient is located.

PRRT strategy in the institution

The institution where the study was carried out is a high-complexity hospital in Medellin, Colombia. The pediatric department has 143 beds, including general hospitalization, emergency room, *Klebsiella pneumoniae* carbapenemase cohort unit, bone marrow transplant unit, PICU, and neonatal intensive care unit (ICU). At the time of the study, 5 pediatricians were available on the morning shift (7 am to 1 pm), 2 on the afternoon shift (1 pm to 7 pm), and 1 on the night shift (7 pm to 7 am).

The implementation of the PRRT at the *Hospital Pablo Tobón Uribe* began in 2009 in the pediatric hospital wards, with the participation of the pediatrician as team leader, training of care staff in the strategy and

in the clinical record, which was initially performed in written format and since 2015, in the electronic medical record. The last update to the protocol was carried out in 2017, where new training was given to the healthcare personnel, pediatricians, nurses, and nursing assistants, and the PRRT response time began to be measured, with a goal of 15 minutes. A pre-designed note was designed in the electronic medical record, with some clinical variables for follow-up, and a medical reevaluation was implemented within 6 hours of its activation.

The team is made up of the pediatrician on duty in the hospital wards who is the team leader, the hospital ward nurse, and the patient's nursing assistant. Activation is performed by the nursing staff due to an alteration in the patient's vital signs or general condition (Supplementary Figure 1, available online version), risk factors of the patient, clinical concern of the health staff, or concern of the family. A detailed description of the institutional PRRT strategy is provided in Appendix 1 (online version available).

Statistical analysis

A descriptive analysis was performed. Categorical variables are reported as frequencies and proportions; for quantitative variables, normality was assessed using the Shapiro-Wilk test and, according to this, they are presented as median and interquartile range (IQR) or mean and standard deviation (SD). The data were analyzed in the RStudio Version 1.3.1093 software.

The study was approved by the institution's ethics committee (2022.026, March 2022).

Results

227 PRRT activations were registered. Of these, there were two simultaneous emergency system activations with the PRRT that were excluded, so a total of 225 events were analyzed. The activation rate was 17 per 1,000 admissions. Activation occurred most frequently in children under two years of age (n = 112; 50%), during the night shift (44%), and in general hospital wards (n = 193; 88%). Oncologic disease was the most frequent pathology (35%), and 13 (50%) patients had recently undergone bone marrow transplantation. Sepsis was diagnosed at the same time as activation in 10 (4%) patients. Table 1 presents the demographic and clinical characteristics of the participants.

The most frequently involved system leading to PRRT activation was the respiratory system in 48% of cases. Two patients (1%) presented CPA within 24 hours of PRRT activation. Table 2 shows the characteristics of PRRT activation, its causes, and patient outcomes. Overall, the mean response time was two minutes and most evaluations occurred within the first five minutes (n = 167; 74%).

When vital signs were analyzed at the time of activation, 69 (31%) patients had at least one alteration, 55 (25%) two, and 43 (19%) three abnormalities (Table 3). Glucose levels were measured by fingerstick in 25 patients: 20 (80%) were normal, four (16%) were hypoglycemic, and one (4%) was hyperglycemic.

Table 4 summarizes the interventions performed after PRRT activation. The most frequent were oxygen requests (45%), intravenous fluid bolus (43%), blood tests (40%), and X-rays (34%).

Outcomes

Of the total number of patients, 102 (45%) required admission to the PICU after activation of a PRRT. The median length of stay in the PICU was five days (IQR: 3-11 days). Transfer to this unit was justified in 99 patients (97%); three patients did not meet clear criteria for transfer to a higher complexity unit and of these two remained in the PICU for less than 24 hours.

Of all patients admitted to the PICU, 31 (30%) required invasive mechanical ventilation, 18 (17%) high-flow cannula, 7 (7%) non-rebreathing mask, 1 (1%) Venturi mask at 50%, and 1 (1%) noninvasive ventilation. In addition, 22 (21%) patients required vasopressor support, 4 (4%) renal replacement therapy, and 30 (29%) analgesic or anticonvulsant infusion.

Figure 1 shows the number of CPAs between 2016 and 2021 in the general hospital ward and PICU. Between August and December 2015, six PRRTs were activated and six CPAs occurred (5 in the PICU and 1 in the general ward). Between January and May 2022, there were 13 PRRT activations and 24 CPAs (24 in the PICU). During the study period, 8% of the CPAs occurred in general hospitalization. The decrease of CPAs in hospitalization was progressive, occurring in 2015 at 17%, in 2016 at 20%, in 2017 at 14%, in 2018 at 8%, in 2019 at 6%, in 2020 at 2%, in 2021 at 4%, and in what was evaluated in 2022, no CPA was reported.

Discussion

We report the implementation of pediatric rapid response team, led by a general pediatrician. Most activations occurred in patients under two years of age, the respiratory system was the most involved, and most responses occurred within the first five minutes. 45% of patients were admitted to the PICU. With this strategy, the number of CPAs in hospital wards decreased in the reporting period.

Most of the existing literature on RRTs comes from North America and Australia, with few studies in Latin America[6,10]. With our ten years of institutional experi-

Table 1. Clinical characteristics of pediatric rapid response team activations

Characteristics	n = 225 n (%)
Male	118 (52)
Age (months), median (IQR)	24 (8-120)
< 2 years	112 (50)
3 - 7 years	37 (16)
8 - 12 years	46 (21)
13 - 17 years	30 (13)
Length of stay (days), median (IQR)	20 (10-33)
Treating specialty	
Pediatrics	203 (90)
Hemato-oncology	17 (8)
Nephrology	3 (1)
Pediatric surgery	2 (1)
Unit	n = 219
General ward	193 (88)
KPC cohort unit	16 (7)
The bone marrow transplant unit	9 (4)
Radiology	1 (1)
Comorbidity	75 (33)
Oncological disease	26 (35)
Epilepsy	6 (8)
Benign hematologic disease	5 (7)
Heart disease	5 (7)
Metabolic disease	5 (7)
Liver disease	4 (5)
Tracheostomy	4 (5)
Chronic kidney disease	3 (4)
Chronic lung disease	3 (4)
Cerebral palsy	3 (4)
Others[a]	11 (14)

KPC: Klebsiella pneumoniae carbapenemase. IQR: interquartile range. [a]Others: Down syndrome (3), Diabetes mellitus type 1 (2), postoperative (2), traumatic brain injury (1), autoimmune disease (1), liver transplant (1), and heart transplant (1).

Table 2. Characteristics of pediatric rapid response team activations and their outcomes

Characteristics	
Time	
Morning events (07:00-13:00)	52 (23)
Afternoon events (13:00-19:00)	75 (33)
Nighttime events (19:00-07:00)	98 (44)
Median response time in minutes (IQR)	n = 193 2 (1-5)
The compromised system	
Respiratory	109 (48)
Circulatory	69 (31)
Central nervous	47 (21)
Activation alarm sign	
Respiratory distress	69 (31)
Seizure	32 (14)
Desaturation	30 (13)
Hypotension	29 (13)
Tachycardia	17 (8)
Altered state of consciousness	10 (4)
Cyanosis	8 (4)
Poor perfusion	6 (3)
High blood pressure	5 (2)
Syncope/lipothymia	4 (2)
Bradypnea/apnea	4 (2)
Others	8 (4)
Evolution	
Improvement	123 (55)
Pediatric ICU transfer	102 (45)
Outcome	
Discharge	207 (92)
Death	18 (8)
Cause of death	
Septic shock	12 (67)
Respiratory failure	5 (28)
Gastrointestinal bleeding	1 (5)
The time between PRRT and death (Days), Mean (SD)	30,1 (± 25.7)

PRRT, pediatric rapid response team; IQR, interquartile range; ICU, intensive care unit; SD, standard deviation.

ence, the PRRT strategy has improved significantly. We observed a steady increase in protocol compliance, along with improved training of team members. As a result, PRRT activation rates have also tended to increase.

Our PRRT activation rate was 17 per 1,000 admissions. This figure is below that proposed by some authors, where a successful RRT proposes to have more than 25/1,000 and a mature team should reach at least 40/1,000 admissions since an increase in effective calls is associated with a progressive reduction in arrest events[16]. However, our strategy was able to markedly reduce the occurrence of CPA in children hospitalized in the pediatric ward.

The main strength of our PRRT strategy is the leadership of the pediatric hospitalist along with the participation of well-trained nursing staff. At our institution, we use the strategy based on altered vital signs, similar to the study by Olson et al.[17]. Other PRRT protocols have been described, comprising pediatric intensivists, critical care nurses, and anesthesiologists,[21] who responded to 614 activations, including in the emergency department, PICU, and neonatal PICU. Furthermore, their experience differs from ours in that PRRT activations were more frequent in the afternoon (43%). This difference could be explained by the lower availability of pediatricians on the night shift at our institution. Similar findings to our study were the response time of less than five minutes, the frequency of activation in children under 12 months of age (43%), and activation secondary to respiratory distress (45.8%). These findings are

Table 3. Patient's vital signs at the time of activation of the pediatric rapid response team

Characteristics	n (%)
Blood pressure	
Normal	171 (77)
Hypotension	32 (14)
High blood pressure	20 (9)
Heart rate	
Normal	136 (60)
Tachycardia	81 (36)
Bradycardia	8 (4)
Respiratory rate	
Normal	115 (51)
Tachypnea	98 (44)
Bradypnea	11 (5)
Saturation	
> 90%	144 (65)
≤ 90%	78 (35)
Temperature	
Normal	168 (75)
Feber	44 (20)
Hypothermia	11 (5)

Table 4. Interventions performed after pediatric rapid response team

Interventions	n (%)
Investigations	
Blood test	95 (42)
Blood gases	55 (24)
Microbiological cultures	45 (20)
Chest X-ray	77 (34)
Computerized tomographic scan	17 (8)
Ultrasound	4 (2)
Electrocardiograph	14 (6)
Respiratory assistance	
Oxygen	102 (45)
Endotracheal tube	2 (1)
Tracheostomy permeabilization	2 (1)
Circulatory interventions	
Intravenous fluid bolus	97 (43)
Blood products	11 (5)
Drugs	
Bronchodilators	38 (17)
Antibiotics	32 (14)
Analgesics	11 (5)
Benzodiazepines for seizure	8 (4)
Adrenaline for anaphylaxis	8 (4)
Electrolytic reposition	4 (2)
Other interventions	
Surgery	2 (1)
Endoscopy	2 (1)
TIPS	1 (0.5)

TIPS: transjugular intrahepatic portosystemic shunt.

comparable to those of other studies, in which 3,647 activations were reported mainly in children under 3 years of age.[21,22]

Recently, some studies suggested that the strategy could be based on PEWS, which can improve team con-

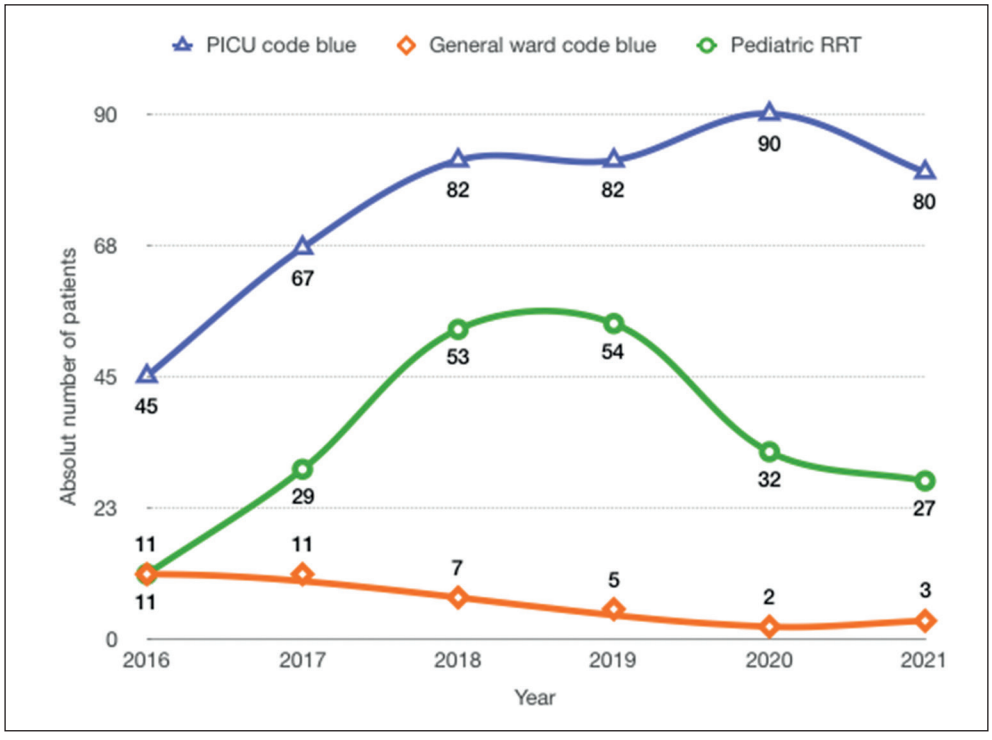

Figure 1. Number of pediatric rapid response team activated per full year to code blues in the same period. PICU: pediatric intensive care unit. RRT: rapid response team.

fidence in detecting and managing critically ill patients, in addition to allowing greater autonomy to the nursing staff[11,18-20]. The multicenter study by Agulnik et al. evaluated the implementation of the PEWS scale. They found that clinical deterioration events were higher for sepsis and secondly for respiratory dysfunction[6]. However, this study only included patients with oncologic disease. It is important to clarify that there is still no standardized tool to evaluate the clinical deterioration of pediatric patients hospitalized outside the PICU.

Our PICU admission rates after PRRT activation were similar to those reported by other authors, ranging from 24% to 59.6%[21-25], but were much higher in the study by Agulnik et al. after PEWS implementation (88%), probably due to the characteristics of their study population (oncologic patients)[6] On the other hand, the frequency of pharmacological (42%) and nonpharmacological (43%) interventions, as well as patients requiring ventilatory support, were different from another study in which rates of 89%, 59%, and 6.1%, respectively, were found[22]. We attribute this to the nature of our institution, which focuses on high-complexity care. Our results showed that most of the therapeutic interventions derived from the PRRT were of low or medium complexity, similar to other reports, which endorse the pediatric hospitalist as team leader[25,26].

Mortality after PRRT activation was 8%, which is within the 6.7% and 12.6% previously described[22,27,28]. However, the study by Agulnik et al[6]. reported higher hospital mortality (39.5%) and mortality from clinical deterioration events (32.9%) compared with our results, related to oncologic comorbidities. Another Brazilian study in an adult population showed no reduction in mortality. However, the RRT strategy improved ICU admission flow, with a decrease in ICU bed waiting times and an increase in the recognition of patients eligible for palliative care[10]. This type of strategy could prove valuable in settings where PICUs are scarce, such as in Latin America, improving the timeliness and effectiveness of admissions to these units.

Low rates of CPA in hospital wards should be one of the main objectives of any institution. The universal consensus is that CPA should occur in the PICU because, given continuous monitoring, real-time detection is possible, where there is immediate assistance from highly trained personnel more familiar with pediatric cardiopulmonary resuscitation, with specialized resources and logistics for adequate care of such events[29]. However, the evidence for this claim is controversial. An Italian study concluded that the location of a patient experiencing CPA affected survival at discharge. When CPA occurred in areas with continuous monitoring and an immediately available response team, for example in the PICU, survival was higher than when it occurred in the general hospital ward[30]. However, other studies have failed to replicate these findings[31,32]. Despite contradictory evidence, the trend over time has been for pediatric CPAs to occur in PICUs, causing an increase in CPAs in these specialized units from 87% to 96% between 2004 and 2011[33]. This is also our case, with only 8% of CPAs occurring in general hospital wards during the study period, similar to other reports.[25] The multicenter study by Agulnik et al. similarly reported a reduction in CPA in hospitalization, as well as the need for cardiopulmonary resuscitation[6].

One of the most important questions in the findings of the RRT studies is the implementation of the teams and the thoroughness of the resulting actions. Some of the critical aspects found have been the leadership of the team, the capacity for teamwork, indecision in the face of the behaviors, and distress that the evaluation of the patient by an RRT may generate in the family, in the patient, or in the treating team, which may lead to inappropriate medical behaviors[34]. Our results show that 3% of PICU admissions did not meet clear criteria for transfer to this more complex unit according to institutional protocols. Although this is a low percentage, it is crucial to monitor the behaviors derived from the PRRT, since inappropriate behaviors can lead to greater risks for the patient and cost overruns in care.

The PRRT system requires careful planning that is adjusted to the context, needs, and resources of each institution. The benefits obtained from the implementation of this system may go beyond the reduction of patient morbidity and mortality, especially when the PICU resource may be limited, and may reduce unexpected admissions and increase access to more specialized health care with improved quality of care because of better planning.

Our experience suggests that a PRRT led by a pediatric hospitalist and based on a strategy of detecting alterations in vital signs is effective in reducing CPA in hospital wards in the following context: second- or third-level of care hospitals with medium- or high-complexity hospital wards and in low- or middle-income countries. This strategy allows initial care and subsequent transfer to the PICU on time.

We suggest that for the implementation of this strategy, an education program focused on the recognition and stabilization of pediatric critically ill patients, aimed at the entire care team in charge of the patient, such as nursing staff and general practitioners, and a team led by the pediatric hospitalist should be formed, with specific actions to be performed after the activation of this. This implementation can be carried out with the available resources of each institution, framed in high-quality care policies.

Regarding the limitations of the study, we highlight the fact that it was conducted in a single center and that the tool for detecting and activating the PRRTs

was adapted by the institution, so the results cannot be generalized.

Conclusions

With the implementation of the PRRT, we found a tendency for fewer CPA events to occur in hospital wards. Most of the therapeutic interventions derived from the PRRT were of low or medium complexity, which endorses the pediatric hospitalist as the team leader.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

Financial Disclosure

Authors state that no economic support has been associated with the present study.

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