Characteristics and Outcomes of Pediatric Rapid Response Teams Before and After Mandatory Triggering by an Elevated Pediatric Early Warning System (PEWS) Score

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KEY WORDS
early warning system, pediatric, rapid response team

ABBREVIATIONS
PEWS: Pediatric Early Warning System
RRT: rapid response team

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abstract

BACKGROUND: The Pediatric Early Warning System (PEWS) was created to identify unstable patients before their deterioration. Rapid response teams (RRTs) were developed to assist with management of such patients. In 2009, our institution mandated the activation of RRTs if a PEWS score was elevated (ie, ≥5).

OBJECTIVES: The goal of this study was to examine changes in characteristics of RRT calls before and after the implementation of a mandatory hospital policy requiring RRT activation due to an elevated PEWS score.

METHODS: This study was a retrospective database review, with RRT data from June 2007 to December 2010 examined. A total of 44 RRTs were recorded before mandatory triggering and 69 RRTs afterward in the study period ($P = .32$).

RESULTS: Compared with the premandatory group, the mandatory triggering group found that tachycardia was a more frequent trigger for RRTs, with an increase of 26.1% ($P = .004$). RRTs triggered by a change in mental status/agitation decreased by 22.9% ($P = .009$). An increase of 15.1% of RRTs required no interventions with mandatory triggering. Nighttime RRTs increased by17.5% ($P = .07$). There was a trend toward decreased PICU transfers in the mandatory triggering group, with no significant change in code blue calls.

CONCLUSIONS: A hospital policy of mandating RRT activation based on PEWS scores increased nighttime calls and altered the primary reasons for RRT activation in our center, with no evidence of improvements in patient care. These findings should be interpreted with caution given the relatively rare outcomes the policy is intended to prevent; however, our findings highlight the difficulties inherent in evaluating methods to improve pediatric patient safety.

The delay in timely recognition of the decompensating pediatric patient, with subsequent delay in treatment, has been identified as a source of preventable cardiac arrest and mortality.[1] Systems solutions that have been created to address this delay of care include rapid response teams (RRTs) and Pediatric Early Warning System (PEWS) scoring.

The implementation of RRT programs at institutions caring for pediatric patients has been associated with a decrease in cardiopulmonary arrest as well as a decrease in PICU mortality after readmission to the PICU.[2–5] Research by Sharek et al[6] demonstrated that the implementation of an RRT system was associated with a statistically significant reduction in the mean monthly mortality rate by 18% and the mean monthly code (respiratory or cardiopulmonary arrest) rate by 71.2% outside of the PICU.

Several early warning scoring systems have been developed for pediatric populations to help identify deteriorating patients earlier. One of these tools includes the Brighton PEWS, developed by Monaghan[7] to preemptively identify children at risk for cardiopulmonary collapse. The Brighton PEWS was validated by Tucker et al[8] in a prospective study which demonstrated that high PEWS scores were associated with increased likelihood of transfer to the PICU. In a retrospective study by Skaletzky et al,[9] the Brighton PEWS was modified further to a total 9-point score (Fig 1) that exhibited 62% sensitivity and 89% specificity for transfer to a higher level of care with a score of ≥2.5. However, it remains unclear whether this PEWS scoring paradigm can improve the quality of patient care and, ultimately, outcomes.

Recently, the combination of using early warning scoring systems as well as RRTs has been studied to assess whether further improvements in patient safety could be made and influence outcomes. In a 2010 study by Akre et al,[10] 170 non-ICU RRT and 16 code events were analyzed with retrospective PEWS scoring to evaluate the sensitivity of the score as an early indicator of patient deterioration. The results showed that 85.5% of patients had at least 1 critical PEWS score before an RRT or code blue was called, with a median time of >11 hours before the event. The data suggest PEWS scoring can play a substantial role in improving recognition of worsening patient conditions and provide earlier RRT interventions.

There is a paucity of data, however, examining what the effects of mandatory activation of RRT calls by an elevated early warning system score, such as the modified Brighton PEWS score, are on the characteristics of the RRTs. The present single-center retrospective study was designed to evaluate the effects of such a mandatory hospital policy on the characteristics of RRT calls before and after implementation. Specifically, we examined changes in the location and timing of RRT calls, the reasons RRTs were activated, the interventions undertaken during the RRT calls, and subsequent outcomes.

METHODS

We conducted a retrospective review of the Pediatric Rapid Response database compiled by the Division of Quality and Safety at a single children's hospital before and after mandatory reporting and activation of RRTs with the modified Brighton PEWS score. RRT data from June 2007 to December 2010 were examined, with the mandatory hospital-wide policy having gone into effect January 1, 2009.

This quality assessment project was approved by Stony Brook University Medical Center's Division of Medical and Regulatory Affairs. The study was performed at Stony Brook Long Island Children's Hospital an accredited children's hospital with a university affiliation. Since 2007, our institution has used the modified Brighton PEWS scoring on all admitted pediatric patients, with repeated scoring conducted on every set of serial vital signs during hospitalization, excluding patients admitted to the PICU (where PEWS scoring was not performed after admission). The PEWS scores were tallied by the nurse, with each set of vital signs based on scores in the 3 domains of behavior, cardiovascular, and respiratory profiles.

In January 2009, the institution implemented a new hospital policy, which required the activation of RRTs based on the modified PEWS score totaling 5 ("red" score) or higher. The red PEWS score mandated that an RRT call be made, independent of other patient factors or caregivers' concerns. The RRT was called on the overhead paging system, and it was made regardless of previous RRT calls a patient may have had, even if the previous set of vital signs indicated a red PEWS score and launched a previous RRT call. As with RRT activations before the mandatory triggering period, pediatric RRTs could be activated by patients, caregivers, or any member of the hospital staff, based on any concerns, including abnormal vital signs,

Score	0	1	2	3
Behavior	Playing/appropriate	• Sleep • Fussy but consolable	Irritable/inconsolable	• Lethargic • Confused • Reduced response to pain
Cardiovascular	• Pink • Capillary refill 1 to 2 seconds	• Pale • Capillary refill 3 seconds	• Grey • Capillary refill 4 seconds • Tachycardia of 20 above normal rate	• Mottled • Capillary refill ≥5 seconds • Tachycardia of 30 above normal rate or bradycardia
Respiratory	• Within normal parameters • No retractions	• >10 above normal parameters • Use of accessory muscles •≥30% Fio_2 •≥3 L/min	• >20 above normal parameters • ≥6 L/min • Tracheostomy and ventilator dependent	• Below normal parameters with retractions • Grunting • 50% Fio_2 • ≥8 L/min

FIGURE 1 PEWS scoring algorithm as adopted from the earlier version by Monaghan.

a significant change in the physical examination, acute respiratory compromise, or an acute change in mental status (eg, seizures).

The initial PEWS score was recorded by the nurse caring for the patient in the emergency department. After admission, the PEWS score was tabulated by the nurse assigned to the patient every time vital signs were taken, which was every 4 hours on the general pediatrics ward and hematology/oncology ward. If the patient's PEWS score totaled ≥5, a rapid response was called overhead regardless of any other circumstances.

The RRTs included a senior pediatric resident, critical care nurse, respiratory therapist, and the patient's bedside nurse. In addition, a dedicated RRT nurse practitioner covered all hospital-wide rapid responses during the daytime hours (7:00 AM to 7:00 PM). The pediatric RRTs did not respond to events in the emergency department or the NICU. Code blue calls were considered separate entities from rapid responses, but the RRT could have become a component of the code team.

The data were collected retrospectively based on information entered on the pediatric RRT documentation/data collection form in each patient's paper chart when the RRT was called. These forms were completed by a pediatric resident who participated in the RRT. A check box on the collection form indicated whether a primary reason for the RRT activation was due to a red PEWS score, but the numerical score was not reported consistently. These data were collected and placed in a database maintained by the Rapid Response Committee, Division of Quality and Safety, at our institution. For patients who had repeated RRTs, each RRT was counted as a separate event. The Division of Quality and Safety concurrently attempted to collect all the PEWS scores for all RRT calls as well; however, not all scores were known for all calls. In addition, for the RRTs with red PEWS scores, it was unknown whether the primary reason for the RRT was due to a red PEWS score alone. Therefore, individual PEWS scores were not used for analysis.

Additional data that were reviewed from the database included the reason for the RRT activation, what interventions were performed, and whether the attending was notified by telephone or pager or was present at the bedside. Finally, we examined patient outcomes of the RRT activations occurring during the period under study, including whether a subsequent code blue was called, the number of transfers to the PICU, and overall hospital mortality. We compared these characteristics of RRT activations between the preautomation group and the postautomation group. Data also obtained for the RRTs included mean age of the patient; initial location such as the general pediatric floor, hematology/oncology floor, or other (ie, computed tomography or MRI suite, endoscopy suite); and on what shift the event occurred (ie, "day" events were from 7:00 AM to 7:00 PM and "night" events were from 7:00 PM to 7:00 AM).

RRT data before and after mandatory triggering from June 2007 to December 2010 were analyzed. The χ^2 test of independence was calculated to determine whether the differences between groups were statistically significant. All tests of significance were 2-tailed and evaluated at the level of $P < .05$.

RESULTS

A total of 44 RRTs were recorded before mandatory triggering and 69 RRTs afterward in the study period ($P = .32$). There were 40 patients in the premandatory triggering group and 63 patients in the mandatory triggering group. The proportion of RRT events relative to the total number of patient-days in the premandatory and postmandatory triggering periods were 3.14 RRTs per 1000 patient-days and 4.23 RRTs per 1000 patient-days, respectively. Although this finding represents a 26% increase in the total number of RRTs triggered, the change was not significant ($P = .11$).

The patient age and location and times of all the RRT calls from each group are reported in Table 1. The time of events showed that the number of daytime events was almost unchanged in the total number of events (from 23 to 24

TABLE 1 Location and Time of RRT Activations and Patient Age in the Preautomation and Postautomation Groups

Characteristic	Preautomation Total RRT Calls ($n = 44$)	Postautomation Total RRT Calls ($n = 69$)
Location, % (n)		
General pediatrics floor	72.7 (32)	73.9 (51)
Pediatric hematology/oncology floor	20.5 (9)	20.3 (14)
Other floors	6.8 (3)	5.8 (4)
Time, % (n)		
Daytime events	52.3 (23)	34.8 (24)
Nighttime events	47.7 (21)	65.2 (45)
Patient age, mean ± SD, y	8.4 ± 7.5	9.4 ± 8.8

[before and after the mandatory periods, respectively]). However, the number of nighttime events increased from 21 to 45, a 17.5% increase ($P = .07$).

The reasons for RRT calls, interventions undertaken, attending notification, and outcomes are reported in Table 2 for the before and after automation groups. These data points were collected from the RRT database, which kept the categories listed in Table 2. The most significant changes as to reasons RRTs were called were for tachycardia, which became the most common trigger for an RRT call in the postautomation group, with a net increase of 26.1% ($P = .004$). In addition, there was a significant reduction of 22.9% ($P = .009$) in RRTs called due to an acute change in mental status or agitation in the postautomation group. Comparison of RRTs that received interventions between the 2 groups showed that in the preautomation group, 2.3% of RRT calls ($n = 1$) had no interventions conducted. However, in the postautomation group, a larger number of patients received no interventions, up to 15.1% of RRTs ($n = 12$). Specifically, the RRT calls in the postautomation group required fewer respiratory interventions, with the most significant decrease in the use of supplemental oxygen via nasal cannula or face mask by 24.5% ($P = .011$) as well as bag-mask ventilation by 11.6% ($P = .035$). Finally, along with decreased interventions, there was a trend toward decreased frequency of PICU transfers in the postautomation group by 17.5% ($P = .06$) with no change in the number of code blue calls or mortality.

DISCUSSION

A hospital policy requiring the triggering of RRT calls based on red PEWS scores was associated with more nighttime RRT calls and recognition of tachycardia, although with fewer interventions by the RRT, particularly noninvasive respiratory interventions. In the postmandatory period, there were

TABLE 2 Characteristics of RRT Activations Preautomation and Postautomation

Characteristic	Preautomation Total RRT Calls ($n = 44$)		Postautomation Total RRT Calls ($n = 69$)		Δ (%)	*P*
	%	*N*	%	*N*		
Reason for RRT						
Tachycardia	15.9	7	42	29	26.1	.004
Bradycardia	2.3	1	2.8	2	0.5	.850
Blood pressure/poor perfusion	6.8	3	10.1	7	3.3	.544
Cyanosis	15.9	7	7.2	5	−8.7	.145
Saturations	22.7	10	15.9	11	−6.8	.366
Increased work of breathing/tachypnea	50	22	34.8	24	−15.2	.108
Worsening respiratory status	15.9	7	17.4	12	1.5	.837
Acute change in consciousness or agitation	43.2	19	20.3	14	−22.9	.009
Staff concern	59.1	26	58	40	−1.1	.906
Intervention						
Cardiovascular						
ECG performed	6.8	3	1.4	1	−5.4	.132
Intravenous fluid bolus	15.9	7	15.9	11	0.0	.996
Blood transfusion	4.5	2	2.9	2	−1.6	.644
Respiratory						
No interventions	2.3	1	17.4	12	15.1	.014
Supplemental oxygen via NC or FM	63.6	28	39.1	27	−24.5	.011
Bag-mask ventilation	15.9	7	4.3	3	−11.6	.035
Arterial blood gas analysis performed	9.1	4	2.9	2	−6.2	.152
Chest radiograph	31.8	14	27.5	19	−4.3	.625
Noninvasive positive pressure ventilation	6.8	3	2.9	2	−3.9	.323
Nebulizers given	25	11	23.2	16	−1.8	.826
Airway suctioning	20.5	9	14.5	10	−6.0	.409
Staffing						
Attending notified	88.6	39	90.3	63	1.7	.641
Outcomes						
Code blue called	2.3	1	2.9	2	0.6	.840
PICU transfer	52.3	23	34.8	24	−17.5	.060
Died	0	0	1.4	1	1.4	.420

Characteristic categories sum to more than the number of RRT calls because a patient could have had >1 reason, intervention, and/or outcome per RRT. ECG, electrocardiogram; FM, face mask; NC, nasal cannula.

fewer PICU transfers with no changes in code blue calls or mortality.

Previous studies in adults have shown that emergency response teams and RRTs did not affect the incidence of cardiac arrest, ICU admissions, or mortality, introducing controversy to the practice.[4,11] However, the meta-analysis by Chan et al[4] did find a 37.7% reduction in rates of cardiopulmonary arrest outside the ICU and a 21.4% reduction in hospital mortality rates in children, suggesting a difference in the pediatric population. The literature also provides other studies in support of RRT effectiveness, such as the reports by Brilli et al[3] and Sharek et al[6] showing a reduction in cardiopulmonary arrests and mortality with an RRT system. In addition, as demonstrated by work from Duncan et al[12] and Parshuram et al,[13] PEWS scores are a validated method of early recognition of pediatric patients in danger of deterioration. Finally, recent work by Al-Qahtani et al[14] further demonstrated that using physiologic-based RRT triggers such as respiratory, cardiovascular, and neurologic criteria to launch intensivist-led RRTs resulted in reduced adult cardiopulmonary arrests and total mortality for patients on wards.

However, to date, there are no published data integrating the 2 resources of PEWS and RRT together with a mandatory hospital policy for pediatric patients, as described in our study. Analysis of our data showed that in the mandatory triggering period, tachycardia was more often identified as a trigger for RRT calls. Acute changes in mental status were significantly less frequent triggers, with behavioral states being a more subjective score than heart rate. Heart rates were readily quantifiable numeric parameters for scoring and were therefore more likely amenable to discrete scoring. In addition, the need for supplemental noninvasive respiratory support, including supplemental oxygen and bag-mask ventilation, was less frequent after mandatory triggering; this finding suggests that patients were potentially recognized earlier and did not require support with initial respiratory intervention(s).

The data in the mandatory triggering period also show that there was a trend toward fewer transfers to the PICU. This trend may be a consequence of more timely recognition of, and greater interventions on, deteriorating patients on the wards, resulting in improved patient stabilization and lessened transfers to higher levels of care. However, our data revealed that fewer interventions were reported with the RRT calls in the mandatory period. This incongruity may be explained by a change in practice by physicians and nursing staff who, after implementation of this policy, knew a priori that a patient could trigger a red PEWS score and subsequently requested transfers preemptively to the PICU to avoid launching an RRT call, even though an RRT call did not necessarily lead to an admission or transfer to the PICU. If so, mandating RRTs could have increased unnecessary resource utilization with PICU admissions that did not require further interventions.

In addition, the data did not discern patients who had repeated RRT calls made. These children could have affected the data by increasing the number of RRT calls with subsequently fewer and no interventions, such as those with persistent fevers that triggered a red PEWS score due to coinciding tachycardia and/or tachypnea. These patients would likely have a red PEWS score every time vital signs were repeated, thereby setting off another RRT call that did not require more interventions or transfers to the PICU.

There are several limitations to this study. First, the data in the premandatory policy group show a limited number of documented red PEWS scores with RRT calls and a large number of RRT activations without documented PEWS scores for each RRT. This limitation makes it difficult to associate the actual PEWS scores with how many RRT calls were triggered due to an elevated score.

Another concern is why the number of night events in the postmandatory triggering period increased. This result may have been influenced by the presence of an experienced daytime dedicated RRT nurse as well as daytime attending presence. In-house availability of these personnel could have biased guardians, nursing, and house staff to call for help earlier, before red PEWS scores could be observed, thereby limiting RRT calls during the daytime hours. Having greater consistency in the composition of staffing and the RRT at all times could address this issue.

A third limitation to the study is that it is unknown how many transfers to the PICU from the emergency department or the wards would have occurred if activation by PEWS was not in effect. Knowing the number of transfers that occurred in both study periods would have helped to determine whether mandatory triggering directly decreased transfers to the PICU. If this decreasing trend existed, one could suggest patients were being intervened upon sooner and avoiding

escalating care. However, the data were unavailable for review. Finally, the low number of pediatric code blue calls and in-patient pediatric mortality at baseline made it difficult to assess the effect of mandatory triggering of RRTs on outcomes. This limitation could be overcome potentially with a larger and longer study. However, the fact that there were no increases in code blue calls or mortality in the postmandatory triggering period was reassuring.

The present study stimulates future research to better understand the trends of admissions and transfer rates to the PICU before and after mandatory RRT triggering policies, which would be helpful to discern whether patients with RRT calls are triaged to the appropriate level of care. Specifically, the question is whether such a mandatory policy leads to increased PICU admissions or transfers to the PICU simply because of clinicians' concerns of the risk of a future red PEWS score, with subsequent overuse and misallocation of resources. A robust data collection tool and a consistent composition of RRT members would be beneficial for such future studies.

CONCLUSIONS

A hospital policy of mandating RRT activation based on PEWS scores increased nighttime calls and altered the primary reasons for RRT activation in our center, with no evidence of improvements in patient care. These findings should be interpreted with caution given the relatively rare outcomes the policy is intended to prevent; however, our findings highlight the difficulties inherent in evaluating methods to improve pediatric patient safety.

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