RESEARCH ARTICLE

Here and Gone: Rapid Transfer From the General Care Floor to the PICU

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ABSTRACT

BACKGROUND: Children admitted to the general care floor sometimes require acute escalation of care and rapid transfer (RT) to the PICU shortly after admission. In this study, we aim to investigate the characteristics of RTs and the impact RTs have on patient outcomes, including PICU length of stay (LOS), mortality, and emergency transfer defined as critical care interventions occurring within 1 hour on either side of transfer to the PICU.

METHODS: We conducted a 2-year, single-center, retrospective analysis including all patients admitted to the general care floor of a tertiary children's hospital that were subsequently transferred to the PICU, with attention to those transferred within 4 hours of admission, meeting criteria as RTs. Patient-level data and outcomes were tracked. Statistical summaries were stratified by RT or non-RT strata and between-strata comparisons were performed. Significant univariate factors were entered into a multivariate logistic regression model and reduced with statistical significance required for final model inclusion.

RESULTS: Of 450 patients with an unplanned PICU transfer, 105 (23.3%) experienced RTs. Significant factors in the reduced multivariate logistic regression model associated with decreased risk for RT were increased baseline Pediatric Overall Performance Category ($P = .046$) and PICU origin of admission ($P = .012$). RT patients had shorter PICU LOSs (2.8 vs 5.5 days, $P < .001$) compared with non-RT patients despite a higher rate of emergency transfer (15.2% vs 7.5%, $P = .018$) and no difference in mortality ($P = .741$).

CONCLUSIONS: In this study, we demonstrate RTs have an increase in emergency transfer rate but no apparent risk of increased PICU LOS or mortality.

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Researchers estimate the mortality rate of pediatric codes outside the ICU ranges from 50% to 67%.[1,2] There has been significant work nationally and locally to decrease codes outside the ICU, including implementation of rapid response teams and use of various pediatric early warning scores.[3–10] However, these events have not been eliminated. Before a code outside the ICU occurs, a patient often experiences a phase of deterioration, which may go unrecognized, considered by many as a precursor event to the code.[11] We, along with Ohio Children's Hospitals' Solutions for Patient Safety, have recognized that some children admitted to the general care floor (GCF) require acute escalation of care and rapid transfer (RT) to the PICU within 4 hours after admission. These patients may meet the criteria of an emergency transfer by receiving critical care interventions within 1 hour on either side of transfer to the PICU but do not actually represent unrecognized clinical deterioration. These patients likely represent a separate issue: inappropriate admission disposition. It is possible that this represents another opportunity to decrease codes outside the ICU by decreasing code precursor events, RTs.

The authors of adult literature on the subject suggest patients who are transferred from the floor to the ICU within 24 hours of arrival to the floor have significantly higher morbidity and mortality.[12,13] In 1 study, researchers demonstrated that deterioration of patients on the GCF is associated with delayed physician notification of deterioration and delayed physician presentation to the bedside, resulting in delayed ICU transfer and increased risk of death.[13] In another study, even when the deterioration or inappropriate triage of the floor patient was noted early and the patient was transferred to ICU within 8 hours of admission to the floor, there was still a significantly increased mortality rate.[12] In addition to the adverse patient outcomes, these RT events require a disproportionate amount of resources from the GCF physicians, nurses, and ancillary staff. The authors of a previous pediatric study evaluated patients transferred to PICU within 12 hours of arrival for direct admission to the GCF compared with patients admitted from the emergency department (ED) to the GCF and subsequently transferred to the PICU. They found no significant difference in frequency of these ICU transfers on the basis of origin of admission.[14]

Aside from this single pediatric study in which rapidly transferred children were described, the nature of RTs is poorly understood in children. Recognizing the need to further decrease codes outside the ICU and considering the impact of RTs on patient outcomes in the adult literature, we sought to further describe RTs and compare them to non-RTs in the pediatric population. In this study, we aim to investigate the characteristics of RTs, including origin of admission, admitting service, severity of illness, PICU length of stay (LOS), mortality, and emergency transfer at a large tertiary free-standing children's hospital and the impact of RTs on patient outcomes. We hypothesized that RT outcomes would be similar to adult data with increased morbidity among RT children, although mortality difference was not expected.

METHODS

We conducted an institutional review board–approved retrospective analysis including all patients admitted to the GCF of a tertiary, 421-bed, free-standing children's hospital from January 2014 through December 2015 who were subsequently transferred to the PICU in an unplanned fashion. The GCF includes 24-7 in-house pediatric hospital medicine attending physician coverage, although pediatric hospital medicine consultation is not standard for surgical or subspecialty medical admissions. Patients may be admitted or transferred to the GCF from various locations, including the postanesthesia care unit, ED, PICU, hospital-based pediatric critical care transport team, and directly from community hospitals via local emergency medical services (EMS) squads and local pediatric primary or subspecialty care practices. Patients directly admitted from community hospitals (via local EMS squads) and community primary care offices (by private car or local EMS squads) standardly undergo clinical triage examination and vital sign assessment by a registered nurse in a direct admission area, whereas patients admitted directly from an on-campus general pediatric or subspecialty office go from the office directly to the GCF.

Patients transferred to the PICU were identified by the Midas (MidasPlus, Tucson, AZ) safety reporting system and verified by using the Virtual Pediatric Systems database (VPS, LLC, Los Angeles, CA), a national multicenter clinical PICU database. Two of the primary investigators then reviewed all patients for RT and emergency transfer criteria. An RT was defined as a patient transferred to the PICU within 4 hours of admission to the GCF. The narrower 4-hour RT window was selected for analysis with the intent to detect the most rapidly transferred patients, a cohort believed to most accurately represent mistriaged children. Admission time was defined by arrival time to the unit in the electronic medical record event manager, which was then confirmed by comparing it with the first nursing documentation of patient presence on the GCF (vital sign documentation, handoff documentation, etc). Transfer to PICU time was defined by transfer time in the electronic medical record event manager, which was validated with PICU admission nurse documentation. A modified version of the unrecognized situation awareness failures events transfer metric, developed by Brady et al,[11] was used to define an emergency transfer that represented unrecognized clinical deterioration. An emergency transfer was defined as acute resuscitative measures within 1 hour on either side of transfer from GCF to PICU, including 60 mL/kg or more of fluid boluses, intubation, inotropes, chest compressions, and/or cardioversion or defibrillation.

Patients identified as having an RT were then further analyzed by using the electronic medical record, Virtual Pediatrics Systems data query, and a custom Microsoft Excel database (Microsoft, Redmond, WA). Patient-level data included patient demographics, origin of admission, admitting service, time spent on GCF before PICU transfer, patient characteristics at time of admission including vital signs and pediatric early warning score, acute clinical interventions including emergency transfer criteria, PICU illness severity, PICU LOS, and mortality. Pediatric Risk of Mortality III (PRISM III), Pediatric Index of Mortality 2 Risk of Mortality (PIM2 ROM), and baseline Pediatric Overall Performance Category (POPC) data were standardly collected as validated severity of illness measures for critically ill children. PRISM III is a third-generation physiology-based severity of illness score developed with multiple logistic regression analysis by using data collected in the first 12 to 24 hours after ICU admission; the data come from a database of diverse ICUs, which represents ~10% of PICUs in the United States.[15] PIM2 ROM, which was developed by using data from Australia, New Zealand, and the United Kingdom, is a second-generation severity of illness score in which 10 variables collected from admission data are used to predict ICU outcome and risk for mortality in children.[16] The POPC scale was developed to quantify overall short-term functional morbidity of ICU patients by using a score from 1 to 6 to categorize a patient's level of disability from "good overall performance" to "brain death."[17]

Statistical summaries were performed by using appropriate descriptive statistics for the RT and non-RT strata. Statistical testing was then performed by using SPSS 24.0 software (IBM Corporation, Armonk, NY), with $P < .05$ considered statistically significant via 2-sided testing. Comparisons between strata for categorical measures were performed via Pearson χ^2 tests of proportions or Fisher's exact tests depending on cell sample size distribution. For numeric data, independent sample Student's *t* tests or Mann–Whitney *U* tests were used depending on whether the normality of the data were fulfilled. Significant ($P < .05$ via 2-sided testing) univariate factors were entered into a multivariate logistic regression for predicting the RT outcome. Adjusted, exponentiated odds ratios (ORs) with 95% confidence intervals (CIs) were determined along with significance tests. The model was then reduced by using the backward elimination stepwise procedure to remove any factors that were not statistically significant when considered in concert with the other predictive factors. Diagnostic testing including the Hosmer-Lemeshow test was performed on the regression model to confirm the adequacy of the reduced model.

RESULTS

There were 105 patients who met criteria for RT out of 450 total unplanned transfers from GCF to PICU, yielding an RT rate of 23.3%. Demographics for the non-RT and RT patients are reported in Table 1. Unplanned RTs and non-RTs to PICU had similar PRISM III and PIM2 ROM scores, although RT patients had a lower baseline POPC score (Table 1).

When comparing RTs to non-RTs, both the hospital-based pediatric critical care transport team origin and the community site direct admission origin trended toward increased odds of RT. Because of the small sample size, these 2 individual origins did not reach statistical significance, but when combined as 1 larger group of patients coming from outside the receiving tertiary care institution, the increased odds of RT was significant (Table 2). The PICU to GCF origin was found to have decreased odds of RT and was the only significant heterogeneous subcategory (see Table 2 footnote). Pediatric hospital medicine had the highest number of RTs ($n = 56$) out of total unplanned PICU transfers ($n = 208$), although there was no difference in the rate of RTs on the basis of service line (Table 2).

Multivariate regression analysis of the significant variables demonstrated that patients transferred to the GCF from the PICU had decreased odds of RT in both the full model (OR 0.383; 95% CI: 0.166–0.881; $P = .024$) and reduced model (OR 0.347; 95% CI: 0.153–0.789; $P = .012$), as seen in Table 3. Odds of RT decreased as POPC increased in the reduced model (OR 0.810; 95% CI:

TABLE 1 Non-RT and RT Patient Demographics

Variable	Non-RT, $N = 345$	RT, $N = 105$	*P*
Age, mo			.74
Mean (SD)	90.7 (97.66)	94.3 (92.09)	
Median	59	72	
Min–max	0–761	0–423	
Wt, kg			.81
Mean (SD)	28.7 (26.19)	29.4 (25.02)	
Median	17.8	19.2	
Min-max	2.5–113.9	2.2–98.3	
PRISM III score			.71
Mean (SD)	2.56 (3.89)	2.4 (3.64)	
Median	0	0	
Min-max	0–20	0–26	
PIM2 ROM score			.83
Mean (SD)	1.51 (2.50)	1.58 (3.60)	
Median	0.87	0.84	
Min-max	0.16–22.96	0.11–35.1	
Baseline POPC, *n* (%)			
1: good	140 (40.6%)	55 (52.4%)	—
2: mild	70 (20.3%)	23 (21.9%)	—
3: moderate	73 (21.2%)	14 (13.3%)	—
4: severe	61 (17.7%)	13 (12.4%)	—
5: coma	1 (0.3%)	0	—
6: brain death	0	0	—
Median (IQR)	2 (1–3)	1 (1–3)	.01

P values from independent samples Student's *t* tests except for baseline POPC comparison which employed the Mann–Whitney *U* test. Min-max, minimum-maximum; —, not applicable.

TABLE 2 Service Line and Origin of Admission for Non-RT and RT Patients

Variable	Non-RT, $N = 345$	RT, $N = 105$	P
Service line, n (%)			.362
Pediatric hospital medicine	152 (44.1)	56 (53.3)	
Medical subspecialties	148 (42.9)	39 (37.1)	
Pediatric surgery	17 (4.9)	3 (2.9)	
Surgical subspecialties	28 (8.1)	7 (6.7)	
Origin of admission, n (%)			.033
Direct admission	28 (8.1)	14 (13.3)	
ED	132 (38.3)	41 (39.0)	
PACU	52 (15.1)	14 (13.3)	
PICU	64 (18.6)[a]	7 (6.7)[a]	
Transport	44 (12.8)	20 (19.0)	
Other	25 (7.2)	9 (8.6)	
Direct admission or transport origin of admission, n (%)	72 (20.9)	34 (32.4)	.010

Medical subspecialties include pulmonology, hematology oncology, adolescent, neurology, cardiology, endocrinology, allergy immunology, nephrology, gastroenterology, rheumatology, and palliative care. Surgical subspecialties include otolaryngology, plastic surgery, urology, and neurosurgery. Other includes on-site primary care and subspecialty clinics and Metro Life flight or other transport. P values from Pearson χ^2 tests with Bonferroni adjusted P values. PACU, postanesthesia care unit.
[a] Significant heterogeneous subcategory.

0.659–0.996; $P = .046$). Although patients transferred to the floor from the hospital-based pediatric critical care transport team or community site direct admission process appeared to have increased odds of RT in the initial analysis, this was no longer significant when considered in concert with the other significant factors and eliminated from the reduced multivariate regression model (OR 1.424; 95% CI: 0.860–2.355; $P = .169$).

Regarding PICU LOS as a proxy of morbidity, the RT patients had a shorter PICU LOS (2.8 vs 5.5 days, $P < .001$). There was no difference in RT mortality ($P = .741$) when compared with non-RT unplanned transfers (Table 4).

Emergency transfer was also measured as a morbidity because of unrecognized deterioration outside of the PICU. There were 42 total unplanned transfers to the PICU requiring emergency transfer (9.3%). RT patients were more likely to result in emergency transfer when compared with non-RT patients (15.2% vs 7.5%, $P = .018$). Severity of illness scores and mortality of RT patients who were emergency transfers versus nonemergency transfers were also compared (Table 5). RT patients who were also emergency transfers were found to have significantly higher PIM2 ROM and PRISM III scores compared with nonemergency transfer RT patients reported as median (interquartile range [IQR]) values, respectively (2.11 [0.87–4.40] vs 0.82 [0.19–1.09], $P = .001$; and 4 [0.25–9.25] vs 0.00 [0–3], $P = .003$). Mortality was also significantly increased for emergency transfer RT patients compared with nonemergency transfer RT patients (12.5% vs 0%, $P = .022$).

DISCUSSION

We found that nearly 25% of all unplanned transfers to the PICU from the GCF occurred within 4 hours of arrival to the GCF, qualifying them as an RT. Although that may seem high, the contrasting perspective of the same data reveals that triage decisions resulting in GCF admission are made correctly >99.5% of the time (0.4% GCF admission result in RT). From the PICU perspective, 1 in 4 patients transferred from the floor in an unplanned fashion arrive within 4 hours of admission. This poses the problem of intense resource use on the GCF and in the PICU while subjecting patients to risk caused by additional transitions of care.[18] There is new evidence that quantifies the "collateral damage" to other patients in a unit in which a critically ill ICU transfer is required. Volchenboum et al[19] report an increased risk of cardiac arrest or ICU transfer in other patients on the same ward as well as a discharge delay for patients meeting discharge criteria. This analysis was beyond the scope of our current study, although it raises additional considerations around the impact of pediatric RT.

In regard to origin of admission, we found that patients admitted to the GCF from the PICU had a decreased risk of RT. This is likely because most of these patients have endured the peak of their illness during their PICU stay and are significantly improved by the time of transfer to the floor. In addition, these patients are being evaluated by a pediatric intensivist to determine appropriateness for floor admission. Interestingly, during primary analysis, both the origins of community site direct admissions and hospital-based pediatric critical care transport team admissions trended toward increased risk for RT. These 2 groups of patients, coming from outside the tertiary care institution's main campus, when combined and analyzed together, demonstrated an increased risk of RT. However, it did not maintain significance

TABLE 3 Multivariate Logistic Regression for RT Outcome

Factor	Full Model OR (95% CI)	P	Reduced Model OR (95% CI)	P
Constant	0.451	.002	0.526	.005
PICU origin of admission	0.383 (0.166–0.881)	.024	0.347 (0.153–0.789)	.012
Direct admission or transport origin of admission	1.424 (0.860–2.355)	.169	—	—
Baseline POPC	0.830 (0.673–1.025)	.083	0.810 (0.659–0.996)	.046

Significantly associated ($P < .05$) univariate factors were selected for multivariate logistic regression. Stepwise elimination reduced the model to significant factors ($P < .05$). Insignificant Hosmer-Lemeshow test supports reduced model ($P = .961$, $\chi^2 = 0.620$, df = 4). df, degrees of freedom; —, not applicable.

TABLE 4 Non-RT and RT Patient Mortality, LOS, and Emergency Transfer

Variable	Non-RT, $N = 345$	RT, $N = 105$	P
Mortality, n (%)	11 (3.2%)	2 (1.9%)	.74
LOS, d			<.001
Mean (SD)	5.5 (12.01)	2.8 (3.75)	
Median	2.4	1.5	
Min-max	0.1–144.5	0.2–25.7	
Emergency transfer, n (%)	26 (7.5%)	16 (15.2%)	.018

P value for mortality and emergency transfer comparisons via Pearson χ^2 tests. LOS was compared for rank equality via Mann–Whitney U test. Min-max, minimum-maximum.

once multivariate regression analysis was performed. Nonetheless, if the results of further studies with larger sample size reveal an increased risk, it would certainly necessitate investigation into this cohort of patients and the evaluations they are undergoing before admission to the tertiary care hospital.

The most frequent primary admitting service of RT patients is the pediatric hospital medicine service. We speculate there are several reasons for this. First, pediatric hospital medicine admits the greatest proportion of medical patients on our hospital's GCF, thus providing the most "chances" for RT. In addition, the pediatric hospital medicine service is the only service on the GCF with 24-7 in-house attending physician coverage. Thus anecdotally, sicker patients are preferentially assigned to the pediatric hospital medicine service with surgical or subspecialty medical consultation. In addition, it is possible that sick patients are recognized faster after arrival to the floor if the attending physician is present and able to recognize the need for PICU transfer. These patients may have otherwise remained on the floor for several more hours until the attending physician arrived to see them.

With regard to risk for RT, we also found that elevated baseline POPC was actually protective against these events. One possible explanation for this is that patients with worse overall baseline function, likely due to multiple comorbidities, may be systematically triaged to the PICU preferentially because of medical complexity or fragility and concern for higher risk for deterioration. As a result, patients with higher baseline POPC values may be admitted to the floor only when they are deemed to be stable with low risk for transfer. PRISM III and PIM2 ROM scores reveal physiologic derangements in the early ICU stay, whereas baseline POPC scores reveal functional impairments, which may explain why the difference was only seen in the baseline POPC scores.

We hypothesized that patients admitted to the GCF and rapidly transferred to the PICU within 4 hours of their admission would have an increased morbidity, similar to what has been shown in adult studies. We considered PICU LOS and requirement of emergency transfer as morbidities. We showed that RT patients had a shorter PICU LOS (2.8 vs 5.5 days), suggesting lower ICU morbidity, compared with non-RT unplanned transfers. This effect of RT was in the opposite direction of the hypothesis. Perhaps the narrow time window identified those patients who were recognized early to be actively deteriorating clinically, providing those patients with RT and thus quick resuscitation in the PICU setting allowing for more rapid recovery. Conversely, patients undergoing nonplanned ICU transfer beyond the 4-hour window may in fact have been languishing or subtly deteriorating over hours and days without recognition of the clinical deterioration. Contrary to adult data, there was no increase in mortality for RT patients. This is likely related to the comparatively low overall mortality described in PICU patients, a 2% to 6% mortality rate in PICUs versus a 10% to 29% rate in adult ICUs.[20] This overall lower mortality rate makes it difficult to study mortality as an endpoint in a single-center pediatric study.

Regarding the emergency transfer morbidity, we found that among all RTs, >15% required emergency transfer. This validates that there are increased resource needs on the GCF and the receiving PICU, and perhaps increased morbidity for RTs. The significantly elevated PIM2 ROM, PRISM III, and mortality in patients who are both RTs and emergency transfers compared with RTs who were not emergency transfers also supports the increased morbidity and severity of illness in this subset of RTs. We speculate that if the emergency transfer patients were instead initially admitted to the PICU, possibly the emergent interventions would have happened earlier and in the setting designed for these aggressive resuscitative measures, or perhaps not at all.

The biggest limitation of this study is the single-center nature of this analysis. It is not clear that other hospitals have the same thresholds for ICU transfer or processes for admission. Although we did look at mortality and acute morbidity, we did not look at long-term outcomes of RT patients. Additionally, although resource use is touted as a risk of mistriage or RT, we were unable to quantify the cost associated with RTs. Another potential limitation of the study is the choice to analyze RT versus non-RT patients as opposed to RT patients versus

TABLE 5 Severity of Illness Scores and Mortality in RT Patients in the Presence and Absence of Emergency Transfer

Subgroup or Variable	Emergency Transfer and RT, $N = 16$	Nonemergency Transfer and RT, $N = 89$	P
Severity of illness score			
Baseline POPC, median (IQR)	1 (1–2.75)	1 (1–3)	.701
PIM2 ROM, median (IQR)	2.11 (0.87–4.40)	0.82 (0.19–1.09)	.001
PRISM III, median (IQR)	4 (0.25–9.25)	0.00 (0–3)	.003
Mortality, n (%)	2 (12.5%)	0 (0%)	.022

P values from baseline POPC, PIM2 ROM, PRISM III comparisons via Mann–Whitney U tests. Results are reported as median (IQR) because of small sample size. Mortality was compared via Fisher's exact tests.

all admissions to the GCF. Theoretically, the non-RT to RT comparison should control for confounding variables. However, if there are certain origins from which a large portion of mildly ill children are admitted and thus few ever require PICU transfer, 1 RT from that origin could significantly increase the rate of RTs from that origin in the analysis, devaluing what may be an overall excellent triage process. However, because much of the data were manually collected, it was not within the scope of this study to collect that data for every patient admitted to the hospital within the 2-year study timeframe. Lastly, the selected 4-hour RT window may have been either too short or too long to fully define RTs.

We conclude that RTs do not result in higher PICU LOS, although they are more likely to result in emergency transfer to the PICU. Pediatric patients requiring hospital admission can significantly benefit from a robust triage assessment process before arrival to the floor to ensure adequate disposition. Specifics of additional resource use and factors influencing or resulting from RTs warrant further investigation. We propose that our definition of RT could be a quality performance metric among pediatric hospital systems, allowing for identification of best practices yielding low RT rates. Ideally, we would be able to compare various centers using standard definitions and further quantify the full impact of RTs on patients and resources.

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