BRIEF REPORT

Pediatric ICU Transfers Within 24 Hours of Admission From the Emergency Department: Rate of Transfer, Outcomes, and Clinical Characteristics

Nicole Nadeau, MD,[a] Michael C. Monuteaux, ScD,[b] Jaya Tripathi, BS,[b] Anne M. Stack, MD,[b] Catherine Perron, MD,[b] Mark I. Neuman, MD, MPH[b]

ABSTRACT

BACKGROUND: There is a paucity of data describing pediatric patients transferred to an ICU within 24 hours of hospital admission from the emergency department (ED).

METHODS: We conducted a retrospective cohort study of patients ≤21 years old transferred from an inpatient floor to an ICU within 24 hours of ED disposition from 2007 to 2016 in a tertiary children's hospital. Patients transferred to an ICU after planned operative procedures were excluded. Rate of transfer, clinical course, and baseline demographic and/or clinical characteristics of these patients are described.

RESULTS: The study cohort consisted of 841 children, representing 1% of 82 397 non-ICU ED admissions over the 10-year period. Median age was 5.1 years, 43% had ≥1 complex chronic condition, and 47% were hospitalized within the previous year (27% in the ICU). The majority of transfers were for respiratory conditions (65%) and cardiovascular compromise (18%). Median time from hospitalization to ICU transfer was 9.1 hours (interquartile range 5.1–14.9 hours). Thirty-eight percent of transfers received 1 or more critical interventions within 72 hours of hospitalization, most commonly positive pressure ventilation (29%) and vasoactive infusion (9%). Median time to intervention from hospitalization was 13.6 hours (interquartile range 7.5–21.6 hours), 0.8% of children died within 72 hours of hospitalization, and 2.4% died overall.

CONCLUSIONS: In this single pediatric academic center, 1% of hospitalized children were transferred to an ICU within 24 hours of ED disposition. One-third of patients received a critical intervention, and 2.4% died. Although most ED dispositions are appropriate, future efforts to identify patients at the highest risk of deterioration are warranted.

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Address correspondence to Nicole Nadeau, MD, Division of Pediatric Emergency Medicine, Massachusetts General Hospital, 55 Fruit St, Boston, MA 02114. E-mail: nnadeau@partners.org

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[a]Division of Pediatric Emergency Medicine, Massachusetts General Hospital, Boston, Massachusetts; and [b]Division of Emergency Medicine, Boston Children's Hospital, Boston, Massachusetts

Dr Nadeau conceptualized and designed the study and drafted the initial manuscript; Mr Monuteaux helped design the study and the plan for data analysis and helped perform all data analyses; Ms Tripathi assisted in data collection and analysis; Drs Neuman, Stack, and Perron helped conceptualize and design the study; Dr Nadeau conceptualized and designed the study, abstracted data, conducted the initial analyses, and drafted the initial manuscript; Dr Monuteaux conducted the initial analyses; Drs Perron and Stack conceptualized and designed the study and reviewed the data; Ms Tripathi abstracted data; Dr Neuman conceptualized and designed the study, abstracted data, and drafted the initial manuscript; and all authors reviewed and revised the manuscript, approved the final manuscript as submitted, and agree to be accountable for all aspects of the work.

Early ICU transfer, commonly defined as transfer to an ICU within 24 hours of hospitalization,[1–5] is an important quality measure of emergency department (ED) care. ICU transfer may reflect progression of disease shortly after admission from the ED; however, other ICU transfers may relate to an underestimation of the severity of illness during the ED assessment. Previous studies have demonstrated that children transferred to an ICU shortly after admission have higher morbidity and mortality than children directly admitted to an ICU.[6–8]

There is a paucity of information on the rate of early pediatric ICU transfer as well as the clinical course and baseline characteristics of these patients. Although few studies have attempted to shed light on this patient population, they have been limited by small sample sizes.[4,9,10] Attempts to date to apply a scoring system or prediction model to determine which patients are likely to transfer have had limited success.[3,4,11–16]

To address gaps in knowledge around pediatric early ICU transfers, we sought to determine the rate of early ICU transfer and evaluate the outcomes and baseline characteristics of children transferred to an ICU within 24 hours of admission from the ED.

METHODS

We conducted a retrospective cohort study of patients ≤21 years of age transferred from an inpatient floor to an ICU after admission from the ED from 2007 to 2016. Transferred patients were identified by using an existing hospital administrative database. The study was conducted in a single pediatric academic hospital with ~60 000 annual ED visits, 400 inpatient beds, and 4 distinct ICUs (cardiac, medical, medical and/or surgical, and newborn) with 113 critical care beds. In addition to formal ICUs, our institution contains an intermediate care unit, which was considered an ICU for the purpose of this study, given that transfers to these units represented an escalation in care after ED disposition. Our institution requires that children receiving high-flow nasal cannula or continuous albuterol be hospitalized in an ICU setting.

We included children admitted to any medical or surgical inpatient ward from the ED and subsequently transferred to any ICU within 24 hours of hospitalization, as measured by time stamp of arrival on the inpatient ward to time stamp of arrival to an ICU. We excluded patients transferred to an ICU after a planned operative procedure as well as children documented as having been transferred for nonclinical reasons (ie, bed allocation). We abstracted from the electronic medical record each patient's basic demographic characteristics as well as the presence of 1 or more complex chronic conditions (CCCs) using a previously defined classification system[10] and history of hospital or ICU admission in the previous year.

We assessed the time interval between admission and transfer to an ICU. We categorized reasons for transfer into respiratory, cardiovascular, or neurologic compromise; surgical emergency; laboratory abnormality; or other. When there was overlap, such as seizures causing apnea, we would reflect the underlying etiology of instability (neurologic, in this example). We also assessed whether ICU transfer followed an acute interval event, defined as a sudden change in a patient's clinical status unrelated to his or her admitting presentation (eg, new seizure or anaphylaxis to a medication received during hospitalization), representing ICU transfers that could never be anticipated. Abrupt but potentially predictable events, such as mucous obstruction in a tracheostomy patient admitted for respiratory illness, were not considered acute interval events. Determination of the reason for transfer and presence of an acute interval event was made by study investigators, and ambiguous cases were resolved by group consensus.

We evaluated outcomes of children transferred to an ICU, including critical interventions received within 72 hours of admission, hospital and ICU length of stay (LOS), and mortality (within 72 hours and throughout hospitalization). The rate, timing, and type of critical interventions were assessed. Critical interventions were identified a priori on the basis of existing literature[1,17,18] and included extracorporeal membrane oxygenation, cardiopulmonary resuscitation, cardioversion and/or defibrillation, an emergent operative procedure, vasoactive infusion, positive pressure ventilation (including high-flow nasal cannula, continuous positive airway pressure, bilevel positive airway pressure, intubation, and initiation of new positive pressure ventilation in a patient with tracheostomy), or management of elevated intracranial pressure. Other potential critical care interventions were identified during data abstraction; ambiguous cases were resolved by group consensus.

Data analyses were conducted by using Stata version 13 (Stata Corp, College Station, TX). This study was approved by the institutional review board at the study institution.

RESULTS

Over 10 years, 1075 patients were transferred to an ICU within 24 hours of ED admission to a pediatric floor. A total of 234 patients were excluded, the majority ($n = 201$) were due to ICU transfer after a planned operative procedure. Other patients were excluded because of inability to assess the timing of transfer relative to hospitalization ($n = 31$) and for transfer for nonclinical indications ($n = 2$). After exclusions, 841 children were transferred to an ICU within 24 hours of ED disposition, representing a 1% rate of transfer among the 82 397 non-ICU admissions from the ED during the study period.

Median age was 5.1 years (interquartile range [IQR] 1.4–10.8), and 57% were of male sex. Forty-three percent of patients had at least 1 CCC (11% had 3 or more). Forty-seven percent of patients were hospitalized in the previous year, and 27% were within the ICU.

Median time from ED disposition to ICU transfer was 9.1 hours (IQR 5.1–14.9 hours); 64% of children were transferred within 12 hours (Fig 1). Most transfers were due to respiratory decompensation (65%). Eighteen percent of early ICU transfers were due to cardiovascular compromise. Twenty-one children (2.5%) were transferred after an acute interval event, most commonly new seizure activity (1.0%; Table 1).

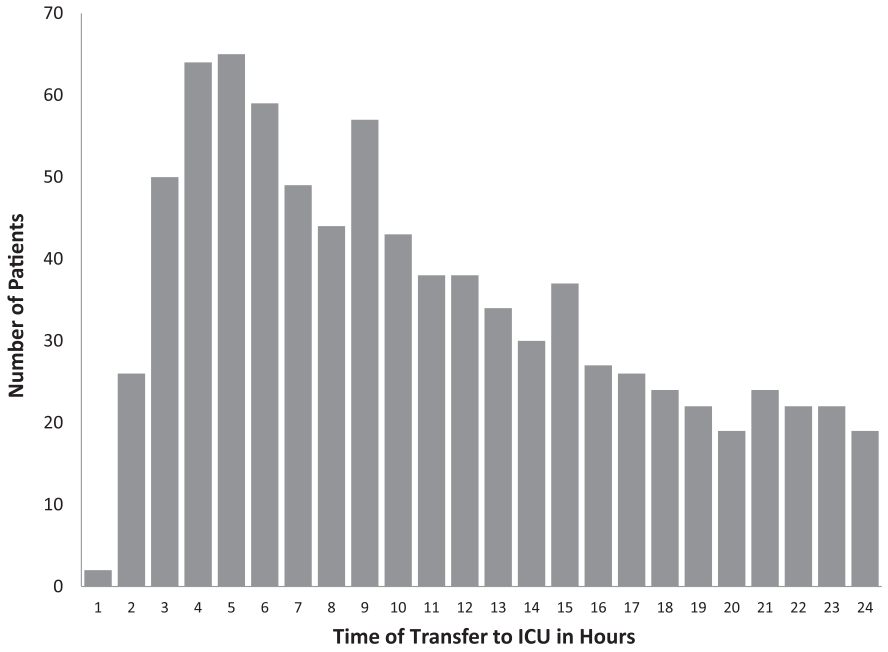

FIGURE 1 Distribution of transfer timing among pediatric early ICU transfer patients.

Three hundred and sixteen children (38%) received a critical intervention within 72 hours of hospitalization, most commonly positive pressure ventilation (29%) and vasoactive infusion (9%). Median time from hospital admission to critical intervention was 13.6 hours (IQR 7.5–21.6). Interventions occurred in close proximity to ICU transfer, with 15.5% of interventions occurring before ICU arrival and another 36.9% occurring within the first hour of ICU arrival (Table 2).

Patients transferred to an ICU within 24 hours of hospitalization had a median ICU LOS of 2.4 days (IQR 1.4–4.8) and hospital LOS of 4.9 days (IQR 2.9–9.6). Seven children (0.8%) died within 72 hours of ED admission, and 20 (2.4%) died during the hospitalization (Table 2). Sixteen (80%) of the patients who died had at least 1 CCC.

TABLE 1 Transfer Event Reason and Timing of Children Transferred to an ICU Within 24 Hours of Hospitalization From an ED, $N = 841$

Transfer Event Reason and Timing	
Hours to transfer, median (IQR)	9.1 (5.1–14.9)
Primary reason for transfer, *n* (%)	
Respiratory	549 (65.3)
Cardiovascular	151 (18.0)
Neurologic	71 (8.4)
Surgical	12 (1.4)
Laboratory abnormality	38 (4.5)
Other	20 (2.4)
Rate of occurrence of interval event, *n* (%)	21 (2.5)
Event type of new seizure activity, *n* (%)	8 (1.0)
New dysrhythmia	0 (0.0)
New anaphylaxis	3 (0.4)
New apnea	3 (0.4)
Abrupt desaturation	5 (0.6)
Other	2 (0.2)

DISCUSSION

We conducted the largest study to date characterizing pediatric early ICU transfers, most often defined as children being transferred to an ICU within 24 hours of hospitalization from an ED. Although there may be many reasons why children may be transferred to an ICU shortly after ED disposition, some transfers may relate to underestimation of severity of illness by ED providers, prompting the use of this metric as a benchmark of pediatric ED care.[19,20] In our study, we aimed to further the understanding of the rate of such early ICU transfers in the pediatric population as well as their clinical course and patient characteristics.

We observed a 24-hour ICU transfer rate of 1% among all ED admissions to the floor. This transfer rate is within the range of existing studies (0.5%–3%),[1,5,11] supporting the fact that a majority of patients are being appropriately triaged to the floor.

Our study demonstrates that one-third of children transferred to an ICU within 24 hours of ED disposition receive a critical intervention. This is slightly lower than the 49% rate previously reported,[1] and this is likely related to our not defining continuous albuterol as a critical intervention. This further suggests that some of the patients transferred may have remained safe on the floor, but we were not able to account for the role of higher nursing ratios, more frequent suctioning, and other benefits of ICU care less easily measured. Although many transferred patients did not require a critical intervention, importantly, our data do show that those who did received them in close proximity to the timing of ICU transfer. This is of particular importance given recent data observing higher mortality for pediatric early ICU–transfer patients with a need for critical intervention within 1 hour of ICU arrival.[21]

Also consistent with other studies, we observed that ~2% of children transferred to an ICU within 24 hours of ED admission died, with one-third of those deaths occurring within 72 hours of admission from the ED.[1,2] Patients admitted for respiratory indications and patients with CCCs made up a large proportion of the

TABLE 2 Patient Outcomes: Critical Care Interventions, LOS, and Mortality for Children Transferred to an ICU Within 24 Hours of Hospitalization From an ED, $N = 841$

Outcome	
1 or more critical interventions received, *n* (%)	316 (37.6)
ECMO	0 (0.0)
CPR	4 (0.5)
Cardioversion and/or defibrillation	3 (0.4)
Unplanned emergent operative procedure	16 (1.9)
Vasoactive infusion	78 (9.3)
Arrhythmia abortive medication	4 (0.5)
Elevated intracranial pressure intervention	11 (1.3)
Positive pressure ventilation	241 (28.7)
Bag-mask ventilation	40 (4.8)
High-flow nasal cannula	79 (9.4)
Continuous positive airway pressure	75 (8.9)
Bilevel positive airway pressure	90 (10.7)
Intubation	66 (7.9)
Other[a]	46 (5.5)
Critical intervention received before ICU transfer, *n* (%)	45 (5.4)
Critical intervention received within 1 h of ICU transfer, *n* (%)	152 (18.1)
ICU LOS, d, median (IQR)	2.4 (1.4–4.8)
Hospital LOS, d, median (IQR)	4.9 (2.9–9.6)
Mortality within 72 h, *n* (%)	7 (0.83)
Mortality during hospitalization, *n* (%)	20 (2.4)

CPR, cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation.

[a] Other included heliox ($n = 20$), terbutaline infusion ($n = 5$), nitric oxide ($n = 3$), midazolam infusion ($n = 5$), vasopressin infusion ($n = 3$), pericardiocentesis ($n = 2$), plasmapheresis ($n = 2$), emergent dialysis ($n = 1$), exchange transfusion ($n = 1$), massive transfusion ($n = 1$), pentobarbital coma ($n = 1$), botulism immunoglobulin infusion ($n = 1$), and cardiac pacing ($n = 1$).

early ICU–transfer population, as has been seen in other studies,[1,2] although without a comparison group, we cannot adequately assess if they are at increased risk for transfer, intervention, or mortality.

The primary limitation of this study is that it was conducted in a single institution, and the generalizability of our findings may be limited by institutional variation in ICU admission criteria and allowance of certain interventions outside of the ICU setting. However, we believe that because our categorization of critical interventions was taken from the existing literature,[1,17,18] it should be fairly universal across institutions, minimizing the impact of regional differences in the provision of ICU care. This study is also limited by its retrospective nature, which does not allow for a real-time understanding of patients' true degree of instability or circumstances surrounding transfer and critical interventions. Thus, we make no effort to determine if the transfer was preventable or a reflection of suboptimal ED care.

CONCLUSIONS

To our knowledge, this is the largest study to date characterizing the rate, outcomes, and characteristics of children transferred to an ICU within 24 hours of hospitalization from the ED. Approximately 1% of ward admissions were transferred to an ICU within 24 hours of hospitalization, and most transfers were related to respiratory decompensation. A minority of ICU transfers receive escalated care, suggesting that most children are triaged to an appropriate level of care. Half of those who did receive escalated care, however, received their interventions urgently either before or within 1 hour of ICU transfer. This subpopulation of early ICU–transfer patients receiving rapid peritransfer intervention should be a focus of future safety efforts by emergency physicians, hospitalists, and intensivists.

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