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Factors associated with interhospital transfer of children with respiratory failure from level II to level I pediatric intensive care units☆,☆☆,★,★★,☆☆☆

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ABSTRACT

Purpose: Of all sources of admission to level I pediatric intensive care units (PICUs), interhospital transfer admissions from level II PICUs carry the highest mortality and resource use burden. We sought to investigate factors associated with transfer of children with respiratory failure from level II to level I PICUs.
Methods: A case-control study was conducted among children with respiratory failure admitted to 6 level II PICUs between January 1, 1997, and December 31, 2007, with frequency matching of 466 nontransferred children (controls) to 187 transferred children (cases).
Results: Among 653 children, transferred children were younger and had more comorbidities. After multivariable analysis, transferred children were more likely to have comorbidities (odds ratio [OR], 2.02; 95% confidence interval [CI], 1.36-2.98) and receive escalated care including high-frequency ventilation (OR, 2.57; 95% CI, 1.04-6.37) and surfactant therapy (OR, 5.33; 95% CI, 1.35-21.0).
Conclusions: The study identified patient-level and process-of-care factors associated with transfer from level II to level I PICUs. These findings highlight the influence of escalated care on transfer decision making for critically ill children in respiratory failure.

1. Introduction

Provision of optimal and timely care to critically ill and injured children is essential to ensuring the best possible clinical outcome. Survival for the most severely ill and injured children might be enhanced by admission to highly specialized level I pediatric intensive care units (PICUs) [1]. Published guidelines advocate for integration of regional systems of PICU services, with transfer of children with high risk of mortality from level II to level I PICUs [2]. They urge level II PICUs to admit children with stable and noncomplex disorders and transfer less stable, seriously ill, and injured children to level I PICUs for greater access to advanced technological expertise and subspecialty care capability. The guidelines do not, however, outline criteria to be used by level II PICUs to identify which patients to transfer to level I PICUs.

In prior studies, significantly higher unadjusted mortality rates at a level I PICU were observed among children transferred from level II PICUs compared with those who were admitted directly from other settings including the emergency department (ED), operating room, or clinics [3,4]. Importantly, however, severity-adjusted mortality was similar across these various sources of admission to the level I PICU, highlighting the significant influence of pretransfer illness severity on

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outcomes at the receiving level I PICU and the important need to investigate the determinants of transfer from level II to level I PICUs.

The current study was conducted to determine the factors associated with the transfer of children from level II to level I PICUs with emphasis on patients in respiratory failure, a leading cause of mortality and morbidity among children transferred to level I PICU care [5]. It was hypothesized that transfer from level II PICUs to level I PICUs would be associated with younger patient age and greater illness severity at initial presentation to the ED of the referring hospital.

2. Materials and methods

2.1. Study design

This is a frequency-matched case-control study of children admitted with respiratory failure to 6 level II PICUs in Michigan and Ohio, in the Midwest census region of the United States.

2.2. Delineation of PICU levels of care

Definition of the levels of PICU care was in line with prior published guidelines [2]. The level I PICU had to provide multidisciplinary definitive care for a wide range of complex, progressive, and rapidly changing medical, surgical, and traumatic disorders occurring in pediatric patients of all ages, excluding premature newborns. Although level I PICUs had to have a full complement of medical and surgical subspecialists, a level II PICU was not required to have the full spectrum of subspecialists. Furthermore, for the purpose of this study, the level II PICUs did not have the capacity to provide extracorporeal membrane oxygenation for children in respiratory failure.

2.3. Setting and study population

2.3.1. Definition of cases and controls

A case was defined as a patient with respiratory failure who was transferred from 1 of the 6 level II PICUs to 1 of 3 level I PICUs in Michigan, between January 1, 1997, and December 31, 2007. These level II PICUs were selected given previous referrals to the level I PICUs. Patients at the same level II PICU hospitals with the same diagnosis during the same period, who were not transferred to level I PICU care, were eligible to be controls.

2.3.1.1. Exclusion criteria. Medical records of all subjects were reviewed to exclude the following patients due to their inability to be "at risk" for transfer to Level I PICU care:

- Patients who died within 4 hours of level II PICU admission.
- Patients discharged to the wards within 6 hours of level II PICU admission.
- Terminally ill patients discharged for "comfort or terminal care" on the ward or at home.

The study was approved by the institutional review boards at the University of Michigan Medical School and at all 6 participating level II PICU hospitals.

2.3.2. Selection and validation of cases and controls

A 2-step approach was used to select and validate the cases and controls.

2.3.2.1. Step 1: Identification of potentially eligible subjects. At each level II PICU, admission and discharge log books were queried to identify patients with respiratory failure admitted to the PICU during the study period. These log books were the only source of data with the discharge destination for all patients admitted to the PICUs. Included were all patients in the PICU whose diagnoses included respiratory failure, pneumonia, bronchiolitis, acute respiratory distress syndrome, acute lung injury, or airway obstruction.

2.3.2.2. Step 2: Identification and validation of cases and controls. All patients with a diagnosis of respiratory failure were identified as potential subjects. Cases were patients transferred from level II PICU to level I PICU care, whereas controls were patients not transferred. Controls were frequency matched to the case distribution on diagnosis (respiratory failure) and calendar month ($\pm$3 months of the index case) of PICU admission; from that pool, 2 or more control subjects were randomly selected per case.

2.3.2.2.1. Validation of diagnosis. Each subject's medical record chart was reviewed by the lead investigator (FO) to validate the log book diagnosis of respiratory failure. A diagnosis of respiratory failure was verified by documentation of the use of artificial ventilation (noninvasive or invasive positive pressure ventilation) during the level II PICU admission.

2.3.2.2.2. Validation of nondiagnosis. All transferred patients who did not have a diagnosis of respiratory failure had their medical record reviewed to ensure that there was no mislabeling with a diagnosis that was not respiratory failure. Furthermore, review of the medical records of a random sample (5%) of all nontransferred patients without a diagnosis of respiratory failure was done to ensure that potential control subjects were similarly not erroneously omitted.

In this process, there were no instances of missed cases or controls.

2.4. Data collection

For each subject, paper and/or electronic medical records at the level II PICU hospitals were reviewed to abstract the following information, using a standardized data collection form:

1. Demographics: age and sex.
2. Type of insurance coverage.
3. Pediatric Risk of hospital Admission (PRISA) II score, calculated from data on severity of illness in the ED among children admitted via the ED, with higher values indicating greater illness severity [6].
4. Source of admission to the level II PICU including the wards, ED, or operating rooms of the level II PICU hospital or from similar settings at referring hospitals.
5. Use of therapeutic modalities and medical devices (yes/no) before level II PICU admission. These included antibiotics, vasoactive agents, prostaglandins, steroids, central venous catheters, arterial catheters, tracheal intubation, invasive ventilation, noninvasive ventilation, occurrence and volume of fluid resuscitation (bolus administration of crystalloids and colloids), and the occurrence and volume of blood transfusion.
6. Pediatric Risk of Mortality (PRISM) III score, calculated from data on severity of illness within the first 24 hours of PICU admission, with higher values indicating greater illness severity [7].
7. Use of specific therapeutic modalities and medical devices while in the PICU (yes/no). These included tracheal intubation, invasive mechanical ventilation (conventional mechanical ventilation and high-frequency ventilation), noninvasive ventilation, renal replacement therapy, central venous catheters, arterial catheters, antibiotics, inhaled nitric oxide therapy, surfactant, vasoactive agents, prostaglandins, steroids, fluid resuscitation, and blood transfusion.
8. Pediatric Logistic Organ Dysfunction (PELOD) score: Multiple values of the score were calculated daily, with higher values indicating worse organ dysfunction [8]. The highest patient-specific daily value was designated the peak PELOD score. Furthermore, at the end of the level II PICU stay, the proportion of children with organ-specific dysfunction was determined using the PELOD algorithm [8].
9. Comorbidities: Given that comorbid illness was felt to be a potential factor in decision making regarding transfer or nontransfer to level I PICU care, patient comorbidities at level II PICU admission were identified using *International Classification of Diseases*,