

Six year mortality profile of a Pediatric Intensive Care Unit: association between out-of-hours and mortality

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ABSTRACT

Introduction. Recent improvements in pediatric intensive care units (PICUs) were achieved through trained personnel and better technology, leading to an increase in patient care, survival rates and good prognosis. Nevertheless the quality of care varies according to the availability of human and technical resources.

Objective. The aim was to determine the correlation of mortality rates with daytime shifts compared to other shift periods (off-hours).

Methods. Work hours were defined as week days between 8:00 a.m. and 5:00 p.m., with in-house attendance of senior staff, and off-hours as week days between 5:00 p.m. and 8:00 a.m., weekends and public holidays, with one resident covering the PICU and senior staff directly available only on-call. Mortality causes in children hospitalized in the intensive care unit were classified.

Results. During this period, a total of 2,187 patients were hospitalized in the PICU. A total of 394 patients died; 151 were girls (38.3 %) and 243 boys (61.7 %). Evaluating time of mortality showed that death occurred mostly at out-off hours: 244 (61.9 %) vs. 150 (38.1 %) during the daytime shift, which was statistically significant ($p < 0.05$). In addition, age, gender and the length of stay in the PICU were not significant ($p > 0.05$) when daytime was compared to out-off hours. The conditions which accompanied death were evaluated, the relationship between working hours and death was also significant ($p < 0.05$). More conditions related to mortality were encountered at off-hours.

Conclusion. Off-hours without 24 hour attendance of senior staff, was associated with higher mortality.

Key words: critical ill; child; mortality; after-hours care; intensive care unit, pediatric

<http://dx.doi.org/10.5546/aap.2019.eng.120>

To cite: Ayar G, Uysal Yazici M, Sahin S, Gunduz RC, et al. Six year mortality profile of a Pediatric Intensive Care Unit: association between out-of-hours and mortality. *Arch Argent Pediatr* 2019;117(2):120-125.

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Funding:
None.

Conflict of interest:
None.

Received: 4-11-2018
Accepted: 12-27-2018

INTRODUCTION

Survival rates are gradually increasing and the prognosis is improved through highly qualified personnel and technology in Pediatric Intensive Care Units (PICUs), where critical patients are followed up.^{1,2} Experience is necessary when planning PICUs in developed countries.³ Recently, mortality rates have begun to decrease thanks to an increased number of educated personnel in the pediatric intensive care field.^{4,5} Artificial respiration support is provided through mechanical ventilators in addition to many life saving medical procedures such as periton/hemodialysis, plasmapheresis, ECMO (extracorporeal membrane oxygenation) and various surgical operations. In these units, nosocomial infections may lead to prolonged duration of hospital stay, increased costs and antibiotic resistance as in adults.⁶ Studies are available indicating that mortality is higher in night time admissions.⁷ Some studies state that admission out of daytime shift may not increase mortality⁸⁻¹⁰ and admission after daytime shift is associated with reduced mortality.¹¹ However, the number of studies evaluating the outcomes of the patients who were hospitalized in the PICU is limited. Presumably, a difference in human and technical resources during different daytimes is possible and the problem might be not only fewer trained health providers but also tired professionals and other factors influencing the quality of care. Therefore, the aim was to determine the correlation of mortality rates with daytime shifts compared to other shift

periods (off-hours) to contribute to the improved quality of patient care in these units.

MATERIAL AND METHODS

For the purposes of this study, the medical records of children admitted consecutively to the PICU over a time period of six years, from December 2006 to December 2012, were retrospectively reviewed after approval from the Institutional Ethics Committee. The PICU is a 14-bed, multidisciplinary, tertiary referral centre in which 400 and 450 patients are followed up each year. Patients are accepted from all across the country and the hospital serves as a hematology oncology referral centre where bone marrow transplantation can be performed. Children admitted to the PICU were enrolled in the study independent of the underlying disease. The age group of the admitted children ranged from 40 days to 18 years. Demographics like age, gender, diagnosis, duration of hospitalization, diagnosis, comorbidities and the time of death were recorded as outcomes. Patients were assigned to the groups according to the system implications regarding the most important problems that may cause death, and incomplete medical records were excluded.

In our unit, three pediatricians (two of them have been specially trained/licensed for PICU), four pediatric research assistants and six nurses (experienced in PICU) worked on the daytime shift. A pediatric intensive care unit specialist also worked during two years of the study period. In night time and weekend shifts, only one pediatric research assistant worked in the unit, as well as a senior research assistant and a pediatrician (not experienced for PICU) who were responsible for all units of hospital as well as the PICU. The number of nurses also decreased in out-off hours to four nurses on this shift. Work hours were defined as week days between 8:00 a.m. and 5:00 p.m., with in-house attendance of senior staff, and off-hours was defined as week days between 5:00 p.m. and 8:00 a.m., weekends and public holidays, with one resident covering the PICU and senior staff directly available only on-call. When we made calculations, we assumed that the personnel worked all weeks of the year without taking holidays, and that times between 08:00 am and 5:00 pm five days of the week were day time working hours and the remaining times were out-off times.

Statistical analysis

Data were evaluated using SPSS (Statistical Package for Social Sciences) for Windows version 16. Normality of data was evaluated with Shapiro-Wilk normality test. Normally distributed variables were expressed as mean \pm SD, and non-normally distributed variables as median (minimum-maximum). Student *t* test is used for normally distributed variables and Mann Whitney *U* test was used for comparisons between groups in non-normally distributed variables. Pearson Chi-square test was used for comparison of categorical variables. A *p*-value $< 0,05$ was considered statistically significant.

RESULTS

A total of 2,187 children was admitted to the PICU over a time period of six years and 394 patients who died in the intensive care unit were included to the study with 151 being girls (38.3 %) and 243 boys (61.7 %). Six patients were excluded because of incomplete medical records. The mean age of the patients was 5.5 months (min: 2 months, max: 250 months, median: 35.5 months). The mean duration of hospitalization was five days (min: 1 day, max: 79 days, median: 9 days).

Diagnosis of the patients and the relationship between working hours and death were analyzed. Death occurred in out-off times in 244 patients (61.9 %) and in daytime working hours in 150 patients (38.1 %), and the difference was statistically significant ($p < 0.05$). In addition, age, gender and the length of stay in the PICU werenot significant ($p > 0.05$) when daytime was compared to out-off hours. The conditions which accompanied death were recorded and the sum of these conditions were evaluated; the relationship between working hours and death was also significant ($p < 0.05$). More conditions related to mortality were encountered at off-hours. Regarding the diagnosis of mortality, conditions which accompanied death in the PICU are summarized in *Table 1* and detailed mortality profile at off-hours versus daytime is demonstrated at *Table 2*.

Hematologic system diseases had a great percentage in our hospital where relatively more hematology and oncology patients were followed up. In addition; primary immune deficiency was seen in 17 patients (4.3 %), secondary immune deficiency was seen in 10 patients (2.5 %) and graft versus host disease (GVHD) developed in four patients who underwent bone marrow transplantation. Sepsis was detected in 4 patients

TABLE 1. Conditions which accompany with death in PICU

| Variables | n (%) |
|---|-------------------|
| Distribution diagnoses | 685 (100) |
| Respiratory diseases | 168 (24.5) |
| Pneumonia | 129 (18.8) |
| Aspiration pneumonia | 13 (1.9) |
| Pleural effusion | 8 (1.2) |
| H1N1 pneumonia | 7 (1.0) |
| Acute respiratory distress syndrome | 7 (1.0) |
| Pneumothorax | 4 (0.6) |
| Infectious diseases | 106 (15.5) |
| Sepsis | 69 (10.1) |
| CNS infection | 16 (2.3) |
| Acute gastroenteritis | 8 (1.2) |
| Cytomegalovirus (CMV) infection | 6 (0.9) |
| Crimean congo hemorrhagic fever | 3 (0.4) |
| Tuberculosis | 2 (0.3) |
| Varicella | 2 (0.3) |
| Hematological diseases | 89 (13.0) |
| Anemia | 34 (4.9) |
| Acute myeloid leukemia | 17 (2.5) |
| Acute lymphoblastic leukemia | 12 (1.8) |
| Lymphoma | 11 (1.6) |
| Disseminated intravascular coagulation | 10 (1.5) |
| Deep venous thrombosis | 5 (0.7) |
| Intracranial events | 81 (11.8) |
| Intracranial hemorrhage | 25 (3.7) |
| Intracranial mass | 24 (3.5) |
| CNS anomaly | 14 (2.0) |
| Cerebral edema | 14 (2.0) |
| Herniation | 4 (0.6) |
| Neurological diseases | 77 (11.2) |
| Cerebral palsy / motor mental retardation | 27 (3.9) |
| Hypotonia | 22 (3.2) |
| Spinal muscular atrophy | 14 (2.1) |
| Neurodegenerative diseases | 7 (1.0) |
| Mitochondrial diseases | 7 (1.0) |
| Cardiological diseases | 58 (8.5) |
| Congenital heart disease | 32 (4.7) |
| Pulmonary hypertension | 8 (1.2) |
| Hypertrophic cardiomyopathy | 8 (1.2) |
| Dilated cardiomyopathy | 7 (1.0) |
| Myocarditis | 3 (0.4) |
| Nephrological diseases | 46 (6.7) |
| Acute renal failure | 38 (5.6) |
| Vasculitis | 5 (0.7) |
| Chronic renal failure | 3 (0.4) |
| Endocrinological diseases | 10 (1.5) |
| Diabetes incipitus | 4 (0.6) |
| Hypothyroidism | 3 (0.4) |
| Adrenal insufficiency | 2 (0.3) |
| Diabetes mellitus | 1 (0.2) |
| Gastrointestinal diseases | 36 (5.3) |
| Hepatic failure | 21 (3.1) |
| Gastrointestinal hemorrhage | 5 (0.7) |
| Chronic gastroenteritis | 5 (0.7) |
| Intestinal obstruction | 3 (0.4) |
| Perforation of intestine | 1 (0.2) |
| Acute pancreatitis | 1 (0.2) |
| Trauma | 14 (2.0) |
| Traumatic brain injury | 9 (1.3) |
| Thoracic trauma | 3 (0.4) |
| Penetrating trauma | 2 (0.3) |

PICU: Pediatric intensive care unit.

CNS: Central nervous system.

who were detected to have primary immune deficiency, cytomegalovirus (CMV) infection in 2 patients, tuberculosis in 1 patient, central nervous system infection in 1 patient. *Candida* sepsis was seen in 2 out of 12 patients who had fungal infection and invasive pulmonary aspergillosis in 10 patients (2.5 %).

Metabolic diseases were detected in 29 patients (7.4 %). Genetic syndromes were seen in a total of 22 patients (5.6 %) (Down syndrome in 9 patients, other syndromes in 13 patients). Thirteen patients had arrived to the emergency room as arrested and died in PICU. In addition, drowning was detected in two patients, carbon monoxide poisoning in one patient, intoxication with various drugs in five patients.

Trauma-related deaths were detected in only 14 patients in our hospital, lower than expected because our neighbouring hospital serves as a trauma center. Head trauma was detected in four patients (1 %), general body trauma was detected in 10 patients (2.5 %). There was brain death in 13 patients (3.3 %).

DISCUSSION

In this study we aimed to show the relationship between mortality and off-hours shifts in an environment with limited resources. We believe that number and quality of devices and trained personnel is an important factor to increase survival rates in PICUs. There are different outcomes in studies investigating the influence of admission hours on mortality in PICUs. In a 6-year multicenter retrospective study conducted by Arias et al. in 15 centers, it was shown that mortality rate was higher in patients who were admitted to the hospital at night time, and there was not a significant difference between mortality rates of the patients who were admitted to the hospital on weekdays and on weekends.⁷ Similar to our results; in a study from the USA, mortality rate was higher in off-hours when mortality rates were compared between working hours, off-hours, and weekends.¹¹ In several studies conducted in Turkey, the USA, Australia, Italy and England, patient admission to PICU on an off-hours shift was shown to not increase mortality, while patient admission on off-hours shift was shown to be related with decreased mortality in a single center study conducted in Australia.⁸⁻¹² In a study conducted in Italy, absence of the person in charge in the unit during 24 hours was shown to not affect mortality.⁹

In our study, we analyzed hour of death in patients who died in the PICU in daytime shifts and off-hours. However, whereas the studies in literature mostly have investigated the influence of admission time to PICU on mortality, we investigated the relation with the time at death.

Consistently with the literature, in our study respiratory system diseases were the most common cause of mortality,¹⁴ that was followed by other infectious diseases and hematological diseases. When the primary diagnoses of the patients who died in the PICU were analyzed, it was seen that the highest mortality was seen with neoplastic diseases.¹³ In most of the studies, sepsis was shown to be the most common cause of death.^{5,14} We also found that sepsis was the most common cause of secondary infection. In a study conducted on patients who died in PICU in the Netherlands, diagnoses of the patients on admission were reported as neurological diseases, respiratory diseases, circulatory diseases and others respectively.¹⁵ In another study, respiratory problems, neurological problems and circulatory problems were reported as the most common diagnoses at admission in patients who died in PICU.¹⁶ Nosocomial infections lead to increased morbidity and mortality, prolonged duration of hospital stay, increased costs and antibiotic resistance in pediatric patients as in adults.⁶ Previous studies indicated an association between mortality and hematological diseases, underlying neurological problems, congenital heart diseases, immune deficiencies, renal failure and nosocomial infections.¹⁷⁻¹⁹

Primary or secondary immune deficiencies lead to more severe pneumonia, prolonged duration of hospitalization, and increased mortality. Bone marrow transplantation was performed in four patients with primary immune deficiency who developed GVHD.

In our study, cerebral palsy / motor mental retardation and hypotonic infants comprised 18 % of patients who died, while convulsion was detected in 15 % of these patients. Aspiration pneumonia was the most common problem among the patients with an underlying neurological disease. That may be due to frequent respiratory infections as the result of swallowing dysfunction and increased secretions due to some antiepileptics which lead to increased hospitalization and severe prolonged duration of stay on ventilator, ventilator-related pneumonia and increased mortality because of severe scoliosis, contractures and chest deformities.

In our study, total number of hospitalization was 2,187 during six years and mortality rate was found as 18 %. The reported rate of mortality in PICU is around 5-10 % in developed countries^{8-11,15,16,20} and it was 12.2-17.4 % in another study in our country.⁴ In our study, the higher mortality rate was considered to be associated with the profile of the higher ratio of fatal hematology-oncology patients referred to our PICU nationwide. It is expected that disease profiles show some differences depending on the features of the region. The number of studies investigating mortality in PICUs is still inadequate. The authors are aware of limitations

TABLE 2. Detailed mortality profile at out-of-hours versus day time

| Variables | Total (n = 394) | Out-of-hours (n = 244) | Day time (n = 150) | Significance |
|---|--------------------|---------------------------|-----------------------|--------------|
| Age (months), Mean ± SD (median) | 93.1 ± 69.2 (70.5) | 95.4 ± 69.8 (72.5) | 89.3 ± 68.1 (67.5) | p < 0.05 |
| Gender, Male, n (%) | 243 (61.7) | 158 (64.8) | 85(56.7) | p < 0.05 |
| Female, n (%) | 151 (38.3) | 86 (35.2) | 65(43.39) | |
| Hospital stay (days) Mean ± SD (median) | 9.0 ± 10.8 (5) | 8.5 ± 10.7 (4) | 9.7±10.9 (7) | p < 0.05 |
| Conditions which accompany with death in PICU, n (%) | | | | |
| Respiratory diseases | 168 | 94 (38.5) | 74 (49.3) | |
| Infectious diseases | 106 | 69 (28.3) | 37 (24.7) | |
| Hematological diseases | 89 | 52 (21.3) | 37 (24.7) | |
| Intracranial events | 81 | 44 (18) | 37 (24.7) | |
| Neurological diseases | 77 | 43 (17.6) | 34 (22.7) | p < 0.05 |
| Cardiac diseases | 58 | 36 (14.8) | 22 (14.7) | |
| Nephrological diseases | 46 | 32 (13.1) | 14 (9.3) | |
| Gastrointestinal diseases | 36 | 21 (8.6) | 15 (10) | |
| Trauma | 14 | 14 (5.7) | 0 | |
| Endocrinological diseases | 10 | 9 (3.7) | 1 (0.7) | |

SD: Standard deviation; PICU: Pediatric intensive care unit.

of the study related to its single centered and retrospective medical record review design. However, we believe that the sample size being adequate and long study time (six years) are the strengths of our study.

Duration of PICU stay and disease severity did not change in the past 10 years, but a significant reduction was detected in mortality rates. On the other hand, ratio of mild or severe disability increased among surviving patients. This trend concerns our patients and families, and therefore the whole community.^{21,22} Studies about quality and reliability of patient care have increased recently, so that intensive care specialists should increase their knowledge and increment efforts to improve quality of care.^{23,24} In addition, mortality rate is closely associated with the facilities with PICUs. Following evidence-based guidelines, monitoring the procedures and evaluating the performance outcomes have a critical importance for improving the quality of care. Health care services should depend on team work, be reliable, effective, patient-centered, timely, sufficient and equal.

Sufficient number of well educated health teams, adequate technical equipment, infection control, rehabilitation of children with neurological and genetic anomalies, and enhancing support and supervision in off-hours shifts all have importance for improving quality and survival in PICUs where critically ill children are treated.

CONCLUSION

According to our results, off-hours without 24 hour attendance of senior staff, was associated with higher mortality compared to mortality during daytime work hours, when senior staff were available. ■

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