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Orjinal Araştırma / Original Article

# Evaluation of Patients with Severe Asthma Exacerbation treated in a Pediatric Intensive Care Unit: 8 Years of Single-Center Experience

## Çocuk Yoğun Bakım Ünitesinde Tedavi Edilen Şiddetli Astım Ataklı Hastaların Değerlendirilmesi: 8 Yıllık Tek Merkez Deneyimi

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## Abstract

**Aim**: In this study, we aimed to evaluate the demographic and clinical characteristics of pediatric patients followed in a tertiary pediatric intensive care unit (PICU) due to severe asthma exacerbation (SAE) and to discuss the optimal intensive care management for these patients.

**Material and Method**: We retrospectively analyzed a total of 103 patients between the ages of 12 months and 18 years who were followed up in the PICU with a diagnosis of SAE between 2013 and 2020.

**Results**: On the evaluation of data in terms of respiratory support, it was observed that 34 (33%) of the patients were treated during follow-up with, nasal oxygen cannula or standard non-rebreather oxygen face mask (NC/NRB), 13 (12.6%) with high-flow nasal cannula oxygenation (HFNC), 46 (44.7%) with non-invasive mechanical ventilation (NIMV), and 10 (9.7%) with invasive mechanical ventilation (IMV). When the respiratory supports applied by years were evaluated, the rate of invasive mechanical ventilation usage decreased significantly in recent years compared to the first years (5.6% and 20%; respectively; $p < 0.001$). Pneumothorax developed in one (1%) patient. No patient died among 103 patients who were followed up.

**Conclusion**: We think that early initiation of HFNC or NIMV in combination with bronchodilators, systemic corticosteroids, and if necessary, intravenous magnesium sulfate is a safe and viable treatment option for SAE treatment. In SAE cases in the PICU, the pediatric intensive care specialist should systematically evaluate the patient and quickly decide whether there is a need for respiratory support and additional treatment.

**Keywords**: Severe asthma exacerbation, pediatric intensive care, non-invasive mechanical ventilation

## Öz

**Amaç**: Bu çalışmada, Şiddetli astım atağı (ŞAA) nedeniyle üçüncü basamak çocuk yoğun bakım ünitesinde (ÇYBB) izlenen çocuk hastaların demografik ve klinik özelliklerini değerlendirmeyi ve bu hastalar için optimal yoğun bakım yönetimini tartışmayı amaçladık.

**Gereç ve Yöntem:** 2013-2020 yılları arasında ÇYBB'de ŞAA tanısıyla izlenen 12 ay ile 18 yaşları arasında toplam 103 hastayı geriye dönük olarak inceledik.

**Bulgular**: Solunum desteği açısından değerlendirildiğinde; hastaların 34'ünün (%33) nazal kanül yada geri soluması oksijen maskesi, 13'ünün (%12,6) yüksek akışlı nazal kanül oksijenizasyonu (YANKO), 46'ünün (%44,7) non-invaziv mekanik ventilasyon (NIMV), 10'unun (%9,7) da invaziv mekanik ventilasyonda (IMV) takip edildiği görüldü. Yıllara göre kullanılan solunum destek tedavileri değerlendirildiğinde, son yıllarda IMV kullanım oranımız, ilk yıllara göre istatistiksel olarak azalmıştı (%5.6 vs %20; sırasıyla; $p<0.001$). Bir (% 1) hastada pnömotoraks gelişti. İzlenen 103 hastadan ölen hasta olmadı.

**Sonuç**: Bronkodilatörler, sistemik kortikosteroidler ve gerekirse intravenöz magnezyum sülfat ile birlikte YANKO veya NIMV'in erken başlatılmasının ŞAA tedavisi için güvenli ve uygulanabilir bir tedavi seçeneği olduğunu düşünmekteyiz. ÇYBÜ'de ŞAA'da, çocuk yoğun bakım uzmanı, hastayı sistematik olarak değerlendirmeli, solunum desteği ve ek tedavi ihtiyacına hızlı bir şekilde karar vermelidir.

**Anahtar Kelimeler:** Şiddetli astım atağı, çocuk yoğun bakım, non-invaziv mekanik ventilasyon

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## INTRODUCTION

Severe asthma exacerbation (SAE) is a life-threatening asthma attack that does not respond to acute asthma treatment. Children with acute asthma attacks generally respond to bronchodilators, corticosteroids, and oxygen therapy.[1] Some patients need treatment in the pediatric intensive care unit (PICU) for advanced treatment and respiratory support. In patients with SAE, apnea, cardiac arrhythmia, and respiratory depression may develop and cause morbidity and mortality if acidosis, hypoxia, and hypercarbia are not treated.[2,3] Risk factors associated with SAE include inadequate asthma treatment, poor compliance with current treatment, delayed admission to hospital, and a history of the previous hospitalization for asthma.[1-3] Patients transfer to intensive care if there are signs of severe exacerbation, or if the patient drowsy, confused, or has a silent chest.[2-3]

Respiratory support in SAE consists of oxygen therapy, high-flow nasal cannula oxygenation (HFNC), non-invasive mechanical ventilation (NIMV), and invasive mechanical ventilation (IMV). The majority of cases can be managed without the use of endotracheal intubation and mechanical ventilation. NIMV offers an alternative to IMV for the treatment of acute respiratory failure.[4] Many studies are supporting the safety and efficacy of NIMV for asthmatic patients.[4-6] However, the most recent Cochrane review concluded that there is no sufficient evidence to evaluate the positive effects of NIMV on critical asthmatic patients.[7]

In general, there are different approaches among the centers in follow-up and treatment practice in SAE, which require PICU. There are no detailed guidelines regarding invasive and non-invasive respiratory support options and treatment timing in SAE. This study aims to evaluate the demographic and clinical characteristics of pediatric patients followed in tertiary PICU due to SAE and to discuss the optimal intensive care management for these patients.

## MATERIAL AND METHOD

The study was performed between February 1, 2021, and May 1, 2021, in the PICU of Ankara City Hospital. The study was designed as a retrospective, single-center, descriptive study. The approval for our study was obtained from the Clinical Research Ethics Committee of Ankara City Hospital (with approval number E200/15). The study was carried out by the principles of the Declaration of Helsinki.

### Participant Selection

Four of the 110 pediatric patients with asthma were excluded from the study because we could not be reached patients' data. Patients (n=103) aged between 12 months and 18 years who were followed up in the PICU with a diagnosis of SAE between 2013 and 2020 were included in the study. The following three basic criteria were determined as the inclusion criteria: 1) presence of diagnosed asthma with objective diagnostic criteria, such as pulmonary function test, early reversibility test, bronchial provocation tests, before intensive care admission, 2) patients who were treated in PICU due to their first attack, but then followed up in the pediatric allergy and immunology clinic due to recurrent attacks, 3) patients who have a maintenance treatment report for asthma registered in the electronic prescription system. Patients who do not respond to first-line asthma treatment (inhaled/oral steroid and oxygen therapy) and who have signs of severe airway obstruction (wheezing or silent chest, tachypnea, tachycardia, usage of accessory respiratory muscles, altered consciousness, acidosis, hypoxia, hypercarbia) were defined as SAE. Respiratory supports in the PICU (oxygen, HFNC, NIMV, or IMV) and the decision of additional treatments (intravenous magnesium sulfate, inhaled adrenaline) were left to the pediatric intensive care specialist. The age group under 12 months was excluded because the clinical condition could be confused with bronchiolitis in this group. In addition, patients with other chronic diseases besides asthma-related to the respiratory or cardiovascular system, such as cystic fibrosis, pulmonary hypertension, bronchiectasis, bronchopulmonary dysplasia, congenital heart disease, were not included in the study.

### Data Collection Tools

All patients included in the study were evaluated with a form consisting of three parts. This form included sociodemographic data form, clinical evaluation form, the mortality and morbidity assessment form consisting of standard scales prepared by the authors.

1. **Sociodemographic Data Form:** This form includes sociodemographic characteristics, such as age, sex, personal history, and family history, as well as asthma history (previous exacerbation, severity of exacerbation, hospitalization history, prescribed maintenance treatment data) which was obtained from the medical records of the patients.
2. **Clinical Evaluation Form:** Data including indication for intensive care admission, examination and laboratory findings, clinical course, treatments applied, durations, and clinical responses to treatments, if any, treatment complications were obtained from the follow-up charts of patient used during the intensive care period. In addition, the duration of PICU stay and hospital stay, and the clinical condition of the patients during hospital discharge were also evaluated.
3. **Mortality Assessment Form:** Pediatric Risk of Mortality III (PRISM III) scoring was applied to all patients to determine the severity of the disease, to predict recovery from the disease, to examine the mortality rate, and to evaluate the performance of our intensive care unit.

### Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics software for Windows, version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean and

standard deviation for normally distributed data, and as the median and interquartile range (IQR, 25th–75th percentile) for non-normally distributed data. Chi-square test was used to compare nonparametric data, Kruskal–Wallis test was used to compare continuous variables between groups. The value of p <0.05 was considered statistically significant.

## RESULTS

### Demographic Data and Asthma History

The number of patients with the diagnosis of SAE was determined to be 103 among a total of 6086 patients followed up in the PICU between January 1, 2013, and December 31, 2020, accounting for 1.6% of all hospitalizations. Fifty-six (54.4%) of the patients were male and 47 (45.6%) were female. The mean age was 44.9±38.5 months.

When the clinical indications for admission to the PICU are evaluated, it was observed that 92 (89.3%) patients had respiratory distress/tachypnea, 21 (20.4%) patients had cyanosis, and 10 (9.7%) patients had respiratory failure. Considering the acid-base status of patients during the application for the PICU, median pH was determined as 7,35 in arterial blood gas (IQR: 7.30 - 7.38), median $PaCO_2$ was 40 mmHg (IQR: 35.7 - 50), median $PaO_2$ was 47,2 (IQR: 38.4–53.3). The highest number of hospitalizations was observed in March and April. The distribution of hospitalizations by months is shown in **Figure 1**.

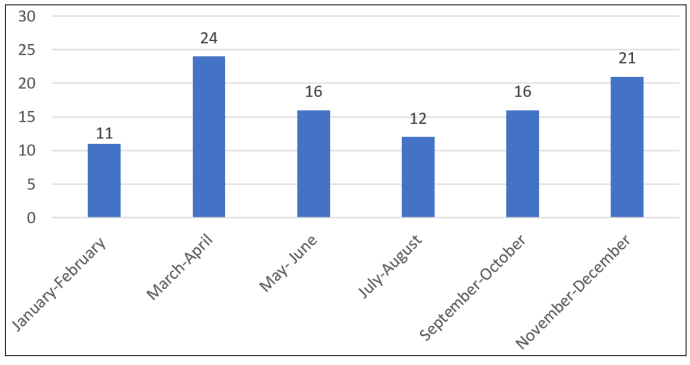


**Figure 1**. The distribution percentage of hospitalizations by months

The mean age at diagnosis of asthma was 30.76±25.42 months. Seventy-eight of the patients (75.7%) applied to the hospital within 24 hours after the onset of their symptoms. Eleven (10.7%) patients had a family history of asthma. 13.6% of the patients were exposed to passive smoking. It was found that 58 patients (56.3%) had a previous hospitalization, and 8 patients (7.7%) had an asthma attack that required PICU admission. The demographic data of the patients are shown in **Table 1**.

### Clinical Evaluation and Treatment Data

On the evaluation of data in terms of respiratory supports, it was observed that 34 (33%) of the patients were treated during follow-up with free oxygen, nasal oxygen cannula, or standard non-rebreather oxygen face mask (NC/NRB), 13 (12.6%) with HFNC, 46 (44.7%) with NIMV, and 10 (9.7%) with intubation. **Figure 2** shows the change in respiratory supports treatment methods applied in SAE patients in our unit monitored over the years. The mean duration of NIMV was 73.2±31.4 hours, and the mean follow-up time with IMV was 5.7±4.6 days. One (1%) patient who was followed up with IMV, developed pneumothorax due to positive pressure ventilation, and a chest tube was required for drainage. Although other respiratory support techniques and medical treatment were successful in most of the patients, 10 (9.7%) patients required intubation and IMV support. When patients were divided into groups according to respiratory support needs, in the group requiring IMV, the median pH value in blood gas was lower, the median $PaCO_2$ value was higher, the median length of stay in the intensive care unit and the hospital was longer, and the PRISM III scores were higher than the other groups, and these were statistically significant (**Table 2**).

**Table 1.** The demographic and clinical data of the patients (n = 103)

| Parameter | n=103 |
|---|---|
| Male, n (%) | 56 (54.4) |
| Mean age (SD), month | 44.9±38.5 |
| Tachypnea, n (%) | 92 (89.3) |
| Cyanosis, n (%) | 21 (20.4) |
| Respiratory Failure (%) | 10 (9.7) |
| Admission pH median, (IQR) | 7.35 (7.30-7.38) |
| Admission $PaCO_2$, median (IQR) | 40 (35.7-50) |
| Admission $PaO_2$, median (IQR) | 47.2 (38.4-53.3) |
| Asthma diagnosis age, mean (sd), | 30.76±25.42 |
| Previous hospital stay, n (%) | 58 (56.3) |
| Smoking in the family, n (%) | 15 (14.6) |
| Family history, n (%) | 11 (10.7) |
| **Respiratory support** | |
| NR/NRB, n (%) | 34 (33) |
| HFNC, n (%) | 13 (12.6) |
| NIMV, n (%) | 46 (44.7) |
| IMV, n (%) | 10 (9.7) |
| **Treatment** | |
| Systemic corticosteroid, n (%) | 103 (100) |
| Inhale ipratropium, n (%) | 31 (30.1) |
| Inhale adrenaline, n (%) | 17 (16.5) |
| Intravenous magnesium sulphate, n (%) | 67 (65) |
| Systemic antibiotics, n (%) | 59 (57.3) |
| Sedation, n (%) | 36 (35) |
| Inotrop support, n (%) | 2 (1.9) |
| **Outcome** | |
| PICU LOS, day, median (IQR) | 3 (2-5) |
| Hospital LOS, day, median (IQR) | 7 (6-9) |
| PRISM III, median, (IQR) | 2 (2-2) |
| Complication, n (%) | 1 (1) |
| Mortalite, n (%) | 0 |

SD: standard deviation, IQR: Interquartile range, NC/NRB: Nasal oxygen cannula or standard non-rebreather oxygen face mask, HFNC: high-flow nasal cannula oxygenation, NIMV: non-invasive mechanical ventilation, IMV: invasive mechanical ventilation, PICU: pediatric intensive care unit, LOS: length of stay, PRISM III: Pediatric Risk of Mortality score

Table 2. Demographic findings, medical treatments, and clinical findings of the patients according to their respiratory support requirement

| Parameter | NC/NRB (n = 34) | HFNC (n = 13) | NIMV (n = 46) | IMV (n=10) | P |
|---|---|---|---|---|---|
| Male (%) | 19 (55.9) | 6 (46.2) | 25 (54.3) | 6 (60) | 0.909 |
| Mean age (SD), month | 54.08±44.88 | 41.84±35.47 | 33.80±22.54 | 69±60.08 | 0.056 |
| pH median, (IQR) | 7.35 (7.32-7.37) | 7.37 (7.35-7.39) | 7.36 (7.31-7.38) | 7.22 (7.09-7.28) | <0.001* |
| $PaCO_2$, median (IQR) | 38.5 (35.3-44.2) | 38 (36.1-41) | 42.3 (35-50.2) | 63.3 (54.75-83,5) | <0.001* |
| $PaO_2$, median (IQR) | 41.9 (35.9-52-87) | 46.9 (40-53.15) | 50 (40.37-56.3) | 47.25 (36.9-51,3) | 0.293 |
| Asthma diagnosis age, mean (sd), | 36.94±28.21 | 26.84±22.55 | 24.23±18.63 | 44.90±37.21 | 0.051 |
| Previous hospital stay, n (%) | 17 (50) | 9 (69.2) | 25 (54.3) | 7 (70) | 0.447 |
| Smoking in the family, n (%) | 6 (17.6) | 2 (15.4) | 6 (13) | 1 (10) | 0.474 |
| Family history, n (%) | 4 (11.8) | 1 (7.7) | 5 (10.9) | 1 (10) | 0.772 |
| **Treatment** | | | | | |
| Systemic corticosteroid, n (%) | 34 (100) | 13 (100) | 46 (100) | 10 (100) | |
| Inhale ipratropium, n (%) | 10 (29.4) | 5 (38.5) | 13 (28.3) | 3 (30) | 0.812 |
| Inhale adrenaline, n (%) | 5 (14.7) | 2 (15.4) | 7 (15.2) | 3 (30) | 0.661 |
| Intravenous magnesium sulphate, n (%) | 19 (55.9) | 8 (61.5) | 35 (76.1) | 5 (50) | 0.302 |
| Systemic antibiotics, n (%) | 8 (23.5) | 6 (46.2) | 35 (76.1) | 10 (100) | <0.001* |
| Sedation, n (%) | 0 | 3 (23.1) | 23 (50) | 10 (100) | <0.001* |
| Inotrop support, n (%) | 0 | 0 | 0 | 2 (20) | 0.02* |
| **Outcome** | | | | | |
| PICU LOS, day, median (IQR) | 2 (2-3) | 2 (2-4.5) | 4 (3-5) | 7.5 (4.5-18) | <0.001* |
| Hospital LOS, day, median (IQR) | 6 (4-7) | 7(4-7.5) | 8 (7-9.25) | 15.5 (9.75-22.25) | <0.001* |
| PRISM III, median, (IQR) | 2 (2-2) | 2 (2-2) | 2 (2-2) | 4 (3-4.5) | <0.001* |
| Complication, n (%) | 0 | 0 | 0 | 1 (10) | 0.102 |
| Mortalite, n (%) | 0 | 0 | 0 | 0 | |

SD: standard deviation, IQR: Interquartile range, NC/NRB: Nasal oxygen cannula or standard non-rebreather oxygen face mask, HFNC: high-flow nasal cannula oxygenation, NIMV: non-invasive mechanical ventilation, IMV: invasive mechanical ventilation, PICU: pediatric intensive care unit, LOS: length of stay, PRISM III: Pediatric Risk of Mortality score, *P< 0.05

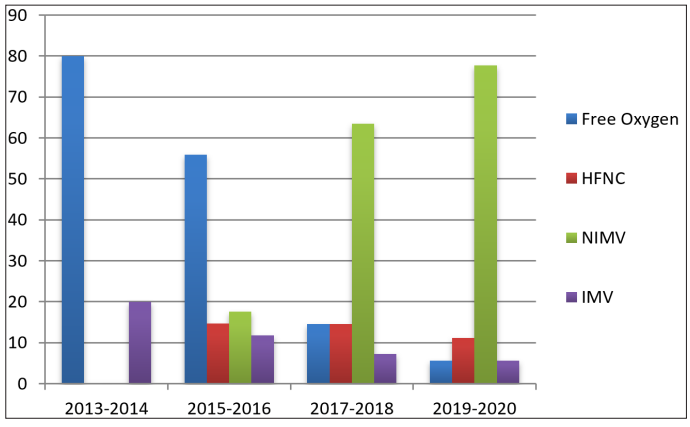


**Figure 2**. The changes in respiratory support treatment over the years in our PICU HFNC: high-flow nasal cannula oxygenation, NIMV: non-invasive mechanical ventilation, IMV: invasive mechanical ventilation

Sedation was applied to 3 (23.1%) patients followed up with HFNC and 23 (50%) patients with NIMV treatment to ensure patient coordination and effective treatment. Dexmedetomidine was used for sedation during HFNC and NIMV. During mechanical ventilation application, all patients received sedation (dormicum and fentanyl) to enable safe and effective mechanical ventilation. Neuromuscular blockade (vecuronium) was used to maintain stable respiratory parameters in 4 patients (40%) with IMV, whose respiratory synchronization could not be achieved despite severe sedation. Inotropic support (adrenaline infusion) was given to 2 (20%) patients who were followed up intubated.

Antibiotic treatment was given to 59 (57.3%) patients, a systemic corticosteroid to all (100%), inhaler steroid to 31 (30.1%) patients and intravenous magnesium sulphate to 67 (65%) patients. **Table 2** summarizes the demographic findings, medical treatments, and clinical findings of the patients according to their respiratory support requirements.

### Outcome

The median length of stay in the intensive care unit of our patient group was 3 (IQR=2–5) days. The median length of stay in the hospital was 7 (IQR=6–9) days. The median PRISM III score of the study group was 2 (IQR; 2–2). Among the 103 patients who were followed up due to SAE in PICU, no patient died.

## DISCUSSION

SAE in children is one of the most difficult causes of respiratory failure to manage. Previous studies have shown that SAE is more common in men.[1-4] The reason for this situation has not been clearly explained; however, it is estimated that it is associated with a narrower airway size in boys compared to girls and a rapid decline in lung function.[8] In our study, we observed that boys were admitted to the intensive care unit more frequently than girls, which can be explained by the higher prevalence of asthma in boys. It was observed that the highest number of hospitalizations occurred in March and April. This situation is thought to be related to the fact that March and April are the peak period for viral infections in our country, such as rhinovirus and influenza virus.

### Respiratory Support

HFNC is a device that is currently used as the primary respiratory support for respiratory distress, especially in emergency rooms.[9,10] HFNC reduces anatomical dead space in the nasopharyngeal cavity and $CO_2$ clearance. In addition, depending on the flow rate applied and the effectiveness of the cannula, it provides a certain level of positive end-expiratory pressure (PEEP) (2–7 $cmH_2O$) and reduces inspiratory resistance.[11,12] Follow-up of patients with HFNC can also be performed inwards other than intensive care in our hospital. The number of patients we apply HFNC is less than NIMV because we accept more severe patients who need NIMV or IMV in our intensive care unit.

With the widespread use of NIMV and HFNC treatment and its effective use in intensive care units, patients with SAE can be successfully treated without IMV. However, in SAE, 6%–20% of children may not respond to treatment and may progress to life-threatening respiratory failure that requires positive pressure ventilation.[13] NIMV has been suggested as a safer, intermediate alternative technique that potentially reduces the need for endotracheal intubation in patients with SAE, considering the risks and morbidity associated with IMV.[15] In addition, there are randomized controlled studies proving the effectiveness of NIMV in reducing the respiratory load in SAE together with nebulized bronchodilator and anti-inflammatory therapy.[15-17] This study showed that NIMV is the most common ventilation method used in patients with SAE hospitalized in the PICU. NIMV is used in our unit as primary respiratory support for children with SAE.

The frequency of IMV requirement in SAE has been reported as 3.7%–33.3% in the literature.[2,3,13,18] IMV requirement was found to be at a rate of 9.7% when all patients in the study were evaluated. When the respiratory supports applied by years were evaluated, the rate of IMV usage decreased significantly in recent years compared to the first years (5.6% and 20%; $p < 0.001$). We think that this situation is related to the absence of a PICU specialist in our unit in the first years of the study and therefore ineffective use of HFNC and NIMV. In addition, we think that HFNC and NIMV therapy and early initiation of additional therapies by making a quick decision in SAE treatment may play a role in reducing the need for intubation.

Bronchospasm and mucosal obstruction are important factors affecting the duration of mechanical ventilation.[3,8] Bronchospasm regresses and the patient can be extubated in a short time with treatment. In the literature, data are showing that IMV prolongs the duration of the PICU stay.[18,19] In our study, the duration of stay in PICU and hospital was found to be longer in patients receiving IMV ($p < 0.001$).

Hon et al. stated that the most important difference between the NIMV and IMV groups was the presence of $CO_2$ retention.[2] When the patient groups were evaluated according to the respiratory support need, it was observed that the group in need of IMV support had a significantly lower median pH value and significantly higher median $PCO_2$ value ($p < 0.001$, $p < 0.001$, respectively). Early treatment of these variables, which is an indicator of respiratory failure symptoms, with appropriate respiratory support is important for morbidity and mortality. In the laboratory follow-ups of the patients during treatment, blood gas values remained within normal ranges.

### Co-infection

Difficulty in distinguishing viral and bacterial infections is one of the clinical problems faced by pediatric intensive care professionals in SAE follow-up. Empirical antibiotics are often used in the initial phase of any curable bacterial co-infections. Rapid diagnosis of respiratory viral infections in children is important because it can cause a reduction in antibiotic use and prevent unnecessary isolation for respiratory viruses. Chiang et al. stated that 57% of the patients who required PICU stay for SAE had bronchopneumonia.[3] In our study, chest radiography was performed in all patients. It was observed that 59 (57.3%) of them had findings indicating pneumonia in addition to asthma, and antibiotics were added to the treatment.

### Treatment and Outcome

Data in the literature indicate that a single dose of intravenous $MgSO_4$ contributes positively to the clinical course in SAE that does not improve with standard initial treatments.[20] In previous studies, the rate of intravenous $MgSO_4$ usage in SAE in need of intensive care was reported to be 17%–36%.[18,21] In recent years, nebulized $MgSO_4$ treatment has also been used in the treatment of SAE.[22] In our study, it was observed that 67 patients (65%) received $MgSO_4$ treatment. $MgSO_4$ was given 40 mg/kg/dose four times a day (up to a maximum of 2 g daily). We did not encounter any significant side effects in any of the patients who received $MgSO_4$. The rate of use of $MgSO_4$ in our intensive care unit has been found to be higher than in the literature since we mostly follow severe attacks that are unresponsive to initial treatments and have found that it benefits the treatment.

In a study, the rate of intensive care rehospitalization of patients in intensive care due to asthma was reported as 17%.[23] In our study, the number of patients re-admission to PICU due to asthma was found to be 8 (7.7%). According to the information obtained from the patient data, the common feature of these patients was that they were not regularly followed up for asthma in the clinics. We think that not regularly attending asthma polyclinic controls makes disease control difficult and increases the risk of readmission to intensive care.

In the literature, it has been shown that 0%–8% of children admitted to the PICU with SAE developed one or more complications during their treatment. The most common complications are aspiration pneumonia, ventilator-associated pneumonia, pneumomediastinum, pneumothorax, and rhabdomyolysis.[15,24,25] In our study, it was found that pneumothorax developed in 1 patient (1%).

In intubated children, the risk of morbidity and mortality is higher due to the longer stay in the intensive care unit and the invasive nature of the procedure. Previously reported mortality rates for SAE ranged from 0% to 18%.[2,3,17] Respiratory failure, barotrauma, or hypotension are among the most frequently reported causes of death. In our study, all patients survived and were discharged from the hospital without clinically significant respiratory sequelae after service follow-up. Early transfer of children with SAE to intensive care, initiation of appropriate treatment as soon as possible, and optimal management of therapy are important in terms of providing positive results.

### Limitation

Our study has limitations because it is a retrospective and descriptive study and there is no comparison group. Clinical scoring of asthma severity is difficult, and physiological markers and PRISM III data may not be accurate indicators of respiratory distress. The Global Initiative for Asthma consists of a table of physical findings, blood gas values, and peak expiratory flow rates to assist clinicians in assessing asthma severity, but does not include a scoring system recommendation.[26] For this reason, a scoring system was not used in our study.

In response to these limitations; the strength of our study is to summarize the systematic treatment approach followed in the PICU together with the clinical characteristics of our cases with SAE over a sufficient number of pediatric patients in a limited number of literature data.

## CONCLUSION

Although our data indicate the survival of all patients, asthma management requiring PICU may be associated with high morbidity and even mortality. We think that early initiation of HFNC or NIMV in combination with bronchodilators, systemic corticosteroids, and if necessary, intravenous magnesium sulfate is a safe and viable treatment option for SAE treatment. In our study, we showed that the need for IMV in the SAE has decreased with the arrival of our pediatric intensive care specialist in our unit in recent years. In SAE cases in the PICU, the pediatric intensive care specialist should systematically evaluate the patient and quickly decide whether there is a need for respiratory support and additional treatment. Multi-center randomized controlled studies should be conducted to assess NIMV effectiveness in SAE. Patient follow-up by a pediatric allergist after the PICU hospitalization and the regulation of maintenance treatment will be effective in terms of asthma control and reduction of re-admission.

## ETHICAL DECLARATIONS

**Ethics Committee Approval:** The approval for our study was obtained from the Clinical Research Ethics Committee of Ankara City Hospital (with approval number E200/15).

**Informed Consent:** Because the study was designed retrospectively, no written informed consent form was obtained from patients.

**Referee Evaluation Process:** Externally peer-reviewed.

**Conflict of Interest Statement:** The authors have no conflicts of interest to declare.

**Financial Disclosure:** The authors declared that this study has received no financial support.

**Author Contributions:** All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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