The management of acute severe asthma in a pediatric intensive care unit

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ABSTRACT

Objective: The hospitalization and mortality rates incurred from acute childhood asthma continue to rise in the past decade. The purpose of this study is to examine the outcome, morbidity and the management of children admitted with acute asthma to our pediatric intensive care unit (PICU) and compare it with those described in the literature.

Methods: Medical records of all children admitted with acute severe asthma to PICU at King Khalid University Hospital, Riyadh, Kingdom of Saudi Arabia over an 8-year period (1994-2001) were reviewed.

Results: Fifty-six patients were analyzed. The male to female ratio was 1.3:1 and the mean age was 3.6 ± 2.8 years. The mean duration of symptoms prior to admission was 2 ± 1.5 days with 39.3% <24 hours. A positive family history of allergy was present in two third of patients. The average stay in PICU was 2 ± 0.9 days. Seventy-three percent of patients received prophylaxis bronchodilator therapy before hospital admission including inhaled steroid in 62%. All the patients received nebulized salbutamol and intravenous corticosteroid. Two third of our patients received nebulized ipratropium bromide and 62% intravenous aminophylline. From arterial blood gases analysis, 46.4% had hypercapnia ($PaCO_2$ >45 mm Hg). None of our patients required mechanical ventilation. Only 2 patients developed pneumomediastinum with pneumothorax that has resolved spontaneously without intervention. There were no deaths among our 56 patients admitted to PICU.

Conclusion: We conclude that the mortality and morbidity in children with severe asthma, who require PICU admissions are minimal, provided optimal early use of bronchodilators and intravenous steroids. Using this approach, it could also be possible to avoid mechanical ventilation and shorten the duration of hospital admission.

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Asthma is the most common chronic pediatric illness in developed countries.[1] Current data indicates an increase in the prevalence of asthma in children,[2] in addition to an increase in the rate of admission of acute severe asthma.[3] Despite extensive advances in understanding pathophysiology and in the treatment of asthma, mortality rate of severe acute asthma has increased.[4] Several factors have been implicated as probably responsible for the increasing mortality, including late referrals, underdiagnosis and inappropriate therapy.[5,6] The benefit use of intensive care unit (ICU) for admissions of severe acute asthma, has been implicated an iatrogenic contributing factor for the increase in asthma mortality.[5] In view of this, we decided to study retrospectively all children admitted with acute severe asthma managed in our pediatric intensive care unit (PICU) over the last 8 years with emphasis on the mortality and morbidity.

Methods. The records of all children (age ≤12) admitted with primary diagnosis of acute severe asthma (severe progressive attack in whom conventional forms of therapy have failed) to our PICU during the period between January 1994 and December 2001 were identified and retrospectively reviewed. Our unit is an

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8-bed multidisciplinary PICU located at King Khalid University Hospital (KKUH), Riyadh, Kingdom of Saudi Arabia. Patient data was collected systemically from the file, using designed data sheet. The diagnosis of asthma was ascertained from the record, as all met the American Thoracic Society criteria for the diagnosis of asthma. The data obtained from medical records included 3 main areas: 1) patient characteristics - age of patient upon admission, sex, month of admission, duration of symptoms before admission, precipitating factors, maintenance therapy, age of diagnosis of asthma, previous admissions, family history of asthma; 2) intensive care management and complications; and 3) clinical outcome.

Results. Over the 8-year study period, 1565 patients with acute asthma were admitted to the pediatric service at KKUH, which accounted for 3.4% of the total admission. Fifty-six (3.6%) of those patients were admitted to PICU for the treatment of severe acute asthma. During the study period, the annual admission rate of patients with severe acute asthma to PICU ranged from 2.1-5.5% of the total admission of children with acute asthma to the pediatric ward. The rate was 4% in 1994 and 3.7% in 2001. The admission criteria to the PICU were: deterioration in level of consciousness, exhaustion, decreased air entry, air-leak syndromes, worsening or failure to improve on standard therapy or near normal or elevated $PaCO_2$ > 45 mm Hg.

Patient characteristics. The male to female ratio of our study population was 1.3: 1; the mean age was 3.6 ± 2.8 years. The age distribution was as follows: infants 16.1%, one to 3 years of age 28.6%, 3-6 years 32.1%, 6-10 years 17.9% and >10 years of age 5.4% (**Table 1**). A positive family history of allergy was obtained in 66% of patients (asthma 59% and hay fever 7%). Triggering factors was documented in 64.3% of cases (upper respiratory tract infections in 60.7%) and the remaining had no clear precipitating factors. Fifty seven percent of patients were admitted between November and March to PICU and the remaining during the rest of the year. The duration of symptoms before admission to hospital was <24 hours in 39.3%, between 2-3 days in 46.4%, 4-5 days in 8.9% and 6-7 days in 5.3%. The mean age for diagnosis of asthma for the first time was 11.7 ± 13.2 months. There was previous admission to pediatric ward in 53.6% and to ICU in 23.2% of patients. Fifty percent of patients had their management supervised by either pediatric pulmonologist or allergist and the remaining by general pediatrician. Seventy three percent of the patients were receiving prophylaxis using one or more of the following medications: inhaled steroid (46.4%), sodium cromoglycate (11%), theophylline (5.4%), ketotifen (1.8%) and combined medications in 8.9% of patients. Sixty-two percent of children were using inhaled salbutamol on an "as needed" basis. Twenty-seven of patients were on no medication prior to their hospitalization.

Intensive care management. In general, patients were admitted to the PICU if their clinical status or blood gases deteriorated. All patients had arterial blood gases measurement once they are admitted to the PICU. The pH was between 7-7.3 in 42.9% of cases and more than 7.3 in the rest. Partial pressure of carbon dioxide values were >45 mm Hg in 46.4% and <35 in 21.4% of the patients. All patients were treated with inhaled salbutamol and intravenous hydrocortisone or methylprednisolone. Continuous inhaled salbutamol (>1 hour) was used in 73% of cases. Inhaled anticholenergic drug (ipratropium bromide) was used in two third of cases, while aminophylline infusion was given to 62.2 of patients (**Table 2**).

Outcome. The average stay of the patient in the ICU was 2 ± 0.9 days. None of our patient required mechanical ventilation. Two patients (3.6%) developed pneumomediastinum with subcutaneous emphysema that has resolved spontaneously without intervention. Pneumonia was not seen in the chest x-rays of any patient. Oxygen was supplemented to all patients during the PICU course via nasal cannula or face mask. Less than 10% of the patients required 100% non-rebreather mask to maintain the saturation >90%. All patients have

Table 1 - Age distribution of 56 children admitted to pediatric intensive care unit with acute severe asthma.

Age (year)	n
0-1	9
1-2	12
2-3	4
3-6	18
6-10	10
>10-13	3

Table 2 - Medication used to treat patients admitted to pediatric intensive care unit.

Drug	Patients %
Inhaled salbutamol	100
Steroids (intravenous)	100
Theophylline (intravenous)	62.2
Inhaled ipratropium bromide	67.9
Salbutamol (intravenous)	3.6
Ketamin (intravenous)	3.6

survived and transferred to the pediatric wards following stabilization with advice to discharge them when they are ready to go home on prophylactic inhaled therapy for asthma.

Discussion. Our data shows that both the overall hospitalization rate and admission rate to the PICU for severe acute asthma in our area remained unchanged during the study period (1994-2001). This finding is similar to Stein et al[7] finding in his study from Toronto, Canada but it differs from other medical centers[8,9] who reported an increase in asthma admission. It has been reported that <5% of asthmatic children admitted to PICU required mechanical ventilation.[10] None of our patients required mechanical ventilation. This maybe contributing to no single death in our study. All patients survived and were eventually discharged home without apparent respiratory sequelae. No mortality among 89 ICU-treated children was also reported by Pirje et al[11] from Toronto during 1983-1985 and 1990-1992. A higher mortality rate was reported from Melbourne, wherein 27 mechanically ventilated patients 5 (19%) died.[12] In other studies, mortality rates have been reported ranging from 0-38% in patients requiring mechanical ventilation for severe acute asthma.[13] The aggressive use of bronchodilator in conjunction with systemic corticosteroids, which was used for all patients (100%), may contribute to the no mortality in our study (**Table 2**). None of our patients required mechanical ventilation, which may contribute to no fatality in this series. The average stay of patient in PICU in this series was 2 ± 0.9. Roberts et al[14] found that centers with higher use of mechanical ventilation had longer median intensive care stay and hospital stays. Before hospital admission, 73% of our patients were receiving one or more specific anti-asthmatic medications at home, including inhaled steroid in 46.4%. The use of such preventive therapy might have reduced the morbidity and mortality in this series as has been reported in some studies.[15] We found boys were more commonly admitted to the PICU than girls, which is in keeping with the higher prevalence of asthma in boys.[16] In agreement with other studies[7,8] upper respiratory tract infection was the most common triggering factor for acute asthma in this series (61%). The seasonal trend in ICU admission for asthma is higher during cold weather, which is similar to previously published reports.[17] Increase rate of upper respiratory tract infections during cold season another contributing factor for increased rate of admission during this period. Two third (66%) of our patients have a positive family history of allergic diseases which is similar to other study.[17] In contrast, others found no connection between a family history of allergy and ICU admission.[18] The mean duration of symptoms before hospital admission in this study was 48 hours. This delay in seeking hospital care suggests that parents and physicians may have underestimated the severity of symptoms. Respiratory failure as indicated by hypercapnia was present in 46.4% of our cases. Inspite of this none of them required mechanical ventilation. This finding is consistent with other studies,[7] where probably the use of aggressive bronchodilators along with systemic steroids can lead to successful management of acute asthma without mechanical ventilation.

In conclusion, the outcome of children admitted to our ICU was excellent in term of both morbidity and mortality. Mechanical ventilation can be avoided provided the use of optimal and aggressive bronchodilators in conjunction with systemic steroids. This approach will reduce the hospital stay and probably the mortality in children with acute severe asthma.

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