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Abstract

Asthma remains a common cause for presentation to the emergency department. Multiple clinical asthma scores (CAS) have been developed to assess the severity of an asthma exacerbation. The objective of this retrospective study was to determine if adoption of a CAS and asthma guidelines identifies patients with more severe asthma and to identify factors that predict the need for hospital admission. The results identified the admission rates in the pre- and post-CAS groups to be similar. Within the post-CAS group, patients requiring admission received more aggressive therapy and were frequently hypoxic on initial presentation. In conclusion, CAS aids in identifying severe asthma exacerbations. Lack of response to aggressive therapy or hypoxia on initial presentation should prompt the emergency department physician to arrange for admission.

Keywords

asthma, clinical asthma score, predictors of admission

Introduction

Asthma remains a significant cause of morbidity in children and is a common cause for presentation to the emergency department (ED), frequently requiring hospital admission. Each year in the United States, asthma exacerbations account for more than 2 million ED visits with approximately 20% requiring hospital admission.¹ Many patients with asthma have multiple pediatric emergency department (PED) visits and hospitalizations, which amount to significant cost and lifestyle burden.² The cost of inpatient treatment of an asthma exacerbation is significantly greater than the cost of PED treatment of an asthma exacerbation, approximately \$3600 versus \$340, respectively at our institution.³

National Institutes of Health (NIH) guidelines were developed in 1992 and revised in 1997, 2002, and 2007 to optimize asthma management at multiple points of care, including primary care settings, EDs, and inpatient hospitalizations. The guidelines involve clinical assessment, objective measures of episode severity, appropriate and timely treatment, asthma education with use of preventative medications, and appropriate follow-up.⁴ Multiple clinical asthma scores (CASs) and guidelines have been developed to assess the severity of an asthma exacerbation and to treat accordingly. Several studies

have shown that asthma guidelines in the ED have been effective in appropriate patient assessment, drug therapy per national guidelines, and patient education.^{4,5} Little evidence exists regarding whether the initiation of CAS and protocol in the ED leads to more aggressive therapy with more patients discharged to home from the ED.⁶

In treating an acute asthma exacerbation in the ED, one of the most critical decisions for the physician is whether outpatient therapy will be adequate or hospitalization is required. In high-volume and often overcrowded EDs, it is also important to make a timely decision early in the course of treatment. Several studies have attempted to identify a single prognostic factor to indicate if inpatient treatment is necessary. In adults, it has been suggested that peak expiratory flow after 15 minutes of treatment may be used to identify those patients who will need further inpatient therapy.⁷ Patients who do not improve expiratory flow after initial therapy followed a more severe course.⁸ In the pediatric population,

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spirometry has been used to predict need for admission, but it has not been a universal finding and is limited to older children who are able to cooperate with this test.⁹ Prior to the NIH guidelines, several studies in pediatric patients attempted to identify single factors predictive of admission, including measured oxygen saturation by pulse oximetry, arterial blood gas measurements, and spirometry but had variable results.^{9,10} Though groups of hospitalized and discharged patients had differences in oxygenation and pulmonary function, a clinical score based on physical exam findings at the decision point for disposition was shown to be correlate best with patient outcome, admission versus disposition home. However, no factors early in the course of treatment in the PED were identified as prognostic.¹¹

The aim of this study was to determine if adoption of a CAS and asthma guidelines in a PED identifies patients with more severe asthma and thus prompts the patient care team to deliver more aggressive care. An additional primary outcome is to identify factors in the PED course that, despite early aggressive therapy, predict the need for hospital admission.

Materials and Methods

This is a retrospective cross-sectional descriptive study of children aged 2 to 18 years who received care at our urban PED for asthma. Charts coded with the diagnosis of asthma requiring hospital admission over an 18-month period (January 2005 through June 2006) prior to the initiation of an asthma protocol and treatment guidelines were compared to charts with the same diagnosis with a CAS of 5 or greater (range 0 to 10) over an 18-month period (January 2007 through June 2008) following a 6-month transition period. Patients admitted from the PED were included in the first group in an effort to capture patients with more severe asthma exacerbations and to compare them with patients with asthma who have high CAS in the second group of patients. Exclusion criteria included diagnoses that were not clearly asthma, for example, lobar pneumonia without wheezing, croup, and sickle cell disease with acute chest syndrome. Charts were reviewed for the following information: age, gender, race, previous asthma diagnosis, home medications, treatments prior to arrival, initial and final oxygen saturation on room air, initial CAS, treatment received, and disposition. If patients were admitted, length of hospital stay and further treatment obtained were recorded. Secondly, patients in the post-CAS population were further subdivided into those admitted versus those discharged home from the PED. This subdivision further assessed differences in

Table 1. Clinical Asthma Score

Parameters	Score 0	Score 1 for Each Item	Score 2 for Each Item
Respiratory effort	Full sentences	Short phrases or cries	Maximum ability single words or grunts
Accessory muscle use	No retractions	Inter/subcostal retractions	Inter/subcostal, supraclavicular retractions, $\pm$ nasal flaring
Auscultation	Clear/minimal expiratory wheeze	Inspiratory and expiratory wheeze	Diminished or absent breath sounds
O ₂ saturation on room air	>95%	91% to 95%	<91%
Sensorium	Normal	Slightly decreased or agitated	Markedly depressed or nonresponsive
Total score			

therapy received and factors predicting need for hospital admission.

At our institution, children can present to the PED for assessment and treatment of acute exacerbations either by self-referral, by primary care referral, by referral from another ED or via ambulance service. Prior to the initiation of the CAS and treatment guidelines, patient care was determined by the treating physicians. The initiation of the treatment guidelines was developed by an interdisciplinary Children's Hospital Asthma Committee in an effort to improve asthma care and increase discharges from the PED. The CAS was designed based on various other protocols already in place in other PEDs and according to the NIH asthma guidelines.

Patients are assigned an asthma score based on 5 clinical characteristics: respiratory effort, accessory muscle use, auscultation, oxygen saturation on room air, and sensorium (Table 1). Scores are given independently by multiple members of the patient care team, including physicians, nurses, and respiratory therapists. The CAS is broken into 3 groups according to the severity of the asthma exacerbation: mild (scores 0 to 2), moderate (scores 3 to 6), and severe (7 to 10). Patient care is directed by the guideline recommendations for each asthma severity group (Table 2). Following each intervention, the patient is reassessed and assigned a new CAS. Further treatment is initiated per treatment guidelines depending on changes in their severity classifications. Hypoxia is defined as oxygen saturation 92% or

Table 2. Asthma Treatment Guidelines

Severity	Asthma Score	Recommendations
Mild	0-2	Albuterol 5 mg nebulized or 4-6 puffs metered dose inhaler (MDI) with spacer Ipratropium bromide 500 µg nebulized or 4-6 puffs MDI with spacer Consider prednisone p.o. 2 mg/kg (max 60 mg)
Moderate	3-6	Albuterol 10-20 mg continuous nebulized or 6-10 puffs MDI with spacer Ipratropium bromide 500 µg nebulized or 4-8 puffs MDI with spacer Prednisone p.o. 2 mg/kg (max 60-100 mg) or methylprednisolone IV (same dose)
Severe	7-10	Albuterol 10-20 mg continuous nebulized or 6-10 puffs MDI with spacer Ipratropium bromide 500 µg nebulized or 4-8 puffs MDI with spacer Prednisone p.o. 2 mg/kg (max 60-100 mg) or methylprednisolone IV (same dose) Magnesium sulfate 50-75 mg/kg IV (max 2 g) over 20-30 min

less and is the point when oxygen supplementation is initiated.

Another major focus on the PED visit is asthma education. Respiratory therapy begins patient and family education on initial patient evaluation using multiple resources developed and identified by the interdisciplinary Children's Hospital Asthma Committee. During the PED visit, nursing staff, respiratory therapists, and physicians all reinforce asthma education. Prior to discharge from the PED, each patient receives an individualized asthma action plan and follow-up is ensured with the primary care physician or pediatric pulmonology.

Results

Patient demographics, including age, gender, race, and percentage with preexisting diagnosis of asthma were similar for both sets of patients (Table 3).

Over the first 18-month period, there were 619 PED visits for asthma with 22% admitted, 84% of which were admitted to the floor and 16% to the PICU. In the

Table 3. Patient Demographics

	Pre-CAS Population	Post-CAS Population
Age, years (range)	5.8 (2-15)	6.4 (2-17)
Race, n (%)		
White, non-Hispanic	38 (29)	35 (22)
Black, non-Hispanic	86 (67)	117 (75)
Hispanic	4 (3)	4 (3)
Other	1 (1)	0 (0)
Gender, n (%)		
Male	77 (60)	98 (63)
Female	52 (40)	58 (37)
Previous asthma diagnosis, n (%)		
Yes	110 (85)	134 (86)
No	19 (15)	22 (14)

Abbreviation: CAS, clinical asthma score.

18-month period following initiation of the CAS, there were 811 PED visits of patients with an overall admission rate of 21%. In total, 79% of admissions were to the pediatric floor and 21% to the PICU. There was also little difference between the groups in average length of stay once admitted, 2.4 days (range 1 to 10 days, median 2 days) versus 2.7 days (range 1 to 6 days, median 2.5 days). Of the 811 PED visits for asthma in the post-CAS group, 19% of patients had a CAS ≥ 5 . Only 54% of those patients with moderate to severe asthma exacerbations in the post-CAS group required admission to the hospital.

Overall albuterol dosing, including total dose and number of treatments, increased slightly between the pre and post-CAS groups (Table 4). However, the use of intravenous magnesium sulfate increased in the post-CAS group from 28% to 38% whereas the average dose given remained at 55 mg/kg/dose. Steroids were given similarly in both groups. The rate of chest X-rays decreased in the post-CAS group with low rates of antibiotic usage in both groups, although less in the post-CAS group.

Within the post-CAS group, patients requiring hospital admission received significantly more aggressive therapy than those who were discharged home from the PED (Table 5). In patients requiring admission, the average number of continuous (1-hour long) nebulized albuterol treatments given was 3.2 (range 1 to 12 treatments, median 3), with an average first dose of 15 mg (range 0 to 20 mg, median 15 mg) and total dose of 48 mg (range 0 to 200 mg, median 45 mg) compared with 1.6 (range 0 to 4 treatments, median 2) average continuous albuterol treatments with average first dose of 14 mg

Table 4. Comparison of Patient Therapy Before and After Implementation of the CAS and Asthma Protocol

	Pre-CAS Population	Post-CAS Population
Total visits to ED, n	619	811
Total admissions, n (%)	129 (21)	170 (21)
Study population, n (%)	129 (21)	156 (19)
Admissions, n (%)	129 (100)	84 (54)
Floor	108 (84)	66 (79)
PICU	21 (16)	18 (21)
Discharged home, n (%)	0 (0)	72 (46)
Initial dose of albuterol in mg; average (median, range)	11 (10, 0-20)	14 (15, 0-20)
Number of continuous nebs; average (median, range)	2.0 (2, 0-6)	2.5 (2, 0-12)
Total dose of albuterol in mg; average (median, range)	33 (30, 0-105)	37 (30, 0-200)
Steroid use, n (%)		
Yes	123 (95)	151 (97)
No	6 (5)	5 (3)
Magnesium sulfate		
Use, n (%)	36 (28)	59 (38)
Dose in mg/kg, average	55	56
CXR, n (%)		
Obtained	100 (78)	78 (50)
Positive	15 (12)	8 (5)
Antibiotics prescribed, n (%)	15 (12)	5 (3)
Length of stay in days; average (median, range)	2.4 (2, 1-10)	2.7 (2.7, 1-6)

Abbreviations: CAS, clinical asthma score; ED, emergency department; PICU, pediatric intensive care unit; CXR, chest X-ray.

(range 0 to 20 mg, median 15 mg) and average total dose 23 mg (range 0 to 70 mg, median 20 mg) in the patients discharged home. In addition to more aggressive treatment with albuterol, use of intravenous magnesium sulfate was used in 66% of admitted patients whereas use was limited to 5.6% of patients discharged from the PED. Steroids were given similarly at 99% of patients in both groups. In the group of patients admitted, chest X-rays were obtained at rate of 76% with only 6% showing an infiltrate. That rate was 21% in patients discharged home with 2.8% showing an acute infiltrate. Antibiotics were prescribed at a low rate in both groups, 3.6% and 1.4%. Patients requiring hospitalization required were hypoxic on initial presentation more frequently than those who were discharged home, 49% versus 11%, respectively.

Table 5. Patient Therapy in Patients Requiring Admission Versus Those Discharged From the PED in the Post-CAS Population

	Admitted	Discharged From the PED
Study population, n (%)	84 (54)	72 (46)
Oxygen saturation at initial presentation	41 (49)	8 (11)
92% or lower		
Initial dose of albuterol in mg; average (median, range)	15 (15, 0-20)	13 (15, 0-20)
Number of continuous nebs; average (median, range)	3.2 (3, 1-12)	1.6 (2, 0-4)
Total dose of albuterol in mg; average (median, range)	48 (45, 0-200)	23 (20, 0-70)
Steroid use, n (%)		
Yes	83 (99)	71 (99)
Magnesium sulfate, n (%)		
Use	56 (66)	4 (5.6)
CXR, n (%)		
Obtained	64 (76)	15 (21)
Positive	5 (6)	2 (2.8)
Antibiotics prescribed, n (%)	3 (3.6)	1 (1.4)

Abbreviations: PED, pediatric emergency department; CAS, clinical asthma score; CXR, chest X-ray.

Discussion

Following the introduction of the CAS and asthma guidelines, nurses, physicians and respiratory therapists in the PED quickly and consistently implemented the new guidelines. Repeat assessments following each intervention were performed to ensure that patients were responding appropriately to each therapy. It was noted by the authors that there was a significant improvement in documentation of asthma symptoms, treatment given, reassessment, and plan in the post-CAS group. Prior to the CAS and asthma guidelines, documentation of clinical status and reassessments following each intervention was inconsistent and incomplete.

Although the initiation of a CAS and asthma guidelines did not reduce overall admission rate or length of inpatient stay, factors predicting need for admission were identified more clearly and earlier in the course of treatment. Despite therapy per the asthma guidelines, more than half of the patients with moderate to severe asthma exacerbations required hospital admission. These patients are more refractory to aggressive therapy in the

PED setting. The lack of significant response indicates that other factors beyond bronchospasm and inflammation may be contributing, such as mucous plugging. Therapies specifically directed at mucous plugging, including chest physiotherapy and medical therapies, such as Dornase alfa, represent an area for future studies. Therapy with Dornase alfa is currently used in patients with cystic fibrosis to decrease the viscosity of mucous and enhance airway clearance.¹² In patients with asthma who have significant mucous plugging, these additional therapies may also aid airway clearance leading to an improvement in lung function. Additional studies are needed.

Patients who required further inpatient therapy received an average of 3.2 continuous nebulized albuterol treatments. Those who were discharged home received an average of 1.6 treatments and showed significant clinical improvement after 1 or 2 continuous nebulized treatments. By identifying a lack of response or lack of improvement in CAS after 2-hour long continuous treatments of albuterol, patients requiring further inpatient treatment may be identified. This allows the ED physician to make the decision of disposition earlier in the course of treatment, thus expediting the process of hospital admission and decreasing time spent in the ED. As the number of ED visits continues to increase, it is imperative to make timely decisions regarding disposition to alleviate ED overcrowding. Recent studies showed PED overcrowding as potential to have a negative impact on the quality of patient care and affect clinical outcomes.¹³ Faster identification of patients who unable to be discharged home is one way to alleviate overcrowding by prompting quicker disposition.

The CAS accounts for multiple patient factors and supports the previous findings that no single aspect is predictive of outcome.^{10,11} However, hypoxia at presentation does indicate a high likelihood of admission. In all, 49% of patients who required further inpatient treatment had hypoxia on initial presentation. A total of 11% of patients discharged home from the ED were initially hypoxic. Though hypoxia may be an indicator of more severe disease, our data supports previous studies¹¹ that normal oxygen saturation does not necessarily correlate with a mild asthma exacerbation. Multiple clinical factors and response to therapy should be considered in the overall evaluation.

Supplementing the ED visit with intensive education for patients and families on management of asthma, as well as ensuring close follow-up with primary care physicians and asthma specialists, also improves overall care.^{14,15} Respiratory therapists were able to review medications, inhaler technique, peak flow measurements, as

well as, an asthma action plan while patients were treated in the ED. The goal in improving asthma education and parental understanding of asthma is to improve asthma symptom control and prevent ED visits, hospitalization, and intensive care unit admissions for asthma-related illness. Ensuring close primary care physician follow-up helps to reinforce the asthma plan and represents another opportunity for intervention prior to onset of severe symptoms.

Adherence to NIH guidelines was assessed during this chart review.¹⁶ The use of corticosteroids in acute asthma exacerbation was consistently high in accordance with the 2007 asthma guidelines. Additionally, it has also been well established that a chest X-ray is not necessary in the setting of acute asthma. The rate of obtaining a chest X-ray at our institution is high, although the rate decreased after initiation of the CAS. The low rate of prescribing antibiotics further supports that X-rays are often negative for infiltrate and unnecessary. Peak flow measurements were attempted with children able to perform the technique per the protocol, but documentation was very inconsistent. These represent areas for continued education.

Limitations

This study was limited by the fact that it was retrospective. In addition, we speculated that the group of admitted patients prior to the initiation of the CAS most closely resembled the patients with high CAS. Therefore, our group comparisons are based on this assumption.

Conclusion

Overall, the addition of a CAS and asthma guidelines significantly enhanced management of asthma exacerbations and should be considered in other EDs. The use of an asthma scoring system allows caregivers and researchers to discriminate asthma severity and be consistent with therapy and outcomes. Patients with more severe asthma exacerbations were treated more aggressively, though this did not improve our rate of admission. Improvements were also noted in documentation and asthma education. Lack of response to aggressive therapy after 2-hour long albuterol nebulizer treatments or hypoxia on presentation should prompt the physician to arrange for admission earlier in their ED course. Deciding disposition earlier in the course of treatment directly improves flow of patients through frequently overcrowded EDs.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interests with respect to the authorship and/or publication of this article.

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