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Brief Report

Initial ED oxygen saturation ≤90% increases the risk of a complicated hospital course in pediatric asthmatics requiring admission

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ABSTRACT

Emergency physicians are responsible for admitting children with asthma who do not respond to initial therapy. We examined the hypothesis that an initial room air pulse oximetry ≤90% elevates the risk of a complicated hospital course in children who require admission with acute asthma.

Methods: Charts of all patients ages 2 years–17 years admitted for asthma from January 2017 to December 2017 were reviewed. An explicit chart review was performed by trained data extractors using a standardized form. Results: A total of 244 children meeting inclusion criteria were admitted for asthma from the ED during the study period. All patients had an initial room air pulse oximetry documented. Sixty-five were admitted to PICU status (27%), and 179 (73%) were admitted to floor status. The relative risk of a complicated course in those patients presenting with a saturation of ≤90% was 11.3 (95% CI 3.9–32.6). The mean initial pulse oximetry on patients with a complicated course was 85% versus 93% for those without a complicated course ($p < 0.005$).

Conclusion: Our data suggest that in pediatric asthmatics that require admission from the ED, those with pulse oximetry readings less than or equal to 90% on presentation are at higher risk of a complicated hospital course.

Emergency physicians are responsible for admitting children with asthma who do not respond to initial therapy in the ED. Determining the optimal inpatient hospital setting and level of monitoring required for admitted asthmatics is challenging for the emergency physician. Identifying who is at risk of a complicated inpatient course can assist the ED physician in this decision-making process. In an effort to examine the hypothesis that an initially low pulse oximetry (≤90% on room air) elevates the risk of a complicated hospital course in children who require admission with acute asthma, the following observational study was performed.

1. Methods

The charts of all patients ages 2 years through 17 years admitted for asthma from January 2017 to December 2017 were reviewed. Asthma was defined as those wheezing patients presenting with a history of this diagnosis or those presenting for the first time with wheezing and receiving repeated doses of bronchodilators and glucocorticoids. An established asthma pathway based on a synthesis of published guidelines was utilized on all patients. Patients requiring continuous albuterol therapy or those needing >40% FIO2 after the first 2 h of therapy were admitted to the pediatric ICU setting. All others were admitted to a general pediatric ward. Criteria for admission to the inpatient ward followed the guidelines established by the National Asthma Education and Prevention Program [1], summarized as those requiring ongoing, frequent beta-agonist therapy and/or intravenous fluids, parenteral glucocorticoids, supplemental oxygen to maintain a saturation >90% or close monitoring. Children who presented with a saturation less than or equal to 90% who responded well to initial therapy such that they were not hypoxic and could be managed with standard outpatient therapy, were discharged to home. An explicit chart review was performed by trained data extractors using a standardized form. Agreement between chart reviewers was monitored. A complicated hospital course was defined as: patients admitted to floor status who subsequently required transfer to the PICU for more aggressive therapy within 24 h of admission, patients admitted to the PICU who subsequently required BIPAP or endotracheal intubation during the first 48 h of the ICU stay, or patients who required an ICU stay of 7 days or more. Patients with chronic lung disease, prior oxygen requirement, sickle cell disease, pneumonia as a primary diagnosis or respiratory failure prompting intubation prior to admission, were excluded. We hypothesized that a presenting oxygen saturation on room air less than or equal to 90% would be associated with a higher risk of clinical deterioration or complicated hospital course.

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2. Results

A total of 244 children meeting inclusion criteria were admitted for asthma from the ED during the study period. All patients had an initial room air pulse oximetry documented. One hundred and eighty patients presented with oxygen saturations of >90% (normal saturation, NS), and sixty-four patients presented with pulse oximetry of 90% or less (low saturation, LS). LS patients were twice as likely to receive parenteral magnesium therapy in addition to standard therapy. The mean hospital length of stay was 3.2 days for NS patients versus 3.8 days for LS patients ($p < 0.05$). Sixty-five children were admitted to PICU status (27%), and 179 (73%) were admitted to floor status. The average patient age was 7.3 years. All patients were treated in the ED with appropriate beta-agonist, ipratropium and glucocorticoid therapy. Three patients admitted to the floor required transfer to the PICU within 24 h of admission (1.7%); 26.2% of patients admitted to the PICU had a complicated course. The relative risk of a complicated course in those patients presenting with a saturation of ≤90% was 11.3 (95% CI 3.9–32.6). The mean initial pulse oximetry on patients with a complicated course was 85% versus 93% for those without a complicated course ($p < 0.005$). The test characteristics of the initial presenting oxygen saturation of ≤90% for predicting a complicated hospital course were a positive likelihood ratio of 3.74 (95% CI 2.68–5.21) and a negative likelihood ratio of 0.25 (95% CI 0.11–0.61). Secondary analysis identified that in asthmatic children requiring admission presenting with a pulse oximetry reading of 85% or less, the relative risk of the subsequent need for BiPap was 26.5 (95% CI 5.5–128.6). There was one fatality in the study population. The clinical details of patients with in-hospital deterioration or complicated clinical course are listed in Table 1.

3. Discussion

Acute asthma exacerbation is one of the most common pediatric emergencies managed by emergency physicians. The large majority of children presenting with acute asthma exacerbation respond well to initial therapy but approximately a notable minority require admission for ongoing care despite initial clinical improvement. In children requiring admission, the ED physician must determine the optimal inpatient setting. Depending on their practice setting, the ED physician may need to transfer the patient to a children's hospital for pediatric intensive care or inpatient care on the ward of a children's facility. Alternatively, some ED physicians will admit children to the inpatient unit of a general hospital.

There are many factors that can be used in an effort to predict the child's inpatient asthma course such that they are admitted to the ideal hospital setting. The amount of therapy required in the ED, clinical response to therapy, pediatric asthma scores, the child's prior admission history, and the need for prior intensive care, are a few of the many factors to be considered. Our results suggest that initial room air pulse oximetry can contribute useful information during this multi-factorial decision-making process. Patients with an initial oxygen saturation less than or equal to 90% were 11 times more likely to have a complicated hospital course. Patients presenting with oxygen saturations 85% or less were 26 times more likely to require BiPap during the admission.

Pediatric asthma scores have been utilized for over forty years to assist with clinical assessment and decision making [2-6]. These scores incorporate a variety of clinical parameters including respiratory rate, work of breathing, quality of air exchange, degree of wheeze, severity of retractions, prolongation of the expiratory phase and mental status. Research on the ability of these scores to predict the need for hospitalization after ED therapy have yielded good results but their ability to predict subsequent deterioration once in the hospital has not been well studied. Clinical scores are inherently subjective leading to challenges with inter-observer agreement and reproducibility.

Initial room air pulse oximetry is useful given it is an objective measurement and is easy to obtain. Physiologic studies have also identified a correlation between low oxygen saturation and airway obstruction in children with acute asthma [7]. Prior research has also -demonstrated that initial room air pulse oximetry, while lacking test characteristics strong enough for it to be used exclusively in clinical decision making, aids in the risk stratification of asthmatic children managed as outpatients [8-13]. Even in studies demonstrating limitations to the diagnostic utility of pulse oximetry in isolation, a relationship between the severity of an asthma exacerbation and pulse oximetry has been demonstrated. Keahey et al. published a large multicenter study examining the test characteristics of pulse oximetry for prediction of the need for admission in pediatric acute asthma in an unblinded protocol [12]. The sensitivity and specificity were found to be insufficient for pulse oximetry to be used independently, but a clear inverse relationship between lower pulse oximetry and admission frequency was demonstrated. The external validity of the data was limited by the fact that 12% of the presenting cohort did not have initial pulse oximetry obtained and an additional 7% of patients were excluded for being 'too sick'. This would likely eliminate many patients with low initial pulse oximetry readings and limit its diagnostic utility. Wright et al. performed a single center blinded study which again demonstrated weak test characteristics for pulse oximetry, but an association between

Table 1
Patients with complicated course.

Age, yr	O2,%	Exam	Mg^{++}	T	HR	RR	Complication
8	63	Retractions, wheeze	Y	98.8	170	50	Long ICU stay
2	73	Wheeze, rales	Y	100.5	162	50	Required BiPap
15	75	Poor aeration, wheeze	Y	98.5	155	32	Required BiPap
8	80	Wheeze, rales	Y	98.8	130	40	Long ICU stay
16	82	Wheeze	Y	97.9	163	28	Required BiPaP
6	82	Retractions, wheeze	Y	98.0	156	40	Transfer to PICU from floor
10	83	Retractions, wheeze	Y	99.2	136	44	Long ICU stay
5	84	Wheeze and grunt	Y	97.7	127	40	Required BiPaP then intubation*
9	84	Retractions, wheeze	Y	98.4	136	36	Long ICU stay
10	85	Wheeze	Y	98.0	128	26	Required BiPap
3	87	Rales, wheeze	N	100.7	160	40	Transfer to PICU from floor
5	89	Retraction, wheeze	Y	100.3	163	40	Long ICU stay
11	89	Retractions and wheeze	Y	99.9	165	32	Long ICU stay
10	89	Poor aeration	N	98.8	159	48	Long ICU stay
6	90	Poor aeration, dropped sats to 88% after nebulizer therapy	N	100.2	133	20	Transfer to PICU
7	90	Poor aeration	Y	98.2	157	41	Long ICU stay
14	92	Wheeze	N	100.8	119	24	Long ICU stay
4	93	Retractions, wheeze	Y	97.8	147	60	Long ICU stay
14	93	Wheeze, retractions, dropped sats to 88% after nebulizer therapy	N	98.0	139	26	Required BiPaP
6	94	Retractions and wheeze	N	99.1	160	34	Transferred to PICU from floor

lower oxygen saturation readings and admission was found [11]. The study was limited by the fact that there were very few patients in the cohort that had low oxygen saturations on presentation and the admission rate was quite high (39%). This would impact the study's ability to evaluate the prognostic properties of initially low oxygen saturation readings.

Our study is limited by the fact that providers were not blinded to the initial pulse oximetry reading and these readings may have impacted their initial therapy. Initial therapy in turn may have had impact downstream on the management of these patients. For example, a patient with an initially low oxygen saturation could have received more aggressive beta agonist therapy in the ED. While this lowers airway resistance, it can transiently increase ventilation/perfusion mismatch and result in lower pulse oximetry readings [14]. Lower oximetry readings could then subsequently lead to escalation of therapy such that the initial low oxygen saturation reading directly impacted our outcome measures. Lastly, our study did not follow the outcomes of patients who presented with low pulse oximetry and who, after initial ED treatment, were improved enough to be discharged from the ED. Therefore, data from our study cannot be used to make inferences about those children with asthma who are discharged from the emergency department after initially presenting with a room air saturation less than or equal to 90%.

4. Conclusion

ED physicians are responsible for choosing the optimal initial inpatient setting for children requiring admission for asthma. Our data suggest that in pediatric asthmatics that require admission from the ED, those with pulse oximetry readings less than or equal to 90% on presentation are at higher risk of a complicated hospital course. This can add information to the multiple factors ED physicians use to determine the optimal inpatient setting for pediatric patients requiring admission.

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