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To cite this article: Caleb D. Wasser , Anna Grushevsky , Stephanie T. Johnson & Sharon R. Smith (2017): Asthmonia: A clinical definition of a commonly used colloquial term, Journal of Asthma, DOI: [10.1080/02770903.2017.1409235](https://doi.org/10.1080/02770903.2017.1409235)

To link to this article: <https://doi.org/10.1080/02770903.2017.1409235>



Published online: 28 Dec 2017.



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Asthmonia: A clinical definition of a commonly used colloquial term

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ABSTRACT

Objective: To describe the clinical characteristics of pediatric asthmonia, a syndrome in which children have both an acute asthma exacerbation and a concomitant diagnosis of community acquired pneumonia. **Methods:** A retrospective chart review was conducted on children admitted to Connecticut Children's Medical Center in the pediatric emergency department from January 1, 2012 to December 31, 2012. Children with asthma and pneumonia were identified using ICD-9 codes 493 (asthma) or 482 (pneumonia). In this study, we defined asthmonia, a third group, based on the following criteria: (1) history of asthma based on documentation in the past medical history section of the chart, (2) documented wheezing on presentation, (3) administration of bronchodilator(s), and (4) new focal infiltrate on chest radiograph during ED visit. The three nonoverlapping groups (asthma, pneumonia, and asthmonia) were described. **Results:** Three hundred and sixty-eight children were identified for our study population. In the study population, 66.0% ($N = 243$) had asthma, 20.4% ($N = 75$) pneumonia, and 13.6% ($N = 50$) met our definition of asthmonia. We found that 84.0% ($N = 42$) of children who met asthmonia criteria in our study were treated with antibiotic therapies. Also, 28.0% ($N = 14$) of children who met asthmonia criteria had documented fever during admission or by parent report. **Conclusions:** This study defined clinical features of the coexistence of pneumonia in children with asthma. Overall, these children frequently presented with fever and were treated with antibiotics. More studies are needed to better elucidate this clinical entity and its ramifications.

ARTICLE HISTORY

Received 2 August 2017
Revised 26 October 2017
Accepted 20 November 2017

KEYWORDS

Asthma; asthmonia; children; emergency department; pneumonia; wheeze

Introduction

Asthma and pneumonia are two common clinical conditions encountered in emergency departments (EDs) throughout the country. It is estimated that seven million children nationwide have asthma (1). Approximately, four percent of US children are diagnosed with community acquired pneumonia each year (2). As leading causes of acute care visits and hospitalizations, it is important to appreciate the clinical features of both entities, as they may present concurrently.

Acute asthma exacerbations can be caused by or can mimic pneumonia (3). Clinicians recognize the overlapping clinical presentation of pneumonia and asthma. Although asthmonia is a colloquial term used by medical providers to describe the overlap of symptoms for pneumonia and asthma, little is written about this clinical entity and how to manage children with asthma who also have new pulmonary infiltrates. Although the use of imaging in the evaluation of children with asthma in the ED is not routinely necessary, radiographs are obtained for those with severe exacerbations or those not responding to therapy (4,5). The etiology of new densities include

atelectasis and bacterial pneumonia, and it is unclear if antibiotics are necessary or beneficial.

Medical diagnoses are constantly evolving as evidenced by Sir William Osler's 1892 definition of asthma as a neurotic affection compared to the more recent definition of asthma as chronic inflammation with constriction (6). With time, further clinical research and pharmaceutical developments, advancements are made to better elicit medical entities and their therapies. With this progress, we need to consider if the colloquial use of terms such as asthmonia, bear weight in influencing medical care. The overlap of asthma with chronic obstructive pulmonary disease lead to a descriptive paper regarding therapeutic options for this newly defined syndrome (7). Another example of a syndrome defined by the intersection of two disease entities is acute chest syndrome; sickle cell pain crisis with concurrent new infiltrate on chest radiograph (8). There is an accepted definition of acute chest syndrome that includes a new infiltrate, chest pain, fever, hypoxia and respiratory symptoms. Although the etiology of acute chest syndrome is complex, infections have been documented in about 1/3 of cases. Management

for acute chest syndrome is now recognized as requiring therapy for sickle cell pain crises, respiratory support as necessary and broad spectrum antibiotics (9). We believe that management of asthmonia will also require a multifactorial approach in proper management as well.

The objective of this study is to describe the clinical characteristics of the colloquial term asthmonia. Children suffering from an acute asthma exacerbation, who also meet criteria for the diagnosis of community acquired pneumonia. By first defining this term, further research can then be done to determine proper management of children with these overlapping entities.

Materials and methods

Study design

A retrospective chart review was performed on children admitted to Connecticut Children's Medical Center from the pediatric ED between January 1, 2012 and December 31, 2012. Permission for this study was obtained from the Institutional Review Board at Connecticut Children's Medical Center. Children admitted to the hospital were chosen because they typically represent the sickest children with either asthma or pneumonia.

Setting

The study hospital is a 187-bed urban tertiary care children's hospital with more than 50,000 ED visits annually. The pediatric ED treats asthma exacerbation visits per protocol with albuterol, ipratropium, and systemic steroids. Depending on response, therapies are repeated versus escalated to continuous albuterol and/or magnesium. On the other hand, children diagnosed with suspected bacterial pneumonia are educated on supportive care and given antibiotics. Pediatric patients with asthma or pneumonia are either discharged home with education and necessary medications or admitted to the inpatient or intensive care units based on clinical status.

Selection of participants

Inclusion criteria included (1) patients seen in the ED and admitted to in-patient unit, (2) age inclusive between 2 and 17 years, and (3) a primary admission diagnosis of asthma or pneumonia (based on ICD-9 codes: 493 (asthma) or 482 (pneumonia)). Exclusion criteria included chronic lung disease (such as cystic fibrosis, chronic aspiration and bronchopulmonary dysplasia) as well as complex medical histories (such as immunodeficiency, congenital heart disease, cancer and history of

tracheostomy). Patients with complex medical histories were excluded from analysis in order to prevent confounding factors, including increased risk of pneumonia. Children younger than 2 years were excluded primarily due to the difficulty in distinguishing asthma from viral bronchiolitis in this age group.

Data collection

Patients were selected from a computerized database of all children presenting to the ED who met inclusion and exclusion criteria. Children with other diagnoses such as "wheezing" or "bronchiolitis" were not included in order to capture a group of children with physician diagnosed acute asthma exacerbations with less likelihood of primary viral infections. Information collected included (1) demographic variables of age, gender, date of presentation, (2) historical parameters such as past medical history, fever, (3) physical examination findings noted during ED evaluation, including temperature, wheezing, (4) asthma severity score (modified pulmonary index score [MPIS]), (10,5) interventions with bronchodilators and/or antibiotics, (6) chest radiograph interpretations, and (7) disposition. This information was entered into a computerized database.

Outcome measures

Asthma and pneumonia were defined based on ICD-9 code labeling each chart with either or both diagnoses. In this study, we defined asthmonia as a syndrome including: (1) a history of asthma based on documentation in the past medical history section of the chart, (2) documented wheezing on presentation, (3) administration of bronchodilator(s), and (4) new focal infiltrate on chest radiograph during ED visit, determined by a board certified pediatric radiologist. To try and decrease equivocal results such as viral etiologies or atypical infections, interstitial infiltrates and radiographs that specifically stated "atelectasis" were excluded. Asthma severity was categorized using the MPIS. The MPIS is a validated severity measure ranging from 0 to 18 (most severe). In the MPIS, 6 categories are evaluated: oxygen saturation, accessory muscle use, inspiratory to expiratory flow ratio, degree of wheezing, heart rate, and respiratory rate. For each of these 6 measurements or observations, a score of 0 to 3 is assigned. (Carroll et al., 2005)

Data analysis

Three non-overlapping groups were described; acute asthma, community acquired pneumonia, and asthmonia (based on the above previous definition). These

three separate disease entities were then analyzed only to outline commonalities and differences amongst each diagnosis group using proportions and mean value. All conclusions were derived under the hypothetical situation in which asthmonia is its own entity, separate from that of asthma and pneumonia. There was no hypothesis tested and no further comparative analysis was performed.

Results

We identified 461 children that were admitted from the ED with the primary diagnosis of asthma or pneumonia between January 1, 2012 and December 31, 2012. Ninety-three (20.2%) were excluded due to chronic lung disease and complex medical problems, with 368 (79.8%) subjects remaining in the study population. The mean age for asthma, pneumonia and asthmonia groups was 6.5, 5.5, and 5.3 years old, respectively. All three groups had approximately equal distributions of genders. While 66.0% ($N = 243$) of our study's population had asthma, 20.4% ($N = 75$) had pneumonia and 13.6% ($N = 50$) met our study's definition for asthmonia. Refer to [Table 1](#) for an illustration of this study's clinical demographic characteristics.

When examining the data further, it shows 84.0% ($N = 42$), of children who met asthmonia criteria and were admitted to the inpatient floor, were treated with antibiotic therapies. Also, 28.0% ($N = 14$) of children who met our definition of asthmonia had documented fever during admission or were febrile during illness by parent report. Further, there were 15.2% ($N = 37$) of the asthma and 53.3% ($N = 40$) of the pneumonia populations with fever as a clinical feature. Readmission rates were similar among the three groups, 8.0% asthmonia, 8.7% asthma (3 subjects missing readmission data) and 14.7% pneumonia (2 subjects missing readmission data). The difference in severity scores (MPIS) of children with asthma versus those with asthmonia also did not show significance.

Finally, only 42.8% ($N = 104$) of children admitted with asthma had chest radiographs; of those 2.9% ($N = 3$) had a focal infiltrate. However, there were 96.0% ($N = 72$) of admitted patients with pneumonia evaluated with imaging. Overall, 94.2% ($N = 98$) of children diagnosed with asthma, and had imaging obtained, did not have infiltrates on chest radiographs and therefore did not meet the definition of asthmonia.

Table 1. Clinical demographics.

	Asthma ($N = 243$)	Pneumonia ($N = 75$)	Asthmonia ($N = 50$)
Age in yrs.	Mean 6.5, SD 4.0	Mean 5.5, SD 4.1	Mean 5.3, SD 3.1
Males	57.6% (140)	49.3% (37)	54.0% (27)

Discussion

Asthma and pneumonia are two of the most common reasons children in the United States visit the ED on an annual basis (4). Further, it is widely recognized in the medical community that these disease entities have some overlap. In this study, we defined asthmonia as a syndrome including: (1) a history of asthma based on documentation in the past medical history section of the chart, (2) documented wheezing on presentation, (3) administration of bronchodilator(s), and (4) new focal infiltrate on chest radiograph during ED visit, determined by board certified pediatric radiologist. Among children admitted to the hospital with either asthma or pneumonia as primary diagnoses, we found 13.6% had asthmonia using this definition. This study highlights the overlapping clinical features between asthma and pneumonia among children initially presenting to an ED. To our knowledge, this is the first study in the pediatric literature defining the term asthmonia.

Other studies have evaluated children with clinical features of both asthma and pneumonia. A recent article in the Journal of the American Medical Association published in 2016 found that, having an acute asthma exacerbation and being 5 years of age or older, female, febrile, and/or hypoxic, was statistically associated with radiographic pneumonia (11). Further studies have recently demonstrated a significant percentage of children admitted with a dual diagnosis of asthma exacerbation and community acquired pneumonia. In 2015, Wilson et al. reported that of 25,124 hospital admissions in a multi-center study, 43% of these children had the dual diagnosis. They expanded on this information further noting a propensity for longer length of stay and increased use of hospital resources for these children (12). A study of children presenting to the ED with asthma revealed that 25.0% had a chest radiograph and that 10.0% had a new focal infiltrate (5). The prevalence of pneumonia in previous investigations varied widely, ranging from 8.6% to 35.0%, and those that included children with wheezing had similar ranges 1.0–23.0% (4,13,14). (13,14). Most recently, a multicenter study was conducted in an effort to improve care for children admitted to the hospital with community acquired pneumonia. Part of the aim was to utilize evidence-based management to decrease the treatment of concurrent asthma exacerbation and pneumonia. There was initially a decrease in the co-diagnosis of asthma and pneumonia following their guidelines, however this decrease was not sustained (15). We believe that all of this information directly correlates with the findings of this descriptive study. Asthma, pneumonia and asthmonia are three separate disease entities. By clearly defining asthmonia we can begin to determine

practical guidelines for the treatment of this disease process using evidence-based medicine protocols.

One of the more important aspects in diagnosing specific respiratory illnesses in children is evaluating the necessity of imaging. Scarce information is available on the term asthmonia; however, other studies do discuss the relationship between pneumonia and asthma. Mathews et al reviewed the challenges associated with the diagnosis of pneumonia in children with wheezing and deduced that only 2.0% of children with wheezing and no fever had radiographic pneumonia. (16) Children with wheezing had a clinical history and auscultatory findings that are challenging to distinguish from those children with pneumonia. Their prospective cohort study evaluated historic and clinical features of children with wheezing and subsequent chest radiographs diagnosing pneumonia, and concluded the routine use of chest radiographs for afebrile children with wheezing has no benefit. Several studies have shown that focal findings on chest radiograph are infrequent, do not change management and may cause unnecessary use of antibiotics (19,20,5,18). Similarly, Pavia's study stated that fever with concurrent cough and/or wheezing does not increase one's probability of having bacterial pneumonia (17). Our data also shows that fever did not correlate with disease severity as well. As our asthmonia population only had a fever 28.0% of the time, but 84.0% of these children required use of antibiotics as part of their management. Given the study inclusion criteria required hospital admission, this may be an over-representation of the general population as whole. However, we believe that it accurately depicts the level of illness attributed to children that warrant use of the term asthmonia.

The need for antibiotics in children with both wheezing and infiltrates on chest radiographs is not clear. Many of these children have viral illness. Pavia reviewed the commonly encountered practice of prescribing antibiotics to treat likely viral illnesses. This article re-emphasized that existing viral diagnostics are limited in sensitivity (17). Further publications discussed that lower respiratory illnesses, such as pneumonia, contribute to acute asthma exacerbations, but most of the microbial etiology has been associated with viral infections (21). While studies allude to the idea that a majority of exacerbations have a viral origin, Berce et al's data identified more than a quarter of their patients to have mixed viral and bacterial infectious etiologies (22). It is, however, difficult to delineate between bronchiolitis and asthma in very young children, as both illnesses can be associated with viral infections. It has also been demonstrated that, focal consolidation on chest radiograph, and elevated inflammatory markers increase the likelihood of bacterial co-infection (17). We did not include children younger than two years of age for this reason.

Evidence has shown that, in children hospitalized for acute wheezing with defined viral etiologies, only 3.0% of children with acute viral wheezing actually had bacterial-type pneumonia. (25) However, Juven et al concluded that for children hospitalized with pneumonia, viral infections become less common with increasing age, whereas the incidence of bacterial infections remains relatively constant (23). Further, it has been argued that viral pneumonia may also predispose infected children to bacterial pneumonia due to the damage of the mucosal barriers. (Lichenstein et al., 2003) Terraneo et al evaluated the hypothesis that asthma may be associated with an abnormal immune response to pneumococci. (24) Their study reviewed 4079 adult hospitalized patients with the coexistence of pneumonia caused by pneumococci and asthma and concluded that clinical outcomes of community acquired pneumonia (CAP) in patients with asthma was similar to the general population at risk for CAP. Although our study does not have enough evidence to suggest an alteration to clinical management of children with asthmonia, further research may see similar findings.

Our study attained the goal of describing the clinical entity of asthmonia. A limitation of this study is that it was performed in a single center and may not reflect the same characteristics of asthmonia elsewhere. While, we attempted to exclude equivocal chest radiograph interpretations, the challenge persists that biased conclusions may be made during a retrospective chart review causing over-representation. A prospective study design with larger cohort would be more effective in determining therapeutic interventions. Another limitation is there were a relatively small number of subjects due to the restrictive definitions that were used in attempting to evaluate a group of children with a low likelihood of primarily viral etiologies. Viral etiologies cannot be ruled out in a retrospective study. Chest radiographs were also not done on all children. A prospective study could address this better. Chest radiographs were done at discretion of the attending physician, and some children with asthma may have also had focal infiltrates but were not identified. It is possible that the children admitted with pneumonia had wheezing due to the infection and not from underlying asthma. However, our definition of asthmonia included children with a history of previous wheezing, no chronic illness or disease that would account for wheezing, were all 2 years or older, and received bronchodilators. Infection is a trigger for asthma and complicates this clinical entity.

Conclusions

This study analyzed and defined clinical features of the co-existence of pneumonia in children with asthma. In

children admitted to the hospital with pneumonia and/or asthma, 13.6% could be classified as having asthma. Overall, these children frequently presented with fever and were treated with antibiotics. The use of antibiotics was equivocal for the asthma and pneumonia groups, but rate of fever was highest in the pneumonia group. More studies are needed to better elucidate this clinical entity and its ramifications.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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