A Single-Institution Experience in the Use of Chest Radiographs for Hospitalized Children Labelled as Asthma Exacerbation

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Abstract

Background: Risks of cancer have become more notable lately, especially for young children with a chronic condition such as atopy. This study reports on cumulative radiation from chest radiographs in children with asthma. Its main aims were to consider our current practice, and suggest minimizing chest radiograph use in this vulnerable people. Methods: The study was retrospective and conducted at tertiary center. Eligibility criteria included children 2-15 y who were admitted between January-2017 and December-2018 for asthma management. Results: Of 643 children who were admitted as 'asthma exacerbation', 243 (40% females; age [mean±SD] 5.4±3.3 y) met the study criteria for inclusion. Ninety-two (38%) children had temperature 38.8±0.7oC on the day of admission. Antibiotics were prescribed for 148 (61%) children, mainly for presumed pneumonia. Chest radiographs were requested for 214 (88%) children, mainly on the day of admission. Only 38 (18%) chest radiographs showed focal/multifocal pneumonia justifying antibiotic use. Significant predictors for requesting chest radiographs were antibiotic use for presumed pneumonia, lower oxygen saturation at presentation, and requesting blood culture. Rate of chest radiographs per year was negatively related to child's age; the younger the child the higher the rate (model coefficient -0.259, P<0.001). For children <5 y, rate of chest radiographs was 1.39±1.21/y and radiation dose 0.028±0.025 mSV/y. The corresponding rates for children [?]5 y were 0.78+-0.72/y and 0.008+-0.007 mSV/y, respectively (P<0.001). Conclusion: Chest radiographs were commonly requested for children with asthma, especially the young ones. Prospective studies are necessary to measure the impact of this practice on their health.

INTRODUCTION

Compared to adults, young children are more sensitive to the damaging effects of low-level ionizing radiation, such as that produced by the medical imaging [1]. Although the negative impact of such repeated exposures is yet to be measured systematically [2], the consensus has been that diagnostic radiographs should be kept at the minimum, especially for young children with a chronic condition such as asthma [3]. As pointed out recently, childhood asthma is a leading cause of hospitalization, and disparities in its management are substantial [4].

The American Academy of Pediatrics (AAP), the National Heart, Lung and Blood Institute (NHLBI), and the Global Initiative for Asthma (GINA) have issued statements addressing the hospital-based care for children with asthma [5-7]. The consensus is that requesting a radiographic imaging requires thoughtful considerations. As wisely stated, there is an urgent need to improve the awareness of radiation dosing, and communicating its risk with children's families [8-9].

Respiratory disorders are especially common in our community [10]. In one study, the estimated prevalence of childhood asthma was about 13% [11]. Many of these children, however, have joint causes, such as atopy, infection, and inherited entities such as primary ciliary dyskinesia [12]. Nevertheless, as expected [13], the presumptive diagnosis of 'asthma exacerbation' remains a primary cause of our pediatric admissions. This study aims to determine the prevalence of requesting chest radiographs for these children. Its main objectives are to explore our current practice, and suggest rules for improvement.

Methods

This retrospective data collection study was conducted at Tawam Hospital, a tertiary referral center in Al Ain (Abu Dhabi, UAE) that covers a population of over 600,000. The study was approved by 'Tawam Human Research Ethics Committee' (AA/AJ/784; 'antibiotics and radiographical investigation misuse in children admitted with acute asthma exacerbations, Tawam Hospital experience'). Informed consent to participate in this 'Retrospective Chart Review' was exempt.

In our institution, the utilized equipments were expected to result in a radiation dose of 0.02 mSV per chest radiograph for children <5 y, and 0.01 mSV per chest radiograph for children [?]5 y. Abnormal chest radiographs were independently reviewed by the pediatric radiologist (M.I.T.); the findings are summarized in Results.

The participants were children 2 to 15 y who were admitted to the pediatric ward between January 2017 and December 2018, had a primary diagnostic label of 'asthma exacerbation', and received corticosteroids as a treatment for asthma. Only the last admission was considered for those who had multiple hospitalizations during the study period. Children with group A streptococcus pharyngitis (n = 9) or positive mycoplasma IgM antibody (n = 3) were included, as these pathogens could trigger asthma. Children who were admitted to the pediatric intensive care unit (n = 35) or did not receive corticosteroids (n = 155) were excluded. Other exclusion criteria were children with Down syndrome, complex heart disease, swallowing dysfunction, sickle cell disease, primary ciliary dyskinesia, interstitial lung disease, cystic fibrosis, Stuve-Wiedemann syndrome, chronic lung disease of prematurity, tracheostomy, bronchiectasis, pulmonary hypertension, malignancy, tracheoesophageal fistula, and diaphragmatic hernia.

Nasopharyngeal swabs were performed on admission for viral antigen detection (typically included influenza A and B, respiratory syncytial virus [RSV], parainfluenza, and adenovirus) and/or for pathogen genome detection by real-time one-step polymerase chain reaction (RT-PCR). The latter methodology used Allplex Respiratory Panels One and Two (Seegene Biotechnology Inc., Seoul, Korea). Panel One included influenza A, influenza B, human RSV A and B, influenza A subtypes H1, and H1pdm09. Panel Two included adenovirus, metapneumovirus, enterovirus, and parainfluenza viruses 1, 2, 3, and 4.

Statistics . The analysis was performed using SPSS (version 20). Multiple logistic regression of requesting chest radiographs versus various predictors was performed using backward selection (likelihood ratio). Similarly, multiple logistic regression of using antibiotics versus various predictors was performed using backward selection (likelihood ratio). Analysis of the rate of chest radiographs per year was performed using a negative binomial model with log(age) as offset variable (sample size = 243). The explanatory variables were age and age^2. P <0.05 was considered significant.

RESULTS

A total of 643 children were admitted with the label 'asthma exacerbation' during the study period. Of those, 243 children met the study eligibility criteria and their characteristics are summarized in Table 1. Ninety-two (38%) children had temperature [?]38.0°C on the day of admission. Blood culture was requested for 173 (71%) children. Three blood cultures were positive; one for *viridans streptococci* (a 4-year-old child with temperature 39.2°C), one for micrococcus (a 7-year-old child who was afebrile), and one for unspecified 'gram positive rods' (a 4-year-old child with temperature 38.0°C). Antibiotics were prescribed for 148 (61%) children, mainly for presumed pneumonia (48%); three of these children had positive mycoplasma IgM antibody. Five (2%) children received antibiotics for otitis media, nine (4%) for group A streptococcus pharyngitis, and 14 (6%) as an empiric dose of ceftriaxone or augmentin in the emergency department. The duration of antibiotics was 8.4 ± 2.8 days (median, 10 days). The most commonly used antibiotic was augmentin, followed by ceftriaxone, cefuroxime, amoxicillin, penicillin V, azithromycin, and clarithromycin.

Pathogen studies were requested for 180 (74%) children; 40 (16%) children had a positive test (Table 1). Temperature (36°C to 41°C) on the day of admission did not correlate with either the white blood cell count or the C-reactive protein (R^2 <0.03 for both).

Chest radiographs were requested for 214 (88%) children. Eighteen (8%) children had two views. Hundred and seventeen (54%) chest radiographs were normal. Ninety seven (46%) chest radiographs were interpreted as abnormal, and were all reviewed by the pediatric radiologist (M.I.T.). His evaluations were as follows. 'Frontal chest radiographs of 97 children were available for review. Previous chest radiograph(s) were available for comparison in 95 children. The radiographic findings were classified into three categories: (1) Normal, when no radiographic abnormalities were identified; (2) Pneumonia, when either unifocal or multifocal consolidation was identified; and (3) Small airways disease related changes, when the chest radiograph showed one or more of the following radiographic features: (a) Hyperinflation, (b) Perihilar bronchial wall thickening, or (c) Long standing bands of atelectasis. The results show seven chest radiographs were interpreted as normal, 52 as small airways disease related changes, and 38 as pneumonia (of which 27 as focal pneumonia and 11 as multifocal pneumonia).'

The adjusted rate of chest radiographs for children <5 y was 1.39±1.21/y and *[?]* 5 y was 0.78+-0.72/y (P = 0.000). The corresponding radiation dose was 0.028+-0.025 mSV/y and 0.008+-0.007 mSV/y, respectively (P = 0.000). The cumulative radiation was 5-fold higher in children <5 y than that in children *[?]* 5 y (P = 0.000).

Multiple logistic regression of requesting chest radiograph or using antibiotics versus selected predictors was performed using backward selection (likelihood ratio), Tables 2-3. Significant predictors for requesting chest radiograph were use of antibiotics for presumed pneumonia (P = 0.002), lower oxygen saturation at presentation (P = 0.031), and requesting blood culture (P = 0.035), Table 2. The significant predictor for using antibiotics was abnormal chest radiograph (P = 0.009), Table 3.

The next analysis investigated whether the rate of chest radiographs (mean number divided by age in years) differed with age. As shown in Fig. 1, a negative binomial model fit the data well. The deviance/degrees of freedom (df) was 1.029, indicating the chi-square test of goodness-of-fit was non-significant (deviance = 246.016, df = 239, P = 0.223). Akiake Information Criterion (AIC) and Bayesian Information Criterion (BIC) for the negative binomial model were smaller than those for the Poisson model: AIC = 1280.94 versus 1549.00 and BIC = 1294.75 versus 1559.38. Thus, the negative binomial model fit the data better than the Poisson model.

The rate of chest radiographs per year was significantly different for children of different ages (likelihood ratio chi-square test = 56.61, df = 2, P = 0.000). This rate was negatively related to the child's age; that is, the younger the child the higher the rate (model coefficient of age = -0.259, P = 0.000; and model coefficient of age^2 = 0.010, P = 0.016), Table 4. Gender was not significant when added to the negative binomial model described above (P = 0.336). Thus, gender was dropped from the model.

DISCUSSION

The GINA Report defines *asthma exacerbation* as 'an acute or subacute deterioration of symptoms and lung function from the baseline control' [7]. As shown here, this term was used imprudently, as the majority (400 of 643, or 62%) of our admissions with this label had considerable comorbidities and, thus, were unfairly designated as asthma exacerbation. Therefore, we have used the following joint criteria for the study eligibility: (1) Use of systemic corticosteroids for the management of asthma exacerbation, and (2) Absence of associated (relevant) clinical conditions that could influence the assessment and management. A misuse of the diagnostic tag "asthma exacerbation" impedes the development and implementation of practical evidence-based rules for these children. In addition, variations linked to regional medical resources (e.g., national health coverage versus self-paid) play an important role in these admissions. In a recent study that involved several emergency departments, the prevalence of chest radiograph use in children with asthma was about 30% [18]. This practice did not significantly change after implementing a quality improvement approach (pathway) [18].

Radiation is a well-known cause of cancer, especially for *high*exposures in early life [14]. We show here that young children with asthma receive significantly more chest radiographs than older children do. Therefore, every effort should be taken to alter this current practice and the habits of unnecessary use of medical radiation (including computerized tomography scan) for these youngsters [15-16]. Suggested recommendations toward this goal include: (*1*) Educating healthcare providers about potential adverse events coupled with diagnostic radiation (e.g., the AAP initiative for "improving the value of care delivered to children with asthma") [17-18], (*2*) Relying on the medical history and physical examination to attain clinical assessment [19-20]; (*3*) Regulating radiation equipments to deliver minimum necessary dosing [14], (*4*) Establishing evidence-based thresholds for the allowed radiation dose as function of age [21], and (*5*) Advancing ultrasound and magnetic resonance imaging (MRI) technologies to replace the diagnostic radiation procedures.

The study here also shows that the significant predictor for using antibiotics was abnormal chest radiograph. Therefore, a proper interpretation of chest radiographs is essential to minimize the use of antibiotics. As shown here, only 38 (18%) of the 215 chest radiographs showed focal or multifocal pneumonia justifying antibiotic use.

Study limitations include being retrospective, single institution experience, limited number of older children (>5 y), not including infants (<1 y) and young toddlers (1 to 2 y), and missing the total radiation dose from all diagnostic procedures. These issues are subjects of future research.

Conclusions : Evidence-based guidelines are needed to minimize the medical radiation, especially in young children. Parents' education and counseling are crucial to achieve this goal. The electronic medical record should alert healthcare providers on the cumulative medical radiation (green, yellow, or red); only a valid reasoning for the imaging procedure should be allowed in the 'yellow and red' zones. Evidence-based guidelines are also needed to define the proper assessment and management of hospitalized children for asthma.

DECLARATIONS

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Legends

Fig. 1 . Mean observed rates of chest radiographs per year and the corresponding predicted rates, estimated using the negative binomial regression model versus age and age^2; the model fitting curve is: Rate of chest radiographs = $\text{Exp}\{1.124 - 0.259\ \text{Age} + 0.010\ \text{Age}^2\}$.

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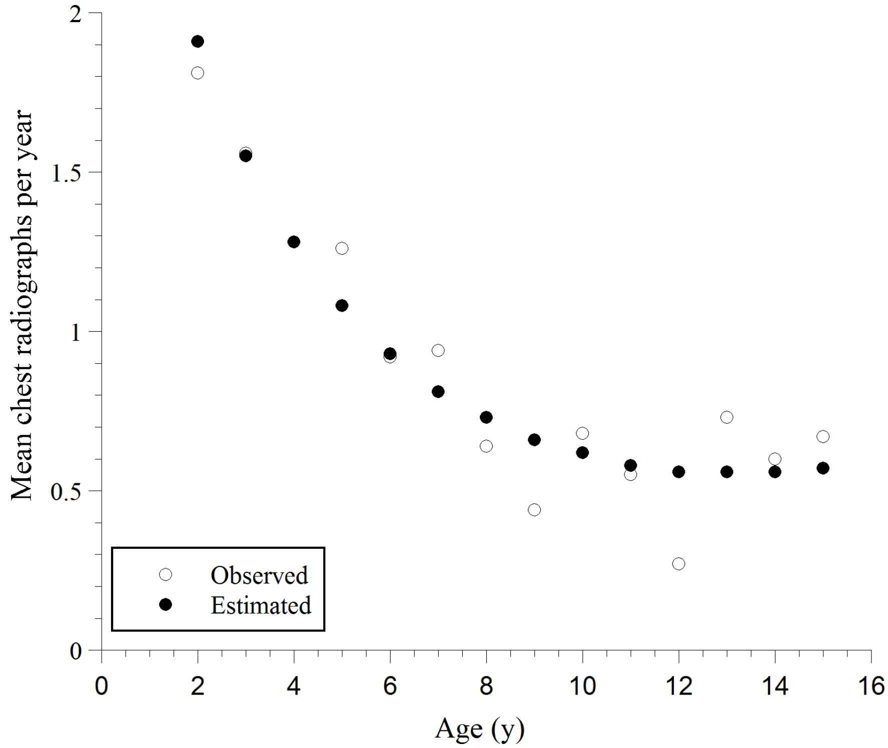
Mean chest radiographs per year
2
1.5
1
0.5
0
Observed
Estimated
0
2
4
6
8
10
12
14
16
Age (y)