Original Article
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Medical Journal of the Islamic Republic of Iran (MJIRI)
Iran University of Medical Sciences

Arterial blood gas and spirometry parameters affect the length of stay in hospitalized asthmatic patients

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Received: 24 Feb 2013 Accepted: 8 June 2013 Published: 16 Feb 2014

Abstract

Background: Asthma is a common condition in general medical practice, and it accounts for about 1% of all ambulatory hospital visits. Nowadays, hospitalization rates for asthma have actually been increased in some demographic subgroups despite recent advances in treatment. Understanding the underlying factors that contribute to hospitalization and especially duration of the hospitalization of asthmatics could help elucidate the recent rise in morbidity and also reduce the high demand on health care systems of the disease. The aim of this study was to evaluate factors affecting the duration of hospitalization for Iranian patients with asthma.

Methods: This study was conducted on 55 asthmatic patients (diagnosis of asthma was in accordance with the criteria of the American Thoracic Society). The study was performed on patients hospitalized in Rasoul-e-Akram hospital in Tehran, Iran during the period 2005-2006. During hospitalization, the patients' most common complaints were recorded as the symptoms and signs of the medical condition, results of physical examinations, spirometry, arterial blood gas analysis (ABG), and ICU admission.

Results: There were 18(32.7%) male and 37(67.3%) female patients with a mean age of 54.96 (SD=17.54) years. The mean duration of hospitalization was 8.31(SD=4.69) days that ranged between 2 and 23 days. The mean baseline arterial PH ($p=0.039$, $R_{Pearso} = -0.362$), baseline arterial $[HCO_3]$ ($p=0.042$, $R_{Pearson} = 0.361$), changes of FEV_1 after bronchodilator ($p=0.041$, $R_{Pearson} = -0.363$) and patient's age ($p=0.002$, $R_{Pearson}=0.0433$) were determined as factors affecting duration of hospitalization.

Conclusion: Our results showed that more attention needs to be given to the findings of arterial blood gas and spirometry which can potentially affect the duration of hospitalization of asthmatic patients.

Keywords: Asthma, Hospitalization, Length of Stay.

Cite this article as: Mousavi S A J, Fereshtehnejad S. M, Khalili N, Naghavi M, Yahyazadeh H. Arterial blood gas and spirometry parameters affect the length of stay in hospitalized asthmatic patients. *Med J Islam Repub Iran* 2014 (16 Feb). Vol. 28:4.

Introduction

Asthma is a common chronic inflammatory lung disease worldwide (1) and a leading cause of morbidity which can often lead to hospitalization and in some severe cases, death (2). This disease accounts for about 1% of all ambulatory hospital visits in the USA (3). The mortality rate from asthma has risen sharply since the late 1970s, which may reflect an increasing severity of the disease (4). The hospitalization rate for asthma patients provides a marker of the level of asthma within the population and is an indicator of the severity of the problem, which remains substantial, generating near-

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ly one-half of all US health care costs for asthma (4, 5). Hospitalization rates for asthma have actually increased in some demographic subgroups, such as in young adults and the urban poor, despite recent therapeutic advances (4). Nine percent of hospitalized asthma patients account for 49% of the global expense associated with the disease (6). It is estimated that 10% of patients with asthma present with severe manifestations of the disease. Severe asthma results in a disproportionately high burden (7), which has a direct effect on the health care system and an indirect social cost. The former effect, can be attributed to the utilization of health care resources due to a high rate of hospitalization and visits to the emergency department and the latter derives from absence from work and lost productivity (1, 2), and another effect of the condition, the cruelest consequence, is the personal one that also affects the family of the sufferer and is caused by recurrent asphyxia (7).

To reduce this burden and elucidate the recent rise in asthma morbidity and also to improve survival of these patients, information about predictors of the severity of the disease and the underlying factors that contribute to hospitalization for asthma is very important (3).

Research has identified some outcomes at a patient's level that can determine the severity of an illness on admission, such as mortality, hospitalization rate, length of stay (LOS) in days, Conditional Length of Stay (CLOS), and readmission (8). These researches have shown that co-morbid conditions experienced by older asthmatic patients may contribute to post hospital admission mortality for asthma; asphyxia and cardiovascular diseases are the most common causes attributed to mortality in these patients; non-white race, low income, old age, female gender, and greater asthma severity are associated with a higher risk of hospitalization. However, an increased use of inhaled corticosteroids is associated with reduced hospitalization. Moreover, hospital admission for asthma occurs mainly in autumn (3, 7, 9-10). Finally, parameters related to LOS are characteristics of the physician and the hospital (8, 11, 12). The results however, are controversial and are not necessarily specific for asthma. Additionally, overcrowding in an emergency department is associated with longer LOS (13). Unfortunately, there is not enough study on patient characteristics that relate to LOS in asthma as a marker of overall allocation of resources by the provider (8).

This is an important issue as research has shown that prolonged hospital stays are associated with increased complications (14). Therefore, the aim of our study was to identify factors affecting LOS among patients with asthma.

Methods

Patients and study protocol

This study was conducted on 55 asthmatic patients. Diagnosis of asthma was in accordance with the criteria of the American Thoracic Society (ATS) (15). The patients in the study were hospitalized in Rasoul-e-Akram hospital in Tehran, Iran for the period 2005-2006. All patients had been admitted for an asthma attack to the emergency and pulmonology wards of Rasoul-e-Akram University Hospital (affiliated to Iran University of Medical Sciences). Besides its academic role, Rasoul-e-Akram University Hospital more importantly functions as a regional and referral center; therefore, this patient population is an acceptable representative of general pulmonary practice. Patients were hospitalized for one or more of the following indications: respiratory distress, significant co-morbidities, failure to respond to initial treatment, and a judgment that treatment at home would be insufficient. Asthmatic patients not responding to bronchodilator and with FEV1 more than 12-15% were excluded.

Each patient was included only once in the study, even if the patient had been hospitalized more than once. During hospital admission, patients were treated with the standard procedure consisting of the IV

administration of corticosteroids, short acting beta-agonist and corticosteroid sprays and in cases of patients that were not responding, Aminophiline. O_2 was titrated according to the results of blood gas analyses.

Moreover, the criteria for discharging the patients were as follows:

1. Remission of clinical signs and symptoms.
2. FEV1 more than 70.
3. O_2 saturation more than 94%.
4. Having good and appropriate family care at home.

In addition, all patients were evaluated and assessed by a single group of pulmonologists that included four doctors.

Prior to the beginning of the study, patients were fully informed of the conduct and consequences of the study and they signed a consent form. This study was conducted following approval by institutional review board and the ethics committee of Tehran University of Medical Sciences and was in accordance with the ethical principles described in the Declaration of Helsinki.

Data collection

Demographic, baseline and clinical data were collected for all patients including: age, sex, smoking status and load (pack-yrs), opium consumption and its route, history of snoring, spirometric and Arterial Blood Gas (ABG) analysis on admission, and also last day ABG. In addition, the baseline symptoms and the chief complaints were the results of a physical examination and pulmonary auscultation, admission to ICU and its outcome; length of hospital stay was also noted for each patient. For determination of the duration of hospital stay, the date of the first administration to the hospital and the exact date of their discharge or expiration were recorded. This information, together with time since hospitalization, was obtained from reviews of personal and official medical documents and also by questioning the patients directly.

Measurements

Both on hospital admission and after recovery (immediately before hospital discharge), resting Arterial Blood Gas (ABG) were assessed by a puncture of the radial artery during room air breathing prior to nasal or oral oxygenation. ABG results included PH, $PaCO_2$, PaO_2, O_2 saturation and HCO_3^- concentration.

Standard spirometric examination at admission was performed using a Vmax 20c spirometer (SensorMedics Corp., Yorba-Linda, CA, USA), with the spirograms having the largest Forced Expiratory Volume in one second (FEV_1) and Forced Vital Capacity (FVC), selected from at least two technically acceptable spirometric measurements that were used in the analysis. If spirometric measurements could not be taken just after admission, they were taken as soon as possible within 24 h. For each patient, FEV_1, FVC, FEV_1/FVC and Vital Capacity (VC) were measured twice, before and after using a bronchodilator. These values were also expressed as percentages of the reference values.

Statistical analysis

All data are expressed as mean±SD. The distribution of nominal variables was compared using the Chi-square test. In order to compare the mean values of quantitative variables the Independent T-test and One Way ANOVA procedures were performed. In order to univariate analysis of the factors that may be related to duration of hospitalization, Pearson Correlation was also used. Further analysis with Linear Regression Model was performed to evaluate whether any variable could potentially predict length of hospitalization in asthmatic patients. A maximum number of 5 variables were included in this model with a stepwise method. A two-sided p-value<0.05 was considered to be statistically significant.

Results

Baseline & clinical characteristics

A total number of 55 asthmatic patients were included in our study. There were 18

(32.7%) male and 37 (67.3%) female patients with a mean age of 54.96 (SD=17.54) years. As listed in Table 1, 4 (7.8%) patients were current smokers with a mean smoking amount of 16.25 (SD=4.78) pack.yr. Additionally, 1.9% of the patients were opium addicts. Regarding the season of admission, descriptive data showed that 41.5% of all admissions were in autumn.

On evaluation of the medical records, it was revealed that 14.9% of the patients had a family history of respiratory tract disease; and 3.6% were habitual snorers.

Patients' symptoms and signs are also shown in Table 1. As listed, the most common symptoms were dyspnea (80%), sputum production (52.7%), and coughing for less than 3 weeks (49.1%). Moreover, wheezing (87.3%) and crackle (23.6%) were the most frequent sounds heard on their lung auscultation.

Laboratory Characteristics

The results of baseline and discharge ABG's are shown in Table 2. The mean values of $PaCO_2$ and PaO_2 were 40.56 (SD=8.99) mmHg and 74.6 (SD=27.66) mmHg on admission, respectively. However, the mean values of $PaCO_2$ and PaO_2 were 39.9 (SD=9.49) mmHg and 78.99 (SD=22.48) mmHg on discharge, respectively.

Table 1. Demographics and clinical main variables of Asthmatic patients

Variable	Value
Age (year) mean±SD	54.96±17.54
Gender %	
Female	67.3
Male	32.7
Smoking %	7.8
Amount of smoking (pack.yr) mean±SD	16.25±4.78
Addiction %	1.9
Family history of respiratory disease %	14.9
Symptoms %	
Dyspnea	80
Sputum production	52.7
Cough less than 3 weeks	49.1
PND	40
Orthopnea	38.9
Cough more than 3 weeks	29.1
Lung sounds %	
Wheezing	87.3
Crackle	23.6
Rhonchi	7.3
Snoring %	3.6
ICU admission %	2.2
Duration of hospital stay (day) mean±SD	8.31±4.69

A spirometry was performed on all asthmatic patients. The mean value of FEV_1, before and after using bronchodilator, was 58.43% (SD=18.52) and 71.48% (SD=20.68) of predicted values, respectively. Moreover, the mean values for FEV_1/FVC, before and after the bronchodilator was 61.87% (SD=18.67) and 67.52% (SD=17.23), respectively. Other mean values for the different spirometric indices are listed in Table 2.

Length of study & it's affecting factors

The mean duration of hospitalization was 8.31 (SD=4.69) days that ranged between 2 and 23 days. A significant difference was found between low-level educated (<11 yr of school-year studying) and highly college educated (≥11 yr of study) patients regarding the length of hospital stays [9.14 (SD=3.98) days vs. 4.92 (SD=2.14) days, p=0.045].

More detailed analysis showed that there were not significant differences in outcomes of the measurements and the corresponding physician of the asthmatic patients (p=0.48). The mean baseline arterial PH (p=0.039, $R_{Pearson}$ = -0.362), baseline arterial $[HCO_3]$ (p=0.042, $R_{Pearson}$= 0.361), changes of FEV_1 after bronchodilator (p=0.041, $R_{Pearson}$= -0.363) and patient's age (p=0.002, $R_{Pearson}$=0.0433) were determined as factors affecting the duration of hospitalization.

Linear Regression Analysis

A significant linear regression model was done to predict length of stay (p=0.001, Adjusted R^2=0.482) including baseline arterial $[HCO_3]$ (p=0.002, Standardized Beta=0.581), changes of FEV_1 after bronchodilator (p=0.003, Standardized Beta=-0.556) as the following formula:

Length of hospital stay= 0.581× Baseline $[HCO_3]$ – 0.556× changes of FEV_1 after bronchodilator – 5.42

Table 2. Results of ABG and spirometric indexes of Asthmatic-patients during their admission in the hospital. (Values are expressed as mean±SD)

Variable	Values
Arterial Blood Gas (ABG)	
● On admission	
PH	7.45±0.07
$PaCO_2$ (mm Hg)	40.56±8.99
PaO_2 (mm Hg)	74.60±27.66
$[HCO_3^-]$	28.38±4.03
O_2 Saturation (%)	93 ±5.86
● On discharging	
PH	7.47± 0.06
$PaCO_2$ (mm Hg)	39.90±9.49
PaO_2 (mm Hg)	78.99±22.48
$[HCO_3^-]$	31.33±5.27
O_2 Saturation (%)	94.90±4.64
Spirometric Indexes	
● Before bronchodilator	
FEV_1 (lit)	1.72±1.40
FEV_1 (% predicted)	58.43±18.52
FVC (lit)	2.34±0.84
FVC (% predicted)	70.98±20.53
FEV_1/FVC	61.87±18.67
VC (lit)	2.63±1.27
VC (% predicted)	76.32±15.93
● After bronchodilator	
FEV_1 (lit)	1.84±0.77
FEV_1 (% predicted)	71.48±20.68
FVC (lit)	2.86±1.26
FVC (% predicted)	85.42±18.14
FEV_1/FVC	67.52±17.23
VC (lit)	2.83±1.07
VC (% predicted)	86.53±18.74

Discussion

Many studies have evaluated factors related to survival and mortality of asthmatic patients, but this is one of a few studies to assess factors affecting duration of hospital stay among patients. The results show that factors such as lower baseline arterial PH, higher baseline arterial $[HCO_3]$, lower changes of FEV_1 after bronchodilator, and higher patient age could potentially lead to longer duration of hospital stay among asthmatic patients.

In a recent study by Watson et al (6), the authors found that co-morbid conditions experienced by older asthma patients may contribute to post admission mortality for asthma and that the female gender and old age were introduced as demographic risk factors for asthma mortality and hospital admission. Similar to our study, Tsai et al (16) showed that older asthmatic adults had longer hospital length of stay in a nation-wide survey on emergency departments in the USA. In line with these findings, the results from the Finnish Asthma Programme (17) also emphasized on the effect of older age in the LOS for asthma. They concluded that asthmatic patients with ≥65 years old, especially women, accounted for 39% of the hospital days, and they need more attention to reduce hospital burden (17). While in our study patients' sex had no effect with the length of hospitalization,

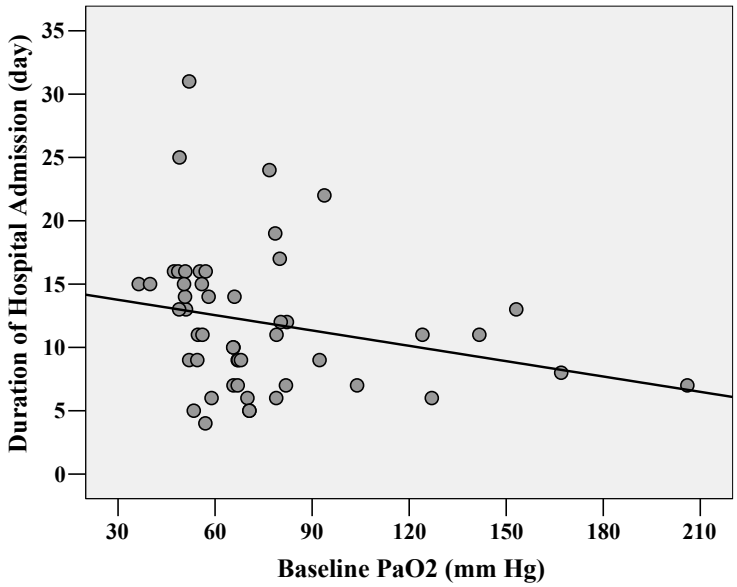

Fig.1. Statistically significant reverse correlation between baseline PaO_2 and duration of hospital stay ($p=0.010$, $r_{Spearman}= -0.361$)

a recently published cohort multi-center study on 183 adult asthmatic patients showed that female gender is a risk factor for asthma-related hospitalization (18).

There are also studies on hospitalization rates such as the one done by Eisner et al (3) in which non-white race, low income, and greater asthma severity were associated with a higher risk of hospitalization. Another study by Ishihara et al. (10) suggested that increased use of inhaled corticosteroids were associated with reduced hospitalization.

Another factor found to affect hospitalization was season; in the study by Serrano et al (7) admission due to asthma occurred mainly in autumn and they concluded that this result was probably related to respiratory infection, rather than exclusively to asthma severity. Research similar to this study also found that the higher proportion of all admissions was in autumn.

Parameters related to the LOS were investigated by some other authors such as Silber JH et al (8), who showed significant differences in LOS in different states of United States America. Huang ZJ et al (19) indicated that hospitals providing medical education to pediatricians and safety net care do so without increasing LOS or cost of care for pediatric asthma patients.

Conversely, some other hospital characteristics shown to affect LOS where Lin et al (20) showed that compared with district hospitals, medical centers and regional hospitals had longer and more statistically significant LOS, as well as higher costs. Hospitals operating on a for-profit basis had shorter LOS and lower costs than public and not-for-profit hospitals. This study showed an existence of wide variation in LOS and cost per discharge for asthma hospitalization, between the various types of hospitals in Taiwan.

Despite the findings of the aforementioned studies, there is yet no study on patient characteristics affecting LOS in asthma. Therefore, this was one of a few researches to assess factors related to LOS in asthma patients and it recommends comparative designs for future research to better explain the issues here introduced.

Conclusion

Hospitalization for asthma patients is potentially avoidable. However, it is an important marker of the severity of asthma at the population-level and highlights the importance of factors affecting duration of hospitalization in these patients. The results of this study show that more attention needs to given to readings of arterial blood gas (ABG) and spirometry, factors that contribute to duration of hospitalization for asthmatic patients.

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