A Predictive Score for Unfavorable Outcome of Acute Asthma in the Emergency Room

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Background: *It is sometimes difficult to decide on a safe discharge of an acute asthmatic patient from the emergency room (ER).*
Objective: *To develop a predictive score for safe discharge of an acute asthmatic patient from the ER.*
Material and Method: *All adult asthmatic patients who visited the ER at Ramathibodi Hospital from January 2004 to August 2005 were recruited. Vital signs, oxygen saturation, and severity factors were recorded. Salbutamol was nebulized initially and repeatedly if the peak expiratory flow rates (PEFR) were < 70% predicted or if unfavorable physical signs were seen. Systemic steroids were administered to those patients whose severity factors had been identified. Patients were admitted if further treatments were needed after the 4th nebulization. An unfavorable outcome was defined as either hospital admission or relapse within 48 hours of the ER discharge. Univariate analysis of each variable was performed, followed by multivariate analysis of those with statistical significance. Predictive scores were derived from statistically significant factors at the cutoff point of receiver-operating curve that yielded the best area under the curve.*
Results: *There were 905 visits from 568 patients. Predictive factors included inability to lie down on presentation and wheezing or low PEFR after the last dose of bronchodilator. A comparison of score sensitivity, specificity, and predictive values, across different cutoffs indicated that a score of $\geq$ 2 predicted an unfavorable outcome.*
Conclusion: *A predictive score based on three bedside parameters might be used for a safe discharge of asthma patients from the ER.*

Keywords: *Acute asthma, Predictive score, Emergency*

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Acute asthma is an episode of rapid, progressive increase in one or more symptoms of shortness of breath, cough, wheezing, and chest tightness[1]. The severity of exacerbations may range from mild to life threatening which often brings the patient for emergency room treatment[2]. In Thailand, 14.8% of asthma patients are admitted to hospitals and 21.7% reported one or more emergency room visit each year[3]. In the emergency room (ER), the on-duty physician assesses the disease severity, provides appropriate treatments, and makes decisions regarding home-discharge or hospital-admission. Although a variety of clinical and laboratory measures are currently used to assess acute asthma severity, no single finding has been found to predict outcomes reliably[4,5]. The purpose of the present study was to develop a predictive score for safe discharge of patients with acute asthma from the ER.

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Material and Method

Subjects

A prospective cohort study was conducted from January 2004 to August 2005 in the ER of

Ramathibodi Hospital (a tertiary care university hospital). All emergency visits of adult acute asthma patients during this period were recruited. The diagnosis of asthma was based on criteria proposed by the National Heart, Lung, and Blood Institute (NHLBI)[1]. Patients who could not perform peak expiratory flow rate (PEFR) measurement and were respiratory arrest imminent received immediate intubations and admissions were excluded. The present study protocol was approved by the Ethics Committee on Human Experimentation of Ramathibodi Hospital, Faculty of Medicine, Mahidol University.

Acute asthma treatment protocol and data collection

The present study protocol (Fig. 1) was run closely to The Global Initiative for Asthma (GINA) Treatment Guideline[1]. Upon arrival to the ER, patients were examined and briefly evaluated for severity factors which included factors obtained from history (previous intubation or admission, excessive use of inhaled β_2-agonists, current use of steroid) and unfavorable physical examination (inability to lie down on general physical examination or complete a sentence, active use of accessory muscles, presence of respiratory paradox). Salbutamol (2.5 mg), or an equivalent drug, was then nebulized followed by assessments of vital signs, oxygenation, wheezing, physical signs indicative of severity and peak expiratory flow rates (PEFR). Repeated doses of β_2 nebulization (15 min interval) were needed only if the assessed PEFR were < 70% predicted based on age, sex, height and race and/or presence of unfavorable physical findings. Systemic steroid was also added initially (intravenous dexamethasone or oral prednisolone) for those patients

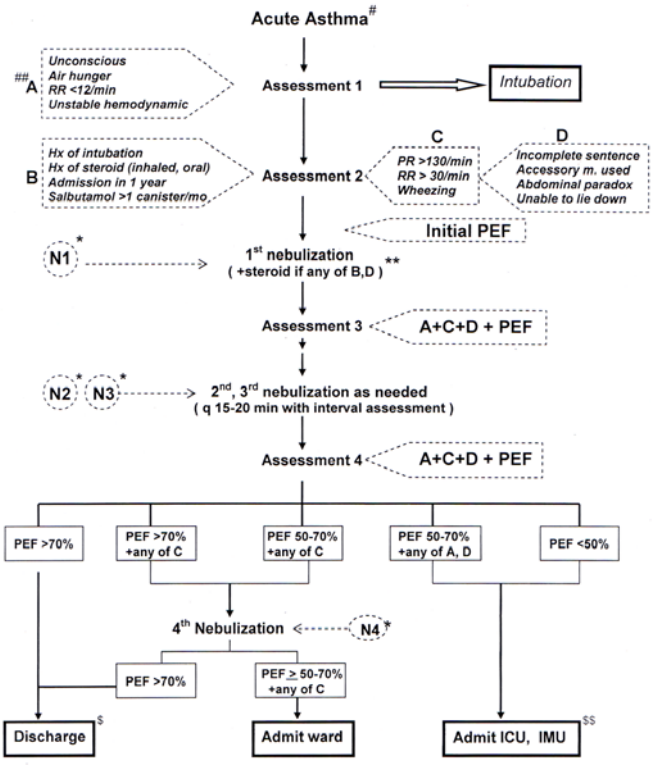

Fig. 1 Acute asthma treatment protocol

whose severity factors were identified. Patients were scheduled to admission if further treatments were needed after the 4th nebulization, as judged by the treating physician.

Collected data included patients' demographic variables, vital signs, severity factors, arterial oxygen saturations at presentation, frequency of nebulization, physical signs, and PEFRs after last nebulization or before discharge. An unfavorable outcome was defined as either hospital admission or relapse within 48 hours of the ER discharge.

Statistical analysis

Mean value and standard error of the mean were calculated for continuous variables. For dichotomous variables, both individual and pooled statistics were expressed as odds ratio (OR) with 95% confidence interval (CI).

Univariate analysis was performed on each clinical variable to obtain predictive variables for the multivariate model. The authors then included the statistically significant univariate predictors ($p < 0.1$) in the multivariate logistic regression analysis to determine the significance and strength of association between each candidate predictor in predicting treatment outcome.

A predictive score was developed from those identified by multivariate analysis (p-value ≤ 0.05)

Table 1. Characteristic of patients

	Favorable (n = 808)	Unfavorable (n = 97)	All (n = 905)
Sex, Male (%)	30.7	31.3	31.0
Age, yrs*	45.3 (0.5)	51.4 (1.6)	57.6 (1.5)
Duration of symptom, hr*	36.4 (2.9), SD = 82.1	29.2 (3.4), SD = 32.9	35.7 (2.7)
Severity factors by history			
Previous intubation**	12.0	18.7	12.7
Current steroid use**	64.0	66.7	64.3
Admission within 1 yr**	16.3	31.9	17.9
Use of β_2-agonists > 1 canister/mo.**	20.5	30.8	21.6
Initial examination			
Unconsciousness**	0	1	0.3
Air hunger**	0	2	0.4
RR < 12/min**	0	1	0.2
Unstable hemodynamic**	0	2	0.4
Wheezing**	99.9	100	99.9
Inability to complete a sentence**	11.5	26.7	13.1
Use of accessory muscles**	56.6	75.6	58.6
Paradoxical respiration**	0.3	7.7	3.7
Inability to lie down**	12.1	31.1	14.1
Need O_2 supplement**	8.1	16.3	9.0
Pulse, beats/min*	99.7 (1.1)	108.4 (2.1)	100.6 (30.1)
RR, breaths/min*	26.7 (0.4)	30.4 (1.2)	27.1 (10.9)
O_2 saturation, percent*	96.6 (1.2)	93.0 (0.8)	96.2 (31.6)
Systolic BP, mmHg*	133.9 (0.9)	134.5 (3.2)	134.0 (25.1)
Diastolic BP, mmHg*	82.1 (1.1)	79.3 (1.8)	81.7 (29.7)
After last nebulization			
Wheezing **	24.4	28.4	26.5
PR > 130 beats/min**	2.7	15.3	4.1
RR > 30 breaths/min**	2.6	7.1	3.1
Duration of treatment in ER*	2.4 (0.1)	3.5 (0.3)	2.4 (0.1)
No. doses of bronchodilators*	2.8 (0.5), SD = 12.8	3.8 (0.1)	2.9 (0.0)
PEFR , % predicted*	62.0 (0.9)	45.9 (2.5)	61.2 (0.8)
PEFR < 35% predicted**	8.8	31.3	10.7
PEFR 35-60% predicted**	30.1	45.8	31.4

* Mean values (standard error of mean); ** percentage of cases (%)

according to the regression coefficient. The authors then computed the score for each patient, performed a receiver operating characteristic (ROC) curve analysis, and computed the area under the ROC curve and its corresponding 95% CI. Area under the ROC curve, score sensitivity, specificity, and positive and negative predictive values at optimal cutoffs of each test were compared. All data were analyzed with a statistical software package (SPSS, version 11.5 for Windows; SPSS Inc; Chicago, IL).

Results

Population characteristics

There were 905 eligible visits from 568 patients in the present study. The mean age of enrolled patients was 57.6 years and women accounted for 70% of cases. The mean duration of symptoms before ER arrival was 35.7 hours. Fifty-eight percent of patients used accessory muscles actively at presentation. Mean ER length of stay was 2.5 hours (Table 1).

Univariable analysis

There were 808 among 905 visits (89.3%) that yielded favorable treatment outcome. Univariate analysis of clinical parameters resulted in a number of significant predictors. These included patients' age, need of oxygen supplement, history, and physical signs containing severity factors, extreme variations of vital signs on ER arrival and prior to discharge, number of doses of nebulized bronchodilators, last PEFR, and the presence of wheeze before discharge (Table 1). Significance of last PEFR was better demonstrated by further classification into three subgroups i.e. < 35%, 35-60% and > 60% predicted.

Multivariable analysis

All significant univariable predictors were included in a multivariate logistic regression model. The results indicated only three clinical parameters that were independently associated with treatment outcome. They were the inability to lie down on ER arrival, the presence of wheeze and the measured PEFR at discharge (Table 2).

Score derivation

A score of 0, 1 or 2 was assigned to each of the three independent predictors obtained from multivariate analysis, in accordance with the regression coefficients (Table 3). The minimal score was 0 and the maximal score was 4. Then, the authors retrospectively computed the score in the presented patients; the area under the ROC curve was 0.804 (CI, 0.740 to 0.867) (Fig. 2). Comparisons of the index sensitivity, specificity, predictive values and area under the ROC curve were done across different cutoff scores. The results indicated that a cutoff score of 2 yielded the more power distinction between a favorable or unfavorable outcome (Table 4).

Of the 905 visits, 75.1% had a score of ≤ 1 and 24.9% had a score of ≥ 2.

Table 2. Relative risks of unfavorable factors

	OR (95% CI)	p-value
Inability to lie down	3.46 (1.55-7.72)	0.002#
Wheezing after last nebulization	2.60 (1.28-5.28)	0.008#
PEF < 35% of predicted	8.30 (3.05-22.58)	0.001#
PEF 35-60% of predicted	4.58 (1.94-10.84)	0.001#
PEF > 60% of predicted	1.0	

Statistical significance

Table 3. Predictive scoring system

Predictive score	Score
Inability to lie down at presentation	
Absent	0
Present	1
Wheezing after last nebulization	
Absent	0
Present	1
PEF (% predicted) after last dose of bronchodilator	
> 60	0
35-60	1
< 35	2

Table 4. Predictive score, sensitivity, specificity, predictive values, and areas under the ROC by score for 905 asthma visits

	AUC	Sensitivity	Specificity	PPV	NPV
Score ≥ 1	0.701	95.2	45.0	13.6	99.1
Score ≥ 2	0.741	69.0	79.1	23.0	96.6
Score ≥ 3	0.615	28.6	94.4	31.6	93.6

AUC, area under the curve; PPV, positive predictive value; NPV, negative predictive value; ROC, receiver operating characteristic

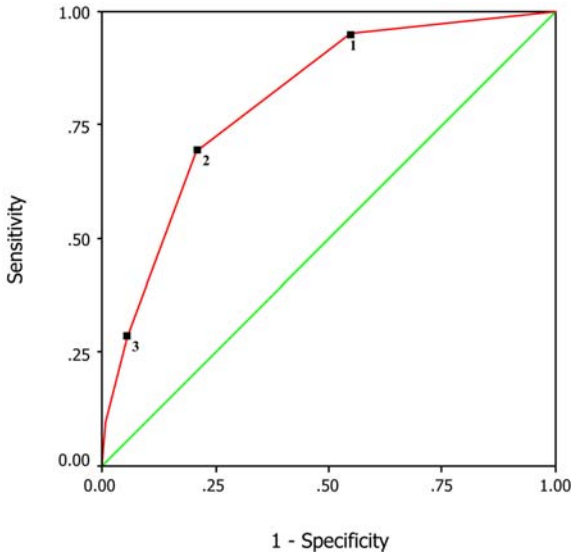

Fig. 2 ROC curves for asthma predictive score and unfavorable outcome, squares represent the score of the analysis sample

Unfavorable outcome was demonstrated in 23% of patients scored ≥ 2, as compared to 3.4% of patients scored ≤ 1 ($p < 0.001$).

Discussion

Acute asthma is one of the most common medical emergencies in clinical practice that requires urgent treatment. Morbidity and mortality were usually associated with the inability to evaluate the severity of exacerbations, which resulted in delayed treatments. A common pitfall for ER physicians concerned with the decision-makings of discharging or admitting the patient. Several studies done in the past have failed to demonstrate any single clinical or laboratory parameter that would precisely predict acute asthma treatment outcome[4,5]. Recent studies using the factor analysis techniques demonstrated that asthma is a multidimensional disease[6,7]. Several investigators also emphasized the necessity of ongoing process evaluations during acute asthma treatment, as the degree and time course of the response to therapy varied considerably among patients[8,9]. From these concepts, several predictive scores were developed for ER physicians in helping decision judgment of safe home discharge or hospital admission[10-12].

The aim of the present study was to develop a predictive score for safe discharge of patients with acute asthma from the ER. Upon clinical data analysis, the authors found that three bedside parameters (inability to lie down at presentation, presence of wheeze and PEFR after last nebulization) appeared to be the most effective predictors of unfavorable treatment outcome. This supports the previously-mentioned concept that evaluations of acute asthma should combine an integral part of the assessment of disease severity (static assessment) and the response to therapy (dynamic assessment)[2].

The presented predictive factors were not totally different from other studies. Wilson et al[10] found the ability to lie down was the best indicator of treatment outcome. Significance of PEFR as an important predictor was also confirmed in many studies[7,11-13]. NHLBI/WHO has therefore recommended PEFR measurement as an important tool in the management of acute asthma exacerbation[1]. The present study included wheezing at the time of discharge as the third variable that could predict outcome. Apparently, presence of wheeze at the time of ER discharge indicates the poor therapeutic response and persistent airways constriction that may lead to hospital admission or early relapse.

The proposed predictive score composed of three bedside variables that are easily and commonly measured during the assessment of acute asthma treatment. The NHBL guideline stated that a PEFR of < 60% predicted post treatment indicated a severe acute asthma that needed hospitalization[1]. With the presented predictive score, PEFR alone is not a single predictor to predict outcome reliably. This finding was similar to and confirmed the results from many previous studies[7,11,14]. The authors also demonstrated that a discharge PEFR of < 35% predicted by itself could predict unfavorable outcome, while a PEFR of 35-60% predicted needed the addition of another significant factor to extend its power of prediction. From Table 4, a score of ≥ 2 was considered a positive test with a high negative predictive value of 0.96, which excluded the low risk asthmatic patients. In other words, acute asthmatic patient could be discharged home safely if his or her predictive score was ≤ 1. Nevertheless, with a low positive predictive value, 77% may be admitted unnecessarily. This proposed predictive scoring system needs future validation for its precision of prediction, particularly when applied to patients of different population.

In summary, the present study suggested the 3-bedside-items predictive score as a good guide for a proper emergency room discharge of acute asthmatic patients.

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Conflict of interest statement

All of the authors declare that the authors do not have a conflict of interest and that we do not have a financial relationship with a commercial entity that has an interest in the subject of this manuscript.

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คะแนนในการทำนายการไม่ตอบสนองต่อการรักษาในผู้ป่วยหอบหืดเฉียบพลันที่เข้ารับการรักษาที่ห้องฉุกเฉิน

วิบูลย์ บุญสร้างสุข, นราธิป หวังศุภสวัสดิ์, สุมาลี เกียรติบุญศรี, ชาญ เกียรติบุญศรี, สไบทิพย์ จูฑะกาญจน์

ภูมิหลัง: *การที่จะแน่ใจได้ว่าผู้ป่วยที่มาห้องฉุกเฉินด้วยอาการหอบหืดเฉียบพลัน ภายหลังการรักษาจะสามารถกลับบ้านได้โดยปลอดภัย มักเป็นเรื่องยากในเวชปฏิบัติ*

วัตถุประสงค์: *เพื่อสร้างคะแนนในการทำนายเพื่อช่วยให้แพทย์มั่นใจในการจำหน่ายผู้ป่วยกลับบ้านโดยปลอดภัย*

วัสดุและวิธีการ: *ทำการศึกษาในผู้ป่วยหอบหืดเฉียบพลันที่เข้ารับการรักษาที่ห้องฉุกเฉินของโรงพยาบาลรามาธิบดี ในช่วงระหว่างเดือนมกราคม พ.ศ. 2547 ถึงเดือนสิงหาคม พ.ศ. 2548 ข้อมูลทางด้านสัญญาณชีพ, ความอิ่มตัวของออกซิเจนในเลือด และปัจจัยที่บ่งถึงความรุนแรงของหอบหืดเฉียบพลันจะถูกบันทึก หลังจากนั้นให้การรักษาผู้ป่วยโดยการใช้ salbutamol โดยวิธีการพ่นเป็นฝอยละอองและให้ซ้ำถ้าค่าความเร็ว ลมหายใจออกสูงสุดต่ำกว่าร้อยละ 70 ของค่าปกติหรือมีการตรวจพบที่บ่งถึงภาวะหายใจล้มเหลว นอกจากนั้น ในรายที่มีปัจจัยที่บ่งถึงหอบหืดรุนแรงจะได้รับ systemic steroid ภายหลังการพ่นยาครั้งที่ 4 ถ้าอาการยังไม่ดีขึ้น ผู้ป่วยจะได้รับการรักษาต่อในโรงพยาบาล การไม่ตอบสนองต่อการรักษาหมายถึงการที่ผู้ป่วยต้องถูกรับเข้ารักษาในโรงพยาบาลหรือเกิดการกำเริบภายใน 48 ชั่วโมงภายหลังจำหน่ายจากห้องฉุกเฉิน ข้อมูลจะถูกนำมาวิเคราะห์ทางสถิติเพื่อหาปัจจัยที่มีผลต่อผลของการรักษาโดยใช้ univariate และ multivariate analysis หลังจากนั้นนำปัจจัยที่มีผล มาสร้างเป็นคะแนนในการทำนายผลการรักษาและหาจุดตัดที่เหมาะสม*

ผลการศึกษา: *มีภาวะหอบหืดเฉียบพลัน 905 ครั้งจากผู้ป่วย 568 ราย ปัจจัยที่มีผลต่อการรักษาได้แก่การที่ผู้ป่วยเหนื่อยจนไม่สามารถนอนราบได้เมื่อมาถึงโรงพยาบาล, การตรวจพบเสียงวี้ด และค่าความเร็วลมหายใจออกสูงสุดที่ต่ำ ภายหลังให้ยาขยายหลอดลม ภายหลังการสร้างเป็นคะแนนในการทำนายการไม่ตอบสนองต่อการรักษาแล้วพบว่าคะแนนที่เหมาะสมในการทำนายการไม่ตอบสนองต่อการรักษาคือ ≥ 2*

สรุป: *คะแนนในการทำนายการไม่ตอบสนองต่อการรักษาในผู้ป่วยหอบหืดเฉียบพลันที่เข้ารับการรักษาที่ห้องฉุกเฉิน ซึ่งสร้างจาก 3 ปัจจัยที่สามารถตรวจได้ง่ายอาจเป็นแนวทางช่วยให้แพทย์มั่นใจในการตัดสินใจจำหน่ายผู้ป่วยจากห้องฉุกเฉิน*