

ASSESSMENT AND CONTROL

A simplified severity score for acute asthma exacerbationR. Dankner, MD, MPH^{1,4}, L. Olmer, MSc², A. Ziv, MBA³, and A. G. Bentancur, MD, MHA⁵

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Abstract

Background: To evaluate a simplified severity score designed to facilitate decision making in the Emergency Department (ED) regarding hospital admission of young adult patients with acute asthma exacerbation (AAE). **Methods:** All AAE-related ED encounters during two calendar years of patients aged 17–35 years were retrospectively classified as “mild”, “moderate” or “severe”, according to vital and readily available signs and symptoms, including pulse rate, presence of respiratory wheezes, rales or prolonged expiration, oxygen saturation, and the use of accessory muscles, measured upon arrival to the ED. All medical records of ED and hospital admissions were reviewed for treatment and outcomes. **Results:** During the study period, 723 AAE-related ED encounters were recorded among 551 asthma patients. Of them, 35.0% were classified as “mild”, 37.9% “moderate” and 27.1% “severe”. For increasing levels of AAE severity, hospital admission rate increased (11.5%, 42.0%, 61.2%, respectively, $p < 0.001$). Adjusting for age and sex, odds ratios for hospitalization were 12.2 (95% CI: 7.5–19.9) and 5.6 (95% CI: 3.5–8.9) for the “severe” and “moderate” categories, respectively, compared to the “mild” category. “Mild” asthma patients also had shorter length of hospital stay and none required mechanical ventilation or died during hospitalization. **Conclusion:** The simplified asthma severity score requires no additional tests or costs in the ED, and could facilitate the decision of whether to hospitalize or discharge adult AAE patients. Prospective validation of this tool is needed.

Keywords

Epidemiology, treatment

History

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Introduction

Acute asthma exacerbation (AAE) is a frequent diagnosis related to Emergency Department (ED) encounters. Despite improvements in the treatment approach, morbidity remains relatively high and has been shown to be steadily increasing during the past 3 decades [1,2].

According to the Israel Center for Disease Control, in 2010 the prevalence of asthma was 5.5% in adults (age 21+), with slight sex and ethnic differences (5.8%, 6.1%, 4.2% and 2.3% for Jewish males, Jewish females, Arab males and Arab females, respectively) [3]. In 2009, asthma prevalence was 8.2%, affecting 24.6 million people in the United States [2]. Asthma prevalence has increased from 2001 to 2010 in the United States, reaching an estimated rate of 25.7 million persons in 2010 [3]. The crude mortality rate has been declining since the late 1980s and is ~1 per 100 000 in Israel [4] and 1.6 per 10 000 in the United States [2]. These figures are yet higher for female patients [2,4].

In 2008 there were 27 682 hospitalizations due to AAE in Israel [3]. In the United States, half a million patients are

admitted through the ED each year due to AAE [5]. Estimates of the annual costs of asthma in the US range between \$12.7 and \$19.7 billion [6,7]. A considerable portion of these expenses derive from unnecessary hospitalizations and readmissions. Improving the criteria of patients safe to be discharged may help reduce these costs. Consensus guidelines recommend that lung function monitoring, along with historical and clinical factors, should be used to manage patients with AAE in the ED [8]. Tools for accurate and timely assessment of the severity of AAE may reduce the chances of discharging patients at risk of deterioration and even of dying at home.

This study retrospectively examined the relationship between hospital admission rate and the severity of AAE among young adult patients, based on readily available signs and symptoms measured upon arrival to the ED.

Methods

A description of the study population and procedure was previously detailed [9].

Study design

This is a retrospective review of AAE patients' ED discharge files. Following instruction, two nurses accessed data using a structured form consisting of demographic, clinical,

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Table 1. The simplified severity score for acute asthma exacerbation classification in the emergency department.

Sign/Symptom	Severity score		
	Mild	Moderate	Severe
Pulse rate	≤90	91–119	≥120
Wheezing	Absent	Present	Present
Rales	Absent	Present	Present
Prolonged expirium	Absent	Present	Present
O ₂ saturation	95–100%	90–94%	≤89%
Use of accessory Muscles	Absent	Present	Present
Minimal number of parameters required to qualify for categories	Any 3 of the above	Any 3 of the above or the use of accessory muscles only	Any 3 of the above or O ₂ saturation ≤89% only

diagnostic, therapeutic characteristics, disposal items and of in-hospital parameters of hospitalized patients.

Study population

Our medical center is a tertiary referral academic medical center, staffed by emergency and internal medicine physicians and residents. It serves an urban area with an approximate mean annual census of 110 000 visits.

All AAE-related ED encounters of patients aged 17–35 (hereby called young adults) during a two-year period, between 2000 and 2001, in the ED of the Sheba Medical Center at Tel Hashomer in Israel were reviewed.

Exclusion criteria

Patients older than 35 years were not included in the present analysis, in order to decrease the possibility of including patients with obstructive airway diseases other than AAE. Only 5 AAE-related ED encounters were excluded from the final analysis due to missing information regarding the outcome.

Selection of participants

ED encounters evaluated for AAE during the study period were accessed by query of the hospital database. Encounters were identified according to a coding system of major diagnoses for discharge records, filled by the ED treating physician at discharge. Re-admissions of the same patient within one week ($n = 38$) were recorded as a continuation of the previous ED admission, under the assumptions that these re-admissions were due to the same attack as the previous admission, and that the patient may have been prematurely discharged.

Modified severity criteria

A simplified severity scoring system was used based on previously described clinical severity criteria, including vital signs and symptoms measured prior to treatment [10]. These criteria included pulse rate (per minute), presence of respiratory wheezing or rales or prolonged expirium by auscultation, oxygen saturation (O₂ saturation in percent) and the use of accessory muscles. AAE-related ED encounters were assigned to one of three levels of severity: ‘mild’, ‘moderate’ and ‘severe’ according to criteria summarized in Table 1. Classification is performed by first comparing symptoms to the most severe category, i.e. ‘severe’, then ‘moderate’ and finally ‘mild’. A ‘severe’ AAE was

assigned if 3 or more ‘severe’ symptoms presented or if the O₂ saturation was ≤89%, regardless of the other parameters. A ‘moderate’ AAE was assigned if the attack was not classified as ‘severe’ and if 3 or more ‘moderate’ symptoms presented, or if the use of accessory muscles presented, regardless of the other parameters. An AAE that did not meet criteria of a ‘moderate’ or ‘severe’ attack was classified as ‘mild’.

Measured outcomes

The primary outcome was rate of admission to the hospital. Length of hospital stay served as a secondary outcome, as well as Asthma-related pharmacological treatment, and length of ED stay.

Ethical approval

The study was approved by the Sheba Medical Center IRB committee. An exemption from obtaining informed consent was received due to the retrospective design of the study.

Statistical analysis

Analyses were performed using SAS software [11]. Data are presented as a mean ± SD and proportions with 95% confidence intervals (CI).

All p values are two-sided, with $p < 0.05$ considered statistically significant. A final standard logistic regression model [12] was built to determine the odd for hospitalization associated with the severity categories adjusting for age and sex.

There were missing values for each of the parameters used in the severity scoring system: pulse rate was missing for 26 ED of the total 723 encounters, O₂ saturation for 160, rales for 19, wheezes for 11, prolonged expirium for 50 and the use of accessory muscles for 141. The pattern of missing values was not monotone, preventing the use of a standard SAS procedure MI for multiple imputations. Therefore, we used an alternative method of multiple imputation based on sequentially improved regressions, which is a variant of the fully conditional specification approach [13].

Results

All and all, there were 551 asthma patients aged 17–35 hospitalized in our medical center during the 2-year study period, and these patients created 723 AAE-related ED

Table 2. Baseline demographic and pre-hospital characteristics of the 723 ED encounters of acute asthma exacerbation patients.

Characteristic	Mild n = 253	Moderate n = 274	Severe n = 196
Age (years) mean $\pm$ SD	23.4 $\pm$ 5.1	23.7 $\pm$ 4.9	24.5 $\pm$ 4.9
Sex			
Male	135 (53.4)	131 (47.8)	86 (43.9)
Female	118 (46.6)	143 (52.2)	110 (56.1)
Previous asthma related hospitalizations	26 (3.6)	79 (10.9)	76 (10.5)
Previous ICU admissions	0	7 (1.0)	18 (2.5)
Asthma related medications at home			
Bricalin/Albuterol	161 (63.6)	183 (66.8)	151 (77.0)
Steroids,			
Tablets	14 (5.5)	23 (8.4)	22 (11.2)
Inhalation	41 (16.2)	57 (20.8)	34 (17.4)
Amino/theophylline	22 (8.7)	27 (9.9)	27 (13.8)

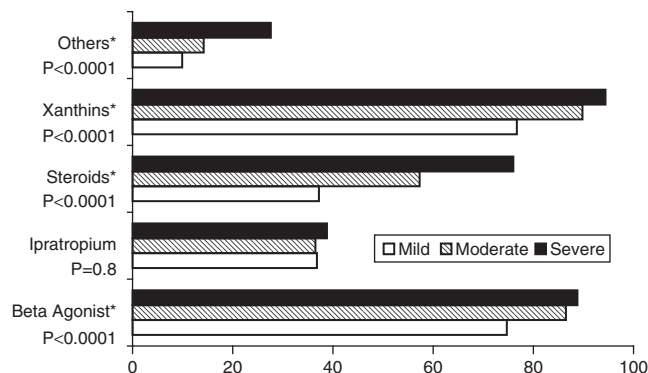
encounters. The mean age of these patients was 23.6 ± 5.0 years with no gender preference. In this young population, 20.3% were previously hospitalized due to asthma and the majority (69.7%) reported the use of inhalations at home. Only 24.5% used steroids at home, and as few as 5.4% used aminophylline or theophylline at home. Previous ICU admission was reported by 2.0% of all patients. Table 2 shows the baseline characteristics of the 723 AAE-related ED encounters according to their severity score. The mean age of the severe AAE encounters was 1 year older and their female proportion was greater. In addition, this category had a more frequent history of ICU admissions and reported a greater proportion of home treatment with oral steroids and non-steroidal inhalations.

Frequencies of measured parameters according to severity score categories are shown in the Appendix. The most frequent missing parameters were peak-flow and respiratory rate (61.7% and 55.3% of ED files, respectively), which were therefore not included as parameters in the severity scoring system. It shows that when information on peak flow and respiratory rate were available the severity scoring system seems to have categorized patients appropriately, according to the severity of these two parameters.

For the 723 total AAE encounters, pulse rate was available for 697 (96.4%), O_2 saturation for 563 (77.9%), rales for 704 (97.4%), wheezes for 712 (98.5%), prolonged expirium for 673 (93.1%) and the use of accessory muscles for 582 (80.5%).

Following multiple imputations, the simplified severity classification system categorized 35.0% of all ED encounters as ‘mild’, 37.9% as ‘moderate’ and 27.1% as ‘severe’ AAE. Figure 1 shows that patients assessed with mild severity received less intense treatment during their ED stay compared to those classified in the moderate and severe categories. A dose-response relationship was demonstrated between the proportion of patients treated by a medication class and AAE severity, for all but ipratropium bromide treatment.

No statistically significant difference in the mean length of ED stay was observed among the severity categories ($p = 0.2$), averaging 2.3 hours (± 2.3). The overall hospitalization rate was 36.5% ($n = 263$), and increased as the level of severity increased from 11.5% to 42.0% and 61.2% in the mild, moderate and severe categories, respectively, $p < 0.001$. For those patients who were admitted to the hospital, length of

Figure 1. Frequency of asthma-related pharmacological treatment prescribed for AAE in the ED according to the severity score (% treated). * p for trend < 0.001 .

hospital stay increased as the severity increased, from 1.9 days to 2.5 and 4.1 days in the mild, moderate and severe categories, respectively, though the trend was not statistically significant ($p = 0.12$). In-hospital mortality rate also increased with severity from 0, to 0.4% and 1%, respectively, $p = 0.3$. Rates of returning to the ED within one week did not differ among the three AAE severity groups (Table 3), although it was somewhat lower, without statistical significance in the ‘severe’ category, $p = 0.7$. The ‘severe’ AAE-related ED encounters had a higher proportion of hospitalizations due to infection and lack of response to treatment ($p < 0.001$). None of the ‘mild’ patients were ventilated, and none died during hospitalization.

Table 4 shows that the odds ratio for hospitalization was 12.2 times higher for patients categorized with ‘severe’ AAE (95% CI = 7.5–19.9; $p < 0.001$), and 5.6 times higher for those with moderate AAE (95% CI = 3.5–8.9; $p < 0.001$), as compared to those with ‘mild’ AAE. An additional factor associated with an elevated risk for hospital admission was age older than 31 (OR = 1.8, 95%CI = 1.1–2.8, $p = 0.01$). The logistic regression model to predict hospital admissions showed good predictive ability (concordance index of 0.748).

Discussion

Our results show a simplified classification of AAE severity according to routinely recorded and readily available parameters to be strongly associated with hospitalization rate for patients admitted to the ED. Patients classified with ‘severe’ AAE were 12.2 times more likely to be hospitalized and those with ‘moderate’ AAE were 5.6 times more likely than patients with ‘mild’ AAE, after adjusting for age and sex.

The criteria in the proposed classification system are based on the most trivial and objective parameters, routinely recorded during the initial evaluation of dyspnea at the ED. Cyanosis or diaphoresis were not included as criteria in this scoring system, since they were infrequently recorded in patients’ ED charts. Respiratory rate measurement and peak flow meter were recorded in less than half of the encounters, and thus not used in the proposed scoring system. A prospective multi-centered study involving 64 emergency departments demonstrated that only 69% of asthma patients undergo peak flow testing in the ED, and even when tested,

Table 3. Measured outcomes of 723 AEE-related ED encounters according to severity classification.

	Mild <i>n</i> = 253	Moderate <i>n</i> = 274	Severe <i>n</i> = 196	Total <i>n</i> = 723	<i>p</i>
Mean length of ED stay ^d (hours, mean ± SD)	2.2 ± 1.7	2.2 ± 2.2	2.5 ± 3.0	2.3 ± 2.3	0.2 ^a
Admissions to hospital (%)	11.5	42.0	61.2	36.5	<0.001 ^b
Reasons for hospitalization (%)					
Infection	0.4	1.5	11.7	3.9	<0.0001 ^c
No improvement	5.9	35.4	42.4	27.0	
No response to treatment	0.8	2.2	3.6	2.1	
Other	0.8	1.1	0.5	0.8	
In-hospital LOS (days, mean ± SD)	1.9 ± 1.0	2.5 ± 2.1	4.1 ± 9.3	3.2 ± 6.6	0.12 ^a
Mechanical ventilation (%)	0.0	0.4	2.0	0.7	<0.03 ^c
In-hospital mortality (%)	0.0	0.4	1.0	0.4	<0.3 ^c
Returns to ED (%)					
<48 hours	3.6	2.6	2.0	2.8	0.7 ^b
48 hours to 1-week	4.4	3.7	2.6	3.6	

AAE: acute asthma exacerbations; ED: emergency department; LOS: length of hospital stay; SD: standard deviation.

^aBy Analysis of Variance (ANOVA).

^bBy χ^2 test.

^cBy Fisher exact test.

^d49 missing.

Table 4. Odds ratios for hospitalization according to severity criteria, age, and sex in 723 AAE-related ED encounters.

Predictor for hospitalization	Prevalence (%)	OR	95% CI	<i>p</i> Value
Age (years)				
31+	119 (16.5)	1.8	1.1–2.8	0.01
Sex				
Female	371 (51.3)	1.1	0.8–1.6	0.5
Severity category				
Mild	253 (35.0)	1.0		
Moderate	274 (37.9)	5.6	3.5–8.9	<0.001
Severe	196 (27.1)	12.2	7.5–19.9	<0.001

C statistics = 0.748.

more than half of those who should be admitted according to the measured value are discharged [14].

This study excluded patients older than 35 years in order to minimize the chance of including patients with chronic airway disease. Older patients generally present with respiratory distress symptoms and have a differential diagnosis, mainly smoking related disorders, and cardiac diseases. Previously described pediatric scores have included similar criteria [15,16] with excellent results, adding to the external validity of the simplified score, and supporting the findings of the present study.

In a study conducted in Australia, only moderate agreement was found between ED physicians’ assessment of acute asthma and severity classification according to national guidelines [17]. Thus, simplified and clearly defined criteria, as well as better educational interventions among emergency physicians, should be developed as means to improve treatment and outcomes.

The 11.5% of patients categorized with “mild” AAE in the current study, who were hospitalized, had short and uneventful hospital stays. Assuming that these hospitalizations were avoidable, implementation of the proposed criteria would have reduced the hospital admission rate by 11%. Nevertheless, no follow up information regarding patients’

out-of hospital outcomes or re-hospitalizations in other medical centers was available in the current study.

There are a few important limitations to this study. First is the retrospective design. Patient parameters were accessed from patients’ charts, and some missing values were imputed. The severity scoring was also applied retrospectively and was not a component of patients’ decision trees for evaluation, treatment and disposition during ED encounters. Nevertheless, the proposed scoring system offers a tool composed of the signs and symptoms that were actually used in the daily routine of our ED, and thus do not impose an unpracticed protocol. The time frame of this study, which occurred a decade ago, is another potential limitation, although not much has changed in the practices of ED physicians in the treatment of AAE over the last 10 years. Thus, the relevance of our data still holds. In addition, our “low-tech” scoring system proposes the use of classic signs and symptoms to assist in decision making of AAE patients disposition, and these are as relevant as ever.

The proposed scoring system is based on six items of the patient examination. Clinicians may be reluctant to base patient disposition and management on a small subset of clinical findings. However, the system demonstrates how routine care practiced by ED physicians can rapidly and easily provide information that may facilitate efficient decision making regarding the need for hospitalization.

Even within a relatively young cohort outcomes were worse among the older patients (31–35 years old), with a 1.8 greater chance of being hospitalized (95%CI = 1.1–2.8) compared to those aged under 31 years.

The 6.4% readmission rate during one week was somewhat lower than the 9% rate, reported by Canadian EDs [18], but close enough to reflect similar clinical practices to those prevalent in urban North American centers, supporting the external validity of this study and its applicability to other countries.

The reliance on readily and frequently measured clinical signs and symptoms increases the potential for feasibility and physician adherence to the proposed severity scoring system.

We believe that with minimal training or with a targeted ED chart redesign, data collection may approach 100%. Further, the proposed system may be a useful tool for nurse triage at the ED, as it is simpler than previously recommended adult scores [19]. The effective implementation of the most recently issued United States national severity score criteria has not been systematically investigated; thus, such guidelines only serve as general recommendations [8]. Finally, the present results support the use of the simplified score as a tool to facilitate file review in retrospective research of interventions in asthmatic patients in the ED.

Further prospective research comparing the proposed severity classifications should take into account not only clinical effectiveness but also the feasibility of implementation in EDs with large patient turnover. In the meantime, we believe that a conservative approach should be adopted in an ED setting when evaluating a life threatening condition such as asthma.

Conclusions

This retrospective study shows a proposed simplified asthma severity score to be potentially useful to facilitate decision making regarding hospitalization of young adult patients with AAE in the ED. Prospective validation of the effectiveness of the proposed tool in the ED on placement of adult asthma patients is warranted.

Acknowledgments

Dr. Rachel Dankner takes responsibility for the content of the manuscript, including the data and analysis.

Rachel Dankner designed the study and lead the interpretation of the results and the writing of the manuscript, Liraz Olmer participated in the design, conducted the statistical analysis, and contributed to writing the manuscript, Arnona Ziv was the study file manager, she was involved in the study design and statistical analysis, Ariel Bentancur conceived of the study, and was involved in the design and conduct of the study, as well as writing the manuscript.

Declaration of interest

None of the authors have any conflict of interest to declare.

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Appendix

Appendix 1. Distribution of signs and symptoms, in 723 AAE related ED encounters*.

	Total number (%)	Mild	Moderate	Sever
<i>Pulse (b.p.m.)</i>				
≤90	217 (30.0)	144 (56.9)	53 (19.3)	20 (10.2)
91–119	332 (45.9)	86 (34.0)	200 (73.0)	46 (23.5)
≥120	144 (19.9)	18 (7.1)	2 (0.7)	124 (63.3)
Unknown	30 (4.2)	5 (2.0)	19 (6.9)	6 (3.1)
<i>Respiratory rate (r.p.m.)</i>				
≤14	20 (2.8)	13 (5.1)	4 (1.5)	3 (1.5)
15–28	206 (28.5)	64 (25.3)	85 (31.0)	57 (29.1)
≥29	81 (11.2)	9 (3.6)	29 (10.6)	43 (21.9)
Unknown	416 (57.5)	167 (66.0)	156 (56.9)	93 (47.5)
<i>Peak-flow (ml/sec)</i>				
0–100 = ‘Severe’	22 (3.0)	2 (0.8)	11 (4.0)	9 (4.6)
101–250 = ‘Moderate’	118 (16.3)	32 (12.7)	49 (17.9)	37 (18.9)
251–400 = ‘Mild’	87 (12.0)	39 (15.4)	33 (12.0)	15 (7.7)
401–900 = ‘Normal’	34 (4.7)	19 (7.5)	12 (4.4)	3 (1.5)
Unknown	462 (63.9)	161 (63.6)	169 (61.7)	132 (67.4)
<i>O₂ saturation** (%)</i>				
95–100	387 (53.5)	178 (70.4)	140 (51.1)	69 (35.2)
90–94	131 (18.1)	18 (7.1)	66 (24.1)	47 (24.0)
≤89	44 (6.1)	0	0	44 (22.5)
Unknown	161 (22.3)	57 (22.5)	68 (24.8)	36 (18.4)
<i>Wheezing</i>				
Present	585 (80.9)	153 (60.5)	250 (91.2)	182 (92.9)
Absent	124 (17.2)	99 (39.1)	22 (8.0)	3 (1.5)
Unknown	14 (1.9)	1 (0.4)	2 (0.7)	11 (5.6)
<i>Rales</i>				
Present	82 (11.3)	11 (4.4)	19 (6.9)	52 (26.5)
Absent	619 (85.6)	241 (95.3)	253 (92.3)	125 (63.8)
Unknown	22 (3.1)	1 (0.4)	2 (0.7)	19 (9.7)
<i>Prolonged expiration</i>				
Present	519 (71.8)	118 (46.6)	233 (85.0)	168 (85.7)
Absent	151 (20.9)	127 (50.2)	21 (7.7)	3 (1.5)
Unknown	53 (7.3)	8 (3.2)	20 (7.3)	25 (12.8)
<i>Use of Accessory Muscles</i>				
Present	58 (8.0)	0	19 (6.9)	39 (19.9)
Absent	521 (72.1)	253 (100)	164 (59.9)	104 (53.1)
Unknown	144 (19.9)	0	91 (33.2)	53 (27.0)

*According to categories used in the severity score system

**Oxygen saturation was measured while breathing room air.

e - Appendix- Distribution of signs and symptoms, in 723 AAE related ED encounters*.

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Pulse (b.p.m.)				
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251 - 400 = 'Mild'	87 (12.0)	39 (15.4)	33 (12.0)	15 (7.7)
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95-100	387 (53.5)	178 (70.4)	140 (51.1)	69 (35.2)
90-94	131 (18.1)	18 (7.11)	66 (24.1)	47 (24.0)
≤89	44 (6.1)	0	0	44 (22.5)
Unknown	161 (22.3)	57 (22.5)	68 (24.8)	36 (18.4)

Wheezing					
	<i>Present</i>	585 (80.9)	153 (60.5)	250 (91.2)	182 (92.9)
	<i>Absent</i>	124 (17.2)	99 (39.1)	22 (8.0)	3 (1.5)
	<i>Unknown</i>	14 (1.9)	1 (0.4)	2 (0.7)	11 (5.6)
Rales					
	<i>Present</i>	82 (11.3)	11 (4.4)	19 (6.9)	52 (26.5)
	<i>Absent</i>	619 (85.6)	241 (95.3)	253 (92.3)	125 (63.8)
	<i>Unknown</i>	22 (3.1)	1 (0.4)	2 (0.7)	19 (9.7)
Prolonged expiration					
	<i>Present</i>	519 (71.8)	118 (46.6)	233 (85.0)	168 (85.7)
	<i>Absent</i>	151 (20.9)	127 (50.2)	21 (7.7)	3 (1.5)
	<i>Unknown</i>	53 (7.3)	8 (3.2)	20 (7.3)	25 (12.8)
Use of Accessory Muscles					
	<i>Present</i>	58 (8.0)	0	19 (6.9)	39 (19.9)
	<i>Absent</i>	521 (72.1)	253 (100)	164 (59.9)	104 (53.1)
	<i>Unknown</i>	144 (19.9)	0	91 (33.2)	53 (27.0)

*According to categories used in the severity score system

**Oxygen saturation was measured while breathing room air.