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Original Contribution

Validity of SMART-COP score in prognosis and severity of community acquired pneumonia in the emergency department

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ABSTRACT

Background: Determining prognosis in community acquired pneumonia (CAP), is very important. Many scores are introduced up to now for prediction of pneumonia prognosis like SMART-COP.
Objective: To evaluate validity of SMART-COP score in prognosis and severity of CAP in emergency department (ED).
Methods: All patients older than 18 years old with clinical suspicion of CAP (meeting the inclusion criteria), were enrolled in our study. In this prospective study, patients were admitted to the ED of a tertiary referral center. Hospital length of stay, rate of intensive care unit (ICU) admission, mortality rate, number of intensive respiratory or vasopressor support (IRVS) use, patients' SMART-COP scores and all demographic data were recorded. Validity of SMART-COP in the prediction of IRVS rate and its correlation with other variables were determined.
Results: In this study, 47.6% and 52.4% of patients were females and males respectively. The mean age of patients was 68.13 ± 16.60 years old. The mean hospital length of stay was 13.49 ± 5.62 days. Of all patients entered in our study, 55 cases (38.5%) needed ICU admission, 29 cases (20.3%) were expired within 1 month and 44 cases (30.8%) needed IRVS during their treatment. SMART-COP ≥5 (high risk CAP) accurately predicted the rate of ICU admission, one-month mortality and IRVS need (p-value = 0.001).
Conclusions: SMART-COP≥5 had a high sensitivity and specificity in the prediction of patients' prognosis with severe CAP in the ED.

What this paper adds:

1. What is already known on this subject
   - Many scoring systems are nowadays used in pneumonia prognosis.
   - There is no general consensus on which one accurately predict the prognosis.
   - SMART-COP has been used limitedly and locally in prediction of IRVS.
   - Most studies are done in ICU.
   - Some reported its high validity but some vice versa.
2. What this study adds
   - SMART-COP≥5 had a high sensitivity and specificity in the prediction of patients' prognosis with severe CAP in the ED.
   - Patients with high scores had a high mortality, ICU admission, and IRVS need.

1. Introduction

Pneumonia is a pathologic process of alveolar, distal airway and lung interstitial tissue infection and infiltration [1]. Its clinical definition is a collection of clinical presentations of fever, chills, coughs, pleuritic chest pain, sputum, tachypnea, respiratory crackles or increased bronchial lung sounds that are accompanied by infiltration in chest X-ray (CXR). Community acquired pneumonia (CAP), is a type of pneumonia happened in non-hospitalized patients [2].

Pneumonia incidence is 20–30% in developing countries while 3–4% in developed ones [1-3].

It is one of the most common reasons of morbidity and mortality. Based on some studies, it is the four leading cause of death in elderlies. The highest mortality and morbidity rate of CAP, is among patients needing hospital admission, as 35-day-mortality rate in those patients is reported to be up to 13% [4,5].

A variety of prognostic models are applied nowadays in pneumonia. Pneumonia severity index (PSI) was first introduced by Fine et al., based on pneumonia patient outcomes research team (PORT) table. Hospitalization is recommended in score > 90 [6,7].

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CURB-65 is another scoring system widely used and is first presented by the American Thoracic Society/Infectious Diseases Society of America (ATS/IDSA). Patients with CURB-65 > 2 scores should be admitted in the hospital and score > 3 is severe CAP. Its modified version, CRB-65, is one of the most applicable models used in pneumonia severity estimation [8,9].

One of the newest models in scoring pneumonia is SMART-COP which is collected and declared by a group of Australian researchers. SMART-COP was created to find patients with pneumonia who needed either intensive respiratory (mechanical ventilatory support in an acute respiratory failure performed best in an intensive care unit (ICU) or vasopressor support (IRVS) [10]. SMART-COP includes: systolic blood pressure (SBP) <90 mmHg-2 scores, multiple lobes involvement on CXR-1 score, albumin level < 3.5 g/dL-1 score, respiratory rate (RR) >30 N/min-1 score, tachycardia (heart rate (HR)) >125 beats/min-1 score, confusion (acute)-1 score, oxygenation low (oxygen saturation (spo2)) <90%-2 scores and potential hydrogen (pH) <7.35–2 scores. SMART-COP is a severity scoring system with the intention of finding patients with pneumonia needing ICU admission. Their study revealed that scores were as follows: 0–2 points = low risk, 3–4 points = moderate risk (1 in 8), 5–6 points = high risk (1 in 3) and ≥ 7 points = very high risk (2 in 3) for needing IRVS [10,11]. A SMART-COP score above 3 points identified 92% of patients needing IRVS, including 84% of patients who did not need immediate admission to the ICU [12].

As mentioned previously, SMART-COP is a risk stratification index that is actually based on the severity of illness not the patient's underlying risk factors. This scoring has been used to predict the need for IRVS. Comparing to other old scoring systems, SMART-COP's advantages are: its simplicity, ease to remember and early access in the course of pneumonia management even before declaration of biochemistry or radiology results. In contrast to other scoring systems, SMART-COP is useful for ruling out patients at risk of severe disease, thus it is necessary for

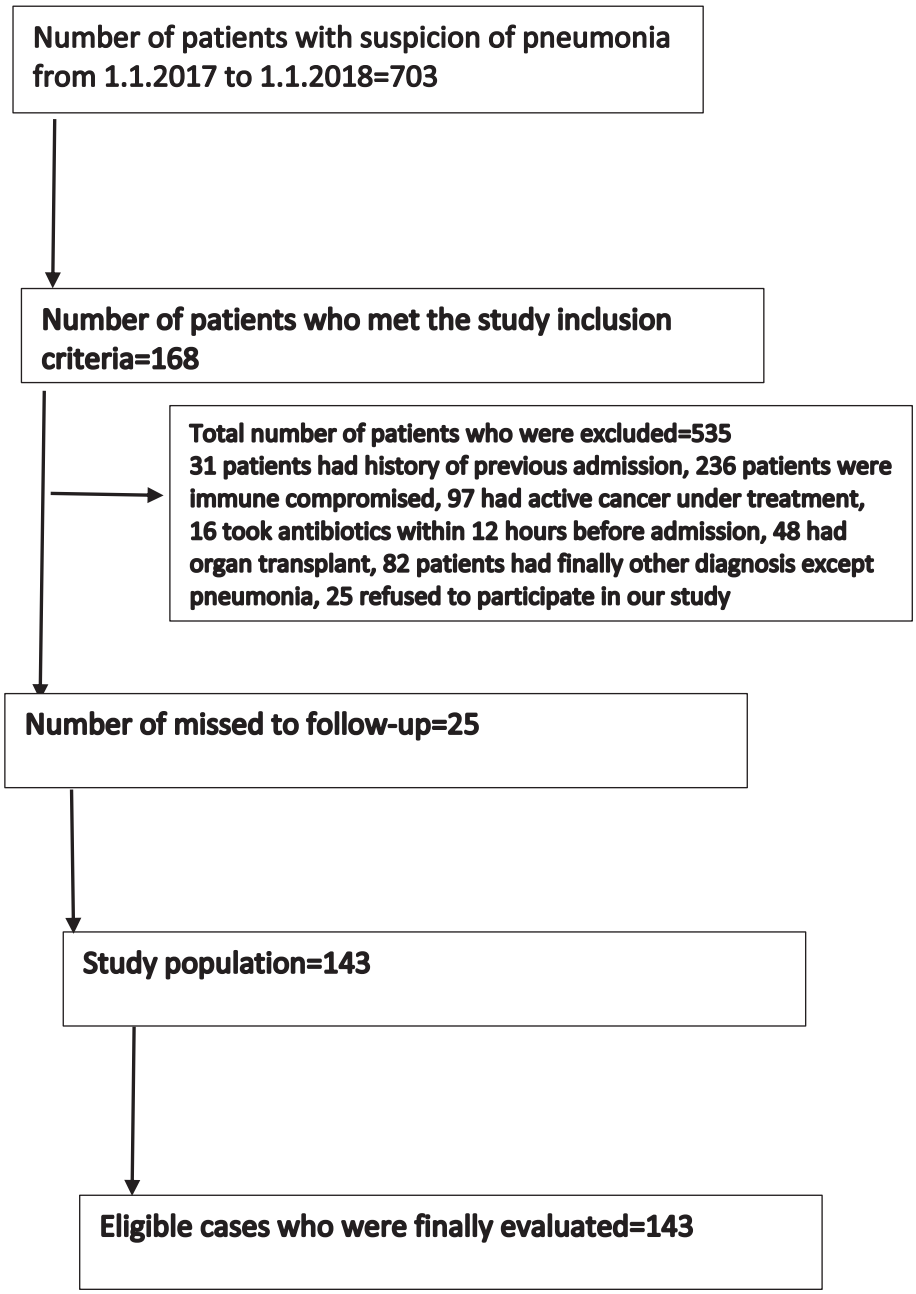

Fig. 1. Flow chart of recruitment of cases.

Table 1
Frequency of study variables

Variable N (%)		Frequency
Systolic blood pressure < 90 mmHg		20 (14)
multiple lobes involvement on chest X-ray		143 (100)
albumin level < 3.5 g/dL		38 (26.6)
Respiratory rate > 30		70 (49)
Heart rate > 125		34 (23.8)
Acute confusion		64 (44/8)
oxygen saturation < 90%		84 (58.7)
potential hydrogen < 7.35		54 (37.8)
Intensive care unit admission		55 (38.5)
Intensive respiration or vasopressor support		44 (30.8)
Death within 1 month		29 (20.3)
SMART-COP	Low risk (0–2)	36 (25.2)
	Moderate risk (3–4)	38 (26.6)
	High risk (5–6)	38 (26.6)
	Very high Risk (≥7)	31 (21.6)

making management decisions in pneumonia. It differs from the PSI and CURB-65 in that its principle goal is determination of most seriously ill patients who need to be referred to ICU [6,10].

SMART-COP has been used in many countries like the United States of America, Australia and Scotland to predict outcomes in pneumonia. Because of the scarce studies done up to now, the validity of this scoring system has been discussed by ambiguity based on different strata of patients in different geographical areas [10,11,13].

In the present study, we decided to determine the validity of SMART-COP severity scoring system in an ED of a tertiary referral center, gathering a population of patients with critically ill conditions and many comorbidities. Lots of our patients were managed in the ED for days after the admission, in spite of their need to be admitted to the ICU. "ICU admission" included all patients who at some point had an ICU admission order and this order was confirmed by the anesthesiology consult. ICU in our center is occupied with many patients and has usually the lack of enough admission beds. Therefore, many critical cares including intensive respiratory support and mechanical ventilation or starting vasopressor support are performed in the ED. Prediction of prognosis in such a population and applying the appropriate intervention could help us to treat these patients in a way similar to the real ICU environment.

2. Materials and methods

This was a prospective cohort study done on patients with clinical suspicion of CAP referring to the ED of Dr. Shariati hospital during 2017–2018. The study was approved by the Ethics Committee of Tehran University of Medical Sciences. Our inclusion criteria were: age older than 18 years old, having at least 3 specific clinical presentations and signs of pneumonia including; productive coughs, pleuritic chest pain and dyspnea, fever, tachypnea or hypoxia, lung auscultation in favor of pneumonia or leukocytosis. Patient's diagnosis was confirmed by CXR reported by the attending emergency physician. Definite diagnosis of CAP should be confirmed before entering the study. Patients whose diagnosis was changed later in the course of treatment were excluded. Our exclusion criteria were: history of admission within the last 2 weeks, severely immune compromise, taking >10 mg prednisolone daily within the last month, taking immunosuppressive drugs, active cancer treatment, recent organ transplant, taking antibiotics within the last 12 h or aspiration pneumonia diagnosis. Sampling was convenience sampling. All patients signed the informed written consent to participate in our study.

The treating emergency medicine (EM) resident diagnosed and managed patients, evaluated them during the treatment course and filled the questionnaire. All patients were followed for 1 month. Demographic data, hospital length of stay, 1-month mortality and morbidity, ICU admission, IRVS needing rates and SMART-COP score were evaluated and documented.

3. Primary and secondary endpoints

Our primary endpoint was to determine the validity of SMART-COP in pneumonia severity prediction (IRVS needing rate) in the ED. Our secondary endpoints were estimating the sensitivity and specificity of this score and its association with the mortality and ICU admission rates.

4. Statistical analysis and sample size calculation

Based on previous studies, SMART-COP had a sensitivity of 70–90% in the prediction of IRVS need. By considering a sensitivity of 85% and $d = 0.1$, we had to find 30 patients needing IRVS in this study. Based on Joshua study [13], 21% of patients with pneumonia needed IRVS. Thus, we calculated a sample size of 143 patients for this study.

Categorical data are expressed as number and frequency. Continuous data are presented as mean ± SD and for nonparametric variables as median (interquartile range (IQR)). Chi-square test, or Fisher's exact test was used for categorical variables. We used Kolmogorov Smirnov for checking normality. For comparison of hospital length of stay between subgroups, we used Kruskal-Wallis test. Receiver operating characteristic (ROC) analysis was used to calculate best cut-off point of SMART-COP in prediction of IRVS, mortality or ICU admission (based on Youden index) and area under the receiver–operator characteristic curve (AUC) was determined. The sensitivity and specificity were calculated with their 95% confidence intervals (CIs). A value of $p < 0.05$ was

Table 2
Frequency of baseline characteristics of patients in comparison to SMART-COP score

Variable		SMART-COP				p-Value
		Low risk (0–2)	Moderate risk (3–4)	High risk (5–6)	Very high risk (≥7)	
Underlying disease N (%)	Diabetes mellitus	10 (27.8)	11 (28.9)	11 (28.9)	8 (25.8)	0.988
	Renal failure	7 (19.4)	8 (21.1)	7 (18.4)	6 (19.4)	1.0
	Hepatic failure	4 (11.1)	3 (7.9)	4 (10.5)	3 (9.7)	0.980
	Underlying lung disease	10 (27.8)	8 (21.1)	9 (23.7)	8 (25.8)	0.936
	Underlying cardiac disease	10 (27.8)	14 (36.8)	12 (31.6)	9 (29.0)	0.853
	Newly diagnosed hematologic or solid organ malignancies (the treatment was not started)	5 (13.9)	5 (13.2)	6 (15.8)	5 (16.1)	0.988
	None	7 (19.4)	8 (21.1)	7 (18.4)	9 (19.4)	1.0
Hospital length of stay Median (IQR[a])		3.5 (5.0)	3.0 (4.2)	2.5 (4.2)	3.0 (3.0)	0.001

[a] IQR: Interquartile range.

Table 3
Association of SMART-COP with pneumonia prognosis

Variable N (%)		Intensive respiration or vasopressor support need	Intensive care unit admission	Death within 1 month
SMART-COP	Low risk (0–2)	1 (2.77)	2 (5.55)	1 (2.77)
	Moderate risk (3–4)	2 (5.26)	6 (15.78)	1 (2.63)
	High risk (5–6)	14 (36.84)	20 (52.63)	9 (23.68)
	Very high risk (≥7)	27 (87.10)	27 (87.09)	18 (58.60)
p-Value		0.001	0.001	0.001

accepted as statistically significant. Data were analyzed using SPSS v. 22 and Stata v.14.

5. Results

We evaluated 703 patients suspicious of having CAP during one year. 535 patients were excluded. We had 25 patients missed to follow-up. Finally, we analyzed 143 patients in this study. Flow chart of the recruitment is shown in Fig. 1. In our study, 68 patients (47.6%) were females and 75 patients (52.4%) were males. The mean age of our patients was 68.13 ± 16.60 years old. The mean time of hospitalization was 13.49 ± 5.62 days. The frequency of the study variables is shown in Table 1.

Patients' baseline characteristics are shown in Table 2. There were no association between the baseline characteristics of patients and pneumonia severity. Hospital length of stay had no significant association with SMART-COP severity index.

Our results showed that SMART-COP had statistically a significant association with the rate of ICU admission, mortality and IRVS need (p-value = 0.001). SMART-COP accurately predicted the rate of IRVS need, ICU admission and mortality in patients, in other words low risk patients had a low rate of IRVS need, ICU admission and mortality and very high-risk patients had a high rate of IRVS need, ICU admission and mortality. We calculated SMART-COP≥5 as the best cut-off point. In this study, 7 patients with SMART-COP score ≥ 5 were identified who at the initial time of scoring did not require IRVS but went on to require this. We observed that during the first 24 h after their admission this occurred.

Data are shown in Table 3.

By considering the cut-off point of 5 for SMART-COP (high risk patients with CAP), we estimated a good sensitivity and specificity in predicting the rate of IRVS need, ICU admission and mortality. Data are shown in Table 4.

6. Discussion

CAP is one of the most common reasons of adults' referral to EDs, its annual incidence is 5–11 in each 1000 cases [1]. In the United States of America at the end of last century, pneumonia had a total annual cost of 8.4 milliard dollars and 95% of this cost was for patients who were admitted at hospitals [5].

In our study, it was determined that in patients with CAP and low risk SMART-COP score, the rates of IRVS need, ICU admission and mortality were low. On the other hand, by increasing severity of CAP and in patients with high risk SMART-COP score, the rates of IRVS need, ICU admission and one-month mortality were increased significantly (p-value = 0.001). By considering the cut-off point of 5 for SMART-COP, we found high sensitivity and specificity in prediction of CAP prognosis in our population (best cut-off point).

There are many studies comparing different scoring systems in pneumonia [9,11,14]. None of these scoring systems could accurately predict the need for IRVS or ICU admission [6,7,14,15].

Robins-Browne et al. in 2012, revealed that of 367 patients with pneumonia over one year, 10% required IRVS and 2.8% were expired. They confirmed the high sensitivity and negative predictive value of SMART-cop score in CAP risk stratification in tropical areas in the ED. Their cut-off point was score ≥ 3 [16]. In our study, the rate of IRVS and ICU admission was way more because our patients probably were more complicated and high risk.

In a retrospective study by Davis et al. in 2010, SMART-COP was found to underestimate pneumonia severity and they created a modification in this scoring system. They increased the weighting of hypoalbuminemia and added a point for indigenous status thus changed the scoring in to SMARTACOP. They announced that the later had a more sensitivity comparing to the former one. In their study of 184 patients, >20% of cases needed IRVS and 10% died within a month [13]. On the contrary, Robins-Browne et al. performed a prospective study with a larger sample size and found the same results for both SMART-COP and SMARTACOP scoring systems [16].

Marti et al. in 2012, performed a meta-analysis comparing different scoring systems in pneumonia prognosis. They concluded that new severity scores for CAP in predicting the need for IRVS or ICU admission (ATS/IDSA 2007 minor criteria [17], SCAP score [18,19] and SMART-COP), had better discriminative performance in comparison to the previous ones (PSI and CURB-65) [20].

Chalmers et al. in 2008, studied CAP prognosis in young adults. In this study of 335 patients <50 years old, 1.5% died within 1 month, 9.9% needed IRVS. They showed that SMART-COP had a sensitivity of 84.8% with a negative predictive value of 98.0% and AUC = 0.87 in predicting the need for IRVS [11].

Charles et al. in 2008 for the first time, introduced SMART-COP as a useful tool with high validity in severity prediction of CAP and they found the same results as ours. In Australian CAP study, 10.3% of patients finally received IRVS and the 30-day mortality rate was 5.7% and it was announced that SMART-COP≥3 points identified 92% of patients needed IRVS including those who was not immediately admitted to the ICU [10].

Whilst clinical judgment is the most vital part in prediction of severity in pneumonia, physicians can apply high sensitivity scoring systems for pneumonia risk stratification in order to alert them to critical

Table 4
Validity of high-risk SMART-COP in pneumonia prognosis (considering SMART-COP≥5 as best cut-off point)

Variable	Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Area under curve (95% CI)
Intensive respiration or vasopressor support need	93.2% (81.3, 98.6)	71.7% (61.8, 80.3)	59.4% (46.9, 71.1)	95.9% (88.6, 99.2)	0.914 (0.856, 0.954)
Intensive care unit admission	85.5% (73.3, 93.5)	75.0% (64.6, 83.6)	68.1% (55.8, 78.8)	89.2% (79.8, 95.2)	0.876 (0.810, 0.925)
Death within 1 month	93.1% (77.2, 99.2)	63.2% (53.6, 72.0)	39.1% (27.6, 51.6)	97.3% (90.6, 99.7)	0.855 (0.786, 0.908)

patients who may be at risk of deterioration, closer observation or more aggressive management. In the present study, it was emerged that SMART-COP was useful in predicting CAP prognosis in our sample studied. Our population was a complicated case mix, most of our patients suffered multiple severe underlying diseases like diabetes mellitus, renal, hepatic or heart failure, obstructive lung disease, etc. We can reliably apply SMART-COP in our center and find patients at high risk of severe pneumonia needing emergent intervention.

7. Limitations of the study

Our study was conducted in a single tertiary referral center full of complicated cases, therefore the results might be influenced by local clinical decisions about starting IRVS. There are several limitations to our study. We only enrolled patients admitted to the ED; however, it seems unlikely that patients not admitted would require IRVS.

8. Conclusion

SMART-COP score performed well in this population with high sensitivity and negative predictive value. SMART-COP accurately predicted patients with CAP who needed IRVS, ICU admission and ones who expired. Predicting outcomes in CAP is an important safety concern and by applying severity risk stratification, physician can intervene appropriately in timely manner.

Prior Presentations.

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No

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References

[1] Woodhead M, Blasi F, Ewig S, et al. Guidelines for the management of adult lower respiratory tract infections. Eur Respir J 2005;26(6):1138–80.
[2] Hak E, Bont J, Hoes AW, et al. Prognostic factors for serious morbidity and mortality from community-acquired lower respiratory tract infections among the elderly in primary care. Fam Pract 2005;22(4):375–80.
[3] Kontou P, Kuti JL, Nicolau DP. Validation of the Infectious Diseases Society of America/American Thoracic Society criteria to predict severe community-acquired pneumonia caused by Streptococcus pneumonia. Am J Emerg Med 2009;27(8):968–74.
[4] Flannery MT, McCool MJ. Community acquired pneumonia guidelines and resident behavior. Am J Med 2005;118(8):929–30.
[5] Aleva RM, Boersma WG. Guideline 'diagnosis and treatment of community-acquired pneumonia' from the Dutch Thoracic Society. Ned Tijdschr Geneeskd 2005;149(45):2501–7.
[6] Fine MJ, Auble TE, Yealy DM, et al. A prediction rule to identify low-risk patients with community-acquired pneumonia. N Engl J Med 1997;336(4):243–50.
[7] Yende S, D'Angelo G, Kellum JA, et al. Inflammatory markers at hospital discharge predict subsequent mortality after pneumonia and sepsis. Am J Respir Crit Care Med 2008;177(11):1242–7.
[8] Lim WS, Baudouin SV, George RC, et al. Pneumonia Guidelines Committee of the BTS Standards of Care. "BTS guidelines for the management of community acquired pneumonia in adults: update 2009". Thorax 2009;64(Suppl. 3):iii1–55.
[9] Mandell LA, Wunderink RG, Anzueto A, et al. Infectious Diseases Society of America: Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults. Clin Infect Dis 2007;44(Suppl. 2):S27–72.
[10] Charles PG, Wolfe R, Whitby M, et al. SMART-COP: a tool for predicting the need for intensive respiratory or vasopressor support in community-acquired pneumonia. Clin Infect Dis 2008;47(3):375–84.
[11] Chalmers JD, Singanayagam A, Hill AT. Predicting the need for mechanical ventilation and/or inotropic support for young adults admitted to the hospital with community-acquired pneumonia. Clin Infect Dis 2008;47(12):1571–4.
[12] Pachucki Kelly F, Padkin A. SMART-COP score for patients with community acquired pneumonia to an ICU in a district general hospital: a smarter way of identifying patients with severe CAP? Crit Care 2013;17(2):171–2015.
[13] Davis JS, Cross GB, Charles PG, et al. Pneumonia risk stratification in tropical Australia: does the SMART-COP score apply? Med J Aust 2010;192:133–6.
[14] Marrie TJ. Epidemiology, pathogenesis and microbiology of community acquired pneumonia in adults. In: Bartlett JG, editor. UpToDate. Waltham, MA: UpToDate; 2013.
[15] Katayoon V, Nemati R, Emrani A, et al. Seroepidemiology of mycoplasma pneumonia in patients with pneumonia in Bushehr Province. Majaleh Teb-e-Jonub 2004;7(2):128–34.
[16] Robins-Browne KL, Cheng AC, Thomas KAS, et al. The SMART-COP score performs well for pneumonia risk stratification in Australia's tropical Northern Territory: a prospective cohort study. Trop Med Int Health 2012;17(7):914–9.
[17] Niederman MS, Bass Jr JB, Campbell GD, et al. Guidelines for the initial management of adults with community-acquired pneumonia: diagnosis, assessment of severity, and initial antimicrobial therapy: American Thoracic Society, Medical Section of the American Lung Association. Am Rev Respir Dis 1993;148:1418–26.
[18] Espana PP, Capelastegui A, Gorordo I, et al. Development and validation of a clinical prediction rule for severe community-acquired pneumonia. Am J Respir Crit Care Med 2006;174:1249–56.
[19] Renaud B, Labarere J, Coma E, et al. Risk stratification of early admission to the intensive care unit of patients with no major criteria of severe community-acquired pneumonia: development of an international prediction rule. Crit Care (London) 2009;13:R54.
[20] Marti C, Garin N, Grosgurin O, et al. Prediction of severe community-acquired pneumonia: a systematic review and meta-analysis. Crit Care 2012;16(4):141.