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Original Contribution

Comparison of two scores of short term serious outcome in COPD patients

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ABSTRACT

Introduction: Chronic Obstructive Pulmonary Disease (COPD) related visits to the emergency department have increased substantially during the past decade. An important challenge facing emergency physicians when treating COPD patients is deciding on disposition. The aim of this study was to evaluate Integrated Pulmonary Index scoring to guide the disposition decisions of emergency physicians by comparing its compatibility with Ottawa COPD Risk Score.

Methods: This is a prospective methodological study, in which we compared the accuracies of the Integrated Pulmonary Index and Ottawa COPD Risk Score in predicting of the short-term serious outcomes in patients admitted to the emergency department with COPD exacerbation. Patients who admitted to our emergency department between 01.01.2019–31.03.2019 were evaluated.

The results: Among the 208 patients, there were 154 (74.0%) short-term serious outcomes. The AUCs were 0.915 and 0.943 for Integrated Pulmonary Index and Ottawa COPD Risk Score, respectively. The difference between AUCs for two scores was not statistically significant. The best cut-off point for Integrated Pulmonary Index and Ottawa COPD Risk Score were ≤3 and >4, respectively. For these best cut-off points, the sensitivity and specificity of Integrated Pulmonary Index were 92.9 and 87.1, respectively. The sensitivity and specificity of Ottawa COPD Risk Score were 99.3 and 85.2, respectively. Besides, the accuracy of Integrated Pulmonary Index was 91.3, and the accuracy of Ottawa COPD Risk Score was 95.7.

Conclusions: Integrated Pulmonary Index was a potential candidate for evaluating respiratory status and prediction of short-term severe events in patients with acute COPD exacerbation in emergency departments.

1. Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a common and serious condition that is the fourth leading cause of death in the world, but is projected to be the third leading cause of death by 2020 [1]. COPD is a respiratory disorder, preventable and treatable characterized by persistent respiratory symptoms, airflow limitations and exacerbations of respiratory distress [2]. Exacerbations of COPD, defined as periods of acute worsening of respiratory symptoms, include the presence of an increase in at least 2 of breathlessness, sputum volume or sputum purulence [2]. Exacerbations of COPD is a leading cause of hospital admission, the majority of the admission taking place in the emergency department (ED), and COPD-related visits to the ED have increased substantially during the past decade [3]. COPD often coexists with other chronic diseases (such as heart failure and diabetes mellitus), which further contribute to admission and extended lengths of stay both in the EDs and other wards of the hospitals [1,4].

An important challenge for emergency physicians when treating COPD patients is deciding on disposition, whether to admit with or without monitoring, or whether to discharge [5]. It is not reasonable to admit all COPD patients due to chronic bed and staff shortage [5]. However, a number of patients have short-term serious adverse events, they die from any cause, require admission to a monitored unit, endotracheal intubation, or non-invasive ventilation [6]. Also many patients, which are evaluated and treated in the ED and then are discharged, return to receive additional ED care and/or be admitted due to serious adverse events [6,7]. The disposition decision is an important challenge because a lot of hospitals that have a shortage of hospital beds and staff or many EDs are overcrowded [5].

Ottawa COPD Risk Scala (OCRS), including 10 unique risk factors (4 from the initial clinical assessment, 5 from bedside investigations and 1 from reassessment after emergency department treatment), was

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composed and validated by Stiell et al. to ensure appropriate admission of high-risk patients while minimizing the admission of low-risk patients in the ED [2,8]. Although they emphasized that these risk factors are readily available and do not require sophisticated imaging or expensive testing to assist decision-making [2,8], but nevertheless OCRS requires extended length of stay of patients in the ED department and several testing and that could be a challenge in the overcrowded EDs and hospitals. Integrated Pulmonary Index (IPI) is a mathematically-determined factor that incorporates four real-time respiratory parameters (end-tidal CO2, respiratory rate, pulse rate, SpO2) which should enable a non-invasive assessment of the respiratory state of the patient [9,10]. It was emphasized that all clinicians could use IPI in order to determine whether their patients need additional clinical assessment or intervention [10]. Close correlation between IPI and respiratory status of patients who are monitored spontaneous ventilation has been demonstrated [10,11], and it was reported that IPI could be a valuable tool in early determination of respiratory problems [12].

The overall goal of this study was to evaluate IPI scoring to guide the disposition decisions of ED physicians by comparing its compatibility with Ottawa COPD Risk Score (OCRS) in predicting of short-term serious outcomes in patients with COPD.

2. Material and method

2.1. Study design and setting

Our study was a prospective methodological study, in which we studied the accuracies of the IPI and OCRS in predicting of short-term serious outcomes in patients with COPD. All patients were informed about the study and its procedures, and informed consents on paper were collected from the agreeing volunteers before inclusion in the study. Our research was conducted in accordance with Good Clinical Practice standards, and according to the Standards for the Reporting of Diagnostic accuracy studies (STARD) [13]. The study was approved by the Ataturk University Faculty of Medicine Ethics Committee, and was carried out between 01.01.2019 and 31.03.2019 at Ataturk University Research Hospital, the major hospital of the Eastern Anatolia Region in Turkey.

2.2. Patients

Patients who admitted to our ED between 01.01.2019 and 31.03.2019 were evaluated for eligibility. The inclusion criteria were: (1) diagnosed with COPD, and (2) admission to the ED with exacerbation. The exclusion criteria: (1) pregnancy, (2) cognitive impairments or psychiatric disorders, (3) any type of cancer, (4) presence of bleeding disorder, (5) taking medications that increase the risk of bleeding, and (6) chronic disease (including, diabetes mellitus, hypertension, chronic liver disease, chronic kidney disease, chronic heart disease failure etc.). So that the patients, who were diagnosed with COPD in chest diseases polyclinic and who admitted to our Emergency department with COPD exacerbations, were included in the study. We defined COPD exacerbation as an acute worsening of respiratory symptoms that results in additional therapy according to the Global initiative for the management of chronic Obstructive Lung Disease (GOLD) Science Committee Report 2019 [14].

Age, sex, vital signs (blood pressure, pulse rate, respiratory rate, Body temperature, and oxygen saturation) of the patients who agreed to participate in the study were recorded.

2.3. Test methods

IPI scores and OCRS scores of the patients were used to predict the short-term serious outcome. IPI (Capnostream-20, Medtronic, Israel) is an automated system which was described as an algorithm that simplifies the interpretation of end-tidal CO2 (PetCO2), respiration rate, pulse rate, and oxygen saturation (SpO2) to assess the patient's respiratory status. This assessment based on a mathematical model combining of these parameters into a single value ranged between 1 and 10 [15].

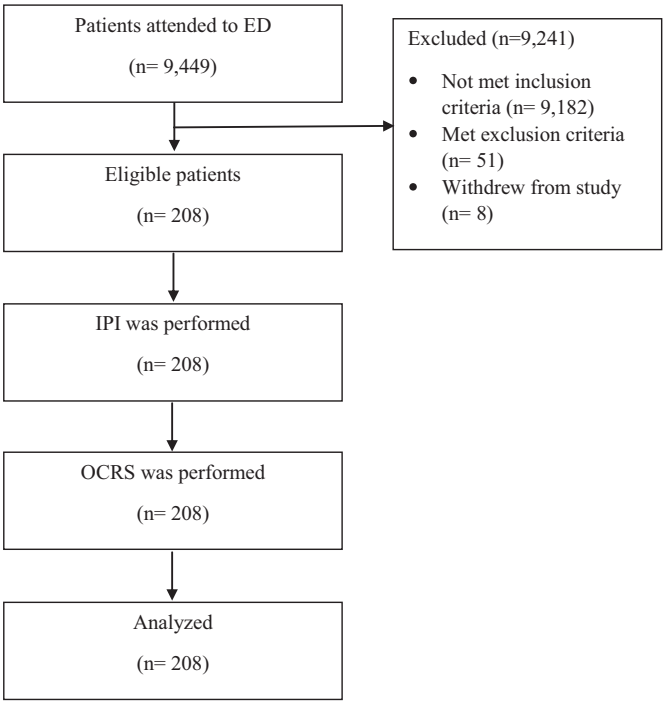

Fig. 1. Flow diagram of the study. Note: IPI: Integrated Pulmonary Index, OCRS: Ottawa COPD Risk Scale.

We accepted the descriptions OCRS made by the authors of the original study. The authors assessed OCRS as 10 component: 1. Initial assessment; a) History of CABG, b) History of intervention for PVD, c) History of intubation for respiratory distress, d) Heart rate on ED arrival>110, 2. Investigations; a) ECG has acute ischemic changes, b) Chest X-ray has any pulmonary congestion, c) Hemoglobin<100 g/L, d) Urea 12 mmol/L, e) Serum CO2 35 mmol/L, 3. Re-Assessment after ED treatment; a) SaO2 < 90% on room air or usual O2, or HR 120 [8].

Table 1
Demographics and clinical characteristics of the patients with COPD.

Variables (n = 208)	
Age (years), Median (IQR)	67.5 (64.0–75.0)
Female, n (%)	66 (31.7)
Arrival examination	
Body temperature (°C), Median (IQR)	36.8 (36.7–36.9)
Respiratory rate (BrPM), Median (IQR)	29 (24–36)
Oxygen saturation level (%), Median (IQR)	84.0 (75.3–89.0)
$ETCO^2$ concentration (mmHg), Median (IQR)	31.0 (27.0–35.0)
Systolic blood pressure (mmHg), Median (IQR)	130.0 (121.0–145.8)
Diastolic blood pressure (mmHg), Median (IQR)	76.0 (69.3–81.0)
IPI, Median (IQR)	1.0 (1.0–4.0)
OCRS, Median (IQR)	6.0 (5.0–7.0)
History of CABG, n (%)	2 (1.0)
History of intervention for PVD, n (%)	63 (30.3)
History of intubation for respiratory distress, n (%)	32 (15.4)
Arrival heart rate > 110 BPM, n (%)	54 (26.0)
ECG has acute ischemic changes, n (%)	146 (70.2)
Chest X-ray has any pulmonary congestion, n (%)	139 (66.8)
Hemoglobin<100 g/L, n (%)	3 (1.4)
Urea>12 mmol/L, n (%)	24 (11.5)
Serum CO^2 > 35 mmol/L, n (%)	123 (59.1)
SaO^2 < 90%, or HR > 120 BPM after ED treatment, n (%)	154 (74.0)

Note: BrPM: breaths per minute, $ETCO^2$: End-tidal carbon dioxide, IPI: Integrated Pulmonary Index, OCRS: Ottawa COPD Risk Scale, CABG: coronary arterial bypass grafting, PVD: peripheral venous disease, BPM: beat per minute, ECG: electrocardiogram, SaO^2: oxygen saturation on room air or usual O^2, HR: heart rate.

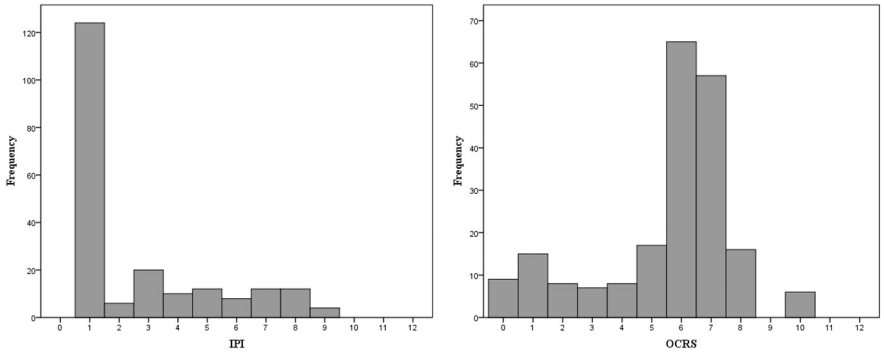

Fig. 2. Distributions of IPI and OCRS data.

Short-term serious outcome was defined as death from any cause within 30 days of the admission to the ED; or any of the following within 14 days of the initial admission to ED: (1) Admission to a monitored unit, (2) Need to endotracheal intubation or noninvasive ventilation after hospital admission, unless the patient was using noninvasive ventilation at home, (3) Diagnosis of myocardial infarction (MI), (4) Undergoing a major surgery, (5) Return to the ED for any related medical problem. We accepted the definitions of these criteria made by the authors in the original study [16].

2.4. Analysis

Statistical analyses were performed with SPSS version 23 (IBM Corp. in Armonk, NY) and Medcalc version 16 (MedCalc Software bvba, Ostend, Belgium). Descriptive statistics were presented as frequency (n) and percentage (%) for categorical variables, and median with interquartile range (IQR) for non-normally distributed variables. ROC analysis was used for estimating the accuracy of IPI and OCRS in predicting SSO in patients with COPD exacerbations. Area under ROC curves (AUCs) for IPI and OCRS were calculated, and Delong et al. method was used for AUCs [17]. Youden J index was used for estimating best cut-off values. Sensitivity, specificity, positive likelihood ratio (+LR), negative likelihood ratio (−LR), accuracy with 95% confidence intervals (CIs) were calculated. $p < 0.05$ was set as statistically significance level.

3. Results

3.1. Patients

From 01.03.2019 to 31.03.2019, 9449 patients were attended to our ED, 9241 were excluded (9182 didn't meet inclusion criteria, 51 met exclusion criteria, 8 withdrew from the study), and 208 patients were considered eligible for the study. Both IPI (Integrated Pulmonary Index) and OCRS (Ottawa COPD Risk Scale) were performed in all of the eligible patients (n = 208), and there has been no lost to follow up, finally all patients were analyzed for presence of short-term serious outcome (SSO) (Fig. 1).

Of the patients who were enrolled, median age was 67.5 years, and 66 (31.7%) were female. Among the arrival examinations, median respiratory rate was 29 breaths per minute, the median oxygen saturation was 84.0%, the median end tidal carbon dioxide concentration was 31 mmHg, and the median systolic blood pressure was 130.0 mmHg (Table 1). The median IPI score was 1.0 (IQR:1.0–4.0), and the median OCRS was 6.0 (IQR:5.0–7.0) (Table 1 and Fig. 2).

Among the 208 patients who were followed, there were 154 (74.0%) short-term serious outcomes. Of the patients, 96 (46.2%) were admitted to a monitored unit, 3 (1.4%) required endotracheal intubation or noninvasive ventilation, 5 (2.4%) had myocardial infarction, 4 (1.9%) underwent a major cardiac procedure, and 46 (22.1%) returned to the ED within 14 days (Table 2).

Table 2
Short-term serious outcome occurrence in the patients with COPD.

Variables (n = 208)	
Short-term serious outcome, n (%)	154 (74.0)
Death from any cause within 30 days, n (%)	0 (0.0)
Admitted to a monitored unit, n (%)	96 (46.2)
Endotracheal intubation or noninvasive ventilation, n (%)	3 (1.4)
Diagnosis of myocardial infarction, n (%)	5 (2.4)
Underwent a major cardiac procedure, n (%)	4 (1.9)
Returned to the ED within 14 days, n (%)	46 (22.1)

3.2. Test results

The areas under ROC curves (AUCs) were 0.915 and 0.943 for IPI and OCRS, respectively. The difference between AUCs for IPI and OCRS were not statistically significant. The best cut-off point for IPI and OCRS, estimated by Youden J indexes (0.799 and 0.845, respectively) were ≤3 and >4, respectively (Fig. 3 and Table 3). For these best cut-off points, the sensitivity and specificity of IPI were 92.9 and 87.1, respectively, and the sensitivity and specificity of OCRS were 99.3 and 85.2, respectively. Besides, the accuracy of IPI was 91.3 with a +LR of 7.2 and a −LR of 0.08, and the accuracy of OCRS was 95.7 with a +LR of 6.7 and a −LR of 0.01 (Table 4). Also, the comparisons of sensitivities, specificities, +LRs, −LRs and accuracies of IPI and OCRS according to different cut-off values were shown in Appendix Table A.1.

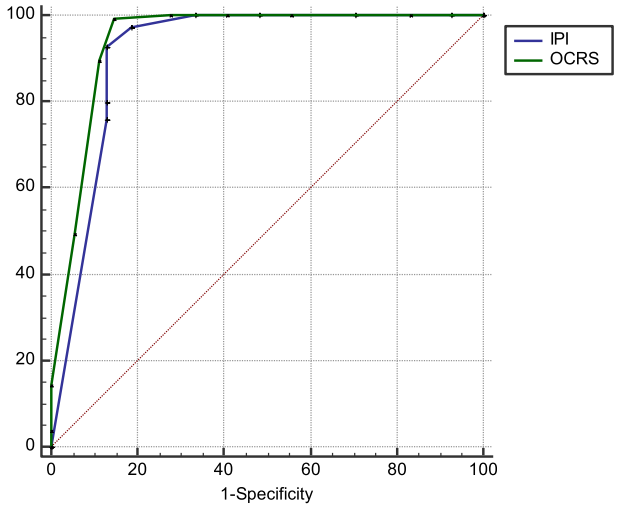

Fig. 3. Comparison of ROC curves of IPI and OCRS data.

Table 3
Comparison of AUC of the ROC curves of IPI and OCRS data.

	IPI	OCRS	p
AUC (95% CI)	0.915 (0.868–0.949)	0.943 (0.902–0.970)	0.060
Youden index (95% CI)	0.799 (0.677–0.880)	0.845 (0.734–0.919)	
Associated cut-off	≤3	>4	

Note: AUC: area under curve, IPI: Integrated Pulmonary Index, OCRS: Ottawa COPD Risk Score.

4. Discussion

To the best of our knowledge, this study is the first to investigate the practicability of IPI scoring to guide the disposition decisions of ED physicians. For that purpose, we evaluated the compatibility between IPI scoring and OCRS for predicting of short-term serious outcomes in patients with COPD. They exhibit a high degree of meaning overlap according to comparison of ROC curves of IPI and OCRS and comparison of AUC of the ROC curves of IPI and OCRS data. For the best cut-off points, the sensitivity and specificity of IPI were 92.9 and 87.1, respectively, and the sensitivity and specificity of OCRS were 99.3 and 85.2, respectively. We also found that IPI had an equivalent accuracy with OCRS in predicting short-term severe event in patients with COPD exacerbation.

Spirometry is an essential test to diagnose COPD and stage severity based on different transformations of the forced expiratory volume in 1 second (FEV1) and other lung function variables [18]. However, multidimensional indices of COPD, aimed to classify the severity of COPD better than FEV1 alone, can be used either to predict death or to stratify the severity of COPD patients [18,19]. In patients with COPD, ADO (age, dyspnea and forced expiratory volume in 1 second), BODE (body mass index (BMI), airflow obstruction, dyspnea, exercise capacity) index, and e-BODE (BODE plus exacerbations) were the most commonly used indices to foresee the severity of disease and long-term mortality [18]. Though these multicomponent indices predict well the long term severity of disease and therefore they could be used to predict hospitalization, but they could not predict well short term severe adverse events [18]. OCRS was developed in order to help disposition decision for patients presenting to ED with exacerbation of COPD [2,8], but it also requires several testing and transient stay in an ED for additional examination and wait for the results of the tests requested. We believe that IPI are readily applicable at presentation in order to support emergency physician's decision-making process for admission in patients with acute exacerbations of COPD.

The IPI evaluates patient's respiratory status immediately. Thus all clinicians use it in order to detect that a patient requires additional clinical assessment and intervention [10,15]. IPI is demonstrated as a single indexed value from 1 to 10, where 8–10 shows a nearly normal ventilation, whereas a level ≤ 6 shows that intervention might be required, whereas level ≤ 4 shows that intervention is ultimately necessary, respectively [9,15,20]. From this point of view, IPI score has been widely used for monitoring in patients undergoing sedation for various reasons [9,10,21]. In pediatric patients undergoing endoscopy under sedation, IPI alerted physicians earlier for all apnea episodes and hypoxia conditions [22]. Mermer D et al. investigated the role of IPI in monetarizing patients have spontaneous ventilation under spinal block and they emphasized that IPI is a practical and a noninvasive monetarization tool in early detection of respiratory failure by correlating clinical respiratory status [10]. IPI also has been studied in the respiratory management of patient recovering in intensive care unit [10,20,21,23], and it might be a potential candidate to be a more dynamic measurement than arterial blood gas was reported [20,21,23,24]. Respiratory status is a cornerstone of patient management in patients with acute exacerbation of COPD in the EDs, and our analysis demonstrates high levels of sensitivity and specificity (92.9% and 87.1% for short-term severe outcomes with IPI equal to or <3, respectively). We think that our findings should be supported with further studies.

The ratio of short-term adverse event is extremely high and thereby the ratio of hospitalization is also high in COPD patients with acute exacerbations [8,25,26]. If patients require re-admission, they are more likely to have poor clinical outcomes and also a high mortality rate [6,27]. On the other hand, admissions to hospital the previous year due to acute exacerbation of COPD have a higher risk of severe adverse event and hospitalization was reported [6,16,19,28]. Of the patients, there were 154 (74.0%) short-term serious outcomes in the presented study and this ratio was a little bit higher than literature. Higher ratio of short-term serious outcomes could be explained with multifactorial situations, such as our hospital is a third degree references hospital and more complicated and advanced age of patients with a comorbid condition were referred to our ED and hospital. OCRS was developed to identify patients who are at risk of deterioration [2,8]. But it requires ECG, chest radiography, examination of some blood analysis and also a walk test after treatment in ED. These requirement limit its use in EDs which have especially shortage of bed and staff and if the hospital or ED are overcrowded [2,8]. The IPI provides non-invasive methods to monitor respiratory status of patients in the EDs [15,20]. IPI involve several variables into one value and that may ameliorate clinician's ability to detect patients with respiratory failure sooner by monitoring trends [15,29]. We thought that detection of an existing downward trend in IPI may allow application of timely intervention and accurate disposition decision in the EDs.

4.1. Limitations

The main limitation of this study is the external validity, because of being a single center study and therefore including relatively small sample size.

5. Conclusion

In conclusion, many previous studies have emphasized that the clinical utility of the IPI algorithm should be investigated as a predictive tool for early warning and making decision in different clinical environments. IPI was a potential candidate for evaluating respiratory status and prediction of short-term severe events in patients with acute exacerbation of COPD in the ED's. The present study suggests that IPI was compatible with the OCRS to foresee the short-term serious outcomes in patients with COPD. Further clinical trials are needed to assess the

Table 4
Cross tabulation of IPI and OCRS results by the occurrence of SSO in the patients with COPD.

Test	SSO occurrence, n (%)		Sensitivity (95% CI)	Specificity (95% CI)	+LR (95% CI)	−LR (95% CI)	Accuracy
	Not occurred	Occurred					
IPI > 3	47 (81.0)	11 (19.0)	92.9 (87.6–96.4)	87.1 (75.1–94.6)	7.2 (3.6–14.3)	0.08 (0.05–0.10)	91.3
IPI ≤ 3	7 (4.7)	143 (95.3)					
OCRS ≤ 4	46 (97.9)	1 (2.1)	99.3 (96.4–100.0)	85.2 (72.9–93.4)	6.7 (3.5–12.7)	0.01 (0.00–0.05)	95.7
OCRS > 4	8 (5.0)	153 (95.0)					

Note: IPI: Integrated Pulmonary Index, OCRS: Ottawa COPD Risk Score, +LR: positive likelihood ratio, −LR: negative likelihood ratio.

role of IPI in guiding the disposition decisions of ED physicians in COPD patients with acute exacerbation.

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Declaration of competing interest

The author declares no competing interests to disclose.

Appendix A

Table A.1
Comparisons of IPI and OCRS according to different cut-off values.

	Cut-off value	Sensitivity	95% CI	Specificity	95% CI	+LR	95% CI	−LR	95% CI
IPI	<1	0,00	0,0–2,4	100,00	93,4–100,0			1,00	1,0–1,0
	≤1	75,97	68,4–82,5	87,04	75,1–94,6	5,86	2,9–11,8	0,28	0,2–0,4
	≤2	79,87	72,7–85,9	87,04	75,1–94,6	6,16	3,1–12,4	0,23	0,2–0,3
	≤3	92,86	87,6–96,4	87,04	75,1–94,6	7,16	3,6–14,3	0,082	0,05–0,1
	≤4	97,40	93,5–99,3	81,48	68,6–90,7	5,26	3,0–9,2	0,032	0,01–0,08
	≤5	100,00	97,6–100,0	66,67	52,5–78,9	3,00	2,1–4,4	0,00	
	≤6	100,00	97,6–100,0	51,85	37,8–65,7	2,08	1,6–2,7	0,00	
	≤7	100,00	97,6–100,0	29,63	18,0–43,6	1,42	1,2–1,7	0,00	
	≤8	100,00	97,6–100,0	7,41	2,1–17,9	1,08	1,0–1,2	0,00	
	≤9	100,00	97,6–100,0	0,00	0,0–6,6	1,00	1,0–1,0		
OCRS	≥0	100,00	97,6–100,0	0,00	0,0–6,6	1,00	1,0–1,0		
	>0	100,00	97,6–100,0	16,67	7,9–29,3	1,20	1,1–1,4	0,00	
	>1	100,00	97,6–100,0	44,44	30,9–58,6	1,80	1,4–2,3	0,00	
	>2	100,00	97,6–100,0	59,26	45,0–72,4	2,45	1,8–3,4	0,00	
	>3	100,00	97,6–100,0	72,22	58,4–83,5	3,60	2,3–5,5	0,00	
	>4	99,35	96,4–100,0	85,19	72,9–93,4	6,71	3,5–12,7	0,0076	0,001–0,05
	>5	89,61	83,7–93,9	88,89	77,4–95,8	8,06	3,8–17,2	0,12	0,07–0,2
	>6	49,35	41,2–57,5	94,44	84,6–98,8	8,88	2,9–27,0	0,54	0,5–0,6
	>7	14,29	9,2–20,8	100,00	93,4–100,0			0,86	0,8–0,9
	>8	3,90	1,4–8,3	100,00	93,4–100,0			0,96	0,9–1,0
	>10	0,00	0,0–2,4	100,00	93,4–100,0			1,00	1,0–1,0

Note: IPI: Integrated Pulmonary Index, OCRS: Ottawa COPD Risk Score, +LR: positive likelihood ratio, −LR: negative likelihood ratio.

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