Validity of the Pulmonary Embolism Rule-Out Criteria (PERC) for ruling out pulmonary embolism in low-risk patients at high altitudes

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DOI: https://doi.org/10.36104/amc.2021.2010

Abstract

Objectives: to validate the diagnostic yield of the PERC score for ruling out pulmonary embolism in low-risk patients at high altitudes (>2500 meters above sea level [ASL]).

Methods: a cross-sectional study with diagnostic test analysis in patients over the age of 18 with suspected pulmonary embolism on admission or during hospitalization, who underwent chest computed tomography angiography between August 2009 and January 2020 in a tertiary care hospital located on the Bogotá savannah. The yield of the PERC score was assessed, calculated with an SaO2<95% and an SaO2<90% in patients with different risk levels according to the Wells, Geneva and Pisa scores for pulmonary embolism.

Results: one thousand eighty-seven were included in the final analysis, 42% with PE. Patients classified as low-risk using the Wells score had a PERC ACOR calculated with SaO2<95% of 0.56 (95%CI:0.50-0.62) (p=0.049), and calculated with SaO2<90% of 0.60 (95%CI:0.54-0.66) (p=0.002). The ACOR for subjects classified as low-risk using the Geneva score, with a PERC calculated with SaO2<95%, was: 0.53 (95%CI:0.45-0.60) (p=0.459) and for a PERC calculated with SaO2<90% it was: 0.55 (95%CI:0.47-0.62) (P=0.218). The ACOR for subjects with a less than 10% probability of PE according to the Pisa score classification, with a PERC calculated with SaO2<95%, was: 0.54 (95%CI:0.44-0.64)(p=0.422), and for a PERC calculated with SaO2<90% it was: 0.56 (95%CI:0.46-0.66)(p=0.236).

Conclusions: the PERC score calculated with an oxygen saturation <90% has a similar diagnostic yield to the PERC score calculated with an oxygen saturation <95% for ruling out PE in patients classified as low-risk by the Wells score at high altitudes (>2,500 meters ASL). **(Acta Med Colomb 2021; 46. DOI: https://doi.org/10.36104/amc.2021.2010).**

Keywords (DeCS): *pulmonary embolism, clinical decision rules, diagnosis, probability, altitude and reproducibility of the results.*

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Received: 10/IX/2020 Accepted: 15/VI/2021

Introduction

Pulmonary embolism (PE) is a condition affecting the pulmonary arteries and their branches, and if not suspected and diagnosed in time, it may be potentially fatal (1). It is characterized by a nonspecific clinical picture consisting mainly of sudden onset dyspnea, pleuritic chest pain (exacerbated by inspiratory effort), tachycardia, tachypnea, fever and a dry cough or hemoptysis, with a possible general deterioration to the point of hemodynamic instability and even cardiorespiratory arrest (2). The respiratory symptoms may be similar to those of other diseases such as acute coronary syndrome, pneumothorax and other pulmonary diseases, with laboratory tests and computed tomography angiography (CTA) of the pulmonary arteries required for the differential diagnosis (3).

Since evaluating each symptom separately to diagnose pulmonary embolism is nonspecific, the sum of the signs, symptoms and laboratory findings is used to suspect or rule out this disease. Over the last few years, the use of clinical prediction scales has become popular to guide the assessment of these patients. One of the most widespread scales is the Wells scale, which assesses admission vital signs such as heart rate, a suspect clinical picture for PE and significant medical history. Its result groups patients according to the

cut-off point used; thus, patients may be classified as high, moderate and low probability (three levels), or high and low probability (two levels) of PE (4-6). Similarly, other scores such as the Geneva and Pisa scales which, in addition to clinical symptoms, evaluate paraclinical findings, have also proven useful in the diagnostic approach to this disease (7, 8).

These scales have been widely validated in different populations and in our setting for diagnosing pulmonary embolism (9-11). However, scores such as PERC, which is used to rule out this condition, have limited biographical data in special populations, such as those at high altitudes. The PERC scale, which assesses eight clinical variables including arterial oxygen saturation (SaO2), has proven useful in ruling out PE. A PERC score of zero could have a similar yield for ruling out PE as a negative D-dimer (12, 13). However, using SaO2 < 95% to construct the PERC score at high altitudes could affect the diagnostic yield of this score. Considering that saturation decreases as altitude increases, we must evaluate whether this score requires some type of adjustment for calculations in populations at high altitudes (greater than 2,500 m.a.s.l.) (14, 15). The objective of this study is to evaluate the diagnostic yield of the PERC score for ruling out PE using different levels of oxygen saturation in patients classified as low risk according to the Wells, Geneva and Pisa scales.

Methods

A cross-sectional study with diagnostic test analysis was carried out in subjects with suspected pulmonary embolism seen in the emergency room and hospitalized at Clínica Universidad de la Sabana (Chía, Colombia) between August 2009 and January 2020. All individuals over the age of 18 with a chest CTA due to a clinical suspicion of PE were included. Individuals undergoing this test for other suspected disorders such as aortic aneurysm, suspected vascular trauma, suspected nontraumatic aortic disease, or acute aortic syndrome; those without data or whose clinical chart could not be located due to problems with the data system; and individuals with an unavailable radiology reading were excluded. This study was approved by the ethics committee at Clínical Universidad de la Sabana.

All the clinical and paraclinical variables required for constructing Wells, revised Geneva, Pisa with radiological findings and PERC scores were recorded, following the recommendations of the authors of the original studies for constructing each of these scores when there is a diagnostic suspicion of PE (13, 16, 17). Data recorded in the medical history (demographic variables, comorbidities and symptoms), physical exam findings, D-dimer reports, the chest x-ray, electrocardiogram, computed tomography angiography of the pulmonary arteries, need for mechanical ventilation, admission to intensive care and status at hospital discharge were included separately.

Each of the scores was calculated numerically and subsequently classified according to the probability of PE; the Wells score in three levels (low: <2, intermediate: 2-6 and high: >6) (6, 18) and two levels (less likely ≤4 and likely >4) (19); the revised Geneva score in three levels (low: 0-3, intermediate: 4-10, high 11-22) (20); and the Pisa score in four levels (low: 0-10, intermediate: 11-50, moderately high: 51-90 and high: 91-100) (21). The PERC score was calculated in two levels: probable (≥ 1) or not probable (= 0) (12, 13). Pulmonary embolism was diagnosed with the result of the CTA read by a radiologist as positive for pulmonary embolism (22, 23). The sample size was calculated according to Kline et al.'s original study, which for a sensitivity of 96%, specificity of 27%, prevalence of 8%, level of precision of 5% and level of confidence of 95% required a minimum of 751 subjects; the subjects were included sequentially until the required number was met.

The data obtained from the clinical charts were collected using RedCap electronic data capture software and subsequently analyzed with the licensed SPSS-25 statistical program. An initial data review by variable was conducted to evaluate the percentage of data loss. Following this, qualitative variables were summarized as frequencies and percentages and quantitative variables were summarized according to their distribution, using average and standard deviation for normally distributed variables and median and interquartile range for non-normally distributed variables. A bivariate analysis was performed for each of the study variables and the diagnosis of PE. The quantitative variables were compared according to their distribution with Student's t-test or the Mann-Whitney U test, and the qualitative variables were compared with Chi^2. An initial PERC score was calculated assigning one point to an SaO2<95%, and a second PERC score was calculated assigning one point to an SaO2<90%. The results of the two PERC scores, grouped according to the different risk categories of the Wells, Geneva and Pisa scores, were compared with positivity or negativity for PE on the CTA, and SaO2<90% was selected, considering González-Garcia et al.'s study in 2013 and 2020 on arterial gas levels at 2,640 m.a.s.l. (24). Subsequently, the sensitivity, specificity and area under the receiver operating characteristic curve (AUC-ROC) were estimated, with a 95% confidence interval for the PERC score calculated

with an SaO2<95% and the PERC score calculated with an SaO2<90%, and a p <0.05 considered statistically significant. The Helsinki ethical recommendations and Resolution 8430 of 1993 for human research were followed, with the study being considered no-risk, and not requiring informed consent. Likewise, the recommendations of the Law of *Habeas Data for the treatment and confidentiality of personal data were followed*.

Results

A total of 1,087 patients were included in the final analysis. Figure 1 shows the flowchart for patient inclusion in the study. Pulmonary embolism was found in 42% of the subjects evaluated. Table 1 shows the sociodemographic characteristics and PE related medical history of the population, where a statistically significant relationship was found between PE and dementia (p=0.027), active cancer in the last year (p=0.022), a history of PTE (p=0.035) and the use of oral contraceptives in women (p=0.016). Table 2 presents the clinical characteristics and physical exam findings with PE; a statistically significant relationship was found between PE and chest pain (p=0.001), hemoptysis (p=0.035) and unilateral lower extremity pain (p=0.010), together with a statistically significant relationship with signs of DVT excluding venous distention and non-varicose collateral veins. The vital signs analysis only found a statistically significant relationship between PE and heart rate (p=0.003).

Regarding the laboratory tests drawn on the patients, there was a statistically significant relationship between the diagnosis of PE and right ventricular overload on the electrocardiogram, chest x-ray findings of oligemia, hilar artery amputation and consolidation due to pulmonary infarct, all of which had a p<0.001. In addition, patients diagnosed with PE were found to have higher D-dimer levels, with a median of 3.43 μg/mL (IQR: 4.7) vs. 1.31 μg /mL (IQR: 1.53), as seen in Table 3.

Table 4 shows the results according to the different variables used to calculate the PERC score and their relationship with PE. It also shows the relationship between PE and the PERC score calculated using SaO2<95% and SaO2<90% and the diagnosis of PE, where a PERC ≥1 calculated with an SaO2<90% was statistically significantly related to PE (p=0.006). Table 5 shows the sensitivity, specificity and AUC-ROC results of the PERC score calculated using SaO2<95% and SaO2<90% in patients classified in the different risk groups according to the Wells, Geneva and Pisa scores. The PERC score using SaO2<95% was found to have a sensitivity of 99.3%, specificity of 1.3%, false negatives of 0% and an AUC-ROC of 0.56 (95% CI:0.52-0.59) (P=0.001), while the PERC score calculated with SaO2<90% had a sensitivity of 98.0%, specificity of 5.2%, false negatives of 2.4% and an AUC-ROC of 0.60 (95% CI:0.54-0.66) (p=0.002).

Discussion

This study found that using a 90% oxygen saturation cut-off point to calculate PERC maintains high sensitivity while it improves specificity, compared to the PERC score calculated with a 95% SaO2 cut-off at high altitudes (2,640 m.a.s.l.). These results correlate with the decreased oxygen saturation at higher altitudes and the physiological adaptive processes found in individuals who live at altitudes above 2,500 m.a.s.l. Our findings are similar to those reported in studies which applied PERC at altitudes of 1,500 m.a.s.l.,

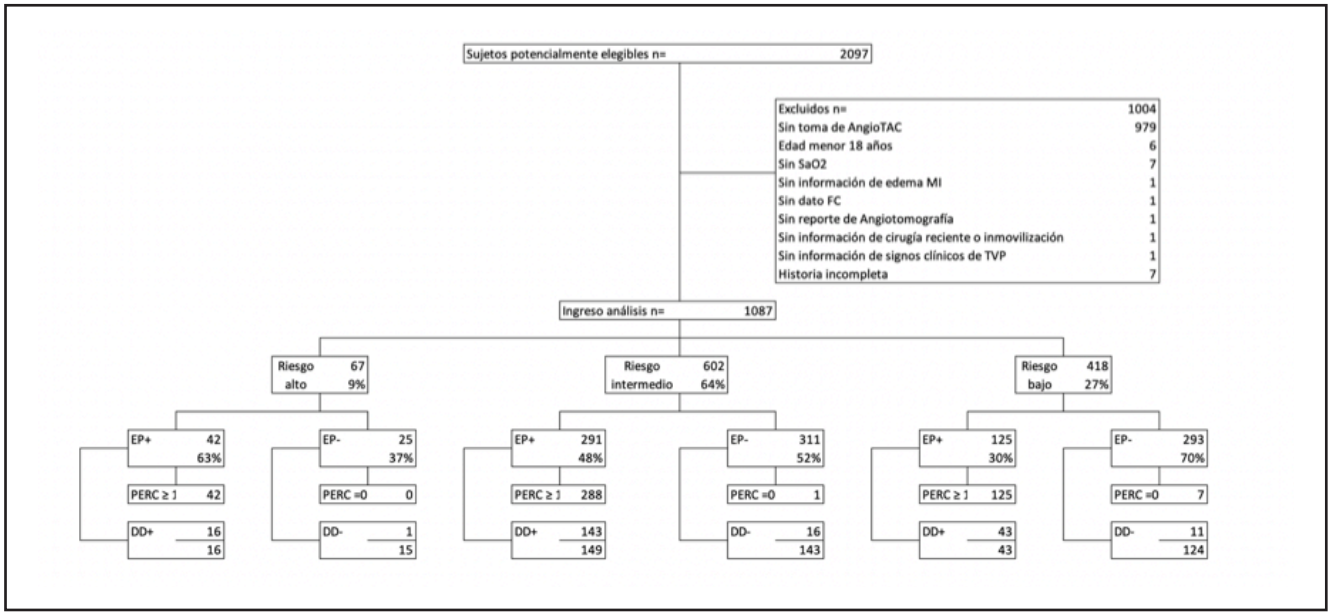

Figure 1. *Flowchart of patients' inclusion in the study. HR: heart rate. DVT: deep vein thrombosis, CTA: computed tomography angiography of the pulmonary arteries, LE: lower extremity, SaO2: oxygen saturation.*

which found that using a 90% oxygen saturation to construct the score maintained a sensitivity of 94.8-100% and a specificity of 17.8-22% (25, 26). In addition, this score maintains a discriminatory power for diagnosing PE in patients classified as low risk by the Wells score in this study population (13, 25, 26).

Oxygen levels decrease as altitude increases, decreased atmospheric pressure leads to a decreased alveolar pressure of oxygen and decreased gas exchange which may ultimately decrease SaO2 levels in individuals living at high altitudes (14). Thus, an SaO2 <95% at altitudes above 2,000 m.a.s.l. is not necessarily related to the presence of PE. In a study in Bogotá (24), values between 90 and 95% were within normal limits for most of the population. Assigning one point to SaO2 values <95% when calculating PERC increases the score's sensitivity, but when compared to the value

Table 1. *General characteristics of the population and the diagnosis of pulmonary embolism.*

	Total population n=1,087	PE n= 458	No PE n= 629	P value
Age (years) x(sd)	59.8 (19.3)	61.3 (19.7)	58.7 (18.8)	0.028
Female sex n(%)	585 (53.8)	242 (52.8)	343 (54.5)	0.58
Medical history n(%)				
Cardiovascular disease	260 (23.9)	73 (15.9)	187 (29.7)	<0.001
AMI in the last three months	25 (2.3)	8 (1.7)	17 (2.7)	0.299
Congestive heart failure	69 (6.3)	28 (6.1)	41 (6.5)	0.787
Arterial hypertension	443 (40.8)	185 (40.4)	258 (41)	0.836
Atrial fibrillation	58 (5.3)	26 (5.7)	32 (5.1)	0.669
Peripheral vascular disease	54 (5)	28 (2.6)	26 (2.4)	0.138
Cerebrovascular disease	36 (3.3)	10 (2.2)	26 (.1)	0.076
Dementia	29 (2.7)	18 (3.9)	11 (1.7)	0.028
Valve disease	23 (2.1)	5 (1.1)	18 (2.9)	0.045
COPD	183 (16.8)	71 (15.5)	112 (17.8)	0.316
Asthma	25 (2.3)	4 (0.87)	21 (3.3)	0.007
Pulmonary fibrosis	15 (1.4)	4 (0.87)	11 (1.7)	0.222
Connective tissue disorders	32 (2.9)	7 (1.5)	25 (4)	0,018
Autoimmune diseases	69 (6.3)	27 (5.9)	42 (6.7)	0.602
Coagulation disorder	41 (3.8)	17 (3.7)	24 (3.8)	0.929
Diabetes mellitus	130 (12)	53 (11.6)	77 (12.2)	0.737
Hemiplegia	8 (0.7)	4 (0.87)	4 (0.64)	0.651
Obesity (BMI >30)	53 (4.9)	25 (5.5)	28 (4.5)	0.447
Immobility for more than three days	182 (16.7)	89 (19.4)	93 (14.8)	0.043
Surgery in the last four weeks	236 (21.7)	101 (22.1)	135 (21.5)	0.816
Hip or knee replacement	42 (3.9)	15 (3.3)	27 (4.3)	0.39
Spinal cord injury	6 (0.6)	2 (0.44)	4 (0.64)	0.662
Trauma in the last four weeks	116 (10.7)	42 (9.2)	74 (11.8)	0.171
LE fracture in the last four weeks	75 (6.9)	30 (6.6)	45 (7.2)	0.698
History of malignancy	132 (12.1)	63 (13.8)	69 (11)	0.165
Active cancer in the last year	77 (7.1)	42 (9.2)	35 (5.6)	0.022
Use of oral hormones	12 (1.1)	9 (2)	3 (0.48)	0.015
History of DVT	109 (10)	49 (10.7)	60 (9.5)	0.53
History of PTE	64 (5.9)	35 (7.6)	29 (4.6)	0.036
HIV/AIDS	3 (0.3)	1 (0.22)	2 (0.32)	0.757

AMI: acute myocardial infarction, COPD: chronic obstructive pulmonary disease, BMI: body mass index, LE: lower extremity, DVT: deep vein thrombosis, PTE: pulmonary thromboembolism; n: number of patients, %: percentage, x: average, SD: standard deviation.

Table 2. *Signs and symptoms of the population and the diagnosis of pulmonary embolism.*

	Total population n=1,087	PE n= 458	No PE n= 629	P value
Symptoms n(%)				
Acute dyspnea	705 (64.9)	289 (63.1)	416 (66.1)	0.301
Chest pain	581 (53.4)	271 (59.2)	310 (49.3)	0.001
Hemoptysis	66 (6.1)	36 (7.9)	30 (4.8)	0.035
Unilateral LE pain	142 (13.1)	74 (16.2)	68 (10.8)	0.01
Physical exam n(%)				
Unilateral LE edema	140 (12.9)	74 (16.2)	66 (10.5)	0.006
Pain on palpation	119 (10.9)	66 (14.4)	53 (8.4)	0.002
Signs of DVT	111 (10.9)	65 (14.2)	46 (7.3)	<0.001
Non-varicose collateral veins	10 (0.9)	4 (0.9)	6 (0.95)	0.891
Venous distension in the affected extremity	11 (1)	6 (1.3)	5 (0.79)	0.402
A >3 cm difference in diameter between the LEs	34 (3.1)	23 (5)	11 (1.7)	0.002
Vital signs x(sd)				
Temperature	36,5 (1.2)	36.4 (1.7)	36.5 (0.3)	0.159
Heart rate	91 (19.1)	93 (18.5)	89.6 (19.5)	0.003
Systolic blood pressure	124 (21.3)	124.2 (21.2)	123.9 (21.4)	0.972
Diastolic blood pressure	73.8 (14)	74.6 (13.4)	73.2 (14.4)	0.101
O2 saturation (SaO2)	89.1 (7.1)	88.9 (7.3)	89.3 (6.9)	0.91
Fraction of inspired O2 (FiO2)	24.6 (9)	24.6 (10.6)	24.6 (7.7)	0.953
SaO2/FIO2 ratio	383.5 (72.7)	385.8 (73.6)	381.7 (72)	0.909

LE: lower extremity, DVT: deep vein thrombosis, SaO2: Arterial oxygen saturation measured by pulse oximetry, FiO2: Fraction of inspired oxygen, SaO2/FiO2: ratio of arterial oxygen saturation to fraction of inspired oxygen, n: number of patients, %: percentage, x: average and SD: standard deviation.

found when PERC is calculated with one point assigned to SaO2<90% in a low-risk population at high altitudes, the sensitivity obtained does not differ by more than two percentage points and remains over 97%. Likewise, the proportion of false negatives with a PERC calculated with SaO2<90% was 2.4%, lower than that reported in the literature where false negatives may range from 5.4-6.4% (13, 27, 28). The presence of false negatives using D-dimer or scores like PERC could be due to evaluating patients with small subsegmental emboli which cause few symptoms and generally have a benign course even without treatment (22, 29).

Other variables which may affect saturation levels are age and the presence of comorbidities; our population had an average age 12 years greater than Kline et al.'s study (12) in which the original PERC validations were performed. However, this variation in age in different populations (12, 13, 22) does not seem to significantly affect the score's performance. Regarding comorbidities, there was a greater proportion of subjects in our study with a history of pulmonary disease, compared with other PERC validation studies (12). However, the proportion of subjects with chronic obstructive pulmonary disease in our population was similarly distributed between subjects with and without PE, and subjects with asthma and pulmonary fibrosis made up only 5%, which we believe is unlikely to have influenced the results obtained regarding PERC's discriminatory power using an SaO2<90%. On the other hand, dementia was found to be related to PE, which could be explained by decreased mobility and the presence of comorbidities in these patients. This condition, which has not been reported much in previous studies, has been related to greater severity and increased mortality in patients with PE (30).

The analysis of PERC's performance calculated with SaO2<95% and SaO2<90% in patients classified as low risk on the Wells, Geneva and Pisa scales showed better classification with the PERC score when the patients were classified as low risk on the Wells scale (<2) and simplified Wells scale (<4), similar to what has been reported in the literature. Madsen et al. used the simplified Wells classification (<4), and Wolf et al. used the Wells classification (<2) in

Table 3. *Laboratory and imaging results and outcomes with the diagnosis of pulmonary embolism.*

	Total population n=1087	PE n= 458	No PE n= 629	P value
Paraclinical tests n(%)				
Electrocardiogram	714 (65.7)	293 (64)	421 (66.9)	0.31
RV overload	99 (9.1)	60 (13.1)	39 (6.2)	<0.001
Chest x-ray	876 (80.6)	341 (7.5)	535 (85.1)	<0.001
Oligemia	11 (1)	8 (1.7)	3 (0.5)	<0.001
Hilar artery amputation	4 (0.4)	4 (0.9)	0 (0)	<0.001
Consolidation due to pulmonary infarction	33 (3)	23 (5)	10 (1.6)	<0.001
Consolidation without pulmonary infarction	136 (12.5)	50 (10.9)	86 (13.7)	<0.001
Pulmonary edema	41 (3.8)	20 (4.4)	21 (3.3)	<0.001
D-dimer M(IQR)	2.35 (3.89)	3.43 (4.7)	1.31 (1.53)	<0.001
LE thrombosis n(%)				
SVT	32 (2.9)	21 (4.6)	11 (1.7)	<0.001
DVT	132 (12.1)	91 (19.9)	41 (6.5)	<0.001
Outcomes n (%)				
Mechanical ventilation	112 (10.3)	44 (9.6)	68 (10.8)	0.519
ICU admission	284 (26.1)	132 (28.8)	152 (24.2)	0.084

RV: right ventricle. LE: lower extremity. SVT: superficial vein thrombosis. DVT: deep vein thrombosis. ICU: intensive care unit. MV: mechanical ventilation. n: number of patients. %: percentage. M: median: IQR: Interquartile range.

the PERC evaluation, obtaining a good yield for this score in ruling out PE (25, 26). In contrast, when PERC's yield was evaluated in low-risk patients classified with the Geneva scale vs. a low-risk classification using clinical criteria (low risk being defined as patients with a sufficiently low risk for it to be ruled out by D-dimer), the PERC score's yield was found to decrease when patients were classified as low risk using the Geneva score (13). Therefore, with these data, we suggest that the initial risk classification for PE be done using the Wells scale, for a better PERC performance.

Regarding weaknesses, since this study was retrospective, the quality of the information was restricted to what

Table 4. *Comparison of the PERC score variables and pulmonary embolism diagnosis.*

	Total population n=1087	PE n= 458	No PE n= 629	P value
PERC age >50 years n(%)	761 (70)	328 (71.6)	433 (68.8)	0.324
PERC HR >100 n(%)	381 (35.1)	176 (38.4)	205 (32.6)	0.046
PERC SaO2 <95% on room air n(%)	979 (90.1)	406 (88.6)	573 (91.1)	0.182
PERC SaO2 <90% on room air n(%)	643 (59.2)	267 (58.3)	376 (59.8)	0.624
PERC hemoptysis n(%)	66 (6.1)	36 (7.9)	30 (4.8)	0.035
PERC use of estrogens n(%)	12 (1.1)	9 (0.8)	3 (0.3)	0.02
PERC history of DVT or PTE n(%)	149 (13.7)	71 (15.5)	78 (12.4)	0.142
PERC history of trauma or surgery n(%)	282 (25.9)	117 (25.5)	165 (26.2)	0.799
PERC unilateral LE edema n(%)	140 (12.9)	74 (16.2)	66 (10.5)	0.006
PERC SaO2<95% ≥1 n(%)	1076 (99)	455 (99.3)	621 (98.7)	0.316
PERC SaO2<90% ≥1 n(%)	1,045 (96.1)	449 (98)	596 (94.8)	0.006

PERC: *Pulmonary Embolism Rule Out Criteria*. DVT: deep vein thrombosis. PTE: pulmonary thromboembolism. LE: lower extremity. SaO2: Arterial oxygen saturation measured by pulse oximetry. n: number of patients. %: percentage.

Table 5. *Performance of PERC with SaO2<95% and PERC with SaO2<90% for pulmonary embolism categorized by Wells, Geneva and Pisa scores.*

	Sensitivity	Specificity	AUC-ROC (95% CI)	P value
PERC SaO2<95%	**99.3**	**1.3**	**0.56 (0.52-0.59)**	**0.001**
Dichotomous Wells				
Not probable	99.1	1.8	0.53 (0.48-0.57)	0.223
Probable	99.6	0.0	0.49 (0.44-0.55)	0.801
Three-level Wells				
Low risk	100.0	2.4	0.56 (0.50-0.62)	0.049
Intermediate risk	99.0	0.3	0.48 (0.44-0.53)	0.482
High risk	100.0	0.0	0.52 (0.37-0.67)	0.775
Geneva				
Low risk	98.8	3.5	0.53 (0.45-0.60)	0.459
Intermediate risk	99.4	3.5	0.51 (0.46-0.55)	0.905
High risk	100.0	0.0	0.39 (0.27-0.51)	0.081
Pisa				
≤ 10%	97.8	0.8	0.54 (0.44-0.64)	0.422
> 10% ≤ 50%	100.0	1.3	0.55 (0.49-0.61)	0.093
> 50% ≤ 90%	100.0	3.4	0.5 (0.36-0.64)	0.971
> 90%	100.0	0.0	0.35 (0.0-0.71)	0.497
PERC SaO2<90%	**98.0**	**5.2**	**0.55 (0.52-0.59)**	**0.003**
Dichotomous Wells				
Not probable	96.6	7.6	0.55 (0.50-0.59)	0.040
Probable	99.6	0.0	0.47 (0.41-0.42)	0.251
Three-level Wells				
Low risk	97.6	7.8	0.6 (0.54-0.65)	0.002
Intermediate risk	97.9	3.2	0.47 (0.42-0.51)	0.140
High risk	100.0	0.0	0.49 (0.34-0.64)	0.881
Geneva				
Low risk	92.7	13.1	0.55 (0.47-0.62)	0.218
Intermediate risk	99.1	1.8	0.5 (0.45-0.54)	0.905
High risk	100.0	0.0	0.41 (0.29-0.52)	0.145
Pisa				
≤ 10%	95.7	5.6	0.56 (0.46-0.66)	0.236
> 10% ≤ 50%	99.3	4.9	0.55 (0.49-0.60)	0.139
> 50% ≤ 90%	100.0	3.4	0.55 (0.41-0.69)	0.471
> 90%	100.0	0.0	0.29 (0.0-0.63)	0.350

SaO2: Arterial oxygen saturation measured by pulse oximetry. AUC-ROC: area under the curve of receiver operating characteristics. 95% CI: 95% confidence interval.

was recorded in the medical chart, and the ability of the research group members to gather adequate data. However, the research team had sufficient medical knowledge to adequately interpret the clinical data. As a study performed in a tertiary care hospital, there is a risk of selection bias and disease spectrum bias, wherein the proportion of subjects with intermediate and high risk may be greater than the proportion of low-risk subjects. Low-risk subjects do not routinely undergo pulmonary artery CTA, and therefore may be excluded from the final analysis, and high-risk subjects may have severe complications such as early death or the inability to undergo a CTA test due to hemodynamic instability. This situation could affect and increase the frequency of PE in the study population, sensitivity and false negatives; nevertheless, the study has a sufficiently large sample size to be able to reach valid conclusions. Our results propose as possible future studies the economic assessment of the use of strategies based on these clinical prediction rules compared to or together with D-dimer in the Colombian population.

Conclusion

The PERC score calculated with an oxygen saturation <90% has a diagnostic yield similar to the PERC score calculated with an oxygen saturation <95% for ruling out PE in patients classified as low risk at high altitudes (>2,500 m.a.s.l.) The ability to rule out PE with the PERC score continues to be statistically significant with a low-risk classification on the Wells scale and loses statistical significance when using a low-risk classification from the Geneva and Pisa scores. The PERC score could be considered as an additional diagnostic tool for evaluating patients at risk for PE at high altitudes. These results may not be extrapolatable to special populations such as pregnant women and those under 18 years of age.

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