

**The LAS VEGAS Risk Score for  
Prediction of Postoperative  
Pulmonary Complications – an  
observational study**

Online Supplement

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**eTable 1 – Definition of postoperative pulmonary complications**

Complications	Definitions
Unplanned supplementary oxygen	Supplemental oxygen administered due to PaO <sub>2</sub> < 60 mmHg or SpO <sub>2</sub> < 90% in room air, excluding oxygen supplementation given as standard care (e.g. directly after arrival in the PACU)
Respiratory failure	PaO <sub>2</sub> < 60 mmHg or SpO <sub>2</sub> < 90% despite oxygen therapy, or need for non-invasive mechanical ventilation
Unplanned new or prolonged invasive mechanical ventilation	After discharge from operating room
Acute respiratory distress syndrome	According to the Berlin definition*
Pneumonia	Presence of a new or progressive radiographic infiltrate plus at least two of three clinical features; fever > 38°C or > 100.4°F, leucocytosis or leukopenia (WBC count > 12,000 cells/mm <sup>3</sup> or < 4,000 cells/mm <sup>3</sup> ) or purulent secretions
Pneumothorax	Air in the pleural space with no vascular bed surrounding the visceral pleura on the chest X-ray

\*#ARDS Definition Task Force, Ranieri VM, Rubenfeld GD, *et al.* Acute respiratory distress syndrome: the Berlin Definition. JAMA 2012;307:2526-33.

**eTable 2 – Comparison of the overall cohort with the cohort of patients included due to missing in some of the interest variables**

	Overall Cohort (n = 6063)	Cohort Excluded Due Missing (n = 3801)	P value
<b>Demographic characteristics</b>			
Age, years	55 [41 to 67]	54 [40 to 66]	0.100
Gender, male	2709 / 6063 (44.7)	1730 / 3801 (45.5)	0.418
BMI, kg m <sup>-2</sup>	26.3 [23.3 to 30.0]	26.2 [23.4 to 30.1]	0.568
ASA PS	2 [1 to 2]	2 [1 to 2]	0.101
1	1671 / 6063 (27.6)	1142 / 3777 (30.2)	
2	3000 / 6063 (49.5)	1743 / 3777 (46.1)	
3	1285 / 6063 (21.2)	818 / 3777 (21.6)	0.200
4	104 / 6063 (1.7)	69 / 3777 (1.8)	
5	3 / 6063 (0.0)	5 / 3777 (0.1)	
<b>Functional status</b>			
Independent	5692 / 6063 (92.8)	3507 / 3795 (92.4)	0.089
Partially dependent	368 / 6063 (6.1)	253 / 3795 (6.7)	
Totally dependent	67 / 6063 (1.1)	35 / 3795 (0.9)	
ARISCAT score	16 [3 to 26]	15 [3 to 26]	0.333
< 26	4302 / 6063 (71.0)	2441 / 3350 (72.9)	
26 – 44	1448 / 6063 (23.9)	767 / 3350 (22.9)	0.055
> 44	313 / 6063 (5.2)	142 / 3350 (4.2)	
Smoking	1425 / 6063 (23.5)	865 / 3794 (22.8)	0.420
Pre-operative SpO <sub>2</sub> , %	98 [96 to 99]	98 [96 to 99]	0.786
Pre-operative anemia <sup>*</sup>	208 / 6063 (3.4)	81 / 2202 (3.7)	0.555
Respiratory infection < 30 days	253 / 6063 (4.2)	153 / 3801 (4.0)	0.664
<b>Co-morbidities</b>			
Cancer	287 / 6063 (4.7)	157 / 3801 (4.1)	0.175
Chronic kidney failure	212 / 6063 (3.5)	126 / 3801 (3.3)	0.634
COPD	382 / 6063 (6.3)	214 / 3801 (5.6)	0.173
Heart failure	393 / 6063 (6.5)	273 / 3801 (7.2)	0.191
Obstructive sleep apnea	117 / 6063 (1.9)	88 / 3801 (2.3)	0.191
Neuromuscular disease <sup>**</sup>	56 / 6063 (0.9)	32 / 3801 (0.8)	0.674
Liver dysfunction	68 / 6063 (1.1)	34 / 3801 (0.9)	0.277
<b>Surgical characteristics</b>			
<b>Surgical procedure<sup>***</sup></b>			
Lower gastrointestinal	695 / 6063 (11.5)	401 / 3801 (10.5)	0.160
Upper GI, HB, and pancreas	904 / 6063 (14.9)	578 / 3801 (15.2)	0.706
Vascular surgery <sup>††</sup>	219 / 6063 (3.6)	143 / 3801 (3.8)	0.646
Aortic surgery	51 / 6063 (0.8)	27 / 3801 (0.7)	0.662
Neurosurgery and HN	1137 / 6063 (18.8)	698 / 3801 (18.3)	0.552
Urological and kidney	559 / 6063 (9.2)	29 / 3801 (7.9)	0.020
Gynecological	686 / 6063 (11.3)	45 / 3801 (12.0)	0.321
Endocrine	147 / 6063 (2.4)	47 / 3801 (1.2)	< 0.001
Transplant	28 / 6063 (0.5)	10 / 3801 (0.3)	0.183
Plastic, cutaneous, breast	663 / 6063 (10.9)	374 / 3801 (9.8)	0.084
Bone, joint, trauma, spine	939 / 6063 (15.5)	656 / 3801 (17.3)	0.020
Others	344 / 6063 (5.7)	241 / 3801 (6.3)	0.172
<b>Surgical technique<sup>***</sup></b>			
Open	1191 / 6063 (19.6)	804 / 3801 (21.1)	0.074
Laparoscopic	1118 / 6063 (18.4)	619 / 3801 (16.3)	0.006
Laparoscopic assisted	114 / 6063 (1.9)	53 / 3801 (1.4)	0.068
Peripheral	1063 / 6063 (17.5)	677 / 3801 (17.8)	0.723
Other	2624 / 6063 (43.3)	1655 / 3801 (43.5)	0.861
<b>Condition of surgery</b>			
Elective	5432 / 6063 (89.6)	3380 / 3799 (89.0)	0.101
Urgent	495 / 6063 (8.2)	313 / 3799 (8.2)	

Emergency	136 / 6063 (2.2)	106 / 3799 (2.7)	
Duration of surgery, minutes	76 [45 to 130]	73 [42 to 127]	0.234
Duration of anesthesia, minutes	106 [72 to 170]	102 [70 to 166]	0.334
<b>Intraoperative characteristics</b>			
Use of supraglottic devices	805 / 6063 (13.3)	508 / 3794 (13.3)	0.975
Epidural anesthesia	352 / 6063 (5.8)	224 / 3796 (5.9)	0.871
Fluid infused, milliliters	1000 [1000 to 2000]	1000 [900 to 1900]	0.878
Blood transfusion	240 / 6063 (4.0)	149 / 3799 (3.9)	0.845
Use of opioid	6030 / 6063 (99.5)	3777 / 3795 (99.5)	0.883
Type of anesthesia			
Totally intravenous	813 / 6063 (13.4)	569 / 3774 (15.1)	
Volatile	4286 / 6063 (70.7)	2575 / 3774 (68.2)	0.033
Balanced	964 / 6063 (15.9)	630 / 3774 (16.7)	
Use of NMBA	5309 / 6063 (87.6)	3366 / 3782 (89.0)	0.040
Desaturation	231 / 6063 (3.8)	156 / 3781 (4.1)	0.432
Unplanned recruitment maneuver	208 / 6063 (3.4)	124 / 3774 (3.3)	0.698
Hypotension	1574 / 6063 (26.0)	1043 / 3782 (27.6)	0.077
Arrhythmia	38 / 6063 (0.6)	22 / 3775 (0.6)	0.785
Need of vasoactive drugs	1324 / 6063 (21.8)	884 / 3782 (23.4)	0.075
Reversal of NMBA	2435 / 6063 (40.2)	1409 / 3624 (38.9)	0.213
Antibiotic prophylaxis	4324 / 6063 (71.3)	2676 / 3796 (70.4)	0.349
<b>Mechanical ventilation characteristics</b>			
Tidal volume, ml/kg PBW	8.2 [7.3 to 9.2]	8.0 [7.1 to 9.0]	0.099
PEEP, cmH <sub>2</sub> O	4 [0 to 5]	3 [0 to 5]	0.902
Peak pressure, cmH <sub>2</sub> O	17 [15 to 21]	18 [15 to 21]	0.148
FiO <sub>2</sub>	0.50 [0.45 to 0.70]	0.53 [0.47 to 0.73]	0.101
Respiratory rate, bpm	12 [12 to 13]	12 [11 to 13]	0.207
<b>Clinical outcomes</b>			
Postoperative pulmonary complications	665 / 6063 (11.0)	439 / 3634 (12.0)	0.142
Hospital length of stay, days	2 [1 to 4]	2 [1 to 4]	0.178
In-hospital mortality	32 / 5635 (0.6)	24 / 3338 (0.7)	0.379

Data are median (IQR) and n / total (%)

BMI, body mass index; ASA PS, American Society of Anaesthesiology physical score; ARISCAT, Assess Respiratory Risk in Surgical Patients in Catalonia risk; SpO<sub>2</sub>, Peripheral oxygen saturation; COPD, Chronic Obstructive Pulmonary Disease; GI, gastrointestinal; HB, hepato-biliary; HN, head and neck; NMBA, neuromuscular blocking agents; PBW, predicted body weight; PEEP, positive end-expiratory pressure; FiO<sub>2</sub>, inspired fraction of oxygen; BPM, breaths per minute; IQ, lower quartile; UQ, upper quartile.

\* defined as hemoglobin < 10 g/dL

\*\* neuromuscular disease affecting the respiratory system

\*\*\* a patient can have more than one type of surgical procedure or technique

†† carotid endarterectomy, aortic surgery and peripheral vascular taken together

**eTable 3 – Development of postoperative pulmonary complications in both cohorts**

	<b>Development Cohort (n = 3919)</b>	<b>Validation Cohort (n = 2144)</b>	<b>P value</b>
All	419 / 3919 (10.7)	246 / 2144 (11.5)	0.351
Need of oxygen	318 / 3919 (8.1)	205 / 2144 (9.6)	0.054
Respiratory failure	76 / 3919 (1.9)	43 / 2144 (2.0)	0.858
Need of mechanical ventilation	57 / 3919 (1.5)	20 / 2144 (0.9)	0.082
ARDS	7 / 3919 (0.2)	1 / 2144 (0.0)	0.175
Pneumonia	19 / 3919 (0.5)	9 / 2144 (0.4)	0.721
Pneumothorax	7 / 3919 (0.2)	4 / 2144 (0.2)	0.944

*Data are n / total (%)*

*ARDS, acute respiratory distress syndrome*

**eTable 4 – Impact of postoperative pulmonary complications on outcome**

	Development Cohort ( <i>n</i> = 3919)			Validation Cohort ( <i>n</i> = 2144)		
	PPCs ( <i>n</i> = 419)	No PPCs ( <i>n</i> = 3500)	<i>P</i> value	PPCs ( <i>n</i> = 246)	No PPCs ( <i>n</i> = 1898)	<i>P</i> value
Hospital length of stay, days	4 [1 to 7]	2 [1 to 4]	< 0.001	4 [1 to 5]	2 [1 to 4]	< 0.001
In-hospital mortality	15 / 379 (4.0)	8 / 3270 (0.2)	< 0.001	4 / 224 (1.8)	5 / 1762 (0.3)	0.001

Data are median [LQ to UQ] and *n* / total (%)

PPCs, postoperative pulmonary complications, LQ, lower quartile, UQ, upper quartile.

**eTable 5 – Univariable logistic regression of risk factor for postoperative pulmonary complications in the development cohort**

	Odds Ratio (95% CI)	P value
<b>Demographic characteristics</b>		
Age, years	1.03 (1.02 to 1.04)	< 0.001
Gender, male	1.15 (0.94 to 1.41)	0.180
BMI, kg m <sup>-2</sup>	1.03 (1.01 to 1.04)	0.002
ASA PS	2.21 (1.93 to 2.53)	< 0.001
Smoking	0.76 (0.59 to 0.98)	0.035
Functional status		
Independent	1 (Reference)	
Partially dependent	3.22 (2.36 to 4.39)	< 0.001
Totally dependent	3.08 (1.59 to 5.96)	0.001
Pre-operative anemia	2.91 (1.92 to 4.38)	< 0.001
Respiratory infection < 30 days	1.87 (1.23 to 2.85)	0.004
Pre-operative SpO <sub>2</sub> , %	0.83 (0.80 to 0.86)	< 0.001
COPD	2.19 (1.58 to 3.03)	< 0.001
Liver dysfunction	1.02 (0.40 to 2.59)	0.969
Cancer	3.63 (2.61 to 5.04)	< 0.001
Chronic kidney failure	2.15 (1.40 to 3.29)	< 0.001
Heart failure	1.61 (1.12 to 2.30)	0.009
Obstructive sleep apnea	3.08 (1.83 to 5.19)	< 0.001
Neuromuscular disease	0.90 (0.32 to 2.54)	0.846
<b>Surgical characteristics</b>		
Condition of surgery		
Elective	1 (Reference)	
Urgency	2.51 (1.87 to 3.36)	< 0.001
Emergency	3.25 (1.98 to 5.35)	< 0.001
Type of surgery		
Non-laparoscopic	1 (Reference)	
Laparoscopic	0.91 (0.71 to 1.18)	0.491
Duration of surgery	1.01 (1.00 to 1.01)	< 0.001
<b>Intraoperative characteristics</b>		
Use of supraglottic devices	0.28 (0.17 to 0.45)	< 0.001
Epidural anesthesia	2.79 (2.02 to 3.86)	< 0.001
Antibiotic prophylaxis	1.65 (1.28 to 2.11)	< 0.001
Fluid infused, milliliters		
< 1000	1 (Reference)	
1000 – 1999	1.47 (1.09 to 1.98)	0.012
2000 – 2999	2.57 (1.82 to 3.62)	< 0.001
≥ 3000	4.56 (3.21 to 6.49)	< 0.001
Blood transfusion	3.75 (2.63 to 5.36)	< 0.001
Use of opioid	0.56 (0.16 to 1.95)	0.359
Type of anesthesia		
Totally intravenous	1 (Reference)	
Volatile	1.11 (0.81 to 1.53)	0.508
Balanced	1.63 (1.13 to 2.36)	0.009
Use of NMBA	2.30 (1.53 to 3.46)	< 0.001
Desaturation	4.50 (3.48 to 7.10)	< 0.001
Unplanned recruitment maneuver	3.19 (2.16 to 4.72)	< 0.001
Hypotension	2.15 (1.75 to 2.65)	< 0.001
Arrhythmia	4.50 (1.99 to 10.15)	< 0.001
Need of vasoactive drugs	2.71 (2.19 to 3.35)	< 0.001
Reversal of NMBA	0.72 (0.58 to 0.89)	0.003
<b>Mechanical ventilation characteristics</b>		
Tidal volume, ml/kg PBW	0.98 (0.91 to 1.04)	0.474
PEEP, cmH <sub>2</sub> O	1.20 (1.14 to 1.25)	< 0.001
Peak pressure, cmH <sub>2</sub> O	1.06 (1.04 to 1.09)	< 0.001
FiO <sub>2</sub>	0.99 (0.99 to 1.00)	0.151
Respiratory rate, bpm	1.03 (0.97 to 1.10)	0.281

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*BMI, body mass index; ASA PS, American Society of Anaesthesiology physical score; SpO<sub>2</sub>, Peripheral oxygen saturation; COPD, Chronic Obstructive Pulmonary Disease; NMBA, neuromuscular blocking agents; PBW, predicted body weight; PEEP, positive end-expiratory pressure; FiO<sub>2</sub>, inspired fraction of oxygen; BPM, breaths per minute; CI, confidence interval*

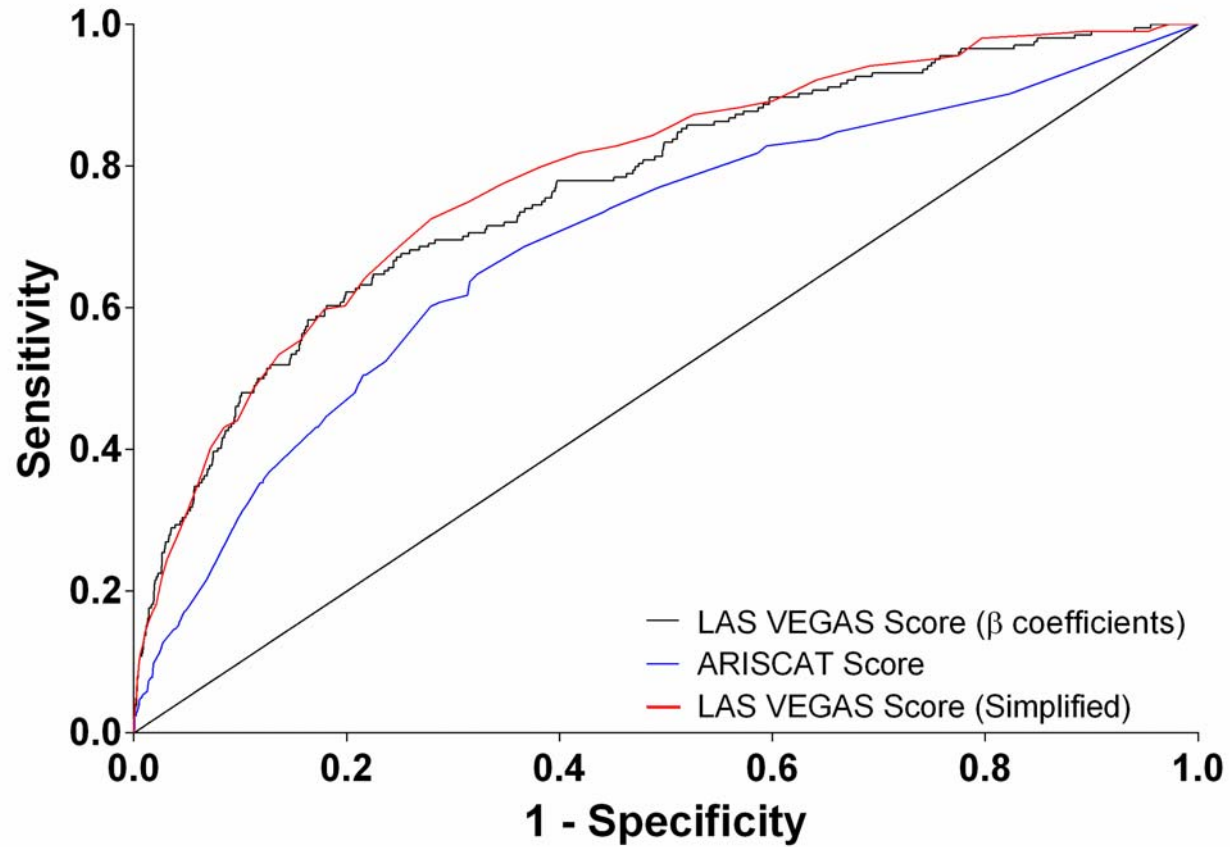


**eTable 6 – Multivariable logistic regression of risk factor for postoperative pulmonary complications in the development cohort after bootstrapping**

	<i>P</i> value
<b>Demographic characteristics</b>	
Age, years	0.004
ASA PS	0.002
Pre-operative anemia	0.038
Pre-operative SpO <sub>2</sub>	0.030
Cancer	0.009
Obstructive sleep apnoea	0.001
<b>Surgical characteristics</b>	
Condition of surgery	
Elective	
Urgency	0.001
Emergency	0.003
Duration of surgery, min	0.001
<b>Intra-operative characteristics</b>	
Use of supraglottic device	0.012
Type of anesthesia	
Totally intravenous	
Volatile	0.993
Balanced	0.003
Desaturation	0.001
Need of vasoactive drug	0.007
<b>Mechanical ventilation characteristics</b>	
PEEP, cmH <sub>2</sub> O	0.002

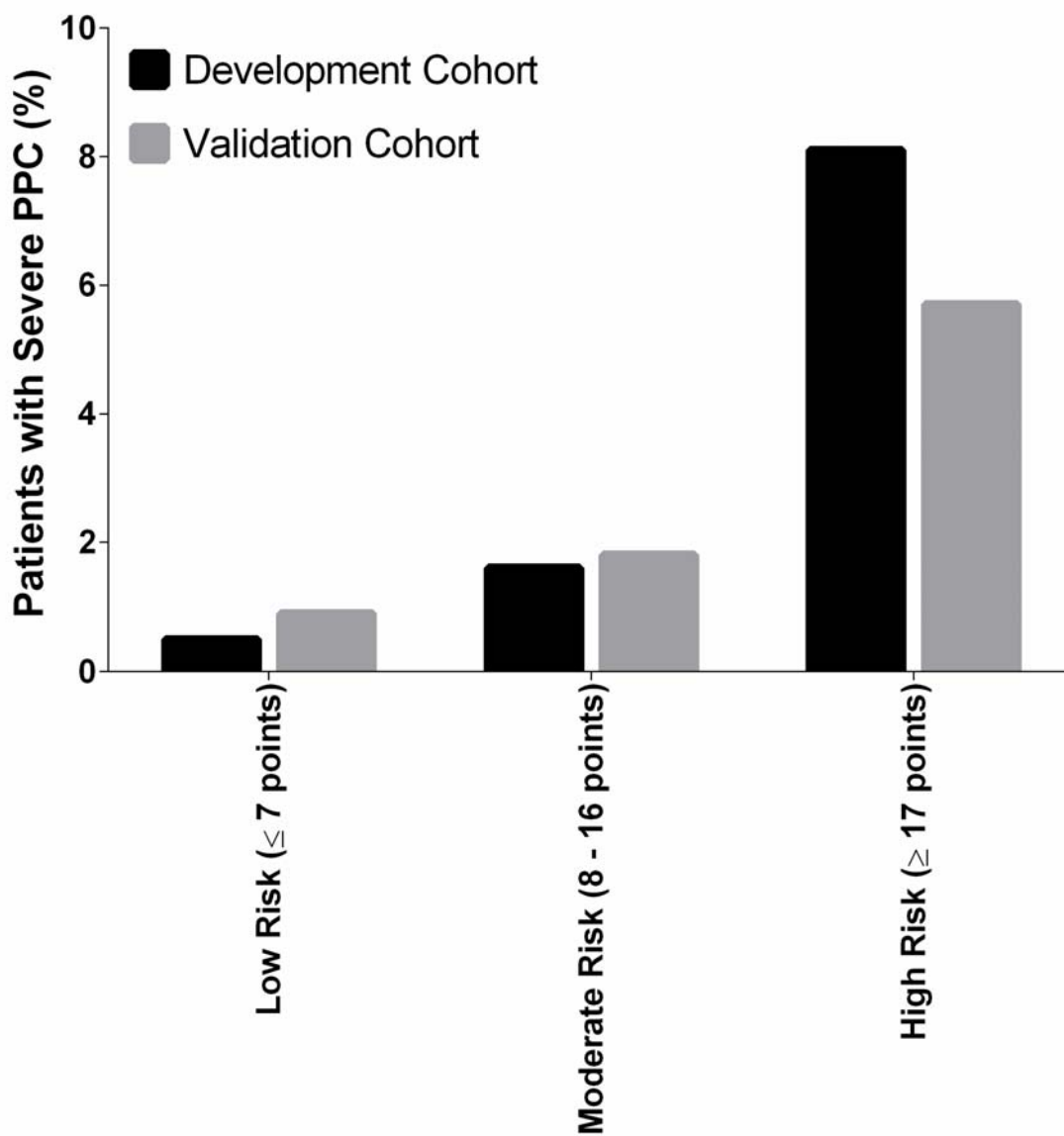
*ASA PS, American Society of Anaesthesiology physical score; SpO<sub>2</sub>, Peripheral oxygen saturation; PEEP, positive end-expiratory pressure; CI, confidence interval*

**eFigure 1 – Receiver operating characteristic (ROC) for the LAS VEGAS Score using  $\beta$  coefficients or the simplified score in comparison to ARISCAT Score for prediction of severe PPCs**



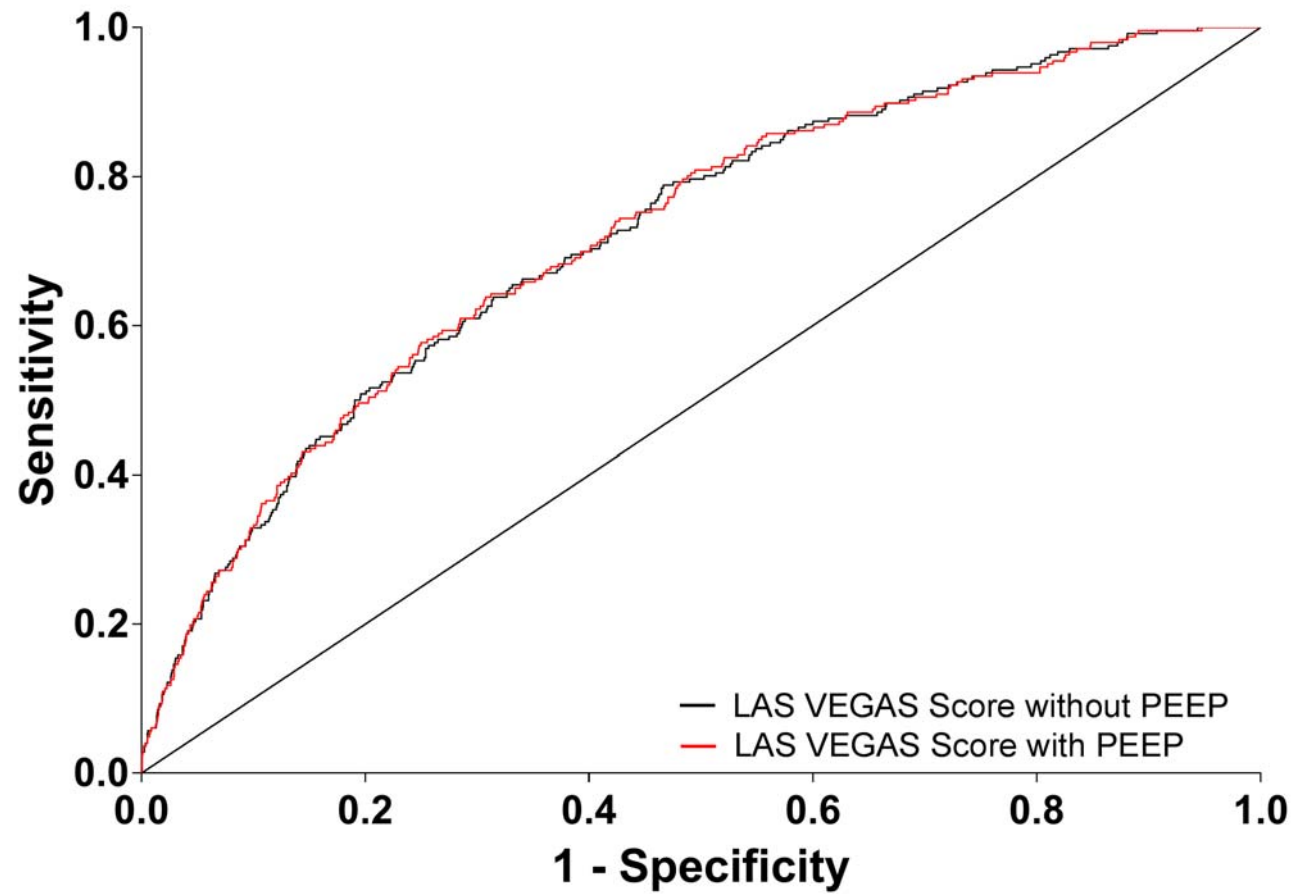
Severe PPCs is PPCs not considering unplanned supplementary oxygen. c-statistic for the area under the ROC curve (AUC): LAS VEGAS using  $\beta$  coefficients (0.772, 95% CI, 0.737 – 0.806); LAS VEGAS using the simplified score (0.787, 95% CI, 0.754 – 0.819); and ARISCAT score (0.694, 95% CI, 0.655 – 0.734)

**eFigure 2 – Incidence of severe PPCs according to cut-offs of LAS VEGAS Score**



Low risk,  $\leq 7$ ; moderate risk, 8 – 16; and high risk,  $\geq 17$ . PPCs: postoperative pulmonary complications

eFigure 3 – Receiver operating characteristic (ROC) for the LAS VEGAS Score without PEEP for prediction of PPCs



c-statistic for the area under the ROC curve (AUC): LAS VEGAS without PEEP (0.721, 95% CI, 0.688 – 0.754); LAS VEGAS with PEEP (0.724, 95% CI, 0.690 – 0.757);  $p = 0.530$