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Lung Injury Prediction Score in Hospitalized Patients at risk of Acute Respiratory Distress Syndrome

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Abstract

Objective—The lung injury prediction score (LIPS) identifies patients at risk for ARDS in the emergency department (ED) but it has not been validated in non-ED hospitalized patients. We aimed to evaluate whether LIPS identifies non-ED hospitalized patients at risk of developing ARDS at the time of critical care contact.

Design—Retrospective study.

Setting—Five academic medical centers.

Patients—Nine hundred consecutive patients (≥ 18 y/o) with at least one ARDS risk factor at the time of critical care contact.

Interventions—None.

Measurements and Main Results—LIPS was calculated using the worst values within the 12 hours before initial critical care contact. Patients with ARDS at the time of initial contact were excluded. ARDS developed in 124 (13.7%) patients a median of 2 days (IQR 2–3) after critical care contact. Hospital mortality was 22% and was significantly higher in ARDS than non-ARDS patients (48% vs. 18%, $p < 0.001$). Increasing LIPS was significantly associated with development of ARDS (OR 1.31, 95% CI 1.21–1.42) and the composite outcome of ARDS or death (OR 1.26, 95% CI 1.18–1.34). A LIPS ≥ 4 was associated with the development of ARDS (OR 4.17, 95% CI 2.26–7.72), composite outcome of ARDS or death (OR 2.43, 95% CI 1.68–3.49), and ARDS after accounting for the competing risk of death (HR 3.71, 95% CI 2.05–6.72). For ARDS development, the LIPS has an AUROC of 0.70 and a LIPS ≥ 4 has 90% sensitivity (misses only 10% of ARDS cases), 31% specificity, 17% positive predictive value, and 95% negative predictive value.

Conclusions—In a cohort of non-ED hospitalized patients, the LIPS and LIPS ≥ 4 can identify patients at increased risk of ARDS and/or death at the time of critical care contact but it does not perform as well as in the original ED cohort.

Keywords

acute respiratory distress syndrome; acute respiratory failure; lung injury; prediction model; mortality; prevention

Introduction

The acute respiratory distress syndrome (ARDS) is associated with high morbidity and mortality worldwide (1) (2). Lung protective ventilation is the only treatment available to lower the risk of death with ARDS (3). Given the lack of effective treatments, the focus of the scientific and clinical communities has shifted to ARDS prevention with the goal of delivering interventions in the pre-ARDS state to halt the progression to ARDS in patients at risk (4) (5). This is the objective of the NHLBI-funded PETAL Network which focuses on clinical trials aimed at the Prevention and Early Treatment of Acute Lung Injury (5). ARDS does not develop in the majority of patients with established predisposing conditions (6) (7). To minimize harm from exposure to therapeutic strategies, we need tools for early identification of patients at higher risk of ARDS for whom preventive interventions have a favorable risk-benefit ratio. The lung injury prediction score (LIPS) is a validated prediction model that uses clinical data at the time of presentation to the emergency department (ED) to identify patients at high risk for ARDS (6) (8) (9). A LIPS 4 is currently used to enroll high risk patients in clinical trials on ARDS prevention (10) (11) (12).

Although the LIPS successfully stratifies patients at higher risk for ARDS at the time of ED presentation, it is not validated for patients at risk of ARDS in the hospital wards. Half of patients with an ARDS-predisposing condition on hospital admission are not admitted to an ICU (13) (14) and over half of patients with sepsis or pneumonia are initially treated in the hospital wards (15) (16) (17). Since the LIPS uses criteria *at the time of hospital admission*, it is not clear how well it performs in patients who develop predisposing conditions after the initial ED presentation or who deteriorate clinically after hospital admission requiring critical care evaluation or ICU transfer. Such validation is important to use the LIPS in prevention trials to identify ward patients at higher risk of ARDS.

Therefore, the purpose of this study is to validate the LIPS in non-ED hospitalized patients at higher risk of ARDS when they require critical care evaluation from areas of the hospital other than the ED.

Materials and Methods

Study Design and Patient Population

This multicenter retrospective cohort study included 5 academic medical centers (Montefiore Medical Center, Mayo Clinic, Brigham and Women's Hospital, University of Michigan, and Bridgeport Hospital) from January 1, 2011–September 30, 2012. The study was approved by the Human Subjects Committees of each of the participating centers with an exemption for informed consent and HIPAA waiver.

Consecutive adult hospitalized patients (≥ 18y/o) were eligible if they presented with at least one study-defined ARDS predisposing condition at the 'time of critical care contact' (Appendix 1, Supplemental Digital Content). The 'time of critical care contact' was either the time of 'critical care evaluation' (rapid response team (RRT) or critical care consult for ICU transfer) or ICU admission, whichever came first. Only the first critical care evaluation or ICU admission during the study period was included. Patients were excluded if they were:

1) in ARDS at the time of critical care contact, 2) receiving comfort or hospice care, 3) not committed to full support (e.g., DNR/DNI), 4) in the ED at the time of critical care contact or admitted to ICU directly from ED (including those who required emergency surgery from the ED), 5) previously enrolled into the study, or 6) scheduled for ICU admission after planned, uncomplicated elective surgery (patients after elective surgery who were emergently evaluated by critical care for ICU admission were included). Patients who required emergency or high-risk surgery after hospital admission to the wards or intermediate-level-of care were eligible.

Data Collection

Baseline demographic characteristics, clinical and laboratory data, interventions at the time of critical care contact, mechanical ventilation parameters, study-defined ARDS predisposing conditions and risk modifiers were collected. The LIPS was calculated using the worst values within the 12 hours preceding the time of critical care contact as per prior report (Appendix 2, Supplemental Digital Content) (6). Missing data were considered normal, similar to the Acute Physiology and Chronic Health Evaluation (APACHE) II score calculation (18). For patients admitted to the ICU, the APACHE II score was calculated as a measure of severity of illness. De-identified subject information was entered at each site into the password-protected NIH-supported webform: REDCAP (<http://www.project-redcap.org>) (19). Electronic range checks and validation rules were used to eliminate erroneous data entry and artifacts in numeric values. The investigators at each site were responsible for quality control of data collection and entry.

Outcomes

The primary outcome was the development of ARDS after critical care contact according to the Berlin criteria (20). CXRs for ARDS determination were reviewed by site investigators who are board-certified intensivists or pulmonary physicians. All investigators were blinded to the patient's LIPS and received structured online training for assessment of bilateral infiltrates and ARDS as described previously (21). Secondary outcomes included hospital mortality, ICU and hospital length-of-stay (LOS).

Statistical Analysis

Univariate analyses compared patients with and without ARDS using Student's t-test or Wilcoxon rank-sum test for continuous variables and Chi-square or Fisher's exact test for categorical variables. The primary analysis included the validation of the predictive ability of the LIPS model for non-ED hospitalized patients who developed ARDS during the hospitalization. Model discrimination and calibration were assessed by calculating the area under the receiver operating characteristic curve (AUROC) and the Hosmer-Lemeshow test statistic respectively. The threshold LIPS score providing the best combination of sensitivity, specificity, positive and negative predictive values to identify ARDS cases was determined by evaluating the model performance at different cut-off points.

We performed three sensitivity analyses to evaluate the LIPS performance by: 1) using a composite outcome of ARDS or death during the hospitalization, 2) excluding all deaths from analysis, and 3) performing a competing risk Cox regression analysis (22) to take into

account mortality as a competing risk when analyzing the association of LIPS and ARDS development. For the competing risk analysis, models that included the LIPS as a dichotomous variable at different cut-points were also compared using the Akaike information criterion (AIC), the lower value representing the model with the better fit for the dataset.

The secondary analyses compared clinical outcomes between patients at risk who did or did not develop ARDS, and those who did or did not have a critical care evaluation. The distribution of the time to death between ARDS and non-ARDS patients was estimated using Kaplan-Meier survival analysis and the Gehan-Breslow-Wilcoxon test for statistical significance. *Post hoc* analyses evaluating LIPS performance in patient subgroups are presented in the supplementary material. All statistical analyses were performed using STATA 11.2 (College Station, TX) or SAS software (version 9.4; SAS Institute, Inc., Cary, NC, USA). A two-tailed p-value <0.05 was used for statistical significance.

Results

Out of 2248 patients screened with at least one ARDS risk factor, 900 were enrolled and 124 (13.7%) developed ARDS a median of 2 days after critical care contact (IQR: 2–3) (Figures 1–2). Thirty-three patients had ARDS at the time of critical care contact and were excluded. The majority of ARDS patients (81.5%) met criteria within the first 3 days after critical care contact. Deaths during this time were common. Half of the cohort died within the first week of critical care contact, when most cases of ARDS developed, and non-ARDS patients died earlier than those with ARDS. Indeed, 50% of non-ARDS patients died within 6 days of critical care contact (95%CI 4–8) compared to 10 days for ARDS patients (95%CI 7–13) (Wilcoxon test: $p<0.01$).

Critical care contact occurred a median of 2.3 days after hospital admission (IQR: 1–6). At the time of contact, ARDS patients had significantly higher rates of pneumonia, sepsis, and aspiration as well as higher severity of illness, hypoxemia, hypoalbuminemia, and received more life-sustaining interventions (e.g., cardiopulmonary resuscitation, intubation, and vasopressors) (Table 1). Non-Whites and Hispanics had significantly higher rates of ARDS. The majority of the cohort (84%) and ARDS patients (91%) required ICU admission. Of note, 480 out of 627 patients (76.5%) who were evaluated on the wards required ICU transfer. On critical care contact, 44% of ARDS patients were intubated compared to 13% of non-ARDS patients ($p<0.001$). Ultimately, 94% of ARDS patients required mechanical ventilation any time after study enrollment compared to 33% of non-ARDS patients ($p<0.001$).

The LIPS ranged from 0 to 12.5 (median 5, IQR: 3.5–7) and the median LIPS was significantly higher in patients who developed ARDS (6.5 vs 5, $p<0.001$). ARDS development significantly increased with increasing LIPS ($p<0.001$, Figure 3). Each point increase in LIPS was associated with a 31% increased likelihood of ARDS (OR 1.31, 95%CI 1.21–1.42). The LIPS model had an AUROC of 0.70 (95%CI 0.64–0.74) for ARDS development (Table 1, Supplemental Digital Content) and was well calibrated (GOF test, p -value = 0.30). A LIPS ≥ 4 has 90% sensitivity, 31% specificity, and is significantly associated

with a four-fold increased likelihood of ARDS (OR 4.17, 95%CI 2.26–7.72; AUC 0.60, 95%CI 0.57–0.63) (Table 2). Using a LIPS 4, 17% of patients develop ARDS and only 10% of the ARDS cases are missed. With a LIPS 5, 20% of patients develop ARDS but a higher number of ARDS patients are missed (21% of cases) (Table 2, Supplemental Digital Content).

Several sensitivity analyses accounting for in-hospital deaths were performed. First, we evaluated the performance of LIPS for the composite outcome. During the hospitalization, 264 patients (29.3%) developed ARDS or died. The composite outcome significantly increased with increasing LIPS points (Figure 3, $p < 0.001$). The effect estimates for the association of LIPS with either the composite outcome or ARDS were similar and patients with a LIPS 4 had a two-fold risk of ARDS or death (Table 2). The specificity and positive predictive value of the LIPS at different cut-offs improved for the composite outcome (Table 3, Supplemental Digital Content). With a LIPS 4, 34% of patients develop ARDS or die during the hospitalization and only 17% of these patients are missed. A LIPS 5 increases the percentage of patients who develop the outcome by 4%, but misses 12% more of the cases.

When all deaths were excluded, 64 (9.1%) patients had ARDS. The effect estimate for the association between LIPS and ARDS did not change compared to the full cohort (Table 2). The performance of the LIPS at several cut-offs showed a lower positive predictive value compared to the full cohort (Table 4, Supplemental Digital Content).

Next, we used competing risk analysis where death was modeled as a competing risk to ARDS. After accounting for the risk of hospital death, each point increase in LIPS was associated with a 27% increased risk of ARDS (HR 1.27, 95%CI 1.19–1.35). In addition, patients with a LIPS 4 had a significant increased risk of ARDS (HR 3.71, 95%CI 2.05–6.72) with a similar model fit when compared to a LIPS 5 or 6 (Table 5, Supplemental Digital Content).

Lastly, the ability of the LIPS model to predict either ARDS or the composite outcome in patients at risk was better for patients on the medical service or those who had a critical care evaluation. In these subgroups, there was a higher prevalence of the primary outcome and a LIPS 4 had a higher positive predictive value than in the full cohort (Tables 6–7, Supplemental Digital Content). The LIPS performance did not differ by age group.

The hospital mortality was 22.2% and the median time to death in the cohort was 7 days (IQR: 3–18) (Table 1). ARDS patients had significantly higher hospital mortality, more days on mechanical ventilation and longer ICU and hospital LOS. Patients who had a critical care evaluation had significantly higher rates of ARDS, composite outcome, hospital mortality and death within 7 days (Table 8, Supplemental Digital Content).

Discussion

In this multicenter study, we validated the LIPS as a prediction model to identify hospitalized non-ED patients at high risk for ARDS at the time of clinical deterioration and prior to ICU admission. This patient population has a high risk of ARDS and dying in the

hospital. The LIPS identifies patients at high risk of ARDS, the composite outcome of ARDS or death, or ARDS when excluding all deaths. In addition, a LIPS 4 can identify patients at high risk of ARDS or death when they require critical care services after hospital admission.

Our findings are consistent with prior studies that used the LIPS to predict ARDS (8) (6) (9). The positive predictive value of a LIPS 4 in this cohort (17%) is similar to the value reported in the ED LIPS study (18%), probably due to the higher ARDS prevalence in our cohort. The positive predictive value of LIPS 4 to identify ARDS or death was higher (34%): one in 3 patients with LIPS 4 will develop ARDS or die during the hospitalization.

We report several novel findings. This study evaluates non-ED hospitalized patients who were not included in prior LIPS studies (6, 8, 9) and are at risk of ARDS later during their hospitalization. Epidemiological data indicates that the great majority of patients with sepsis (50–70%) (15, 17), community-acquired pneumonia (80–90%) (23) (24), and hospital-acquired pneumonia (60%) (16) are initially treated in the hospital wards. This represents a large population with the most common ARDS risk factors who might be excluded if research and clinical efforts target only patients identified in the ED. Our study shows a higher rate of ARDS than other studies that used the LIPS (6) (9) or evaluated the rates of ‘nosocomial’ ARDS (7, 25). This is probably due to the sicker patient population that required critical care evaluation for enrollment compared to prior studies (6) (9) (26). Indeed, 76.5% of patients evaluated on the wards required ICU admission and the hospital mortality was high (22%). Floor patients who needed a critical care evaluation had higher rates of ARDS and worse outcomes. In addition, the LIPS model has improved predictive ability for floor patients who had a critical care evaluation. The median LIPS for our cohort (5) was twice as high as the median LIPS in the original ED study (2.5) indicating that patients in our cohort have more physiologic, metabolic, and oxygenation derangements than the ED patients in prior LIPS studies.

Similarly, the higher severity of illness and need for critical care evaluation may explain the higher hospital (22% vs. 5%) and ARDS mortality (48% vs. 23%) in our cohort compared to the original ED LIPS. This cohort, in particular non-ARDS patients, had a high mortality early on when most ARDS developed and a higher risk of dying within the first 7 days from critical care contact. This suggests that those patients admitted to the floor who later on develop ARDS may have different clinical characteristics compared with those in the ED, thus, the lower AUROC and accuracy of LIPS in our cohort. In our cohort, early mortality is a competing risk in which some of these patients may die before meeting ARDS criteria.

This study builds upon earlier ED LIPS studies to support the use of the LIPS to identify patients at higher risk of ARDS either in the ED or when they require critical care evaluation in the wards. This may prove useful to select patients for ARDS prevention and treatment trials as the great majority of patients with predisposing conditions do not develop ARDS or need ICU admission (7). Inclusion of all unselected patients with such conditions into prevention trials is not feasible. The low positive predictive value of a LIPS 4 may limit its usefulness, however, it helps identify those high-risk patients in whom the risk-benefit ratio

of interventions aimed at ARDS prevention would be justifiable, especially if the interventions have low risk.

In addition, the LIPS may help identify patients at risk of ARDS or dying during the hospitalization. Our data support the high mortality encountered in ARDS and in patients at risk for ARDS. Given the limited strategies to improve mortality once ARDS develops (3) (27), there is greater interest in the earlier treatment and prevention of ARDS (4) with the recent development of the NHLBI-funded PETAL Network (5). There has been criticism that focusing on ARDS prevention alone is short-sighted since ARDS is not a patient-centered outcome like mortality (28). In fact, the PETAL Network will continue to examine mortality as an outcome. Our results indicate that LIPS may identify ward patients at higher risk of ARDS or dying for inclusion into prevention and early treatment trials, especially those studies with a favorable risk-benefit ratio of the interventions. Since more than 50% of ICU patients were transferred from the wards rather than admitted from the ED (13) (14), having a single prediction score validated for both ED and non-ICU floor patients could significantly increase enrollment into ARDS prevention trials.

The strengths of this study include the enrollment of a heterogeneous group of surgical and medical critically ill patients from a geographically diverse population, the use of competing risk analysis and routinely available clinical data to identify patients at higher risk of ARDS, enrollment was not restricted to ICU patients, and minimizing seasonal variation by spanning a period of 21 months. Limitations of this study include its retrospective nature and the lower AUROC of the LIPS in this cohort (0.70) compared to the AUROC in the ED LIPS study (0.80). The LIPS does not perform as well in this cohort as in ED patients suggesting that floor patients who develop ARDS may be different from the ED population. Another limitation is that not every hospital has RRT available and these results may be less generalizable for hospitals without RRT.

Despite these limitations, the LIPS discriminates well between those hospitalized patients who have a high risk of developing ARDS at the time of clinical deterioration while having adequate sensitivity as a screening tool. Our study identifies a group of patients at high risk for ARDS or death during the hospitalization who should be considered for inclusion into clinical trials for prevention and early treatment of ARDS.

Conclusion

This study is the first to apply the LIPS and a LIPS 4 as a clinical prediction rule to screen and stratify non-ED hospitalized patients at higher risk of ARDS. By identifying hospitalized patients at higher risk of ARDS or death outside of the ED, patients may benefit from preventive measures and inclusion into ARDS prevention trials aimed at improving outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Outline of Screening Protocol and Data Collection

^aExclusion criteria are not mutually exclusive; therefore, patients with more than 1 exclusion may be counted more than once

ABG, arterial blood gas

ARDS, acute respiratory distress syndrome

DNR/DNI, do-not-resuscitate/do-not-intubate

ED, emergency department

ICU, intensive care unit

LIPS, lung injury prediction score

Figure 2. Timing of ARDS development by Study Day
ARDS, acute respiratory distress syndrome

Figure 3. Rate of ARDS development and Composite Outcome by LIPS

^a p value is for the association between the rate of ARDS development or Composite

Outcome by increasing LIPS points

ARDS, acute respiratory distress syndrome

LIPS, lung injury prediction score

Composite Outcome, onset of ARDS or death during the hospitalization

Table 1

Baseline Demographics, Clinical Characteristics, and Outcomes

Characteristic	Cohort (N = 900)	No ARDS (N = 776)	ARDS (N = 124)	p-value ^a
Demographics				
Age (median, IQR) ^b	65 (53, 76)	65 (53, 76.5)	64.5 (53.5, 75.5)	0.98
Gender				
Female	451 (50)	391 (50)	60 (48)	0.68
Male	449 (50)	385 (50)	64 (52)	
Race				
White	587 (66)	517 (67)	70 (57)	0.02
Non-White	308 (34)	255 (33)	53 (43)	
Ethnicity				
Non-Hispanic	535 (60)	469 (61)	66 (53)	0.006
Hispanic	115 (13)	88 (11)	27 (22)	
Unknown/Unavailable	243 (27)	212 (28)	31 (25)	
Smoking				
None	420 (46)	359 (46)	61 (49)	0.80
Former	352 (39)	306 (39)	46 (37)	
Current	113 (13)	97 (12)	16 (13)	
Unknown/Unavailable	15 (2)	14 (2)	1 (1)	
Initial Critical Care Contact				
#days from hospital admission to initial contact	2.36 (1, 6)	2.27 (1, 6)	3 (1, 7.5)	0.02
Type of Contact				
Critical care evaluation	627 (70)	527 (68)	100 (81)	0.004
Direct ICU ^c admission	273 (30)	249 (32)	24 (19)	
ICU admission after critical care evaluation (N=627) ^d	480 (76)	391 (74)	89 (89)	0.001
Time to ICU admission (hours) (N=479) ^e	1 (1, 2.5)	1 (1, 1.75)	1.6 (1, 5)	<0.001
Prior critical care evaluation	49 (5)	33 (4)	16 (13)	<0.001
APACHE II ^f (median, IQR)	15 (11, 20)	15 (11, 19.7)	18 (15, 22)	<0.001
Location of Contact				
Floor/Wards	650 (72)	553 (71)	97 (78)	0.02
Step-down-unit	92 (10)	76 (10)	16 (13)	
OR/Recovery Room	147 (16)	138 (17)	9 (7)	
Other (Endoscopy, Dialysis)	11 (1)	9 (1)	2 (2)	
ARDS predisposing conditions				
Pneumonia	352 (39)	284 (37)	68 (55)	<0.001
Sepsis	494 (55)	415 (53)	79 (64)	0.03
Pancreatitis	51 (6)	48 (6)	3 (2)	0.09
Aspiration	117 (13)	87 (11)	30 (24)	<0.001
Shock	258 (29)	214 (28)	44 (35)	0.07
High-risk surgery				

Characteristic	Cohort (N = 900)	No ARDS (N = 776)	ARDS (N = 124)	p-value ^a
Cardiac	8 (0.8)	8 (1)	0 (0)	0.25
Thoracic	4 (0.4)	3 (0.4)	1 (0.8)	0.51
Acute Abdomen	69 (8)	64 (8)	5 (4)	0.10
Orthopedic Spine	11 (1)	11 (1)	0 (0)	0.18
Risk Modifiers				
Alcohol abuse	159 (18)	133 (17)	26 (21)	0.29
Obesity (BMI ^g > 30)	315 (35)	272 (35)	43 (35)	0.93
Chemotherapy	115 (13)	93 (12)	22 (18)	0.07
Diabetes mellitus	345 (38)	295 (38)	50 (40)	0.62
Emergency Surgery	104 (12)	99 (13)	5 (4)	0.005
Respiratory rate (bpm)	23 (20, 30)	22 (20, 28)	27 (20, 33)	<0.001
Tachypnea (RR ^h > 30)	208 (23)	167 (22)	41 (33)	0.005
SpO ₂ ⁱ (%) (N=881)	94 (91, 97)	94 (91, 97)	92 (88, 96)	<0.001
Low SpO ₂ (< 95%)	477 (53)	399 (51)	78 (63)	0.01
FiO ₂ ^j (%) (N=768)	32 (24, 60)	30 (21, 50)	55 (30, 100)	<0.001
High FiO ₂ (>35% or >4 l/min)	455 (51)	370 (48)	85 (68)	<0.001
Albumin (g/dL) (N=305)	2.9 (2.4, 3.4)	2.9 (2.5, 3.4)	2.6 (2.2, 3.3)	0.02
Hypoalbuminemia (< 3.5 g/dL)	233 (26)	188 (24)	45 (36)	0.004
Acidosis (pH < 7.35)	190 (21)	151 (19)	39 (31)	0.002
Arterial pH (N=422)	7.37 (7.28, 7.43)	7.37 (7.29, 7.43)	7.38 (7.21, 7.44)	0.39
LIPS ^k (median, IQR)	5 (3.5, 7)	5 (3.5, 6.5)	6.5 (5.5, 8)	<0.001
Mechanical Ventilation				
Invasive MV ^l after initial contact	158 (18)	103 (13)	55 (44)	<0.001
Invasive MV anytime within 7 days	366 (41)	251 (33)	115 (93)	<0.001
Invasive MV at any time after initial contact	369 (41)	253 (33)	116 (94)	<0.001
Time to intubation	1 (1, 1)	1 (1, 1)	1 (1, 2)	0.01
Duration of invasive ventilation (days)	3.5 (2, 7.82)	2.89 (1.17, 6.85)	5.11 (2.6, 11.5)	<0.001
Non-invasive ventilation after initial contact	63 (7)	54 (7)	9 (7)	0.90
Non-invasive ventilation at any time after contact	114 (21)	71 (17)	43 (35)	<0.001
Ventilator parameters on initial intubation				
TV ^m (ml)	450 (400, 500)	450 (400, 500)	450 (400, 500)	0.35
TV (ml/Kg by PBW ⁿ)	7.31 (6.5, 8.44)	7.31 (6.50, 8.37)	7.07 (6.49, 8.59)	0.88
Peak Inspiratory Pressure	23 (18, 28)	22 (18, 27)	25 (20, 32)	<0.001
Plateau Pressure	18 (14, 23)	18 (14, 22.5)	18 (14, 25)	0.51
PEEP ^o	5 (5, 6)	5 (5, 5)	5 (5, 8)	0.14
Outcomes				
Hospital Mortality	200 (22)	140 (18)	60 (48)	<0.001
Death within 7 days of contact	101 (11)	77 (10)	24 (19)	0.002
Time to death (days)	7 (3, 18)	6.5 (3, 16)	10.5 (5, 20)	0.01
ICU LOS ^p	3 (1.75, 6.4)	2.83 (1.5, 5.29)	7 (4, 13)	<0.001

Characteristic	Cohort (N = 900)	No ARDS (N = 776)	ARDS (N = 124)	p-value ^a
Hospital LOS	14 (8.2, 24)	13.6 (8, 22)	21 (12.4, 36)	<0.001
Death location (N=200)				
ICU	111 (55)	77 (55)	34 (56)	
Floor	88 (44)	63 (45)	25 (42)	
SDU ^q /Intermediate Care	1 (1)	0 (0)	1 (2)	0.29
Disposition (N=700)				
Home	341 (49)	320 (50)	21 (33)	
Nursing Home	34 (5)	32 (5)	2 (3)	
Skilled Nursing Facility	236 (34)	209 (33)	27 (42)	0.05
Rehabilitation Center	60 (8)	49 (8)	11 (17)	
Transferred to another hospital	14 (2)	13 (2)	1 (2)	
Hospice	2 (0.2)	2 (0.3)	0 (0)	
Other (AMA ^r)	13 (2)	11 (2)	2 (3)	

^a p-values compare patients with and without ARDS

^b IQR, interquartile range

^c ICU, intensive care unit

^d The denominators are 527 for the non-ARDS group and 100 for the ARDS group

^e The data represent 390 patients in the non-ARDS group and 89 in the ARDS group

^f APACHE, acute physiology and chronic health evaluation

^g BMI, body mass index

^h RR, respiratory rate

ⁱ SpO₂, oxygen saturation by pulse oximetry

^j FiO₂, fraction of inspired oxygen

^k LIPS, lung injury prediction score

^l MV, mechanical ventilation

^m TV, tidal volume

ⁿ PBW, predicted body weight

^o PEEP, positive end-expiratory pressure

^p LOS, length-of-stay

^q SDU, step-down unit

^r AMA, against medical advice

Table 2

LIPS performance and association of LIPS with ARDS or the Composite Outcome (ARDS or death) in the full cohort, excluding all deaths, and in the competing risk analysis

LIPS ^a performance	ARDS (full cohort)	Composite (full cohort)	ARDS (excluding deaths)
LIPS [OR ^b (95%CI ^c)]	1.31 (1.21–1.42)	1.26 (1.18, 1.34)	1.31 (1.18, 1.45)
LIPS 4 [OR (95%CI)]	4.17 (2.26, 7.72)	2.43 (1.68, 3.49)	3.40 (1.59, 7.26)
Sensitivity (95%CI)	90.3 (83.7, 94.9)	83.3 (78.2, 87.6)	87.5 (76.8, 94.4)
Specificity (95%CI)	30.9 (27.6–34.3)	32.7 (29–36.5)	32.7 (29–36.5)
Positive predictive value (95%CI)	17.3 (14.4, 20.4)	33.9 (30.3, 37.7)	11.5 (8.86, 14.7)
Negative predictive value (95%CI)	95.2 (91.8–97.5)	82.5 (77.2, 87)	96.3 (92.8, 98.3)

^aLIPS, lung injury prediction score

^bOR, odds ratio

^cCI, confidence interval