Published in final edited form as:

J Crit Care. 2007 December ; 22(4): 275–284. doi:10.1016/j.jcrc.2007.02.001.

ICU Exposures for Long-Term Outcomes Research: Development and Description of Exposures for 150 ALI Patients

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Abstract

Purpose—Long-term follow-up studies in critical care have described survivors' outcomes, but provided less insight into the patient/disease characteristics and intensive care therapies ("exposures") associated with these outcomes. Such insights are essential for improving patients' long-term outcomes. This report describes the development of a strategy for comprehensively measuring relevant exposures for long-term outcomes research, and presents empirical results from its implementation.

Materials and Methods—A multi-step, iterative process was used to develop the exposures strategy. First, a comprehensive list of potential exposures was generated and subsequently reduced based on feasibility, redundancy, and relevance criteria. Next, data abstraction methods were designed and tested. Finally, the strategy was implemented in 150 acute lung injury patients with iterative refinement.

Results—The strategy resulted in development of >60 unique exposures requiring <45 minutes per patient-day for data collection. The vast majority of exposures had minimal missing data and adequate reliability. These data revealed that evidence-based practices including lower tidal volume ventilation, spontaneous breathing trials, sedation interruption, adequate nutrition, and blood glucose <6.1 mmol/L (110 mg/dl) occurred in only 23%-50% of assessments.

Conclusions—Using a multi-step, iterative process, a comprehensive and feasible exposure measurement strategy for long-term outcomes research was successfully developed and implemented.

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INTRODUCTION

As the short-term mortality for acute lung injury/acute respiratory distress syndrome (“ALI”) has improved [1,2], there is growing interest in studying longer-term outcomes of survivors. Existing studies describing and measuring these outcomes have revealed that many survivors have significant and persistent physical and mental health morbidities [3-5]. However, the relationship of patient and disease characteristics and intensive care unit (ICU) therapies (“exposures”) with these long-term outcomes has received less attention. Only half of the published cohort studies of ICU survivors report exposures related to ICU management [6]. Moreover, the sample sizes of most of these studies were too small to detect clinically meaningful differences in exposure-outcome relationships [6]. Studying ICU exposures is critical to understanding how patients’ disease and ICU management affect long-term outcomes.

Exposure-outcome relationships have been evaluated in some studies, but additional research is required. For example, Herridge *et al.* empirically demonstrated that systemic corticosteroid use was associated with impaired physical function, as measured by 6-minute walk distance [3]. However, additional research is needed to understand how the dose and duration of corticosteroids and other ICU therapies are associated with long-term muscle strength and physical function [7].

An appropriate exposure measurement strategy must have sufficient breadth, relevance, and validity [8], while also being feasible from a data collection perspective. There is no accepted process for achieving this goal, but consensus regarding identifying and abstracting ICU exposures is needed to create consistency and comparability between future long-term outcomes studies [8].

This report aims to help advance research methodology in this field through two objectives. First, in the Methods section, we describe the process used to develop an ICU exposure measurement strategy relevant to long-term outcomes research. Second, in the Results section, we assess this strategy’s data collection burden, frequency of missed data, and qualitative reliability, and present empirical results from implementing the strategy using the first 150 patients in our ongoing long-term outcomes study [9].

MATERIALS AND METHODS

Study Overview

This research was conducted as part of an ongoing prospective cohort study, the Improving Care of ALI Patients (ICAP) study. The objective of the ICAP study is to evaluate associations between ALI, lower tidal volume ventilation, and other aspects of ICU care with several categories of long-term patient outcomes, including physical function (including muscle strength and lung function), mental health (including symptoms of depression, anxiety and post-traumatic stress disorder) and quality of life [9]. This multi-site study enrolls mechanically ventilated patients with ALI [10] and measures exposures daily in the ICU and outcomes at 3, 6, 12 and 24 months after ALI diagnosis. Ethics approval for this research was granted by the Institutional Review Boards (IRB) of each participating study site.

Generation and Reduction of a Comprehensive List of Exposures

Based on expert opinion, prior long-term outcomes research experience, and published research regarding associations of ICU exposures with either short- or long-term outcomes, a list of exposures was generated by six critical care physicians from four academic medical centers. This team also received multidisciplinary input from experts in the fields of

nephrology, neurology, geriatrics, physical medicine and rehabilitation, psychiatry, psychology, pharmacy, nutrition, speech language pathology, nursing and respiratory therapy. The exposures generated for the measurement strategy related to patients' major body systems, including pulmonary, cardiovascular, renal, neurologic, gastrointestinal, endocrine, hematologic, infectious disease, and musculoskeletal exposures.

After exposure generation, the study team reduced the list of exposures by eliminating those which were: (1) unable to be abstracted or measured accurately, precisely or efficiently; (2) redundant with other exposures on the list; or (3) of little potential relevance to long-term patient outcomes. Relationships between exposures and outcomes will be evaluated in a selective manner using subsets of the exposure variables that are potentially relevant for each outcome. For example, mechanical ventilation exposure data may be relevant to understanding long-term lung function while data on sedation medications may be relevant to understanding long-term symptoms of post-traumatic stress disorder.

Development of Methodology for Exposure Measurements

Methods for collecting data on each exposure must address several important considerations. For example, time-varying exposures require frequent collection to adequately detect changes [8]. However, this frequency must be balanced with the associated data collection burden. Furthermore, the data collection strategy must allow flexibility in subsequent modeling of the exposure. This flexibility is critical because it is unclear what aspect of many exposures (e.g., duration of use, average daily dose, cumulative dose, maximum daily dose or dose in excess of a particular threshold) is most strongly associated with long-term outcomes.

Given its importance to the study objectives, ventilator settings were abstracted from the medical record twice daily, while most other exposures were recorded once daily. For certain highly time-variable exposures, more frequent abstraction was proposed, including recording the most extreme values in a 24-hour period when potentially relevant. For example, blood glucose was abstracted four times each day, including the 24-hour minimum and maximum values. When possible, validated epidemiological measurement instruments were used. For example, severity of illness and organ dysfunction were measured using APACHE II [11] and SOFA [12] scores, and sedation and delirium status were assessed using the Richmond Agitation-Sedation Scale (RASS) and Confusion Assessment Method for the ICU (CAM-ICU) [13,14], respectively.

As an observational study, the exposures considered in this research were generally limited to data available within patients' medical records. Although this approach enhances feasibility, it is subject to inconsistency and incompleteness. For example, collection of laboratory data was constrained by the frequency and timing of tests ordered by the ICU clinicians. Similarly, as in other observational research, certain ventilator-related parameters, such as plateau pressure, were not consistently measured or documented in the medical record [15]. In these situations, related data were recorded when available.

Creation and Pilot Testing of Case Report Forms

After the ICU exposures and data collection methodology were determined, paper-based case report forms (CRF) were created. A combination of paper and 7 different electronic medical systems were used for data abstraction across the 3 study sites. Pilot testing was conducted at each site, with iterative revisions to the CRFs to improve their clarity and feasibility.

Implementation of Exposure Measurement Strategy

“Live” data collection was initiated with a slowly escalating patient enrollment process in one study site at a time. Since study initiation, the CRFs have been regularly refined based on questions, problems and suggestions raised by study coordinators during monthly meetings with the lead investigator (DMN).

Quality Assurance of Exposure Measurements Strategy

Several steps were taken to ensure data quality. First, comprehensive training was held for all study coordinators followed by mandatory certification through comparison of their performance with independent duplicate data collection by the supervising study coordinator or lead investigator (DMN). Second, monthly meetings were held with all study coordinators to address questions and review data collection procedures. Third, study coordinators regularly received e-mail alerts and queries regarding particular data items based on detailed review of completed CRFs and automated validity checks during data entry into a relational database.

Evaluation of Exposure Measurement Strategy

The exposures strategy developed from the foregoing process was evaluated using three criteria: data collection burden, missing data and reliability. Data collection burden was measured by the time required for patient enrollment and daily assessments based on pilot testing of the case report forms. Missing data were calculated by dividing the number of instances in which data were not available by the number of instances in which it should have been available. Reliability was assessed using a 3-point scale (low, medium and high) based on an overall qualitative assessment from the previously-described quality assurance activities. Exposures with high missing data or low reliability were subjected to additional quality assurance activities during the ongoing study.

Results

The exposure measurement strategy included data on patients’ baseline clinical status (Table 1) and on each organ system (Tables 2 - 5). Over 60 unique exposures were collected, establishing a relatively comprehensive approach to exposure measurement.

Evaluation of the Exposures Strategy

The exposures strategy was evaluated using three criteria as previously described. First, the total data collection time was 30 minutes for enrollment and <45 minutes for daily ICU assessment [9]. The data collection times for specific exposures are reported in Tables 1 - 5. At each study site, 0.5 – 1.5 full-time equivalent study coordinators were employed depending on enrollment levels. Second, missing data was 6% for 97% of the exposures. Only two exposures, peak and plateau pressures during mechanical ventilation, had >6% of missing data primarily reflecting that one study site did not routinely record these measures. Third, reliability was qualitatively assessed as “low” for only 1 of the exposures, the APACHE II score, similar to observations in previous research [16]. Additional training and quality assurance activities directed at APACHE II data collection improved these results.

Findings from Implementation of the Exposures Strategy

The demographic and baseline clinical characteristics of the first 150 consecutive ALI patients enrolled in this ongoing study are presented in Table 1. These patients had a median age of 52 years with 41% female and 47% Black. Approximately 80% were enrolled from a medical ICU and had pulmonary or non-pulmonary sepsis as their primary ALI risk factor. Patients’ median (inter-quartile range (IQR)) ICU length of stay was 11 (6 – 18) days.

Exposures relating to patients' pulmonary status and interventions are summarized in Table 2. Volume-controlled ventilation was most commonly used. The median (IQR) tidal volume, plateau pressure and peak pressure were 6.5 (6.0, 8.0) ml/kg of predicted body weight (PBW), 23 (19, 29) cmH₂O and 32 (27, 38) cmH₂O, respectively. The proportion of ventilator assessments with a tidal volume in compliance with the ARDS Network protocol [17] was 50%. A tidal volume of 6.5 ml/kg PBW was considered compliant since the ARDS Network clinical trial allowed for a 0.5 ml/kg PBW measurement error with their 6 ml/kg PBW tidal volume goal (Roy Brower, MD personal communication 2006). Of those assessments that included a plateau pressure, 46% had both a plateau pressure <30 cmH₂O and a tidal volume <6.5cc/kg PBW [17]. Spontaneous breathing trials were observed in 23% of all ICU days in which patients were eligible for this intervention.

Cardiovascular, renal and neurological exposures are summarized in Table 3. Cardiovascular status and use of vasopressors was evaluated daily using the SOFA score classification [12]. Furosemide and intravenous contrast were common renal exposures used in 59% and 23% of patients, respectively. Furthermore, almost 40% of ALI patients required hemodialysis, a known predictor of long-term morbidity in survivors of critical illness [18]. From a neurological perspective, almost all patients were exposed to benzodiazepines and narcotics with interruption of sedative infusions on only 25% of all eligible ICU days.

Table 4 summarizes gastrointestinal and endocrine exposures. In 48% of ICU days, patients received <25% of their daily caloric intake goal. Although relatively little weight change was observed in the majority of patients from enrollment to ICU discharge, survivors' median cumulative fluid balance during this period was +6.1 liters (Table 3) potentially masking considerable loss of muscle mass. Insulin was delivered intravenously for 29% of patients during 15% of their ICU days. Blood glucose levels 6.1 mmol/L (110 mg/dl) [19] were observed in 63% of all the twice-daily values recorded. In addition, 15% of patients had at least 1 minimum daily blood glucose level <2.2 mmol/L (40 mg/dl).

Table 5 summarizes hematology, infectious disease and musculoskeletal exposures. Transfusion of blood products was conservative [20] with a median (IQR) nadir hemoglobin on the day of transfusion of 75 (68, 84) mg/L (7.5 (6.8, 8.4) mg/dl). Among the potential nephrotoxic antibiotics, approximately 10% of patients received drugs within the aminoglycoside or amphotericin classes, and 75% received vancomycin. Data from the APACHE II scoring system revealed that 58% of patients had a white blood cell count <3 or $15 \times 10^9/\text{liter}$ (<3 or $15 \times 10^3/\text{mm}^3$) at ICU admission. Of exposures potentially associated with long-term muscle weakness, neuromuscular blockade use was relatively infrequently; however, 65% of patients were exposed to systemic corticosteroids [3,21,22] and exposure to physical and occupational therapy occurred on only 6% and 8% of all ICU days, respectively.

DISCUSSION

This report describes the development and implementation of an exposure measurement strategy relevant to long-term outcomes after critical illness. Given the emerging nature of this research field, choosing a suitable exposures strategy is subjective and involves challenges and compromises. However, through our development process and its implementation in 150 ALI patients, we believe that our strategy is relatively comprehensive and feasible. This strategy may be beneficial for other studies in this field to help ensure consistency and comparability of exposure measures [8] – a process that is also occurring with outcomes measures [23,24].

The empirical results from implementation of the exposures strategy provided a foundation for better understanding the ICU exposures experienced by ALI patients, particularly the utilization of evidence-based practice. For example, even though all study sites are part of the ARDS Network, approximately 50% of all assessments revealed tidal volumes exceeding 6.5 ml/kg PBW and, especially at one study site, plateau pressures frequently were not documented. Furthermore, the proportion of ICU days with spontaneous breathing trials [25], interruption of sedation [26], adequate nutritional intake [27-29], and strict glycemic control [19] appears low. These findings reinforce prior research which generally evaluated individual evidence-based therapies and demonstrated their slow translation into ICU practice [30-37]. Discovering long-term benefits of relevant ICU exposures (e.g. daily interruption of sedation decreasing the prevalence of PTSD [38]) may help reinforce the importance of translating evidence into practice.

The current study has potential limitations. First, although a rigorous approach was taken in developing the exposures strategy, a single study cannot comprehensively record data on all exposures that may be potentially relevant to long-term outcomes. Furthermore, given the dynamic nature of many ICU exposures, more frequent assessments may be necessary for appropriate statistical modeling. However, given the lack of prior research in this area, the importance of these potential limitations is uncertain. Second, given that only a small number of teaching hospitals in a single city are involved in this study, local expert opinion, practice patterns and protocols may have influenced development of the exposures strategy and results of its implementation, potentially limiting the generalizability of our results. However, the detailed description of our developmental process and the resulting exposures strategy may be useful for future larger, multi-center studies. Lastly, the exposures strategy may include more, or less, exposures than required to understand the relationships between exposures and long-term outcomes. Further evaluation of this issue will only be possible at the end of the study after analyses of the exposure-outcome relationships have been completed.

Despite these limitations, there are important strengths of this study. It is novel in describing the development process, implementation and results of a comprehensive exposures strategy for long-term outcomes research in critical care. Furthermore, this study describes the current utilization of several evidence-based practices relevant to ALI patients at three academic hospitals.

In conclusion, a multi-step, iterative process was used to develop a comprehensive set of patient and ICU exposures for studying long-term outcomes after critical illness. Implementation of this exposures strategy in 150 acute lung injury patients demonstrated the feasibility of this approach and revealed that patients frequently did not receive recommended ICU therapies. By evaluating the association of these exposures with patients' long-term outcomes, researchers may identify potential methods for improving the long-term morbidities experienced by survivors of critical illness.

Acknowledgments

The authors acknowledge the important contributions provided by our research staff in helping with pilot testing and implementation of this exposures strategy. We are especially grateful for the assistance provided by Rachel Bell, Kim Boucher, Victor Dinglas, Carinda Feild, Kim Forde, Thelma Harrington, Praveen Kondreddi, Stacey Murray, Kim Nguyen, Amy Scully, Shabana Shahid, Rameswari Radhakrishnan, and Nsikak Umoh. In addition, we acknowledge the important contribution made by David Dowdy, ScM and Margaret Herridge, MD, MPH who critically reviewed an earlier draft of the manuscript.

This research is supported by the National Institutes of Health (Acute Lung Injury SCCOR Grant # P050 HL 73994). Dr. Needham is supported by a Clinician-Scientist Award from the Canadian Institutes of Health Research. Drs. Dennison and Sevransky are supported by Mentored Patient-Oriented Research Career Development Awards

from the National Institutes of Health (K23 NR009193 and K23 GM071399, respectively). The funding bodies had no role in the study design, manuscript writing or decision to submit the manuscript for publication.

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Table 1

Baseline Characteristics of ALI Patients

Characteristic	Reliability	% Missing	Value n=150)
Demographic and Clinical Characteristics (DCT = 30 minutes)			
Age, median (IQR) years	+++	0	52 (43, 66)
Male, %	+++	0	59
Race, %	+++	0	
White			50
Black			47
Other			3
Co-morbidities, %	++	0	
Liver disease			23
Chronic lung disease			21
HIV/AIDS			20
Kidney disease			19
Diabetes mellitus			18
Congestive heart failure			17
Alcohol abuse			9
Stroke			9
Illicit drug use			9
None			17
Charlson Index, ^a median (IQR) (DCT = 5 minutes)	++	0	2 (1, 4)
Type of ICU admission, %	+++	0	
Medical			85
Surgical			14
Trauma			1
Source of ICU admission, %	+++	0	
Emergency			43
Hospital ward			38
Transfer			9
Another ICU at study site hospital			7
Operating/recovery room			3
ICU admission diagnosis, %	++	0	
Respiratory, including pneumonia			54
Infectious disease			18
Gastrointestinal			13
Cardiovascular			5
Other			10
APACHE II score ^b at ICU admission, median (IQR) (DCT = 7 minutes)	+	0	24(20, 32)
Acute lung injury risk factor, %	++	0	
Pneumonia			39
Sepsis, non-pulmonary			37

Characteristic	Reliability	% Missing	Value n=150)
Aspiration			11
Transfusion			4
Other			9
Lung injury score ^c at enrollment, median (IQR)	++	0	2.3 (1.7, 3)
SOFA score ^d , median (IQR) (DCT = 3 minutes)	+++		
At enrollment		0	9 (7, 11)
Maximum daily score		0	11 (8, 15)

ALI, acute lung injury; DCT, data collection time; HIV/AIDS, human immunodeficiency virus/acquired immunodeficiency syndrome; ICU, intensive care unit; IQR, inter-quartile range

^aThe Charlson Index is a measure of comorbid disease. Using medical chart review, it is calculated as the weighted sum of 19 comorbid conditions with an overall score ranging from 0 to 37. A higher score indicates greater comorbidity and a higher risk of death [39,40].

^bThe Acute Physiology and Chronic Health Evaluation II (APACHE II) score ranges from 0 to 71, with a higher score indicating greater severity of illness [11].

^cThe modified Lung Injury Score ranges from 0 to 4 with a higher score indicating more severe lung injury [41]. This score is the mean of individual scores for the chest radiograph, hypoxemia and positive end-expiratory pressure. This score is modified because respiratory compliance was not measured and included its calculation.

^dThe Sequential Organ Failure Score (SOFA) score assesses dysfunction for 6 organ systems and ranges from 0 to 24, with a higher score indicating greater organ failure [12].

Table 2**Pulmonary Status and Interventions for ALI Patients in the ICU**

Status or Intervention	Reliability	% Missing	Value (n=150)
Pulmonary (DCT = 14 minutes)			
PaO ₂ /FiO ₂ ratio, % of ICU days	++	4	
<100			18
100-199			40
200-299			22
300			20
Mechanical ventilation mode, % of twice-daily assessments	+++	1	
Assist control or pressure regulated volume control			59
Pressure support			8
Airway pressure release			5
High frequency oscillation			4
Non-invasive/continuous positive airway pressure			4
Other			6
None			14
Alternative/adjunctive therapy, % of patients	+++		
High frequency oscillation		1	13
Prone positioning		1	3
Inhaled nitric oxide		1	1
Mechanical ventilation assessments, ^a median (IQR)	++		
Respiratory rate		2	28 (21, 35)
Tidal volume, ml per kg predicted body weight		2	6.5(6.0, 8.0)
Peak pressure, cmH ₂ O		9	32 (27, 38)
Plateau pressure, ^b cmH ₂ O		40	23 (19, 28)
PEEP, cmH ₂ O		2	5 (5, 10)
FiO ₂ , %		2	50 (40, 60)
Of all ventilator assessments, ^a %			
Tidal volume <6.5cc/kg PBW		2	50
Plateau pressure ^b <30 cmH ₂ O		40	82
Both of above ^c		40	46
Barotrauma requiring chest tube, % of patients	+++	1	1
Spontaneous breathing trial, ^d % of ICU days	++	1	23
Tracheotomy	+++	5	
Proportion of patients			15
Surgery performed at bedside (percutaneous), %			29
Days after ALI diagnosis, median (IQR)			17 (8, 20)

ALI, acute lung injury; DCT, data collection time; FiO₂, fraction of inspired oxygen; ICU, intensive care unit; IQR, inter-quartile range; ml, milliliter; PaO₂, pressure of arterial oxygen; min, minute; PBW, predicted body weight; PEEP, positive end expiratory pressure

^aExcluding assessments in which the patient was receiving face mask, nasal cannula, or the following modes of ventilation: non-invasive, continuous positive airway pressure, high frequency oscillation, pressure support or airway pressure release. Mechanical ventilation assessments were completed twice daily.

^bA comparison of all assessments in which both plateau and peak pressures were simultaneously available demonstrated that the mean (standard deviation) difference by which peak pressure exceeded plateau pressure was 13 (8) cmH₂O. Peak pressure was <30 cmH₂O in 36% of assessments.

^cCalculated using only ventilation assessments in which plateau pressure was available.

^dExcluding assessments of patients not eligible for spontaneous breathing trial: FiO₂>50%, PEEP>10, or the following modes of ventilation: non-invasive, continuous positive airway pressure, high frequency oscillation, jet, or airway pressure release.

Table 3

Cardiovascular, Renal & Neurological Status and Interventions for ALI Patients in the ICU

Status or Intervention	Reliability	% Missing	Value (n=150)
Cardiovascular , % of ICU days (DCT < 1 minute)	+++	2	
Mean arterial pressure 70 mmHg, no vasopressor			48
Mean arterial pressure 70 mmHg, no vasopressor			28
Dopamine 15, epinephrine 0.1, and norepinephrine 0.1 mcg/kg/min			8
Dopamine >15, epinephrine >0.1, or norepinephrine >0.1 mcg/kg/min			16
Renal (DCT = 3 minutes)			
Creatinine, median (IQR), mmol/L [(mg/dl)]	+++	6	107(61, 206) [1.4(0.8, 2.7)]
Daily fluid balance, median (IQR) liters	+++	1	1.0(-0.3, 2.3)
Cumulative fluid balance to ICU discharge, median(IQR) L			6.1 (0.5, 17.6)
Furosemide use	+++	0	
% of patients			59
% of ICU days			19
Daily dose, median (IQR) milligrams			80 (40, 120)
Intravenous contrast, % of patients	++	6	23
N-acetylcysteine, ^a % of patients	+++	0	11
Hemodialysis, % of patients	+++	1	38
Intermittent			
% of dialysis days			46
Hours per day of use, median (IQR)			3 (2.5, 3.1)
Continuous			
% of dialysis days			57
Hours per day of use, median (IQR)			20 (13, 23)
Neurological^b (DCT = 4 minutes)			
Benzodiazepines	+++	0	
% of patients			93
% of ICU days			52
% of ventilation days given as continuous IV infusion			47
Daily dose (IV midazolam-equivalent), median(IQR) mg			68 (20, 196)
Narcotics	+++	0	
% of patients			98
% of ICU days			64
% of ventilation days given as continuous IV infusion			64
Daily dose(IV morphine-equivalent), median(IQR) mg			101(30, 240)
Propofol	++	0	
% of patients			24
% of ICU days			11
Daily dose, median (IQR) grams			3.2 (1.4, 6.0)
Haloperidol	+++	0	
% of patients			23

Status or Intervention	Reliability	% Missing	Value (n=150)
% of ICU days			5
Daily dose, median (IQR) milligrams			5 (3, 15)
Daily interruption of sedation infusions, % of ICU days	++	1	25

ALI, acute lung injury; DCT, data collection time; ICU, intensive care unit; IQR, inter-quartile range; IV, intravenous; mg, milligram; L, liter

^a Administered to prevent contrast-induced nephropathy [42].

^b Data on neuromuscular blocking agents is presented in Table 5 with the Musculoskeletal system

Table 4**Gastrointestinal and Endocrine Status and Interventions for ALI Patients in the ICU**

Status or Intervention	Reliability	% Missing	Value (n=150)
Gastrointestinal (DCT = 3 minutes)			
Enteral nutrition, % of patients	+++	3	81
Total parenteral nutrition, % of patients	+++	1	11
Daily caloric intake (parenteral and enteral), median (IQR) calories	++	5	560 (0, 1440)
Daily caloric intake (parenteral and enteral), % of ICU days			
<25% of goal ^a			48
25 – 49%			14
50 – 74%			13
75%			25
Weight change to ICU discharge, median (IQR) kg	+++	5	0(-10, 4)
Albumin	+++		
At enrollment, median (IQR) g/L [g/dl]		1	24(20, 30) [2.4(2, 3)]
Change from enrollment to ICU discharge, median (IQR) g/L [g/dl]		1	0 (-4, 4) [0(-0.4, 0.4)]
Bilirubin >33 mmol/L (1.9 mg/dl), % of ICU days	+++	2	19
Endocrine (DCT = 4 minutes)			
Glucose, mmol/L (mg/dL), % of twice-daily lab values	+++	2	
2.2 - 4.4 (40 – 79)			7
4.5 - 6.0 (80 – 109)			30
6.1 - 8.3 (110 – 149)			40
8.4 - 11.1 (150 – 200)			16
>11.1 (200)			7
Glucose, % of patients with 1 value <2.2 mmol/L (40 mg/dl)			15
Glucose, % of patients with 1 value 8.4 mmol/L (150 mg/dl)			89
Insulin administration	++	0	
Daily dose, median (IQR) units			18 (6, 56)
% of patients			81
% via intravenous infusion			29
% of ICU days			42
% via intravenous infusion			15

ALI acute lung injury; DCT, data collection time; ICU, intensive care unit; IQR, inter-quartile range; kg, kilogram

^aGoal based on 25 kcal/kg of usual body weight [29].

Table 5

Hematology, Infectious Disease, and Musculoskeletal Status and Interventions for ALI Patients in the ICU

Status or Intervention	Reliability	% Missing	Value (n=150)
Hematology (DCT = 2 minutes)			
Lowest daily hemoglobin, median (IQR) g/L [g/dl]	+++	5	89(81, 100) [8.9 (8.1, 10)]
Packed red blood cell transfusion	+++	1	
% of patients			61
Total units received, median (IQR)			4 (2, 8)
Nadir hemoglobin on day of transfusion, median (IQR) g/L [g/dl]			75 (68, 84) [7.5 (6.8, 8.4)]
Lowest daily platelet count, median (IQR) 10 ⁹ /L	+++	5	176(89, 288)
Platelet transfusion	++	1	
% of patients			23
Total units received, median (IQR)			12 (6, 26)
Nadir platelet count on day of transfusion, median (IQR) 10 ⁹ /L			28 (15, 39)
Albumin transfusion, % of patients	++	1	8
Erythropoietin use, % of patients	+++	0	25
Iron, % of patients	+++	0	21
Infectious Disease (DCT = 2 minutes)			
Activated protein C, % of patients	+++	2	7
Aminoglycoside, % of patients	+++	2	11
Amphotericin B, % of patients	+++	0	12
Vancomycin, % of patients	+++	0	75
Musculoskeletal (DCT = 5 minutes)			
Corticosteroids	+++	0	
% of patients			65
Duration of use, median (IQR) days			6 (3, 9)
Daily prednisone-equivalent dose, median (IQR) mg			50 (27, 75)
Total prednisone-equivalent dose, median (IQR) mg			300 (126, 658)
Neuro-muscular blockade	+++	0	
% of patients			26
% of ICU days			4
Daily dose (vecuronium), median (IQR) milligrams			14(8.5, 25)
Physical therapy ^a , % of patients	++	1	27
Physical therapy ^a , % of ICU days	++		6
Occupational therapy ^b , % of patients	++	1	29
Occupational therapy ^b , % of ICU days	++		8

ALI, acute lung injury; DCT, data collection time; ICU, intensive care unit; IQR, inter-quartile range; mg, milligram

^aPhysical therapy activities include assistance with sitting, transferring, standing/walking, and range of motion^bOccupational therapy activities include activities of daily living (ADL) training, functional mobility, splinting/positioning and upper extremity rehabilitation