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Respiratory Events After Intensive Care Unit Discharge in Trauma Patients: Epidemiology, Outcomes, and Risk factors

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Abstract

Background—Respiratory complications are associated with significant morbidity and mortality in trauma patients. The care transition from the intensive care unit (ICU) to the acute care ward is a vulnerable time for injured patients. There is a lack of knowledge about the epidemiology of respiratory events and their outcomes during this transition.

Methods—Retrospective cohort study in a single level 1 trauma center of injured patients ≥ 18 years old initially admitted to the ICU from 2015–2019 who survived initial transfer to the acute care ward. The primary outcome was occurrence of a respiratory event, defined as escalation in oxygen therapy beyond nasal cannula or facemask for ≥ 3 consecutive hours. Secondary outcomes included unplanned intubation for a primary pulmonary cause, adjudicated via manual chart review, as well as in-hospital mortality and length of stay. Multivariable logistic regression was used to examine patient characteristics associated with post-transfer respiratory events.

Results—6,561 patients met inclusion criteria with a mean age of 52.3 years and median injury severity score of 18 (IQR=13–26). 262 patients (4.0%) experienced a respiratory event. Respiratory events occurred early after transfer (median day 2, IQR 1–5), and were associated with high mortality (16% vs. 1.8%, p<0.001), and ICU readmission rates (52.6% vs. 4.7%, p<0.001). Increasing age, male sex, severe chest injury, and co-morbidities including: pre-existing

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JER: Literature search, study design, data collection, data analysis, data interpretation, writing, critical revisions
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JC: Study design, data interpretation, writing, critical revisions

Supplemental Material
SDC 1: AIS codes used to classify injury characteristics
SDC 2: ICD-9 and ICD-10 PCS codes used to identify surgical procedures
SDC 3: Additional information about study cohorts
SDC 4: Causes of intubation in 58 patients
SDC 5: Criteria for ward suitability

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alcohol use disorder, congestive heart failure, and chronic obstructive pulmonary disease, were associated with increased odds of a respiratory event. 58 patients experienced an unplanned intubation for a primary pulmonary cause, which was associated with an in-hospital mortality of 39.7%.

Conclusions—Respiratory events after transfer to the acute care ward occur close to the time of transfer and are associated with high mortality. Interventions targeted at this critical time are warranted to improve patient outcomes.

Level of Evidence: Level III, Prognostic and Epidemiological

Keywords

respiratory failure; care transition; respiratory event

Background

Respiratory complications are a significant source of morbidity and mortality in hospitalized trauma patients,[1,2] and are a leading cause of unplanned intensive care unit (ICU) readmissions.[3–6] During the past decades, efforts have focused on identifying high-risk groups[7,8] and developing care pathways aimed at decreasing their occurrence.[9,10] Currently, many institutions triage high-risk patients to the ICU for initial monitoring and stabilization, after which they are transferred to the acute care ward ("floor"). Care transitions represent a potentially vulnerable period for trauma patients, as they leave the highly monitored environment of the ICU and go to a floor bed with limited monitoring and less frequent nursing and respiratory therapy interventions, including those aimed at preventing respiratory complications, such as frequent coughing and deep breathing, effective analgesia, and aspiration prevention.[9,11]

Given the potential severity of respiratory complications in trauma patients data regarding the incidence and risk of respiratory complications following transfer from the ICU is needed to develop effective policies and practices to reduce these potentially morbid events. Existing work on respiratory complications following injury has typically focused on characterizing them either in the ICU,[7,12–15] in specific patient sub-groups,[16–18] or predicting their occurrence across an entire hospitalization at the time of admission.[8,19–22] As a result, it is difficult to identify times and locations for targeted interventions. Furthermore, prior work solely utilizing clinical registry data is limited to complications adjudicated by abstractors, which may miss clinically relevant events.

To address this knowledge gap, the present study describes the epidemiology of respiratory events in trauma patients after transfer from the ICU to the acute care ward. We hypothesized that post-transfer respiratory events are more common in the elderly and those with more severe chest trauma. We also hypothesized that post-transfer respiratory events are associated with increased morbidity and mortality.

Methods

Data Source and Patient Selection

The institutional trauma registry at a regional level I trauma center was queried for all non-burn trauma patients admitted to the hospital from 2015–2019. Exclusion criteria included: patients readmitted for a missed injury, < 18 years of age, patients not initially admitted to the ICU, those who died or were discharged before floor transfer, those who underwent a tracheostomy prior to initial floor transfer, and those who had prolonged floor stays (>100 days) before an ICU readmission (Figure 1).

Data on patient demographics, comorbidities, injury characteristics, procedures, and outcomes were obtained from the trauma registry. Specific injury characteristics were identified using abbreviated injury scale (AIS) codes. Surgical procedures were identified using International Classification of Diseases Procedure Coding System (ICD-PCS) codes version 9 and 10 as appropriate. All codes used are listed in the supplemental digital content (SDC 1 and 2). Massive transfusion was defined as receiving ≥ 10 units of packed red blood cells in the first 24 hours after presentation for patients whose initial blood transfusion was within 4 hours of hospital arrival. Additional time-stamped data characterizing the type of oxygen support (e.g., nasal cannula, ventilator, room air, etc.) for all patients throughout their hospital stay were obtained from an institutional data warehouse of electronic health records (EHR). This study was reviewed by the institutional review board at the University of Washington and was considered exempt.

Outcome Definition

The primary outcome was the occurrence of a respiratory event after transfer to the acute care floor. A respiratory event was defined as any escalation in oxygen therapy beyond simple nasal cannula (e.g., non-rebreather mask, high-flow nasal cannula, intubation) that lasted for at least 3 continuous hours. The specific etiology of these events is unspecified and is not used in the definition of the primary outcome. The first significant respiratory event was assessed as the primary outcome. A secondary outcome was unplanned intubation for a primary pulmonary cause after transfer to the floor. If intubation occurred as a result of the first respiratory event, then the case was coded as meeting both the primary and secondary endpoints. For patients with a primary respiratory event and delayed intubation, these outcomes were coded based on the time each event occurred.

To categorize intubation events, all patient’s receiving ventilator support after the date of their initial floor transfer were identified using EHR and trauma registry data. Chart review was conducted by one author (JER) to identify intubations that were unplanned and due to a pulmonary cause. Intubations were classified as a pulmonary cause if clinical documentation indicated that the reason for reintubation was pneumonia, presumed/witnessed aspiration, uncontrolled pain, pleural effusion/empyema, retained/reaccumulated hemothorax, pneumothorax, or hypoxemic arrest. We excluded cases of reintubation that were clearly non-pulmonary in origin such as planned operating room procedures, endoscopic or radiologic procedures, altered mental status/seizures in the setting of intracranial pathology (e.g. expanding subdural hematoma), sepsis from a confirmed non-pulmonary source (e.g. intraabdominal), code/arrest that was clearly non-hypoxemic in origin (e.g. myocardial infarction). In situations that were ambiguous, adjudication was performed by all three authors (JER, EMB, JC). If the cause was not clearly non-pulmonary in origin, the intubation was classified as a pulmonary etiology.

Statistical Analysis

We summarized continuous covariates using means with standard deviations (SD) for normally distributed continuous covariates, and medians with inter-quartile ranges (IQR) for non-normally distributed covariates. T-tests were used to compare the means of normally distributed covariates and Wilcoxon rank-sum tests were used for non-normally distributed covariates. Distributions of categorical covariates were compared with Pearson's chi-squared test. Logistic regression models were specified a-priori based on literature review of prior studies, clinical experience, and inspection of bivariate data analyses. Model discrimination was assessed using the area under the receiver operating curve and calibration was assessed using a Hosmer-Lemeshow goodness of fit test. Levels of missing covariate data were low (highest being 3.6% for racial identity), thus missing data was treated as a separate covariate level for analyses (i.e., missing was coded as a separate level for categorical covariates)1. An alpha level of 0.05 was chosen for significance. All analyses were performed in Stata version 16.1 (Stata Corp, College Station, Texas).

Results

During the study period, a total of 23,568 trauma patients were admitted, of whom 11,137 were initially admitted to the ICU, with 6,561 patients meeting inclusion criteria (Figure 1). The mean age was 52.3 (SD=21.3) years, the majority were male (69.1%), with a median injury severity score (ISS) of 18 (IQR 13–26). Overall, 262 patients (4.0%) experienced a respiratory event after transfer from the ICU, and this rate was relatively stable over the study period (3.6% – 4.3% per year, p=0.88, SDC 3). There was a total of 167 intubation events of which 58 were unplanned and for a primary pulmonary cause. Among these intubations 34 were immediate, and 24 occurred during an escalation of support (Figure 1). Respiratory events generally occurred early after transfer (median 2 days, IQR 1–5, Figure 2).

Table 1 shows the characteristics of the study cohort, those who experienced a respiratory event, and those who were intubated, and additional information is presented in SDC 3. Overall, patients who experienced respiratory events were older, more likely to be male, were more severely injured (median ISS 24.5 vs. 18.0, p<0.001), had more severe chest injury (median abbreviated injury score [AIS] chest 3.0 vs. 2.0), were more likely to be intubated at the time of admission, and if intubated had a longer duration of intubation during their initial ICU stay (median 48 vs. 25 hours). Patients who experienced a respiratory event were more likely to have comorbid alcohol use disorder, chronic obstructive pulmonary disease, diabetes, congestive heart failure, hypertension, or a diagnosed personality disorder and were more likely to have undergone either craniotomy or thoracic surgery during their hospital course.

Respiratory events were associated with high in-hospital mortality (16.0% vs. 1.8%, $p<0.001$) as well as a longer total length of stay (LOS) (median 19.0 vs. 8.0 days, $p<0.001$), and longer total ICU LOS (median 7.0 vs. 2.0 days, $p<0.001$). Patients who experienced respiratory events had higher rates of ICU readmission (52.6% vs. 4.7%, $p<0.001$). Full outcome data is shown in Table 2.

In a multivariate logistic regression model for the outcome of any respiratory event (Table 3), older age, male sex, comorbid alcohol use disorder, congestive heart failure, chronic obstructive pulmonary disease, diabetes, increasing injury severity, massive transfusion in the first 24 hours, and more severe chest injury (intubation at the time of admission, ≥3 rib fractures or flail chest) were significantly associated with increased odds of respiratory complications. The model had an area under the receiver operating curve of 0.72 (95% CI 0.69–0.75) and a Hosmer-Lemeshow goodness of fit test yielded a p-value of 0.23.

Fifty-eight patients experienced an unplanned intubation for a primary pulmonary cause. Causes of reintubation are listed in the supplemental digital content (SDC 4). These patients typically were older, had more severe chest injury, and had higher rates of pre-existing cardio-pulmonary disease (Table 1). Patients reintubated for a pulmonary cause a had very high mortality rate (39.7%) and prolonged hospital and ICU LOS (Table 2).

Discussion

This study examined a large cohort of diverse trauma patients who survived their initial ICU admission and were transferred to the acute care ward in a level one trauma center. Overall, respiratory events occurred in 4% of patients and were associated with significant in-hospital mortality (16%) and increased total ICU and hospital LOS. These data are further confirmation of the importance and severity of respiratory events in trauma patients throughout their hospital course. In a 2016 National Trauma Databank study, Prin and Li found a 16.9% mortality across all trauma patients who required ICU admission and suffered an in-hospital complication.[14] Chung et al. examined failure-to-rescue in trauma patients at a single trauma center and found an 11.6% mortality rate in ICU patient's after a defined major complication.[23] The fact that the mortality rate in the present study was comparable at 16% is notable, given that the patients in this study had survived their initial ICU admission, and were likely considered stable enough to merit transfer to the acute care floor. However, exact transfer criteria and moderating factors for individual patients are not available in our data set (see SDC 4 for typical ward transfer criteria).

We used a highly sensitive and objective definition for a respiratory event as the main outcome measure in this study. Like the use of ventilator-associated events (VAEs) versus ventilator-associated pneumonia (VAP), this definition has the advantage of increased sensitivity and objectivity by not relying on inconsistent clinical documentation and abstractor review for identification.[15,24] While this increased sensitivity will naturally come at the expense of specificity for clinical pulmonary diagnoses (e.g. pneumonia) the high mortality rate associated with these events (16% in this study) reflects their importance, similar to what has been found for VAEs.[15] In a similar study, Chung et al. utilized complication definitions from the Pennsylvania Trauma Systems Foundation and found a

1.4% mortality rate amongst patients experiencing any complication on the ward and a 9.1% mortality rate for those with a defined pulmonary complication using the TQIP definitions.[23] This is lower than the 16% mortality rate we found and may reflect our broader capture of events with this sensitive and objective definition.

To complement our sensitive measure of respiratory events, our approach to identifying intubation events allowed for both high sensitivity and specificity by combining EHR data with manual chart review. Of the 167 intubation events after floor transfer identified by EHR data, 70 of these were categorized as “unplanned intubations” based on Trauma Quality Improvement Program (TQIP) criteria and 58 of them were ultimately determined to be from a pulmonary etiology by chart review. The majority of the 167 patients that were not captured in the trauma registry were appropriate as they did not meet criteria for an unplanned intubation (e.g. intubation for a planned operating room procedure). Notably, of the 58 intubations for a pulmonary cause that we identified, 13 were not captured in the trauma registry based on TQIP criteria. The reasons for this are likely varied including inadequate or confusing provider documentation, or due to the sequencing of events leading abstractors to feel it was not “unplanned”, or simply due to errors associated with the high volume of clinical documentation that abstractors must parse through. Overall, these results highlight the utility of pairing sensitive (oxygenation data) and specific (targeted chart review) measures to understand the true incidence of pulmonary complications to guide research and quality improvement activities and are already informing efforts at our institution to improve the capture of etiology-specific data in our trauma registry.

In-line with prior work, we found increasing age, more severe chest injury and pre-existing cardio-pulmonary disease to be significant risk factors for respiratory events.[17,25] Notably, much of this prior work has focused on high-risk sub-populations of trauma patients (e.g., elderly, blunt chest injury), has not used a broad definition of respiratory events, and has not focused on the timing of events relative to specific care transitions.[7,17] Our data extends this work to a more generalized population of trauma patients, using a highly sensitive measure of respiratory events and emphasizes that these risk factors continue to be important throughout the hospital stay. For example, 129 of the 262 patients who experienced respiratory events (46%) had no rib fractures, which would have excluded them from many studies focusing exclusively on blunt chest trauma.

Most respiratory events occurred within 5 days of transfer to the acute care ward (median day 2). This may indicate that current protocols for evaluating suitability for floor transfer are inadequate for identifying this small but consequential population. There are multiple possible strategies to address post-transfer respiratory events including 1) revising criteria for floor transfer, 2) increased non-invasive continuous monitoring of patients following floor transfer, 3) protocols for respiratory therapy interventions aimed at decreasing respiratory events, 4) dedicated teams composed of either ICU or specified non-ICU personnel to monitor and evaluate recently transferred patients, 5) clustering at risk patients in a common physical location (e.g. step-down unit[26]) or on a common hospital service to promote increased monitoring and prevent, 6) a combination of the above.

Criteria used for transfer to the acute care ward must balance patient safety and the utilization of limited hospital resources such as ICU beds. For example, our institutional protocol[9] for patients with rib fractures supports primary ICU admission for patients over 65 years old with ≥ 3 rib fractures and involves a functional assessment (incentive spirometry, cough strength, pain control) in addition to standard ICU transfer criteria (SDC 5). While the rate of respiratory events was overall not large (4%), the associated morbidity and mortality was high even with these stringent criteria. Floor transfer criteria could be modified either by applying existing criteria to a broader group of patients, or by using better risk stratification models. For instance, of the 262 patients who experienced respiratory events, 138 of them (53%) did not meet criteria to be included in our initial rib fracture management pathway for high-risk patients. However, expanding the use of these criteria to all trauma patients would require significant investment of resources and personnel, which are not currently justified based on the lack of empirical evidence for their effectiveness in a broader trauma population. Furthermore, changes to ICU transfer criteria must be considered in the context of a specific institutions bed-capacity and patient flow needs. A second approach would involve developing additional criteria for floor transfer, or further refining risk prediction methods. Significant effort has been devoted to developing prediction algorithms and risk scores to identify patients at high risk of pulmonary complications.[8,9,20,27–30] However, many of these algorithms rely only on patient characteristics at the time of admission, retrospectively look at the entire hospital course (not just the time of floor transfer), utilize defined pulmonary complications as an outcome (as opposed to respiratory events), have not been extensively validated in other cohorts, and have been limited to patients with chest wall injury. The applicability and utility of these scoring systems at the time of ward transfer is not currently established. Notably, the prediction task involved in identifying a small number of events across a heterogeneous population in a way that optimizes resource utilization is not trivial and may not be possible with current approaches and data sources, but ideally, targeted therapy to individual patients at greatest risk should be the goal. Specifically, newer approaches employing machine learning techniques for event prediction from large datasets may be beneficial in this area.[26]

An alternate strategic approach is to accept the limits of our ability to refine predictions currently and deploy interventions for increased monitoring and support of patients outside of the ICU setting. Given that most respiratory events occurred early after transfer, it is possible that interventions such as frequent respiratory therapy sessions and nursing checks, continuous oxygen saturation monitoring, and provider adjustments targeted in this high-risk window could be an effective way to reduce respiratory events. Many of the interventions currently employed for the prevention of pulmonary complications (respiratory hygiene, multi-modal analgesia, catheter-based analgesia, frequent monitoring)[9] could theoretically be delivered on an acute care ward if sufficient resources were available. Although targeted therapy would be optimal, such an approach may allow for the reduction of respiratory events while still preserving limited ICU resources for patients requiring interventions such as mechanical ventilation and vasopressor support that cannot be delivered in other settings. A 2016 study by Nyland and colleagues evaluated a standardized preventative protocol for high-risk trauma patients on the acute care floor. In a pre-post analysis, they demonstrated a reduction in unplanned ICU admissions in the intervention period.[10] While the outcome of

ICU readmissions is a surrogate marker for respiratory events and may represent appropriate care escalation rather than a negative outcome in itself, this study and others[31] demonstrate the feasibility of implementing an intensive respiratory hygiene protocol outside of the ICU setting. The major limitation of such an approach is the cost in terms of manpower and resources needed to implement these protocols, which merits further exploration.

Strengths of this study are the inclusion of a diverse group of trauma patients, the use of detailed EHR data to implement a highly sensitive and objective definition of a respiratory event, the use of manual adjudication for intubation events to isolate those related to pulmonary causes, and the use of timing data to study respiratory events relative to important transitions of care, which can inform the development and implementation of interventions to address them. The main limitations include focusing on the experience of a single high-volume level one trauma center which may not reflect patterns of care in other settings, and lack of detailed information about specific medical interventions performed, functional covariates, and service staffing information (e.g., medications, pulmonary function, fluid balance, diet status, service transferred to) in the peri-transfer period to examine additional clinical risk factors. Furthermore, while our institution has generally acceptable criteria for transfer suitability (SDC 5), some of these can be modified at the attending's discretion, and we are not able to capture the specific factors that led to the decision to transfer a patient a given time (e.g., bed flow concerns to accommodate higher acuity patients). Finally, for this study we chose to exclude patients who underwent tracheostomy placement during their initial ICU stay. This was done to create a more homogeneous sample population for study, as the risk factors and care patterns of tracheostomy patients on the floor are likely to be different than patients without a tracheostomy. This is an important group of patients that merits separate study.

In conclusion, respiratory events tend to occur early after transfer to the acute care ward and are associated with significant morbidity and mortality.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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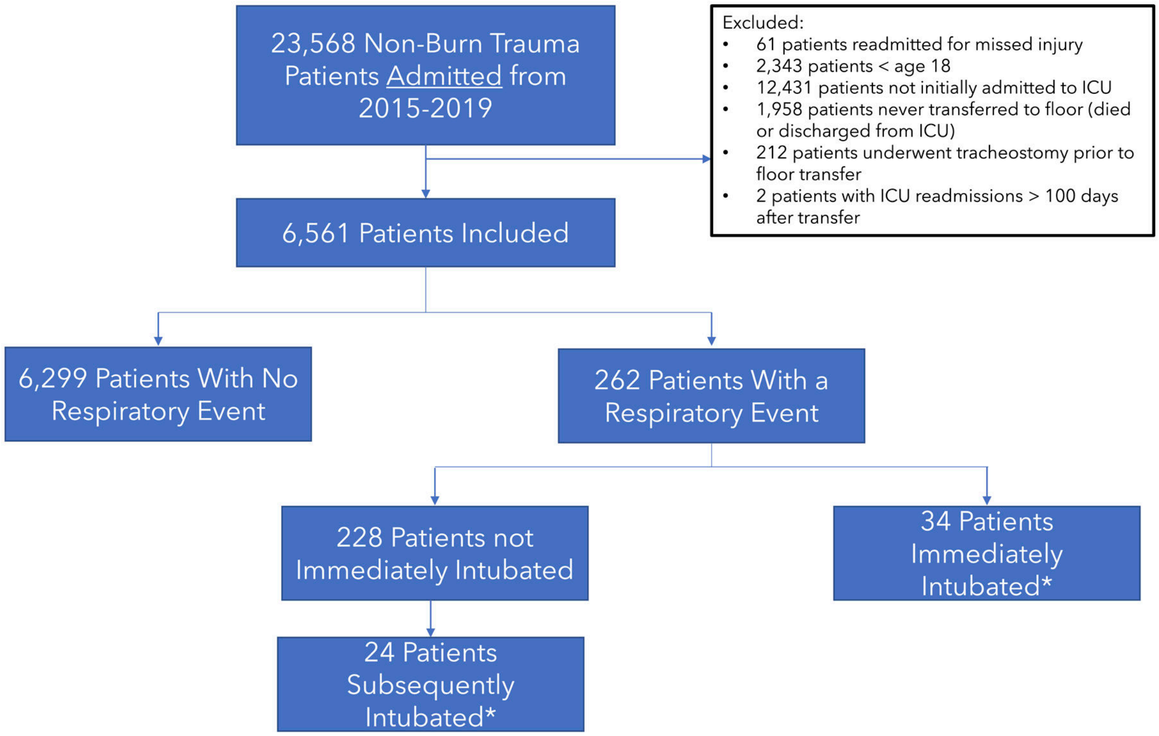

Figure 1:

Patient selection flow diagram

*Intubated for primary pulmonary causes

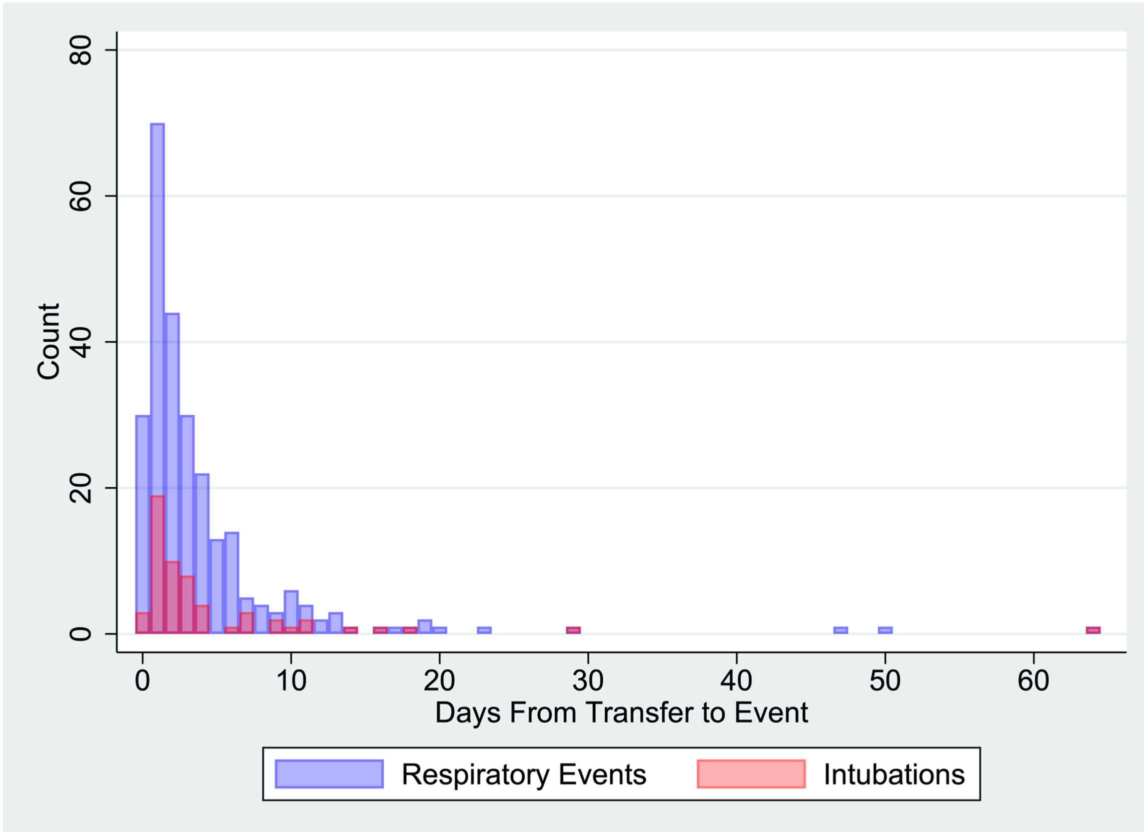

Figure 2:
Number of days from ICU transfer until first occurrence of a respiratory event and unplanned intubation for a pulmonary cause

Table 1:

Characteristics of the study cohort, as well as those experiencing and not experiencing a respiratory event and intubation for a primary pulmonary cause.

		Total	No Respiratory Event After Floor Transfer	Respiratory Event After Floor Transfer	p-value	No Unplanned Intubation for Pulmonary Cause	Unplanned Intubation for Pulmonary Cause	p-value
		N=6,561	N=6,299	N=262		N=6,503	N=58	
Age	Mean (SD)	52.3 (21.3)	52.0 (21.3)	59.9 (19.1)	<0.001	52.2 (21.3)	63.6 (15.7)	<0.001
Sex					0.004			0.59
	Male	4,535 (69.1%)	4,333 (68.8%)	202 (77.1%)		4,493 (69.1%)	42 (72.4%)	
	Female	2,026 (30.9%)	1,966 (31.2%)	60 (22.9%)		2,010 (30.9%)	16 (27.6%)	
Race					0.82			0.91
	White	5,153 (78.5%)	4,944 (78.5%)	209 (79.8%)		5,104 (78.5%)	49 (84.5%)	
	Black	501 (7.6%)	486 (7.7%)	15 (5.7%)		497 (7.6%)	4 (6.9%)	
	Asian	394 (6.0%)	380 (6.0%)	14 (5.3%)		392 (6.0%)	2 (3.4%)	
	Native American	207 (3.2%)	197 (3.1%)	10 (3.8%)		205 (3.2%)	2 (3.4%)	
	Pacific Islander	62 (0.9%)	60 (1.0%)	2 (0.8%)		62 (1.0%)	0 (0.0%)	
	Other	5 (0.1%)	5 (0.1%)	0 (0.0%)		5 (0.1%)	0 (0.0%)	
	Unknown	239 (3.6%)	227 (3.6%)	12 (4.6%)		238 (3.7%)	1 (1.7%)	
Ethnicity					0.45			0.37
	Non-Hispanic	5,856 (89.3%)	5,616 (89.2%)	240 (91.6%)		5,801 (89.2%)	55 (94.8%)	
	Hispanic	550 (8.4%)	533 (8.5%)	17 (6.5%)		548 (8.4%)	2 (3.4%)	
	Unknown	155 (2.4%)	150 (2.4%)	5 (1.9%)		154 (2.4%)	1 (1.7%)	
Penetrating Trauma		627 (9.6%)	603 (9.6%)	24 (9.2%)	0.82	623 (9.6%)	4 (6.9%)	0.49
Injury Mechanism					0.30			0.84
	Bicycle Crash	250 (3.8%)	238 (3.8%)	12 (4.6%)		248 (3.8%)	2 (3.4%)	
	Stab or Laceration	224 (3.4%)	213 (3.4%)	11 (4.2%)		223 (3.4%)	1 (1.7%)	
	Fall	2,355 (35.9%)	2,246 (35.7%)	109 (41.6%)		2,330 (35.8%)	25 (43.1%)	
	Firearm Injury	375 (5.7%)	362 (5.7%)	13 (5.0%)		372 (5.7%)	3 (5.2%)	

		Total	No Respiratory Event After Floor Transfer	Respiratory Event After Floor Transfer	p-value	No Unplanned Intubation for Pulmonary Cause	Unplanned Intubation for Pulmonary Cause	p-value
		N=6,561	N=6,299	N=262		N=6,503	N=58	
	Motor Vehicle Crash	2,175 (33.2%)	2,093 (33.2%)	82 (31.3%)		2,155 (33.1%)	20 (34.5%)	
	Pedestrian Struck by Vehicle	566 (8.6%)	549 (8.7%)	17 (6.5%)		562 (8.6%)	4 (6.9%)	
	Other	616 (9.4%)	598 (9.5%)	18 (6.9%)		613 (9.4%)	3 (5.2%)	
Injury and Clinical Characteristics								
Intubated at Time of Admission		2,033 (31.0%)	1,929 (30.6%)	104 (39.7%)	0.002	2,004 (30.8%)	29 (50.0%)	0.002
Massive Transfusion in First 24 Hours		117 (1.8%)	106 (1.7%)	11 (4.2%)	0.003	115 (1.8%)	2 (3.4%)	0.34
Total Length of Intubation During ICU Admission (Among those Intubated [hrs])	Median (IQR)	26.25 (12.9–66.6)	25.0 (12.6–64.9)	48.4 (21.0–102.9)	<0.001	25.6 (66.0–12.8)	66.4 (216.5–35.7)	<0.001
>=3 Rib Fx or Flail Chest		2,111 (32.2%)	1,987 (31.5%)	124 (47.3%)	<0.001	2,082 (32.0%)	29 (50.0%)	0.004
Pneumothorax or Hemothorax		1,967 (30.0%)	1,851 (29.4%)	116 (44.3%)	<0.001	1,944 (29.9%)	23 (39.7%)	0.11
Pulmonary Contusion or Laceration		1,296 (19.8%)	1,222 (19.4%)	74 (28.2%)	<0.001	1,277 (19.6%)	19 (32.8%)	0.012
Injury Severity Score					<0.001			0.010
	0–9	872 (13.3%)	857 (13.6%)	15 (5.7%)		869 (13.4%)	3 (5.2%)	
	10–16	1,491 (22.7%)	1,447 (23.0%)	44 (16.8%)		1,484 (22.8%)	7 (12.1%)	
	>16	4,183 (63.8%)	3,980 (63.2%)	203 (77.5%)		4,135 (63.6%)	48 (82.8%)	
	Missing	15 (0.2%)	15 (0.2%)	0 (0.0%)		15 (0.2%)	0 (0.0%)	
AIS Head Score	Median (IQR)	2.0 (0.0–3.0)	2.0 (0.0–3.0)	2.0 (0.0–4.0)	0.023	2.0 (0.0–3.0)	3.0 (0.0–4.0)	0.020
AIS Chest Score	Median (IQR)	2.0 (0.0–3.0)	2.0 (0.0–3.0)	3.0 (0.0–3.0)	<0.001	2.0 (0.0–3.0)	3.0 (1.0–4.0)	<0.001
AIS Abdomen Score	Median (IQR)	0.0 (0.0–2.0)	0.0 (0.0–2.0)	0.0 (0.0–2.0)	0.12	0.0 (0.0–2.0)	0.0 (0.0–2.0)	0.90
Surgical Procedures During Hospital Stay								
Exploratory Laparotomy		538 (8.2%)	510 (8.1%)	28 (10.7%)	0.13	533 (8.2%)	5 (8.6%)	0.91
Thoracotomy		88 (1.3%)	80 (1.3%)	8 (3.1%)	0.014	86 (1.3%)	2 (3.4%)	0.16
VATS		73 (1.1%)	62 (1.0%)	11 (4.2%)	<0.001	69 (1.1%)	4 (6.9%)	<0.001

		Total	No Respiratory Event After Floor Transfer	Respiratory Event After Floor Transfer	p-value	No Unplanned Intubation for Pulmonary Cause	Unplanned Intubation for Pulmonary Cause	p-value
		N=6,561	N=6,299	N=262		N=6,503	N=58	
Craniotomy		376 (5.7%)	341 (5.4%)	35 (13.4%)	<0.001	368 (5.7%)	8 (13.8%)	0.008
Comorbidities								
Smoker		1,520 (23.2%)	1,450 (23.0%)	70 (26.7%)	0.16	1,509 (23.2%)	11 (19.0%)	0.45
Alcohol Use		932 (14.2%)	881 (14.0%)	51 (19.5%)	0.013	917 (14.1%)	15 (25.9%)	0.011
Substance Use Disorder		599 (9.1%)	575 (9.1%)	24 (9.2%)	0.99	593 (9.1%)	6 (10.3%)	0.75
Anticoagulation Use		353 (5.4%)	334 (5.3%)	19 (7.3%)	0.17	347 (5.3%)	6 (10.3%)	0.092
Cirrhosis		120 (1.8%)	114 (1.8%)	6 (2.3%)	0.57	118 (1.8%)	2 (3.4%)	0.36
Chronic Obstructive Pulmonary Disease		358 (5.5%)	328 (5.2%)	30 (11.5%)	<0.001	349 (5.4%)	9 (15.5%)	<0.001
Dementia		271 (4.1%)	255 (4.0%)	16 (6.1%)	0.10	270 (4.2%)	1 (1.7%)	0.35
Diabetes		682 (10.4%)	636 (10.1%)	46 (17.6%)	<0.001	672 (10.3%)	10 (17.2%)	0.086
Congestive Heart Failure		283 (4.3%)	255 (4.0%)	28 (10.7%)	<0.001	276 (4.2%)	7 (12.1%)	0.003
Hypertension		1,889 (28.8%)	1,792 (28.4%)	97 (37.0%)	0.003	1,863 (28.6%)	26 (44.8%)	0.007
Peripheral Vascular Disease		36 (0.5%)	32 (0.5%)	4 (1.5%)	0.029	36 (0.6%)	0 (0.0%)	0.57
History of Myocardial Infarction		11 (0.2%)	11 (0.2%)	0 (0.0%)	0.50	11 (0.2%)	0 (0.0%)	0.75
Chronic Kidney Disease		37 (0.6%)	34 (0.5%)	3 (1.1%)	0.20	35 (0.5%)	2 (3.4%)	0.003
Steroid Use		101 (1.5%)	94 (1.5%)	7 (2.7%)	0.13	97 (1.5%)	4 (6.9%)	<0.001
Personality Disorder		463 (7.1%)	434 (6.9%)	29 (11.1%)	0.010	454 (7.0%)	9 (15.5%)	0.012
Bleeding Disorder		313 (4.8%)	292 (4.6%)	21 (8.0%)	0.012	310 (4.8%)	3 (5.2%)	0.89
Cancer		32 (0.5%)	28 (0.4%)	4 (1.5%)	0.014	31 (0.5%)	1 (1.7%)	0.17
Functionaly Dependent Status		509 (7.8%)	478 (7.6%)	31 (11.8%)	0.012	500 (7.7%)	9 (15.5%)	0.026

AIS = Abbreviated Injury Scale, SD = Standard Deviation, IQR = Interquartile Range, VATS = Video Assisted Thoracoscopic Surgery

Table 2:

In-hospital outcomes of patients who experienced a respiratory event or unplanned intubation for a primary pulmonary cause compared to those who did not

		Total	**No Respiratory Event After Floor Transfer**	**Respiratory Event After Floor Transfer**	**p-value**	**No Unplanned Intubation for Pulmonary Cause**	**Unplanned Intubation for Pulmonary Cause**	**p-value**
		N = 6,561	**N = 6,299**	**N = 262**		**N = 6,503**	**N = 58**	
Mortality		153 (2.3%)	111 (1.8%)	42 (16.0%)	<0.001	130 (2.0%)	23 (39.7%)	<0.001
Hospital Disposition (for those surviving to discharge)					0.015			<0.001
	Home	3466 (54.1%)	3384 (54.5%)	82 (41.4%)		3460 (54.3%)	6 (17.1%)	
	Home with Home Health	226 (3.5%)	220 (3.5%)	6 (3.0%)		224 (3.5%)	2 (5.7%)	
	Skilled Nursing Facility	1639 (25.6%)	1573 (25.3%)	66 (33.3%)		1626 (25.5%)	13 (37.1%)	
	LTAC/ Acute Care	672 (10.5%)	646 (10.4%)	26 (13.1%)		660 (10.4%)	12 (34.3%)	
	Hospice	20 (0.3%)	19 (0.3%)	1 (0.5%)		20 (0.3%)	0 (0.0%)	
	Other	376 (5.9%)	359 (5.8%)	17 (8.6%)		374 (5.9%)	2 (5.7%)	
	Unknown	9 (0.1%)	9 (0.1%)	0 (0.0%)		9 (0.1%)	0 (0.0%)	
Total LOS (days)	Median (IQR)	8.0 (4.0–15.0)	8.0 (4.0–15.0)	19.0 (11.0–35.0)	<0.001	8.0 (4.0–15.0)	30.0 (16.0–46.0)	<0.001
Total ICU LOS (days)	Median (IQR)	2.0 (1.0–4.0)	2.0 (1.0–4.0)	7.0 (3.0–14.0)	<0.001	2.0 (1.0–4.0)	16.0 (9.0–23.0)	<0.001
Any ICU Readmission		420 (6.4%)	300 (4.7%)	120 (52.6%)	<0.001	367 (5.6%)	58 (100%)	<0.001

LTAC = Long Term Acute Care, LOS = Length of Stay, IQR = Interquartile Range

Table 3:

Logistic regression model for outcome of respiratory event after transfer from the intensive care unit

Covariate		Odds Ratio	95% Confidence Interval	p-value
Age > 65 Years		1.68	(1.20, 2.36)	0.003
Male Sex		1.55	(1.14, 2.11)	0.005
Injury Mechanism				
	Bicycle Crash	Ref		
	Stab or Laceration	1.35	(0.56, 3.28)	0.506
	Fall	0.75	(0.39, 1.43)	0.381
	Firearm Injury	0.71	(0.31, 1.67)	0.438
	Motor Vehicle Crash	0.63	(0.33, 1.19)	0.157
	Pedestrian Struck by Vehicle	0.49	(0.22, 1.06)	0.07
	Other	0.64	(0.30, 1.37)	0.252
Functionally Dependent		1.46	(0.92, 2.32)	0.105
Smoker		1.33	(0.98, 1.81)	0.063
Alcohol Use		1.60	(1.14, 2.26)	0.007
Substance Use Disorder		1.03	(0.66, 1.61)	0.9
Anticoagulation Use		0.87	(0.51, 1.49)	0.616
Cirrhosis		0.94	(0.39, 2.22)	0.88
Chronic Obstructive Pulmonary Disease		1.72	(1.11, 2.65)	0.015
Dementia		1.31	(0.73, 2.34)	0.367
Congestive Heart Failure		2.16	(1.34, 3.49)	0.002
Diabetes		1.78	(1.24, 2.55)	0.002
Chronic Kidney Disease		1.70	(0.48, 5.94)	0.409
Steroid Use		1.21	(0.53, 2.75)	0.657
Injury Severity Score				
	0–9	Ref		
	10–16	1.51	(0.82, 2.77)	0.184
	>16	2.47	(1.39, 4.40)	0.002
	Missing	0.00	(0.00, 0.00)	0.991
AIS Head		1.04	(0.96, 1.13)	0.324
Intubated at Time of Admission		1.68	(1.25, 2.25)	0.001
>=3 Rib Fractures or Flail Chest Present		1.90	(1.40, 2.57)	<0.001
Pulmonary Contusion or Laceration Present		1.38	(1.00, 1.89)	0.051
Massive Transfusion in First 24 Hours		2.50	(1.28, 4.91)	0.008

AIS = Abbreviated Injury Scale