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Outcomes of traumatically injured patients after nighttime transfer from the intensive care unit

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ABSTRACT

Background Prior studies have associated nighttime transfer of patients from the intensive care unit (ICU) with increased morbidity. This study sought to examine this relationship in traumatically injured patients, as this has not been previously performed.

Methods A retrospective review of traumatically injured patients admitted to a Level I Trauma Center's ICU from January 2021 to September 2022 was performed. "Day shift" (DS) was defined as 07:00 to 19:00 and "night shift" (NS) as 19:01 to 06:59. The time of transfer completion was based on the time of the patient arrival at the destination unit. The univariate analysis compared patients with completed transfers during DS and NS. Multivariate logistic regression was performed to predict readmission to the ICU.

Results A total of 1,800 patients were included in the analysis, with 608 patients that had completed transfers during NS, and 1,192 during DS. Both groups were similar, with no significant differences in age, sex, Injury Severity Score (ISS), mechanism of injury, or median total comorbidities. The NS group had a longer median time to transfer completion (10.1 (IQR 5.5–13.6) hours vs 5.1 (IQR 2.9–8.4) hours; p<0.001). A significantly higher proportion of the NS group had a readmission to the ICU (60 (10.0%) vs 86 (7.0%); p=0.03) or a major complication (72 (11.9%) vs 107 (9.0%); p=0.048). When controlling for age, comorbidities, ISS, time to bed assignment and to transfer completed, and ICU length of stay, transfer completion during NS was associated with 1.56 times higher odds of having an ICU readmission (OR 1.56 (95% CI 1.05, 2.33); p=0.03).

Conclusions Trauma patients transferred from the ICU during NS experienced longer delays, readmission to the ICU, and major complications significantly more often. With increasing hospital bed shortages, patient transfers must be analyzed to minimize worsened outcomes, especially in traumatically injured patients.

Level of evidence Level III, therapeutic/care management.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Prior work has demonstrated increased morbidity and mortality for non-traumatically injured patients who were transferred from the intensive care unit (ICU) to the acute care floor at nighttime.

WHAT THIS STUDY ADDS

⇒ This study evaluates outcomes for trauma patients transferred from the ICU at nighttime compared with those whose transfer completion occurred during the day and demonstrates that nighttime transfer correlated with increased morbidity and mortality.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ With increasing hospital bed shortages across the country, patient transfers must be analyzed to minimize worsened outcomes despite the need for bed availability.

BACKGROUND

Unintentional injury is the leading cause of death in the USA for individuals between 1 and 44 years of age. In 2019, the estimated cost associated with injury in the USA was US$4.2 trillion, with US$327 billion associated with medical care.[1] After initial resuscitation, polytrauma patients require vigilant monitoring and ongoing treatment due to the extent and severity of their injuries.[2 3] One study demonstrated that 44.5% of traumatically injured patients required admission to the intensive care unit (ICU).[4] Individualized and focused care is often best delivered in the ICU where an emphasis can be placed on continued resuscitation, restoring homeostasis, close monitoring for missed injuries, and mitigation of the sequelae of injury or organ dysfunction.[5 6] Guidelines for initial admission to the ICU are well-described, with top priority given to patients requiring life support, in addition to patients requiring intensive monitoring or treatment of shock or severe hypoxemia.[7]

Even before the COVID-19 pandemic, ICU care was a valuable commodity. There is finite ICU bed availability and expensive resources are consumed to deliver adequate treatment and stabilize in a timely manner.[8] ICU care duration varies based on a number of factors including mechanism of trauma, pretrauma health conditions, patient age, and secondary effects or complications.[9] Discharge criteria for patients leaving the ICU differ among institutions, but it is recommended that institutions develop clear guidelines and criteria to prevent premature subjective judgments on discharge readiness in an effort to make beds available and curtail costs. These guidelines are recommended to be structured based on admission criteria, physiological status, patient prognosis, and ongoing need for treatment.[7] Patients leaving the ICU may be transferred to a different specialized ICU, a step-down bed, the general ward, or directly home. Delays in patient transfers out of the ICU are commonly due

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TSICU Transfer (out) Criteria

- Patients should be transferred out of the TSICU when they no longer require Surgical Critical Care (SCC) services
- Patients who meet criteria for transfer may remain in the TSICU if this is agreed to be in the patient's best interest after a discussion between the primary surgeon and the surgical intensivist
- Criteria for transfer out of the TSICU
    - Mechanical ventilation no longer needed (unless PCU)
        - If transferring to PCU, mechanical ventilation via tracheostomy with stable (> 24 hours), minimal PEEP (≤ 8 cm H2O)
    - Non-invasive positive pressure not required other than during sleep (OSA)
    - SpO2 ≥ 88% on FiO2 ≤ 50%
    - Frequency of airway clearance interventions no more than once every 4 hours
    - Absence of respiratory distress
    - Chest trauma patients
        - Incentive Spirometry > 50% age predicted (see nomogram Table 1)
            - 100% predicted nomogram provided for reference (Table 2)
        - If on lidocaine gtt, stop time must be > 12 hours **after physical transfer**
            - If < 12 hours, stop gtt at transfer decision time and ensure adequate, multimodal pain control
    - SBP ≥ 100 mmHg and ≤ 220 mmHg for > 24 hours
    - Heart rate between 50 and 110 bpm
    - Absence of change in condition over last 3 hours
        - Change in heart rate by > 20 bpm
        - Increase in respiratory rate by > 5 bpm
        - increase in oxygen requirement by > 2 lpm
    - No need for inotropes or vasopressors for > 24 hours
    - No need for > 2 L of IVF boluses or > 2 units PRBCs for > 24 hours
    - No evidence of hypoperfusion
        - Confusion
        - Cool, cyanotic extremities
        - Poor capillary refill
        - Metabolic acidosis
        - Poor urine output (if not an/olig-uric previously)
    - Stable GCS and seizures controlled (if present)
    - Neurologic checks less frequent than every hour
        - every 4 hours → any acute care floor
        - every 2 hours → 7 South only
    - Mental status that can be safely managed outside of the TSICU
    - No evidence of new, un-treated infection
        - New onset SIRS
    - No deterioration in renal function for > 24 hours
        - Increased creatinine ≥ 50 %
        - New onset an/olig-uria
    - REVIEW NECESSITY/APPROPRIATENESS OF BEERS MEDICATIONS (https://doi.org/10.1111/jgs.15767)

- ***These criteria are meant to assist transfer decisions and do NOT replace the clinical judgement of the SCC team***

Figure 1 Institutional standardized checklist of criteria for appropriateness of patient transfers from the trauma ICU. FiO2, fraction of inspired oxygen; GCS, Glasgow Coma Scale; ICU, intensive care unit; PCU, progressive care unit; SCC, surgical critical care; TSICU, trauma/surgical ICU; H2O, water; IVF, intravenous fluid; OSA, obstructive sleep apnea; PEEP, positive end expiratory pressure; PRBC, packed red blood cells; SBP, systolic blood pressure; SIRS, systemic inflammatory response syndrome; SPO2, oxygen saturation.

to a lack of available non-ICU beds and an increased hospital census.[10]

A systematic review of non-traumatically injured patients admitted to the ICU found that after-hours discharge of patients from the ICU was associated with higher rates of hospital mortality and readmission to the ICU.[11] A meta-analysis of non-traumatically injured patients composed of 14 studies from multiple countries demonstrated similar findings, in that nighttime ICU discharges were associated with higher in-hospital mortality rates.[12] A potential consequence of improper ICU discharge is unplanned readmission to the ICU, which is associated with higher in-hospitality mortality among traumatically injured patients. Further investigation of factors that contribute to ICU readmission, including time of discharge from the ICU is warranted.[13–15]

Previous studies demonstrate that non-traumatically injured patients with nighttime transfer out of the ICU have more frequent unplanned readmission to the ICU and increased morbidity and mortality. We studied this relationship in traumatically injured patients employing a retrospective cohort study of traumatically injured patients admitted to the ICU at a single institution. The primary outcome was unplanned readmission to the ICU, and secondary outcomes were hospital discharge disposition, in-hospital mortality, individual complications, and major complications. We hypothesized that those traumatically injured patients with completed transfers during the nighttime would more often experience unplanned readmissions to the ICU, in-hospital mortality, and develop more complications when compared with those with completed transfers during the daytime.

METHODS

A retrospective cohort study was performed of traumatically injured patients admitted to a Level I Trauma Center's ICU from January 2021 to September 2022 in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology statement and checklist (Supplemental Digital Content 1). This study period was chosen as a convenience sample. All patients admitted to the ICU trauma service during the study period who had a completed transfer to an acute care floor, stepdown unit, or other ICU were considered for inclusion. Patients were excluded if they died in the ICU, were discharged directly from the ICU, or had incomplete records for the study variables of interest. All variables were extracted from a prospectively maintained institutional trauma surgery quality improvement database and a prospectively maintained institutional patient transport database. Follow-up information included rehospitalization within at least 30 days.

Patients were divided into exposure groups based on the time of completed transfer from the ICU. Transfers were defined as "completed" when the patient arrived at their destination unit and bed. "Time to transfer completion" was defined as the time from when the transfer order was placed and initiated and when the patient arrived to their destination unit and bed. "Day shift" (DS) was defined as 07:00 to 19:00 and "night shift" (NS) as 19:01 to 06:59. This timing was chosen as it reflects the nursing staff changes at our institution at 07:00 and 19:00. The surgical critical care and trauma surgery attendings involved in the patient's care changes at 17:00 and 06:00, whereas the general surgery residents involved in the patient's care change at 06:00 daily. Time of transfer completion was based on the time of the patient arrival at the destination unit. The primary outcome was unplanned readmission to the ICU. Secondary outcomes included hospital discharge disposition, in-hospital mortality, individual complications, and major complications. "Major complications" were defined as death, unplanned visits to the operating room, unplanned intubation, or cardiac arrest with cardiopulmonary resuscitation. The studied institution uses standardized criteria for patient readiness for transfer from the ICU after multidisciplinary team review (figure 1), and includes verbal and written handoff between providers when transfer orders are placed and at the time of transfer completion, in addition to nursing handoff at the time of transfer completion. The multidisciplinary team consists of surgical critical care intensivists/trauma and acute care surgeons, general surgery residents, residents from other specialties, such as anesthesia and family medicine, pharmacists, nutritionists, respiratory therapists, and nursing staff. The trauma/surgical ICU (TSICU) houses all surgical patients who require ICU care, including patients with traumatic injuries. The trauma and acute care surgeons group manages all trauma/surgical patients whether in the ICU or on the acute care floor. The standardized criteria referenced in figure 1 apply to all patients to be transferred from the ICU under the trauma/surgical critical team's care.

A univariate analysis was conducted comparing patients with completed transfers during DS and NS. No imputation methods were used to find missing values in any variables. All continuous variables were found to have a non-normal distribution; thus, a Mann-Whitney U test was used to compare between-group differences. A χ^2 or Fisher's exact test was used for all categorical variables. To account for potential bias and confounding in our sample, a backward stepwise multivariable logistic regression model was conducted predicting unplanned readmission to the ICU after fit was assessed with the Hosmer and Lemeshow goodness-of-fit test. The initial model for the regression included all non-colinear covariates with a p value of less than 0.15 when observations were grouped based on an unplanned readmission to the ICU. Covariates were then removed based on p value; however, the timing of transfer completion was forced into the model. All analyses were conducted with SAS (V.9.4 (TS1M70); SAS Institute, Cary, North Carolina, USA). Statistical significance was assumed at an alpha value of 0.05.

RESULTS

Of the 1,800 patients included in the analysis, 608 patients had completed transfers during NS, and 1,192 during DS. Transfer orders were placed and initiated during the DS in 1,608 (89.3%) patients, whereas 192 (10.7%) had transfer orders initiated during the NS hours. The NS and DS groups were similar with no significant differences in age, sex, Injury Severity Score (ISS), mechanism of injury, comorbidities, median total number of comorbidities, or initial emergency department disposition (table 1). The most common mechanisms of injury for both groups were motor vehicle collisions and falls under 1 m (table 1). The most common comorbidities for both groups were hypertension, diabetes mellitus, functionally dependent health status, anticoagulation use, chronic obstructive pulmonary disease, current smoking status, and chronic renal failure (table 1).

There was a significant difference in the hospital discharge disposition, with a higher proportion of NS patients discharged to a long-term care facility (21 (3.5%) vs 13 (1.1%); p=0.02), and with in-hospital mortality (40 (6.6%) vs 62 (5.2%); p=0.02), whereas a higher proportion of DS patients were discharged with hospice (25 (2.1%) vs 5 (0.8%); p=0.02) or home with services (209 (17.6%) vs 8 (14.6%); p=0.02). The most common

Table 1 Comparison of patients with completed transfers from the intensive care unit during night shift and day shift

Variable	Night shift (n=608)	Day shift (n=1192)	P value
Age (years)*	61 (42.0–77.0)	63 (41.0–77.0)	0.44
Sex			
Female	235 (39.0%)	496 (41.6%)	0.28
Male	373 (61%)	696 (58.4%)	
Injury Severity Score*	17 (11.0–25.0)	17 (11.0–24.0)	0.18
Mechanism of injury			0.44
Fall	273 (44.9%)	528 (44.3%)	
Motorized vehicle collision	222 (36.5%)	491 (41.2%)	
Other blunt	59 (9.7%)	93 (7.8%)	
Penetrating	47 (7.7%)	77 (6.5%)	
Unknown	7 (1.2%)	3 (0.2%)	
Comorbidities			
Hypertension	286 (47.4%)	606 (50.8%)	0.17
Diabetes mellitus	129 (21.4%)	234 (19.6%)	0.38
Functionally dependent health status	132 (21.9%)	223 (19.7%)	0.11
Dementia	57 (9.5%)	95 (8.0%)	0.29
Heart failure	30 (5.0%)	67 (5.6%)	0.57
Stroke	17 (2.8%)	34 (2.9%)	0.97
Anticoagulant	132 (21.9%)	248 (20.8%)	0.60
Chronic obstructive pulmonary disease	92 (15.3%)	168 (14.1%)	0.51
Mental health disorder	50 (8.3%)	91 (7.6%)	0.62
Current smoker	172 (28.5%)	360 (30.2%)	0.46
Steroid use	7 (1.2%)	9 (0.8%)	0.39
Advance directive limiting care	29 (4.8%)	45 (3.8%)	0.30
Alcohol use disorder	16 (2.7%)	43 (3.6%)	0.28
Chronic renal failure	97 (16.1%)	178 (14.9%)	0.52
Peripheral artery disease	17 (2.8%)	28 (2.4%)	0.55
Angina	3 (0.5%)	1 (0.1%)	0.11
Myocardial infarction	37 (6.1%)	64 (5.4%)	0.51
Cirrhosis	14 (2.3%)	29 (2.4%)	0.88
Bleeding disorder	13 (2.2%)	17 (1.4%)	0.25
Currently receiving chemotherapy	9 (1.5%)	9 (0.8%)	0.14
Disseminated cancer	9 (1.5%)	9 (0.8%)	0.14
Substance use disorder	21 (3.5%)	41 (3.4%)	0.96
Congenital anomalies	5 (0.8%)	4 (0.3%)	0.17
Attention deficit disorder	9 (1.5%)	12 (1.0%)	0.37
Pregnancy	1 (0.2%)	4 (0.3%)	0.67
Unknown	6 (1.0%)	15 (1.3%)	0.62
Total of comorbidities*	2 (1.0–4.0)	2 (1.0–3.0)	0.45
Initial emergency department disposition			0.06
Intensive care unit	467 (77.5%)	934 (78.4%)	
Floor	23 (3.8%)	72 (6.0%)	
Operating room	91 (15.0%)	140 (11.7%)	
Interventional radiology	22 (3.7%)	46 (3.9%)	
Hospital discharge disposition			**0.02**
Home to self-care	274 (45.4%)	516 (43.3%)	
Rehabilitation facility	48 (7.95)	89 (7.5%)	
Skilled nursing facility	110 (18.2%)	232 (19.5%)	
Long-term care facility	21 (3.5%)	13 (1.1%)	
Left against medical advice	7 (1.2%)	19 (1.6%)	
In-hospital mortality	40 (6.6%)	62 (5.2%)	
Correctional facility	6 (1.0%)	17 (1.4%)	
Home with services	8 (14.6%)	209 (17.6%)	
Hospice	5 (0.8%)	25 (2.1%)	
Intermediate care facility	1 (0.2%)	1 (0.1%)	
Mental health/psychiatric hospital	3 (0.5%)	5 (0.4%)	

Continued

Table 1 Continued

Variable	Night shift (n=608)	Day shift (n=1192)	P value
Transfer destination to progressive care unit	44 (7.3%)	54 (4.5%)	**0.01**
Transfer destination to floor	510 (84.6%)	1076 (90.3%)	**<0.001**
Transfer destination to other intensive care unit	49 (8.1%)	62 (5.2%)	**0.02**
Time from requested transfer to bed assignment (hours)*	3.7 (0.4–8.9)	1.3 (0.2–4.5)	**<0.001**
Time from requested transfer to transfer complete (hours)*	10.1 (5.5–13.6)	5.1 (2.9–8.4)	**<0.001**

Bold indicates statistical significance p<0.05.
*Denotes value expressed as median (25th and 75th IQR).

discharge disposition in both groups was home to self-care (274 (45.4%) NS vs 516 (43.3%) DS; p=0.02). A significantly higher proportion of NS patients were transferred from the ICU to the progressive care (step-down) unit (44 (7.3%) vs 54 (4.5%); p=0.01), and to another ICU (49 (8.1%) vs 62 (5.2%); p=0.02). A significantly higher proportion of DS patients were initially transferred to the floor from the ICU (1,076 (90.3%) vs 510 (84.6%); p<0.001). The NS group had a longer median time to bed assignment (3.7 (IQR 0.4–8.9) hours vs 1.3 (IQR 0.2–4.5) hours; p<0.001), and longer median time to transfer completion (10.1 (IQR 5.5–13.6) hours vs 5.1 (IQR 2.9–8.4) hours; p<0.001).

Complications after completed transfer from the ICU were compared between the NS and DS groups (table 2). A significantly higher proportion of the NS group had an unplanned readmission to the ICU (60 (10.0%) vs 86 (7.0%); p=0.03). There was no significant difference in the proportion of unplanned intubations among groups. There was no significant difference in individual complications among groups, but the NS group had a significantly higher proportion of major complications (72 (11.9%) vs 107 (9.0%); p=0.048).

Table 2 Comparison of complications after completed transfer from the intensive care unit during night shift and day shift

Variable	Night shift (n=608)	Day shift (n=1192)	P value
Unplanned readmission to the intensive care unit	60 (10.0%)	86 (7.0%)	**0.03**
Unplanned intubation	28 (4.6%)	40 (3.4%)	0.18
Complications			
Stroke	3 (0.5%)	7 (0.6%)	>0.99
Cardiac arrest with cardiopulmonary resuscitation	4 (0.7%)	8 (0.7%)	>0.99
Unplanned operating room trip	18 (3.0%)	22 (1.9%)	0.12
Deep vein thrombosis	5 (0.8%)	17 (1.4%)	0.28
Pulmonary embolism	8 (1.3%)	7 (0.6%)	0.10
Myocardial infarction	4 (0.7%)	10 (0.8%)	0.78
Postoperative hemorrhage	0 (0.0%)	1 (0.1%)	>0.99
Acute kidney injury	5 (0.8%)	10 (0.8%)	0.98
Acute respiratory distress syndrome	3 (0.5%)	5 (0.4%)	>0.99
Catheter-related urinary tract infection	2 (0.3%)	4 (0.3%)	>0.99
Catheter-related blood stream infection	1 (0.2%)	1 (0.1%)	>0.99
Alcohol withdrawal syndrome	7 (1.2%)	17 (1.4%)	0.64
Readmission to hospital	26 (4.3%)	40 (3.4%)	0.31
Major complication	72 (11.9%)	107 (9.0%)	**0.048**

Major complications defined as: Death, unplanned visit to the operating room, unplanned intubation, or cardiac arrest with cardiopulmonary resuscitation.
Bold indicates statistical significance, p<0.05.

A backward stepwise multivariable logistic regression model predicting unplanned readmission to the ICU after the transfer was performed (table 3). When controlling for age, comorbidities, ISS, time to bed assignment and to transfer completed, and ICU length of stay, transfer completion during NS was associated with 1.56 times higher odds of having an unplanned ICU readmission (OR 1.56 (95% CI 1.05, 2.33); p=0.03). Increasing age was significantly associated with 1.02 times higher odds of unplanned readmission to the ICU (OR 1.02 (95% CI 1.01, 1.03); p=0.001), whereas alcohol use disorder was significantly associated with 2.79 times higher odds (OR 2.79 (95% CI 1.23, 6.33); p=0.02), and increasing ICU length of stay was significantly associated with 1.20 times higher odds (OR 1.20 (95% CI 1.16, 1.24); p<0.001).

DISCUSSION

We found that trauma patients transferred from the ICU at night had worsened outcomes, similar to non-traumatically injured patients reported in the literature. With the continued concern for the limited availability of ICU beds and high associated costs, safe and timely transfer of patients from the ICU is necessary, however, we must not do so at the expense of worsened outcomes for current ICU patients.

This study retrospectively examined 1,800 traumatically injured patients admitted to the ICU of a Level I Trauma Center, of which 608 ultimately had a transfer from the ICU completed during the "night shift" (NS), and 1,192 had a transfer completed during the "day shift" (DS). Both groups were similar, with no significant differences in age, sex, ISS, mechanism of injury, comorbidities, median total number of comorbidities, or initial emergency department disposition. The most common mechanisms of injury and comorbidities among both groups were similar to those reported in previous studies and nationally. This study found that those patients who had transfers from the ICU completed during the NS had worsened outcomes when compared with those who had transfers completed during the DS despite being similarly matched cohorts.

The NS group had a significantly longer median time from requested transfer to bed assignment, as well as time from requested transfer to transfer completion. The studied institution's trauma surgical critical care workflow consists of daily morning multidisciplinary review and examination to deem appropriateness for transfer from the ICU using standardized criteria (figure 1). Once deemed appropriate, a transfer order is placed and the corresponding bed in the selected unit is sought and arranged for with written and verbal handoff performed. Patient transfer orders are not routinely placed outside DS hours, with only 10.7% of our patients having transfer orders

Table 3 Backwards stepwise multivariable logistic regression model predicting for unplanned readmission to the intensive care unit after transfer

Variable	Estimate	SE	OR	95% CI	P value
Intercept	−3.93	0.50	--	--	**<0.001**
Age	0.02	0.01	1.02	1.01, 1.03	**0.001**
Diabetes mellitus	−0.49	0.25	0.62	0.38, 1.01	0.05
Functionally dependent health status	0.25	0.24	1.29	0.80, 2.05	0.29
Chronic obstructive pulmonary disease	−0.28	0.82	0.76	0.15, 3.78	0.74
Alcohol use disorder	1.02	0.42	2.79	1.23, 6.33	**0.02**
Chronic renal failure	0.81	0.80	2.24	0.46, 10.81	0.32
Injury Severity Score	−0.02	0.01	0.98	0.96, 1.00	0.06
Intensive care unit length of stay	0.18	0.02	1.20	1.16, 1.24	**<0.001**
Time from requested transfer to bed assignment	0.03	0.04	1.03	0.95, 1.11	0.46
Time from requested transfer to transfer completion	−0.04	0.04	0.96	0.89, 1.03	0.25
Transfer completed during night shift	−0.45	0.20	1.56	1.05, 2.33	**0.03**

All ORs expressed as predictors of unplanned readmission to the intensive care unit.
$\beta=0$ $p<0.0001$, Hosmer and Lemeshow goodness-of-fit p=0.42.
Bold indicates statistical significance, p<0.05.

initiated during the NS. This means that the NS cohort represents patients who had significant delays due to bed availability. The finding that patients who arrived in their destination unit during NS had significantly longer times to bed assignment and transfer completion when compared with DS corresponds to these delays caused by the lack of bed availability. Anecdotally, the hospital census reported by the administration during the study period was 100% occupancy.

The NS group also had a significantly higher proportion of patients transferred to the progressive care (step-down) unit or to another ICU, which also corresponds with further delays in transfer as these beds are more limited than floor (general ward) beds. Reasons for transfer to the progressive care unit include the presence of a tracheostomy, which may portend these patients to have higher risk of readmission to the ICU. Transfers between ICUs (lateral transfers) were completed to move patients who were initially admitted to other specialty ICUs (cardiovascular ICU, neurocritical care, medical critical care) due to unavailable TSICU beds. Patients that were transferred between ICUs is most commonly due to a lack of available TSICU beds at admission; this was more frequent during COVID as all the ICUs were at capacity. Delays due to lack of bed availability are not unique to this studied institution, as previous literature has demonstrated that delays in patient transfer out of the ICU are commonly due to a lack of available beds and an increased hospital census.[10] Delays are not only costly but also limit access for new ICU admissions.[16,17] One study found that avoidable discharge delays out of the ICU accounted for 12.8% of ICU days and 6.4% of total ICU costs.[18] The most common cause of delay was due to lack of an available ward bed and 70.3% of patients being discharged to the general wards experienced an avoidable delay.[18] Delays were positively associated with the global hospital census. The median delay was 7 hours, but approximately 25% of patients experienced a delay of over 24 hours.[18] An additional study demonstrated similar findings with delays out of the surgical ICU costing an excess of US$21,547 a week, with the majority of delays attributed to the unavailability of ward beds.[10]

A significantly higher proportion of the NS cohort had an unplanned readmission to the ICU or developed a major complication when compared with the DS group on univariable analysis. The NS group also had a significantly higher proportion of patients who died during their hospitalization, with an in-hospital mortality rate of 6.6% compared with the 5.2% seen in the DS group. This finding coincides with the significantly higher proportion of unplanned readmissions to the ICU, and higher proportions of the development of major complications among the NS group. The significantly higher proportions of in-hospital mortality, unplanned readmissions to the ICU, and major complications seen in the NS cohort are consistent with previous studies of non-traumatically injured patients.[11,12,19,20] Multivariable logistic regression analysis predicting unplanned readmission to the ICU after transfer whereas controlling for age, comorbidities, ISS, time to bed assignment and to transfer completed, and ICU length of stay was performed demonstrating higher odds of unplanned ICU readmission with increasing age, alcohol use disorder, and increased ICU length of stay. The findings of increasing age, alcohol use disorder, and increased ICU length of stay being significantly associated with higher odds of unplanned readmission to the ICU is not unexpected, as these are known risk factors for developing need for readmission to the ICU.[21–23]

The multivariable analysis findings also suggest that transfer completion during NS is an independent predictor of unplanned readmission to the ICU. Unplanned ICU readmission is a major complication among trauma patients and is associated with higher in-hospital mortality as previously discussed.[13–15] Numerous practices have been identified that may be protective during ICU transfer. The studied institution abides by current recommendations, including a standardized process of transfer criteria (figure 1), and performance of both verbal and written reports, as studies have suggested this may have a positive effect on outcomes after transfer from the ICU.[7,24,25] Despite this, transfers occurring at night are more difficult because of staffing differences, changes in nursing roles, reduced familiarity with patient conditions, limited resources, potential provider fatigue, and communication challenges. Night staff work to provide their patients with safe and comfortable environments to rest, but in doing so have less direct interactions with their patients. As a result, night shift nurses have more indirect patient care responsibilities than direct.[26] The transfer of patients to lower acuity units with nighttime staff less familiar with their patients due to decreased direct involvement, and with fewer ancillary resources at their disposal, may contribute to the poorer outcomes found. This is especially true in typically complex traumatically injured patients with multiple injured organ systems. Transfers from the ICU require a multidisciplinary approach and nursing interventions are essential in the process.[27]

A study of traumatically injured patients found that delay in transfer out of the ICU was protective against unplanned ICU readmission.[28] This study hypothesized that the extended care these patients received by the ICU team although awaiting transfer accounted for the beneficial outcomes, but they did not evaluate the time of day that the transfer occurred. These findings suggest that delay of transfer may mitigate the worsened outcomes found in this study. Patients with significant delays resulting in transfer to their destination unit to be completed during the nighttime could benefit from a hold on transfer until it can be completed during the daytime. As there is a high associated cost with additional days of ICU care, as well as implications in causing ICU bed scarcity for new admissions, further study is certainly needed prior to recommending this practice.

This study has several limitations, including its retrospective and single-institution nature. All data was collected from prospectively maintained institutional databases, and an additional individual electronic medical record chart review was not performed. A major limitation of the study was the lack of granular detail for the timing of patient complications in relation to their transfer, as well as the inclusion of patients who had multiple ICU admissions and transfer completions during their stay. As this was a retrospective analysis using a prospective database, we are only able to analyze that a patient had a complication or readmission to the ICU during their hospitalization, but not the specifics surrounding those events. As the study was performed at a single institution, these findings may not be replicable in a different system with different resources. Follow-up after discharge from the hospital was not included beyond accounting for readmissions to the hospital within at least 30 days and should be considered in future research. The period of study coincides with the COVID-19 pandemic, which has caused significant stress on hospital systems throughout the world, and likely contributed to increased delays due to the resulting lack of bed availability.

Traumatically injured patients transferred from the ICU who arrived at their destination unit during the nighttime experienced longer delays, unplanned readmission to the ICU, and major complications, including in-hospital mortality significantly more often. Completed transfers during the nighttime were an independent predictor of unplanned readmission to the ICU. With increasing hospital bed shortages across the country, patient transfers must be analyzed to minimize worsened outcomes, especially for at-risk populations.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by University of Tennessee Medical Center Knoxville Institutional Review Board #4956. All data variables were extracted from a prospectively maintained trauma surgery quality improvement database. All data extracted was de-identified prior to our review.

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