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ICU Bounce Back in Trauma Patients: An Analysis of Unplanned Returns to the Intensive Care Unit

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Abstract

Background—Discharging patients from the intensive care unit (ICU) often requires complex decision making to balance patient needs with available resources. Unplanned return to the ICU (“bounce back”, BB) has been associated with increased resource utilization and worse outcomes but few data on trauma patients are available. The goal of this study was to review ICU BB and define ICU discharge variables that may be predictive of BB.

Methods—Adults admitted to ICU and discharged alive to a ward from 11/18/04 to 9/01/09 (interval with no changes in coverage) were selected from our trauma registry. Patients with unplanned return to ICU (BB cases) were matched 1:2 with controls on age, ISS and duration of post-ICU stay. Data were collected by chart review then analyzed with univariate and conditional multivariate techniques.

Results—1971 of 8835 hospital admissions (22.3%) were discharged alive from ICU to a ward. 88 patients (4.5%) met our criteria for BB (male 75%, mean age 52.9 + 21.9, mean ISS 23.1 + 10.2). Most (71.6%) occurred within 72 hours. Mortality for BB cases was high (19.3%). Regression analysis showed that male gender (Odds Ratio 2.9, $p=0.01$), GCS<9 (Odds Ratio 22.3, $p<0.01$), discharge during day shift (Odds Ratio 6.9, $p<0.0001$) and presence of one (Odds Ratio 3.5, $p=0.03$), two (Odds Ratio 3.8, $p=0.03$) or three or more co-morbidities (Odds Ratio 8.4, $p<0.001$) were predictive of BB.

Conclusion—In this study, BB rate was 4.8% and associated mortality was 19.3%. At the time of ICU discharge, male gender, a GCS <9, higher FiO₂, discharge on day shift and presence of

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one or more co-morbidities were the strongest predictors of BB. A multi-institutional study is needed to validate and extend these results.

Keywords

Unplanned return; Bounce back; ICU; trauma

Background

Discharging patients from the intensive care unit (ICU) often requires complex decision making to balance patient needs with available resources and avoid unplanned readmission to the ICU (“Bounce Back”). Unplanned readmission to the ICU is associated with significant hospital mortality compared to non-readmitted patients: 21.3 to 40% compared to 3.6 to 8.4% (1–9). Odds of death remain six to seven times higher among readmitted patients independent of other factors (3). Unplanned readmission is associated with up to two-fold longer hospital length-of-stay (LOS) (2, 3, 5, 10), which can affect ICU-bed availability. Identifying patients at risk for readmission may prevent worse outcomes and allow better use of resources. Physicians may experience administrative pressure to discharge patients from ICU resulting in patients being discharged “quicker and sicker” (11). This led the Society of Critical Care Medicine to consider readmission rate to the ICU an index of quality of care (12).

The decision to discharge a patient from the ICU is heavily dependent on the physician’s clinical sense and judgment. Several studies have demonstrated inconsistent risk factors (1–5, 13–21) and physiologic scores (1, 2, 5, 7, 13, 16, 22, 23) associated with unplanned readmissions although few have targeted trauma patients (23). The primary goal of this study was to determine variables placing trauma patients at high risk for readmission to the ICU, including patient demographic, clinical variables and hospital factors at the time of ICU discharge. Secondary goals were to determine the percent of unexpected readmission and mortality within a week of discharge from the ICU, and characterize the reasons for readmission or mortality. Identifying variables associated with increased risk of “bounce back” may allow clinicians to modify risk factors and/or ensure that higher risk patients receive appropriate levels of monitoring and nursing care.

Methods

A retrospective review of our institution’s trauma registry was conducted for all trauma admissions 15 years and older admitted to an ICU between 11/18/2004 and 9/1/2009. Of 8835 hospital admissions, 1971 (22.3%) were admitted to an ICU and later discharged alive to a ward. One hundred sixty-two (8.2 %) patients returned to and/or died after leaving the ICU. Unplanned readmissions (or ICU discharge failures) were defined as patients discharged from ICU to a ward who, within seven days of ICU discharge, had an unplanned return to the ICU or died unexpectedly. No changes in the faculty on the surgical critical care service occurred during this time.

Demographic and discharge data were obtained from our administrative discharge and trauma registry data bases. Additional data were manually abstracted from the medical

records of potential cases using an on-line abstraction form. Surgeries that occurred after ICU discharge, emergency medical response team mobilization, and reasons for return to ICU were noted. All returns and deaths were independently reviewed by 2 trauma surgeons (SMF, SL), and the reason for return or death was verified, with additional abstraction if needed. Excluded as cases (or controls) were those whose only ICU return was the result of a planned surgery, whose death or ICU return was seven or more days after ICU discharge, and/or whose death after ICU discharge was anticipated (i.e. had 'do not resuscitate' orders). Seventy-four of the 162 ICU returns/deaths were thus excluded, for an ICU return rate within our defined parameters of 4.5% (88/1971).

Cases were matched in a 1:2 ratio to controls also discharged from an ICU to the ward by age (within 5 years) and category of injury severity score (ISS) (1–8, 9–24, or 25+), and with the stipulation that the time to outcome (i.e. number of days from ICU discharge to discharge from hospital) was equal to or longer than for its matched case (i.e. number of days from ICU discharge to ICU return and/or death). We chose to match on age and severity since increasing age has been shown to be an independent risk factor for readmission, (8–10) and increased post-ICU mortality (7, 14, 24, 25), with one study quantifying the risk as mortality increasing 4% for each year of age (6). Severity of injury is also associated with readmission to the ICU and increased mortality (22, 24, 26). Of the 88 cases, 86 matched to two controls and 2 matched to only 1 control, for a total of 164 controls.

Discharge International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) and Diagnosis-Related Group (DRG) codes were used to create comorbid disease groupings (none, one, two, three or more) using the Agency for Healthcare Research and Quality (AHRQ) Comorbidity Software, versions 3.0–3.5 (27). Race was categorized as 'white' or 'nonwhite'; GCS was grouped into three categories: mild (13–15), moderate (9–12), and severe (<9). In five instances, arterial bicarbonate was substituted for a missing venous bicarbonate value. Insurance payers were categorized as 'private' (commercial insurance, Champus, or workmen's compensation), 'indigent' (Medicaid, other low income program, or self-pay), and Medicare. Since pulse oxygenation values had a small range (92–100%) and are naturally skewed they were categorized. The same abstraction and review was conducted for the controls.

Analyses were done using SAS version 9.2 (SAS Institute: Cary, NC). The study was approved by the Institutional Review Board of the Medical University of South Carolina. Primary reasons for ICU discharge failure were identified, categorized and graphed. Outcome variable was return to ICU or death within seven days of ICU discharge. Continuous independent variables in which values tended to group (i.e. oxygen saturation), or which are traditionally grouped (i.e. GCS), were categorized. Imputed values were used for five patients missing insurance payer (most common payer group for each patient's gender, age group, and race group), two missing race (most common race group for each patient's gender, age group, and payer group), and one heart rate (mean value for other control patients with same age group, gender, race group, ISS group, and heart rhythm). The group discharged on night shift was small with a larger proportion in the control group, similar to the evening shift discharges, so night and evening shift discharges were combined

for the regression model. Descriptive statistics (proportions, mean with standard deviation, and median with 25th and 75th percentiles, respectively, for categorical, normally distributed continuous, and non-normally distributed variables) were calculated for potential predictor variables, days to return to ICU were graphed, and each variable was entered in a univariate conditional logistic regression with the outcome of ICU discharge failure. Continuous variables were tested for normality to ensure linearity between the outcome and the independent variables, which prevails if the variable is normally distributed. When departure from normality was found, log transformation was attempted. Variables with a univariate p -value of less than 0.25 were entered into a multivariate conditional logistic regression, to create a full model. Using stepwise selection modeling, variables were entered at $p=0.25$ and retained at $p=0.05$. Subsequently, each variable removed in the backward selection was individually added back to assess its effect on the model to examine its impact on the overall model.

Results

The rate of ICU discharge failure was 4.5% (88/1971), with little variation by year. In the 88 cases, ages ranged from 15 to 91 years (mean = 52.9) and mean total ISS score was 23.1. There were 174 controls, also ranging from 15 to 91 years (mean = 52.5), with a mean total ISS score of 22.0. Descriptive statistics of potential predictor variables for cases and controls are in Table 1, along with the significance of the association of each variable with the outcome of ICU discharge failure using univariate conditional logistic regression. Cases were significantly more likely to be male, to be discharged from the ICU during the day shift (7 am to 5 pm), to have a moderate or severe GCS prior to discharge to the floor, to have a higher average respiratory rate and fraction of inspired oxygen, and lower average P/F ratio, and to have a higher average BUN prior to discharge. The time to return to ICU or death after ICU discharge is shown in Table 2. Most ICU discharge failures occurred early, within 72 hours (71.6%) If there was more than one reason for failure, the one considered the primary driver was chosen. Reasons were categorized as respiratory (n=38), bleeding (n=13, includes intracranial bleeding), cardiovascular (n=9), neurologic (n=8), non-respiratory infection (n=7), pulmonary embolism (n=6), and other (n=7). The most common complication, respiratory, most often occurred early, within 48 hours after leaving the ICU. The second most common complication, bleeding, most often occurred after 48 hours.

Seventeen of the 88 cases died (19.3%). Six died within the first seven days after ICU discharge; the remainder died as late as 99 days after. Variables entered in the full multivariate model included gender, comorbidity, discharge shift, GCS group, mechanism of injury, heart rhythm, respiratory rate, fraction of inspired oxygen, heart rate, systolic blood pressure, log of platelets and BUN. Log of creatinine was entered in lieu of BUN since the variables were correlated (Spearman rho = 0.44), but there was no difference in variables selected for the final model. Heart rate was entered as increments of 10 beats per minute. While P/F ratio showed a significant relationship with outcome, it was removed from further analyses due to 27% missingness. Gender, GCS group, discharge shift, comorbidity, and heart rate were significantly associated with discharge failure ($p<0.05$) in multivariate conditional logistic regression (Table 3). Log of fraction of inspired oxygen approached significance when added back to the model (p -value=0.07) but there was little change to the

model so it was not retained. None of the other initial model variables, when added back into the model, strongly affected the model and also were not retained. Log transformation of some of the continuous variables led closer to normality, but with none of the variables did it change the results of the regression. Therefore, the original scale of the variables was used for convenience of interpretation. The final model was significant with a likelihood ratio p-value of <0.0001 , appeared to have a good fit, and had no evidence of multicollinearity or influential outlying values. Independent variable interactions, as well as interactions with the matched variables, were tested and none were significant. The final model excluded one patient due to missing GCS). Male sex, severe versus mild GCS on initial day of ICU discharge, being initially discharged from the ICU during the day versus during the evening or night, increasing heart rate, and having 1 or more comorbidities versus none were all related to ICU discharge failure ($p<0.05$). Specifically, the odds of a male returning to the ICU were almost 3 times higher than for females. The odds of returning to the ICU were 22 times higher for patients with a severe GCS compared to the odds of those with mild. There was no significant difference in outcome between those with moderate and mild GCS. For those discharged during the day the odds were almost 7 times greater for return to the ICU than the odds of those discharged later in the evening or night. Patients were increasingly likely to return to the ICU with increasing number of comorbid conditions. The odds of returning to the ICU increased 1.3 times for each 10 beat per minute increase in a patient's heart rate.

Discussion

In this cohort of adult trauma patients, the ICU “bounce back” rate was 4.5%. Most failed ICU discharge relatively quickly (within 72 hours). Factors associated with “bounce back” included physiologic (severity of injury, heart rate, number of comorbidities, and possibly oxygenation), demographic (gender), and hospital-related (discharge shift) factors. Patients failed ICU discharge due most commonly to either respiratory complications or bleeding. Male gender was significantly associated with higher ICU discharge failure rates, as was the case in some (9, 10, 25, 28); but not the majority of studies (1, 2, 4, 6, 8, 13, 16, 19, 21, 23, 24, 29). Other demographic variables, race and insurance payer, were not related to readmission.

Studies vary in their definition of ICU readmission. While most studies define it as an unplanned admission to the ICU within 48 hours of discharge (3, 5, 6), definitions range from 3 to 30 days (4, 6, 26, 29). This may partly explain the discrepancy in reported readmission rates, from 0.89% to 19% (1–5, 7, 9, 13–16, 18, 22, 29). However, lower percentages do not necessarily infer better quality of care. Two studies have suggested that lower readmission rates might actually reflect longer initial ICU stays (3, 30), predisposing patients to infections (31, 32) and increased costs. In our population, using a cut-off of 48 hours from ICU discharge would have captured only 51% of the ICU discharge failures. Selection of the appropriate cut-off may ultimately best be determined by cost-benefit analyses that promote specific, desirable outcomes and are consistent with locally available resources. Since most patients returned to ICU within 72 hours, this may an appropriate cut-off for trauma patients.

Only one hospital-related factor, discharge during the day shift, rather than evening or night, was associated with discharge failure. We speculate that the threshold for discharge from ICU may be higher at night than during the day. Daytime discharges may be more “routine” and initiated by the regular ICU team based on the patient’s course to date and expected progress. The night coverage team is likely less familiar with the patients and thus more reluctant to transfer them out, generally doing so when there is an ICU bed shortage. They may also impose a higher threshold because of their sense that nursing coverage at night is lighter. Week-end and night time discharges were not associated with readmission in some studies (16, 29), while others found significantly higher readmission with night time discharges (17, 18, 20, 33). Similarly, Hanane et al (20) found no increase in mortality from night time discharges, but other studies reported a significant increase in mortality (17–20, 28, 33). Night discharges in other studies may have been related to hospital census, since one of the studies reported that 42% of nighttime discharges were due to lack of ICU beds compared to 10% during daytime (17). In our institution, week-end versus weekday shift discharge was not related to ICU discharge failure, nor was hospital ICU census. We only had total hospital ICU census, however, so were unable to assess whether the census in specific ICUs affected discharge decisions. Dexter et al. found that ICU census is not associated with a change in readmission rate (34), but this finding is not universal (10). Iwashyna et al. also found severity of illness as measured by Acute Physiology Score did not markedly change with increasing occupancy of the ICU (35). Our results showed no difference in outcome between those with initial admission to ICU or to the ward.

The number of comorbidities in our patients was positively associated with the odds of ICU discharge failure, especially if the patient had three or more comorbid conditions. Having more than one comorbid condition has been shown to be associated with an increase in the risk of readmission to the ICU (9); other work showed that the number of comorbidities was associated with late (> 72 hours) but not early (< 72 hours) unplanned readmission to the ICU (4). We detected no difference in number of comorbidities between those returning to ICU early versus late. While Elixhauser’s original article (36) advocates using their comorbid groups separately, a recent systematic review of comorbidity indices (37) determined that counts of diagnoses ranked as a better predictor of short-term mortality than Elixhauser’s individual groups. While we used DRG codes in order to exclude acute conditions, the AHRQ comorbidity groups do include such diagnoses as acute pulmonary embolism, protein-calorie malnutrition, and metabolic derangements, which could be considered complications rather than comorbidities.

A systematic review reported vital sign instability as the most consistent predictor of ICU readmission across studies (3). We found increasing heart rate to be associated with increased readmission, as did other studies (3, 29, 38), although one study found no association between heart rate and readmission or death after discharge (39). Our study identified low GCS at ICU discharge as strongly associated with unplanned readmission to the ICU. One other study showed a GCS score of < 5 in patients with traumatic brain injury was significantly associated with increased complications in the ICU but there was no evaluation of the effect of GCS on unplanned readmission to the ICU (23).

This study has limitations. It is the experience of one trauma center and may not reflect conditions elsewhere. There is the possibility that the 74 patients excluded may bias the control group, although we feel this is unlikely due to having matched the cases and controls on ISS and that the 74 represent only 3.8% of the patients being admitted to an ICU and later discharged to a ward. While we attempted to include all variables we felt were pertinent, this is a retrospective study and we were limited by available data. There likely are other factors that affect ICU discharge failure that have not been addressed, including individual comorbid conditions. One factor that might be important and could not be fully assessed was P/F ratio. This variable was significantly associated with ICU discharge failure in a univariate model, but was not included in the multivariate model due to its high missingness.

In conclusion, the BB rate of trauma patients in this study was 4.5% and associated mortality was 19.3%. At the time of ICU discharge, male gender, severe GCS (vs. mild), increasing heart rate, discharge on day shift and presence of one or more co-morbidities were significantly associated with BB in trauma patients. These data may be useful for establishing benchmarks and for evaluating the effect of interventions designed to enhance patient care quality and safety in the ICU and the post-ICU discharge setting. It may be possible to decrease rates of readmission by either delaying discharge of patients with one or more of the risk variables until they improve or by better matching at risk patients to the receiving nursing unit. A multi-institutional study is needed to validate and extend these results.

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Table 1

Descriptive statistics* and univariate conditional logistic regression results for cases and matched controls (N=262).

Characteristic	Cases	Controls	p-value
Gender			
Female	25.0%	36.8%	0.04
Male	75.0%	63.2%	
Race			
Nonwhite	34.1%	36.2%	0.71
White	65.9%	63.8%	
Payor			
Private	40.9%	35.1%	0.42
Medicare	29.6%	28.2%	
Indigent	29.6%	36.8%	
Number of comorbidity groups			
0	9.1%	19.0%	0.07
1	28.4%	28.7%	
2	27.3%	28.7%	
3+	35.2%	23.6%	
Discharge shift from initial ICU stay**			
Day (0701-1700)	55.7%	27.6%	<0.0001
Evening (1701-2300)	40.9%	63.8%	
Night (2301-0700)	3.4%	8.6%	
Hospital ICU census on day of discharge	48.0 (7.7)	47.9 (7.0)	0.99
Initial admission			
Intensive care unit	89.8%	93.7%	0.32
Ward/floor	10.2%	6.3%	
GCS prior to initial discharge from ICU (n=261)			
Mild	80.5%	93.1%	<0.01
Moderate	11.5%	5.8%	
Severe	8.1%	1.2%	
Mechanism of injury (n=261)			
Blunt	96.6%	90.8%	0.10
Penetrating	3.4%	9.3%	
Intubated on initial admission to ICU	54.6%	51.2%	0.59
Tracheostomy at initial discharge from ICU (n=261)	13.6%	16.7%	0.53

Characteristic	Cases	Controls	<i>p</i> -value
Suctioning after leaving ICU (n=252)			
No	90.0%	91.3%	0.74
Yes	10.0%	8.7%	
8 cases & 2 controls = unknown			
Values prior to initial ICU discharge	Cases	Controls	<i>p</i> -value
Heart rhythm			
Sinus	97.7%	94.3%	0.17
Pulse oximeter			
<96%	17.1%	12.1%	0.52
96–99%	50.0%	52.9%	
100%	33.0%	35.1%	
Respiratory rate	21.6 (6.1)	19.7 (5.3)	0.01
Fraction of inspired oxygen	29 [21, 37]	27 [21, 30]	<0.01
P/F ratio (n=192)	321.1 (136.6)	355.2 (117.9)	0.04
PaCO ₂ (n=193)	40.9 (7.5)	40.0 (6.4)	0.70
pH (n=193)	7.41 (0.06)	7.41 (0.06)	0.89
Venous bicarbonate	25.4 (3.6)	25.3 (3.2)	0.71
Temperature (Celsius)	37.2 (0.8)	37.2 (0.7)	0.44
Heart rate	95.3 (20.7)	91.3 (18.2)	0.09
Systolic blood pressure	138.1 (21.7)	134.4 (18.1)	0.14
Diastolic blood pressure	68.4 (14.4)	68.2 (13.8)	0.85
Hemoglobin	10.2 (1.9)	10.3 (1.7)	0.70
White blood cells	11.0 [8.6, 13.8]	10.5 [7.5, 14.1]	0.54
Platelets	177.0 [125.5, 309.5]	206.5 [136.0, 323.0]	0.49
Blood urea nitrogen	15.5 [10.0, 23.0]	12.0 [7.0, 18.0]	0.01
Creatinine	0.85 [0.70, 1.10]	0.80 [0.60, 1.00]	0.33
Glucose	123.0 [104.0, 144.5]	115.5 [101.0, 141.0]	0.57
Potassium	4.01 (0.49)	4.01 (0.48)	0.91
Sodium	138.9 (5.2)	138.3 (3.8)	0.35

* Categorical variables expressed as fractions, and continuous variables as mean (with standard deviation) if normally distributed or median [with 25th, 75th quantiles] if non-normally distributed.

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Evening & night shifts combined for analyses

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Table 2

Primary reasons for return to the ICU or death (number & percent per day).

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Row Total
Respiratory	14 (58.3%)	11 (52.4%)	4 (22.2%)	2 (25.0%)	2 (33.3%)	3 (60.0%)	2 (33.3%)	38 (100%)
Pulmonary Embolism	4 (16.7%)	0	1 (5.6%)	0	1 (16.7%)	0	0	6 (100%)
Neurologic	3 (12.5%)	2 (9.5%)	0	1 (12.5%)	0	1 (20.0%)	1 (16.7%)	8 (100%)
Bleed	1 (4.2%)	2 (9.5%)	7 (38.9%)	1 (12.5%)	2 (33.3%)	0	0	13 (100%)
Cardiovascular	0	4 (19.0%)	2 (11.1%)	2 (25.0%)	0	1 (20.0%)	0	9 (100%)
Non-respiratory Infection	1 (4.2%)	1 (4.8%)	0	2 (25.0%)	0	0	3 (50.0%)	7 (100%)
Other	1 (4.2%)	1 (4.8%)	4 (22.2%)	0	1 (16.7%)	0	0	7 (100%)
Column Total	24 (100%)	21 (100%)	18 (100%)	8 (100%)	6 (100%)	5 (100%)	6 (100%)	88

Respiratory = pneumonia, atelectasis, aspiration, empyema, pulmonary edema

Cardiovascular = bradycardia, atrial fibrillation, pulseless electrical activity, non-bleeding hypotension, non-ST-segment myocardial infarction

Other = alcohol withdrawal, Ogilvie syndrome, pneumothorax, renal failure, thyroid storm, falls

Table 3

Multivariate conditional logistic regression results, with outcome of ICU discharge failure.

Variable	Odds Ratio (95% CI)	<i>p</i> -value
Male	2.9 (1.29, 6.47)	.01
Glasgow Coma Scale (vs mild)		
Moderate	2.7 (0.79, 9.04)	0.11
Severe	22.3 (3.48, 142.92)	<0.01
Discharge during day shift	6.9 (3.09, 15.18)	<0.0001
10 beat per minute increase in heart rate	1.3 (1.04, 1.51)	0.02
Number of comorbid conditions (vs none)		
One	3.5 (1.12, 10.91)	0.03
Two	3.8 (1.13, 12.70)	0.03
Three or more	8.4 (2.40, 29.58)	<0.001