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Clinical paper

Acute respiratory compromise on hospital wards: Association between recent ICU discharge and outcome

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Abstract

Introduction: Acute respiratory compromise (ARC), respiratory distress requiring emergent assisted ventilation, has a mortality of 20–40%. The relationship between recent discharge from an intensive care unit (ICU) and outcomes of patients suffering ARC on hospital wards is not well known. We hypothesized that a significant percentage of ARC events would occur in patients recently discharged from an ICU, that these patients would have worse outcomes than those without prior ICU stays, and that weekend ICU discharge would be associated with higher than expected post-ICU ARC frequency.

Methods: Using the Get-With-The-Guidelines-Resuscitation ARC registry, we included adult, index ARC events occurring on hospital wards. Our primary analysis used multivariable logistic regression accounting for clustering by hospital to examine the association between prior ICU discharge and survival after an ARC event.

Results: Of 11,800 ARCs, 937 (8%) occurred within two calendar days and 1010 (9%) >two calendar days after an ICU discharge. Patients with ICU discharge within two days had higher survival compared to those with no prior ICU stay (odds ratio 1.28 (95% CI: 1.11–1.48, p = 0.001)). Survival was not different in those with an ICU discharge more than two days prior and no prior ICU stay. Patients with ARC within two days of ICU discharge were not more likely to have left the ICU on a weekend.

Conclusions: Contrary to our hypothesis, discharge from an ICU within two calendar days was associated with better odds for survival compared to no prior ICU discharge or ICU discharge more than two days prior.

Keywords: Acute respiratory compromise, Acute respiratory failure, ICU, Intensive care

Introduction

Acute respiratory compromise (ARC), defined as the sudden onset of respiratory distress requiring emergency assisted ventilation, occurs in over 40,000 patients annually on inpatient wards in the United States.[1] Approximately 40% of these patients will not survive the hospital stay, making in-hospital ARC as lethal as septic shock.[2,3] In spite of this, ARC is comparatively understudied, and targets for intervention are thus poorly characterized.

Approximately one in ten patients admitted to an ICU die during the hospital stay, with even higher mortality if organ failure is present.[4–7] Multiple efforts have been made to identify subsets with especially high mortality, with the goal of finding modifiable targets for intervention. Prior literature has shown that patients discharged from an ICU subsequently requiring readmission to the ICU (so-called

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"bounce backs") have a mortality up to five times higher than those not requiring ICU readmission.[8] Leaving the ICU on a night or a weekend, compared to a weekday, may also be associated with higher mortality.[9,10] Whether ward patients with ARC occurring shortly after ICU discharge are at increased risk of death compared to those with no prior ICU admission has not been reported previously. Whether the frequency of ARC events in ward patients recently in the ICU varies by day of ICU discharge is also unknown.

We utilized the American Heart Association's GWTG-R database to investigate whether ICU discharge withing two calendar days is a risk factor for mortality for patients experiencing ARC on hospital wards. We secondarily assessed whether the frequency of ARC events in patients recently discharged from the ICU varies by day of ICU discharge. Finally, we compared the outcome of ARC events occurring on weekdays and weekend days.

Methods

Study design and data source

This was an analysis of prospectively collected data from the GWTG-R registry, a national quality improvement registry of in-hospital cardiac arrests, medical emergency team events, and ARC events sponsored by the American Heart Association. Trained personnel at each site collect data on all acute respiratory compromise events according to standard definitions. Data integrity is enhanced through certification of data entry personnel and the use of standardized software. Additional details on the validity of the registry have been provided elsewhere.[11] The GWTG-R registry is a de-identified database collected primarily for quality improvement purposes; this analysis was not considered human subjects research.

Patient population

GWTG-R defines acute respiratory compromise as absent, agonal or inadequate respiration requiring emergency assisted ventilation, including non-invasive or invasive positive pressure ventilation and eliciting a hospital-wide or unit-based emergency response. We included adult ($\geq$18) inpatients experiencing an index ARC event on a hospital ward from April 2007-December 2014. We excluded events occurring in the ICU, Emergency Ward or procedural areas, patients with a pre-existing do not attempt resuscitation (DNAR) order and those with missing data on prior ICU discharge, the time between ICU discharge and ARC event, or survival.

Statistical analysis

The patient population was described using descriptive statistics. Continuous variables were presented using means $\pm$ standard deviations or medians (interquartile range), depending on data distribution. Categorical variables were presented as counts with frequencies.

For the primary analysis, patients were divided into three groups: ICU discharge within 2 calendar days, ICU discharge >2 day prior, and no prior ICU stay. We first looked at unadjusted mortality in the three groups. We then used multivariable logistic regression (see Table 1 for variables), with generalized estimating equations to account for correlations within hospitals, to determine the association between prior discharge from an ICU and hospital survival after an ARC event.

Analysis of whether discharge from the ICU on a Friday or weekend day (Friday included as leaving the ICU on a Friday means arriving on the wards just as staffing levels decrease) was associated with having an ARC event within two calendar days was limited by the fact that GWTG-R only includes data on patients who had an event. We did not have the total number of patients leaving the ICU on a given day of the week, precluding direct comparison of the percentage of ICU discharged on different days who have a subsequent ARC event. We therefore compared observed to expected frequencies of day of ICU discharge in all patients having an ARC event within two days of leaving the ICU, with the null hypothesis being that frequencies would be similar. We set the expected count of preceding ICU discharges on a given day as the total number of ARC events that happened within two days of ICU discharge divided by seven. We compared this number to the observed number of preceding ICU discharges occurring on each day in this group.

Finally, we compared survival rates of ARC events occurring on a weekday (Monday–Friday) or a weekend in unadjusted analysis and with multivariable adjustment controlling for patient and event characteristics. In this analysis Friday was included as a weekday since we were interested in staffing levels at the time of the event only. All analyses were performed using Stata 14.2 (College Station, TX).

In the primary analyses, patients with missing data for any of the covariates were excluded. As a sensitivity analysis, we addressed covariate missingness in our models using multiple imputation using multivariate normal regression, after confirming non-monotone missingness, with 20 iterations. Because the variable identifying the rhythm at ARC event onset contained the option "Unknown/Not Documented," we used that as a category in the primary analysis but treated it as missing and imputed values when performing multiple imputation in the sensitivity analysis.

Results

Study population

Out of 28,843 ARC events occurring at 276 hospitals from 2007 to 2014, 11,800 met our inclusion criteria (see Fig. 1). Of these, 937 (8%) occurred within two calendar days of an ICU discharge and 1010 (9%) occurred greater than two days after an ICU discharge. Overall approximately 4% of ARC events progressed to cardiac arrest for which chest compressions were done. The distribution of cardiac arrest events matched the distribution of ARC events across the 3 groups. Baseline characteristics of the three patient groups are presented in Table 1. Patients with an ICU discharge more than two days prior were more likely to have pre-existing sepsis or hypotension. Patients with no prior ICU discharge were less likely to be admitted for surgical reasons. They were also slightly less likely to be on a telemetry floor or have supplemental oxygen in place when the event occurred. Other patient and event characteristics were similar between groups.

Primary analysis

There was a significant difference in unadjusted survival between groups, with the highest likelihood of surviving to hospital discharge in

Table 1 – Patient and event characteristics according to prior ICU discharge.

	ICU discharge in prior 2 days (n = 937 [8%])	ICU discharge >2 days prior to event (n = 1,010 [9%])	No prior ICU stay (n = 9,853 [84%])	p-value
Demographics				
Age (years)	65 (56, 75)	67 (55, 76)	66 (55, 77)	0.49
Sex (female)	431 (46)	464 (46)	4818 (49)	0.06
Race[a]				0.01
White	691 (77)	689 (71)	6734 (72)	
Black	174 (19)	248 (26)	2277 (24)	
Other	34 (4)	35 (4)	316 (3)	
Admission diagnosis[b]				< 0.001
Medical cardiac	133 (14)	131 (13)	1777 (18)	
Medical non-cardiac	525 (56)	584 (58)	6491 (66)	
Surgical cardiac	69 (7)	62 (6)	157 (2)	
Surgical non-cardiac	210 (22)	233 (23)	1424 (14)	
Pre-existing conditions				
CHF this admission	133 (14)	156 (15)	1470 (15)	0.74
Hypotension	122 (13)	178 (18)	1267 (13)	<0.001
Acute stroke	55 (6)	74 (7)	473 (5)	0.001
Acute non-stroke neurological event	108 (12)	138 (14)	1076 (11)	0.03
Pneumonia	197 (21)	239 (24)	1983 (20)	0.03
Septicemia	154 (16)	211 (21)	1303 (13)	<0.001
Major trauma	31 (3)	31 (3)	181 (2)	0.001
Location of the event				<0.001
Floor without telemetry	391 (42)	436 (43)	4687 (48)	
Floor with telemetry/step-down unit	546 (58)	574 (57)	5166 (52)	
Event characteristics				
Monitored	690 (74)	715 (71)	6653 (68)	<0.001
Hospital wide response activated	692 (74)	784 (78)	7485 (76)	0.15
Patient conscious[c]	438 (50)	438 (49)	4167 (46)	0.04
Breathing pattern[d]				0.18
Breathing	463 (52)	501 (54)	4821 (52)	
Not breathing	130 (15)	109 (12)	1265 (14)	
Agonal	236 (26)	236 (25)	2511 (27)	
Assisted	63 (7)	88 (9)	708 (8)	
Supplemental oxygen in place[e]	718 (79)	739 (75)	6727 (71)	<0.001
Rhythm at start of event				0.20
Bradycardia	87 (9)	111 (11)	869 (9)	
Sinus (including sinus tachycardia)	574 (61)	580 (57)	5808 (59)	
Supraventricular tachycardia	53 (6)	50 (5)	581 (6)	
Other	39 (4)	42 (4)	379 (4)	
Unknown	184 (20)	227 (22)	2216 (22)	

[a] 602 missing race.
[b] 4 missing admission diagnoses.
[c] 1071 missing consciousness.
[d] 669 missing breathing status.
[e] 426 missing supplemental oxygen.

the group with previous ICU discharge within two calendar days (Table 2). After multivariable adjustment, patients with an ICU discharge within two calendar days continued to have higher odds of survival compared to the reference group of no prior ICU stay (OR 1.28, 95% CI: 1.11–1.48, p = 0.001). Using the group with discharge from the ICU within two calendar days as the reference, both ICU discharge more than two days prior and having no prior ICU stay were associated with worse survival (see Table 2).

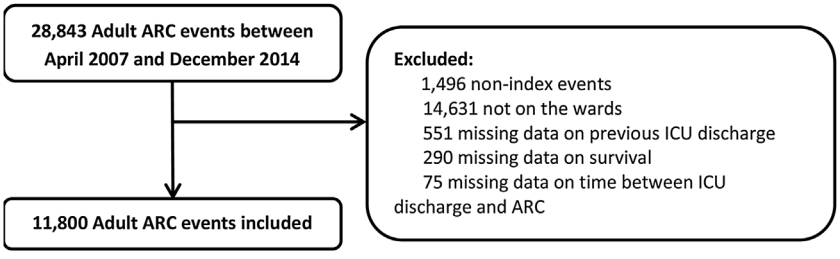

Fig. 1 – CONSORT diagram of included and excluded patients.

Table 2 – Unadjusted hospital survival and adjusted odds ratio for hospital survival in all groups.

	ICU discharge within two calendar days (n = 957)	ICU discharge > two days prior (n = 1,010)	No prior ICU stay (n = 9,853)
Unadjusted survival	633 (67.6%)*	571 (56.5%)*	6155 (62.5%)*
Adjusted Odds Ratio for survival	1.28 (95% CI: 1.11-1.48)*	0.95 (95% CI: 0.78-1.16)	reference
Adjusted Odds Ratio for survival (alternative reference group)	reference	0.75 (95% CI: 0.62-0.90)*	0.78 (95% CI: 0.67-0.90)*

An * indicates a p-value of <0.005 for the difference between groups. Other differences are nonsignificant. Pairwise comparisons were done for unadjusted analysis.

Secondary analyses

Patients with an ARC event within two calendar days of ICU discharge were not more likely to have left the ICU on a weekend or Friday than a non-Friday weekday, while ICU discharges on Tuesday occurred at 139% of the expected frequency (95% CI 120–160%, $p < 0.001$) (Fig. 2). Looking at all ARC events, regardless of prior ICU admission, there was no significant difference in frequency by day of week. Among ARC events within two calendar days of ICU discharge, events occurred less frequently on Mondays (67.2% of the expected frequency, 95% CI 54–83%, $p < 0.001$) [Figs. 3a and b].

Unadjusted hospital survival rates for ARC events occurring on weekdays and weekends were similar (62.8% vs. 61.1%, $p = 0.09$). These results did not change after multivariable adjustment (adjusted OR 0.98, 95% CI 0.88–1.08, $p = 0.63$).

Sensitivity analysis

Results were not significantly changed in the combined estimate from the 20 data sets generated using multiple imputation to account for missing data (see Table 3).

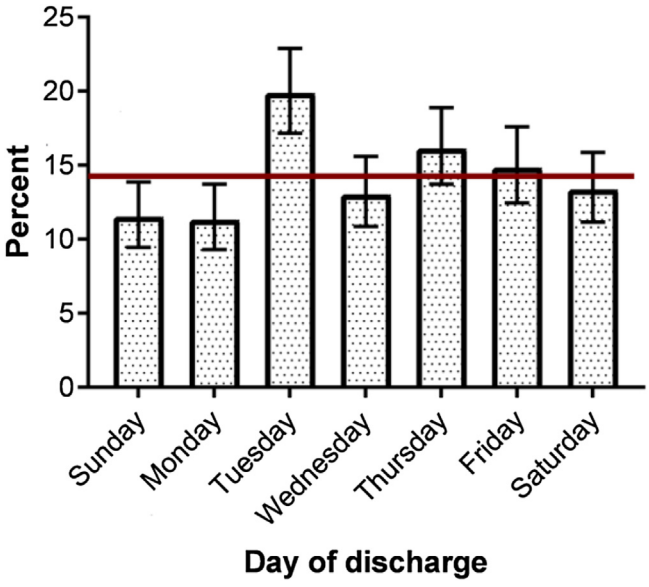

Fig. 2 – Distribution of day of ICU discharge in patients experiencing an ARC event within two calendar days of leaving the ICU.

Discussion

In this analysis of over 11,000 ARC events occurring on hospital wards across the United States, we found that patients who had been discharged from an ICU within two calendar days were more likely to survive to hospital discharge than patients either discharged from an ICU more than two calendar days prior or with no prior ICU stay. We also found that preceding discharge from the ICU on a Friday or weekend day did not occur with disproportionate frequency in patients with an ARC event within two calendar days of leaving the ICU. There was however an unexpectedly high frequency of ICU discharge on a Tuesday in this group. We found no difference in survival for ARC events occurring on a weekend compared to a weekday.

The finding that patients who are readmitted to an ICU after ICU discharge have significantly higher mortality than those not requiring ICU readmission has been reported previously.[8] Based on this literature, as well as the supposition that patients recently discharged from an ICU would have a higher severity of illness than those without a previous ICU stay, we hypothesized that recent ICU discharge would be associated with worse outcome from ward ARC events. Contrary to our initial hypothesis, we actually found that patients who have left the ICU within two calendar days are at lower risk of death from an ARC event than other ward patients.

There are several elements that could explain this finding. Patients with no prior ICU admission were less likely to be on telemetry or in a step-down unit. They were also less likely to be found conscious or to be on supplemental oxygen, as were those with an ICU discharge more than two days before the event. This combination of variables suggests that these events may have been detected by clinical staff at a more advanced point, when some degree of harm had already occurred. Patients with ICU discharge more than two days prior were more likely to have diagnoses of sepsis, hypotension and pneumonia, suggesting a sicker patient population, although variables to calculate severity of illness scores are not available in this registry. Finally, patients with no prior ICU admission were less likely to be surgical patients, and patients admitted for elective surgeries, in the setting of which a brief ICU stay is sometimes expected, may be at less risk from ARC than those admitted for acute medical illness.

Patient trajectory may also play a role. Valentini and colleagues conducted a study of patients treated with noninvasive ventilation in a specialized respiratory unit.[13] They compared outcomes in patients coming from the Emergency Department, ICU and wards, and found that admission from the wards was associated with worse survival. The authors suggested this could be because patients who are improving (going from the ICU to what was essentially a step-down

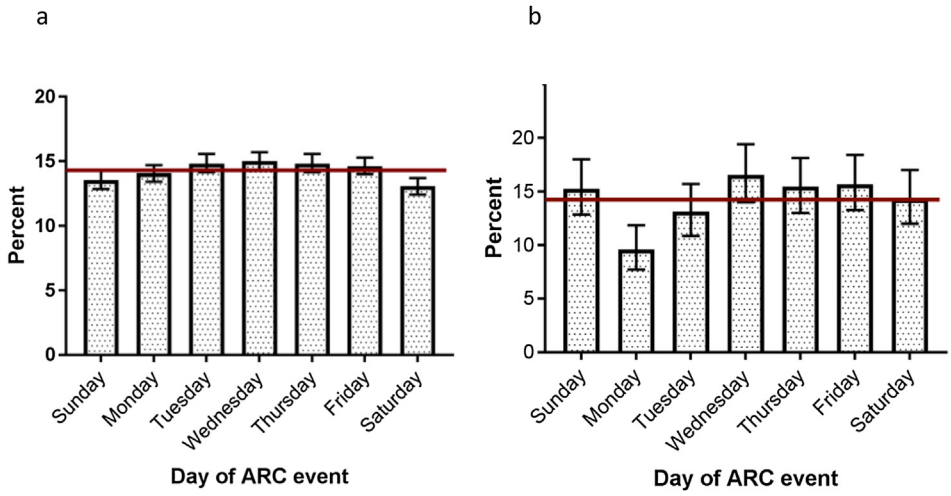

Fig. 3 – (a) Frequency of ARC events by day of week, entire cohort. (b) Frequency of ARC events by day of week in those with ICU discharge in prior two days.

Table 3 – Sensitivity analyses using multiple imputation for hospital survival in all groups.

	ICU discharge within two calendar days (n = 957)	ICU discharge >two days prior (n = 1,010)	No prior ICU stay (n = 9,853)
Adjusted Odds Ratio for survival	1.27 (95% CI: 1.10–1.47), p = 0.001	0.90 (95% CI: 0.77–1.06), p = 0.20	reference
Adjusted Odds Ratio for survival	reference	0.71 (95% CI: 0.60–0.84), p < 0.001	0.79 (95% CI: 0.68–0.91), p = 0.001
Adjusted Odds Ratio for survival (weekend vs. weekday)	0.94 (95% CI: 0.87–1.03), p = 0.18		

unit) have better outcomes than those who are worsening (going from floor to ICU), even if their current severity of illness is similar. A retrospective study of ICU patients found a similar association between admission source and mortality for patients with sepsis, with patients coming from the inpatient wards having a significantly higher mortality than those from the Emergency Department or the operating room.[14] In this case the authors hypothesized that different thresholds for recognition and triage of sepsis in different clinical settings may play a role in the difference in outcome. Our findings that patients with no prior ICU stay were less likely to be on oxygen or telemetry and more likely to be found unconscious suggest something similar in that we may be less likely to detect impending respiratory compromise in patients not recently in the ICU because we are monitoring them less closely.

Although the reasons for the difference between patients with ICU discharge within two calendar days and those who left the ICU more than two days prior are not entirely clear, it may be that the etiologies of the events differ. Patients with respiratory distress on day one or two after ICU discharge may be more likely to have a relatively simple and reversible event such as a mucous plug or volume overload. Additionally, surgical patients recently discharged from the ICU may be more likely to have events related to analgesic medications, often more easily treatable. In patients more than 2 days out from ICU discharge, a sudden decompensation may be more likely to be from a new complication such as hospital-acquired pneumonia or other infection.

Previous investigators have reported that discharge from the ICU on a weekend is associated with increased mortality.[9,10,15] This is thought to be due to different staffing levels on hospital wards on weekends and weekdays. We therefore anticipated, but did not find, that ICU discharge on a weekend or Friday might occur more frequently in those experiencing an ARC event within two days. The unexpected finding of higher frequency of ICU discharge on Tuesdays for patients with ARC within two calendar days of leaving the ICU remains unexplained, but a simple explanation could be variation in the number of patients discharged from the ICU by day of the week. Our analysis assumed similar frequency of ICU discharges each day, but this may be an incorrect assumption. Data from the United Kingdom and the United States suggest that discharges from the hospital occur less frequently on weekends, with lower presence of senior physicians being the hypothesized cause.[16,17] This weekend dip may also occur in discharges from the ICU to the wards, which could explain why we also found that ARC events in patients within two days of ICU discharge occurred less frequently on Mondays.

These findings, along with our finding that the outcome of ARC events does not vary by day of week, are reassuring in that lower levels of staffing on weekends do not appear to be having a major influence on the occurrence or outcomes from ARC events on the wards. Our results do however raise the question of whether higher levels of monitoring may be helpful for some ward patients. How to determine which patients would benefit from such monitoring needs further study.

Our results should be interpreted in light of the following limitations. The database utilized is large and samples a wide range of hospitals in the United States, but information on patient characteristics, severity of illness and reasons for the presence or absence of various

monitoring parameters such as telemetry or continuous pulse oximetry is limited. Although we were able to adjust for many patient and event characteristics, additional confounding could be present. Finally, we were not able to assess the relative frequency of ARC events with respect to total ICU discharges in this study, significantly limiting our analysis of an association between day of ICU discharge and likelihood of having a subsequent ARC event on the floor.

Conclusions

In a large database of patients experiencing an acute respiratory compromise event on the hospital wards, patients who had been discharged from an ICU within two calendar days had better odds of survival than patients with no ICU stay within the prior two days or those with an ICU stay more than two days before the ARC event. Mortality from an ARC event was not higher on weekends when compared to weekdays.

Conflict of interest

No authors have any relevant conflict of interest to disclose.

Author contributions

All authors contributed to study design and critically revised the manuscript at all stages of development. In addition, KMB conceived the research question and drafted the manuscript. LWA and AVG performed all analyses and AVG oversaw the final version.

Subject Category: 4.6 (ICU Management and outcome).

At-a-glance commentary

Scientific knowledge on the subject: Acute respiratory compromise occurring on hospital wards has a high mortality. Patients who return to the ICU shortly after ICU discharge are known to have worse outcomes than those who do not require readmission, but whether patients with acute respiratory compromise who have recently left the ICU have worse outcomes than those without a recent ICU stay is unknown.

What this study adds to the field: In this study we found that patients having an acute respiratory compromise event on hospital wards were actually more likely to survive the hospital stay if they had recently been in the ICU. The reasons for this remain unclear but may have to do with higher levels of monitoring in those recently in the ICU, and unrecognized severity of illness in some ward patients.

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