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Receiving Early Mobility During An ICU Admission Is A Predictor Of Improved Outcomes In Acute Respiratory Failure

Peter E. Morris, MD, Leah Griffin, MS, Michael Berry, Ph.D¹, Clif Thompson, RN, R. Duncan Hite, MD, Chris Winkelman, Ph.D², Ramona O. Hopkins, Ph.D^{3,4}, Amelia Ross, MSN⁵, Luz Dixon, RN⁵, Susan Leach, RN⁵, and Edward Haponik, MD

Pulmonary, Critical Care, Allergy and Immunologic Disease Wake Forest University School of Medicine, Winston Salem, NC

¹Department of Health and Exercise Science, Wake Forest University, Winston Salem, NC

²Francis Bolton Payne School of Nursing, Case Western Reserve, Cleveland, OH

³Department of Medicine, Pulmonary and Critical Care Division, Intermountain Medical Center, Salt Lake City, Utah

⁴Psychology Department and Neuroscience Center, Brigham Young University, Provo, Utah

⁵Department of Nursing, Wake Forest University Baptist Medical Center, Winston Salem, NC

Abstract

Introduction—Hospitals are under pressure to provide care that not only shortens hospital length of stay, but reduces subsequent hospital admissions. Hospital readmissions have received increased attention in outcome reporting. We identified survivors of acute respiratory failure who then required subsequent hospitalization. A cohort of acute respiratory failure survivors, who participated in an early ICU-mobility program, was assessed to determine if variables from the index hospitalization predict hospital readmission or death, within 12 months of hospital discharge.

Methods—Hospital database and responses to letters mailed to 280 ARF survivors. Univariate predictor variables shown to be associated with hospital readmission or death ($p < 0.1$) were included in a multiple logistic regression. A stepwise selection procedure was used to identify significant variables ($p < 0.05$).

Results—Of the 280 survivors, 132 (47%) had at least one readmission or died within the first year, 126 (45%) were not readmitted, and 22 (8%) were lost to follow-up. Tracheostomy [OR 4.02 (CI 1.72, 9.40)], female gender [OR 1.94 (CI 1.13, 3.32)], a higher Charlson Comorbidity Index assessed upon index hospitalization discharge [OR 1.15 (CI 1.01, 1.31)], and lack of early ICU mobility therapy [OR 1.77 CI (1.04, 3.01)] predicted readmission or death in the first year post-Index hospitalization.

Conclusions—Tracheostomy, female gender, higher Charlson Comorbidity Index and lack of early ICU mobility were associated with readmissions or death during the first year. Although the

Corresponding Author: Peter E. Morris Pulmonary, Critical Care, Allergy and Immunology Wake Forest University School of Medicine Room 3141 Gray Building Winston Salem, NC, 27157 Phone 336-716-8898 Fax 336-713-4718 pemorris@wfubmc.edu.

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mechanism(s) of increased hospital readmission are unclear, these findings may provide further support for early ICU mobility for acute respiratory failure patients.

Keywords

Critical Care; Rehabilitation; Acute Respiratory Failure; Long Term Outcomes; Mobility

Reports for disease-specific hospital readmission rates suggest strategies to reduce readmissions can be successful, such as in heart failure^{1,2}. A report across all Medicare recipients found multiple contributing factors accounted for hospital readmissions, including discharge planning failures, insufficient outpatient and community care, and severe progressive illness³. Chronic disorders are important factors in multiple readmission patterns. Findings of high readmission rates for certain individuals with chronic disorders have prompted some to call for dramatic changes in outpatient care delivery strategies⁴. Interestingly, there are few reports in patients who require mechanical ventilation specifically examining factors that contribute to hospital readmission. In the parent study to this report, mechanically ventilated acute respiratory failure patients who underwent early ICU mobility therapy, had a shorter ICU and hospital stay than similar patients who received standard physical therapy care⁵. While early rehabilitative strategy has a theoretical appeal in reducing longer term outcomes, no study has assessed whether early ICU mobility therapy improves post-hospital outcomes such as hospital readmission or death. The purpose of this study was to determine if index medical variables and early mobility are ultimately associated with readmissions or death in acute respiratory failure survivors.

Materials and Methods

Setting of Study and Study Sample

In the current study we assessed a cohort of 280 survivors, all of whom required mechanical ventilation for acute respiratory failure during their hospitalization (index hospitalization)⁵. This patient population was composed of the survivors from a previous in-patient report regarding the utility of early ICU rehabilitation strategies, namely the use of a protocol and independent team inclusive of a physical therapist⁵. All patients described within the parent study experienced acute respiratory failure from diverse etiologies and all required mechanical ventilation. Patient medical variables were used to predict rehospitalization or death 12 months post-hospital discharge. This study had Institutional Review Board (IRB) approval and informed consent was waived.

Data Collection

The number of hospital readmissions and mortality status within 12 months of discharge were obtained for each patient. Readmissions occurred at the academic medical center (AMC), or several non-affiliated community hospitals (CH). The AMC's hospital records were reviewed and the Social Security Administration's Death Index (SSDI) was queried for death notices⁶. To determine CH readmissions in the year post-hospital discharge, a letter was sent. The letters were sent up to three times to individuals that did not respond. The IRB stipulated that only the frequency of patient's post-Index hospitalization readmissions could be provided, not details of the readmission or data regarding outpatient rehabilitation treatment. As well, the authors were restricted by the IRB from sending a query to the family of a patient regarding admissions at other facilities, if the patient was known to have died at the time of mailing. Readmission data from the AMC was obtained and included readmission etiology using the International Classification of Diseases, 9th version (ICD9) diagnoses.

If a patient was admitted to a CH and directly transferred to the AMC, the patient's illness spanning both hospitals was counted as a single hospitalization. Patients only readmitted to a CH were counted as a single CH readmission. In the parent early mobilization study, patients were assigned to mobilization treatment in a block-allocation design. For the current study, all survivors were pooled to determine characteristics of the Index hospitalization that were associated with hospital readmission or death. The Charlson co-morbidity index was selected to approximate one-year mortality based upon these patients' co-morbid conditions such as heart disease, AIDS, or cancer (a total of 22 conditions). Each condition is assigned with a score of 1,2,3 or 6 depending on the risk of dying associated with this condition.⁷

Statistical Analysis

All statistical analyses were performed with SAS version 9. Descriptive statistics included means and standard deviations for continuous measures and counts and percentages for categorical measures. All statistical tests were two-sided and significance was determined at the 0.05 probability level. The distribution of length of stay data was skewed so data were log transformed for data analysis. Comparisons between patients with and without a readmission or death were done using t-tests for continuous variables or chi square for categorical variables to identify potential predictor variables for further analysis. The variables whose significant level was $p < 0.10$, were included in the multi-variable logistic regression. A stepwise selection procedure was used to identify variables ($p < 0.05$) that predicted hospital readmission or death.

Results

Of the 280 survivors, status at one year following index hospitalization was confirmed for 258 (92.1%). Figure 1 shows the study follow-up flow diagram for survivors. Of the 280 survivors, 132 (47%) required at least one hospital readmission or died within the first year post-Index hospitalization, and 126 (45%) did not require hospital readmission within the first year and were alive at 12 months. Twenty-two (8%) did not respond and were considered lost to follow-up. All patients lost to follow-up were presumed to be alive due to the absence of death data in the SSDI. Hospital readmission and death information was confirmed for 258 of the survivors; therefore, the subsequent analyses were limited to Index hospitalization information of these 258 patients. Following discharge from the Index hospitalization, 44 patients (17%) died within this first year. There were 88/258 (34%) patients who had at least one hospital readmission, 21/258 (8%) who had at least one readmission and subsequently died within 12 months, 20/258 (8%) who had no readmissions but died in the facility to which they were discharged following Index hospitalization, and 3 (1%) who died at home.

Characteristics of Index Hospitalization Associated with Readmission or Death

Index medical and demographic characteristics (Table 1) were included in the analysis as predictors of hospital readmission or death. Variables with a $p < 0.10$ were included in the multi-variable logistic regression model. Table 2 shows the final multivariable model and female gender, tracheostomy, Charlson Comorbidity Index, and early ICU mobility predicted hospital readmission or death. Females were 1.9 times more likely to be readmitted or die ($p = 0.0159$) [Odds Ratio 1.94 (95% CI 1.13, 3.32)]. Patients with a tracheostomy were 4.0 times more likely to be readmitted or die ($p = 0.0013$) [OR 4.02 (CI 1.72, 9.40)]. A one point increase in the Charlson Comorbidity Index increased the odds of readmission or death by 15% ($p = 0.0327$) [OR 1.15 (1.01, 1.31)]. Finally, patients not in the early ICU mobility therapy group had higher odds of readmission or death ($p = 0.0362$) [OR 1.77 (CI 1.04, 3.01)].

To further address the association between gender and hospital readmissions or death, gender-specific mortality was assessed. Table 3 shows mortality by gender both within the hospitalization and within the first year post-discharge. Although there were numerically more deaths for men compared to women, there was no difference in mortality between men and women, as such, mortality among males did not account for the larger proportion of hospital readmissions for women. Further, a comparison of APACHE II scores for females vs. males, found the index hospitalization APACHE II scores did not differ for men and women (men: APACHE II score = 22.6; women: APACHE II score = 21.7; $p = 0.3704$), Table 3. Similarly, no difference was found for Charlson Comorbidity Index scores for men and women, Table 3.

Since tracheostomy predicted hospital readmission or death, differences in APACHE II scores for those patients who received a tracheostomy were compared to patients without tracheostomy. Patients with a tracheostomy had numerically higher APACHE II scores than patients without a tracheostomy (24.9 vs. 21.7, $p = 0.0255$); however, APACHE II scores were not associated with hospital readmission.

Within the parent early ICU mobility 5study, lack of early ICU mobility predicted hospital readmission or death.

Relationship between Diagnoses for Index Hospitalization and Academic Medical Center Readmissions

To determine if survivors who had a hospital readmission etiology was the same as the index hospitalization, International Classification of Diseases, 9th version (ICD9) diagnosis from the index hospitalization and AMC readmissions were obtained. There were 73 survivors readmitted to the AMC for a total of 167 readmissions (mean = 2.29 readmissions per readmitted survivor). The primary ICD-9 diagnosis for survivors' index AMC readmission and all AMC readmissions were reviewed for similarities.

In general, there was significant variability and heterogeneity between patient's index hospitalization primary ICD-9 diagnosis and their AMC readmission primary diagnosis. The most common readmission diagnoses were respiratory-related which accounted for 44 of 167 (27%) of AMC readmissions. Twelve of the 73 (16%) AMC readmitted patients had the same primary diagnosis as their index hospitalization, accounting for 14 of the 167 (8%) readmissions. Thirty-seven survivors had multiple AMC readmissions, of which 10 patients (27%) with two or more readmissions had the same primary diagnosis as their index AMC hospitalization, accounting for 12 of 131 (9%) hospital readmissions.

Discussion

We found that survivors of acute respiratory failure who required mechanical ventilation were often readmitted to the hospital and had a one-year mortality rate of 17% (44/258 subsequent one year mortality) after hospital discharge. Four variables from the index hospitalization predicted hospital readmission including (1) tracheostomy (2) female gender (3) lack of receipt of early ICU mobility and (4) Charlson Comorbidity Index scores.

Interestingly, patients who received early ICU mobility therapy had fewer hospital readmissions or death. The precise mechanism by which early ICU mobility might lead to fewer readmissions is unclear. The survivors who were not readmitted compared to survivors who were readmitted to the hospital or died, had nearly four fewer days in bed during the index hospitalization. Fewer days in bed may prevent some physical debilitation as immobility may result in 1.3% to 3% loss in muscle strength per day in healthy individuals⁸. Other possible reasons for fewer readmissions or death in those who

underwent early ICU mobilization therapy include: (1) The patients who underwent ICU mobility therapy experienced decreased hospital length of stay thereby reducing potential exposure to iatrogenic harm and debilitation. (2) The patients who underwent early ICU mobility therapy were observed more frequently by medical staff during their Index hospitalization during the mobility sessions thereby preventing complications and morbidities that may reduce hospital readmissions. (3) Although more patients who received index hospitalization early mobilization remained alive and without a readmission (74 patients in early mobility vs 52 with usual care in their index hospitalization, $p = 0.0329$, Table 1), patients with index hospitalization early mobilization might have received more outpatient rehabilitation opportunities augmenting the effect of early mobilization. This is unlikely since the percent of survivors who were discharged to rehabilitation hospitals were the same between groups.

Frutos-Vivar, et al., reported that tracheostomy was associated with a lower ICU mortality, a longer ICU stay and similar in-hospital mortality as compared to mechanically ventilated patients without a tracheostomy⁹. In the current study, although tracheostomy was associated with readmission or death, it remains unclear whether there was some specific cardiopulmonary abnormality requiring a tracheostomy or whether simply undergoing a tracheostomy identified illness severity of the survivors that ultimately associated with a readmission or death.

Neither the index APACHE II nor SOFA scores, predicted readmission or death within one year of hospital discharge. Discharge disposition did not predict hospital readmission or death within 12 months. However, a higher Charlson Comorbidity Index was associated with a readmission or death. The finding that comorbidities rather than markers of acute illness severity predicted one year hospital readmission or death, may hold promise for future use in predicting which patients will be readmitted or die within the first year. A larger confirmatory study to assess the utility of this finding is needed.

Female gender predicted hospital readmission or death. The explanation for this association is unclear as there were no differences between men and women in the index hospitalization's APACHE II scores. The data indicate a numerical trend. It remains unclear whether female gender itself represents a risk for readmission, or whether other factors in the females or undocumented comorbid factors among the males contributed to increased risk of death within the first year. Further, this finding may be due to the relative small size of our cohort.

Interestingly, the index hospitalization diagnosis was not associated with either readmission or death (although the diagnosis of Coma had a probability value of 0.0558 with Coma favoring no readmission, Table 1). The survivors demonstrated a wide variation in their index hospitalization's primary ICD-9 diagnosis and their AMC readmission primary diagnosis. Of the patients returning to the AMC, 27% of readmissions had a respiratory-associated primary ICD-9 code. Only 16% of patients readmitted had the same primary ICD-9 code in both the index and subsequent hospitalizations, emphasizing significant variability.

In summary, the strengths of this study may be that the follow-up design identified predictors of 12-month readmission or death, in the survivors of the parent study. Follow-up data was obtained from hospital databases, the SSDI, and from survivors, using a mailed survey. The findings indicate four factors that were associated with readmission or death during the first year. One of these factors was the lack of early ICU mobility, which is an aspect of care that has potential to be altered in future ICU practice. The four factors have been identified through an analysis stemming from a large cohort, and with a reasonable follow-up. These data provide further support for the use of early ICU mobility.

Limitations

One important limitation is the retrospective nature of the study. Further, approximately 8% of survivors were lost to follow-up, although they were believed to be alive based on Social Security Administration's Master Death data. Dates of readmission were not available for all readmitted patients which prohibited a time-to-readmission analysis. There were no data collected to examine the survivors' social and economic status, number of outpatient clinic visits received, nor the patients' lifestyle after ICU discharge, so other variables may account for our findings.

Only a small number of survivors returned to the AMC within the same ICD-9 primary diagnosis as their index hospitalization. This finding may reflect the chronic nature of these patients' multiple health problems rather than a specific recurring problem. However, the Charlson Comorbidity Index was associated with readmissions or death. Independent of chronicity or multiplicity of conditions, patients who received early ICU mobility had fewer rehospitalizations.

Conclusion

Survivors of respiratory failure requiring mechanical ventilation are vulnerable to hospital readmission and have a high 1-year mortality rate. In this survivor cohort, 51% (132/258) required at least one readmission or died in the year following hospitalization. Hospital readmission or death were associated with tracheostomy, female gender, lack of early ICU mobility therapy and higher Charlson Comorbidity score. Early ICU mobility therapy represents a potentially modifiable in-patient variable. Administration of such rehabilitative therapy early in ICU treatment may be important to optimize patients' chances to avoid recurrent hospital admission or death. Administration of early ICU mobility in critically ill respiratory failure patients is not only associated with a reduction in index hospitalization length of stay⁵, but with this report's data, may possibly be associated with a reduction in rehospitalizations. Prospective longitudinal outcome studies are needed to determine the long-term effects of early ICU rehabilitation¹⁰.

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Figure 1. Flow diagram for the number and percentage of survivors with and without readmissions or death.

TABLE 1

Index Medical and Demographic Characteristics among Survivors with Documented Readmission or Death Status

		Readmission &/or Death n = 132	Alive & No Readmission N = 126	p-value
Demographics	Age (mean $\pm$ std)	55.8 $\pm$ 16.2	52.2 $\pm$ 16.2	0.0833
	Body Mass Index (mean $\pm$ std)	26.7 $\pm$ 6.9	29.0 $\pm$ 6.7	0.1858
	Male (no. and %)	61 (46.2%)	76 (60.3%)	0.0232
	Caucasian	105 (79.6%)	99 (78.6%)	0.8476
	African American	27 (20.4%)	24 (19.1%)	0.8476
Insurance	Medicare	63 (47.7%)	45 (36.7%)	0.0506
	Medicaid	33 (25.0%)	27 (21.4%)	0.4973
	Private Insurances	28 (21.2%)	41 (32.5%)	0.0399
	Uninsured	8 (6.1%)	13 (10.3%)	0.2113
Acuity Score	APACHE II (mean $\pm$ std)	22.9 $\pm$ 8.5	21.5 $\pm$ 8.0	0.1547
	SOFA (mean $\pm$ std)	7.7 $\pm$ 2.8	7.9 $\pm$ 3.3	0.7398
Diagnosis	Acute Lung Injury (no. and %)	94 (71.2%)	85 (67.5%)	0.5132
	Coma (no. and %)	14 (10.6%)	24 (19.1%)	0.0558
	Acute on Chronic Lung DX (no. and %)	21 (15.9%)	17 (13.5%)	0.5840
Interventions	Vasopressors (no. and %)	39 (29.6%)	35 (27.8%)	0.7537
	Dialysis (no. and %)	22 (16.7%)	12 (9.5%)	0.0900
	Tracheostomy (no. and %)	30 (22.7%)	10 (8.0%)	0.0010
	Ventilator Assoc. Pneumonia (no. and %)	6 (4.5%)	6 (4.8%)	0.9342
	Sedation Days (mean $\pm$ std)	6.4 $\pm$ 9.4	4.5 $\pm$ 6.7	0.1778*
Outcomes	Vent Days (mean $\pm$ std)	9.4 $\pm$ 10.3	6.9 $\pm$ 8.7	0.0250*
	Previous Study Early ICU Mobility (no., %)	60 (45.5%)	74(58.7%)	0.0329
	Days In Bed (mean $\pm$ std)	13.4 $\pm$ 14.0	8.5 $\pm$ 9.5	0.0008*
	ICU Length of Stay (mean $\pm$ std)	8.9 $\pm$ 7.7	6.7 $\pm$ 6.3	0.0070*
	Hospital Length of Stay (mean $\pm$ std)	18.1 $\pm$ 14.6	13.2 $\pm$ 11.6	0.0010*
Discharge	Charlson Comorbidity Index (mean $\pm$ std)	3.2 $\pm$ 2.1	2.5 $\pm$ 2.1	0.0153
	DNR (no. and %)	5 (3.8%)	2 (1.6%)	0.4476
	Ventilator Hospital upon d/c (no. and %)	12 (9.1%)	4 (3.2%)	0.0489
	Nursing Home upon d/c (no. and %)	18 (13.6%)	8 (6.4%)	0.0519
	Rehab Hospital upon d/c (no. and %)	14 (10.6%)	12 (9.5%)	0.7728
	Discharge to Home (no. and %)	88 (66.7%)	102 (81.0%)	0.0092

* log transformed

Ventilator Hospital = Long Term Acute Care hospital (LTAC); Nursing Home = Skilled Nursing Facility (SNF).

TABLE 2

Final Model Predicting Readmission or Death

		Odds Ratio (95% CI)	p-value
Gender	Female	Female vs. male	0.0159
	Male	1.94 (1.13, 3.32)	
Tracheostomy	Yes	Yes vs. No	0.0013
	No	4.02 (1.72, 9.40)	
Charlson Comorbidity Index		1.15 (1.01, 1.31)	0.0327
Early Mobility	Usual Care	Usual Care vs. Protocol	0.0362
	Protocol	1.77 (1.04, 3.01)	

Table 3

Gender Characteristics

	Male	Female	p-value
Death within Index hospitalization	32 of 181 (17.7%)	18 of 149 (12.1%)	0.1580
Death within 1 year from discharge (survivors only)	26 of 149 (17.5%)	18 of 131 (13.7%)	0.3948
Any Death within Index Hospitalization or subsequent year	58 of 181 (32.0%)	36 of 149 (24.2%)	0.1143
APACHE II (mean $\pm$ std) (cohort only)	22.6 $\pm$ 8.1	21.7 $\pm$ 8.4	0.3704
Charlson Comorbidity Index (mean $\pm$ std) (cohort only)	3.0 $\pm$ 2.2	2.7 $\pm$ 2.0	0.2566

Death within index hospitalization discharge takes into account 330 patients included in the parent early ICU mobilization study. Death within 1 year from Index hospitalization discharge accounts for 280 survivors included in the parent early ICU mobilization study. APACHE II and Charlson Comorbidity Index from Index hospitalization reflects the cohort of survivors with verified information on readmission and death status, n total = 258.