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Original Article

Home return following invasive mechanical ventilation for the oldest-old patients in medical intensive care units from two US hospitals

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ABSTRACT

Background: The aging of the US population has been associated with an increase in intensive care unit (ICU) utilization and correspondingly, invasive mechanical ventilation (IMV) among the oldest-old (age ≥80 years). While previous studies have examined ICU and IMV outcomes in the elderly, very few have focused on patient-centered outcomes, specifically home return, in the oldest-old. We investigated the rate of immediate home return following IMV in the medical ICU in previously home-dwelling oldest-old patients relative to that of a comparison group of 50–70-year olds. **Methods:** Data were extracted retrospectively from patient records at Elmhurst Hospital Center in Elmhurst, NY, USA, encompassing the period from January 2009 to May 2014 and Jacobi Medical Center in the Bronx, NY, USA, from January 2010 to March 2014. Medical ICU admissions within those date ranges were screened for possible inclusion into one of two study groups based on age: ≥80 years old and 50–70 years old. The primary end point was hospital discharge: home return versus no home return (death or nonhome discharge). Cox proportional hazards' regression models were used to estimate crude and multivariable-adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) for failure to return home. **Results:** A total of 375 patients were included in the analysis: 279 (74%) patients aged 50–70 years and 96 (26%) patients aged ≥80 years. Compared to 50–70-year olds, being ≥80 years old was associated with a nearly two-fold greater risk of no home return: adjusted HR: 1.96; 95% CI 1.43–2.67. The oldest-old was at significantly increased risk of both being discharged to a skilled nursing facility or subacute rehabilitation (adjusted HR: 2.19; 95% CI 1.33–3.59) as well as of dying in the hospital (adjusted HR: 1.81; 95% CI 1.21–2.71). **Conclusion:** Previously home-dwelling oldest-old are at significantly increased risk of failing to return home immediately following medical ICU admission with IMV as compared to patients aged 50–70 years. These results can help medical ICU staff establish appropriate expectations when addressing the families of their oldest patients. Further studies are needed to evaluate the potential for delayed home return among the oldest old and to assess the ability of frailty indices to predict home return within this ICU population.

KEY WORDS: Home return, mechanical ventilation in old, octogenarians, outcome

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INTRODUCTION

The fastest growing segment of the aging US population is those 65 years of age and older with a substantial increase in those aged 85 years and older.[1-3] Critical care medicine stands to be especially affected by this demographic shift because intensive care unit (ICU) utilization and the attendant cumulative expense increase with age.[4-6] The incidence of invasive mechanical ventilation (IMV), a common reason for ICU admission, likewise increases with age. Furthermore, the requirement for IMV is associated with greater mortality in the elderly,[6,7] over 40% of whom would refuse it were they in a position to decide.[8] The initiation of IMV in this age group, therefore, involves the reconciliation of increased cost with inferior outcomes and patient preferences to the contrary.

Many studies examining ICU outcomes in the elderly have defined 65 years as the age threshold[9-13] and have focused primarily on survival metrics.[10-18] In addition, the vast majority of studies have included both ventilated and nonventilated cases from a mixed ICU population consisting of cardiac, surgical, and medical admissions, each representing a fundamentally distinct category of patients with differences in prognosis.[19-21] In fact, when considered individually, these studies have yielded mixed results about chronological age as a risk factor for mortality.[15,17] Study participants have also had variable degrees of functional independence before their respiratory failure.[18,22] There has been a growing realization in the critical care community that perhaps ICU outcomes ought to be viewed in the context of accompanying disability, particularly in the elderly.[23-26] The issue of postsurvival disposition is especially salient when initiation of IMV is being contemplated in octogenarians and nonagenarians. Many of these patients and their families consider survival without return to their premorbid domicile to be an unsatisfactory outcome.[27]

The rate of home discharge among previously home-dwelling elderly after an ICU stay has been studied only once previously as the primary outcome measure and representation of their functional recovery.[28] Those investigators used 65 as the age criterion and included both ventilated and nonventilated cases from all ICU types in a retrospective cohort study. Home return has never been evaluated in a population restricted to the most vulnerable[19,21,29] and therefore most challenging patients: acute IMV recipients aged ≥80 years admitted to a medical ICU. The aim of the present study was to investigate the risk of not returning home ("no home return") among previously home-dwelling patients aged ≥80 years who underwent IMV and were admitted to a medical ICU compared to patients 50–70 years of age fulfilling the same criteria.

METHODS

Setting

This was a retrospective cohort study conducted at two university-affiliated municipal academic hospitals serving a multiethnic population: Elmhurst Hospital Center (EHC) in Elmhurst, NY, USA and Jacobi Medical Center (JMC) in Bronx, NY, USA. The Institutional Review Boards of both institutions approved the study. Each hospital has a dedicated medical ICU admitting exclusively medical patients and is staffed by a team of intensivists and trainees. EHC has an 8-bed medical ICU, while JMC has a 12-bed medical ICU.

Participants

Patients admitted to the medical ICU at EHC between January 1, 2009, and May 31, 2014, and to the JMC medical ICU between January 1, 2010, and March 31, 2014, were eligible for enrollment. Table 1 lists the study's inclusion and exclusion criteria. The exclusion criteria were designed to restrict the analysis to those participants with the highest baseline functionality. Patients were divided into two age groups to reduce misclassification while assessing the impact of age: 50–70 years old and ≥80 years old.

Measurements

Calculated composite critical illness scores included the Acute Physiology Chronic Health Evaluation (APACHE) II, Sequential Organ Failure Assessment, and the Simplified Acute Physiology Score (SAPS) II.[30-34] Calculations were based on the worst measurements taken over the first 24 h of admission. The contribution of age to both the APACHE II and SAPS II scores was eliminated by calculating modified APACHE II and SAPS II scores without including age as has been done previously.[17] Body mass index (BMI) was evaluated as a categorical variable. BMI quartiles were calculated using the study population with 1st quartile defined as BMI <23, 2nd quartile BMI = 23–26.9, 3rd quartile BMI = 27–32.9, and 4th quartile defined as BMI ≥33.

Statistical analysis

The primary study end point was hospital discharge: home return versus no home return. Failure of home return was coded as either death by the end of the study period or discharge to a skilled nursing facility (SNF), or to subacute rehabilitation (SAR). Age-specific person-days were calculated from the participants' cumulative survival time during the total hospitalization. Medians and ranges for baseline characteristics and hospital characteristics were calculated for both age groups. Variables were log

Table 1: Inclusion and exclusion criteria

Inclusion	Exclusion
Age 50-70 years or ≥80 years	Admission after cardiac arrest
Home-dwelling before admission	Nursing home residency
	24 h home health attendant
	Bedbound
IMV on arrival to the medical ICU	Baseline mechanical ventilator dependence
	Active malignancy
	Dementia
	Do not resuscitate status
	Palliative extubation within 96 h of medical ICU admission

IMV: Invasive mechanical ventilation, ICU: Intensive Care Unit

transformed if they violated normality. Descriptive analysis included baseline characteristics of the two age groups and statistical testing included Pearson's Chi-square test for categorical variables and ANOVA for continuous variables.

Cox proportional hazards' regression models were used to estimate crude and multivariable-adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) for outcomes assessed. Baseline characteristics considered to be potential confounding factors were selected *a priori*. Potential confounding variables included in the multivariable model were critical illness scores, BMI quartile, ICU admission source, and vasopressor use within the first 24 h. Interactions were assessed between age and critical illness scores (i.e., APACHE II and SAPS II) as well as between these critical illness scores themselves. There was no evidence for departure from assumption of proportional hazards. All statistical tests were based on two-sided probability and $P < 0.05$ was considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics (Version 20, Armonk, NY, USA).

RESULTS

A total of 774 patients admitted to the two medical ICUs during the study period met our inclusion criteria. Of these, 399 patients were excluded based on our exclusion criteria, leaving a total of 375 patients (168 from EHC and 207 from JMC) eligible for analysis as shown in Figure 1.

The study participants' baseline characteristics are shown in Table 2. There were 96 patients aged ≥80 years and 279 patients aged 50–70 years. The median age was 85 years in the oldest-old group and 59 years in the younger group. The two age groups differed by baseline characteristics of sex, race and ethnicity, hospital site, admission site, and BMI. The majority of the oldest-old (54%) were female compared to 36% of those aged 50–70 years ($P < 0.05$). About 60% of those aged 50–70 years were from JMC compared to 41% of patients from EHC ($P < 0.05$). Most participants admitted to the medical ICU came from the emergency department (94% for 50–70-years olds and 77% for the oldest-old; $P < 0.05$). Approximately 30% of those aged 50–70 years had a BMI of 33 or greater, whereas 33% of the oldest-old had a BMI of <23 ($P < 0.05$). Discounting age, there was no difference in critical illness scores between the two groups.

The hospital course characteristics of the two groups are shown in Table 3. Median hospital length of stay (LOS) and median medical ICU LOS were similar between patients 50–70 years and the oldest-old. There was no significant difference between the two groups in ICU-free days and IMV-free days. The most common admission diagnosis category in the 50–70-year-old group was pulmonary (32%) followed by infectious disease (25%), whereas the most common admission diagnosis category for the oldest-old was infectious disease (35%) followed by pulmonary (30%). In the younger group, the majority of participants were discharged home as opposed to the oldest-old (58% of 50–70-year olds and 19% of the oldest-old; $P < 0.05$).

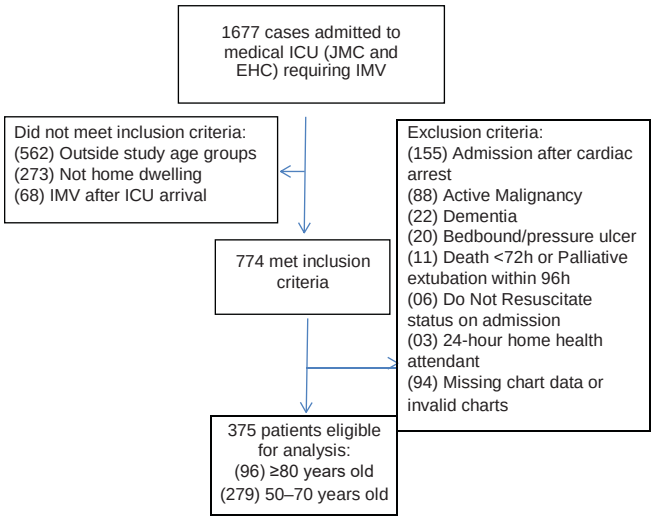

Figure 1: CONSORT diagram of chart inclusion and exclusion for analysis at Jacobi Medical Center Intensive Care Unit from January 1, 2010 to March 31, 2014 and at Elmhurst Hospital Medical Center Intensive Care Unit from January 1, 2009 to May 31, 2014

Table 2: Baseline patient characteristics

Variables	Age 50-70 (*n*=279)	Age ≥80 (*n*=96)	*P*‡
Sex, *n* (%)			
Female	101 (36.2)	52 (54.2)	<0.05
Male	178 (63.8)	44 (45.8)	
Ethnicity, *n* (%)			
Hispanic	90 (32.3)	27 (28.1)	<0.05
African American	47 (16.8)	9 (9.4)	
White/European	74 (26.5)	37 (38.5)	
Asian	24 (8.6)	14 (14.6)	
Other	44 (15.8)	9 (9.4)	
Age†	59.4 (50, 70)	85 (80, 96)	<0.05
Hospital, *n* (%)			
JMC	164 (58.8)	43 (44.8)	<0.05
Elmhurst	115 (41.2)	53 (55.2)	
Source, *n* (%)			
ED	261 (93.5)	74 (77.1)	<0.05
Wards	18 (6.5)	22 (22.9)	
Scores$			
APACHE II	22 (5, 47)	25 (8, 47)	<0.05
SAPS II	46 (7, 105)	54 (50, 86)	<0.05
Modified APACHE II	18 (2, 44)	19 (2, 41)	NS
Modified SAPS II	36 (0, 93)	36 (12, 68)	NS
SOFA	9 (0, 20)	8 (2, 19)	NS
BMI quartiles (%)			
1 (<23)	58 (20.8)	32 (33.3)	<0.05
2 (23-26.9)	65 (23.3)	26 (27.1)	
3 (27-32.9)	72 (25.8)	26 (27.1)	
4 (>33)	84 (30.1)	12 (12.5)	

†Values expressed as median (minimum,maximum), ‡Statistical significance was tested using Pearson's Chi-square test for categorical variables and ANOVA for continuous variables, $Modified scores were calculated after the exclusion of the age parameter,[17] APACHE: Acute Physiology and Chronic Health Evaluation, BMI: Body Mass Index, ED: Emergency Department, JMC: Jacobi Medical Center, NS: Non-significant, SAPS: Simplified Acute Physiology Score, SOFA: Sequential Organ Failure Assessment

Table 4 shows crude and multivariable-adjusted HR with the reference group being those aged 50–70 years. The oldest-old had a more than two-fold (adjusted HR: 2.19; 95% CI: 1.33–3.59) increased risk of being discharged to a SNF/SAR after adjusting for confounding variables. The oldest-old had an 81% increased risk of death (adjusted HR: 1.81; 95% CI: 1.21–2.71) compared to their younger counterparts. In aggregate, the oldest-old had a nearly two-fold (adjusted HR: 1.96; 95% CI: 1.43-2.67) increased risk of no home return after medical ICU stay with IMV.

Table 3: Hospital course characteristics

Variables	Age 50-70 (*n*=279)	Age ≥80 (*n*=96)	*P*‡
Medical ICU diagnosis category (%)			
CV	8 (2.9)	4 (4.2)	<0.05
ID	70 (25.1)	34 (35.4)	
Pulmonary	89 (31.9)	29 (30.2)	
Neurology	43 (15.4)	22 (22.9)	
GI	25 (9.0)	4 (4.2)	
Toxic/metabolic/renal	29 (10.4)	3 (3.1)	
Other	15 (5.4)	0 (0.0)	
LOS hospital days†	14 (1, 107)	16 (1, 98)	NS
LOS ICU days†	8 (1, 48)	7 (1, 70)	NS
ICU-free days†	5 (0, 89)	6 (0, 70)	NS
IMV-free days†	7 (0, 66)	8 (0, 98)	NS
Vasopressor use in first 24 h (%)	104 (37.3)	42 (43.8)	NS
Disposition (%)			
Home return	163 (58.4)	18 (18.8)	<0.05
No home return			
SNF/SAR	41 (14.7)	33 (34.4)	
Death/hospice	75 (26.9)	45 (46.9)	

†Values were expressed as median (minimum,maximum), ‡Statistical significance was tested using Pearson's Chi-square test for categorical variables and ANOVA for continuous variables. Significance tested on log10 transformation for improved normality distribution. CV: Cardiovascular, GI: Gastrointestinal, ICU: Intensive Care Unit, ID: Infectious Disease, IMV: Invasive Mechanical Ventilation, JMC: Jacobi Medical Center, LOS: Length of stay, NS: Non-significant, SAR: Subacute Rehabilitation, SNF: Subacute Nursing Facility

Table 4: Crude and adjusted hazard ratios for the primary end points for the oldest-old compared to the 50-70-year-old group

	Age 50-70 (*n*=279)	Age ≥80 (*n*=96)
Home return (*n*)	163	18
Crude HR (95% CI)	Reference	0.29 (0.18-0.47)
Adjusted HR (95% CI)‡	Reference	0.32 (0.19-0.53)
No home return (*n*)	116	78
Crude HR (95% CI)	Reference	1.70 (1.28-2.27)
Adjusted HR (95% CI)‡	Reference	1.96 (1.43-2.67)
Death/hospice (*n*)	75	45
Crude HR (95% CI)	Reference	1.60 (1.10-2.32)
Adjusted HR (95% CI)‡	Reference	1.81 (1.21-2.71)
SNF/SAR (*n*)	41	33
Crude HR (95% CI)	Reference	1.87 (1.18-2.97)
Adjusted HR (95% CI)‡	Reference	2.19 (1.33-3.59)

‡Cox proportional hazard regression model adjusted for: admission source, vasopressor use, SOFA, Modified APACHE II,[17] Modified SAPS II,[17] BMI quartile APACHE: Acute Physiology and Chronic Health Evaluation, BMI: Body Mass Index, CI: Confidence Interval, HR: Hazard Ratio, JMC: Jacobi Medical Center, LOS: Length of Stay, SOFA: Sequential Organ Failure Assessment, SAPS: Simplified Acute Physiology Score, SAR: Subacute Rehabilitation, SNF: Subacute Nursing Facility

DISCUSSION

In this retrospective study of previously home-dwelling, mechanically ventilated oldest-old from the medical ICUs of two community teaching hospitals in the US, the proportion of home return upon hospital discharge was approximately 19% as compared to 58% among participants 50–70 years of age. The octa- and nonagenarians were nearly twice as likely as the generation of their children – the current "Baby Boomers" – not to return home immediately following their critical illness. The low likelihood of home return among participants ≥80 years of age occurred despite exclusion criteria designed to restrict the analysis to the most highly functional representatives of this age group. Mortality was significantly higher among the oldest old in our study.

Our study builds on the work of Conti *et al*.[28] in drawing attention to home return as a valid patient- and family-centered primary outcome of critical illness in the geriatric ICU population. We submit that, when elderly patients admitted from home confront the possible initiation of IMV, they or their surrogates often reduce the decision of whether or not to proceed with intubation to the tangible question of probability of home return following IMV. Home return, though on the one hand not necessarily synonymous with functional recovery, can be a summative measure of short-term ICU outcome vis-à-vis restoration of quality of life. It offers an element of objectivity missing from the assessment of return to usual activities for example.[28] Home return at the end of an index hospitalization can also be the surest validation that the critical care team has accomplished its most important immediate goal.

We limited our scope to those admitted to the medical ICU because including a mixed population, as has been done by others,[18,20,29,35] combines medical patients with participants (e.g., elective surgery and cardiac cases) who have a more favorable prognosis *a priori*. Similarly, prolonged IMV is a prognostic game changer in the elderly ICU population,[5,12,20] which affects the applicability of studies that include spontaneously breathing patients and even those only briefly ventilated.[35,36] Defining the elderly as those 65 years and older can be considered too liberal with respect to age because we posit that it is those over 80 who are of greatest interest to both intensivists and policymakers. The two age groups were selected to highlight the differences in age, reduce misclassification, and underscore the possible impact of age on outcome. Although we have demonstrated a remarkably low rate of home return and increased risk of no home return – both in absolute and comparative terms – among the most functional of the oldest-old mechanically ventilated in medical ICUs, it is worth noting that nearly 1 in 5 such patients were in fact discharged back home following their hospitalization. The present study supports the notion that a chronological age limit to ICU admission is not an elegant way to allocate critical care resources.[36] One

intriguing parameter receiving increasing attention in the prognostication of the critically ill elderly has been the concept of frailty.[10,19,37,38] Due to the retrospective nature of our study, we were unable to examine this characteristic as a predictor of no home return. Supplemental analysis using BMI as a surrogate for frailty did not yield a significant association [Table 1S]. The enrollment of an analogous patient population into a prospective cohort study would allow the determination of frailty by means of surrogate-derived information and would enable the investigators to assess not only the initial disposition – as was done in the present study – but also the vital and residence status at a time point after the initial discharge (e.g., 6 months). However, limited available data suggest that delayed home return is not a frequent occurrence.[21,22]

Our study has several important limitations. Design limitations include its retrospective nature dependent on the accuracy of medical record review and the slight discordance in the timeframes for case collection between the two participating hospitals, which may introduce selection bias. Furthermore, although the exclusion criteria were designed to generate a study population of the most highly functional octa- and nonagenarians with the best recovery potential, these criteria are certainly an imperfect filter. For example, patients with pressure ulcers detected on admission were excluded, but we had no means of distinguishing such ulcers caused by chronic immobility from those that might newly form in a patient rendered immobile by acute illness. Likewise, 24 h home aides were an exclusion criterion intended to identify persons with a high level of dependence, but the absence of such an aide may be a matter of financial well-being or medical insurance coverage rather than functional status. Furthermore, we chose not to collect the participants' comorbid illnesses due to their inconsistent and unreliable reporting in the medical record of patients incapable of providing history. This precluded an analysis of any association between specific chronic health conditions and home return in our study population. All investigations involving ICU patients are handicapped by the selection bias inherent in any ICU triage system. Studies examining the critically ill oldest-old could be disproportionately affected by this type of bias. Notably, if one is interested in restricting a study to the most robust among such patients, the ICU triage filter may, in fact, help refine the intended study population.

CONCLUSION

Only a small minority of even the most highly functional oldest-old return home immediately after receipt of IMV in a medical ICU. This rate of home return is significantly lower than that of the 50–70-year-old comparison group. These results can inform discussions between frontline clinicians and patients and their representatives while setting appropriate expectations for the time when medical ICUs will be confronted with current "Baby Boomers" having reached their 80s and 90s. Further investigations in this area should focus on the comparative likelihood of delayed home return among the oldest-old discharged to institutions following IMV in a medical ICU. Likewise, it would be instructive to assess the ability of frailty indices to predict home return within the subset of mechanically ventilated medical ICU survivors ≥80 years of age.

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Conflicts of interest
There are no conflicts of interest.

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