Assessment of geriatrics outcomes in the cardiac intensive care unit

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ABSTRACT

Objective: Critically ill older adults greater than or equal to 80 years old are routinely admitted to contemporary cardiac intensive care units (CICU). Little has been reported about their outcomes when compared to the general CICU population. The primary aim of this study was to compare the mortality, length-of-stay, and disposition outcomes of elderly patients (greater or equal to 80 years old) admitted to the CICU with a younger cohort (less than 80 years old).

Methods and Results: A single-center, retrospective cohort study was conducted including 6,194 adult patients admitted to a cardiovascular intensive care unit in Newark, Delaware, from July 1, 2012, to June 30, 2019. Coronary intensive care unit (CICU) mortality, CICU length-of-stay and discharge disposition were compared between elderly patients (greater than or equal to 80 years old) and younger patients (less than 80 years old), adjusted for comorbidities.

We observed increased mortality for elderly patients (OR 1.686, CI 1.361–2.090, $p < 0.001$) compared with patients less than 80 years old, even after adjusting for comorbidities. Median length of stay was not statistically different between the two groups. However, the elderly patients were significantly more likely to be discharged to a facility, such as a skilled nursing facility, than those less than 80 years old (26.8% versus 12.5%, respectively, $p < 0.001$).

Conclusions: Among patients admitted to the CICU, elderly patients have higher mortality rates than those less than 80 years old. Advanced age (greater or equal to 80 years old) was not a reliable predictor of outcome in the CICU. A large proportion of elderly patients are not able to live independently at home after CICU admissions.

Keywords: octogenarians, nonagenarians, cardiac intensive care unit, elderly, ICU mortality

INTRODUCTION

As the United States population ages, the number of older adults admitted to cardiac intensive care units (CICUs) will likely continue to rise. Care of elderly patients in a CICU can be complex and requires an understanding of not only cardiovascular diseases but of conditions specific to older adults. Polypharmacy, cognitive decline, delirium, and frailty commonly impact the care of the hospitalized elderly.[1–4] The modern CICU has evolved to treat multiple acute cardiovascular diseases in addition to acute coronary syndromes. As the CICU continues to change and accommodate increasingly older patients, it is important to understand the outcomes and characteristics of these patients in an effort to improve future care. This study investigates the mortality, discharge disposition, and length of stay of elderly patients (defined as greater than or equal to 80 years old for the purpose of this study) admitted to the CICU compared to younger (less than 80 years old) patients.

METHODS

This study is a retrospective cohort study approved by ChristianaCare's Institutional Review Board under waiver of informed consent as posing minimal risk to

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patients. The study was conducted in a large tertiary care academic medical center in Newark, Delaware. Over 1,500 patients are admitted to this CICU yearly; the CICU is a sixteen-bed open model CICU that is shared between cardiac medical and cardiac surgical services.

Study Population

Patients included in this study were consecutive medical admissions over 18 years of age to the CICU between July 1, 2012, and June 30, 2019. Cardiac surgery patients were excluded from the study cohort. Demographic information, including age, sex, race, ethnicity, primary language, admission type, vasopressor use, mechanical circulatory support use, lactic acid, creatinine, left ventricular ejection fraction (LVEF), discharge disposition, Charlson-Deyo comorbidity score, Acute Physiology and Chronic Health Evaluation (APACHE) III score, ICU length of stay, and ICU mortality, were collected from the electronic medical records (EMR) data warehouse.[5,6] APACHE III scores, vasopressor data, and mechanical circulatory support data were available from July 2016 onwards, accounting for 27% of the total population.

Statistical Analysis

Patient demographic and clinical variables were summarized using count and percent, mean and standard deviation, and median and interquartile range (IQR) depending on distribution. The unadjusted effect of age (less than 80 years old versus greater than or equal to 80 years old) on ICU mortality was estimated by fitting a simple logistic regression model without other covariates. A± multiple logistic regression model was employed to estimate the adjusted effect of age on ICU mortality.

The covariates included in the models were age, arrival day and time (weekday day [Monday-Friday 8:00–17:59] arrival versus other), sex, race, primary language (English versus other), and comorbid conditions of cerebrovascular disease, heart failure, chronic lung disease, liver disease, diabetes, renal failure, and myocardial infarction. We also adjusted for Charlson-Deyo comorbidity score. A continuous variable representing the year of admission was introduced in the model to adjust for possible temporal trends in ICU mortality. A Chi-squared test was performed to evaluate the association of age group with discharge disposition classes.

To evaluate the factors associated with the ICU length of stay (LOS), a generalized linear model (GLM) with log link function and gamma distribution was estimated. The gamma model was selected to account for the highly right-skewed distribution of the ICU LOS. For ease of interpretation, the estimates from the gamma model are presented as a ratio of expected LOS calculated as e^{β}, where β is the regression coefficient from the gamma model. The patients who died in the CICU or had missing admission or discharge times were excluded in the analysis of ICU LOS. All statistical analyses were done using SAS® version 9.4.[7]

Results

During the study period, there were 6,194 medical patients admitted to the CICU and used for final statistical analysis. Table 1 summarizes the study population characteristics. The mean age was 64.57 ± 14.75 years with the average age of 60.38 ± 12.36 years in the less than 80 years old and 85.3 ± 4.31 years in the older group. There were 62.58% males in the entire cohort with 65.25% males in the less than 80 years old group compared to 49.33% male in the older group (p < 0.001). White race represented 73.03% of the less than 80 years old group compared to 87.88% of the older group (p < 0.001). The majority of patients were English-speaking (95.54% less than 80 years old versus 95.48% in the older group, p = 0.935). Vasopressor use occurred in 2.52% of all patients, 2.62% in the less than 80 years old compared to 2.02% in the older group (p = 0.259). Mechanical circulatory support was used in 3.47% of all patients, 3.78% in the younger than 80 years old versus 1.92% in the older group (p = 0.002). Lactic acid and creatinine values were missing in a large number of the patients. Left ventricular ejection fraction (LVEF) had a mean value of 43.38% ± 17.16 % in all patients with a LVEF of 43.21% ± 17.3% in the less than 80 years old group compared to 44.20% ± 16.42% in the older group. Mean Charlson-Deyo comorbidity score was 4.3 ± 3.24 in less than

Table 1. Characteristics of the Study Population

Variable	All (n = 6194)	Age < 80 Years Old (n = 5154)	Age ≥ 80 Years Old (n = 1040)	P-Value*
Age (mean, SD)	64.57 (14.75)	60.38 (12.36)	85.38 (4.31)	
Gender				**<0.001**
Male	3876 (62.58)	3363 (65.25)	513 (49.33)	
Female	2318 (37.42)	1791 (34.75)	527 (50.67)	
Race				**<0.001**
White	4678 (75.52)	3764 (73.03)	914 (87.88)	
Black	1212 (19.57)	1117 (21.67)	95 (9.13)	
Other	304 (4.91)	273 (5.30)	31 (2.98)	
Ethnicity				**0.001**
Hispanic or Latino	174 (2.81)	162 (3.14)	12 (1.15)	
Non-Hispanic or Latino	5736 (92.61)	4754 (92.24)	982 (94.42)	
Unknown	284 (4.59)	238 (4.62)	46 (4.42)	
Language				**0.935**
English	5917 (95.53)	4924 (95.54)	993 (95.48)	
Other	277 (4.47)	230 (4.46)	47 (4.52)	
Insurance Type				**<0.001**
Commercial	2738 (44.20)	2621 (50.85)	117 (11.25)	
Medicaid	222 (3.58)	222 (4.31)	0	
Medicare	3234 (52.21)	2311 (44.84)	923 (88.75)	
Admission Type				**<0.001**
Elective	186 (3.00)	159 (3.08)	27 (2.60)	
Emergency	5174 (83.53)	4298 (83.39)	876 (84.23)	
Trauma Center[†]	24 (0.39)	11 (0.21)	13 (1.25)	
Urgent[‡]	810 (13.08)	686 (13.31)	124 (11.92)	
Arrival Day time				**0.050**
Weekday Day[§]	2465 (39.80)	2023 (39.25)	442 (42.50)	
Other	3729 (60.20)	3131 (60.75)	598 (57.50)	
Vasopressor use	156 (2.52)	135 (2.62)	21 (2.02)	0.259
Mechanical support device use	215 (3.47)	195 (3.78)	20 (1.92)	**0.002**
Lactic Acid (mean, SD)[#]	3.27 (3.83)	3.28 (3.89)	3.27 (3.52)	0.973
Creatinine (mean, SD)	1.33 (1.49)	1.36 (1.57)	1.19 (0.96)	
Creatinine (median, IQR)**	1.0 (0.8, 1.0)	1.0 (0.8, 1.0)	1.0 (0.8, 1.0)	**0.0186**
LVEF (mean, SD)	43.38 (17.16)	43.21 (17.30)	44.20 (16.42)	
LVEF (median, IQR)[††]	50 (30, 60)	50 (30, 60)	50 (30, 60)	0.170

(*continued*)

Table 1. Characteristics of the Study Population (*Continued*)

Variable	All (n = 6194)	Age < 80 Years Old (n = 5154)	Age ≥ 80 Years Old (n = 1040)	P-Value*
Charlson Comorbidity Score (mean, SD)	4.46 (3.23)	4.30 (3.24)	5.23 (3.10)	**<0.001**
Apache III Score (mean, SD)‡‡	45.82 (22.50)	44.65 (22.45)	51.37 (21.97)	**<0.001**
ICU length of stay (hour) (median, IQR)	38 (22, 70)	38 (22, 70)	39 (22, 70)	0.561
ICU Mortality	507 (8.19)	383 (7.43)	124 (11.92)	<0.001

The values are count and percentage unless otherwise mentioned.
*The P values are from Chi-squared test for categorical variables, t-test for APACHE III, Charlson Comorbidity score, and lactic acid use, and from Wilcoxon-rank sum test for creatinine, LVEF. †Trauma admissions were cleared by the trauma service before admission to their respective services. ‡Urgent admissions represented unscheduled emergent admissions that did not originate in the emergency department; for example, scheduled elective surgery with complications, pre-admissions from home or a doctor's office, or transfers from other facilities. §Weekday day admissions occurred Monday-Friday 8:00–17:59. Other designates admission times outside this window. The vasopressor and mechanical support were coded as 1 and missing. #Lactic acid data is missing for 82.7% of the population. **Creatinine is missing for 47.5% of the population. ††LVEF is missing for 12.37% of the population. ‡‡Apache III is missing for 73.10% of the population.

80 years old group and 5.23 ± 3.10 in the older cohort (p < 0.001). The mean APACHE III score was 44.65 ± 22.45 in the less than 80 years old group compared to 51.37 ± 21.97 in the older cohort (p < 0.001). ICU mortality was 7.43% for age less than 80 years old patients compared with 11.92% in the older patients (p < 0.001).

Univariate analysis reported in Table 3 demonstrated that for elderly patients, the odds of dying in the CICU were 1.68 times higher than that of patients less than 80 years old (CI 1.361–2.09; p < 0.001). When adjusting for sex, race, language, arrival day and time, Charlson-Deyo score and admission year, the odds of ICU mortality for the older patients was 1.45 (CI 1.15–1.82) times the odds of ICU mortality for the age less than 80 years old group (Table 4). Upon evaluation of discharge disposition, there were substantially more patients discharged to home in the age less than

80 years old group (53.67%) compared with the older group (25.41%). In addition, more patients were discharged/transferred to skilled nursing facilities in the older group compared to the less than 80 years old patient group (22.14% versus 6.52%, respectively). Table 2 summarizes discharge disposition between the two groups. Table 4 shows adjusted odds ratio of factors associated with ICU mortality. Age greater than or equal to 80 years old was a significant factor associated with mortality with an adjusted odds ratio 1.446 (CI 1.151–1.817; p = 0.0015).

ICU length of stay was evaluated in 5,684 patients, shown in Table 5. Patients who died in the ICU were excluded from analysis. In the age less than 80 years old group, 5,146 patients had a mean LOS of 64.91 hours, median LOS 37.70 hours (SD 88.09, Q1 22.17, Q3 70.34). In the older group, 1,039 patients had a mean LOS of 57.46 hours, median LOS 38.76 hours (SD 65.47, Q1 21.43, Q3 69.71). The median length

Table 2. Discharge Disposition by Age Group

Disposition	Age < 80 Years Old (n = 5154)	Age ≥ 80 Years Old (n = 1040)	P-Value
Self-care	3913 (75.92)	496 (47.69)	**<0.001**
Other facility	645 (12.51)	279 (26.83)	
Hospice	213 (4.13)	141 (13.56)	
Expired	383 (7.43)	124 (11.92)	

Table 3. Univariate Analysis of Mortality

Odds Ratio Estimates		
Effect	**Point Estimate**	**95% Wald Confidence Limits**
Elderly	1.686	1.361	2.090

For patients ≥80 years old, the odds of dying in ICU is 1.68 times that of the patients <80 years old (p < 0.001).

Table 4. Adjusted Odds Ratio (AOR) of the Factors Associated with ICU Mortality and Results from the Multiple Logistic Regression

Effect	AOR	95% CI of AOR		P-Value
Age ≥80 years old versus < 80 years old	1.446	1.151	1.817	**0.0015**
Sex: Female versus Male	0.879	0.722	1.070	0.1984
Race: Black versus White	0.768	0.595	0.991	0.0427
Language: English versus Other	0.221	0.155	0.316	**<.0001**
Arrival day and time: Weekday day versus other	0.821	0.678	0.996	**0.0449**
Comorbidities				
Cerebrovascular Disease	1.287	1.034	1.602	**0.0240**
Congestive heart failure	1.272	1.022	1.584	**0.0312**
Chronic lung disease	1.041	0.843	1.286	0.7082
Liver Disease	1.871	1.141	3.067	**0.0130**
Diabetes	1.018	0.827	1.254	0.8640
Renal Failure	1.374	1.085	1.741	**0.0085**
Myocardial Infarction	0.832	0.683	1.015	0.0693
Charlson Comorbidity Score	1.076	1.031	1.123	**0.0009**
Admission year	1.001	0.955	1.050	0.9575

After adjusting for sex, race, language, arrival day and time, comorbidities, and admission year, the odds of ICU mortality of patients older than or equal to 80 years old is 1.45 times the odds of ICU mortality of patients with age less than 80 years old (CI: 1.15–1.82, p = 0.0015).

of stay was not statistically different between the two groups. Table 5 summarizes determinants of ICU LOS with estimates from the gamma model exponentiated for ease of interpretation. After adjusting for gender, race, language, arrival day and time, and comorbid conditions, the average length of stay of elderly patients is 0.84 times the average ICU LOS of patients less than 80 years old. Factors associated with an increased length of stay include weekday versus other admission time (e^{β} 1.07, CI 1.02–1.12, p = 0.004) and comorbidities, including cerebrovascular disease (e^{β} 1.14, CI 1.07–1.20, p < 0.001), congestive heart failure (e^{β} 1.54, CI 1.46–1.62, p < 0.001), chronic lung disease (e^{β} 1.11, CI 1.05–1.16, p < 0.001), liver disease (e^{β} 1.36, CI 1.15–1.61, p < 0.001), and renal failure (e^{β} 1.11, CI 1.04–1.18, p = 0.001).

Discharge disposition was compared between the two groups. The older patient group had 47.69% discharged home compared to 75.92% in the age less than 80 years old group (p < 0.001). The older patients were also more likely to be discharged to another facility, such as a skilled nursing facility, compared to the less than 80 years old group (26.83% versus 12.51%, respectively). Combined hospice discharge and death during hospitalization occurred in 25.48% of all older patient discharges compared with 11.56% of patients less than 80 years old.

DISCUSSION

Our data show an increased mortality for older adult medical patients admitted to the CICU when compared with younger patients less than 80 years of age. The increase in mortality was noted after adjustment for measured comorbidities. Previous literature has examined the effect of age as a primary determinant of ICU outcomes, particularly in the very advanced age

Table 5. Determinants of ICU Length of Stay: Results from the Multiple Gamma Regression Model

Parameters	e^β-Ratio of Expected LOS	95% CI of e^β		P-Value
Age greater than or equal to 80 years old versus less than 80 years old	0.84	0.79	0.89	**<0.001**
Sex: Female versus Male	0.97	0.93	1.02	0.280
Race: Black versus White	0.97	0.92	1.03	0.309
Language: English versus Other	1.09	0.96	1.24	0.188
Arrival day and time: Weekday day versus Other	1.07	1.02	1.12	**0.004**
Comorbidities				
Cerebrovascular Disease	1.14	1.07	1.20	**<0.001**
Congestive heart failure	1.54	1.46	1.62	**<0.001**
Chronic lung disease	1.11	1.05	1.16	**<0.001**
Liver Disease	1.36	1.15	1.61	**<0.001**
Diabetes	1.04	0.98	1.09	0.172
Renal Failure	1.11	1.04	1.18	**0.001**
Myocardial Infarction	0.79	0.75	0.83	**<0.001**
Charlson Comorbidity Score	1.02	1.01	1.03	**0.001**
Admission year	0.99	0.98	1.00	0.404

For ease of interpretation, the estimates from the gamma model are exponentiated. The exponentiated coefficients (e^β) can be interpreted as a ratio of expected ICU LOS. For example, after controlling for sex, race, language, arrival day and time, and comorbid conditions, the average LOS of patients with age greater than or equal to 80 years old is 0.84 times the average ICU LOS of patients of age less than 80 years old years.

subsets (typically greater than or equal to 80 years old).[8–12] In our study, advanced age (greater or equal to 80 years old) was not seen as a reliable clinical marker for ICU mortality prediction as it had little ability to discriminate between survivors and non-survivors (ICU mortality 11.92% in the older cohort compared to 7.43% in the younger cohort).

Median CICU lengths of stay was not significantly different between the two groups. This was an unexpected finding that may benefit from further investigation. Possible explanations are that elderly patients in our cohort reached similar dispositions/decisions about their medical care goals (nursing home, hospice, etc.) or they clinically improved at a rate similar to the younger cohort.

In this study, older patients were twice as likely to be discharged to skilled nursing facilities when compared with their younger patients. Only 48% of the older patients were discharged home compared to 76% of the younger patients. This was not unexpected as advanced age in the intensive care setting is associated with increased risk of delirium, cognitive impairments, and functional deconditioning that ultimately affect discharge disposition.

This also has significant societal implications given our aging United States population. At present clinicians do not have accurate tools that can reliably assist clinicians and families in outcome predictions or discharge disposition in the older CICU patient. Clinicians and families are often left to make treatment decisions based on limited outcome data that can lead to unwanted, futile, and/or expensive medical care. Advanced age is a marker for increased CICU mortality but does not reliably predict a poor outcome. Many authors have advocated for the use of frailty scores

with age and severity of illness calculators to assist in decision making for older patients.[13,14] These tools, if used, should not only be accurate mortality predictors but also assist in predicting independent function and quality of life. Financial ramifications of futile care and end-of-life care were not evaluated in our study but should be considered in future research.[15,16]

LIMITATIONS

This study is limited since it is a retrospective electronic chart review and a single-center study which may prevent generalization of the results to other institutions. In addition, our analysis relied on the assumed accuracy of diagnosis coding and data entry in the electronic medical record, which can be subject to errors. This study may be prone to selection bias, as many patients of advanced age may not be admitted to the CICU due to patient goals of care preferences. Another possible limitation is that our analysis does not factor functional status, cognitive status, and frailty scores that can have prognostic value in this patient population. Many of these older patients may have been admitted from skilled nursing facilities; however, only the discharge dispositions were available for this analysis. Last, we paired patients based on Charlson-Deyo comorbidity scores and not ICU severity of illness scores. We did not use APACHE III or IV scores as they adjust for age, and this would have confounded our analysis. Future research should consider ICU specific severity of illness scores, such as the Sequential Organ Failure Assessment (SOFA), that do not include age.

CONCLUSIONS

Adult patients 80 years or older admitted to the CICU have a higher mortality rate than the general population. However, advanced age alone (greater or equal to 80 years old) was not a reliable predictor of outcome in the CICU given its poor ability to differentiate between survivors and non-survivors. A large proportion of elderly patients are not able to live independently at home after CICU admission. This has important societal implications given the rising number of patients reaching advanced age in our country.

Additional studies on the frailty, functional status, and outcomes of these patients post CICU admission are needed.

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