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Medical resource utilization patterns and mortality rates according to age among critically ill patients admitted to a medical intensive care unit

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Abstract

There is ongoing controversy about how to address the growing demand for intensive care for critically ill elderly patients. We investigated resource utilization patterns and mortality rates according to age among critically ill patients.

We retrospectively analyzed the medical records of patients admitted to a medical intensive care unit (ICU) in a tertiary referral teaching hospital between July 2006 and June 2015. Patients were categorized into non-elderly (age <65 years, n = 4140), young-elderly (age 65–74 years, n = 2306), and old-elderly (age ≥75 years, n = 1508) groups.

Among 7954 admissions, the mean age was 61.5 years, and 5061 (63.6%) were of male patients. The proportion of comorbidities increased with age (64.6% in the non-elderly vs 81.4% in the young-elderly vs 82.8% in the old-elderly, $P < .001$ and P for trend <.001), whereas the baseline Sequential Organ Failure Assessment (SOFA) score decreased with age (8.1 in the non-elderly vs 7.2 in the young-elderly vs 7.2 in the old-elderly, $P < .001$, $R = -.092$ and P for trend <.001). Utilization rates of mechanical ventilation (48.6% in the non-elderly vs 48.3% in the young-elderly vs 45.5% in the old-elderly, $P = .11$) and renal replacement therapy (27.5% in the non-elderly vs 25.5% in the young-elderly vs 24.8% in the old-elderly, $P = .069$) were comparable between the age groups. The 28-day ICU mortality rates were lower in the young-elderly and the old-elderly groups than in the non-elderly group (35.6% in the non-elderly vs 34.2% in the young-elderly, $P = .011$; and vs 32.6% in the old-elderly, $P = .002$).

A substantial number of critically ill elderly patients used medical resources as non-elderly patients and showed favorable clinical outcomes. Our results support that underlying medical conditions rather than age per se need to be considered for determining intensive care.

Abbreviations: ANOVA = analysis of variance, CI = confidence interval, ECMO = extracorporeal membrane oxygenation, GCS = Glasgow coma scale, HR = hazard ratio, ICU = intensive care unit, IQR = interquartile range, LOS = length of stay, PaO_2/FiO_2: the ratio of partial pressure of oxygen in arterial blood to fraction of inspired oxygen, RRS = renal replacement therapy, SCCM = society of critical care medicine, SD = standard deviation, SOFA score = sequential organ failure assessment score, VIF = variance inflation factor.

Keywords: aged, critical care, frail elderly, intensive care units, mortality

1. Introduction

The ageing of the general population has inevitably increased the demand for intensive care services.[1,2] Elderly patients now account for 20% to 30% of intensive care unit (ICU) admissions, with associated costs estimated at $110–$260 billion per year in United States.[3–5] The trend of increased demand and expenditure is expected to increase consistently with the acceleration of global population ageing.[5]

However, controversy exists regarding the balance between the costs and benefits of admitting elderly patients to ICUs. Despite research that has revealed survival benefits of ICU care for elderly patients,[6–8] there is evidence that mortality reductions may not be substantial.[9] Functional outcome and quality of life considerations further complicate the debate about the benefits of ICU care among elderly patients.[10–12] These uncertainties, coupled with the absence of definitive criteria for ICU admissions, contribute to the insufficient ICU admissions for critically ill elderly patients.[13]

Furthermore, elderly patients are not given the same amount of intensive treatment as their younger counterparts even after admission to the ICU. Previous studies have observed that,

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compared to matched younger patients, elderly patients received less mechanical ventilation, fewer tracheostomies, and less renal support in the ICU.[14,15] Considering the possible association between the increased intensity of treatment and improved survival among critically ill elderly patients,[16] it seems necessary to investigate mortality outcomes together with ICU resource utilization rates.

However, there are limited studies which present both medical resource utilization patterns and clinical outcomes according to age among critically ill patients. In addition, epidemiologic studies regarding critical illness in the ICU, particularly those including elderly patients above 75 to 80 years of age, are limited to a few geographical regions such as Western Europe, North America, Australia, and New Zealand.[1] Therefore, herein, we aimed to investigate both medical resource utilization patterns and mortalities according to age among critically ill patients admitted to ICU in an Asian cohort.

2. Methods

2.1. Study design and population

The study site was a tertiary referral teaching hospital in Seoul, South Korea, with 2704 beds including 28 medical ICU beds. The data were retrospectively collected from the electronic medical records of adult patients (age ≥19 years) who were admitted to medical ICU for ≥1 days between July 2006 and June 2015. Multiple re-admissions of same patient to ICU were considered separate cases. Patients were categorized into non-elderly (age <65 years), young-elderly (age 65–74 years) and old-elderly (age ≥75 years) groups based on age at the time of ICU admission. Baseline characteristics, utilization of medical resources in the ICU, and the 28-day ICU mortality rates were compared between the age groups.

The study was approved by the institutional review board of our hospital (approval number of 2015–1015). The need for informed consent was waived because of the de-identified and retrospective nature of the study.

2.2. Data collection

All data used in the study were collected using the de-identified clinical data warehouse system, which we described in detail elsewhere.[17] Data on baseline characteristics were collected from the time of ICU admission and include age, gender, comorbidities (solid and hematologic malignancies, cardiac disease, chronic airway disease, diabetes, and neurologic disease), and severity of illness. The severity of illness was assessed using the Sequential Organ Failure Assessment (SOFA) scoring system which was calculated using the ratio of the partial pressure of oxygen in arterial blood to the fraction of inspired oxygen (PaO_2/FiO_2), mean arterial pressure or administration of vasopressors, the Glasgow Coma Scale (GCS), platelets, and serum bilirubin and creatinine levels.[18]

To assess the utilization of medical resources in the ICU, we investigated the implementation rates of vasopressors, mechanical ventilation, renal replacement therapy (RRT), and extracorporeal membrane oxygenation (ECMO) during ICU stays. The vasopressors investigated in the present study were limited to norepinephrine, epinephrine, dopamine, and vasopressin. The length of stay (LOS) in ICU and the 28-day ICU mortality rates were also investigated and compared between the age groups.

2.3. ICU triage process

ICU triage decisions were based on the potential for patients to benefit from ICU care; ethnic origin, race, sex, social status, and sexual orientation were never considered. Comorbidities, severity of illness, prehospital functional status, expected long-term prognosis, and patient preferences about life-sustaining treatment were more strongly considered in the ICU triage decisions for patients ≥65 years of age and those with solid or hematologic malignancies.[19]

The priorities regarding ICU admission in our hospital were complied with consideration of the recommendations set by the Society of Critical Care Medicine (SCCM) and were as follows:

1. patients who require life support for organ failure, intensive monitoring, and therapies only provided in the ICU environment;
2. patients with a significantly lower probability of recovery and who would like to receive intensive care therapies but not cardiopulmonary resuscitation in the case of cardiac arrest;
3. patients with organ dysfunction who require intensive monitoring or therapy;
4. patients with a lower probability of recovery or survival who do not want to be intubated or resuscitated;
5. terminal or moribund patients with no possibility of recovery.[19]

2.4. Statistical analysis

For continuous variables, data were presented as mean ± standard deviation (SD) or median (interquartile range). Analysis of variance (ANOVA) and Kruskal-Wallis tests were used, as appropriate, and Scheffe test was used for the multiple comparisons. For the categorical variables, the data were presented as number (%). Chi-square and Fisher exact tests were used, as appropriate. Pearson coefficient of correlation, Spearman rho, and linear by linear association were used, as appropriate, for the correlation analyses. Kaplan-Meier plots were used for the survival analyses and compared using log-rank tests. Cox proportional hazards regression models were used to assess the relationships between independent variables and the 28-day ICU mortalities, and hazard ratios (HRs) were used to quantify the associations. Univariate analyses were initially performed to identify potentially significant risk factors with $P < .10$ for the multivariate analyses. The multicollinearity effects between risk factors were assessed using variance inflation factors (VIFs) with a cut-off level of > 5. A P value less than .05 was considered statistically significant, and, if necessary, was revised using Bonferroni adjustment. Statistical analyses were performed using SPSS 21.0 software (IBM Corporation, Armonk, NY) and R 3.3.1 software (http://cran.r-progject.org).

3. Results

3.1. Baseline characteristics

A total of 7954 admissions to medical ICU were identified for 7524 patients between July 2006 and June 2015. Table 1 shows the baseline characteristics of the study population. Among 7954 admissions, the mean age was 61.5 ± 14.9 years, and 5061 (63.6%) were of male patients. The non-elderly group accounted for 52.0% (n = 4140) of all medical ICU admissions, while the

Table 1

Comparison of baseline characteristics between the age groups.

Variables	Total (N = 7954)	Age group, years			*P* value
		< 65 (N = 4140)	65–74 (N = 2306)	≥75 (N = 1508)	
Age, mean (SD)	61.5 (14.9)	50.3 (11.3)	69.6 (2.8)	80.1 (4.5)	<.001
Gender					<.001
Male (%)	5061 (63.6)	2580 (62.3)	1544 (67.0)	937 (62.1)	
Female (%)	2893 (36.4)	1560 (37.7)	762 (33.0)	571 (37.9)	
Comorbidities					
None (%)	2153 (27.1)	1464 (35.4)	429 (18.6)	260 (17.2)	<.001
Any (%)	5801 (72.9)	2676 (64.6)	1877 (81.4)	1248 (82.8)	<.001
Cancer (%)					
Solid malignancy (%)	2864 (36.0)	1346 (32.5)	951 (41.2)	567 (37.6)	<.001
Hematologic malignancy (%)	995 (12.5)	710 (17.1)	215 (9.3)	70 (4.6)	<.001
Cardiac disease (%)	1712 (21.5)	561 (13.6)	626 (27.1)	525 (34.8)	<.001
Chronic airway disease (%)	992 (12.5)	276 (6.7)	402 (17.4)	314 (20.8)	<.001
Diabetes mellitus (%)	2254 (28.3)	907 (21.9)	807 (35.0)	540 (35.8)	<.001
Neurological disease (%)	1050 (13.2)	310 (7.5)	339 (14.7)	401 (26.6)	<.001
Number of comorbidities, mean (SD)	1.2 (1.0)	0.9 (0.9)	1.4 (1.0)	1.6 (1.1)	<.001
SOFA score, mean (SD)	7.7 (4.0)	8.1 (4.2)	7.2 (3.7)	7.2 (3.5)	<.001

SD = standard deviation, SOFA score = sequential organ failure assessment score.

young-elderly and old-elderly groups comprised 29.0% (n = 2306) and 19.0% (n = 1508), respectively.

Comorbidities were identified in 5801 (72.9%) admissions, and the mean number of comorbidities increased with age (0.9 in the non-elderly, 1.4 in the young-elderly, and 1.6 in the old-elderly, $P < .001$ and P for trend <.001) (See Table 1, Supplemental Fig. 1, http://links.lww.com/MD/D9, which shows the comparisons of the baseline comorbidities between the age groups). The prevalence of comorbidities—including cardiac disease, chronic airway disease, diabetes, and neurologic disease—increased with age, but the prevalence of hematologic malignancy decreased (17.1% in the non-elderly, 9.3% in the young-elderly, and 4.6% in the old-elderly, $P < .001$ and P for trend <.001). The mean baseline SOFA score, representing the severity of illness at the time of ICU admission, decreased as the age increased (8.1 in the non-elderly, 7.2 in the young-elderly, and 7.2 in the old-elderly, $P < .001$, $R = -.092$, and P for trend <.001). In the multiple comparison analysis, the mean baseline SOFA score for the non-elderly group (8.1) was significantly higher than the mean baseline scores for the young-elderly group (7.2, $P < .001$) and the old-elderly group (7.2, $P < .001$) (Table 1).

3.2. Utilization of medical resources

The ICU resource utilization rates did not decrease for the young-elderly and old-elderly groups, except for the rate of ECMO utilization (Table 2). The implementation rates of mechanical ventilation and RRT were comparable between the age groups (48.6% in the non-elderly, 48.3% in the young-elderly, and 45.5% in the old-elderly, $P = .11$ for mechanical ventilation; and 27.5% in the non-elderly, 25.5% in the young-elderly, and 24.8% in the old-elderly, $P = .069$ for RRT). The rate of vasopressor administration increased with age (72.7% in the non-elderly, 74.2% in the young-elderly, and 76.1% in the old-elderly, $P = .032$ and P for trend = .009). On the other hand, ECMO was the only treatment that was less frequently applied as the age group increased (4.2% in the non-elderly, 1.8% in the young-elderly, and 1.3% in the old-elderly, $P < .001$ and P for trend <.001). The median LOS in the ICU was 3 (1–8) days, and median LOS increased with age (2 [1–7] days in the non-elderly, 3 [1–9] days in the young-elderly, and 3 [1–10] days in the old-elderly, $P < .001$, $rho = .910$, P for trend <.001) (See Supplemental Table 1, http://links.lww.com/MD/D9, which shows comparison of ICU length of stay between the age groups).

3.3. 28-day ICU mortality rates and risk factors

The 28-day ICU mortality rates were 35.6% in the non-elderly group, 34.2% in the young-elderly group, and 32.6% in the old-elderly group ($P = .002$) (Fig. 1). Subgroup analysis revealed that the 28-day ICU mortality rate in the non-elderly group (35.6%) was significantly higher than those in the young-elderly (34.2%, $P = .011$) and old-elderly groups (32.6%, $P = .002$).

Table 3 shows the risk factors for 28-day ICU mortality. In the multivariate analysis, age was not a significant risk factor, while baseline SOFA score (HR 1.140, $P < .001$), presence of solid

Table 2

Comparison of the implementation rates of vasopressors, mechanical ventilation, RRT, and ECMO between the age groups.

Variables	Total (n = 7954)	Age group, years			*P* value
		< 65 (n = 4140)	65–74 (n = 2306)	≥ 75 (n = 1508)	
Vasopressors (%)	5865 (73.7)	3008 (72.7)	1710 (74.2)	1147 (76.1)	.032
Mechanical ventilation (%)	3810 (47.9)	2010 (48.6)	1114 (48.3)	686 (45.5)	.11
RRT (%)	2099 (26.4)	1137 (27.5)	588 (25.5)	374 (24.8)	.069
ECMO (%)	234 (2.9)	174 (4.2)	41 (1.8)	19 (1.3)	<.001

ECMO = extracorporeal membrane oxygenation, RRT = renal replacement therapy.

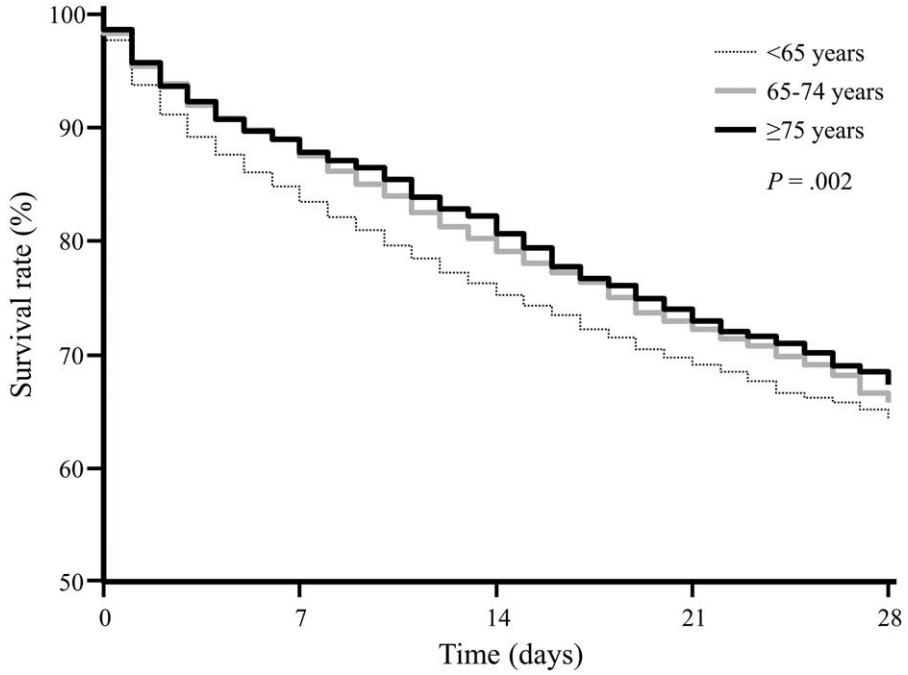

Figure 1. Comparison of the 28-day ICU mortality rates between the age groups.

malignancy (HR 1.255, $P<.001$), presence of hematologic malignancy (HR 1.374, $P<.001$), as well as the administration of vasopressors (HR 1.776, $P<.001$), mechanical ventilation (HR 1.334, $P<.001$), RRT (HR 1.119, $P=.032$), and ECMO (HR 1.492, $P<.001$) during ICU admission were significantly associated with the 28-day ICU mortality.

4. Discussion

As far as we know, this is one of the largest studies describing the clinical characteristics and outcomes of critically ill elderly patients in an Asian population. In our study, a substantial number of critically ill elderly patients with comorbidities was admitted to the medical ICU, and they had a comparable mortality rate to non-elderly patients.

Despite the increased demand for intensive care among elderly patients, the justification for admitting such patients to ICU remains controversial.[6–12] Moreover, the uncertain benefit may contribute to insufficient intensive care being provided to critically ill elderly patients, which may undermine the advantages of ICU care.[13–16] In the present study, we described our 9-year experience in a medical ICU, which encompassed 1508 admissions of patients ≥75 years of age. As most epidemiological studies regarding ICU care—particularly those involving critically ill elderly patients—are limited to a few geographical regions, there are currently huge gaps in epidemiological data and knowledge about ICU care in several geographical areas around the world.[1] This study was performed in Seoul, South Korea, where the population is ageing rapidly, and the study objectives were deemed meaningful because of the potential contribution towards filling these large geographical knowledge gaps.[20]

In the present study, the 28-day ICU mortality rates in the young-elderly and old-elderly groups were lower than that in the non-elderly group although the SOFA score was lower in these elderly groups. Interestingly, the multivariate analysis revealed that age was not a significant risk factor for 28-day ICU mortality, while other variables, such as baseline severity of illness and the presence of comorbidities, were significantly associated with death. These findings are inconsistent with the

Table 3

Risk factors for 28-day ICU mortality.

Variables	Unadjusted HR	95% CI	*P* value	Adjusted HR*	95% CI	*P* value
Baseline SOFA score	1.166	1.152–1.179	<.001	1.140	1.125–1.155	<.001
Solid malignancy	1.303	1.198–1.416	<.001	1.255	1.139–1.382	<.001
Hematologic malignancy	1.755	1.582–1.947	<.001	1.374	1.220–1.548	<.001
Vasopressors	3.004	2.611–3.457	<.001	1.776	1.494–2.110	<.001
Mechanical ventilation	1.799	1.650–1.963	<.001	1.334	1.206–1.477	<.001
RRT	1.933	1.778–2.102	<.001	1.119	1.007–1.245	.037
ECMO	1.694	1.401–2.049	<.001	1.492	1.197–1.860	<.001

CI = confidence interval, ECMO = extracorporeal membrane oxygenation, HR = hazard ratio, ICU = intensive care unit, RRT = renal replacement therapy, SOFA score = sequential organ failure assessment score.
* Adjusted for age (continuous variable), gender, baseline SOFA score, solid malignancy, hematologic malignancy, cardiac disease, chronic airway disease, and implementation of vasopressors, mechanical ventilation, RRT, and ECMO during ICU stays.

stereotypes that ICU and post-ICU mortality increase with advancing age and that age is an important risk factor for death.[21] Our findings indicate that it is not age per se but rather associated factors, such as severity of illness and the comorbidities, that contribute to increased mortality. These are in line with the results of recent studies which have supported the position that elderly patients should not be excluded from intensive care just because of their chronological age.[1,8,22–24]

We also found interesting differences in the baseline characteristics of the age groups. The mean baseline severity of illness, assessed by SOFA score, was significantly higher in the non-elderly group than in the other age groups. As physicians have traditionally regarded old age as an important risk factor for poor outcomes in the ICU, critically ill elderly patients in the present study might have been less frequently transferred to the ICU even when their illnesses were of comparable severity to their younger counterparts. Moreover, in our ICU triage process, the severity of illness and the premorbid functional status were emphasized when assessing critically ill elderly patients. Considering both the lower severity of illness scores and the better 28-day ICU mortality rates among young-elderly and old-elderly patients, we believe that our findings support previous studies, which indicate that appropriately triaged critically ill patients, including octogenarians, may benefit from ICU care.[25]

Furthermore, there were significant differences in the comorbidity rates between the age groups. In general, comorbidity prevalence increased with age. However, patients with hematologic malignancies were more frequently identified in the non-elderly group than other age groups. Moreover, hematologic malignancies were significantly associated with the 28-day ICU mortality (HR 1.367, after adjusting other confounding variables). Considering the poor short- and long-term outcomes among patients with hematologic malignancies admitted to ICU,[26] the presence of hematologic malignancies at baseline might have contributed to the higher 28-day ICU mortality rate for the young-elderly group and support the suggestion that differences in baseline characteristics need to be considered when assessing ICU outcomes.[27]

The implementation rates of mechanical ventilation and RRT were comparable between the age groups, and the vasopressor administration rate was higher in young-elderly and old-elderly patients. These findings are inconsistent with previous researches performed in Western countries,[14,15] but are interestingly in concordance with research conducted in South Korea,[28] which suggest that regional and cultural factors might have influenced the results. As ICU care requires substantial resources, and because some interventions can be unnecessary, harmful, or futile —particularly when caring for critically ill elderly patients— specific ICU treatment decisions are influenced by multiple factors, such as regional health care capacity, health insurance systems, and cultural and religious considerations.[1,29,30] However, our knowledge about critical care in different regional and cultural contexts is currently limited.[1] Further researches are required to address the effects of different cultural and regional backgrounds on critical care.

Our study had several limitations. First, it was a retrospective non-interventional study performed at a single medical ICU, suggesting inherent biases and that it may not be generalizable to other health care systems. Second, as we did not have a control group of patients who were not admitted to the ICU, comparative analyses between ICU and non-ICU groups were unavailable. Third, variables which may affect the use of medical resources and clinical outcomes such as cause of ICU admission and the frailty index were not assessed in the present study.[23,24,31] Finally, no long-term functional outcomes were investigated, and outcome prediction models were not used. Future studies that address these limitations are warranted.

5. Conclusion

During the study period, a substantial number of critically ill elderly patients received intensive care. They used medical resources in ICU as non-elderly patients and showed favorable clinical outcomes in terms of 28-day ICU mortality rate. These suggest that the chronological age may not be the major limitation on determining intensive care and underlying medical conditions such as severity of illness need to be emphasized more in the ICU triage process.

Author contributions

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