Critically Ill Elderly Who Require Mechanical Ventilation: The Effects of Age on Survival Outcomes and Resource Utilisation in the Medical Intensive Care Unit of a General Hospital

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Abstract

***Introduction**: Advanced age has been a criterion for denying admission to the medical intensive care unit (MICU) due to the perceived poorer outcome and increased resource utilisation. We studied the relationship between age and outcome of the critically ill mechanically-ventilated patients admitted to the MICU. **Materials and Methods**: This prospective study included patients admitted to the MICU for mechanical ventilation between 1994 and 1998. These were divided into 2 cohorts, with 206 patients aged 65 and above and 159 below 65 years. Outcome measures were MICU and hospital mortality and length of stay (LOS) in the MICU and hospital. Logistic and linear regression analyses were performed to determine the association between age and MICU and hospital mortality, as well as MICU and hospital LOS. Factors adjusted for included gender, smoking history, pre-hospitalisation functional status, ambulatory status, use of inotropes and APACHE II (m) scores (APACHE II scores were modified to exclude age points). **Results**: Multivariate analysis revealed no statistically significant relationship between age and MICU or hospital mortality and LOS. However, APACHE IIM scores were significantly related to both MICU and hospital mortality (OR, 1.1; CI, 1.07-1.14 and OR, 1.1; CI, 1.09-1.18 respectively), but did not predict MICU or hospital LOS. **Conclusion**: Severity of acute illness and chronic co-morbidities, but not age, are predictors of MICU and hospital mortality in elderly ventilated patients.*

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Key words: Elderly, Intensive care, Length of stay, Mechanical ventilation, Mortality

Introduction

Increasing life expectancy and ageing of the "post-war baby boomer" generation have led to the rapidly ageing demographic of many Asian countries. Singapore's elderly population above the age of 65 will rise from 7.5% in 2002 to 18.9% by the year 2030.[1] The rates of acutely ill elderly are expected to rise accordingly. Data from various developed populations have noted the "greying" of their intensive care patient profile.[2]

Intensive care units (ICUs) and other life support facilities are often scarce and expensive. The decision to utilise such resources for the elderly, in particular mechanical ventilation, often requires a balance of clinical judgement, ethical and even financial considerations. While researchers are divided in their opinion on whether age should be considered an independent poor prognostic indicator for mechanical ventilation, there are few studies in our Asian population. The objective of this study was to observe the effect of age on mortality and length of stay (LOS) in mechanically ventilated elderly patients in our medical intensive care unit (MICU).

Materials and Methods

Patients

This study was conducted in the 8-bedded MICU of a general hospital in Singapore. All patients admitted to the MICU between 1994 and 1998 were prospectively included in a database. They were followed up till death, discharge or transfer from the hospital. The MICU accepts medically-related cases, including primary cardiac problems, as there

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was no coronary care unit (CCU) in the hospital. All surgical or postoperative cases were admitted to the surgical intensive care unit (SICU).

A total of 953 patients were admitted during the study period. Of these, only 365 were ventilated and were divided into 2 cohorts: those aged 65 and above (n = 206) and those below 65 years (n = 159).

Data Collection

The data collected were divided into 6 groups: demographics, pre-hospitalisation functional status, diagnoses, severity indicators, resource mobilisation/utilisation and outcomes.

The important pre-hospitalisation parameters to highlight include the ambulatory status and activities of daily living (ADLs). These were categorised into ambulant, needs support or bed-bound. “Ambulant” referred to totally independent persons with no need for any walking aid. “Needs support” included persons requiring any form of walking aid, wheelchair or support/supervision by others for movement and “bed-bound” included only bed-bound patients. The ADLs assessed included basic functions of self-grooming, eating/feeding and toileting activities. The patients were divided into totally independent, dependent in certain areas or semi-dependent and dependent groups.

The Acute Physiology and Chronic Health Evaluation (APACHE) II scores[3] were obtained from the patients within the first 24 hours after admission to the MICU. From these, APACHE IIM scores[4] were calculated without the inclusion of points for age.

Admitting diagnoses were also tabulated and grouped into 5 types:

1) *Cardiology*: these included myocardial infarction, pericarditis, arrhythmia, acute pulmonary oedema and acute bacterial endocarditis.
2) *Respiratory*: these included pneumonia, chronic obstructive pulmonary disease, asthma, pulmonary embolism and tuberculosis.
3) *Neurology*: these included cerebrovascular accidents, intracranial haemorrhages, meningoencephalitis, Guillan-Barre syndrome, neurotoxin poisoning and myasthenic crisis.
4) *Infectious disease*: these included typhoid, malaria and severe septicaemia, with or without definite source.
5) *Others*: these comprised drug overdose, liver failure and renal failure.

The parameters surveyed for the utilisation of MICU resources included the duration of ventilation, length of MICU and hospital stay. Finally, the outcomes measured in this study were MICU and hospital mortality. All data were collected prospectively on standard forms. Any missing data was updated and verified with case records on a later date. These were subsequently entered into the database.

Statistical Analysis

An analysis of the distribution of age was first performed on all patients in the study (Fig. 1). Patients were then divided into 2 cohorts: those aged 65 years and above and those below the age of 65.

The distribution of baseline, potential prognostic and outcome variables were compared between the 2 cohorts. Continuous variables were expressed as mean ± standard deviations (SDs) and the differences between the 2 groups tested using Student’s *t*-test. Categorical variables were expressed as numbers and percentages and differences compared using chi-square tests.

Multivariate analysis was then performed to study the independent statistical association of age (analysed as 2 categories) and APACHE IIM scores (analysed as a continuous variable) with resource utilisation and mortality outcomes as described below.

Logistic regression was performed to determine the association between age and mortality (MICU and hospital mortality). Factors adjusted for included gender, smoking history, pre-hospitalisation functional status, ambulatory status, use of inotropes and APACHE IIM scores. These were entered in a one-step logistic regression analysis and reported as odds ratios, together with their *P* values and 95% confidence intervals. Linear regression was also performed for the association between age and LOS (MICU

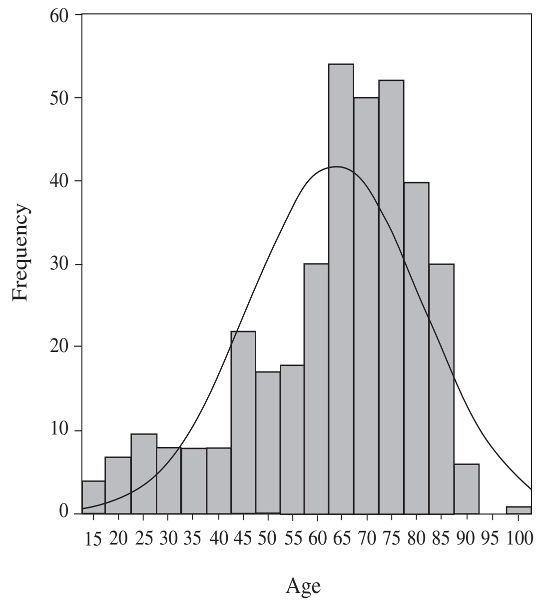


Fig. 1. Histogram showing the distribution of age of all ventilated patients.

and hospital), with adjustments for similar covariates. However, to correct for the non-linearity of data and to obtain a better regression model fit, the LOS for MICU and hospital were log transformed.

Finally, to further explore the trend of age and mortality risk, age was categorised into quintiles. The odds ratios for MICU and hospital mortality (based on logistic regression with similar covariates) were plotted against quintiles of age.

All statistical analyses were performed using the SPSS software package version 10.1 (Singapore). Results were considered significant when P <0.05.

Results

Baseline Characteristics

The median age for all patients in the study was 67 years, with a mean ± SD of 63.6 ± 17.4 years. The baseline characteristics of the 2 groups are compared in Table I. The mean age of the older group was 75.7 ± 6.7 years compared to 48 ± 14.3 years in the younger cohort. Males were noted to have a slightly higher representation in both groups. The racial representations were also consistent with the demographic distribution of the country, especially for the Chinese, Malay and Indian races. There were certain baseline differences in the pre-hospitalisation status between both groups, especially ADLs, ambulatory status and smoking status, which were statistically different. Other significant differences included the reason for ventilation and the use of inotropes. The main diseases that presented to the MICU were largely cardiology- and respiratory-related. Though the APACHE score showed some differences in the 2 groups, these were similar when the age factor was taken out.

Outcome Measures

The outcome measures are shown in Table II. The mean MICU LOS was 6.7 days for the older group and 6.4 days for the younger group. Mean hospital LOS was 15.2 days for the older group and 12.7 days for the younger group. In the older group, the MICU mortality was 33.5% and the hospital mortality was 51.9%. A small percentage of patients were transferred to other facilities, largely for interventional purposes.

Multivariate Analysis

The multivariate model containing age, APACHE IIM scores, gender and pre-hospitalisation factors revealed that age did not show any significant statistical relationship with MICU or hospital mortality and LOS. APACHE IIM scores were significantly related to both MICU and overall hospital mortality, but did not predict both MICU and hospital LOS.

Discussion

Age has always been considered a major prognosticator of hospital outcome and a factor for increased utilisation of ICU resources. As such, it has been a criterion for denying MICU admissions and care. Recent reviews on the triage decision for intensive care admission have shown that age

TABLE I: DEMOGRAPHIC DATA, PRE-HOSPITALISATION FACTORS AND SEVERITY INDICES

Variable	Group 1 (≥65 years old) n = 206 (%)	Group2 (<65 years old) n = 159 (%)	*P* value
Gender			
Male	119 (57.8)	108 (67.9)	0.47
Female	87 (42.2)	51 (32.1)	
Race			
Chinese	146 (70.9)	80 (50.3)	<0.01
Malay	34 (16.5)	41 (25.8)	
Indian	23 (11.2)	23 (14.5)	
Others	3 (1.5)	15 (9.4)	
ADLs			
Independent	146 (70.9)	146 (91.8)	<0.01
Semi-independent	43 (20.9)	10 (6.3)	
Dependent	17 (8.3)	3 (1.9)	
Ambulatory status			
Fully ambulant	111 (53.9)	145 (91.2)	<0.01
Needs support	80 (38.8)	12 (7.5)	
Chair/bed-bound	15 (7.3)	2 (1.3)	
Smoking			
Still smoking	49 (23.8)	66 (41.5)	<0.01
Stop <5 years ago	21 (10.2)	12 (7.5)	
Stop >5 years ago	69 (33.5)	23 (14.5)	
Non-smoker	63 (30.6)	53 (33.3)	
Disease type			
Cardiology	79 (38.3)	41 (25.8)	<0.01
Respiratory	91 (44.2)	55 (34.6)	
Neurology	16 (7.8)	29 (18.2)	
Infections	10 (4.9)	18 (11.3)	
Others	10 (4.9)	16 (10.1)	
Reason for ventilation			
Oxygenation failure	82 (39.8)	80 (34.6)	0.03
Ventilation failure	56 (27.2)	41 (28.3)	
Cardiovascular collapse	57 (27.7)	23 (23.3)	
Airway protection	11 (4.9)	15 (13.8)	
Use of inotropes			
None	99 (48.5)	96 (60.4)	0.05
Single	73 (35.0)	39 (24.5)	
>1	34 (16.5)	24 (15.1)	
APACHE II	21.5 ± 7.4	18.5 ± 7.9	<0.01
APACHE IIM	16.3 ± 8.3	16.8 ± 7.8	0.56

ADLs: activities of daily living; APACHE II: Acute Physiology and Chronic Health Evaluation II score; APACHE IIM: Acute Physiology and Chronic Health Evaluation II score modified to exclude age points

TABLE II: COMPARISON OF MICU AND HOSPITAL MORTALITY AND RESOURCE UTILISATION

Variable	Group 1 (≥65 years old) n = 206 (%)	Group2 (<65 years old) n = 159 (%)	*P* value
MICU outcome			
Survivor	135 (65.5)	96 (60.4)	0.56*
Mortality	69 (33.5)	56 (35.2)	
Transferred out	2 (1.0)	7 (4.4)	
Overall hospital outcome			
Discharge	94 (45.6)	81 (50.9)	0.16**
Death	107 (51.9)	68 (42.8)	
Transferred out/others	2 (2.1)	10 (6.3)	
Re-admitted to MICU	3 (1.5)	0 (0)	
No. of ventilation days	5.5 ± 6.6	5.1 ± 6.7	0.53
MICU LOS (days)	6.7 ± 7.0	6.4 ± 6.9	0.65
Total hospital LOS (days)	15.2 ± 15.2	12.7 ± 15.1	0.11

LOS: length of stay; MICU: medical intensive care unit
* Analysis was performed for survivor and mortality only
** Analysis was performed for discharge and death only

was negatively correlated to the decision for admission of ICU care.[5,6] The Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatment (SUPPORT) trial also showed that age greatly affected the intensity of care given to patients.[7]

However, many studies have shown conflicting results in the correlation between age and hospital outcome. A review of 15 studies done previously,[8-22] confined to mechanically ventilated patients only, is shown in Table IV. Of these, only 2 were prospectively collected and adjusted for important confounders, such as disease severity. Zilberberg and Epstein[20] found age to be an independent predictor of death (P <0.001), while Ely et al[22] found no association. However, both these studies have a small sample size. Another similar study by Leong and Tai[23] on Asian cohorts showed no association between age and ICU or hospital outcome. However, not all patients were ventilated.

In this study, we analysed both the MICU and hospital mortality, adjusting for APACHE IIM scores (which included only the severity of acute disease and chronic co-morbidities), pre-hospitalisation functional status and gender. The results revealed no statistically significant difference in MICU and hospital mortality. However, the APACHE IIM score was an independent predictor of MICU and hospital mortality. Thus, it is not justified to exclude patients from MICU care based on chronological age alone. The severity of the acute illness and contributions of chronic co-morbidities should form the objective guide to MICU triage decision. Arguably, patients in the older cohort could have been pre-selected by the geriatrician and the intensivist to be the "fitter" elderly. In our study, the 2 groups did not differ significantly in APACHE IIM scores, which reflect the severity index of the patient without the contribution of age. The lack of influence of chronological age on mortality, given similar severity, could perhaps be explained by the bias of selecting physiologically fitter elderly. Thus, it is physiological state, and not chronological age, that influences outcome.

Age is also cited as an associated factor for increased utilisation of MICU resource. Frezza et al[24] noted that older patients stayed longer in the MICU and SICU compared to younger cohorts. Ely et al,[22] however, found that after adjusting for severity of illness, the LOS in ICU (medical and coronary ICUs) and hospital did not differ between the elderly and younger cohorts. In our study, we used similar surrogate indices for resource utilisation, including LOS for MICU and hospitalisation. After multivariate analysis, these were not statistically associated with age (Table III).

The decision for utilisation of life support measures in the elderly goes beyond mere statistical figures of survival alone. Not unlike most medical intervention, attending physicians must know the risks and benefits of these support measures, but perhaps more importantly the patient's problems and wishes before committing to this path of management. Therefore, it is not unreasonable to forego life support if the physician deems the outcome to be dismal and that life support is causing more suffering than relief. Though age was not found to be statistically related to increased mortality or increased resource utilisation, the

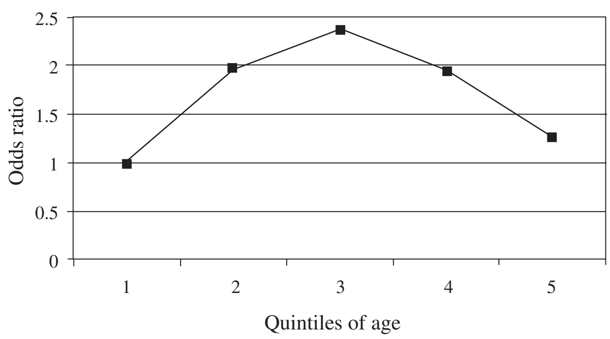
TABLE III: ASSOCIATION OF AGE, APACHE IIM SCORES AGAINST MICU AND HOSPITAL MORTALITY, MICU AND HOSPITAL LOS, AFTER MULTIVARIATE ANALYSIS

	MICU mortality	Hospital mortality	MICU LOS*	Hospital LOS*
Age (<65 years old vs >65 years old)	OR = 0.8 95% CI = 0.46 to 1.37	OR = 1.2 95% CI = 0.72 to 2.1	β = -7.3×10^{-3} 95% CI = -0.16 to 0.15	β = -0.20 95% CI = -0.43 to 0.03
APACHE IIM (per unit increase in score)	OR = 1.1 95% CI = 1.07 to 1.14	OR = 1.1 95% CI = 1.09 to 1.18	β = -1.8×10^{-3} 95% CI = -0.01 to 0.007	β = -8.0×10^{-3} 95% CI = -0.02 to 0.005

β: regression coefficient; APACHE IIM: Acute Physiology and Chronic Health Evaluation II score modified to exclude age points; CI = confidence interval; LOS: length of stay; MICU: medical intensive care unit; OR: odds ratio
* Values of both MICU and hospital LOS were log transformed

TABLE IV: COMPARISON OF PREVIOUS STUDIES ON MECHANICAL VENTILATION IN ELDERLY PATIENTS

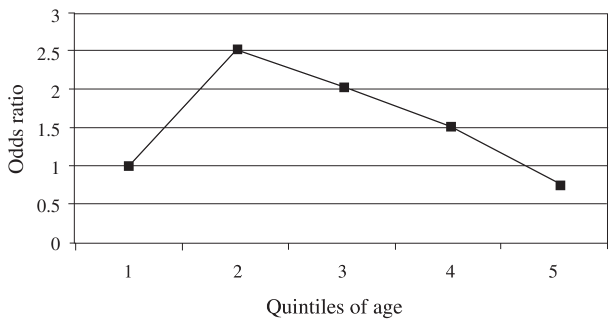
Reference (year)	No.	Age (years)	Design	Multivariate analysis	Severity adjustment	Influence of age on mortality
Nunn et al[8] (1979)	15	>74	Prospective	No	No	Yes
McLean et al[9] (1985)	49	>74	Prospective	No	No	No
Elpern et al[10] (1989)	95	>59	Retrospective	No	No	Yes
O'Donnell et al[11] (1991)	17	>70	Retrospective	No	No	No
Chelluri et al[12] (1992)	34	>84	Retrospective	No	No	No
Swinburne et al[13] (1993)	282	>79	Retrospective	No	No	No
Cohen et al[14] (1993)	109	>79	Retrospective	No	No	Yes
Papadakis et al[15] (1993)	138	>69	Retrospective	Yes	No	Yes
Dardaine et al[16] (1995)	110	>69	Retrospective	No	No	No
Cohen at al[17] (1995)	21,342	>69	Retrospective	No	No	Yes
Steiner et al[18] (1997)	40	>65	Prospective	No	No	Yes
Kurek et al[19] (1997)	3256	>69	Retrospective	No	No	Yes
Zilberberg et al[20] (1998)	31	>65	Prospective	Yes	Yes	Yes
Kurek et al[21] (1998)	4101	>74	Retrospective	No	No	Yes
Ely et al[22] (1999)	63	>74	Prospective	Yes	Yes	No



Quintiles	1	2	3	4	5
Age (y)	13-48	49-63	64-71	72-77	78-99
No.	65	68	69	63	76
OR	1.0	2.0	2.4	1.9	1.3
95% CI	-	0.81-4.82	0.97-5.76	0.76-4.92	0.47-3.39

CI: confidence interval; OR: odds ratio

Fig. 2. Trends in odds ratio for hospital mortality (based on multivariate analysis) and quintiles of age.



Quintiles	1	2	3	4	5
Age (y)	13-48	49-63	64-71	72-77	78-99
No.	67	68	72	64	76
OR	1.0	2.5	2.0	1.5	0.7
CI	-	1.04-6.18	0.82-5.04	0.58-3.93	0.26-2.12

CI: confidence interval; OR: odds ratio

Fig. 3. Trends in odds ratio for MICU mortality (based on multivariate analysis) with increasing quintiles of age.

intention of the study was to highlight the need for objective evaluation of the candidate for ICU admission and to move away from age prejudice. Unfortunately, the decision for such measures occurs in urgent situations, often leaving the physician with very limited time for decision-making. It underlines the importance of reviewing and documenting these issues even before they occur. The SUPPORT study revealed a poor correlation between doctors' perception of patients' wishes and their actual desires.[25] Leong and Tai[26] also found that surrogate decision-making occurred in 66.7% of the cases, rather than the patients deciding for themselves.

We realised that the definition of "elderly" was indeed arbitrary, and that various authors had used different age as a cut-off for analysis (Table IV). We chose the division at 65 years as an approximate to the median age of the study cohort. It also coincided with the standard definition of "elderly" employed by the local hospital. However, to further explore the trend of mortality risk with increasing age, we plotted the odds ratios of MICU and hospital mortality against quintiles of age (Figs. 2 and 3). Although the confidence intervals were wide, it can be seen that for MICU mortality the youngest group did best, but there was a trend towards decreasing MICU mortality with greater age in the other groups. With respect to hospital mortality, there was a modest, though insignificant, increase with greater age, consistent with the findings when categorised into 2 groups. These results lend support to our argument against age discrimination in the MICU.

Finally, we also noted that this study did not review the post-ICU quality of life, functional status or subsequent survival rates and, hence, the cost-benefit ratio of committing an elderly to mechanical ventilation. We recommend that further studies be made in these areas to further understand the outcomes for our local population. We also recommend that a meta-analysis be done based on the various similar but small trials.

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