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Association between weight change and clinical outcomes in critically ill patients☆

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A R T I C L E I N F O

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A B S T R A C T

Purpose: Body weight fluctuates daily throughout a patient's stay in the intensive care unit (ICU) due to a variety of factors, including fluid balance, nutritional status, type of acute illness, and presence of comorbidities. This study investigated the association between change in body weight and clinical outcomes in critically ill patients during short-term hospitalization in the ICU.
Methods: All patients admitted to the Gyeongsang National University hospital between January 2010 and December 2011 who met the inclusion criteria of age 18 or above and ICU hospitalization for at least 2 days were prospectively enrolled in this study. Body weight was measured at admission and daily thereafter using a bed scale. Univariate and multivariate linear and logistic regression analyses were performed to evaluate factors associated with mortality and the association between changes in body weight and clinical outcomes, including duration of mechanical ventilation (MV) use, length of ICU stay, and ICU mortality.
Results: Of the 140 patients examined, 33 died during ICU hospitalization, yielding an ICU mortality rate of 23.6%. Non-survivors experienced higher rates of severe sepsis and septic shock and greater weight gain than survivors on days 2, 3, 4, 5, and 6 of ICU hospitalization ($P < .05$). Increase of body weight on days 2 through 7 on ICU admission was correlated with the longer stay of ICU, and increase on days 3 through 7 on ICU admission was correlated with the prolonged use of mechanical ventilation. Increase of body weight on days 3 through 5 on ICU admission was associated with ICU mortality.
Conclusions: Increase in body weight of critically ill patients may be correlated with duration of mechanical ventilation use and longer stay of ICU hospitalization and be associated with ICU mortality.

1. Introduction

Several studies have identified a relationship between fluid balance and mortality in critically ill patients [1–3], indicating that assessment and management of fluid balance may be critical in this patient population. In clinical practice, fluid balance is estimated by calculating the difference between fluid intake and output or scaling body weight on a daily basis. However, estimating fluid balance by subtracting output from input may produce inaccurate values by failing to account for fluid losses due to sweating, diarrhea, and respiration. Moreover, during a long period of hospitalization in the intensive care unit (ICU), metabolic status, which is typically measured by assessment of catabolism, nutritional status, or extent of bone demineralization, impacts fluid balance. Some studies have demonstrated that the agreement between calculated fluid balances and measured body weight changes was poor and calculated fluid balance is not reliable for predicting body weight change [4–6].

Considering these limitations, measurement of body weight may be a better means of assessing the fluid status as well as metabolic status of critically ill patients compared to traditional means of assessment. In accordance, we observed a significant weight change during ICU hospitalization in the majority of the critically ill patients whom we had examined in a previous study [7]. Daily body weight can be measured accurately if all equipment can be removed from the patient and the patient's setting and sufficient staff, including nurses, is present in the ICU to assist with the measurement.

Despite the potential of using this means of measurement to increase the accuracy of assessing fluid balance and, thus, mortality, to our knowledge, no research has examined whether changes in body weight as a whole and on specific days are associated with clinical outcomes, such as duration of mechanical ventilation use, length of ICU stay, and ICU mortality. To fill this research gap, this study

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evaluated the association between changes in body weight and clinical outcomes, including mortality, in critically ill patients during a short-term period of ICU hospitalization.

2. Methods

2.1. Patients and measurements of body weight and fluid balance

This prospective observational cohort study was conducted between January 2010 and December 2011 at Gyeongsang National University Hospital. All patients admitted to the medical ICU (15 beds of a total of 900 beds of the hospital) during this period were screened for eligibility, and those patients who met the inclusion criteria of (1) 18 years or older and (2) ICU admission 2 days or longer were enrolled in the study. Patient data regarding demographics, comorbidities, reason for ICU admission, disease severity score, laboratory values, length of ICU and overall hospitalization, and ICU and hospital outcomes were collected from review of patient records.

Body weight was measured at ICU admission using a bed scale (VersaCare Bed; Hill-Rom, Batesville, Ind). The assigned nurses were educated on how to use a bed scale and measure daily body weight of patients. Items such as extra blanket and pillow on the bed affecting body weight were removed before measuring patients' body weight. The head of the bed should be tilted to less than 30°, and the weighing button was pressed. Before measurement, the bed was calibrated; body weight was measured daily from days 1 to 7 of ICU hospitalization.

Weight change was calculated by subtracting body weight as measured on a specific day from body weight as measured on day 1 of ICU hospitalization. Fluid input and output were also measured everyday throughout ICU hospitalization. Clinical outcomes included length of ICU hospitalization, duration of application of mechanical ventilation (MV), and ICU mortality. This study was approved by the institutional review board of Gyeongsang National University.

2.2. Statistical analysis

Descriptive data are presented as numbers and percentages and continuous data in terms of the mean ± SD or median (range). Categorical variables were compared using the χ^2 test or Fisher exact test, as appropriate. The comparison of continuous variables was performed using the parametric *t* test or the Mann-Whitney *U* test. Pearson correlation tests were performed for a relationship between change of body weight and fluid balance. A Bland-Altman method was used to evaluate agreement. The range of agreement was defined as mean bias±2 SD. Repeated-measures analysis of variance was used to compare repeated measured value between two groups. Univariate and multivariate linear or logistic regression analyses were performed to evaluate factors associated with clinical outcomes. Factors found to be significant at the $P < .2$ level in the univariate analysis and factors considered significant were subjected to backward-step linear or logistic multivariate analysis. Values that reached a $P < .05$ level of significance were considered significant. All analyses were performed using SPSS version 18.0 for Windows (SPSS Inc, Chicago, Ill).

3. Results

The mean age of the 140 patients enrolled in this study was 66.3 years, and the majority (77%) were men. As 33 of these 140 patients died during their ICU stay, the ICU mortality rate was 23.6%. Table 1 compares the baseline characteristics, laboratory findings of the survivors and non-survivors. Other than rates of sepsis and septic shock, which were higher among non-survivors, and cerebrovascular disease, which were higher among survivors, no significant differences were found between survivors and non-survivors.

Table 2 compares body weight change and fluid balance of survivors and non-survivors until day 7of ICU admission. More body weight gain and positive fluid balance were shown in non-survivors than those of survivors The correlation between daily change of body weight measured by bed scale and the corresponding fluid balance was evaluated. Fig. 1 shows the correlation between change of body

Table 1
Comparison of baseline characteristics and laboratory findings of survivors and non-survivors of ICU hospitalization

Baseline characteristics	Total	Survivors	Non-survivors	*P*
No. of patients	140	107	33	
Age, y	66.3 ± 13.3	66.2 ± 13.8	66.8 ±1 1.7	.830
Men, n	108(77.1)	82 (76.6)	26 (78.8)	.797
BMI on admission(kg/m^2)	21.1 ± 3.9	21.3 ± 3.8	20.7 ± 4.5	.466
APACHE-II	20.6 ± 6.2	20.2 ± 6.3	21.8 ± 5.8	.189
SOFA	7.6 ± 3.9	7.3 ± 3.8	8.5 ± 3.9	.148
Mechanical ventilation	134 (95.7)	101 (94.4)	33 (100)	.336
Admission diagnosis				
Post-surgical status	13 (9.3)	9 (8.4)	4 (12.1)	.505
Sever sepsis or septic shock	61 (43.6)	38 (35.5)	23 (69.7)	.001
ARDS	11 (7.9)	5 (4.7)	6 (18.2)	.021
Comorbidities				
Diabetes mellitus	45 (32.1)	36 (33.6)	9 (27.3)	.493
COPD	29 (20.7)	23 (21.5)	6 (18.2)	.681
History of pulmonary tuberculosis	16 (11.4)	10 (9.3)	6 (18.2)	.209
Hematologic malignancy	9 (6.4)	6 (5.6)	3 (9.1)	.440
Solid tumor	17 (12.1)	13 (12.1)	4 (12.1)	1
Congestive heart failure	7 (5)	6 (5.6)	1 (3)	1
Chronic kidney disease	10 (7.1)	9 (8.4)	1 (3)	0.452
Cerebrovascular disease	30 (21.4)	27 (25.2)	3 (9.1)	.048
Chronic liver disease	24 (17.1)	17 (15.9)	7 (21.2)	.478
Laboratory finding at ICU admission				
BUN, mg/dL	25.1 ± 18.7	24.3 ± 18.6	27.4 ± 19.2	.407
Cr, mg/dL	1.3 ± 1.3	1.4 ± 0.1	1.0 ± 0.2	.460
Albumin, g/dL	2.5 ± 0.4	2.6 ± 0.4	2.5 ± 0.5	.237

Data are presented as number (%) unless otherwise indicated.
BMI, body mass index; ARDS, acute respiratory distress syndrome; COPD, chronic obstructive lung disease; CRP, C-reactive protein, Cr, creatinine.