

Original Paper

Protein-Energy Undernutrition and the Risk of Mortality Within Six Years of Hospital Discharge

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Key words: mortality, geriatric, protein-energy undernutrition

Objective: The primary objective was to determine whether protein-energy undernutrition among elderly patients discharged from the hospital remains a significant risk factor for mortality beyond 1 year.

Design: Prospective Survey (cohort study).

Setting: Outpatient follow-up of patients discharged from a Geriatric Rehabilitation Unit (GRU) of a Veterans Administration hospital.

Participants: Of 350 randomly selected admissions to the GRU, 322 were discharged alive from the hospital. These 322 patients represented the study population of whom 99% were male, and 75% were white. The average age of the study patients was 76 (range 58 to 102) years.

Measurements: At admission and again at discharge, each patient completed a comprehensive medical, functional, neuro-psychological, socioeconomic, and nutritional assessment. Subsequent to discharge, each subject was tracked for an average of 6 years. In addition to including serum albumin and other putative nutrition indicators in the data set, a "nutrition-risk" indicator variable was created. Subjects were stratified into the nutrition "high-risk" group if their albumin was less than 30 g/L or BMI was less than 19; and, "low-risk" group if albumin was equal to or greater than 35 g/L and BMI equal to or greater than 22. All others represented the "moderate-risk" group.

Results: Within the 6-year post-hospital-discharge follow-up period, 237 study subjects (74%) died. Based on the Cox proportional hazards survival model, the variable most strongly associated with mortality was discharge "nutrition-risk" followed by the Katz Index of ADL Score, diagnosis of congestive heart failure, discharge location (home vs. institution), age, and marital status. Within the first 4.5 years of follow-up, the relationship between "nutrition-risk" and mortality remained constant. After 4.5 years, the strength of the correlation began to diminish.

Conclusions: Among the elderly, protein-energy undernutrition present at hospital discharge appears to be a strong independent risk factor for mortality during the subsequent 4.5 years or longer.

INTRODUCTION

Among the hospitalized elderly, protein-energy undernutrition (PEU) is a very common problem with potentially serious and long-lasting consequences. Studies indicate that up to 61% of the hospitalized elderly have clinically significant protein-energy nutritional deficits [1,2]. Even when their acute medical and surgical problems stabilize, older undernourished patients are slow to replete their nutritional deficits [3]. As a conse-

quence, many remain undernourished throughout their hospitalization and for variable periods subsequent to discharge [4–6]. The detrimental consequences of these persisting nutritional deficits appear to be substantial. Elderly patients undernourished at hospital discharge are at increased risk of early non-elective hospital readmission and death within the subsequent 1 to 4 years [6–9].

Although it has been consistently demonstrated that albumin and other putative nutrition indicators are strongly correlated

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with post-discharge mortality among the hospitalized elderly, it is less certain as to whether the mortality risk associated with undernutrition remains constant over time. Little is known about the older patients' ability to replete nutritional deficits after hospital discharge or whether the association between discharge nutritional status and mortality diminishes with time. There is some suggestion that the relationship between undernutrition and mortality may be confounded by the patients' medical instability [10,11]. If such is the case, undernutrition may be a risk factor for mortality primarily in the early recuperative phase of illness.

To investigate this issue, we examined the relationship between patient discharge characteristics and the risk of 1-year mortality in a prior study of 322 elderly patients discharged from a geriatric recuperative care and rehabilitation unit (GRU) [6]. All subjects were free of cancer, end-stage organ failure, and other terminal conditions. Based on the Cox regression analysis, serum albumin and body mass index (BMI) were identified to be powerful predictors of 1-year mortality after controlling for level of functional disability and other indicators of health status. In order to exclude the possibility that a low serum albumin might simply represent acute medical instability at the time of hospital discharge, a time-dependent variable was added to the analysis to determine if the relationship between serum albumin and mortality changed over time. Similar analyses were conducted for the other independent variables in the Cox regression model. From these analyses it was determined that the hazard function with respect to each independent variable in the model remained proportional over the 1-year follow-up interval. These results indicated that the instantaneous risk of death associated with a low discharge serum albumin or low body weight was fairly constant throughout the year following hospital discharge. The results also provided support for the hypothesis that low albumin and body weight are indicators of protein-energy nutritional deficits and that such deficits represent a potentially correctable source of increased mortality for hospitalized elderly patients within the year subsequent to discharge. Whether undernutrition continues to have prognostic significance in this population beyond 1 year remains to be determined.

The purpose of this study was to examine this issue further. In order to determine whether any of the putative nutritional indicators maintained prognostic significance among the hospitalized elderly over a period of follow-up greater than 1 year, we continued to follow the same cohort of patients from our original study. In this paper, we report the results of the 6-year survival analysis.

METHODS

Subjects

During a 2-year interval, 350 patients were selected at random from the 589 admissions to a Geriatric Rehabilitation

Unit (GRU) of a Veterans Administration (VA) Hospital. The randomization process was designed to keep study admissions in the targeted range of 3 to 4 patients per week. During the hospitalization, 28 subjects (8%) died. The remaining 322 patients comprised the study population. The average age of the study population was 76 years (range 58 to 102). The majority (75%) of the subjects were white and nearly all (99%) were male. Each received oral and written explanations of the nature of the study and the possible risk involved prior to signing an informed consent in accordance with the ethical standards as outlined by the Department of Veterans Affairs, and the Human Research Advisory Committee of the University of Arkansas for Medical Sciences. The study population and the Little Rock VA Hospital GRU are described in detail elsewhere [6,12,13].

Patient Evaluations

Within 48 hours of admission to the GRU, each subject completed a standardized diagnostic evaluation including a basic medical, neuro-psychological, functional, and nutritional assessment. The details of this evaluation are described elsewhere [6,12]. Throughout the remainder of the hospitalization, each subject's nutritional status was reassessed every 7 to 10 days and, when possible, at discharge. The last assessment obtained was used as the discharge assessment. At hospital discharge, repeat functional, social, and medical assessments were completed utilizing information attained from the therapists, aides, nurses, and physicians caring for the patient; the patient's hospital chart; and direct observation and testing of the patient. Subsequent to discharge, each subject was tracked via telephone and the VA computer system. They were also interviewed when they returned for clinic visits or were readmitted to the hospital. For those patients who died during this interval, record was made of the date of death. Average time from hospital discharge to end of study was 6.0 ± 0.6 (range 4.8 to 6.9) years. Average time to death or last follow-up was 3.2 ± 2.1 (range 0.1 to 6.9) years. There were no losses to follow-up.

Based on the discharge assessments, a database consisting of 98 variables was created for each patient. The functional, social, and medical assessment variables were included as indicators of health status/disease severity. A detailed description of the database variables is provided elsewhere [6,12].

In addition to including serum albumin and body mass index in the data set, a "nutrition risk" indicator variable was created. Subjects were stratified into the nutrition "high-risk" group if their albumin was less than 30 g/L or BMI was less than 19, and "low-risk" group if albumin was equal to or greater than 35 g/L and BMI equal to or greater than 22. All others represented the "moderate-risk" group. The variable was coded as 0 for "low-risk," 1 for "moderate-risk," and 2 for "high-risk." In order to examine the relationship between survival and serum albumin, a class variable was created to stratify subjects into one of three groups based on albumin values (A:

<30 g/L; B: \geq 30 to <35 g/L; and C: \geq 35 g/L). Similarly, a class variable was created to stratify subjects by BMI (A: <19; B: 19–21; C: \geq 22).

Statistics

To investigate the probability of death as a function of time during the 6 years of follow-up, the relationship between the database variables and mortality (as the dependent variable) was analyzed using Cox proportional-hazards regression [14,15]. For each subject, a time to event and a status variable were created. The status variable indicated whether the event was death or the last follow-up. Given the large size of the database, it was important to limit the multivariable proportional-hazards regression analyses to those database variables which were likely to contribute most significantly to the discriminating power of the test. For this reason, the strength of the correlation between each database variable and mortality was identified using a univariable Cox regression analysis. Only those database variables which entered the univariable model at a significance level of $p < 0.01$ were selected for further analysis. A stepwise procedure was then utilized in the model building process with the pre-selected database variables entered as the independent variables. In order to diminish the possibility that the model would be “overfitted” (i.e., too many independent variables for the number of outcome events) or specific to the given data set [16], the significance level for a variable to remain in the model was set at 0.01. Using this strategy, two models were developed. The process of building each model was the same except that the “nutrition-risk” variable was entered into the analysis only for the second model.

The Cox proportional-hazards model assumes that the hazard function with respect to each independent variable remains proportional over time (i.e., the relative risk is constantly proportional). To test this hypothesis for each of the two models developed, subsequent analyses were run. For each model, the subsequent analyses included the variables from the original model as well as a time-dependent variable. The time-dependent variable was defined to be the product of the log time-to-event and an independent variable from the original model. In these analyses, the value of the time-dependent variable was recalculated at each event time for those subjects who remained at risk (i.e., were still alive). A parameter estimate for the time-dependent variable which was not significantly different from zero was considered evidence for the validity of the proportional hazards model with respect to the given covariate [17,18]. The proportional hazards assumption was tested in this manner for each of the independent variables in each of the two original models. Because time-dependent variables were identified, the relationship between survival and each time-dependent variable was examined further. These examinations included the use of Kaplan-Meier survival curves (as described under results). Subsequent analyses were then performed to determine whether the hazard function with respect to the given

covariate remained proportional over a shorter period of follow-up.

RESULTS

Population Characteristics

Of the 322 patients discharged alive, 261 (81%) returned home, 59 (18%) were admitted to a nursing home, and 2 (1%) entered a group home for elderly adults. Although all of the subjects were frail, there was a fairly wide range of functional disability within the population. Katz Index of ADL scores ranged from zero (totally independent) to 12 (totally dependent) with an average of 4.8 ± 4.0 (mean \pm SD). The characteristics of this population are described in further detail below and elsewhere [6,12,13].

Predictors of Mortality

During the 6-year follow-up period, 237 patients (74%) died. Discharge assessment variables found by univariable Cox proportional-hazards regression to correlate with 6-year mortality are listed on Table 1.

Multivariable Cox Proportional-Hazards Models

When the 31 database variables from Table 1 were entered into the stepwise Cox regression analysis, the Katz Index of ADL Score was the first variable to enter the model followed by serum albumin, diagnosis of congestive heart failure, discharge location (home vs. institution), body mass index, marital status, age, diagnosis of depression, presence of renal disease (i.e., blood urea nitrogen greater than 30), and diagnosis of cardiac arrhythmia (usually atrial fibrillation). When all 10 of these variables were included in the logistic regression analysis, the final model was highly significant by the -2Log Likelihood Chi-square goodness-of-fit criterion (Chi-square of 135 with 10 d.f., $p < 0.0001$). BMI, albumin, and home as discharge location were all inversely related to mortality risk. The other variables in the model were all positively correlated with mortality.

When the previously described “nutrition-risk” variable was entered into the stepwise Cox regression analysis along with the 31 database variables from Table 1, it was the first variable to enter the model followed by the Katz Index of ADL Score, diagnosis of congestive heart failure, discharge location (home vs. institution), age, and marital status. When all six of these variables were included in the logistic regression analysis, the final model was highly significant by the -2Log Likelihood Chi-square goodness-of-fit criterion (Chi-square of 122 with 6 d.f., $p < 0.0001$). Serum albumin and body mass index did not enter the model. Home as discharge location was inversely related to mortality risk, whereas all of the other variables in the model were positively correlated with mortality.

Table 1. Discharge-Assessment Variables That Correlated with 6-Year Mortality*

Variable	p value*	Hazard function with respect to variable remains proportional over time†
Age	0.0032	Yes
Katz Index of ADL score	0.0001	Yes
Average # of hours spent in bed each day	0.0001	No
Mini Mental State Exam score	0.0012	Yes
Number of medications	0.0144	Yes
Diagnosis of:		
Congestive heart failure	0.0006	Yes
Cardiac arrhythmia	0.0011	Yes
COPD‡	0.0017	Yes
Pressure ulcer	0.0003	No
Incontinence	0.0002	No
Resolving pneumonia	0.0008	Yes
Number of chronic diseases§	0.0001	Yes
Discharge to home (vs. institution)	0.0001	Yes
Admitted for nurse home placement	0.0067	Yes
Midarm circumference	0.0010	No
Suprailiac skinfold	0.0090	No
Midarm muscle circumference	0.0112	No
Weight as % of usual weight	0.0017	Yes
Weight as % of ideal body weight	0.0001	No
% Usual weight lost in year prior to discharge	0.0001	No
lost in 6 months prior to discharge	0.0001	No
Weight loss >10% during prior year (No/Yes)	0.0001	Yes
Weight loss >5% during prior 6 months (No/Yes)	0.0001	Yes
Amount of weight lost in prior year	0.0001	Yes
Amount of weight lost in prior 6 months	0.0007	No
Body mass index	0.0001	No
Serum albumin	0.0001	No
Serum bicarbonate	0.0020	Yes
Serum cholesterol	0.0019	No
Serum transferrin	0.0136	Yes
Hemoglobin	0.0004	Yes

* Variable entered univariable Cox proportional hazards regression model at a significance level for the parameter estimate of p less than 0.01.

† A time-dependent variable was created for each independent variable. The time-dependent variable was defined to be the product of the log time-to-event and the independent variable. Both the independent variable and its corresponding time-dependent variable were forced into the Cox regression analysis. A parameter estimate for the time-dependent variable which was not significantly different from zero was considered evidence for the validity of the proportional hazards model with respect to the given co-variate [17,18]. See text for details.

‡ Chronic obstructive pulmonary disease.

§ Number of diagnoses (from 0 to 7) from the following categories: congestive heart failure, non-insulin dependent diabetes mellitus, cerebral vascular accident, dementia (Alzheimer's or multi-infarct), Parkinson's, chronic obstructive pulmonary disease, and end stage renal failure.

Confirming That the Hazard Function Remains Proportional Over Time

For each of the two Cox proportional-hazards models developed, the validity of the proportional hazards assumption with respect to each independent variable in the model was tested by forcing the corresponding time-dependent variable (i.e., the product of the independent variable and the log of event time) into the model. For the first model, the parameter estimates for the time-dependent variables corresponding to albumin, BMI, and diagnosis of depression, respectively, were significantly different from zero ($p < 0.01$) in all three cases. This indicated that the hazard function with respect to these covariates did not remain proportional over time. In all three cases, the parameter estimate of the time-dependent variable was opposite in sign to that of the corresponding covariate. This indicated that the relationship between the covariate and mortality diminished with time. In a similar fashion, each covariate in the second model was evaluated. From these analyses, it was determined that the relationship between “nutrition-risk” and mortality diminished with time.

In order to examine further the relationship between albumin levels and survival, subjects were stratified into one of three groups based on albumin values (<30 g/L, ≥ 30 to <35 g/L, and ≥ 35 g/L). The Kaplan-Meier survival curves for each of these three substrata of patients are shown in Fig. 1. It is apparent from this figure that the most severely hypoalbuminemic subjects (those with albumin levels <30 g/L) experienced much higher rates of mortality within the first 1 year of observation than did the subjects with albumin levels ≥ 35 g/L. However, it is also apparent that the mortality rate for the severely hypoalbuminemic subjects diminished with time. By the fourth year of observation, the mortality rate for this group appears to be less than that of the subjects with normal albumin levels. A plot of the survival estimates using a log(-log) scale likewise demonstrated that the curve for the severely hypoalbuminemic subjects was not parallel to the other two. Although this observation is based on unadjusted Kaplan-Meier survival curves, it is consistent with the findings from the Cox proportional-hazards analysis. The hazard function with respect to albumin does not remain proportional over time. Stratifying subjects by BMI (e.g., <19 , $19-21$, ≥ 22) produced similar results (graph not shown).

In the second Cox regression model developed, “nutrition-risk” was found to be time-dependent. The Kaplan-Meier survival curves for subjects stratified by nutritional risk (“high,” “moderate,” and “low” as defined previously) are shown in Fig. 2. These curves suggest that the hazards function with respect to “nutrition-risk” remains constantly proportional during the first 4 to 5 years of follow-up. To confirm this finding, additional Cox proportional-hazards regression analyses were performed using shorter follow-up periods. The analyses were run

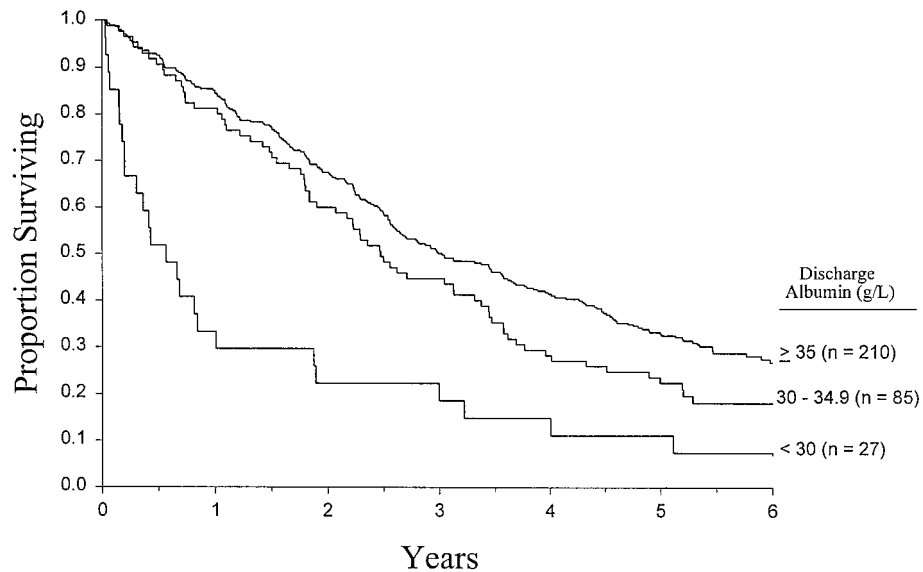


Fig. 1. Kaplan-Meier survival curves for the three groups of subjects stratified by discharge serum albumin as indicated. (See text for details.)

at 4, 4.5, 5, and 5.5 years of follow-up. The time-dependent variable for “nutrition-risk” did not reach statistical significance at a $p < 0.05$ level until the fifth year of follow-up. For each analysis, the other independent variables which entered the regression model remained the same as for the 6-year follow-up. Compared to those in the low-risk group, patients classified as high-risk had an adjusted relative risk of dying within 4.5 years of hospital discharge of 3.25 (95% C.I. 2.20 to 4.80 $p < 0.0001$).

As an alternative approach to identify predictors of long-term mortality, deaths within the first year of follow-up were

excluded. Discharge assessment variables found by univariable Cox proportional-hazards regression to correlate with 6-year mortality after deaths within the first year of follow-up were excluded are listed in Table 2. As shown, albumin, BMI, and functional status remain power predictors of mortality. However, all of the variables became time-dependent with this approach. Although these findings are consistent with the results of the analyses using the entire data set, this approach did not offer any methodologic advantage in that the hazard function with respect to each independent variable again failed to remain proportional over time.

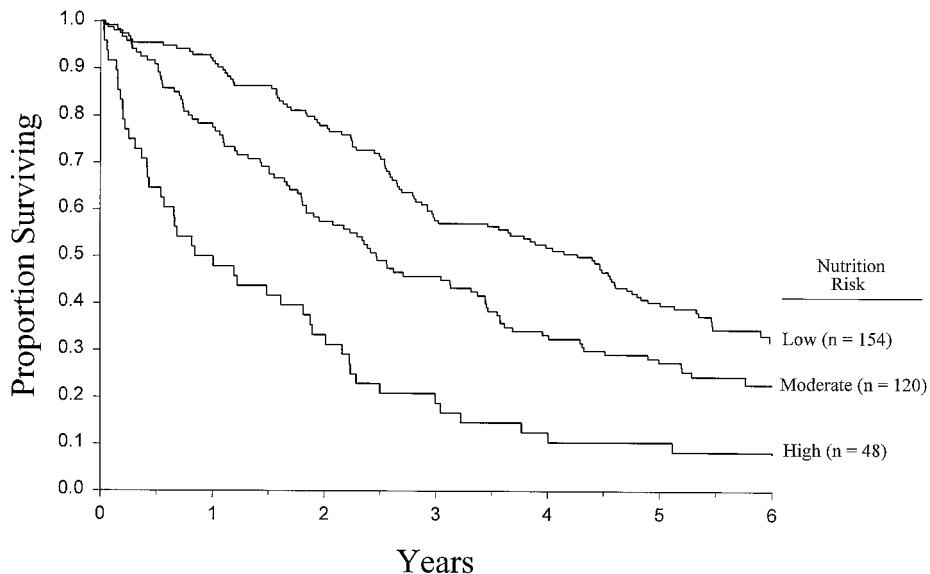


Fig. 2. Kaplan-Meier survival curves for the three groups of subjects stratified by “nutrition-risk” as indicated. Subjects were stratified into the nutrition “high-risk” group if their albumin was less than 30 g/L or BMI was less than 19; and, “low-risk” group if albumin was equal to or greater than 35 g/L and BMI equal to or greater than 22. All others represented the “moderate-risk” group. (See text for details.)”

Table 2. Discharge-Assessment Variables That Correlated with 6-Year Mortality after Deaths Within First Year Excluded*

Variable	p value*
Katz Index of ADL score	0.0001
Walking endurance†	0.0001
Average # of hours spent in bed each day	0.0014
Diagnosis of:	
Congestive heart failure	0.0094
COPD‡	0.0092
Pressure ulcer	0.0030
Incontinence	0.0001
Recurrent urinary tract infections	0.0028
Resolving pneumonia	0.0068
Number of chronic diseases§	0.0001
Discharge to home (vs. institution)	0.0001
Body mass index	0.0087
Weight as % of usual weight	0.0097
Weight loss >5% during prior 6 months (yes/no)	0.0093
Serum albumin	0.0094
Hemoglobin	0.0080

* Variable entered univariable Cox proportional hazards regression model at a significance level for the parameter estimate of p less than 0.01.

† Average distance patient could walk (yards) without stopping to rest.

‡ Chronic obstructive pulmonary disease.

§ Number of diagnoses (from 0 to 7) from the following categories: congestive heart failure, non-insulin dependent diabetes mellitus, cerebral vascular accident, dementia (Alzheimer's or multi-infarct), Parkinson's, chronic obstructive pulmonary disease, and end stage renal failure.

DISCUSSION

Among the hospitalized elderly, protein-energy undernutrition (PEU) is associated with poor short-term clinical outcomes. Numerous studies have demonstrated that the risk of morbid complications during hospitalization or within 12 months of discharge increases in direct proportion to the severity of the older patient's nutritional deficits [4,6–9]. Whether PEU impacts clinical outcomes beyond 1 year after discharge is less certain. This study was undertaken in order to investigate this issue.

The population for this study consisted of debilitated elderly patients admitted to a recuperative care and rehabilitation unit. Nearly all had multiple co-morbidities, were prescribed multiple medications, or had other indicators of frailty. However, all were medically stable and assessed to have a good prognosis for long-term survival. Patients with a documented near-terminal medical disorder (e.g., advanced malignancy or heart failure resistant to medical management) were excluded.

Previously, we reported that serum albumin and BMI were both strong independent predictors of 1-year post-discharge mortality in this cohort [6]. These results indicated that patients could be stratified into "nutrition-risk" categories based on these two variables. In order to keep the risk assessment simple and clinically practical, three categories of risk were created; the highest risk category consisting of patients with an albumin

less than 30 g/L or a BMI less than 19. The current study demonstrates the validity of this approach. "Nutrition-risk" was strongly correlated with long-term mortality. The adjusted relative risk of dying within 4.5 years of hospital discharge was significantly greater in the patients classified as high-risk, compared to those in the low-risk group. Based on this simple classification scheme, it is possible to identify patients with exceptional nutritional needs. Further research efforts and clinical attention should be focused on improving the outcomes of this population group.

In this study, predictors of 6-year mortality were identified using Cox regression analysis. An underlying assumption of this analytic technique is that the hazard function with respect to each independent variable entering the model remains proportional over time [14–16]. In order to determine the validity of this assumption, we used the approach of forcing time-dependent covariates into the proportional hazards model [14–18]. When we examined survival out to 6 years, the parameter estimates for the time-dependent covariates for albumin, BMI, and "nutrition-risk" were all significantly different from zero indicating that the relative risk with respect to each of these covariates was not constantly proportional over this period of time. Consistent with the Kaplan-Meier survival curves (Figs. 1 and 2), the model was valid for shorter follow-up intervals. This finding supports the hypothesis that PEU continues to be an important determinant of clinical outcomes well beyond 1 year.

There are a number of possible reasons why the strength of the relationship between mortality and the putative nutrition variables albumin, BMI, and "nutrition-risk" diminished with time. It is likely that some of the patients were able to avoid intervening complications, resumed an adequate nutrient intake, slowly repleted their nutritional deficits, and moved into a lower risk category over time. Serial measurements of nutritional, functional, and overall health status are needed to determine how often this occurs. However, the high mortality rates during the first 3 years of observation, especially in the two groups categorized to be at nutritional risk, suggest that nutritional recovery is unlikely to occur in most subjects. The data also suggest that the diminished strength of the relationship between nutritional status and mortality with time is artificial. As shown in Fig. 2, the Kaplan-Meier survival curves for the moderate and high risk groups plateau after 3 to 4 years. However, there are few survivors by that point. Even by the end of the second year, fewer than 20% of the high-risk group were still alive. After the third year of observation, the survival analyses are highly influenced by the few surviving outliers.

An alternate approach to assess the impact of PEU on long-term clinical outcomes is to exclude deaths which occur within the first year of follow-up. Using this approach, we found albumin, BMI, and "nutrition-risk" remained significantly correlated with subsequent mortality. However, this approach did not resolve the issue of time dependency of the hazard function with respect to each covariate. Functional

status, as well as the nutrition variables, became time-dependent with this approach.

The literature provides conflicting evidence as to the potential importance of PEU as a determinant of long-term outcomes. In various community-based studies with follow-up intervals from 4 to 12 years, both albumin and BMI have been identified to be powerful predictors of subsequent mortality [19–25]. In some of the studies, the relationship remained significant after deaths within the first 1 to 4 years were excluded from the analysis [22,23]. One of the largest of these studies was that by Phillips et al who followed over 7,700 middle-aged relatively healthy men for an average of 9.2 years [23]. They found a strong correlation between serum albumin and mortality which persisted after deaths occurring within the first 3 years of the study were excluded. The correlation was strong even within the commonly accepted range of normal values for serum albumin.

Most other studies have provided less convincing evidence of the long-term significance of PEU on survival. In a study of 463 subjects over age 60 followed for 9 to 12 years, Sahyoun et al identified a strong correlation between albumin and subsequent mortality [25]. After deaths occurring within 3 years of study entry were excluded, however, the correlation remained significant for the community-dwelling, but not the institutionalized subjects. Similarly, Corti et al followed 1486 men and 2630 women aged 71 and older for a mean of 3.7 years [22]. In this cohort, albumin was a powerful predictor of mortality after controlling for age, race, disability status, and social factors. However, when deaths within 1 year were excluded from the analysis, the correlation between albumin and mortality remained significant for females but not males. Comparable results have been obtained from studies which examined the relationship between BMI and mortality [19–21,24]. Based on a study of 1723 65-year old nonsmokers followed for a mean of 9.5 years, Harris et al reported finding a U shaped relationship between BMI and mortality [20]. Although a low BMI was associated with increased mortality, the strength of the relationship diminished after deaths within the first 4 years were excluded. A subsequent study by Cornoni-Huntley et al confirmed these results [21]. The reasons for the disparity in the findings from these various studies have yet to be elucidated.

Compared to these community-based studies, the prevalence of moderate to severe PEU was much greater in our population sample. A larger sample size than what was available in our study would be needed to evaluate the relationship between albumin or other nutritional variables and long-term outcomes among the patients classified as well-nourished.

Despite the limitations of the study, the results implicate undernutrition as an important determinant of post-hospital discharge mortality for the elderly. The fact that mortality remains high among the undernourished even up to 4 years after discharge raises the concern that the frail elderly may have difficulty repleting their illness-induced nutritional deficits after hospital discharge. If this is the case, it would suggest the

need for more aggressive nutritional care in the recuperative phase of illness. Prior studies have shown that the frail elderly, such as those who entered this study, are capable of significantly improving their nutrient deficits in response to aggressive nutritional support therapies. In a study by Lipschitz et al [26], each of nine severely undernourished elderly male subjects experienced a substantial improvement in their physical and cognitive level of functioning after 21 days of enteral hyperalimentation via a nasogastric tube. Objective evidence for an improvement in their nutritional status was also demonstrated. By day 21, the average serum albumin rose from a nadir of 2.3 g/dl to a mean of 3.5 g/dl. This uncontrolled study indicates that even severe PEU can be reversed in elderly hospitalized patients with the use of aggressive nutritional intervention. Although no assessment was made of the long-term benefit of such therapy to the patient, it can be concluded that appropriately managed nutrition intervention can be of substantial advantage.

Other investigators have also demonstrated the benefits of nutrition support in the elderly. Hebuterne et al evaluated the use of nightly enteral nutrition support as a supplement to regular daytime meals in a group of 46 elderly and 51 non-elderly severely undernourished subjects [27]. In this nonrandomized trial, both groups received the nightly feedings for a mean of 27 days. Total daily energy intakes averaged 288% and 282% of resting energy expenditure in the two groups, respectively. Although the older patients' response to the nutritional therapy was somewhat less than that of the younger group, both groups demonstrated significant improvement in seven nutritional parameters including body weight, serum albumin, serum prealbumin, serum transferrin, and 24-hour urinary creatinine. After 1 year, 62% in the elderly and 76% in the younger patients ($p = .18$) were alive and without relapse. This indicates that enteral nutrition is an effective treatment of undernutrition in older malnourished ambulatory patients.

CONCLUSIONS

Among the elderly, protein-energy undernutrition present at hospital discharge appears to be a strong independent risk factor for mortality during the subsequent 4.5 years or longer. This fact raises the concern that the frail elderly may have difficulty repleting their illness-induced nutritional deficits after hospital discharge. If this is the case, it would suggest the need for more aggressive nutritional care in the recuperative phase of illness.

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