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Impact of Malnutrition in Critically Ill Patients on Intensive Care Unit

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Abstract

Background: Malnutrition is one of the major problems during the stay in the intensive care units (ICUs). Critically ill patients are at high risk of developing malnutrition, associated with worse clinical outcomes. This work aimed to detect the severity of malnutrition in critically ill patients by using the Subjective Global Assessment score (SGA) and its association with the length of ICU stay and mortality. **Methods:** This prospective cohort observational study was carried out on 50 patients aged >18 years old, both sexes, with clinical criteria of malnutrition, involuntary weight loss, low body mass index, decreased mass of muscles, history of decreased food intake or absorption and inflammation or acute disease or injury with severe inflammation. All patients were subjected to mid-arm circumference (MAC), triceps skin fold (TSF) and hand grip strength **. Results:** The mean length of stay in ICU was 13.5±11.2 days. 18 patients needed mechanical ventilation (MV) representing 36% of cases with mean ventilation days 10.7±7.1, and the mortality proportion 34%. A statistically substantial correlation existed between mortality, smaller MAC (P = 0.001), and TSF (P = 0.001). In addition, the Handgrip was lower in mortality but didn't reach statistical significance (P = 0.091). A substantial association existed between the advanced grade of SGA (grade C) and mortality (P = 0.001). **Conclusions:** There was a strong association between mortality in critically ill patients and smaller triceps skin fold, MAC. Severe malnutrition in critically ill patients SGA (grade C) was significantly associated with mortality and the need for MV .

Keywords: Critically Ill, Intensive Care Unit, Subjective Global Assessment, Malnutrition

1. Introduction:

Nutrition is a fundamental biological process that involves the intake of nutrients from the surrounding environment and their utilization for essential physiological processes such as development, reproduction, and maintenance of overall bodily health, regardless of a person's level of well-being [1].

Malnutrition is a significant health concern that may arise from fundamental factors, including poverty which results in insufficient food availability, or secondary factors stemming from disease-induced conditions [2]. Secondary malnutrition can arise from various processes, including diminished food consumption due to disease-related anorexia, and metabolic stress resulting from the disease or its therapies [3]. The physiological reaction to stress accelerates the metabolic rate, inducing a hormonal disruption that triggers heightened protein breakdown, depleting protein stores and subsequently affecting the functioning of many organs and immunological defense mechanisms [4]. Individuals hospitalized in intensive care units (ICUs) have acute critical illness. This condition elicits significant catabolic stress, potentially leading to substantial wasting of muscles and protracted impairment of functional capabilities. It is believed that supplying sufficient nutrition containing vital nutrients has been widely acknowledged as a potential means of minimizing the effects of the catabolic response. Nonetheless, determining the optimal timing, dosage, and method of administering nutrition support continues to present a multifaceted challenge for ICU medical professionals. Implementing nutritional treatment helps to reduce the potential for an energy or protein shortage, a condition previously linked in retrospective studies to unfavorable outcomes. These adverse effects include extended hospitalizations in the ICU and hospital, prolonged lengths of mechanical ventilation (MV), and increased occurrences of infection problems. Malnutrition is recognized as a contributing factor that heightens the likelihood of unfavorable patient outcomes, such as increased morbidity and mortality rates [5, 6].

The American Society for Parenteral and Enteral Nutrition has defined nutritional assessment as the process of determining an individual's nutritional status through the use of clinical and nutritional history, anthropometric measurements, physical examinations, and laboratory data. This comprehensive approach to nutrition evaluation, which

considers dietary history, clinical state, and social background, acknowledges the critical link between nutritional status and illness severity [7]. Patients at nutritional risk, either have existing malnutrition or have the potential to develop it are identified through nutritional assessment [8]. Hospital malnutrition can be prevented and treated, which presents a great potential to optimize patient care in general, improve clinical results, and cut expenses. Early nutrition management can lower death rates, readmission rates, complication rates, hospital stay times, and cost of treatment [9]. This study aimed to detect the severity of malnutrition in critically ill individuals by using a subjective global assessment score (SGA) and its association with the length of intensive care unit stay and mortality.

2. Patients and Methods:

This prospective cohort observational work was performed on 50 individuals aged >18 years old, both sexes, with clinical criteria of malnutrition, decreased body mass index (BMI), involuntary weight loss, reduced mass of muscles, history of decreased food intake or absorption, and inflammation or acute disease or injury with severe inflammation.

The study was done after approval from the Ethical Committee Beni-Suef University Hospital from May 2022 to February 2023. Informed written consent was obtained from the patients.

Exclusion criteria were patients transferred from another hospital or another department at the same hospital, very obese patients, extensive burns, upper limb bone fracture, and induced malnutrition as malignancy, chemotherapy, and radiotherapy.

All patients were subjected to careful medical history, full general examination, caloric requirements, routine laboratory investigations [complete blood count (CBC) with differential including lymphocytic count, liver function tests [aspartate transaminase (AST), alanine transaminase (ALT), prothrombin time (PT), serum albumin, prothrombin concentration (PC), international normalized ratio (INR)], renal function tests [serum creatinine, blood urea, electrolytes and trace elements (Na, K, Ca, Mg and phosphorous)] and C reactive protein (CRP)].

Subjective global assessment score (SGA) [10]:

Detailed history and physical assessment about prior loss of weight, marked alterations in food intake, subcutaneous fat loss in two locations (facial, triceps), and muscle tissue loss. Symptoms related to nutrition and its effects on functional capacity were obtained by collecting data

from either the patient themselves, a relative member, or by reviewing the individual's medical records. The process of subjectively evaluating all available data yielded a numerical value that categorized the individuals as either adequately nourished (SGA-A), mildly to moderately malnourished (SGA-B), or severely malnourished (SGA-C).

Mid-arm circumference (MAC) and subcutaneous fat at the triceps area

Herpeden's skinfold calipers were utilized to evaluate the triceps skinfold. The measurement of MAC was conducted utilizing a SECA soft fabric measure tape. All measures were performed three times at admission to avoid any bias, and the average was recorded [11].

Hand grip

Evaluated through the Saehan Hydraulic Hand Dynamometer (Saehan Corporation, Korea). Three evaluations were conducted on the non-dominant hand upon admission, and the resulting average was afterward contrasted with a standard reference value that considers the patient's age and sex [12].

During their ICU stay, patients were screened daily for ICU-acquired infection (infection after 48 h from ICU admission detected by signs, and symptoms such as fever, chemical biomarkers, and culture results), bedsores/skin breaks, ICU-acquired weakness and duration of MV if the patient was intubated.

The primary outcome was the length of ICU stay and the final ICU outcome (alive or dead). The secondary outcomes were hospital-acquired infection, ICU-acquired weakness, bedsores/skin breaks, and duration of MV .

Statistical analysis

The statistical analysis was conducted using SPSS v26 (IBM Inc. in Chicago, IL, USA). The mean and standard deviation (SD) were used to represent the quantitative data, and a comparison among both groups was made using an unpaired Student's t-test. The presentation of qualitative parameters involved using frequencies and percentages (%), and their analysis was conducted utilizing either the Chi-square or Fisher's exact test, depending on appropriateness. The diagnostic performance of the various tests was evaluated through the analysis of (ROC) curves. A two-tailed P value < 0.05 was considered statistically significant.

3. Results:

The mean age of the studied patients was 55.9±19.9 years. 52% of them were males, and 48% were females. 48% were diabetic, and 48% were hypertensive. Three patients were admitted due to trauma, 9 for AKI, 10 for stroke, and 28 for other acute

conditions. The mean arterial blood pressure (MAP) was 91.8±17.1 mmHg, HR was 99.6±24.7 beat/minute, RR was 24.8±5.1 breath/minute and temperature was 37.5±0.7 C. Most patients had positive CRP and normal platelet count, serum sodium and potassium levels, liver enzymes, and INR while TLC, urea, and creatinine were elevated and Hb, and serum albumin were decreased. **(Table 1)**

Table 1: Clinical examination and laboratory parameters of the studied patients

Items		**Values (no=50)**
Age		55.9±19.9
Sex	**Males**	26 (52.0%)
	Females	24 (48.0%)
DM		24 (48.0%)
HTN		24 (48.0%)
Cause of admission	**Trauma**	3 (6.0%)
	AKI	9 (18.0%)
	Stroke	10 (20.0%)
	Others	28 (56.0%)
Clinical examination		
Mean arterial blood Pressure (mmHg)		91.8±17.1
Heart rate (bpm)		99.6±24.7
Respiratory rate (breath/min)		24.8±5.1
Temperature (C)		37.5±0.7
Laboratory parameters		
Hb (g/dL)		10.69±1.89
TLC x 10^3		12.56±6.39
PLT x 10^3		222.42±112.23
Urea (mg/dL)		77.18±53.48
Creatinine (mg/dL)		2.34±2.66
Na (meq/L)		137.82±4.21
K (meq/L)		4.24±0.73
Serum albumin		2.96±0.30

(g/dL)	
ALT (IU)	33.84±30.74
AST (IU)	39.22±38.00
INR	1.17±0.19
CRP (mg/dL)	24.52±35.57874

Data are presented as mean ± SD or number (%). DM: Diabetes mellitus, HTN: high or raised blood pressure, AKI: Acute Kidney Injury, Hb: Hemoglobin, TLC: Total Leucocyte Count, PLT: Platelet Count, Na: sodium, K: potassium, ALT: alanine transaminase, AST: aspartate aminotransferase, INR: international normalized ratio and CRP: C-reactive protein.

The mean triceps skin fold (TSF) was 23.2±4.5, the mean MAC was 29±3.9, and the mean HG was 29.9±8.3. 52% of cases had SGA score grade A, 17 (34%) had SGA score grade B, and only 7 (14%) of cases of SGA had grade C. The mean length of stay (LOS) was 13.5±11.2 days, 18 patients needed MV representing 36% of cases with mean ventilation days 10.7±7.1, and the mortality proportion 34%. **(Table 2)**

Table 2: Nutritional status, length of stay, mortality, and need to mechanical ventilation days of the studied patients

Items			**Values (no=50)**
Nutritional status	**Triceps Skin Fold (Cm)**		23.2±4.5
	Mid arm circumference (Cm)		29±3.9
	Hand grip (no=30)		29.9±8.3
	SGA	**A**	26 (52.0%)
		B	17 (34.0%)
		C	7 (14.0%)
ICU LOS (days)			13.5±11.2
Need to MV			18 (36.0%)
MV days (no=18)			10.7±7.1
Mortality	**Survival**		33 (66.0%)
	Mortality		17 (34.0%)

Data are presented as mean ± SD and number of (%), SGA: Subjective Global Assessment, ICU: intensive care unit, LOS: length of stay, and MV: mechanical ventilation.

No statistically substantial variation existed among the LOS and patients' sex (p-value = 0.360), cause of admission (p-value = 0.914), and hypertension (p-value = 0.429), but unexpectedly, there was a significantly longer LOS in non-diabetic patients with p-value 0.018 (May be explained by mortality earlier in diabetic patients). **(Table 3)**

Table 3: Association between patients' sex and comorbidities and ICU LOS

Items		Values of LOS (no=50)	P-value
Sex	**Males**	14.9±13.8	0.360
	Females	12±7.6	
DM		9.7±6.5	0.018*
HTN		12.2±9	0.429
Cause of admission	**Trauma**	15.7±5	0.914
	AKI	14.5±12.7	
	Stroke	11.4±5.6	
	Others	13.8±12.9	

Data are presented as mean ± SD. DM: Diabetes mellitus, HTN: high or raised blood pressure, AKI: Acute Kidney Injury

A statistically substantial relationship existed among the mortality, smaller TSF, and MAC (p-value 0.001). In addition, the hand grip was lower in mortality but didn't reach statistical significance (p-value 0.091). A substantial association existed between the advanced grade of SGA (grade C) and mortality (p-value 0.001). A statistically substantial association existed between the need to MV, smaller TSF, and MAC (p-value 0.001), but hand grip was non-significant (p-value 0.049). There was a significant association between the advanced grade of SGA (grade C) and the need to MV (p-value 0.001). **(Table 4)**

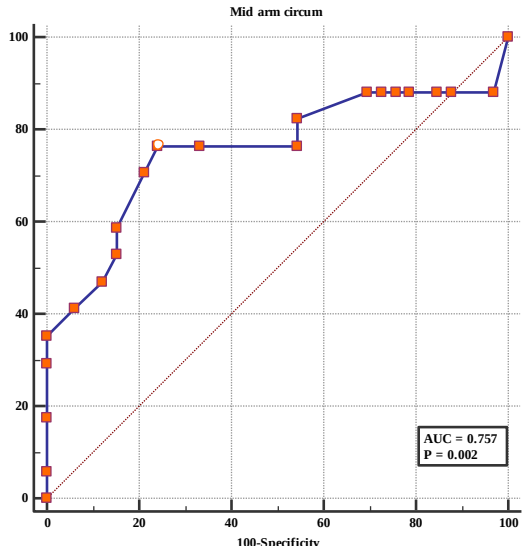
Table 4: Relation between mortality and nutritional status and need to MV and nutritional status of the studied patients

Mortality and nutritional status				
Items		**Alive (no=33)**	**Died (no=17)**	**P-value**
Triceps Skin Fold (Cm)		24.7±4.4	20.2±3.1	0.001*
Mid arm circumference (Cm)		30.3±2.6	26.5±4.7	0.001*
Hand grip (no=30 concious)		31.4±8.3	25.3±7.1	0.091
SGA	**A**	22 (66.7%)	4 (23.5%)	<0.001*
	B	11 (33.3%)	6 (35.3%)	
	C	0 (0.0%)	7 (41.2%)	

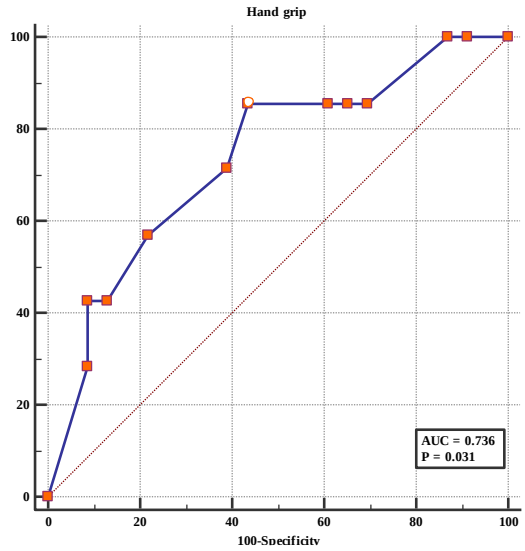
Need to MV and nutritional status				
Items		**No MV (no=32)**	**MV (no=18)**	**P-value**
Triceps Skin fold (Cm)		24.2±4.2	21.3±4.6	0.001*
Mid arm circumference (Cm)		30.2±2.6	26.9±4.8	0.001*
Hand grip (no=30 concious)		31.5±8.2	24.8±7	0.049* (MW)
SGA	**A**	20 (62.5%)	6 (33.3%)	<0.001*
	B	12 (37.5%)	5 (27.8%)	
	C	0 (0.0%)	7 (38.9%)	

Data are presented as mean ± SD and number of (%). SGA: Subjective Global Assessment, ICU: intensive care unit, LOS: length of stay, and MV: mechanical ventilation.

The mid-arm circumference, hand grip, and TSF have a predictive role in the mortality. At a cut off ≤29, ≤25, and ≤22 of MAC, hand grip and TSF respectively, with sensitivity 76.5%, 71.4%, and 70.6%, specificity 75.8%, 60.9% and 66.7%, and area under the curve (AUC) 0.757, 0.736 and 0.784 for the three parameters, respectively. **(Figure 1)**



A



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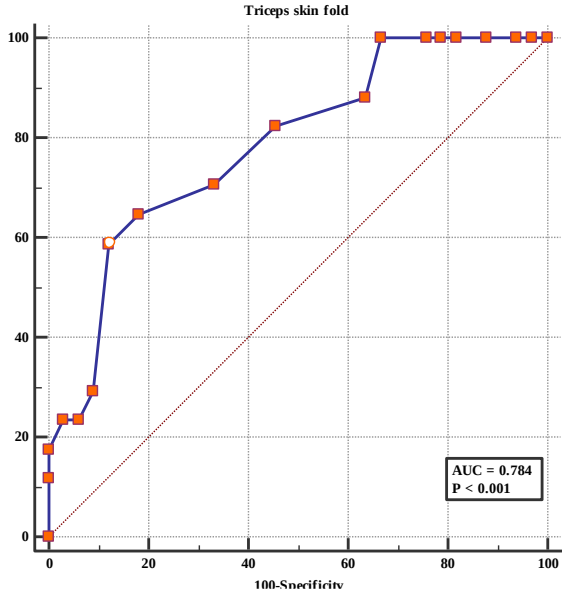

C

Figure 1: Receiver Operating characteristic curve for prediction of mortality from (A) mid-arm circumference, (B) hand grip, and (C) TSF

4. Discussion:

Malnutrition is one of the major problems during the stay in the ICU. Individuals in critical conditions have a significant likelihood of experiencing malnutrition, a condition linked to unfavorable clinical outcomes. The nutritional condition of individuals who are severely ill tends to decline rapidly upon their admission, primarily due to intense catabolism induced by stress, pro-inflammatory cytokines, and hormones. This deterioration can occur even in cases where individuals initially possess adequate nutritional status. Individuals may experience a reduction in body protein content, ranging from 10% to 25%, within ten days of being in. This phenomenon is particularly pronounced in individuals with multi-organ dysfunction syndrome. Individuals may also observe a decrease in body weight, up to 10 kg, based on the LOS [13].

In the current work, we found that the mean TSF was 23.2±4.5, the mean MAC was 29±3.9, and the mean Hand grip (HG) was 29.9±8.3. Also, (52%) of cases had SGA score grade A, 17 (34%) had SGA score grade B, and only 7 (14%) of cases of SGA had grade C.

Similar results were found in Suzie Ferrie, et al. [14] who reported that, out of 1034 individuals involved in the work 636 individuals (61.5%) had SGA grade A, 327

individuals (31.6%) had grade B and 71 individuals (6.9%) had grade C.

Another study by Konstantina Vamvakari et al. [15] reported that the median values of MAC, TSF, and HG were 29.5 cm, 20.1mm, and 26 kg, respectively.

Our current study found that, the mean LOS was 13.5±11.2 days, 18 patients needed MV representing 36% of cases with mean ventilation days 10.7±7.1, and mortality proportion 34%. This was in line with Canan Gürsoy, et al. [16] who stated that, the mean number of ICU stays was 8.67±7.63 days, 51 % of cases needed MV with mean ventilation days 7.51±6.20 and the overall mortality was 37.2%.

The present study revealed that, no statistically substantial variation existed between the LOS and patients' sex (p-value 0.360), cause of admission (p-value 0.914) or hypertension (p-value 0.429), but unexpectedly there was a significantly longer LOS in non-diabetic patients (p-value 0.018) that may be explained by earlier mortality in diabetic patients. This was in the same direction with Zaki et al. [17] who reported that, no substantial variation existed in age, sex, or diagnosis and ICU-LOS in malnourished patients.

Our study found that a statistically substantial association between the mortality and smaller TSF with MAC (p-value 0.001). In addition, the Handgrip was lower in mortality but didn't reach statistical significance (p-value 0.091). A substantial association existed between the advanced grade of SGA (grade C) and mortality with p-value <0.001. Severely malnourished ICU patients identified by small TSF, MAC, and SGA (grade C) had a higher mortality rate compared with well-nourished patients (with larger TSF, MAC, and SGA grade A).

A similar study done by Suzie Ferrie, et al. [14] who reported that, there was a significant independent influence of SGA on ICU mortality with SGA-C had significantly higher mortality ($p < 0.001$) as the mortality rate was (12.8%) in SGA-A, (15.3%) in SGA- B and (28.2%) in SGA-C. Contrasted to well-nourished individuals, mortality was substantially greater in the malnourished, throughout the ICU admission.

Another study by Santer, et al. [18] who reported that, decreased MAC and TSF values were significantly associated with higher mortality ($p < 0.05$). For each 1 cm increase in MAC, there was a 3% reduction in hospital mortality risk.

Our work found a statistically substantial association between the need to MV and smaller TSF, and MAC, but Hand grip was non-significant. There was a significant association between the advanced grade of SGA (grade C) and the need to MV. This

was in agreement with Ferrie, et al. [14] who reported that there was a significant relation between SGA and the need to MV with a higher SGA score was significantly associated with more days of MV. Also, Domenech-Briz V, et al. [13] reported that, SGA-C, decreased TSF and MAC were significantly associated with additional days of MV.

In our study, ROC curve analysis was used to demonstrate the predictive value of MAC, and TSF as regards the mortality in ICU patients and hand grip strength as regards the mortality in ICU patients.

This was in agreement with a recent study by Tsuyoshi Matsumoto, et al. [19] who reported that, ROC analysis determined 27cm as the cut-off value of the relative change in the MAC as a predictor of mortality in ICU individuals with a p-value <0.001 sensitivity of 77.8%, a specificity of 55.6%, and the area under the curve (AUC) was 0.681.

Another multicenter prospective cohort study by Wu, T., et al. [20] reported that, ROC curve analysis of triceps skinfold, MAC and hand grip strength being predictors of mortality revealed that, MAC<24.5 cm could predict ICU mortality with a sensitivity of 61.7%, a specificity of 87.3% and p-value <0.001. TSF can be a predictor of mortality in the ICU at a cut-off point <21.75 cm with a sensitivity of 58.3%, specificity of 78.5%, and $p < 0.001$. They also reported that, the measurement of MAC and HGS has demonstrated the potential to offer valuable prognostic insights into the risks of complications and mortality among those suffering from severe malnutrition. Notably, individuals identified as having severe malnutrition employing the MAC and HGS method exhibited the highest hazard ratio (HR) for mortality when contrasted to those in the normal group (HR, 1.51; 95% CI, 1.34–1.70; $p < 0.001$). Furthermore, MAC displayed an inverse relationship with mortality from all causes.

We recommend that further studies on large numbers of patients identify malnutrition risk factors among patients in critical conditions. Routine usage of SGA score as a non-invasive feasible, inexpensive assessment tool to assess the nutritional status in ICU patients. Early identification and management of malnutrition among patients in critical conditions to improve their prognosis.

5. Conclusions:

There was a strong association between mortality among patients in critical conditions and smaller triceps skin fold and mid-arm circumference. Severe malnutrition in critically ill patients SGA (grade C) was significantly associated with mortality and need to MV.

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Conflict of Interest: Nil

6. References:

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