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Dietary Intake and Biochemical Indicators and their Association with Wound Healing Process among Adult Burned Patients in the Gaza Strip

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Abstract:

Burn is a traumatic injury that causes immunological, endocrine, inflammatory, many metabolic responses and emotional stress which can affect dietary, micronutrients and antioxidants intake, which in turn have effects on recovery outcomes. To investigate the role of the nutrition and dietary intake on the progression of the different stages of the healing process among burned patients in Gaza strip. One hundred burned adult patients (36males and 64 females) were enrolled in this cross-sectional clinic-based study at Médecins Sans Frontières/ France clinics in Gaza Strip. Pretested interview questionnaires, Food Frequency Questionnaires, 24 hour dietary recall, anthropometric measures, and biochemical tests were used to assess dietary, health, and healing score among burned patients. This study reported positive association between Magnesium (x2=8.700, p=0.013), Copper (x2=60.916, p=<0.0001), and Vitamin C (x2=91.684, p=<0.0001)) with healing score. The results reported that the protein and energy intake were significantly lower (< 0.001) than the recommendations for both components, which might explain the higher prevalence of moderate healing (65%) among the participants. The adequacy of micronutrients such as Magnesium, Copper, and Vitamin C might be associated with positive wound healing outcomes. Consumption of healthy food is very important for healing process among burned patients. There is a real need for planned and well-balanced meals for burned patients.

Keywords:

Burn Injury; Macronutrients; Micronutrients; Nutritional Assessment; Wound Healing

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Background

Burned injury places a great socio- economic stress on patients, their families as well as health services.[1]Along with the financial burden imposed on patients, families, communities and the nation, it also leads to pain, emotional sufferings, infections, extensive damage to the skin, wound and scar contractures, amputations and death in some of the cases. According to World Health Organization, fire alone was responsible of about 265000 deaths each year, with more deaths from scalds, electrical burns, and other forms of burns, for which no global data are available.

Oxidative damage to the cell membranes can occur by different mechanism such as the peroxidation of polyunsaturated fatty acids residues in membranes that can lead to membrane damage and rupture, in addition to fragmentation of proteins at vulnerable points in the amino acid chain.[2]

Increased metabolic response in burned patients is accompanied with massive lipid and protein breakdown, negative energy and protein balance, muscle wasting, elevation in the peripheral insulin resistance, hyperthermia, increased the occurrence of infections and provoked the synthesis of acute phase responses located in the liver and intestinal mucosa.[3] The elevation in the rate of metabolic reaction is correlates with the increase size of the burned area.[4] Fifteen to twenty five percent total body surface area (TBSA) burn injury provokes hyper metabolic activities where the immune responses and fluid shifts are compromised. A 25 per cent total body surface burn injury produce a dramatic shift in the basal metabolic rate (BMR) between 118 to 210 percent of that original BMR.[5]

Adequate nutrition demands high priority in the management of burn injuries, but is unfortunately often neglected in clinical practice.[4] Estimation of the amount of energy required by burned patient prevent overfeeding as well asthe extremes of starvation, and is subject to continued monitoring, evaluation and revision based upon the metabolic characteristics of patients.[6] Because negative energy balance can easily develop among burned patients, estimating energy expenditure provides a particular challenge in burn injury management.[7,8] As a result of irreversible damage to protein sites where metal ions normally bind to functional protein.[2] The trace element and vitamins deficiencies occurred because of extensive exudative losses of the tissues and repeated surgeries,[9,10] as a result it may increase the risk of morbidity and mortality.[11] It is concluded that trace elements and vitamins supplementations such as zinc, selenium, and vitamin C are play an crucial role in supporting immune function and wound healing.[6,12]

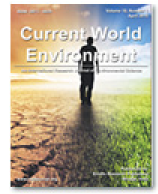
Nutritional assessment can be classified as two distinct categories: the initial requirements and the ongoing requirements. The assessment of caloric requirements generates a primary goal so that nutritional rehabilitation and support can be implemented. However, the most critical component is to adjust the ongoing demands during what is often a prolonged recovery linked with a prolonged course of hyper metabolism which probably extends for up to three years post-injury.[7] The purpose of the dietary assessment is to obtain relevant information from the current diet to identify dietary components that may raise or lower health risks among burned patients. This will help determine which dietary lifestyle changes are reasonable for a given patient, and any beneficial dietary habits that may be increased.[13] The importance of this study, emerges from the fact that no previous studies had been conducted regarding this issue in Gaza Strip. The aim of this study was to investigate the association between the dietary intake and the healing process among burned patients in Gaza strip.

Subjects and Methods

In this descriptive analytical cross-sectional and clinic-based study, 130 burned patients aged 17 – 72 years were registered in the Médecins Sans Frontières/ France (MSF/F) clinics in Gaza Strip. Due to the limited number of cases in all MSF/F centers, convenience sampling was done. After applying the inclusion and exclusion criteria, only one hundred burned patients matched the eligibility criteria and agreed to participate in the study program. The present study was approved by Helsinki committee in the Gaza Strip (PHRC/HC/18/15).

Eligibility Criteria

Inclusion Criteria; All burned adults (males or females) with different burn degrees registered at MSF/F clinics in Gaza Strip with agreement to participate in the study. **The Exclusion Criteria**



includes; who use (insulin, calcium channel blockers agents, Mg, calcium containing supplements, and or diuretic drugs), who have reduced renal function (serum creatinine levels more than 1.3mg/dl in women and more than 1.5mg/dl in men), who have elevated hepatic enzymes, recent infections (less than one month prior to study), who have chronic inflammatory diseases, cerebrovascular accident, acute coronary syndrome less than one month prior to the study, pregnant or lactating female, chronic diarrhea, and participating in other clinical trial.

Data Collection

Numerous descriptor variables were collected by the researchers to explore dietary, environmental, behavioral, anthropometrics, and biochemical influences on the health of patient using a standardized data collection instrument.

The demographic and clinical characteristics were recorded at the beginning of the study; these encompassed gender, age, marital status, education level, anthropometric measurements, and characteristics of the burn.

Anthropometric Data

Body weight was measured twice to the nearest 100 g and the average reading were calculated. Each subject was asked to take off the heavy clothes and shoes, and to keep on light clothes and remove heavy objects such as wallet and mobile prior to standing on the weighing scale (SECA-Germany) and then, step onto it with weight distributed evenly on both feet and where the arrow aligned, the weight was recorded. The height was measured twice in centimeter by using SECA stadiometer. Each patient was asked to stand fully erected against the wall, maintain head in a position of a straightforward gaze and feet slightly apart with the back of the head, scapulae, buttocks, calves, and heels are positioned in contact with the wall, then the sliding bar was lowered horizontally to the participant's head to where the bar is locked and the measurement was read and recorded. For more accuracy, height and body weight were recorded by the same observer and by using the same scales on the two occasions and the mean of the two readings was obtained. The body mass index (BMI) was calculated for each patient. Also, Mid-upper arm circumference (MUAC) was measured twice to the nearest 0.1 cm using arm circumference "insertion" tape at a level midway between the lateral projection of the acromion process at the shoulder and the olecranon process of the ulna (at the point of the elbow), with the elbow flexed to 90° and the arm hanging loosely and comfortably at the side.

Score of Healing (Estimated Percentage of Recovery (%)

A photographic wound assessment tool is a tool for measuring the process of wound healing among burned patients. Condition of all ulcers/wounds is assessed by examining: 1) Edge of the ulcer/wound; 2) Type of necrotic tissue present inside the ulcer/wound; 3) Amount of necrotic tissue present inside the ulcer/wound; 4) Color of skin surrounding the ulcer/wound; 5) Type of granulation tissue and its amount present inside the ulcer/wound; 6) Amount of wound healing by means of epithelization of the ulcer/wound;[14,15] 7) Type of exudate inside the ulcer/wound; 8) Amount of exudate inside the ulcer/wound.[16] The eight determinants of wound healing are depicted in Table 1. A score between (0 – 4) is assigned for each determinant; the total score for each wound is calculated by summing up the scores assigned to the various determinants. Score of healing (estimated percentage of recovery (%) is calculated by applying the following formula; (initial score − final score) / initial score × 100. Whereas the initial score was obtained from the medical records of the burned patients, that was reported at the time of injury, while the final score is reported at the time of data collection. The outcome of treatment (Epithelization %) is categorized on the basis of score of healing as poor (0–<25%), moderate (25–<50%), good (50–<75%), or excellent (75–100%).[17]

Table 1: Determinants of Burn Wound Assessment

Score	Edge	Necrotic tissue type	Necrotic Tissue amount%	Exudate type	Exudate amount	Skin color surrounding wound	Granulation tissue type and amount %	Epithelization %
0	Clearly visible	None	0	None	Dry	Pink/ normal	Intact skin and 100 covered	100
1	Distinct but attached	White/ nonadherent	>25	Serous/ clear	Just moist	Bright red	Beefy red and 75-<100 covered	75-<100
2	Not attached	Yellow slough	25-<50	Pale red	Small	White/ hypo-pigmented	Beefy red and 50-<75 covered	50-<75

Score	Edge	Necrotic tissue type	Necrotic Tissue amount%	Exudate type	Exudate amount	Skin color surrounding wound	Granulation tissue type and amount %	Epithelization %
3	Rolled under	Adherent	50-<75	Bloody	Moderate	Dark red/ purple	Pink/husky red and 25-<50 covered	25-<50
4	Fibrotic/ scarred	Black escher	75-100	Purulent	Large	Black/ hyperpigmented	None	<25

Biochemical analysis

Iron, Sodium, Calcium, Potassium, Magnesium, Copper, Zinc, Vitamin C, Total protein, and Albumin were measured and analyzed in specialized LAB, using appropriate kits and devices as show in the table 2.

Table 2: Kits and Devices

Reagent	Manufacturer
Albumin Kit	DiaSys (Germany)
T.Protein Kit	DiaSys (Germany)
(Na) Sodium Kit	BioMed (Germany)
(K) Potassium Kit	BioMed (Germany)
(Ca) Calcium Kit	DiaSys (Germany)
(Mg) Magnesium Kit	DiaSys (Germany)
(Cu) Copper Kit	Centronic (Germany)
(Zn) Zinc Kit	LabKit (Spain)
Iron Kit	BioSys (Spain)
Vitamin C Kit	MyBioSource (USA)
Chemistry Control	DiaSysTruLab (Germany)
Chemistry Control	BioSys (Spain)

Food Frequency Questionnaire

A validated Food Frequency Questionnaire (FFQ) in Arabic was used to assess the diets of the burned patients. The FFQ was modified from the Diet History Questionnaire I of the US National Cancer Institute and was validated for use in the Palestinian setting.[18] Participants were asked about their food intake before burn injury. A 1-year period was chosen for the data collected by the FFQ so that seasonal variations of fruits and vegetables would be available, although most participants indicated a constant dietary pattern during the last 5 years. FFQ tool was used to cover the main food groups included; carbohydrates group, vegetable group, fruits group, meats, chicken and fish group, milk and milk product group, beverage, nuts, snacks, soups, sauces, and candies. The answer recorded was a number of daily, weekly, monthly and annually or no consumption. Number of consumptions of mentioned kind of food was scored from 0-10 as the following; do not consume = 0, from 1 – 6 times per year = 1, from 11 – 7 times per year = 2, once a month = 3, from 2 – 3 times a month = 4, once a week = 5, twice a week = 6, from 4 – 3 times a week = 7, from 6 – 5 times a week = 8, once a day = 9, twice or more a day = 10.

24-hour Dietary Recall

The 24-hour dietary recall gave a vivid representation of the foods that were taken by the enrolled patients, taking into consideration leftover foods. The 24-hour dietary recalls were done for all patients, using handy measures, the weights of all the foods consumed by the patients were recorded. The nutrient compositions of the foods and the total energy provided from consumed foods were calculated using ESHA the Food Processor 11.5.226 application. The actual energy and macronutrients consumed were compared with the daily caloric and macronutrients requirements in burn patients. It is worth to mention that, due to the limitation of the ESHA program for the dietary analysis of Arabic food, the dietary micronutrients were replaced by biological markers such as (Iron, Na, Ca, K, Mg, Cu, Zn, and Vitamin C).

Daily Caloric Requirements Calculation

Daily caloric requirements were calculated using Harris Benedict Equation with Injury Factor[19] (Williamson, 1989), using the following formula; Total calorie needed = Basel Energy Expenditure * Activity factor * stress factor. TBSA was calculated using the Rule of Nines. The activity factor calculated as 1.2 if the patient combined with the bed and 1.3 if the patient out of the bed. Also, the stress factor was calculated according to TBSA% according to Table (3). The Basel Energy Expenditure was calculated according to the following formula; For woman = 655.1 + (9.563 x kg) + (1.850 x cm) – (4.676 x age). For men = 66.5 + (13.75 x kg) + (5.003 x cm) – (6.775 x age).

Table 3: Stress Factor according to TBSA%

TBSA%	Activity Factor
< 20 %	1.5
20-25 %	1.6
25-30 %	1.7
30-35 %	1.8
35-40 %	1.9
40-45 %	2.0
> 45 %	2.1

Statistical Analysis

Data storage, cleaning and analysis was done by Microsoft excel 2007. Then data were analyzed using Statistical Package for the Social Sciences(SPSS) software (v 22.0; IBM Corporation, Armonk, NY, USA). Descriptive statistics, including x^2 (Chi square), were used to compare the nominal variables of respondent's characteristics. Continuous variables were presented as mean ± standard deviation after checking the normality of the data. Independent *t* -tests and one- Way ANOVA were used to assess the difference between the groups. A *P*-value of < 0.05 was set as level of significance.

Ethical Considerations

Prior to data collection, a written permission to carry out the study was obtained from; MSF/F, Helsinki committee with reference no: PHRC/HC/18/15, General Directorate of Human Resources Development in Palestinian Ministry of Health gave its ethical approval and allowance, with reference number 15/844, and written consent form was obtained from all respondents; every respondent received a complete explanation about the purpose of the study, length of interview, the risk and benefits of the study and the investigation agency as well as the name of the researcher.

Results

Table (4) presents the important characteristics of the respondents. The male respondents represent 36% from total respondents, while 64% of all respondents were female. The mean age of the espondents was 34.48 years. The majority of the responders 39% and 29% attained a secondary school and graduate level, respectively. The mean BMI of all respondents was 26.58 kg/m2. The majority of respondents 76% had 2nd Degree burn. While 51% of respondents had TBSA less than 10%, also 40% of respondents ranged from 10 to 25% TBSA. In addition, the healing score of the majority of respondents 65% were classified as moderate healing score.

Table 4: Characteristics of Respondents

Variable	Profile	Mean(SD)	*n*(%)
Gender	Male		36(36%)
	Female		64(64%)
Age in years		34.48(12.92)	
Age categories	Less than 30 years		39 (39%)
	31-44 years		44(44%)
	45-60 years		11(11%)
	More than 60 years		6(6%)
Marital status	Single		18(18%)
	Married		80(80%)
	Widow		2(2%)

Education level	Illiterate		6(6%)
	Primary		9(9%)
	Preparatory		17(17%)
	Secondary		39(39%)
	Graduate		29(29%)
Weight(kg)		73.13(14.89)	
Height(m)		1.66(0.093)	
BMI		26.58(5.717)	
	Underweight		2(2)
	Normal weight		42(42)
	Overweight		30(30)
	Obese		26(26)
MUAC(cm)		26.05 (3.507)	
Degree of Burn	1st Degree		2 (2%)
	2nd Degree		76(76%)
	3rd Degree		19(19%)
	Mix (2nd + 3rd degree)		3(3%)
	Less than 10%		51(51%)
TBSA %	10 to 25%		40(40%)
	Above 25%		9(9%)
	Moderate Healing		65(65%)
Healing Score	Good Healing		19(19%)
	Excellent Healing		16(16%)

Table (5) shows that there is a statistically significant difference between (Vegetables, fruits, meats, poultry, snacks, soups, nuts) and healing score (p=<0.001, p=<0.001, p=0.013, p=0.002, p=0.029, p=0.005, p=0.028, respectively) as determined by one-way ANOVA, while the other food groups showed no statistically significant differences. However, a Tukey post-hoc test was used to find out if there are any statistical differences between the three different healing groups. There was significant difference between moderate and good group and, between good and excellent healing score and also between moderate and excellent healing score regarding the vegetables and fruits intake score. The results reported significant differences between moderate and good healing score and also between good and excellent healing score but no statistical differences were reported between moderate and excellent healing score regarding the meat and the poultry intake score.

Table 5: Diet Diversity and Healing Score

Variables	Moderate Healing	Good Healing	Excellent Healing	*F* Statistics	*P* value
	Mean (SD)	Mean (SD)	Mean (SD)		
Vegetables	73.20 (12.29)***	98.10 (4.92)***	114.12 (12.68)***	100.07	<0.001
Fruits	45.23 (13.10)***	72.14 (12.29)***	103.14 (21.00)***	110.89	<0.001
Meat	26.44 (8.28)*	33.2 (10.02)*	29.12 (8.87)	4.53	0.013
Poultry	13.92 (4.75)**	18.47 (5.796)**	15.87 (4.92)	6.64	0.002
Fish	19.98 (11.85)	15.15 (11.14)	14.56 (11.25)	2.19	0.117
Cereals	25.52 (8.683)	25.52 (7.493)	24.00 (6.693)	0.23	0.793
Legumes	32.46 (7.97)	35.89 (5.20)	30.93 (9.58)	1.99	0.141
Milk	33.58 (3.99)	35.26 (4.80)	32.37 (5.77)	1.88	0.157
Beverages	27.93 (11.39)	24.05 (12.38)	27.93 (10.89)	0.87	0.419
Snacks	26.20 (10.92)	19.47 (13.05)	20.31 (9.80)*	3.67	0.029

Variables	Moderate Healing	Good Healing	Excellent Healing	*F* Statistics	*P* value
	Mean (SD)	Mean (SD)	Mean (SD)		
Soups	27.16 (12.34)	19.78 (12.33)	17.18 (12.99)**	5.58	0.005
Sweets	17.06 (9.72)	13.89 (9.75)	11.81 (10.16)	2.20	0.116
Eggs	10.43 (3.88)	10.68 (5.49)	9.62 (5.23)	0.27	0.759
Nuts	3.63 (2.73)	5.15 (3.02)	5.25 (2.51)	3.69	0.028

Note:- One- Way ANOVA.
* Statistically significant at level $P< 0.05$, **Statistically significant at level $P< 0.01$, and ***Statistically significant at level $P< 0.001$.

24-Hours Dietary Recall

By analyzing the dietary data obtained by the 24-hr dietary recall, particularly for total energy and for total protein intake, Table 6 shows that the actual intake of protein is much lower than the recommended amount of protein for burn injury patients (Mean Difference; 62.86 and P value < 0.001) in all the cases. Table 7 shows that only 3% of the cases met the recommended dietary intake which is (body weight *1.5g of protein). The same is true for energy input, which was either much less than the recommended number of calories (Mean Difference; 1019.94 Kcal and P value < 0.001) in all the cases. Only 13% of the cases met the recommended energy intake which estimated by modified Harris-Benedict equation for burn injury patients.

Table 6: Protein and Energy Status among the Burned Patients

	RequirementsMean (SD)	IntakeMean (SD)	Mean Difference	*P* value
Protein	109.69(22.34)	46.83 (26.37)	62.86(33.83)	< 0.001
Energy	2832.42(708.30)	1812.48(553.01)	1019.94(851.41)	< 0.001

Independent sample t-test
Significant level set at $P< 0.05$

Table 7: Protein and Energy Adequacy Percentage among the Burned Patients

	Meet Requirements	Doesn't Meet Requirements
Protein	3(3%)	97(97%)
Energy	13(13%)	87(87%)

Table (8) presents the associations between some important biochemical parameters and healing score among burn patients. Results of this study show that there is a statistically significant association between Magnesium (x2=8.700, p=0.013), Copper (x2=60.916, p=<0.0001), and Vitamin C (x2=91.684, p=<0.0001) on one side and healing score on the other side.

Table 8: The association between healing score and biochemical parameters

		Moderate Healing	Good Healing	Excellent Healing	Test value	*P*Value
		n (%)	*n* (%)	*n* (%)		
Iron	Less than normal	16(69.6%)	14(17.4%)	3 (13.0%)	x^2=0.300	0.861
	Normal[a]	49(63.6%)	15(19.5%)	13(16.9%)		
Na	Less than normal	0 (0.00%)	0 (0.00%)	1(100.0%)	x^2=6.807	0.146
	Normal (135.0 - 155.0 mEq/L)	44(68.8%)	10(15.6%)	10(15.6%)		
	Above normal	21(60.0%)	9 (25.7%)	5 (14.3%)		
Ca	Less than normal	6 (75.0%)	1 (12.5%)	1 (12.5%)	x^2=0.394	0.821
	Normal (8.6 - 10.8) (mg/dL)	59(64.1%)	18(19.6%)	15(16.3%)		

		Moderate Healing	Good Healing	Excellent Healing	Test value	*P*Value
		n (%)	*n* (%)	*n* (%)		
K	Normal (3.4 – 5.5 mEq/L)	64(64.6%)	19(19.2%)	16(16.2%)	x^2=0.544	0.762
	Above normal	1(100.0%)	0 (0.00%)	0 (0.00%)		
Mg	Less than normal	0 (0.00%)	2(100%)	0 (0.00%)	x^2=8.700	0.013*
	Normal (1.6-2.5 mg/dl)	65(66.3%)	17(17.3%)	16(16.3%)		
Cu	Less than normal	60(92.3%)	3 (4.6%)	2 (3.1%)	x^2=60.916	<0.001***
	Normal (63.0– 140.0 mcg/dL)	5 (14.3%)	16(45.7%)	14(40.0%)		
Zn	Less than normal	43 (72.9%)	10(16.9%)	6 (10.2%)	x^2=4.751	0.093
	Normal [b]	22 (53.7%)	9(22.0%)	10 (24.4%)		
Vit C	Less than normal	63(69.6%)	0 (0.00%)	0 (0.00%)	x^2=91.684	<0.001***
	Normal (0.6-2.0 mg/dL)	2 (5.4%)	19(51.4%)	16(43.2%)		
T. Protein	Less than normal	12 (75.0%)	2(12.5%)	2(12.5%)	x^2=0.862	0.650
	Normal (6.6 – 8.8 g/dL)	53 (63.1%)	17(20.2%)	14 (16.7%)		
Albumin	Less than normal	1 (100%)	0 (0.00%)	0 (0.00%)	x^2=0.544	0.762
	Normal (3.5 – 5.2 g/dL)	64 (64.6%)	19(19.2%)	16 (16.2%)		

Note:- x^2: chi-square value.
*Statistically significant at level *P*< 0.05, **Statistically significant at level *P*< 0.01, ***Statistically significant at level *P*< 0.001.
a = normal range of iron for male is 65.0-175.0 mcg/dl and for female is 50.0-170.0 mcg/dl.
b = normal range of zinc for male is 72.0 – 127.0 mcg/dl and for female is 70.0 -114.0 mcg/dl.

Discussion

This study was designed to enhance healing status among burned patients through recognition of the role of nutrition in their disease.

The majority of the patients were female patients, and they were relatively distributed throughout the Gaza Strip governorates. These results might be attributed to the fact that the Palestinian females spend most of their times in the kitchen, preparing and handling foods, hence they are more susceptible to burn injuries. It has been indicated that female burn patients have an increased risk for delayed burn injury healing and mortality than male patients.[20] This may due to sex hormone differences, also need further clinical research and investigations.[21] One-third of patients' in this study were ranged from illiterate to preparatory educational level. Hence, they may be not aware of the importance of safety environment to reduce the risk of burn injury, and a lot of studies indicated that illiterate patients were at risk for more than the educated patients.[22] Low educated patients have lack of knowledge about infections and their complications.[23] In addition, increased household size may impact the economic status among families. Some literature pointed out that, economic ability of the households was associated with the risk of burn injuries.[24]

More than half of participants are overweight and obese. A lot of studies ascertained that, body mass index has relatively high correlation with estimates of body fatness and obesity hinder the process of wound healing.[25,26] As anthropometric measurements are crucial in the initial assessment of energy and protein needs among burned patients,[27] obesity linked to negative outcomes, such as; slower healing among pediatrics[28] and adults[25] burned patients.

Nutritional assessment and determination of nutrient requirements is challenging, particularly given the metabolic disarray that frequently accompanies inflammation.[8] Inadequate nutrition before or during the healing process may lead to poor healing and impair wound strength.[29] A lot of researches stressed on the importance of nutrition in promoting good wound healing and rapid recovery from burn injuries[30] and minimizing risk of complications including infections during the treatment period.[31] The hyper catabolic state among burned patients' needs high energy requirements from carbohydrates and proteins in the nutritional managements of those patients.[32,33] Inadequacy of protein also disrupts the immune system, with resultant decreased leukocyte phagocytosis and increased susceptibility to infection.[34]

Results of this study indicated that there are significant differences between different types of protein-based foods and healing quality. The protein requirements are high because, protein catabolism exceeds anabolism.[4] Increased catabolism of protein leads to losses of over 1 kg of skeletal muscle and visceral proteins a day.[35] The increased demand on proteins requirements among burned patients considered the key of nutritional management of burn wound healing.[8] Thus, the intake or supplementation of protein may be necessary in enhancement of host defense mechanisms and replacement of losses. Regardless of protein types must burned patient's intake, the higher proteins intakes improve burn wound healing and decrease mortality among burned patients.[36]

Interestingly, fruits and vegetables showed statistically significant differences between healing score category. The significance results may due to antioxidant and anti-inflammatory proprieties of some fruits and vegetables.[37-39] Fruits and vegetables that contain a high amount of vitamin C are highly recommended for burned patients.[40] The only rationalization of this significant association between snacks and burn healing is the selectiveness of snacks.

Hypoalbuminemia is common in burn patients.[41] More important, hypoalbuminemia causes some complications like; edema, abnormalities in healing, and increased susceptibility to sepsis.[42] The reduction of albumin might triggers subsequent complications that predispose patients to malnutrition, impaired immune responses, and an increased risk of infection.[43] Given that serum albumin link with inflammatory markers rather than nutritional markers, hence serum albumin levels do not offer a good nutritional marker in burns patients.[44,45]

In this study, there are marked differences in serum micronutrient status among burned patients, which may due to a lot of factors; losses through the wounds, acute-phase responses, consumption during metabolism and inadequate replenishments. The reduced gastrointestinal absorption following serious burn injuries, increased urinary losses, altered distribution, and altered carrier protein concentrations may lead to a deficiency in many micronutrients if not supplemented.[46] The acute phase response is characterized by a decrease in serum iron, zinc and selenium, as well as an increase in serum copper, and this is accompanied by an increase in ferritin and ceruloplasmin.[47] Low serum tocopherol, vitamin C, retinol and ß-carotene levels have been reported after burn injuries.[11] Using doses of vitamin E and C proven to be beneficial in reduction of oxidative stress, and improved wound healing.[48] Among trace elements, three have been documented to be particularly important in immunity and wound healing. Copper, zinc and selenium are lost in significant quantities with the exudative losses, the losses persisting as long as the burns wound are not closed. A lack of certain trace elements such as; selenium and zinc can worsen poor immunity, and burns are the second leading cause of immunodeficiency disease.[49]Although a role for free radicals and lipid peroxides in burn trauma has been established.[50]

As iron is known to play an important role in wound healing, iron deficiency among burn patients has not been associated with healing outcomes.[51] In fact, iron level typically decreased after burn, but it will return to normal level without supplementation in the majority of conditions.[52] Even though, iron contributes to collagen syntheses as a cofactor for hydroxylation of proline and lysine as well as plays a role in oxygen transport to the tissues,[29,53] iron supplementation is thought to be associated with an increased risk for infections, deter bacterial growth and increased mortality.[53]

Vitamin C have an important role in burn wound healing by several mechanisms; serve to scavenge free radicals within the extracellular space,[54] attenuates oxidative stress.[48] Vitamin C is involved in all phases of wound healing such as the inflammatory phase, proliferative phase, and maturation and formation of collagen[25] and consider an essential cofactor for collagen synthesis.[55] However, the adequate intake and replacement of Vitamin C among burned patients have an important effect in burn wound healing and recovery outcomes.[56] Results of this study indicate that there is a strong statistical association between healing and Vitamin C score. The relation between Vitamin C and healing after burn have gained great importance to many researchers.[12,57] Copper plays an essential role in wound repair; indeed, lysyl oxidases are extracellular copper enzymes that initiate the cross-linking of collagen and elastin,[9] and their activities decrease with poor copper status. Normal copper store decreases from 20 to 40 percent one-week post burn.[58] More important, recent studies indicated that copper deficiency cause impaired healing among burn patients.[29,59] This study indicated that there is a significant association between copper and burn injury healing, and these results were supported by a lot of up mentioned studies.

Zinc plays many important roles in the human body, such as; immune function, protein and collagen synthesis, cellular proliferation, and wound healing, cross-linked collagen.[60,61] The total loss of zinc one-week post to burn accounts for roughly 5–10 percent of the normal body content.[58] This study indicated that there is no statistically significant association between zinc and healing outcomes among burn patients. But the percentage of patients who have zinc level less than normal value account (59%) of all respondents.

This study sheds the light on the importance of appropriate nutritional intervention in the management of burned patients, and the study also highlights some of the important limiting nutrients and have a curial role in wound healing among burn patients. Our study has few limitations such as the sample size and the sampling method. With a larger sample size and random sampling method, the result would have been more representative and can be generalized. Due to the limited budget, important equipment such as a metabolic card for measuring the actual Resting Metabolic Rate (RMR) was not used in the study.

Conclusion

Nutritional adaptations have been recognized as a crucial factor that affects wound healing. The results reported that caloric and protein deficits are common among burned patients and the results also indicated that serum level of important micronutrients such as vitamin C, Cupper and Magnesium might be associated with positive wound healing progression.

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