Egypt, J. Plast. Reconstr. Surg., Vol. 49, No. 2, April: 169-175, 2025

Serum Albumin and Interleukin 6 Levels as Risk Factors of Morbidity and Mortality in Burn Patients

MOHAMED AHMED SAAD SHORBA, M.Sc.*; HELMY AHMED SHALABY, M.D.**; HISHAM ALMOHAMADY ALMETAHER, M.D.*** and SAMIR MOHAMED GHORABA, M.D.**

The Department of General Surgery, Plastic & Reconstruction Surgery** and Paediatric Surgery***, Faculty of Medicine, Tanta University*

Abstract

Background: Interleukin-6 (IL-6) is a major player in setting off this cascade of inflammatory responses. The loss of plasma proteins like albumin and a decrease in plasma colloid osmotic pressure led to increased fluid leakage from blood capillaries into normal tissue and the lungs.

Objective: The objective of this investigation was to evaluate serum albumin and IL-6 level as risk factors of morbidity and mortality in burn patients.

Patients and Methods: The prospective cohort investigation was conducted on 25 burn patients aged from 8 to 70 years, both sexes, with second, or third-degree burn, scald or a flame burn if the surface area is >15%. IL-6 and serum albumin were measured at first, third and seventh days in all patients.

Results: The body surface burned and abbreviated burn severity index (ABSI) were significantly increased in non-survivors than survivors ($p<0.001$). Sodium and albumin were significantly decreased in non-survivors than survivors ($p<0.05$). Potassium and IL-6 were significantly increased in non-survivors than survivors ($p<0.05$). Albumin was significantly decreased after 3 days than on admission ($p<0.001$) and it was significantly decreased after 1 week than on admission and after 3 days ($p<0.05$). IL-6 was significantly increased after 3 days and 1 week than on admission ($p<0.001$). Length of hospital stay was significantly higher in survivors than non-survivors ($p=0.048$) and it increased with increase total body surface area.

Conclusions: Serum albumin and IL-6 levels were strongly correlated with injury severity and progression.

Key Words: *Serum Albumin – Interleukin 6 – Morbidity – Mortality – Burn Patients.*

Ethical Committee: Study was done from January 2023 and January 2024 after approval from the Ethical Committee Tanta University Hospitals, Tanta, Egypt (approval code: 36264MSS6/2/23).

Disclosure: No conflict of interest.

Correspondence to: Dr. Mohamed Ahmed Saad Shorba, E-Mail: mohamedshorba2@gmail.com

Introduction

Thermal stress injuries, which may develop from a few different sources, are often referred to as burns. A hemodynamic system injury may cause symptoms such as shock, pain, bleeding, infection and decreased function. Burn injuries significantly affect the physical, mental, and physiological health of patients. Serious burns account for around 8% of all deaths annually and are a major contributor to disability worldwide. Because hypermetabolism connected to burns, lipids, proteins, and carbohydrates are broken down **[1,2]**.

Regrettably, burn injuries are still linked to a high incidence of morbidity and overall death. The compensatory anti-inflammatory syndrome and the initial systemic inflammatory response syndrome (SIRS) are the two stages of the burn process. The biology of burn wound healing, sepsis, and septic shock is now understood to be significantly influenced by cytokines. Burns reduces the T helper type 1 cells (Th1) response, which in turn raises the risk of infection, disease, and mortality **[3,4]**.

List of Abbreviations:

SIRS : Systemic Inflammatory Response Syndrome.
CBC : Complete Blood Count.
ABG : Arterial Blood Gas.
ELISA : Enzyme-Linked Immunoassay.
BCG : Bromocresol Green.
BUN : Blood Urea Nitrogen.
ALP : Alkaline Phosphatase.
ALT : Alanine Transaminase.
AST : Aspartate Aminotransferase.
iNOS : Inducible Nitric Oxide Synthase.
ROC : Receiver Operating Characteristic.
IL-6 : Interleukin-6.
Th1 : T helper type 1 cells.

Evaluating the risk of death in burn patients is essential for their overall treatment and selecting and improving their future management regimens. The use of prognostic factors has been attempted in these patients, and several scales, such as the abbreviated burn severity index (ABSI), which includes variables such as sex, age, total burned body surface area (BSA), full-thickness injuries, and burns attributable to inhalation, have been implemented but do not include biochemical variables. The acute physiology and chronic health evaluation (APACHE) II and APACHE III scales include serum albumin levels and comorbidities to improve predictive power **[5]**.

Because the most important function of albumin is to maintain an oncotic pressure of at least 80% of the normal level, its reduction could induce complications that predispose patients to malnutrition, the loss of immune responses, and an increased risk of infection. Several studies have shown the deleterious effects of hypoalbuminemia in terms of hospital stay, morbidity, and mortality in patients with various conditions, including critically ill patients or those patients undergoing chronic renal replacement therapy and surgical patients **[6]**.

White blood cell count, neutrophil count, C-reactive protein (CRP), serum procalcitonin (PCT), biomarkers [such as interleukin-6 (IL-6) and interleukin-8 (IL-8)] and proteomic data analysis have all been studied in the prediction of burn injury-related outcomes such as sepsis and mortality **[7]**.

In the severely burned patient, the differentiation between sepsis and inflammation represents a challenge with implications for appropriate clinical management **[8]**.

PCT is established with a wide clinical application. Due to the late onset of changes and the weak predictive value, a recent comparative review questioned the reliability of PCT for the early diagnosis of sepsis **[8]**.

The objective of this investigation was to evaluate serum albumin and IL-6 level as a risk factor of morbidity and Mortality rates among burn patients.

Patients and Methods

This prospective cohort study was carried out on 25 burn patients aged from 8 to 70 years old, both sexes, with second, or third-degree burn, scald or a flame burn if the surface area >15%. The study was done from January 2023 and January 2024 after approval from the Ethical Committee Tanta University Hospitals, Tanta, Egypt (approval code: 36264MSS6/2/23). An informed written consent was obtained from the patient or relatives of the patients.

Exclusion criteria where patients with comorbidities include conditions such as diabetes, chronic renal failure, liver disease, other similar conditions, radiation, chemicals, inhalation, electrical current are some potential causes of burns, carrying a kid around and subsequent harm.

All patients were subjected to complete survey and initial resuscitation, establish a patent airway, provide humidified oxygen by facemask, establish vascular access with large-bore venous cannula. Remove all clothes to assess burn severity. Intravenous fluid was given according to (parkland formula). Hypothermia was prevented by an increase in room temperature, thorough history taking and secondary survey; exclude associated injuries such as fracture or internal hemorrhage, general examination [degree of awareness, blood pressure, pulse, oxygen saturation and respiratory rate], local examination [burn site, degree of burn, severity of burn, and total BSA] and laboratory investigations [electrolytes such as (Na, K and Mg), complete blood count (CBC), blood glucose, urea, creatinine, arterial blood gas (ABG), IL6 level and albumin].

Study measures:

Mortality was reported. Survivor patients were evaluated as follows: Feneral: General condition of the patient, chest condition and body temperature (daily), local: Wound healing and skin oedema (daily), laboratory: Assessment of serum IL-6 level on admission, 3 days after admission and after one weak by ELISA and serum albumin assessment on admission, 3 days after admission and after one weak, unexpected complication and hospital stay. We were correlated patients with plasma if needed in hypoalbuminemia. We didn't use albumin due to its higher cost, not available and cause anaphylaxis. If wound deviation occurred, an infection happened. All patients weren't exposed to the excision or graft but had closed dressing. Statistic methods was used to interpret the collected data.

Interleukin 6:

The use of an enzyme-linked immunoassay (ELISA) specific to this protein allowed for the detection of elevated levels of IL-6 in the blood. All analytical techniques were executed precisely as per the guidelines provided by the manufacturer. A correction for total protein content was applied to the measured levels of IL-6. The linearity, detection limit, and imprecision of the IL-6 electro-chemiluminescent immunoassay were validated according to the protocols supplied by the national institute for biological standards and control.

Serum albumin:

Using a dye-binding method, which relies on the protein's ability to produce a stable compound with bromocresol green dye (BCG), the albumin content was ascertained. As the free dye emits light of different wavelengths, the BCG-albumin complex absorbs all of them. Correlated patients with hypoalbuminemia with plasma.

Statistical analysis:

Statistical analysis was done by SPSS v26 (IBM Inc., Armonk, NY, USA). With the use of histograms, we conducted the Shapiro-Wilks test to see whether the data had a normal distribution. Quantitative data was shown using means and standard deviations (SD). An unpaired student *t*-test was used for the study of the two groups. An analysis of variance (F) with a Tukey post hoc test was used for the three groups. The qualitative data, presented as frequencies and percentages, were evaluated using Fisher's exact test or a Chi-square test, as appropriate. A two-tailed *p*-value of 0.05 or less was used to determine statistical significance.

Results

Demographic data, vital signs and ABG were enumerated in this table. Table (1).

Laboratory investigations on admission, after (3 days and 1 week) were enumerated in this table. Table (2).

Table (1): Demographic data, vital signs, and ABG of the studied patients.

	N=25
Age (years)	39.44±19.52
Sex:	
Male	16 (64.0%)
Female	9 (36.0%)
Body surface burned (%)	25.52±13.73
Burn agent:	
Flame	13 (52.0%)
Scald	12 (48.0%)
ABSI at admission	5.96±2.35
Vital signs:	
Pulse (beats/min)	88.68±8.41
RR (breaths/min)	24.44±3.83
ABG:	
PH	7.4±0.09
PO_2 (mmHg)	86.72±15.75
PCO_2 (mmHg)	32.6±8.76

Data are presented as mean ± SD or frequency (%).
ABSI : Abbreviated burn severity index.
RR : Respiratory rate.
ABG : Arterial blood gases.
PH : Potential of hydrogen.
PO_2 : Partial pressure of oxygen.
PCO_2 : Partial pressure of carbon dioxide.

Table (2): Laboratory investigations on admission, after (3 days and 1 week) of the studied patients.

	On admission	After 3 days	After 1 week
Na (mEq/L)	129.76±5.67	130.84±6.71	131.2±6.96
K (mmol/L)	5.2±0.81	5.26±0.84	5.28±0.9
Mg (mmol/L)	0.74±0.11	0.75±0.12	0.75±0.12
Hb (g/dl)	13.28±1.69	13.28±1.68	13.28±1.67
HCT (%)	41.2±7.72	41.28±7.9	41.44±8.06
Leucocytes ($x10^9$/L)	15.38±7.39	15.3±7.72	15.35±7.66
Total lymphocytes ($x10^9$/L)	3.57±1.43	3.52±1.72	3.44±1.76
Total neutrophils ($x10^9$/L)	10.65±6.51	10.34±6.55	10.24±6.82
Platelets ($x10^9$/L)	276.8±70.38	286.2±78.76	297.04±80.71
Glucose (mg/dl)	132.2±48.54	131.8±49.71	131.68±50.21
Urea (mg/dl)	13.48±4.18	14.2±5.18	15.56±5.06
Creatinine (mg/dl)	0.9±0.19	0.95±0.19	0.95±0.18
Urine output (ml/h)	28.48±2.79	29.48±3.11	31.12±3.59
Albumin (g/dl)	3.46±0.33	3.12±0.3	2.96±0.45
IL-6 (pg/ml)	63.4±40.73	636.8±357.85	567.52±333.27

Data are presented as mean ± SD.
Na: Sodium, K: Potassium, Mg: Magnesium, Hb: Hemoglobin, HCT: Hematocrit, IL: Interleukin.

Wound healing, complications and length of hospital stay were enumerated in this table. Table (3).

Table (3): Wound healing, complications and length of hospital stay of the studied patients.

	N=25
Wound healing	14 (56.0%)
Pulmonary embolism	1 (4.0%)
Length of hospital stay (days)	23.56±14.25

Data are presented as mean ± SD or frequency (%).

The body surface burned, and ABSI were significantly increased in non-survivors than survivors (p<0.001). Age, sex, burn agent, pulse, RR, PH, PO_2, and PCO_2 were insignificantly different between survivors and non-survivors. Table (4).

Table (4): Demographic data, vital signs and ABG according to survival.

	Survivors (n=21)	Non-survivors (n=4)	p
Age (years)	38.24±19.69	45.75±19.97	0.492
Sex:			
Male	13 (61.9%)	3 (75.0%)	1.000
Female	8 (38.1%)	1 (25.0%)	
Body surface burned (%)	20.76±2.95	50.5±21.42	<0.001*
Burn agent:			
Flame	10 (47.62%)	3 (75.0%)	0.593
Scald	11 (52.38%)	1 (25.0%)	
ABSI at admission	5.24±1.41	9.75±2.87	<0.001*
Vital signs:			
Pulse (beats/min)	87.81±8.55	93.25±6.7	0.244
RR (breaths/min)	24.24±3.63	25.5±5.26	0.557
ABG:			
PH	7.41±0.09	7.38±0.1	0.488
PO_2 (mmHg)	87.19±15.36	84.25±20.07	0.740
PCO_2 (mmHg)	31.95±9.17	36±5.89	0.409

Data are presented as mean ± SD or frequency (%).
*Significant p-value <0.05.
ABSI : Abbreviated burn severity index.
RR : Respiratory rate.
ABG : Arterial blood gases.
PH : Potential of hydrogen.
PO_2 : Partial pressure of oxygen.
PCO_2 : Partial pressure of carbon dioxide.

Na, albumin and wound healing were significantly decreased in non-survivors than survivors (p<0.0). K and IL-6 were significantly increased in non-survivors than survivors (p<0.05). Length of hospital stay was significantly higher in survivors than non-survivors (p=0.048) and it increased with increase total BSA. Mg, Hb, HCT, leucocytes, total lymphocytes, total neutrophils, platelets, glucose, urea, creatinine, urine output, and pulmonary embolism were insignificantly different between survivors and non-survivors. Table (5).

Table (5): Laboratory investigations, wound healing, complications and length of hospital stay on admission according to survival.

	Survivors (n=21)	Non-survivors (n=4)	p
Na (mEq/L)	130.81±5.42	124.25±3.59	0.031*
K (mmol/L)	5.05±0.77	5.98±0.5	0.033*
Mg (mmol/L)	0.76±0.12	0.66±0.07	0.128
Hb (g/dl)	13.45±1.5	12.4±2.59	0.265
HCT (%)	41.57±7.84	39.25±7.8	0.592
Leucocytes ($x10^9$/L)	14.76±7.16	18.65±8.84	0.345
Total lymphocytes ($x10^9$/L)	3.66±1.45	3.13±1.41	0.506
Total neutrophils ($x10^9$/L)	10.1±6.37	13.53±7.44	0.345
Platelets ($x10^9$/L)	273.62±72	293.5±68	0.615
Glucose (mg/dl)	126.38±44.83	162.75±62.98	0.175
Urea (mg/dl)	13.14±4.35	15.25±2.99	0.367
Creatinine (mg/dl)	0.88±0.19	1.03±0.17	0.170
Urine output (ml/h)	28.52±2.91	28.25±2.36	0.861
Albumin (g/dl)	3.52±0.29	3.15±0.37	0.035*
IL-6 (pg/ml)	47.57±12.62	146.5±35.29	<0.001*
Wound healing	14 (66.67%)	0 (0.0%)	0.026*
Pulmonary embolism	0 (0.0%)	1 (25.0%)	0.160
Length of hospital stay (days)	39.8±18.56	20.03±5.5	0.048*

Data are presented as mean ± SD.
*Significant p-value <0.05.
Na: Sodium.
K : Potassium.
Mg: Magnesium.
Hb: Hemoglobin.
HCT: Hematocrit.
IL: Interleukin.

Albumin and IL-6 levels were significantly different regarding time measurements in survivors (p<0.001). Albumin was significantly decreased after 3 days than on admission (p<0.001) and it was significantly decreased after 1 week than on admission and after 3 days (p<0.05). IL-6 was significantly increased after 3 days and 1 week than on admission (p<0.001) with no significant difference between after 3 days and 1 week. Table (6).

Table (6): Serum albumin and IL-6 levels for survivors.

	On admission	After 3 days	After 1 week	*p*
Albumin (g/dl)	3.52±0.29	3.11±0.28	2.84±0.35	<0.001*
IL-6 (pg/ml)	47.57±12.62	727.81±314.68	647.33±301.72	<0.001*

Data are presented as mean ± SD. *Significant *p*-value <0.05. IL: Interleukin.

Case (1): Was presented in this figure. Fig. (1).

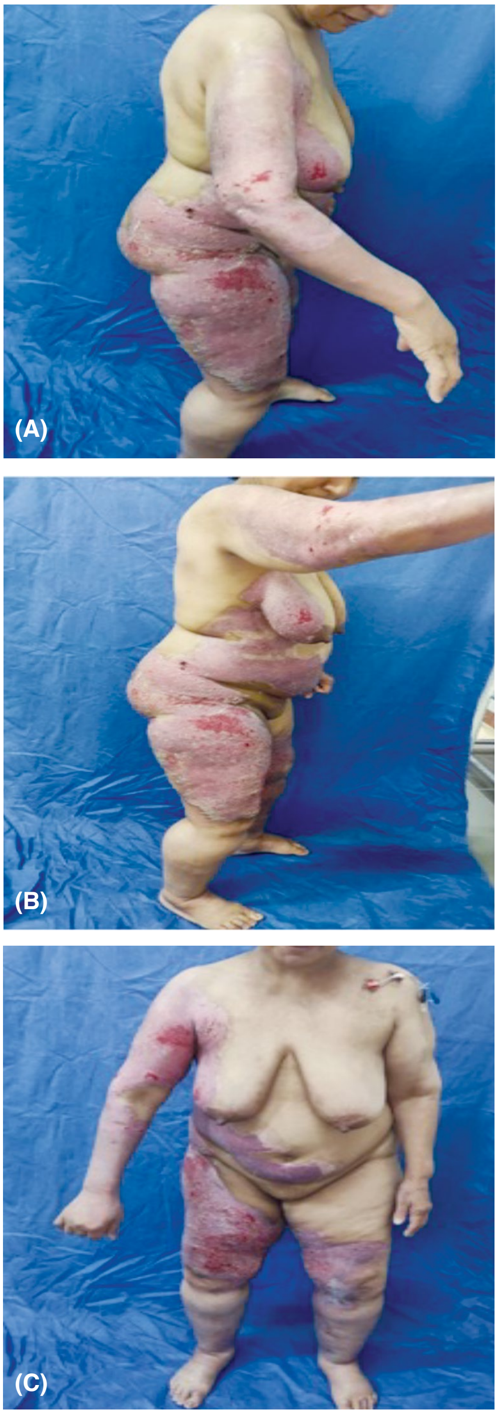

Fig. (1): Clinical pictures of case with severe burns with area of infection plain wound healing.

Discussion

The liver synthesizes albumin, the key serum binding protein that transports fatty acids, hormones, and medications throughout the body. Albumin is also essential for maintaining appropriate plasma colloid oncotic pressure. As far as blood protein levels are concerned, a normal range is 3.5 to 4.5g/dL **[9]**.

From 8 to 60 days is the range that our data showed hospital stays may be, with an average of 23.56±14.25 days. The length of hospital stays for survivors compared to non-survivors was significantly longer and it increased with increase total BSA, which is an intriguing finding. Using the American Burn Association's (ABA) criteria for moderate to severe burns, Jeschke et al. **[10]** showed that, on average, guests stayed for 9 days, with 5.7 days being the standard deviation. According to the research conducted by Dolp et al. **[11]** found that longer hospital stays are often associated with patients needing more intensive or comprehensive burn treatment, fluid resuscitation, surgery and rehabilitation.

Wound recovery was significantly delayed for non-survivors in comparison to survivors. Burn injury survivors and non-survivors were both examined to determine metabolic and inflammatory responses by Rehou **[11]** found that the non-survivor group had a higher prevalence of inflammatory biomarkers, such as IL-6, IL-8, and TNF-α, which were associated with a higher chance of mortality.

Our study revealed that non-survivors had significantly lower levels of Na and albumin compared to survivors. According to Pérez-Guisado et al. **[12]** revealed that serum albumin levels were significantly lower in non-survivors compared to survivors. Aguayo-Becerra et al. **[13]** determined that total proteins, albumin levels, and the albumin/globulin ratio were all significantly different between the two groups.

When comparing the groups of survivors and non-survivors, we did not find any significant differences in magnesium, hemoglobin, hemocytokines, platelets, glucose, urea, creatinine, or creatinine output. Jeschke et al. [14] found that there was no significant change in magnesium, glucose, urea, creatinine, or urine output between the groups who survived and those that did not.

Creatinine, blood urea nitrogen (BUN), alkaline phosphatase (ALP), alanine transaminase (ALT), aspartate aminotransferase (AST), and bilirubin levels, among other organ biomarkers, were significantly higher in non-survivors than in survivors in the study by Rehou et al. [11] and this difference persisted even after controlling for patient and injury variables.

Death row inmates' albumin levels were significantly lower than those of survivors. While admission and three days did not vary statistically, albumin levels were significantly lower after one week compared to admission and three days. Of the 73 burn patients studied by Ramos et al. [15] found that 20% have significant hypoalbuminemia (<2g/dL). Kim et al. [16] demonstrated that hypoalbuminemia during the first twenty-four hours after damage is a clear sign of imminent organ failure.

In their follow-up cross-sectional study, Eljaiek and Dubois [17] demonstrated that hypoalbuminemia during the first twenty-four hours after damage is a clear sign of imminent organ failure. Aguayo-Becerra et al. [13] found that albumin levels might be useful in predicting burn patients' death.

Our study revealed that non-survivors had significantly greater levels of K and IL-6 compared to survivors. Sasaki et al. [18] discovered a strong association between burns and IL-6 in connection to the immune-inflammatory response that happens during the healing process of burns. Modi et al. [19] discovered elevated IL-6 levels within hours of thermal injury. Lakshmi et al. [20] showed that low molecular weight heparin was effective in treating burn patients, highlighting the role of IL-6 and inducible nitric oxide synthase (iNOS) in the healing process.

Analysis of the receiver operating characteristic (ROC) curve revealed that the diagnostic performance was low, with an area under the curve of 0.7. With a specificity of 56.5% and a sensitivity of 79.5%, these data may be used to guide choices for the empirical use of antibiotics and other diagnostic and therapeutic procedures, such as device adjustments, microbiological samples, CT scans, and surgery. In one cell line study Hessle CC et al. [21] found that gram-negative bacteria secreted much more IL-6 than gram-positive bacteria did. Modi et al. [19] found that all burn patients initially had elevated IL-6 levels. The average IL-6 levels were found to be higher in correlation with the fraction of burn damage. In comparison to the control group, the second group of people who had 60% burns or more likewise showed very high mean IL-6 levels.

Limitations of the study included that the sample size was relatively small. The investigation was in a single center.

Conclusions: Serum albumin and IL-6 levels were strongly correlated with injury severity and progression. These parameters may be employed to estimate the likelihood of morbidity and mortality in burn victims.

References

1- Suzuki D.R.R., Santana L.A., Ávila J.E.H.G., Amorim F.F., Modesto G.P., Gottems L.B.D., et al.: Quality indicators for hospital burn care: A scoping review. BMC Health Serv. Res., 24: 486-20-2024.

2- Hosner J.: An Epidemiological Study of Michigan Occupational Burns: The Positive Correlation Between Men and Severe Burn Injuries: Michigan State University, 2024.

3- Hur J., Yang H.T., Chun W., Kim J.H., Shin S.H., Kang H.J., et al.: Inflammatory cytokines and their prognostic ability in cases of major burn injury. Ann Lab Med., 35: 105-10-2015.

4- Hager S., Foldenauer A.C., Rennekampff H.O., Deisz R., Kopp R., Tenenhaus M., et al.: Interleukin-6 serum levels correlate with severity of burn injury but not with sex. J. Burn Care Res., 39: 379-86, 2018.

5- Nunez Lopez O., Cambiaso-Daniel J., Branski L.K., Norbury W.B. and Herndon D.N.: Predicting and managing sepsis in burn patients: Current perspectives. Ther. Clin. Risk Manag., 13: 1107-17, 2017.

6- Moon J.J., Kim Y., Kim D.K., Joo K.W., Kim Y.S. and Han S.S.: Association of hypoalbuminemia with short-term and long-term mortality in patients undergoing continuous renal replacement therapy. Kidney Res. Clin. Pract., 39: 47-53, 2020.

7- Xiao L.N., Ran X., Zhong Y.X. and Li S.S.: Clinical value of blood markers to assess the severity of coronavirus disease 2019. BMC Infect Dis., 21: 921-60, 2021.

8- Stanojcic M., Vinaik R. and Jeschke M.G.: Status and challenges of predicting and diagnosing sepsis in burn patients. Surg Infect (Larchmt), 19: 168-75, 2018.

9- Yu Y.T., Liu J., Hu B., Wang R.L., Yang X.H., Shang X.L., et al.: Expert consensus on the use of human serum albumin in critically ill patients. Chin. Med. J., 134: 1639-54, 2021.

10- Jeschke M.G., van Baar M.E., Choudhry M.A., Chung K.K., Gibran N.S. and Logsetty S.: Burn injury. Nat. Rev. Dis. Primers, 6: 11, 2020.

11- Dolp R., Rehou S., McCann M.R. and Jeschke M.G.: Contributors to the length-of-stay trajectory in burn-injured patients. Burns, 44: 2011-7, 2018.

12- Pérez-Guisado J., de Haro-Padilla J.M., Rioja L.F., Derosier L.C. and de la Torre J.I.: Serum albumin levels in burn people are associated to the total body surface burned and the length of hospital stay but not to the initiation of the oral/enteral nutrition. Int. J. Burns Trauma, 13: 159-63, 2013.

13- Aguayo-Becerra O.A., Torres-Garibay C., Macías-Amezcua M.D., Fuentes-Orozco C., Chávez-Tostado Mde G., Andalón-Dueñas E., et al.: Serum albumin level as a risk factor for mortality in burn patients. Clinics, 68: 940-5, 2013.

14- Jeschke M.G., Gauglitz G.G., Finnerty C.C., Kraft R., Mlcak R.P. and Herndon D.N.: Survivors versus nonsurvivors postburn: Differences in inflammatory and hypermetabolic trajectories. Ann. Surg., 259: 814-23, 2014.

15- Ramos G., Bolgiani A., Guastavino P., Prezzavento P., Patiño O. and Benaim F.: Hypoalbuminemia in burned patients: An outcome marker that could define evolution periods. Rev. Arg. Quem., 15: 20-8, 2000.

16- Kim G.H., Oh K.H., Yoon J.W., Koo J.W., Kim H.J., Chae D.W., et al.: Impact of burn size and initial serum albumin level on acute renal failure occurring in major burn. Am. J. Nephrol., 23: 55-60, 2003.

17- Eljaiek R. and Dubois M.J.: Hypoalbuminemia in the first 24h of admission is associated with organ dysfunction in burned patients. Burns, 39: 113-8, 2013.

18- Sasaki J.R., Zhang Q. and Schwacha M.G.: Burn induces a Th-17 inflammatory response at the injury site. Burns, 37: 646-51, 2011.

19- Modi S., Rashid M., Malik A. and Shahid M.: Study of complement activation, C3 and interleukin-6 levels in burn patients and their role as prognostic markers. Indian J. Med. Microbiol., 32: 137-42, 2014.

20- Lakshmi R.T., Priyanka T., Meenakshi J., Mathangi K.R., Jeyaraman V. and Babu M.: Low molecular weight heparin mediated regulation of nitric oxide synthase during burn wound healing. Ann. Burns Fire Disasters, 24: 24-9, 2011.

21- Hessle C.C., Andersson B. and Wold A.E.: Gram-positive and gram-negative bacteria elicit different patterns of proinflammatory cytokines in human monocytes. Cytokine, 30: 311-8, 2005.