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Evaluation of Serum L-carnitine in Late Onset Neonatal Sepsis

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ABSTRACT

Background: Neonatal sepsis is defined as a systemic inflammatory response elicited by blood-stream infection. It is associated with high morbidity and mortality, especially during the first 28 days of life [neonatal period], particularly in resource limited settings.

Aim of work: The aim of the work was to evaluate serum level of carnitine in neonate with sepsis. In addition, to study the relation between L-carnitine concentration with birth data and the presence of neonatal sepsis.

Subjects and methods: This was a case control study, which was conducted at Al-Azhar University Hospital [New Damietta; Egypt]. It included 60 neonates, 30 with neonatal sepsis [the sepsis group], and 30 without sepsis [control group]. All were carefully evaluated by neonatal and maternal history taking, clinical examination and laboratory workup. Serum-L-carnitine was measured and values were compared between groups and correlated with other variables. The predictive power of L-carnitine in diagnosis sepsis and prediction of its associated mortality was calculated.

Results: L-carnitine levels were significantly reduced in sepsis than healthy controls [3.6±0.99 vs. 15.3±2.1 mg/l]. Serum carnitine less than 4.69 had a significant value for sepsis prediction with sensitivity of 90%, specificity of 70% and area under curve of 0.83. In addition, serum carnitine less than 2.97 had a significant value for prediction of mortality [sensitivity of 80%, specificity of 89% and area under curve equal 0.86]. sepsis associated mortality was 16.7%. Finally, there was moderate negative significant correlation between serum carnitine with C-reactive protein [r=-0.68] and total leucocyte count [r=-0.44]; while, there was mild positive significant correlation between serum carnitine and birth weight [r=-0.26] and hemoglobin [r=0.27].

Conclusion: L-carnitine is significantly reduced in neonatal sepsis and it can be used as predictor for neonatal sepsis and sepsis-related mortality.

Keywords: Birth weight; L-carnitine; Neonates; Prediction; Sepsis.

INTRODUCTION

Neonatal sepsis is a defined as a systemic inflammatory response to blood stream infection [bacterial, viral or fungal]. It is marked by hemodynamic changes and other systemic manifestations. Furthermore, the neonatal sepsis is associated with high risk of substantial morbidity and mortality. It is responsible for 15% of neonatal deaths [1-3]. The early onset neonatal sepsis diagnosis is settled when culture proven infection was reported within the first three days of life [4]. However, the late onset neonatal sepsis is defined as postnatal acquisition of infection or positive blood and/or cerebrospinal fluid culture. But in continuously hospitalized very low birth weight neonate, the late onset sepsis is defined as the positive culture at > 72 hours of age [5,6].

L-carnitine is a natural compound that plays a significant role in the metabolism, energy production and oxidation of fatty acids. In addition to its role in the regulation of oxidative stress, inflammation and mitochondrial function [7,8]. However, the role of L-carnitine in sepsis is not fully elucidated. Some researchers suggested that, it may provide beneficial effects. For instance, it may improve cardiac function and decrease the need for vasopressors in septic shock [9-11]. It may also affect the immune response and reduce the cytokine production in response to inflammation in sepsis. L-carnitine deficiency may be the results of sepsis endotoxemia due to impaired lipid metabolism, energy production and oxidation of fatty acids [12].

The aim of this study was to estimate the serum levels of L-carnitine in neonates with sepsis, and examine its possible associations.

PATIENTS AND METHODS

After approval of the local ethics committee of Al-Azhar Faculty of Medicine [New Damietta; Egypt], this case-control study included 60 neonates [30 with neonatal sepsis as the sepsis group and 30 without sepsis as the control group]. They were selected from the neonatal intensive care unit [Al-Azhar University Hospital, New Damietta].

The inclusion criteria were full or pre-term neonates of both sexes. However, the exclusion criteria were neonates with early onset sepsis, those with major congenital anomalies and those who need major surgical intervention.

All eligible neonates were submitted to full clinical assessment in a standard manner and according to the protocol adopted by the institution. Firstly, full history was collected to detect risk factors for sepsis. After that, a detailed clinical examination [from head to toe] was performed with stress on the clinical signs of sepsis [e.g., high temperature, respiratory, circulatory, gastrointestinal [GIT] or neurological dysfunction], hypo-or hyper-glycemia and petechial, bleeding or disseminated intravascular coagulation [DIC].

The assessment then completed by laboratory investigations, which included complete blood count with differential leucocyte count, quantitative assay of C-reactive protein, blood culture and measurement of L-carnitine. The assay of L-carnitine was performed by an enzymatic ultraviolet test through examination of the peripheral venous samples.

Statistical analysis: All data were managed using SPSS 26 for windows [SPSS Inc., Chicago, IL, USA]. The data were tested for normal distribution, and qualitative data were represented as frequencies and relative percentages, while quantitative data were expressed as mean ± SD [Standard deviation]. Chi square test and fisher exact test was used to calculate difference between categorical variables as indicated. Independent T test and Mann Whitney test were used to calculate difference between quantitative variables in two groups for parametric and non-parametric variables respectively. ROC curve analysis was done for prediction of neonatal sepsis and mortality. Pearson correlation was done between serum carnitine and different variables. All statistical comparisons were two tailed with significance Level of P-value ≤ 0.05 indicates significance.

RESULTS

Comparing baseline neonatal and maternal data revealed that, both groups were comparable [no significant differences], except significant increase of prematurity, large for gestational age and previous NICU admission in the sepsis than control group [53.3%, 60.0%, 33.3% vs. 10.0%, 16.7% and 10.0%, successively]. However, birth weight was significantly lower in the sepsis than sepsis group [2057±787 vs 2881± 574.3 g] **[Table 1].**

Laboratory workup showed that, hemoglobin and L-carnitine values were significantly reduced in the sepsis than the control groups [14.1±2.6, 3.6±0.99 vs. 15.3±2.1 and 4.98±1.1, respectively]. However, there was significant increase of total leucocyte count [TLC] and CRP in the sepsis than the control group [17.9±4.2, 115.9±108.9 vs 8.8±2.3, and 0 respectively]. All subjects in sepsis group had positive CRP, while all in the control group had negative CRP **[Table 2].**

Regarding results of the blood culture in the sepsis group showed that, no growth was reported in 11 cases [36.7%]. On the other side, gram negative bacilli, *Staphylococcus aureus*, group D streptococci, Klebsiella, candida and aerobic coagulase negative *Staphylococcus* in 6.7%, 23.3%, 13.3%, 6.7%, 10.0% and 3.3%, successively] **[Table 3].**

Figure [1] showed that, 16.7% of septic cases died and the remaining 83.3% were improved.

Table 4 and Figures [2 and 3] showed that, serum carnitine less than 4.69 had a significant prediction power for sepsis [AUC 0.83] with sensitivity of 90%, specificity of 70% In addition, serum carnitine less than 2.97 had a significant value for mortality prediction with sensitivity of 80%, specificity of 89% and area under curve equal 0.86.

Table [5] and figures [4 to 7] showed that, there is moderate negative significant correlation between serum carnitine and CRP [r=-0.68] and TLC [r=-0.44]. On other hand there was mild positive significant correlation between serum carnitine and birth weight [r=-0.26] and HB [r=0.27].

Table [6] showed that, there was a significant difference in serum carnitine regarding prematurity, Weight for GA, Blood culture and mortality among septic cases [p value <0.05] as the mean serum carnitine was significantly lower among premature, LGA, cases with positive blood culture and died cases than among full term, AGA, cases with negative blood culture and improved cases

Table [1]: Baseline data among sepsis and control groups

		Sepsis [cases] [n=30]	No sepsis [control; n=30]	P value
Gestation age at delivery [weeks]	Mean±SD	36.1±1.0	37.8±0.83	0.07
	Min. – Max.	32- 39	35-39	
Sex [n,%]	Male	16[53.3%]	18[60.0%]	0.60
	Female	14[46.7%]	12[40.0%]	
Prematurity [n,%]		**16[53.3%]**	**3[10.0%]**	***<0.001****
Birth weight (g)	Mean±SD	**2057±787**	**2881±574.3**	***<0.001****
	Min. – Max.	1100-3750	1500-3900	
Weight for GA [n,%]	Large for GA	**18[60.0%]**	**5[16.7%]**	***<0.001****
	Appropriate for GA	12[40.0%]	25[83.3%]	
Postnatal days	Mean±SD	10.1±7.1	6.6±5.5	0.08
	Median [IQR]	7[4-28]	5[3-29]	
Maternal age [year]	Mean±SD	30.9±4.9	30.4±5.4	0.71
	Min. – Max.	20-39	20-39	
Mode of delivery [n,%]	Normal	14[46.7%]	14[46.7%]	1.00
	CS	16[53.3%]	16[53.3%]	
Previous NICU admission [n,%]		**10[33.3%]**	**3[10%]**	***0.021****
Maternal history	Irrelevant	15[50.0%]	23[76.7%]	0.28
	PROM	4[13.3%]	2[6.7%]	
	Gestational diabetes	5[16.7%]	3 [10.0%]	
	Preeclampsia	2[6.7%]	1 [3.3%]	
	Maternal fever	1[3.3%]	1 [3.3%]	
	UTI	3 [10.0%]	0 [0.0%]	

[*] indicate statistical significance

Table [2]: Laboratory data among sepsis and control groups

		Sepsis [cases] n=30	No sepsis [control; n=30]	P value
Hemoglobin [g/dl]	Mean±SD	**14.1±2.6**	**15.3±2.1**	***0.05****
	Min. – Max.	**8.8-19.2**	**9.7-19.2**	
RBCs [x 10^6 /ml]	Mean±SD	4.47±0.81	4.5±0.77	0.75
	Min. – Max.	3.1-6.52	3.03-6.39	
TLC [x 10^3/ml]	Mean±SD	***17.9±4.2***	***8.8±2.3***	***<0.001****
	Min. – Max.	12.6-34	5.23-13.7	
Platelets [x 10^3/ml]	Mean±SD	272.4±132.3	298±73	0.36
	Min. – Max.	28-535	176-455	
CRP code [n,%]	Negative	0[0%]	30[100%]	***<0.001****
	Positive	30[100%]	0[0%]	
CRP values	Mean±SD	**115.9±108.9**	---	-
	Median [IQR]	64[12-367]	---	
L-carnitine	Mean±SD	**3.6±0.99**	**4.98±1.1**	***<0.001****
	Min. – Max.	1.65-4.97	2.9-7.98	

[*] indicate statistical significance

Table [3]: Distribution of septic cases regarding the results of blood culture

	Frequency [N=30]	Percentage
No growth	11	36.7%
Gram negative bacilli	2	6.7%
Staphylococcus aureus	7	23.3%
Group D Streptococcus	4	13.3%
Klebsiella	2	6.7%
Candida	3	10%
Aerobic coagulase negative Staphylococcus	1	3.3%

Table [4] Diagnostic performance of serum carnitine for prediction of sepsis and mortality

Serum carnitine	AUC	95% CI	Cut off value	P value	Sensitivity	Specificity	PPV	NPV
Sepsis	0.83	0.73-0.93	<4.69	<0.001*	90%	70%	75%	87.5%
Mortality	0.86	0.68-0.99	<2.97	0.007*	80%	89%	40%	98%

[*] significant at p value <0.05

Table [5]: Correlation between serum carnitine and different variables

	Serum carnitine	
	r	**P value**
Age [days]	-0.09	0.47
Gestational age	-0.008	0.95
Maternal age	-0.05	0.65
Birth weight	**0.26**	**0.04***
HB	**0.27**	**0.03***
TLC	**-0.44**	**<0.001***
RBC	0.12	0.33
Platelet	0.003	0.98
CRP	**-0.68**	**<0.001***

_* significant at p value <0.05

Table [6]: Association between serum carnitine and different variables among cases group

		Serum carnitine		P value
		Mean ±SD	**Range**	
Prematurity	Preterm	2.9±1.02	1.65-4.34	**0.006***
	Full term	3.98±.81	2.64-4.97	
Weight for GA	LGA	3.2±1.01	1.65-4.5	**0.03***
	AGA	4.01±0.85	2.38-4.9	
Blood culture	Negative	4.3±0.73	2.6-4.9	**0.006***
	Positive	3.3±0.94	1.6-4.9	
Mortality	Improved	3.8±0.85	2.3-4.9	**0.01***
	Died	2.7-1.1	1.65-4.5	

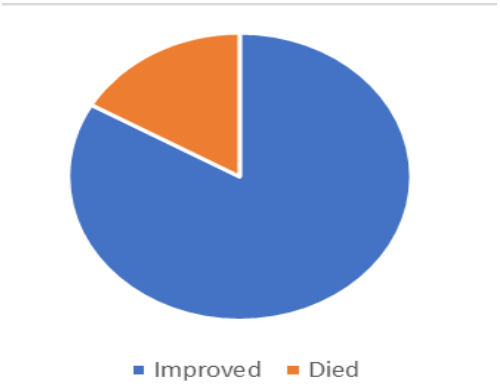

Figure [1]: Outcome among sepsis group

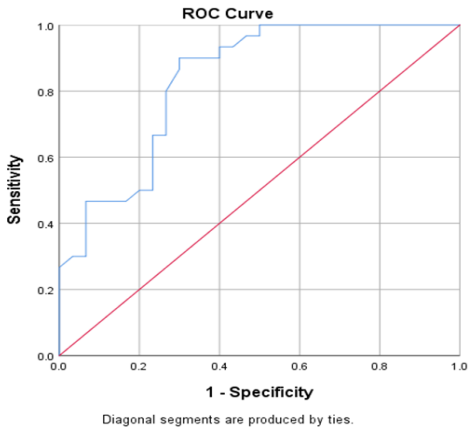

Figure [2]: ROC curve analysis for serum carnitine for prediction of sepsis

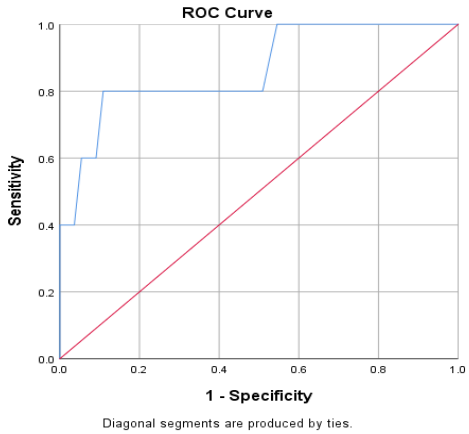

Figure [3]: ROC curve analysis for serum carnitine for prediction of mortality

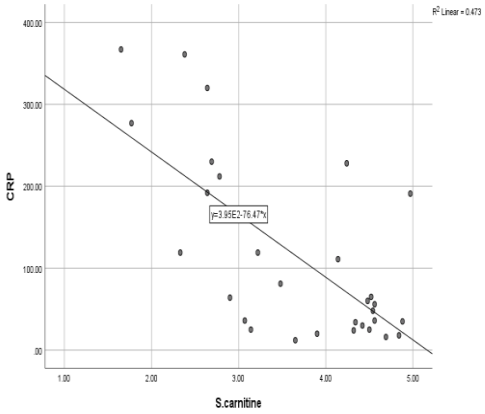

Figure [4]: scatter plot represent correlation between serum carnitine and CRP

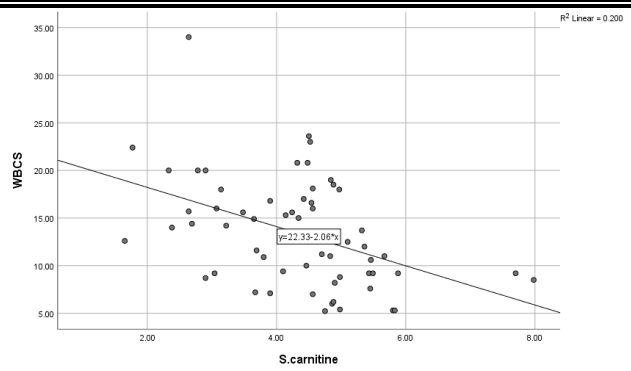

Figure [5]: Scatter plot represent correlation between serum carnitine and TLC

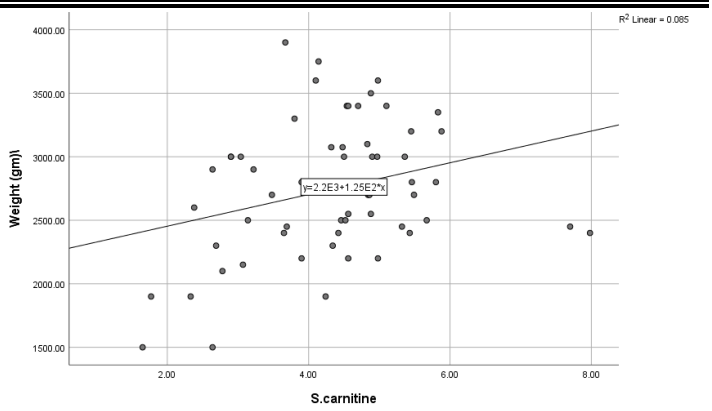

Figure [6]: Scatter plot represent correlation between serum carnitine and birth weight

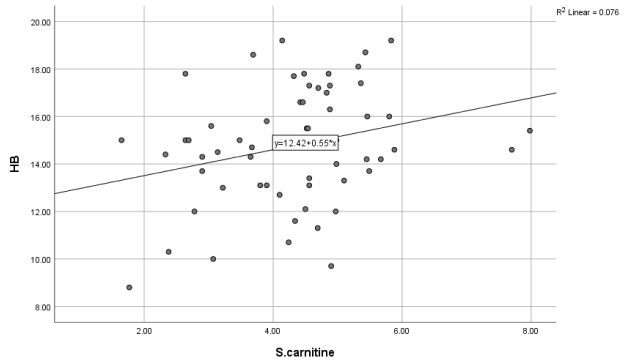

Figure [7]: Scatter plot represent correlation between serum carnitine and Hb.

DISCUSSION

The pattern of bacterial pathogens responsible for neonatal sepsis has changed with time and varies from place to place. There has also been a difference in the causative organism of neonatal sepsis between the developed and developing countries [13].

The present study aimed to evaluate serum level of carnitine in neonate with sepsis, and its relation to gestational age, birth weight, and presence of neonatal sepsis. The main results of the study showed that, L-carnitine was significantly reduced in sepsis than control group. L-carnitine was negative and significantly correlated with total leucocyte count and C-reactive protein, but positively correlated with birth weight and hemoglobin concentrations. Furthermore, L-carnitine was significantly reduced in preterm and LGA neonates. The mortality rate was 16.7% and serum L-carnitine had a good predictive power for neonatal sepsis and its associated mortality. In line with our results, **El-Lahony *et al.*** [12] reported non-significant differences between neonates with sepsis when compared to healthy control regarding gestational age, neonatal gender, maternal age, mode of delivery, birth weight for gestational age. They also found that healthy group had negative CRP; but, septic group showed positive CRP and significantly lower values of L-carnitine in the sepsis than control groups [2.63±0.35 mg/l vs 5.06±1.03 mg/l]. **Ozkan *et al.*** [14] reported comparable results, with no significant differences regarding GA and gender.

On the other side, our results do not agree with **El-Lahony *et al.*** [12] regarding birth weight and weight of gestational age. They did not found any significant differences in the sepsis than control group [p=0.147]. This may be explained by different inclusion criteria.

Maternal history in the current work was comparable between the sepsis and control groups. This is consistent with **Puskarich *et al.*** [15] who intended to predict the value of metabolites of L-carnitine treatment in mortality benefit in septic shock. They found non-significance between cases and controls regarding the maternal history. Our results agree with **Omran *et al.*** [16] who demonstrated that all the case group [sepsis] were positive CRP.

Staphylococcus aureus was the commonest detected organism in sepsis group followed by group β-streptococci [23.3%] then gram negative bacilli [16.7%] and the least was aerobic coagulase negative Staphylococcus aureus [6.7%]. **El-Lahony *et al.*** [12] who reported that, all patients in their study reported positive blood culture, and the commonest detected organism was gram-negative organisms [71.04%], and gram positive organisms were reported in 28.6% and fungi were reported in 7.7%. **Ozkan *et al.*** [14] reported that gram negative organisms are the most frequent microorganism. These results are quite different than the current work. This reflected wide and variable distribution of causative organisms of sepsis. This reflected the value of our study and studies like it, aimed to detection of the causative organisms and planning infection control policies

The mortality rate in case group was 16.7% compared to none in the healthy control group. **Puskarich *et al.*** [17] reported that there was a statistically significant difference between cases and controls regarding mortality [p value<0.05]. In addition, **Chung *et al.*** [18] aimed to evaluate the association between serum carnitine and mortality. They demonstrated that serum carnitine can reflect the severity of organ dysfunction, inflammation, and infection in sepsis and can serve as a prognostic biomarker for mortality prediction.

L-carnitine was a good predictor of sepsis and its associated mortality [AUC was 0.83 and 0.86 respectively]. This result agrees with **Yahyapoor *et al.*** [11] showed that serum carnitine had a significant value for sepsis prediction and it may help to reduce mortality risk in sepsis patients.

L-carnitine supplementation was associated with lower mortality in patients with sepsis. This reflected the role in the development of sepsis, prediction of sepsis and its associated mortality. This was supported by **Evans *et al.*** [19] who reported a slight significant reduction in one-year mortality rate in response to L-Carnitine supplementation compared to placebo. In addition, **Puskarich *et al.*** [15] studied the efficacy of L-carnitine infusion for the treatment of vasopressor-dependent septic shock. They reported that serum carnitine predicted for sepsis mortality in neonate and associated with a significant decrease in 28-days mortality among patients who received L-Carnitine supplementation [p=0.048].

Concerning correlation between serum carnitine and different variables, results supporting that of **El-Lahony *et al.*** [12] who revealed no correlation between l-carnitine and maternal age or gestational age. In addition, **Sánchez-Pintos *et al.*** [20] who reported that, there was positive significant correlation between serum carnitine and birth weight. L-carnitine deficiency was demonstrated in all very low birth weight babies. However, birth weight restriction has been suggested as a risk factor for impaired carnitine status. Similarity, **Beshir *et al.*** [21] reported no correlation between L-carnitine and gestational age or maternal age.

In contrast with **El-Lahony *et al.*** [12] found that there was no correlation between L-carnitine and birth weight. As well, **Beshir *et al.*** [21] found that there was no correlation between L-carnitine and birth weight. This contrast may be explained by the number of cases and selection criteria.

In conclusion, the current work confirmed the value of L-carnitine in neonatal sepsis as a predictor of the condition and its associated mortality. The reduced levels of L-carnitine in septic group significantly associated with birth weight and prematurity. Thus, L-carnitine supplementation for neonatal sepsis is recommended. However, due to small sample size [a limiting step of the current work], the results of the current work needs further validation in future large scale and multi-centers studies.

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REFERENCES

1. Attia Hussein Mahmoud H, Parekh R, Dhandibhotla S, Sai T, Pradhan A, Alugula S, et al. Insight into Neonatal Sepsis: An Overview. Cureus. 2023 Sep 19;15[9]: e45530. doi: 10.7759/cureus.45530.
2. Beudeker CR, Vijlbrief DC, van Montfrans JM, Rooijakkers SHM, van der Flier M. Neonatal sepsis and transient immunodeficiency: Potential for novel immunoglobulin therapies? Front Immunol. 2022 Oct 18; 13:1016877. doi: 10.3389/fimmu.2022.1016877.
3. Yadav P, Yadav SK. Progress in Diagnosis and Treatment of Neonatal Sepsis: A Review Article. JNMA J Nepal Med Assoc. 2022 Mar 11;60[247]:318-324. doi: 10.31729/jnma.7324.
4. Ershad M, Mostafa A, Dela Cruz M, Vearrier D. Neonatal Sepsis. Curr Emerg Hosp Med Rep. 2019;7[3]:83-90. doi: 10.1007/s40138-019-00188-z.
5. Fleischmann C, Reichert F, Cassini A, Horner R, Harder T, Markwart R, et al. Global incidence and mortality of neonatal sepsis: a systematic review and meta-analysis. Arch Dis Child. 2021 Jul 19;106[8]:745-752. doi: 10.1136/ archdischild-2020-320217.
6. Markwart R, Saito H, Harder T, Tomczyk S, Cassini A, Fleischmann-Struzek C, et al. Epidemiology and burden of sepsis acquired in hospitals and intensive care units: a systematic review and meta-analysis. Intensive Care Med. 2020;46[8]:1536-1551. doi: 10.1007/s00134-020-06106-2.
7. Virmani MA, Cirulli M. The Role of l-Carnitine in Mitochondria, Prevention of Metabolic Inflexibility and Disease Initiation. Int J Mol Sci. 2022 Feb 28;23[5]:2717. doi: 10.3390/ijms23052717.
8. Modanloo M, Shokrzadeh M. Analyzing Mitochondrial Dysfunction, Oxidative Stress, and Apoptosis: Potential Role of L-carnitine. Iran J Kidney Dis. 2019 Mar;13[2]:74-86. PMID: 30988244.
9. Keshani M, Alikiaii B, Askari G, Yahyapoor F, Ferns GA, Bagherniya M. The effects of L-carnitine supplementation on inflammatory factors, oxidative stress, and clinical outcomes in patients with sepsis admitted to the intensive care unit [ICU]: study protocol for a double blind, randomized, placebo-controlled clinical trial. Trials. 2022 Feb 22;23[1]:170. doi: 10.1186/s13063-022-06077-3.
10. Keshani M, Alikiaii B, Babaei Z, Askari G, Heidari Z, Sharma M, Bagherniya M. The effects of L-carnitine supplementation on inflammation, oxidative stress, and clinical outcomes in critically Ill patients with sepsis: a randomized, double-blind, controlled trial. Nutr J. 2024 Mar 6;23[1]:31. doi: 10.1186/s12937-024-00934-4.
11. Yahyapoor F, Sedaghat A, Feizi A, Bagherniya M, Pahlavani N, Khadem-Rezaiyan M, et al. The effects of l-Carnitine supplementation on inflammatory markers, clinical status, and 28 days' mortality in critically ill patients: A double-blind, randomized, placebo-controlled trial. Clin Nutr ESPEN. 2022 Jun; 49:61-67. doi: 10.1016/j.clnesp.2022.04.001.
12. El-Lahony DM, El-Sayed HM, El-Hawy MA, El-Naga NT. L-carnitine serum level in healthy and septic neonates. Kasr Al Ainy Med J 2018; 24 [1]: 26-31. DOI: 10.4103/kamj.kamj_9_18.
13. Zelellw DA, Dessie G, Worku Mengesha E, Balew Shiferaw M, Mela Merhaba M, Emishaw S. A Systemic Review and Meta-analysis of the Leading Pathogens Causing Neonatal Sepsis in Developing Countries. Biomed Res Int. 2021 Jun 5; 2021:6626983. doi: 10.1155/2021/6626983.
14. Ozkan H, Cetinkaya M, Koksal N, Celebi S, Hacımustafaoglu M. Culture-proven neonatal sepsis in preterm infants in a neonatal intensive care unit over a 7-year period: coagulase-negative Staphylococcus as the predominant pathogen. Pediatr Int. 2014 Feb;56[1]:60-6. doi: 10.1111/ped.12218.
15. Puskarich MA, Jennaro TS, Gillies CE, Evans CR, Karnovsky A, McHugh CE, et al.; RACE Investigators. Pharmacometabolomics identifies candidate predictor metabolites of an L-carnitine treatment mortality benefit in septic shock. Clin Transl Sci. 2021;14[6]:2288-2299. doi: 10.1111/cts.13088.
16. Omran A, Maaroof A, Mohammad MHS, Abdelwahab A. Salivary C-reactive protein, mean platelet volume and neutrophil lymphocyte ratio as diagnostic markers for neonatal sepsis. J Pediatr [Rio J]. 2018 Jan-Feb;94[1]:82-87. doi: 10.1016/j.jped.2017.03.006.
17. Puskarich MA, Kline JA, Krabill V, Claremont H, Jones AE. Preliminary safety and efficacy of L-carnitine infusion for the treatment of vasopressor-dependent septic shock: a randomized control trial. JPEN J Parenter Enteral Nutr. 2014 Aug;38[6]:736-43. doi: 10.1177/0148607113495414.
18. Chung KP, Chen GY, Chuang TY, Huang YT, Chang HT, Chen YF, et al. Increased Plasma Acetylcarnitine in Sepsis Is Associated with Multiple Organ Dysfunction and Mortality: A Multicenter Cohort Study. Crit Care Med. 2019 Feb;47[2]:210-218. doi: 10.1097/CCM.0000000000003517.
19. Evans CR, Karnovsky A, Puskarich MA, Michailidis G, Jones AE, Stringer KA. Untargeted Metabolomics Differentiates l-Carnitine Treated Septic Shock 1-Year Survivors and Nonsurvivors. J Proteome Res. 2019 May 3;18[5]:2004-2011. doi: 10.1021/acs.jproteome.8b00774.
20. Sánchez-Pintos P, Pérez-Muñuzuri A, Cocho JÁ, Fernández-Lorenzo JR, Fraga JM, Couce ML. Evaluation of carnitine deficit in very low birth weight preterm newborns small for their gestational age. J Matern Fetal Neonatal Med. 2016 Mar; 29[6]:933-7. doi: 10.3109/14767058.2015. 1024647.
21. Beshir SA, Zannoun MAS, El Samanoudy MI, Al-Samee A, Samir H. Evaluation of the effect of L-carnitine supplementation in preterm neonates suffering from respiratory distress syndrome. Int J Med Arts 2022; 4[6], 2400–2406, doi: 10.21608/ijma.2022.142433.1460.

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