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Serum Magnesium Level Impact on the Outcome of Patients Admitted to the Intensive Care Unit

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Abstract Objective: Magnesium (Mg) is the fourth most common cation in the body and second most common intracellular cation after potassium, So its deficiency in critically ill patients should be frequently monitored**.** The study was structured to assess Serum magnesium level impact on the outcome of patients admitted to the intensive care unit. **Materials and Methods:** sixty patients of both sex newly admitted to the medical and surgical ICU were assessed in the first four days of admission by measuring abnormalities in serum magnesium level. They were divided to three groups, normal range for magnesium concentration is 1.5 to 2.3 mg/dl, Serum (Mg) level < 1.50 mg/dl was considered as hypomagnesemia and ≥ 2.3 mg/dl as hypermagnesemia. Data was divided into normomagnesemic -control group- (C group), hypomagnesemic (L group) and hypermagnesemia (H group). Patients were assessed by using SOFA and MOD scores in the first four days of ICU admission. **Results:** This study included patients admitted to the Intensive Care Unit whose were evaluated by (SOFA) and (MOD) scores, it had shown that the abnormalities in the serum (Mg) level had significant relation with both (SOFA) and (MOD) scores. **Conclusion:** The correction of the serum (Mg) level has a significant impact in on the Outcome of (ICU) patients.
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Key Words: Magnesium, SOFA, MOD, ICU.

1. Introduction:

Magnesium (Mg) is the fourth most common cation in the body and second most common intracellular cation after potassium, so its deficiency in critically ill patients should be frequently monitored **(1)** Normal serum magnesium level ranges from 1.5 to 2.3 mg/dl **(2).** Hypomagnesemia occurs in 40% of hospitalized patients, 60% of postoperative patients, 65% of medical Intensive Care Unit (ICU) patients and up to 90% of surgical (ICU) patients **(3)** Magnesium is released after cell injury or cell death in critically ill-patients, so the higher severity scores in these patients may explain the positive correlation between hypermagnesemia and mortality rate. Another factor that could affect this association is the development of acute renal failure which is a frequent complication in the critically ill patients and also a major cause of hypermagnesemia **(4).** A number of organ dysfunction scores have been developed. The two most useful as outcome measures are the Sequential Organ Failure Assessment (SOFA) score and the Multiple Organ Dysfunction (MOD) score, both are based on serial measurement of easily available parameters of organ dysfunction **(5)** The Sequential Organ Failure Assessment (SOFA) score is a scoring system that assesses the performance of several organ systems in the body (neurologic, blood, liver, kidney, and blood pressure) and assigns a score based on the data obtained in each category. The higher (SOFA) score, the higher mortality **(6)**.

2. Materials and Methods:

This prospective, randomized observational study was carried out in the Intensive Care Unit of Al-Azhar university hospitals, involving sixty (60) patients (aged above 18 years) of both sex in medical and surgical (ICU), within the time period from October (2017) to September (2018). Inclusion criteria was newly admitted patients (aged above 18 years) to the medical and surgical) ICU (in the first four days. Exclusion criteria were patients who were on magnesium supplementation before hospital admission, hospitalized patients who were receiving magnesium supplementation before) ICU (admission, patients who received magnesium supplementation at operating room. Investigations of (MOD) and (SOFA) scores as (ABG, Serum Bilirubin, Serum Creatinine and complete blood Count). Admission (MOD) and (SOFA) scores were calculated from the data recorded at admission and daily scores from the data recorded at (8.00am) each morning.

About (1ml) of venous blood was taken daily in the first four days of (ICU) admission and immediately was used for serum separation. The results were expressed as… mg/dl. Normal range for magnesium concentration is (1.5) to (2.3) mg/dl. Serum (Mg) level < (1.5) mg/dl was considered as hypomagnesemia and ≥ (2.3) mg/dl as hypermagnesemia. Data was divided into normomagnesemic -control group- (C group), hypomagnesemic (L group) and hypermagnesemia (H group) and monitoring of serum (Mg) before and after correction.

Table (1): Table of sofa score

	0	1	2	3	4
Respiratory: PaO_2/FIO_2 (mmHg)	>400	≤400	≤300	≤200	≤100
Renal: creatinine (mg/dl) or urine output	<1.2	1.2-1.9	2.0-3.4	3.5-4.9 or <500 ml/dl	≥5.0 or <200 ml/d
Hepatic: bilirubin (mg/dl)	<1.2	1.2-1.9	2.5-5.9	6.0-11.9	≥12.0
Cardiovascular: hypotension	No hypotension	MAP <70 mmHg	Dopamine ≤5 or dobutamine (any dose)	Dopamine >5 or epinephrine ≤0.1 or norepinephrine ≤0.1	Dopamine >15 or epinephrine >0.1 or norepinephrine >0.1
Hematologic: platelet count ($\times10^3/mm^3$)	>150	≤150	≤100	≤50	≤20
Neurologic: Glasgow Coma Score	15	13-14	10-12	6-9	<6

(Vincent et al., 1996)

Table (2): The (MOD) Score

Organ system	Score				
	0	1	2	3	4
Respiratory; PO_2/FIO_2 ratio (mmHg)	>300	226-300	151-225	76-150	≤75
Renal: serum creatinine (mg/dl)	≤1.1	1.2-2.2	2.3-3.9	4.5.6	≥5.7
Hepatic: serum bilirubin bin (mg/dl)	≤1.2	1.3-3.5	3.6-7	7-14	>14
Cardiovascular: PAR	≤10	10.1-15	15.1-20	20.1-30	>30
Hematologic: platelet count ($\times10^3/mm^3$)	>120	81-120	51-80	21-50	≤20
Neurologic: Glasgow Coma Score	15	13-14	10-12	7-9	≤6

(Marshall et al., 1995)

3. Results:

Table (3): Comparison between abnormalities in serum (Mg) level in surgical and medical (ICU) patients.

Diagnosis	Group								Chi-Square	
	Control group		Hypomagnesemic group		Hypermagnesemic group		Total			
	N	%	N	%	N	%	N	%	X^2	P-value
Surgical	10	55.56	20	57.14	0	0.00	30	50.00	7.937	0.019*
Medical	8	44.44	15	42.86	7	100.00	30	50.00		
Total	18	100.00	35	100.00	7	100.00	60	100.00		
Chi-Square										
C & HPO				**C & HPR**			**HPO & HPR**			
0.912				0.011*			0.006*			

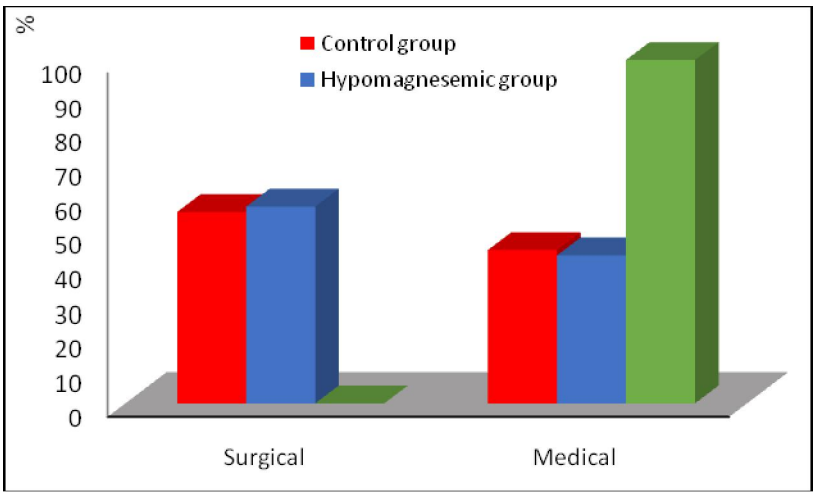

Fig. (1): Comparison between abnormalities in serum (Mg) level in surgical and medical (ICU) patients

Hypomagnesiemia is much more common than Hypermagnesiemia either in surgical and medical (ICU) patients. The most common abnormality of (Mg) level is Hypomagnesiemia (P-value <0.05).

Table (4): Comparison between abnormalities in serum (Mg) level and mortality between surgical and medical (ICU) patients.

Outcome	Group								Chi-Square	
	Control group		Hypomagnesemic group		Hypermagnesemic group		Total			
	N	%	N	%	N	%	N	%	X^2	P-value
Improved	16	88.89	29	82.86	3	42.86	48	80.00	7.103	0.029*
Death	2	11.11	6	17.14	4	57.14	12	20.00		
Total	18	100.00	35	100.00	7	100.00	60	100.00		

Chi-Square		
C & HPO	C & HPR	HPO & HPR
0.561	0.016*	0.023*

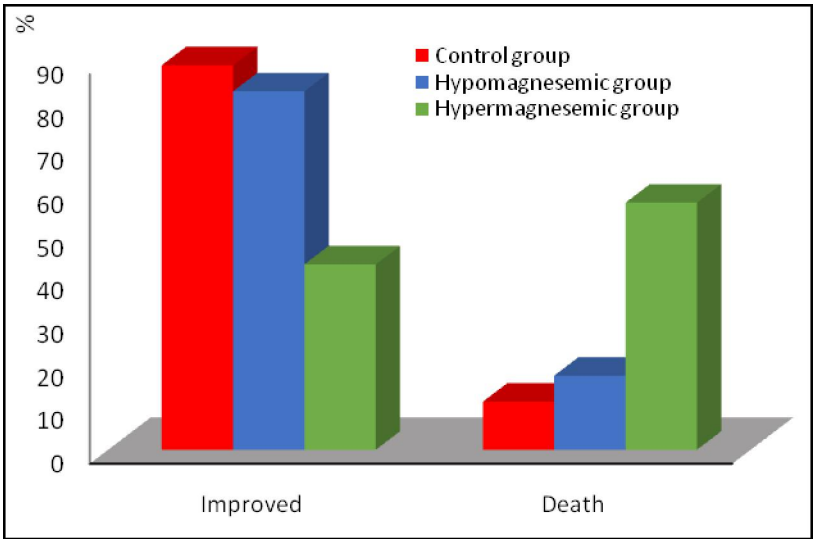

Fig. (2): Comparison between abnormalities in serum (Mg) level and mortality between surgical and medical (ICU) patients

(Mg) level has a great effect on the outcome of (ICU) patients (P-value <0.05).

I. Correlation between abnormalities in serum (Mg) level and (SOFA) score in the 1st four days of (ICU) admission between surgical and medical (ICU) patients:

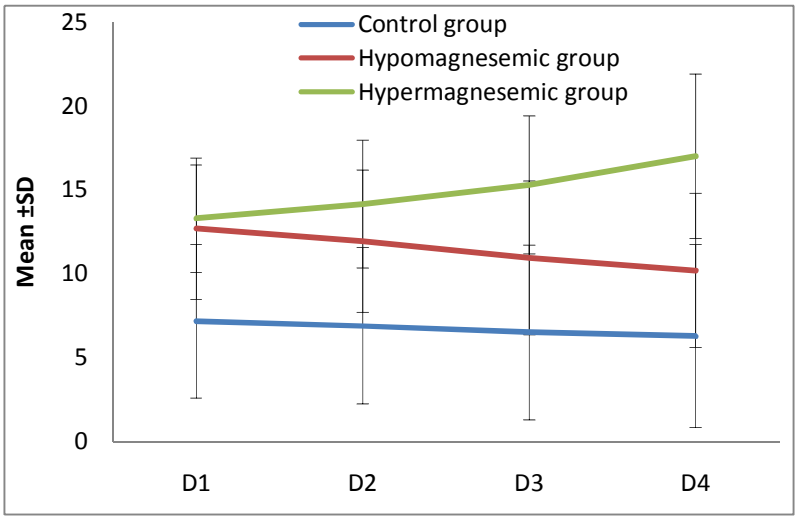

Fig. (3): Correlation between abnormalities in serum (Mg) level and (SOFA) score in the 1st four days of (ICU) admission between surgical and medical (ICU) patients
There is significant correlation between (Mg) level and (SOFA) score (P-value <0.05).

II. Correlation between abnormalities in serum (Mg) level and (MOD) score in the 1st four days of (ICU) admission between surgical and medical (ICU) patients:

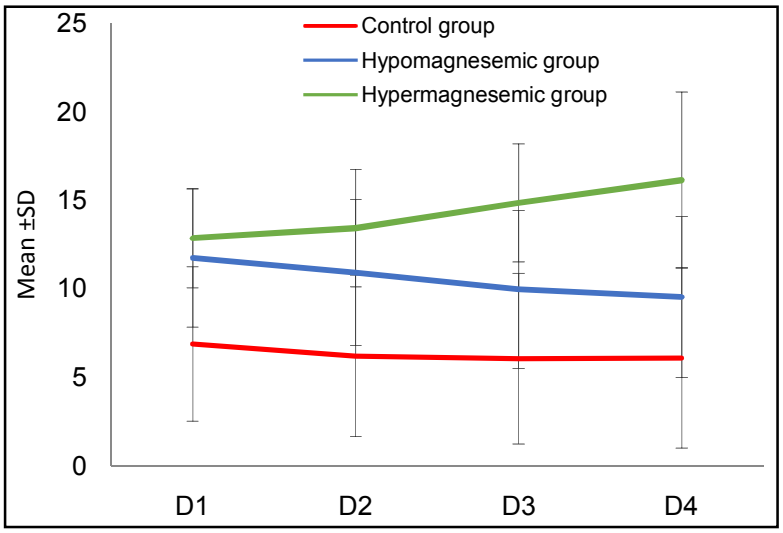

Fig. (4): Correlation between abnormalities in serum (Mg) level and (MOD) score in the 1st four days of (ICU) admission between surgical and medical (ICU) patients
There is significant correlation between (Mg) level and (MOD) score (P-value <0.05).

4. Discussion:

Our study included patients admitted to the Intensive Care Unit whose were evaluated by (SOFA) and (MOD) scores in the first 4 days of (ICU) admission. Our current study had proven that the abnormalities in the serum (Mg) level had a significant relation with both (SOFA) and (MOD) scores and correction of serum (Mg) level helps in improvement of both surgical and medical (ICU) patients. Various studies were worked out trying to demonstrate the significance of evaluating serum (Mg) level in the critically ill patients.

Hypomagnesemia has been linked to poor outcome in several different patient populations, patients with the lowest serum magnesium levels were at highest risk for death ***(7)***. Hypomagnesemia is a common development in critically ill patients, and indicates a poor prognosis. Although evidence is derived largely from observational studies, it shows a significant association between hypomagnesemia and with increased need for mechanical ventilation, prolonged intensive care unit stays, and increased mortality in this patient population ***(8)*** A study including (374) adult patients admitted to (ICU) were enrolled, All patients were monitored for serum magnesium levels within (24) hours after (ICU) admission, and they were divided into three groups: normomagnesemic group, hypomagnesemic group and hypermagnesemic group. Various parameters were recorded for every patient, including general information, disease composition, laboratory indexes, duration of mechanical ventilation, (ICU) stay days and final outcome, (APACHEII) score and (SOFA) score during the first (24) hours after (ICU) admission were calculated. The results showed that serum magnesium levels were closely related to mortality rate in patients in (ICU). So, more attention to the occurrence of hypomagnesemia in critically ill patients were recommended ***(9)***. As shown in a cross sectional study was done on (100) patients who were admitted to the Geriatrics medical (ICU) at Ain Shams university Hospital in Cairo, Data collected included patients demographics, medical history and length of stay in the (ICU), Lab tests included serum Magnesium on admission, serum sodium and potassium. In addition, the Acute Physiology and Chronic Health Evaluation (APACHE) II score and the Sequential Organ Failure Assessment (SOFA) score were determined at the day of admission. Among the studied groups, those with high (Mg) level were found to have higher (APACHE) II score and (SOFA) score. So Significant positive correlation was found between serum (Mg) level and (SOFA) score and the development of hypermagnesaemia during an (ICU) stay is associated with bad prognosis ***(10)*** A retrospective study was done on (100) patients admitted to the medical and surgical intensive care unit (ICU) at the University Hospital over 2 years period. Observations were made on admission as regard total serum magnesium level, a variety of lab tests related to magnesium, need for ventilator, duration of mechanical ventilation, hospital (ICU) lengths of stay, and general patient demographics. The serum magnesium level was measured at admission, 51% of patients had hypomagnesemia, 49% had normal magnesium levels. There was significant difference in mortality rate, the length of hospital or (ICU) stay between these two groups. Hypomagnesemic patients had higher Acute Physiology And Chronic Health Evaluation II (APACHE) II and Sequential Organ Failure Assessment (SOFA) scores at admission. The higher maximum (SOFA) score during their (ICU) stay, the more need to ventilator and longer duration of mechanical ventilation ***(11)***. In a Mayo Clinic review of 65,974 hospitalized adult patients, hypomagnesemia on admission was associated with increased in-hospital mortality ***(12)*** A study that screened 5.339 patients with plasma magnesium concentrations reported that 36.9% of the 151 patients with hypermagnesemia died and that hypermagnesemia was a strong independent risk factor for mortality ***(13)***

"These results were concordant with our study."

So, in our study the correction of the serum (Mg) level has a significant impact in on the Outcome of (ICU) patients. A number of organ dysfunction scores have been developed, the two most useful as regard the outcome measures are the Sequential Organ Failure Assessment (SOFA) score and the Multiple Organ Dysfunction (MOD) score ***(14)*** The (SOFA) score is the most commonly used in the (ICU) practice setting, the higher the (SOFA) score, the greater the patient's risk of morbidity and mortality ***(15)*** A prospective Cohort Study was conducted on (500) patients, clinical data were noted within (24) hours of admission. Then the points to each score were applied and calculated. (MODS) and (LODS) were taken on the day of admission while (SOFA) was calculated daily until patient got discharged from the (ICU). The commonly used scoring systems are Acute Physiology and Clinical Health Evaluation (APACHE), Simplified Acute Physiology Score (SAPS), Mortality Prediction Model (MPM), Glasgow Coma Score (GCS), Logistic Organ Dysfunction Scoring (LODS), Multiple Organ Dysfunction Score (MODS) and Sequential Organ Failure Assessment (SOFA). Among the previous scores (SOFA) was a very useful validated tool for predicting mortality in Intensive care Unit, (SOFA) was more sensitive and specific compared to (MODS) and (LODS). (SOFA) scoring could be widely used in the ICUs to predict mortality ***(16)*** A prospective observational study was observed on (949) patients to compare outcome prediction using the Multiple Organ Dysfunction Score (MODS) and the Sequential Organ Failure Assessment (SOFA). Proving that, the (MODS) and the (SOFA) scores had better predictive values for mortality than the (APACHE) II score When directly compared, there were no differences between the (MODS) and the (SOFA) score in outcome prediction ***(17)*** As shown in a previous study that screened (454) adult patients presented with community-acquired sepsis within (24) h of admission at nine public hospitals in Indonesia (n = 3), Thailand (n = 3), and Vietnam (n = 3). In patients with

organ dysfunction (total SOFA score ≥2), they analyzed sepsis management and outcomes and evaluated mortality prediction of the (SOFA) scores. Organ failure was defined as the maximum (SOFA) score ≥3 for an individual organ system. So the higher (SOFA) scores were associated with higher mortality ***(18).*** Other study of (248) patients examined the utility of the (SOFA) score for assessing outcome of patients with severe sepsis with evidence of hypoperfusion at the time of emergency department (ED) presentation, (SOFA) scores were calculated at (ED) recognition and (72) hours after intensive care unit admission. These data suggested that The (SOFA) score demonstrated fair to good accuracy for predicting in-hospital mortality when applied to patients with severe sepsis with evidence of hypoperfusion at the time of (ED) presentation and The Δ (SOFA) over (72) hours have a significant positive relationship to in-hospital mortality ***(19***) Another study including (44) patients between (15) and (80) years were admitted to (ICU) and were studied over (8) weeks period. (SOFA) score was determined (24) h post admission to (ICU) and subsequently every (48) h for the first (10) days. Patients were followed till discharge/ death/ transfer from the (ICU). Initial (SOFA) score, highest and mean (SOFA) scores were calculated and correlated with mortality and duration of stay in (ICU). And Suggested that (SOFA) score on admission has shown a strong correlation with the outcome, and can help triage patients, (SOFA) score is a simple, but effective prognostic indicator and evaluator for patient progress in (ICU). Day 1 (SOFA) can triage the patients into risk categories ***(20)*** A study that screened (352) patients admitted to the (ICU) for more than (24) hours for whom the (SOFA) score was calculated on admission and every (48) hours until discharge. Showing that, evaluation of the (SOFA) score throughout the (ICU) stay was a good prognostic indicator. Increase in the (SOFA) scores during the first (48) hours of (ICU) admission were associated with a mortality rate of at least 50%***(21).***

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