Magnesium level derangement among critically ill patients with acute kidney injury: Association with acute kidney disease

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Introduction

With acute kidney injury (AKI) transitioning to Acute kidney disease (AKD), the burden of the disease on mortality, morbidity, and healthcare costs increases.

Serum magnesium (Mg) level plays a crucial role in generating adenosine triphosphate (ATP), glucose metabolism, and regulating calcium and potassium membrane transport. Mg disturbances are linked to endothelial dysfunction, atherosclerosis, and inflammation. Mg levels <1.7 mg/dL have been associated with a decline in renal function and increased risk of death in CKD and hemodialysis patients. In addition, some studies also highlight that hypermagnesemia was also one factor associated with an increased risk of mortality and CKD progression

This study aims to assess the significance of various serum Mg derangements as a risk factor for the progression of AKI to AKD among critically ill patients.

Methods and Materials

This study was conducted among patients with AKI admitted to the ICUs at Mayo Clinic from January 2007 to December 2017.

Population: Adult (>18 yr.) critically ill patients with AKI by KDIGO criteria.
Exclusion: ESKD, lack of serum Cr. during admission and after discharge., lack of serum Mg at AKI onset, and no research authorization.

Serum Mg levels at AKI onset were categorized into 5 groups: <1.7, 1.7-1.9, 1.9-2.1, 2.1-2.3, and >2.3 mg/dL, with 1.9-2.1 mg/dL as the reference group for outcome comparison.

AKD diagnosis by Cr criteria of ADQI work group. The damage and/or loss of renal function ≤ 3 months of AKI diagnosis or 50% increase in SCr. for < 3 months.

Statistical Analysis: Chi-square was used for categorical data. ANOVA or Kruskal-Wallis test for continuous variable. Multivariable logistic regression was used to evaluate the independent association between Mg levels and AKD.

Outcome:
- 1st: To assess Mg level derangements as an independent risk factor for progression to AKD.
- 2nd: To determine the incidence of AKD in critically ill patients with AKI.

Results

20,139 critically ill patients with AKI were included, with a mean age of 66±16 years. Of these, 57% (11,579) were male, 90% (18,255) were white.

The average serum Mg at AKI was 1.9±0.4 mg/dL. The mean serum creatinine was 1.2±0.6 mg/dL. Most patients (70%) had AKI stage 1, while 9% and 20% of patients had AKI stage 2 and 3, respectively. The median ICU and hospital length of stay was 2.4 days and 8.8 days, respectively.

The overall incidence of AKD was 31.4%. The association between serum Mg and AKD was a U-shaped pattern. The association of serum Mg levels and AKD was shown in the Table and Figure
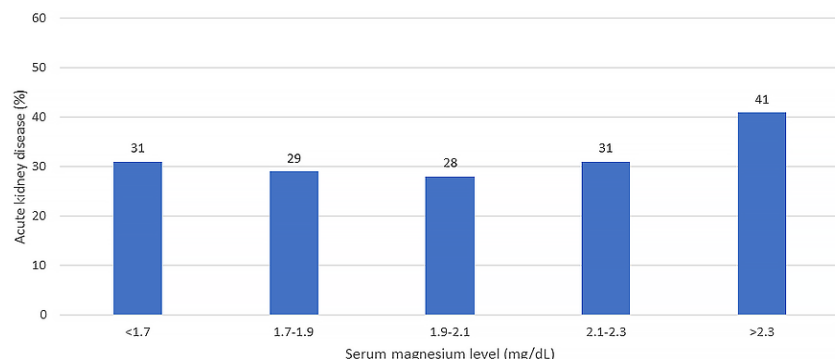

Figure 1. Acute kidney disease and distribution of serum Mg levels in critically ill patients with AKI

Results

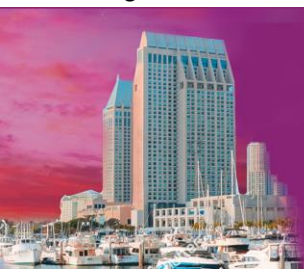| Characteristic	All	Serum Magnesium level (mg/dL)					p-value
		<1.7	1.7-1.9	1.9-2.1	2.1-2.3	≥2.3	
N	20,198	5,736 (28.4%)	4,570 (22.6%)	4,344 (21.5%)	2,935 (14.5%)	2,613 (12.9%)	
Age years, mean, SD	66±16	65±16	67±16	67±17	67±16	68±16	<0.001
Male, n, (%)	11,579 (57)	2,939 (51)	2,514 (55)	2,632 (61)	1,836 (63)	1,658 (63)	<0.001
White, n, (%)	18,255 (90)	5,185 (90)	4,168 (91)	3,94 (90)	2,648 (90)	2,310 (88)	0.034
Comorbidities, n, (%)							
Diabetes Mellitus	4,839 (24)	1,567 (27)	1,141 (25)	968 (22)	630 (21)	533 (20)	<0.001
Ischemic heart disease	4,780 (24)	1,301 (23)	1,057 (23)	1,079 (25)	721 (25)	622 (24)	0.076
CHF	287 (1.4)	63 (1.1)	73 (1.6)	65 (1.5)	44 (1.5)	43 (1.7)	0.169
COPD	2,413 (12)	725 (13)	526 (12)	561 (13)	318 (11)	283 (11)	0.008
Charlson score, mean, SD	4.6±2.4	4.6±2.4	4.6±2.4	4.6±2.4	4.5±2.4	4.5±2.3	<0.054
AKI stage n, (%)							<0.001
Stage 1	14,220 (70)	4,120 (72)	3,311 (72)	3,144 (72)	2,061 (70)	1,584 (61)	
Stage 2	1,913 (9)	555 (10)	368 (8)	346 (8)	256 (9)	388 (15)	
Stage 3	4,065 (20)	1,061 (19)	891 (20)	854 (20)	618 (21)	641 (25)	
Procedure							
Mechanical ventilator, n, (%)	6,067 (30)	2,074 (36)	1.358 (29)	1,231 (28)	803 (27)	601 (23)	<0.001
ECMO, n, (%)	75 (0.4)	19 (0.3)	22 (0.5)	18 (0.4)	9 (0.3)	7 (0.3)	0.553
ICU LOS, days, median, (IQR)	2.4 (1.2, 4.6)	2.6 (1.3, 5.2)	2.3 (1.3,4.6)	2.3(1.3,4.3)	2.2 (1.2, 4.2)	2.2 (1.2, 4.3)	0.127
Hospital LOS, days, median, (IQR)	8.8 (5.3,15.8)	9.3 (5.8, 16.9)	8.7 (5.3, 15.9)	8.6 (5.3, 15.3)	8.2 (5.0, 14.5)	8.9 (5.2, 15.8)	0.580

Outcome: AKD

Serum Mg (mg/dL)	AKD (%)	Univariable Analysis	P-value	Multivariable Analysis*	P-value
	n= 6,327	OR (95%CI)		Adjusted OR (95%CI)	
<1.7	1,770 (31%)	1.13 (1.03-1.23)	0.007	1.17 (1.07-1.29)	0.001
1.7-19	1,343 (29%)	1.05 (0.959-1.152)	0.29	1.06 (0.97-1.17)	0.21
1.9-2.1	1,232 (28%)	1 (Ref.)	Ref.	1 (Ref.)	Ref.
2.1-2.3	909 (31%)	1.13 (1.023-1.255)	0.02	1.13 (1.01-1.26)	0.03
>2.3	1,073 (41%)	1.76 (1.589-1.949)	<0.001	1.65 (1.48-1.84)	<0.001

Subgroup Analysis AKD based on Stage of AKI

Serum Mg (mg/dL)	AKD (%)	Univariable Analysis	P-value	Multivariable Analysis*	P-value
	n= 6,327	OR (95%CI)		Adjusted OR (95%CI)	
<1.7	1,770 (31%)	1.13 (1.03-1.23)	0.007	1.17 (1.07-1.29)	0.001
1.7-19	1,343 (29%)	1.05 (0.959-1.152)	0.29	1.06 (0.97-1.17)	0.21
1.9-2.1	1,232 (28%)	1 (Ref.)	Ref.	1 (Ref.)	Ref.
2.1-2.3	909 (31%)	1.13 (1.023-1.255)	0.02	1.13 (1.01-1.26)	0.03
>2.3	1,073 (41%)	1.76 (1.589-1.949)	<0.001	1.65 (1.48-1.84)	<0.001

Conclusions

Abnormal serum magnesium level during AKI is an independent risk factor of AKD in critically ill patients. The association between magnesium levels and AKD was found to be in a U-shape relationship.