

ASSESSMENT OF SERUM MAGNESIUM LEVEL IN CHRONIC RENAL FAILURE PATIENTS AND ITS CLINICAL SIGNIFICANCE AND CORRELATION WITH SODIUM, POTASSIUM AND CALCIUM

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ABSTRACT

BACKGROUND

Electrolyte metabolism and its pathological alteration in relation to clinical features is subject of modern interest. There are four major cations in the body namely sodium, potassium, calcium and magnesium; first three cations have been extensively studied but studies concerning magnesium metabolism have lagged in words of Peter and Vanslyke [1931]⁹; so far no clinical significance has been attached to changes in magnesium metabolism due to the fact that Meltzer and Aner [1905]⁸ demonstrated that raising the blood magnesium gives rise to coma and that Kruse et al [1932]⁶ produced a form of tetany by inducing magnesium deficiency. It is possible that magnesium imbalance may be playing a greater role in clinical medicine than has been suspected heretofore. There are conflicting report in literature concerning serum magnesium in chronic renal diseases, Huschfelder and Haury [1934], Marti et al [1952] and Boutwell [1961] found hypomagnesaemia, while Predhan et al [1961] and numerous others works found definite hypermagnesaemia in chronic renal disease. Pathophysiology of certain symptoms in uraemia remains a mystery. It is generally regarded that end products of metabolism accumulate lead to depression of central nervous system. If in cases of renal diseases without uraemia, when magnesium is given to the patient, depression of central nervous system is produced, Hirschfelder 1934,⁴ which suggest that increase in serum magnesium may explain the nervous depression in uraemia patients. Engbaek [1952] and Cantarow [1959] stated that rise in serum magnesium is associated with the depression of central nervous system. These workers and others who found hypermagnesaemia in chronic renal disease found relationship with central nervous system depression in renal uraemia.

The aims of this study are,

1. To find out the co-relationship of serum magnesium and blood urea in patients suffering from various types of kidney diseases.
2. To correlate the serum magnesium level with the depression of central nervous system if possible.
3. To find out the prognostic significance of serum magnesium level in cases wherever possible.
4. To find out the co-relationship to serum magnesium and serum potassium, serum calcium and serum sodium.

MATERIALS AND METHODS

The present study comprised of 35 cases of chronic renal failure, 20 healthy control cases.

Criteria for Selection of Cases - Diagnosis of chronic renal failure was established by measuring raised blood urea, nitrogen (BUN) and serum creatinine with clinical sign and symptoms of renal failure. Out of this 35 cases, 8 patients underwent haemodialysis procedures and followed the patients.

Method for Estimation of Serum Electrolyte and Blood Urea and Serum Creatinine and other Investigations-

1. Serum magnesium estimation was done by modified titan – yellow method as cited by Hawk et al.
2. Serum sodium and serum potassium estimation was done by flame photometry using E.E.L. Flame Photometry. Normal value for serum sodium - Range 137 - 148 mEq/L and for Serum Potassium - Range 3.6 - 5 mEq/L.
3. Blood urea estimation was done by King and Wooton (1964) and using serum creatinine estimation was done by Jaffe reaction as detailed by Folin and Wu modified by Bonson and Tausky.

RESULT

It has been observed in the present study of 35 cases of CRF, the mean value of serum magnesium level was 4.11% (Range 2.97 - 7.18 mg%), which is more than normal 1.94 mg%. All the 35 cases of CRF had high blood urea level i.e. mean 137.54 mg% and high creatinine value i.e. mean 5.6 mg%, so there was positive correlation between serum magnesium level and blood urea and serum creatinine level. This serum potassium level was mean 5.1 mEq/L and serum calcium level was mean 9.37 mEq/L, so there was a positive correlation between serum potassium and serum magnesium level and negative correlation between serum magnesium and serum calcium level. Regarding the effect of hypermagnesaemia, it is universally accepted that magnesium is central nervous system depressant. However, the relationship between serum magnesium level and various grades of central nervous system depression is not established. In present series 35 cases of chronic renal disease hypermagnesaemia was present in 34 (97.14%) cases, but only 12 cases (34.28%) had central nervous system depression of various grades; out of this 3 cases had coma with serum magnesium level of 5.61 mg%.

Role of Dialysis - Dialysis in form reduces serum magnesium level as observed in this study. Patient with high serum magnesium level with CNS depression improved with dialysis. In cases of CRF mean serum magnesium level was 4.25 ± 0.95 mg%, which become 3.41 ± 0.55 mg% after haemodialysis with 0.86 ± 0.48 mg% fall in serum magnesium level.

CONCLUSION

1. There was definite positive correlation between serum magnesium and blood urea level.
2. There is positive correlation between magnesium level and serum potassium level.
3. There is positive correlation between serum magnesium and serum creatinine level.
4. There is negative correlation between serum magnesium and serum calcium level.
5. There is no correlation found between serum magnesium and serum creatinine level.
6. The cases having central nervous system depression had high serum magnesium level.
7. There is definite role of haemodialysis in lowering the serum magnesium level and clinical improvement of patient.
8. There is negative correlation between serum magnesium and urine output level.

KEYWORDS

Chronic Renal Failure, Magnesium, Sodium, Potassium Calcium, Haemodialysis.

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BACKGROUND

Electrolyte metabolism and its pathological alteration in relation to clinical features is subject of modern interest. There are four major cations in the body namely sodium, potassium, calcium and magnesium. First three cations have been extensively studied, but studies concerning magnesium metabolism have lagged in words of Peter and Vanslyke [1931]; so far no clinical significance has been attached to changes in magnesium metabolism due to the fact that Meltzer and Aner [1905] demonstrated that raising the blood magnesium gives rise to coma and that Kruse et al [1932] produced a form of tetany by inducing magnesium deficiency. It is possible that magnesium imbalance may be playing a greater role in clinical medicine than has been suspected heretofore.

Serum magnesium is of particular interest in kidney diseases, eclampsia, delirium tremens and myocardial infarction.

There are conflicting report in literature concerning serum magnesium in chronic renal diseases. Huschfelder and Haury [1934],³ Marti et al [1952]⁷ and Boutwell [1961] found hypomagnesaemia, while Predhan et al [1964]¹⁰ and numerous others works found definite hypermagnesaemia in chronic renal disease.

Pathophysiology of certain symptoms in uraemia remains a mystery; it is generally regarded that end products of metabolism accumulate and lead to depression of central nervous system and if in cases of renal diseases without uraemia, when magnesium is given to the patient, depression of central nervous system is produced, Hirschfelder 1934,⁴ which suggest that increase in serum magnesium may explain the nervous depression in uraemia patients. Engbaek [1952]² and Cantarow [1959] stated that rise in serum magnesium is associated with the depression of central nervous system. These workers and others who found hypermagnesaemia in chronic renal disease, found relationship with central nervous system depression in renal uraemia.

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**Aims and Objectives**

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3. Blood urea estimation was done by King and Wooton (1964) using and serum creatinine estimation was done by Jaffe reaction as detailed by Folin and Wu modified by Bonson and Tausky.

Observation

35 patients suffering from chronic kidney disease were selected to study the serum magnesium level; 20 normal individuals of various age groups were selected as controls.

Sl. No.	Age in Yrs.	Sex	S. Magnesium in mg%
1	25	M	1.75
2	20	M	1.66
3	35	M	2.62
4	23	F	2.15
5	50	F	1.66
6	36	F	1.54

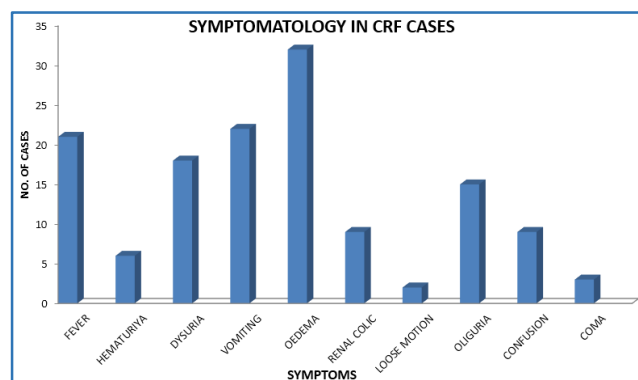
7	29	M	1.70
8	31	M	1.82
9	24	F	2.08
10	28	M	2.17
11	26	M	1.75
12	32	M	1.83
13	30	F	2.04
14	60	M	1.58
15	29	F	1.88
16	38	M	2.38
17	13	M	1.78
18	15	M	1.66
19	17	F	2.00
20	25	F	2.80
RANGE 13 - 60		1.54 - 2.80	
MEAN 29.3 Yrs.		1.94 mg%	

Table 1

Sl. No.	No. of Cases	Symptoms
1	21	Fever
2	6	Haematuria
3	18	Dysuria
4	22	Vomiting
5	32	Oedema
6	9	Renal Colic
7	2	Loose Motion
8	15	Oliguria
9	9	Confusion
10	3	Coma

Table 2. Showing Main Symptoms in 35 Cases of CRF

Above table shows main symptoms in 35 cases of chronic renal failure patient.



Sl. No.	Case No.	S. Magnesium in mg%	CNS Status
1	1	4.17	Confusion
2	5	4.19	Confusion
3	9	4.19	Confusion
4	10	5.14	Coma
5	12	3.84	Confusion
6	15	3.65	Confusion
7	17	3.39	Confusion
8	18	3.7	Confusion
9	28	3.9	Confusion
10	30	7.04	Coma
11	33	5.65	Confusion
12	35	7.18	Coma
RANGE 3.39 - 7.18			
MEAN 4.83 ± 1.44			

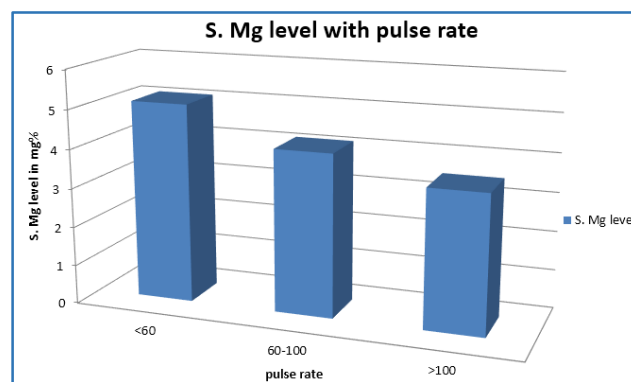
Table 3. Showing Serum Magnesium Level in Cases of Chronic Renal Failure with Central Nervous System Depression

Above table shows that out of 35 cases of CRF, 12 cases (34.28%) had CNS depression. Among the 12 cases, 9 had confusion and 3 had coma. Their mean S. magnesium level was $3.96 \pm .57$ mg% and 5.61 ± 1.02 mg% respectively.

Group	Pulse Rate	No. of Cases	S. mg in mg%
1 (4)	< 60	4 (11.42%)	5.1 ± 1.93
2 (17)	60 - 100	17 (48.57%)	4.16 ± 0.72
3 (14)	> 100	14 (40%)	3.53 ± 0.56

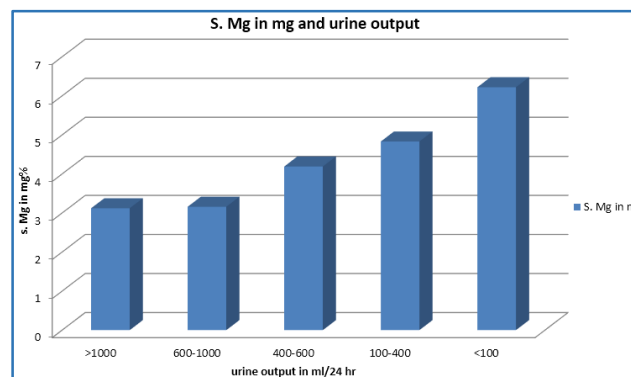
Table 4. Showing Serum Magnesium Level with Pulse Rate in Cases of CRF

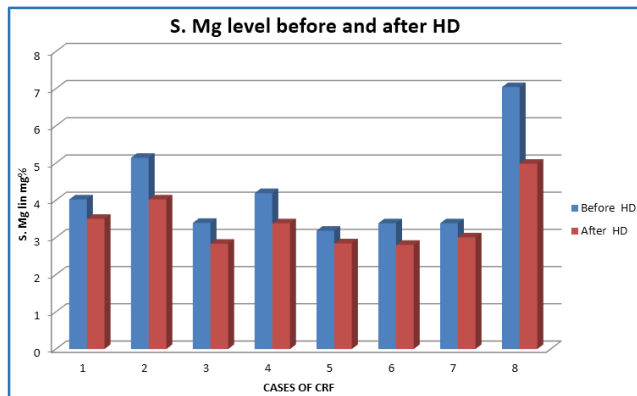
Above table showing serum magnesium level in comparison to pulse rate, which shows negative co-relationship between serum magnesium level and pulse rate of the patient.



Group	Urine Output in mL/24 hrs.	No. of Cases	S. mg in mg%
1	> 1000	7	3.12 ± 0.15
2	600 - 1000	11	3.16 ± 0.23
3	400 - 600	9	4.19 ± 0.29
4	100 - 400	4	4.83 ± 0.31
5	< 100	4	6.22 ± 0.86

Table 5. Showing Serum Magnesium Level with Urine Output in Cases of CRF





Above table shows serum magnesium level in comparison to 24-hour urine output of the patients and there is negative co-relationship between serum magnesium level and 24-hour urine output.

Sl. No.	Case No.	S. mg Level in mg%		S. mg Difference in mg%
		Before HD	After HD	
1	20	4.02	3.5	0.52
2	10	5.14	4.02	1.12
3	17	3.39	2.83	0.56
4	14	4.19	3.38	0.56
5	24	3.18	2.84	0.81
6	12	3.38	2.80	0.34
7	26	3.38	3.00	0.58
8	30	7.04	4.98	2.06
		4.25 ± 0.95	3.41 ± 0.55	0.86 ± 0.48

Table 6. Showing Serum Magnesium Level Before and After Haemodialysis of CRF Patients

Above table shows serum magnesium level before and after haemodialysis and their mean serum magnesium level. There is significant fall in serum magnesium level after haemodialysis, i.e. 0.86 ± 0.48 mg% and definite symptomatic improvement.

Sl. No.	Serum Mg in mg%	Blood Urea in mg%
1	2.97	60
2	3.04	62
3	3.07	68
4	3.09	78
5	3.18	84
6	3.28	88
7	3.38	96
8	3.27	96
9	3.39	98
10	3.5	100
11	3.63	104
12	3.64	108
13	3.65	114
14	3.7	116
15	3.74	124
16	3.75	128
17	3.84	133
18	3.9	139
19	3.85	144
20	4.02	148
21	4.08	154
22	4.17	164
23	4.19	168
24	4.65	168

25	4.19	170
26	4.45	172
27	4.52	174
28	4.37	176
29	4.48	182
30	4.89	189
31	5.14	191
32	5.36	200
33	5.56	212
34	7.04	223
35	7.18	240
Mean	4.11	137.54

Table 7

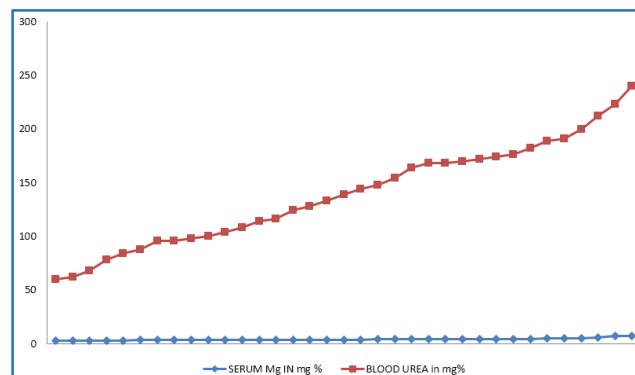
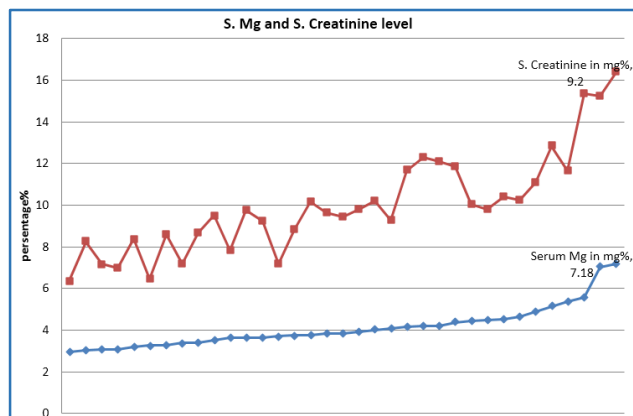


Table 7. Showing serum magnesium and blood urea level in chronic renal failure patients. This is showing significant positive co-relationship between serum magnesium level and blood urea level.

Sl. No.	Serum Mg in mg%	S. Creatinine in mg%
1	2.97	3.4
2	3.04	5.2
3	3.07	4.1
4	3.09	3.9
5	3.18	5.2
6	3.27	3.2
7	3.28	5.3
8	3.38	3.8
9	3.39	5.3
10	3.5	6
11	3.63	4.2
12	3.64	6.1
13	3.65	5.6
14	3.7	3.5
15	3.74	5.1
16	3.75	6.4
17	3.84	5.8
18	3.85	5.6
19	3.9	5.9
20	4.02	6.2
21	4.08	5.2
22	4.17	7.5
23	4.19	8.1
24	4.19	7.9
25	4.37	7.5
26	4.45	5.6
27	4.48	5.3
28	4.52	5.9
29	4.65	5.6
30	4.89	6.2
31	5.14	7.7

32	5.36	6.3
33	5.56	9.8
34	7.04	8.2
35	7.18	9.2
Mean	4.11 ± 2.10	5.6 ± 4.2

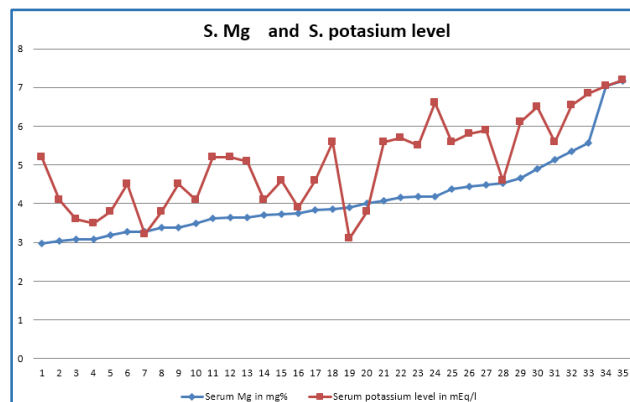
Table 8



Above table showing in cases of chronic renal failure, mean serum magnesium level was 4.11 ± 2.10 mg% and mean serum creatinine level was 5.6 ± 4.2 mg%, so this is showing positive co-relationship between serum magnesium and serum creatinine level.

Sl. No.	Serum Mg in mg%	Serum Potassium Level in mEq/L
1	2.97	5.2
2	3.04	4.1
3	3.07	3.6
4	3.09	3.5
5	3.18	3.8
6	3.27	4.5
7	3.28	3.2
8	3.38	3.8
9	3.39	4.5
10	3.5	4.1
11	3.63	5.2
12	3.64	5.2
13	3.65	5.1
14	3.7	4.1
15	3.74	4.6
16	3.75	3.9
17	3.84	4.6
18	3.85	5.6
19	3.9	3.1
20	4.02	3.8
21	4.08	5.6
22	4.17	5.7
23	4.19	5.5
24	4.19	6.6
25	4.37	5.6
26	4.45	5.8
27	4.48	5.9
28	4.52	4.6
29	4.65	6.1
30	4.89	6.5
31	5.14	5.6
32	5.36	6.55
33	5.56	6.85
34	7.04	7.05
35	7.18	9.2
Mean	4.11 ± 2.10	5.1 ± 1.95

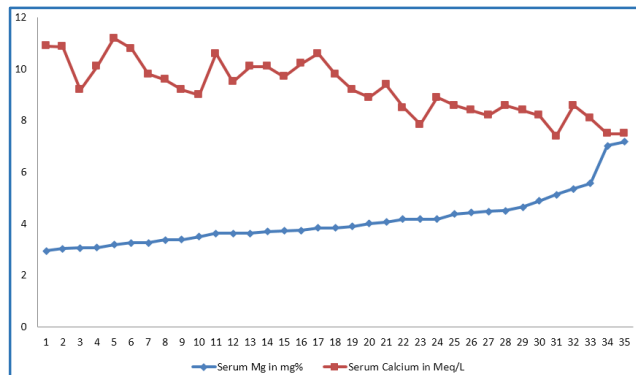
Table 9



Above table showing serum magnesium and serum potassium level and this showing positive co-relationship between serum magnesium and serum potassium level.

Sl. No.	Serum Mg in mg%	Serum Calcium in mEq/L
1	2.97	10.90
2	3.04	10.85
3	3.07	9.20
4	3.09	10.10
5	3.18	11.20
6	3.27	10.80
7	3.28	9.80
8	3.38	9.60
9	3.39	9.20
10	3.5	9.00
11	3.63	10.60
12	3.64	9.50
13	3.65	10.10
14	3.7	10.10
15	3.74	9.70
16	3.75	10.20
17	3.84	10.60
18	3.85	9.80
19	3.9	9.20
20	4.02	8.90
21	4.08	9.40
22	4.17	8.50
23	4.19	7.85
24	4.19	8.90
25	4.37	8.60
26	4.45	8.40
27	4.48	8.20
28	4.52	8.60
29	4.65	8.40
30	4.89	8.20
31	5.14	7.40
32	5.36	8.60
33	5.56	8.10
34	7.04	7.50
35	7.18	7.50
Mean	4.11 ± 2.10	9.3 ± 1.75

Table 10



Above Table showing Serum Magnesium and Serum Calcium Level. This showing Negative Co-relationship between Serum Magnesium and Serum Calcium Level Sl. No.	S. Magnesium in mg%	S. Sodium in mEq/L
1	2.97	148
2	3.04	142
3	3.07	122
4	3.09	138
5	3.18	132
6	3.27	132
7	3.28	132
8	3.38	139
9	3.39	136
10	3.5	148
11	3.63	148
12	3.64	146
13	3.65	146
14	3.7	142
15	3.74	156
16	3.75	138
17	3.84	146
18	3.85	128
19	3.9	138
20	4.02	148
21	4.08	148
22	4.17	148
23	4.19	156
24	4.19	140
25	4.37	140
26	4.45	150
27	4.48	152
28	4.52	150
29	4.65	140
30	4.89	132
31	5.14	156
32	5.36	156
33	5.56	152
34	7.04	152
35	7.18	142
Mean	4.11 ± 2.10	143 ± 17

Table 11

Above table showing serum magnesium level in comparison to serum sodium level. There is no co-relationship between serum magnesium level and serum sodium level.

DISCUSSION

It has been observed in the present study of 35 cases of CRF, the mean value of serum magnesium level was 4.11% (range 2.97 - 7.18 mg%), which is more than normal 1.94 mg%.

All the 35 cases of CRF had high blood urea level i.e. mean 137.54 mg% and high creatinine value i.e. mean 5.6 mg%, so there was positive correlation between serum magnesium level and blood urea and serum creatinine level. This finding is similar to Smith et al 1958,¹² Pradhan et al 1964¹⁰ and Sharma et al 1990.¹¹

In this serum potassium level was mean 5.1 mEq/L and serum calcium level was mean 9.37 mEq/L, so there was a positive correlation between serum potassium and serum magnesium level and negative correlation between serum magnesium and serum calcium level. These findings are supported by work done by Smith and Hammarsten 1959.¹³

Regarding the effect of hypermagnesaemia, it is universally accepted that magnesium is central nervous system depressant. However, the relationship between serum magnesium level and various grades of central nervous system depression is not established.

Cantarow 1959¹ stated that at 5 mg% of serum magnesium level sedation and mild hypnosis develops and at 15 mg% profound coma is produced. In present series of 35 cases of chronic renal disease hypermagnesaemia was present in 34 (97.14%) cases, but only 12 cases (34.28%) had central nervous system depression of various grades, out of this 3 cases had coma with serum magnesium level of 5.61 mg%.

Role of Dialysis

Dialysis in form reduces serum magnesium level as observed in this study. Patient with high serum magnesium level with CNS depression improved with dialysis.

In cases of CRF mean serum magnesium level was 4.25 ± 0.95 mg%, which become 3.41 ± 0.55 mg% after haemodialysis with 0.86 ± 0.48 mg% fall in serum magnesium level.

Findings observed in dialysed cases in present study is similar to the finding of Jain and Singh et al 1969,⁴ Karim and James et al 1970⁵ and Sharma et al 1990.¹¹

Summary and Conclusion

1. There is definite positive correlation between serum magnesium and blood urea level.
2. There is positive correlation between magnesium level and serum potassium level.
3. There is positive correlation between serum magnesium and serum creatinine level.
4. There is negative correlation between serum magnesium and serum calcium level.
5. There is no correlation found between serum magnesium and serum creatinine level.
6. The cases having central nervous system depression had high serum magnesium level.
7. There is definite role of haemodialysis in lowering the serum magnesium level and clinical improvement of patient.
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