

# Magnesium deficiency in heart failure patients with diabetes mellitus

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## Abstract

**Objective:** To assess the serum magnesium level in heart failure patients with diabetes mellitus.

**Methods:** A case-control study was conducted at Basic Medical Sciences Institute (BMSI), Jinnah Postgraduate Medical Centre (JPMC), Karachi, in collaboration with National Institute of Cardiovascular Diseases (NICVD), Karachi, from April 2003 to December 2003. The study included 45 diagnosed cases of heart failure with diabetes mellitus, between the age group 35-65 years. Serum magnesium and glucose levels were estimated and compared by using the student "t" test and p value (<0.01, <0.05, <0.001) were used to analyze the statistical significance.

**Results:** Out of 45 cases of heart failure, 15 were diabetic. Of these, eleven (73.3%) had low serum magnesium (<1.8 mg/dl), one (6.7%) was within normal range (1.8-2.0 mg/dl) and three (20%) were in the high level range(>2.0 mg/dl).

**Conclusion:** The study showed low serum magnesium level in heart failure patients with diabetes mellitus.

**Keywords:** Serum Magnesium, Diabetes Mellitus, Heart failure (JPMA 61:901; 2011).

## Introduction

Diabetes mellitus is the most frequent chronic disease associated with secondary magnesium deficit. Hypomagnesaemia is the central feature of the deficit, which is often reported in experimental and clinical forms of the disease. Some studies indicate that increased urinary loss of magnesium caused by osmotic diuresis might contribute to diabetic hypomagnesaemia.<sup>1</sup>

Magnesium deficiency could be important in diabetes for several reasons. Many of the enzymes involved in glycolysis are magnesium dependent. Increased insulin resistance has been found in patients with reduced free magnesium levels, and animal studies have shown increased glucagon stimulation decreased insulin secretion and reduced insulin uptake with magnesium deficiency.<sup>2</sup>

Abnormal dietary deficiency of magnesium as well as abnormalities in magnesium metabolism play important roles in different types of heart diseases such as ischaemic heart disease, congestive heart failure, sudden cardiac death, atherosclerosis, a number of cardiac arrhythmias and ventricular complications in diabetes mellitus.<sup>3</sup>

Individuals with diabetes mellitus are at 2 to 3 fold increased risk for cardiovascular disease (CVD) relative to those without diabetes.<sup>4</sup>

In spite of the abundance of magnesium on the earth and in living tissue, it is very easy to develop a magnesium deficiency. This is caused by a relatively poor magnesium absorption and rapid turnover (the half-life is below 40 hours) of the magnesium pools relevant to the survival

dependent biochemical pathways.<sup>5</sup>

This case control study was carried out to assess the serum magnesium level in heart failure patients with diabetes mellitus.

## Patients and Methods

This case-controlled study was conducted at BMSI, JPMC, Karachi with collaboration of NICVD, Karachi from April 2003 to December 2003.

The study comprised of 45 diagnosed cases of heart failure with and without diabetes mellitus between the ages of 35-65 years. The inclusion factors were, subjects with major risk factors of heart failure; hypertension, diabetes, smokers and family history of heart diseases. Patients receiving drugs as diuretics and digoxin along with other cardiovascular medication were also included. Patients were excluded if they had renal failure, thyroid disorders, liver disease and history of alcohol consumption.

Diabetes mellitus was defined as a fasting glucose level  $\geq 126$  mg/dl, a non-fasting glucose level  $\geq 200$  mg/dl, use of hypoglycaemic agents or a history of physician diagnosed Diabetes mellitus.<sup>6</sup> The normal serum magnesium level was considered as 1.8 to 3.0 mg/dl ( $=0.75$  to  $1.25$  mmol/L =  $1.5$  to  $2.5$  mEq/L).<sup>7</sup>

Blood samples were collected under antiseptic measures. Serum glucose was determined by enzymatic colorimetric (GOD PAP) method, using kit, Lot No. B02868 B supplied by Pioneer Diagnostics.

Serum magnesium was determined by colorimetric

method using kit Cat No.0137 supplied by STANBIO Laboratory.

Data feeding and analysis was carried out by using Computer package SPSS ver. 11.0. The results were calculated as number and percentages for qualitative data whereas mean and Standard deviation was used for quantitative data. For comparison between diabetic and non-diabetic, test of proportion was used for qualitative data and student t-test for quantitative data. In all statistical analysis,  $p < 0.05$ ,  $< 0.01$ , and  $< 0.001$  were considered significant.

## Results

Table-1 shows the demographic distribution of diabetic and non-diabetic heart failure patients. Patients with diabetes were seen to be of a significantly older age.

It was also observed that female patients with diabetes were significantly ( $P < 0.01$ ) higher in percentage.

Table-2 shows biochemical comparison of variables

**Table-1: Demographic Distribution of Diabetic and Non-Diabetic Heart Failure Patients.**

Variable	Diabetic (n=15)	Non-Diabetic (n=30)	P value	
Gender			0.011**	
Male	4 (26.7%)	20 (66.7%)		
Female	11 (73.3%)	10 (33.3%)		
Age (Years)	Mean $\pm$ SD	58.3 $\pm$ 8.0	51.5 $\pm$ 9.7	0.025*

\* P value  $< 0.05$ ; \*\* P value  $< 0.01$ .

**Table-2: Glucose (mg/dl) and Magnesium (mg/dl) level in Diabetic and Non-Diabetic Heart Failure Patients.**

Variable	Diabetic (n=15) Mean $\pm$ SEM	Non-Diabetic (n=30) Mean $\pm$ SEM	P value
Glucose (mg/dl)	187 $\pm$ 84.2	113 $\pm$ 31.6	0.001***
Magnesium (mg/dl)	1.67 $\pm$ 0.47	1.75 $\pm$ 0.47	0.572

\*\*\* P value  $< 0.001$ .

**Table-3: Comparison of Risk Factors of Heart Failure Patients according to Serum Magnesium Level (mg/dl).**

Risk Factors	No. of Patients	Serum Magnesium Levels (mg/dl)			P value	
		Low <1.8 n (%)	Normal 1.8-2.0 n (%)	High >2.0 n (%)		
Smoking	Yes	19	7 (36.8)	9 (47.4)	3 (15.8)	0.224
	No	26	15 (57.7)	6 (23.1)	5 (19.2)	
Hypertension	Yes	24	13 (54.2)	8 (33.3)	3 (12.5)	0.577
	No	21	9 (42.0)	7 (33.3)	5 (23.8)	
Diabetes mellitus	Yes	15	11 (73.3)*	1 (6.7)	3 (20.0)	0.022*
	No	30	11 (36.7)	14 (46.7)	5 (16.6)	
Family History	Yes	11	5 (45.5)	6 (54.5)	-	0.101
	No	34	17 (50.0)	9 (26.5)	8 (23.5)	

\*  $P < 0.05$  = Significant when compared Diabetes mellitus with other risk factors.

of diabetic and non-diabetic patients. It was seen that patients with diabetes had a significantly higher serum glucose level. (187 $\pm$ 84.2mg/dl). The serum magnesium in diabetics was lower than the non-diabetics..

Table-3 compares the mean values of serum magnesium, with the risk factors of heart failure. Patients were classified on the basis of their serum magnesium level, as low magnesium group ( $< 1.8$  mg/dl), high magnesium group ( $> 2.0$  mg/dl) and normal magnesium group (1.8 - 2.0 mg/dl). Out of 45 patients, 15 were diabetic. Eleven (73.3%) showed significant ( $P < 0.05$ ) low serum magnesium when compared with non-diabetic and other risk factors of heart failure.

## Discussion

Magnesium, the second most abundant intracellular cation plays a key role in cellular metabolism.<sup>8</sup> The level of glycaemic control is found to be inversely proportional to magnesium deficiency. Both Type 1 and Type 2 diabetics have increased urinary losses and reduced serum and intracellular levels of magnesium.<sup>2</sup> In humans, sugar loading causes magnesiuresis, possibly converting a marginal intake to a deficient one. Previous studies showed that magnesium metabolism is altered in patients with diabetes mellitus. In type II diabetic patients, hypomagnesaemia can be a consequence or a cause of increased insulin resistance. It has been established that chronic magnesium supplements in diabetic patients improve both islets beta cell response and that hypomagnesaemia is closely related to insulin resistance in these patients.<sup>9</sup>

Domanski et al<sup>10</sup> reported that diabetes mellitus is associated with increase in most adverse cardiovascular events including myocardial infarction (MI), chronic heart failure (CHF) and stroke. Diabetes is also associated with structural and metabolic abnormalities that can adversely affect myocardial function.

Established diabetes has been associated with

reduced serum and tissue magnesium including myocardial magnesium concentration.<sup>3</sup>

Magnesium is an essential element as a cofactor in both glucose transporting mechanism of cell membranes and various enzymes important in carbohydrate oxidation. A study by Shafique et al<sup>11</sup> concluded, that magnesium supplementation improves the overall metabolic homeostasis and thus may be a useful adjuvant to the classic hypoglycaemic agents in the treatment of Type 2 Diabetic subjects.

The interrelationships between magnesium and carbohydrate metabolism have regained considerable interest over the last few years. Insulin secretion requires magnesium and magnesium deficiency results in impaired insulin secretion while magnesium replacement restores insulin secretion. Furthermore, experimental magnesium deficiency reduces the tissues sensitivity to insulin. Subclinical magnesium deficiency is common in diabetes. It results from both insufficient magnesium intakes and increase magnesium losses, particularly in the urine.<sup>12</sup>

### Conclusion

The study showed that patients with diabetes mellitus have lower levels of magnesium and are therefore at increased risk of complications related to magnesium.

In light of these potential complications, periodic determination of magnesium levels and appropriate magnesium replacements should be considered.

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