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Association between Lipid Profile and Macro Metals Calcium and Magnesium

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Abstract

There is a large and rapidly growing body of literature on the importance of calcium and magnesium in biochemical and physiological processes.
The objective of this study was to examine the relationship of serum lipid profile to the macro metals calcium and magnesium. Recent findings suggest that both calcium and magnesium play a vital role in many disease states notably in cardiovascular disease. Both calcium and magnesium intake is directly related to cardiovascular disorders.
Magnesium acts as a mild calcium antagonist on vascular disease. Prospective studies involving both calcium and magnesium has given inconsistent results.
This study done on 50 patients (25 males & females) attending cardiac clinic has shown good correlation between lipid profile and calcium and magnesium suggesting that along with the gold screening test of lipid profile in the diagnosis of cardio vascular disease (CVD), Calcium and magnesium should also be investigated to decide an appropriate supplementation therapy.

Key Words: Lipid profile, Calcium, Magnesium, CVD, Total Cholesterol (TC), HDL Cholesterol HDL-C), LDL Cholesterol (LDL-C) and Triglycerides

Introduction

Cardiovascular disease is the number one killer in the world causing 4.5 million heart attacks and strokes each year. With the incidence of cardiovascular disease on a constant growth curve, test modalities that can provide specific inexpensive screening tools for CVD before the onset of symptoms is the proverbial "License to Print Money" and a large number of tests have been developed such as lipid profile, proteins, genetic markers and even tests for viral infections.

Advances in the use of cardiac markers for evaluation of suspected myocardial infarction have been made in the past 5 decades. Tests such as total cholesterol, triglycerides, LDH, AST, CK- Total which were popular in the 1950's and 1960's were replaced in the 1970's and 1980's by newer markers like HDL & LDL cholesterols, CK-MB, and Troponins. The new tests offered enhanced cardiac specificity, sensitivity & turn around time due to the use of advanced test kits and fully computerized automatic analyzers.

The established risk factors that may precipitate cardiovascular disease include, Hypertension (inherited & acquired), ageing men, women after onset of menopause, Type II diabetes mellitus, Low HDL- cholesterol (inherited & acquired), High LDL – cholesterol (inherited & acquired), cigarette smokers, stress, sedentary life style, over weight by 30% or more called obesity, smoking and family history accounts 25-79% of cases and Infection by pneumonia in 70-80% of cases(1).

300 predictors of heart disease have been identified so far. The recent findings include: Male baldness, increased hair in the crown area and elevated male hormone causes 3 fold increases in cardiac problems(2).

Markers for cardiovascular disease

Lipid profile

It is the earliest marker, even today it is the first line marker done in almost all clinical laboratories. It is a group of 4 tests, often ordered together determine the risk of coronary heart disease. The test that make up lipid profile are tests that have been shown to be good indicators of whether someone is likely to have a heart attack or stroke caused by blockage of blood vessels (Hardening of the arteries)

The lipid profile includes, total cholesterol, HDL-cholesterol, LDL – cholesterol & triglycerides. Sometimes the report will include additional calculated values such as T cholesterol / HDL cholesterol ratio and VLDL.

The lipid profile is used as a guide provider in deciding how a person at cardiac risk should be treated. The results of the lipid profile are considered along with other known risk factors of heart disease to develop a plan of treatment & follow up. Many develop cardiovascular disease in spite of normal serum cholesterol. About 50% of people who have heart attack have normal cholesterol. Hence lipid profile done in overnight fasting specimen is a traditional marker to predict cardiac arrest(3)

Diabetes and cardiovascular disease

It has been established that CVD is the leading cause of diabetes related death. People with diabetes are two to four times more likely to develop cardiovascular disease due to a variety of risk factors, including: High blood pressure, Lipid disorders, High LDL (bad cholesterol), High triglycerides, Low HDL (good cholesterol), Smoking, Obesity, Lack of physical activity and poorly controlled blood sugars Another emerging risk factor is insulin resistance, a core metabolic dysfunction of type II diabetes(4).

Understanding insulin resistance

Insulin resistance is a condition in which the body doesn't respond efficiently to the insulin it makes. It affects about 60 million people in the United States. One in four of them will develop type II diabetes when their body becomes unable to maintain normal insulin and glucose levels.

Here's a list of conditions typically found in people with type II diabetes and an explanation of how they contribute to a patient's risk for developing CVD.

- Obesity is a major risk factor for cardiovascular disease and has been strongly associated with insulin resistance. Insulin resistance may be a mechanism by which obesity leads to CVD.

Weight loss can improve cardiovascular risk, decrease insulin concentration and its sensitivity. Obesity and insulin resistance also has been associated with other risk factors, such as high blood pressure (5).

- Physical inactivity is another modifiable major risk factor for insulin resistance and cardiovascular disease. Exercising and losing weight can prevent or delay the onset of type II diabetes, reduce blood pressure and help reduce the risk for heart attack and stroke.

It's likely that any type of physical activity – whether sports, household work, gardening or work related physical activity is similarly beneficial (6).

- Hypertension (high blood pressure) has long been recognized as a major risk factor for cardiovascular disease. Studies report a positive association between hypertension and insulin resistance. When a person has both hypertension and diabetes, the risk for CVD doubles (7).
- Dyslipidemia Atherogenic dyslipidemia, often called diabetic dyslipidemia in people with diabetes is a condition associated with insulin resistance, this type of dyslipidemia is characterized by high levels of triglycerides (hypertriglyceridemia), high levels of small LDL particles and low levels of HDL. This lipid triad often occurs in patients with premature coronary heart disease (8).

Growing evidence suggests that all of the components of the lipid triad can contribute to the development of arteriosclerosis (fatty buildups in artery walls) and can be considered a risk factor, Even though most patients with diabetes don't have marked elevation of LDL cholesterol, their levels are high enough to support the development of atherosclerosis (5).

Other markers of cardiac disease which have been identified recently include lipoprotein A: Lp(a), the normal for which is <20mg/dL and level > 30mg/dL are considered risk.. Improper standardized techniques available are the major drawback for using this as routine cardiac marker (8).

Other tests include: Apo-B, Homocysteine, often called the "Hidden cause of Heart attack", Fibrinogen, High Sensitive CRP, D-Dimer, Co-enzyme Q10, Ascorbate & free radicals, Vitamin E deficiency .

If the factors including cardio vascular disease are not controlled, Acute Myocardial Infarction (AMI) will result and to detect AMI, a battery of tests are available. They include CK-Total, CK-MB, Troponins I & Troponins –T(9).

Magnesium

There is increased interest in the role of magnesium ions in clinical medicine, nutrition and physiology. The characteristics of the binding of magnesium and calcium ions to various components, macromolecules and biological membranes have been described extensively. Magnesium affects many cellular functions including transport of potassium and calcium ions and modulates signal transduction, energy metabolism and cell proliferation (10).

Magnesium is the most important major mineral which is used by our body. In order to function correctly and efficiently, our body needs nutrients. Over 300 bioreactions in vivo has been identified involving magnesium (11).

Magnesium has a unique role inside cells in that it attaches to ATP, the energy molecules that do work in every living cell. Most enzymes which use ATP for energy need the Magnesium bound form. Studies have been carried out with the uptake of Magnesium using radioisotopes and by making measurements of the total amount of Magnesium. But nobody has been able to molecularly identity the proteins involved in the process (12).

Magnesium is called 'anti-stress mineral' and it aids in relaxing nerves, relieving tension, assisting digestion, activating enzymes for metabolic pathways and modulating the electrical potential across all cell membranes. Magnesium is important in the production and transfer of energy, muscle contraction and relaxation. It also aids regularity, necessary to keep vertebrates in their proper position, induces restful sleep, purifies and paves body tissues and lowers fever. Chlorophyll and green vegetables contain large amounts of Magnesium.

Adequate level of Magnesium is essential for the heart muscle. Those who die from heart attacks have very low Magnesium but high calcium level in their heart muscles. Patients with coronary heart disease who have been treated with large amounts Magnesium survive better than those with drug treatment (13).

Magnesium is an important element for health and disease. It is the fourth most abundant intracellular cation, has been identified as a cofactor for more than 300 enzyme reactions involving energy metabolism, protein and nucleic acid synthesis. Approximately half of the total body magnesium is present in soft tissues, the other half in bone and less than 1% in serum and red blood cells. The majority of experimental information comes from the measurements of Magnesium in serum and red blood cells. Little information is available in the literature about its equilibrium within the body pools. Magnesium is absorbed uniformly from the small intestine and the serum concentration is controlled by its excretion by the kidneys. The clinical laboratory evaluation of Magnesium status is primarily limited to the serum Magnesium level and 24hr urinary excretion and percent retention following parenteral administration. However results for those do not

correlate with intracellular levels. There is no reliable test to determine intracellular total body Magnesium (14).

Factors that deplete magnesium

Mental stress, physical stress, coffee, sugar, high sodium diet, alcohol, cola type sodas, tobacco ,high perspiration, medical drugs of all types, low thyroid, diabetes, chronic pain diuretics, a high carbohydrate diet and a high calcium diet.

Deficiency Effects

According to the nutrition almanac, magnesium deficiency can easily occur because magnesium is refined out of many foods during processing, cooking food removes the minerals, the oxalic acid in food like spinach and phytic acid found in cereals bind magnesium in the body (13).

A deficiency can occur in people with diabetes, use of diuretics or digitalis preparation, the elderly pancreatitis, chronic alcoholism, kwashiorkor, pregnancy and cirrhosis. Magnesium deficiency is thought to be closely related to coronary heart disease including myocardialnecrosis. An inadequate supply leads to formation of clots in the heart and brain and may contribute to calcium deposit in the kidneys blood vessel (15).

Magnesium deficiency may cause weakness, tremors, seizures, cardiac arrhythmias, hypokalemia and hypocalcaemia. Studies have documented that inadequate intake of Magnesium may lead to atherosclerosis, myocardial infarction, hypertension, cancer, kidney stones, premenstrual syndrome and psychiatric disorders. Hypomagnesaemia is primarily seen in acute and chronic renal failure, which is treated effectively by dialysis (16,17).

Early signs of magnesium deficiency are loss of appetite, sleeplessness, weakness, nausea, vomiting, fatigue, muscle contractions and cramps, seizures, personality change, abnormal heart rhythms and coronary spasm. Due to magnesium deficiency people may develop headache, pain in the lower back: time goes by and body starts getting muscles cramps, then calcium muscle twitches and tics, high blood pressure, nervousness, have trouble sleeping and continually wake up feeling tired, spasms and finally chest pain (18).

Hypomagnesemia

In hypomagnesaemia, the level of magnesium in the blood is too low. The most common causes of hypomagnesaemia are decreased dietary intake (due to starvation) and decreased intestinal absorption (malabsorption). Hypomagnesaemia occurs frequently in people who have protracted diarrhea, increased excretion of Magnesium by the kidneys, high levels of aldosterone, anti diuretic hormone, or thyroid hormones. Diuretics, the antifungal drug amphotericin B, or the chemotherapy drug cisplatin can also cause hypomagnesemia (19,20,21).

Magnesium is replaced when the deficiency causes symptoms or when the magnesium level is very low. Magnesium can be taken by mouth (usually as small amounts of magnesium hydroxide) or by injection into a muscle or vein.

Hypermagnesemia

In hypomagnesaemia, the level of magnesium in the blood is too high. Hypermagnesaemia usually develops only in people with kidney failure who are given magnesium salts or who take drugs that contain magnesium (such as some antacids or laxatives).

Beneficial Effects

Magnesium is necessary for the correct assimilation of calcium, potassium and the correct and efficient functioning of enzymes. Magnesium is nothing short of a miracle in its healing effect on a wide variety of diseases. Magnesium works together with hydrogen and antioxidants to keep our body structure soft. Magnesium has a calming effect on the nervous system and is frequently used to promote good sleep. It can be used to calm irritated and over excited nerves. Magnesium is vital in helping prevent heart attacks. It has also proved beneficial in the treatment of neuromuscular disorder, nervousness, tantrums, sensitivity to noise and hand tremor, reduce blood cholesterol and keep the arteries healthy, used for controlling conclusions in pregnant women, premature labor and epileptic seizures (22).

ATP without magnesium is non functional and leads to cell death. All detoxification mechanisms have as the basis of the energy required to remove a toxicant the need for Mg-ATP to drive the process. There is nothing done in the body that does not use energy and without magnesium this energy can either be made or used.

Calcium

Calcium is the king of all alkalizing nutrients. The appropriate oxygen type of Calcium effectively douses acid the same way that water douses fire. It destroys oxygen robbing acid in the body fluid there by keeping the body alkaline so that it can prevent disease effortlessly and can reverse cancer.

The American journal of nutrition states that virtually no major organ system escapes calcium influence. Dietary supplements of calcium along with vitamins prevent further spread of cancer (12,23,24).

Calcium Deficiency

Chronic calcium deficiency is associated with some forms of hypertension, prostate and colorectal cancer, some types of kidney stones, miscarriage, premenstrual problems, Joint and periodontal disease, sleep disturbances, mental depression, cardiovascular disease. Calcium levels are associated with arthritic or joint and vascular degeneration, calcification of soft tissues, hypertension, and stroke, mood and depressive disorders inhibits the cancer protective effects of vitamins (25,26).

A weak heart rate means that calcium is deficient and the contraction phase is weak and short. This results in an increase in heart rate and also irregular heart rate because some contractions are missed entirely.

Magnesium and Calcium

Calcium and Magnesium are extremely important minerals that are often out of balance in persons with thyroid disease. Imbalance of these minerals can result in very rapid, low and irregular heart rate. Thyroid function itself is most likely controlled by the ratio of the minerals.

Calcium is needed for muscle contraction and magnesium for muscular relaxation. The heart muscles are like all muscles. Calcium causes heart contraction; magnesium cause heart relaxation.

During hyperthyroidism, the magnesium is low and calcium is high. This measure is the result of other mineral imbalance (copper, zinc, iron, etc) but the effects on the heart rate are direct effects of a Ca/Mg and imbalance.

To balance calcium and magnesium; a normal person needs a Ca/Mg ratio of about 2:1; a hyper needs more magnesium and a hypo needs more calcium, but these ratio need to be constantly adjusted to the normality (27).

Never take calcium without magnesium. Calcium needs magnesium for it to assimilate. Intake of magnesium without any calcium will help to feel younger and more energetic.

Calcium and magnesium belong to a group of parasympathetic elements that exhibit anti inflammatory or degenerative properties at higher amounts in contrast to potassium ions which are pro inflammatory when high.

Dr. Linus Pauling, winner of two Nobel prizes once said "you can trace every sickness, every disease and every ailment to a mineral deficiency. Just as the human body needs adequate amounts of water and air for survival it also needs minerals or it will die"(28).

Dr. Otto Warburg, also a winner of two Nobel prizes discovered in 1932 that cancer is the result of lack of oxygen in the body fluids which expels oxygen from the body stands to reason, therefore, that when you provide your body with the necessary minerals, you drive out the acid your body becomes more alkaline(29).

Literature Review

A link between Mg deficiency and sudden death is suggested by a substantial number of studies published over the past three decades. Data come from epidemiologic, autopsy, clinical, and animal studies. Sudden death is common in areas where community water supplies are Mg-deficient. Myocardial Mg content is low in people who die of sudden death. Cardiac arrhythmias and coronary artery vasospasm can be caused by Mg deficiency and Intravenous Mg reduces the risk of arrhythmia and death immediately after acute myocardial infarction (13,15,25,30).

Because of these data, Mg supplementation has been proposed as a possible method of reducing the risk of sudden death. Suggested ways of supplementing Mg include public education to change dietary habits, addition of Mg to community water supplies, fortification of foods, and oral supplementation. Despite the substantial number of studies linking Mg deficiency with sudden death, no prospective studies have yet been investigated whether large-scale Mg supplementation is useful for the primary prevention of sudden death (31).

Oral magnesium supplementation in ischaemic heart disease patients with low erythrocyte magnesium levels led to significant increases of erythrocyte magnesium in these patients, and to an impressive decrease of anginal attacks and nitrate consumption, as well as to a lesser degree of ST segment depression on surface ECG obtained at exercise testing (32,33).

In the examined geographic area a high prevalence of coronary artery disease was verified through the records of the Public Health Service, which documents the main causes of mortality in Tuscany, and through the hospitalization data and the services provided for ischemic heart disease at the local coronary care unit compared with the national average.Moreover, research was accomplished on physical and chemical properties of drinking water in the same area, and this revealed a very low total hardness due to the paucity of calcium and magnesium.It has been shown that magnesium, hypertensive vascular diseases, atherogenesis, subcellular compartmentation of Ca and Mg and vascular contractility are all observed in Ca/Mg deficient populations (16,34).

Abnormal dietary deficiency in Mg as well as abnormalities in Mg metabolism appear to play important roles as risk factors for ischemic heart disease and acute myocardial infarction, namely in hypertensive vascular disease, diabetic vascular disease, insulin resistance, atherosclerosis and vasospasm. Experimental, epidemiological as well as clinical evidence that supports a role for Mg in these risk factors are reviewed (35).

Recent findings suggest that the ionized level of Mg is an important determinant of vascular tone, contractility and reactivity.Low extracellular magnesium induces intracellular free Mg deficits, ischemia, depletion of high-energy phosphates and cardiac failure in intact working rat hearts. Low magnesium can result in marked reduction in oxygen and substrate delivery to the cardiac myocytes, probably as a result of coronary vasoconstriction (36).

It is well established that clinically significant changes in a number of electrolytes occur in patients with congestive heart failure (CHF)(30). Magnesium ions are an essential requirement for many enzyme systems, and evidence is rapidly emerging that magnesium deficiency is a major risk factor for survival of CHF patients(37). In animal experiments, magnesium has been shown to be involved in several steps of the atherosclerotic process and, although in humans the situation is somewhat more complex, magnesium ions play an extremely important role in CHF and various cardiac arrhythmias (38). A number of drugs commonly used to treat CHF can significantly affect not only cellular magnesium ion homeostasis, but potassium as well. These include mercurial, thiazide, and loop diuretics (40). It has also been reported that hypomagnesemia is common in digitalis intoxication. In contrast, a number of agents have been shown to have either a magnesium-conserving effect (potassium-sparing diuretics) or not to affect magnesium ion balance (angiotensin-converting enzyme inhibitors). The clinical consequences of magnesium deficiency include the development of various cardiac arrhythmias, all of which respond well to magnesium treatment. Thus, it is more than apparent that magnesium ion homeostasis is of major importance in CHF. Future studies should address the complex role of magnesium ions in electrolyte imbalance, particularly in relation CVD (41).

Materials and Methods

After thoroughly going through the review of literature in which magnesium and calcium have a role in the regulation of cardiovascular disease and modulation in various physiological activities, we have decided to select a reasonable number of patients (both male and female, numbering 50 in the age group of 27 to 85 years attending the Master Health Checkup (MHC) at Apollo Speciality Hospital, Chennai for the evaluation of their routine health. We therefore made use of these patients for our study to establish a relationship between lipid profile and macro metals magnesium and calcium. As this study is mainly

to find out the association between lipid profile and the metals calcium and magnesium, we did not select established cardiac patients.

Sample Collection

As lipid profile will be affected due to non fasting, all samples were collected in the morning between 8 to 9am from the patients who had under gone over night fasting from 8pm till they reported to the blood collection centre at 8am the next day.

All possible standard precautions were under taken while collecting blood samples. The use of sterile disposable needle and vaccutainer were employed for sample collection. All blood collections were done by qualified phlebotomists.. Correct procedure was followed at every step such as correct site for veins puncture and pressure used to transfer into vaccutainer. On the whole occurrence of haemolysis was prevented.

Sample processing

As soon as the sample was received it was allowed to clot at room temperature for 30 minutes. The tubes were gently tapped and then centrifuged for 10 minutes at 2500 rpm. After centrifugation, serum was transferred to clean glass tube using disposable pipettes. The samples were either analyzed immediately or preserved at <-15 °C until analysis.

Biochemical assays

State of art fully automatic Olympus AU 640 Analyser was used to measure all the analytes undertaken in this study. Roche Diagnostics,GmBH,Manheim, Germany kits were used for the measurements of all analytes. Bio-Rad, USA accuracy controls were used to validate the accuracy of all analytes.

Statistical analysis and presentation of results

A software, downloaded from the website www.easycalculation.com was used to calculate correlation coefficient(r), t values and the probability(p), all of which are presented in Tables IV V and V1, for all patients, males and females Each Table contains the pair of analytes compared, the correlation coefficient, t values and probability.

Table I: Lipid Profile vs. divalent metals Ca & Mg for all patients

S.NO	AGE	SEX	TC	HDL	LDL	TG	TC/HDL	Ca	Mg	Ca/Mg
1	68	M	234	48	154	115	4.9	9.8	2.15	4.56
2	43	F	198	56	112	122	3.5	10.1	1.85	5.46
3	72	M	185	50	143	178	3.7	8.9	1.75	5.09
4	54	M	155	49	98	164	3.2	10	2.15	4.65
5	60	M	212	53	162	165	4.0	9.7	1.95	4.97
6	67	F	205	45	134	156	4.6	9.3	1.95	4.77
7	48	F	278	49	89	136	5.7	10.4	2.1	4.95
8	35	F	295	46	102	185	6.4	9.6	1.85	5.19
9	40	M	184	51	138	125	3.6	9.9	2	4.95
10	29	M	232	50	149	133	4.6	9.1	1.75	5.20
11	55	F	198	43	93	164	4.6	9.8	2.3	4.26
12	47	F	145	45	88	178	3.2	9.6	2.05	4.68
13	37	F	250	44	138	175	5.7	9.3	1.75	5.31
14	39	M	142	54	149	146	2.6	9.6	1.85	5.19
15	42	M	208	56	93	110	3.7	10.1	2	5.05
16	67	F	190	50	88	125	3.8	9.8	1.95	5.03
17	51	M	198	47	138	188	4.2	9.9	2.05	4.83
18	39	F	164	48	154	176	3.4	9.7	2.1	4.62
19	38	M	146	58	110	168	2.5	8.9	1.65	5.39
20	40	M	198	49	114	154	4.0	9.5	1.95	4.87
21	47	F	205	42	87	210	4.9	9.9	2.05	4.83
22	51	M	170	43	90	127	4.0	9.7	2.1	4.62
23	46	M	184	50	108	152	3.7	8.9	1.75	5.09
24	28	M	192	36	110	118	5.3	8.6	2.15	4.00
25	27	M	175	54	138	102	3.2	9.4	1.85	5.08
26	53	M	226	59	177	190	3.8	10.4	1.75	5.94
27	54	F	185	49	114	157	3.8	9.8	2.04	4.80
28	47	M	145	42	91	120	3.5	8.5	2.1	4.05

29	50	M	176	46	116	114	3.8	8.9	2	4.45
30	33	M	207	62	130	220	3.3	10.3	1.68	6.13
31	46	F	153	44	99	151	3.5	8.8	2.05	4.29
32	32	M	196	51	138	157	3.8	10	1.97	5.08
33	50	F	223	62	189	198	3.6	10.1	1.59	6.35
34	85	F	163	35	97	144	4.7	8.8	2.27	3.88
35	41	M	194	53	119	166	3.7	9.9	1.94	5.10
36	25	F	151	42	96	112	3.6	8.9	2.07	4.30
37	46	M	157	45	95	160	3.5	8.6	2.07	4.15
38	48	M	210	69	161	166	3.0	10	1.45	6.90
39	45	F	185	40	113	165	4.6	9.6	1.88	5.11
40	86	F	210	35	148	210	6.0	9.8	1.52	6.45
41	54	F	231	31	157	210	7.5	10.1	1.72	5.87
42	50	M	144	43	89	151	3.3	8.8	2.24	3.93
43	38	F	160	30	89	156	5.3	8.9	2.3	3.87
44	27	F	183	45	113	120	4.1	9.6	1.95	4.92
45	63	F	202	35	114	210	5.8	10.2	1.65	6.18
46	67	M	181	39	124	188	4.6	9.8	2	4.90
47	47	F	139	33	77	56	4.2	8.5	2.44	3.48
48	63	F	228	65	157	142	3.5	10.2	1.65	6.18
49	35	F	151	37	103	179	4.1	8.7	2.39	3.64
50	57	F	186	48	136	172	3.9	9	1.85	4.86
MEAN	48	-	191	47	120	156	4.2	9.5	2.0	4.9
SD	13.9	-	34.3	8.6	27.3	33.4	1.0	0.6	0.2	0.7
NORMAL	-	-	< 200	> 40	< 130	< 150	< 4.5	8.4 - 10.2	1.6-2.3	

Table II: Lipid Profile vs. divalent metals Ca & Mg for Male patients

S.NO	AGE	TC	HDL	LDL	TG	TC/HDL	Ca	Mg	Ca/Mg
1	68	234	48	154	115	4.9	9.8	2.15	4.56
2	72	185	50	143	178	3.7	8.9	1.75	5.09
3	54	155	49	98	164	3.2	10	2.15	4.65
4	60	212	53	162	165	4.0	9.7	1.95	4.97
5	40	184	51	138	125	3.6	9.9	2	4.95
6	29	232	50	149	133	4.6	9.1	1.75	5.20
7	39	142	54	149	146	2.6	9.6	1.85	5.19
8	42	208	56	93	110	3.7	10.1	2	5.05
9	51	198	47	138	188	4.2	9.9	2.05	4.83
10	38	146	58	110	168	2.5	8.9	1.65	5.39
11	40	198	49	114	154	4.0	9.5	1.95	4.87
12	51	170	43	90	127	4.0	9.7	2.1	4.62
13	46	184	50	108	152	3.7	8.9	1.75	5.09
14	28	192	36	110	118	5.3	8.6	2.15	4.00
15	27	175	54	138	102	3.2	9.4	1.85	5.08
16	53	226	59	177	190	3.8	10.4	1.75	5.94
17	47	145	42	91	120	3.5	8.5	2.1	4.05
18	50	176	46	116	114	3.8	8.9	2	4.45

19	33	207	62	130	220	3.3	10.3	1.68	6.13
20	32	196	51	138	157	3.8	10	1.97	5.08
21	41	194	53	119	166	3.7	9.9	1.94	5.10
22	46	157	45	95	160	3.5	8.6	2.07	4.15
23	48	210	69	161	166	3.0	10	1.45	6.90
24	50	144	43	89	151	3.3	8.8	2.24	3.93
25	67	181	39	124	188	4.6	9.8	2	4.90
Mean	46	186	50	125	151	3.8	9.5	1.9	5.0
SD	12	27	7	26	30	0.7	0.6	0.2	0.7

Table III: Lipid Profile vs. divalent metals Ca & Mg for Female patients

S.NO	AGE	TC	HDL	LDL	TG	TC/HDL	Ca	Mg	Ca/Mg
1	43	198	56	112	122	3.5	10.1	1.85	5.46
2	67	205	45	134	156	4.6	9.3	1.95	4.77
3	48	278	49	89	136	5.7	10.4	2.1	4.95
4	35	295	46	102	185	6.4	9.6	1.85	5.19
5	55	198	43	93	164	4.6	9.8	2.3	4.26
6	47	145	45	88	178	3.2	9.6	2.05	4.68
7	37	250	44	138	175	5.7	9.3	1.75	5.31
8	67	190	50	88	125	3.8	9.8	1.95	5.03
9	39	164	48	154	176	3.4	9.7	2.1	4.62
10	47	205	42	87	210	4.9	9.9	2.05	4.83
11	54	185	49	114	157	3.8	9.8	2.04	4.80
12	46	153	44	99	151	3.5	8.8	2.05	4.29
13	50	223	62	189	198	3.6	10.1	1.59	6.35
14	85	163	35	97	144	4.7	8.8	2.27	3.88
15	25	151	42	96	112	3.6	8.9	2.07	4.30
16	45	185	40	113	165	4.6	9.6	1.88	5.11
17	86	210	35	148	210	6.0	9.8	1.52	6.45
18	54	231	31	157	210	7.5	10.1	1.72	5.87
19	38	160	30	89	156	5.3	8.9	2.3	3.87
20	27	183	45	113	120	4.1	9.6	1.95	4.92
21	63	202	35	114	210	5.8	10.2	1.65	6.18
22	47	139	33	77	56	4.2	8.5	2.44	3.48
23	63	228	65	157	142	3.5	10.2	1.65	6.18
24	35	151	37	103	179	4.1	8.7	2.39	3.64
25	57	186	48	136	172	3.9	9	1.85	4.86
Mean	50	195	44	115	160	4.6	9.5	2.0	4.9
SD	15	40	9	29	37	1.1	0.5	0.2	0.8

Table IV: statistical data: lipid profile, calcium and magnesium for All patients

S.No	PAIRS COMPARED	CORRELATION COEFFICIENT	't' VALUE	PROBABILITY (P)
1	TC Vs Ca	0.559971825	4.68	< 0.0001
2	TC Vs Mg	0.43689431	3.37	< 0.001
3	TC Vs Ca/Mg	0.535715527	4.4	< 0.0001
4	HDL Vs Ca	0.443937569	3.43	< 0.001
5	HDL Vs Mg	0.53649881	4.4	< 0.0001
6	HDL Vs Ca/Mg	0.569157303	4.8	< 0.0001
7	LDL Vs Ca	0.398875033	3.01	< 0.01
8	LDL Vs Mg	0.63573157	5.71	< 0.0001
9	LDL V s Ca/Mg	0.652301347	5.96	< 0.0001
10	TG Vs Ca	0.379852436	2.8	< 0.01
11	TG Vs Mg	0.43793585	3.39	< 0.001
12	TG Vs Ca/Mg	0.493792774	3.93	< 0.0001

Table V: Statistical data: lipid profile, calcium and magnesium Male patient

S.No	PAIRS COMPARED	CORRELATION COEFFICIENT	't' VALUE	PROBABILITY (P)
1	TC Vs Ca	0.5023	2.79	<0.01
2	TC Vs Ca/Mg	0.443857	2.38	<0.05
3	HDL Vs Ca	0.536452	3.05	<0.01
4	HDL Vs Mg	-0.80058	6.41	<0.0001
5	HDL Vs Ca/Mg	0.898512	9.82	<0.0001
6	LDL Vs Ca	0.463544	2.51	<0.01
7	LDL Vs Mg	-0.51908	2.91	<0.01
8	LDL V s Ca/Mg	0.614157	3.73	<0.001
9	TG Vs Ca	0.364106	1.87	<0.05
10	TG Vs Mg	-0.39362	2.05	<0.05
11	TG Vs Ca/Mg	0.483489	2.65	<0.01

Table VI: Statistical data: lipid profile, calcium and magnesium Female patient

S.No	PAIRS COMPARED	CORRELATION COEFFICIENT	't' VALUE	PROBABILITY (P)
1	TC Vs Ca	0.623822	3.83	<0.01
2	TC Vs Mg	0.548953	3.15	<0.01
3	TC Vs Ca/Mg	0.601648	3.61	<0.001
4	HDL Vs Ca	0.470564	2.56	<0.01
5	HDL Vs Mg	0.379823	1.97	<0.05

6	HDL Vs Ca/Mg	0.406488	2.13	<0.05
7	LDL Vs Ca	0.371931	1.91	<0.05
8	LDL Vs Mg	-0.711992	4.97	<0.0001
9	LDL V s Ca/Mg	0.693011	4.61	<0.0001
10	TG Vs Ca	0.395031	2.06	<0.05
11	TG Vs Mg	0.497897	2.75	<0.01
12	TG Vs Ca/Mg	0.514605	2.88	<0.01

Results

Table I shows the results for 6 analytes measured along with the two calculated parameters viz TC/HDL-C & Ca to Mg ratios.

This table gives the entire data for all the patients along with the mean and standard deviation for each group. The mean age of the selected patient group is 48 years indicating the age at which cardiac problem may start developing. As the population selected were not cardiac related, the mean values for all the analytes studied lies within the normal range used in this laboratory. As the sole aim of this study is to find the association between the lipid profile and the metals Ca and Mg, grouping as cardiac and non – cardiac was not done.

Tables II & III present similar data for Male and Female group

Table IV presents the statistical data (r,t & p) for all the patients. This Table presents 12 pairs of comparison. Almost all the lipid profile parameters shows very good correlation to both Calcium & Magnesium and to Ca/Mg ratio ($p < 0.001$). Only LDL Vs Ca & Tg Vs Ca gives a significant level of < 0.01. These observations indicate that lipid profile indeed shows strong association to both Calcium & Magnesium, indicating that these two metals are indeed related to cardiac function.

Table V presents similar data for the 25 male patients. Only HDL Cholesterol shows a significance level of < 0.0001 to both Mg and to Ca/Mg ratio, indicating that it is the most important lipid as cardiac marker. However TC shows a significance of , <0.01 to Ca as well as Ca/Mg ratio. LDL also shows significance level of ,0.01 to both Ca & Mg as well as to its ratio. TG too shows some significance to both metals and its ratio. (<0.05, < 0.01)

Table VI presents similar statistical parameters for the 25 females included in this study. LDL cholesterol shows very good correation to Mg and Ca/Mg ratio($p < 0.0001$), contrary to HDL cholesterol showing good correlation to these metals in the case of male patients.

Almost all parameters of lipid profile shows good correlation, p ranges from

(< 0.05 to < 0.0001), indicating that irrespective of sex, lipid profile are associated with the metals Ca & Mg. This study strongly suggests that measurement of Ca and Mg should also be undertaken along with lipid profile for all patients suspected of having cardiac problem

On the whole all the lipid profile para meters shows good associations to both metals and its ratio.

Discussion

Previous studies observed in the literature review have linked the role of calcium and magnesium in reducing cardiac related problems and magnesium supplementation studies have shown improvement in cardiac related complications (11,38,42).

A recent study has linked cardio vascular disease pattern to both Ca and Mg and all cardiac patients are found to have low levels of Ca and Mg (43). In this study also we observed that the mean value for Ca and Mg were found to be around 9.5 and 2.0, both values are at the lower end of the normal ranges, since the outcome of this study is also in consistency with previously established studies(44,45,46,47,48). All the lipid profile undertaken are found to have an association with the metals Ca and Mg and its ratio.

Very few studies have been carried out linking post cardiac enzymes and the metals. Literature mentioning this aspect is very much lacking especially in the Indian scenario. As stated in some studies, myocardial magnesium content was low in people who died of sudden death due to cardiac arrest (34).

Relationships have been established between lipid, Calcium & Magnesium in thyroid & CVD(49). Our study shows similar results to previous ones, but high light the importance of measuring the Ca & Mg in cardiac patients

Summary

- The main aim of this study was to find out the association between Lipid profile to the macrometals calcium and magnesium and their ratio.
- 50 patients comprising of 25 males and 25 females were enrolled for this study
- Fasting blood samples were collected between 8 to 9 am from all the patients.
- Standard precautions and protocols were followed while collecting the sample and transporting to the laboratory.
- The blood was allowed to clot for 30 minutes, centrifuged as per laboratory procedure, serum transferred to another tube , analyzed immediately or preserved at < – 15^{0}c until analysis.
- Lipid profile and metals calcium and magnesium were measured using Olympus AU 640 fully automatic analyzer using Roche Diagnostic kits.
- Established operating instructions and protocol were followed when carrying out the analysis.

- Internationally validated Bio-Rad Accuracy controls were included in each batch of analysis to assess the accuracy of the results obtained.
- Statistical analysis was carried out using a software downloaded from easycalculation.com to calculate r, t and p values using the analytes in pairs.
- The associations between the pairs were compared based on the p value obtained.
- Very good association was found out between the lipid profile parameters and metals calcium and magnesium and its ratio.

Conclusion

- As the sole aim of this study was to find out the association between lipid profile and the two important macro metals Calcium and Magnesium, we did not select established cardiac patients.
- Good correlations were observed between lipid profile and the macro metals Calcium and Magnesium and its ratio for all the patients as well as in separate male and female groups.
- Further studies are required to ascertain if Calcium and Magnesium supplementation will improve the pre and post cardiac biochemical markers to the normal level.

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