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LIPIDS AND MAGNESIUM DEFICIT

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LIPIDS AND MAGNESIUM DEFICIT

Rarely has magnesium been investigated in clinical studies of the influence on arteriosclerosis of altering blood lipids. Laboratory investigations of magnesium deficiency, and of the effects of magnesium administration on lipids, reveal data suggestive of a link between the two nutritional approaches to the pathogenesis of cardiovascular disease. There is evidence that high fat intakes in animals (36, 47) and man (19, 42), or malabsorption of fat (2, 5, 14, 43) interfere with magnesium absorption. Magnesium deficit intensifies cardiovascular lipid deposition and lesions in animals on atherogenic diets (9, 13, 16, 32, 33, 49, 51-53); high fat intakes intensify the magnesium deficiency syndrome (9, 29, 36); and high intakes of magnesium exert a cardiovascular protective effect in hyperlipemic animals (13, 17, 26, 32, 34, 40, 41, 45, 49, 53).

EXCESS LIPIDS AND MAGNESIUM DEFICIT:
? LINK IN PATHOGENESIS OF CARDIOVASCULAR DISEASE

HIGH FAT INTAKE
MALABSORPTION OF FAT
↓
HIGH FAT INTESTINAL CONTENT
→ ↓ MAGNESIUM ABSORPTION
↓ PLASMA MAGNESIUM
(ANIMALS; MAN)

HIGH FAT INTAKE → ↑ ACUTE MAGNESIUM DEFICIENCY SYNDROME (MAGNESIUM-DEFICIENT ANIMALS)

MAGNESIUM DEFICIT → ↑ CARDIOVASCULAR LIPIDS, LESIONS (ANIMALS ON ATHEROGENIC DIETS)

SERUM AND TISSUE LIPIDS IN MAGNESIUM-DEFICIENT ANIMALS ON ATHEROGENIC DIETS.

Dogs. KRUSE *et al.* (24) first showed that young dogs on a diet low in magnesium (.08 % of diet) and containing butter fat (8 % of diet) (23), exhibited no change in total blood lipids, little or no change in free cholesterol, a drop in fatty acids, but a substantial rise in esterified cholesterol. As the magnesium level dropped, the percentage of esterified cholesterol rose. The young [illegible] on a magnesium-free, but otherwise well balanced diet, that delivered no lipid other than corn oil, was found by VITALE *et al.* (50) to develop neither elevation of blood cholesterol nor atheromatous plaques. BUNCE *et al.* (9) demonstrated that increasing the magnesium intake from 80 to 180 ppm, in dogs fed 20 % animal fat diets, prevented the aortic lesions seen in dogs on the lower magnesium intake, but allowed for a slight further rise in serum cholesterol. The Mg- and KCl-free diet, containing animal fat, vitamin D, and sodium phosphates, that was contrived by SOS *et al.* (45) to be cardiopathogenic also produced elevated serum cholesterol levels (Table I).

Rats. The atherogenic diet fed to rats by VITALE *et al.* (17, 52, 53), that produced marked hypercholesterolemia (639-808 mg %), also contained saturated fat (20 % of diet), cholesterol and cholic acid. Early arteriosclerotic lesions were diminished by increasing the magnesium intake; serum cholesterol levels were not lowered (34, 53) (Table II). In rats on the atherogenic diet, also high or low in protein (53) or calcium (49), increasing the magnesium content caused a further rise in serum cholesterol. A high intake of both magnesium and calcium reduced the sudanophilia of the hearts to 4.0 from the high value of 8.3, but exerted little influence on serum lipids (Table III). Increasing the magnesium intake of rats on low calcium intake substantially lowered the β-lipoproteins. A high magnesium intake slightly lowered the serum

TABLE I

LIPIDS IN EXPERIMENTAL MAGNESIUM DEFICIENCY IN DOGS

Mg INTAKE	FAT INTAKE		
(0.08 %) OF DIET	BUTTER FAT (8 % OF DIET)	↑ % ESTERIFIED CHOLESTEROL ↓ FATTY ACIDS NO CHANGE IN TOTAL SERUM LIPIDS	Kruse et al. (1933)
0	CORN OIL (9 % OF DIET)	NO CHANGE IN BLOOD CHOLESTEROL	Vitale et al. (1959)
80 ppm	ANIMAL FAT (20 % OF DIET)	AORTIC LESIONS ↑ SERUM CHOLESTEROL	Bunce et al. (1962)
180 ppm		NO AORTIC LESIONS ↑ SERUM CHOLESTEROL	
0 (ALSO, FREE OF K, HIGH IN VITAMIN D; Ca, PO_4, PROTEIN)	ANIMAL FAT	CARDIO PATHOGENIC ↑ SERUM CHOLESTEROL	Sos et al. (1954)

TABLE II

EFFECT OF MAGNESIUM ON LIPIDS IN RATS ON HIGH FAT DIET
(Adapted from Vitale, Hellerstein, Nakamura et al., 1957, 1966)

FAT INTAKE	SERUM LIPIDS		CARDIOVASCULAR LIPIDS	
	CHOLESTEROL (mg %)	LIPOPROTEINS	HEART	ARTERIES
	Low Mg ¦ High Mg	Low Mg ¦ High Mg	Low Mg ¦ High Mg	Low Mg ¦ High Mg
20 % SATURATED + 1 % CHOLESTEROL + 0.3 % CHOLIC ACID	639-808 (NO CHANGE)			n.s. ¦ ↓ a.s.
20 % SATURATED	115 → 97	α: 15.9 → 7.7 β: 11.8 → 6.3	0	0
20 % UNSATURATED	115 → 102	α: 8.1 → 4.0 β: 8.5 → 4.8	0	0
OR 20 % SATURATED 20 % UNSATURATED + 1 % CHOLESTEROL + 0.3 % CHOLIC ACID	1063 → 1085 210 → 355		6.0 → 4.1 2.0 → 2.3	
20 % UNSATURATED + 3 % CHOLESTEROL + 1.0 % CHOLIC ACID	440 → 385		5.2 → 2.9	
20 % SATURATED + 1 % CHOLESTEROL + 0.3 % CHOLIC ACID + HIGH Ca	748 → 818	α: 2.1 → 3.7 β: 35.9 → 29.7	8.3 → 4.0	
+ LOW Ca	515 → 705	α: 3.5 → 2.4 β: 26.1 → 4.7	4.7 → 3.0	

LONG-TERM Mg SUPPLEMENTATION (192 mg %)
→ ↓ BOTH SERUM AND AORTA LIPIDS
(Nakamura et al., 1966)

TABLE III

EFFECT OF DIETARY MAGNESIUM AND CALCIUM ON SERUM CHOLESTEROL AND LIPOPROTEINS, AND ON HEART SUDANOPHILIA IN RATS ON ATHEROGENIC DIET

(Adapted from J.J. Vitale, E.E. Hellerstein, D.M. Hegsted, M. Nakamura, and A. Farbman[49])

DIET*	SERUM			HEART
	CHOLESTEROL mg %	α-LIPO-PROTEIN	β-LIPO-PROTEIN	SUDANOPHILIA (HEART SCORE)
NO CHOLESTEROL OR CHOLIC ACID				
• LOW CALCIUM				
LOW MAGNESIUM	108	7.3	10.0	0.0
HIGH MAGNESIUM	114	6.6	6.1	0.0
• HIGH CALCIUM				
LOW MAGNESIUM	117	2.4	4.7	0.0
HIGH MAGNESIUM	115	3.8	5.7	0.0
WITH CHOLESTEROL (1.0 g%) + CHOLIC ACID (0.3 g%)				
• LOW CALCIUM				
LOW MAGNESIUM	515	3.5	26.1	4.7
HIGH MAGNESIUM	705	2.4	4.7	3.0
• HIGH CALCIUM				
LOW MAGNESIUM	748	2.1	35.9	8.3
HIGH MAGNESIUM	818	3.7	29.7	4.0

*Casein (10 g%); saturated cottonseed oil (20 g%); glucose (58.4 g%) salt mixture, without Ca or Mg (15 g%); cellufiflour (5 g%), + vitamins.

Low Calcium = 600 mg %
High Calcium = 1200 mg %
Low Magnesium = 24 mg %
High Magnesium = 192 mg %

TABLE IV

EFFECT OF SATURATED AND UNSATURATED FATS AND OF HIGH AND LOW MAGNESIUM INTAKES ON SERUM CHOLESTEROL AND HEART SUDANOPHILIA IN RATS ON ATHEROGENIC DIET

(Adapted from E.E. Hellerstein, M. Nakamura, D.M. Hegsted, and J.J. Vitale[16])

	SERUM MAGNESIUM mg%		SERUM CHOLESTEROL** mg%		HEART SCORE	
DIETARY FAT*	SATUR.	UNSATUR.	SATUR.	UNSATUR.	SATUR.	UNSATUR.
WITH CHOLESTEROL (1.0 g%) + CHOLIC ACID (0.3 g%)						
• LOW FAT INTAKE (5%)						
LOW MAGNESIUM	0.88	0.98	724	397	9.0	3.6
MODERATE MAGNESIUM	2.29	1.89	794	341	8.8	2.8
HIGH MAGNESIUM	2.22	2.15	821	385	6.2	5.3
• HIGH FAT INTAKE (20%)						
LOW MAGNESIUM	1.08	1.11	1086	210	6.0	2.0
MODERATE MAGNESIUM	2.08	1.99	653	270	3.8	2.3
HIGH MAGNESIUM	1.91	2.14	1085	355	4.1	2.3

*Dietary Fat - Saturated: Hydrogenated Cotton Seed Oil
Unsaturated: Corn Oil

Low Mg = 24 mg%
Moderate Mg = 96 mg%
High Mg = 192 mg%

**Serum Lipoproteins were 2.7-7.5 for the α Lipoproteins and 20-50 for the β Lipoproteins. Effect of Mg not demonstrable because of imprecision of method.

cholesterol and more profoundly lowered the lipoproteins of rats on high and low fat intakes, whether the fats were saturated or unsaturated (Table IV) (16). No cardiac sudanophilia developed, unless cholesterol and cholic acid were added to the diet. The markedly elevated plasma cholesterol, seen in rats also given cholesterol and cholic acid, was actually increased on the higher Mg intakes, although the cardiac lipid deposition in the rats on saturated fats and high Mg was reduced. Altering the Mg-intake did not notably affect the lesser heart scores of rats on high intakes of unsaturated fat (Table IV). The elevation of heart scores of rats on low unsaturated fat diets when their magnesium intake was increased requires elucidation. HELLERSTEIN *et al.* (16) suggested that magnesium might protect against lipid deposition in the cardiovascular system by means of its effect on lipoprotein metabolism (16, 49) (Table V). They demonstrated that further increasing the cholesterol to 3 % and cholic acid to 1 %, of rats on 20 % unsaturated fat, increased serum cholesterol levels only slightly (to 440 mg/100 ml), but increased the heart scores of rats on low magnesium intake to 5.2. High magnesium intake protected against this increased heart score (16) (Table VI). Increasing the magnesium intake of rats on atherogenic diets, given alcohol or water to drink, also resulted in higher serum cholesterol levels, but less cardiovascular sudanophilia (52). NAKAMURA *et al.* (32) showed that long-term feeding of 192 mg % of magnesium to rats on this atherogenic diet resulted in lowering of both serum and aorta cholesterol levels.

MULLICK *et al.* (30) reported that magnesium supplementation of weanling rats fed whole milk (containing 4 g butter fat/100 ml milk) alone, or with added cholesterol, appreciably lowered serum cholesterol levels. RADEMEYER and BOOYENS (39) found that adding 25 % saturated fat to diets low in magnesium caused hypercholesterolemia, whereas the same content of unsaturated fat did not. When, instead of sugar, they substituted maize meal, a food rich in magnesium, that also interfered with the absorption of fat, serum cholesterol levels dropped. Female rats on diets low in magnesium, and that caused only slight elevation in serum cholesterol, were shown by KREHL and BARBORIAK (22) to have both

TABLE VI

PROTECTIVE EFFECT OF HIGH MAGNESIUM INTAKE AGAINST CARDIAC LIPID DEPOSITION IN RATS ON HIGH CHOLESTEROL + CHOLIC ACID INTAKES

(Adapted from E.E.Hellerstein, M.Nakamura, D.M.Hegsted and J.J.Vitale[16])

	SERUM CHOLESTEROL mg%	HEART SCORE
ATHEROGENIC DIET* (With 1% Cholesterol and 0.3% Cholic acid)		
• LOW MAGNESIUM**	210	2.0
• HIGH MAGNESIUM	355	2.3
ATHEROGENIC DIET* (With 3% Cholesterol and 1.0% Cholic acid)		
• LOW MAGNESIUM**	440	5.2
• HIGH MAGNESIUM	385	2.9

*Dietary Fat = 20% Corn Oil

**Low Magnesium = 24 mg/100 gm
High Magnesium = 192 mg/100 gm

TABLE V

EFFECT OF HIGH AND LOW SATURATED AND UNSATURATED FAT INTAKES AND OF MAGNESIUM ON SERUM LIPIDS IN RATS

(Adapted from E.E.Hellerstein, M. Nakamura, D.M. Hegsted and J.J. Vitale[16])

	SERUM MAGNESIUM mg%		SERUM CHOLESTEROL mg %		SERUM LIPOPROTEINS α		SERUM LIPOPROTEINS β	
DIETARY FAT*	SATUR.	UNSATUR.	SATUR.	UNSATUR.	SATUR.	UNSATUR.	SATUR.	UNSATUR.
LOW FAT INTAKE (5%):								
LOW MAGNESIUM	1.08	1.25	105	127	9.7	6.9	11.7	8.8
MODERATE MAGNESIUM	2.21	2.03	99	138	8.5	10.0	10.3	10.6
HIGH MAGNESIUM	2.56	1.91	83	116	4.1	7.3	4.8	7.7
HIGH FAT INTAKE (20%)								
LOW MAGNESIUM	1.51	0.96	115	115	15.9	8.1	11.8	8.5
MODERATE MAGNESIUM	1.89	1.99	113	123	16.3	6.9	12.6	5.4
HIGH MAGNESIUM	2.09	1.95	97	102	7.7	4.0	6.3	4.8

Low Magnesium = 24 mg %
Moderate Magnesium = 96 mg %
High Magnesium = 192 mg %

*Dietary Fat - Saturated: Hydrogenated Cottonseed Oil
Unsaturated: Corn Oil

lower serum cholesterol and magnesium levels than males.

Rabbits. NAKAMURA *et al.* (33) found that rabbits on atherogenic diets required substantial amounts of magnesium supplementation to exert a notable effect on the deposition of lipids in the aorta. More than 950 mg Mg/100 g of diet was necessary for an effect on serum and tissue lipids. The authors commented that aortic lipid deposition is significantly enhanced by magnesium deficiency; high magnesium intake merely slows down the process. ADAMS *et al.* (1) also found that magnesium supplementation had little effect on serum and aorta lipid levels in rabbits on atherogenic diet; NEAL and NEAL (35) found higher serum phospholipid and triglyceride levels in rabbits on atherogenic diet and magnesium supplemented water, but less atherosclerosis than in rabbits on the same diet, but given distilled water to drink. MCCANN *et al.* (26) found that administration of magnesium (as $MgNa_2EDTA$) had little effect on the marked hypercholesterolemia or on hyperphospholipidemia of rabbits on atherogenic diets, but substantially reduced the formation of atheromatous plaques.

there has been little investigation of the influence of magnesium administration on the abnormal lipid patterns associated with cardiovascular disease in man. The failure to show a significant difference in serum magnesium and lipid levels in patients with cardiovascular disease from levels seen in controls (3, 7, 12, 18, 21, 31) has been interpreted to negate the likelihood that magnesium deficit plays a contributory role. Several of these clinicians, however, have commented that, despite their negative findings in patients other than diabetics (3, 20, 46), who fairly consistently show low magnesium levels, the experimental evidence still points to the need for further study in man (7, 18).

The laboratory findings indicate that screening procedures which measure serum lipid and magnesium levels at a single point in time, can be expected to show little. Chronic, or even subacute magnesium deficits in animals have long been known not necessarily to exert a profound effect on plasma magnesium levels (48). The lipid/magnesium studies just cited demonstrate that even when high doses of magnesium are given to hypercholesterolemic animals, the changes in serum lipids are less consistent

TABLE VII

PROTECTION BY MAGNESIUM AGAINST CARDIOVASCULAR LIPIDS IN RABBITS ON ATHEROGENIC DIETS

MAGNESIUM DEFICIENCY →	↑ AORTIC LIPIDS	Nakamura et al. (1955)
MAGNESIUM SUPPLEMENTS → (950 mg Mg/100 gm DIET)	↓ SERUM LIPIDS SLOWED DEPOSITION OF AORTIC LIPIDS	
MAGNESIUM-SUPPLEMENTED →	↓ ATHEROSCLEROSIS ↑ SERUM PHOSPHOLIPIDS AND CHOLESTEROL	Neal & Neal (1962)
MAGNESIUM SUPPLEMENTATION →	LITTLE EFFECT ON SERUM & AORTIC LIPIDS	Adams et al. (1962)
MAGNESIUM SUPPLEMENTATION →	LITTLE CHANGE IN HYPERCHOLESTEROLEMIA ↓ ATHEROMATOUS PLAQUES	McCann et al. (1962)

MONKEYS ON ATHEROGENIC DIET (Vitale et al., 1963)

Mg DEFICIENCY → ↑ SERUM AND ARTERIAL LIPIDS (NOT SEEN ON ADEQUATE Mg INTAKE)

Another interesting dissociation between serum and tissue cholesterol levels in magnesium-supplemented rabbits has been reported by KWITKO *et al.* (25). They found that rabbits fed high cholesterol diets developed lipid deposition in the iris, that could be prevented by providing $MgCl_2$ in their drinking water, even though this Mg-supplementation did not affect the marked hypercholesterolemia.

Monkeys. The magnesium-deficient cebus monkeys on atherosclerotic diets, reported by VITALE *et al.* (51) showed both elevated serum cholesterol values and marked intimal lipid deposition in the aorta, not seen in controls.

MAGNESIUM AND SERUM LIPIDS IN MAN.

Although magnesium has been shown to exert a protective effect in many experimental cardiopathic models, including those producing hyperlipemia, than is the lowering of tissue lipids. The serum levels of cholesterol have been unaffected, or even raised in some of the studies; the β-lipoprotein fraction seems to be influenced somewhat more. Although magnesium deficit intensifies atheromatosis, it takes quite large doses and/or prolonged administration of magnesium to protect against the disease in hyperlipemic animals (17, 32, 33, 40, 41).

Thus, to determine the effect of magnesium on lipids in man, we must investigate the response to effective doses of magnesium. Several clinical reports have indicated, not only symptomatic improvement following intramuscular magnesium therapy, but also some improvement in serum lipids. MALKIEL-SHAPIRO *et al.* (27, 28) first reported lowering of β-lipoproteins in patients with coronary insufficiency, findings which have been confirmed by PARSONS *et al.* (10, 37, 38), who also reported correction of low lecithin/cholesterol ratios in their patients, as well as elevation of plasma magnesium levels. BROWNE (8) reported an

HUMAN STUDIES ON MAGNESIUM/LIPID

NO SIGNIFICANT DIFFERENCE IN SERUM Mg AND LIPIDS (IN NORMAL V.S. PATIENTS WITH C.V. DISEASE)

RESPONSE OF C.V. PATIENTS TO MAGNESIUM THERAPY

i.m. $MgSO_4$
- → ↓ β-LIPOPROTEINS (Malkiel-Shapiro)
- → ↑ LECITHIN/CHOLESTEROL (Parsons et al., Butler)
- → ↓ SERUM CHOLESTEROL (Browne)

ORAL $MgCL_2$ (Long Term) → 10 % ↓ β/α LIPOPROTEIN (Haywood, Selvester)
NO CHANGE-SERUM CHOLESTEROL

•HIGHER MAGNESIUM/LOWER CHOLESTEROL SERUM LEVELS IN BANTUS; ABORIGENES THAN CAUCASIANS; CORRELATED WITH LOWER INCIDENCE OF CARDIOVASCULAR DISEASE (Bersohn & Oelofse; Booyens et al., Charnock et al.)

average fall of 23 % in serum cholesterol in his patients with arterial disease, who were treated with intramuscular magnesium; HAYWOOD and SELVESTER (15) reported 10 % lowering of the β/α lipoprotein ratio as compared with placebo controls in a 12-30 month double blind study of administration of orally administered $Mg\ CL_2 + KCl$. No significant changes were seen in cholesterol levels.

BERSOHN and OELOFSE (4) correlated the lower serum cholesterol and higher magnesium levels in Bantus than in white South Africans, with their lower incidence of arteriosclerosis, and their higher dietary intake of magnesium. Having shown that the maize meal dietary constituent of the Bantus had a hypocholesterolemic effect in rats, because of its high Mg content and its interference with fat-absorption (39) BOOYENS *et al.* (6) demonstrated that supplementation with maize meal of diets of hyperlipemic whites raised their serum Mg and lowered their serum cholesterol levels. Although lower serum cholesterol levels were demonstrable by CHARNOCK *et al.* (11) in Australian aborigines than in whites, and although their dietary intake of magnesium was higher, there was less difference in serum Mg levels in the two groups than was shown in the South African study (4).

NEED FOR FURTHER STUDY

- ROLE OF MAGNESIUM IN FAT METABOLISM
- EFFECTS OF MAGNESIUM ON FAT UTILIZATION (ANIMALS; MAN)
- MAGNESIUM REQUIREMENTS OF PATIENTS CARDIOVASCULAR DISEASES
- INFLUENCE OF THERAPEUTIC DOSES OF MAG ON ABNORMAL LIPID METABOLISM AND COURSE OF CARDIOVASCULAR DISEASE

CONCLUDING REMARKS.

Not included in this report is the [illegible] dence cited by SIMON (44) that ma[illegible]m is involved in fat metabolism. High [illegible]take fere with magnesium absor[illegible]y ing to a conditioned mag[illegible]eit. need for additional study of [illegible] of deficit, and of its adminis[illegible] the of lipids in animals. In [illegible]igation mal lipid metabolism in c[illegible]scular dis include the influence of th[illegible]eutic doses sium.

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SUMMARY.

Lipids and magnesium deficit

There is a link between two diverse approaches to the pathogenesis of cardiovascular disease: that emphasizing the importance of fat and of magnesium respectively. Excess dietary fat interferes with magnesium absorption and intensifies magnesium deficiency which, in turn, intensifies the cardiovascular lesions produced by atherogenic diets. Attention should also be paid to the possibility that high vitamin D and cholesterol intakes may affect the incidence and severity of arteriosclerosis, possibly by increasing magnesium requirements and decreasing magnesium utilization. Magnesium supplements decrease cardiovascular lipids, but have inconsistent effects on serum lipids. Since there is both clinical and animal evidence of magnesium's cardiovascular-protective effect, long-term therapeutic magnesium should be evaluated in arteriosclerotic patients.

RÉSUMÉ.

Lipides et déficit magnésique

Il existe un lien entre deux conceptions diverses sur la pathogénie des affections cardio-vasculaires : celle soulignant l'importance des graisses et celle soulignant l'importance du magnésium. Un excès d'apport graisseux inhibe l'absorption magnésique et aggrave un déficit magnésique ; celui-ci à son tour aggrave les lésions cardiovasculaires produites par les régimes athérogènes. Il faut aussi souligner qu'il est possible que de hauts apports de vitamine D et de cholestérol pourraient agir sur la fréquence et la gravité de l'athérosclérose, en augmentant les besoins magnésiques et en diminuant l'utilisation de l'ion. Des suppléments magnésiques diminuent les graisses cardiovasculaires, mais n'exercent que des effets négligeables sur les lipides sériques. Puisqu'il existe à la fois des preuves expérimentales et cliniques d'effets cardiovasoprotecteurs du magnésium, une magnésothérapie au long cours devrait être évaluée chez les artérioscléreux.

ZUSAMMENFASSUNG.

Die Lipoide und Magnesiummangel

Zwischen den zwei Gesichtspunkten zur Pathogenese von Herz- und Gefässkrankheiten, wobei man die Hauptrolle den Fetten einerseits und dem Magnesium andrerseits zuschreibt, besteht ein Zusammenhang. Ein Fettübersschuß in der Diät behindert nämlich die Absorption von Magnesium und steigert den Magnesiummangel — ein Mangel, der seinerseits die durch eine atherogene Diät erzeugten Herz- und Gefäß-Schädigungen vertieft. Es gibt auch die Möglichkeit, daß die Aufnahme hoher Dosen von Vitamin D und Cholesterin sich ungünstig auf die Häufigkeit und Schweregrad von Arteriosklerose auswirkt, vielleicht auf dem Wege eines gesteigerten Bedürfnisses an Magnesium bei gleichzeitigem Abfall in der Ausnützung dieses Elements. Zusätzliche Gaben von Magnesium vermindern die Lipoidmenge im Herz- und Gefässsystem, üben aber keinen folgerichtigen Einfluß auf den Lipoidspiegel des Blutes aus. Da die Schutzwirkung des Magnesiums auf das Herz- und Gefässsystem sowohl klinisch als auch tierexperimentell bewiesen ist, erscheint es der Mühe wert, die Wirkung von Magnesium-Dauerbehandlung bei arteriosklerotischen Patienten zu bewerten.

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