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Clinical Association Between Alterations of Boron, Cesium, Rhenium and Rubidium with the Pathogenesis of Atherosclerosis

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Abstract: *Background and Objectives:* Certain trace elements are now being investigated as possibly having a role in pathogenesis of atherosclerosis, the possible association between (boron, cesium, rhenium and rubidium) with atherosclerosis that, trace elements may be directly or indirectly involved in cardiovascular disease processes including atherosclerosis. This study was aimed to measure the serum levels of boron, cesium, rhenium and rubidium in Iraqi patients with atherosclerosis as compared with the control group, in addition to study the role of other confounding factors age, gender and finally estimate the correlation coefficient between the studied parameters. *Method:* This case control study conducted on 40 patients of both genders 15 men and 25 women with the mean age (52.4 ± 10) years and 40 of apparently healthy adults age and gender matched were also enrolled in this study as a control group for comparing purposes. The patients were free from any diseases except atherosclerosis and this was confirmed by clinical examination and biochemical and hematological tests. Serum levels of parameters were estimated using atomic absorption spectrophotometers. *Results:* There were a significant reductions in the level of rubidium and boron while, there was a significant elevation in the serum level of rhenium in patients group as compared with the control group, and there was no significant difference between studied group regarding cesium. There was no age and gender effects on the level of focused parameters and there was a significant weak negative correlation between age and Rb (r=-0.38, p=0.016). *Conclusion:* Boron and rubidium were significantly reduced, so supplementation could be important for therapy and even more necessary for individuals who are at high risk of developing atherosclerosis. While the level of rhenium was significantly elevated in patients and there was no significant variation in level of cesium. These variations could be proved the possible correlation with pathogenesis of atherosclerosis. Therefore, the estimation of these elements could be an important complementary diagnostic tool to determine trace elements status for therapy and diagnosis. These alterations are could be due to oxidative stress and inflammation which affect the trace elements homeostasis in patients with atherosclerosis. Boron, cesium, rhenium, rubidium are a natural element and micronutrient in human, they would be meaningful to compare these trace elements in atherosclerotic patients and controls for evaluating these elements as a biomarkers of the risk assessment, early detection, diagnosis, prognosis, and prevention of atherosclerosis.

Keywords: Atherosclerosis, Boron, Cesium, Rhenium, Rubidium

1. Introduction

1.1. General View

Atherosclerosis is a specific form of arteriosclerosis in which an artery wall thickens as a result of invasion and accumulation of white blood cells (WBCs) foam cell and proliferation of intimal smooth muscle cell creating a fibrofatty plaque. These accumulations contain both living, active WBCs (producing inflammation) and remnants of dead cells, including cholesterol and triglycerides.

Atherosclerosis is therefore a syndrome affecting arterial blood vessels due to a chronic inflammatory response of WBCs in the walls of arteries. This is promoted by low-density lipoproteins (LDL, plasma proteins that carry cholesterol and triglycerides) without adequate removal of

fats and cholesterol from the macrophages by functional high-density lipoproteins (HDL).

1.2. Atherosclerosis and Risk Factors

Hyperlipidemia, cigarette smoking and hypertension together increases the risk seven times [1]. Diabetes [1] dyslipoproteinemia [1] (unhealthy patterns of serum proteins carrying fats & cholesterol) or impaired glucose tolerance (IGT), high serum concentration of low-density lipoprotein and / or very low density lipoprotein (VLDL) particles. Low serum concentration of functioning high density lipoprotein (HDL). An LDL: HDL ratio greater than 3:1. Elevated serum C-reactive protein concentrations [1, 2].Vitamin B6 deficiency [3], postmenopausal estrogen deficiency [1], elevated serum levels of triglycerides, chronic systemic inflammation as reflected by upper normal WBC concentrations, high carbohydrate intake [1].

Dietary iodine deficiency and hypothyroidism, which cause elevated serum cholesterol and of lipid peroxidation [4], advanced age [1], male sex [1]. Atherosclerosis is typically associated with men in their 40s and women in their 50s to 60s.

1.3. Trace Elements and Atherosclerosis

It is well established that several trace elements (TEs) are of great importance in a number of biological processes, through their action as activators or inhibitors of enzymatic reactions, by competing with other elements and proteins for binding sites, by affecting on the permeability of cell membranes, or through other mechanisms. It is therefore reasonable to assume that these minerals would also exert an action, either directly, or indirectly, on the blood vessel walls, on the cardiac cell, on the blood-pressure-regulating centers, or on other systems related to cardiovascular function e.g. the lipid and carbohydrate metabolism.

Man-made variations of the environment, such as the use of food processing, fertilizers, canning, treatment and softening of drinking water, food additives, and the industrial pollution of air and water, may bring about variations in the mineral balance and, as a consequence, in some biological functions, including the cardiocirculatory function including atherosclerosis.

The involvement of TEs in the pathogenesis and prevention of cardiovascular diseases including atherosclerosis have been suggested by some previous studies.

Epidemiological surveys have suggested the possibility that some TEs depletion are associated with a reduced anti-oxidant potential in organisms (which is believed to possibly underlie the onset of cancer and atherosclerosis), accelerated aging, developmental retardation in children, and an increased incidence of abnormal pregnancies, immunological abnormalities, and lifestyle-related diseases [5].

1.3.1. Boron

Boron (B) is a TE that is required for health of the body, normal growth, bone metabolism and endocrine function in humans has been proposed. Boron is known for its role in bone and joint health because of the effects on steroid hormones including estrogen, testosterone, dehydroepiandrosterone (DHEA), and 1,25 dihydroxycholecalciferol. Boron is a TE which has an important effect on the activity of various metabolic enzymes, metabolism of steroid hormones as well as several micronutrients including calcium (Ca), vitamin D as it plays a role in converting vitamin D to its more active form, thus increasing Ca uptake and deposition into bone, phosphorus, aluminum, magnesium (Mg), and molybdenum [6].

Boron significantly reduces urinary Mg and Ca loss [7], as well as elevates Mg and Ca absorption. Boron affects on cell membrane activity [8].

Evidence is accumulating that dietary B has a marked effect on certain metabolic processes, such as arthritis, coronary heart disease and osteoporosis (OP) [9]. Boron may prevent these chronic diseases by the production of certain steroid hormones (estrogen, testosterone) as well as it decreases menopausal symptoms. Boron may help decrease menstrual pain by increasing the estradiol level. Boron regulates the inflammatory response, B alleviates arthritis by modifying the levels of serum antibodies and limiting T-cell activity and [10].

It was found that dietary boron had the same effect as estrogen supplementation [11], and support the hypothesis that boron is necessary for the hydroxylation step in the formation of specific steroid hormones [12].

Based a study with 15 human subjects, high boron ingestion lowered serum calcitonin concentrations, increased serum ionized Ca, and increased the serum levels of 1,25dihydroxycholecalciferol. The adequate dietary levels of boron decreased serum calcitonin levels is important, because calcitonin has been shown to increase Ca loss in humans, and serum calcitonin concentrations are higher in women with postmenopausal OP [11].

In human deficiency studies, supplementation with boron improved many parameters including mineral metabolism, memory and blood hemoglobin. It is believed that B can influence some of the blood clotting factors in the body as well as may help to protect against atherosclerosis [9].

Boron aids to decrease lipid accumulation and causes the removal of cholesterol through different means, lead to reduce the opportunity for developing atherosclerosis and blood clots, and protecting the body from strokes and heart attacks.

Boron supplementation increase steroid hormone production (testosterone) and therefore may be of interest to athletes, increase bone growth and strength, support estrogen function and therefore may help prevent atherosclerosis, improve brain function and affect thyroid hormone level, alleviate harmful effects of vitamin D, Mg, and potassium (K) deficiency in postmenopausal bone loss, as well as play a role in the prevention of OP, treatment of arthritis, prevents Ca loss in postmenopausal women.

Deficiency in B has been shown to associate with abnormal embryo development, decrease in electrical activity in the brain, decreased sperm count, impaired hand-eye coordination, ovarian deterioration, damage in reproductive function, sub optimal mineral metabolism.

Deprivation of B in humans and animals causes increased urinary Ca loss [8] as well as B deficiency symptoms may result from an altered macromineral status such vitamin D3 deficiency (e.g., abnormal bone formation) [13].

Boron plays a role in carbohydrate metabolism, hormone action, and nucleic acid synthesis [14] as well as regulating enzymatic activity in pathways involved in energy substrate metabolism, insulin release, immune system and it is known to enhance RNA production in plants [11].

1.3.2. Cesium

Caesium or cesium is a chemical element with symbol Cs and atomic number 55. It is a soft, silvery-gold alkali metal with a melting point of 28 °C (82 °F), it is one of five metals that are liquid at or near room temperature.

Cesium is a naturally occurring metal found combined with other elements in soil, rocks, and dust in low amounts. Cesium is released into the environment in pollucite mining and production of energy and electronics. Fly ash from coal burning power plants contains cesium.

Cesium is an alkali metal and has chemical and physical properties similar to those of rubidium (Rb) and K. The metal is extremely reactive and pyrophoric, reacting with water at −116 °C (−177 °F). It is used in photoelectric cells, scintillation counters, photo emitter devices and atomic clocks.

Cesium is used for the separation of deoxyribonucleic acid (DNA). Cesium compounds are used as catalysts in chemical and biomedical research, and for tagging or tracing compounds.

It has been used in cancer therapy to elevate the pH of the cell. Cesium is a mineral salt that limits the cellular uptake of glucose; this starves the cancer cells and reduces their growth. It also increases the cells' pH to approximately 8.0. A pH range of 8.0 produces an environment that slows cancer cell growth. It may even promote cancer cell death.

Little is known about the biological activity of Cs. Radioactive isotopes of Cs have long been used for radiation treatment of prostate cancer and the sterilization of food and surgical equipment, treat epilepsy [15], therapy of manic depressives, nerve stimulant, regulating heart arrhythmia.

Radioactive Cs is another important radioactive element in nuclear crisis to be concern. The radioactive Cs 134 and Cs137 can result in cellular oxidative disturbance and can cause the problem. In addition, radioactive Cs is also reported to be an important interference on normal vitamin D metabolism [16].

Blood, feces, saliva, and urine have been used to measure levels of cesium in the body. Cesium absorbed through the skin, lung and gastrointestinal tract and distributed through the body and concentrated in muscles. It has been said that, “Cs mimics K for cellular transport.”

Mild toxicity symptoms from Cs include numbness or tingling of the lips, gastrointestinal distress, hypotension and loss of consciousness.

Total Cs intakes of 6 g/day or more can cause severe hypokalemia, hypomagnesemia, ventricular tachycardia, and cardiac arrest. Studies on experimental animals suggested that Cs would pose an acute health hazard only when ingested in large quantities. The biological half life of Cs is 15 days in infant and 100-150 days in adults.

Cesium ions are effective in activating Na-K ATPase enzyme [17]. Cesium has a useful role in cardiovascular physiology and pharmacology decrease diastolic depolarization and an increase in monophasic action potential [17] cause premature ventricular beat and ventricular arrythemias [17].

Cesium shows a significant effect on the nervous system both peripherally and centrally. It affects lipid production and distribution in subcellular fraction of isolated plasma membrane during membrane fusion [17].

1.3.3. Rubidium

Rubidium (Rb) is a soft, silvery-white metallic element of the alkali metals group. It is an alkaline element. It is liquid at ambient temperature, but only on a hot day given that its melting point is about 40°C. It ignites spontaneously in air and reacts with water and even with ice at -100 °C, setting fire to the liberated hydrogen. As so with all the other alkali metals, it forms amalgams with mercury. It alloys with gold, Cs, sodium, and K. It's flame is yellowish-violet.

Rubidium and it's salts have few commercial uses. The metal is used in the manufacture of photocells. Rubidium salts are used in ceramics, glass and in fireworks to give them a purple color.

Rubidium isotopes have been used as tracers in medical tests to observe blood flow in the heart, brain, and kidney.

Rubidium has no known biological role but has a slight stimulatory effect on metabolism, probably because of its similarity to K. The two elements are found together in minerals and soils, although K is much more abundant than rubidium.

Rubidium enters the food chain and so contributes to a daily intake of between 1 and 5 mg. It is moderately toxic by ingestion. Overexposure to Rb can cause failure to gain weight, ataxia, skin ulcers, and extreme nervousness. Rubidium readily reacts with skin moisture to form rubidium hydroxide, which causes chemical burns of eyes and skin. The signs and symptoms of overexposure are skin and eye burns.

Since Rb and K have similar properties, K imbalance occurs when replaced with Rb in the body. Rubidium can be tested in human RBC, urine, or plasma. Hair levels are thought to indicate Rb exposure.

Rubidium has been used in cancer therapy to raise pH. Toxicity studies in rats showed that rubidium chloride resulted in decreased growth, anemia, and changes to hepatic lipid composition, liver cells, kidney cells and brain enzymes. Ascorbic acid supplementation appeared to prevent the Rb induced liver and kidney effects.

Studies on experimental animals suggested that Rb would pose an acute health hazard only when it is ingested in large quantities. Rubidium toxicology has not been fully investigated. It appears to displace K in rats, with symptoms of muscle spasms, hyperirritability and neuromuscular effects.

There have not been reports of industrial exposure leading

to injury. However, in one small human study, Rb replaced 10-15% of the body's K and the subjects showed no symptoms of toxicity. Exposure could lead to irritation, burns, or ulceration.

Rubidium and its salts have few commercial uses. The metal is used in the manufacture of photocells and in the removal of residual gases from vacuum tubes. Rubidium salts are used in glasses and ceramics and in fireworks to give them a purple color. Potential uses are in ion engines for space vehicles, as working fluid in vapor turbines, and as getter in vacuum tubes.

Rubidium is considered to be the 16th most abundant element in the earth's crust. The relative abundance of Rb has been reassessed in recent years and it is now suspected of being more plentiful than previously calculated. It is very like K and there are no environments where it is seen as a threat.

No minerals of Rb are known, but Rb is present in significant amounts in other minerals such as lepodite (1.5%), pollucite and carnallite. It is also present in trace amounts in other minerals such as zinnwaldite and leucite. The amount of Rb produced every year is small, and what demand there is can be met from a stock of a mixed carbonate by-product that is collected during the extractium of litium from lepodite.

The little Rb that is produced is used for research purposes only, these is no incentive to seek commercial outlets for the material.

1.3.4. Rhenium

Rhenium is a chemical element. It has the chemical symbol Re. It has the atomic number 75. It is a rare metal. It is silver white. In chemistry it is placed in a group of metal elements named the transition metals. The chemistry of rhenium is similar to manganese (Mn). It was the last natural element to be discovered.

It has a high melting point, which is the third highest after carbon and tungsten. Rhenium is very hard, it resists corrosion but slowly tarnishes in moist air.

Rhenium made as a by-product of molybdenum refinement. Rhenium does not occur as the free uncombined metal.

The Potential health effects it may cause eye irritation, skin irritation, the ingestion may cause irritation of the digestive tract and inhalation may cause respiratory tract irritation.

The isotopes 188Re and 186Re are radioactive and are used for treatment of liver cancer. They both have similar penetration depth in tissue [18]. 188Re is also being used experimentally in a novel treatment of pancreatic cancer where it is delivered by means of the bacterium Listeria monocytogenes.

Related by periodic trends, Re has a similar chemistry to that of technetium; work done to label Re onto target compounds can often be translated to technetium.

Very little is known about the toxicity of Re and it's compounds because they are used in very small amounts. Soluble salts, such as the Re halides or perrhenates, could be hazardous due to elements other than Re or due to Re itself.

Rhenium is a radionuclide with physical and chemical properties suitable for radioimmunotherapy.

2. Patients and Methods

The study was performed to assess the association between the serum level of focused parameters with the pathogenesis of atherosclerosis. This study was done at Hawler Medical University, College of Pharmacy in period between 2014 and 2015.

2.1. Study Design

This case control study conducted on 40 Iraqi patients of both genders (15 men and 25 women) with the average age (37-70) years, in addition an equal number of apparently healthy adults age and gender matched randomly selected were also participated in this study as a control group for comparing purpose. Serum trace elements were determined using Atomic Absorption Spectrophotometer in Baghdad city at Ministry of Science and Technology /Department of Research of Biochemical Science. The protocol of the study was approved by Ethical Committee of College of Pharmacy. Verbal consent was obtained from all subjects before participation.

Samples were collected under the guidance of cardiologist. All reagents and chemicals were of high analytical grade. Exclusion criteria: None of the patients and controls were smokers or consuming alcohol or had any other chronic disease except atherosclerosis and this is confirmed by clinical examination and laboratory estimations of biochemical and hematological tests.

2.2. Sample Collection

The Protocol of the Study: Ten ml of the fasting blood (overnight for 12–14 hours) samples was collected from the vein of the participants (healthy adults and patients with atherosclerosis) of both genders without using tourniquet. The blood samples were left for 30 minutes for coagulation purpose, and then centrifuged for 15 minutes at 2500-3500 revolution per minutes (rpm). The sera of the patients were separated and divided into several parts and put them into several plastic plain tubes to do the biochemical tests of the current study.

The sera of the patients were stored at (-80 C º) till the day of the analysis within (1-2 months). The sera samples were prepared for measurement by warming the frozen sera at room temperature.

2.3. Statistical Analysis

The SPSS 18.0 software was used for statistical analysis. Statistical significance was defined as $P<0.05$.

3. Results

3.1. Disease Effect

This study evaluate the atherosclerosis effect on the serum

level of focused parameters by comparing between patients and control groups, (Table 1) shows the general characteristic of the patients group while, (Table 2) shows that, there were a significant reduction in the serum level of Rb and B while, there was a significant elevation in the serum level of Rh in patients group as compared with the control group (Rb, Rh, B, p< 0.001), and there was no significant difference between studied group regarding Cs (p=0.105).

Table 1: *Characteristic of the patients group.*

		AGE	Rb	Cs	Rh	B
N	Valid	40	40	40	40	40
	Missing	0	0	0	0	0
Mean		52.40	23.0655	.4648	46.2983	22.60
Std. Error of Mean		1.598	.70044	.01520	1.58056	.866
Median		52.00	21.4950	.4600	48.1950	21.50
Std. Deviation		10.109	4.43000	.09613	9.99633	5.476
Minimum		37	15.20	.28	26.18	12
Maximum		71	33.13	.68	63.08	35
Percentiles	25	44.25	19.6325	.3950	38.6625	18.25
	50	52.00	21.4950	.4600	48.1950	21.50
	75	60.75	26.1800	.5200	53.0600	28.00
		Frequency	Percent	Valid Percent	Cumulative Percent	
Valid	Male	15	37.5	37.5	37.5	
	Female	25	62.5	62.5	100.0	
	Total	40	100.0	100.0		

Table 2: *Comparison between patients and control groups regarding the focused parameters.*

Trace element	N	Mean	±SD	Control group	±SD	p
Rb	40	23.066	4.430	37	2.150	< 0.001
Cs	40	.465	.096	0.49	0.011	.105
Rh	40	46.298	9.996	28	1.581	< 0.001
B	40	22.600	5.476	43	2.866	< 0.001

3.2. Age –Effect

Table 3: *Comparison between different age categories regarding the focused parameters.*

	Age groups	N	Mean	SD	p
Rb	< 40	6	25.322	4.869	.265
	40-49	9	23.550	3.124	
	50-59	13	21.238	4.598	
	60+	12	23.553	4.633	
	Total	40	23.066	4.430	
Cs	< 40	6	.427	.117	.575
	40-49	9	.460	.081	
	50-59	13	.459	.069	
	60+	12	.493	.122	
	Total	40	.465	.096	
Rh	< 40	6	49.788	5.480	.254
	40-49	9	49.408	6.119	
	50-59	13	46.735	10.991	
	60+	12	41.748	12.010	
	Total	40	46.298	9.996	
B	< 40	6	23.000	6.419	.784
	40-49	9	22.444	4.773	
	50-59	13	21.462	5.502	
	60+	12	23.750	5.910	
	Total	40	22.600	5.476	

The patients group divided into different age categories, this table shows that there were no significant differences between different age categories regarding the focused parameters (Table 3). Accordingly, there was no age effect on the serum levels of the focused parameters.

3.3. Gender Effect

This study demonstrated that there was no gender effect. (Table 4) shows that there were no significant differences between men and women regarding the focused parameter.

Table 4: *Comparison between men and women regarding the focused parameters.*

	GENDER	N	Mean	SD	SE	p
AGE	Female	25	50.240	10.670	2.134	.081
	Male	15	56.000	8.203	2.118	
Rb	Female	25	23.236	4.635	.927	.758
	Male	15	22.782	4.208	1.087	
Cs	Female	25	.458	.100	.020	.551
	Male	15	.477	.092	.024	
Rh	Female	25	47.733	8.213	1.643	.298
	Male	15	43.907	12.366	3.193	
B	Female	25	23.760	5.840	1.168	.084
	Male	15	20.667	4.320	1.116	

3.4. Correlation Coefficient

This study investigate the correlation coefficient between all studied parameters, (Table 5) shows that, there were no significant correlations between focused parameters, except that, there was a significant weak negative correlation between age and Rb (r=-0.38, p=0.016).

Table 5: *Correlation coefficient between all focused parameters.*

		AGE	Rb	Cs	Rh	B
AGE	Pearson Correlation	1	-.075	.296	-.380*	.071
	Sig. (2-tailed)		.645	.064	.016	.665
	N	40	40	40	40	40
Rb	Pearson Correlation	-.075	1	.008	.043	.227
	Sig. (2-tailed)	.645		.963	.794	.159
	N	40	40	40	40	40
Cs	Pearson Correlation	.296	.008	1	-.220	-.033
	Sig. (2-tailed)	.064	.963		.173	.838
	N	40	40	40	40	40
Rh	Pearson Correlation	-.380*	.043	-.220	1	.019
	Sig. (2-tailed)	.016	.794	.173		.909
	N	40	40	40	40	40
B	Pearson Correlation	.071	.227	-.033	.019	1
	Sig. (2-tailed)	.665	.159	.838	.909	
	N	40	40	40	40	40

4. Discussion

4.1. General View

It is emphasized that boron, cesium, rhenium and rubidium have the potential roles for assessment risk factor, early detection, diagnosis, prognosis, and prevention of atherosclerosis.

The possible relationship between trace element (B,Cs,Re and Rb) serum levels and atherosclerosis was studied on the basis of indications in the literatures that TEs may be directly or indirectly involved in cardiovascular disease processes including atherosclerosis.

This study is an attempt to look for the diagnostic and prognostic importance of serum TEs levels in patients with atherosclerosis. So, This data have been used for investigating the possible relation between variation in TEs concentrations and the degree of atherosclerosis.

4.2. Effect of Atherosclerosis of the Serum Levels of Focused Parameters

4.2.1. Boron

Boron may help to protect against atherosclerosis [9] which was in harmony with the current result that, there was a significant reduction in the serum level of boron in patients with atherosclerosis as compared with the control group (Table 2).

It is thought that the average person would not come in contact with enough boron lead to cause negative health effects, this suggestion was supported the current finding that, the serum levels of boron was significantly decreased in patients with atherosclerosis as compared with the control group (Table2).

Boron supplementation was found to augment estrogen function and therefore may help prevent atherosclerosis, reduce HDL cholesterol. In addition, [9] reported that, the elevation of endogenous estrogen as a result of supplementation suggests a protective role for B in atherosclerosis.

The explanation for the association of decreased serum level of boron with atherosclerosis that boron play a role in blood pressure regulation due to its relationship to calcium metabolism. Abnormal calcium metabolism may lead to plaque formation on the artery wall, which attributes to atherosclerosis. Boron has also been found to increase steroid hormone concentrations in postmenopausal women [7] and to have antioxidant properties [19], which could make it beneficial in preventing atherosclerosis.

Boron may also lower the level of oxidative damage, which is accomplished by decreasing the production of NADPH and the activity of γ-glutamyl transpeptidase [10]. This action could possibly increase the amount of glutathione (GSH) in the body [10], which plays a role in protecting cells from toxic oxygen radicals [20].

Dietary boron may play a role in lowering plasma lipid levels, boron-containing drugs may be of therapeutic benefit to atherosclerosis, because the compounds promoted cholesterol removal from tissues and decreased lipid accumulation [21].

4.2.2. Cesium

There was a no significant difference in the serum level of Cs in patients with atherosclerosis as compared with the control group (Table 2). There was a reduction in the serum level of Cs in patients group but it did not reach the significant result (0.465± 0.096 vs 0.49±0.011, p= 0.105), this unexpected result may be due to small number of studied population. Cesium is an alkali metal, increase the alkalinity of the body and increase oxygen flow. Low oxygen environments contribute to disease incidence. With alkalinity and more oxygen in the body, the probability of disease prevalence is decreased.

There were no any previous researches dealing with the relation of atherosclerosis with the serum levels of Cs. So, this research was the first attempt dealing with the variation in the serum level of Cs in atherosclerotic patients as compared with control group.

Little is known about the association of the cesium with the pathogenesis of atherosclerosis, so further studied are needed for clarification.

4.2.3. Rhenium

There was a significant elevation in the serum level of Re in patients with atherosclerosis as compared with the control group (Table 2).

The scientific researches were carefully reviewed and detected that there were no any previous results dealing with the association of atherosclerosis with the serum levelof Re, accordingly, this research was the first study dealing with the change in the serum level of Re in atherosclerotic patients as compared with control group.

The exact explanation for the significant elevation in the serum level of Re was not clear and need further studies to explain this clinical correlation between serum levels of Re with atherosclerosis.

4.2.4. Rubidium

There was a significant reduction in the serum level of Rb in patients with atherosclerosis as compared with the control

group (Table 2).

It is an alkaline element, increase the alkalinity of the body and increase oxygen flow. Anaerobic (low oxygen) environments can contribute to disease incidence. With less acid and more oxygen in the body, the probability of disease incidence is reduced. This fact is compatible with the current result significant reduction in the serum level of Rb level could contribute to atherosclerosis.

These variations in the serum level of focused parameters may provide a good chance to the physician to detect individuals who are at high risk for developing atherosclerosis and correcting these variations of these elements.

The variation of TEs in sera of patients with atherosclerosis can enable us to fox and shade more light on the role of TEs in physiological and pathological conditions. This findings proved the possible relation between the imbalance of the serum levels of focused parameters with atherosclerosis.

The scientific researches were carefully reviewed and detected that there were no any previous results dealing with the association of atherosclerosis with the serum levels of Rb, accordingly, this research was the first study dealing with the change in the serum level of Rb in patients with atherosclerosis as compared with control group.

It could be suggested that the imbalance of focused TEs might be used as complementary non-invasive biomarkers for early investigation and therapy of atherosclerosis.

The mechanisms by which particular elements or their compounds may affect atherosclerosis risk are not clear, but it is likely that they involve effects on enzymes, hormones, and messenger molecules.

It was observed that, more than 27% of known enzymes contain mineral elements and/or require minerals for activity[22].

Trace elements are important catalysts for many biological processes, most of them still unknown.

4.3. Age Effect

The mean age of the patients at the diagnosis was 52.4 (Table 1), this finding was in harmony with the fact that advanced age is risk factor for atherosclerosis incidence.

Atherosclerosis is typically associated with men in their 40s and women in their 50s to 60s due to postmenopausal estrogen deficiency [1]. These findings were concordant with the current data the average age of women atherosclerotic patients was (37-71), while the average age in men was (41-70).

In addition, (Table 3) demonstrated that, there was no age effect on the serum levels of the focused parameters.

4.4. Gender Effect

In the current study the 62.5% was female. and 37.5% was male (Table 1), this result was not concordant with previous result [1] who reported that male gender is a risk factor for atherosclerosis, the explanation of this unexpected finding might be due to small number of studied population in the current study.

4.5. Correlation Coefficient

This study investigated the correlation coefficient between all studied parameters, (Table 5) shows that, there were no significant correlations between focused parameters, except that, there was a significant weak negative correlation between age and Rb (r=- 0.38, p=0.016).

5. Conclusion

There were significant reduction in the serum levels of B and Rb and there was a significant elevation in the serum level of Re while, there was a reduction in the in the serum level of Cs but did not reach the significant reduction.

In summary, our finding suggests a possible link between serum boron, cesium, rhenium and rubidium levels and atherosclerosis as a biomarker for risk assessment of atherosclerosis.

Serum levels of B, Cs, Rb and Re appear to be associated with the pathogenesis of atherosclerosis in Iraqi patients.

Further studies are necessary to confirm these findings.

Abbreviations

B: Boron; Ca: Calcium; Cs: Cesium; DHEA: Dehydroepiandrosterone; HDL: High density lipoprotein; K: Potassium; LDL: Low density lipoprorein; Mg: Magnesium; Mn: Manganese; OP: Osteoporosis; RBC: Red blood corpuscle; Rb: Rubidium; Re: Rhenium; TE: Trace element; VLDL: Very low density lipoprorein; WBC: White blood cell

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