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Investigating the Relationship Between Hardness of Drinking-Water and Severity of Coronary Artery Disease Based on Angiographic Findings in East Azerbaijan Province, Iran

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Abstract

Objectives: Cardiovascular diseases (CVDs) are a major cause of hospital admission and the main reason for mortality in the world, which are triggered by both genetic and environmental factors. In addition, minerals and trace elements have long been considered potential risk factors for CVD among which calcium and magnesium may play a significant role. Accordingly, the present study aimed to assess the relationship between coronary atherosclerotic diseases and hardness of drinking-water in the residence of patients admitted to Shahid Madani hospital in Tabriz.

Materials and Methods: The population of the study included 780 patients undergoing coronary angiography out of whom 547 cases were entered into this case-control study. The subjects were then divided into 5 groups based on the severity of coronary artery involvement: with the least or no involvement (control group), one artery involved (group 1), 2 arteries involved (group 2), 3 arteries involved (group 3), and severe diffuse involvement of all coronary arteries (group 4). Residences of the patients were located from their medical history and then 200-mL of drinking-water samples were then taken from each area in plastic containers. Next, the levels of calcium and magnesium were measured using the EDTA method. Finally, the samples were divided into 4 groups based on the hardness of water.

Results: The mean age of the participants was 59.7 years and the most frequent type of water in the residential areas was the soft water. Further, the highest frequency related to the severity of atherosclerosis belonged to groups 4 and 3, respectively. Based on the results, no significant relationship was found either between the severity of atherosclerosis and calcium level of water or the severity of atherosclerosis and magnesium level of water.

Conclusions: In general, the results revealed that there was no significant relationship between the levels of calcium and magnesium in the drinking water of the patients residing in East Azerbaijan province and their severity of atherosclerosis. The findings further suggest that the drinking water of the province can be divided into hard and soft water and the severity of atherosclerosis of the patients is independent of the hardness of the drinking water in their residences.

Keywords: Calcium, Magnesium, Hardness of drinking-water, Atherosclerosis

Introduction

Cardiovascular diseases (CVDs) are considered one of the main causes of hospital admissions and mortality worldwide. These diseases are multifactorial and are caused by both genetic and environmental factors (1). Despite the lack of precise information regarding mortality, there is ample evidence indicating an increasing prevalence of coronary artery disease (CAD) in Iran similar to other parts of the Middle East. The principal cause of CAD is atherosclerosis which is a progressive disease characterized by the accumulation of fibers and elements such as calcium in the arteries. One of the early incidents in the pathogenesis of atherosclerosis is the oxidation of low-density lipoprotein (LDL) which leads to modified LDL recognized and swallowed by scavenger macrophage receptors (1). This generates fat-laden foam cells which contribute to the formation of atherosclerotic lesions. In addition, the progress of atherosclerosis depends on the balance between inflammatory and anti-inflammatory stimulations, as well as the antioxidant defense mechanisms. Epidemiologic research on CVDs demonstrated numerous risk factors some of which are non-modifiable (e.g., age, gender, and genetics) while the others including the environmental factors are modifiable and can be reduced to decrease the risk of developing coronary diseases (2).

Although hypertension, smoking, and lipid disorders are thought to be the main risk factors of CAD, they alone

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cannot account for the high prevalence of such diseases, thus making it necessary to identify other risk factors. Minerals and trace elements have long been considered potential risk factors of CVD among which calcium and magnesium may have an important role (3).

Further, the researchers believe that the genetic source of cardiac diseases should not be overlooked, especially in developed countries. However, the role of diet and its mineral contents particularly calcium and magnesium is undeniable in preventing the incidence and prevalence of the century disease (4).

Calcium and magnesium are 2 essential elements for human and their deficiency may lead to various CVD (5-9). Therefore, assessing the association between CVD and the amount of these 2 elements in a given environmental source can help reduce the incidence of such diseases if there is a relationship. The researchers sought to implement the current study considering that the residents of the East Azerbaijan province use drinking water of the area instead of the refined mineral water and since there is no comparable study in this regard. Accordingly, this study attempted to investigate the relationship between CAD and the hardness of drinking water in the residence of patients admitted to Shahid Madani hospital of Tabriz. Therefore, in case of a significant relationship, while underscoring the importance of drinks in cardiovascular health, proper solutions could be provided for the Iran Water Resources Management Organization to improve the quality of drinking water by replacing calcium and magnesium in order to reduce the risk of developing atherosclerosis.

Materials and Methods

The participants of the current case-control study included all the patients in East Azerbaijan Province who were suspected to have coronary diseases and thus underwent coronary angiography in Shahid Madani hospital of Tabriz during 2009-2011 and their angiography reports were present in their medical records. Exclusion criteria were patients who: died in the first 24 hours, from other provinces and countries, had immigrated to and resided in East Azerbaijan for less than 5 years; and patients younger than 40 years because of the high prevalence of genetic coronary disease.

The research process began following the approval and permission by the Research and Ethics Committees of Tabriz University of Medical Sciences. A total of 780 patients underwent coronary angiography during the process out of whom 233 were excluded because of either meeting or not meeting the exclusion or inclusion criteria, respectively.

Furthermore, the remaining 547 patients were categorized into 5 groups based on the severity of coronary artery involvement including the group with: the least or no involvement (control), one artery involved (group 1), 2 arteries involved (group 2), 3 arteries involved (group 3), and severe diffuse involvement of all coronary arteries (group 4).

Residences of the patients were located from their demographic information. Then, under the supervision of environmental health professionals, 200-mL samples of drinking water were taken from each area in plastic containers and the levels of calcium and magnesium were measured using the EDTA method. Next, the samples were divided into 4 groups based on the hardness of water including soft, semi-hard, hard, and very hard water. Finally, the data were analyzed in the SPSS software, version 16 using the chi-square and *t* test. The significance level was considered $P < 0.05$.

Results

A total of 547 patients who underwent coronary angiography participated in this study out of whom 406 (74.2%) cases had CAD and were placed in the case group while 141 (25.8%) patients had a normal angiogram and were included in the control group. As regards gender, 366 (66.26%) of the patients were males while 181 (33.74%) of them were females. The results demonstrated no significant difference between the 2 groups in terms of gender distribution (P=0.329).

Moreover, the mean age of the patients was 59.76 years with a maximum and minimum of 87 and 41 years. The mean age of the case and control groups was 59.89 and 59.36 years, respectively and the difference was found to be insignificant. Additionally, the amounts of calcium and magnesium and the overall hardness of the drinking water in the residential areas are presented in Table 1.

Based on the data in Table 1, the difference in the mean amounts of calcium, magnesium, and water hardness in the case (14.04, 10.01 and 58.22 mg/L, respectively) and control (13.26, 9.43 and 55.26 mg/L, respectively) groups was not significant.

The frequency of severity of coronary stenosis regarding of water hardness is shown in Table 2. The frequency of water hardness in residential area regarding of severity of coronary stenosis is shown in Table 3.

As shown in Table 4, the highest frequency in terms of the severity of coronary stenosis is observed in groups 4 and 3, respectively. In addition, examining the hardness of water yields the following frequencies for different groups. Further, the results of the relationship between the hardness of water and the severity of atherosclerosis are provided in Table 4. Based on the results, there is no significant relationship between the hardness of water and the severity atherosclerosis in the patients.

Discussion

The current study was conducted on 547 heart patients who were admitted to Shahid Madani hospital of Tabriz. Based on the aim of the study, the hardness of drinking water in the patients' residential areas was classified into soft and hard water. Nearly 67% of the patients were males

Table 1. The Amounts of Calcium and Magnesium and the Overall Hardness of Drinking Water in the Patients' Residential Areas

Town	Ca (mg/L)	Mg (mg/L)	Overall Hardness (mg/L)
Ahar	6	1.5	45
Bostan Abad	41	29	172
Bonab	48	34	187
Sarab	52	37	190
Shabestar	49	38	180
Kaleybar	8	4	47
Maragheh	9	5.4	35
Marand	10	5	43
Mianeh	12	6	45
Haris	9	6	38
Hashtroud	9	7	39
Azarshahr	8	5	29
Sardroud	7	4	27
Ajabshir	7	6	32
Gougan	7	5	30
Jolfa	7	6	29
Varzeghan	48	39	178
Tabriz	11	8	47
Oskou	7	7	31

Ca: Calcium; Mg: Magnesium.

Table 2. The Frequency of Severity of Coronary Stenosis in the Participants

Group	No.	Percent
Normal Group	141	25.8
Group 1	41	10.1
Group 2	82	20.2
Group 3	119	29.3
Group 4	164	40.4

Note. Group 1: With one artery involved; Group 2: With two arteries involved; Group 3: With three arteries involved; Group 4: With severe diffuse involvement of all coronary arteries.

Table 3. The Frequency of Different Groups Based on Water Hardness in Residential Areas

Type of Water	No.	Percent
Soft water	492	89.9
Hard water	55	10.1
Very hard water	0	0

Note. Soft water: Hardness range 0-75 mg/L in calcium carbonate; Moderately hard water: Hardness rang 75-100 mg/L in calcium carbonate; Hard water: 150-300 mg/L in calcium carbonate; Very hard water: Over 300 mg/L in calcium carbonate.

Table 4. The Distribution of Water Hardness Among the Patients

Severity of Atherosclerosis	Soft Water	Hard Water
Normal Group	129	12
Group 1	37	4
Group 2	71	11
Group 3	106	13
Group 4	149	15

Note. Group normal: With the least or no involvement.

suggesting that cardiac diseases are more prevalent among the male patients. Furthermore, the highest frequency of the severity of atherosclerosis was detected in group 4 with diffuse involvement of coronary arteries. However, no significant relationship was found between the amounts of calcium, magnesium and the hardness of drinking water and the severity of coronary stenosis.

Miyake et al (10) demonstrated that hardness of water and the amount of its calcium have no protective effect against mortality caused by CADs. Moreover, Rosenlund did not support the protective effect of hard water and its high calcium and magnesium levels against myocardial infarction (11). However, Yang et al reported a significant protective effect against the risk of death due to acute myocardial infarction by receiving calcium in drinking water (12). Conversely, Morris et al (13) argued that the hardness of water is not significantly associated with the prevalence of coronary diseases or mortality related to such diseases.

Additionally, Leurs et al examined the relationship between calcium and magnesium levels and hardness of drinking water and mortality rate resulted from the cardiac ischemic diseases and stroke and found no significant relationship (14). In addition, statistical analysis in the present study represented no meaningful association between the hardness of water and the severity of coronary stenosis in angiograms, which is in line with the findings of the above-mentioned study.

Based on the findings, although the levels of calcium and magnesium in drinking water were lower in the control group, no significant difference was observed between these levels in the control and case groups. This implies that the hardness of water is not correlated with the risk of developing atherosclerotic diseases. Further, despite the lower mean of water hardness in the control group, no significant difference was found between the 2 groups in terms of hardness which does not confirm the protective effect of hard water against the risk of developing atherosclerotic diseases.

However, Rubenowitz et al (15) reported that the amount of calcium and magnesium in drinking water was one of the most protective factors against mortality related to the myocardial infarction. These contradictory results may be attributed to different sampling methods. In the present study, the participants were selected without considering the angiographic findings and excluding the dead patients (at the first 24 hours) or those (378 patients) who died of MI. Furthermore, all the subjects of the above-mentioned study were females while those of the current study included nearly 33% of the cases.

Conversely, Bain et al collected highly hard water samples from cities of Ohio and by analyzing the pH, sulfate, bicarbonate, hardness, or calcium and magnesium of these samples, and found no relationship between hearing diseases and pH and hardness of the water in those areas. Such diseases were prevalent in areas with

sulfate-rich and low-bicarbonate water located on coal-bearing strata while they were not prevalent in areas with bicarbonate-rich and low-sulfate water located glacial deposits (16).

Sampling of drinking water from 48 regions in South Wales to identify the correlation between elements in water and CVDs, Elwood et al reported that the relationships between the elements were strong and complicated and it was only calcium which had a high correlation with mortality in those regions playing a negative role in mortality rate (17). Addition of other elements led to a slight increase in the correlation coefficient.

Considering the results obtained by Bain et al, the lack of a correlation between CVD and calcium and magnesium in the present study may be attributed to the presence of other ions in the water samples. Moreover, the findings of other researchers such as Kobayashi and Muss revealed that concentrations of sulfate ion were high in regions with high hardness of water and prevalence of CVD while those of the bicarbonate ion were high in regions with a low prevalence of such diseases. Nevertheless, despite the fact that sulfate and bicarbonate ions have controlling features in preventing the CVD, it was claimed that CVD is correlated with less used elements the presence of which may be controlled with the same features that control bicarbonate and sulfate ions (18, 19).

The regions of water sampling in the present study were located on limestone bedrocks (geological report of East Azerbaijan, 2004), therefore the presence of other ions in their water seems improbable. However, several mines surrounding these regions may have directed the run-offs to the water of the nearby regions and thus increased the concentration of some ions in the water. Finally, Yanick found no correlation between CVD and the presence of calcium and magnesium in the water of regions located on limestone bedrocks in Haiti (20).

Concerning the negative results of this study, it can be claimed that the hardness of water was considered to be similar in different urban areas, particularly Tabriz with the highest proportion of the patients while, in practice, it varied in different areas. Additionally, the classification of atherosclerosis severity was based on the number of arteries involved in angiography. However, more accurate and even different results were obtained if the scoring systems were used for the severity of coronary atherosclerosis.

Conclusions

In general, the results revealed that there was no significant relationship between the amounts of calcium and magnesium in drinking water of East Azerbaijan cities and the severity of atherosclerosis in patients. Finally, based on the findings, the severity of atherosclerosis among the patients was found to be independent of the hardness of drinking water in their residential areas.

Suggestions for Further Research

Future research should take into account more influential matched factors including employment conditions, body mass index, and the amounts of personal activities. In addition, water sampling is suggested to be adapted in different areas of a given city. Eventually, and scoring systems are recommended to be used for defining the severity of atherosclerosis.

Further, larger sample size from different parts of the country may provide a clearer picture of the impact of calcium and magnesium of drinking water on the severity of atherosclerosis and address other sources of calcium and magnesium such as diet.

Limitations of the Study

Although cases who immigrated or had a history of frequent travels were excluded from the study, the study failed to investigate the possibility of changing the concentration of calcium or magnesium in drinking water across the studied city at an earlier time. Furthermore, the effect of other available solutes was not investigated.

Conflict of Interests

The authors declare that there is no conflict of interests.

Ethical Issues

Written informed consent was obtained from the patients for publication of this study. In addition, the study was approved by the Local Ethics Committee of Tabriz University of Medical Sciences under the Ethical code of IR.TBZMED.REC.1393.5.4.10674.

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