Original Article

Study of the Levels of Trace and Ultra-Trace Element Profile in Patients with Acute Myocardial Infarction in Babylon Province

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Abstract

Background: Acute myocardial infarction (AMI) is considered one of the most threatening cardiovascular diseases, also called a heart attack, which occurs when there is a blockage in the blood flow to the heart muscle. **Objectives:** The aim of this study was to investigate the levels of trace and ultra-trace element profiles in patients with acute myocardial infarction. **Materials and Methods:** This study involved 100 patients with AMI. The study also included a control group (CG) of 100 participants. The period of the study extended from August 2022 to August 2023. The study was conducted within Iraq, specifically at the Department of Biochemistry within the College of Medicine, University of Babylon, and at Shaheed al-Muhrab Center situated in Marjan Teaching Hospital within Hilla City, Iraq. Determination of trace and ultra-trace elements was done by using a fully automated Shimadzu AA-7000 series of atomic absorption spectrophotometers. **Results:** Results indicate higher levels of some elements, copper, iron, and nickel, in the AMI group, and lower levels of other elements, such as zinc and selenium, in the patient group when compared to the control group. **Conclusion:** Abnormal levels of trace elements like zinc, copper, iron, selenium, and nickel have been observed in myocardial infarction patients. These imbalances may contribute to oxidative stress, inflammation, and altered metabolic processes, potentially influencing the development and progression of heart attacks. Further research is needed to clarify their specific roles and therapeutic implications.

Keywords: Copper, myocardial infarction, selenium, zinc

Introduction

An acute myocardial infarction (AMI), commonly referred to as a heart attack, is a medical emergency that occurs when there is a sudden and severe reduction or blockage of blood flow to a portion of the heart muscle. This typically happens due to the formation of a blood clot in one of the coronary arteries, which are responsible for supplying oxygen-rich blood to the heart.[1] The blockage results in a lack of oxygen and nutrients to the affected part of the heart, causing tissue damage or death. Symptoms of an acute myocardial infarction can include chest pain or discomfort, which may radiate to the left arm, shoulder, jaw, or back, as well as shortness of breath, sweating, nausea, and lightheadedness. Prompt medical attention is crucial when someone is experiencing these symptoms as quick intervention can help minimize heart muscle damage and improve the chances of survival.[2]

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Treatment for acute myocardial infarction often involves medications to dissolve or prevent blood clots, procedures like angioplasty and stent placement to open blocked arteries, and lifestyle changes to reduce the risk of future heart problems.[3]

Selenium, a trace element, is vital for human health in small quantities. It functions as an antioxidant, aiding in DNA repair and protecting against oxidative stress when obtained through a balanced diet. Some studies suggest that selenium deficiency may be associated with an increased risk of cardiovascular diseases, including heart attacks.[4]

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Iron, a trace element, is crucial for human health. It plays a pivotal role in hemoglobin, transporting oxygen in red blood cells, and in cellular metabolism. While iron deficiency can lead to anemia and decreased oxygen-carrying capacity, excessive iron levels can contribute to oxidative stress and may have some indirect impact on cardiovascular health.[5]

Copper, a trace element, is essential for human health. It supports enzymatic activity, including antioxidant defense and connective tissue formation. Adequate copper intake is vital, but excess levels can be toxic and lead to health problems. It is not directly linked to heart attacks, but maintaining proper copper levels as part of a balanced diet is essential for overall health.[6]

Zinc is a vital trace element for the human body. It supports immune function, DNA synthesis, and wound healing and plays a role in taste and smell. Zinc deficiency can lead to growth retardation, weakened immunity, and various health issues, highlighting its importance in maintaining overall health.[7]

Cobalt is an ultra-trace element that is essential for the human body in the form of cobalamin, also known as vitamin B12. Vitamin B12 is crucial for the production of red blood cells, DNA synthesis, and proper nerve function. Cobalt deficiency can lead to anemia and neurological problems, highlighting its importance in maintaining human health.[8]

Boron is a trace element that may play a role in human health, although it is not considered essential. Some studies suggest it may help support bone health, brain function, and hormonal balance.[9]

In the context of AMI, certain trace elements like zinc, selenium, and copper have been studied for their potential impact on cardiovascular health. These elements can influence oxidative stress, inflammation, and antioxidant defense mechanisms, which are relevant factors in heart health and AMI risk.[10] A previous study done by Shi *et al.* 2020 concludes various potential trace elements that modulate peroxisome proliferator-activated receptor (PPAR) expression and activity. PPARs, members of the nuclear receptor superfamily and transcriptional factors, may serve as effective molecular targets of trace elements in the treatment of AMI. The nuclear location and epigenetic modification of PPARs play mainstream roles in their transcriptional function.[11]

Materials and Methods

Study design and patients

This case–control study was carried out in Iraq, at the Department of Biochemistry in the College of Medicine at the University of Babylon, as well as Shaheed al-Muhrab Center at Marjan Teaching Hospital in Hilla City, Iraq, during the period extending from August 2022 to August 2023. In this study, 100 patients with AMI were included; additionally, 100 apparently healthy participants were included as the control group.

Inclusion and exclusion criteria

Inclusion criteria included all the patients with AMI diagnosed by ECG and a positive troponin test. Exclusion criteria included patients with other coronary artery syndromes, such as angina pectoris.

Determination of selenium, cobalt, and boron contents

Determination was done by using graphite furnace atomic absorption spectrophotometer, Shimadzu/Japan.

Determination of zinc, copper, and iron contents

Determination was done by using Abbott Architect Hcy, a two-stage immunoassay for quantitative identification of Hcy (Abbott Diagnostics, United States).

Statistical analysis

The statistical software for the Statistical Package for the Social Sciences (SPSS) version 26.0 (SPSS, IBM Company, Chicago, IL 60606, USA) was used for the description, analysis, and display of the data.

Ethical approval

The study was conducted in compliance with ethical principles based on the Declaration of Helsinki. Patients provided both verbal and written consent before the sample was taken. The study protocol and the subject information was reviewed and approved by a local Ethics Committee at the College of Medicine, University of Babylon.

Results

In this study, zinc, iron, selenium, and cobalt contents were significantly lower in AMI patient groups compared with normal subjects (control group) P value < 0.001, < 0.01, < 0.05 and < 0.01 respectively, as shown in Table 1 and Figure 1.

Table 1: The mean ±SD of zinc, selenium, and cobalt in AMI compared to the control group

Parameter	AMI	Control	P value
Zinc (μg/dL)	40.5 ± 7.1	80.1 ± 11.2	***< 0.001
Selenium (μg/L)	15.6 ± 2.8	20.3 ± 4.6	**< 0.01
Cobalt (μg/L)	0.4 ± 0.04	1.1 ± 0.2	*< 0.05
Iron (μg/L)	44.1 ± 5.5	78.3 ± 8.5	**< 0.01

*significant at $P \leq 0.05$

**significant at $P \leq 0.01$

***High significant at $P \leq 0.001$

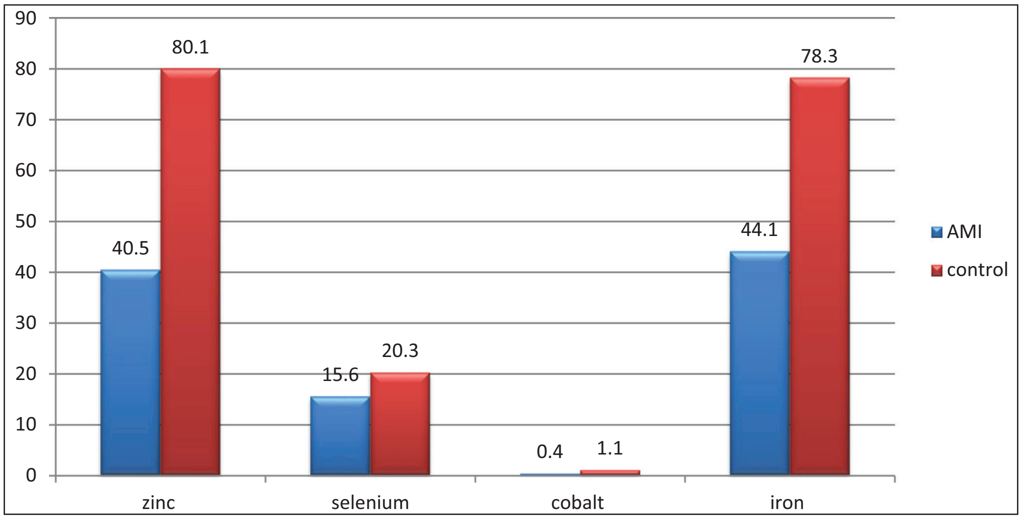

Figure 1: Explanation of the varying levels of zinc, selenium, iron, and cobalt in the study groups

Table 2: The mean ±SD of zinc, selenium, and cobalt in AMI compared to the control group

Parameter	AMI	Control	P value
Copper (μg/dL)	24.3 ± 5.1	7.1 ± 2.3	***< 0.001
Boron (μg/L)	0.91 ± 0.02	0.23 ± 0.02	**< 0.01

**significant at $P \leq 0.01$

***High significant at $P \leq 0.001$

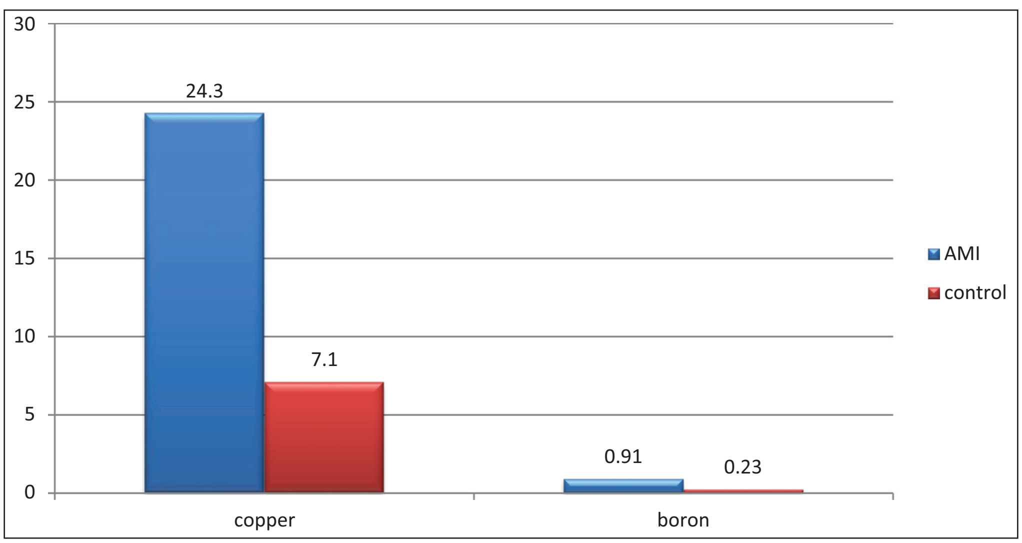

Figure 2: Explanation of the varying levels of copper and boron in the study groups

In this study, copper and boron contents were significantly higher in the AMI patient groups compared with normal subjects (control group) P value < 0.001 as shown in Table 2 and Figure 2.

Discussion

The current study found low levels of zinc in AMI patients when compared to the control group. One important meta-analysis study conducted by Liu *et al.* that included 41 case–controls concluded that there is a significant association between Zn deficiency and AMI.[12] Some studies have suggested that zinc supplementation may have a positive impact on lipid profiles, including reducing LDL cholesterol and increasing HDL cholesterol. Improving lipid profiles can reduce the risk of atherosclerosis, a condition that can lead to AMI.[13] Zinc deficiency can lead to oxidative stress through several mechanisms, primarily related to its role in antioxidant defense and redox regulation within cells. Zinc is a cofactor for several antioxidant enzymes, including superoxide dismutase (SOD), glutathione peroxidase, and catalase. These enzymes play a crucial role in neutralizing reactive oxygen species (ROS) and preventing oxidative damage. In the absence of sufficient zinc levels, the activity of these enzymes can be impaired, leading to an accumulation of reactive oxygen species and oxidative stress.[14]

The current study also found low levels of selenium in AMI patients when compared to the control group. Decreased levels of selenium may negatively impact redox regulation, thyroid hormone metabolism, and calcium flux while increasing atherogenesis and oxidative stress.[15]

Additional reports suggest a role of microRNAs (miRNAs) during selenium deficiency in sustaining cardiovascular function.[16] Selenium has been shown to prevent lipid peroxidation of biological membranes via scavenging free radicals that are constantly produced in the human body through glutathione peroxidase (GPX). This process can protect the normal structure and physiological functions of cells. A decrease in selenium levels is observed in the body.[17]

It is known that cobalt in ruminants is an essential component for the microbial synthesis of vitamin B12, a water-soluble vitamin belonging to group B, commonly known as cobalamin, cyanocobalamin, or also called the pernicious anti-anemia factor.[18]It is obvious that defects in the cobalt element lead to vitamin B12 deficiency. A previous study conducted by Qin *et al.* suggested that high doses of vitamin B12 supplements improved myocardial injury by suppressing the accumulation of reactive oxygen species and apoptosis of the myocardial tissue through modulation of the SIRT3/AMPK signaling pathway while reducing inflammation.[19]

In this study, iron levels were also found to be lower in AMI patients compared to the control. This result was compatible with that of the study conducted by several authors worldwide who found decreased levels of iron in different types of AMI.[20-22] Dysregulated iron intake or output can cause illness. Iron is involved in the pathogenesis of atherosclerotic coronary heart disease. Iron plays a cardinal role in cellular metabolism and energy production by participating in the formation of vital mitochondrial proteins. Iron is incorporated in hemoproteins and in Fe–S cluster proteins, which mediate mitochondrial oxidative phosphorylation, a process that yields ATP. Given that cardiomyocytes have high energy demands,[23] iron deficiency is frequently observed in patients with acute coronary syndrome and is associated with poor prognosis after acute myocardial infarction (AMI). Anemia is linked to dysregulation of iron metabolism, red blood cell dysfunction, and increased reactive oxygen species generation[24]

In this study, a higher level of copper was found in AMI patients. Copper-induced angiogenesis thus reconstructs the conduit for the transduction of tissue injury signaling, recruitment of tissue repair materials such as stem cells, and the homing of stem cells, leading to the promotion of myocardial regeneration. Thus, copper promotes myocardial regeneration through the reactivation of HIF-1-regulated angiogenesis. This would constitute an alternative therapeutic approach to ischemic heart disease.[25]

The results of this study revealed higher levels of boron and iron in AMI patients when compared to the control group. Boron is thought to aid in the metabolism of calcium and magnesium, which are important for maintaining strong bones. Healthy bones are indirectly linked to heart health because they protect the heart and other vital organs. High levels of boron may alter blood pressure hemostasis and disrupt hormone secretion, increasing the risk for AMI.[26]

Conclusion

Abnormal levels of trace elements like zinc, copper, iron, selenium, cobalt, and boron have been observed in myocardial infarction patients. These imbalances may contribute to oxidative stress, inflammation, and altered metabolic processes, potentially influencing the development and progression of heart attacks. Further research is needed to clarify their specific roles and therapeutic implications.

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Conflict of interest

There are no conflicts of interest.

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