



# **New Insight of Methylenetetrahydrofolate Reductase (MTHFR) C677T Gene Polymorphisms, and Serum Electrolytes in Cardiac Syndrome X Patients**

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## **Authors' contributions**

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## **ABSTRACT**

**Background:** Cardiac Syndrome X (CSX) is a condition affecting the cardiovascular system with a significant degree of morbidity. Diagnosis and treatment are challenging when the cause is unclear. Subsequently, a molecular marker for screening of people with CSX is highly recommended. The present study evaluated the association between MTHFR C677T gene polymorphism among Sudanese patients with CSX.

**Materials and Methods:** A total of 100 subjects were enrolled. Venous blood sample was collected from each participant in Ethylene Diamine Tetracetic Acid (EDTA) containers. DNA was extracted from blood samples using guanidine chloride method and MTHFR mutation was detected by PCR-restriction fragment polymorphism (PCR-RFLP). Statistical package for social sciences (SPSS) was used to analyze data.

**Results:** Most patients 30(60%) were females, their age ranged between 30-60 with mean age 44.98±7.34 SD. MTHFR 677CT genotype frequency was statistically significant ( $P \leq 0.014$ ), where 10(20%) had 677CT and 1(2%) had 677TT among patients group respectively compared to control

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individuals who had only 2(4%) 677CT. T alleles were significantly more frequent among our participant than C alleles. There is insignificant slightly decreased ( $2.4 \pm 2.8$ , and  $2.5 \pm 3.2$ ) in serum magnesium levels among patients compared to control respectively, as well as random blood glucose. Elevated mean levels of total cholesterol, and HDL among patients ( $182 \pm 18.1$ , and  $49.7 \pm 7.1$ ) vs ( $180 \pm 20.3$ , and  $46.6 \pm 11.3$ ) among control group, all findings were statistically non-significant. Slightly decrease in magnesium level ( $2.2 \pm 2.1$ , vs  $2.9 \pm 0.8$ ) among heterozygous CT genotypes compared to homozygous genotypes.

**Conclusion:** MTHFR C677T is linked to CSX in the Sudanese population, and serum magnesium level was slightly decreased among heterozygous MTHFR C677T. Furthermore, the mutation could be used as a disease molecular screening technique.

**Keywords:** MTHFR 677CT; Cardiac Syndrome X; gene polymorphisms.

## 1. INTRODUCTION

A general definition of Cardiac syndrome X (CSX) highlights the triad of cardiac pain, a normal coronary angiogram with a positive stress testing [1]. A more restricted definition adds ST-segment depression during angina, absence of spontaneous or inducible epicardial coronary artery spasm upon acetylcholine provocation, and absence of cardiac or systemic diseases [2]. Cardiac syndrome X accounts for 20-30% of patients undergoing coronary angiography [3,4]. The disease is more common in women than men, furthermore, it is more common pre-menopausal and postmenopausal women pointing to a possible hormonal contribution [5]. The etiology of the disease is not clearly understood. However, some theories have been proposed. The most common theory is that cardiac syndrome X is due to endothelial dysfunction [6]. A properly functioning endothelium necessitates a balance between vasoconstrictors such as endothelin-1, and vasodilators, such as nitric oxide (NO). therefore, an imbalance may result in vasoconstriction of the vessels, leukocyte adherence, plaque activation, mitogenesis, and increases in the oxidative state, thrombosis, activation of coagulation, vascular inflammation, and atherosclerosis [7,8]. Increased resistance to coronary flow is also incriminated in the pathogenesis of endothelial dysfunction [9,10]. MTHFR is a 77 kDa flavoprotein involved in folate metabolism. It is essential for the conversion of homocysteine to methionine. Hence enzyme deficiency may be associated with the accumulation of elevated levels of homocysteine in the blood (hyperhomocysteinemia). The gene is present at position 1p36.3 on chromosome 1 [11]. As polymorphism may be associated with reduced enzyme activity, MTHFR 677 C-T can cause hyperhomocysteinemia [12]. A point mutation at

position 677 of the gene, at which cytosine (C) changes into a thymine (T); is responsible for the replacement of alanine with valine (2, 8). This from of the enzyme is considered as thermolabile [13]. Thus, MTHFR activity is greatly reduced among C677T homozygotes (2). Heterozygotes are in the intermediate range. People who are homozygous for the C677T allele tend to have mildly increased blood homocysteine levels if their folate intake is insufficient but normal blood levels if their folate intake is adequate [14,15]. The frequency of Methylene tetrahydrofolate reductase 677C-T mutation (MTHFR C677T) is low in Africa (6.6%) compared with Europe and Asia [16]. The current study evaluated the association between MTHFR C677T and cardiac syndrome among Sudanese patients.

## 2. MATERIALS AND METHODS

The study was carried out among Sudanese patients attending outpatients' clinics at Al-shaab hospital, Khartoum Sudan by typical symptoms of CSX. pre-structured questionnaire was used for collection of baseline and clinical data. A total of fifty patients with a confirmed diagnosis with CSX were recruited during the study period using nonprobability sampling technique. Any subjects have had coronary heart disease, heart valve diseases, congestive heart failure, current infectious diseases, and malignancy were excluded from the study.

A total of 10 ml of venous blood were collected from each subject. For DNA extraction and molecular analysis, a total of 6 ml of blood was contained in Ethylene Diamine Tetracetic Acid (EDTA) tubes and stored at  $-20^{\circ}\text{C}$ . Another four milliliters of blood were collected in a plain tube and centrifuged for measurement of serum electrolytes, renal and liver functions. Magnesium was measured using the calmagite

method. hypomagnesaemia was considered when serum magnesium was less than 1.6 mg/dl. Lipid profile, random blood glucose, and serum creatinine were calculated using standard procedures.

DNA was extracted using guanidine chloride method. DNA was amplified by polymerase chain reaction using Taq DNA polymerase and suitable primers. GeneAmp PCR kit (Perkin-Elmer Cetus) was used to perform PCR using the sequences 5'-TGAAGGAGAAGGTGTCTGCGGGA-3' and 5'-AGGACGGTGC GG TGAGAGTG-3', as sense and antisense primers, respectively. The 198-bp amplified fragments were cut with *Hinf*I endonuclease, which identifies C-T substitution. Accordingly, the 198-bp fragment derived from the mutated allele was digested by *Hinf*I into 175- and 23- bp fragments. The *Hinf*I-treated fragments were electrophoresed in polyacrylamide gels and stained with ethidium bromide. The wild type (CC) appeared as 198 bp band, TT as 175 bp band, and CT appeared as two bands (175 and 198 bp).

## 2.1 Statistical Analysis

SPSS version 20 was to analyze the results. Means were compared using Student t-test and frequencies were calculated using Chi-square test. A P-value equal to or less than 0.05 was considered significant.

## 3. RESULTS

About 100 subjects participates in the study, and categorized as two group: case group, and control group. Most patients 30(60%) were females, their age range between 30-60 years old with mean age  $44.98 \pm 7.34$  SD and

compared to  $40.38 \pm 5.21$  SD years for control group. MTHFR 677CT genotypes frequency was statistically significant (P value  $\leq 0.014$ ), where 10(20%) had 677CT and 1(2%) had 677TT among patients group respectively compared to control individuals who had only 2(4%) 677CT. moreover no 677CC genotypes was detected among both group. T alleles were significantly more frequent among our participant than C alleles. All data were illustrated in Table 1.

Table 2 displayed the mean levels of all measured mean level of magnesium and lipids profiles among cardiac syndrome X participants and control. There is slightly decreased ( $2.4 \pm 2.8$ , and  $2.5 \pm 3.2$ ) in magnesium level among patients compared to control respectively, as well as random blood glucose. Conversely there were elevated mean levels of total cholesterol, and HDL among patients ( $182 \pm 18.1$ , and  $49.7 \pm 7.1$ ) vs ( $180 \pm 20.3$ , and  $46.6 \pm 11.3$ ) mean level among control group, all findings were statistically non-significant.

Correlation between Single Nucleotides Polymorphisms (SNPs) and serum magnesium in patients with cardiac syndrome X were summarized in Table 3. There were slightly decrease in magnesium level ( $2.2 \pm 2.1$ , vs  $2.9 \pm 0.8$ ) among heterozygous CT genotypes compared to homozygous genotypes TT respectively, the result was statistically in significant difference (P value  $\leq 0.063$ ).

Fig. 1 show an Agarose Gel electrophoresis for MTHFR C677T after digestion with *Hinf*-I: Lane 1: 25-bp DNA marker, Lanes 3,6,12: (CC) genotype with one fragment 198 bp, Lanes 2,4,5: (TT) genotype with two fragments 175 and 23 (*faint*), Lanes 7-11,13-15: (CT) genotype with three fragments 198, 175 and 23 bp (*not shown*).

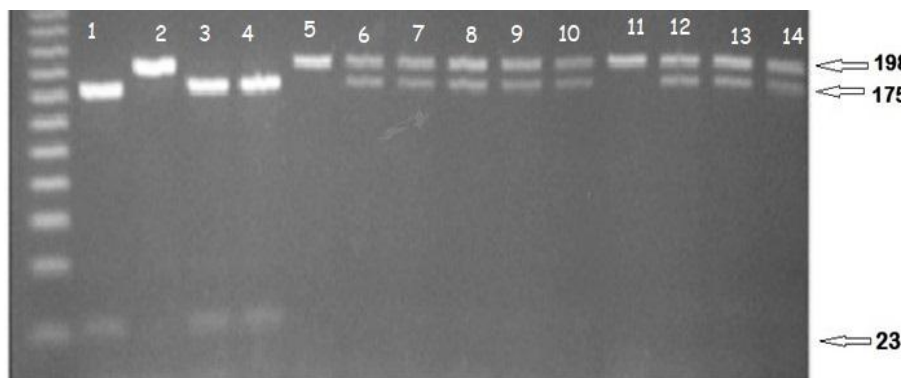


Fig. 1. Agarose Gel electrophoresis for MTHFR C677T

**Table 1. Frequency of MTHFR Single Nucleotide Polymorphisms (SNPs) among study subjects among**

	Patients N=50 (%)	Control group N=50 (%)	P-value
Sex			
Male	20 (40%)	23 (45%)	0.921
Female	30 (60%)	27 (54%)	
Age	44.9±8.0	40.3±8.4	0.06
677 CT	10 (20%)	2 (4%)	
677 TT	1 (2%)	0	0.014
677 CC	0	0	
Total	11 (22%)	2 (4%)	
C alleles	23 (45%)	0	0.013
T alleles	27 (54%)	1 (100%)	

**Table 2. Mean level of Magnesium and lipids profiles among cardiac syndrome X participants and control**

Variables	Patients N=50 (Mean ±SD)	Control group N=50 (Mean ±SD)	P-value
Magnesium mg/dl	2.4 ±2.8	2.5±3.2	0.150
RBG, mg/dl	129 ±39.5	141.3±34.5	0.100
Cholesterol, mg/dl	182 ±18.1	180 ±20.3	0.941
LDL, mg/dl	136.7 ±14.6	136.6 ±16.4	0.971
HDL, mg/dl	49.7±7.1	46.6 ±11.3	0.114
TAG, mg/dl	128.7 ±5	128.1±14	0.712
Urea, mg/dl	32.3±10.7	32.6±8.8	0.976
Creatinine, mg/dl	1.17 ±0.49	1.21±0.13	1.000

\*Data expressed as mean (SD) or N (%) as applicable

**Table 3. Correlation between Single Nucleotides Polymorphisms and serummagnesium in patients with cardiac syndrome X**

	MTHFR Genotypes		P-value
	CT Genotype	Wildtype	
Magnesium mg/dl	2.2 ±2.1	2.9 ±0.8	0.063
RBG, mg/dl	128±37.5	130 ±39.5	0.291
Cholesterol, mg/dl	180 ±13.1	199±11.4	0.050
LDL, mg/dl	136.4 ±4.6	138.7 ±10.6	0.073
HDL, mg/dl	48.3±4.1	44.5±6.8	0.032
TAG, mg/dl	129. 2 ±4	135 .1 ±3	0.743
Urea, mg/dl	29.3±8.5	30.3±9.7	0.912
Creatinine, mg/dl	1.04 ±0.40	1.18 ±0.46	0.123

#### 4. DISCUSSION

MTHFR C677T gene polymorphisms was associated with CSX, supporting data obtained from a study linking the enzyme activity to vascular disorders [16]. Current study revealed that there were statistically significant differences of MTHFR C677T genotypes between patients and control group. These results agreed with Gupta SK et al. [17].

The frequency of the heterozygous allele 677CT was 10(20%) in CSX patients which much higher than 1(2%) detected among the homozygous

allele 677 TT, strongly supported data obtained by Alroy S et al. [18], who find the correlation between the C677T mutation among CSX patients and control, and C677T mutation directly associated with endothelial cell dysfunction, and develop an innovative and affordable therapy for a subset of patients with syndrome X and the C677T mutant.

The low frequency of the homozygous allele TT and CC among CSX participants though it is unexplainable, and it appeared to be less associated with CSX among Sudanese population and had contrasted with what has

been proved that TT is associated with a 3-fold increase in risk for premature cardiovascular disease than CC/CT- corresponded to a report of a family in which two of four family members were affected. Their mother, homozygous for the mutation; was clinically normal. The father, being heterozygous for the polymorphism, exhibited clinical features of CSX. C677T polymorphism effect can be suppressed by addition of folate, which increases enzyme affinity for FAD [19].

This is similar to the globally documented data that conclude that, the occurrence of the wildtype varied from 5.4 percent to 16.0 percent among the control group and from 6.5 percent to 29.7 percent among patients. In all of the investigations, the patterns of genetic background and allele frequencies in the patient and control groups were nearly identical [20].

Regarding allele frequency, T allele was significantly associated with CSX (P value $\leq$ 0.013), and surprisingly it consistent with that noted with T allele was determined to be the contributing allele for CAD and was likely linked to CAD worse [21].

With regard gender, the majority of participants (60%) were females, these findings were agreed with the assumption that CSX is middle-aged women's disease and that it is relatively rare among the age extremities. The same conclusion was documented by Kandaz C, et al. [19] who stated that the majority of female patients in our study group was substantially higher than the control group (P.05), indicating that CSX is more frequent in women. Numerous studies found an association between MTHFR polymorphism and premature CAD and myocardial infarction (MI) despite normal homocysteine levels. A study by Bouzidi, N et al concluded that there was no association between Hcy levels and CAD severity [22] Other studies, however, did not find a significant relationship between MTHFR C677T and cardiac syndrome X [23].

The current study concluded that serum magnesium levels, as well as random blood glucose levels, are somewhat lower (2.42.8 and 2.53.2) in patients compared to controls. In contrast, mean total cholesterol and HDL values were higher in the patients (182 18.1, and 49.77.1) than in the control group (180 20.3, and 46.6 11.3).

This finding agreed to a by Rassoul F et al. [24], in which LDL cholesterol and triglyceride levels

were much greater in CAD patients than in controls, while serum HDL concentrations were considerably lower, and Hcy levels were significantly higher. Triglyceride levels higher than 199 mg/dl may also be a potential risk for CAD in Indians. When all other parameters were tested, elevated amounts of Hcy, cholesterol, excessive LDL and decreased levels of HDL, and smoking were revealed to be predictive factors of CAD [25].

Interestingly, there was a statistically significant difference (P value $\leq$ 0.043) in magnesium levels between heterozygous CT genotypes and homozygous TT genotypes (2.22.1 vs 2.90.8), these were satisfied findings as some risk factors for cardiovascular disease and atherosclerosis, such as lipid profile and blood pressure, have been linked to serum magnesium levels [26]. It is seemed that low serum magnesium concentration along with heterozygous CT genotypes of MTHFR play critical role in development of CSX attack.

Prospectively the clinical presentation of homocystinuria that caused by severe MTHFR deficiency should be investigated.

## 5. CONCLUSION

MTHFR C677T is linked to CSX in the Sudanese population, and serum magnesium level was slightly decreased among heterozygous MTHFR C677T. Furthermore, the mutation could be used as a disease molecular screening technique.

## LIMITATION OF THE STUDY

The current study was limited with the small sample size. Involving a larger number of patients may increase the level of reliability regarding the obtained results. To our knowledge, this is the first study to look into the genetic relationship between MTHFR and CSX. Another significant limitation is that our research solely evaluated at MTHFR genetic polymorphisms. Furthermore, plasma homocysteine levels and MTHFR enzyme activity must be examined in order to better understand the association between homocysteine metabolism and CSX.

## CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the author(s).

## ETHICAL APPROVAL

The study was ethically approved by an institutional committee at faculty of Medicine, Al-Neelain University.

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**Data and materials availability** All data associated with this study are present in the paper.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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