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Original Article

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The Association of Dietary Total Antioxidant Capacity with Inflammatory Biomarkers and Anthropometric Indices in Patients Who Candidate for Coronary Artery Bypass Graft Surgery: a Cross-sectional Study

Zahra Mohammadi [1], **Hadi Abdollahzad** [2], **Shahab Rezaeian** [2], **Feridoun Sabzi** [3], **Nazanin Tafteh** [1]

[1]Student Research Committee, School of Nutritional Sciences and Food Technology, Kermanshah University of Medical Sciences, Kermanshah 6719851351, Iran
[2]Research Center for Environmental Determinants of Health (RCEDH), Kermanshah University of Medical Sciences, Kermanshah 6719851351, Iran
[3]Department of General Surgery, School of Medicine, Kermanshah University of Medical Sciences, Kermanshah 6719851351, Iran

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Correspondence to
Hadi Abdollahzad
Department of Nutritional Sciences, School of Nutritional Sciences and Food Technology, Kermanshah University of Medical Sciences, Isar Sq., across from Farabi Hospital, Kermanshah 6719851351, Iran.
E-mail: hadi_nut@yahoo.com

ORCID iDs
Zahra Mohammadi
https://orcid.org/0000-0002-0520-4876
Hadi Abdollahzad
https://orcid.org/0000-0003-2367-9573
Shahab Rezaeian
https://orcid.org/0000-0002-5094-5315
Feridoun Sabzi
https://orcid.org/0000-0002-9340-3014
Nazanin Tafteh
https://orcid.org/0000-0003-4831-9910

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ABSTRACT

Antioxidant compounds can attenuate inflammation and delay degenerative processes especially in the cardiovascular system. This study aimed to determine the relationship between dietary total antioxidant capacity (DTAC) and serum biomarkers in patients undergoing coronary artery bypass graft surgery. In this cross-sectional study, 146 patients who had referred to Imam Ali Hospital in Kermanshah were recruited and demographic, anthropometric, physical activity and dietary data were collected. Fasting blood glucose (FBG), serum levels of lipid profile, inflammatory markers (interleukin [IL]-17, intercellular and vascular cell adhesion molecules [ICAM, VCAM]), and total antioxidant capacity (TAC) were also measured. A regression model adjusted for confounding variables presented that the coefficients of ICAM and VCAM (ng/dL) in the third tertile of DTAC were lower than those in the first tertile ($\beta = -417.2$, 95% confidence interval [CI] = −509.9 to −324.5, $p < 0.001$; $\beta = -293.2$, 95% CI = −334.3, −252.1, $p < 0.001$, respectively). The β of serum TAC (ng/dL) in the third tertile was 0.86 (95% CI = 0.77, 0.95, $p < 0.001$) higher than that in the first tertile. DTAC had no statistically significant relationship with lipid profile, FBG, and IL-17 levels, and anthropometric indices. In this study DTAC was associated with increased serum TAC and decreased cell adhesion molecules. Therefore, diet antioxidants may be beneficial in attenuating of inflammation in coronary artery diseases.

Keywords: Coronary artery bypass; Diet; Antioxidants; Interleukin-17; Cell adhesion molecules

INTRODUCTION

Cardiovascular diseases (CVDs) are the leading cause of death in the world; over 17.5 million people die annually from CVDs, which was accounted 31% of all deaths [1]. Dietary

Conflict of Interest
The authors declare that they have no competing interests.

compounds have recently been shown as the effective factors in development or prevention of atherosclerosis [2]. The diet containing high amounts of antioxidants is effective in preventing CVDs and their side effects [3,4]. To report the amount of antioxidants received from the diet, the dietary total antioxidant capacity (DTAC) was introduced as a diet index [5,6].

Studies have shown the effect of DTAC on attenuating of interleukin (IL)-17 and cell adhesion molecules [7]; IL-17 increases the incidence of acute coronary syndrome by destabilizing of vascular plaques [8,9]. Intercellular adhesion molecule (ICAM) and vascular cells adhesion molecule (VCAM) are increased during inflammatory responses particularly in the atherosclerotic processes that can be considered as an indicator of endothelial inflammation or the onset of atherosclerosis [10,11]. The amounts of these molecules that are closely related to C-reactive protein (CRP), can predict the onset of heart attacks and death [10,11]. Circulating levels of cell adhesion molecules are lower in individuals with diets rich in fruits, vegetables, and whole grains, due to their contents of fiber and antioxidants [12]. Serum antioxidants can convert free radicals into their inactive forms; therefore, they have anti-inflammatory effects and are associated with a lower risk of CVDs [13,14].

Invasive treatments including the coronary artery bypass graft (CABG) surgery may give rise to inflammatory responses, and systemic inflammation can cause atrial and ventricular arrhythmias, heart attacks, strokes, and eventually death [15]. Regarding the effective role of diet on the inflammatory status, the present study was carried out to determine the relationship between the DTAC and serum levels of IL-17 and cell adhesion molecules in patients undergoing CABG surgery.

MATERIAL AND METHODS

Participants

In this cross-sectional study, the statistical population was all registered candidates for CABG surgery. The individuals were selected by available sampling method among the clients of Imam Ali Hospital, Kermanshah, Iran. The sample size was estimated to be at least 42 subjects based on the study of Kolarzyk et al. [16], however to increase the accuracy of estimation, 150 eligible patients were included in the study. The inclusion criteria were patients under 80 years with clogged arteries who needed the CABG surgery based on the physician's diagnosis and angiography results. Also, the calorie intakes of eligible participants were between 2,000 and 3,000 kcal per day.

Patients with liver disorders (i.e., hepatitis, cirrhosis, and gallstones), kidney stones, pulmonary infection, diabetes, cancer, malabsorption, thyroid disorders, heart attacks and strokes or surgical history in previous six months were excluded. Also, candidates consuming drugs (i.e., aspirin, warfarin, clopidogrel, and immunosuppressive drugs, corticosteroids) and dietary supplements (i.e., antioxidants) in a month before the study were excluded. Other exclusion criteria were unwillingness to continue or failure to have the surgery for any reason.

According to the basic principles of the Helsinki Declaration, the objectives of the study were explained for the candidates and an informed written consent was obtained from each participant. This study was approved by Kermanshah University of Medical Sciences, Kermanshah, Iran (ethics code: IR.KUMS.REC.1398.1113).

Data collection

The data were collected using appropriate questionnaires including demographic questionnaire, food frequency questionnaire (FFQ), and physical activity questionnaire. Through demographic questionnaire the age, sex, marital status, level of education, occupation and income level, personal habits including smoking of cigarette, pipe, and hookah and drinking alcohol, and the general characteristics of the individuals were collected. The other part of the questionnaire contained information about medical history of individuals.

Dietary information was collected using a FFQ including 125 food items by face-to-face interview. Participants responded questions about the frequency and amount of food consumed. The validity and reliability of this questionnaire has already been confirmed [17]. The amount of each food item was based on grams of food consumed per day. According to the reference table that expresses the amount of food antioxidant content in terms of 100 g of foods [18], the daily amounts of food antioxidants consumed by each person were calculated [19]. The antioxidant content of foods based on the oxygen radical absorbance capacity (ORAC) method has already been approved by the U.S. Department of Agriculture [20]; it expresses the degree and duration of inhibition of oxidation induced by proxy radicals and is equivalent to Trolux [18]. Finally, we categorized participants into tertiles according to total antioxidant capacity (TAC) intake, and considered the lowest group as reference.

Physical activity was assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF) which includes seven items related to physical activity during a week. The duration of physical activity was recorded in hours or minutes per day. The data were extracted and used based on metabolic equivalents per hour per week (MET-hour/week). Finally, the results were classified into 3 groups: low, moderate, and severe activity [21].

Height was measured without shoes by a stadiometer with an accuracy of 0.1 cm. Weight was measured with minimal clothes and without shoes in fasting mode using Camry digital scale (EB9320; Camry, Zhaoqing, China). Waist and hip circumferences were measured with minimum clothes in the standing position using a non-elastic tape at the umbilical area and in the widest part of the pelvis respectively. The waist to hip ratio (WHR) was calculated by dividing the waist circumference to hip circumference. The body mass index (BMI) was obtained by dividing weight (kg) to height squared (m^2).

Following 10–12 hours of fasting, 10 mL of venous blood sample (in the first 24 hours of hospitalization) was taken from each participant to evaluate biochemical parameters including lipid profile (total cholesterol [TC], low- and high-density lipoprotein cholesterol [LDL-C and HDL-C], triglycerides [TG]), serum levels of inflammatory markers (IL-17, ICAM, VCAM), and TAC.

Data analysis

The quantitative and qualitative variables are reported as mean ± standard deviation (SD), and number (percentage), respectively. The normality of the data was assessed using the Kolmogorov-Smirnov test. The DTAC was categorized into tertiles. The comparative tests for quantitative and qualitative variables were analysis of variance and χ^2, respectively. The Tukey post hoc test was used to compare each group with others. To examine the relationships, univariate and multiple linear regression models were used in which the effect of confounding variables such as age, sex and BMI were adjusted. For all tests, p value less than 0.05 is considered as a statistically significant level. The analyses were performed with STATA 14.2 software (Stata Corp., College Station, TX, USA).

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RESULTS

A total of 146 patients undergoing CABG surgery with age of 61.78 ± 10.04 years were evaluated. No significant difference was found among the demographic variables based on DTAC tertiles ($p > 0.05$). There was no statistically significant difference in the amount of physical activity of the participants by the tertiles of DTAC ($p = 0.755$) (**Table 1**).

The BMI of patients was 27.0 ± 3.8 kg/m^2 that was not statistically significant among DTAC tertiles ($p = 0.249$). The mean values of WHR was not significantly different among the antioxidant tertiles ($p = 0.664$). The mean values of fasting blood glucose (FBG) was 112.1 ± 34.4 mg/dL, which did not show a statistically significant difference among the tertiles ($p = 0.757$). The mean values of the ICAM and VCAM in all patients were 320.3 ± 288.9 and 271.2 ± 162.4 ng/dL, which were significantly different among the antioxidant tertiles ($p < 0.001$ for both). serum TAC levels were also significantly different among the tertiles ($p = 0.027$). The

Table 1. Distribution of demographic variables among participants based on the DTAC

Demographic variable	Frequency (percentage)	Tertiles of DTAC (μmol TE/100 g)			p value*
		T1 (n = 49) (0.76–2.2)	T2 (n = 49) (2.21–3.19)	T3 (n = 48) (3.2–14.61)	
Age (years)	146 (100)	61.32 ± 10.98	62.16 ± 10.06	61.87 ± 9.22	0.917
Age of disease onset (years)	146 (100)	58.16 ± 12.91	57.10 ± 12.72	58.70 ± 10.36	0.800
Sex					0.178
Male	102 (69.86)	39 (79.59)	31 (63.27)	32 (66.67)	
Female	44 (30.14)	10 (20.41)	18 (36.73)	16 (33.33)	
Marital status					0.510
Marriage	130 (89.04)	42 (85.71)	43 (87.76)	45 (93.75)	
Single	1 (0.68)	1 (2.04)	0 (0)	0 (0)	
Widow	15 (10.27)	6 (12.24)	6 (12.24)	3 (6.25)	
Level of education					0.114
Illiterate	69 (47.26)	17 (34.69)	27 (55.10)	25 (52.08)	
Elementary	45 (30.83)	15 (30.61)	13 (26.53)	17 (35.42)	
High school	22 (15.07)	9 (18.37)	8 (16.33)	5 (10.42)	
University degree	10 (6.84)	8 (16.33)	1 (2.04)	1 (2.08)	
Occupation					0.805
Housewife	40 (27.40)	10 (20.41)	15 (30.61)	15 (31.65)	
Livestock	19 (13.01)	6 (12.24)	8 (16.33)	5 (10.42)	
Manual worker	8 (5.48)	2 (4/08)	4 (8.16)	2 (4.17)	
Freelance	35 (23.97)	12 (24.49)	10 (20.41)	13 (27.08)	
Employee	5 (3.42)	1 (2.04)	2 (4.08)	2 (4.17)	
Retired	36 (24.66)	16 (32.65)	10 (20.41)	10 (20.83)	
Other	3 (2.05)	2 (4.08)	0 (0)	1 (2.08)	
Income level					0.464
Weak	69 (47.26)	20 (40.82)	26 (53.06)	23 (47.92)	
Medium	76 (52.05)	29 (59.18)	23 (46.94)	24 (50)	
Financial	1 (0.68)	0 (0)	0 (0)	1 (2.08)	
Smoking					0.312
Yes	47 (32.19)	19 (38.78)	16 (32/65)	12 (25)	
No	79 (54.11))	27 (55.10)	25 (51.02)	27 (56/25)	
Exposed	20 (13.70)	3 (6.12)	8 (16.33)	9 (18.75)	
Alcohol consumption					0.236
Yes	17 (11.64)	3 (6.12)	9 (18.37)	5 (10.42)	
No	129 (88.35)	46 (93.88)	40 (81.63)	43 (89.58)	
Physical activity					0.755
Low	84 (57.53)	26 (53.06)	29 (59.18)	29 (60.42)	
Moderate	60 (41.10)	23 (46.94)	19 (38.78)	18 (37.5)	
Severe	2 (1.37)	0 (0)	1 (2.04)	1 (2.08)	

DTAC, dietary total antioxidant capacity.
*The p values < 0.05 was considered as significant with one-way analysis of variance for quantitative variables and χ^2 test for qualitative variables.

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Table 2. Comparison of mean anthropometric variables, blood pressure and biochemical factors in DTAC tertiles

Variables	Average (n = 146)	Tertiles of DTAC (μmol TE/100 g)			p value	Tukey post hoc test
		T1 (n = 49) (0.76–2.2)	T2 (n = 49) (2.21–3.19)	T3 (n = 48) (3.2–14.61)		
Height (cm)	164.94 ± 8.56	164.94 ± 7.88	164.45 ± 8.60	164.85 ± 9.32	0.955	-
Weight (kg)	72.95 ± 11.02	73.81 ± 11.46	70.95 ± 10.92	74.12 ± 10.61	0.296	-
BMI (kg/m^2)	27.00 ± 3.83	27.10 ± 3.50	26.31 ± 4.01	27.60 ± 3.87	0.249	-
Hip circumference (cm)	94.79 ± 8.49	95.10 ± 8.01	93.37 ± 7.65	95.94 ± 9.66	0.316	-
Waist circumference (cm)	103.42 ± 8.74	102.97 ± 8.38	101.98 ± 9.36	105.33 ± 8.27	0.153	-
WHR	1.10 ± 0.11	1.09 ± 0.10	1.09 ± 0.08	1.11 ± 0.13	0.664	-
Energy intake (kcal/day)	2,439.9 ± 1,351.7	2,570.50 ± 1,284.8	2,255.3 ± 874.2	2,493.1 ± 1,763.8	0.489	-
FBG (mg/dL)	112.06 ± 33.42	109.67 ± 28.47	114.71 ± 42.49	111.79 ± 27.85	0.757	-
LDL-C (mg/dL)	84.28 ± 25.50	89.59 ± 28.54	80.69 ± 23.62	82.52 ± 23.64	0.190	-
HDL-C (mg/dL)	37.32 ± 9.16	38.26 ± 10.94	36.82 ± 7.54	36.89 ± 8.77	0.684	-
TG (mg/dL)	130.94 ± 51.74	133.73 ± 54.72	127.18 ± 50.43	131.94 ± 48.48	0.813	-
TC (mg/dL)	150.60 ± 37.90	157.45 ± 34.14	150.10 ± 45.22	144.12 ± 32.56	0.223	-
IL-17 (ng/dL)	44.99 ± 52.12	54.24 ± 68.84	43.16 ± 49.17	37.40 ± 30.35	0.271	-
ICAM (ng/dL)†	320.31 ± 288.90	578.58 ± 388.60	224.62 ± 66.49	165.12 ± 26.88	< 0.001*	T2 vs. T1, < 0.001 T3 vs. T1, 0.001
VCAM (ng/dL)	271.24 ± 162.36	447.12 ± 165.25	208.63 ± 51.02	155.60 ± 28.02	< 0.001*	T2 vs. T1, < 0.001 T3 vs. T1, 0.001 T3 vs. T2, 0.030
Serum TAC (ng/dL)	1.03 ± 0.41	0.64 ± 0.30	1.06 ± 0.22	1.45 ± 0.16	0.027*	T2 vs. T1, < 0.001 T3 vs. T1, < 0.001 T3 vs. T2, < 0.001
SBP (mmHg)	128.26 ± 17.44	131.23 ± 19.04	126.38 ± 16.21	127.14 ± 16.91	0.336	-
Number of obstructive vessels	2.82 ± 0.57	2.94 ± 0.59	2.88 ± 0.55	2.66 ± 0.59	0.054	-
Heart rate (number per minute)	73.57 ± 12.51	71.71 ± 12.47	75.73 ± 13.65	73.27 ± 11.20	0.278	-

Values are expressed as mean ± standard deviation.
DTAC, dietary total antioxidant capacity; BMI, body mass index; WHR, waist to hip ratio; FBG, fasting blood glucose; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; TG, triglycerides; TC, total cholesterol; IL-17, interleukine17; ICAM, intercellular adhesion molecule; VCAM, vascular cells adhesion molecule; TAC, total antioxidant capacity; SBP, systolic blood pressure.
*The p values < 0.05 was considered as significant with one-way analysis of variance, †Total number of subjects for ICAM is 144.

number of obstructive vessels in the first, second and third tertiles of the antioxidant index were 2.94 ± 0.6, 2.88 ± 0.6, and 2.7 ± 0.6, respectively (p = 0.054) (**Table 2**).

Mean values of inflammatory biomarkers among the DTAC tertiles presented in **Figure 1**. As shown in **Table 3** the linear regression analysis in the crude and adjusted models indicated that the mean β values of TG (mg/dL) in the third tertile of DTAC was −1.8 (p = 0.865) and −3.6 (p = 0.734) respectively, which were lower than that in the first tertile, but did not reach the statistically significant. The mean values of IL-17 (ng/dL) in the second and third tertile of DTAC were lower than that of the first tertile, but did not reach the statistical significance (p = 0.113 and p = 0.144, respectively). the mean values of ICAM (ng/dL) in the second and third tertiles were lower compared to the first tertile (p < 0.001 for both comparisons). This association remained significant after adjustment of potentially confounding variables. The mean values of the VCAM (ng/dL) in the second and third tertiles were lower than the first tertile (p < 0.001 for both comparisons), and the statistical significance were retained after the adjustment. In the crude model, the mean values of serum TAC (ng/dL) in the second and third tertiles of the DTAC were significantly higher than that in the first tertile (p < 0.001 for both). This association remained significant after the adjustment of confounding variables (**Table 3**).

DISCUSSION

The findings of this study showed that patients undergoing CABG surgery showed significant correlation of the increased DTAC with the increased antioxidant and decreased ICAM

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Table 3. Relationship between DTAC and studied variables in patients undergoing surgery coronary artery bypass graft

Variable	Regression model	Tertiles of DTAC (μmol TE/100 g)				
		T1 (n = 49) (0.76–2.2)	T2 (n = 49) (2.21–3.19)	p value*	T3 (n = 48) (3.2–14.61)	p value†
		References	β (95% CI)		β (95% CI)	
Weight (kg)	Crude model	0	−2.80 (−7.21, 1.52)	0.202	0.31 (−4.10, 4.71)	0.887
	Adjusted model	0	−1.61 (−5.62, 2.32)	0.383	−1.20 (−2.81, 5.33)	0.535
Waist circumference (cm)	Crude model	0	−1.00 (−4.40, 2.41)	0.570	2.31 (−1.10, 5.81)	0.184
	Adjusted model	0	0.58 (−1.35, 2.53)	0.552	1.41 (−0.56, 3.30)	0.163
WHR	Crude model	0	0.004 (−0.04, 0.04)	0.837	0.02 (−0.02, 0.06)	0.387
	Adjusted model	0	0.0004 (−0.04, 0.04)	0.631	0.02 (−0.02, 0.06)	0.504
FBG (mg/dL)	Crude model	0	5.04 (−8.37, 18.45)	0.459	2.12 (−11.43, 15.60)	0.757
	Adjusted model	0	5.74 (−7.84, 19.32)	0.405	1.38 (−12.09, 14.85)	0.840
HDL-C (mg/dL)	Crude model	0	−1.44 (−5.11, 2.22)	0.439	−1.36 (−5.04, 2.33)	0.467
	Adjusted model	0	−2.34 (−6.02, 1.35)	0.212	−1.91 (−5.56, 1.74)	0.303
TG (mg/dL)	Crude model	0	−6.55 (−27.33, 14.22)	0.534	−1.80 (−22.68, 19.09)	0.865
	Adjusted model	0	−6.33 (−27.39, 14.72)	0.553	−3.60 (−24.49, 17.29)	0.734
TC (mg/dL)	Crude model	0	−7.35 (−22.43, 7.73)	0.337	−13.32 (−28.48, 1.83)	0.084
	Adjusted model	0	−11.61 (−26.71, 3.49)	0.131	−14.51 (−29.50, 0.49)	0.172
LDL-C (mg/dL)	Crude model	0	−8.90 (−19.03, 1.24)	0.085	−7.07 (−17.26, 3.12)	0.172
	Adjusted model	0	−10.13 (−20.52, 0.25)	0.056	−7.88 (−18.17, 2.43)	0.113
IL-17 (ng/dL)	Crude model	0	−11.08 (−31.85, 9.69)	0.294	−16.84 (−37.72, 4.03)	0.113
	Adjusted model	0	−10.94 (−31.97, 10.09)	0.305	−15.50 (−36.36, 5.35)	0.144
ICAM (ng/dL)	Crude model	0	−353.96 (−455.13, −262.78)	< 0.001	−413.45 (−505.10, −321.81)	< 0.001
	Adjusted model	0	−359.6 (−453.1, −266.1)	< 0.001	−417.18 (−509.86, −324.50)	< 0.001
VCAM (ng/dL)	Crude model	0	−238.49 (−279.02, −197.42)	< 0.001	−291.52 (−332.25, −250.78)	< 0.001
	Adjusted model	0	−238.84 (−280.27, −197.42)	< 0.001	−293.25 (−334.34, −252.16)	< 0.001
Serum TAC (ng/dL)	Crude model	0	0.47 (0.38, 0.56)	< 0.001	0.85 (0.76, 0.94)	< 0.001
	Adjusted model	0	0.47 (0.38, 0.56)	< 0.001	0.86 (0.77, 0.95)	< 0.001
SBP (mmHg)	Crude model	0	−4.85 (−11.8, 2.11)	0.170	−4.09 (−11.09, 2.90)	0.249
	Adjusted model	0	−5.21 (−12.14, 1.79)	0.143	−4.65 (−11.55, 2.24)	0.185
Heart rate (number per minute)	Crude model	0	4.02 (−0.96, 9.01)	0.113	1.55 (−3.46, 6.56)	0.540
	Adjusted model	0	3.65 (−1.33, 8.64)	0.150	0.77 (−4.18, 5.72)	0.758
Number of obstructive vessels	Crude model	0	−0.08 (−0.3, 0.14)	0.475	−0.27 (−0.49, −0.05)	0.119
	Adjusted model	0	−0.06 (−0.3, −0.17)	0.605	−0.24 (−0.47, −0.02)	0.134

DTAC, dietary total antioxidant capacity; WHR, waist to hip ratio; FBG, fasting blood glucose; HDL-C, high-density lipoprotein cholesterol; TG, triglycerides; TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; IL-17, interleukine17; ICAM, intercellular adhesion molecule; VCAM, vascular cells adhesion molecule; TAC, total antioxidant capacity; SBP, systolic blood pressure.
The p values < 0.05 was considered as significant with Linear regression model by adjusting the age, sex and body mass index. The first tertile (T1) is considered as reference. *The difference between T1 and T2, †The difference between T1 and T3.

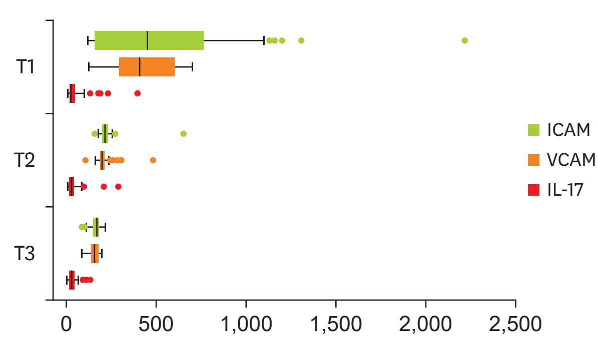

Figure 1. Mean values of inflammatory biomarkers among the DTAC tertiles.
Values are expressed as mean ± standard deviation.
DTAC, dietary total antioxidant capacity; IL-17, interleukine17; ICAM, intercellular adhesion molecule; VCAM, vascular cells adhesion molecule.

and VCAM levels in serum, although statistically significant association between the IL-17 and DTAC was not observed. Meta-analysis studies by Aune et al. [22-24] showed a direct correlation between DTAC and serum antioxidant levels in individuals with cancer and

CVDs. On the other hand, the cohort studies have reported an inverse relationship between serum antioxidant levels and the prevalence of breast cancer [25,26]. The positive effects of antioxidants on reducing the level of adhesion molecules have also been confirmed in clinical trial studies; antioxidant supplementation is usually associated with a reduction in the level of free radicals such as superoxide which in turn inhibits the tumor necrosis factor (TNF)-α signaling pathway and reduces the level of LDL oxidation that are the main factors in stimulating the secretion of adhesion molecules [27].

It has been indicated that dietary antioxidants can reduce the secretion of inflammatory biomarkers such as IL-6, CRP, and adhesion molecules by inhibiting the activity of the nuclear factor-κB pathway [28,29]. The study of Mena et al. [30] showed that Mediterranean diets, which have a high antioxidant content reduces the secretion of IL-6, CRP, ICAM, and VCAM. In a cohort study with a 15-year follow-up on two black and white races performed by Sijtsma et al. [12], the level of adhesion molecules was much lower in the group who consumed fruits and vegetables than the counterpart. In addition, Lopez-Garcia et al. [31] reported that circulating ICAM levels were directly related to the Western diet and inversely related to the Mediterranean diet. To our knowledge, no study has directly examined the association between DTAC and serum IL-17 levels. It can be said that we can attenuate inflammatory conditions and accordingly reduce cardiovascular complications by changing people's diet with food components rich in antioxidants.

In the present study, no significant relationship was observed between DTAC and anthropometric indices. Some studies have reported an inverse relationship between DTAC and anthropometric indices, while some others have shown the lack of such a correlation [32-34]. It has been imagined that inflammatory condition is the consequence of oxidative stress dominance over antioxidant defenses, and insufficient consumption of antioxidant sources can induce obesity [6,32,33]. Some studies have also reported that exposure to reactive oxygen species (ROS) stimulates the differentiation and proliferation of fat cells, and the excess fat leads to the production of more ROS; this vicious cycle exacerbates obesity and increases the likelihood of CVDs [35,36]. Considering the caloric intake of the patients in our study ranged from 2,000 to 3,000 kcal per day and significant difference was not found in their physical activity, the lack of a significant relationship between DTAC and anthropometric indices can be justifiable. The differences in the sample size, age group, race and population may be other causes of these discrepancies because some of these studies have been performed in the healthy individuals.

The findings of this study showed that DTAC was not significantly associated with lipid profiles (TC, TG, LDL-C, and HDL-C) and FBG. In the study conducted by Georgoulis et al. [37], no correlation was found between DTAC and lipid profile. A study on healthy Brazilian youths showed an inverse relationship between DTAC and lipid profile [33]. Other studies in Iran and the United States have shown that the level of lipid profile has also increased with increasing DTAC [1,32,33]. In addition to differences in sample size and the reporting errors in the FFQ, the reason for the differences can be mainly due to the differences in the characteristics of studied populations, so that most significant relationships have been reported in studies including the population with no history of chronic disease and accordingly without use of specific therapies. However, the participants in the present study were patients and those mostly treated with lipid lowering drugs. Some studies have reported inverse relationship between DTAC with FBG and homeostasis model assessment-estimated insulin resistance, and some others have proven lack of such a relationship [1,6,32,34]. In one study, a correlation was found between a diet rich in antioxidants and the prevalence of diabetes [38]. A noteworthy point in stating the cause of these discrepancies is that some diabetics were also included in studies that reported an inverse relationship between DTAC and FBG, but diabetic patients were excluded in our study.

The results of the present study did not show a relationship between DTAC and IL-17 levels. To date, no study has directly examined the relationship between DTAC and IL-17 levels. This molecule plays a role in controlling inflammation and even the secretion of other inflammatory cytokines [39]. Also, it has a key role in the atherosclerotic process by increasing the expression of adhesion molecules, stimulating monocytes, and increasing the adhesion of macrophages to the vascular, as well as increasing the likelihood of LDL oxidation [8,9].

Our findings showed no association between DTAC with systolic blood pressure, heart rate, and number of blocked arteries. The results of the study done by Kim et al. [4] on American adults were in line with the present study. Several studies have shown an inverse relationship between DTAC and blood pressure [6,32,40]. The main cause of the discrepancies can be considered as differences in the studied populations. In studies that reported an inverse relationship between DTAC and blood pressure, the subjects were healthy with no history of chronic diseases; however, the participants of our study mostly suffered from hypertension and were treated with antihypertensive and cardiac drugs.

This cross-sectional study included only a small number of CABG candidates (n = 146). Considering the clinical and emergency conditions of the participants in the present study, a large number of patients could not be included to the study. Also, due to the dependence of the FFQ on memory, reporting errors in completing the FFQ can be inevitable. However, one of the strengths of the present study is the simultaneous investigation of several inflammatory and biochemical factors in patients undergoing CABG surgery.

CONCLUSION

The present study showed that increased DTAC was significantly associated with increased antioxidant and decreased serum concentrations of ICAM and VCAM in candidates for CABG surgery. Considering the role of these factors in the regulation of inflammatory processes, these findings indicate the importance of dietary antioxidants in coronary artery diseases. It seems that consumption of diet containing antioxidant compounds in people with coronary artery diseases along with medication may be useful. To assess this relationship in detail, it is necessary to conduct studies in particular clinical trials with a large sample size.

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