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Original Article

The relationship between nutritional and cardiometabolic factors and epicardial fat thickness in adults in preoperative cardiac surgery

Selena Morra-Coronel [1], Natalia Osorio-Monteverde [1], Noelia Moreira-Diana [1], Tania Vaquero [1], María Alexandra Cabrera-Rodríguez [1], Juan Martín Antelo [2, 3], Marcela Guerendiain [1 *]

[1] Academic Unit of Research, School of Nutrition, University of the Republic, Montevideo, Uruguay

[2] Institute of Integral Cardiology, Montevideo, Uruguay

[3] Department of Cardiac Surgery, Faculty of Medicine, University of the Republic, Montevideo, Uruguay

* Correspondence to: Marcela Guerendiain, Academic Unit of Research, School of Nutrition, University of the Republic, Montevideo, Uruguay. Avenida Américo Ricaldoni s/n, CP-11600, Montevideo, Uruguay; Phone: (+598) 2484 19 49 int. 126; E-mail: mguerendiain@nutricion.edu.uy

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Abstract

Cardiovascular diseases are related to higher epicardial fat thickness (EFT), which has been associated with metabolic diseases. However, the evidence on its relationship with dietary intake is limited. Thus, we aimed to analyze the relationship between nutritional and cardiometabolic factors and EFT in patients in preoperative cardiac surgery. A cross-sectional descriptive study included adult patients (with heart bypass surgery, n=24, and without bypass surgery, n=11). EFT was measured by a transthoracic echocardiogram. Waist circumference (WC), weight, height and body mass index (BMI) were taken. Fat and dietary fiber intake were measured using the Block Screening Questionnaire. The daily free-sugar intake in infusions was quantified. Biochemical data, medications, and blood pressure measurements were collected from the medical history. EFT was higher in patients with heart bypass surgery (p=0.028). A direct relationship was found between EFT and glycemia (p=0.006), triglycerides (p=0.013) and WC (p=0.033). Patients with higher EFT had a higher BMI than those with normal EFT (p=0.001). Participants with diabetes mellitus (p=0.026) or metabolic syndrome (p=0.005) had higher EFT. No association was found between dietary intake and EFT. In conclusion, a higher WC, BMI, glycemia, plasma triglyceride level, and the presence of metabolic syndrome and diabetes mellitus are associated with higher EFT.

Keywords: epicardial fat, cardiac surgery, dietary intake, cardiometabolic profile, nutritional status.

Introduction

Circulatory system diseases are the leading cause of death in Uruguay. In the first half of 2021, they accounted for 4429 deaths [1]. In 2020, 148 heart bypass and non-bypass coronary surgeries were performed at Instituto de Cardiología Integral (ICI) [2].

Heart surgery comprises a series of procedures performed to repair heart or thoracic aorta injuries [3]. One type of procedure, heart bypass surgery, is used to treat issues caused by coronary artery blockage [3, 4]. Patients who do not need bypass surgery (non-bypass surgery) are treated using other types of surgery, such as heart valve surgery or thoracic aorta surgery [3].

Epicardial fat (EF), or epicardial adipose tissue, is defined as a visceral fat deposit located between the heart and the pericardium, which shares many of the physio-pathological properties of other visceral fat deposits and has direct effects on coronary atherosclerosis [5]. This fat is associated with diabetes mellitus, impaired fasting glycemia, oxidized cholesterol, high blood pressure, and coronary diseases [6–10]. It is also associated with increased body mass index (BMI) [11] and high waist circumference [12].

Few studies have been conducted associating EF with diet and referring to humans and pigs [13–15]. A study where adult patients were given eicosapentaenoic acid (EPA) orally for 6 months showed a reduced epicardial adipose tissue and visceral adipose tissue volume [14]. Moreover, there is evidence associating fat intake with the cardiometabolic profile [16, 17]. Evidence shows high fat intake is associated with higher mortality, particularly saturated and trans-fat intake [18, 19]. Replacing saturated fat with omega-3 fatty acids has been found to effectively reduce coronary heart disease events [20, 21].

Studies suggest that a reduction of total cholesterol and low-density lipoprotein (LDL-c) and the lowering of diastolic blood pressure are associated with higher fruit and vegetable fiber intake [22]. Furthermore, a study conducted with adolescents found higher epicardial fat thickness (EFT) values in patients with reduced fruit and vegetable intake [15]. Recent scientific evidence suggests that a lower sugar intake positively affects body weight and, therefore, decreases cardiovascular risk [23–25].

In light of evidence supporting the association between dietary aspects and heart disease [19], studying the relationship between nutritional factors and EFT is considered crucial. Accordingly, the purpose of this research was to study the relationship between nutritional and cardiometabolic factors and epicardial fat thickness in patients in preoperative heart surgery, with heart bypass surgery and without bypass surgery.

Material and methods

Study design and participants

This study was conducted using a cross-sectional descriptive design. Participants were preoperative cardiac surgery patients, adults, from the ICI of Montevideo, Uruguay, in the years 2021–2022. Data and measurements were taken during the COVID-19 pandemic, including when the country was under the highest virus incidence. Non-probabilistic sampling was used, with two groups of subjects (with heart bypass surgery, n=24, and without heart bypass surgery, n=11). Patients with repeated cardiac surgery and transplants, serious diagnosis, late-stage cancer and urgent surgeries coordinated 24 hours before the intervention were excluded.

Anthropometric measurements

The anthropometric measurements obtained were weight (kg), height (cm), and waist circumference (WC, cm) [26]. BMI was calculated based on weight and height [BMI=weight/height^2 (Kg/m^2)] and classified as low weight <18.5 kg/m^2; normal weight 18.5 to 24.9 kg/m^2; overweight 25 to 29.9 kg/m^2; type I obesity 30 to 34.9 kg/m^2; type II obesity 35 to 39.9 kg/m^2; and type III obesity ≥40 kg/m^2 [27].

Measurements were obtained by using: a) Seca 813 high-capacity and stability digital floor scale with a low platform and LCD accommodating up to 200 kg; b) flexible, non-stretchable metric tape, with a maximum length of 2 m and 1 mm precision; c) Seca 213 portable stadiometer for adults, measurement range of 20–205 cm and 1 mm precision.

The technique used for measuring weight was applied with the patient wearing the minimum possible clothes. The patient was positioned standing still at the center of the scale, feet slightly apart, arms stretched alongside the body, ensuring no part of the body was out of the scale and that the patient was not leaning against a wall or another person. The final weight was recorded as the reading appearing on the display for several seconds without blinking. It was recorded in kg and grams [28].

For measuring height, the patient had to be standing, with the chin slightly raised (Frankfort plane), arms hanging on the side, palms facing in, knees together with feet slightly apart, and heels touching the back of the stadiometer. The back of the skull, shoulder blades, buttocks and heels had to touch the back of the stadiometer. After verifying the correct posture, patients were asked to take a deep breath and relax their shoulders, trying to reach their maximum possible height. The stadiometer reading was recorded in cm and mm [28].

Waist circumference was measured with the patient standing up, with no clothes, and relaxed. The costal margin and the iliac crest upper border were located, and at the middle point, the measuring tape was extended around the waist, parallel to the floor. The tape was snug and did not compress the skin, and the measurement was taken at the end of a normal expiration. Measurements were recorded in cm and mm [28].

Three readings were collected for each measure, and an average of the anthropometric results was obtained. The BMI was calculated using the average weight and height measurements.

Cardiometabolic factors

Data on cardiometabolic factors were collected from each patient's digital medical history through the application of Instituto de Cardiología Integral (ICI data) and from the nurse's shift report worksheets.

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The following data were collected: diabetes mellitus diagnosis (presence/absence of diabetes mellitus, 2 fasting glycemia values were considered >126 mg/dl) [29], fasting glycemia (mg/dl), high blood pressure diagnosis (presence/absence of high blood pressure, HBP), blood pressure readings (mmHg, high systolic blood pressure ≥140 mmHg or high diastolic blood pressure ≥90 mmHg) [30], dyslipidemia diagnosis (presence/absence of dyslipidemia), and lipid profile: total cholesterol (mg/dl, high ≥240 mg/dl), HDL-c (mg/dl, low <40 mg/dl), LDL-c (mg/dl, high ≥160 mg/dl), triglycerides (mg/dl, high >150 mg/dl), atherogenic index (total cholesterol/HDL-c, considered of risk >4.5) [31, 32].

Patients were further classified by presence/absence of metabolic syndrome (MS), taking into account as "presence" at least three of the following components: increased WC (in women ≥88 cm, and in men ≥102 cm) [33]; triglycerides ≥150 mg/dl; HDL-c <40 mg/dl in men, and in women <50 mg/dl; under hypertension treatment; diabetes mellitus diagnosis [31]. The type of medication and the number of drugs taken by participants were also considered to characterize the study population. An observation grid was used to record the patient's medical history data.

Epicardial fat thickness

EFT was measured as the echo-free space above the free wall of the right ventricle to the frontal pericardium at end-diastole from the parasternal long-axis view perpendicular to the aortic arch [34]. Cutoff points for assessment were determined based on the data obtained, using 3-6 mm as a reference, according to the bibliography consulted [35, 36]. Image acquisitions were performed prior to open heart surgery, at the operating theatre, and, in exceptional cases, in the inpatient rooms with subjects in the left lateral decubitus position. All patients were performed with a General Electric Vivid E9 – 5 MHz instrument. Standard images were recorded and stored by 2 appropriately trained cardiology surgeons. The measurement of echocardiographic parameters was performed by a doctor with experience in echocardiography, who was unaware of the clinical data and characteristics of the patients.

Dietary factors

For the evaluation of dietary factors, we used the "Block Fat, Fruit/Vegetable and Fiber intake Screener" [37], which was adapted (language and habitual consumption food items) to the population of Uruguay. This tool uses the following intervals and categories for fat intake: a value ≤17 points indicate "appropriate fat intake"; 18–21 points "must make better choices in fat intake"; 22–24 points "generally high fat intake"; 25–27 points "high-fat diet"; >27 points "very high-fat diet". For fiber intake, it accounts for≥30 points "expected fiber intake value"; 20–29 points "must include more vegetables and whole grains"; <20 points "low-fiber intake". The intervals were calculated by adding the 6 scores allocated to the frequency of consumption used in the questionnaire: 0 points for "less than once a month", 1 point for "2 to 3 times a month", 2 points for "1 or 2 times a week", 3 points to "3 to 4 times a week" and 4 points to "5 or more times a week".

Sugar consumption was assessed using brief qualitative and quantitative questions taken from the reviewed literature, and the sugar added to infusions was measured [38, 39]. We used the cutoff point for the healthy adult population established by WHO (<25 g/day recommended intake) to classify sugar intake into "recommended" or "not recommended" [40].

Statistical analysis

Absolute frequency was used to present qualitative variables and mean±standard deviation for quantitative parameters. A Shapiro-Wilk normality test was applied to all quantitative variables. A Student's t-test was conducted to compare anthropometric and cardiometabolic parameters of the heart bypass surgery and without bypass surgery groups. For glycemia and triglycerides, the nonparametric Mann-Whitney test was applied. The Student's t-test was used to compare mean BMI and WC according to the EFT classification and to compare EFT according to the presence/absence of diabetes mellitus, high blood pressure, dyslipidemia and metabolic syndrome.

We applied Fisher's exact test to associate dietary factors with the types of heart surgeries (bypass surgery and without bypass surgery) and the EFT classification. Pearson correlation coefficient was used to associate anthropometric and cardiometabolic parameters with EFT. For variables with non-normal distribution, the Spearman correlation was used. The SPSS version 27.0 software was used, considering a statistically significant difference with $p<0.05$.

Ethical considerations

The study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki [41],

Table 1: Comparison of anthropometric and cardiometabolic parameters according to type of surgery.

Parameters	Total			Type of surgery				p
				Revascularized (n=24)		Not revascularized (n=11)		
	n	Mean	SD	Mean	SD	Mean	SD	
Age (years)	35	69.06	9.08	66.58	9.45	74.45	5.33	0.004
BMI (kg/m²)	35	29.82	5.79	30.57	5.98	28.21	5.26	0.270
Waist circumference (cm)	31	97.00	12.91	100.24	12.91	91.12	11.13	0.058
Epicardial fat thickness (mm)	25	7.44	3.54	8.39	3.45	5.00	2.58	0.028
Glycemia (mg/dl)	30	120.93	36.04	126.05	33.65	109.00	40.59	0.060*
Diastolic blood pressure (mmHg)	30	72.00	12.13	74.43	12.86	66.56	7.60	0.065
Systolic blood pressure (mmHg)	30	126.00	27.24	126.81	20.15	123.56	7.33	0.644
HDL-cholesterol (mg/dl)	29	42.38	12.31	38.47	9.82	49.80	13.58	0.015
Triglycerides (mg/dl)	29	181.24	130.98	210.58	149.70	125.50	57.29	0.077*
LDL-cholesterol (mg/dl)	29	102.10	32.76	102.58	31.53	101.10	36.72	0.910
Atherogenic index	29	4.29	1.14	4.65	1.17	3.61	0.73	0.016
Total cholesterol (mg/dl)	29	172.55	39.25	170.89	36.13	175.70	46.54	0.760
Number of drugs consumed	35	4.46	2.08	5.29	1.65	2.64	1.74	<0.001

Note: Statistically significant differences: p<0.05 (Independent samples t-test and *Mann-Whitney U test). SD – standard deviation; BMI – body mass index; HDL – high-density lipoprotein; LDL – low-density lipoprotein.

and approved by the Research Ethics Committee of the School of the Nutrition, of the University of the Republic (reference number: INV.EST.8/2021). Participants were informed about the characteristics of the study, and signed an informed consent.

Results

Participant features

Table 1 includes a description of study participant characteristics by type of surgery. Average age was 69.06±9.08 years; for BMI and WC, 29.82±5.79 kg/m² and 97.00±12.91 cm, respectively. The mean EFT was 7.44±3.54 mm. Sixty-three percent of the study population were male, 37% were women, and 80% were overweight or obese (results not shown).

Results have shown a statistically significant difference between the groups in the mean EFT assessed by transthoracic echocardiography, which is higher in patients with bypass surgery than those without bypass surgery (p=0.028). Additionally, these groups also showed statistically significant differences in relation to age, where the patients without bypass surgery were older (p=0.004). As for biochemical parameters, a lower HDL-c concentration was observed in patients with heart bypass surgery (p=0.015), while the atherogenic

Table 2: Relationship between dietary factors, type of surgery and classification of epicardial fat thickness.

Variables	Type of surgery		p	Classification of epicardial fat thickness		p
	Revascularized (n=24)	Not revascularized (n=11)		Increased (n=16)	Adequate (n=9)	
Fat intake						
Adequate	5	4	0.416	3	4	0.205
Elevated	19	7		13	5	

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Table 2: Continued.

Variables	Type of surgery		p	Classification of epicardial fat thickness		p
	Revascularized (n=24)	Not revascularized (n=11)		Increased (n=16)	Adequate (n=9)	
Dietary fiber intake						
Low fiber	19	8	0.685	12	8	0.621
You should consume more	5	3		4	1	
Sugar intake						
Adequate	4	2	1.000	3	2	1.000
Elevated	20	9		13	7	

Note: Results are expressed as absolute frequency. Statistically significant differences: p<0.05 (Fisher's exact test).

index was higher (p=0.016). No statistically significant differences were observed in the other study variables.

A statistically significant difference was observed between the groups in relation to the consumption of medication, with patients with heart bypass surgery having a higher consumption (p<0.001). The drugs most used by the total study population were classified into antidiabetic drugs (17%), anti-hypertensive drugs (77%), hematologic drugs (63%) and beta-blockers (69%) (results not shown).

Dietary factors

Table 2 shows the association of dietary factors with the type of surgery and the EFT classification. The data revealed that the type of surgery (bypass surgery and without bypass surgery) did not show an association with fat, dietary fiber, and sugar intake.

As for the EFT classification (increased and adequate), no association was found between fat, dietary fiber, and sugar intake.

Anthropometric parameters and cardiometabolic factors

Figure 1 (A–I) depicts the association of glycemia, lipid profile, blood pressure and waist circumference with epicardial fat thickness. A relationship was found between EFT and glycemia (p=0.006, r=0.563), triglycerides (p=0.013, r=0.543) and WC (p=0.033, r=0.466), showing that an increase of these parameters is associated with a higher EFT (Figure 1 A, E, I, respectively). However, no association was found in the other study parameters.

Figure 2 shows the comparison of BMI and WC by the EFT classification. Patients with higher EF thickness have a greater mean BMI than those with adequate thickness (p=0.001) (Figure 2 A). On the other hand, WC did not show a statistically significant difference between the EFT groups (p=0.101) (Figure 2 B).

Cardiometabolic factors

As shown in Figure 3 (A–D), comparing mean EFT between patients with or without diabetes mellitus (presence or absence) resulted in a statistically significant difference (p=0.026, mean EFT in the absence of diabetes mellitus=6.07 mm, mean EFT in the presence of diabetes mellitus=9.18 mm) (Figure 3 A).

Component D of Figure 3 shows the mean EFT between patients with or without MS (presence or absence). EFT is higher with the presence of MS (p=0.001, mean EFT with the absence of MS=4.00 mm, mean EFT with the presence of MS=8.65 mm).

Discussion

This research was based on the study of nutritional and cardiometabolic factors with epicardial fat thickness in patients waiting for heart bypass surgery and without heart bypass surgery.

One important finding was that EFT differed between the study groups and was higher in patients with heart bypass surgery than those without bypass surgery. This is consistent with the data obtained in other studies, where EFT has been associated with atherosclerotic diseases, in particular coronary artery blockage, evidencing the important role of EFT in the pathogenic mechanisms of the disease [42]. In our study, the mean EFT was 7.44 mm, a measurement

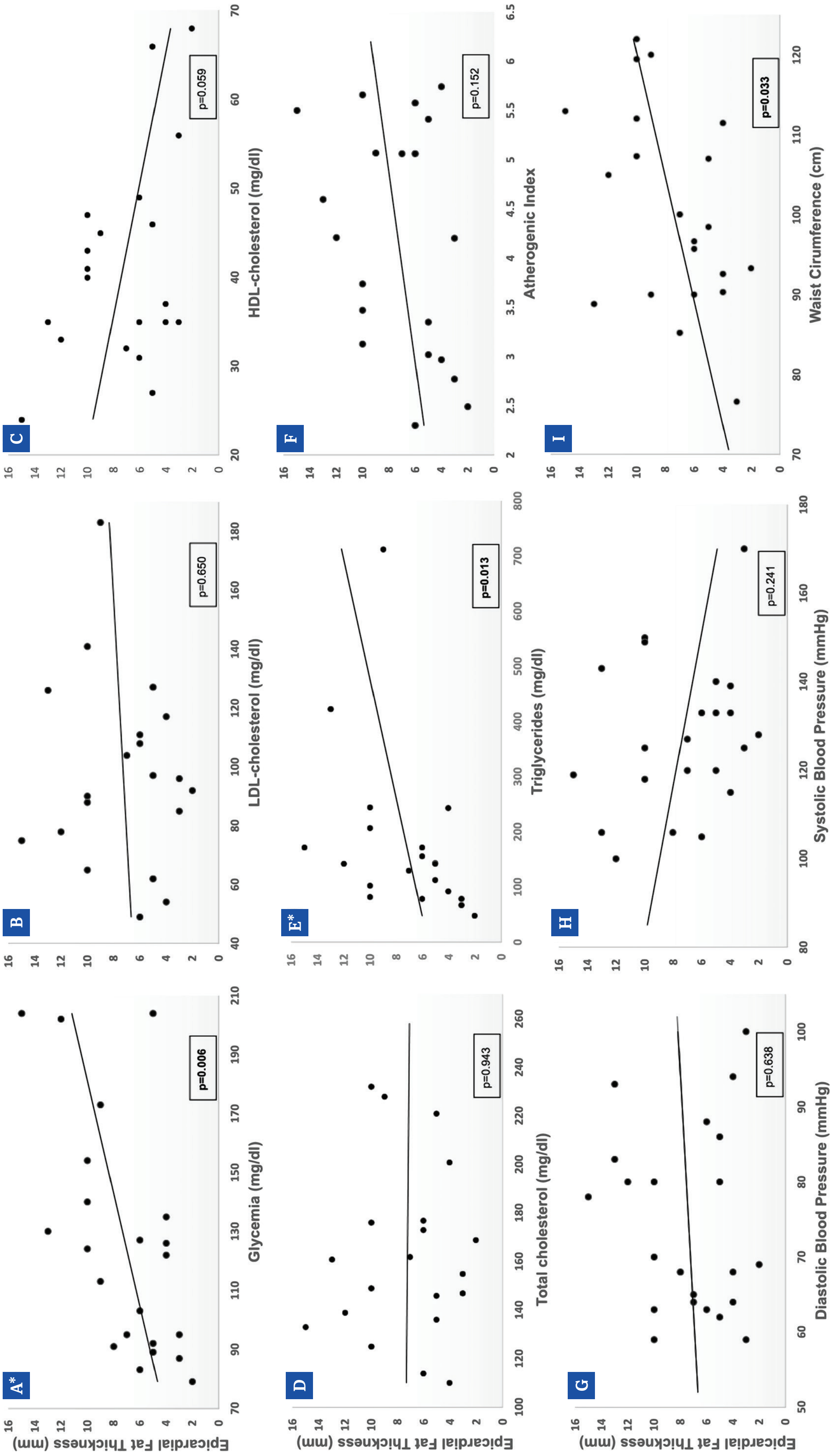

Figure 1: Relationship of glycemia (A), lipid profile (B-F), blood pressure (G, H) and waist circumference (I) with epicardial fat thickness. Statistically significant differences: $p<0.05$ (Pearson's correlation and *Spearman's correlation). LDL – low-density lipoprotein; HDL – high-density lipoprotein. Glycemia, n=22; LDL-cholesterol, n=20; HDL-cholesterol, n=20; total cholesterol, n=20; triglycerides, n=20; atherogenic index, n=20; diastolic blood pressure, n=22; systolic blood pressure, n=22; waist circumference, n=21.

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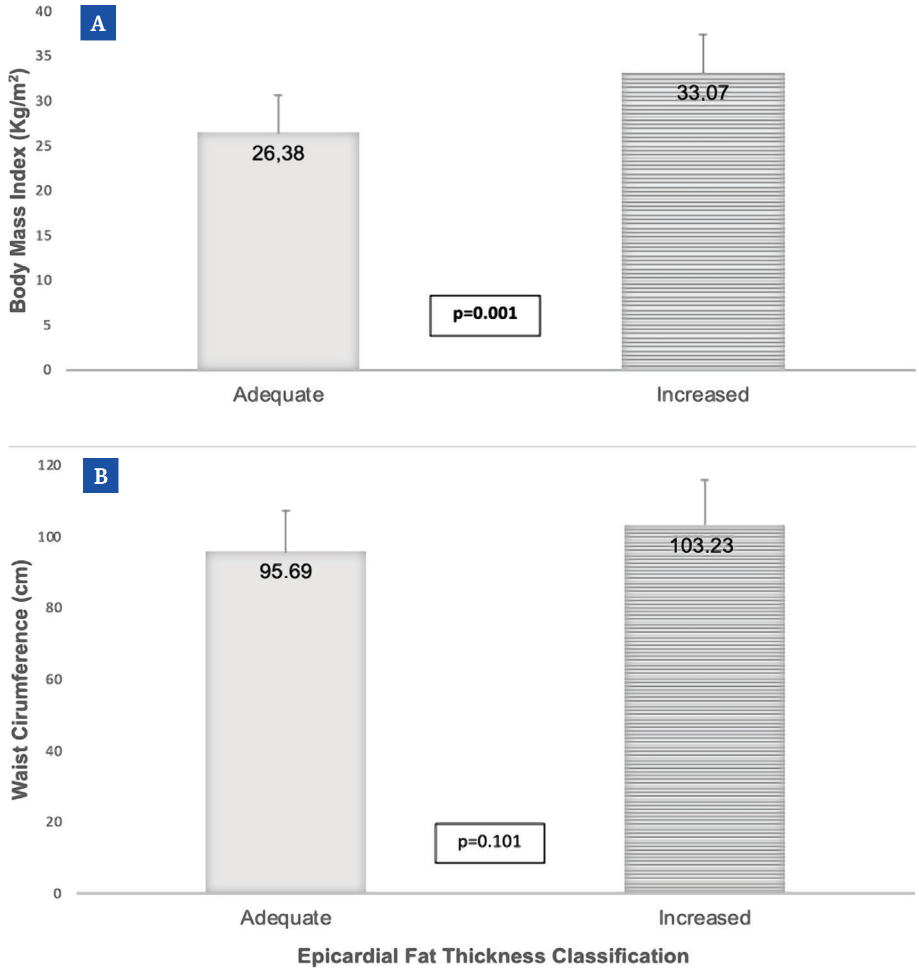

Figure 2: Comparison of body mass index (A) and waist circumference (B) according to epicardial fat thickness classification. Results are expressed as mean±SD. Statistically significant differences: $p<0.05$ (independent samples t-test). Body mass index, n=25; waist circumference, n=21.

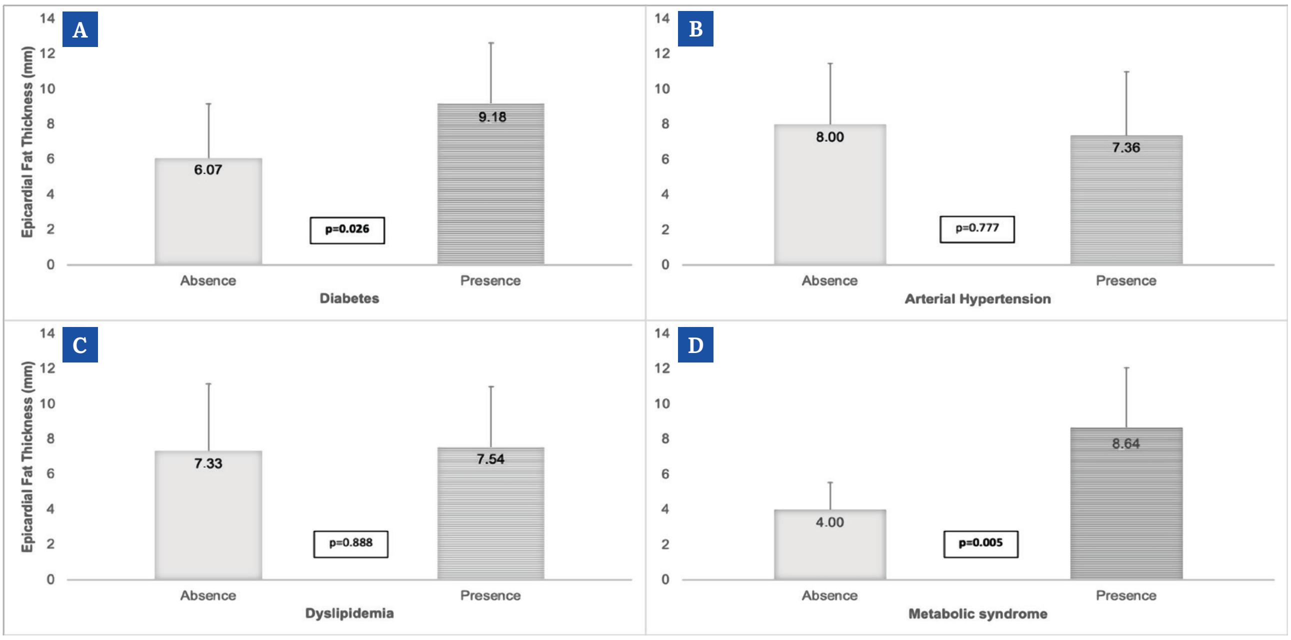

Figure 3: Epicardial fat thickness is determined by the presence or absence of diabetes (A), arterial hypertension (B), dyslipidemia (C), and metabolic syndrome (D). Results are expressed as mean±SD. Statistically significant differences: $p<0.05$ (independent samples t-test). Diabetes, arterial hypertension, dyslipidemia, n=25; metabolic syndrome, n=20.

consistent with the data obtained in previous studies [12, 35, 36]. The absence of fascia separating the EF and the myocardium and the fact that the two tissues share microcirculation may explain the link between epicardial adipose tissue and atherosclerotic risk factors [43].

Concerning biochemical parameters, our findings are consistent with the literature reviewed [9]. The patients with coronary artery disease who underwent heart bypass surgery had higher atherogenic index values than patients without heart bypass surgery [32]. It is well-known that coronary atherosclerosis is associated with impaired lipid levels and is one of the leading causes of coronary occlusion [9]. EFT showed a direct relation to glycemia, a result consistent with that observed. Higher levels of glycemia are associated with insulin resistance, which has been studied for its link to visceral fat and, subsequently, with EF [9, 44].

No differences were found between the study groups in the systolic and diastolic blood pressure; however, evidence shows a direct relationship of high systolic blood pressure values and EF [45]. This discrepancy may be due to the diet habitually prescribed for hypertension, and the use of blood pressure-regulating drugs [30].

As for anthropometric parameters, our results are also consistent with those reported in other studies, showing a direct association between BMI, WC and EFT [46, 47]. Abdominal visceral fat is measured through WC, which is closely associated with epicardial fat; therefore, its volume may indicate the volume of visceral fat [48]. BMI may be defined as an increase in body weight resulting from excess accumulation of adipose tissue, with the possibility of generating accumulation of this tissue in ectopic deposits, such as the heart [49].

Dietary intake did not show any differences between the two groups. Additionally, EFT was not associated with fat, diet fiber and sugar intake levels, even though literature shows an association between diet and EFT [15, 21]. This could be due to the fact that most patients have an inadequate diet, with high fat and sugar intake and low intake of dietary fiber, which impedes the comparison between the groups (with heart bypass surgery and without heart bypass surgery).

Although food intake frequency questionnaires are commonly used to study the relationship between diet and disease, they are not considered the most appropriate methods to study the real intake of subjects [38]. We consider that the questionnaire used to collect information on food intake has some limitations, such as differences arising in the application by different interviewers, which may condition the accuracy of measurement. Another limitation is that the frequency questionnaire is based on long-term recall; additionally, the declared intake may be conditioned by the current diet of the patient, which is adapted to the base pathologies, which may pose a challenge to the accuracy of the responses [39].

Epicardial fat thickness was higher in patients with MS, which includes at least three of the following variables: increased WC, high blood pressure, impaired fasting glycemia, low HDL-c concentrations and high triglycerides concentrations [31]. The combination of an increase in visceral fat and at least two clinical MS parameters is associated with higher epicardial fat thickness [9]. To the best of our knowledge, there is no evidence that contradicts this association.

This study has provided knowledge on EFT and its relationship to dietary, anthropometric, and cardiometabolic factors, identifying those that could predispose to an increase in epicardial adipose tissue in the adult population. However, further research is needed, using a larger sample size, to further study the association between dietary intake and EF and their interaction with cardiovascular disease since we were not able to find an association between them.

Conclusion

Epicardial fat thickness was higher in patients with heart bypass surgery than in patients without bypass surgery, and the atherogenic index was also higher in this group, while high-density lipoprotein cholesterol concentration was lower. On the other hand, patients with higher body mass index, higher waist circumference, glycemia and plasma triglycerides, as well as those with diabetes mellitus and metabolic syndrome, showed a higher epicardial fat thickness. As for dietary factors, no relationship was found between the type of surgery and the epicardial fat thickness.

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Conflict of interest

The authors declare no conflict of interest.

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Ethics approval

The approval for this study was obtained from the Ethics Committee of the School of Nutrition of the University of the Republic (approval ID: INV.EST.8/2021).

Consent to participate

Written informed consent was obtained from all the participants.

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