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Research Article

Aortic Valve Calcium Score in Patients Undergoing Aortic Valve Replacement Surgery

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Abstract

Introduction: The calcium score of the aortic valve is a simple and rapid method that allows to evaluate the degree of calcification emerging as a non-invasive technique in the preoperative period that allows to assess the severity of the aortic stenosis and the possible adverse events of the surgery.

Methodology: A cross-sectional descriptive study was conducted in patients with aortic valve disease who underwent surgery at Provincial University Heart Center "Ernesto Guevara", Villa Clara, from September 2019 to March 2021.

Result: Patients aged 60 to 69 years (47.5%), male sex (85%), with hypertension (87.5%) and coffee consumption (77.5%) being the most frequent history and toxic habit. In (80%) of cases, the main diagnosis was aortic stenosis, and the most frequent electrocardiographic finding was sinus rhythm (97.5%). Echocardiographic variables, normal LVEF (75%). With predominance by the degree of stenosis according to the valvular area (85%), peak speed and peak gradient with (62.5%) respectively and medium gradient (65%).

Conclusion: Stenosis with peak, medium and moderate peak velocity gradient presented the highest values of calcium score of the aortic valve. Most of the operated patients show moderate, severe calcium score, unrelated to the coronary calcium score. In the intraoperative variables, the very calcified aortic valve predominated, anoxic arrest and prolonged extracorporeal circulation, which were in the severe form of the

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valvular calcium score. The most frequent post-surgical complications are anemia, atrioventricular rhythm and conduction disorders, and pleural effusion.

Keywords: Valvular calcium score; Coronary calcium score; Aortic valve replacement; Echocardiographic variables; Intraoperative variables.

Introduction

Cardiovascular diseases have become the leading cause of death worldwide, causing an estimated 17.9 million deaths per year; This figure is expected to rise to more than 23.6 million deaths from this pathology when 2030 is reached. As with high-income countries over the past century, low- and middle-income countries are currently experiencing an accelerating increase in cardiovascular disease [1-2]. The main causes of heart valve disease are age-related or "aging" calcification and inherited or congenital disorders. Rheumatic fever and syphilis, common causes in the first half of the 20th century, are now rare in the developed world [3].

The calcified aortic valve showed that the primary changes included "alterations of valvular collagen with extracellular drops of neutral fat infiltrating the beams", alteration that followed from calcification [2]. Also, the bony components of the extracellular protein matrix (osteoid) provide the scaffolding of the calcification process. There are not only inflammatory cells, such as macrophages and lymphocytes, but also bone cells such as osteoblasts and osteoclasts and even angiogenesis itself demonstrating that calcification is an active process [4]. To date there is no medical therapy that has proven to have an impact on the prevention or reduction of the speed of progression of the disease, although the risk factors associated with aortic valve calcification are shared with atherosclerotic coronary heart disease such as advanced age, male sex, high total cholesterol, High LDL, high blood pressure, smoking, diabetes mellitus and metabolic syndrome. And because there is no known treatment to treat calcification, the statin may be able to stabilize atherosclerotic valve lesions and delay calcification. Randomized studies are needed to know if modifying the lipid profile with statins reduces the incidence of calcified aortic stenosis and the same can be said for treatment with anti-inflammatory drugs such as aspirin [5-8]. Valvular heart disease is responsible for 10 to 20% of all cardiac surgery in the United States and Europe. In Latin America and Cuba, the increase in the incidence of heart valve affections is a fact, standing out for its frequency those that interest the aortic valve, direct consequence of population ageing in countries with high-level or developing health systems. And our province of Villa Clara is one of the oldest provinces in Cuba, so a growing number of patients benefit from valve replacement [1-2].

About two-thirds of all heart valve operations are for aortic valve replacement, mostly for aortic stenosis. All this explains why it is the most common valvular disease to be referred for surgical treatment, in 2016 in the United States 65,000 aortic valve replacements were performed. This has had a notable decrease in recent years with the rise of percutaneous interventional activity [9-12].

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The results of valve replacement surgery are contrasted, with mortality rates estimated below 3%, according to recent data from the Society of Thoracic Surgeons in the USA (STS) and in turn are determined by the patient's comorbidity, the severity of symptoms or the stage of the disease once the procedure is performed [13].

Methods

Developmental research was carried out, through a cross-sectional descriptive study in patients with aortic valve disease who underwent surgery who were admitted to the preoperative room of the Provincial University Heart Center "Ernesto Guevara", Villa Clara province, in the period September 2019 to March 2021. The study population consisted of 61 patients with aortic valve disease and surgical criteria that were admitted to the pre-operative room at the Heart Center "Ernesto Guevara", and in the aforementioned period. A non-probability sample of 40 patients was selected with intentional sampling according to the following criteria:

- Inclusion criteria: That the calcium score has been made in the preoperative period.
- Exclusion criteria: Patients with incomplete data in the medical history.

Results

In this study, patients with aortic valve disease who underwent cardiac surgery who were admitted to the preoperative ward of the Provincial University Heart Center "Ernesto Guevara" in Santa Clara city, Villa Clara Province, in the period September 2019 to March 2021, were studied. As shown in Table 1, the analysis of patients operated on for aortic valve replacement according to age and sex was performed, for which a total of 40 were studied, who were admitted to the preoperative room of the Provincial University Heart Center "Ernesto Guevara" in Santa Clara city. There was a majority of males with 34 patients representing 85% and a predominance of the age group of 60 to 69 years for 47.5%. To better illustrate the result, Figure 1 is designed.

Age (years)	Sex				Total	
	Male		Female			
	No.	%	No.	%	No.	%
<30	2	5	0	0	2	5.0
30-39	0	0	1	2.5	1	2.5
40-49	5	12.5	0	0	5	12.5
50-59	10	25.0	1	2.5	11	27.5
60-69	15	37.5	4	10.0	19	47.5
>70	2	5.0	0	0	2	5.0
Total	34	85	6	15	40	100

Table 1: Distribution of patients operated on aortic valve replacement according to age and sex at the Provincial University Heart Center "Ernesto Guevara". Villa Clara province. September Source: Medical history.

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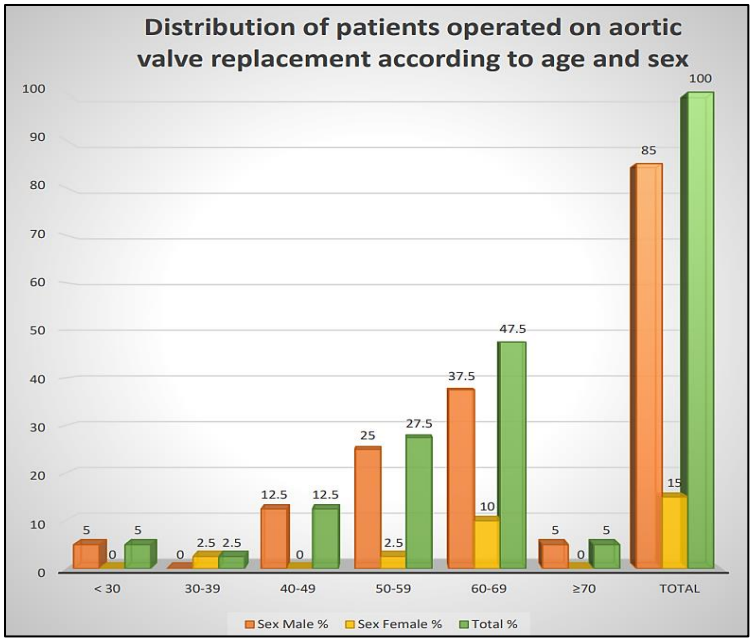

Figure 1: Distribution of patients operated on aortic valve replacement according to age and sex at the Provincial University Heart Center "Ernesto Guevara". Villa Clara province. September Source: Medical history.

Table 2 shows the analysis of the personal pathological history and toxic habits of patients operated on for aortic valve replacement. There was a predominance that, as a personal pathological history, presented arterial hypertension with 35 patients for 87.5%, followed by ischemic heart disease with 13 patients for 32.5% and diabetes mellitus with 7 patients for 17.5%. As for toxic habits, there was a majority with coffee consumption with 31 patients for 77.55%, and tobacco with 22 patients for 55%.

Past Medical History	**No.**	**%**
Hypertension (HTN)	35	87.5
Ischemic Heart Disease	13	32.5
Diabetes Mellitus (DM)	7	17.5
COPD	6	15.0
Periphery Arterial Disease	1	2.5
Rheumatic Heart disease	1	2.5
Toxic habits		
Coffee	31	77.5
Tabacco	22	55.0
Alcohol	3	7.5

Table 2: Past medical History and toxic habits of patients operated on aortic valve replacement.

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Table 3, Figure 2 shows the diagnosis of patients operated on aortic valve replacement according to age and diagnosis. There was a majority with aortic stenosis with 32 patients representing 80%, followed by double aortic lesion with 5 patients for 12.5%. It is noteworthy the age group of 60 to 69 years with 17 patients with aortic stenosis for 42.5%.

Age (yrs)	Diagnosis						Total	
	Aortic stenosis		Aortic Insufficiency		Double aortic injury			
	No.	%	No.	%	No.	%	No.	%
<30	1	2.5	1	2.5	0	0	2	5
30-39	1	2.5	0	0	0	0	1	2.5
40-49	5	12.5	0	0	0	0	5	12.5
50-59	7	17.5	1	2.5	3	7.5	11	27.5
60-69	17	42.5	1	2.5	1	2.5	19	47.5
≥ 70	1	2.5	0	0	1	2.5	2	5
Total	32	80	3	7.5	5	12.5	40	100

Table 3: Distribution according to age and diagnosis at admission of patients operated on aortic valve replacement.

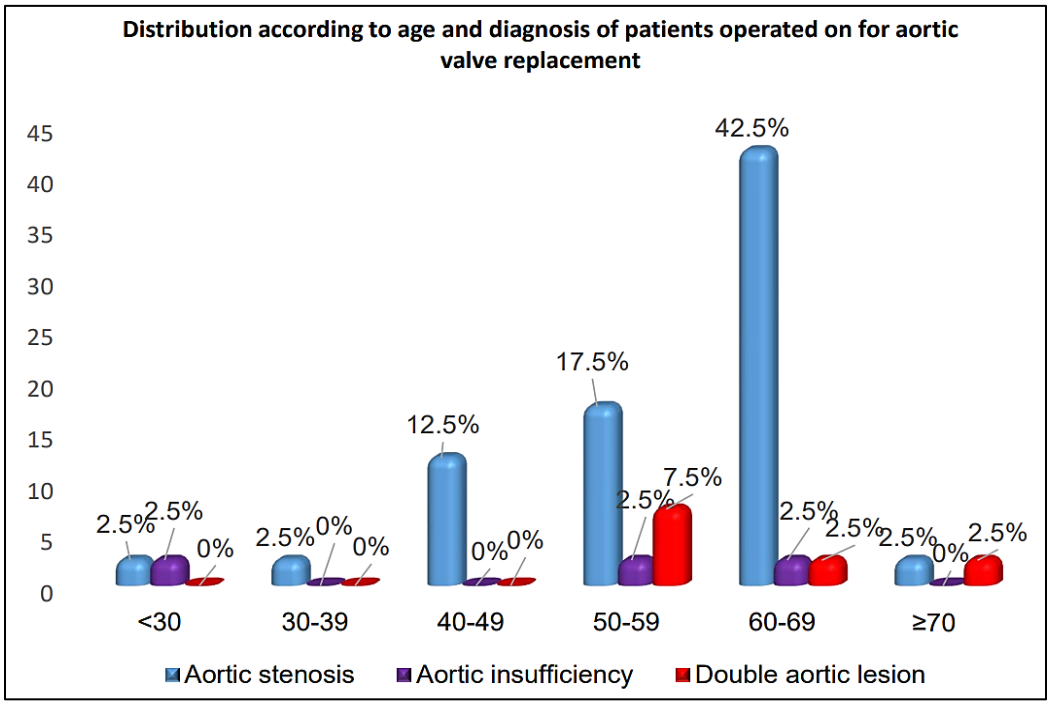

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Table 4 shows the electrocardiographic findings in patients operated on for aortic valve replacement during the preoperative period.

There was a majority who presented sinus rhythm with 39 patients for 97.5%, followed by systolic overload with 28 patients for 70% and signs of LVH with 27 for 67.5%.

Electrocardiographic findings	No.	%
Sinus rhythm	39	97.5
Systolic overload	28	70.0
Signs of LVH	27	67.5
Intraventricular Conduction Defects	8	20.0
Ventricular And Supraventricular Arrhythmias	1	2.5
Atrioventricular Conduction Defects	1	2.5

Table 4: Electrocardiographic findings in patients operated on for aortic valve replacement during the preoperative period.

As shown in Table 5, patients with aortic valve disease were analyzed according to echocardiographic variables during the preoperative period. There was a majority with normal LVEF with 30 patients for 75%, followed by slightly depressed with 7 patients for 17.5%.

Where there was a predominance by the degree of stenosis according to the aortic valve area with 34 patients for 85%, peak speed and systolic peak gradient with 25 patients for 62.5% respectively and mean systolic gradient with 26 patients for 65%. In the aortic regurgitation according to jet area, it was mild with 31 patients for 77.5%, being severe only in 4 patients for 10%, because the diagnosis that had less predominance was that of aortic insufficiency.

Table 6, Figure 3, compares the calcium score of the aortic valve according to the echocardiographic variables. The degree of stenosis according to peak systolic gradient showed in the severe form a greater number of affected patients [14]. The highest values of the aortic valve calcium score were presented in the moderate form, with a median of 4558, showing significantly lower values in the mild form (1110). The degree of stenosis according to mean systolic gradient did not present cases of mild category only moderate and severe, the latter predominating. The values of the mean gradient were higher in the moderate form with a median 4025 and for the severe 3587 although it did not show significant differences. The degree of stenosis according to peak velocity was significantly higher in the moderate form, with a median of 4228. Aortic regurgitation by jet area was significantly lower in severe forms with a median of 1110.1. This may be related to the fact that the patients who present slight y moderate have severe aortic stenosis and double aortic lesion.

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Echocardiographic variables	No.	%
Left ventricular ejection fraction (LVEF)		
Normal	30	75.0
Slightly depressed	7	17.5
Moderately depressed	3	7.5
Degree of stenosis according to aortic valve area		
Slightly depressed	1	2.5
Moderately depressed	5	12.5
Severe	34	85.0
Degree of stenosis according to peak velocity		
Slight	3	7.5
Moderate	12	30.0
Severe	25	62.5
Degree of stenosis according to peak systolic gradient		
Slight	3	7.5
Moderate	12	30.0
Severe	25	62.5
Degree of stenosis according to mean systolic gradient		
Moderate	14	35.0
Severe	26	65.0
Aortic regurgitation by Jet area		
Slight	31	77.5
Moderate	5	12.5
Severe	4	10.0
Total	40	100

Table 5: Echocardiographic variables in patients operated on aortic valve replacement during the preoperative period at the Provincial University Heart Center "Ernesto Guevara".

Table 7 shows the relationship between the aortic valve calcium score and the coronary calcium score of patients undergoing aortic valve replacement.

There was a majority with a normal coronary calcium score with 28 patients representing 70% and aortic valve calcium score major with 30 patients for 75%. It is noteworthy those who presented calcium score, in the case of normal coronary and major aortic valve with 19 patients for 47.5%.

There is no significant relationship between aortic valve calcium score and coronary calcium score.

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Echocardiographic variables	Aortic valve calcium score			p
	No.	Mean	Median	
Degree of stenosis according to systolic peak gradient				
Slight	3	1040	1110	0.023
Moderate	12	3730	4558	
Severe	25	3256	3588	
Degree of stenosis according to the mean systolic gradient				
Moderate	14	3235	4025	0.843
Severe	26	3231	3587	
Degree of stenosis according to peak velocity				
Slight	3	3368	3650	0.015
Moderate	12	3757	4228	
Severe	25	2897	2593	
Aortic regurgitation by Jet area				
Slight	31	3075	3587.4	0.031
Moderate	5	2584	3588	
Severe	4	1110	1110.1	

Table 6: Comparison of echocardiographic variables according to the calcium score of the aortic valve in patients operated on aortic valve replacement.

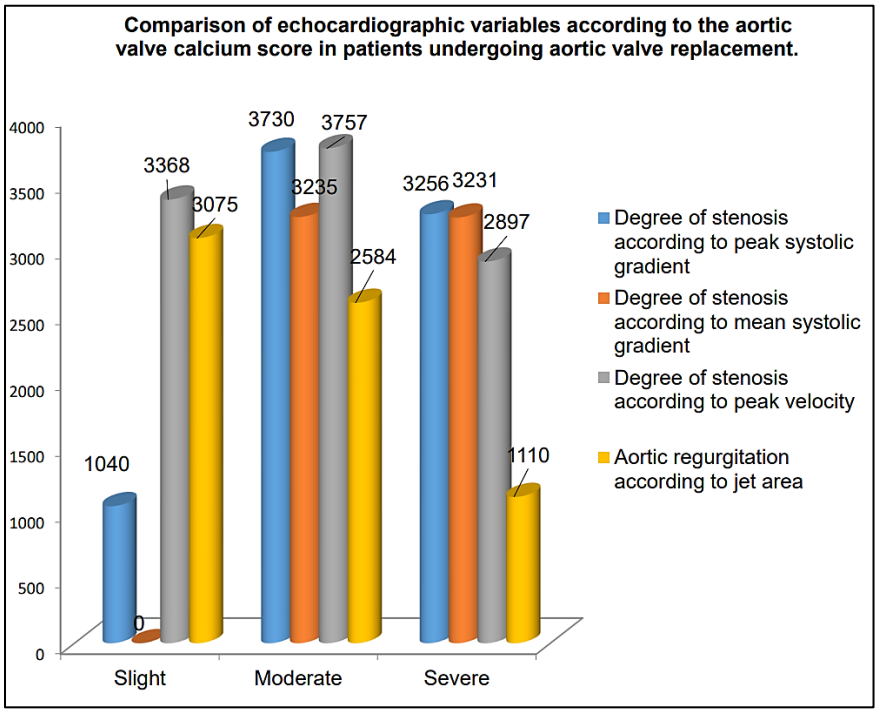

Figure 3: Comparison of echocardiographic variables according to the calcium score of the aortic valve in patients operated on aortic valve replacement.

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Coronary Calcium Score	Aortic valve calcium score				Total	
	Minor (Moderate)		Major (Severe)			
	No.	%	No.	%	No.	%
Normal	9	22.5	19	47.5	28	70.0
Slight	0	0	4	10	4	10.0
Moderate	1	2.5	6	15	7	17.5
Severe	0	5	1	2.5	1	2.5
Total	10	25	30	75	40	100

Table 7: Aortic valve calcium score and coronary calcium score of patients operated on aortic valve replacement. (x2=0.048, p=0.826).

Table 8 shows the calcium score of the aortic valve and intraoperative variables in patients operated on for aortic valve replacement. In the case of aortic valve calcification, 70% of patients had very calcified valve. There is a significant relationship between the calcium score of the aortic valve and the calcification of the aortic valve appreciated by the surgeon during the surgical act.

Of the 25 patients who had prolonged total circulation arrest representing 62.5%, 57.5% had an aortic valve calcium score classified as severe. There is an important statistical significance.

There was a majority with prolonged extracorporeal circulation for 67.5% who were in the severe form of the aortic valve calcium score. All these variables show that there was a significant relationship with the calcium score of the aortic valve. The more severe it is, the longer the time of anoxic arrest and extracorporeal circulation.

Intraoperative variables	Aortic Valve Calcium Score					
	Moderado n=10		Severo n=30		Total	
	No.	%	No.	%	No.	%
Aortic valve calcification*						
Very calcified	0	0	28	70	28	70
Calcified	10	25	2	5	12	30
Total circulatory arrest time**						
Prolonged	2	5	23	57.5	25	62.5
Not prolonged	8	20	7	17.5	15	37.5
Extracorporeal Circulation Time***						
Prolonged	3	7.5	27	67.5	30	75
Not prolonged	7	17.5	3	7.5	10	25

Table 8: Aortic valve calcium score and intraoperative variables in patients operated on aortic valve replacement. (**x2=10.27;p=0.000, **x2=10.27;p=0.000, ***x2=14.40;p=0.000).

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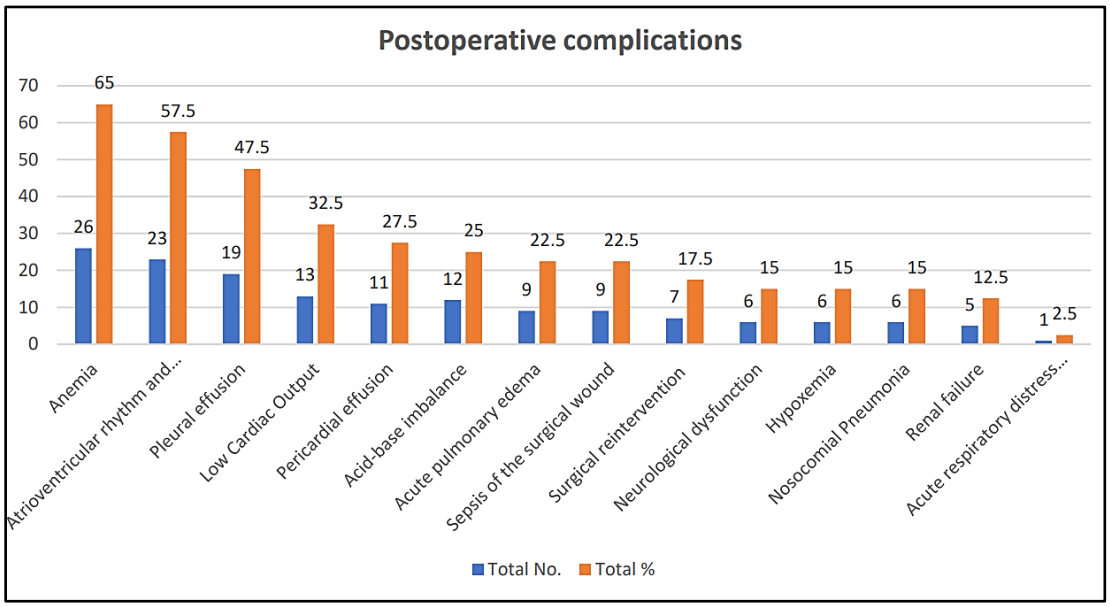
Table 9 presents the postoperative complications of patients operated on for aortic valve replacement. Where the most frequent complications were anemia with 26 patients representing 65%, followed by rhythm disorders and atrioventricular conduction with 23 patients for 57.5%, pleural effusion with 19 patients for 47.5% and low cardiac output with 13 patients for 32.8%. To better illustrate this result, refer Figure 4.

Postoperative complications	Total	
	No.	%
Anemia	26	65.0
Atrioventricular rhythm and conduction disorders	23	57.5
Pleural effusion	19	47.5
Low Cardiac Output	13	32.5
Pericardial effusion	11	27.5
Acid-base imbalance	12	25.0
Acute pulmonary edema	9	22.5
Sepsis of the surgical wound	9	22.5
Surgical reintervention	7	17.5
Neurological dysfunction	6	15.0
Hypoxemia	6	15.0
Nosocomial pneumonia	6	15.0
Renal failure	5	12.5
Acute respiratory distress syndrome (ARDS)	1	2.5

Table 9: Postoperative complications of patients operated on aortic valve replacement.



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Discussion

The calcium score of the aortic valve has shown a close association with echocardiographic parameters that evaluate the severity of aortic valve disease and offers strong predictive values on disease progression and evolution of adverse events [15]. Regarding the results on age and sex, they coincide with a study conducted by Rishi Trivedi, et al., [16] in the United States in 2021, where the average age 55.8 ± 11.7 and that the majority are male with 3603 patients for 64%. They are similar with a study conducted by Ortiz Sagba NR [17] in Ecuador in 2017 where the age group of 60 to 64 years with 34 (50.7%) patients was the most representative, and the majority with 37 patients for 55.2% are men. The present study considers that as age increases, the number of patients with aortic valve disease, with a predominance of stenosis increases, and that decision-making becomes particularly complex in elderly patients, since it represents an extraordinarily heterogeneous population, with a very diverse surgical risk and life expectancy. Depending on individual cardiological and non-cardiological characteristics. On the results of personal pathological history and toxic habits agree with a study conducted by García-Escribano García IA [18] in Spain in 2017, where most have hypertension with 56 patients for 84.8%, followed by diabetes mellitus with 25 patients for 37.9%, are not similar in that most do not have smoking with 55 patients for 83.3%. They coincide with a study conducted by Cubides Nuñez RA [19] in Colombia in 2020 where most have hypertension with 115 patients for 70.5%, followed by coronary heart disease with 31 patients for 19.01%, do not agree that most do not have smoking with 131 patients for 80.4%. They are similar with a study conducted by Rishi Trivedi MS, et al., [16] in the United States in 2021, where most have hyperlipidemia with 5836 patients for 58.3% patients, followed by hypertension with 4595 patients for 45.9%, do not agree that most are non-smokers with 9133 patients for 91.3% patients. They are similar with a study conducted by Rishi Trivedi MS, et al., [16] in the United States in 2021, where most have hyperlipidemia with 5836 patients for 58.3% patients, followed by hypertension with 4595 patients for 45.9%, do not agree that most are non-smokers with 9133 patients for 91.3% patients. They coincide with a study conducted by Cubides Nuñez, RA [19] in Colombia in 2020 where most have aortic stenosis with 122 patients for 74.8% and only double aortic lesion 20% and aortic insufficiency 5.2%. The author believes that the results coincide with those of other studies, since aortic stenosis is the most common aortic valve disease in patients with valvular disease.

With regard to the results on electrocardiogram, they agree with a study conducted by García-Escribano García IA [18] in Spain in 2017, where 153 patients with sinus rhythm were obtained for 84.1% and 126 patients with LVH for 69.2%. They are similar with a study by Cubides Nuñez RA [19] in Colombia in 2020 where 40% with LVH. According to Taboada Martín, R [20] in his thesis "Comparative study of ventricular mass regression after aortic valve replacement surgery according to the type of prosthesis used" in 2020 states that left ventricular

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hypertrophy is the main risk factor for modifiable morbidity and mortality in certain populations. The researcher of the present study considers that the results coincide with those of other studies, since left ventricular hypertrophy is an electrocardiographic finding of high incidence in patients with aortic valve disease. On the other hand, the results on the echocardiogram coincide with a study carried out by García-Escribano García IA [18] in Spain in 2017, where the median LVEF is 65. They agree with a study by Cubides Nuñez RA [19] in Colombia in 2020 where most have an LVEF greater than 50% with 97 patients for 60.2%. They are not similar with a study conducted by Padua Cansigno R [21] in Colombia in 2021 where most have an LVEF less than 50% for 64.5% of patients, being severe in 16.9% with an LVEF less than 30%. In the present study, it is considered that most of the results coincide with those of other studies, since preserved LVEF has a better prognosis in the postoperative period in patients with aortic valve disease.

According to a panel, M45 in its study in 2016 states that there is enough evidence to give importance to the quantification of aortic valve calcium, and it is believed that having an accurate and reproducible method that accompanies echocardiography would be very valuable in-patient care.

Regarding the results on echocardiogram and aortic valve calcium score, they coincide with a study conducted by Calle Valda CM [22] in Spain in 2019 where a mean aortic valve gradient was observed with an average of 48.4 ± 14.3 and a maximum gradient of 77.5 ± 23.9 for a median calcium score of the severe aortic valve of 4432. Similar results were found with a study conducted by Arnold SV, et al., [23] in 2016 where a mean aortic valve gradient was observed with an average of 43.3 ± 14.9, with a very severe median aortic valve calcium score of 4998.

The researcher of the present study highlights that the value of the mean gradient is one of the most reliable and useful echocardiographic variables to evaluate the severity of aortic stenosis accompanied by the calcium score of the aortic valve, especially in cases of stenosis. Regarding the results on coronary calcium score and aortic valve calcium score, and in a study conducted by Han D, et al., [24] they suggest that calcific aortic valve (CAV) is significantly associated with increased risk of the cause of aortic mortality and cardiovascular diseases (CVD), in addition this association is not significant when adjusting the coronary artery calcium score (CAC). However, in patients with CAC <100, there remains a significant association between the VAC score and the increased risk of CMA and CVD independent of CAC. According to Carr JJ, et al., [25] and Budoff MJ, et al., [26] state that the attenuation of significance between the ACV score and the mortality outcome after adjusting for the CAC score is due to three important features. First, this is a unified pathological process underpinned in both calcification contests, particularly, subclinical atherosclerosis (AS). Second, CAC is a very strong predictor of CVD outcome, limiting the possibility of increased utility of an additional predictive tool. There are several reasons why this association is observed only in the CAC subgroup <100.

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Mechanistically, calcification can occur early in the aortic valve than in the coronary arteries due to high levels of major stress mechanisms that accelerate endothelial damage and fibroblast activation [27-28]. Alternatively, individuals with CAC <100 and a >100 ACV are likely to suffer osteogenic changes with predisposition to AS. It is important to identify as an option of a long severe progression of AS and other corrections with the valve replaced. Finally, individuals with CAC >100 are more likely to receive pharmacologic intervention based on initial examinations and indicated therapy may alter the progression of AS and sclerosis in the aortic valve [29].

A recent meta-analysis suggests that a >SCC significantly increases the indication to initiate and maintain a healthy lifestyle and drug therapy for the prevention of cardiovascular disease [21]. Therefore, in our study, no significant relationship was found between both calcium scores. Regarding the calcium score of the aortic valve and intraoperative variables, it coincides with a study conducted by Padua Cansigno R where the extracorporeal circulation time was on average 122.82 minutes [21]. They do not coincide with a study conducted by Cubides Nuñez RA [19] where extracorporeal circulation time was on average 92 minutes. It has been shown that a time greater than 120 minutes of extracorporeal circulation associated with a severe calcium score increases mortality and adverse cardiac events during the postoperative period as mentioned by María Castilla de la Serna, et al., [30], in their study Neurological Monitoring as a Safety System in patients undergoing Cardiac Surgery with Extracorporeal Circulation, performed at the Puerta de Hierro Majadahonda University Hospital in 2015, 442 surgeries with CPB of which 5% had some neurological complication and 1% had irreversible injury [32].

In the present study, the intraoperative variables and the calcium score of the aortic valve were statistically significant at the expense of prolonged anoxic arrest and prolonged extracorporeal circulation, coinciding with the literature that suggest that CPB and BP times increase the mortality of their cases. On the other hand, the results on postoperative complications in our study the most frequent are anemia, rhythm disorders and atrioventricular conduction, pleural effusion and low output. They agree with a study by Cubides Nuñez RA [19] in Colombia in 2020 where there was a predominance of arrhythmia for 36%, and anemia in 28%.They are not similar with a study conducted by Rodríguez-Granillo AM, et al., [31] where there was a predominance of fatal bleeding for 38.4%, followed by major bleeding for 36.7%. Similar results with a study conducted by Paredes Vignoli FA [32] in Spain in 2016, where they presented, low expenditure for 31%, pleural effusion for 30% and atrioventricular conduction disorders for 15%. The present study indicated that in the postoperative period of aortic valve replacement, complications occur as a result of the surgical act due to the highly calcified aortic valve, which is corroborated in the preoperative period with a severe aortic valve score. What triggered a longer time of surgery, prolonged BP and prolonged CPB that also affects the postoperative period.

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Conclusion

Aortic valve replacement surgery is increased after 50 years of age in male patients. Arterial hypertension and ischemic heart disease as personal pathological antecedents, coffee and tobacco as toxic habits predominate in these patients. Aortic stenosis is the most frequent diagnosis leading to valve replacement, with electrocardiographic findings such as sinus rhythm, systolic overload and signs of LVH predominating. Stenosis with moderate peak gradient, mean gradient, and peak velocity have the highest aortic valve calcium score values.

Most patients operated on for aortic valve replacement show severe calcium score, but it is not related to the coronary calcium score. In the intraoperative variables, the highly calcified aortic valve, anoxic arrest and prolonged extracorporeal circulation prevailed, which were in the severe form of the calcium score of the aortic valve. The most frequent post-surgical complications are anemia, atrioventricular rhythm and conduction disorders, and pleural effusion.

Conflict of Interest

No conflict of interest.

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