



Complications and Predictors of Postoperative Mortality in Patients Undergoing Valve Replacement Surgery

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Abstract

Introduction: Valvulopathies continue to be an important cause of medical consultation and hospitalization. Objective: to identify the main complications and predictors of postoperative mortality in patients undergoing valve replacement surgery.

Methods: An observational, analytical and retrospective study was carried out. The universe consisted of 753 patients.

Results: The main complications reported were the need for electric shocks (29.2%), ventricular fibrillation (28.4%) and endocarditis (9.2%). Patients alive at hospital discharge predominated. The complications most related to mortality were cardiogenic shock (18.0%), low output (28.0%) and sepsis (18.0%). Age greater than or equal to 65 years almost tripled the risk of death. Women were 2.5 times more likely to die before hospital discharge. A glomerular filtration rate below 60 ml/min/1.73m² is a predictor of mortality.

Conclusion: Extracorporeal circulation remains the technique of choice for valve replacements which together with good myocardial protection and short anoxic arrest, extracorporeal circulation and surgical times decrease perioperative morbidity and mortality. Surgery is a safe and viable option for these patients, although it is not free of complications. The last one includes the appearance of arrhythmias as a result of alterations in the internal environment and acid-base balance. Aging, the presence of comorbidities such as diabetes and impaired renal function in patients with valvular heart disease predispose to the development of complications and death in the postoperative period.

Keywords: Valvulopathies; Surgery; Mortality; Morbidity; Sepsis

Introduction

Valvulopathies continue to be an important cause of medical consultation and hospitalization worldwide [1]. The improvement in the prevention of rheumatic heart disease and the phenomenon of epidemiological transition has allowed mortality from degenerative heart valve disease to be higher in elderly patients [2]. In Cuba, at the end of 2020, the rate of deaths due to non-rheumatic valvulopathies was 2.7 per-100,000 inhabitants [3]. Early detection and grading of the severity of valvular heart disease has improved

the criteria for selecting patients who are candidates for surgery. In addition, advances in surgical techniques and perioperative management have resulted in a higher success rate and lower morbidity and mortality [4]. Cardiac valve surgery (CVC) requires a specific operative procedure for its performance. The complexity of these procedures is related to patient and surgical factors such as the number of valves to be operated on, the existence of previous cardiac surgery, the association with revascularization or thoracic

aortic surgery and the quality of myocardial protection provided during the surgical procedure, among other factors [5].

Prior identification of all the factors and conditions that favor postoperative complications, together with the availability of resources and access to health care in each region or country, influence the quality and success of the CVC [6]. The purpose of this study conducted at the Institute of Cardiology and Cardiovascular Surgery (ICCCV) was to identify the main complications and predictors of postoperative mortality in patients who underwent valve replacement surgery.

Method

An observational, analytical and retrospective study was carried out at the ICCCV in Havana from January 1, 2016 to December 31, 2019. The universe consisted of 753 patients who met the inclusion criteria of being patients of both sexes, aged over 18 years, diagnosed with any valvulopathy and approved as candidates for CVC. Patients with combined cardiac conditions (valvular heart disease and coronary artery disease), psychiatric patients with difficulties in responding to adequate questioning, patients with a poor acoustic window for echocardiography and patients with consumptive diseases, neoplasms, and acquired immunodeficiency syndrome were excluded.

Variables and their operationalization

The following variables were included in the study: sociodemographic (age and sex) and pre-surgical variables that were grouped into: Clinical variables: arterial hypertension, diabetes mellitus, stroke, chronic kidney disease, chronic obstructive pulmonary disease (COPD), pulmonary hypertension, arrhythmias, bronchial asthma, smoking habit. Laboratory variables: total proteins, creatinine, glomerular filtration rate (GFR). Echocardiographic variables: valvular lesions, left ventricular ejection fraction (LVEF).

Procedural techniques and data collection

The information was obtained from the medical records and echocardiography reports. The data were collected in a model elaborated for this purpose that collected the variables of interest.

Processing and analysis techniques

Frequency distribution tables were prepared and statistical methods were applied using SPSS (Statistical Package for Social Sciences) version 18.0 for Windows. Summary measures were used for descriptive variables, mean, standard deviation and percentage

according to the type of variable. Descriptive statistical techniques such as mean and standard deviation were used.

Ethical Aspects

The research was approved by the scientific board and the ethics committee of the participating institution. The integrity of the data obtained was jealously guarded. The ethical principles for medical research in humans established in the Declaration of Helsinki were complied with at all times.

Result

Patients aged 60 years or older accounted for 52.2% of the total sample. The male sex (52.3%) predominated over the female sex (47.7%). Among the main pathologic antecedents of these cases, arterial hypertension (53.5%), pulmonary hypertension (14.1%) and diabetes mellitus (11.9%) stood out. A total of 31.2% were reported to be former smokers. Aortic valve replacement (48.5%) was the most commonly used surgery, followed by mitral valve replacement (36.7%) and double replacement (14.5%). More than 60% of the patients had filtration values included in categories 1 and 2 and more than 90% of the cases had left ventricular ejection fraction values above 50%. (Table 1) shows variables related to the surgical procedure. The median arrest time was 80 minutes and that of extracorporeal circulation almost 2 hours, while the surgical time and anesthesia time were 4 hours and 5 hours, respectively.

Electrical complications were the most frequent. The use of electric shocks was necessary in 29.2% of the cases. Among the septic complications, endocarditis was the most frequent (9.2%) and the main causal microorganism was staphylococcus aureus (6.9%) (Table 2). 50 patients died in this study which represented 6.6% of the sample. The complications most related to mortality were the cardiogenic shock (34.0%), low output (28.0%) and sepsis (18.0%) (Table 3). It was of interest to know the possible associations between the variables collected and mortality. (Table 4) shows the patient's distribution according to sociodemographic and clinical variables in relation to the patient's condition at discharge. Statistically significant differences were observed for age both in mean values (58.9 vs. 63.9, $p = 0.002$) and in patients aged 65 years and older (34.4% vs. 60.0%, $p = 0.0003$). Diabetes mellitus was present in 32.0% of deceased patients in contrast to 10.5% of those discharged alive ($p < 0.0001$). Regarding renal function, although with normal values, creatinine was slightly higher in deceased patients ($p = 0.051$) and glomerular filtration rate was decreased in this group (81.8 vs. 70.2, $p = 0.025$).

Table 1: Distribution of patients according to variables related to the surgical procedure.

Variables	Mediana RI
Anoxic arrest time	80 (65 - 110)
Extracorporeal circulation time	110 (90 - 151)
Surgical time	240 (200 - 287)

Anesthesia time	300 (255 - 350)
Operated with hypothermia No. (%)	656 (87.1)

Source: Clinical history

Table 2: Distribution of patients according to trans-operative complications.

Variables	No. (%)
Electrical complications	
Atrial fibrillation	128 (17.0)
Ventricular fibrillation	214 (28.4)
AV block	142 (18.9)
Patients in need of electric shocks	220 (29.2)
Electric shocks applied (Median RI)	1 (1 - 2)
No. of patients needing more than one electric shock	84 (11.2)
Septic complications	
Endocarditis	69 (9.2)
Mediastinitis	30 (4.0)
Ventilation-related	41 (5.4)
Main isolated microorganisms	
- Staphylococcus aureus	52 (6.9)
- Enterococcus	12 (1.6)
- Pseudomonas	15 (2.0)
- Acinetobacter/Cinetobacter	7 (0.9)
- Enterobacter	3 (0.4)
- E. Coli	6 (0.8)
- Proteus	5 (0.7)
- Klebsiella	1 (0.1)
- Hafnia Albei	6 (0.8)

Source: Clinical history

Table 3: Distribution of patients according to operative mortality.

Variables	No. (%)
Alive	703 (93.4)
Deceased	50 (6.6)
Complicaciones relacionadas con la muerte	(n= 50)
Low output	14 (28.0)
Cardiorespiratory arrest	5 (10.0)
Cardiogenic shock	17 (34.0)
Pathological bleeding	3 (6.0)
Sepsis	9(18.0)
Multiorgan failure	1 (2.0)

Source: Clinical history

Table 4: Distribution of patients according to sociodemographic and clinical variables in relation to the patient's condition at discharge.

Variables	Alive (n= 703)	Deceased (n = 50)	p
Age (years)	58.9 ± 11.0	63.9 ± 10.5	0.002

- < 65 years	461 (65.6)	20 (40.0)	0.0003
- >= 65 years	242 (34.4)	30 (60.0)	
Sex			
- Female	325(46.2)	34(68.0)	0.003
- Male	378(53.7)	16(32.0)	
- Arterial hypertension	373 (53.1)	30 (60.0)	0.342
-Diabetes Mellitus	74 (10.5)	16 (32.0)	< 0.0001
-Smoker/Ex-smoker	300 (42.7)	21 (42.0)	0.925
Past medical history			
- stroke	17 (2.4)	1 (2.0)	0.661
- Arrhythmias	91 (12.9)	8 (16.0)	0.517
- Chronic renal disease	65 (9.2)	5 (10.0)	0.802
- Pulmonary hypertension	102 (14.5)	4 (8.0)	0.291
- COPD	23(3.3)	1 (2.0)	0.518
- Bronchial asthma	34 (4.8)	5 (10.0)	0.172
Renal function and LVEF			
Total proteins	71.4 ± 7.1	68.4 ± 7.7	0.018
Creatinine	90.0 ± 35.2	103.6 ± 47.1	0.051
Glomerular filtration	81.8 ± 35.5	70.2 ± 33.6	0.025
LV ejection fraction	61.7 ± 10.1	63.3 ± 8.9	0.263

Values are expressed as: mean ± SD and absolute and relative frequencies.

Table 5: Distribution of patients according to variables related to the surgical procedure in relation to the patient's condition at discharge.

Variables	Alive n= 703	Deceased n= 50	p
Anoxic arrest time	80 (65 - 108)	102.5 (78 - 150)	< 0.0001
Extracorporeal circulation time	110 (90 - 149)	127.0 (99-176.)	0.011
Surgical time	240 (200 - 285)	250 (209- 360)	0.037
Anesthesia time	300 (255 - 345)	310 (240- 424)	0.288

Values are expressed in median and interquartile range.

Table 6: Reasons for Disparity with respect to death.

Variables	Odds ratio	IC95%	p
Age >= 65 years	2.9	[1.5-6.1]	0.0003
Female sex	2.5	[3.1-6.4]	0.002
Diabetes mellitus	4	[1.2-6.7]	0.001
Glomerular filtration rate< 60	1.9	[1.1-4.3]	0.03

A similar analysis was performed with respect to mortality with the variables related to the surgical procedure. (Table 5) shows the results, highlighting higher median values for anoxic arrest time (80 vs 102.5), extracorporeal circulation (110 vs 127) and surgical time (240 vs 250) all statistically significant.

Variables found to be significant in the above analyses with respect to mortality were included in a logistic regression analysis to obtain the disparity ratios shown in (Table 6). Age greater than or equal to 65 years almost tripled the risk of dying. Women were

2.5 times more likely to die before discharge after valve surgery. A glomerular filtration rate below 60 ml/min/1.73m² is a predictor of mortality in these patients, almost doubling the risk of occurrence of this adverse event. Diabetes mellitus was a predictor of mortality since patients with this risk factor had a disparity ratio of 4.0, CI = (1.2 - 6.7), the highest in our series.

Discussion

The aging of the population brings with it an increase in the incidence of heart valve disease, particularly aortic valve disease.

Therefore, the number of surgical interventions should benefit an increasing number of patients in the future [7-9]. Valve replacement is usually performed by cardiovascular surgeons with experienced Techniques [10]. This explains why, in this study, most of the valves were replaced with stopping times of less than or equal to 120 minutes. The literature consulted showed a correlation between insufficient myocardial protection, the onset of myocardial necrosis and prolonged arrest times in patients who suffered perioperative myocardial infarction and postoperative cardiogenic shock [11,12]. It was found that most of the valves in this study were replaced with an extracorporeal circulation time of 110 minutes. These times are relatively short and are related to the expertise of the surgeons involved. The use of extracorporeal circulation allows the surgeon to work in a still and bloodless field, but can cause varying degrees of myocardial stunning. This is why, when the patient has a pre-existing deterioration in systolic function, he is most likely to present low cardiac output due to a transient worsening in contractility due to the impact of the pump at the level of the cardiac muscle [13,14].

Increased time in circulation is recognized as a "life-threatening" condition that can lead, if unsuccessful, to intraoperative death. Blood contact with non-endothelialized surfaces can lead to thrombocytopenia, platelet dysfunction, consumption of clotting factors and activation of the fibrinolytic system. All these hematological disorders will be more accentuated the longer the pump time. The objective when weaning from extracorporeal circulation is that the cardiovascular apparatus should allow the patient to maintain sufficient oxidative metabolism and tissue perfusion to meet its own demand [15,16]. Electrical complications were the most frequent. The use of electric shocks was necessary in 29.2% of cases for the recovery of sinus rhythm, followed by ventricular fibrillation with 28.4%. The predominance of ventricular arrhythmias during the first moments of reperfusion is frequent and is conditioned by a series of mechanisms such as the duration of the ischemia period, the severity of the metabolic changes produced by ischemia, cytosolic calcium oscillations, the flow of catecholamines produced during ischemia and even the speed of reperfusion itself [17]. Other favorable circumstances could be the hydroelectrolytic alterations, the release of oxygen free radicals (superoxide O₂, hydrogen peroxide H₂O₂ OH and hydroxyl OH), ventricular dysfunction and hemodynamic instability [18]. All these changes arising during the ischemia-reperfusion phenomenon linked to extracorporeal circulation act as facilitators of automaticity and/or modifiers of cell membrane properties.

Valvular prosthesis infective endocarditis (VPIE) occurs in about 1%-6% of patients with valve prostheses. It has an incidence of about 0.3-1.2% per patient per year. VPIE was the most frequent infectious complication in this investigation and occurred with a higher frequency than reported in the literature (9.2%) [19]. Early VPIE can develop as a result of nosocomial or health care-related

bacteremia [20,21]. VPIE can be acquired in the operating room during surgery, by surgical wound infection or through intravascular catheters in the post-surgical care unit, so that microorganisms such as coagulase-negative and aureus staphylococci, enterococci, fungi and gram-negative bacilli predominate in its etiopathogenesis [21]. These approaches coincide with the results of this study where the main causal germ reported was staphylococcus aureus (6.9%) and another complication reported was mediastinitis (4%). It should be taken into account that perioperative antibiotic prophylaxis is very beneficial in reducing the incidence of infectious complications in patients undergoing cardiac Surgery [22].

In our study, 50 patients died, representing 6.6% of the population studied. The complications most related to mortality were cardiogenic shock (18.0%), low cardiac output (28.0%) and sepsis (18.0%). These results are partially concordant with the study by De la Peña Riveron and collaborators [23], who found postoperative low cardiac output syndrome, atrioventricular block and neurological complications as predictors of postoperative mortality. In the aforementioned research, cardiogenic and hypovolemic shock were reported in 6.7%, while acute myocardial infarction and pulmonary thromboembolism had one death each (3.3%) [23]. In this study performed at the ICCCV, age greater than or equal to 65 years, female sex, a glomerular filtration rate below 60 ml/min/1.73m² and diabetes mellitus were predictors of mortality in patients who underwent valve disease surgery, almost tripling the risk of death. This is in correspondence with what has been reviewed in case series with similar characteristics to ours. Many variables have been pointed out as predictors of mortality, among which advanced age, female sex, urgent surgery, associated coronary revascularization, reoperation, depressed left ventricular ejection fraction, renal failure, and even the number of hospital interventions stand out [24, 25].

Morbidity and mortality associated with valve replacement surgery at a global level has decreased in recent years due not only to advances in surgical technique and myocardial preservation, but also to the fact that valve lesions are detected at earlier stages and that the selection of patients who undergo surgery is more appropriate [26, 27].

Conclusion

1. Extracorporeal circulation continues to be the technique of choice for valve replacements, which, together with good myocardial protection and short anoxic arrest, CPB and surgical times, reduces perioperative morbidity and mortality.
2. Complications in patients operated on for valvular disorders are low, with a predominance of arrhythmias that generally occur due to alterations in the internal environment and acid-base balance.
3. Aging, the presence of comorbidities such as diabetes and impaired renal function predispose to the development

of complications that lead to death in these patients in the postoperative period.

4. Surgery is a safe and viable therapeutic option for patients with valvular apparatus diseases, although it is not free of complications, so adequate preparation and multidisciplinary discussion is necessary in each case.

Acknowledgement

None.

Conflict of Interest

No conflict of interest.

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