Advances in Medicine and Engineering Interdisciplinary Research, 2026, Volume 4, Issue 3
DOI: 10.32629/ameir.v4i3.5476
ISSN Online: 2972-3825
ISSN Print: 2972-3833

Survival of patients with low cardiac output syndrome in the postoperative period

Lorchen Torres Quiñones[1], Yoandro Rosabal García[2]*, Diana Rosa Olivares Álvarez[1]

1. University of Medical Sciences, Santiago de Cuba, Cuba
2. Cardiology and Cardiovascular Surgery Center, Saturnino Lora Provincial Clinical-Surgical Teaching Hospital, Santiago de Cuba, Cuba
*Corresponding author.
Email address: yoandrorg@gmail.com

Abstract: Introduction: Heart surgical intervention is complex, but with satisfactory results for the patient, because it increases his survival and life quality. The low cardiac output syndrome in the postoperative period is one of the entities that darkens the prognosis of this operation and elevates the morbidity and mortality indexes in these patients. Objective: To estimate the survival of patients with low cardiac output syndrome in the postoperative period according to clinical and echocardiographyc variables. Methods: A cohort investigation of survival in 56 operated patients was carried out, who were diagnosed with postoperative low cardiac output syndrome and were assisted in the Cardiology and Cardiovascular Surgery Center of Santiago de Cuba, from January, 2019 to November, 2021. Results: There was prevalence of the 65 years and over age group (60.7%), the diabetes mellitus (44.6%) as personal pathological history and patients with ejection fraction of 45% or more who presented higher quantity of deaths (29.8%). The function of the affected right ventricle was found in 52.6% of deaths. The time of extracorporeal circulation of 90 minutes or more prevailed in 67.9% of those affected, of whom 42.1% died. Conclusions: It was observed that diabetes mellitus, the time of extracorporeal circulation and the long perioperative bleeding, as well as the biventricular systolic function was related to the prognosis of low cardiac output syndrome in the postoperative period.

Key words: low cardiac output; valvular surgical intervention; survival; postoperative period

1 Introduction

Cardiovascular diseases are a silent pandemic and are associated with modern lifestyles, which has led to an increase in the number of surgeries for this condition and, consequently, in the mortality factors associated with them, which are inherent to hospitalization in the intensive care unit [1].

According to Chandler and Kirsch [2], this condition was first described in the 1970s in patients who underwent surgery for congenital heart disease and who experienced an unfavorable clinical course during the postoperative period.

Lorenzo [3], in his review article, reports that low cardiac output syndrome (LCOS) is characterized by oliguria, central venous oxygen saturation below 60%, and/or lactate levels above 3 mmol/L, without relative hypovolemia; it also includes patients who require inotropes to maintain an adequate hemodynamic status.

However, the incidence of this condition is influenced by the diagnostic criteria used by various researchers, including: Weber et al.[4], who report figures as high as 40.0%; the World Health Organization (WHO), which reports percentages

close to 30.0% [1]; and Pérez et al.[5], with figures of approximately 25.0%.

At the height of the COVID-19 pandemic, studies conducted in North America (the United States and Canada) revealed a 45.0% decrease in elective cardiac surgery; however, Ad et al.[6] reported higher numbers of patients undergoing emergency surgery, of whom 28.0% were admitted to intensive care units due to postoperative complications, including LCOS.

Cuba is one of the few developing countries actively engaged in the field of cardiac surgery. Thus, with the establishment of cardiac centers in various regions, the specialty of cardiovascular surgery was developed [7]. Statistical data show that during the 2019-2020 period, a total of 3,004 patients underwent surgical treatment for a cardiovascular condition [8].

In this regard, studies related to this complication remain insufficient, and almost all focus on coronary surgery rather than valvular surgery. Given the above, it was considered that analyzing the clinical, echocardiographic, and periprocedural variables that might be associated with low cardiac output syndrome and survival would contribute to the implementation of future interventions to address this postoperative condition, which has implications for short-, medium-, and long-term prognosis.

2 Methods

A cohort study with survival analysis was conducted in cardiac surgery patients diagnosed with postoperative low cardiac output syndrome who were treated at the Center for Cardiology and Cardiovascular Surgery at the Saturnino Lora Provincial Clinical-Surgical Teaching Hospital in Santiago de Cuba from January 2019 to November 2021.

The study population consisted of 350 patients who underwent valvular heart surgery during the aforementioned period; of these, 140 who met the criteria for postoperative low cardiac output syndrome were included. The minimum sample size was calculated using simple random sampling, and the analysis was performed as described by Cortes et al.[9]:

$$n = \frac{N \cdot p \cdot q \cdot Z^2}{e^2(N-1) + p \cdot q \cdot Z^2}$$

The components of this formula are broken down as follows:

n- sample size.

N- size of the population with low cardiac output syndrome.

e- desired margin of error of 5%.

p- expected proportion meeting the desired characteristic: 25% [5].

q- expected proportion not meeting the desired characteristic: 30%.

Z- desired confidence level: 95%.

Based on the above indicators, with a significance level of 0.05 and a confidence level of 95%, the study sample consisted of 56 patients.

Data were collected from individual medical records and echocardiographic reports; for this purpose, a form was created with the following variables under study:

a. Clinical: Age at the time of diagnosis of acute myocardial infarction (65 years or younger and over 65), sex, history of diabetes mellitus, atrial fibrillation, chronic obstructive pulmonary disease (COPD), and ischemic heart disease; type of surgical procedure (valvular or nonvalvular), as well as type of surgery (emergency or elective).

b. Echocardiographic

- Left ventricular ejection fraction (LVEF): less than 45%; 45% or more
- Tricuspid annular plane systolic excursion (TAPSE): less than 17 mm, 17 mm or more

- Pulmonary capillary pressure (PCP): 15 mmHg or less, greater than 15 mmHg

c. Periprocedural

- Bleeding during the surgical procedure: 500 ml or more, less than 500 ml
- Extracorporeal circulation time

d. Status at discharge: alive or deceased

Subsequently, the data for these variables were coded as follows: survival time in days (status-1: deceased; 0: alive). The survival function was determined using the Kaplan-Meier estimator, and the table was based on the median value obtained. The log-rank test was used as the statistical parameter and analyzed as follows:

H0 = There are no differences between the populations regarding the occurrence of an event (i.e., survival) at any point during follow-up.

Ha: There are differences between the populations regarding the occurrence of an event (i.e., survival) at any point during follow-up.

All patients underwent a transthoracic echocardiogram. The echocardiogram was performed using a Philips IE 33 system, in accordance with the recommendations of the American Society of Echocardiography [10], and was analyzed and interpreted by an experienced echocardiographer.

The study employed theoretical, empirical, and statistical methods (descriptive statistics: absolute and relative frequencies) and inferential statistics: parameter estimation tests for means and proportions, as well as the nonparametric chi-square test of independence. SPSS 22.0 for Windows was used as the statistical software.

The authors declared their commitment to protecting and maintaining the confidentiality of the information collected during the study. Authorization and approval were also requested from the center's administration, the Ethics Committee, and the Scientific Council for the conduct of the research.

3 Results

Table 1 shows a predominance of patients aged 65 or older (34 patients, 60.7%) and of female patients (31, 55.4%). The prevalence of COPD, atrial fibrillation, and diabetes mellitus was 16 (28.6%), 18 (32.1%), and 25 (44.6%), respectively. Emergency surgery (34, 60.7%) and valvular surgery (40, 71.4%) were also more common than non-valvular surgery (16, 28.6%). At discharge, 19 patients (33.9%) had died.

Table 1. Patients by demographic variables and low cardiac output syndrome

Demographic variables		N=56		95% CI
		No.	%*	
Age group (years) (SD ±13.7) ($\bar{X}$=60.95)	Under 65	22	39.3	(25.6% – 52.9%)
	65 or older	34	60.7	(47.03% – 74.39%)
Sex	Female	31	55.4	(41.4% – 69.2%)
	Male	25	44.6	(30.7% – 58.5%)
Personal medical history	Diabetes mellitus	25	44.6	(30.7% – 58.5%)
	Chronic obstructive pulmonary disease	16	28.6	(15.8% – 41.2%)
	Atrial fibrillation	18	32.1	(19.0% – 41.2%)
Type of intervention	Valvular	40	71.4	(58.7% – 84.1%)
Surgical type	Non-valvular	16	28.6	(15.8% – 41.2%)
Type of operation	Elective	22	39.3	(25.6% – 52.9%)
	Emergency	34	60.7	(47.03% – 74.39%)
Status at discharge	Alive	37	66.1	(52.7% – 79.3%)
	Deceased	19	33.9	(20.6% – 47.2%)

SD: standard deviation, $\bar{X}$: mean, CI: confidence interval

*Percentage calculated based on the total number of cases per colum

Regarding echocardiographic parameters, the ejection fraction had a mean of 58.5 with a standard deviation of approximately 11.6, and a predominance of patients with an LVEF of 45% or higher (47, representing 83.9%), of whom 14 (29.8%) died. For other echocardiographic variables, such as right ventricular function less than 17 mm and PCP of 15 mmHg or higher, the percentage of deaths was 52.6% and 28.6%, respectively (Table 2).

Table 2. Patients by echocardiographic parameters and status at discharge

Echocardiographic parameters		Status at discharge						P
		Alive		Deceased		Total		
		No.	%*	No.	%*	No.	%**	
LVEF (%) ($\bar{X}$=58.5%) SD=±11.6	Less than 45	4	44.4	5	55.6	9	16.1	0.13
	45 or greater	33	70.2	14	29.8	47	83.9	
TAPSE (mm) ($\bar{X}$=20.14) (SD=3.26)	Less than 17	9	47.4	10	52.6	17	30.4	0.034
	17 or greater	28	75.6	9	24.3	39	69.6	
PCP (mmHg)	15 or greater	20	71.4	8	28.6	28	50	0.39
	Less than 15	17	60.7	11	39.3	28	50	

$\bar{X}$: mean; X^2: $p \leq 0.05$; RV: right ventricle; * Percentage calculated per row

** Percentage calculated based on the total column population

Table 3 shows that 38 patients (67.9%) had a cardiopulmonary bypass time of 90 minutes or more, of whom 16 (42.1%) died. In addition, periprocedural bleeding of 500 ml or more was predominant, occurring in 34 patients (60.7%); of these, 5 (14.7%) died, for $p \leq 0.05$.

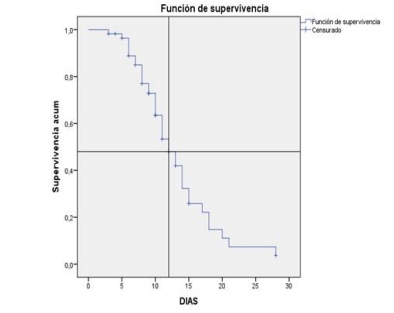
Table 3. Patients by procedure in the perioperative period and status at discharge

Variables Perioperative procedure		Discharge status						P
		Alive		Deceased		Total		
		No.	%*	No.	%*	No.	%**	
CPB time (min)	90 or longer	22	57.9	16	42.1	38	67.9	0.06
	Less than 90	15	83.3	3	16.7	18	32.1	
Perioperative bleeding (ml)	Less than 500	8	36.4	14	63.6	22	39.3	0.001
	500 or more	29	85.3	5	14.7	34	60.7	

CPB: cardiopulmonary bypass; X^2: $p \leq 0.05$; * Percentage calculated based on row totals

** Percentage calculated based on column totals

As shown in the Figure 1, the survival rate was 50.0% at 13.2 days; therefore, with a 95% confidence interval, it was estimated that the survival of patients with low postoperative cardiac output was approximately 9 to 14 days.



Medias y medianas del tiempo de supervivencia

Estimación	Error típico	Intervalo de confianza al 95%		Estimación	Error típico	Intervalo de confianza al 95%	
		Límite inferior	Límite superior			Límite inferior	Límite superior
13,216	,962	11,330	15,102	12,000	1,064	9,914	14,086

Figure 1. Survival curve

It was also found that an LVEF of 40% or less, a cardiopulmonary bypass time of 90 minutes or more, and periprocedural bleeding of 500 ml or less had a p-value <0.05; therefore, the difference between the two groups was statistically significant, whereas a personal history of diabetes mellitus was not.

4 Discussion

The results of the present study were consistent with those of several authors, including Seguel et al.[11], who found low postoperative cardiac output in 32.0% of their cases, with a higher prevalence among males and patients in their sixties. Likewise, Pereira et al.[12] state that there is a tendency for males to be more severely affected in cardiac surgeries, resulting in higher rates of complications, including the aforementioned condition.

On the other hand, González et al.[13] refer to a study by Pérez Vela and colleagues that identifies female sex, diabetes mellitus, age over 70 years, and prolonged cardiopulmonary bypass as independent predictors. In this regard, Rosabal et al.[14] note that, according to Cubides, the main predictors of postoperative complications—including low cardiac output—are diabetes mellitus, hypertension (HTN), and COPD.

In this regard, Pérez et al.[15] analyzed in their study that patients with a confirmed diagnosis of LCOS had high percentages of a history of diabetes mellitus (37.0%) and hypertension (72.0%), in addition to a predominance of males; in that study, prolonged cardiopulmonary bypass was observed in 50.0% of patients, with a low rate of emergency surgeries (4.3%). The present study shows similarities with the findings reported by those researchers regarding variables such as

prolonged cardiopulmonary bypass time, the presence of diabetes mellitus, and hypertension.

The series by Salamanca et al.[16] noted a predominance of valvular surgery (39.0%), with approximately 12.0% of these patients diagnosed with LCOS.

Li et al.[17] report that an ejection fraction of less than 40.0% was a predictive factor. Other researchers [11,12] note that low ejection fractions of 40.0% or less are associated with the presence of LCOS. In the present study, 16.0% of patients had ejection fractions below 45.0%, which is consistent with the results reported in the reviewed literature [13,16,17].

Regarding prolonged cardiopulmonary bypass time, Salamanca et al.[16] report figures close to 3.0%, and 22.0% of patients presented with right ventricular dysfunction, all of which is consistent with the findings in the present series.

Alonso et al.[18] indicate that longer cardiopulmonary bypass times are associated with mortality in patients with LCOS; a similar pattern is observed with TAPSE less than 17 mm, where survival was lower. In fact, Martínez et al.[19] report that cardiopulmonary bypass times and left ventricular ejection fraction dysfunction are associated with low survival, which corresponds to the findings of this study.

Fernández et al.[20] argued that increasing age (HR = 1.15; p = 0.001) and the presence of low cardiac output during the perioperative period (HR = 3.54; p = 0.037) were independently associated with low survival during follow-up.

This study had limitations; therefore, it would be advisable to analyze more representative samples and include additional laboratory parameters, which would yield better results.

Finally, it was observed that certain clinical, echocardiographic, and therapeutic factors—such as the presence of diabetes mellitus, prolonged cardiopulmonary bypass time and perioperative bleeding, as well as biventricular systolic function—were associated with the prognosis of postoperative low cardiac output syndrome.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Organización mundial de la salud. Enfermedades cardiovasculares. Ginebra: OMS; 2023 [citado 08/04/2023]. Disponible en: https://www.who.int/es/health-topics/cardiovascular-diseases#tab=tab_1.

[2] Chandler HK, Kirsch R. Management of the low cardiac output syndrome following surgery for congenital heart disease. Curr Cardiol Rev. 2016 [citado 17/04/2023];12(2):107-11. Disponible en: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4861938/.

[3] Lorenzo S. Síndrome de bajo gasto cardíaco en el posoperatorio de cirugía cardíaca. Rev Urug Cardiol. 2020 [citado 17/04/2023];35(3):292-321. Disponible en: http://www.scielo.edu.uy/scielo.php?script=sci_arttext&pid=S1688-04202020000300292.

[4] Weber C, Esser M, Eghbalzadeh K, Sabashnikov A, Djordjevic I, Maier J, et al. Levosimendan reduces mortality and low cardiac output syndrome in cardiac surgery. Thorac Cardiovasc Surg. 2020;68(5):401-9.

[5] Pérez Vela JL, Martín Benitez JC, Carrasco Gonzalez M, de la Cal López MA, Hinojosa Pérez R, Sagredo Meneses V, et al. Summary of the consensus document: "Clinical practice guide for the management of low cardiac output syndrome in the postoperative period of heart surgery". Med Intensiva. 2012 [citado 06/2/2023];36(4):277-87. Disponible en: https://www.medintensiva.org/en-pdf-S2173572712000781.

[6] Ad N, Luc J GY, Nguyen TC, COVID-19 North American Cardiac Surgery Survey Working Group. Cardiac surgery in North America and coronavirus disease 2019 (COVID-19): Regional variability in burden and impact. J Thorac Cardiovasc Surg. 2021 [citado 16/04/2023];162(3):893-903. Disponible en:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7330597/.

[7] Vera Rivero DA, Chirino Sánchez L, Yanes García R. Orígenes y desarrollo histórico de la cirugía cardiovascular en Cuba durante el siglo XX. Acta médica del Centro. 2020 [citado 16/04/2023];14(1). Disponible en: https://revactamedicacentro.sld.cu/index.php/amc/article/view/988/1354.

[8] Cuba. Ministerio de Salud Pública. Anuario Estadístico de Salud 2021. La Habana: MINSAP; 2022 [citado 06/04/2023]. Disponible: https://files.sld.cu/dne/files/2022/10/Anuario-Estadistico-de-Salud-2021.-Ed-2022.pdf.

[9] Cortés Cortés ME, Mur Villar N, Iglesias León M, Cortés Iglesias M. Algunas consideraciones para el cálculo del tamaño muestral en investigaciones de las Ciencias Médicas. Medisur. 2020 [citado 16/11/2023];18(5):937-42. Disponible en: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1727-897X2020000500937.

[10] Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, et al. Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiog. 2015 [citado 14/08/2023];28(1):1-39. Disponible en: https://www.asecho.org/wp-content/uploads/2016/02/2015_ChamberQuantificationREV.pdf.

[11] Seguel E, Rubilar H, Vera-Calzaretta A, Stockins A, González R, Ramirez S. Resultados de la cirugía de reparación valvular mitral en el Hospital Guillermo Grant Benavente de Concepción (2009-2020). Rev Chil Cardiol. 2021 [citado 17/04/2023];40(1):37-46. Disponible en: https://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-85602021000100037.

[12] Pereira da Silva JR, Baptista Passos MM, Carneiro EM, de Melo Neto AQ, Monteiro Alves AM, Rodrigues Darc Costa N, et al. Perfil epidemiológico de pacientes submetidos à cirurgia cardíaca em Hospital Universitário Do Piauí. Rev. Pesq. Saúde. 2017 [citado 19/04/2023];18(3):173-7. Disponible en: https://periodicoseletronicos.ufma.br/index.php/revistahuufma/article/view/8767/5966.

[13] González Kadashinskaia GO, Bello Carrasco LM, Anchundia Alvia DA. Cirugía cardíaca, complicaciones inmediatas posoperatorias. Universidad y Sociedad. 2020 [citado 17/04/2023];12(2). Disponible en: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S2218-36202020000200293.

[14] Rosabal García Y, Granda Gámez Y de la C, Candel Herrero JA, Pagán Aranda JA, Copa Córdova L. Factores clínicos y ecocardiográficos asociados al bajo gasto cardíaco posoperatorio en pacientes con tratamiento quirúrgico cardiovascular. MEDISAN. 2022 [citado 18/04/2023];26(6):e4332. Disponible en: https://medisan.sld.cu/index.php/san/article/view/4332/html.

[15] Pérez Vela JL, Jiménez Rivera JJ, Alcalá Llorente MA, González de Marcos B, Torrado H, García Laborda C, et al. Síndrome de bajo gasto cardiaco en el postoperatorio de cirugía cardiaca. Perfil, diferencias en evolución clínica y pronóstico. Estudio ESBAGA. Med Intensiva. 2018 [citado 06/04/2023];42(3):159-67. Disponible en: https://www.medintensiva.org/es-pdf-S0210569117301997.

[16] Salamanca MA, Cuba E, Castillo-De la Cadena L, Vidal D. Características de las intervenciones en cirugía cardiaca en un hospital general de Lima, Perú. Rev Med Hered. 2022 [citado 19/04/2023];33(4):227-36. Disponible en: http://www.scielo.org.pe/scielo.php?script=sci_arttext&pid=S1018-130X2022000400227&lng=es&nrm=iso&tlng=es.

[17] Li Z, Zhang GB, Li TW, Zhang Y, Li MD, Wu Y. Risk factors of low cardiac output syndrome after cardiac valvular surgery in elderly patients with valvular disease complicated with giant left ventricle. Chinese Journal of Cardiovascular Diseases. 2021;12:368-73.

[18] Alonso Herrera A, Ceballos Alvarez A, Fuentes Herrera L, Perez Bravet K. Factores asociados a la mortalidad intrahospitalaria en pacientes con hipertensión pulmonar en el postoperatorio de la cirugía cardiaca. Rev Cuba Cardiol Cir.

Cardiovasc. 2021 [citado 08/06/2023];27(1). Disponible en: https://revcardiologia.sld.cu/index.php/revcardiologia/article/view/1026/pdf.

[19] Martínez Clavel LL, Dávila Cabrera SF, Nodal Leyva PE, Hernández Román MA, de Arazoza Hernández A, Alonso Valdéz J. Caracterización de la mortalidad en cirugía cardiaca. Rev Cuba Cardiol Cir. Cardiovasc. 2020 [citado 08/06/2023];26(1). Disponible en: https://revcardiologia.sld.cu/index.php/revcardiologia/article/view/911/pdf.

[20] Fernández Mesa JE, Padrón García KM, Paredes Cordero ÁM, González Greck O, González Trujillo A, Díaz Vázquez E, et al. Supervivencia a los cinco años en pacientes con valvulopatías izquierdas operados de cirugía cardíaca valvular. CorSalud. 2020 [citado 08/06/2023];12(1):38-45. Disponible en: https://www.medigraphic.com/pdfs/corsalud/cor-2020/cor201f.pdf.