ISSN: 2754-6667

Journal of Critical Care & Emergency Medicine

Research Article

Open Access

Behavior of Perfusion Variables in Adult Patients Undergoing Cardiac Surgery in the Hospital Cardiovascular Del Niño De Cundinamarca Descriptive Cohort

Carlos Arturo Laverde[1], Alfonso Velandia Suarez[1], Azael Felipe López[2], Emiro José Noguera[3*], Sergio Alejandro Valdés Pinzón[4] and Claudia Castellanos Peñaranda[4]

[1]Assistant Instructor, Department of Cardiovascular Anesthesiology, University Foundation of Health Sciences, San José Hospital of Bogotá, Cardiovascular Hospital of the Child of Cundinamarca, Colombia

[2]Cardiovascular Anesthesiologist, University Foundation of Health Sciences San José Hospital of Bogotá, Colombia

[3]Anesthesiologist, University Foundation of Health Sciences, Colombia

[4]Anesthesiologist & Clinical Epidemiologist, University Foundation of Health Sciences, Colombia

ABSTRACT

Introduction: Blood lactate levels during extracorporeal circulation (ECC) have been the method used to monitor the state of microcirculation. New studies recommend the central venous oxygen saturation ($SvcO_2$) and the central venous - arterial difference of CO_2 ($Cv\text{-}aCO_2$) as innovative tools to evaluate such state in this group of patients.

Aim: To describe the levels of tissue perfusion biomarkers ($SvcO_2$, $Cv\text{-}aCO_2$ and lactate) of adult patients undergoing ECC cardiac surgery, at the Hospital Cardiovascular del Niño, from April 1 to July 31, 2019.

Methodology: Historical descriptive cohort study. A review of the medical records of adult patients undergoing cardiac surgery of any etiology under ECC was carried out, evaluating the variables to be studied intraoperatively and postoperatively at 6, 12 and 24 hours in the Intensive Care Unit. Descriptive statistics were used.

Results: 54 patients undergoing different types of cardiac surgery with ECC were included. The most frequent one was myocardial revascularization in 24 patients (44,4%). The duration of ECC in 30 cases (55,5%) ranged between 60-120 minutes. During the intraoperative period, a progressive rise in the medians of the Lactate variables was observed, being greater towards the end of the ECC and being reestablished outside the ECC and in the first 24 hours of ICU stay.

Conclusions: This study allowed the integration of 3 tissue perfusion variables and findings that are relevant from the clinical perspective for the perioperative management of patients undergoing cardiac surgery in ECC.

***Corresponding author**
Emiro José Noguera García, Anesthesiologist, University Foundation of Health Sciences, Colombia.

Received: November 07, 2025; **Accepted:** November 11, 2025; **Published:** November 21, 2025

Keywords: Hyperlactatemia, Tissue Perfusion, Extracorporeal Circulation, Central Venous Oxygen Saturation, Venous-to-Arterial Carbon Dioxide Difference

Introduction

Lactic acidosis was first described as a clinical entity in the 1920's [1]. At present, it is one of the most widely used biomarkers whose measurement is an established method to monitor and verify adequate tissue oxygenation in a variety of clinical situations including ECC and its elevated levels have been found to be directly associated with increased morbidity and mortality; ECC initiates a major inflammatory reaction with the activation of immune defense systems, which altogether interfere with normal organ functioning [2,3]. To maintain normal tissue oxygenation, organs depend on a continuous supply of oxygen controlled by the flow of the heart as a pump and on the availability of oxygen dissolved in plasma and bound to hemoglobin. When oxygen availability is limited, anaerobic metabolism is used as an energy source, where pyruvate is converted to lactate. A positive correlation has been defined between hyperlactatemia and ECC duration, presumably regarding to a time-dependent deterioration in adequate circulatory and cellular function. The reference range for blood lactate is 0,5 to 2,2 mmol / L [1].

Patients with severe hyperlactatemia (>10mmol / L -1) have a higher mortality rate [4,5].

Patients undergoing cardiac surgery are at greater risk of presenting inadequate oxygen supply, both due to the ECC to which they are subjected, and due to their limited cardiovascular reserves , in such a way that the elevation of lactate levels is commonly expected with frequencies ranging between 10 and 20% ; the efficacy of this marker could be arguable, as its elevation may not always result from tissue hypoxia or anaerobic metabolism in the context of cardiac surgery [2,6,7]. This inadequate supply can cause tissue dysoxia, considered one of the main triggers of organic dysfunction in this type of surgery [8,9].

Thus, the rapid identification and timely management of tissue dysoxia are the cornerstone of shock treatment in these patients, although it is not always easy to determine it, and it is necessary to use and interpret not only macrohemodynamic variables (which are not very useful in this process since they do not adequately reflect tissue perfusion) but also microhemodynamic variables such as oxygen delivery and consumption (DO_2 / VO_2). Currently, the use of biomarkers is broadly widespread for assessing these types of variables [10,11].

It has recently been shown that the management of other variables in addition to lactate, such as central venous oxygen saturation ($SvcO_2$) y and the central venousarterial CO_2 difference CO_2 ($Cv-aCO_2$) also contribute significantly to reducing morbidity and mortality in patients at increased risk, by detecting and reversing tissue hypoxia triggers and effects [12-15].

The measurement of SvcO2 is a parameter that indirectly provides information about tissue oxygenation, making it possible to comprehensively evaluate the determinants of the DO_2/VO_2 ratio and tissue perfusion; its decline is associated with a poor clinical prognosis [6,12]. In contrast to $SvcO_2$ and / or lactate, some studies have proposed that the central venous - arterial CO_2 difference, better known in the clinical setting as Delta CO_2, is a more useful indicator of microcirculatory flow status to categorize patients at risk of developing postoperative complications and worse outcomes. An increase in the CO_2 Delta (> 6 mm Hg is an indicator of poor tissue perfusion), can be caused by an increase in venous CO_2 from the stagnant blood flow of the capillary bed with continuous CO_2 production, in such a way that this Delta exhibits a correlation with tissue perfusion, which depends on changes in blood flow. Theoretically, the CO_2 Delta may be related to cardiac output and microcirculatory dysfunction. Notwithstanding, it is a matter of paramount importance to clarify that these studies have focused on patients undergoing major surgery or septic shock and few studies report this relationship of the CO_2 Delta and poor results in patients with cardiogenic shock in patients after cardiac surgery [15-17].

Although the association between elevated lactate and its outcomes was described in 1964 in patients with undifferentiated shock, the association between this elevation and outcomes after cardiac surgery has only been thoroughly evaluated in the last 20 years [6]. No studies have been documented in the national literature that describe the behavior of these variables in patients taken to ECC; for this reason, and considering the little information available about these variables in this type of surgery, the aim of this study was to describe the levels of tissue perfusion biomarkers (venous CO_2 saturation, CO_2 Delta and lactate) of adult patients undergoing cardiac surgery with Extracorporeal Circulation (ECC), during and after it, at the Hospital Cardiovascular del Niño de Cundinamarca, during April 01 to July 31, 2019.

Methods

A historical descriptive cohort type study was conducted, where the medical records of all patients over 18 who underwent cardiac surgery of any etiology under extracorporeal circulation at the Hospital Cardiovascular del Niño, municipality of Soacha, Cundinamarca, from April 1 to July 31, 2019 were included. Clinical variables were evaluated in the intraoperative and immediate postoperative period, by measurement of biomarkers from arterial and venous blood gas, carried out by the cardiovascular anesthesiologist in charge (3 samples), as well as upon admission to the intensive care unit, at 6, 12 and 24 hours postoperatively. In this period, a total of 106 surgeries were performed, 54 of which met the inclusion criteria and had all the variables to be investigated. There were no exclusion criteria.

Data was collected in an electronic data format. The variables were grouped as follows: 1) Sociodemographic and clinical variables: age, sex, weight, diagnosis, associated comorbidities, EuroSCORE values, percentage of postoperative left ventricular ejection fraction (LVEF), and 2) Variables related to surgery: type of surgery, lactate levels, CO_2 Delta and venous saturation, ECC duration, aortic clamping time, use of vasoactive drugs and blood transfusion requirement.

The description of the qualitative variables was made by means of absolute and relative frequencies. The description of the quantitative variables was carried out by means of medians and interquartile ranges since their distribution was non-normal according to the Shapiro Wilk test. Descriptive statistics were run using Stata 14 software.

The study was approved by the Academic and Ethics Committee of the Fundación Universitaria de Ciencias de la Salud (FUCS), the Ethics Committee in Research with Human Beings of the Hospital de San José, and the Ethics Committee of the Hospital Cardiovascular del Niño de Soacha-Cundinamarca, organs that considered it a risk-free investigation since no intervention or action was carried out that modified the biological, psychological or social conditions of the subjects, as it was only based on information extracted by reviewing medical records.

Results

For the study period, a total of 106 surgeries were performed, 54 patients met the inclusion criteria, of which 35 (64,8%) were male. Among the range between 50-69 years, 32 patients (59,2%) were found, 10 between 29-49 years (18,5%) and the rest were older than 70 years. 40 patients had a BMI between 18,5-24,99 (74,1%) and only 1 patient BMI > 30. High Blood Pressure was the most frequent comorbidity, 40 patients (74%), followed by Diabetes Mellitus in 14 cases (26%). 1 patient had a history of cardiovascular surgery (1,8%). No patient had a previous intra-aortic balloon pump (Table 1).

Table 1: Demographic & Clinical Characteristics

Variable	n:54 (%)
Age	
29 – 49	10 (18,5)
50 – 69	32 (59,2)
Older than 70	12 (22,2)
Sex	
Female	19 (35,2)
Body Mass Index (kg / m²)	
Less than 18,5	4 (7,4)
18,5- 24,99	40 (74,1)
25 – 29,99	9 (16,6)
Greater than 30	1 (1,8)

Past Medical History	
High Blood Pressure	40 (74)
Type 2 Diabetes Mellitus	14 (26)
Hypothyroidism	10 (18,5)
Chronic Obstructive Pulmonary Disease	5 (9,2)
Cardiac Surgery History	
Yes	1 (1,8%)

In the preoperative assessment, an adequate level of hemoglobin was found independent of sex; in men, a median of 14 g / dl (13-15), while in women, a median of 13 g / dl (11-13,5). 26 patients (48,2%) had glycosylated hemoglobin levels greater than 6,5%, and in 7 of them (12,9%) the level was greater than 8,5%. Hypoalbuminemia (<3,5 mmol / L) was documented in 32 patients (59,2%) (Table 2).

Table 2: Preoperative Test Results

Variable	n:54 (%)
Hemoglobin (gr / dL), Median (IQR)	
Men	14 (131 - 5)
Women	13 (11 - 13,5)
Glycosylated hemoglobin, n (%)	
Less than 6,5	28 (51,8)
Greater than or equal to 6,5	26 (48,2)
Greater than 8,5	7 (12,9)
Albumin, gr/100 ml n (%)	
Less than 3,5	32 (59,2)
Greater than or equal to 3,5	22 (40,7)

The main reported diagnosis was coronary disease, in 24 (44,4%) of all patients and associated to this frequency, myocardial revascularization was the procedure that was most performed (44,4%). Levosimendan infusion was administered in 6 patients (11,1%) prior to surgery (Table 3).

Table 3: Variables Related to Surgical Procedure

Variable	n (%)
Patient diagnosis	
Coronary heart disease	24 (44,4)
Aortic valve disease	10 (18,5)
Mitral valve disease	7 (13)
Ascending aortic aneurysm	1 (1,8)
Tricuspid valve pathology	1 (1,8)
Atrial septal defect	1 (1,8)
More than two diagnoses	10 (18,5)
Surgical procedure performed	
Myocardial revascularization	24 (44,4)
Aortic valve replacement	10 (18,5)
Mitral valve replacement	7 (12,9)
Bentall procedure	5 (9,2)
Surgical closure of an atrial septal defect (ASD)	1 (1,8)
Tricuspid valve replacement	1 (1,8)
More than two procedures	6 (11,2)
Complications	
Bleeding	6 (31,5)
Arrhythmia	3 (15,8)
Ischemic stroke	2 (10,5)
Reinfarction - bridge occlusion	2 (10,5)
Severe oxygenation disorder	2 (10,5)
Late sepsis	1 (5,2)
Vasoplegic shock	1 (5,2)
Arrhythmia - bleeding	1 (5,2)
Bleeding - residual ASD	1 (5,2)

EuroSCORE II	
Median (IQR)	2,1 (1,08 - 4,3)
Average (SD)	3,3 (3,1)
Range (min – max)	0,77 - 13
EuroSCORE II, n (%)	
Less than 4	36 (66,6)
From 4 to 9	15 (27,7)
10 – 14	3 (5,5)
Greater than 14	0

In 24 cases (44,4%) the aortic clamping time was less than 60 minutes, followed by a time between 60-120 minutes in 25 cases (46,3%). In 5 cases (9,3%) the time was greater than 120 minutes. In 30 cases (55,5%) the ECC time was 60-120 minutes, followed by 19 cases where the ECC time was greater than 120 minutes (35,2%) and in 3 of these patients due to the longest time in ECC an additional arterial blood gas sample was taken. Intraoperatively, 7 patients (13%) required transfusion of 1 unit of packed red blood cells (PRBCs) and 3 (5,5%), required of 2 units; 2 cases demanded the transfusion of 2 and 4 units of fresh frozen plasma (FFP), respectively; 3 patients (5,5%) required 6 units of cryoprecipitate; and 1 patient (1,8%), 6 platelet units (Table 4).

Table 4: Intraoperative Variables

Intraoperative variables	N=54 n (%)
Aortic clamping, in minutes	
Less than 60	24 (44,4)
Between 60 & 120	25 (46,3)
Greater than 120	5 (9,3)
Extracorporeal circulation (ECC), in minutes	
Less than 60	
Between 60 & 120	5 (9,3)
Greater than 120	30 (55,5)
	19 (35,2)
Room transfusion of Packed Red Blood Cells (PRBCs), in number of units	
0	44 (81,4)
1	7 (13)
2	3 (5,5)
Plasma, in number of units	
0	52 (96,3)
2	1 (1,8)
4	1 (1,8)
Cryoprecipitates, in number of units	
0	51 (94,4) 3 (5,5)
6	
Platelets, in number of units	53 (98,2)
0	1 (1,8)
6	

There were no intraoperative complications; the most frequent complication reported in the Intensive Care Unit (ICU) was bleeding, present in 6 patients (31,5%), followed by arrhythmias in 3 cases (15,8%) and severe oxygenation disorders and Ischemic Stroke in 2 cases respectively (10,5%), for a total of 19 cases of postoperative complications (35,1%). In the ICU, 15 patients (27,7%) received RBCs transfusion of 1 to 2 units and 10 patients (18,5%) received more than 2 units; between 1 and 4 units of FFP were supplied in 4 cases (7,4%); 1 patient (1,8%) received 6 units of cryoprecipitate; 2 patients required between 1-4 units of platelets, and one more, 4 units of platelets (Table 5).

Table 5: Postoperative Variables

Postoperative variables	n =54
Postoperative IBAP [sic] Yes	n (%) 1 (1,8)
ICU transfusion of Packed Red Blood Cells (PRBCs), in number of units 0 1 2 Plasma, number of units 0 2 4 Cryoprecipitates, number of units 0 6 Platelets, number of units 0 6 >6	 29 (53,7) 15 (27,7) 10 (18,5) 50 (92,6) 2 (3,7) 2 (3,7) 53 (98,1) 1 (1,8) 50 (92,6) 2 (3,7) 2 (3,7)
Postoperative LVEF Less than 30 Between 31 & 40 Between 41 & 50 Greater than 50	n (%) 11 (20,3) 19 (35,2) 7 (12,9) 17 (31,4)
Mechanical ventilation, in days 0 Greater than 1	n (%) 34 (63) 20 (37)
ICU stay, in days	Median (IQR) 4 (3-5)
	Range (min –max) 1 - 11
Renal replacement therapy	0
Reoperations None Sternal closure Cardiac tamponade Bleeding	n (%) 48 (88,9) 1 (1,8) 2 (3,7) 3 (5,5)
Mortality	n (%) 6 (11,1)
Death days Median (SD) Range (min – max)	 18 (13,1) 3 - 30

17 patients (31,4%) had a Left Ventricular Ejection Fraction (LVEF) greater than 50%, and 19 (35,2%), between 31-40%. The median stay in the ICU was 4 days (IQR 3-5). 20 patients (37%) were on mechanical ventilation for more than 24 hours, and a total of 6 patients were reoperated, 3 (5,5%) for bleeding, 2 (3,7%) for cardiac tamponade, and 1 (1,8%) for sternal closure. Of the total population, 6 patients (11,1%) died, and the median death was 18 days (SD 13,1 days) (Table 5).

The median intraoperative lactate levels increased as the extracorporeal circulation time elapsed, until it reached its maximum level at the third blood gas test, 2,83 mmol / L. Later, its progressive decrease begins until it reaches its lowest value 24 hours after surgery, following a slight elevation at six hours where a drop in central venous saturation to 65% is also observed with a persistent elevation of the CO_2 Delta by 7 mm Hg. At 24 hours postoperatively, a normalization in the CO_2 Delta values was evidenced at 6 mm Hg, with an increase in $SvcO_2$; additionally, it is worth mentioning that the $SvcO_2$ and the CO_2 Delta did not show significant changes during the intraoperative period, remaining within the normal range (Tables 6,7; Figures 1-3).

Table 6: Variable of Intraoperative Perfusion

Perfusion Variable	ECC 1st time	ECC 2nd time	ECC 3rd time	Post ECC
	Median (IQR)			
Lactate (mmol / L)	1,3 (1,1 -1,5)	1,8 (1,4 - 2,1)	2,83 (1,5 - 2,85)*	1,8 (1,6 - 2,3)
SvO_2 (%)	82,7 (78,1 - 86,7)	77,5 (74,3 - 81,9)	83,2 (51 - 84)*	78,3 (73,5 - 82,6)
CO_2 Delta (mm Hg)	4 (2,6 - 4,8)	3,2 (2,2 - 4,7)	4,4 (3 - 6,7)*	4,3 (3,3 - 6,1)
Temperature (°C)	33 (32,9 - 34)	36 (36 - 36,5)	36,6 (34 - 36,6)*	36 (36 - 37)
FiO2 (%)	70 (65 - 80)	80 (75 - 80)	85 (80 - 90)*	97,5 (70 - 100)

* Data for three patients. ECC: Extracorporeal circulation

Table 7: Variable of ICU Perfusion

Perfusion Variable	ICU admission	6 hours	12 hours	24 hours
Lactate (mmol / L)	1,7 (1,6 - 2,7)	1,8 (1,4 - 2,5)	1,6 (1,3 - 2,2)	1,4 (1,2 - 2,0)
SvO_2 (%)	70 (62 - 74)	65 (56 - 69)	63,5 (57,5 - 67)	66 (59 - 69)
CO_2 Delta (mm Hg)	8 (6 - 10)	7 (5 - 9)	7 (4,5 - 8,5)	6 (3 - 7)

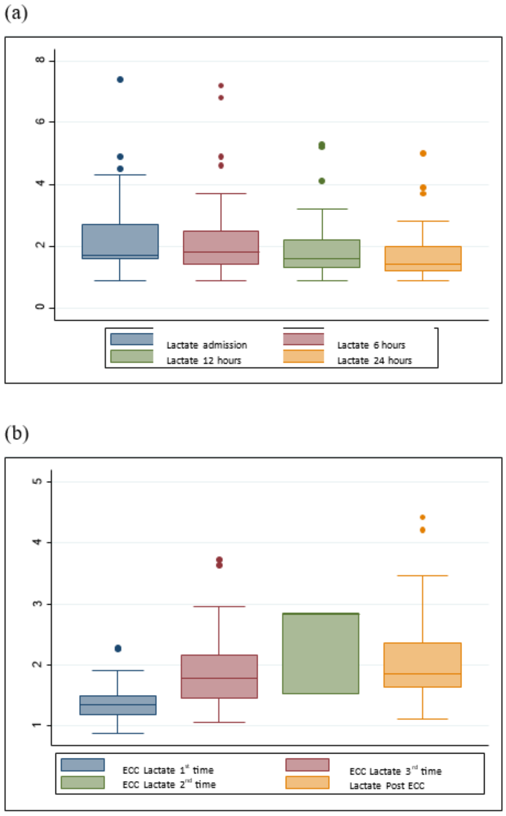

Figure 1: Changes in ICU (a) & ECC (b) of Lactate Level in Patients Undergoing Cardiac Surgery

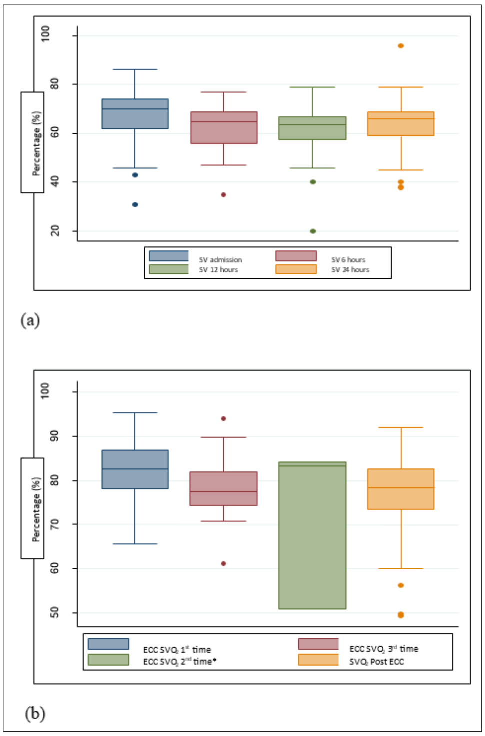

Figure 2: Changes in ICU (a) & ECC (b) of SVO_2 Percentage in Patients Undergoing Cardiac Surgery

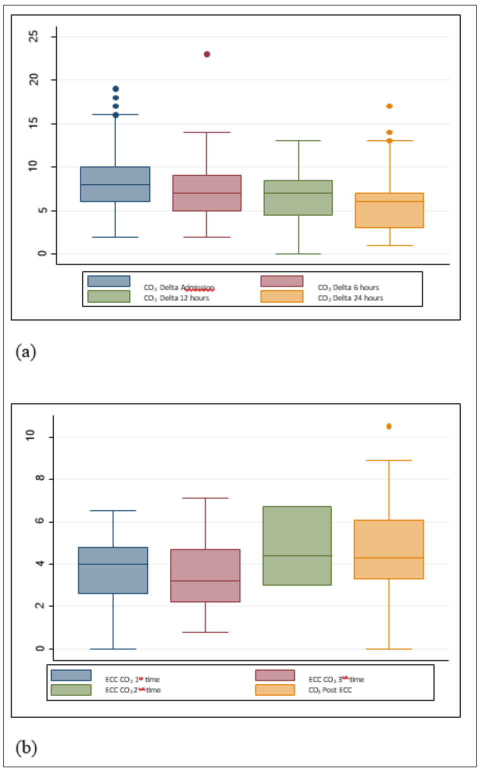

Figure 3: Changes in ICU (a) & ECC (b) of CO2 Delta Level in Patients Undergoing Cardiac Surgery

Discussion

Cardiac surgery procedures under ECC are associated with high morbidity and mortality. Since the pathophysiology of organ dysfunction after cardiac surgery is multifactorial, the relationship between oxygen demand and delivery plays a fundamental role. This imbalance can result in dysoxia, a cause of organ dysfunction in different clinical settings. The rapid identification and management of the causes of dysoxia become the cornerstone of current management, with several biomarkers proposed for use in hemodynamic management [18].

An elevation in lactate levels can be the result of an increase in production or decrease in clearance or a combination of both processes. Tissue perfusion is at risk during cardiac surgery and in the immediate postoperative period, with hyperlactatemia after cardiac surgery being a sign of inadequate tissue perfusion [19].

The preoperative and intraoperative characteristics associated with the postoperative elevation of lactate levels have been measured in a significant number of studies, where a consistency has been found between the duration of ECC and the elevation of lactate. [1,2,20,21]. The proposed threshold for hyperlactatemia set at the 90th percentile of the identified distribution of lactate levels during ECC reaches 2 mmol / L, consistent with the upper normal range for blood lactate; in the vast majority of ECC patients in this study, lactate levels were within the normal range. Our findings agree with the conclusions of these authors where the lactate levels in the patients who were less than 120 minutes in ECC were levels within the range of normality, while in 3 patients, whose ECC time was greater than 120 minutes, the lactate level was close to 3 mmol / L. However, several preoperative factors or comorbidities can create a suitable environment for hyperlactatemia during ECC.

According to Demers et al., age, female gender, congestive heart failure, low LVEF, high blood pressure, atherosclerosis, diabetes, hemoglobin level, complex surgery, and emergency procedures have been documented as risk factors for hyperlactatemia. In our case, the increase in lactate was mainly associated with the ECC time; likewise, they demonstrated the strongly positive correlation between lactate blood levels and the risk of morbidity and mortality in clinical situations such as shock or ECC [22].

An $SvCO_2$ level> 70% is an indicator of normal extraction, O_2 availability> O_2 demand. Recent scientific evidence recommends the use of $SvCO_2$ as a marker of global flux; clinical and experimental studies have shown that changes in $SvCO_2$ reflect circulatory disturbances in hypoxia. In all of our patients, $SvCO_2$ levels above 70% could be documented, a situation that favors adequate tissue perfusion during the ECC period, even in patients who had ECC times greater than 120 minutes.

The CO_2 Delta exhibits a correlation with tissue perfusion that depends on blood flow changes. Theoretically, the CO_2 Delta is related to cardiac output and microcirculatory dysfunction [17].

Nonetheless, the results of Chen et al. showed that arterial lactate and SvcO2 were not better than the CO_2 Delta, thus being able to represent a better predictor of poor composite results related to low cardiac output compared to arterial lactate and $SvcO_2$, demonstrating a correlation between Delta CO_2 and cardiac output in patients after cardiac surgery. They established a cut-off level at 7,12 mm Hg, resulting in a sensitivity of 86% and specificity of 72%, a limit that according to these authors would allow predicting low cardiac output and poor postoperative results with greater precision than with the previous parameters. For patients who spent less than 120 minutes in ECC, the median CO_2 Delta levels in the first measurement was 4 mm Hg (IQR 2,6-4,8) and in the second measurement it was 3,2 (IQR 2,2-4,7) both below the cutoff level proposed by Chen et al. Even in patients who stayed longer than 120 minutes, the level was around 4,4 mm Hg (IQR 3-6,7) and, in all cases, the post-ECC measurement was 4,3 (IQR 3,3-6,1). These results (lactate and $SvcO_2$) did not vary significantly in the first 24 hours in ICU; however, and strikingly, the median levels of CO_2 Delta were significantly altered from admission to the ICU, where the highest value was found, above the cut-off level of Chen et al. (8, IQR 6-10) progressing to a value close to normality at 24 hours (6, IQR 3-7), which could be in accordance with the findings of Chen et al. thus showing this biomarker with the highest sensitivity and specificity for tissue hypoperfusion.

Other findings of great importance in our study were related to BMI and albumin levels. Malnutrition is common in patients with cardiovascular disease such as Heart Failure (HF), hospitalized patients, and the elderly, and it is clearly defined as an independent risk factor for poor clinical outcome in each of these settings. Nutritional status is a marker of frailty associated with increased mortality and morbidity among patients with heart disease [23]. In 74% of our patients, the BMI was in the normal range (18,5-29,99) and only 7,4% of the patients were undernourished, given a BMI <18,5. Albumin as a biomarker in the context of cardiac surgery was below expected levels in almost 60% of our population. Hypoalbuminemia is a common condition in patients with HF and it is mainly related to the malnutrition-inflammation complex syndrome. Other causal factors may be involved, including hemodilution, liver dysfunction, increased transcapillary leak rate, renal and enteral loss [24]. Since the 1970s, it was clearly known that poor nutrition and hypoalbuminemia increased morbidity and mortality after cardiac surgery, defined as a predictor of poor prognosis in critically ill patients with HF. Preoperative hypoalbuminemia has been attributed to cachexia from malnutrition, liver failure, congestive HF, or a combination of these features in patients with heart disease [25]. It is a powerful predictor in patients with coronary artery disease, regardless of their phenotype [26]. In a prospective study by Chen et al., who monitored 734 patients with stable coronary artery disease for 18 months, hypoalbuminemia independently predicted overall mortality (p=0,048) and cardiovascular mortality (p=0,037), even after adjusting LVEF, BMI, liver function and inflammation [27].

There is now growing evidence that hypoalbuminemia independently predicts incident HF in patients with end-stage renal disease and elderly patients, as well as mortality in patients with heart failure, regardless of the left ventricular ejection fraction and the clinical presentation; therefore, it is not unreasonable to consider this factor as an important determinant in the postoperative course in cardiac surgery patients and that it affects, not only postoperative complications in terms of morbidity and mortality, but also the ICU and hospital stay. However, the European System for Cardiac Operative Risk Evaluation (EuroSCORE) has been the surgical mortality reference model since the end of the 20th century, although several studies showed a progressive loss of calibration, which led to the development of its updated version EuroSCORE II. García Valentín et al. conducted their validation in Spain, concluding that crude mortality is acceptable, closer to the EuroSCORE II value [28]. However, both scales show poor calibration: Euro SCORE due to overestimation and EuroSCORE II due to underestimation; this forces us to consider whether it is necessary to include new variables for an estimate closer to reality, such as the inclusion of nutritional status and albumin levels.

The present work, being a descriptive study with a reduced sample size, limits its analysis, making analytical and multicenter studies necessary in order to obtain robust data for decision-making. Given that no single parameter can accurately assess the nutritional status of a patient, in order to minimize postoperative complications, it is highly advisable to use instruments that, through comprehensive assessment, attempt to come near the diagnosis of malnutrition. Nevertheless, this research, being one of the first studies developed in this area together with a detailed and thorough evaluation, allowed the integration of 3 tissue perfusion variables and findings that, from the clinical viewpoint, are relevant for the perioperative management of patients undergoing cardiac surgery in ECC.

Acknowledgments
Our gratitudes to Dr. Erika León for her methodological advice in developing this manuscript.

Our gratitude to the Heads of Perfusion of the Hospital Cardiovascular del Niño de Cundinamarca, Dr. Carlos Eduardo Rojas & Dr. Eleazar González Angarita.

Conflicts of Interest
The ideas and opinión expressed in this article are the sole responsibility of the authors, who declare having no conflict of interest regarding its content.

All researchers must declare any conflict of interest.

Project Funding
There were no funding sources for conducting this article.

References

1. Svenmarker S, Häggmark S, Östman M (2006) What is a normal lactate level during cardiopulmonary bypass? Scandinavian Cardiovascular Journal 40: 305-311.
2. Ranucci M, De Toffol B, Isgrò G, Romitti F, Conti D, et al. (2006) Hyperlactatemia during cardiopulmonary bypass: Determinants and impact on postoperative outcome. Critical Care 10: R167.
3. Andersen LW (2017) Lactate Elevation during and after Major Cardiac Surgery in Adults: A Review of Etiology, Prognostic Value, and Management. Anesthesia and Analgesia 125: 743-752.
4. Okorie ON, Dellinger P (2011) Lactate: Biomarker and Potential Therapeutic Target. Critical Care Clinics 27: 299-326.
5. Zhang Z, Xu X (2014) Lactate clearance is a useful biomarker for the prediction of all-cause mortality in critically Ill patients: A systematic review and metaanalysis. Critical Care Medicine 42: 2118-2125.
6. Pölönen P, Ruokonen E, Hippeläinen M, Pöyhönen M, Takala J (2000) A prospective, randomized study of goal-oriented hemodynamic therapy in cardiac surgical patients. Anesthesia and Analgesia 90: 1052-1059.
7. Ritesh Shah, Hasmukh Patel, Himani Pandya (2015) Hyperlactatemia after Cardiac Surgery as a Prognostic Risk Factor. International Journal of Science and Research (IJSR) 8: 1300-1303.
8. Cain SM (1983) Peripheral oxygen uptake and delivery in health and disease. Clinics in Chest Medicine 4: 139-148
9. Ranucci M, Romitti F, Isgrò G, Cotza M, Brozzi S, et al. (2005) Oxygen delivery during cardiopulmonary bypass and acute renal failure after coronary operations. Annals of Thoracic Surgery 80: 2213-2220.
10. Rivers EP, Ander DS, Powell D (2001) Central venous oxygen saturation monitoring in the critically ill patient. Current Opinion in Critical Care 7: 204-211.
11. Sander M, Spies CD, Foer A, Weymann L, Braun J, et al. (2007) Agreement of central venous saturation and mixed venous saturation in cardiac surgery patients. Intensive Care Medicine 33: 1719-1725.
12. Grow MP, Singh A, Fleming NW, Young N, Watnik M (2004) Cardiac Output Monitoring during Off-Pump Coronary Artery Bypass Grafting. Journal of Cardiothoracic and Vascular Anesthesia 18: 43-46.
13. Reinhart K, Kersting T, Föhring U, Schäfer M (1986) Can central-venous replace mixed-venous oxygen saturation measurements during anesthesia? Advances in Experimental Medicine and Biology 200: 67-72.
14. Robin E, Futier E, Pires O, Lebuffe G, Vallet B (2011) Prognostic value of the central venous-to-arterial carbon dioxide difference for postoperative complications in high-risk surgical patients. Critical Care 15: 38.
15. He H wu, Liu D wei, Long Y, Wang X Ting (2016) High central venous-to-arterial CO2 difference/arterial-central venous O2 difference ratio is associated with poor lactate clearance in septic patients after resuscitation Journal of Critical Care 31: 76-81.
16. Futier E, Robin E, Jabaudon M, Guerin R, Petit A, et al. (2010) Central venous O2saturation and venous-to-arterial CO2difference as complementary tools for goal-directed therapy during high-risk surgery Critical Care 14: R193.
17. Chen T, Pan T, Luo X, Wang D (2019) High Central Venous-To-Arterial CO2 Difference is Associated with Poor Outcomes in Patients After Cardiac Surgery. SHOCK 52: 583-589.
18. Moussa MD, Durand A, Leroy G, Vincent L, Lamer A, et al. (2019) Central venous-to-arterial PCO2 difference, arteriovenous oxygen content and outcome after adult cardiac surgery with cardiopulmonary bypass. European Journal of Anaesthesiology 36: 279-289.
19. Kogan A, Sternik L, Spiegelstein D, Preisman S, Lavee J, et al. (2012) The impact of hyperlactatemia on postoperative outcome after adult cardiac surgery. Journal of Anesthesia 26: 174-178.
20. Dong MF, Ma ZS, Wang JT, Chai SD, Tang PZ, et al. (2012) Impact of Peripherally Established Cardiopulmonary Bypass on Regional and Systemic Blood Lactate Levels. Heart Lung and Circulation 21: 154-158.
21. Ranucci M, Carboni G, Cotza M, Bianchi P, Di Dedda U, et al. (2015) Hemodilution on cardiopulmonary bypass as a determinant of early postoperative hyperlactatemia. PLoS ONE 10: e0126939.
22. Demers P, Elkouri S, Martineau R, Couturier A, Cartier R (2000) Outcome with high blood lactate levels during cardiopulmonary bypass in adult cardiac operation. Annals of Thoracic Surgery 70: 2082-2086.
23. Bonilla-Palomas JL, Gámez-López AL, Anguita-Sánchez MP, CastilloDomínguez JC, García-Fuertes D, Crespin-Crespin M, et al. (2011) Influencia de la desnutrición en la mortalidad a largo plazo de pacientes hospitalizados por insuficiencia cardiaca. Revista Espanola de Cardiologia 64: 752-758.
24. Arques S (2011) Albumine sérique et insuffisance cardiaque: Données récentes sur un nouveau paradigme. Annales de Cardiologie et d'Angeiologie 60: 272-278.
25. Rady MY, Ryan T, Starr NJ (1997) Clinical characteristics of preoperative hypoalbuminemia predict outcome of cardiovascular surgery. Journal of Parenteral and Enteral Nutrition 21: 81-90.
26. Goldwasser P, Feldman J (1997) Association of serum albumin and mortality risk. Journal of Clinical Epidemiology 50: 693-703.
27. Chien SC, Chen CY, Leu HB, Su CH, Yin WH, et al. (2017) Association of low serum albumin concentration and adverse cardiovascular events in stable coronary heart disease. International Journal of Cardiology 241: 1-5.
28. García-Valentín A, Bernabeu E, Pereda D, Josa M, Cortina JM, et al. (2014) Validación de EuroSCORE II en España. Cirugia Cardiovascular 21: 246-251.