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Research Article

Exploration of Acid-base Disorders in the Post-operative Post-cardiac Surgery Period

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Abstract

This retrospective, descriptive, and analytical study was conducted over a six-month period (January to June 2025) at the Cuomo Cardiac Center in Dakar, involving 39 consecutive adult patients undergoing cardiac surgery with cardiopulmonary bypass (CPB). Perioperative data were extracted from medical records, supplemented by systematic arterial blood gas analysis within the first six postoperative hours. Statistical analysis was performed using Sphinx Plus software. Results revealed a high prevalence of acid-base disorders (ABD) at 64.1% (25 patients). Acidosis was largely predominant (56.4%), categorized as respiratory (33.3%), metabolic (15.4%), and mixed (7.7%), while alkalosis remained marginal (7.7%). The study identified the intraoperative use of two or more sympathomimetic agents as a major risk factor, strongly correlated with the occurrence of an ABD ($p = 0.005$). Regarding prognosis, patients with an ABD had a significantly longer mean length of stay in the intensive care unit (4.76 days vs. 3.43 days). Finally, although the sample size limited statistical significance for certain variables, the impact on mortality was notable: all four recorded deaths (10.3%) occurred exclusively in acidotic patients. These findings underscore the imperative for increased monitoring and early correction of imbalances, particularly in patients requiring heavy hemodynamic support.

Keywords

Cardiac Surgery, Acid-base Disorders, Acidosis, Prognosis

1. Introduction

Cardiac surgery under cardiopulmonary bypass (CPB) triggers systemic stress (inflammation, hypoperfusion) generating complex acid-base disturbances, including an incidence of metabolic alkalosis reaching 49% in pediatrics [1, 2]. Among biological indicators, base excess (BE) stands out as a predictor of mortality superior to lactate; a BE threshold ≤ -6.7 mEq/L at admission increases the risk of death by nearly five times (HR = 4.78) by reflecting the collapse of buffer reserves [1, 3].

Concurrently, the physicochemical changes associated with cardiopulmonary bypass (CPB) induce critical electrolyte losses (K^+, Mg^{2+}, PO_4^{3-}) in 88% of patients, increasing the risk of arrhythmias [4]. Proactive management, combining supplementation and ventilatory control, is therefore vital to

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prevent multiorgan failure [5]. In the absence of local data on these prognostic issues, this study analyzes the prevalence, risk factors, and influence of these disorders on patient outcomes.

2. Patients and Methods

We conducted a retrospective descriptive and analytical study at the Cardiac Center of the Fann University Hospital in Dakar, Senegal. Data collection took place over a six-month period, from January 2nd to June 30th, 2025.

The study included all adult patients who underwent cardiac surgery with cardiopulmonary bypass (CPB). Patients under 18 years of age and those who underwent surgery without CPB were excluded from the cohort.

The treatment strategy was standardized for the entire cohort according to a uniform protocol:

1) Preoperative phase: Conducting a standardized anesthesia consultation including a rigorous clinical and paraclinical assessment, coupled with optimization of cardiovascular therapies.
2) Intraoperative phase: Hemodynamic monitoring was based on invasive arterial pressure (IAP), central venous pressure (CVP), and transesophageal echocardiography (TEE). The general anesthesia protocol systematically included antibiotic prophylaxis with cefazolin and a blood-sparing strategy with tranexamic acid.
3) Postoperative phase: Systematic transfer to the intensive care unit. An initial arterial blood gas analysis was performed within the first six hours following admission. Due to technical constraints limiting reliable analysis of pH, $PaCO_2$, and bicarbonate (HCO^{3-}), the study focused on the diagnostic classification of acid-base disorders, without in-depth etiological investigation through lactate, chloride (Cl^-), and sodium (Na^+) measurements.

The information was collected on a pre-established survey form using medical records, anesthesia charts, and resuscitation monitoring sheets. The variables studied included:

1) Sociodemographic variables: Total number of people, age and sex.
2) Preoperative clinical and paraclinical profile: Comorbidities and medical history, drug treatments, signs of cardiac decompensation, left ventricular ejection fraction (LVEF), hemoglobin level, renal function.
3) Intraoperative data and CPB parameters: Extracorporeal circulation duration, aortic clamping duration, thermal profile during CPB, use of sympathomimetic agents.
4) Evolutionary and gasometric indicators: Time to tracheal extubation, results of postoperative arterial gasometry (pH, $PaCO_2$, HCO^{3-}), phenotypic classification of diagnosed acid-base disorders and evolutionary modalities within the intensive care unit.

Statistical analysis was performed using Sphinx Plus software (version 5.0). Continuous variables are expressed as means with their standard deviation (± SD) or as medians. Qualitative variables are presented as counts and percentages. The threshold for statistical significance was set at $p < 0.05$.

3. Results

3.1. Descriptive Results

From an initial group of 94 patients who underwent surgery, 50 adults were identified. After excluding 11 records (22%) due to incomplete blood gas data, the final study sample consisted of 39 patients. The population was predominantly female (64.1%), with a sex ratio of 0.55 and a mean age of 40.97 ± 16.97 years (range: 18 to 76 years).

1) The analysis of the preoperative profile revealed the following elements:
   a) Comorbidities and medical history: An associated condition was present in 35.9% of patients (see Table 1), predominantly hypertension (17.95%) and diabetes (10.25%). Furthermore, 28.2% of the cohort had a history of hospitalization for acute heart failure.
   b) Surgical indications: Valve surgery was the main indication (76.9%), followed by coronary revascularization and ascending aortic surgery (10.3% each). One case of adult congenital surgery was also recorded.
   c) Clinical status: Clinically, cardiac decompensation was noted in four patients (10.3%).
   d) Echocardiographic data revealed an overall preserved mean left ventricular ejection fraction (LVEF) of 62.46%, despite one case of moderate systolic dysfunction (LVEF at 42%).
   e) Biological data: Impaired renal function was observed in 46.2% of patients. In addition, preoperative anemia (Hb < 11 g/dl) was present in 12.8% of the cohort.
   f) Preoperative treatment (see Table 2): Almost all subjects (92.3%) received cardiovascular therapy, mainly consisting of loop diuretics and anti-aldosterones (64.1% for each of these classes).
2) Intraoperative data and management of extracorporeal circulation (ECC):

The use of sympathomimetic agents during surgery was required in 89.7% of patients. Norepinephrine (NAD) was the vasopressor of first choice (87.2%), administered alone in 51.3% of cases or in combination with dobutamine or milrinone in 41.1% of patients (see Table 3).

Regarding cardiopulmonary bypass (CPB) parameters, the mean durations of CPB and aortic clamping were 123 ± 54.22 minutes and 93.10 ± 38.13 minutes, respectively. In terms of thermal management, a hypothermia strategy was preferred for 51.28% of patients.

3) Postoperative arterial blood gas analysis

Blood gas analysis performed within the first six hours post-admission revealed an overall prevalence of acid-base disorders (ABD) of 64.1% (n=25/39). The mean parameters were as follows: pH = 7.34 ± 0.08; HCO_3^- = 23.96 ± 3.58 mmol/L; $PaCO_2$ = 45.85 ± 8.5 mmHg.

The profile of the TABs was marked by a clear predominance of acidosis (56.4%, n=22), manifesting as respiratory (33.3%), metabolic (15.4%), and mixed (7.7%) forms. Conversely, alkalosis was less common (7.7%, n=3), of metabolic (5.1%) or respiratory (2.6%) origin.

4) Clinical evolution and outcome

The management of mechanical ventilation weaning allowed for early extubation in the operating room in 25.6% of patients. For the majority of the cohort (64.10%), extubation was performed in the intensive care unit with a mean delay of 5.42 hours (range: 1-48 hours), while weaning could not be initiated in 10.26% of subjects (n = 4).

Clinical progress in the intensive care unit was favorable for 89.7% of patients who underwent surgery, with a mean length of stay (LOS) of 4.23 days (range: 1-15 days). Overall in-hospital mortality was 10.3% (n = 4).

Table 1. Distribution of patients according to comorbidities.

Ground	Effective	Percentage (%)
HTA	7	17.95
Diabetes	4	10.25
Vascular disease	3	7.69
Obesity	2	5.13
Smoking	2	5.13
Sickle cell disease	2	5.13
Asthma	1	2.56
Chronic kidney failure	1	2.56
Dyslipidemia	1	2.56

Table 2. Distribution of patients according to preoperative treatment.

Treatment	Effective	Percentage (%)
Loop diuretic	25	64.1
Anti-aldosterone	25	64.1
ACE inhibitor	13	33.3
Betablockers	11	28.2
Antiarrhythmics	4	10.3
Statins	3	7.7
Calcium channel blockers	2	5.1

Table 3. Distribution of patients according to the sympathomimetic combination.

Sympathomimetic Association	Effective	Percentage (%)
NAD alone	20	51.3
Milrinone alone	1	2.6
NAD+Milrinone	5	12.8
NAD+Dobutamine	7	28.2
NAD+Dobutamine+Milrinone	1	2.6
NAD+Adrenaline+Milrinone	3	7.7
No sympathomimetics	4	10.3
Total	39	100%

3.2. Analytical Results

1) Risk factors for the occurrence of acid-base disorders

Bivariate analysis of risk factors (Table 4) demonstrates that the occurrence of acid-base disorders is significantly associated with the intraoperative use of at least two sympathomimetics (p = 0.005).

Although not statistically significant at the 5% threshold, clinical trends were observed regarding preoperative renal impairment (p = 0.099) and the duration of cardiopulmonary bypass (p = 0.098). In contrast, age, sex, type of surgery, and thermal strategy (hypothermia vs. normothermia) did not influence the occurrence of these imbalances in our cohort.

2) Impact of acid-base disorders on the course and prognosis.

The impact of acid-base disorders was evident in two major indicators:

a) Length of hospital stay: The average stay in intensive care was longer in patients with an acid-base disorder (4.76 vs 3.43 days), particularly in cases of acidosis (5.06 days), although the difference was not statistically significant (p = 0.153).

b) Mortality: A strong clinical link was observed, as 100% of the deceased patients (n=4) presented with an acid-base disorder, compared to 60% of the survivors. In all cases of death, the identified disorder was acidosis. However, due to the sample size, this association did not reach statistical significance (p = 0.114).

Table 4. *Relationship between parameters and the occurrence of ABD.*

Data	Acid-base disorders: No	Acid-base disturbances: Yes	P-value (p)
Age (average in years)	39.21	41.96	0.638
Sex	M(4/14), F(10/25)	M(10/14), F(15/25)	0.475
Type of surgery	Valvular (12/30), Bypass (0/4), Ascending aorta (2/4), Congenital (0/1)	Valvular (18/30), Bypass (4/4), Ascending aorta (2/4), Congenital (1/1)	0.338
Diuretic treatment	No (5/14), Yes (9/25)	No (9/14), Yes (16/25)	0.451
FEVG (average in%)	63.43	61.92	0.572
Hb (average in g/dl)	12.56	12.10	0.346
Kidney damage (GFR)	No (10/21), Yes (4/18)	No (11/21), Yes (14/18)	*0.099*
Intraoperative sympathomimetics	No (3/4) Yes (11/35)	No (1/4) Yes (24/35)	*0.085*
Number ≥ 2 sympathomimetics	No (13/25), Yes (1/14)	No (12/25), Yes (13/14)	0.005
CEC duration (average in min)	104.00	133.64	*0.098*
Clamping time (average in minutes)	79.93	100.48	0.103
Temperature during CEC	Normothermia (5/19), Hypothermia (9/20)	Normothermia (14/19), Hypothermia (11/20)	0.224
Tabletop extubation	No (10/29), Yes (4/10)	No (19/29), Yes (6/10)	0.753

4. Discussion

The studied cohort (n=39) presented a demographic profile distinct from Western series, characterized by a young median age (39 years) and a female predominance (64.1%) [6]. This epidemiological specificity likely reflects the high local incidence of rheumatic valvular heart disease as well as the case selection criteria used when initiating an adult cardiac surgery program. The prevalence of comorbidities (35.9%), primarily hypertension and diabetes, was lower than usual, which is consistent with the relative youth of this population [7].

Valve surgery was the most frequently performed procedure (76.9%), consistent with the expected epidemiological profile in a developing country setting [8]. A high proportion of patients (92.31%) received preoperative cardiac medication, primarily diuretics. Although no significant association was found with acid-base disorders (ABD) (p=0.451), these medications represent a potential factor in electrolyte and acid-base disturbances [9, 10].

Left ventricular systolic function was generally preserved. However, systolic dysfunction has been identified as a major risk factor for complications [11]. In contrast, the prevalence of preoperative renal impairment was high (46.2%). While the association with TB was only a slight trend (p=0.099), chronic renal failure remains an established risk factor for metabolic acidosis and postoperative morbidity [12, 13].

The durations of cardiopulmonary bypass (CPB) and aortic clamping were within standard parameters. A statistically significant trend was observed between prolonged CPB and the occurrence of aortic hypertension (p=0.098), supporting the role of cardiopulmonary bypass in the development of metabolic disorders [14]. However, the most compelling finding was the significant association between the intraoperative administration of at least two sympathomimetics and the incidence of aortic hypertension (p=0.005). This multiple use reflects severe hemodynamic instability, leading to tissue hypoperfusion and anaerobic metabolism [15]. Furthermore, high doses of catecholamines can induce type B hyperlactatemia through direct metabolic stimulation [16, 17]. Thus, this pharmacological need is emerging as a major predictive marker for patients at high metabolic risk.

The overall prevalence of pulmonary arterial edema (PAE) was high (64.1%), confirming its recurrence in this cardiac surgery setting [1, 3]. Acidosis was largely predominant, affecting 56.4% of the cohort. Respiratory acidosis was the most frequent disorder (33.3%), potentially attributable to post-anesthetic ventilatory depression, pain, and atelectasis [18]. Although metabolic acidosis (15.4%) is a recognized marker of severity, its precise etiologies (lactic, hyperchloremic, or renal) could not be distinguished. This analysis was limited by the frequent unavailability of lactate and electrolyte measurements during blood gas analysis, thus restricting detailed pathophysiological interpretation.

Despite the lack of statistical significance due to the limited sample size, clinically relevant prognostic trends were observed. Patients with acute abdominal pain (AAP), and more specifically acidosis, had a longer ICU stay (4.76 vs. 3.43 days; p=0.153). Notably, all recorded deaths (n=4; 10.3%) occurred in patients with acidosis. This systematic observation underscores that postoperative acidosis should not be considered a mere epiphenomenon; it constitutes a major prognostic marker, forming part of a vicious cycle of multi-organ failure [1, 19, 20].

In summary, our study identifies the intraoperative use of multiple sympathomimetics as the main risk factor associated with acid-base disorders (ABD). Clinical trends were also observed regarding preoperative renal impairment [12] and the duration of cardiopulmonary bypass [14], two determinants whose role is already well documented in the literature. The lack of statistical significance for these parameters, as well as for other variables such as age or type of surgery, is likely attributable to the small sample size (n=39). This low statistical power, along with its retrospective and single-center nature, constitutes the main limitation of this study. Finally, the unavailability of essential biological data (serum lactate, serum chloride) restricted the precise etiological analysis of the acidosis, thus limiting the scope of the pathophysiological interpretation.

5. Conclusion

This first study in a West African setting confirms the high frequency and clinical impact of pulmonary artery edema (PAE) following cardiac surgery with cardiopulmonary bypass. It highlights the importance of intraoperative hemodynamic instability, evidenced by the need for multiple vasoactive supports, as a major predictive factor. The strong association between acidosis and mortality, even if not statistically significant, argues for systematic monitoring and rapid correction of these disorders. Larger prospective studies, including complete metabolic blood gas analysis, are needed to clarify the etiological mechanisms and refine preventive and therapeutic strategies.

Abbreviations

CEC	Extracorporeal Circulation
ABD	Acid-Base Disorders
BE	Base Excess
$PaCO_2$	Arterial Carbon Dioxide Pressure
IAP	Invasive Arterial Pressure
CVP	Central Venous Pressure
TEE	Transesophageal Echocardiography
LVEF	Left Ventricular Ejection Fraction
NAD	Norepinephrine
Hb	Hemoglobin
GFR	Glomerular Filtration Rate
HR	Hazard Ratio (Instantaneous Relative Risk)

Conflicts of Interest

The authors declare no conflicts of interest.

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