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Cardiopulmonary Bypass Complications in a West African Country (Senegal)

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Abstract: Although cardiopulmonary bypass (CPB) has simplified open heart surgery, it causes adverse effects on the body's systems. This study aims to report the complications related to CPB at the Cardiac Surgery Center of the University Hospital in Dakar (Senegal). This is a retrospective analytical and descriptive study covering a 24 months period (from January 2015 to December 2016). All adult and children patients who underwent open heart surgery using CPB machines were included in this study. 193 patients were eligible during this study's period. Patients' mean age was 23 ± 15 years (range, 2–65), and 52% were female patients. Two complications were observed during CPB. One case of hemolysis and one case of an impossible weaning from CPB. Post-CPB complications were allocated as follows: hematological complications (88.5%) followed by cardiovascular (56%), pleuropulmonary (22.4%), septicemia (4%), renal (3%), systemic inflammatory response syndrome (SIRS) (2%) and neurologic (1%) complications. The overall hospital mortality was 5%. One (1) patient died intra operatively and nine (9) patients in the intensive care unit. The morbidity and mortality related to CPB in our cardiac surgery center is superimposed to those of the literature.

Keywords: Cardiopulmonary Bypass, Complications, Open Heart Surgery

1. Introduction

Cardiopulmonary bypass (CPB) is a blood circulation external derivation technique during which the cardiac and pulmonary functions are temporarily assured by a mechanical system connected to the vascular system of the patient. The CPB is the machine that allows surgeons to operate on a nonmoving, bloodless heart. The first successful series of open-heart surgery utilizing CPB machines occurred in 1953 by John Gibbon [1]. Nowadays, and throughout the world, the use of the CPB machine during cardiac surgery has become a widely employed practice. However, open heart surgery (OHS) has only recently been introduced in Africa; in Sub-Saharan Africa, it started in the 70's. The first OHS in the West African sub region was performed in Nigeria in 1974; in Senegal, it was performed 1996. [2, 3]

Although CPB has simplified open heart surgery, it also causes adverse effects on a body systems, including

complications of the inflammatory system, heart, lungs, kidneys, and brain.

The aim of this study is to report the complications related to CPB at the Cardiac Surgery Center of the University Hospital of Fann in Dakar (Senegal).

2. Method

This is a retrospective analytical and descriptive study covering a 24 months period (from January 2015 to December 2016).

2.1. Inclusion et Exclusion Criteria

All adult and children patients who underwent OHS using CPB machine were included in this study.

One hundred ninety-three (193) patients were eligible during this period. The clinical characteristics of all patients are listed in table 1. The patients had no preoperative biological abnormality. Preoperative diagnoses are listed in table 2.

Table 1. *Preoperative features.*

Characteristics	Values
Age Mean ± SD years [range]	23 ± 15 [2–65]
BMI Mean ± SD [range]	18 ± 4.4 [9–35]
Sex Female	52%
Previous cardiac surgery	4%
Comorbidities (frequency)	
Ischemic stroke	4
Down's Syndrome	2
High blood pressure	1
New York Heart Association class	
Absence or NYHA I	1.5%
NYHA II	71%
NYHA III	27.5%
Electrocardiogram	
Normal sinus rhythm	81%
AAF	16%
Other (atrial flutter, atrial fibrillation)	3%
Chest X-ray	
Indirect sign of PAH	60%
Hemoglobin Mean ± SD [range]	13.4 ± 2.5 g/dL [7–25]
Hemoglobin < 12g/dL	22%
Hematocrit Mean ± SD [range]	39.3 ± 8.3% [20-80]
Transthoracic echocardiography	
PAH	58%
Left atrial enlargement	60%
sPAP	63 ± 19 mm [38-123]
LVEF	65% ± 9 mm [40-87]
Tricuspid regurgitation	49%
Grade I	18%
Grade II	49%
Grade III	18%
Grade IV	15%

BMI: body mass index; SD: standard deviations; PAP: systolic pulmonary artery pressure.
PAH: pulmonary arterial hypertension; AAF: Arrhythmia Atrial fibrillation.

Table 2. *Preoperative diagnoses.*

Diagnoses	Frequency	Percentage
Mitral regurgitation	44	22.8
Mixed mitral desease	29	15
Mitral stenosis	34	17.6
Aortic regurgitation	7	3.6
Mixed aortic desease	4	2.1
Aortic stenosis	2	1
Tetralogy of Fallot	23	11.9
Atrial septal defect	19	9.8
Ventricular septal defect	13	6.7
Subaortic diaphragm	12	6.1
Atrioventricular Canal defect	3	1.5
Pulmonary infundibular stenosis	1	0.5
Left Atrial Myxoma	1	0.5
Pentalogy of Fallot	1	0.5

2.2. Statistical Methods

All analyses were conducted with IBM® SPSS®Statistics Version 22 under a bilateral hypothesis with a type-I error set at 5%. For descriptive analyses, the categorical variables were expressed as number and percentage; the quantitative variables were expressed as mean ± standard deviation (SD) in case of Gaussian distribution, or by quartiles and range otherwise.

2.3. Surgery

The CPB had been established using ascending aorta and bicaval cannulations in 90% of cases. In other cases, the aortic cannulation was associated with a single cannulation of the right atrium with a "two-stage" cavoatrial cannula. Heparin-coated circuits were used in all cases. The anticoagulation was performed with heparin. The priming volume contained heparin in 84% of cases with a mean of 8092 ± 3740 IU (range, 1000–15000). By adding the dose of heparin in the priming and that administered parenterally; the mean total dose of heparin was 26167 ± 9720 IU (range, 6000–45000). No cases of heparin resistance have been reported. The mean ACT (Activated clotting time) before starting CPB was 506 ± 167 seconds (sec) (range, 320–1443). During CPB, the mean of minimum ACT was 436 ± 134 sec, the mean of maximum ACT was 561 ±179 sec. No cardiotomy filter was replaced. The surgical procedures are listed in table 3. Operative data of the patients are listed in table 4. Cross clamp times was superior to 120 minutes (min) in 7 cases. The resumption of cardiac activity had occurred in normal sinus rhythm (74.5%), ventricular fibrillation (14.5%), atrioventricular block (AVB) (8.3%). Intra operative hemodynamic status was stable under vasoactive drug in 31% of cases.

Table 3. *Surgical procedures.*

Surgical procedures	Percentage
Mitral valve replacement	26
Mitral valve replacement + Tricuspid valve repair	17
Aortic valve replacement	8
Mitral valve replacement + Aortic valve replacement	6
Mitral valve repair	5
Tetralogy of Fallot correction	12
Correction of atrial septal defect	10
Correction of ventricular septal defect	7
Resection of subaortic diaphragm	6
Correction Atrioventricular septal defect	1.5
Pentalogy of Fallot correction	0.5
Correction of pulmonary infundibular stenosis	0.5
Resection of left atrial myxoma	0.5

Table 4. *Operative data.*

Operative characteristics		Values
Aortic cannula		18 ± 3 F [10-22]
Inferior vena cava cannula	Size: Mean ± SD [range]	27 ± 6 F [14 -34]
Superior vena cava cannula		26 ± 6 F [12–40]
Priming		
Crystalloid		93%
Blood		7%
Cardioplegia		
Crystalloid		69.4%
Cold blood		28.5%
Warm blood		2%
Central temperature		
Mild hypothermia		32%
Moderate hypothermia		32%
Normothermia		36%
CPB Time		90 ± 34min [26–343]
Cross clamp time	Mean ± SD [range]	66.3 ± 28.5 min [18–214]
Minimum Hematocrit during CPB		28.4 ± 6% [14–46]
Hemofiltration (the usage rate of)		63%
UF conventionnelle		94%
UF + MUF		5%
MUF		1%
Flow of CPB		3.1 ± 0.8 l/min/m^2 [0.9–5.5]
Mean arterial pressure	Mean ± SD [range]	60.4 ± 9.3mmHg [40–80]
Diuresis during CPB		286.3 ± 290 ml [10–1800]

F: French; min: minutes; UF: ultrafiltration; MUF: Modified ultrafiltration.

3. Results

Two complications were observed during CPB. One case of hemolysis due to an accident of blood transfusion via the CPB circuit because an inappropriate blood type had been transfused. The second complication was an impossible weaning from CPB. The patient died intra operatively after a voluntary stoppage of CPB assistance. After a CPB time of 343 min, cross clamp time of 214 min and CPB assistance of 120 min. It was a 19-year-old patient operated for a mitral and aortic valve replacement. We did not have an extracorporeal life support device.

Post-CPB complications are listed in table 5. No case of allergic reactions to protamine sulfate and heparin-induced thrombocytopenia had been reported.

Table 5. *Post-cardiopulmonary bypass complications.*

Complications	Values
Hematological	88.5%
Anemia (hemoglobin <10g/dL)	43.5%
Hemoglobin: Mean ± SD [range]	8.5 ± 1.1g/dL [5–9,9]
Hyperleukocytosis (>10000 mm^3)	56%
Leukocytes: Mean ± SD [range]	17123 ± 4854 cells/mm^3 [11100-30400]
Low level of prothrombin ratio	62%
Prothrombin Ratio: Mean ± SD [range]	48 ± 9% [14-63]
Thrombocytopenia	25%
Platelets: Mean ± SD [range]	102277 ± 34355 cells/mm^3 [12000-14800]
Hemolysis	0.5%
Surgical bleeding	1%
Biological bleeding	11%
Reoperation	4%
Reoperation for biological bleeding	2%
Reoperation for Surgical bleeding	1%
Reoperation for accidental removal of temporary electrode epicardials pacing	0.5%
Cardiovascular	56%
Right Ventricular Dysfunction	52%
TAPSE: Mean ± SD [range]	9.5 ± 2.5 mm [4–14]
Left Ventricular Dysfunction	15.5%
LVEF: Mean ± SD [range]	40 ± 5.6% [25–45]
PAH	12.4%
sPAP: Mean ± SD [range]	55 ± 18.4 mmhg [38–104]
Others: (AVB, arrhythmia, AF…)	8.5%
Pleuropulmonary	22.4%

Complications	Values
Bronchopneumonia	16%
Pleural effusion	5%
Pneumothorax	3%
Atelectasis and ARDS	1%
Hepatosplanchnic	18%
Biological hepatic cytolysis (often asymptomatic)	16%
ASAT: Mean ± SD [range]	114 ± 50 mmol/L [58–262].
Functional Intestinal Obstruction	2.6%
Diarrhea and dyspepsia	1%
Renal	3%
Acute kidney injury	3%
Neurologic	1%
Ischemic stroke	0.5%
Anoxic encephalopathy	0.5%
Septicemia	4%
SIRS	2%

AVB: atrioventricular block; ARDS: (acute respiratory distress syndrome); PAH: pulmonary arterial hypertension.
LVEF: Left ventricular ejection fraction; sPAP: systolic pulmonary artery pressure; AF: Atrial fibrillation.
TAPSE: tricuspid annular plane systolic excursion; ASAT: aspartate aminotransferase.
SIRS: systemic inflammatory response syndrome.

The overall hospital mortality was 5% (10 cases). One (1) patient died intra operatively and nine (9) patients in the ICU (intensive care unit). Cause of death was multiple organ failures (4 cases), right ventricular dysfunction associated with pulmonary arterial hypertension (3 cases), septic shock associated with AVB (1 case), bleeding caused by disunity of superior vena cava suture line (1 case). The mean length of stay in the ICU was 3.8 ± 2 days (range, 2–18).

4. Discussion

Complications after use of cardiopulmonary bypass are common. Acute accidents and incidents occurring during CPB are in the order of 0.4 –1% [4]. It was in order of 1% in our series. Apart from a blood transfusion accident via the CPB circuit, the second complication was an impossible weaning from CPB. This case required cardiopulmonary support for failure to wean from CPB. However, we did not have an extracorporeal life support device. Predictors of difficult weaning from CPB are: prolonged aortic cross clamp time > 60 minutes, prolonged bypass time, poor myocardial preservation during CPB, prebypass Delta PCO_2 > 6 mmhg, preoperative diastolic dysfunction, PAH (pulmonary arterial hypertension) [5].

Post-CPB complications were dominated by hematological complications. Postoperative anemia (43.5%), hyperleukocytosis (56%), low level of prothrombin ratio (62%) and thrombocytopenia (25%) were the most prevalent. In the literature, the rate of anemia post-CPB range from 48 to 51% [6], the mean hemoglobin post-CPB ranges from 9.3 to 11g/dL, the ratio of thrombocytopenia ranges from 35 to 65% [8]. The postoperative anemia increases postoperative morbidity or the length of the hospital stay [7]. Lako et al. reported 90.2% of the patients with neutrophilic leukocytosis and the maximal level of the leukocytes was 34.170 mm^3 [7].

Cardiovascular complications were dominated by right ventricular dysfunction (RVD) (52%) followed by left ventricular dysfunction (LVD) (15.5%) and PAH (12.4%). RVD are traditionally described after OHS and evaluated by TAPSE. In the literature, the post-CPB TAPSE ranges from 11 to 18 mm and is correlated with CPB time [9, 10]. LVD after CPB is well known; the LVEF post-CPB ranges from 38 to 59% [10]. However, LVD is transitional with a recovery within 48 hours. PAH are predictors of difficult weaning from CPB, but also have an impact on mortality and RV function [5, 11].

In the literature, pleuropulmonary complications range from 8 to 79% [12]. In our series, these complications were dominated by bronchopneumonia (16%); they range from 2 to 22% in the literature. The rate of pleural effusion ranges from 24 to 95%, that of pneumothorax ranges from 0.7 to 5.3, ARDS (acute respiratory distress syndrome) ranges from 0.4 to 2% [12].

Acute kidney injury post-CPB was in the order of 3% in our series; it ranges from 2 to 40% in the literature [12, 13]. Hemodilution during CPB, anemia and peri operative blood transfusion are factors that contribute to acute kidney injury [14]. Neurologic complications were in the order of 1% in our series; it ranges from 1 to 2% in the low-risk patients and 6 to 8% in the high-risk patients. The rate of SIRS ranges from 10 to 11% in the literature. [12]

Our rate of hepatosplanchnic complications has been overestimated because of biological hepatic cytolysis that was often asymptomatic. Therefore, by ignoring biological hepatic cytolysis the rate of hepatosplanchnic complications would become 3.6%.

In our series, the mean length of stay in the ICU was 3.8. In the literature, it ranges from 1 to 4 days. Five predictors of prolonged ICU stay were identified: ejection fraction < 30%, PAH, prolonged ventilation (≥ 12 hours), number of blood units transfused, and postoperative acute renal failure. Hospital mortality ranges from 2 to 4.6% in the literature. [15]

5. Conclusion

The morbidity and mortality related to CPB in our cardiac

surgery center is superimposed to those of the literature. Post-CPB complications were dominated by hematological complications followed by cardiovascular and pulmonary complications. Anemia was the most prevalent of hematological complications. Cardiovascular complications were dominated by RVD followed by LVD. Pleuropulmonary complications were dominated by bronchopneumonia. Renal complications were represented by acute kidney injury. However, by improving care and monitoring in intensive care unit; we could reduce our morbidity and mortality.

Competing Interests

The authors declare there is no conflict of interest.

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