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Complications of Cardiopulmonary Bypass in Children after Cardiac Surgery in Senegal

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Abstract **Original Research Article**

Introduction: Cardiopulmonary bypass (CPB) is a technique for relieving cardiac function by a pump, lung function by an oxygenator and a heat exchanger, after deflecting blood from the heart-lung block. It allows surgery on a heartless and inactive heart. However, it leads to multiple physiological changes in the major functions of the body. Based on these findings, we propose to study the complications secondary to the use of CPB in pediatric cardiac surgery. ***Materials and Methods:*** This was a longitudinal, retrospective, descriptive and analytical study of children who benefited from cardiopulmonary bypass during cardiac surgery. It takes place in Dakar from January 16, 2017 to December 31, 2017, for one-year duration at Fann's thoracic and cardiovascular surgery center.Any patient up to 15 years of age who benefited from cardiopulmonary bypass during cardiac surgery during the study period was included. ***Results*:** Congenital pathology was dominated by fallot tetralogy (17.65%) and interventricular communication (16.66%). The acquired valvular pathology was dominated by mitral insufficiency (23.53%). Canulation was aorto-bicave in all our patients. The same SARNS ™ 9000 system perfusion roller console was used as well as membrane oxygenators of the MEDOS® type. The mean duration of CPB in our patients was 103.44 +/- 36.01 minutes [42-205]. Mean duration of aortic cross-clamping was 73.33 +/- 28.3 minutes [17-146]. Duration of assistance was specified in 80 patients (78.4%). It averaged 18.9 +/- 10.25 minutes [6-57]. The total enrollment of our study was 102 patients. A male predominance was noted in our series with 52 boys for 50 girls or a sex ratio of 1.04.The age of our patients ranged from 1.08 to 15 years with an average of 9.41 ± 4.2 years. Post-CPB cardiac complications were marked by metabolic (99%), cardiovascular (37.2%), pleuropulmonary (46.1%), renal (2%), hepatosplanchnic (26.5%), neurological (2 %). The postoperative hemorrhages were 6.9% and the systemic inflammatory response syndrome was found in 48%. One patient died intraoperatively after sternal reopening for hemodynamic instability following tamponade. There were 3 patients (2.9%) who died in the postoperative period. That is a mortality of 3.9% in our series. The postoperative mortality time was 36.33 days on average. The average length of stay in intensive care unit (ICU) was 4.38 days [0.29-30]. ***Conclusion*:** Cardiopulmonary bypass allows the replacement or correction of most cardiac and large vessel lesions by perfusion and tissue oxygenation in the absence of cardiac activity. While technical developments have allowed the miniaturization of the material, the artificial surfaces used for such circuits nevertheless remain responsible for an inflammatory reaction that can lead to metabolic disorders and various organ dysfunctions.

Keywords: Complications, Cardiopulmonary bypass, Senegal.

INTRODUCTION

Cardiopulmonary bypass (CPB) is a technique used to supplement cardiac function by a pump, lung function by an oxygenator and a heat exchanger, after deflecting blood from the heart-lung block. It allows surgery on an empty and inactive heart [1]. Despite its recent growth, at the beginning of the last century [2]. the CPB is now an indispensable tool for modern cardiac surgery and pediatric cardiac surgery in particular. However, the CPB causes multiple physiological changes in the major functions of the body (neurological, respiratory, renal, hematological,

cardiovascular ...). The genesis of these changes cannot be dissociated from cardiac surgery itself, but also from the procedure of CPB, anesthesia-resuscitation techniques, patient comorbidities and preoperative cardiovascular status [3]. Based on these findings, we conducted a study to evaluate the complications secondary to the use of CPB in pediatric cardiac surgery.

MATERIALS AND METHODS

It was a longitudinal, retrospective, descriptive and analytical study of children who benefited from cardiopulmonary bypass during cardiac surgery. It takes place in Dakar from 16 January 2017 to 31 December 2017, for a period of one year. The data came from CPB cards, anesthesia cards and hospital records of patients who benefited from cardiopulmonary bypass at the cardiopediatric center CUOMO of the thoracic and cardiovascular surgery clinic of the Fann University Hospital in Dakar.

Criteria for inclusion and non-inclusion

Any patient up to 15 years of age who benefited from cardiopulmonary bypass during cardiac surgery during the study period was included. All incomplete files as well as patients older than 15 years were excluded from the study.

Table-I: Distribution of congenital pathologies preoperatively

Pathologies		Number	Percentage
Atrioventricular canal (AVC)		4	3.92
Atrioseptal defect (ASD)		11	10.82
Ventricular Septal Defect (VSD)	Perimembranous VSD	6	16.66
	VSD+ Aortic Regurgitation	2	
	VSD with medioventricular or infundibular or pulmonary valvular stenosis	8	
	Subaortic VSD + subaortic diaphragm	1	
Subaortic diaphragm		2	3.92
Total Abnomaly of Pulmonary Venous Return (TAPVR)		1	0.98
Medioventricular Stenosis		1	0.98
Mitral Stenosis		1	0.98
Tetralogy of Fallot		18	17,65

Table-II: Distribution of patients according to acquired pathologies

Pathologies	Fréquence	Pourcentage
Aortic Regurgitation	3	2.94
Mitral Regurgitation	24	23.53
Mitral and aortic polyvalvulopathy	13	12.74
Mitral Disease	5	4.9

Calculation methods

The data was collected using a pre-established form. They have been entered with Sphinx software version 5.1.0.2. The analysis of the data was carried out with SPSS software (Statistical package for Social Sciences) version 18. The descriptive study was carried out with the calculation of the frequencies and proportions for the qualitative variables and the calculation of the averages, standard deviation for the variables quantitative.

Cardiopulmonary bypass and surgery data

In the operating room, the conditioning of the patients associated: the usual monitoring according to the recommendations of the French Society of Anesthesia-Resuscitation; a peripheral venous line; a radial or femoral arterial catheter; a central venous catheter with three lumens; a bladder catheter and a rectal thermal probe. Orotracheal intubation was performed after denitrogenation and local anesthesia of the glottis. Initial anticoagulation was provided by intravenous infusion of 300 IU/ KG unfractionated heparin weight to give an ACT (activated clotted time) greater than 400 seconds. At the end of the CPB, heparin was neutralized by administration of protamine sulphate at a rate of 1 mg per 100 units of heparin. Canulation was aorto-bicave in all our patients. The same SARNS ™ 9000 system perfusion roller console was used as well as membrane oxygenators of the MEDOS® type. The flow rate of CPB was adjusted according to charts that take into account body surface area, height and weight. The mean duration of CPB in our patients was 103.44 +/- 36.01 minutes (42-205). Mean duration of aortic cross-clamping was 73.33 +/- 28.3 minutes (17-146). Duration of assistance was specified in 80 patients (78.4%). It averaged 18.9 +/- 10.25 minutes (6-57). For 81.4% of patients, cardiac activity was resumed in a regular sinus rhythm; 2

patients (1.96%) had an atrioventricular block (AVB); 10 patients (9.8%) had ventricular fibrillation; 5 patients (4.9%) had a junctional rhythm.

RESULTS

The total enrollment of our study was 102 patients. A male predominance was noted in our series with 52 boys for 50 girls or a sex ratio of 1.04. The age of our patients ranged from 1.08 to 15 years with an average of 9.41 ± 4.2 years. The average patient weight was 26.21 ± 11.82 kg (7.6-58). The average size was 130.68 ± 25.94 cm (32-180). In our series, we noted only one incident during the CPB; it was a leak of the oxygenator by a bad connection between the oxygenator and the cooling tank.

Table-III : Complications post cardiopulmonary bypass

Complications	Values
Métabolic complications	99%
Acidosis	91,2%
Hypocalcemia	57,8%
Hyperkaliemia	12,8%
Hypokaliema	5,9%
Hypernatremia	2,9%
Hyponatremia	22,5%
Cardiovascular complications	
Left Ventricular Dysfunction	6,9%
Left Ventricular Ejection Fraction	54,68+/-11,61% (33,4-88)
Right Ventricular Dysfunction	9,8%
TAPSE	7,91+/-2,88mm (4-13)
Rythym Disorders	20,5%
Heamatological complications	
Anemia (hemoglobin level<12g/dl)	65,7%
Thrombocytopenia	9,8%
Hyperleucocytosis	63,7%
Postoperative hemorrhages	6,9%
Sternal reopening	9,8%
Pleuropulmonary complications	46,1%
Pleural effusion	18,6%
Pneumonia	13,72%
Acute respiratory distress syndrome	3,9%
Bronchopneumopathy	8,82%
Acute edema of the lung	5,9%
Bilateral hilar overload	3,9%
Kidney Complications	2,9%
Hemoglobinuria	2%
Functional acute renal failure	1%
Hepatosplanchnic complications	26,5%
Hepatic cytolysis	21,6%
Hepatic cholestasis	2%
Transit disorder	4,9%
Neurological complications	2%
Anoxic encephalopathy	1%
Untagged convulsions	1%
Systemic inflammatory response syndrome	48%

One patient died intraoperatively after sternal reopening for hemodynamic instability following tamponade. There were 3 patients (2.9%) who died in the postoperative period, a mortality of 3.9%. The postoperative mortality time was 36.33 days on average. The average length of stay in ICU was 4.38 days (0.29-30).

DISCUSSION

In Senegal, cardiopulmonary bypass is practiced mainly in the context of valvular surgery while in the United States [4] and France [5], it is increasingly used for coronary surgery. All our patients had at least one complication after CPB. This situation is consistent with that found in the Agarwal series [6], in which only 46% of patients operated on CPB

presented at least one complication. The complications we found were dominated by metabolic complications (99%), followed by haematological (86.3%), cardiovascular (57.8%), infectious (48%), pulmonary (46.1%), hepatosplanchnic (26.5%), renal (2.9%) and neurological (2%). The prevalence of patients with anemia with hemoglobin <12g / dL is 65.7% in the series and 8.1% in that of Agarwal [6]. Thrombocytopenia was reported by 9.8% of patients. This rate is relatively low compared to that found by Santos Silva [7] which is 51.8%. Hyperleukocytosis found in 67.3% of patients is related to the inflammatory syndrome that accompanies CPB [8]. Cardiovascular complications are dominated by right ventricular dysfunction (9.8%). Right ventricular systolic dysfunction is classically described in the aftermath of uncomplicated cardiac surgery. Patients with chronic pulmonary arterial hypertension or pulmonary venous hypertension secondary to left cardiac lesions are at high risk of acute right ventricular failure in the immediate postoperative period [3]. This dysfunction assessed by the TAPSE (tricuspid annular plane systolic excursion) seems to improve at a distance from the surgery. Left ventricular dysfunction and alteration of the left ventricular ejection fraction after cardiac surgery are well known [9, 10]. However, this alteration is transient; because there is recovery within 48 hours after surgery. It is found in 6.9% of the cases in the series. Its incidence is low compared to results found in other studies that are 21.4% [6]. Pulmonary complications in the study are 46.1% while they are 11% for Agarwal [6]. Pulmonary complications are attributed to the inflammatory response, ischemia-reperfusion injury [11] but they also have an infectious origin for most of our series.Many of the pulmonary complications that we find may be caused by a failure to eliminate pulmonary secretions resulting in stasis and the resulting consequences such as infection. Indeed, sternotomy and thoracotomy incisions produce pain, leading to impaired ventilatory mechanics and reduced ability to cough, breathe deeply, or eliminate secretions. After surgery, there is at least a 50% decrease in functional vital capacity, forced expiratory volume in one second, and maximal voluntary ventilation [3]. In addition, we have 10.8% pneumonia compared to 40% in the Allou study [12]. The incidence of post-CPB pneumonia varies between 2% and 22% in the literature. Prolonged postoperative intubation and ventilation makes the patient prone to develop pneumonia. Pneumonia after cardiac surgery is associated with high morbidity and mortality [3]. Acute respiratory distress syndrome (ARDS) is a rare event after CPB complicating less than 2% of cardiac surgery. It affected 3.9% of patients in the study. The mortality of patients with post-CPB ARDS is close to 50%. ARDS leads to prolonged ventilation and prolonged stay in the intensive care unit and hospital, increased morbidity, renal, neurological and infectious complications [13]. Most evidence indicates the pathogenesis of post-CPB ARDS as due to an acute inflammatory response to SCC [14]. CPB and aortic clamping result in ischemia/reperfusion injury. During warming, half of all circulating neutrophils are sequestered in the pulmonary capillaries [15].Subsequent degranulation of these neutrophils damages lung endothelial cells [16]. Complement activation also aggravates postoperative pulmonary dysfunction [15]. The use of partial sternotomies and other minimally invasive surgical techniques can accelerate the recovery of postoperative respiratory function [3]. It was found a systemic inflammatory response syndrome (SIRS) in 49 patients is 48% in our series. The influence of age in the inflammatory response, the increased susceptibility to lesions of immature organs, and the length of the extracorporeal circuit compared to the size of the patient lead to a greater susceptibility of younger patients to the detrimental effects of CPB. It should be noted that inflammatory phenomena are involved in the genesis of most of the complications that can occur after cardiopulmonary bypass. Recent and interesting data suggest that the inflammatory response during open heart surgery is at least partly related to the individual's genetic background [17]. After heart surgery, gastrointestinal complications are usually infrequent. However, they are of the order of 26.5% in the study. A relatively recent prospective study found an incidence of 0.35% [18]. In addition, this is consistent with previous data showing the incidence over the last 15 years between 0.5% and 1.5% [18, 19].The most common gastrointestinal complications after cardiac surgery are gastrointestinal bleeding, acute pancreatitis, and acute cholecystitis, perforation of the gastrointestinal tract, paralytic ileus, visceral ischemia and hepatic failure [3]. The hepato-splanchnic complication that predominates in our series is hepatic cytolysis (21.6%). It is a biological hepatic cytolysis marked by the generally isolated elevation of ASAT (aspartate aminotransferase); it is asymptomatic in most cases and this rate decreases gradually. This aspect explains the overestimation of the digestive complications of our study. The incidence of acute renal failure in the postoperative period after cardiac surgery ranges from 5% to 30% in the literature [20, 21]. It is 4.8% for Agarwal [6] and 9.6% for Sethi SK [22]. These figures contrast with those of our study in which only one patient had functional renal failure. Young children with prolonged CPB, prolonged ventilation, pump failure, sepsis, and hematologic complications were found to be more likely to have acute kidney injury [22]. The overall incidence of postoperative neurological complications ranges from 1% to 2% in low-risk patients [23]. It is consistent with ours which is 2%. Mortality in our series was 2.9%. In the literature, overall mortality after congenital cardiac surgery is less than 4% in most facilities [24, 25].

CONCLUSION

Cardiopulmonary bypass allows the replacement or correction of most cardiac and large

vessel lesions by providing tissue perfusion and oxygenation in the absence of cardiac activity. While technical developments have allowed the miniaturization of the material, the artificial surfaces used for such circuits nevertheless remain responsible for an inflammatory reaction that can lead to metabolic disorders and various organ dysfunctions. In Senegal, the practice of cardiopulmonary bypass has been a reality since October 1996. The pediatric surgical activity has become autonomous with the opening of the cardiopediatric center CUOMO in January 2017 within the university hospital center of Fann. This has diversified the offer of cardiac surgery in Senegal in recent years.

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