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Ventricular Fibrillation after Aortic Declamping During Open-Heart Surgery: Incidence and Risk Factors? Assessment in a Sub-Saharan Country

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Abstract **Original Research Article**

Ventricular fibrillation (VF) is a complete desynchronization of ventricular fibers due to multiple reentry wavelets. The aim of our study was to determine the frequency as well as the risk factors for the occurrence of VF after aortic decompression intraoperatively in cardiac surgery. This was a prospective observational study, conducted over a period of 06 months at the CHU de Fann cardiac center. All patients scheduled for cardiac surgery under extracorporeal circulation were included. Exclusion criteria were patients with incomplete preoperative and/or intraoperative data. Our study included 105 patients with a mean age of 24.5 years and a sex ratio of 0.98. All patients underwent scheduled surgery with compensated cardiac status. Intraoperatively, all patients had received general anesthesia with tracheal intubation. The mean duration of aortic clamping was 93.8 min, and half the patients received a single dose of cardioplegia. The incidence of VF after aortic reperfusion was 16.2%, with the main risk factors being valve surgery, preoperative sildenafil use, left ventricular ejection fraction < 50%, severe pulmonary hypertension with systolic pulmonary artery pressure > 80mmHg. VF is one of the most dreaded complications of cardiac surgery. Preventive treatment with amiodarone or lidocaine before releasing the aortic clamp would seem to reduce its incidence. Hence the importance of recommending this measure in our daily practice.

Keywords: Ventricular fibrillation, aortic clamp release, cardiac surgery.

INTRODUCTION

Ventricular fibrillation (VF) is defined by complete desynchronization of ventricular fibers [1] due to multiple reentry wavelets. Its electrocardiographic (ECG) manifestation is totally disorganized electrical activity with an amplitude of around 0.2 mV and a frequency of between 300 and 400 beats/min, irregularly producing anarchic oscillations of different morphology, with no identifiable T-wave or ST segment and no return to the isoelectric line. In patients undergoing cardiac surgery, 74% to 96% of ventricular fibrillation cases following aortic decompression have been detected [2]. It may be secondary to the increased reentry and automaticity induced by ischemia/reperfusion injury. Indeed, the heart undergoing surgery requiring chemical cardioplegia is exposed to both ischemia and reperfusion at several points during the operation, thus responsible for reversible and irreversible damage through vulnerability of the cardiovascular system [3].

The aim of our study was to determine the frequency and risk factors for the occurrence of ventricular fibrillation after intraoperative aortic decompression in cardiac surgery.

PATIENTS AND METHODS

This was an observational, prospective, descriptive and analytical study of patients undergoing cardiac surgery with extracorporeal circulation (ECC) at the CUOMO center of the CHNU de Fann in Senegal over a period of 06 months from 01/10/2021 to 31/03/2022.

All patients scheduled for cardiac surgery with CEC, both adult and pediatric, were included in the

study. Exclusion criteria were patients whose pre- or intraoperative work-up was incomplete or unusable. The data collection form consisted of three sections (preoperative, intraoperative and postoperative), completed by the anesthetist.

All patients included in the study benefited from a cardiology consultation with systematic ECG and TTE. They also underwent a biological workup and a cardiac surgery consultation before being referred to the pre-anaesthetic consultation. Once suitability for anesthesia had been confirmed, patients were scheduled for surgery. All patients were operated on under general anaesthesia and tracheal intubation.

On arrival in the operating room, patients were systematically monitored using an electrocardioscope, non-invasive blood pressure and peripheral oxygen saturation. In addition to this standard monitoring, patients were routinely fitted with a central venous line, arterial catheter and transoesophageal echocardiography (TEE) probe. A blood-sparing strategy was systematically implemented with tranexamic acid. Antibiotic prophylaxis was also administered to all patients.

The following parameters were assessed: Age, gender, field, preoperative treatment, preoperative clinical and paraclinical parameters, CEC priming, duration of aortic clamping, arterial gasometry before declamping, nature and number of doses of cardioplegia, per-CEC temperature and resumption of cardiac activity, treatment of VF, duration of hospitalization, evolution.

At the end of the procedure, all patients were systematically transferred to intensive care.

The following software packages were used for descriptive and analytical statistical analysis of the data and for drawing up the figures: Sphinx plus, Excel spreadsheet.

RESULTS

Descriptive Results

Over this 06-month period, 105 patients were included in our series. Mean age was 24.5 years, with extremes of 06 months and 76 years, with a slight predominance of the adult population (52.4% vs. 47.6%). Sex distribution was almost even, with a sex ratio of 0.98. Comorbidities were found in 10.47% of cases, distributed as follows: Sickle cell disease (4.7%), hypertension (3.8%), diabetes (1.9%). The frequency of patients with a history of cardiac decompensation was 20%, including 6.7% with more than two episodes. Valve surgery was the predominant surgical indication at 59%, followed by surgery for congenital heart disease at 39% (see Fig 1).

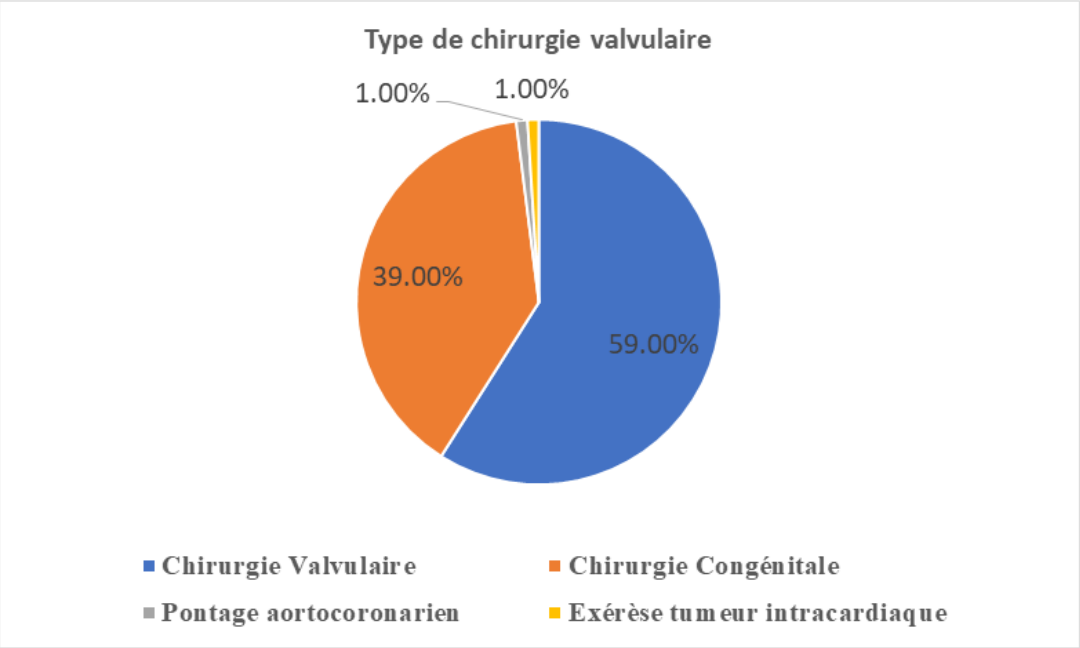

Figure 1: Distribution by type of surgery

Pre-operative phase

The majority of patients (88.6%) were on cardiac treatment, dominated by diuretics (56.2%), anti-aldosterones (47.6%) and betablockers (31.4%) (see Fig 2). Preoperative evaluation revealed:

- Clinical: hypoxia with SpO2 < 95% in 13.3% of patients (tetralogy of Fallot carriers); no patients with cardiac decompensation.
- Biology: anemia with Hb < 10g/dL in 6.7%; chronic renal impairment with GFR < 60L/min in 3.8% of patients; hepatic cytolysis with

transaminases > 2 times normal in 3.8% of cases;

- ECG: atrial fibrillation in 17.1% of cases; electrical left ventricular hypertrophy in 36.2% of patients; electrical right ventricular hypertrophy in 20% of patients;
- On transthoracic echocardiography (TTE): Three patients (2.9%) showed a drop in LVEF < 50%; No severe dysfunction of the longitudinal contracture of the VD (TAPSE > 10 mm); Severe PAH with PAPS > 80 mmHg was observed in 11.4%.

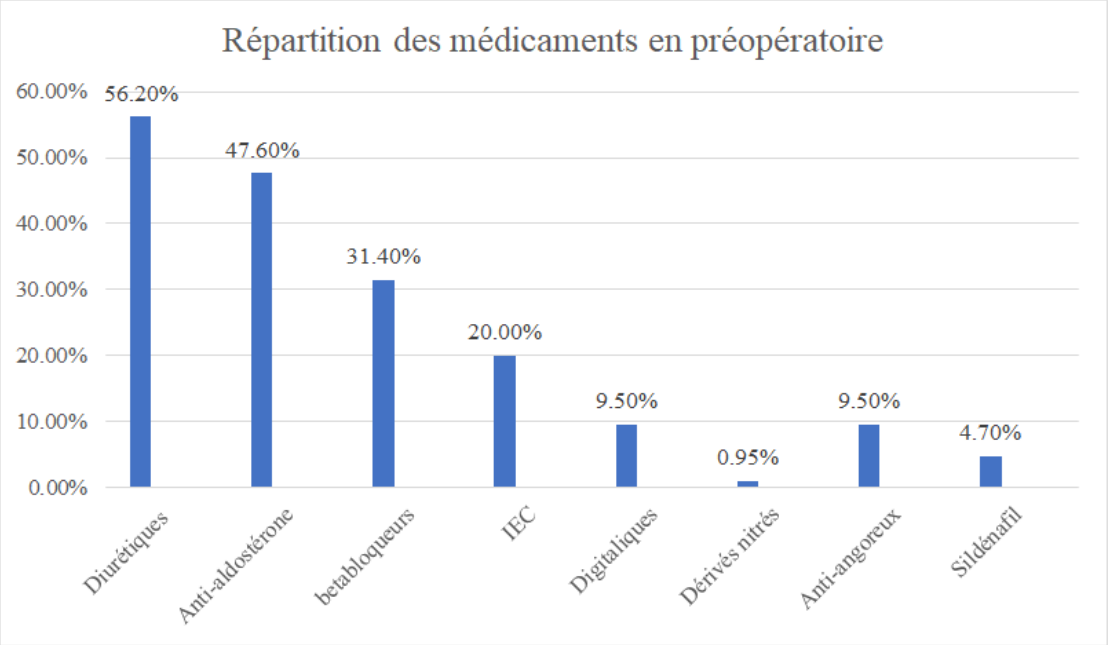

Figure 2: Preoperative drug distribution

Intraoperative phase:

All patients received general anesthesia with tracheal intubation, antibiotic prophylaxis and tranexamic acid administration. CEC priming was performed with solutes alone in 70.5% of cases, compared with 29.5% for patients receiving labile blood products. The mean duration of aortic clamping was 93.8 min +/- 52.8, with a frequency of 32.4% for patients whose duration exceeded 100 min. The rate of patients receiving a single dose of cardioplegia was 50.5%. Temperature during bypass was 34°C in the majority of cases (81.9%), while normothermia and hypothermia at 28°C accounted for 14.3% and 3.8% respectively. At the end of bypass (before release of the aortic clamp), we noted:

- Severe acidosis with ph < 7.20 in 04 patients (3.8%);
- Hypokalemia (< 3.5 mmol/L) in 12.4% of patients and hyperkalemia (> 5.5 mol/L) in 10.5% of cases;
- Hypocalcemia (ionized calcium < 1.15 mmol/L) in 26.7% and hypercalcemia (ionized calcium > 1.30 mmol/L) in 18.1% of patients;
- Hyperlactatemia (> 2 mmol/L) in 63 patients (60%).

The incidence of ventricular fibrillation (VF) after aortic reperfusion was 16.2%. It was reduced in 70.6% of cases by internal electrical cardioversion, in 5.7% by medical treatment combining lidocaine and magnesium, and 01 patient (0.9%) had received an additional dose of cardioplegia enabling a second declamping without complications. After VF reduction, the majority of patients returned to sinus rhythm (76.5%), 11.7% to full BAV requiring electro-systolic training, 5.9% to junctional rhythm and 5.9% to atrial fibrillation.

Post-opérative phase:

The average length of stay in intensive care was 4 days, with extremes of 01 and 30 days. The outcome was favorable in 98 patients (93.3%). However, there were 07 deaths, representing a mortality rate of 6.7%**.**

Analytical Results:

Preoperative data:

Age and gender did not appear to be discriminating factors in the occurrence of VF intraoperatively in cardiac surgery, with p =0.77 and p = 0.8 respectively. Patients who had undergone valve surgery were 10 times more likely to suffer from VF than patients who had undergone surgery for congenital heart disease, indicating a highly significant dependence (p=0.0029). The frequency of VF appears to be slightly increased with the use of anti-aldosterones (Odd ratio=2.30, P= 0.12). Patients on sildenafil also had a 4.3-fold greater risk of VF than those not on sildenafil, despite an insignificant association (Odd Ratio=9.21,

P=0.0064). The incidence of VF was multiplied by 4.5 in patients whose LVEF was less than 50% (Odd Ratio=0.09, p=0.016). Severe PAH with PAPS > 80 mmHg was associated with 2.8 more VF with significant dependence (p=0.0329). Preoperative LVH was associated with 1.9 times more cases of VF and the correlation was insignificant with p=0.116.

Intraoperative data:

In our series, there was an insignificant dependence on the nature of the priming of the extracorporeal circulation, with an incidence 03 times higher in the group of patients who received solutes without association of labile blood products (p= 0.079).

Ph and lactatemia, measured just before aortic unclipping by arterial gasometry, showed no association with the occurrence of VF, with p-values of 0.62 and 0.51 respectively.

The duration of aortic clamping was not a determining factor in the occurrence of VF. However, 23.5% of patients exposed to an aortic clamping time > 100 min developed VF, with a non-significant p-value of 0.157.

The nature and number of doses of cardioplegia, as well as per-CEC temperature, showed no influence on the incidence of VF, with respective p-values of 0.57; 0.17 and 0.61.

Post-operative data:

Ventricular fibrillation after aortic reperfusion did not appear to have any impact on the ICU outcome of our patients, either in terms of length of hospital stay or mortality, with p-values of 0.55 and 0.88 respectively.

DISCUSSION

The incidence of ventricular fibrillation after aortic decompression in our study was 16.2% (17 patients), irrespective of age or type of surgery. However, it was most prevalent in patients who had undergone valve surgery, i.e. 15 of the 17 patients with VF (88.2%). The prevalence in this subgroup was 24.2%, in line with the value found in the work of Mita *et al*., [4] concerning patients operated on for severe aortic valve stenosis. However, the incidence of VF in the group of patients operated on for congenital heart disease was significantly lower, at 2.4% (1/41 patients), similar to the 2.2% incidence found in this category of patients by a study carried out in our department in 2017 [5]. In contrast to our data, age (> 54-74 years) and male gender have been identified in the literature as important factors in the occurrence of VF [2, 6].

Although the dependence was only marginally significant (p=0.116), LVH was associated with 1.9 times more cases of VF in our study. Indeed, it has been reported that in cases of severely hypertrophied left ventricles, particularly aortic valve disease, persistent VF after release of the aortic clamp may ensue [7].

Among the drugs our patients were taking preoperatively, two appeared to play a role in the occurrence of VF. These were spironolactone, with a weak association (p=0.12), and sildenafil, whose dependence was highly significant (p=0.0064). However, no other scientific data described in the literature enabled us to detect this causal link.

In our study, VF was mainly treated by internal electrical cardioversion (70.6% of cases), while 5.7% of the population had received medical treatment combining lidocaine and magnesium. Only 01 patients (0.9%) had received an additional dose of cardioplegia. Furthermore, internal electrical cardioversion has been described in the literature as the method of choice in the emergency treatment of VF [4].

The duration of aortic clamping was not a determining factor in the occurrence of VF (p=0.157). This assertion has been supported in the literature by researchers such as Salah *et al*., [8], who found in their study series a 38% incidence of VF at aortic unclipping. And when stratifying their results according to aortic clamping time: a 36.4% incidence of VF correlates with a duration < 90 min, and 40% for a duration > 90 min, with a non-significant p-value of 0.71. At the same time, in our study, patients exposed to aortic clamping time > 100min (23.5%) were 1.8 times more likely to suffer VF than those exposed to clamping time < 100min.

Although the correlation is not sufficiently representative, it can be stated that the longer the duration of aortic clamping, the greater the incidence of VF, hence the value of preventive treatment of VF during intraoperative cardiac surgery.

Our patients were not treated for VF prevention. However, Samantaray *et al*., reported that the administration of 150 mg amiodarone 3 minutes before aortic declamping was superior to placebo for the prevention of VF in patients undergoing coronary artery bypass grafting [9]. Elsewhere, in the study led by Mita *et al*., the authors found that amiodarone infusion prevented VF in patients with left ventricular hypertrophy [4]. Furthermore, Ayoub *et al*., reported that the administration of lidocaine 2 minutes before aortic declamping reduced the incidence of VF compared with placebo and 150 mg amiodarone [6]. Furthermore, the work of Baraka *et al*., [2] showed that administration of a 100 mg bolus of lidocaine via the pump 2 min before aortic clamp release can significantly decrease the incidence of reperfusion VF, without increasing the incidence of atrioventricular block. In a more recent study by Yilmaz *et al*., although 300 mg amiodarone and 1.5 mg/kg lidocaine reduced the incidence of VF after aortic clamp release in patients undergoing coronary artery bypass grafting compared with placebo,

amiodarone did not show antiarrhythmic effects superior to those of lidocaine [10]. On the contrary, in another publication, Mauerman *et al*., reported that neither 300 mg amiodarone nor 1.5 mg/kg lidocaine reduced the incidence of VF in patients undergoing several types of cardiac surgery [11]. Concerning curative treatment, Tempe *et al*., concluded that administration of amiodarone into the aortic root can successfully terminate VF occurring after release of the aortic clamp. It offers an additional option for the treatment of VF, but should be reserved for situations in which conventional approaches fail [12].

In our study, after VF reduction, the majority of patients (76.5%) returned to sinus rhythm, followed by BAV (11.8%). This is in line with the literature: Tempe *et al*., have described that most of the time patients return to normal sinus rhythm, either spontaneously or after a DC shock [12]. 11.8% of patients had to undergo electro-systolic training. The development of AVB and the need for a pacemaker during open-heart surgery have also been noted in the literature [4].

The overall death rate in our study was 6.7%, or 7 patients. This is significantly higher than the data of Mita *et al*., who recorded no deaths [4].

STUDY LIMITATIONS

- A heterogeneous population: involving an adult and pediatric population with different anatomo-physiological specificities
- Several types of cardiac surgery: mainly valvular and congenital surgery
- Quality of myocardial protection in relation to surgeon expertise

CONCLUSION

Fann University Hospital's cardiac center is the only one of its kind in Senegal, with a population of 17 million, representing an alarming ratio between the scale of cardiovascular pathologies and the surgical management required. Despite this, cardiac surgery is booming in Senegal, especially with the advent of CEC, which has drastically reduced the number of patients evacuated abroad for treatment. However, this surgery is associated with non-negligible complications, including ventricular fibrillation after aortic decompression, the subject of our study. The main risk factors found in our work were: valve surgery, preoperative use of sildenafil, LVEF <50%, severe PAH with PAPS >80mmHg. Preventive treatment with amiodarone or lidocaine prior to aortic clamp release would appear to reduce its incidence. Hence the value of recommending this measure in our daily practice.

WHAT WE ALREADY KNOW ABOUT THE SUBJECT

- Ventricular fibrillation is a fairly frequent complication in cardiac surgery secondary to myocardial vulnerability caused by several ischemia/reperfusion cascades during surgery
- LVH and valvular surgery, particularly for aortic stenosis, increase the incidence of VF after release of the aortic clamp
- Administration of amiodarone and/or lidocaine successfully prevents the onset of VF intraoperatively in cardiac surgery.

WHAT THIS STUDY ADDS:

- Male gender and old age are by no means the prerogatives of the occurrence of intraoperative VF: in our study, it concerns all ages, with a slight predominance of the adult population.
- The use of spironolactone and especially sildenafil can be considered risk factors for the occurrence of intraoperative VF.

Conflicts of Interest: The authors declare no conflicts of interest.

Author Contributions: All authors have read and approved the final version of the manuscript.

LIST OF ABBREVIATIONS:

VF: ventricular fibrillation
ECC: extracorporeal circulation
ECG: electrocardiogram
TTE: transthoracic echocardiography
LVEF: left ventricular ejection fraction
PAH: pulmonary arterial hypertension
PAPS: systolic pulmonary artery pressure
LVH: left ventricular hypertrophy
RVH: right ventricular hypertrophy
RV: right ventricle
AVB: atrioventricular block
GFR: glomerular filtration rate
Hb: haemoglobin

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