

Results of the First 10 Cases of Coronary Bypass Surgery in Senegal

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How to cite this paper: Diagne, P.A., Dione, J.C.N., Ba, P.O., Diop, M.S., Ba, E.H.B., Dioum, M., Mbaye, M.S., Diop, M.S., Camara, M., Mbengue, A.L., Thiaw, A.A., Diallo, A.K., Samba, M.M., Ba, D.I.G., Sall, A.M., Salmaneba, P. and Ciss, A.G. (2024) Results of the First 10 Cases of Coronary Bypass Surgery in Senegal. *World Journal of Cardiovascular Surgery*, **14**, 45-60.

<https://doi.org/10.4236/wjcs.2024.144006>

Received: February 1, 2024

Accepted: April 27, 2024

Published: April 30, 2024

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Abstract

This is a review of the first 10 coronary artery bypass surgeries performed by the local team. The mean age was 62 years old [45 - 74]. The patients were predominantly male, with a M/F ratio of 4:1. Cardiovascular risk factors were mainly myocardial infarction (MI) (60%), hypertension (50%), obesity (40%) and diabetes (30%), with at least two risk factors per patient. Angina was the main symptom (80%). The average time from presentation to surgery was 8 months. The mean Euroscore 2 was 2.92 ± 1.65 [1.33 - 6.60]. Coronary angiography revealed an average of 2 lesions per patient, with 3-vessel involvement in 70% of cases: the Interventricular artery (IVA) (100%), the right coronary artery (90%) and the circumflex artery (70%). On echocardiography, the mean Left ventricular ejection fraction (LVEF) was 59% [33% - 76%]. All patients underwent median sternotomy with bypass grafting. The average duration of the cardiopulmonary bypass was 150 min [46 - 275 min]; that of aortic clamping, 120 min [43 - 232 min]. The grafts used were internal thoracic artery (ITA) in 100% of cases (80% on the left and 20% on the right), and the great saphenous vein (GSV) in 60% of cases (50% on the left and 10 on the right). Double bypass was performed in 60% of cases, single bypass in 30% and triple bypass in 10%. The bypasses were performed on the IVA (100%), the middle lateral of the circumflex (30%) and the bisector (20%). The average time to extubation was 11 hours and the length of stay in the intensive care unit was 7 days [03 - 17 days]. One patient had a reoperation on Day 0 post-op. The average hospital stay was 13 days [06 - 27 days]. Complications occurred in nine of the patients (90%), with a predominance of infectious and neurological complications. Overall operative mortality was 3%, all in intensive care.

Keywords

Coronary Bypass Surgery, Coronary Lesions, Cardiac Surgery, Senegal

1. Introduction

Coronary heart disease (CHD), the leading cause of cardiovascular disease, is a major public health problem, representing the leading cause of death worldwide [1]. In sub-Saharan Africa, the incidence of coronary heart disease is increasing because of improved diagnostic techniques and a rapid epidemiological transition in recent years, due to changes in lifestyle and an ageing population [2]. Surgical treatment using coronary artery bypass grafts (CABG) plays an important role in developed countries, improving patients' quality of life. It follows successful medical treatment or when interventional revascularisation is ineffective or contraindicated. In sub-Saharan Africa, coronary artery surgery is constantly evolving [3]. In Senegal, the first coronary bypass operations were carried out in 2009 during a foreign-led short term medical missions trip, and since 2019 coronary artery surgery has been an integral part of the resources available for the management of coronary disease by the local team. This is the first study of its kind, looking into the surgical management of patients with coronary artery disease in Senegal. This study will greatly contribute to improving patient management by establishing standard protocols. We present the results of the first cases to be operated.

2. Patients and Method

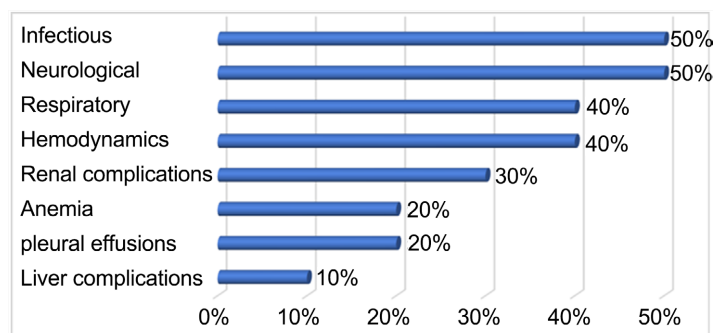
2.1. Population

Between 1 January 2019 and 31 August 2022 (44 months), 10 patients underwent myocardial revascularisation surgery under extracorporeal circulation at the thoracic and cardiovascular surgery department of the Fann National University Hospital (Dakar/Senegal) by the local team.

The mean age of the patients was 62 years [45 - 74 years], and 70% were at least 60 years old. Our series included 8 men (80%) and 2 women (20%), giving a sex ratio of 4:1 (**Table 1**). The most common cardiovascular risk factors were a history of myocardial infarction, smoking, and hypertension in half the patients, overweight (40%) and diabetes (30%) (**Figure 1**). Most patients (80%) had at least 3 cardiovascular risk factors. Two patients (20%) underwent percutaneous coronary intervention (primary angioplasty of the right coronary artery; 1 of which failed). Prevalent clinical signs were angina in eight (8) patients (80%), of whom 4 each were stage 2 and 3, followed by dyspnea in 4 patients (40%) (with NYHA stage II dyspnea in 3 patients and NYHA stage III dyspnea in 1 patient) and chest pain in 3 patients (80%). One patient had intermittent claudication of both lower limbs, with an estimated claudication distance of 100 m. On admission, all patients were stable with a mean systolic blood pressure of 127 mmHg

Table 1. Patients characteristics.

NUMBER OF PATIENTS	Patients (n = 10)
DEMOGRAPHICS	
AGE (YEARS)	
Average	62.1 ± 9.6
Mean Age n (%)	
≤50 years	2 (20%)
51 - 60 years	1 (10%)
61 - 70 years	5 (50%)
>71 years	2 (20%)
GENDER n (%)	
Female	2 (20%)
Male	8 (80%)
CLINICAL HISTORY n (%)	
SURGICAL	
Right coronary angioplasty	1 (10%)
Caesarean section	1 (10%)
Abdominal surgery	1 (10%)
Varicocele and hydrocele surgery	1 (10%)
Undocumented hysterectomy	1 (10%)
Attempted primary angioplasty of right coronary artery	1 (10%)
RISK FACTORS n (%)	
Stress	1 (10%)
Diabetes	3 (30%)
High blood pressure	5 (50%)
Smoking	5 (50%)
Myocardial infarction	6 (60%)
Menopause	0
Obesity	0
Dyslipidemia	0

**Figure 1.** Complications in intensive care.

and a mean diastolic blood pressure of 78 mmHg [56 - 106 mmHg]. Mean heart rate was 74 bpm [50 - 100 bpm]. Mean oxygen saturation was 98% [98% - 100%]. Mean weight was 76 kg [60 - 109 kg], mean height 176 cm [165 - 195 cm]

and mean body mass index 24 ± 5 kg/m² [21 - 28 kg/m²]. Cardiac auscultation revealed no murmur and the respiratory examination was normal. Examination of the great saphenous veins of both limbs was unremarkable. Chest X-rays showed cardiomegaly in half the patients, with a cardiothoracic index greater than 0.5 [0.52 - 0.55]. The resting electrocardiogram showed regular sinus rhythm in 9 patients (90%), ST changes in 5 patients (20%), left atrial hypertrophy in 3 patients (30%), ventricular hypertrophy in 2 patients (1 right and 1 left), and rhythm and conduction disorders in 2 patients (20%). Stress ECG was performed in two patients and stopped at level 3 because of clinical manifestations. Echocardiography showed a mean left ventricular ejection fraction of $59.09\% \pm 11\%$ [37% - 76%]. Only one patient (10%) had moderate to severe LV systolic dysfunction. Left ventricular filling pressures were normal in all patients. Right ventricular longitudinal function was impaired in 1 case (10%). Segmental kinetic disorders such as hypokinesia and akinesia were present in 4 patients (40%). **Table 2** shows the territories affected. The dimensions of the heart chambers showed cavitory dilatation in 6 patients (60%). There were no cases of valvulopathy. Echocardiography with dobutamine in patients with moderate to severe systolic dysfunction showed an improvement in left ventricular function of more than 20%. This demonstrates the presence of a contractile reserve.

Coronary angiography showed a total of 41 significant lesions with at least 2 main branches affected per patient. Most of these lesions were in the anterior interventricular artery in all patients (100%) with a predominance of proximal lesions, followed by the right coronary artery (90%) in segment 1, then the circumflex artery (70%) with a predominance of distal lesions. In our series, 70% of patients had 3-vessel disease, 20% had 2-vessel disease and 10% had single vessel disease. Stenotic lesions were the most common. **Table 3** shows the type and number of lesions according to the coronary artery involved.

The preoperative echocardiography showed carotid atheroma in the supra-aortic trunks in 80% of patients (of which 10% had stenosing lesions with no indication for surgery). The lung functions test showed a mixed syndrome (restrictive and obstructive) in 20% of cases. One patient (10%) presented with peripheral arterial occlusive disease of both lower limbs at stage IIA of the Leriche and Fontaine classification. The mean Euroscore 2 was 2.92 [1 - 6]; 3 patients had a significant operative risk (1 greater than 3 and 2 greater than 5). Biological tests showed a mean fasting blood glucose level of 0.94 g/L [0.86 - 1.29 g/L]. The mean total cholesterol level was 1.71 g/L [1.26 - 2.47 g/L], with hypercholesterolemia in 20% of cases. The mean LDL-cholesterol level was 1.69 g/L [0.36 - 0.83 g/L], with a level above 1.6 g/L in 02 patients (20%). Mean creatinine was 10.42 mg/L [6 - 12 mg/L]. Mean hemoglobin was 13.07 g/dl [8 - 15.4 g/dl]. Retroviral and hepatitis C virus serologies were negative in all patients. Hepatitis B virus serology was positive in 2 cases. The Emmel sickling test was positive in 2 cases, both with the Hb AS profile. ENT and dental examinations did not reveal any infectious foci.

Table 2. Disorders of cardiac kinetics depending on the affected territories.

	Hypokinesia	Akinesia
Antero-septo-basal	01	-
Antero-latero-basal	01	
Antero-median		01
Antero-septo-median	01	
Antero-latero-median	01	01
Antero-apical	02	01
Infero-septo-basal	02	-
Infero-latero-basal	-	01
Infero-septo-median	02	-
Infero-apical	01	01
Septo-apical	01	01
Apex	01	-

Table 3. Type and number of lesions according to the coronary branch affected.

	Intermediaire	Tight	Occlusion	TOTAL
Anterior interventricular artery	2	10	2	14
Right coronary	2	9	3	14
Circumflex	1	3	2	6
Marginals		3		3
Common trunk	1	1		2
Diagonals		2		2

2.2. Surgical Technique

Median sternotomy was the surgical approach for all patients. This allows adequate exposure of the mediastinum and mammary artery harvesting sites. We chose the mammary arteries because they have been established as excellent graft choices. The second stage involves harvesting the internal mammary and saphenous vein grafts. The equipment we use includes: Scalpel blades; Diathermy; Sternal saw (jigsaw/oscillating), Dubost/finochietto retractor; Farabeuf retractors; Dissecting forceps, Vascular needle holder, ordinary dissecting scissors, vascular, Metzenbaum scissors, Pullers, Wires, vessel loops, PleurEvac, defibrillator paddles, electrode cable and Clamps: aortic, vascular. Arterial cannulation was via the ascending aorta. Venous cannulation was via a 2-stage single canula and myocardial protection was achieved by the antegrade administration of the modified DEL NIDO cardioplegia solution. It is comprised of a base solution of Ringers lactate, in addition to potassium chloride, mannitol, magnesium, and lidocaine for hyperkalemic arrest, reducing myocyte edema. The left ventricular vent is achieved through the junction of the right superior pulmonary vein and the left atrium in all patients. Following the arterial graft harvest, the grafts were soaked in 20 mg/20mL of papaverine. Venous grafts were taken exclusively from

the great saphenous vein and were dilated with heparinized saline. Anastomoses to the coronary arteries were performed using two 7/0 polypropylene sutures and to the aorta using two 5/0 polypropylene sutures.

3. Results

3.1. Technique

For arterial grafts, the left internal mammary artery was used in all cases (100%) and the right internal mammary artery in 2 cases (20%); they were all skeletonised and pedicled in 8 cases out of 10. The great saphenous vein was used as a vein graft in 60% of cases, 40% of which involved the right leg. The interventricular artery (IVA) was revascularised in all patients, followed by anastomoses to the marginal arteries in 3 cases. In the series, a single distal anastomosis was performed in 30% of cases, two distal anastomoses in 60% and three distal anastomoses in 10% of cases. The average duration of bypass surgery was 150 min [46 - 275 min], and that of aortic clamping was 120 min [43 - 232 min]. The resumption of cardiac activity was sinus and regular in 70% of cases. All patients required positive inotropes at the end of the bypass procedure.

3.2. Postoperative Data

The average time to extubation was 11 hours and the length of ICU stay was 7 days [03 - 17 days]. Only one patient underwent revision surgery on the day of the operation because of a postoperative infarction that occurred 3 hours after admission to the intensive care unit. In intensive care, all patients were treated with acetylsalicylic acid (100 mg daily), beta-blockers, ACE inhibitors and heparin sodium (50 ui/kg/d). Noradrenaline was used in all patients [minimum duration 24 hours - maximum 08 days] and adrenaline in one patient. Milrinone [minimum duration 04 hours - maximum 07 days] and Dobutamine [minimum duration 24 hours - maximum 03 days] were both administered in 3 patients. Dopamine was not used in any patient.

Complications in intensive care were observed in 9 out of 10 patients. Neurological complications occurred in half of the patients, and were majorly psychomotor agitation in 3 cases, 1 case of delirium tremens and 1 case of left hemiparesis, predominantly brachiofacial.

Infectious complications were observed in 50% of cases, majorly pneumonia. The bacteria isolated on two blood culture samples were *Pseudomonas Aeruginosa* and *Enterobacter Spp*. The antibiotics most commonly used were Ceftriaxone, Imipenem, Vancomycin and Amikacin.

Electrocardiographic complications included ventricular tachycardia (3 cases) and ventricular fibrillation (1 case), and respiratory complications included acute pulmonary oedema (1 case) and respiratory distress with severe hypoxia (1 case). There were 3 cases of renal failure with oliguria. In our series, 3 patients died, all in intensive care. The causes of death were refractory cardiogenic shock in 1 case and multiple organ failure in 2 cases. Postoperative deaths had a range

of 03 to 17 days. There were no in-patient complications and no mortality. The average length of hospital admission was 13 days [06 - 27 days].

4. Discussion

In our series, the mean age of our patients was 62.10 years, like most series in the literature: Mboup *et al.* [4] 65.8 years, M. Ait Houssa *et al.* [5] 57.8 years, Thomas Cautres [6] and Hamza Tobi [7] with 67 and 64.57 years respectively. In our study, 80% of patients were male, *i.e.* M/F ratio of 4:1. This male predominance was found in the series by Mboup *et al.* [4] in Senegal, with a M/F ratio of 1.62:1, and in most series in the literature (Table 4). This male predominance could be explained by the protective effect of oestrogens in women, which disappears after the menopause. The coexistence of several risk factors in the same patient and the severity of coronary artery disease are closely linked. In our series, 70% of patients had at least 2 cardiovascular risk factors compared to an average of 1 risk factor in patients with ischaemic heart disease in Africa [8]. These results are like those of M. Ait Houssa [5], with at least 2.14 ± 1 cardiovascular risk factors. Hypertension was found in half of the patients operated on. In the INTERHEART study carried out in 52 countries worldwide, Steyn *et al.* showed that hypertension appeared to be more strongly associated with the risk of myocardial infarction in the African population than in the general population, with a 3-fold increase in the risk of MI [2]. The silent nature of systemic hypertension often means that the disease is largely under-diagnosed, under-treated and only revealed by its complications. A sedentary lifestyle was a risk factor frequently found in 60% of our patients. Diabetes increases the risk of coronary heart disease by a factor of 2 in men and 3 in women. It increases the incidence of myocardial infarction and modifies its symptomatology, with a higher frequency of pauciously symptomatic forms and silent myocardial ischaemia. It is associated with twice the risk of mortality compared with non-diabetic patients [9]. In our series, 3 patients had diabetes, and 2 died. Several data in the literature have established a link between high LDL cholesterol, low HDL cholesterol and the risk of MI [9]. In our study, none of the patients had dyslipidaemia. This disparity with the data in the literature can be explained by the fact that in our study the rate was probably underestimated because the complete lipid profile was carried out several months before surgery. Smoking is a major risk factor for coronary heart disease. In the INTERHEART study [8], smoking was the second most frequent cardiovascular risk factor found, as in our study, where it was observed in 50% of patients. Obesity was an independent risk factor for cardiovascular events, especially sudden death [9]. In our study, none of the patients was obese, but overweight was found in 40% of cases. In the series by Hamza Tobi [7] and Thomas Cautres [6], obesity was found in 14.9% and 4.5% respectively. Some studies have found that a sedentary lifestyle increases the risk of coronary events by 20% to 30% over 10 years [10]. In our series, myocardial infarction was noted in half the patients, and only 1 patient (10%) had undergone coronary angiop-

lastly, like the results of Hamza Tobi [7], Thomas Cautres [6] and F. Monassier [11], with 11.4%, 16.2% and 28.5% respectively undergoing coronary angioplasty. **Table 5** compares the different cardiovascular risk factors in the literature.

The average time until surgery was 4 months, with a maximum delay of 14 months, like the study by M. Ait Houssa [5], in which 55.8% of patients were operated on before 3 months. These longer delays compared with the pattern seen with western series are linked to a lack of public awareness, a delay in consultation, especially for patients with atypical pain, a lack of diagnostic resources and the high cost of surgery. Pain is the main symptom of coronary artery disease, and was found in 80% of our patients, who had at least stage 2 angina, in contrast to the series by Hamza Tobi [7] 8.5% and that by M. Ait Houssa [5] 34%.

Dyspnoea was found in 40% of patients, a value close to that of the series by Hamza Tobi [7] where 38.3% of patients had NYHA stage III-IV dyspnoea and that of M. Ait Houssa [5] where 33% of patients had stage 3 dyspnoea; but higher than that of Thomas Cautres [6] where only 6% of patients had NYHA stage 3 or 4 dyspnoea. Only one patient had stage IIb chronic peripheral arterial occlusive disease of the lower limbs (10%), whereas M. Ait Houssa [5], Hamza Tobi [7] and Thomas Cautres [6] found a higher rate of 44.6%, 21.3% and 44% respectively. Preoperative ECGs showed an RSR pattern in 90% of cases, like the study by Hamza Tobi [7] with 89.4% of cases. Renal failure is an often-underestimated cardiovascular risk factor. In our study, renal function was normal in all our patients, with a mean creatinine level of 10.42 mg/L, like that of M. Ait Houssa *et al.* [5] (12.08 mg/L). In cardiac surgery, diabetes increases mortality and the rate of infections, because hyperglycaemia disrupts immune defences and scarring processes. It is the most important risk factor for post-operative infection [12]. According to the study by C. Vaislic [13], keeping blood glucose levels below 2 g per litre with insulin infusion reduces mortality. According to data from the USIC 2000 study, blood glucose levels above 1.24 g/L on admission were an independent predictor of in-hospital mortality [12]. In our study, the mean preoperative fasting blood glucose level was 0.90 ± 0.39 g/dl and was elevated in only 1 case. Anemia is thought to be a poor prognostic factor because it contributes to the deterioration of cardiac function, thus aggravating dyspnea [6]. In our study, anemia was present in 2 patients.

Coronary angiography is the gold standard in determining the indication for surgery. In our study, triple vessel involvement was the most frequent and was found in 07 patients (70%). Double vessel involvement was observed in 02 patients (20%) and single vessel involvement in 01 patient (10%). Our results are essentially like those of Thomas Cautres [6] with triple vessel involvement in 67.4% and M. Ait Houssa [5] with triple vessel involvement in 75.6% of cases, double vessel involvement in 19.2% and one-vessel involvement in 5%. In contrast, the study by Hamza Tobi [7] showed double vessel involvement to be predominant in 42.6%, one-vessel in 40.4%, and triple vessel in 17%. In our study,

Table 4. Male sex distribution in literature series.

Our study	80%
Mboup <i>et al.</i> [4]	32%
M. Ait Houssa [5]	80%
Thomas Cautres [6]	79%
Hamza Tobi [7]	78%
F. Monassier [11]	76%

Table 5. Comparison of cardiovascular risk factors in the literature.

	HYPER TENSION	DIABETES	DYS LIPIDEMIA	TABAC	OBESITY
Our study	80%	30%	00%	50%	00%
Ait Houssa [5]		54.5%		59%	
Cautres [6]	69.1%	28.6%	78.13%	24.1%	4.5%
Hamza [7]	42.6%	44.7%	31.9%	48.9%	14.9%
Monassier [11]	54.4%	32.4%	62%	50.8%	
Sak [14]	48%	26%	26%	50%	

the lesions observed were mainly located on the IVA in all our patients, followed by the right coronary artery, which was involved in 90% of cases, and then the circumflex in 70% of cases. Cardiac echocardiography is a fundamental examination in the management of coronary syndromes. Dyskinesias are frequently encountered in coronary artery disease. In our study, 40% of patients presented with cardiac dyskinesias. The most frequently encountered were hypokinesia (20%) and akinesia (20%).

In our study, the mean LVEF was 59.09 +/- 11.02. A left ventricular ejection fraction of less than 50% was found in 1 patient, *i.e.* 10% of cases. These results are like those of the Hamza Tobi study [7] where the mean LVEF was 53.70 +/- 13.51 and 29.8% of patients had an LVEF of less than 50%. They are also comparable to those of Thomas Cautres [6] with a mean LVEF of 59.4% ± 13.4% before surgery. Impaired LVEF is a predictor of mortality. The reported incidence of coronary heart disease in patients with heart valve disease ranges from 7% to 48%. This incidence varies according to the associated valve disease. In our study, there were no cases of valvulopathy. Sak Lee [14] found associated aortic valve disease in 48.8% of cases and mitral valve disease in 36%. A carotid stenosis rate of more than 50% is a risk marker for postoperative ischaemic stroke, but not for mortality. In our study, 80% of patients had abnormalities, including non-stenosing atheromatous lesions in 70% of cases and stenosing lesions in 10% of cases. In the study by F. Poyet [15], the rate of stenosis greater than 50% was 9%, with a predictive value for the occurrence of stroke of 14%, compared with 2% in patients with a stenosis rate of less than 50%. In our study, 40% of patients had abnormalities in lung function in the form of bronchial obstruction reversible on beta-2 mimetics, a restrictive syndrome and a mixed syndrome.

The study showed no relationship between the mortality rate and the existence of a respiratory pathology but demonstrated that most postoperative complications were increased by 25% in patients with ventilatory disorders. The EUROSCORE 2 classification plays an important role in the morbidity and mortality of patients who have undergone coronary bypass surgery. The higher the stage, the greater the risk of postoperative complications. In our study, the mean score was 2.42 ± 1.65 . These values were much lower than in the study by Hamza Tobi [7] and M. Ait Houssa [5], where the mean was 5.87 ± 2.60 and 6.3 ± 3 respectively.

Coronary Bypass Surgery

Thanks to advances in medical imaging, operative cardiac surgery methods, the development of bypass surgery, and improvements in anaesthetic and surgical methods, coronary surgery has become a key component in the treatment of patients with coronary artery disease. Randomized studies show a clear improvement since the advent of coronary bypass surgery, with a 2% reduction in mortality.

As in most studies, the approach was a median sternotomy in the majority of cases (F. Monassier [11]), and in a few cases a mini-incision was performed (thoracotomy or subxiphoid approach).

The mean duration of bypass surgery was 150 minutes and that of aortic clamping 120 minutes, longer than those of Thomas Cautres [6] with a bypass surgery mean duration of 97.8 minutes and aortic clamping of 64.1 minutes. These longer bypass and aortic clamping times can be explained presumably by the learning curve of the local team.

Anastomoses performed with the internal thoracic artery (ITA) represented 100% of cases and those with the great saphenous vein (GSV) 50%. These data are like most studies where the internal thoracic arterial bypass is preferred (M. Ait HOUSSA [5] 100% of anastomoses with the ITA, C. Vaislic [13], 80% of bypasses were exclusively arterial, F. Monassier [11], ITA in 94.9% of cases) to revascularize the IVA territory in most cases. In 60% of cases, double bypass using ATI and VGS was performed; single bypass was performed in 30% using ITA; triple bypass was performed in 01 patient (10%) using ITA (right and left) and the GSV.

The IVA was bypassed in 100% of cases, with a predominance of the bypass site in the midline at 80%, followed by bypasses on the midlateral (2) of the Circumflex at 30%. Our values are like those of the F. Monassier study [11], with anastomoses on the IVA at 97.5%, the diagonal/bisector at 37.2% and the circumflex/marginal at 44.3%, and to the study by M. Ait Houssa [5], the IVA at 100%, the diagonal/bisector at 32% and the circumflex/marginal at 69%. In our series, in 90% of cases two distal anastomoses were performed per patient. According to Dr. F. Monassier [11], in 20.6% of cases only one distal anastomosis was performed, in 42.2% of cases two distal anastomoses were performed, in 31.9% of cases three distal anastomoses were performed, in 4.7% of cases four

distal anastomoses were performed and in 0.6% of cases five distal anastomoses were performed. In all, 36.3% of patients had three or more anastomoses. According to M. Ait Houssa [5], an average of 2.5 ± 0.7 anastomoses were performed per patient. The mean time to extubation was 11.60 hours and the mean length of stay in intensive care was 7.3 ± 5.1 days with inotropic support in 100% of cases; these data are higher than those of M. Ait Houssa [5] where the mean length of stay was 3.4 ± 4.3 days with inotropic support in 38% of cases and those of Damien Voilliot [12] with a mean length of stay in intensive care of 04 days. For F. Monassier [11], the length of stay in intensive care was less than 24 hours in 94.6% of cases, 91.9% of patients were extubated before the 24th post-operative hour and 23 patients (2.7%) required the infusion of positive inotropic substances during or immediately after the operation. These differences may be explained presumably by the learning curve of the anaesthesia and intensive care team. Only one of the 10 patients (1%) was reoperated on day 0 post-op for a postoperative myocardial ischaemic syndrome. These values differ from those of other studies such as M. Ait Houssa [5] where the rate of reoperation was 7.8%. Damien Voilliot [12] reports 07 cases of reoperation for postoperative ischaemia. The extra corporeal circulation and total aortic clamping are responsible for several complications, which significantly increase the operative risk. Bypass surgery triggers a specific diffuse inflammatory reaction which, in its complete form, can lead to a “post-pump syndrome” and multiple organ failure. Total aortic clamping, despite the administration of cardioplegia, is responsible for myocardial ischaemia, which may explain several postoperative low cardiac output states requiring the addition of positive inotropic support postoperatively. It is in this context that “beating heart coronary surgery” has been proposed as an alternative to bypass surgery. Some authors have even gone as far as to state that “eliminating bypass surgery is a necessary condition for improving the results of coronary surgery” [11]. In our study, post-operative outcome was favourable in 70% of cases. The mean length of hospital admission was 13.43 ± 6.6 days, like the study by M. Ait Houssa [5] with a mean length of hospital admission of 13.8 ± 6.8 days, but shorter than the study by Damien Voilliot [12] with a mean length of hospital admission of 04 days. Most retrospective observational studies report low in-hospital mortality. Early operative mortality is defined as mortality on the 30th postoperative day or beyond if the patient has not left the hospital after the operation. In our study, overall operative mortality was 30%. The 3 deaths occurred during the first month and in intensive care. A comparison was made with several studies, as shown in **Table 6**. We noted that the mortality rate in our study was much higher than in the literature. The lower number of patients in this new series may make the mortality estimate more imprecise. In fact, our study is compared with studies that have included a very large number of patients, enabling them to significantly reduce the confidence interval for mortality rates. This reduction in mortality goes hand in hand with the increasing recourse to angioplasty and the use of drugs for secondary prevention.

Table 6. 30-day mortality according to studies.

	30-day mortality (%)
Cautres <i>et al.</i> (2011-2012) France [6]	6.7
F.Monassier [11]	0.65
Your study (2019-2022) Dakar	30

We noted a correlation between diabetes, a high Euroscore, tripple vessel disease, renal insufficiency and systolic dysfunction of the left ventricle with an LVEF of less than 40%, which in our work were predictive factors of mortality. Patients were followed for 2 years and 8 months (32 months). Mortality beyond the first month in our study was nil. All the remaining 07 patients were followed up on an outpatient basis in our department. Our data differs from other studies in The American Journal of CARDIOLOGY [16] where mortality after the first postoperative month was 4.2% per year. For Amsterdam [16], the rate was 8.8% over 60 months.

Coronary artery bypass grafting is a complex technique because of its complications, which can be fatal. In our study, 09 patients (90%) had complications. Despite a rare incidence of 1% to 4%, mediastinitis remains the most serious complication, with a mortality rate of 20% to 25%. Risk factors include bi-mammary sampling, diabetes, obesity, repeat operations, and the duration and complexity of the operation. In our study, there was no case of mediastinitis, and the rate of infectious complications was 50%, with two bacteria found on blood cultures: *Pseudomonas Aeruginosa* and *Enterobacter Spp.* The site of infection was found in 03 cases and was essentially pulmonary in origin (75%). In the study by Damien Voilliot [12], infectious complications accounted for 28.4%, of which 5.9% were deep surgical site infections (including 2.2% mediastinitis and 3.7% sternitis) and 22.5% all other causes of infection (including 42 urinary tract infections, 104 bronchopulmonary infections, 18 sepsis of undetermined origin and 2 ENT infections). Supra ventricular arrhythmias occur with two frequency peaks, one immediately after ECG and the other between the 2nd and 5th postoperative day. The incidence of atrial fibrillation after cardiac surgery is high: 10% - 40% depending on the study [17]. In our study, 30% of patients presented with ventricular fibrillation, making it the second most common complication. In the study by F. Monassier [11] a lower rate of 12.4% was found, in contrast to the Thomas Cautres study [6] of 39.8%. Complete atrial fibrillation arrhythmia (CAFA) is the most frequently observed supraventricular rhythm disorder. In our study, CAFA was present in 01 patients (10% of cases). Other studies, such as that by Damien Voilliot [12], report a higher frequency of 23.1% of complete arrhythmias due to atrial fibrillation, and 12.4% in the study by F. Monassier [11]. These serious rhythm disorders are responsible for most of the mortality in the acute phase. Cardiogenic shock is a serious complication of myocardial infarction. Its occurrence most often reflects very extensive myocardial necrosis (>40%). The post-operative incidence of myocardial necrosis varies

on average between 2.4% and 3.4% depending on the study [18]. The mortality rate associated with this complication is 10 to 15%. In our study, cardiogenic shock was noted in 2 of our patients, *i.e.* 20% of cases. Damien Voilliot [12] found cardiogenic shock in 08 patients with a cardiovascular death rate of 1.7%. Thomas Cautres [6] found a frequency of 4 cardiogenic shocks. Their main causes are atelectasis, pneumonia, post-extracorporeal circulation, ARDS, pleural effusion, pneumothorax or pulmonary embolism. They are particularly common in patients with obstructive lung disease.

One of the specific features of coronary surgery is the risk of damage to the phrenic nerve(s), particularly during mammary sampling. In our study, 3 patients had postoperative pneumonia (30%) and 2 patients had pleurisy, one of which was minimal and recovered well with diuretics, while the other was very large and required thoracic drainage. Other studies such as that by Hutchinson *et al.* [17] report a lower frequency of cerebral embolism (0.5%). Cerebral embolisms are classified into two categories: type 1, which includes focal lesions (stroke and transient ischemic attack) and anoxic encephalopathy (coma); and type 2, which includes diffuse neuropsychological sequelae with no signs of focal lesions. The incidence of type 1 lesions is 1% to 3%, or even up to 17% in cases of combined coronary and carotid surgery [19], and their mortality rate is 21%. In most cases, they are due to embolic phenomena. Neuropsychological dysfunction is much more common (28% - 60%) but is usually reversible [17]. The major risk factors for type 1 complications are atheromatosis of the ascending aorta, previous stroke, carotid stenosis, peripheral vasculopathy, diabetes, female gender, advanced age and CAFA [17]. In our study, 50% of patients presented with type 2 neurological complications in all cases, with psychomotor agitation and spatio-temporal disorientation predominating in 3 cases. Studies by F. Monassier [11] and Thomas Cautres [6] reported stroke frequencies of 4.6% and 1.1% respectively. The study by D. Carrie (syntax) [20] found a stroke rate of 4.1%, 2.3% and 4.9% respectively for syntax scores of 0 to 22, 22 to 32 and greater than 33. Postoperative renal failure presents a spectrum of dysfunction ranging from transient elevation of creatinine levels to recourse to dialysis. The overall incidence of dialysis is 0.5% [21]. Any deterioration in renal function increases post-operative mortality. Worsening renal function is therefore an independent predictor of potentially fatal postoperative complications. In our study, 30% of patients had postoperative renal function abnormalities such as elevated creatinine levels, all of which responded well with fluid and diuretics. Other studies such as that by M. Ait Houssa [5] report lower rates of 19.5% of postoperative renal failure and 1.7% in the study by Damien Voilliot [12]. The incidence of hemorrhagic complications in coronary surgery is between 1% and 3%. The risk of this complication, apart from the hemorrhage itself, is the development of tamponade. Its incidence is only 1% to 2%. In our study, 20% of patients had anemia postoperatively, but in no case did they develop hemorrhagic shock with hemodynamic repercussions. The study by F. Monassier [11] found 10.9% he-

morrhagic complications. In contrast, the study by Thomas Cautres [6] found 02 cases of hemorrhagic shock. Gastrointestinal complications occur in approximately 2.5% of cases but are associated with a high mortality rate (33% on average, up to 70% in cases of hepatic insufficiency or bowel ischemia [17]); These were gastrointestinal hemorrhage (30%), visceral ischemia (18%), pancreatitis (11%), cholecystitis (11%) and liver failure (3.5%). In our study, only one patient (10%) had significant postoperative hepatic cytolysis, which progressed favorably.

A number of challenges had to be met before a surgical program for the management of patients suffering from pulmonary embolism could be launched and sustained. These included the acquisition of specific equipment adapted to microsurgery, and the training of paramedical staff in the various stages of surgery. Surgeons, intensivists and perfusionists have been sent to France and Belgium for skills transfer and capacity building. In the future, we plan to make other specialized adult cardiac surgery services available to patients, as well as minimally invasive coronary bypass surgery.

5. Conclusion

Coronary heart disease is an increasingly common condition in sub-Saharan Africa. Improving the management of these conditions in our developing countries requires access to coronary surgery. The development of this surgery would enable a more detailed analysis of patient profiles. This single-centre consecutive series of 10 patients demonstrates the feasibility of on-pump coronary bypass surgery in Senegal, irrespective of the area to be revascularised. Although it remains a subject of debate, on-pump myocardial revascularisation can be considered a reliable and reproducible technique in most cases. These data suggest that coronary artery disease is increasingly affecting young people in Africa, prompting greater awareness and better management of cardiovascular risk factors.

Conflicts of Interest

The authors declare that they have no competing interests.

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