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Heart Assisting Options in off Pump Coronary Surgery in Al-Najaf center for Cardiac surgery and Trans-catheter Therapy / Al-Najaf / Iraq

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Abstract

Background

Coronary artery disease has increasing frequency worldwide and considered as important cause of mortality, Off-pump coronary artery bypass grafting (OPCAB) has been shown to be a good way for surgical revascularization.

Aim of study

The aim is to find any correlation between the demographic and clinical characteristic of the patients from a side and the need for an assisted option while the patient having an OPCAB and interpretation of any possible cause factor.

Patients and Methods

A retrospective study enrolled a 168 patients who underwent an OPCAB in Al-Najaf Cardiac center in the period from the 1st of January 2015 till the 1st of December 2018. The Pre-operative demographic and clinical characteristics of the studied group were gathered to detect possible cause factors for using any OPCAB assisted option like the conversion to cardiopulmonary bypass machine, Intra-Aortic balloon pump (IABP) use or the epi-cardial pacing. Descriptive statistics used to interpret the data, Chi-squared and Fisher's exact tests used to detect the significant correlation between the dependent and the independent variables beside the bivariate correlation analysis.

Results

Smoking, arrhythmia, low left ventricular ejection fraction (EF) and left circulation dominancy were significantly associated with higher conversion rate ($P_{value}<0.005$), in other hand the use of IABP show significant association with lager body mass indices, renal impairment, arrhythmia, left main stem involvement (LMS), low EF, multi-vessel disease and left coronary circulation dominancy, while temporary pacing implantation show only correlation with age off more than 55 year. Rate of

conversion and the use of an assisted option correlated with more mortality and ICU stay time.

Conclusions

Higher conversion rate, use of IABP and pacing associated with older age, smokers, those with low EF, multi-vessel disease and LMS involvement who required planned application of pre-operative IABP. Assisted options are predictors of mortality and associated with longer ICU stay time.

Keywords

Off-Pump Coronary Artery Bypass (OPCAB) Surgery,Assisted option, On-Pump conversion, Intra-Aortic Balloon Pump (IABP), Pacing.

Introduction

Background

Coronary artery disease is the most common cardiovascular diseases, making it the most common cause of death globally, Atherosclerosis is the principle cause for it. There are a number of treatment options for coronary artery disease, as Lifestyle changes, Medical treatment, Coronary interventions as angioplasty, coronary stent and Coronary artery bypass grafting (CABG) and the Off-pump coronary artery bypass grafting (OPCAB) which has been shown to be an effective strategy for surgical revascularization [1].

Pathophysiology of Coronary Artery Atherosclerosis

Atherosclerosis is a disorder with periods of activity and quiescence, it is systemic disease manifests in a focal manner, it has genetic and environmental risk factors, that cause hardening of the arteries specifically due to an atheromatous plaque formation (fatty deposit in the intima of an artery) [2].

Atheroma which may require 10-15 years for full development, characteristically occur in regions of branching and marked curvature at areas of geometric irregularity and where blood undergoes sudden changes in velocity and direction of flow. Fluid shear stresses generated by blood flow influence the phenotype of the endothelial cells by modulation of gene expression and regulation of the activity of flow- sensitive proteins. High shear segments develop greater necrotic core, regression of fibrous and fibro fatty tissue suggesting transformation to a more vulnerable phenotype [3].

First who tried to describe the process of atherosclerosis was Rokitansky in 1851 and Virchow in 1856. The earliest pathologic lesion of atherosclerosis is the fatty streak which results from focal accumulation of serum lipoproteins within the intima engulfed by macrophages, T lymphocytes, and smooth muscle cells, it may progress to form a fibrous plaque due to migration and proliferation of smooth muscle cells (SMCs).

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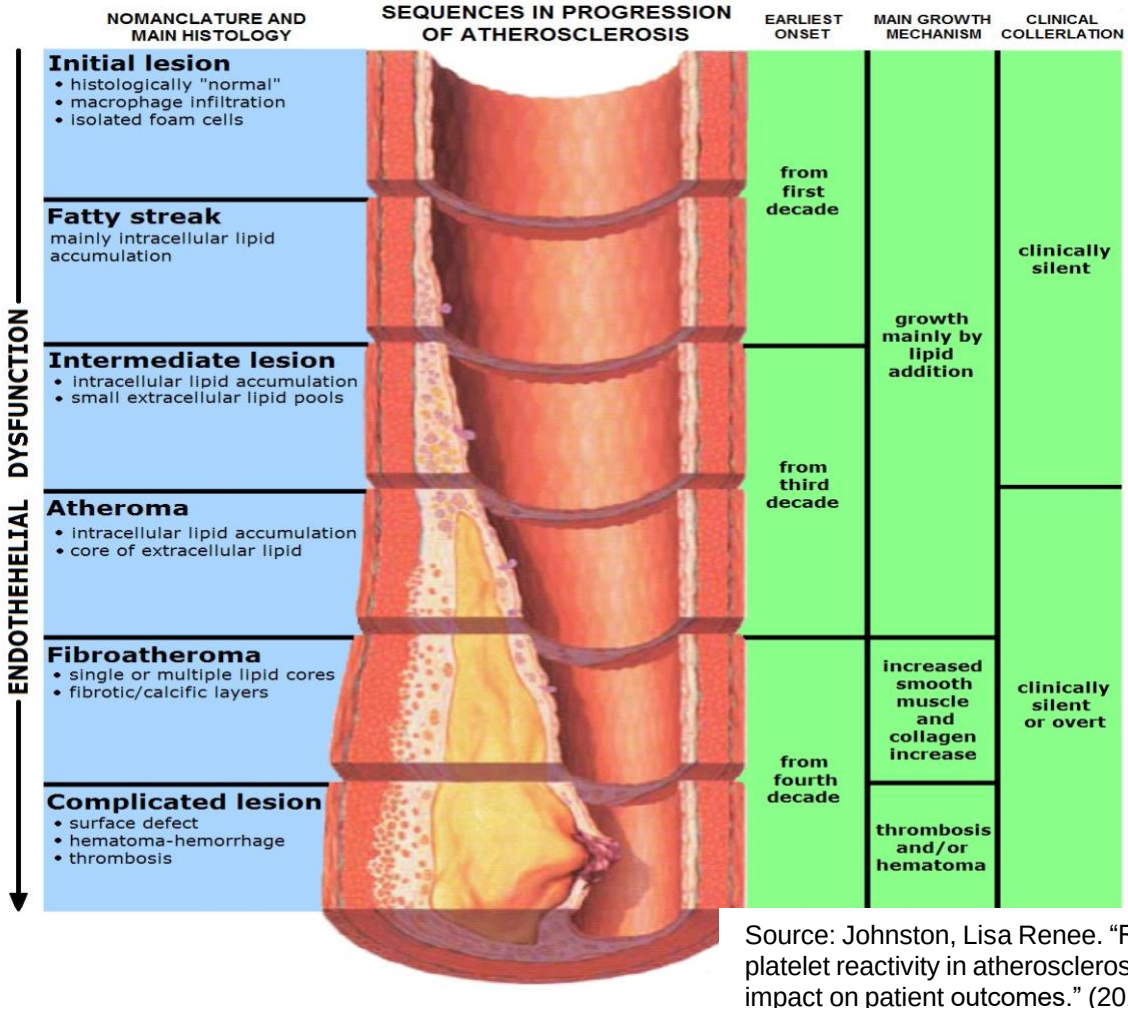
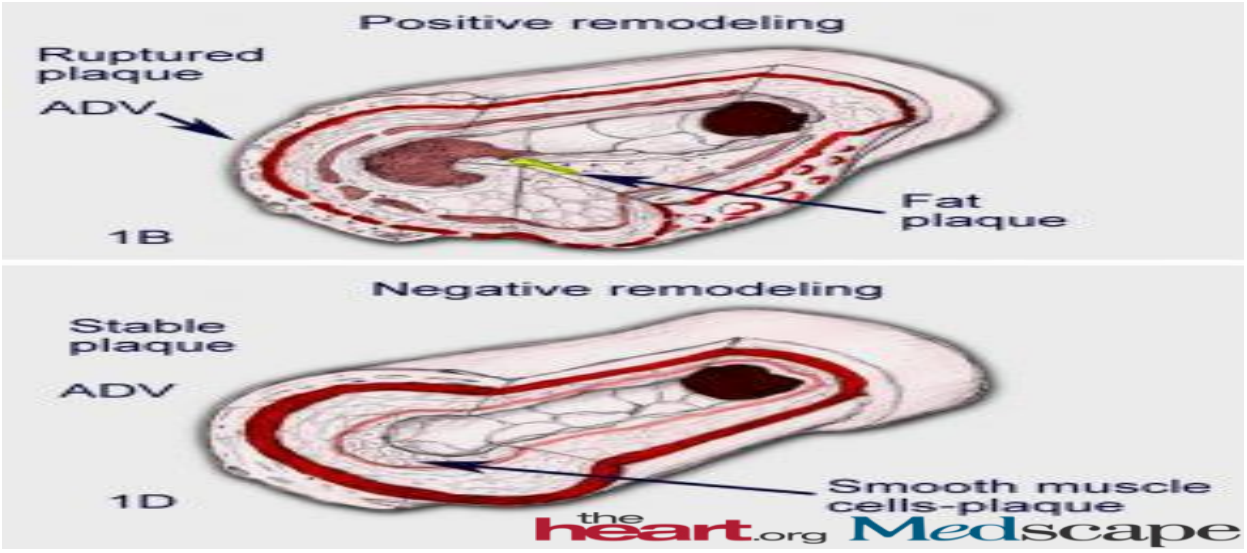
The following Figure illustrates the progression of atherosclerosis [4].



Source: Johnston, Lisa Renee. "Residual platelet reactivity in atherosclerosis and its impact on patient outcomes." (2014).

As the plaque grows, 2 types of remodeling, positive and negative remodeling occur. Positive remodeling, the fibro-fatty plaque (the Glagov phenomenon) in which the arterial wall bulges outward and the lumen remains uncompromised, encroachment must be at least 50-70% to cause flow limitation, it is more prone to result in plaque rupture and arterial occlusion. Many fewer lesions exhibit no compensatory vascular dilation, and the atheroma steadily grows inward as a fibrous plaque, causing luminal narrowing. Many of the plaques with initial positive remodeling eventually progress to the negative remodeling stage, causing narrowing of the vascular lumen. Such plaques usually lead to the development of stable angina. They are also vulnerable to plaque rupture and thrombosis. Denudation of the overlying endothelium or rupture of the protective fibrous cap may result in exposure of the thrombogenic lipid contents of the core of the plaque to the circulating blood result in thrombus formation, leads to partial or complete occlusion of the blood vessel.

The following figure illustrates the progression of atherosclerosis [5].



Risk Factors of the Coronary Artery Disease

Risk factors for atherosclerosis and coronary artery disease (CAD) were not formally established until the initial findings of the Framingham Heart Study in the early 1960s, these includes high blood pressure, smoking, diabetes, lack of exercise, depression, family history, and excessive alcohol, High blood cholesterol (specifically serum LDL), TG and lipoproteins, HDL has a protective effect. Rheumatologic diseases such as rheumatoid arthritis, systemic lupus erythematosus, psoriasis, and psoriatic arthritis are independent risk factors as well. Genetics play a significant role as the heritability of coronary artery disease has been estimated between 40% and 60%, Genome-wide association studies have identified around 60 genetic susceptibility loci for CAD. Other risk factors include endometriosis in women under the age of 40, low HB, High levels of fibrinogen and coagulation factor VII.

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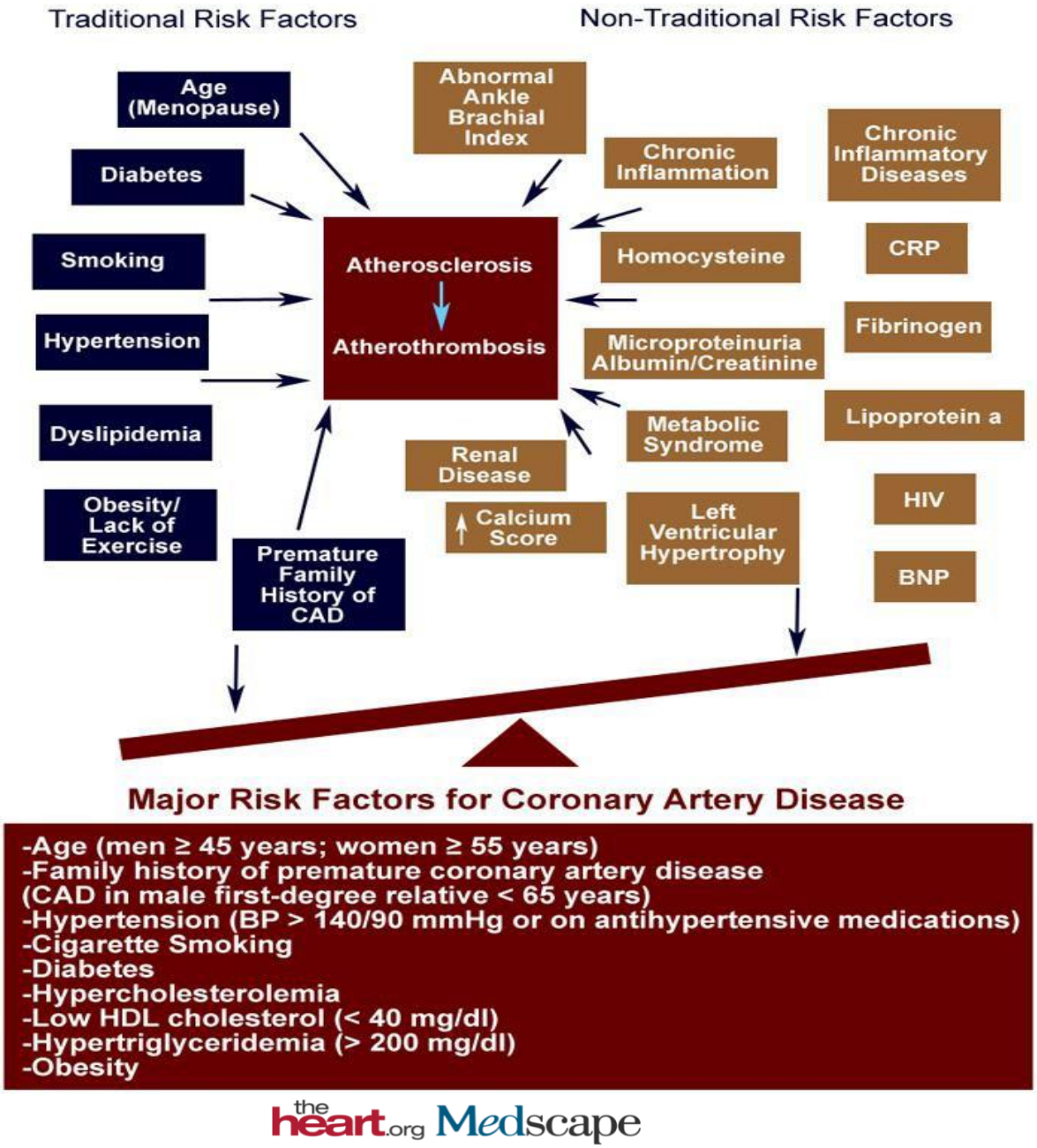
The following Figure illustrates most of the CAD risk factors [6][7]



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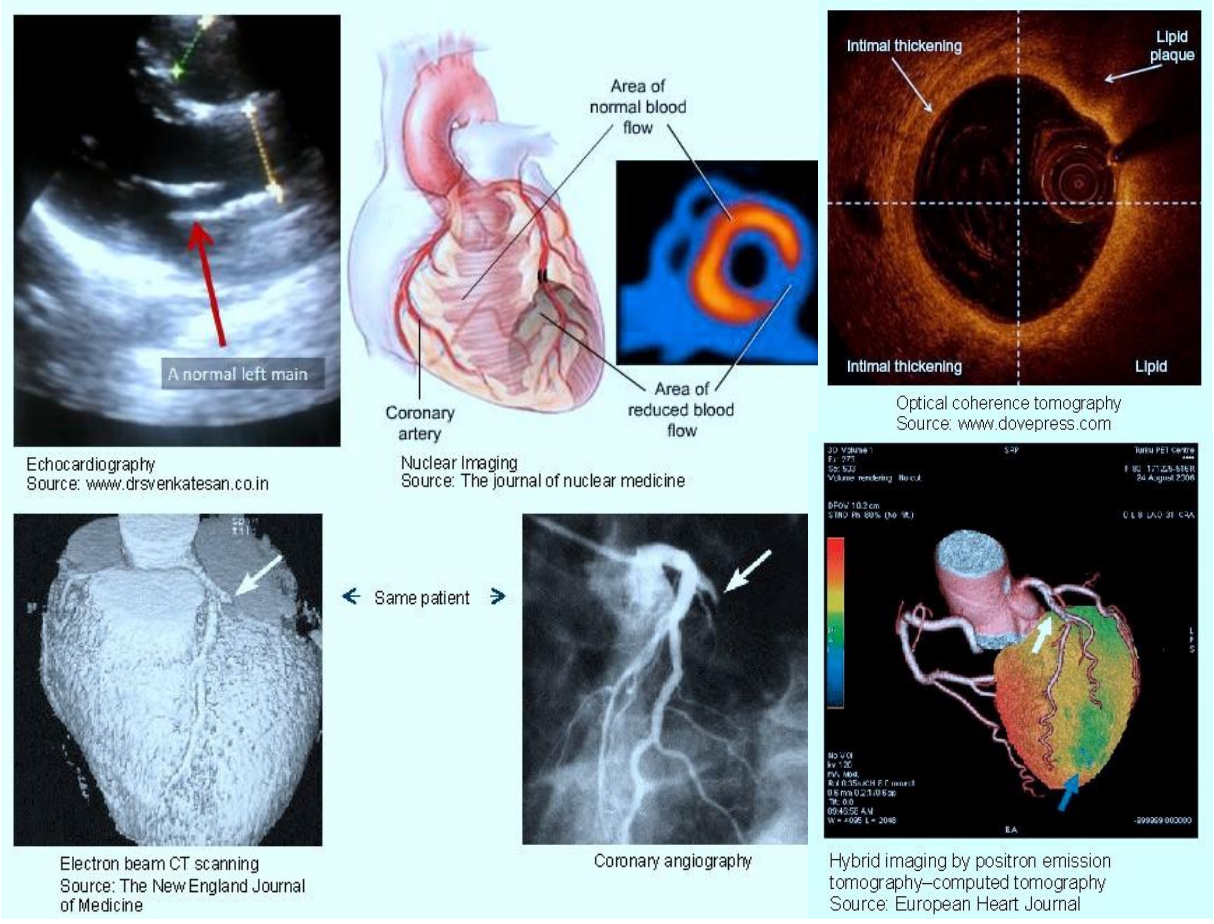
Signs and Symptoms of the Coronary Artery Disease

The signs and symptoms of coronary artery atherosclerosis includes chest pain which may radiate to the left shoulder, neck, jaw or to the back, heart burn, Shortness of breath, Weakness, tiredness, reduced exertional capacity, Dizziness, palpitations, Leg swelling, Weight gain, Diaphoresis, Stable angina pectoris, Intermittent claudication, Mesenteric angina, Tachycardia, High or low blood pressure, S3 or S4 heart sounds, Heart murmurs, Tachypnea, Xanthelasmas, Livedo reticularis, Syncope, Leg edema, Rales. Types include stable angina, unstable angina, myocardial infarction, and sudden cardiac death due to fatal arrhythmia [8].

Diagnosis of the Coronary Artery Disease

Diagnosis can be reached by laboratory tests, like Complete blood count, Chemistry panel, Lipid profile, Thyroid function tests, HbA1C measurement in patients with DM, Myocardial fractional flow reserve (FFR), Coronary flow reserve (CFR), C-reactive protein level and other Serum markers. Imaging studies can id the diagnosis like Echocardiography, Nuclear imaging, Computed tomography, Electron beam CT scanning, Optical coherence tomography imaging, Magnetic resonance imaging, Positron emission tomography, Coronary angiography, Doppler velocity probes, In the following Figure is a demonstration for some of the imaging studies [9][10].



Echocardiography
Source: www.drsvenkatesan.co.in

Nuclear Imaging
Source: The journal of nuclear medicine

Optical coherence tomography
Source: www.dovepress.com

Electron beam CT scanning
Source: The New England Journal of Medicine

Coronary angiography

Hybrid imaging by positron emission tomography–computed tomography
Source: European Heart Journal

Treatment and Prevention of the Coronary Artery Disease

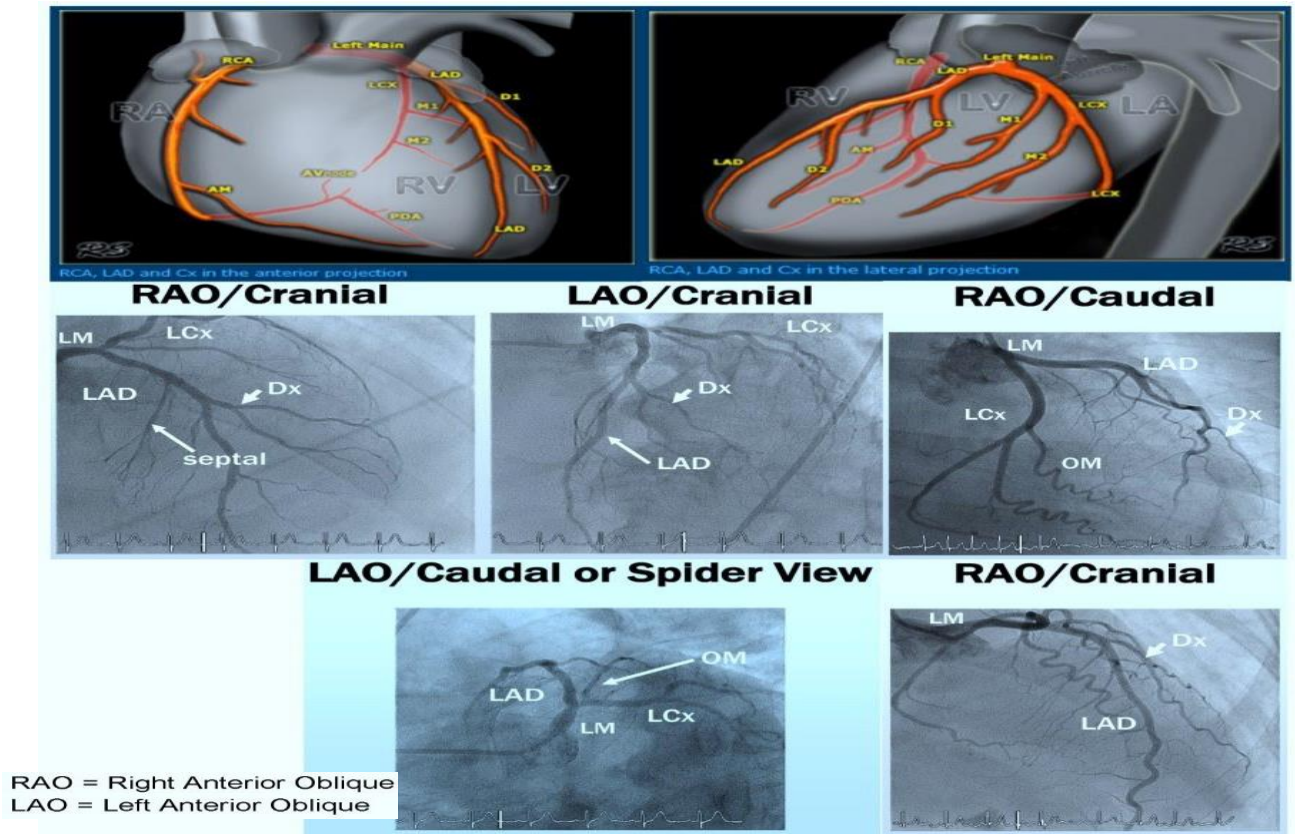
Treatment of the CAD includes lifestyle changes, Medical treatment (e.g., cholesterol lowering medications and HMG-CoA reductase inhibitors, beta-blockers, nitroglycerin, calcium channel blockers, Antiplatelet drugs, Ranolazine). Revascularization treatment procedures for CAD includes Percutaneous coronary intervention (angioplasty and coronary stent), Coronary artery bypass grafting (CABG) and Hybrid coronary revascularization [11].

Prevention of CAD can be achieved by the following, Life style changes (Weight control, healthy diet, smoking cessation, decrease psychosocial stress, exercise), Controlling DM, HT and hyperlipidemia (using of statins, partial ileal bypass surgery) [12].

Angiographic Anatomy of the Coronary Arteries

The aortic valve has three leaflets, each having a cusp, these are known as the left, right coronary cusps and posterior non-coronary cusp. Just above the aortic valves there are anatomic dilations of the ascending aorta, also known as the sinus of Valsalva. The left aortic sinus gives rise to the left coronary artery (LCA=LMS). The right aortic sinus which lies anteriorly, gives rise to the right coronary artery (RCA). The non-coronary sinus is positioned on the right side [13].

The LCA travels between the right ventricle outflow tract anteriorly and the left atrium posteriorly and divides into Left anterior descending (LAD) with its Diagonal (D1, D2, etc) and septal branches, and the Circumflex (Cx) with its Marginal branches (M1, M2) and the ramus intermedius [13][14].



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The First Coronary Angiogram

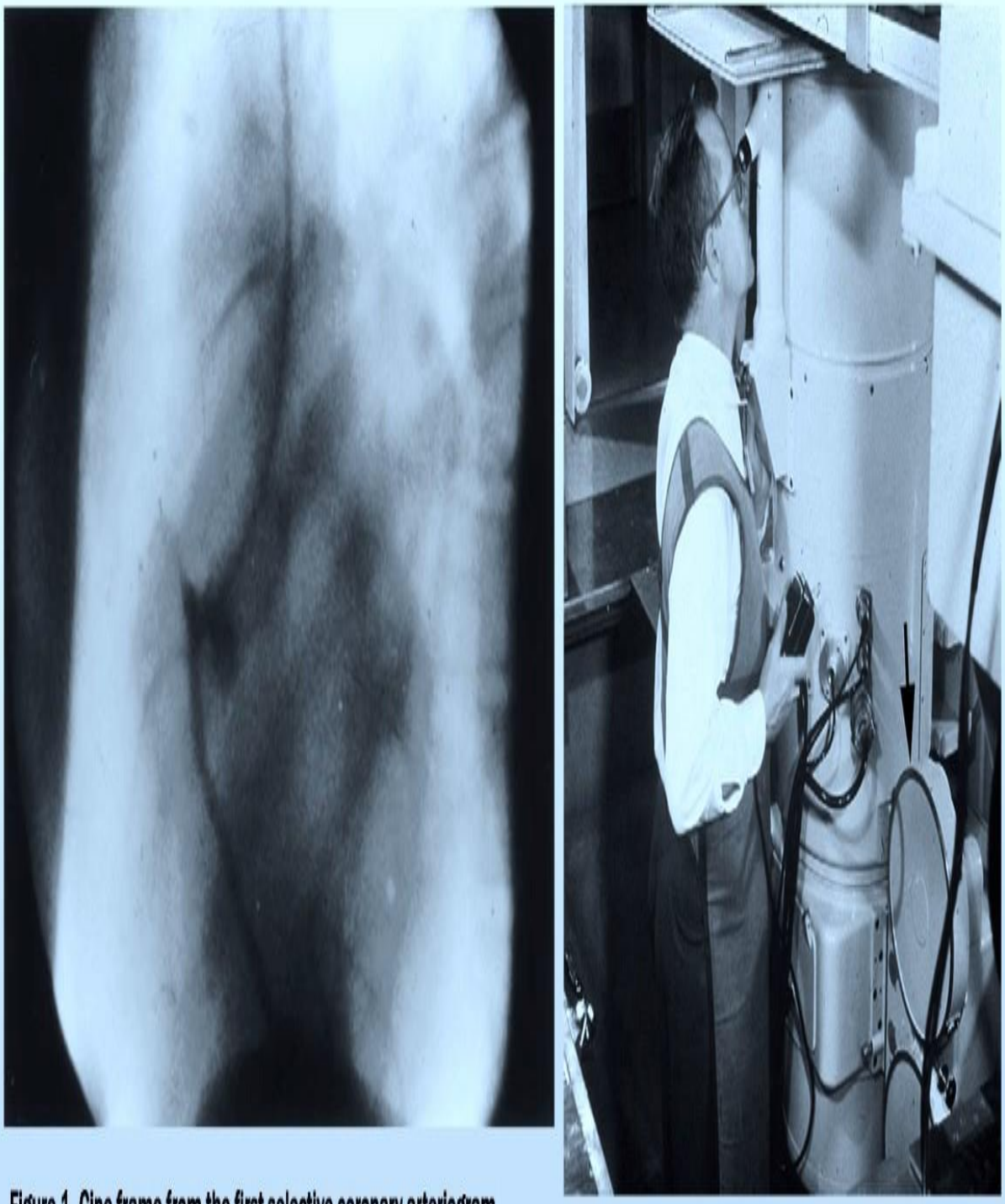
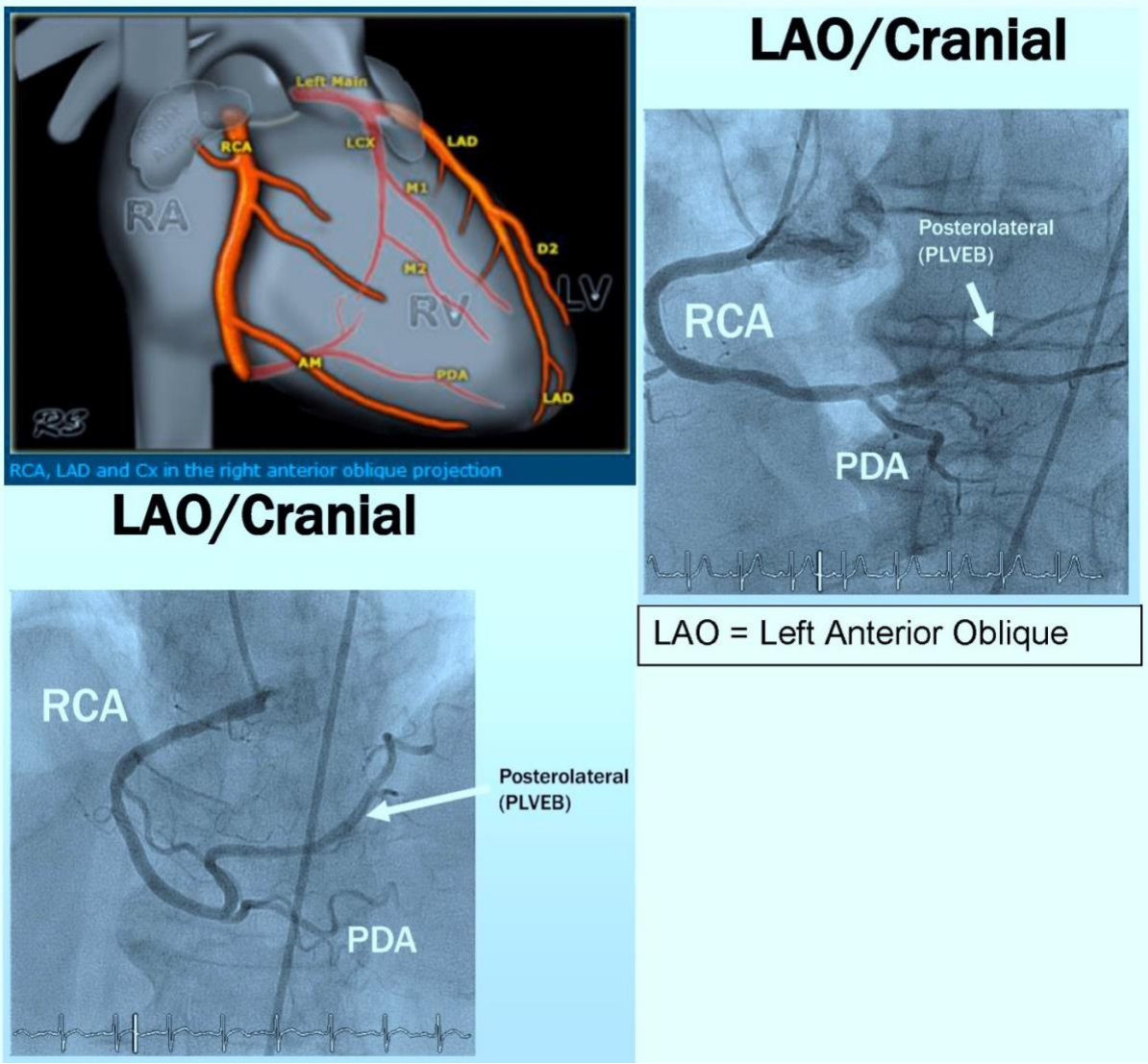


Figure 1. Cine frame from the first selective coronary arteriogram taken by F. Mason Sones, MD, on October 30, 1958.

The LAD travels in the anterior interventricular groove and continues up to the apex of the heart. The LAD supplies the anterior part of the septum with septal branches and the anterior wall of the left ventricle with diagonal branches. The LAD supplies most of the left ventricle and also the AV-bundle. The diagonal branches come off the LAD and run laterally to supply the antero-lateral wall of the left ventricle. The Cx lies in the left AV groove between the left atrium and left ventricle and supplies the vessels of the lateral wall of the left ventricle, these vessels are known as obtuse marginals (M1, M2, etc), in 10% supplies the posterior descending artery (PDA). Figure below can show the course of the LCA and its main branches [13][14]. The right coronary artery courses through the right atrioventricular groove between the right atrium and right ventricle to the inferior part of the septum. In 50-60% the first branch of the RCA is the small conus branch that supplies the right ventricle outflow tract. In 20-30% the conus branch arises directly from the aorta. In 60% a sinus node artery arises as second branch of the RCA that runs posteriorly to the SA-node (in 40% it originates from the Cx). The next branches are some diagonals that run anteriorly to supply the anterior wall of the right ventricle. The large acute marginal branch (AM) comes off with an acute angle and runs along the margin of the right ventricle above the diaphragm. The RCA continues in the AV groove posteriorly and gives off a branch to the AV node. In 65% the PDA is a branch of the RCA (right dominant circulation). The PDA supplies the inferior wall of the left ventricle and inferior part of the septum. Figure below show the course of the RCA and its main branches [14][15].


Left Main
RCA
LCX
LAD
M1
D2
M2
RA
RV
LV
AM
PDA
LAD
RCA, LAD and Cx in the right anterior oblique projection
LAO/Cranial
RCA
Posterolateral
(PLVEB)
PDA
LAO = Left Anterior Oblique
LAO/Cranial
RCA
Posterolateral
(PLVEB)
PDA

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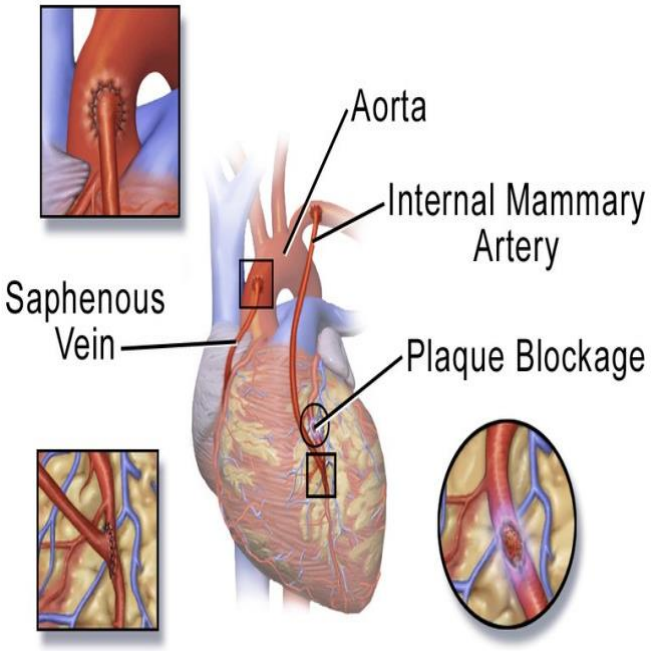
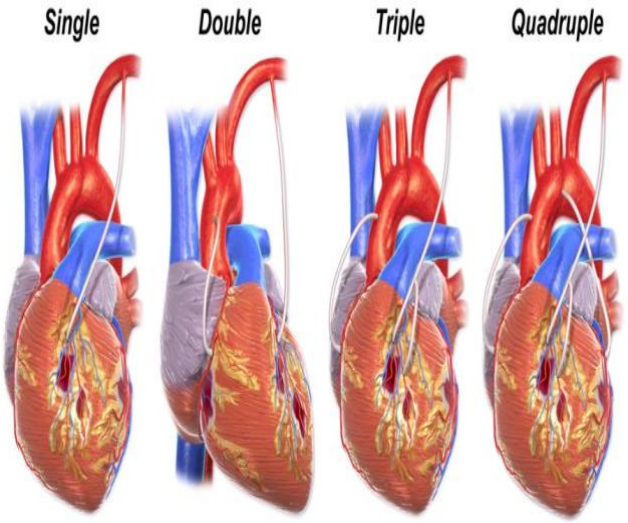
Coronary artery bypass surgery (CABG)

Is a surgical procedure to restore normal blood flow to an obstructed coronary artery, The first coronary artery bypass surgery was performed in the United States on May 2, 1960, at the Albert Einstein College of Medicine-Bronx Municipal Hospital Center by a team led by Robert H. Goetz and the thoracic surgeon, Michael Rohman with the assistance of Jordan Haller and Ronald Dee [16].

There are two main approaches. In one, the left internal mammary artery (LIMA) pedicled and anastomosed with the LAD. In the other, a great saphenous vein is removed from a leg; one end is attached to the aorta or one of its major branches, and the other end is attached to the obstructed artery immediately after the obstruction [16][17].This surgery is usually performed with non-beating heart, necessitating the usage of cardiopulmonary bypass. However, two alternative techniques are also available, allowing CABG to be performed on a beating heart either without using the cardiopulmonary bypass, a procedure referred to as "off-pump" surgery, or performing beating surgery using partial assistance of the cardiopulmonary bypass, a procedure referred to as "on-pump beating" surgery [16][17].



Single, double, triple, quadruple and quintuple bypass refer to the number of coronary arteries bypassed in the procedure (LAD, RCA, LCX, etc.). A coronary artery may be unsuitable for bypass grafting if it is small (less than 1 mm or 1.5 mm), heavily calcified, or located within the heart muscle rather than on the surface [17].



Indications of the Coronary Bypass Surgery

The bypass surgery is indicated in patients with LMS disease, all three LAD, LCX and RCA, Diffuse disease not amenable to treatment with a PCI and patients with low ejection fraction. The Bypass surgery is superior to percutaneous coronary intervention in multi-vessel coronary disease and the rates of major adverse cardiac or cerebrovascular events are lower in the former, also lower rates of death and myocardial infarction, however, patients had a higher risk of stroke events [18].

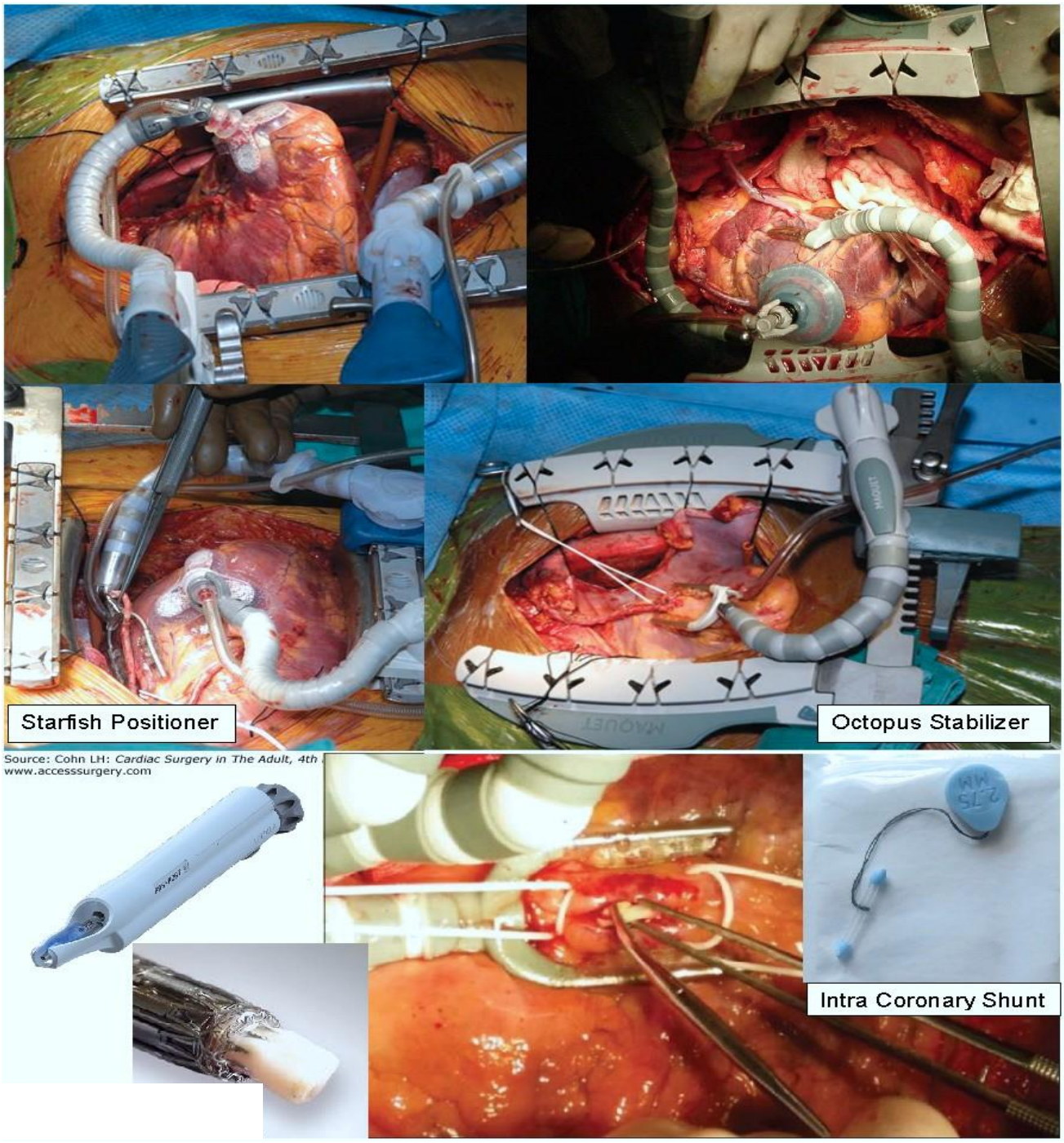
Off-Pump Coronary Artery Bypass Grafting surgery (OPCAB)

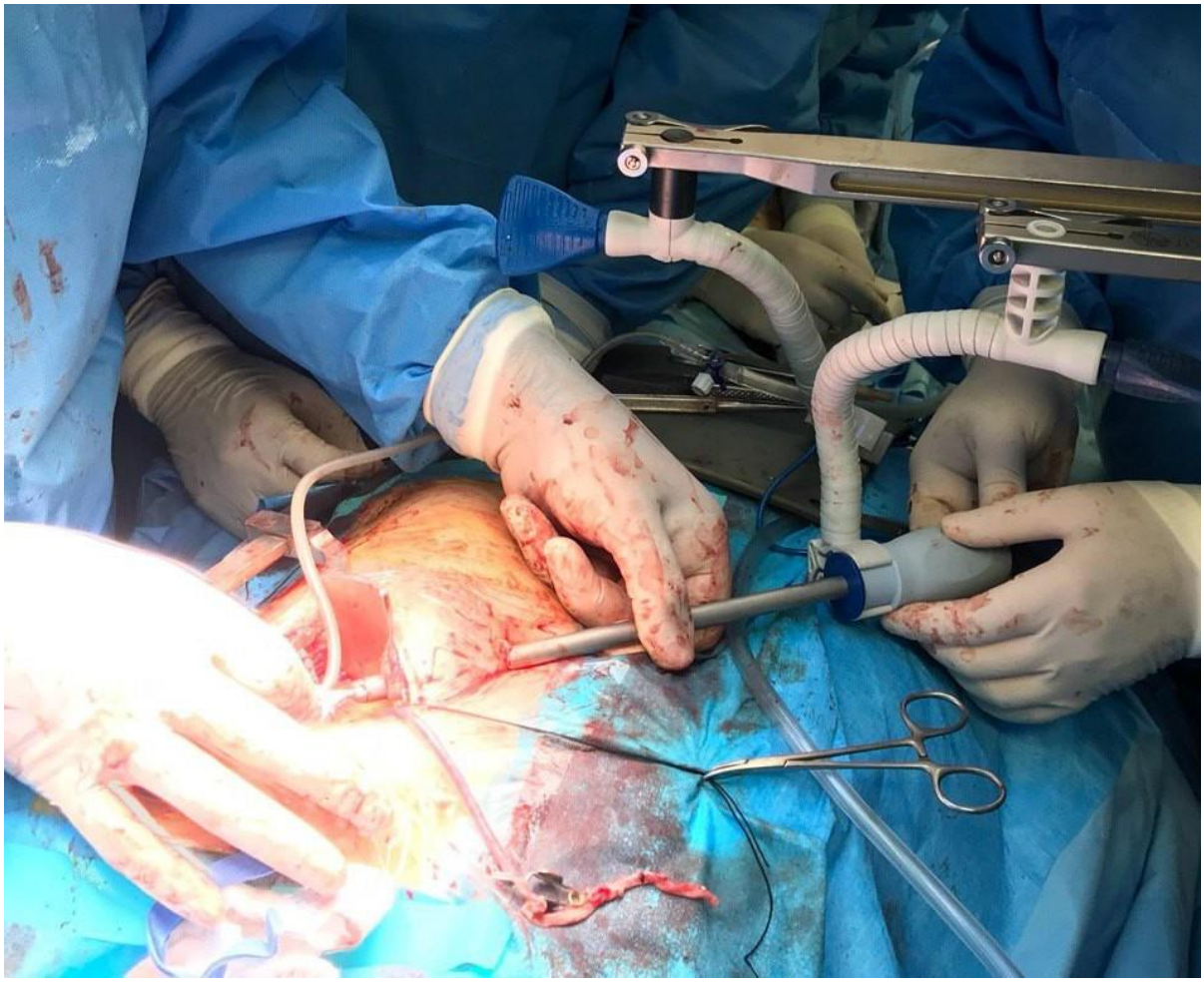
Off-Pump CABG (OPCAB) surgery is performed without cardiopulmonary bypass, It was primarily developed in the early 1990s by Dr. Amano Atsushi developed partly to avoid the complications of cardiopulmonary bypass [19].

Research has shown no long-term difference between on and off pump coronary artery bypass. Data analysis from beating heart surgery patients shows a significant lower stroke rates that bit caused by embolic process during the On-Pump surgery [20].

A growing number of OPCAB surgeons perform "anaortic" or no- touch coronary bypass surgery, by taking all their grafts from sites other than the aorta (e.g. the internal mammary arteries). OPCAB results in a very low risk of stroke, Protection from circuit related complications, avoidance of aortic and atrial cannulation, avoidance of risks of aortic cross clamping, avoidance of the effects of cardioplegia, decreased costs (less equipment, less staff), fewer blood transfusions, and fewer unwanted inflammatory / immune response issues, faster recovery and shorter hospital stay. The OPCAB also has its disadvantages, Potential for myocardial ischemia without the protection of cold cardioplegia during grafting, risk of anastomotic bleeding and suboptimal revascularization (not all the patients) [21][22][23].

The challenge in OPCAB surgery is that it can be difficult to suture on a beating heart. The surgeon must use a "stabilization" system to keep the heart steady. The stabilization system consists of a heart positioner and a tissue stabilizer. The heart positioner guides and holds the heart in a position that provides the best access to the blocked arteries. The tissue stabilizer holds a small area of the heart still while a surgeon works on it. Other techniques used are the insertion of intracoronary shunt, which provides bloodless surgical field and some degree of distal flow at the same time, and automated proximal anastomotic device. The following image show some of these techniques used in the OPCAB [24].


Starfish Positioner
Octopus Stabilizer
Source: Cohn LH: Cardiac Surgery in The Adult, 4th
www.accesssurgery.com
Intra Coronary Shunt



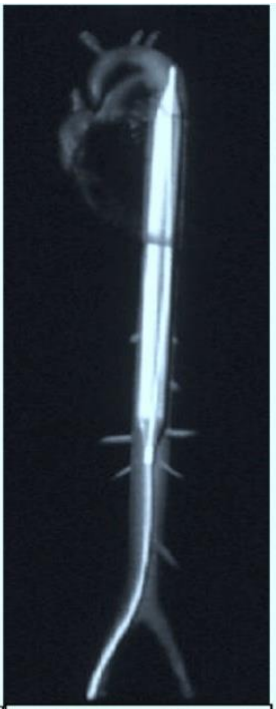
Stabilizors used in Minimal Intervention OPCAB in Al-Najaf center for Cardiac surgery

Intra-Aortic Balloon Pump (IABP)

Since its first introduction in humans in 1962 by Moulopoulos, S. Topaz and W. Kolff., Intra-Aortic Balloon Pump (IABP) is now the most commonly used therapeutic option to support failing heart in cardiac surgery, In OPCAB surgery, the most critical complication is hemodynamic deterioration, which can occur during displacement of the heart to expose the target vessels. The main effects of IABP are an increase in diastolic blood pressure and therefore an improvement in coronary perfusion and a reduction of ventricular after load, thus increasing stroke volume and cardiac output. IABP could be used preoperatively, intraoperatively, or postoperatively. IABP-related complications include limb ischemia, bleeding at the site of IABP insertion, infection, and aortic dissection [25].

Intra-aortic balloon pump, England, 1975-1980. Science Museum Collection

A modern IABP



Balloon positioned 1-2 centimeters distal to the origin of the left subclavian artery.

Temporary Pacing

In 1950, Canadian electrical engineer **John Hopps** designed and built the first external pacemaker based upon observations by cardio- thoracic surgeons at **General Hospital.** In the early postoperative period, patients may suffer from hemodynamically significant bradyarrhythmia and temporary pacing may be required to optimize cardiac function or to suppress both atrial and ventricular tachyarrhythmias [27].

Off-pump coronary artery bypass surgery in patients with depressed left ventricular function

Coronary artery bypass grafting without cardiopulmonary bypass in selected patients with severe left ventricular dysfunction is valid and safe and promotes less mortality and morbidity compared with conventional operations [26].

Aim of study

The aim is to find any correlation between the demographic and clinical characteristic of the patients from a side and the need for an assisted option while the patient having an OPCAB and interpretation of any possible cause factor.

Patients and Methods

Study Design and Setting

This was a retrospective cross sectional study was conducted in Al- Najaf center for cardiac surgery and Trans-catheter Therapy included the patients that have coronary artery disease who admitted in the period from 1st of January 2015 till the 1st of December 2018 and planned for off pump coronary bypass surgery, total number of 168 cases who met the inclusion criteria were included; patients who had a CAD with good LV function that can tolerate an off pump CABG regardless their age and gender. Patients who had coronary artery disease with severe low EF% (less than 30%) whose planned for on pump CABG were excluded from the study. Patient's records with missed data were excluded from the study also.

Data collection

the data collected from patients records including the pre-operative data (gender, age, BMI, EF%, Number of the diseased vessels, single, two or three and more vessel disease and/or LMS involvement depending on the documented coronary angiography report, coronary circulation domination whether right, left or co-dominant, associated comorbidities like diabetes, hypertension, hyperlipidemia, renal impairment, arrhythmia and smoking, the use of IABP pre-operatively. The intra-operative data (number of the grafted vessels, the need of the IABP intra-operatively, the conversion to cardiopulmonary bypass and the need for pacing). The post-operative data (ICU stay time and the fate of the patient if he survived or died).

Operational definitions of the variables

For the purpose of this study and precise data management and analysis the following definitions and categories were used; patients aged under 55 year considered as young adult, whose aged from 55-64 year consider as a middle age adult and whose aged 65 years and above consider as old (based on the Central Intelligence Agency statistics in Iraq).

Patients classified as underweight, normal, overweight and obese according to their BMI as shown in the following box[28] :

BMI < 18.5:	Below normal weight
BMI >= 18.5 and < 25:	Normal weight
BMI >= 25 and < 30:	Overweight
BMI > 30	Obese

Patients who actively smoke included in this study, while those who stop smoking for more than 1 months considered as X-smokers [32]. Ejection fraction percentage, when it is below 50% the patient considered to have LV dysfunction, patients whom had an EF more than 50% considered to have a preserved LV function (American College of Cardiology) Patients with DM are those who had impaired HbA1c, RBS or FBS readings or whom already diagnosed as having diabetes and on insulin or oral hypoglycemic agent. Patients with HT are those who had BP > 140/90 mmhg[29], or whom already diagnosed as hypertensive patients and on oral antihypertensive agent.

Patients with Hyperlipidemia are those whom had abnormally elevated levels of any or all lipids or lipoproteins in the blood [30]. Patients with renal impairment are those whom had creatinine level > 1.3 mg/dL combined with elevated Blood urea nitrogen > 21 mg/dL[31] *P P4*. Arrhythmic patients are those whom had pre-operative arrhythmia like AF or Heart block and so on. Patients considered having a single, two or three and more vessels disease when one or more of the coronary arteries involved like the LAD, LCX and RCA and so on apart from the LMS and the already stented vessels by a previous catheter intervention, While complete revascularization patients are those who had number of graft correspond to the number of their diseased vessels. Number of grafted vessels included apart from the vessels with endarterectomy procedure and the patients classified to two categories either they had a complete or incomplete revascularization. Implantation of pacemaker wires may needed if the patient develops bradycardia or a heart block.

OFF-Pump CABG Procedure Protocol

The off pump CABG patients in Al-Najaf cardiac surgery center managed in the following manner; Pre-operatively, after the patient referred from the cardiologist with a documented coronary angiography report and a documented ECHO study the patient received in the cardiac surgery consultation department to complete his workup, first the patient complete his investigations which includes; CBP, RFT, RBS, LFT, Lipid profile, Coagulation profile, TFT,GUE, Viral screen, ECG, CXR, Abdominal U.S, PFT, Doppler U.S of the lower limbs veins and other specific investigations according to the patient condition. Then the patient meet the cardiac surgeon along with the anesthetist for general and systemic examination and reviewing the previous history of the patient and his investigations and medications to assess his general condition and to discuss the possible risks, complications and outcomes and to predict the need for IABP and other assisted options and explaining the whole procedure for the patient to take his consent. After that all the oral antiplatelet discontinued and switched to subcutaneous LMWH for at least 1 week prior to admission, then the patient admitted to the ward few days before surgery for monitoring and preparation of the banked blood, blood products and blood donors. Pre-operative statin, beta-blockers and antibiotics were given. Surgical procedure; patient admitted to the theatre with standard monitoring ECG, arterial line and CVP catheter after GA and ETT insertion. In supine position the Patient prepped and draped from chin to heels with betadine. The CPB machine prepared a long with the IABP in standby. Median sternotomy with LIMA harvesting started with the same time of GSV harvesting, infusion of Heparin, then pericardiotomy to expose the heart, heart manipulation done with careful monitoring of the BP and the HR, putting a wet pack below the LV can assist in the stabilization of the heart, then localization of the diseased vessel, Octopus and star-fish stabilizers used to fix the anastomosis site, a proximal and distal snares inserted around the targeted vessel, C- shaped vascular clamp used to clamp the aorta to aid in the proximal anastomosis of the venous graft from the aortic side, then anastomosis done, secure hemostasis done before closing the sternum with steel wires, standard mediastinal drain with or without pleural drain inserted. Patient will remain in the ICU for 2 or more days to stabilize his general condition. Patients will be followed by the cardiac surgeon and the cardiologist in the days after the operation and after discharge to home.

Statistical analysis

Data of the patients were entered and analyzed using the statistical package for social sciences (SPSS) version 25, for windows. Descriptive statistics was presented as mean, standard deviation, frequencies (No.) and percentages. Patients were categorized according to the assisted options that used in their surgery into subgroups; according to conversion to on pump , categorized into two subgroups (converted and non-converted), IABP into three subgroups (pre-operative, intra or postoperative and none) and for Pacemaker use they were categorized into two subgroups (Used and not used). Regarding the fate, patients either well or died while the ICU stay categorized into two categories 2-
3 days and 4 or more days. Cross-tabulation was performed and contingency tables were conducted for each dependent variable against the demographic and clinical variables of the patients. Chi-squared test was used to assess the significance of the relationship between each dependent variable from one side and other variables from the other side, Fisher's

exact test used when chi-squared test was inapplicable. Partial bivariate correlation analysis was applied for the correlation between one dependent variable against other variables that showed significant correlation on univariate analysis the purpose of this correlation was to adjust for any confounding effect of the non-significant variables, correlation coefficient was calculated , statistically the value of correlation coefficient ranged between zero (indicates complete no correlation) and one (indicates perfect correlation), however, the value closer to one indicates the stronger correlation.

Level of significance of ≤ 0.05 was considered as significant. Finally, results were presented in tables with an explanatory paragraph for each table using Microsoft Office Word program 2010.

Results

There were 168 patients enrolled in this study with a mean age of 57.5 ± 10.1 (range: 31 - 83) years, moreover, 62 (36.9%) of the patients aged < 55 years, 51 (30.4%) aged 55 – 64 years and 55 (32.7%) aged 65 years or more. Males were the dominant; they were 132/168 (78.6%) and only 36 females (21.4%). A mean BMI was 29.3 ± 3.7 kg/m^2, moreover, only 22 patients (13.1%) had normal BMI level while the remaining patients were overweight or obese. Active smoker patients were 45 (26%), (Table1).

Table (1) Demographic Characteristics of the studied group

Variable		No.	%
Age (Year)	< 55	62	36.9
	55 – 64	51	30.4
	≥ 65	55	32.7
	Mean (SD)	57.5 (10.1)	-
Gender	Male	132	78.6
	Female	36	21.4
BMI	Normal	22	13.1
	Overweight	71	42.3
	Obese	75	44.6
	Mean (SD)	29.3 (3.7)	-
Smoking	Yes	45	26.8
	No	123	73.2
*SD: standard deviation			

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Table (2) Clinical Characteristics of the studied group (N = 168)

		No.	%
Diabetes mellitus		98	58.3
Hypertension		110	65.5
Renal impairment		18	10.7
Hyperlipidemia		56	33.3
Arrhythmia		9	5.4
Left main stem artery involvement		82	48.8
EF	35% - 49%	37	22.0
	≥ 50%	131	78.0
Number of the diseased coronary arteries	< 3	45	26.8
	Three or	123	73.2
Revascularization	Complete	133	79.2
	Incomplete	35	20.8
Coronary circulation domination	Right	146	86.9
	Left	19	11.3
	Co-dominant	3	1.8

The clinical characteristic of the studied group are shown in table (2), where 98 (58%) were diabetic, 110 (65.5%) hypertensive, 18 (10.7&) had renal impairment, 56 (33.3%) had hyperlipidemia, 9 (5.4%) had pre- operative arrhythmia, 82 (48.8%) had LMSinvolvement, 37 (22.0%) hadLow EF%, 131 (78.0%) had a good EF%, 45 (26.8%) had less than 3 vessel disease, 123 (73.2%) had three or more vessel disease, 133 (79.2%) had a complete revascularization, 35 (20.8%) had incomplete revascularization and the dominant coronary circulation was the right in majority of the patients (86.9%), Table (2). The distribution of the dependent variables revealed that 12 patients (7.1%) converted to on-Pump, 41 patients (24.4%) needed IABP insertion while pacemaker used in only 9 patients (5.4%). Regarding the ICU stay time, majority (89.1%) of the patients stayed in the ICU for 2-3 days while only 18 patients (10.9%) stayed for 4 days or more. Unfortunately 3 patients died represent a mortality rate of 1.8%, Table (3).

Thi-Qar Medical Journal (TQMJ):Vol.(26),No.(2),2023
Web Site: https://jmed.utq.edu Email: utjmed@utq.edu.iq
ISSN (Print):1992-9218

Table (3) Distribution of the dependent variables of the studied group (N= 165)

		No.	%
Conversion to on pump		12	7.1
Intra-aortic balloon pump		41	24.4
	Preoperative	22	13.1
	Intra or postoperative	19	11.3
Pacemaker		9	5.4
ICU stay time (days)*			
	2 – 3	147	89.1
	≥ 4	18	10.9
Fate	Well	165	98.2
	Died	3	1.8

* Total number 165 ; 3 patients died and were removed from calculation.

The cross tabulation of the relationship between conversion and other variables revealed that smoking, arrhythmia, EF% less than 50% and left circulation dominancy were significantly associated with higher conversion rate. In all of these comparisons, P value less than 0.05 considered statistically significant. Other variables showed no significant association, Table (4).

Thi-Qar Medical Journal (TQMJ):Vol.(26),No.(2),2023
Web Site: https://jmed.utq.edu Email: utjmed@utq.edu.iq
ISSN (Print):1992-9218

Table (4) Cross-tabulation for the relationship between conversion to on pump and other variables of the studied group (N = 168)

		Conversion to on pump				Total	P value
		Yes (n = 12)		No (n = 156)			
		No.	%	No.	%		
Age (year)	< 55	2	3.2	60	96.8	62	0.215
	55 – 64	6	11.8	45	88.2	51	
	≥ 65	4	7.3	51	92.7	55	
BMI	Normal	1	4.5	21	95.5	22	0.79
	Overweight	5	7.0	66	93.0	71	
	Obese	6	8.0	69	92.0	75	
Gender	Male	6	4.5	126	95.5	132	0.511
	Female	6	16.7	30	83.3	36	
Smoking	Yes	7	15.6	38	84.4	45	0.010
	No	5	4.1	118	95.9	123	
Diabetes mellitus	Yes	8	8.2	90	91.8	98	0.54
	No	4	5.7	66	94.3	70	
Hypertension	Yes	8	7.3	102	92.7	110	0.93
	No	4	6.9	54	93.1	58	
Renal impairment	Yes	3	16.7	15	83.3	18	0.097
	No	9	6.1	138	93.9	147	
Hyperlipidemia	Yes	5	8.9	51	91.1	56	0.53
	No	7	6.3	105	93.8	112	
Arrhythmia	Yes	3	33.3	6	66.7	9	0.002
	No	9	5.7	150	94.3	159	
Left main stem artery	Yes	7	8.5	75	91.5	82	0.49
	No	5	5.8	81	94.2	86	
EF	< 50	7	18.9	30	81.1	37	0.002
	≥ 50	5	3.8	126	96.2	131	
Number of the diseased	< 3	3	6.7	42	93.3	45	0.89
	Three or	9	7.3	114	92.7	123	
Revascularization	Complete	12	9.0	121	91.0	133	0.065
	Incomplete	0	0.0	35	100.0	35	
Domination	Left	4	21.1	15	78.9	19	0.037
	Right	8	5.5	138	94.5	146	
	Co-dominant	0	0.0	3	100.0	3	

For the relationship between IABP use and other variables, 7 variables showed significant association with IABP; Larger BMI (obese) significantly associated with higher rate of IABP use (P value = 0.049), the other significant variables was the presence of renal impairment

(P value = 0.005). Arrhythmia, LMS involvement, EF% less than 50%, three vessel disease or more and left coronary dominancy also show significant association with IABP use (P value < 0.05), while other variables had no significant association, table(5).

Table (5) Cross-tabulation for the relationship between IABP and other variables of the studied group (N = 168)

		Intra-aortic balloon pump						Total	P value
		Preoperative		Intra or postoperat		No			
		No.	%	No.	%	No.	%		
Age (year)	< 55	6	9.7	7	11.3	49	79.0	62	0.27
	55 - 64	3	5.9	9	17.6	39	76.5	51	
	≥ 65	10	18.2	6	10.9	39	70.9	55	
BMI	Normal	0	0.0	1	4.5	21	95.5	22	0.049
	Overweig	11	15.5	5	7.0	55	77.5	71	
	Obese	11	14.7	13	17.3	51	68.0	75	
Gender	Male	16	12.1	16	12.1	100	75.8	132	0.70
	Female	6	16.7	3	8.3	27	75.0	36	
Smoking	Yes	10	22.2	6	13.3	29	64.4	45	0.076
	No	12	9.8	13	10.6	98	79.7	123	
Diabetes mellitus	Yes	13	13.3	13	13.3	72	73.5	98	0.63
	No	9	12.9	6	8.6	55	78.6	70	
Hypertension	Yes	13	11.8	12	10.9	85	77.3	110	0.76
	No	9	15.5	7	12.1	42	72.4	58	
Renal impairment	Yes	3	16.7	6	33.3	9	50.0	18	0.005
	No	19	12.7	13	8.7	118	78.7	150	
Hyperlipidemia	Yes	7	12.5	1	1.8	48	85.7	56	0.19
	No	15	13.4	18	16.1	79	70.5	112	
Arrhythmia	Yes	4	44.4	2	22.2	3	33.3	9	0.010
	No	18	11.3	17	10.7	124	78.0	159	
Left main stem artery involvement	Yes	22	26.8	12	14.6	48	58.5	82	< 0.001
	No	0	0.0	7	8.1	79	91.9	86	
EF	< 50	16	43.2	9	24.3	12	32.4	37	< 0.001
	≥ 50	6	4.6	10	7.6	115	87.8	131	
Number of the diseased coronary	< 3	5	11.1	0	0.0	40	88.9	45	0.014
	Three or	17	13.8	19	15.4	87	70.7	123	
Revascularization	Complete	16	12.0	13	9.8	104	78.2	133	0.29
	Incomplet	6	17.1	6	17.1	23	65.7	35	
Coronary circulation domination	Right	18	12.3	13	8.9	115	78.8	146	0.019
	Left	4	21.1	6	31.6	9	47.4	19	
	Co-	0	0.0	0	0.0	3	100.0	3	

As shown in table (6) older patients (older than 55 year) was significantly associated with higher rate of pacemaker use (P value = 0.006), other variables showed no significant association (P value > 0.05), Table (6).

Table (6) Cross-tabulation for the relationship between Pacemaker use and demographic variables of the studied group (N = 168)

		Pacemaker used				Total	P. value
		Yes (n = 9)		No (n=159)			
		No.	%	No.	%		
Age (year)	< 55	1	1.6	61	98.4	62	0.006
	55 – 64	7	13.7	44	86.3	51	
	≥ 65	1	1.8	54	98.2	55	
BMI category	Normal	0	0.0	22	100.0	22	0.29
	Overweight	3	4.2	68	95.8	71	
	Obese	6	8.0	69	92.0	75	
Gender	Male	5	3.8	127	96.2	132	0.084
	Female	4	11.1	32	88.9	36	
Smoking	Yes	1	2.2	44	97.8	45	0.28
	No	8	6.5	115	93.5	123	
Diabetes mellitus	Yes	3	3.1	95	96.9	98	0.12
	No	6	8.6	64	91.4	70	
Hypertension	Yes	7	6.4	103	93.6	110	0.43
	No	2	3.4	56	96.6	58	
Renal impairment	Yes	1	5.6	17	94.4	18	0.97
	No	8	5.3	142	94.7	150	
Hyperlipidemia	Yes	1	1.8	55	98.2	56	0.15
	No	8	7.1	104	92.9	112	
Arrhythmia	Yes	1	11.1	8	88.9	9	0.43
	No	8	5.0	151	95.0	159	
Left main stem artery	Yes	6	7.3	76	92.7	82	0.27
	No	3	3.5	83	96.5	86	
EF	≥ 50	8	6.1	123	93.9	131	0.42
	< 50	1	2.7	36	97.3	37	
Number of the diseased	< 3	0	0.0	45	100.0	45	0.062
	Three or	9	7.3	114	92.7	123	
Revascularization	Complete	8	6.0	125	94.0	133	0.46
	Incomplete	1	2.9	34	97.1	35	
Coronary circulation domination	Right	7	4.8	139	95.2	146	0.53
	Left	2	10.5	17	89.5	19	
	Co-dominant	0	0.0	3	100.0	3	

No statistically significant relationship had been found between fate of the patients (mortality) and all other variables except arrhythmia where patients who had arrhythmia had higher mortality than those with no arrhythmia, 11.1% versus 1.3% respectively (P value = 0.030), Table (7).

Table (7) Cross-tabulation for the relationship between Fate and other variables of the studied group (N = 168)

		Fate				Total	P. value
		Died		Well			
		No.	%	No.	%		
Age (year)	< 55	0	0.0	62	100.0	62	0.33
	55 – 64	1	2.0	50	98.0	51	
	≥ 65	2	3.6	53	96.4	55	
BMI category	Normal	1	4.5	21	95.5	22	0.58
	Overweight	1	1.4	70	98.6	71	
	Obese	1	1.3	74	98.7	75	
Gender	Male	3	2.3	129	97.7	132	0.36
	Female	0	0.0	36	100.0	36	
Smoking	Yes	1	2.2	44	97.8	45	0.80
	No	2	1.6	121	98.4	123	
Diabetes mellitus	Yes	2	2.0	96	98.0	98	0.78
	No	1	1.4	69	98.6	70	
Hypertension	Yes	2	1.8	108	98.2	110	0.97
	No	1	1.7	57	98.3	58	
Renal impairment	Yes	0	0.0	18	100.0	18	0.55
	No	3	2.0	147	98.0	150	
Hyperlipidemia	Yes	1	1.8	55	98.2	56	1.00
	No	2	1.8	110	98.2	112	
Arrhythmia	Yes	1	11.1	8	88.9	9	0.030
	No	2	1.3	157	98.7	159	
Left main stem artery	Yes	1	1.2	81	98.8	82	0.59
	No	2	2.3	84	97.7	86	
EF	≥ 50	1	.8	130	99.2	131	0.06
	< 50	2	5.4	35	94.6	37	
Number of the diseased	< 3	1	2.2	44	97.8	45	0.80
	Three or more	2	1.6	121	98.4	123	
Revascularization	Complete	3	2.3	130	97.7	133	0.37
	Incomplete	0	0.0	35	100.0	35	
Coronary circulation domination	Right	2	1.4	144	98.6	146	0.47
	Left	1	5.3	18	94.7	19	
	Co-dominant	0	0.0	3	100.0	3	

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Regarding the stay time in the ICU, patients aged 55 and older were more likely to stay for longer duration of 4 days or more compared to those younger than 55 year (P value = 0.012), further more patients with arrhythmia, LMS involvement and EF% less than 50 were also needed longer ICU stay time compared to those who did not have these disorders (P value > 0.05), Table (8).

Table (8) Cross-tabulation for the relationship between ICU stay time and other variables of the studied group (N = 168)

		ICU stay time (days)				Total	P value
		2 - 3		≥ 4			
		No.	%	No.	%		
Age (year)	< 55	61	98.4	1	1.6	62	0.012
	55 – 64	42	84.0	8	16.0	50	
	≥ 65	44	83.0	9	17.0	53	
BMI category	Normal	20	95.2	1	4.8	21	0.580
	Overweight	61	87.1	9	12.9	70	
	Obese	66	89.2	8	10.8	74	
Gender	Male	117	90.7	12	9.3	129	0.210
	Female	30	83.3	6	16.7	36	
Smoking	Yes	35	79.5	9	20.5	44	0.180
	No	112	92.6	9	7.4	121	
Diabetes mellitus	Yes	84	87.5	12	12.5	96	0.439
	No	63	91.3	6	8.7	69	
Hypertension	Yes	99	91.7	9	8.3	108	0.140
	No	48	84.2	9	15.8	57	
Renal impairment	Yes	15	83.3	3	16.7	18	0.400
	No	132	89.8	15	10.2	147	
Hyperlipidemia	Yes	52	94.5	3	5.5	55	0.112
	No	95	86.4	15	13.6	110	
Arrhythmia	Yes	3	37.5	5	62.5	8	0.001
	No	144	91.7	13	8.3	157	
Left main stem artery	Yes	67	82.7	14	17.3	81	0.010
	No	80	95.2	4	4.8	84	
EF	≥ 50	123	94.6	7	5.4	130	0.001
	< 50	24	68.6	11	31.4	35	
Number of the diseased	< 3	40	90.9	4	9.1	44	0.651
	3 or more	107	88.4	14	11.6	121	
Revascularization	Complete	117	90.0	13	10.0	130	0.470
	Incomplete	30	85.7	5	14.3	35	
Coronary circulation domination	Right	131	91.0	13	9.0	144	0.460
	Left	13	72.2	5	27.8	18	
	Co-dominant	3	100.0	0	0.0	3	

Further analysis was performed using bivariate partial correlation testing to adjust for any possible confounding effect of demographic and clinical variable or the significant correlation that appeared on univariate analysis; for conversion to on-pump, smoking, arrhythmia, EF% and coronary circulation dominancy were still significantly associated after adjusting for other variables, table (9).

Table (9) Results of bivariate Partial correlation analysis for adjustment of confounders of the correlation between Conversion to on Pump and univariate significant variables (N = 168)

Adjusted for Variables	Variable to correlate		Conversion to on
Gender ,Age (year) ,BMI ,Diabetes mellitus ,Hypertension ,Renal impairment ,Hyperlipidemia ,Left main stem artery involvement ,Number of the diseased coronary arteries	Smoking	Correlation	0.272
		P. value	0.001
	Arrhythmia	Correlation	0.19
		P. value	0.017
	EF	Correlation	0.251
		P. value	0.001
	Coronary circulation domination	Correlation	0.16
		P. value	0.043

A correlation was made between the intra-operative conversion and mortality with a P value less than 0.001, table (10).

	Died	survived	total
Converted	2	10	12
Not converted	1	155	156
total	3	165	168

Another correlation was made between the ICU stay time and the usage rate of the assisted options (n = 165), P value 0.021, Table (11).

	2-3 days	≥4 days	total
used	49	11	60
Not used	98	7	105
total	147	18	165

Thi-Qar Medical Journal (TQMJ):Vol.(26),No.(2),2023
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The significantly associated variables with IABP use on univariate analysis still significantly associated after adjusting for the effect of the other variables, table (11).

Table (12) Results of Partial bivariate correlation analysis for adjustment of confounders of the correlation between Intra-aortic balloon pump and univariate significant variables (N = 168)

Adjusted variable	Independent variable		Dependent variable : Intra-aortic balloon pump
Gender ,Age (year) ,Smoking ,Diabetes mellitus, Hypertension ,Hyperlipidemia, Number of the grafted coronary vessels ,Revascularization	BMI	Correlation coefficient	0.199
		P. value	0.011
	Arrhythmia	Correlation coefficient	0.231
		P. value	0.003
	Renal impairment	Correlation coefficient	0.186
		P. value	0.039
	Left main stem artery involvement	Correlation coefficient	0.426
		P. value	0.000
	EF	Correlation coefficient	0.543
		P. value	<0.001
	Number of the diseased coronary arteries	Correlation coefficient	0.211
		P. value	0.007
	Coronary circulation domination	Correlation coefficient	0.195
		P. value	0.023

Discussion

Coronary artery disease has increasing frequency worldwide and considered as important cause of mortality, Probably this is due to increasing life span of people in the developed countries as incidence of the CAD increasing with Age [33]. This study try to find any correlation between the demographic and clinical characteristic of the patients from a side and the need for an assisted option while the patient having an OPCAB. Hence a total number of 168 patients who had CAD to whom an OPCAB was performed, the demographic characteristics regarding age, gender, BMI and smoking was in line with the epidemiological characteristics of the CAD as majority of patients aged more than 55 year, male, overweight, obese and almost one third of them were smokers. These findings agreed with that reported in previous epidemiological studies regarding risk factors of CAD. The studied group variables compared with the variables of other studied groups in different countries and different cardiac centers of patients that underwent an OPCAB. In this study average age of patients is 57.5 (SD 10.1), the lowest age 31, it was lower from what found in Shao-peng Fu et al, Tomaso Bottio et al and Louis-Mathieu Stevens et al studies were it ranged from 60 - 69 year [35][36][37]. This probably attributed to our population average age (68) compared to other countries average age [34]. This is not applied for minority of patients with early inherited causes of dyslipidemia. Male gender is highly prominent in this study 5:1 compared to other studies , where it was 4:1 in Shao-peng Fu et al and Louis-Mathieu Stevens et al, and it was around 3:1 in Hendrik M. Nathoe et al and Minoru Tabata et al studies [38][39], this may be not only related to high incidence of CAD in male but also to cultural, social and economic circumstances.

Patients BMI has a slightly higher mean (29.3 ± 3.7) from what found in many other studies, as it was 27 ± 4 Louis-Mathieu Stevens et al study, and much lower in Hendrik M. Nathoe et al study in which obesity reported in just 18 percent of the OPCAB patients, this may be attributed to food, diet and life style.

Diabetes (DM) and hypertension (HT) are the most common associated factors, reported in 58.3% and 65.5% respectively, this goes with Shao-peng Fu et al study regarding the HT (62%) but not the DM (only 25%), and goes with Minoru Tabata et al study regarding the DM (50%), while in Hendrik M. Nathoe et al study DM reported only in 6% of cases and HT in 40%, but in Louis-Mathieu Stevens et al study HT reported in 78% and DM in 38% of cases. Smokers in this study are the active one (26.8%), while in Tomaso Bottio et al and Hendrik M. Nathoe et al studies smoking reported in much lower percentage (8% and 10% respectively), in other hand smoking reported in about 60% of cases in Shao-peng Fu et al and Louis-Mathieu Stevens et al studies, this may be attributed to the lack of rules that prohibit smoking. Most patients in this study has 3VD (three vessel disease) or more (73.2%) and this goes with Shao-peng Fu et al study (79%), but not with Tomaso Bottio et al and Hendrik M. Nathoe et al studies (21% and 14% respectively), while in Louis-Mathieu Stevens et al study more than 55% of patients had 3VD. LMS disease reported in 48.8% of cases, this not goes with the other studies that mentioned previously as it was just 14% in Tomaso Bottio et al study, and around 27% in Louis-Mathieu Stevens et al and Minoru Tabata et al studies, probably

due to doing PCI for many cases of LMS in other centers. In addition, the right coronary circulation was dominant in this study and this is compatible with the anatomical variation of the general population and among the CAD patients.

Regarding the LV ejection fraction (EF), 22% of the studied patients has LV dysfunction (EF% less than 50) with lowest EF of 36%, this not goes with many studies that enrolled in their studies an EF% of 25 and above (Tomaso Bottio et al study), this may be due to better technical and anesthetic resources, however in Hendrik M. Nathoe et al study they mentioned that a 77% of the studied group had normal LV function and about 70% in Louis-Mathieu Stevens et al study also had an acceptable EF (≥50%). Regarding the renal function status of the studied group, 10.7% of them had some sort of renal impairment that require more attention during the peri-operative period (none of them had chronic renal failure with hemodialysis), approximately the same percentages reported by Tomaso Bottio et al and Minoru Tabata et al studies (13% and 11% respectively) but not the same of Shao-peng Fu et al study (only 2%). Hyperlipidemia reported in 33%, same percentage reported by Shao- peng Fu et al, but lower from Minoru Tabata et al percentage (51%), while hypercholesteremia reported in 48% of Hendrik M. Nathoe et al cases and Tomaso Bottio et al report 16% of dyslipidemia in their cases. Percentage of patient that had arrhythmia was differ among all the studies that mentioned above including our study which reports 5.4%, while in Shao-peng Fu et al study (8%), Tomaso Bottio et al study (3.7%) and 2.5% in Louis-Mathieu Stevens et al study. In Tomaso Bottio et al and another study conducted by Robertson M.W. et al [40], around 80% of full revascularization was reported compared to 79.2% in this study, other studies in developed countries reported 90% and more, probably due to better experience and equipment. Smoking, arrhythmia, EF% less than 50% and left circulation dominancy were significantly associated with higher conversion rate (7%) (Pvalue less than 0.005), despite that other variables does not show significant association, age more than 55, larger BMI and females along with diabetic, hypertensive patients, hyperlipidemic patients and those who had renal impairment, multivessel disease and LMS stenosis still show higher percentages. The above mentioned findings are comparable with Minoru Tabata et al study (rate of conversion was 2.3%). In Louis-Mathieu Stevens et al study (conversion rate 7.9%), arrhythmia, multivessel disease and older ages were predictors for conversion. In addition simultaneous PDA and OM grafts also associated with high rate of conversion (surgeon experience) this goes with many other studies [41][42].

The above mentioned facts also applied for the intra operative use of IABP, as if no response the patient converted to the cardiopulmonary bypass machine. In this study IABP use (preoperatively in 13% of cases and 11% intraoperative) significantly associated with larger BMI, presence of impaired renal function, arrhythmia, low EF, multi diseased vessels, left coronary circulation domination and involvement of the LMS. LMS stenosis in this study involved the insertion of IABP pre- operatively in 26% of patients and 14% intra-operatively and considered as planned procedure in the LMS patients, it is mainly the surgeon/anesthetist decision and most of the papers mentioned that the use of IABP is based on low cardiac output state or ST segment changes. In Louis-Mathieu Stevens et al and Minoru Tabata et al (preoperatively in 6% of cases and 0.5% intraoperative) studies, they mentioned that most of the converted group needed placement of IABP.

In this study temporary pacing used only in 5.4% of cases and it is significantly associated with age more than 55 year, compared to 16.7% in Puskas John et al study [43], which show significant association with female sex but show higher percentage in older patient, hypertensive and multidiseased vessel patients. In other hand this study also show higher percentage of pacing in larger BMI patients, females, hypertensive, arrhythmic patients, multivessel diseased patients and the LMS stenotic patients.

As the mortality rate was too low in this study (1.8%), it show no significant correlation with any of the dependent variables, but still older patients, male gender, diabetic, smokers, arrhythmic patients and those who had low EF are the susceptible group. The study also show significant correlation between mortality and the conversion to on-pump (table10), also show that the patients who had assisted option tend to stay more days in the ICU (table11). The above mentioned facts also mentioned in the previously discussed studies

Conclusion

Higher conversion rate was associated with older age patients, Smokers, those with low Ejection fraction and who had left coronary circulation domination. IABP is an important assistant option intra-operatively in patients with three vessel disease or more and low EF%. Cases of LMS require a planned application of pre-operative IABP. On pump conversion is significantly related to the number of diseased vessels and low EF%. Pacemaker use is mostly needed in the older patients group. Shorter duration of hospital stay is associated with less use of assisted options. Intra-operative conversion is significant predictor of mortality. Low mortality rate reported in off-pump procedure applied in Al-Najaf center.

Recommendations

Surgical revascularization of the patients with severe low EF% was considered as exclusion criteria of our patients surgical pool and this necessitate more future surgical and anesthetic training to include those category. The pre-operative planned use of IABP to include those patients with low EF% to avoid unplanned intra-operative use of IABP.

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