

# CARDIO-VASCULAR SYSTEM

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PBL 

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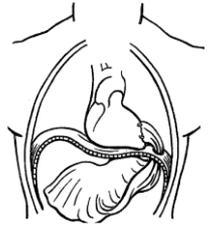
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## History of cardiac surgeries [related to ischemic heart diseases]:

Heart surgeries started to proceed quite recently, just in the middle of the last century. Let's take a ramble between the ages to view part of these surgeries journey, shall we?



- Starting in **1930's**-**Claude Beck** sought to increase myocardial blood flow indirectly by augmenting the heart with pericardial fat and omentum; a procedure that is forbidden nowadays. (*indirect revascularization*)
- Later in the **1940's**- **Arthur Vineberg** had done mobilization of the left internal mammary artery by implanting the bleeding end directly into the muscle of the left ventricle trying to create an *indirect* anastomosis. **Blood loss** is one of the major complications after such an implantation.

*Extra: The idea here is that the myocardium contains relatively large venous sinusoids that would absorb the flow from the bleeding mammary vessels.*

- **Vineberg's** first *direct* anastomosis between grafts & coronary arteries was in **1964**. In a follow-up study on 140 patients, the trial indicated **33%** mortality indications & **85%** successful *angina* relief.

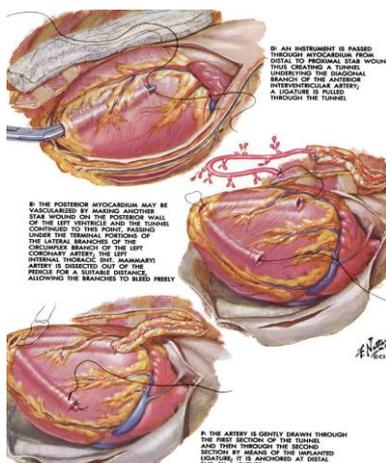
- In May 6, **1953**-**John H. Gibbon, Jr.** performed an ASD [**atrial septal defect**] closure with the first usage of the **heart-lung bypass machine** (known as the **cardiopulmonary bypass machine**). This invention lead to a huge progression in adult cardiac surgeries.

*Additional: The heart-lung machine takes over the function of the heart and lungs during surgery, maintaining the circulation of blood and the oxygen content of the patient's body.*

### Left internal mammary artery

- Russia recorded the first confirmed case of **LIMA-LAD** *direct* anastomosis in **1964** by a surgeon called **Kolesov**. *In other words, he performed the first mammary artery–coronary artery bypass, grafting the left mammary artery to the left anterior descending artery without the use of cardiopulmonary bypass.* However, the Americans claimed that **David C. Sabiston, Jr.** performed the first **aortocoronary saphenous vein** bypass grafting procedure in **1962**.

- The use of **internal** mammary arteries for coronary bypass surgery was pioneered by Frank Spencer and George Green.



Vineberg technique.



The heart-lung machine in the JU hospital, surgical department. It needs 2 technicians to run it.

**- Dr John H. Gibbon, Jr Motive**

*“During the long night, helplessly watching the patient struggle for life as her blood became darker and her veins more distended, the idea naturally occurred to me that if it were possible to remove some of the blue blood...put oxygen into that blood and allow carbon dioxide to escape from it, and then to inject continuously the now-red blood back into the patient's arteries, we might have saved her life.”*

## Ischemic heart diseases etiology

IHD results from an imbalance between oxygen demand and supply. When the heart muscle does not receive the amount of oxygen it needs to function properly, symptoms will start to appear.

Some causative conditions:

- **Atherosclerosis** (>90%): The main reason of IHD [coronary artery diseases]. It narrows the lumen, causing impedance in the blood flow of the coronary arteries, which results in symptoms. The patient might have a spasm in another coronary branch worsening the situation.
- **Embolization**: Causes less than 1% of cases.
- **Coronary spasm**
- **Vasculitis**
- **Coronary ostial stenosis** [aka. ostial lesions]
- **Severe LVH** [left ventricle hypertrophy]: It can cause angina without atherosclerosis.
- **Congenital anomalies of the coronary arteries** -quite uncommon- (ex: anomalous origin of LAD artery from the pulmonary artery)\_The word **anomalous** indicates an abnormal origin of an artery, it could be seen with the **left main coronary artery** originating from the **pulmonary trunk** OR even the **circumflex** artery originating from the **right main coronary artery**.

As atherosclerosis represents the main cause of **ACS** [*acute coronary syndrome*] let's revise its pathophysiology 🧯

Acute coronary syndrome = ischemic heart disease

When a patient has atherosclerosis inside his coronary arteries, a rupture/fissure might happen in a plaque causing **acute thrombosis** [platelets adhesion->platelets activation->platelets aggregation]. This can lead to a thrombotic occlusion so that the patient presents with **acute coronary syndrome**.

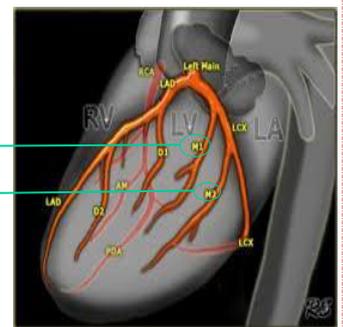
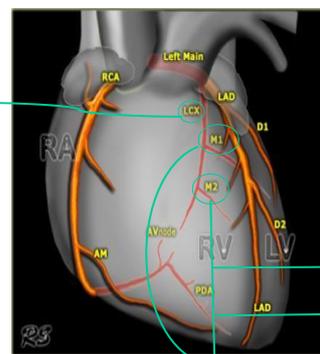
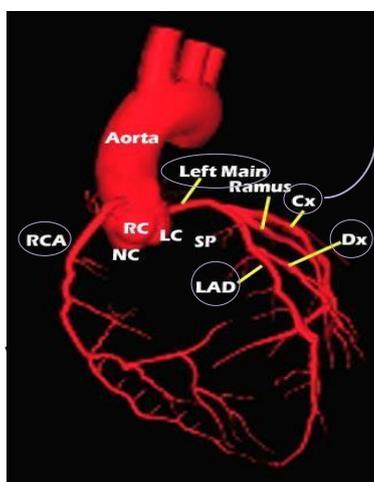
Atherosclerosis affects the coronaries as well as other vessels in the body. So, let's review the anatomical distribution of our vessels of interest:

The heart is supplied by 2 main arteries. The **right** coronary artery arises from the **anterior** [we took it as the right one in anatomy] sinus of valsalva in the root of the aorta, passes between the **right** atrium & the **right** ventricle (in the atrioventricular groove), and gives branches to the (1) **SA node**, (2) **atrial &** (3) **ventricular branches**, (4) **acute marginal branch** (supplies right ventricle), and, on the diaphragmatic surface of the heart, it may give off two or three (5) **posterior descending [interventricular] branches**.

On the other side, the **left** main coronary artery arises from the **left posterior** sinus of valsalva bifurcating early on into two major branches: the left anterior descending (LAD) artery and the circumflex artery.

The **LAD** artery runs between the **right & left ventricles** in the anterior interventricular **groove** [coronary sulcus] down to the **apex**, giving (1) **septal branches** that perforate and supply the anterior 2/3<sup>rds</sup> of the interventricular septum and (2) **diagonal branches** that run along the surface of the heart and supply the lateral wall of the **left ventricle**.

The circumflex artery continues the course of the left coronary, running between the left atrium and left ventricle along the coronary sulcus. It gives off the (1) atrial, (2) anterior ventricular branches, and (3) the left (obtuse) marginal branches.



Circumflex branch

Diagonal branch

Obtuse marginal branches M1&M2 (left) supply the lateroposterior wall of the left ventricle.

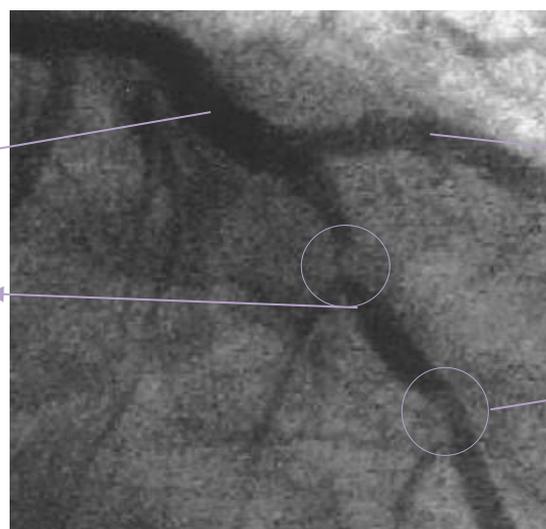
So how do you think an occlusion could look like on an angiograph?

The left main coronary

Diagonal branch

Occluded [stenotic] region in the proximal LAD. It is a significant lesion, causing nearly total occlusion.

distal lesion



[Complex lesions]

A lesion will be significant when more than 70% of the lumen is narrowed, which will cause hemodynamic impedance in blood flow to the myocardium especially during occasions of increased demand [e.g. exercise].

## CAD investigations [how to diagnose IHD]:

P.S. Most of these tests will be done to a patient who's meant to undergo surgery.

- **Take the History of the patient.**
- **Do Physical examination.**
- **Analyze the ECG findings.**
- **Investigate cardiac enzymes.**
- **Analyze the serum lipid profile.**
- **Do a TMT [treadmill test].**
- **Do a cardiac CT-scan.**
- **Take a coronary angiograph [the main indication to rely on for surgery].**

Other investigations [not mentioned by the doctor]:

- \* chest x-ray.
- \* FBS.
- \* Stress, or pharmacologic stress myocardial perfusion studies.

*Extra: The stress test is a diagnostic test used to evaluate blood flow to the heart. During the test, a small amount of a radioactive tracer is injected into a vein. Then, a special camera detects the radiation released by the tracer to produce computer images of the heart.*

## Medical treatment of CAD [IHD]:

- **Nitrates** to vasodilate the artery.
- **Beta blockers.**
- **Aspirin/PLAVIX-DUAL ANTIPLATELET THERAPY.**
- **Ca<sup>+2</sup>-channel blockers** (in coronary spasm).
- **Treating the associated risk factors.**
- **Treating the precipitating factor.**
- **Revascularization**, if indicated. (**SURGICAL vs. INTERVENTIONAL (non-surgical)**).

## Open-heart surgery indications [coronary artery bypass grafting] CABG:

- **Triple vessel disease**, meaning that the three major vessels (LAD, right coronary, and circumflex arteries) have blockages.
- **Left main coronary artery disease**, as this artery represents the main source of blood supply to the left part of the heart. If more than 50% is stenosed, this is a strong indication for heart surgery.
- **Unstable angina with failed Mx. therapy** [*disabling angina despite maximal noninvasive therapy*].
- **Complications of PTCA** This includes rupture, dissection, or perforation of the coronary artery when it is dilated through ballooning or stenting. The patient will need urgent CABG.
- **Life threatening complications of MI**: MI might get complicated by acute mitral regurgitation secondary to papillary muscle rupture, postinfarction VSD, or free wall rupture. These are called mechanical complications of acute MI.
- **Anomalies of Coronary arteries**: An indication of collect de-anatomical malformation.
- **Coronary rupture, dissection, acute occlusions, and thrombosis**; in such cases, urgent CABG surgery is needed.

|| Besides these indications, if a patient needs an (1) aortic valve replacement & (2) has a single vessel disease [e.g. LAD lesion] this will be an indication of **CABG** concomitant to other cardiac surgeries.

Before diving in let's have an overview of CABG surgery:

*The standardized method is to open the chest in the middle → open the pericardium → put the patient on the heart-lung machine → stop the heart completely → use a conduit.*

## Techniques used in CABG:

- **Median sternotomy** (a vertical inline incision is made along the sternum, after which the sternum itself is divided).
- **Cardiopulmonary bypass** (a machine temporarily takes over the function of the heart and lungs)
- **Cardioplegic arrest** (stopping the heart temporarily)
- The preferable conduit of surgeons is the **internal mammary A.** [overwhelmingly the left one]. The second-best conduit could be the radial A. or reversed saphenous vein.

The **sternotomy** approach is used for almost all cardiac procedures as it gives the best overall access to the heart.

CABG starts by opening the chest in the middle using a saw to cut the sternum. The pericardium is then opened, we take the venous [deoxygenated] blood by a special cannula and return oxygenated to the aorta (using the heart-lung machine). Then, after stopping the heart, we open the coronary artery [the diseased one] using a knife or scissor & anastomose the graft [our new conduit] **distal** to the lesion.

Please use this [link](#) to examine the pictures with their associated notes [absolutely required for exam purposes].

## Total arterial revascularization

It's a concept that arised recently and has a lot of literature written about it. The main method uses total arteries for coronary bypass surgery. We can use different configurations of anastomosis. Check this [link](#) to see some of them.

## Percutaneous coronary intervention PCI

It's an invasive procedure during which a small balloon-tipped catheter is inserted into either the femoral or brachial artery and threaded up to the obstructing lesion in the coronary artery. When the balloon is inflated, the plaque is flattened against the endothelial wall, the artery is dilated, and blood flow to the myocardium is increased. A stent may be placed.

Some surgeons use **a rotational burr** to remove calcifications or form a hole through a calcified segment.

*(I.e. to break up calcified plaque that is clogging a coronary artery)*



## Off-Pump Coronary Artery Bypass: OPCAB surgery.

This represents the **new** technique of **CABG** surgery. It can be done through different approaches.

The point here is that we don't use the heart-lung machine. Instead, we **fix** the arterial segment that we will operate on through a **cardiac stabilizer**. Then, CABG is performed **without stopping the heart**. This means the heart continues to provide blood to the rest of the body during the surgery.

We have different mechanical instrumentations to **stabilize** the heart, for example:

### Octopus Device

- Has multiple small suction cups that are applied to the heart surface.
- When the suction is turned on, the cups stick to the surface and hold the heart steady, with movement being less than 1 mm.

We can also use some drugs to **help** us...

### Drug Therapy

- Esmolol and Adenosine have been found effective in slowing, and even temporarily stopping, the heartbeat for short periods of time (around 20 seconds).

Some characteristics of the procedure (both the conventional CABG and OPCAB):

- Median sternotomy of varying sizes.
- Depending on the physiology of the patient, the smallest incision will be made.
- Arteries or veins can be harvested from the patient's chest wall, arm, and or leg.
- Adenosine and Esmolol are used to slow the heart rate.
- Deep pericardial sutures and the use of specialized instruments to prop the heart in a position that will allow the surgeon to access occluded arteries.

## OPCAB VS. CABG

The comparison of OPCAB to CABG patients showed that **OPCAB** had similar or **better** results.

In another study that was presented at an annual meeting of the Society of Thoracic Surgeons, the following information was found:

- The hypothesis for the study was that OPCAB surgery would reduce some of the side effects of conventional cardiopulmonary bypass.
- There were no hospital deaths in the OPCAB group compared to nine deaths in the CABG group.
- OPCAB surgery also reduced the average postoperative hospital stay from 5.5 days to 3.3 days.
- The most significant statistic was the reduction in the need for transfusion after the operation.  
Less than a third of the OPCAB patients (29.6 %) needed transfusions compared to more than half (56.5 %) of the CABG group.

Many literatures these days investigate and compare short-term outcomes and long-term outcomes between patients undergoing the conventional CABG surgery and patients undergoing off-pump CABG. The results revealed that the traditional CABG causes better revascularization and **long-term** survival as compared to off pump CABG, while off pump CABG has much lower post-operative morbidity and mortality, especially in high risk patients (short-term complications).

*Note* | | dashed lines underline information that weren't mentioned nor read by the doctor.

## Complications of CABG:

We can predict the **mortality** of **CABG** using different scoring systems; such as: **STS PROM**, and **EURO SCORE II**. We consider the patient's variables and become able to predict possible complications that the patient might face depending on his/her situation. Some of these complications include:

- **STROKE.**
- **LOW CARDIAC OUTPUT** [heart failure]: the **main** complication.
- **ARRYTHMIAS.**
- **SSI/STERNAL DEHISCENCE** [sternal wound complications].
- **PERIOPERATIVE MI.**
- **BLEEDING /TAMPONADE.**

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غَيْرِ بَيٍّْ وَصَلِحِ الْأَعْمَالِ

وَتَرَى النَّاسَ يَنْظُرُونَ جَمِيعًا

لَيْسَ فِيهِمْ لِمَا كَانَ بَعْضُ أَحْتِيَالِ

-الحارث بن عباد-