

- In this sheet we will talk about “Adult Cardiac Surgery” and what are the most common diseases that need cardiac surgery in adulthood.
- Please refer to the slides, I wrote only what doctor said, & the slides contain additional information.
- “**Adult cardiac surgery**” or “**open heart surgery-عملية القلب المفتوح**” as commonly called means that the surgeons open the chest, explore the heart and do the surgery. So they do NOT take the heart out from the chest.

❖ The indications for adult cardiac surgery are:

1-coronary heart disease → we do “Coronary Artery Bypass Graft (CABG)” surgery as treatment for patients with coronary artery stenosis.

2-valvular heart disease → a strong indication, in relation to:

- * Rheumatic heart fever- which declining in our country
- * Degenerative valvular disease (calcified valves) in elderly is the strongest indication for cardiac surgery- especially in developed countries including Jordan.
- * Infective Endocarditis (الالتهابات الشغافية)- increasing in developed countries- which involve the valves as well as other structures, most commonly Tricuspid valve esp. in drugs abusers

3- Congenital heart anomalies: VSD, ASD, Coarctation of aorta or Congenital abnormalities in great vessels.

4-Major vessels diseases, the most important is Aneurismal Dilatation of Aorta (ascending, arch or descending thoracic aorta) as a result of degeneration in elderly or related to connective tissue disease like: Marfan syndrome & Ehler-Danlos syndrome.

❖ The history of open heart surgeries

-**Heberden** is the first one who described angina pectoris in 1768.

-**Vineberg** was a doctor and he had patients with coronary artery disease, complaining of chest pain increases upon exertion..., stable or unstable angina, so what Vineberg did is that he mobilized the mammary artery from its place, then made it a tunnel inside the myocardium and let it bleed in the myocardium of the left ventricle (he left the bleeding end of this tunnel in myocardium without making an anastomosis with another artery). This was in 1940's before catheterization establishment, so they weren't able to know where is the atherosclerotic lesion in the coronary artery (the first catheter was in 1959), he used many methods to do this and after 20 years those patients had a pain relief and normal life and when they did a catheter for them, they found a new vessel formation and other improvements.

-then a surgeon called **John Gibbon** invented the (**Heart-Lung machine**) → we take the blood from the Rt. Atrium, oxygenate it by this machine outside the body, then return it to Aorta. So it performs the job of the lung (oxygenation of the blood+get rid of CO₂) by pressure gradient, and works as a pump (return the blood to Aorta) and this is the principle of function of the (Heart-Lung machine) started in 1953 for a patient with ASD (he did ASD closure surgery).

-in 1959 and beginning of 60's, they made the catheters and so they became able to determine the place of the coronary stenosis lesions.

- The pioneers of Bypass Surgery, and the most famous was a Russian surgeon **KOLOSOV**, he did a **direct anastomosis** between the coronary artery and the mammary artery (left internal mammary artery LIMA → left anterior descending artery LAD) and the amazing thing that KOLSOV performed this surgery while the heart is beating, this was in 1964.
- the **American surgeons** used the saphenous vein in Aortocoronary bypass surgery in 1962, the doctor said that many books doubt that the American use of **saphenous vein as a conduit** for Bypass surgery was in 1962, they believe it was in 1966.
- many advances in cardiac surgery took place, and many **studies** on it resulted in that CABG surgery is a method that could improve the quality of life and improve survival.
- other studies esp. in Europe & America in 1970's made standardization of the procedures.
- *this was a(brief :D) notes about the history of cardiac surgery
{ I have no idea whether we have to memorize these historical information or not but I tried to write everything the doctor said about them}.

❖ Coronary Artery Disease

- Now let us remind you with the basic knowledge about anatomy of coronary arteries,
- There are two main coronary arteries; right and left
- There is **three sinuses of valsalva**(aortic sinuses); one anterior & two posterior:
 - 1- One of the posteriors to the left give rise to left main coronary artery
 - 2-The anterior give the right main coronary
 - 3- While the other posterior to the right is called Non-coronary sinus of valsalva
- **The left main coronary** is a short artery (1.5-2.5 cm), runs between the ascending aorta and behind the pulmonary trunk, and branches into two coronary arteries:
 - 1-The most important branch is the **Left Anterior Descending** (الشريان النازل الأمامي الأيسر) artery which runs in anterior interventricular groove or sulcus, emerges between rt. & Lt. Ventricles and below it is the interventricular septum and reaches the apex. It gives Septal branches (to the septum) + Diagonal branches (to the Lt. Ventricle).
 - 2- The other branch is the **left circumflex** (الشريان المحيط الملفت الأيسر) which runs in the left atrioventricular groove (between the Lt. Atrium & Lt. Ventricle) and gives branches to the posterior-marginal wall most important of them is the Abtuse marginal branches
- The LAD artery is one of the main targets of surgeries, and the surgeons really take care of this artery and choose the best conduit for it which is the internal mammary artery ; because the LAD supplies the pumping part of the heart = Lt. Ventricle. And in public it is commonly called “the widow artery=الشريان المُرْمَل” that kills patients at young age group esp. males as the coronary artery diseases occur earlier in males than females, and one of the deferential diagnosis of sudden cardiac deaths is occlusion of the LAD artery.
- **The right main coronary** runs first in the right atrioventricular groove, gives branches to SA node, branches to AV node , Acute marginal branch, then continues to the inferior surface of the heart and gives Posterior Descending artery which in most cases the dominant artery to reach the apex .
- Any doctor must be familiar with anatomy of the coronary arteries, esp. here in Jordan; because the coronary artery diseases are one of the leading causes of death in non-cancer deaths in Jordan, and the atherosclerosis became occurring in the young age group (Premature Atherosclerosis which means that the patient have the disease at age below 45 years old) and not at elderly.

- The average age of patients undergo cardiac surgeries in Jordan about 54-55 years old, while it is 74 years old in other countries !!
- The layers of the wall of the arteries are: Intima, Media, & Adventitia.
- **Atherosclerosis** is a disease of the intima & media, in which there is a plaque collection inside the wall of the artery esp. the endothelium, and this gradually building up leads to narrowing of the lumen that cause the symptoms of atherosclerosis, the percentage of **narrowing** that cause clinical symptoms is **70%** and above (the reduction of the radius of the coronary artery that lead to impedance of the blood flow)
- As we took in physiology, the myocardial cells have the maximum extraction of oxygen that delivered to it, so when increases demands it needs to it increases the blood flow by vasodilatation, and when there is narrowing there is no blood flow which lead to symptoms & the most important is Angina pectoris.
- Sometimes there is **a sudden vasospasm** –without atherosclerosis-, in response to drugs or cold exposure or emotional stress which cause (maximum sympathetic tone).
- The process of narrowing in atherosclerosis is gradual in nature, but in clinical scenario it is different , you can see a patient who did a catheter a month ago and the percentage of narrowing was 20%,then comes suddenly with acute myocardial infarction and you have to explain why→ it could be a result of sudden emotional stress or high blood pressure → lead to rupture of the atherosclerotic plaque →exposure of sub-endothelial collagen →binding of Von-Willebarnd factor (ridging with collagen) and this is important platelet aggregator , this why the 20% narrowing suddenly become a thrombus and cause acute MI. This is one of theoretical theories about the mechanism of acute humoral stroke syndrome whether related to acute MI or unstable angina pectoris.
- For these patients with chest pain at rest in unstable angina, one drug of choice to give and to train the civil-defence to give for patients with these symptoms is chewable aspirin to prevent further platelet aggregation .
- In the surgery before even opening of the coronary artery we can see from the outside the calcified atherosclerotic plaque on its wall, it appears yellow in colour, stony hard when you feel it unlike the normal elastic artery .
- The risk factors for atherosclerosis are:
 - 1) Uncontrollable:
 - Age**→ by aging it is a natural process to have calcification of the arteries as a degenerative process.
 - Sex**→ males are more prone to develop it than females before the age of 50, but after the age of 55 the incidence is the same .
 - Hereditary**→ there is problems in cholesterol metabolism in certain families, esp. in low density lipoprotein (LDL) that carries cholesterol , these patients have problems in certain genes in the liver that resulted in increasing cholesterol accumulation in circulation “familial hypercholesterolemia “
 - Race**→ certain races are at higher risk to develop the disease than others
 - 2) Controllable
 - Diabetes mellitus**

Hypertension

Cholesterol related to dietary habits (the food of the Mediterranean region is the best food ever in preventing atherosclerosis as it depend on olive oil, fish, salads, and greens. before the new food styles reach our region which causes severe increase in obesity levels)

Smoking in fact what make us feel sad is many of people esp. the young are smokers whether cigarette or the hubble-bubble, what more sad is that females start to get this bad habits very quickly

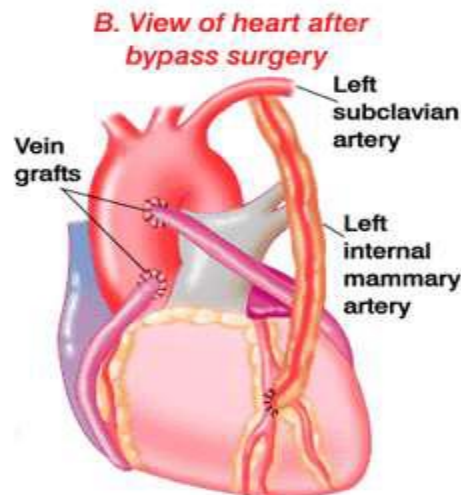
Physical activity is really important, we depend too much on cars, we don't walk

Obesity

Stress & Anger type of personality

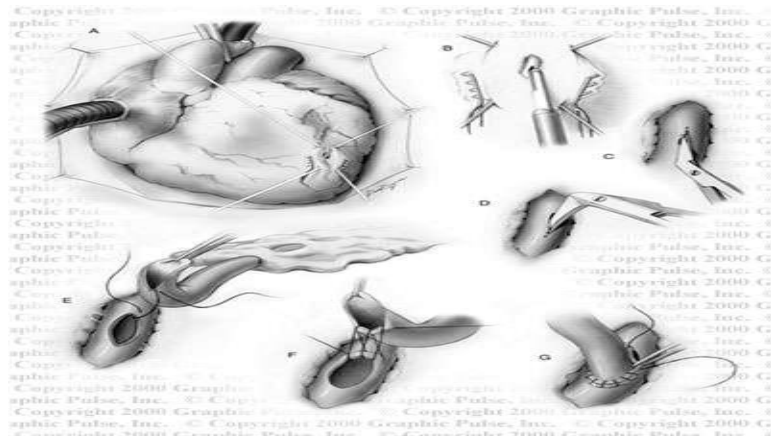
Some types of personality

- The Indications for open-heart surgery (coronary artery bypass graft **CABG**) for patients with Coronary heart disease(not every patient with atherosclerosis we do a CABG surgery for him);
 - 1- Triple vessel disease → the two left branches LAD + Circumflex , and the right coronary artery narrowing , this is a classical indication for Bypass surgery.
 - 2- Lt main coronary artery disease → as we said it is supply the pumping part of the heart, and these patients develop symptoms before reaching the 70% of narrowing, we do the surgery when they reach 50%.
 - 3- Unstable angina with failed maximum treatment
 - 4- Complications of PTCA (Percutaneous Transluminal Coronary Angioplasty), the most important complications during catheters is Rupture of the balloon, Acute Thrombosis, or Dissection , These cases are emergencies and we do CABG for them.
 - 5- Congenital anomalies of coronary arteries
 - 6- Life threatening complication of MI



- How we do the surgery :
 - 1- prepare the conduits
 - 2- Open the chest in the median sternotomy
 - 3- Put the patient on the Heart-Lung machine
 - 4- After open the sternum and pericardium we put a cannula on the right Atrium and another cannula on the ascending Aorta , and we put a clamp below it (ascending aorta) to prevent the returning of blood to heart, so we isolate the heart for the bypass

- 5- we don't want the heart to still beating, so we give the patient Cardiac Beating Solutions; solutions based on riching the cardiac cells with potassium → it arrests the heart in diastolic phase so the heart is flaccid & paralysed to deal easily with it beside decreasing its metabolic rate. (and this is our aim) -while if we use calcium → it will arrests the heart in systolic phase and we get a stony heart.
- 6- Identify the injured coronary artery and open it by a knife, dilate it by a scissors
- 7- Connect the conduit (the new artery) to the side of coronary artery directly, mean that we do the anastomosis distal to the lesion.
- *the final picture of the surgery is that patients who have a lesion in coronary artery, we open distal to it, and connect a new artery we call it a conduit.



- The most important conduits (could be artery or vein) are:
- Right & Left Mammary Artery = (internal thoracic artery) →** the left internal thoracic artery (LITA) is branch of subclavian artery, runs parallel to the sternum, 1 inch lateral to the lateral sternal border inside the chest wall and when it reaches the xiphoid process it gives two branches: the musculophrenic & superior epigastric artery.
(the 1st branch of subclavian artery called vertebral artery, the 2nd called thyrocervical trunk of upward direction, the 3rd is the LITA of downward direction)
 - Radial Artery →** is a good conduit, can reach 20 cm long in tall people.
 - Right Gastroepiploic Artery →** a branch from gastroduodenal artery which is branch of celiac trunk.
 - Great Saphenous Vein & Short Saphenous Vein**

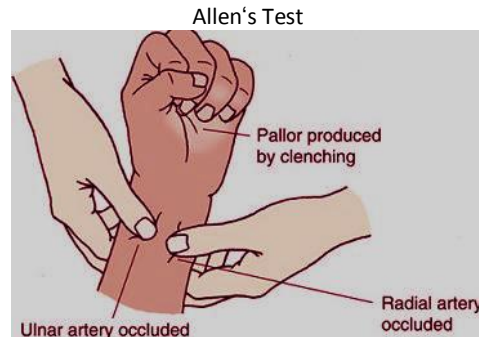
✕ Question :

When we mobilize the conduit artery from its original place, this will not cause problems to the area supplied by this artery??

Answer:

- *-We have rt. & lt. Internal thoracic arteries, they supply only a part of the chest wall, also they are not End arteries; they have many collaterals, and we prefer not to take both of them together esp. in diabetic & obese patients because we afraid of having problems in vascularisation of sternum, but we can take them safely in other patients, they are sort of spare parts.
- *-In case of The right gastroepiploic artery, the stomach is a highly vascularised organ whether from outside or from its submucosal network, so the left Gastroepiploic artery will compensate for the submucosal circulation, and we will not have problems in stomach.
- *-In case of Radial artery; the radial & ulnar arteries are branches of the Brachial artery, when we want to take the radial artery we have to make sure that we will not leave the hand

ischemic, so we do a simple test called Allen's test (the doctor presses on radial & ulnar arteries closing them, then tells the patient to move his fingers until we feel the hand start to be ischemic, then we open the ulnar while keep radial closed, if the hand return normal; we can take the radial, if not and the hand still partially ischemic we cannot take it). Sometimes we use ultrasound or other methods to test the flow.



- We suture continuously, slowly with non-absorbable sutures for life long time. And for the injured artery we leave it in its place, we don't care about it because we depend on the new artery to take over its job.

Question:

Is there a probability of developing thrombus because of the presence of sutures?

We give the patient anticoagulants to prevent thrombosis, and after surgery the patient should take aspirin for a period of time, beside the acute thrombosis occur only in 2% of people..

- So we have arteries and veins, how the surgeons choose the proper conduit??
The LITA is the best conduit ever; because after 10 years of the surgery the possibility of this artery to keep open is 90%
While The saphenous vein graft, after 10 years the possibility to keep patent is 60%,
So the conduit's 10-years patency rate explain why LITA is better than saphenous, and that's why we choose the LITA to be connected to the most important coronary artery LAD ,
EXCEPT if there is a problem prevent this choice.

Question:

Why we use LITA for LAD not RITA??

The reason is anatomical, if we use the right we have to cross the midline to reach the LAD, and next time the surgeon needs to open the chest, he will worry about injuring it, while if you take the Left it will directly reach the LAD (as if it originally designed for this!!)

- For the saphenous, we cut it from both sides, connect it proximally to Aorta, & distally to the right coronary, or left circumflex artery:
While the LITA is already arises from Aorta so we keep it attached to its origin, and we only cut it from one side & connect it to LAD, which is much easier..
- The other methodology to treat coronary artery stenosis is through **Percutaneous Approach**, dilatation of the Coronary artery
-We insert a balloon at site of the atherosclerotic plaque, then blow it so destroying the

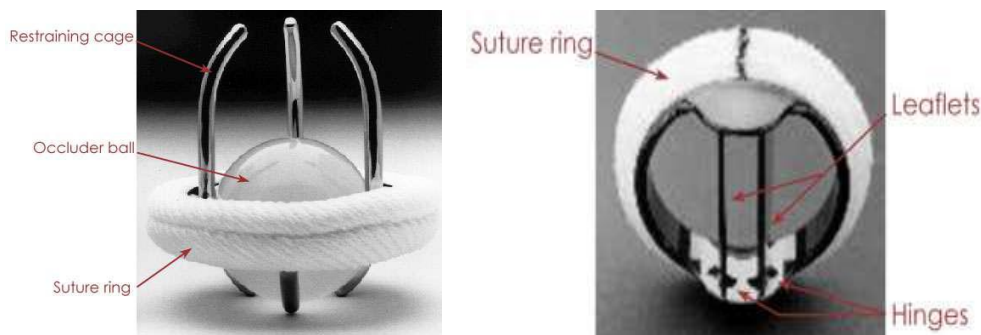
- plaque and dilate the artery, (see the x-ray from slides)
- Its very important to give these patients Anti-Platelet medications, if not, the artery will re-close in 50% of patients
 - Of course after a while it will not keep open, so nowadays they use **STENTS** (شبكة أو دعامة) to put it inside the plaque.
 - Many types of Stents: first one was metallic, the new stents are Drug-eluting Stents which slowly release drugs (sirolimus + other chemotherapies) and keep secreting them to prevent atherosclerosis.

❖ Valvular Heart Disease

- We have 4 valves in the heart: Mitral, Tricuspid, Aortic & Pulmonary.
- The most common valvular pathology is : Aortic Valve Stenosis
- we know from anatomy that the cusps of the normal valve are normally thin clear leaflets, but when it gets calcified or degenerated (by aging) it become very hard, so it will not open properly or close properly → Stenosis & Regurgitation .
- what also make the valve calcified earlier: Bicuspid aortic valve, this lead to enhances of the atherosclerotic processes.
- Most important Symptoms of Aortic Stenosis AS:
 1. Chest pain/ Angina-like
 2. Syncope
 3. Shortness of breath + Dyspnea
 4. Sudden death (if not treated)>> Acute MI , Acute phase of tachycardia
- In order to diagnose AS :
 1. History
 2. Symptoms
 3. Physical examination → the most important is that you hear **Murmurs**
 4. Investigations :
 - **ECG** ,
 - **Chest X-RAY** (lt. vent. hypertrophy),
 - **ECHO cardiogram** → will measure the surface area of the valve (normally 2-4 cm²) & pressure gradient across the valve, this indicates the severity of stenosis; the **less valve surface area the more severe AS**.
 - **Catheter** → esp. for patients >45 years old, in order to know the status of the coronary arteries.
- (AS) causes hypertrophy of lt. ventricle wall & the septum → decrease lt. Ventricular cavity → decrease stroke volume → to compensate → Tachycardia .
- With increased thickness of the wall → decreased supply → subendocardial ischemia → NQMI (non-Q wave MI) + Ventricular Fibrillation + Ventricular Arrhythmias.
- When these calcifications/fibrosis reach the interventricular septum → A-V Bundle → causing A-V Block.
- The severity of the AS depends on: surface area of the valve & the pressure gradient between lt. Ventricle and Aorta.
- The indications of the surgery (Aortic Valve Replacement): Any Symptomatic patient must undergo surgery whether severe or moderate stenosis , there are other indications we will

not go in their details. (the doctor didn't mention) them but they written in slides as follow:

- **Symptomatic** patients with severe AS
 - Patients with severe AS undergoing coronary artery bypass surgery
 - Patients with severe AS undergoing surgery on the aorta or other heart valves
 - Patients with moderate AS undergoing coronary artery bypass surgery or surgery on the aorta or other heart valves
 - **Asymptomatic** patients with severe AS and the following; (refer to slides)
- When we remove the valve, what are the choices we have to replace it, **Valve Prostheses** :
- (a) **Mechanical valves (prosthetic type of valve)** → made of Pyrolocarbons, very stable & not damaged by time (no degeneration) .
- **Caged-ball valves** → we don't use this anymore (عفا عليها الزمن!!)
 - **Tilting disc valves** → the most famous is (Bileaflet valve) open & close



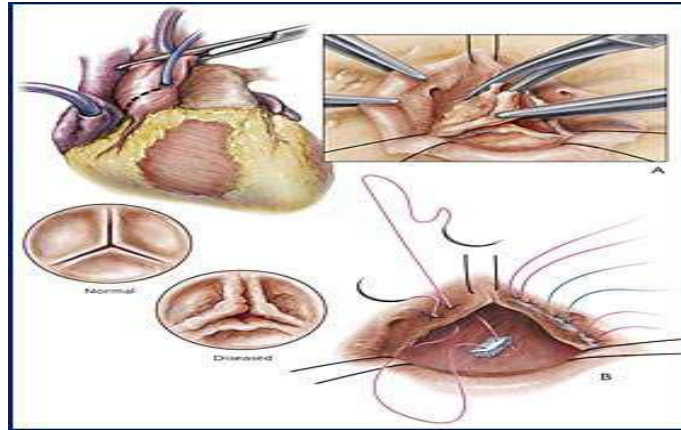
- (b) **Biological valves/ Tissue valves (bio-prosthetic type)** → from animal sources or from cadavers as type of organs donation, and these valves need processing before using.
- **Human tissue (homograft)** → most important of tissue valves.
 - **Animal tissue (heterograft)** → porcine aortic valves or bovine pericardium; a valve manufactured from cow pericardium.
- How to choose a valve? according to the patient:
 - The mechanical valve is very strong and stable and don't undergo degeneration, but the disadvantage of it that the patient needs to take anticoagulants like : **Warfarin**; otherwise the valve would induce thrombosis (by intrinsic pathway) .
 - While tissue valve undergo degeneration after 10-20 years so need to be changed after 15 years, and this is the disadvantage of tissue valves. (note from the slides: for tissue valve; Anticoagulation recommended in first 3 months, although aspirin alone in aortic position in some centres, After 3 months, discontinue unless other circumstances)

** - So, if the patient >65 years → tissue valve, without need to warfarin.

- And patients <65 years → mechanical valve with continuous intake of Warfarin.

*Except if this patient is contraindicated to take Warfarin → tissue valve is used, for example a female, wants to have a child in future, and as we know Warfarin is teratogenic in pregnancy esp. first trimester, so we use tissue valve and we may change it into mechanical later.

- To do the surgery, we open the aorta small opening, excision of the valve, suture the new valve.
- We have to keep monitoring the patient who take Warfarin, to make sure that he is Anti-couglated, by doing Prothrombin "PT blood test" which reflect the "International Normalised Ratio INR" .



- The success ratio of AS surgery is about 95% and above, but its different from one to other, still one of the best result surgeries.
- For CABG surgery there is 2% mortality & 97-98% of good results .

THE END

Good luck ☺

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