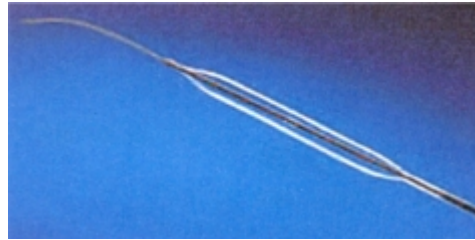


## Invasive Procedures

### Coronary Angioplasty (Balloon PTCA)

Coronary angioplasty makes use of a catheter with a balloon at its tip which is inserted into narrowed or blocked arteries. The balloon is then inflated to flatten plaques, opening the heart artery.



Balloon tip and catheter

This invasive procedure is similar to that previously described for angiography.

The catheter has a tiny balloon at its tip. After passage of a coronary guidewire across the narrowed segment to the distal vessel, the balloon catheter is guided to the area of treatment. The balloon is inflated, flattening plaque and expanding the artery wall. After adequate inflations to expand the narrowed segment to its actual normal size, the catheter is withdrawn.

The average hospital stay for this procedure is only a couple of days. The success rate is as high as 97%. However, there is less than a 1% chance that sudden blockage in the coronary artery may occur during the procedure. In this situation, it may cause complete obstruction of blood flow to an area of the heart. The balloon catheter needs to be inserted back immediately to expand the artery. Another disadvantage of angioplasty is that opened or widened arteries may narrow again. This "recurrent narrowing" can be expected in 35 to 40% of cases over a 6-month period. It may require repeating the procedure with stenting or brachytherapy as discussed in the following section. Recurrent narrowing is the reaction of the body's immune system while recovering from any invasive procedure.

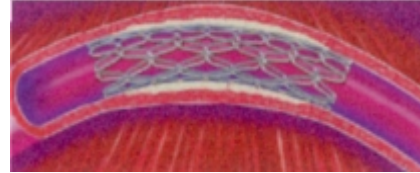
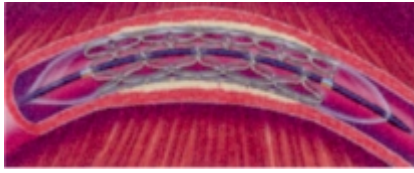
### Coronary Stenting

Stents are metal scaffolding used to open up, support and maintain the patency of the diseased vessel. They are made up of stainless steel or metal alloy, which are biocompatible



Inserting a balloon mounted catheter into the narrowed or blocked section of an artery

A coronary artery stent is a small, self expanding, stainless steel mesh tube that is placed within a coronary artery to keep the vessel open and to support wall of artery.



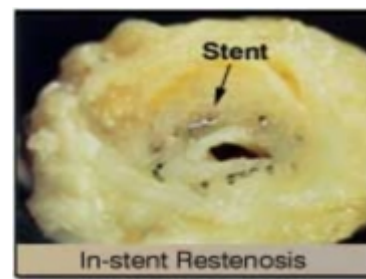
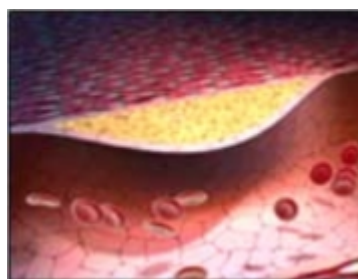
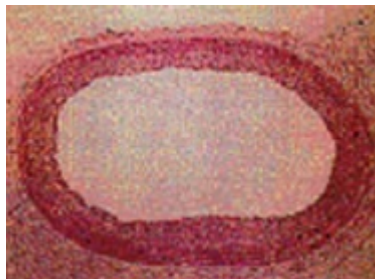
Inflating the balloon to expand the wire mesh stent      Catheter is removed and stent left behind

### Restenosis and Drug Eluting Stent

#### Restenosis

Restenosis is a re-narrowing or blockage of an artery at the site of balloon dilatation. It is an ongoing problem with angioplasty. The arterial narrowing returns in about 20-30% of patients undergoing coronary intervention. This usually occurs within 6 months of the intervention. If the process happens within a stent that has been placed in an artery, it is called "in-stent re-stenosis". Build-up of substances within the stent may eventually block the flow of blood.

The phenomenon of the re-stenosis is not a progression of coronary artery disease but rather the body's immune response to the injury of angioplasty. The mechanism includes elastic re-coil, chronic re-modeling and excessive growth of smooth muscle cells or neointimal hyperplasia.



Cross section of restenosed artery (dark red)

Process of restenosis

Restenosis inside a stent

#### Drug Eluting Stent

Restenosed artery has to undergo another intervention such as balloon angioplasty, atherectomy, and brachytherapy. Although proper stenting reduces incidence of restenosis, the coating of drugs in stent offers much better promise. The programmed release of various drugs coated in stents interferes in different stages of the cell cycle to prevent cell growth. Studies have shown the use of a drug releasing stent can reduce artery re-narrowing to 3 to 4%.

Drug-eluting stent has shed new lights in the horizon

#### Debulking Procedures

In certain situation where presence of deposits may cause plaque shifting or prevent the balloon and stent from full expansion, debulking procedure has to be employed. The purpose is to remove the fatty plaques to reduce blockage of the artery while debulking procedures can be used effectively to remove plaque it can also damage arterial wall and increase the rate of re-narrowing. Therefore, debulking is performed along with other invasive procedures most commonly stenting. Many medical studies have shown better patency and result with debulking before stenting.

#### Directional Atherectomy(DCA)

This procedure is similar to angioplasty (balloon PTCA) but it uses a rotating cutter at the end of the catheter. The high-speed rotating device clears the artery of fatty plaque rather than just flattening the plaque buildup. Directional atherectomy is most useful in coronary artery with especially large and eccentrically deposited fatty plaque. After removing plaque by debulking, a stent can open an artery wider. Despite its benefits, DCA is a relatively big and rigid device. It cannot be utilized in smaller and winding coronary arteries

#### DCA Catheter



#### Rotational Atherectomy (PTCRA)



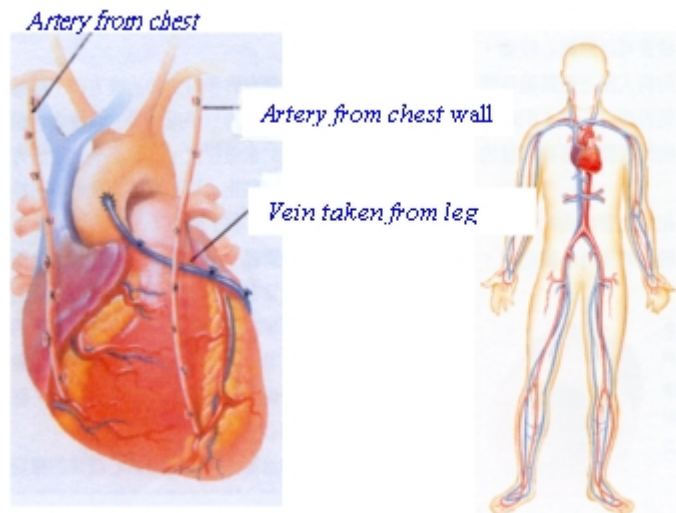
The device is an olive-shaped rotating shaver, plated with nickel. Micron diamonds are bonded to it, and it is attached to a rotating drive shaft.

Rotational atherectomy is most useful for treatment of heavily calcified, tight, long, ostial lesions, and bifurcation lesions. A special guidewire called a rotawire is passed down the distal vessel. A device called a "rotalink" or "burr" tracks through the rotawire to the affected area. Near the tip of the rotalink is an olive-shaped, nickel-plated, rotating shaver with micron diamond chips bonded to it. The drive shaft is flexible. Operated by high-pressure gas and turbine, the tip can be set to rotate around 160,000 revolutions per minute. While normal tissues will be spared, hard plaque will be shaved into debris smaller than that of a red blood cell, which will pass through the circulation and eventually be removed.

#### Intravascular Brachytherapy

Similar to angioplasty, intravascular brachytherapy involves a catheter positioned in the re-narrowed coronary artery with a radioactive metallic wire, emitting very short-range radiation. Treatment time is usually only a few minutes. As the radiation waves travel only in a short distance, the radiation will not affect areas outside the arterial wall. This method can effectively treat re-narrowing.

#### Coronary Artery Bypass Graft (Bypass Surgery)



*"Artery" graft from Internal Mammary is rerouted from the inside of the chest wall and is used to bypass the clogged coronary artery to supply more blood flow to heart muscle.*

*"Vein" graft is taken from the vein in the leg.*

This procedure is considered for serious coronary heart disease that cannot be treated by medications or percutaneous coronary intervention. In general, if many arteries are involved or if the left main artery is blocked, bypass surgery will be necessary. Veins taken from the legs, or arteries passing through the chest wall, can be used to bypass the clogged arteries in the heart. Once the new blood vessels are connected, blood can flow through the bypass arteries to prevent angina and a deadly heart attack.

This procedure usually takes 3 to 4 hours but may extend longer in some complicated cases. After the procedure, the patient needs to stay in the intensive care unit for a few days before going to the general ward. The entire hospitalization may last 10 – 14 days. The procedure has 3 to 5% risks.