Percutanous Coronary Interventions

Andrew Ying-Siu Lee, MD,PhD.

Relative contraindications of cardiac catheterization:-

- acute gastrointestinal bleeding or anemia
- uncontrolled bleeding diathesis
- electrolyte imbalance
- infection and fever
- pregnancy
- recent stroke (< 1 month)
- renal failure
- uncontrolled heart failure, high blood pressure, arrhythmias
- uncooperative patient

Complications of cardiac catheterization

- ***Major:*** **death**
  myocardial infarction
  serious arrhythmias
  stroke

- ***Others:*** **aortic dissection**
  heart perforation, tamponade
  heart failure
  contrast reaction (anaphylaxis, nephrotoxicity)
  heart block, asystole
  hemorrhage (local, retroperitoneal, pelvic)
  infection
  thrombosis, embolism, air embolus
  vascular injury
  vasovagal reaction

Indications for percutanous coronary interventions (PCI):-

- angina not relieved by medical therapy
- angina + evidence of ischemia (exercise test, SPECT) and high grade lesion (>70% stenosis)
- High-risk patients (unstable angina, myocardial infarction)
- angina after coronary bypass surgery or prior PCI (restenoses)

Contraindications of percutanous coronary interventions:-

- unsuitable coronary anatomy (eg. left main, severe diffuse disease)
- high-risk coronary anatomy, closure → death
- bleeding diathesis (low platelet, peptic ulcer, coagulopathy etc.)
- patient noncompliance

Angiographic views

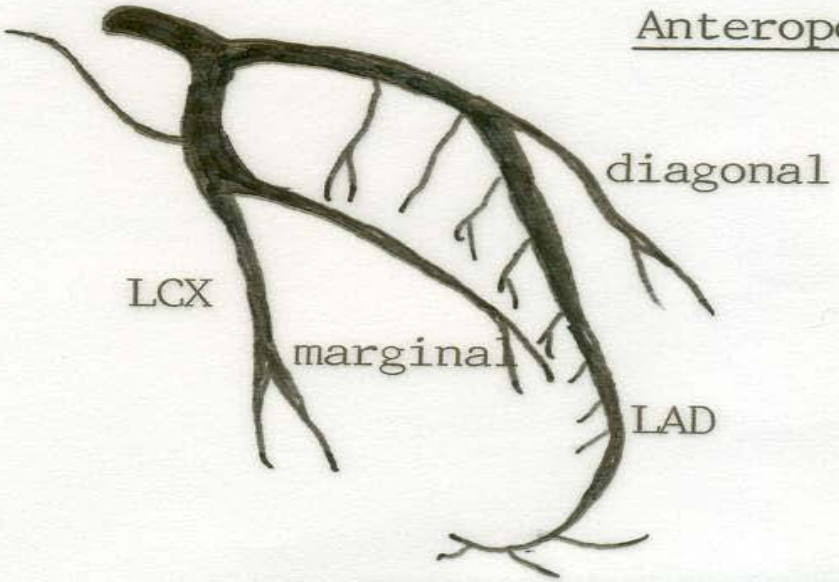
- Left Circumflex (LCX) goes with the image intensifier (camera tube above patient) and Left anterior descending (LAD) goes in opposite direction. Therefore, moving image intensifier to left (LAO views) → LCX to the left and LAD to the right. And cranial angulation → elevate LCX up and pull LAD down. Caudal angulation → pull LCX down and elevate LAD up.

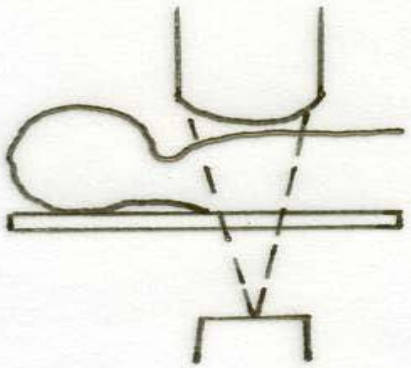
- To straighten a tortuous vessel → image intensifier moved 90^{o} opposite to the present one

- ***Best views for:-***

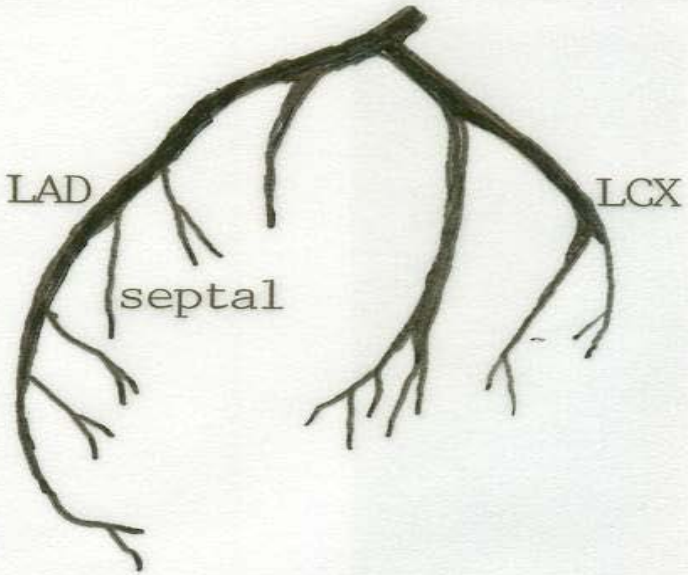
Left main (LM)	:	AP, shallow RAO
LAD	:	RAO cranial LAO cranial AP
LCX	:	RAO caudal LAO caudal (spider)
Right coronary (RCA)	:	LAO (like letter “C”) RAO (like letter “L”)

Anteroposterior View

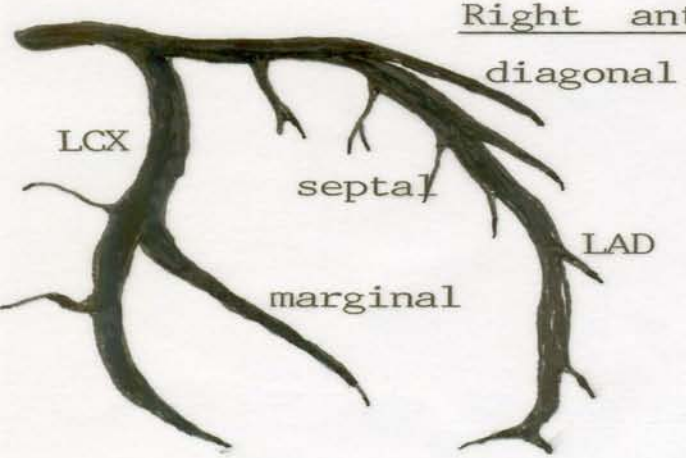


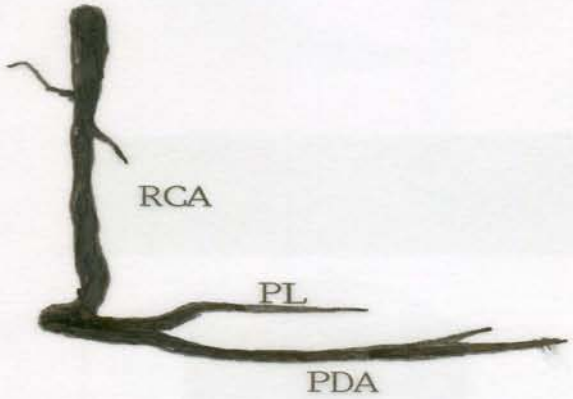


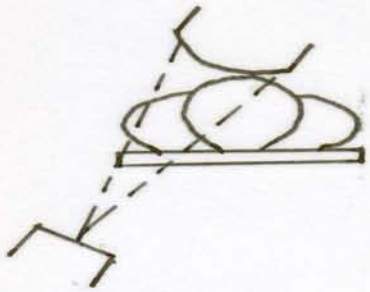
Lateral View



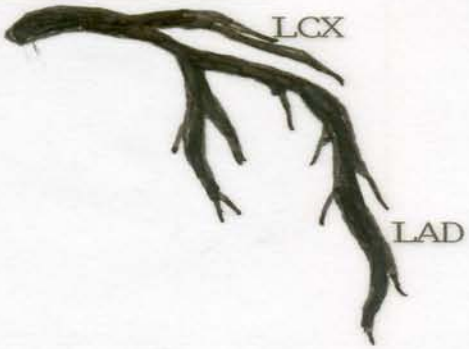
Right anterior oblique view (RAO 30°)



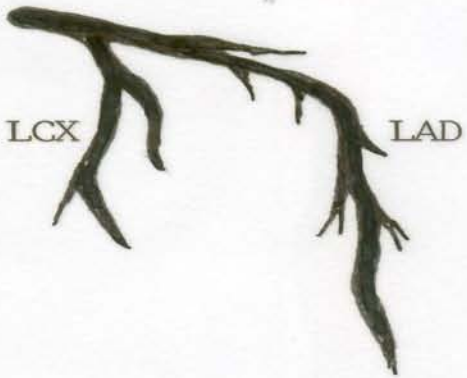




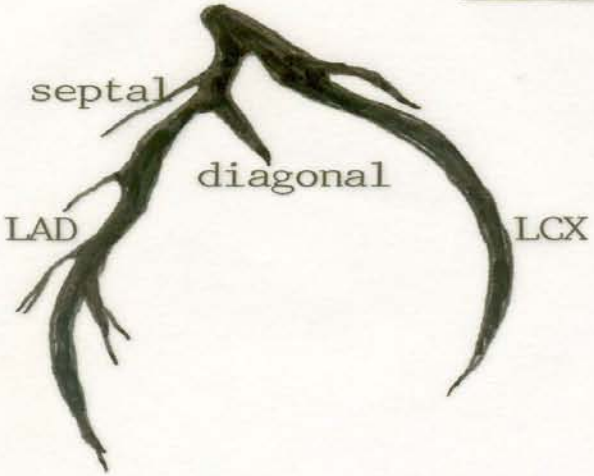
RAO Cranial

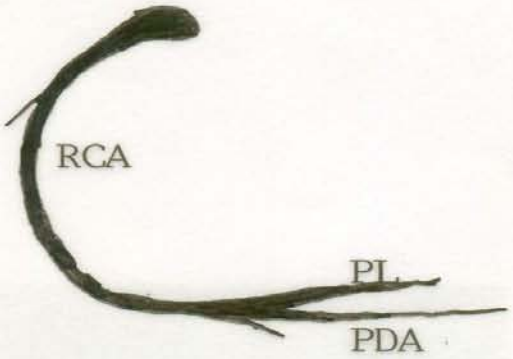


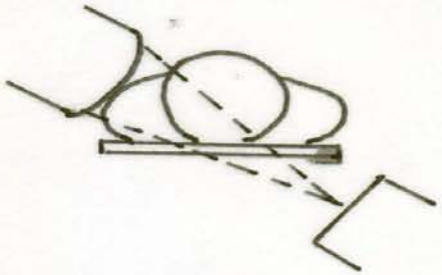
RAO Caudal



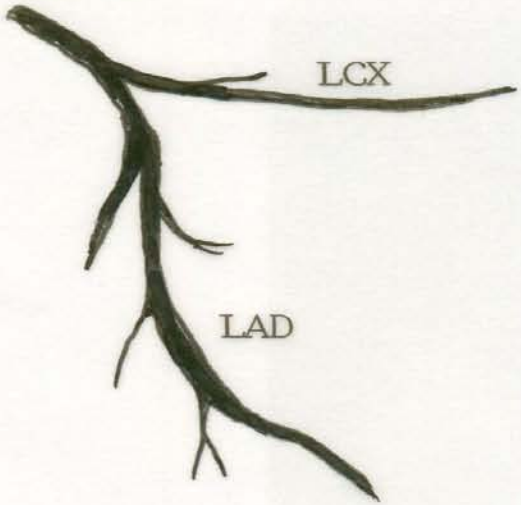
Left anterior oblique view (LAO 55/60°)





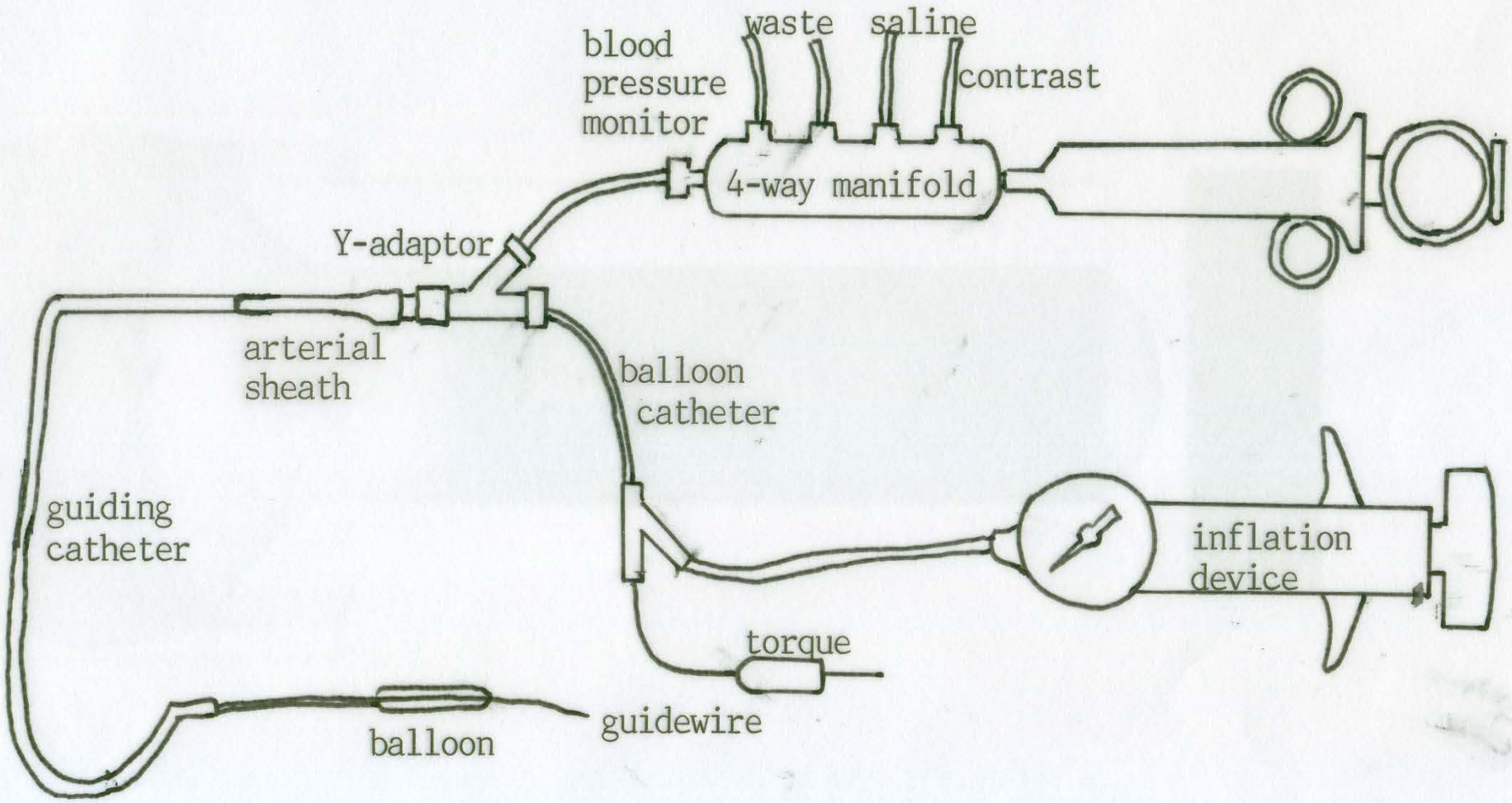


LAO Cranial



LAO Caudal (Spider)

Percutanous coronary intervention equipment



- ***Guiding catheter:*** **usually 4 cm Judkins JL4,JR4, Amplatz AL1, AL2**
  - **seated with tip parallel to artery (coaxial)**

- ***Balloon catheter:*** **select balloon size 1:1 size match with the vessel (for stent 1.1 : 1)**
  - **optimal balloon inflation = balloon pressure to eliminate balloon waist (=balloon indentation), usually 4-12 atm, 1-2 min (cutting balloon 1 atm every 5 sec, max 6-8 atm) (stent 10-18 atm, 10-20 s)**
  - **inflation > nominal pressure (=set pressure for balloon catheter) → 10-20% luminal diameter increase**
  - ***perfusion balloon*** **– with extra lumen for antegrade flow for long-time balloon inflation**
  - ***cutting balloon*** **– microblades along balloon for tight lesion**
  - **profile : low profile in undeployed state**
  - **trackability = ease of advancing balloon over wire**
  - **pushability = ability to push balloon across lesion**

- ***For tight lesion*** → deep seating of guide, advance balloon while pulling back wire, ask patient to take deep breath (elongate heart and vessel less tortuous), change to stiffer wire or add a second wire (buddy wire) alongside the primary wire, change to smaller low profile balloon → often allow balloon to cross lesion.

- ***Failure to dilate a lesion*** → higher inflation pressure, insert a second wire besides the inflated balloon, or use cutting balloon

To untwist a twisted guide (or catheter)

- Move the twisted segment to a larger lumen (aorta)
- Cannulate guide with wire
- Untwist the guide by torquing in opposite direction, while slowly advance the wire to secure the segment just untwisted. Then the damaged guide can be entangled, straightened and removed.

Entrapment of deflated balloon during withdrawal

1. push balloon forward then pull it back
2. twist balloon catheter to rewrap balloon before pulling back
3. add a second wire alongside entrapped balloon and pull it back
4. add a second wire and inflate second balloon (buddy balloon) alongside entrapped balloon and pull it back
5. snaring, loop, forcep etc.
6. surgery = last resort

Guidewires:

- “Choice”=“workhouse” wire. Intermediate or standard wires for total occlusion or severe proximal tortuosity. Soft wire: safe and easier for tortuous vessel. Stiffer wire: better torque for difficult or total occlusion.
- Insert a second wire in addition to the previous one (which persistently entering unwanted branch) may cross the desired lesion
- First cross main branch then pull back wire may “jump” to the desired side branch.
- Better torque control : advance balloon catheter near wire tip

Management for guidewire tip entrapment

- advance balloon over wire then retract wire into balloon catheter
- intracoronary nitroglycerin then gentle retraction of wire

Removal of embolized materials

- ***Removal of wire fragment:***

1. insert 2 or more additional wires into coronary artery → twisting these wires to entrap the wire fragment → remove entire system en bloc.
2. snare, basket, forceps etc

- ***Removal of dislodged stent:***

1. insert second wire through stent struts (not central lumen) → twisting wires to entrap the dislodged stent → remove entire system en bloc
2. low-pressure inflation of stent balloon (if it at least partially within stent) → remove en bloc
3. insert small balloon (1.5 mm) over wire and through stent → inflate balloon distal to stent → retract stent back into guide and remove en bloc
4. snare, basket, forceps etc.

Coronary stents

Indications for stent:-

- Abrupt or threatened vessel closure during PCI, usually due to dissection.
- Restenosis in vessel >2.5 mm
- Focal lesions in vein grafts
- Chronic total occlusion
- Acute myocardial infarction

Contraindications for stent:-

- Small vessel < 2.5 mm
- Vessels with poor distal runoff, or supplying poorly functional myocardium
- Heavily calcified vessels

Managing complications during stent implantation:-

- ***Delivery failure:*** **due to suboptimal guide catheter support, failure to predilate the lesion, tortuosity or calcification of vessel. Management = secure better guide position and backup, additional proximal dilatation, constant forward pressure while pulling back wire, ask patient to take a deep breath, or change to a shorter and better flexibility stent.**
- ***Expansion failure :*** **due to tissue prolapse, calcification, dissection at stent margins, thrombi within or adjacent to stent. Management = higher balloon inflation pressure, use a larger short balloon, or cutting balloon.**

- ***Stent perforation:*** **use a covered stent**
- **When stenting multiple lesions, distal stent first, followed by proximal lesion.**
- **Elective noncardiac surgery postponed for 2-4 weeks after coronary stenting.**

High-risk PCI patients

- ***Angiographic factors:***

  Type A lesion: **discrete, concentric, ready accessibility, nonangulated, smooth, little or no calcification, nonostial, no branch involvement, no thrombus**

  Type B lesion: **tubular, eccentric, moderate tortuosity, moderate angulated, irregular contour, moderate or severe calcification, ostial, bifurcation, thrombus, total occlusion < 3 months old**

  Type C lesion: **difuse, excessive tortuosity, extremely angulated, inability to protect side branch, total occlusion > 3 months old**

- ***Clinical factors:***

  left main, multivessel disease, multi vessel PCI, suboptimal activated clotting time, poor ejection fraction, old age, unstable angina and recent myocardial infarction, diabetes mellutis, renal disease, severe concomitant disease.

- Ad hoc PCI = PCI performed at same time as diagnostic cardiac catheterization
- Routine CK, CKMB, troponin-I 8-12 hours after PCI in all patients. Statins may prevent coronary events
- Stent restenosis = neointimal hyperplasia due to smooth muscle proliferation and extracellular matrix production
- PCI satisfactory result = no major dissection and < 30% residual stenosis
- After PCI, carefully evaluate for residual stenosis, dissection, side-branch occlusion, thrombus, distal emboli, spasm, perforation, no reflow etc.
- "Damping" = catheter engagement obstructing coronary flow → fall in diastolic pressure (="ventricularization") or both systolic and diastolic pressures (="damped pressure"). Causes = ostial lesion, spasm, non-coaxial alignment, mismatch between diameter of catheter and arterial lumen (if small coronary → use perfusion catheter). If still inject contrast → dissection

Thrombolysis in myocardial infarction (TIMI) flow

Grade 0 (no distal runoff)	**no contrast flow through the stenoses**
1 (poor distal runoff)	**small contrast flow through stenoses (fail to fully opacify the artery)**
2 (good distal runoff)	**contrast enters terminal segment slower than proximal**
3 (normal distal runoff)	**contrast enters terminal segment as prompt as proximal**

Grading of coronary artery dissection

Type A : minor radiolucency within lumen

B : parallel tracts or double lumen

C : extraluminal cap with persistent contrast

D : spiral filling defects

E : new persistent intraluminal filling defects

F : total occlusion without distal antegrade flow

Complications of percutanous coronary interventions

- Acute vessel closure 8% (due to dissection, thrombus, spasm).Majority occurring while still in cath room, leading to acute myocardial infarction 3-5% (usually due to side branch occlusion),emergent coronary bypass surgery 3%,death 1%
- Coronary artery emboli or perforation
- Coronary ostial dissection with guiding catheter. Retrograde ascending aortic dissection (if < 40 mm → medical treatment; if > 40 mm → surgery)
- Ventricular tachyarrhythmia, severe angina, transient hypotension, allergy reaction to contrast, contrast nephropathy, local vascular access site complication: bleeding, arterial change, thrombus.

Complications of percutanous coronary interventions

MACE = major adverse cardiac event

- ***Acute threatened coronary closure (8%) :-***
  occurs within 6 hours of intervention

Causes: Suboptimal PCI, inducing injury of coronary artery (eg. intimal dissection, side branch occlusion, interruption of endothelium → local activation of coagulation cascade (thrombosis), spasm (recoil)

Treatment: stenting (most successful), perfusion balloon inflation

Slow flow or no reflow (0.5-3%)

Causes: **distal embolization, microcirculatory vasoconstriction,**

- plugging from fibrin, platelet, thrombus, leukocyte

- microcirculatory structural damage or edema

Treatment: **GpIIb/IIa blockers, heparin, vasodilators (nitroglycerin 100-200 ug, adenosine 18-40 ug repeatedly, isoptin 125-250 ug , nitroprusside 50-200 ug, bolus intracoronarily)**

Coronary artery perforation (0.2-0.6%)

= emergency !

Treatment:

1. Balloon inflations = emergency first action. Inflation of balloon proximal to perforation, or perfusion balloon at site of perforation
2. Prompt control of bleeding (eg. pericardiocentesis if necessary)
3. Reverse anticoagulation.
   Use protamine for heparin.
   All anticoagulants can be reversed by fresh frozen plasma and platelets.
4. Solve the problem:
   - small perforation → prolonged balloon inflations, reverse anticoagulation
   - large perforation → covered stent (14-16 atm, most effective)
   - surgery = last resort

Intraaortic balloon pump (IABP) counterpulsation during high-risk percutanous coronary interventions

- ***Indications:***

  very poor ejection fraction
  hemodynamic instability
  hypotension, cardiogenic shock
  intractable arrhythmias due to ischemia

- ***contraindications:***

  severe iliac/femoral atherosclerotic disease or tortuosity
  aortic dissection or aneurysm
  moderate or severe aortic regurgitation
  bleeding diathesis
  sepsis
  patent ductus

Percutanous coronary interventions for acute myocardial infarction

Treatment of choice for STEMI =

- Primary PCI, to prevent stroke. Facilitated PCI (PCI after initial half-dose fibrinolytic) not recommended. Rescue PCI if thrombolysis failed within 45-60 min. If thrombolysis successful, PCI within 24 hr.
- Coronary bypass surgery in patients with left main, left main equivalent, and severe multivessel disease not suitable for PCI.
- Aspiration device and distal embolic protection NOT routinely recommended for primary PCI, because clinical outcomes no extra improvement.
- stents not indicated in thrombus-laden lesions, because of risk of in-stent thrombosis

- ***PCI for STEMI with current bleeding:***

  - PCI with standard dose of heparin to achieve ACT 250-300. No stent and no heparin after PCI.

  - Contraindication = intracranial, lower intestinal, esophageal variceal bleeding

- ***PCI for STEMI with cardiogenic shock:***

  Open infarct-related (=culprit vessel) immediately.

  May also include noninfarct vessel if it perfuses a large myocardium and the procedure can be performed efficiently.

- ***PCI for unstable angina:***

  Open culprit lesion as initial approach, then subsequent elective interventions at lower risk.

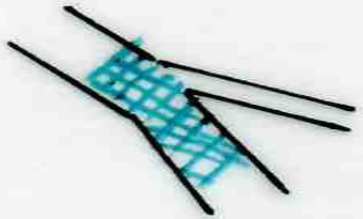
PCI for bifurcation lesions

- Double balloon PCI → sequential or “kissing balloon” dilatations. To avoid wire crossing, wire the most difficult branch (usually the side branch) first.

Bifurcation stenting techniques

1. ***One-stent technique:***

   if side branch small or occlusion
   low risk

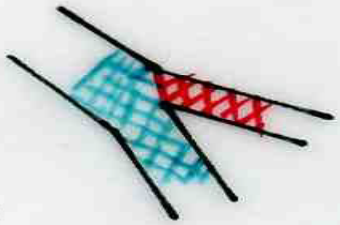


2. ***Stent balloon technique:***

   stent main branch and balloon
   angioplasty side branch when
   needed

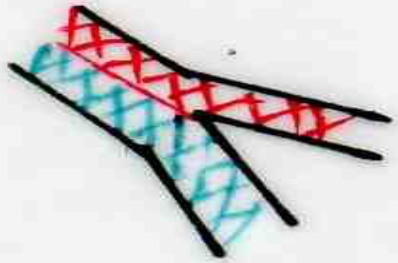
3. ***T stent technique:***

   stent main branch first, then
   stent side branch through the
   stent struts when side branch
   suboptimal or dissect after balloon
   angioplasty



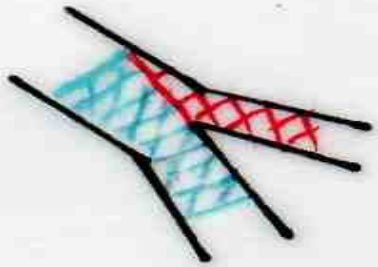
4. ***Kissing stent technique (V stenting):***

simultaneous stent bifurcation side by side



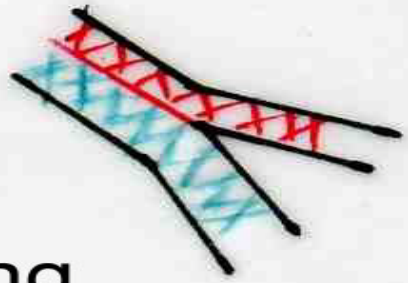
5. ***Crush stent technique:***

simultaneous advance 2 stents into bifurcation. Stent proximal segment of side branch first, then crushed to main branch after stenting the main branch



6. ***Cullotte stent technique:***

stent most diseased branch first, then simultaneous kissing stent bifurcation through stent struts



PCI for multivessel disease

- ***Complete revascularization:***

  PCI all lesions > 70% stenoses. Ideal goal.

- ***Incomplete revascularization:***

  If no ventricular dysfunction, PCI only culprit lesion (with viable myocardium responsive to ischemia) to reduce complications and restenoses.

- ***Staged PCI*** preferred (lower risk). Dilate the most difficult lesion, culprit lesion, and lesions supplying largest myocardium first. If collaterals exist, dilate the recipent vessel first.

PCI for long stenoses:

>20 mm length. Higher rate of abrupt closure and restenoses.

- Use long balloon. Dilate distal lesion first, then the proximal. If proximal lesion severe or tight, dilate proximal lesion first.

Chronic total occlusion

= atherosclerotic plague with complementary thrombi (undergoing organization, fibrosis and calcification). The most recent thrombus obstructs the last lumen (= best site for wiring)

- total occlusion (TIMI flow 0 or 1) > 3 months or bridging collaterals present
- yearly mortality about 10%. Successful recanalization →5%
- “spontaneous recanalization” of chronic total occlusion may occur because of : lysis of clot, new channels through thrombus (=intra-arterial arteries), dilatation of vasa vasorium, or combination. Such spontaneous recanalization produce antegrade flow.

PCI for chronic total occlusion

- “stump” or tapered segment as “entry port”. If no stump, try center of stump.
- clues to improper guidewire position = loss of free rotation, advancement and retraction of wire, unable to advance balloon through occlusion
- inflate balloon at most distal position achievable or at a side branch proximal to stump
- abandon the procedure when fluoroscopic time >30 min or too much contrast used > 300 ml. Further attempt few months later.

PCI for restenoses

- Higher procedural success rate and lower complication
- Stents reduce recurrent restenoses and preferred.

PCI for prior coronary bypass surgery

- ***Early postoperative ischemia (<1 month after surgery):***
  usually due to acute vein graft thrombosis, wrong bypassed vessel, incomplete revascularization, stenoses distal to graft insertion.
- ***Ischemia 1 to 12 months after surgery:***
  perianastomotic stenoses
- ***Ischemia 1 to 3 years after surgery:***
  new stenoses in graft and native coronaries, amenable to PCI.
- ***Ischemia more than 3 years after surgery:***
  atherosclerosis in graft and native coronaries, amenable to PCI.

- At 10 years, only 40% of patent grafts are free of significant stenoses.
- Deterioration of native vessel and graft lumina need revascularization
- Guiding catheter = right Judkins, left Amplatz AL1, AL2

Management:-

- **Whenever possible → PCI. If multivessel, severe vein graft disease, poor ventricular function → consider reoperation.**
- **Whenever possible, native vessel PCI. Restrict graft PCI (more elastic recoil and complications) to:-**
  1. **AMI after bypass surgery (60-70% culprit vessel = vein graft)**
  2. **unbypassed native vessel**
  3. **graft-native vessel anastomosis lesions**
  4. **focal, non-bulky graft lesions**
  5. **distal anastomoses < 3 years old**
  6. **graft < 3 years old**
  7. **distal native vessel reached through fully patent graft**

Complication **= abrupt closure, distal embolization, no reflow, coronary artery perforation**

- **Embolic protection routinely used for graft PCI (to avoid no reflow)**