Percutaneous Coronary Interventions and Other Interventional Procedures

Chapter 287 | Part 6: Disorders of the Cardiovascular System

KEY CLINICAL POINTS

1. Dual antiplatelet therapy (DAPT) with aspirin and a P2Y12 inhibitor is recommended for 12 months after STEMI in the absence of high bleeding risk.
2. Drug-eluting stents (DES) reduce clinical restenosis by 50% compared to bare metal stents, with symptomatic restenosis occurring in 5–10% of patients in uncomplicated lesions.
3. The ISCHEMIA trial confirmed that optimal medical therapy is similar to revascularization (PCI or CABG) for stable patients with moderate ischemia and no left main disease or reduced LV function.
4. Complete revascularization of all functionally significant lesions (FFR ≤0.80) is favored over treating only the culprit lesion in multivessel disease (COMPLETE trial).
5. TAVR is an effective treatment for low-, intermediate-, high-, and extreme-risk patients with severe symptomatic aortic stenosis, showing similar outcomes to surgery in randomized trials.
6. Stent thrombosis occurs in 1–3% of cases, with premature discontinuation of DAPT increasing risk three- to nine-fold.
7. In patients with diabetes and multivessel disease, CABG showed significantly lower primary endpoints (death, MI, stroke) compared to PCI (FREEDOM trial).
8. Intravascular imaging (IVUS, OCT) optimizes stent diameters and reduces delayed complications like in-stent restenosis and thrombosis.
9. Rotational atherectomy is useful for heavily calcified plaques resistant to balloon dilatation, while IVL catheters fracture calcium to enhance stent deployment.
10. Percutaneous closure of atrial septal defects (ASD) and patent foramen ovale (PFO) is indicated for recurrent paradoxical stroke or TIA despite medical therapy.

1. DEFINITION & OVERVIEW

- **Percutaneous Coronary Intervention (PCI):** The most common revascularization procedure; performed more than twice as often as coronary artery bypass surgery (>900,000 patients a year).
- **Scope:** Includes structural heart disease (congenital and valvular) and peripheral vascular disease.
- **Historical Evolution:**
  - 1964: Concept demonstrated by Charles Dotter in peripheral vessels.
  - 1977: Percutaneous transluminal coronary angioplasty (PTCA) introduced by Andreas Gruentzig.
  - 1994: Introduction of coronary stents → reduced acute complications and late restenosis by half.
  - 2003: Drug-eluting stents (DES) introduced → further reduction in restenosis.
  - Current Status: Nearly 100% of stents placed today are DES.

2. EPIDEMIOLOGY

- **Utilization:** Over 900,000 PCI procedures performed annually in the United States.
- **Scope Expansion:** Interventional cardiology has expanded from coronary interventions to include structural heart disease and peripheral vascular disease.
- **Effectiveness:** Percutaneous interventions for arterial obstruction in carotid, renal, aortic, and peripheral vessels are effective alternatives to surgical options.

3. ETIOLOGY & PATHOPHYSIOLOGY

- **Mechanism of Action:** Stretches the artery, displaces plaque away from the lumen, and enlarges the vessel.
- **Balloon Angioplasty Effects:** Results in small, localized dissections that can protrude into the lumen → potential nidus for acute thrombus formation.
- **Stent Function:** Holds dissection flaps against the vessel wall to prevent elastic recoil.
- **Restenosis Mechanisms:**
  - Neointimal Hyperplasia: Excessive growth over stent leads to restenosis.
  - Drug-Eluting Stents (DES): Release antiproliferative drugs into the plaque over a 1–3 month period → reduces neointimal growth.
  - Neoatherosclerosis: Primary cause of very late restenosis (>1 year).
- **Restenosis Rates:**
  - Balloon angioplasty alone: 20–50%.
  - Bare metal stents (BMS): 10–30%.
  - Drug-eluting stents (DES): 5–15% within the first year.
- **Stent Types:**
  - Bare Metal Stents: Wire meshes (stainless steel, cobalt chromium, nitinol).
  - Drug-Eluting Stents (DES): Antiproliferative agent attached via thin polymer coating; includes 1st generation (sirolimus, paclitaxel) and 2nd generation (everolimus, biolimus, zotarolimus).
  - Drug-Coated Balloons (DCBs): Covered with antiproliferative drug; primarily used to treat in-stent restenosis.

4. CLINICAL FEATURES

- **Clinical Restenosis:** Recognized by recurrence of angina or symptoms within 12 months.
  - NSTEMI: Occurs in 10% of cases.
  - STEMI: Occurs in 2% of cases.
  - Requirement: Significant stenosis at the site of prior PCI.
- **Risk Factors for Restenosis:**
  - Diabetes
  - Myocardial infarction
  - Long lesions
  - Small-diameter vessels
  - Suboptimal initial PCI result.

5. DIFFERENTIAL DIAGNOSIS

- **Restenosis Etiology:** Neoatherosclerosis vs. intimal hyperplasia.
- **Causes of Acute Closure:**
  - Acute occluding thrombus.
  - Severe coronary dissection.
  - Embolization of thrombus or atherosclerotic material.
  - Closure of a side branch vessel at the site of angioplasty/stent placement.
- **Stent Thrombosis:**
  - Acute (<24 h) or subacute (1–30 days) events; risk increased 3- to 9-fold by premature DAPT discontinuation.

6. INVESTIGATIONS & DIAGNOSIS

1. **Pre-Procedure Evaluation:**
   - LV Function: Evaluated via echocardiography, cardiac MRI (using gadolinium), or nuclear myocardial perfusion imaging.
2. **Medication Preparation:**
   - Aspirin: 325 mg.
   - P2Y12 Inhibitors: Clopidogrel (600 mg), Prasugrel (60 mg), Ticagrelor (180 mg).
   - Cangrelor: Potent IV P2Y12 inhibitor for patients not receiving an oral agent prior to procedure.
   - Anticoagulation: Unfractionated heparin, enoxaparin, or bivalirudin.
   - Glycoprotein IIb/IIIa Inhibitors: Tirofiban or eptifibatide (STEMI, high-risk ACS, or large thrombus).
3. **Intravascular Imaging:**
   - IVUS: Piezoelectric ultrasound; provides info on optimal treatment strategy and improves long-term durability.
   - OCT: Near-infrared light; higher resolution than IVUS.
   - Purpose: Optimize stent diameters and reduce risk of in-stent restenosis and thrombosis.
4. **Lesion Assessment:**
   - Classification:
     - Type A: High success (e.g., proximal noncalcified subtotal lesions).
     - Type B1/B2: Intermediate success based on unfavorable characteristics.
     - Type C: Low success/high complication (e.g., chronic total occlusions).
   - Functional Assessment:
     - FFR ≤ 0.80: Hemodynamically significant lesion.
     - iFR: As predictive as FFR but quicker and easier to perform.

7. MANAGEMENT & TREATMENT

1. **Post-Procedure Care:**
   - Recovery: Generally <24 h.
   - Discharge: Same day for elective; 3–5 days for uncomplicated STEMI.

- Activity: Increase activity (walking) during first 1–2 weeks; resume sexual activity.
- Work: Return to work typically within 2–4 weeks.

2. **Secondary Prevention:**
   - Aspirin: Indefinite use → 25% reduction in risk of recurrent infarction, stroke, or mortality.
   - DAPT: Recommended for 12 months after STEMI (unless high bleeding risk).
   - ACE Inhibitors/ARBs: Indefinite if HF, reduced LVEF, or large regional wall motion abnormality.
   - Beta-Adrenoceptor Blockers: At least 1 year post-STEMI.
   - Colchicine: 0.5 mg once daily (consider for STEMI with recurrent events).
3. **Structural Heart Interventions:**
   - ASD: Closure via wire mesh or covered disk; success rate 85–95%.
   - PFO: Closure for recurrent paradoxical stroke/TIA despite medical therapy.
   - Mitral Valve: Valvuloplasty (rheumatic stenosis); TEER (MitraClip, PASCAL) for severe regurgitation.
   - Aortic Valve: TAVR effective for low-, intermediate-, high-, and extreme-risk patients.
   - Pulmonic Stenosis: Balloon valvuloplasty or Melody valve replacement.
   - Tricuspid Valve: TEER and replacement devices.
4. **Advanced & Peripheral Interventions:**
   - Rotational Atherectomy: Used for heavily calcified plaques resistant to balloon dilation.
   - Intravascular Lithotripsy (IVL): Catheters fracture calcium to enhance stent deployment.
   - Carotid Stenting: For high-risk patients not candidates for endarterectomy.
   - Peripheral Artery: Use of DCBs and stents to treat segments previously only amenable to surgery.

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8. PROGNOSIS & COMPLICATIONS

- **Stent Thrombosis:**
  - Incidence: 1–3%.
  - Risk Factor: Premature DAPT discontinuation (first month) → 3- to 9-fold increased risk.
  - Outcomes: Death in 10–20%; MI in 30–70% of cases.
- **Restenosis Rates:**
  - Balloon Angioplasty: 20–50%.
  - Bare Metal Stents (BMS): 10–30%.
  - Drug-Eluting Stents (DES): 5–15% within first year.
- **Clinical Trial Outcomes:**
  - SYNTAX Trial: No difference in death/MI at 1 year; higher repeat revascularization in stent group; higher stroke in surgery group.
  - FREEDOM Trial: CABG superior to PCI in patients with diabetes and multivessel disease.
  - ISCHEMIA Trial: Optimal medical therapy (OMT) similar to revascularization for stable patients with moderate ischemia, no LM disease, and preserved LV function.

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9. SPECIAL CONSIDERATIONS

- **Patient Selection:**
  - Unfavorable Anatomy: 25–30% of patients not candidates for PCI.
  - CABG Inoperability: Only 5% of patients not candidate for surgery due to anatomy.

– Comorbidities: Advanced age, frailty, severe COPD, poor LV function → favor medical management or specific interventions.

- **Revascularization Strategy:**

  – Multivessel Disease: Complete revascularization of all functionally significant lesions (FFR ≤ 0.80) is favored.

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10. KEY PEARLS & CLINICAL TRAPS

- **DAPT Duration:** 12 months for STEMI; avoid premature discontinuation in first month to prevent stent thrombosis.
- **Stent Thrombosis Risk:** Premature DAPT cessation → 3–9x risk increase.
- **Restenosis Drivers:** Diabetes, MI, long lesions, small vessels, and suboptimal initial PCI result.
- **TAVR Efficacy:** Effective for all risk levels (low to extreme) in severe symptomatic aortic stenosis.
- **Clinical Decision Making:** Use of 'Heart Team' to weigh risks of CABG vs. PCI.