Advances in Cardiology and Cardiac Interventions

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Cardiology is never static…

- "what we can do."
- "what we should do"

The future appears very promising…

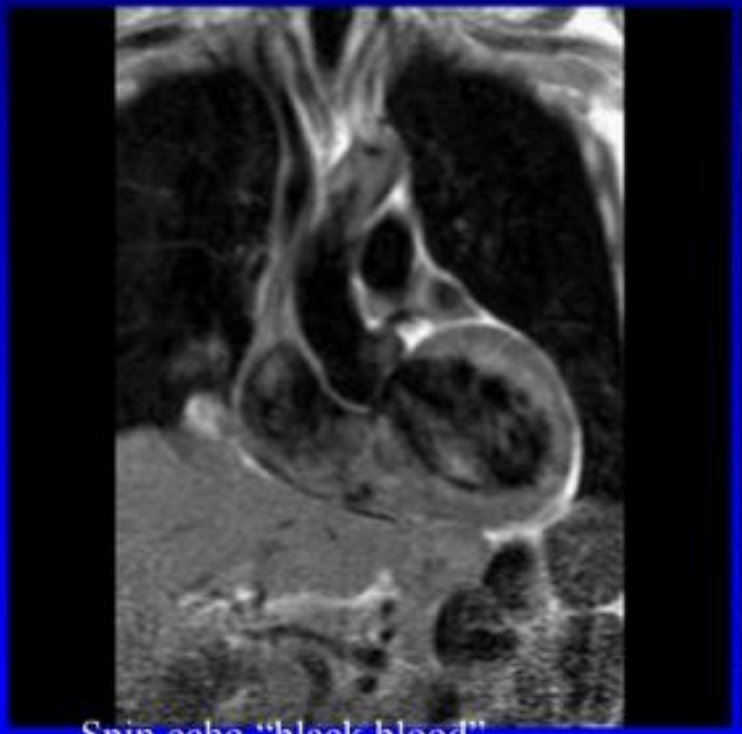
- Diagnostics
- Therapeutics

DIAGNOSTICS

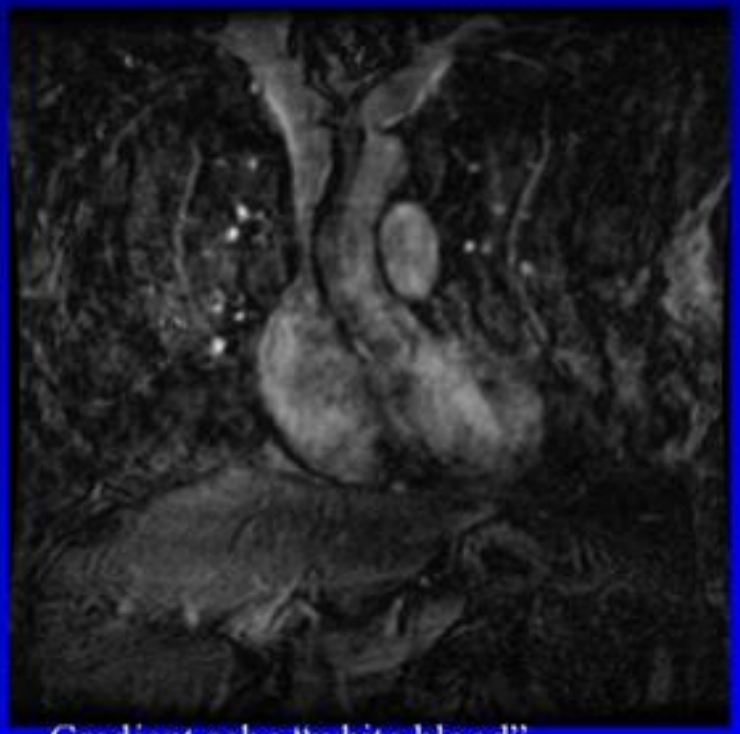
Cardiac MRI

- Cardiac and great vessel anatomy
- Cardiac volumes and mass
- Global and regional contractile function
- Regional myocardial tissue perfusion
- Regional myocardial tissue characteristics: Viability, oedema, inflammation, fibrosis, metabolism
- Coronary artery lumen, wall anatomy, blood flow

Coronal MRI shows aorta, av, lv (can eval for stenosis and regurg)



Spin echo "black blood" anatomy

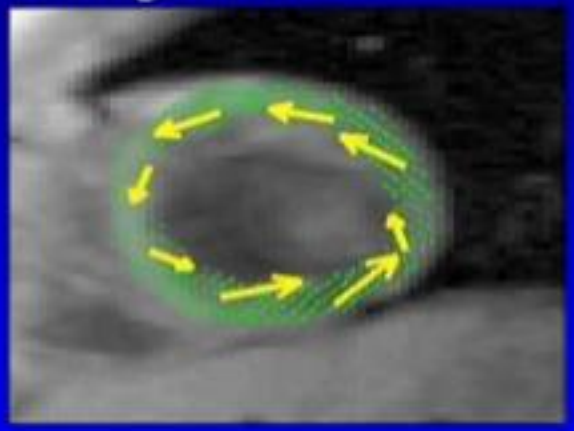


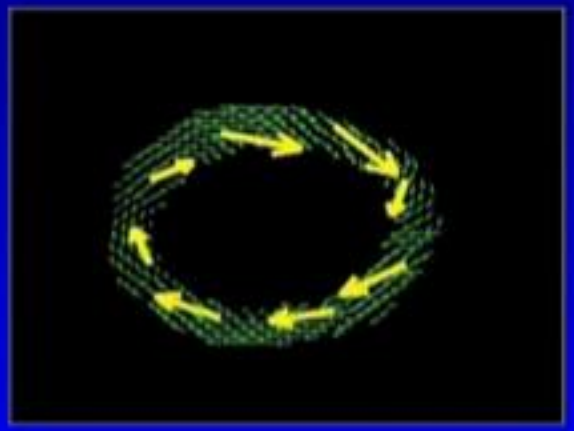
Gradient echo "white blood" function & flow

Regional Tissue Contractility

Tissue Phase Mapping

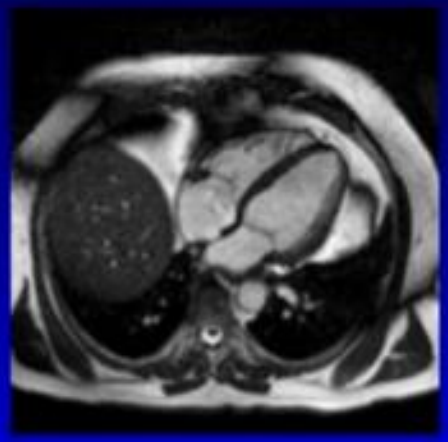
3D Velocities: Radial, circumferential, longitudinal



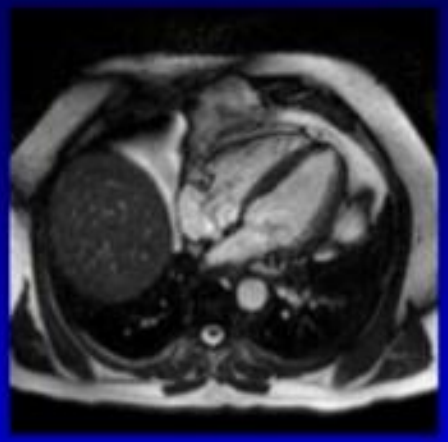


Dobutamine-Stress MR: 4-Chamber

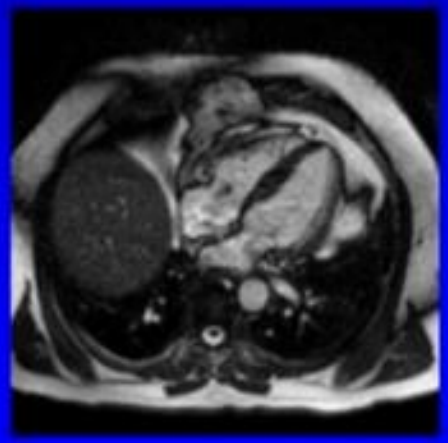
rest



20 µg



30 µg



40 µg

Delayed Enhancement MRI

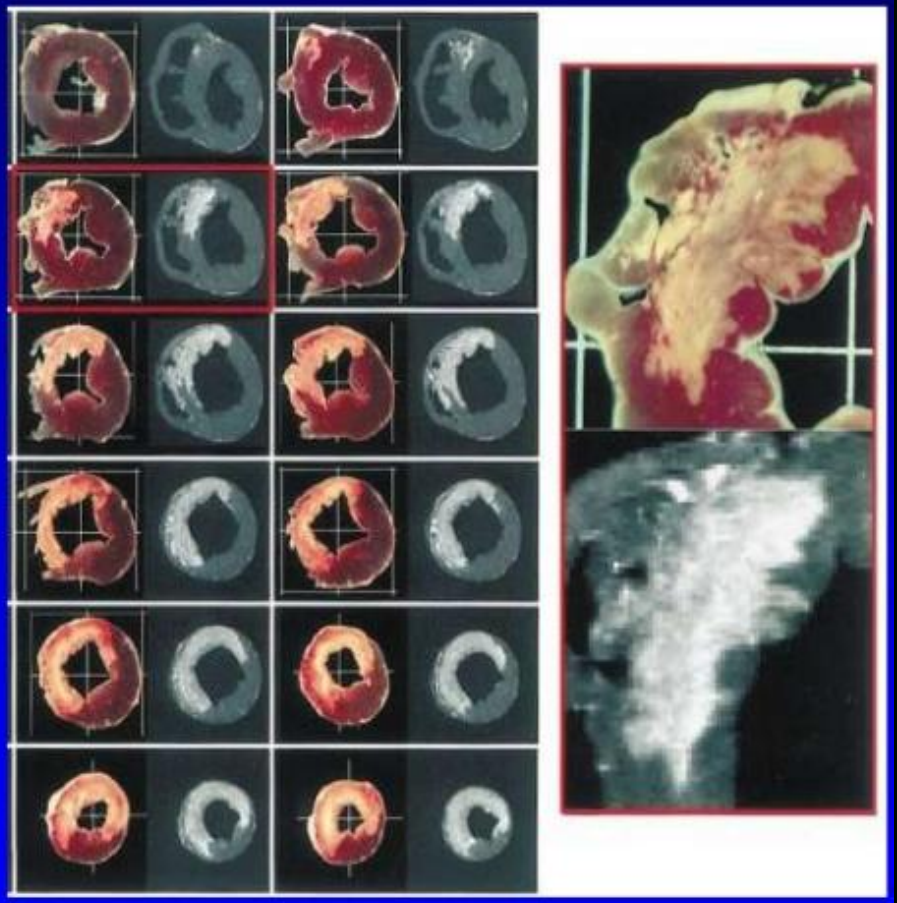
10 – 20 min post Gd DTPA

Inversion recovery

FLASH or True FISP

"Bright is dead"

Normal, stunned, hibernating myocardium is dark



Delayed Enhancement MRI

In vivo infarct imaging

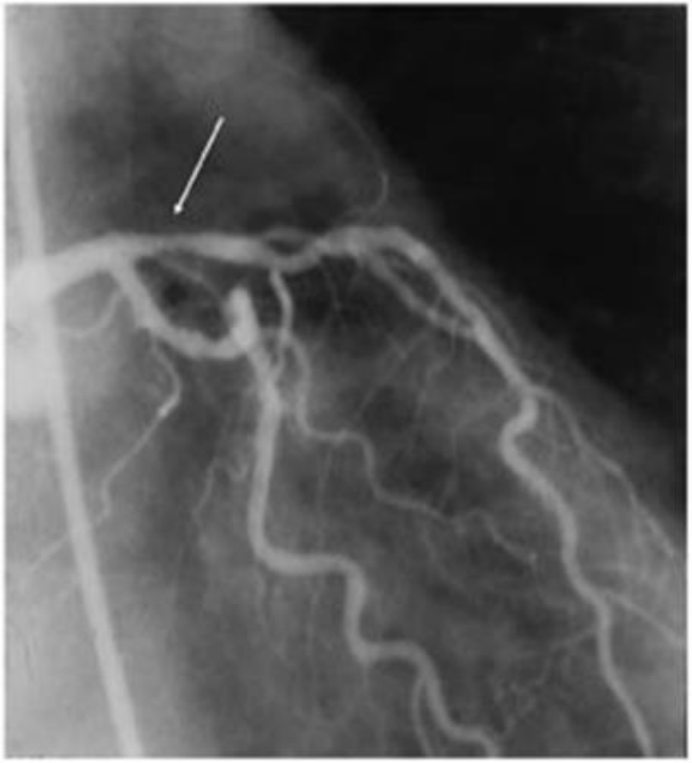
FFR, IVUS, OCT

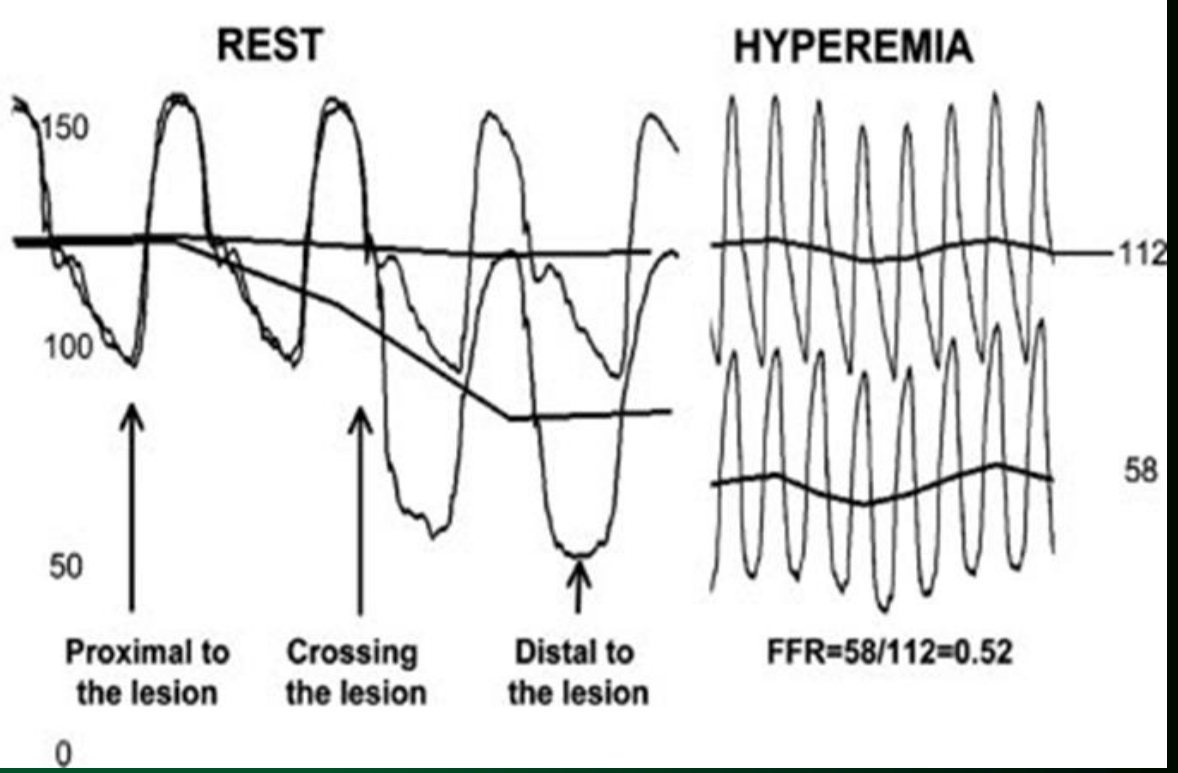
Limitations of CAG ….

- Intermediate lesion (40-70%) significance cannot be accurately determined
- Won’t provide intraluminal detail ; vessel wall details ;
- diffuse disease, angiographic artifacts of contrast streaming, image foreshortening and calcification often complicates the interpretation ;
- Bifurcation or ostial lesion locations may be obscured by overlapping branch

FFR(Fractional Flow Reserve)

- Gold standard for invasive assessment of physiologic stenosis significance.
- Ratio of the coronary pressure distal to the stenosis to aortic pressure as the normal perfusion pressure (distal coronary pressure/aortic pressure) when the microvascular resistance was minimal and assumed to be constant (ie at maximal hyperemia).
- Normal value of FFR - 1
- FFR <0.75 …. inducible myocardial ischemia [88% sensitivity, 100% specificity, 100% positive predictive value and overall accuracy 93%]



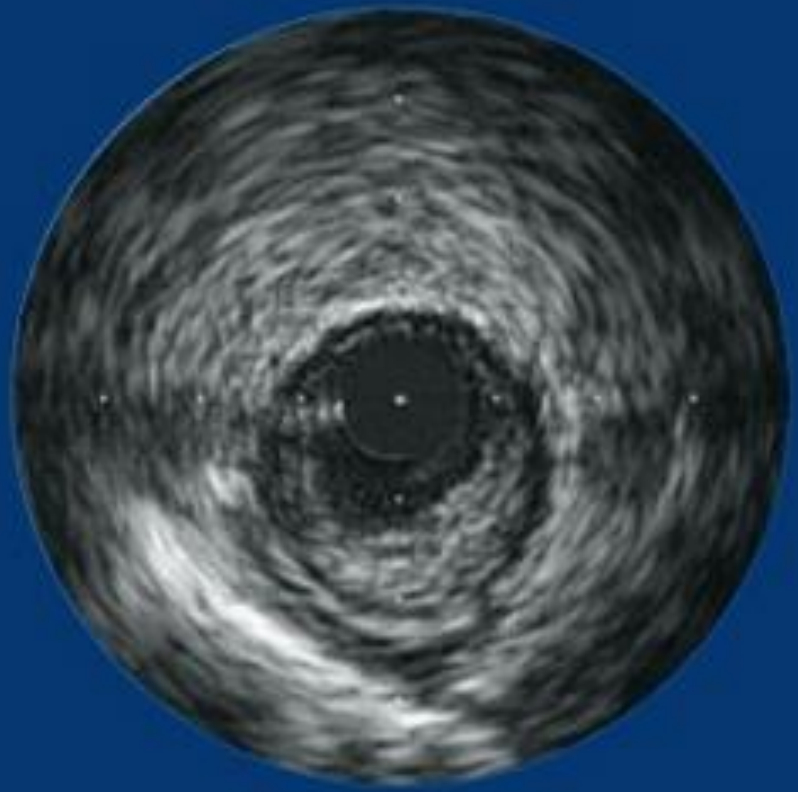


- In this example….During maximal hyperemia (at the right side of the pressure tracing), the hyperemic distal pressure decreased to 58 mm Hg with aortic pressure of 112 mm Hg for an FFR of 0.52 (58/112).
- Maximal blood flow to the myocardium of the anterior wall of this patient is decreased to 52% of expected normal flow.

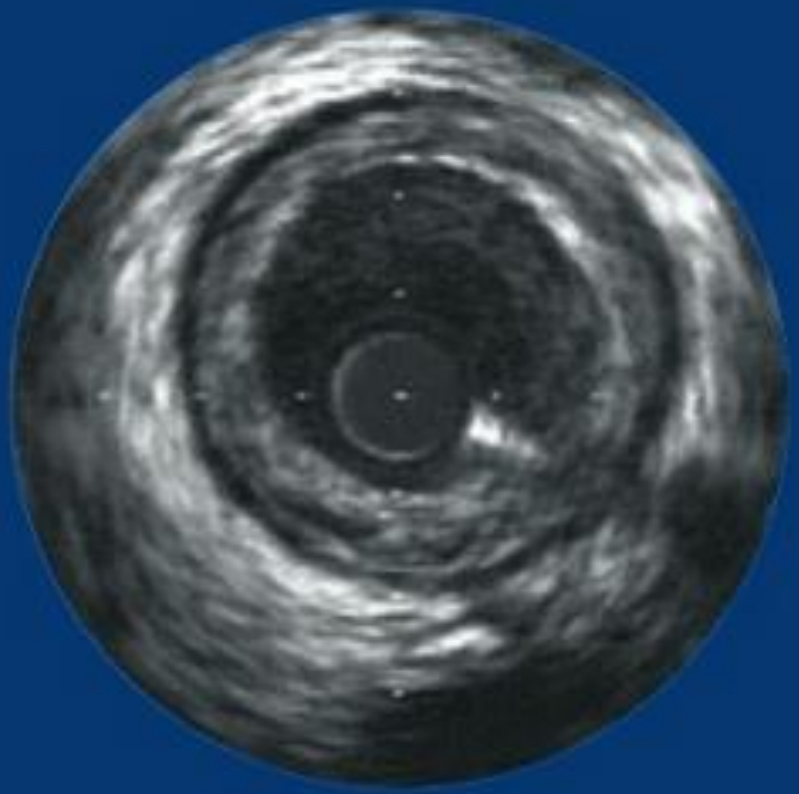
IVUS to guide PCI :

- plan interv strategy & to optimise stent deployment…..
- find reference lumen dimensions and lesion length for appropriate stent sizing;
- identification of superficial calcium
- Assess thrombus burden
- Post-stent IVUS assessment may detect complications of PCI and suboptimal stent deployment
- Addition of radio frequency backscatter signal analysis allows for improved characterization of plaque composition1)virtual histology IVUS 2) iMAP 3) Integrated Backscatter IVUS

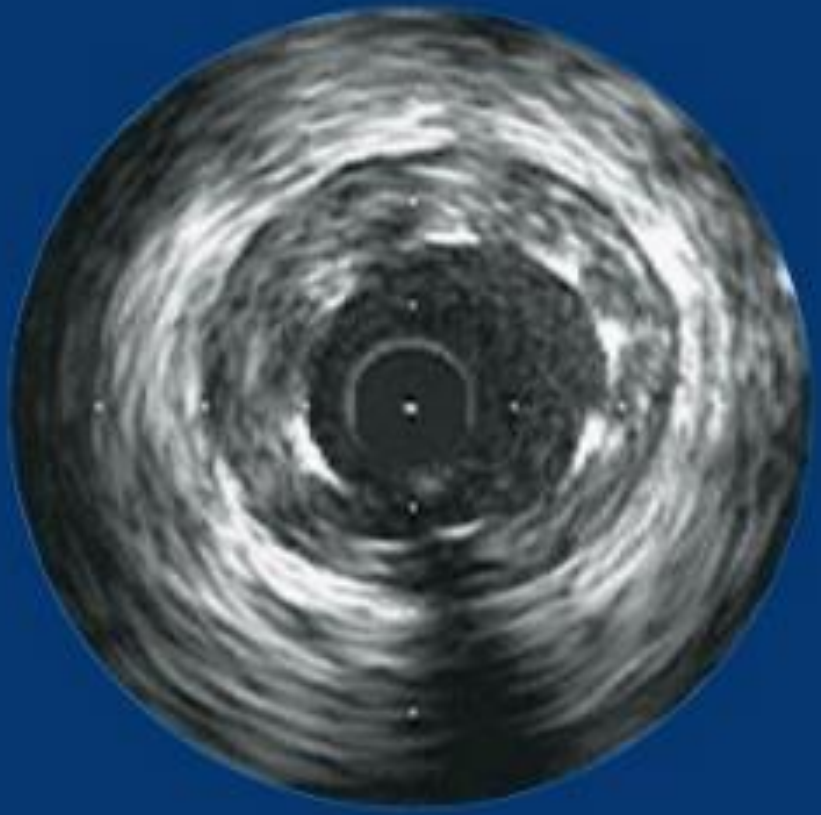
IVUS images



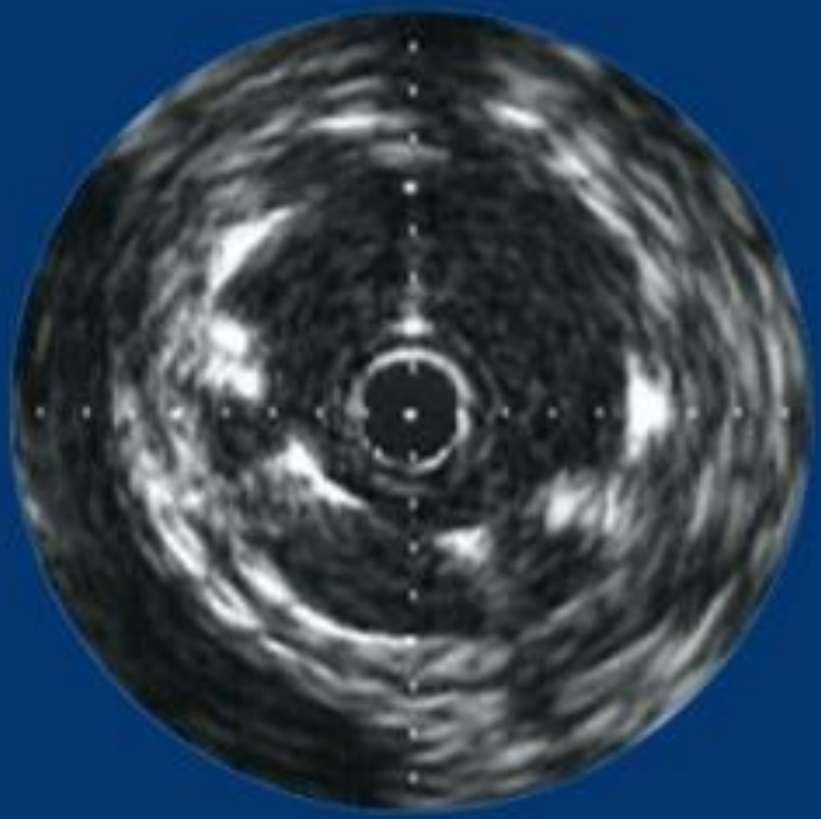
Eccentric fibrous plaque



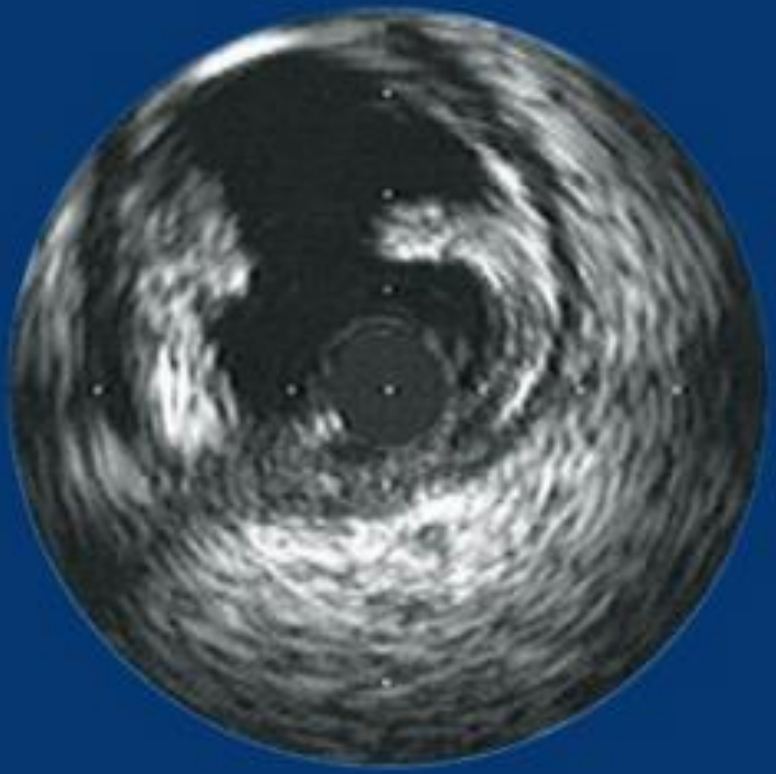
Concentric fibro-fatty plaque



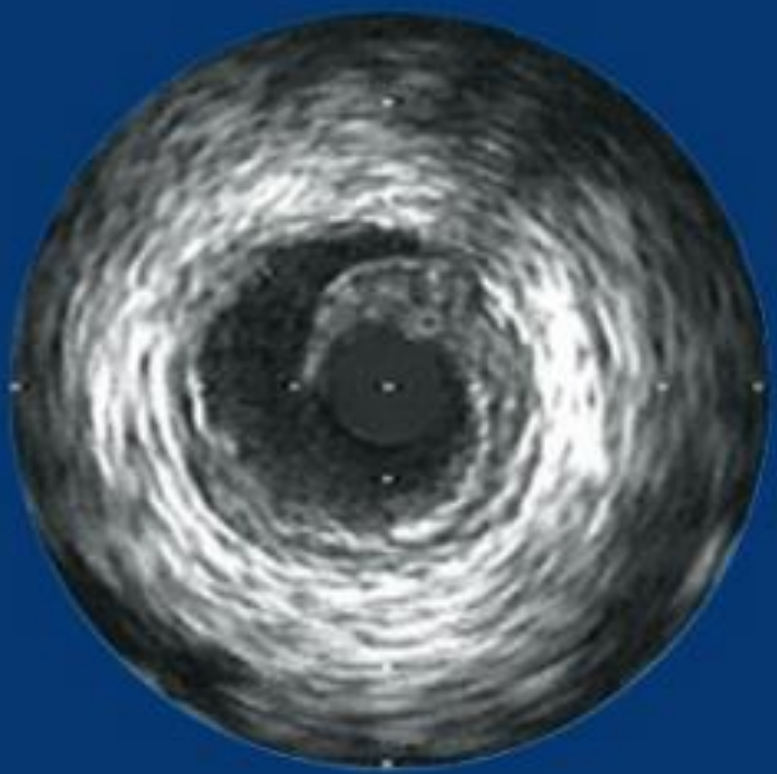
Fully apposed stent



Incompletely apposed stent



Fibrous plaque dissection extending into the intima

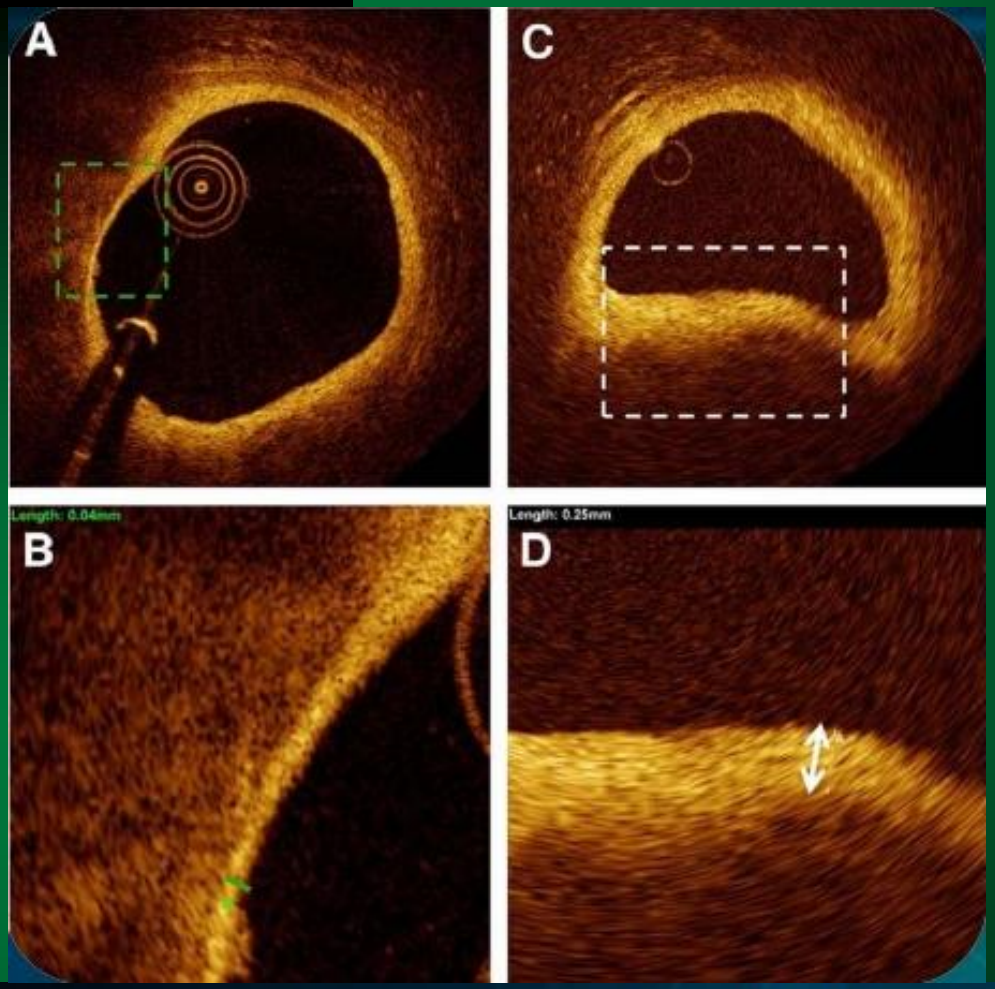


Deep fibro-fatty plaque dissection extending into the media

OCT

- ACS ------ Rupture of a coronary plaque .
- Detection of lesions at high risk of rupture (so called "vulnerable plaques") is of major importance for the prevention of future ACS.
- OCT --- one of the most promising --- provides unique information about the plaque composition, the presence of macrophages, and the thickness of the fibrous cap

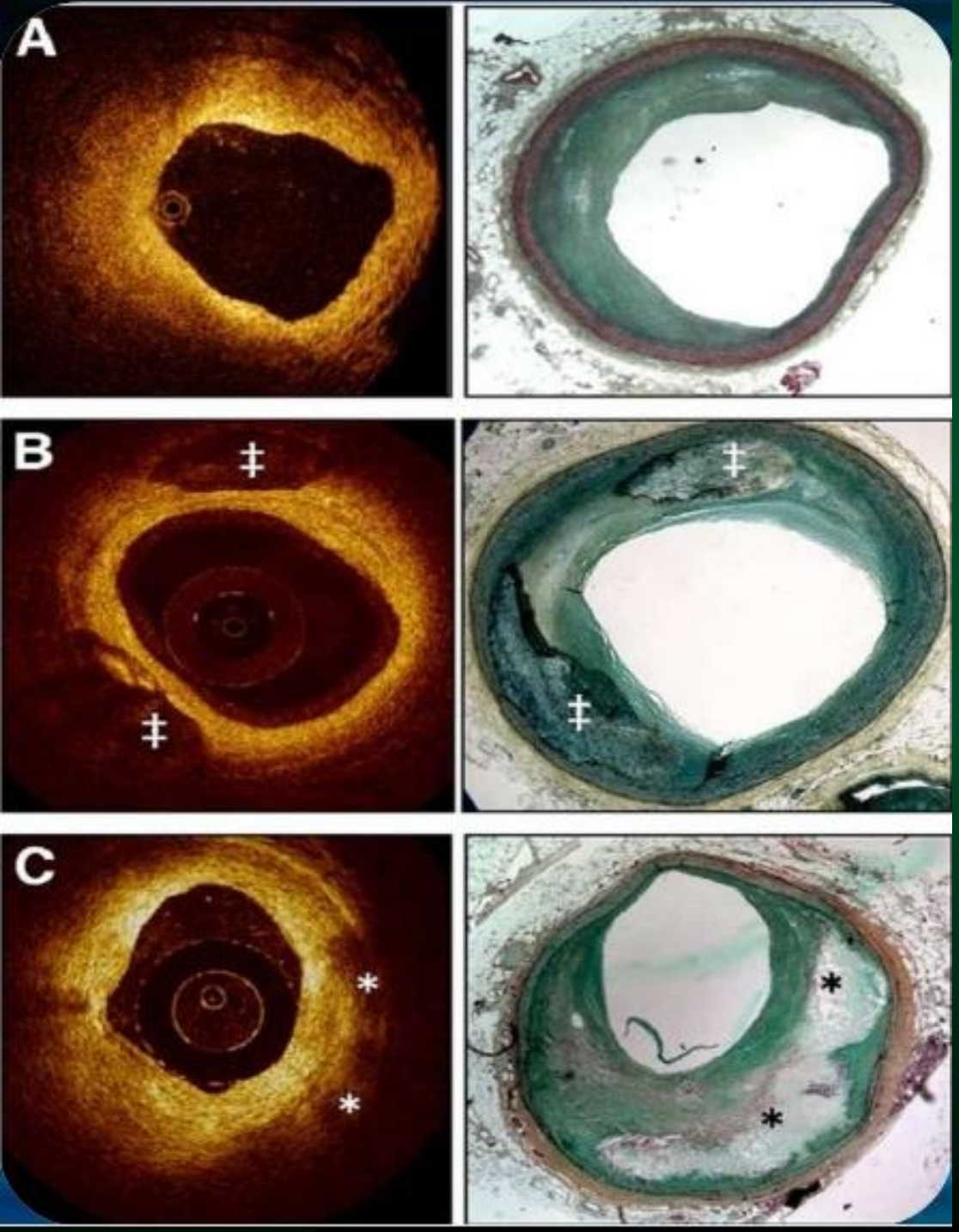
- **Fibrous plaques** -- homogeneous, signal-rich regions
- **Fibro - calcific plaques** --- signal-poor regions/ sharp borders
- **Lipid-rich plaques** ---signal-poor regions with diffuse borders



OCT images

- Thin capped fibroatheromas (TCFA) - defined pathologically by the triad of:

- ❑ **Lipid core.**
- ❑ **Fibrous cap with a thickness < 65 micron m.**
- ❑ **Cell infiltration of the fibrous cap.**



OCT- Histology co-relation

NUCLEAR CARDIAC IMAGING

Available for the evaluation of -

- **Myocardial Perfusion**
- **Ventricular Function**
- **Cardiac Metabolism**
- **Myocardial Viability**
- **Myocardial Innervation**
- **Infarct Imaging**

- It involves the injecton of a radiolabelled substance which is extracted by the myocardium and accumulates in proportion to myocardial blood flow.
- Such radipharmaceuticals are injected under stress as well as resting conditions,
- **Myocardial ischaemia** is defined as a perfusion defect present during stress but not resting conditions.
- **Scar** tissue is associated with a relative perfusion defect at rest as well as under stress.

- **Exercise Stress**
- **Pharmacologic Stress**

  * vasodilators : adenosine
    dipyridamole
  * inotropic : dobutamine

SIEMENS
1
Symbia
TruePoint SPECT

REVERSIBILE DEFECT

STRESS [fbp]
21-Nov-2007 11:40:20
Intervals: 1
Pharma: Tc-99m MIBI
Ug Vol: 62 ml, TID: 1.72
SSS: 26
V2-GSRD/TC/NC/M

100%
50%
0%

REST [fbp]
28-Nov-2007 14:00:05
Intervals: 1
Pharma: Tc-99m MIBI
Ug Vol: 36 ml, TID: N/A
SRS: 7
V2-GSRD/TC/NC/M

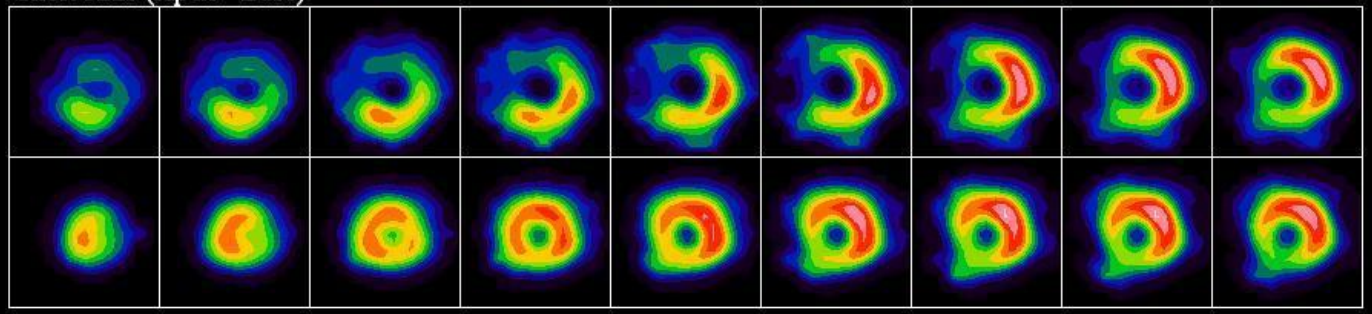
100%
50%
0%

Study Info

Short Axis (Apex->Base)

Str

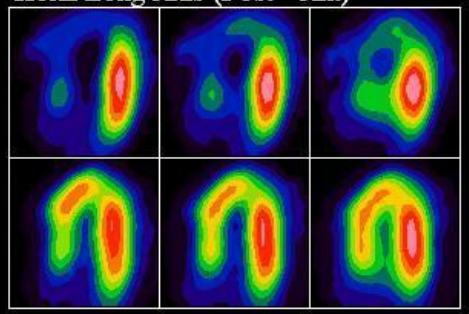
Rst



Horiz Long Axis (Post->Ant)

Str

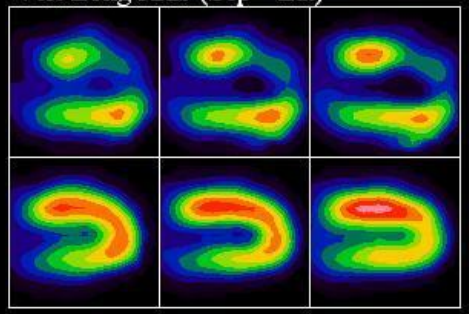
Rst



Vert Long Axis (Sep->Lat)

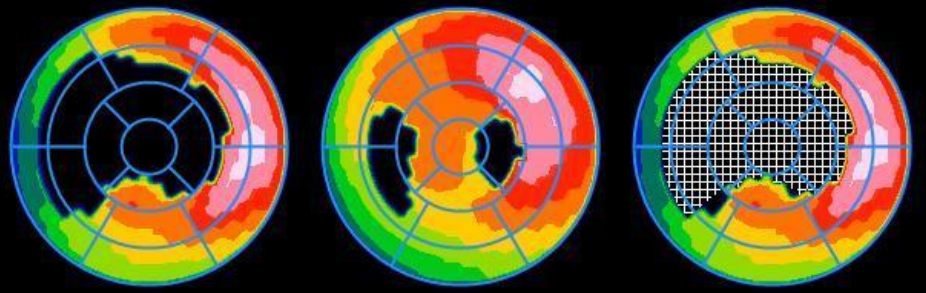
Str

Rst

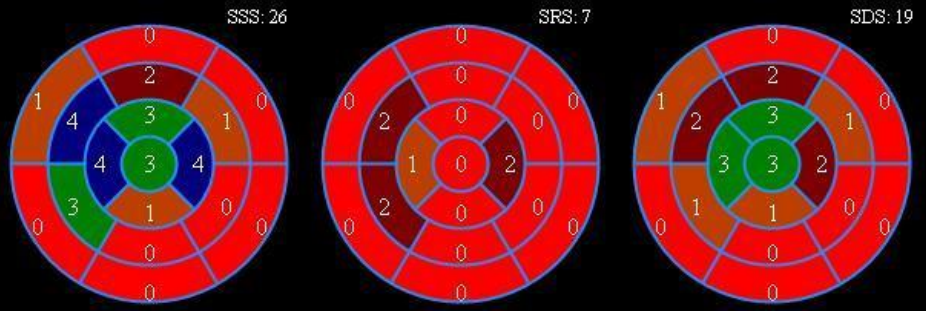


Defect Blackout Map

STRESS [fbp] REST [fbp] Reversibility



SSS: 26 SRS: 7 SDS: 19



Perf: 0: Normal 1: Equivocal 2: Abnormal 3: Severe 4: Absent

PET - Scan

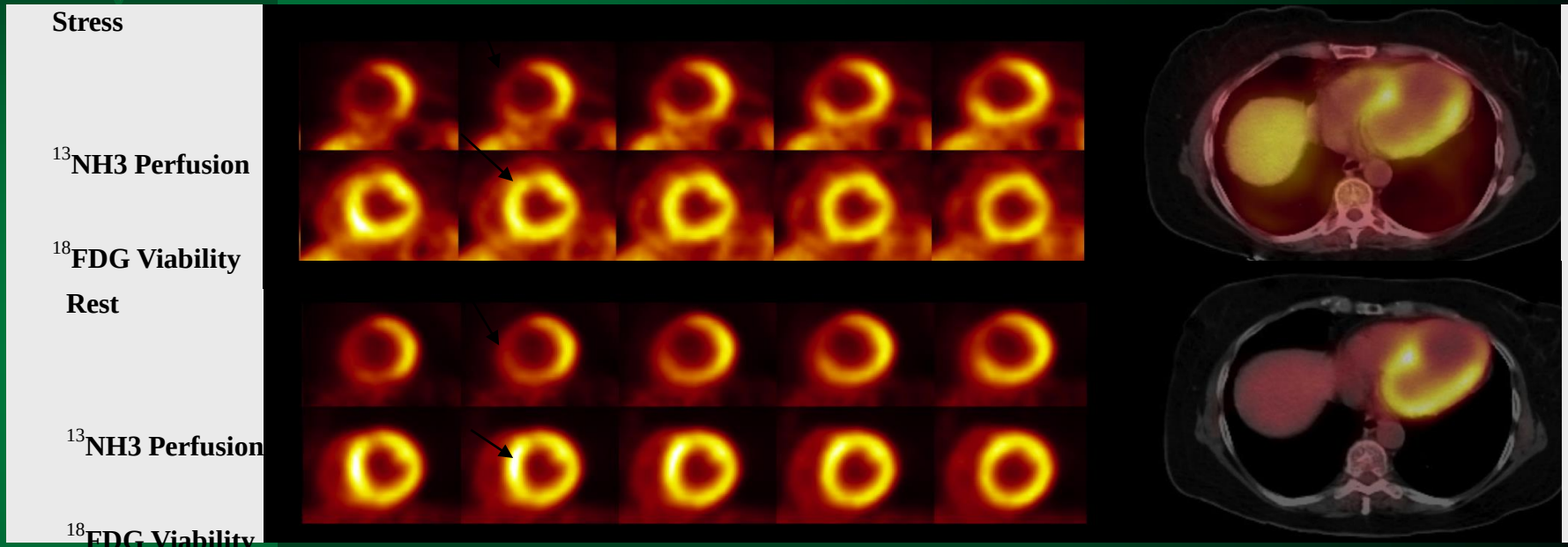
- **The gold standard method for myocardial viability-** evaluation of myocardial glucose utilisation with **fluorine-18 fluorodeoxyglucose (FDG)**

- **Principle -**Under fasting conditions the normal myocardium primarily utilises free fatty acids. In ischaemic myocardium glucose becomes an important energy substrate, FDG uptake will be enhanced.

- **^{13}NH3 for Perfusion**

  ^{18}FDG for Metabolism

PET•CT cardiac perfusion and viability mismatch study



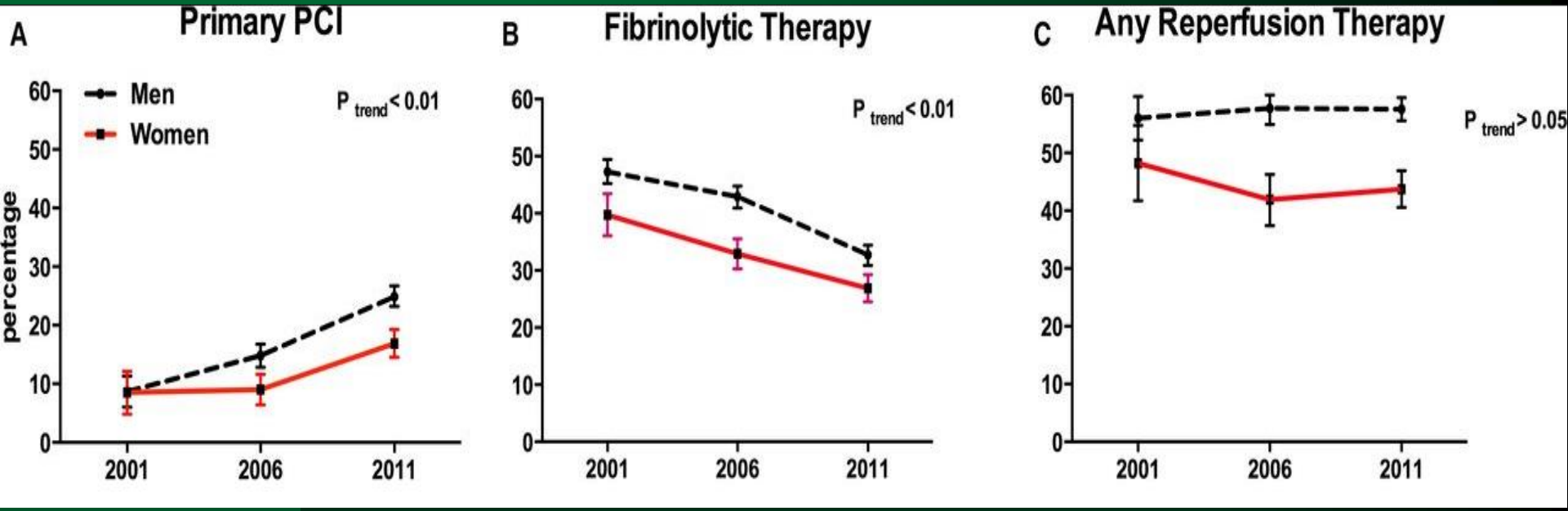
Perfusion-viability mismatch in 13N-NH3 PET perfusion and 18F-FDG PET viability study

Mismatch indicative of ischemic but viable myocardium - capable of return to normal contractility with revascularization

Patient identified as a candidate for revascularization.

THERAPEUTICS

Primary PCI … on the rise



Culprit Artery – Only Versus Multivessel PCI

- Previous clinical practice guidelines recommended against PCI of nonculprit artery stenoses at the time of primary PCI in hemodynamically stable patients with STEMI, based primarily on the results of nonrandomized studies and meta-analyses and safety concerns.
- Four RCTs (PRAMI, CvLPRIT, DANAMI 3 PRIMULTI, PRAGUE-13) have since suggested that a strategy of multivessel PCI, either at the time of primary PCI or as a planned, staged procedure, may be safe and beneficial in ***selected patients*** with STEMI.
- On the basis of these findings, the prior Class III-harm recommendation with regard to multivessel primary PCI in hemodynamically stable patients with STEMI has been upgraded and modified to a Class IIb recommendation to include consideration of multivessel PCI, either at the time of primary PCI or as a planned, staged procedure.
- The writing committee emphasizes that this change should not be interpreted as endorsing the routine performance of multivessel PCI in all patients with STEMI and multivessel disease. Rather, when considering the indications for and timing of multivessel PCI, physicians should integrate clinical data, lesion severity/complexity, and risk of contrast nephropathy to determine the optimal strategy.

WHY TO OPEN UP A CTO ?

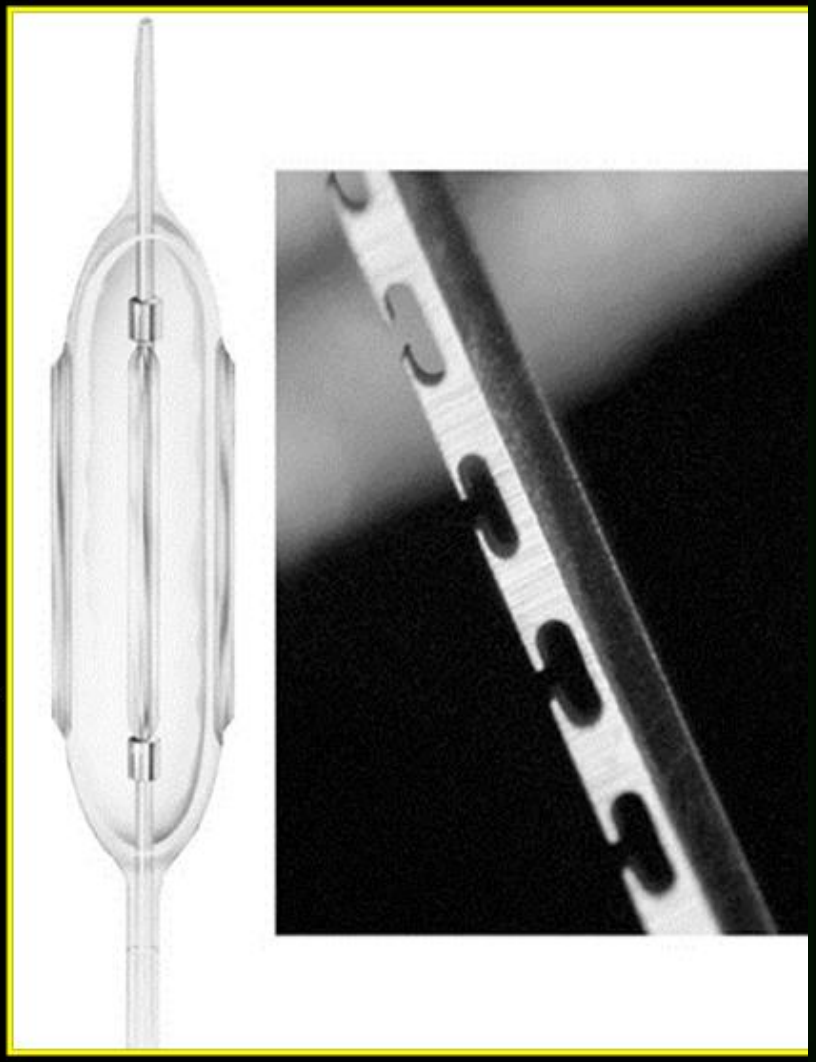
Significant clinical problem	JACC intvn 2009;2:489 –97
Similar risk to non CTO PCI	JACC intvn 2009;2:489 –97
Angina relief	(FACTOR TRIAL-2010)
Improved L V function	JACC 2006;47:721–5
Improved tolerance of a future ACS	JACC intvn 2009;2:1128 –34
Potentially better survival with successful PCI	AmHeart J 2010;160:179-87
Avoidance of CABG	AmHeart J 2010;160:179-87

- Cutting Balloon Angioplasty (CBA)
- Directional Coronary Atherectomy (DCA)
- Laser angioplasty
- **Percutaneous Transluminal Rotational Atherectomy (PTRA)**

CUTTING BALLOON ANGIOPLASTY

- Makes controlled microincisions into the atheromatous plaque (radial atherectemy)

- Lesser barotrauma to vessel

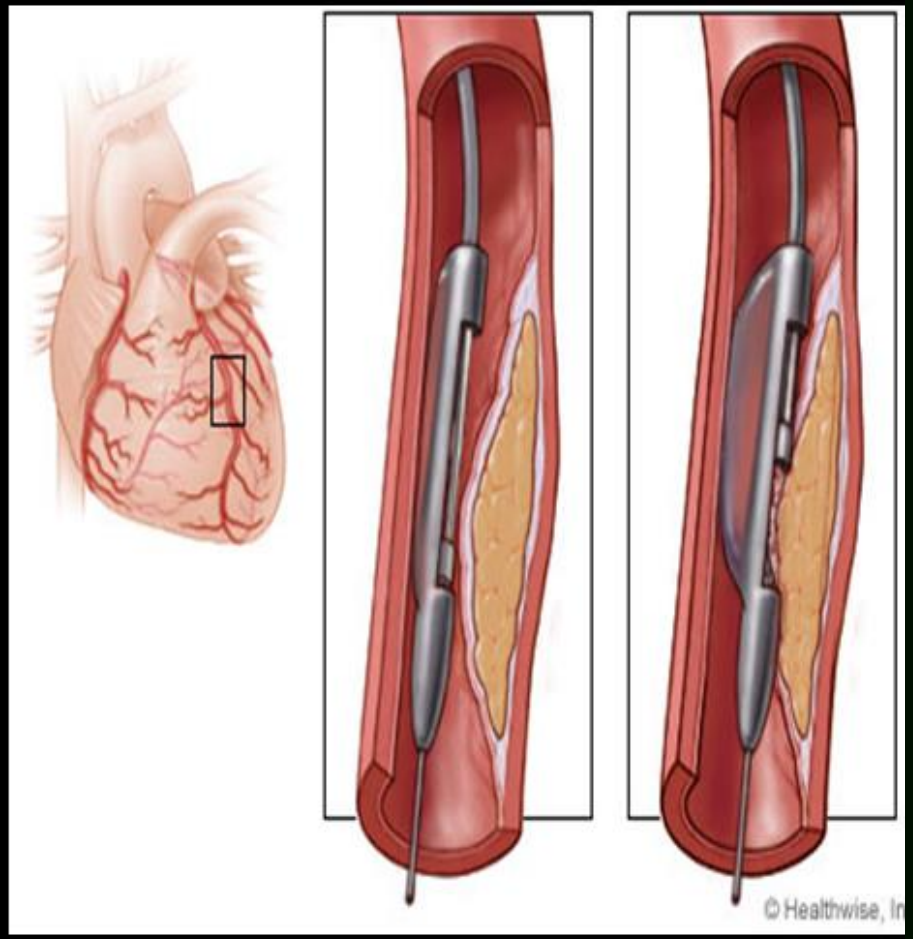


DIRECTIONAL ATHERECTOMY

- Apposes a cutting device to a section of the plaque.

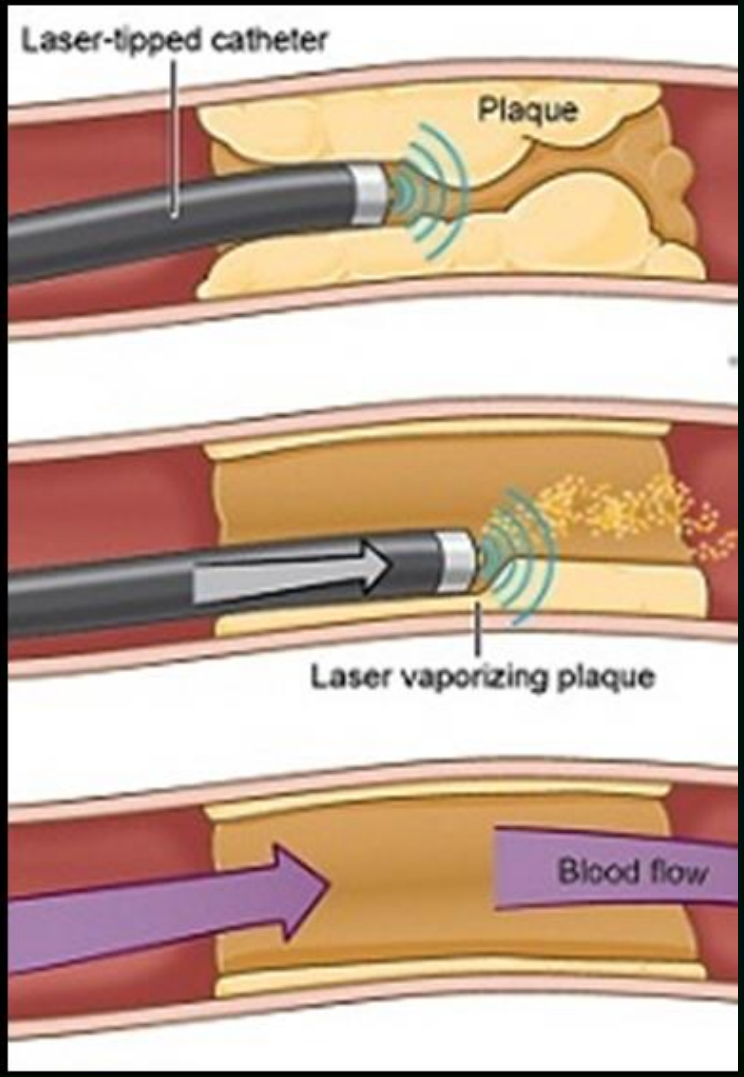
- Manually advances the cutting cup

- Debulking procedure

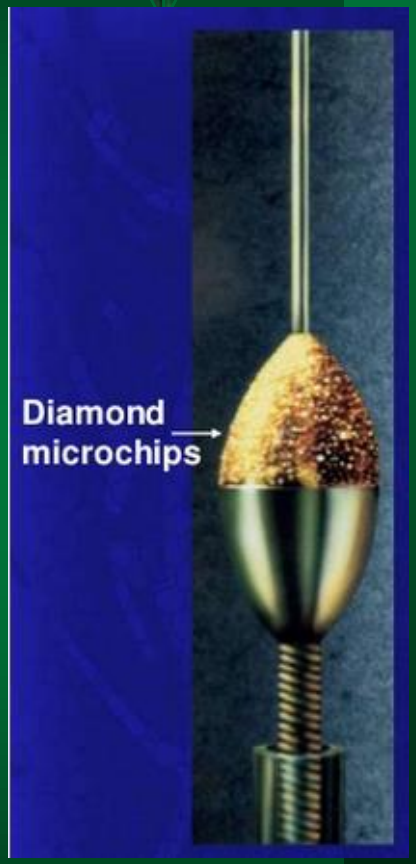


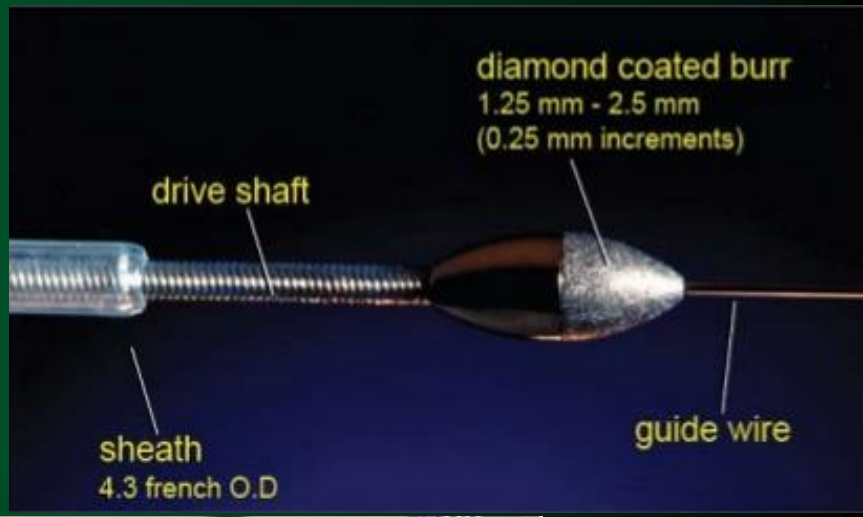
LASER ANGIOPLASTY

- Laser beam is channelled in pulse/continuous from to help in debulking.
- Photo-thermal effect, photo-acoustic effect, photo-chemical dissociation



ROTABLATOR


Diamond
microchips


diamond coated burr
1.25 mm - 2.5 mm
(0.25 mm increments)
drive shaft
sheath
4.3 french O.D
guide wire


Rotablator
Rotational Angioplasty System
147000
00:08
0123

Encouraging results were reported from the 'Synergy Between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery' **(SYNTAX) trial**

	PCI ($n = 358$)	CABG ($n = 357$)	*P*-value
1-year clinical outcomes			
Death (%)	4.2	4.4	0.88
Stroke (%)	0.3	2.7	0.0009
MI (%)	4.3	4.1	0.97
Revascularization (%)	12	6.7	0.02
ST or graft occlusion (%)	2.7	3.7	0.49
Overall MACCE (%)	15.8	13.6	0.44
MACCE low SYNTAX score (0–17)	7.7	13	0.19
MACCE intermediate SYNTAX score (23–32)	12.6	15.5	0.54
MACCE high SYNTAX score (≥33)	25.3	12.9	0.008
3-year clinical outcomes			
Death (%)	7.3	8.4	0.64
Stroke (%)	1.2	4	0.02
MI (%)	6.9	4.1	0.14
Revascularization (%)	20	11.7	0.004
ST or graft occlusion (%)	4.1	3.7	0.80
Overall MACCE (%)	26.8	22.3	0.20
MACCE low SYNTAX score (0–17)	18	23	0.33
MACCE intermediate SYNTAX score (23–32)	23.4	23.4	0.90
MACCE high SYNTAX score (≥33)	37.3	21.2	0.003

Coronary Bifurcation Stenosis

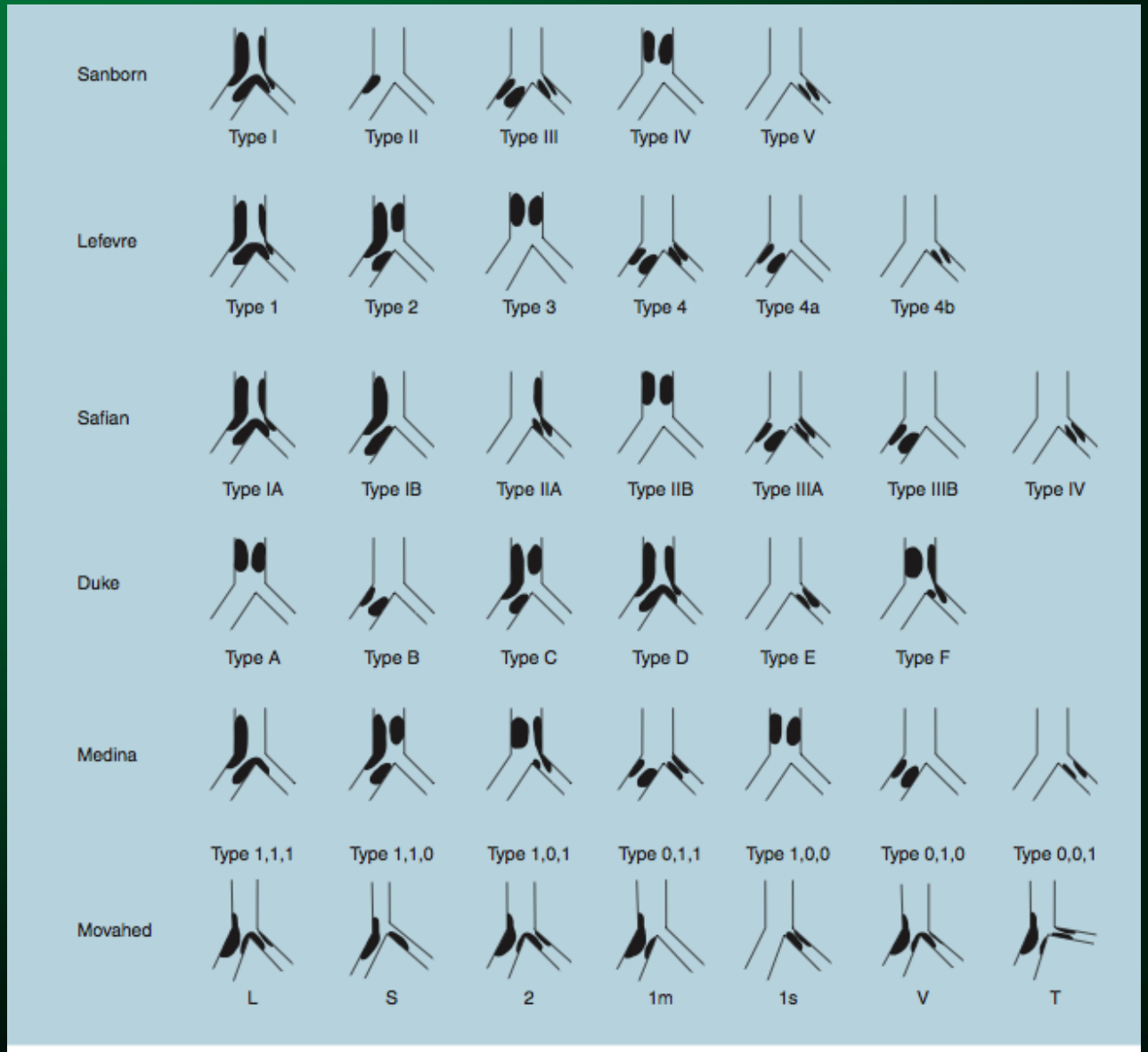
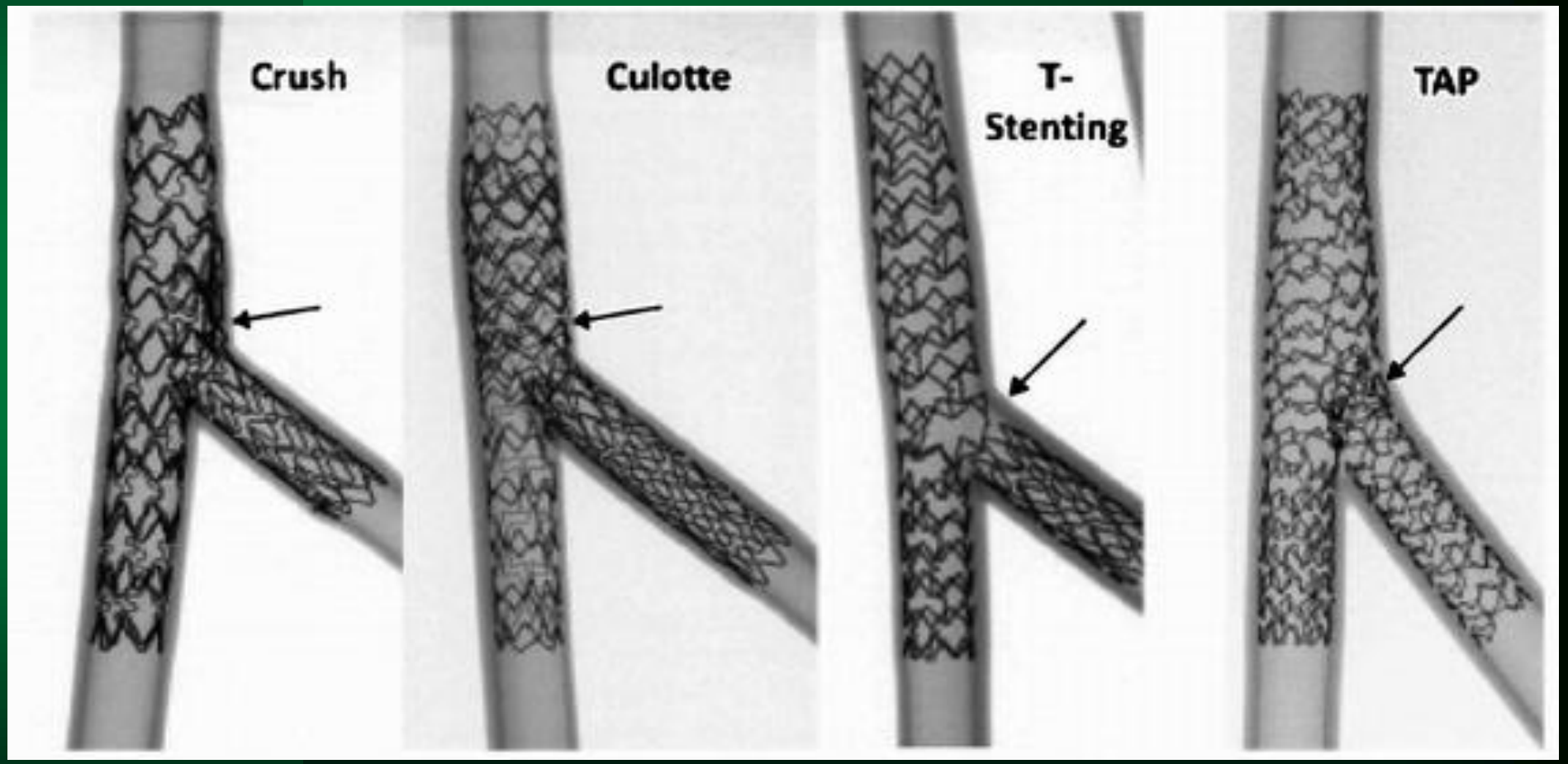


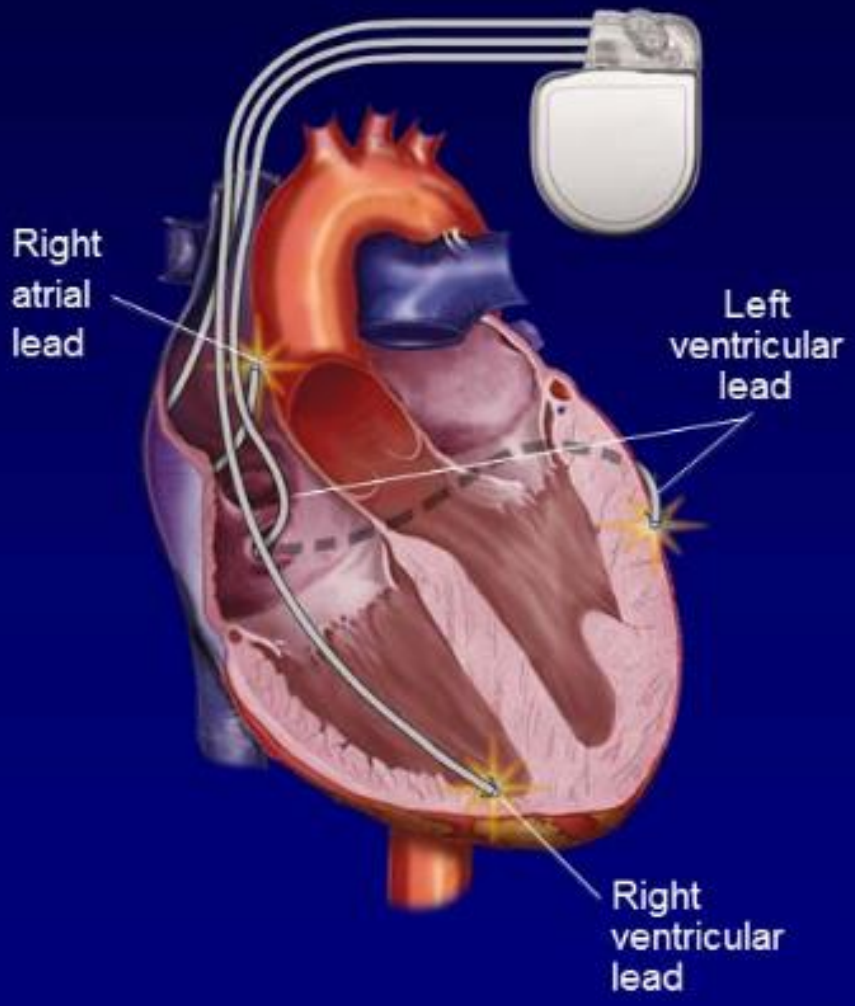
Figure 1. Summary of currently published major coronary bifurcation classifications.


Crush
Culotte
T-
Stenting
TAP

CARDIAC RESYNCHRONIZATION THERAPY (CRT-D)

CRT-D System Adds LV Lead to an ICD System

- Provides Biventricular Pacing With ICD Capability
- Composed of:
  - Pulse generator
  - Right atrial pacing and sensing lead
  - Right ventricular pacing plus defibrillation lead
  - Left ventricular pacing lead
- Implant of right atrial and right ventricular leads is the same as a dual chamber ICD



CRT Indications

- LBBB with QRS duration >150 ms.
- chronic HF patients and LVEF ≤35%
- who remain in NYHA functional class II, III and ambulatory IV despite adequate medical treatment.

LEADLESS PACEMAKERS

EVOLUTION OF PACEMAKER TECHNOLOGY

1958
Weight: 73.4g
Size: 35cc

1981
Weight: 55g
Size: 25cc

1995
Weight: 14g
Size: 6cc

2009
Weight: 23g
Size: 12.8cc

2013
Weight: 2g
Size: 1cc

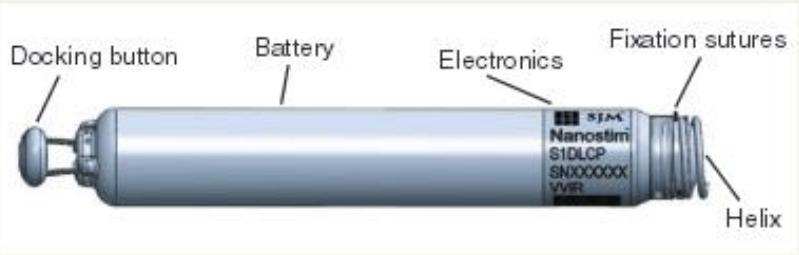
Leadless systems for right ventricle pacing

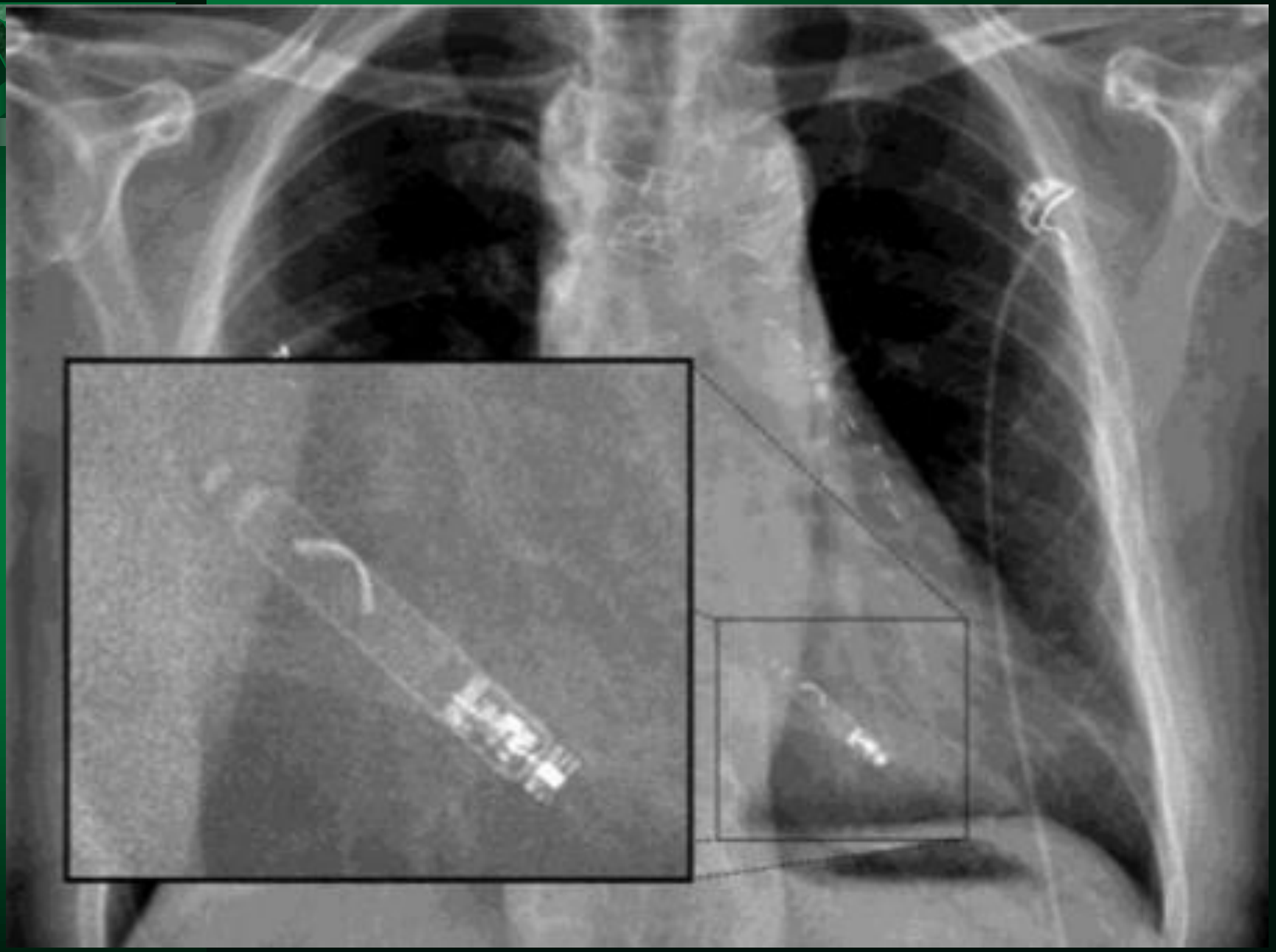
St. Jude Medical Nanostim™ leadless pacemaker (LCP)

- Available in 2012
- VVI(R)
- Screw-in helix

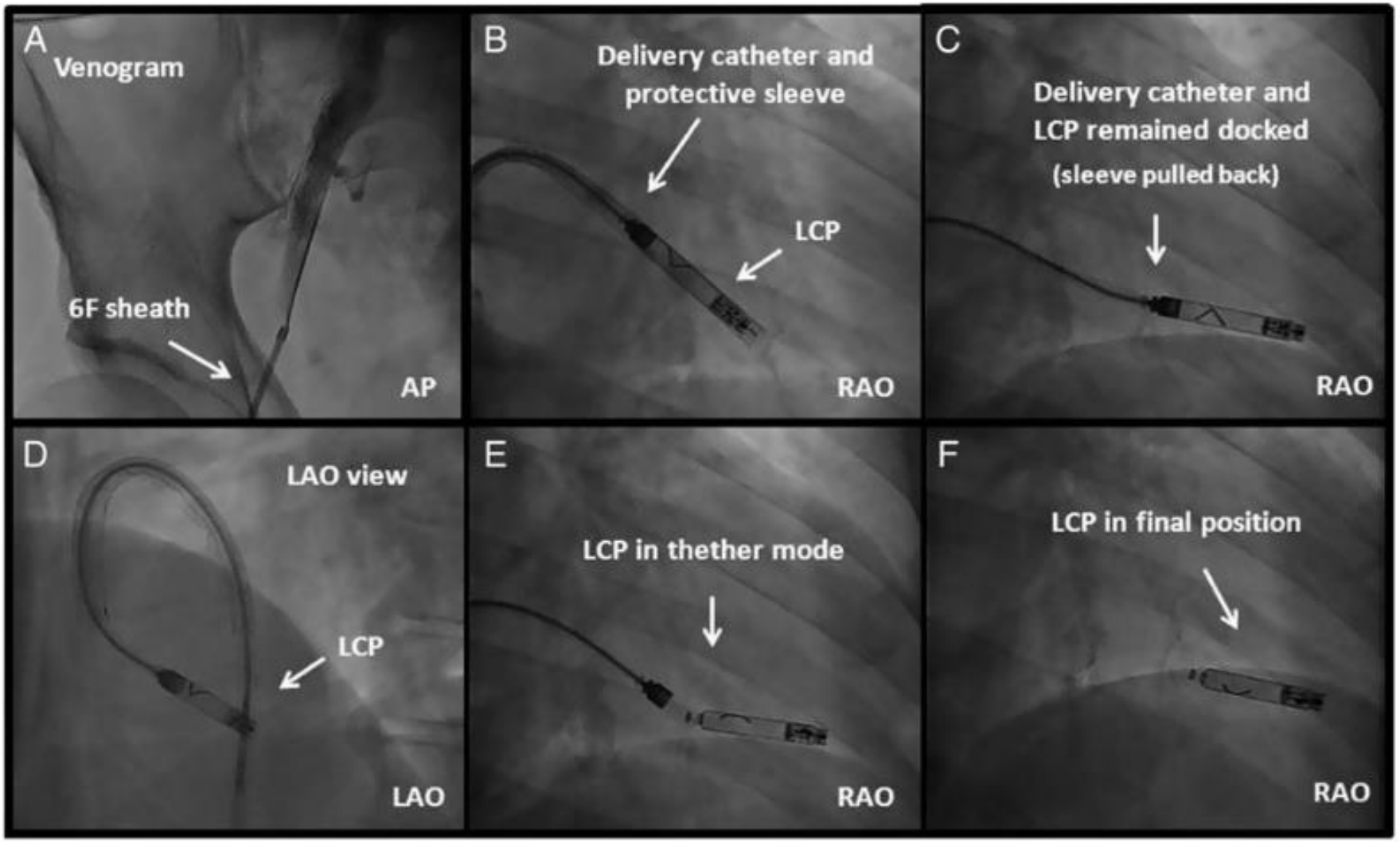
Medtronic Micra™ Transcatheter Pacing System (TPS)

- Available in 2013
- VVI(R)
- Self-expanding nitinol tines





Implantation (LCP)



Leadless Pacemaker: Potential Advantages

- Less Invasive
- More cosmetic for patient (“invisible”)
- More readily MRI conditional
- Reduced length of hospital stay (same day)
- Fewer acute and chronic complications (infection, erosion)

Leadless Pacemaker:Potential Disadvantages

Only VVIR pacing

External communication interference

Memory capacity and download limitations

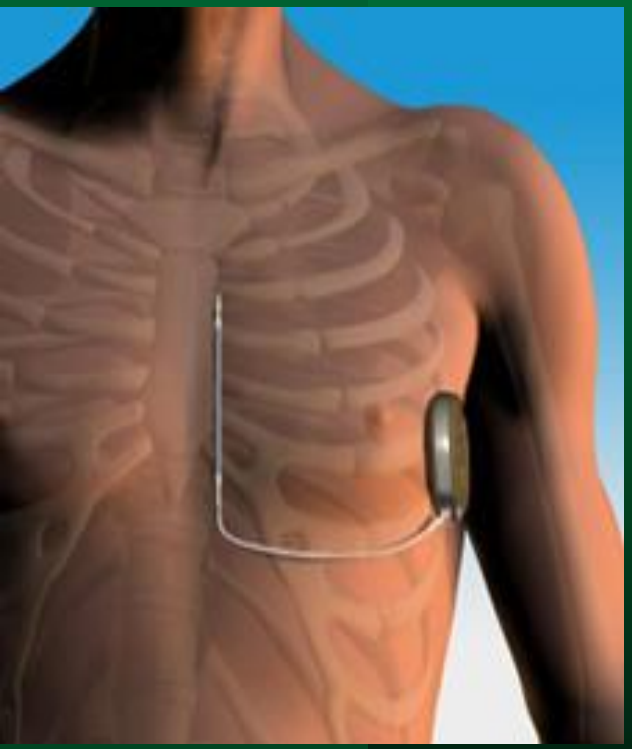
Large diameter sheaths

Embolization / retrieval

Repositioning difficulty for high threshold

Longevity limitations (Less battery life)

Subcutaneous AICD



AICD- Indications Class I

- Structural heart disease, sustained VT
- Syncope of undetermined origin, inducible VT or VF at electrophysiologic study (EPS)
- Left ventricular ejection fraction (LVEF) ≤35% due to prior MI, at least 40 days post-MI, NYHA class II or III
- LVEF ≤35%, NYHA class II or III
- LVEF ≤30% due to prior MI, at least 40 days post-MI
- LVEF ≤40% due to prior MI, inducible VT or VF at EPS

AICD- Indications Class IIa

- Unexplained syncope, significant LV dysfunction, nonischemic cardiomyopathy
- Sustained VT, normal or near-normal ventricular function
- Hypertrophic cardiomyopathy with 1 or more major risk factors
- Arrhythmogenic right ventricular dysplasia/cardiomyopathy (ARVD/C) with 1 or more risk factors for sudden cardiac death (SCD)
- Long QT syndrome, syncope or VT while receiving beta-blockers
- Nonhospitalized patients awaiting heart transplant
- Brugada syndrome, syncope or VT
- Catecholaminergic polymorphic VT, syncope or VT while receiving beta-blockers
- Cardiac sarcoidosis, giant cell myocarditis, or Chagas disease

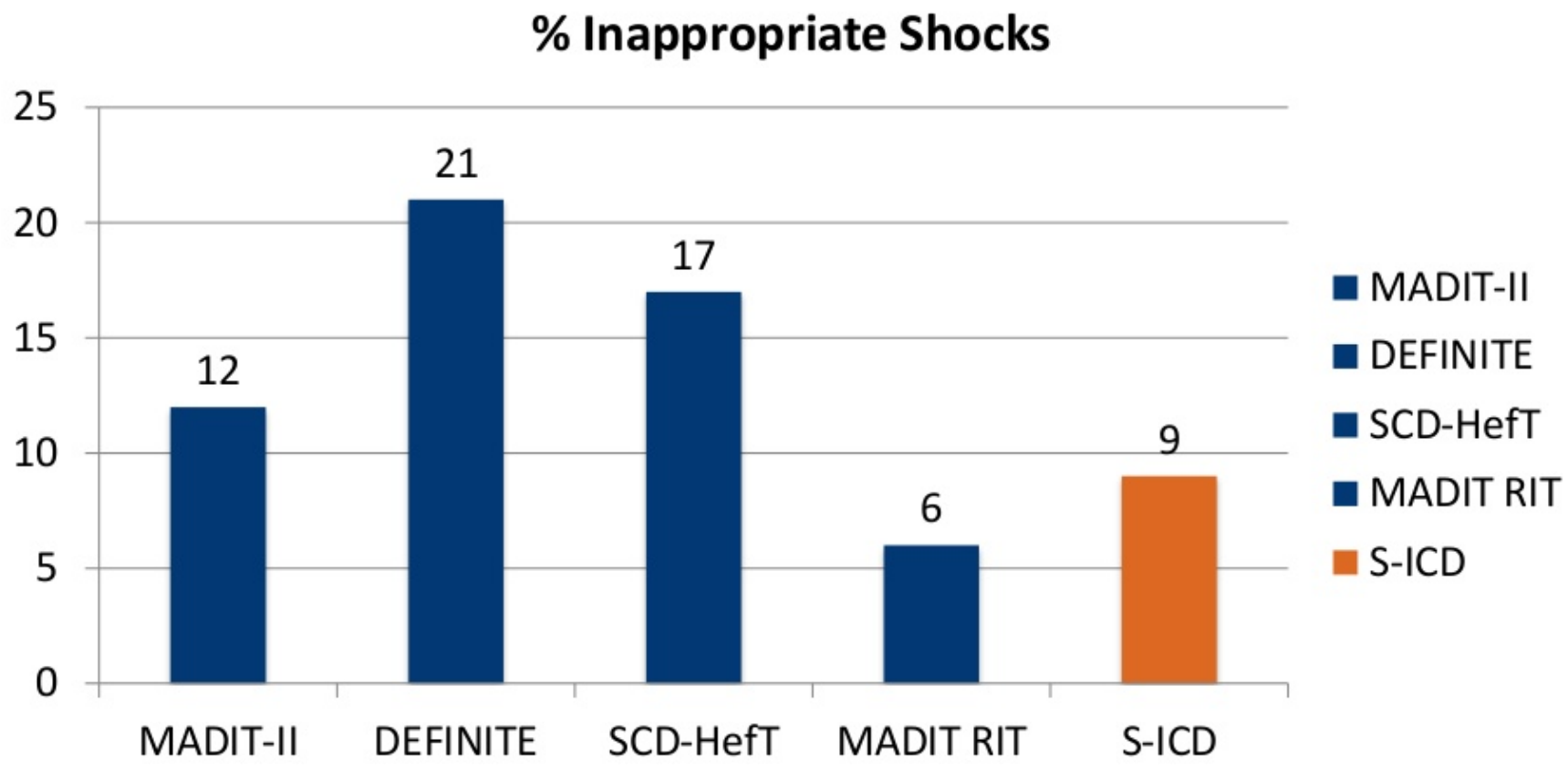
Advantages:

- Less invasive surgery
- Eliminates potential for infection and damage to venous system
- May be implanted using anatomical landmarks
- Potential for less inappropriate shocks in children

Disadvantages:

- Size
  - Twice that of current T-ICD
- Battery life
  - 5 years as opposed to upwards of 10 with T-ICD
- Does not provide anti-tachycardia pacing (ATP) or bradycardia pacing

Inappropriate Shocks



Transcatheter aortic valve implantation

TAVI is indicated in patients with
severe symptomatic AS
who are not suitable for AVR,
have a >1-year life expectancy
and are likely to gain improvement
in quality of life

From PVT to Edwards balloon expandable Valves

Edwards Valves

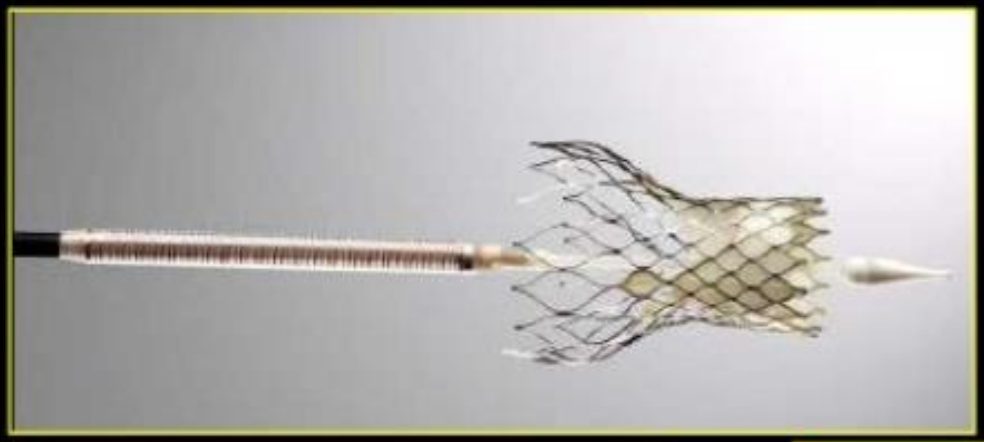
2000: PVT Valve	2003-2004	2005-2009	2009
Percutaneous Heart Valve	Cribier Edwards	Edwards Sapien	Edwards Sapien XT
			
Bovine pericardium Stainl. steel frame 23mm	Equine pericardium Stainl. steel frame 23mm	Treated bovine peri Stainl. steel frame 23 and 26mm	Next to come **20mm / 29mm**
24F	22F	22F, 24F	Next generation **18F, 19F**

TF sheath sizes

Self expandable Medtronic CoreValve

Generation 1	Generation 2	Generation 3	Generation 4
25F	21F	18F	18F

2004-2005 → From 2006 → 2010



Porcine pericardium valve
Nitinol stent

Improved delivery ?

Antegrade technique

The catheter is advanced via the femoral vein, traversing the interatrial septum and the mitral valve, and is positioned within the diseased aortic valve.

Advantages

Femoral vein accommodates the large catheter sheath

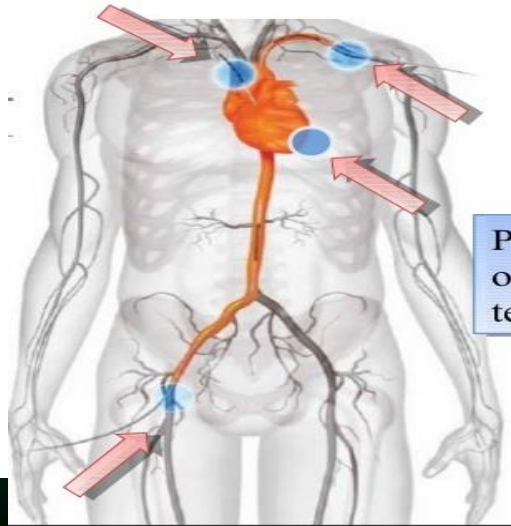
Easy management of peripheral access site

Disadvantages

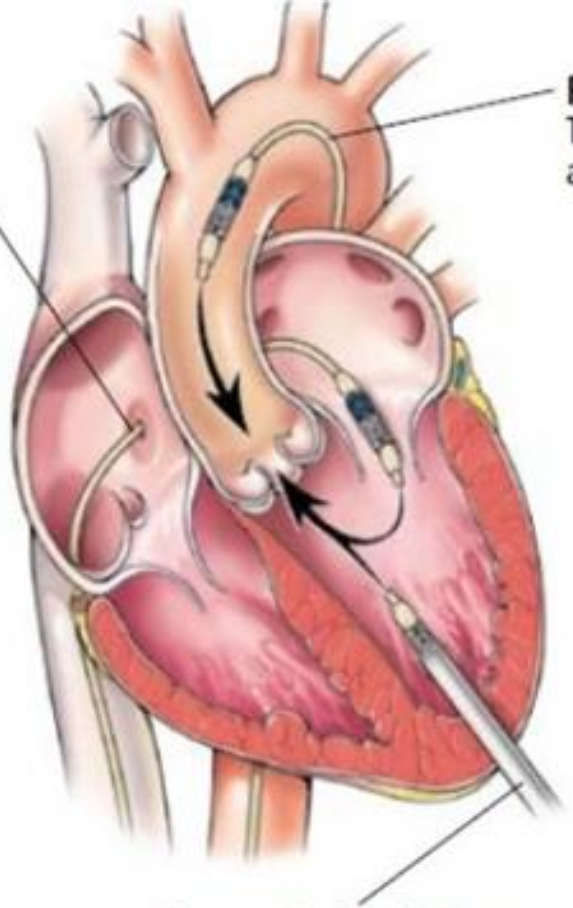
Risk of mitral valve injury and severe mitral valve regurgitation

Correctly positioning the prosthetic valve can be challenging

This technique is no longer in use.



Percutaneous or Cut-down technique



Retrograde or transfemoral technique

The catheter is advanced to the stenotic aortic valve via the femoral artery.

Advantages

Faster, technically easier than antegrade approach

Disadvantages

Potential for injury to the aortofemoral vessels

Crossing the stenotic aortic valve can be challenging

Transapical technique

A valve delivery system is inserted via a small intercostal incision. The apex of the left ventricle is punctured, and the prosthetic valve is positioned within the stenotic aortic valve.

Advantages

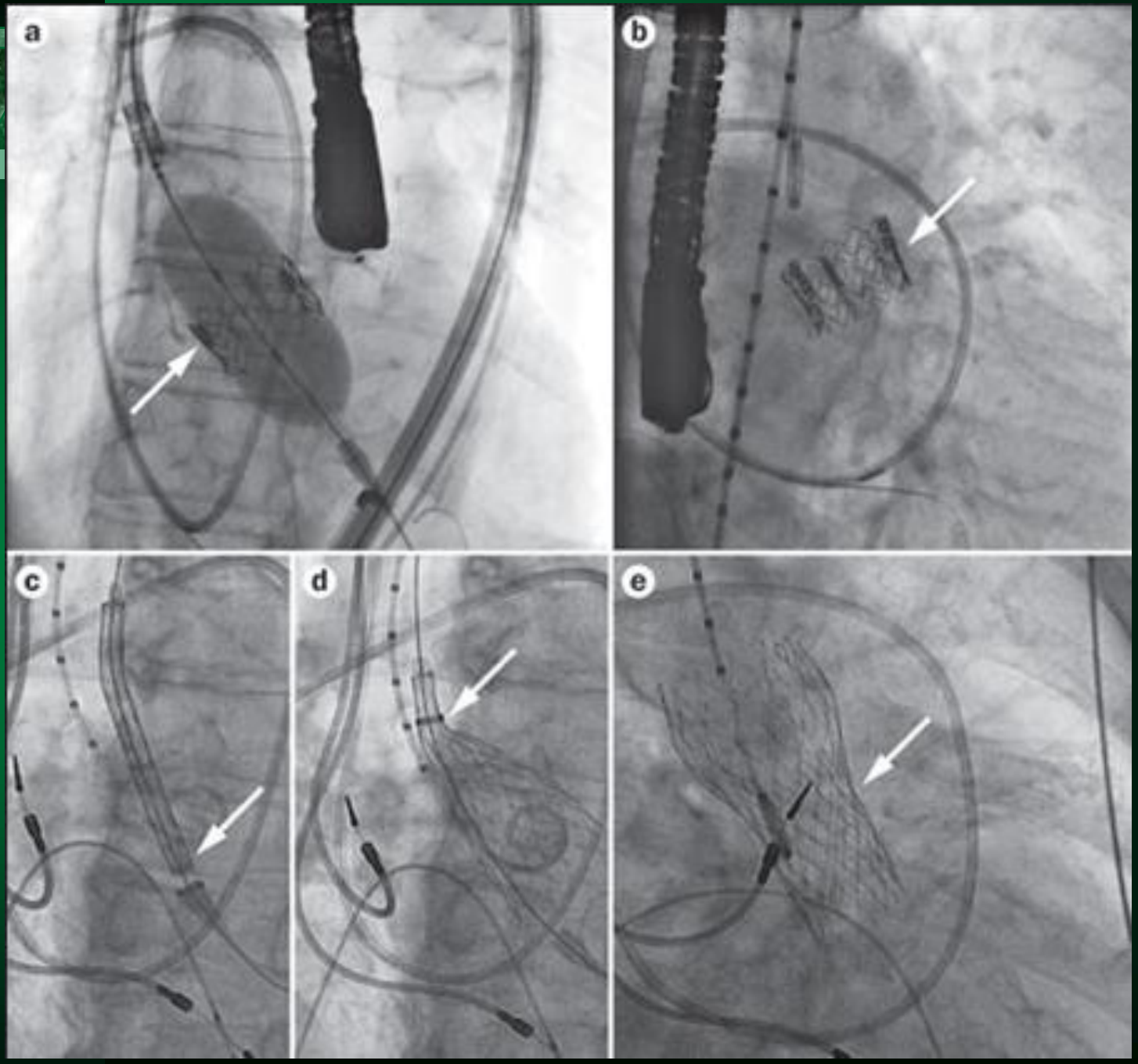
Access to the stenotic valve is more direct

Avoids potential complications of a large peripheral access site

Disadvantages

Potential for complications related to puncture of the left ventricle

Requires general anesthesia and chest tubes

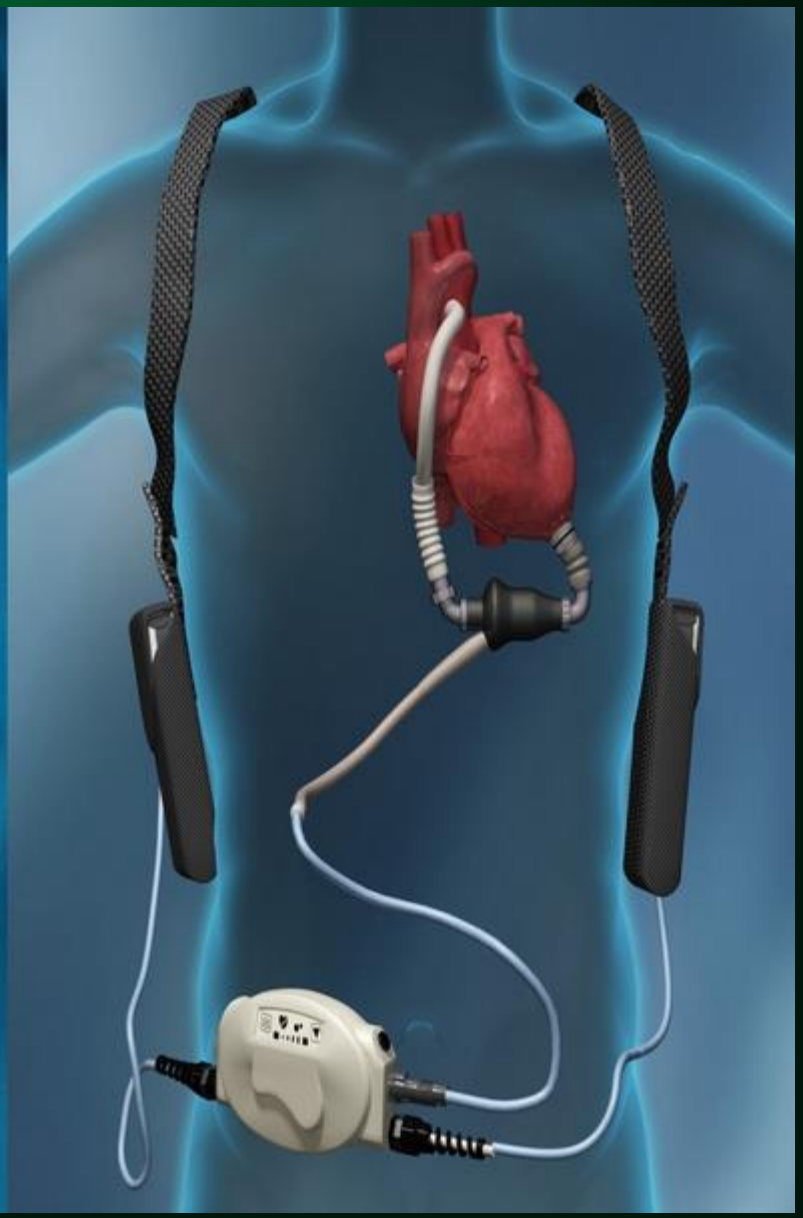

a
b
c
d
e

Contraindications to TAVI

- Inadequate annulus size (<18 mm, >29 mm),
- Active endocarditis,
- Symmetric valve calcification,
- Short distance between the annulus and the coronary ostium,
- Plaques with mobile thrombi in the ascending aorta,
- Inadequate vascular access ,
- Haemodynamic instability,
- Severe LV dysfunction.

Ventricular Assist Device (VAD)

- A mechanical pump that is surgically attached to one of the heart's ventricles to augment or replace native ventricular function
- Can be used for the left (L VAD), right (R VAD), or both ventricles (Bi VAD)
- Are powered by external power sources that connect to the implanted pump via a percutaneous lead (driveline) that exits the body on the right abdomen
- Pump output flow can be pulsatile or nonpulsatile



ENHANCED EXTERNAL COUNTERPULSATION (EECP)

- Have chronic stable angina
- Are not receiving adequate relief from angina by taking nitrates
- Do not qualify as a candidate for invasive procedures (bypass surgery, angioplasty, or stenting)

- A set of cuffs is wrapped around the calves, thighs and buttocks. These cuffs are sequentially inflated followed by the rapid release of pressure on deflation.

- Inflation and deflation are electronically synchronized with the heartbeat and blood pressure using the ECG and blood pressure monitors.

- EECP may encourage blood vessels to open small channels or collaterals that may eventually create "natural bypass" vessels to provide blood flow to heart muscle. This contributes to the relief of angina symptoms.

Novel Oral Anticoagulants

New Oral Anticoagulants

	Dabigatran Pradaxa®	Rivaroxaban Xarelto®	Apixaban Eliquis®	Edoxaban Savaysa®
Atrial fibrillation	FDA approved	FDA approved	FDA approved	Applied for FDA approval 1/8/2014
VTE Treatment	FDA approved	FDA approved	FDA approved	Applied for FDA approval 1/8/2014
VTE Prevention, Ortho surgery	No FDA activity	FDA approved	FDA approved	No FDA activity

NOACs - Advantages

- Fixed dose regimen
- Less drug interaction
- No food interaction
- No need for regular blood test

And miles to go…


Rabindranath Tagore International
Institute of Cardiac Sciences


Innova

……. *Thank You*


Filter: Filter 3
Filter: Filter 3