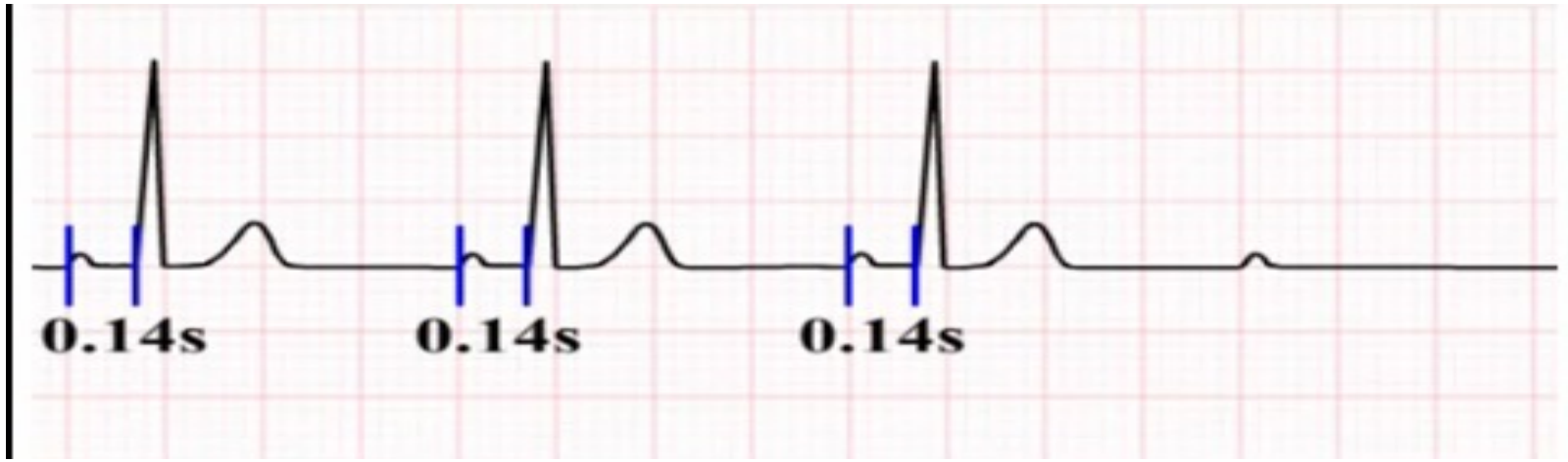
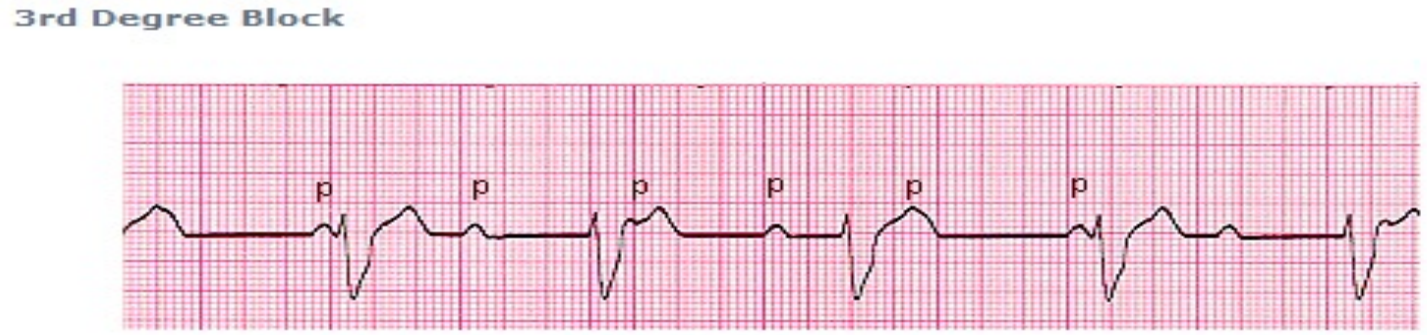
MOBITZ TYPE II



- **Constant PR interval in a group**

3rd DEGREE BLOCK



- Complete failure of conduction between atria and ventricles
- Complete independence of atria and ventricular contractions
- P waves bear no relation with QRS complexes
- Usually proceed with faster rate

AV BLOCK SUMMURY

- **1st DEGREE AV BLOCK**

All P waves conducted with prolonged PR

- **2nd DEGREE AV BLOCK**

Some P waves not conducted

Mobitz type I : Progressive PR prolongation

Mobitz type II : Constant PR interval

- **3rd DEGREE AV BLOCK**

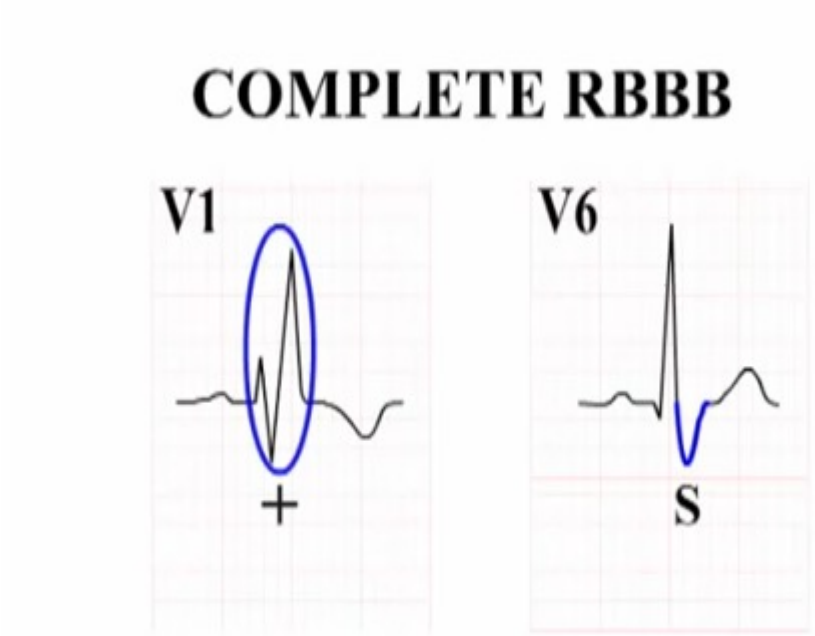
No P waves conducted

BUNDLE BRANCH BLOCK

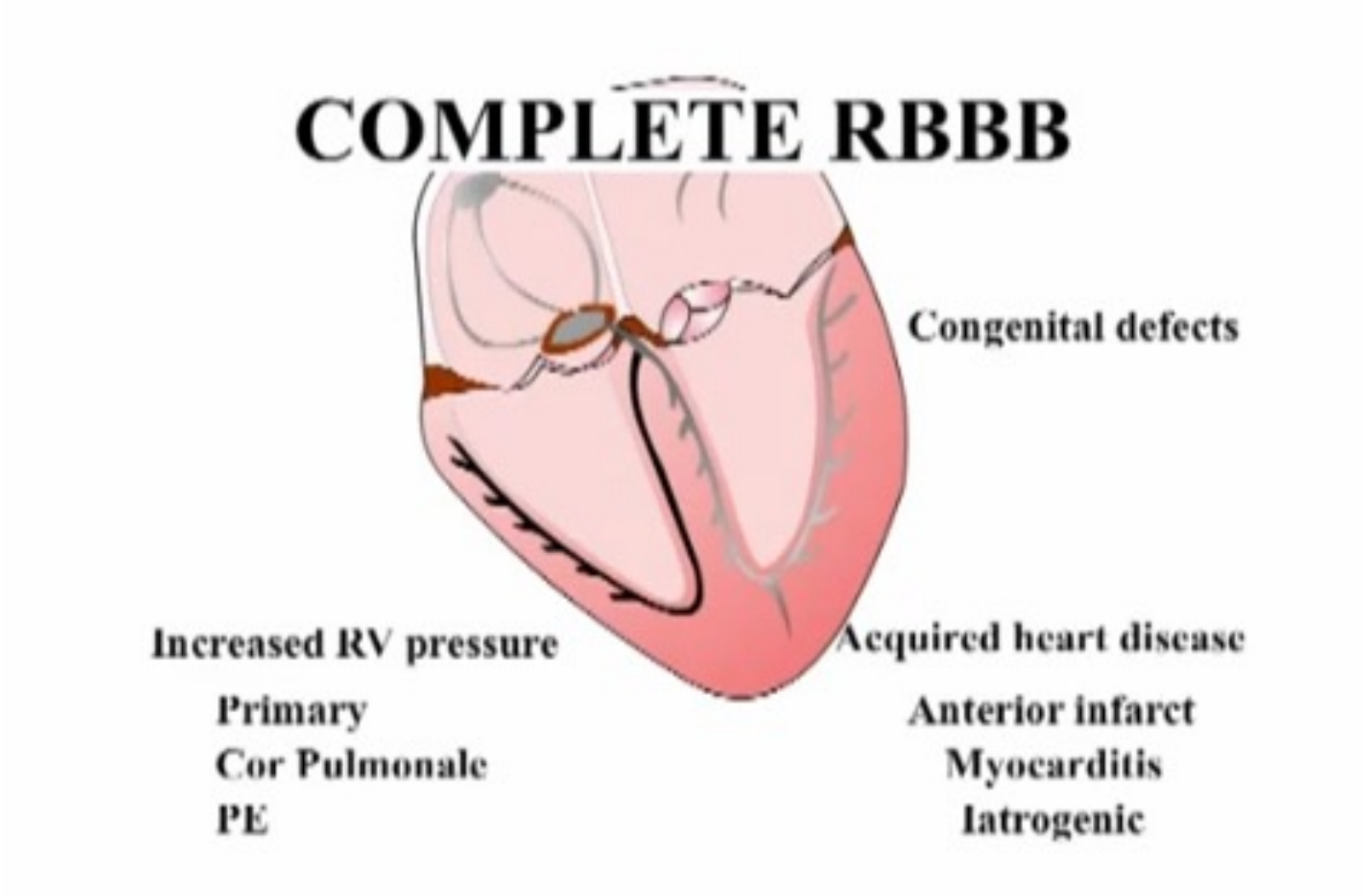
- **Right bundle branch block**
- **Left bundle branch block**

COMPLETE RBBB

- **QRS prolongation** (≥ 0.12s)
- **Slurred S** wave in lead **V6** and/or rSR pattern in lead V1
- Overall **positive QRS** complex **in lead V1** (**a must**)

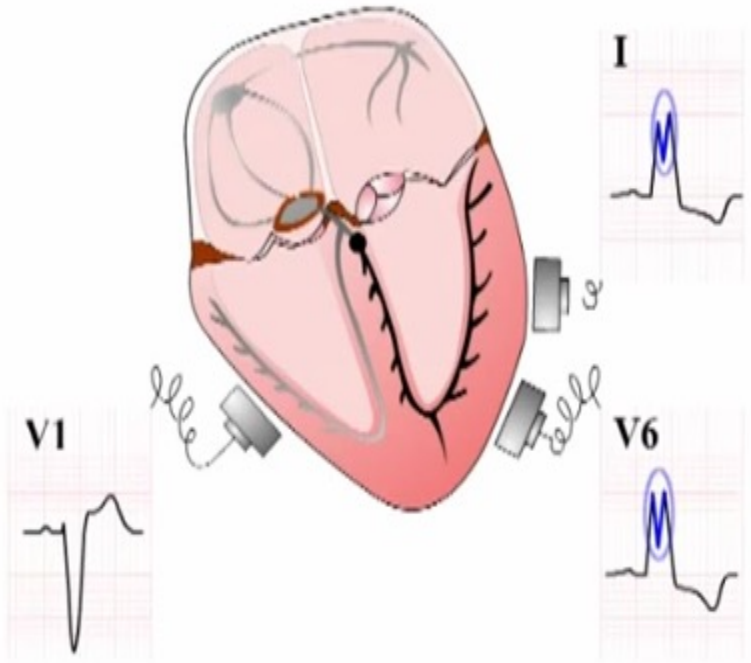


RBBB

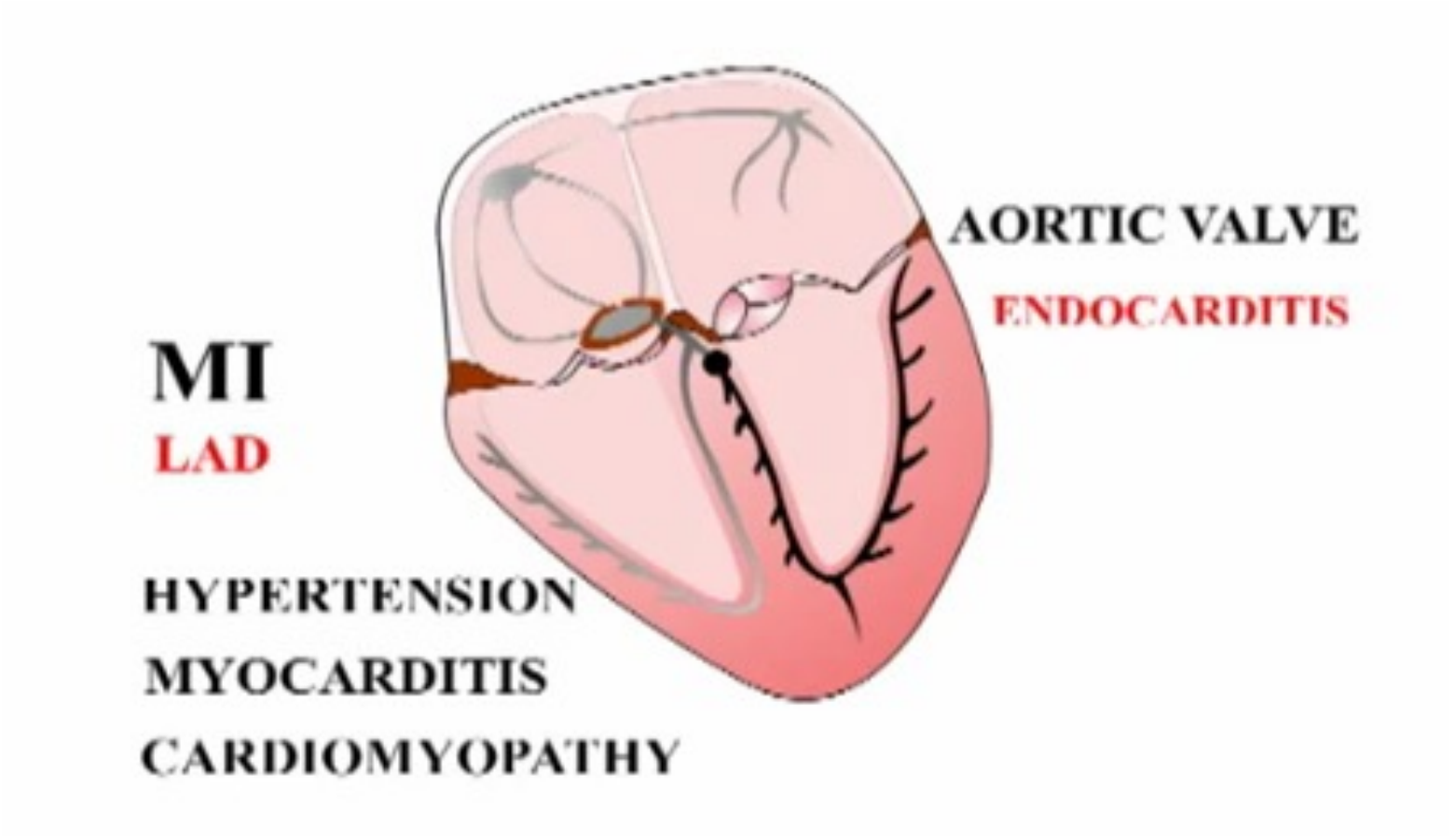

COMPLETE RBBB
Congenital defects
Increased RV pressure
Primary
Cor Pulmonale
PE
Acquired heart disease
Anterior infarct
Myocarditis
Iatrogenic

COMPLETE LBBB

- **QRS prolongation** (≥ 0.12s)
- **Broad R** waves in **lead I** and **V6** with **no Q** waves
- Broad S waves in the septal leads

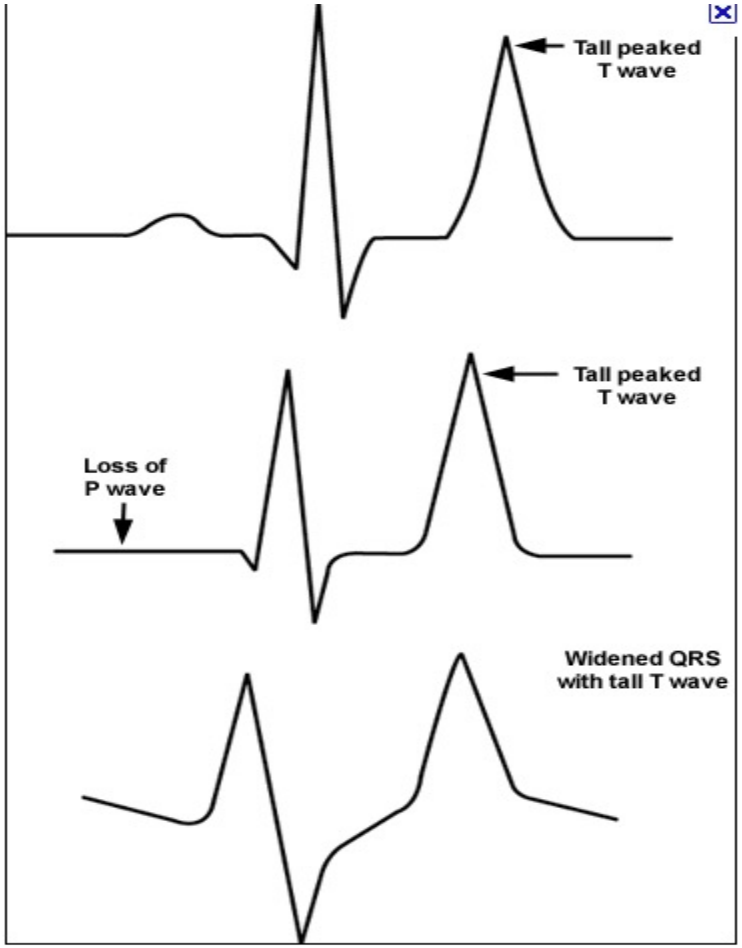


LBBB


AORTIC VALVE
ENDOCARDITIS
MI
LAD
HYPERTENSION
MYOCARDITIS
CARDIOMYOPATHY

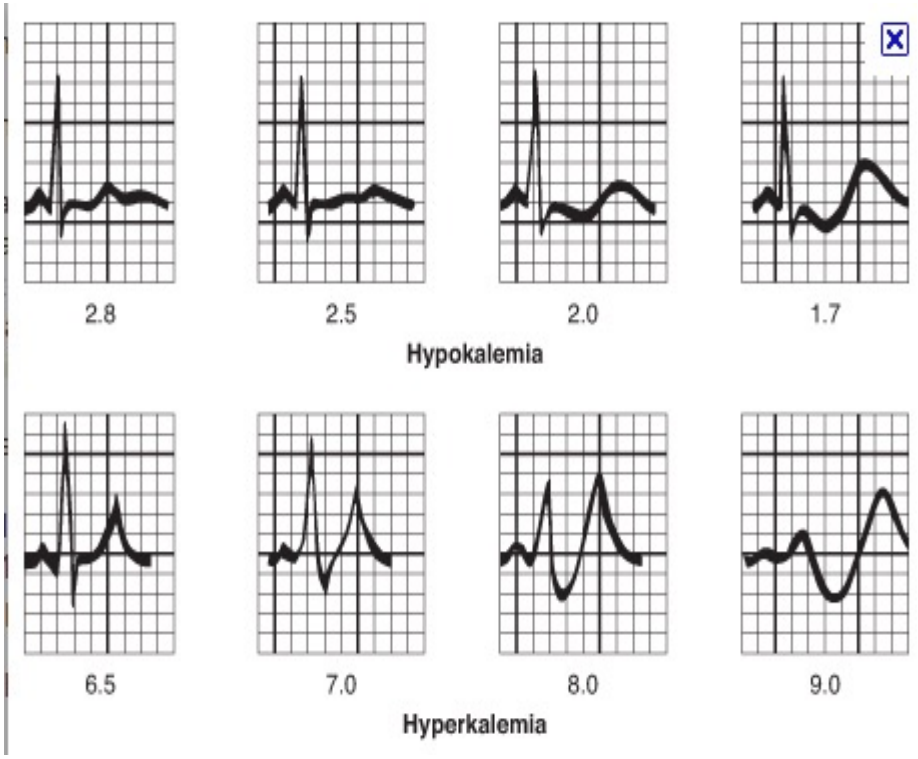
HYPERKALAEMIA

- Potassium concentration rises above 5.5-6.5 mmol/L
- Classic tall, symmetrically narrow and peaked T waves

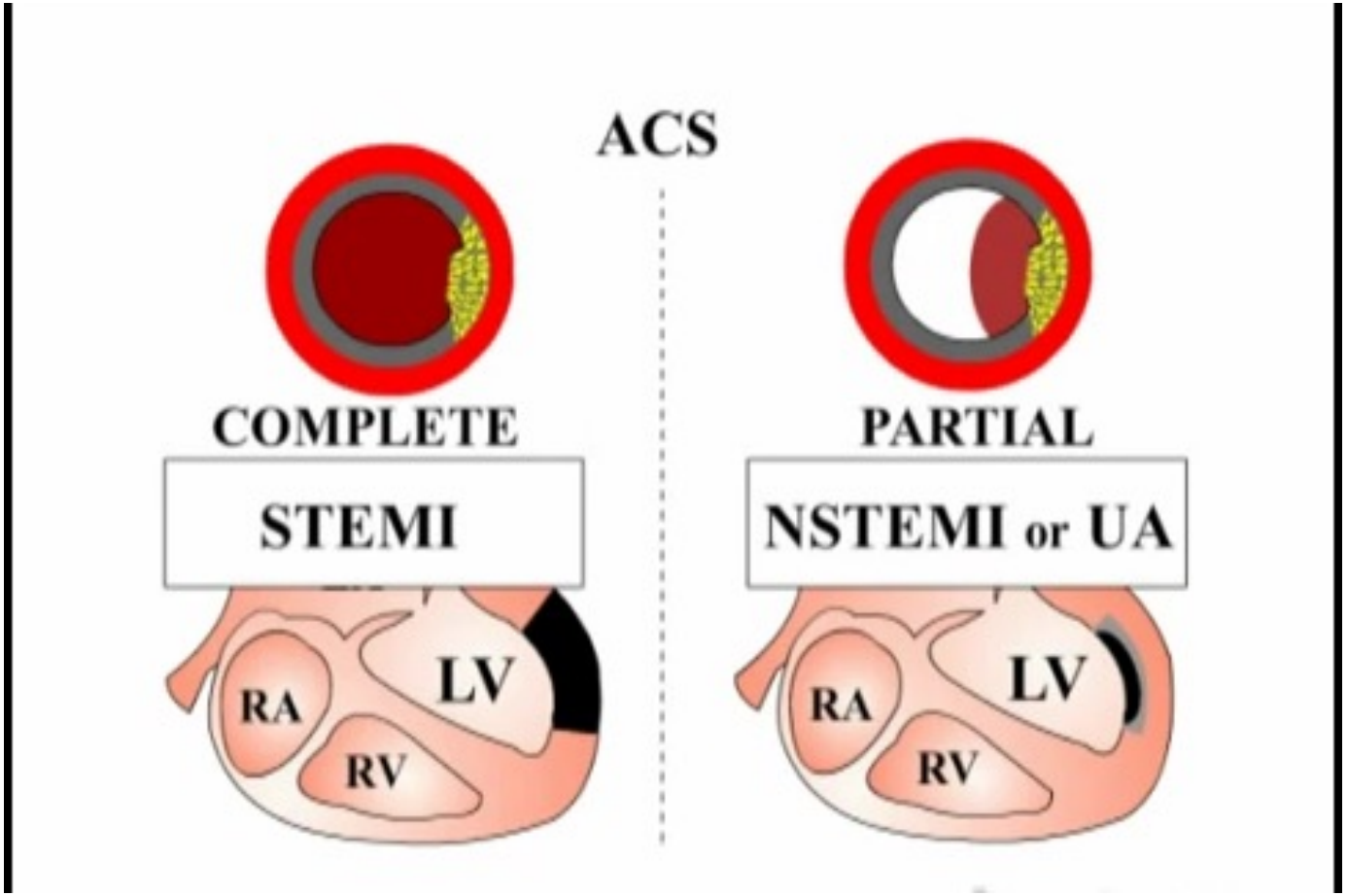


HYPOKALEMIA

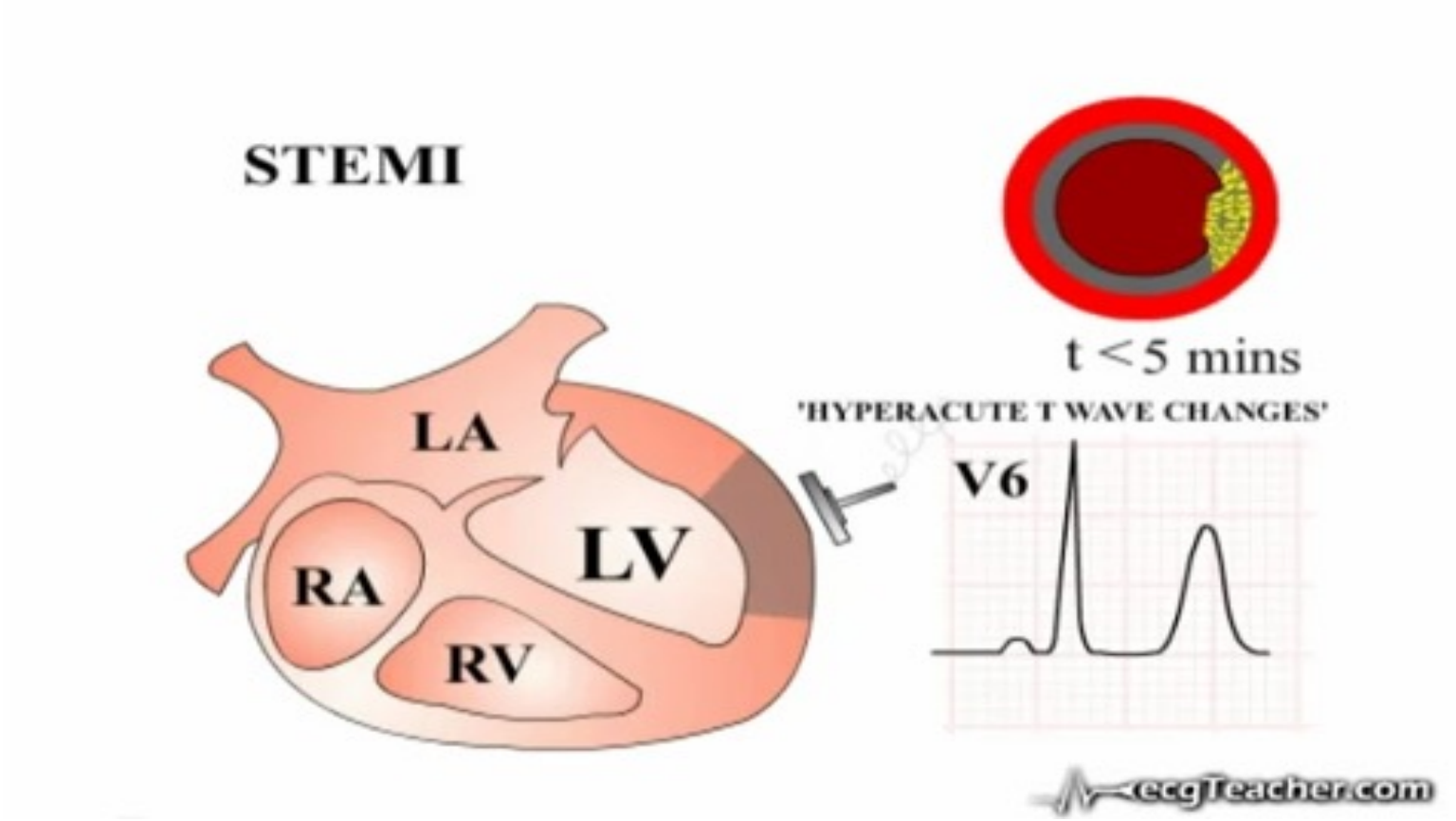
- Serum potassium < 2.7 mmol/L
- Broad, flat T waves
- ST depression
- QT interval prolongation



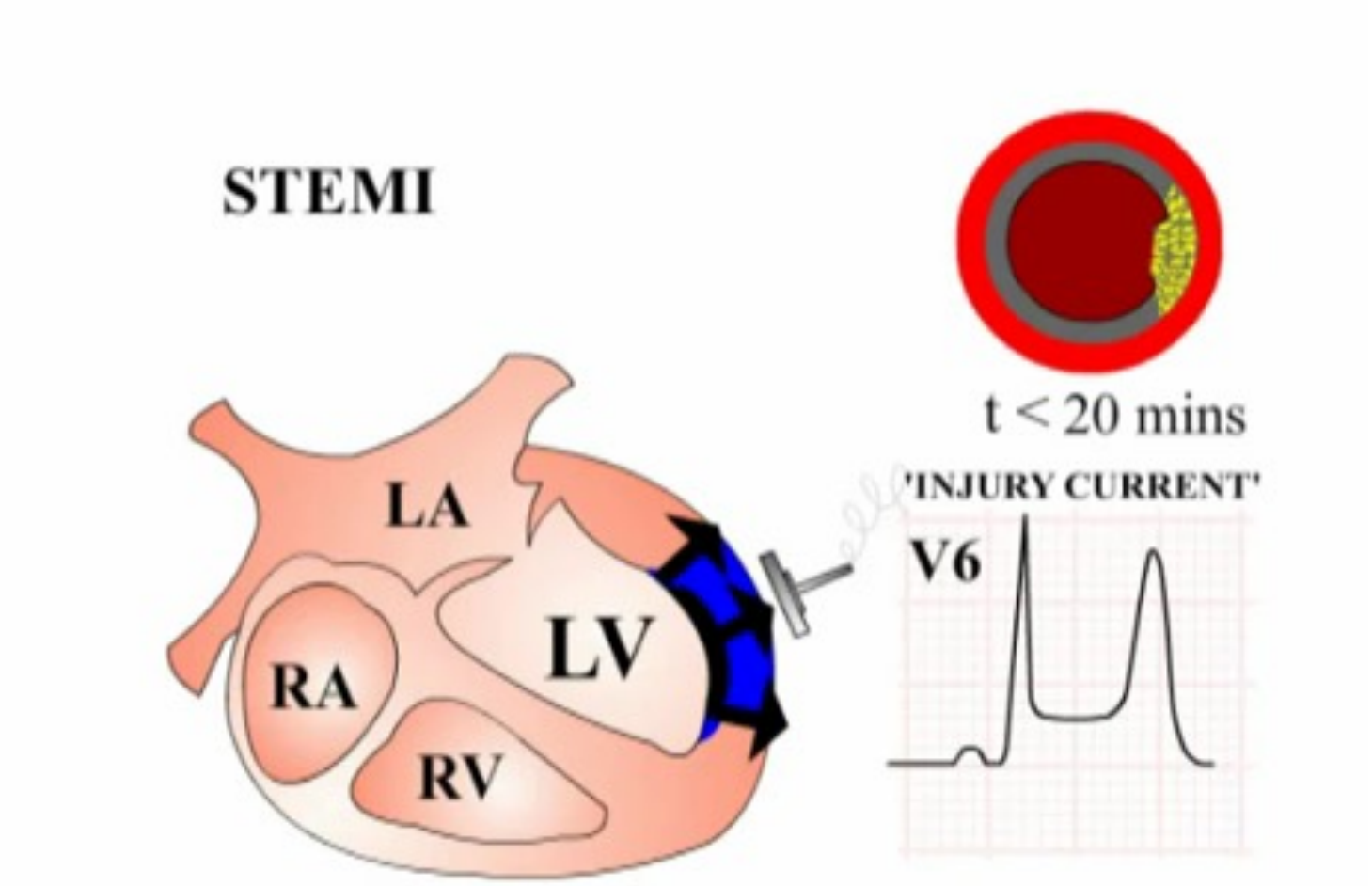
ACUTE CORONARY SYNDROME



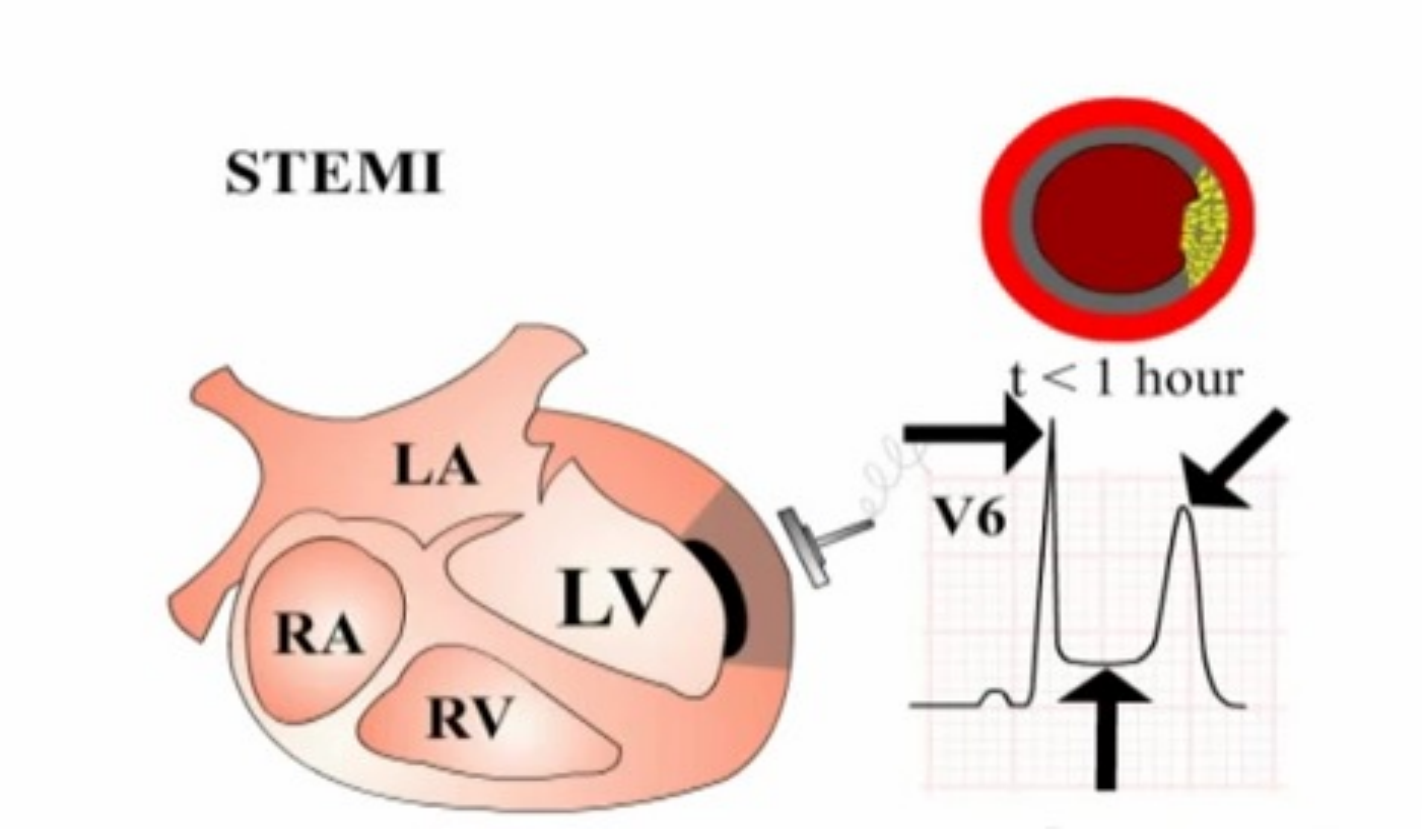
STEMI


STEMI
LA
RA
LV
RV
t < 5 mins
'HYPERACUTE T WAVE CHANGES'
V6
ecgTeacher.com

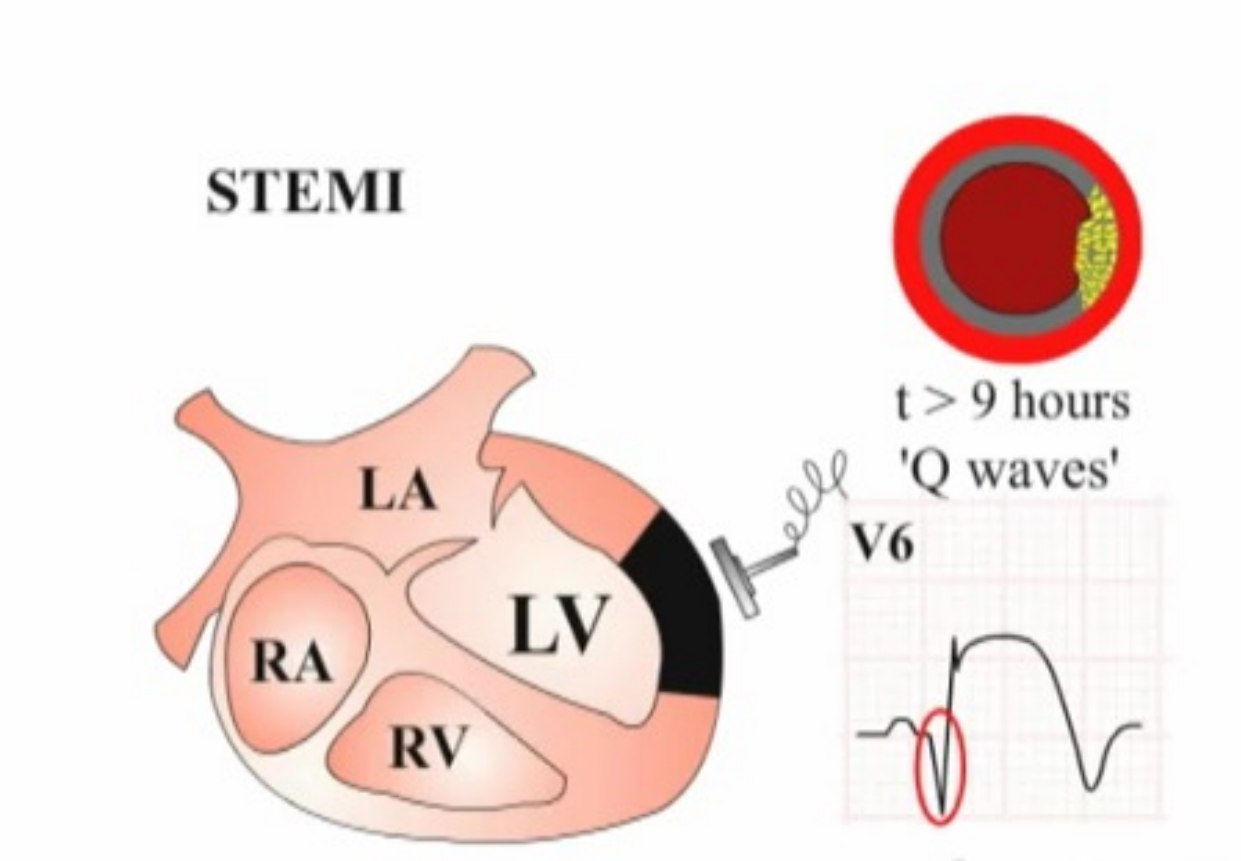
STEMI



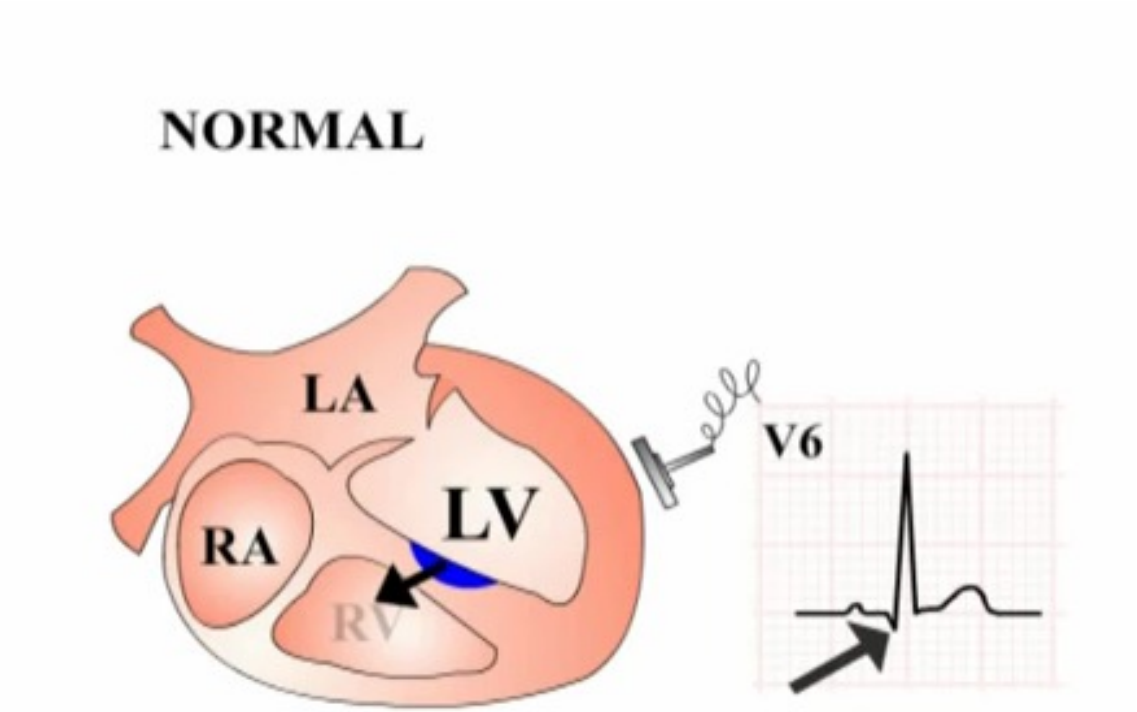
STEMI



STEMI

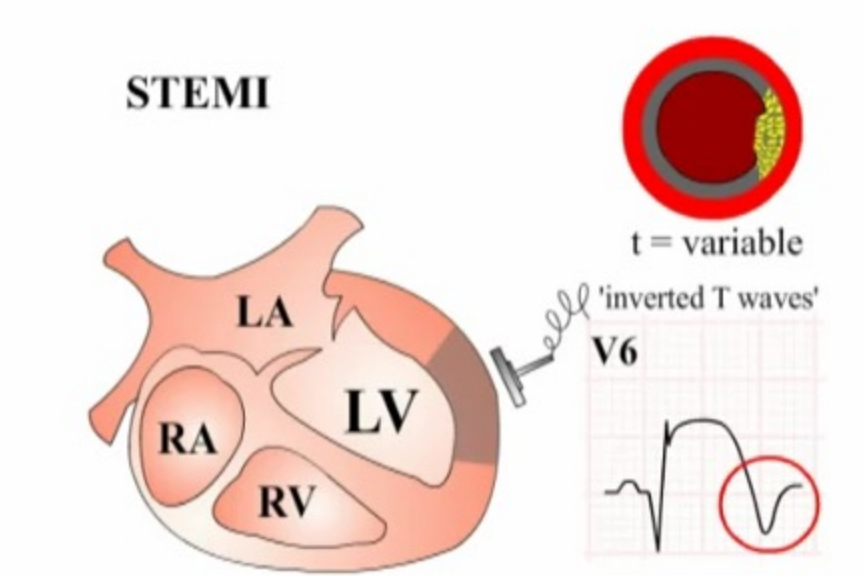


STEMI

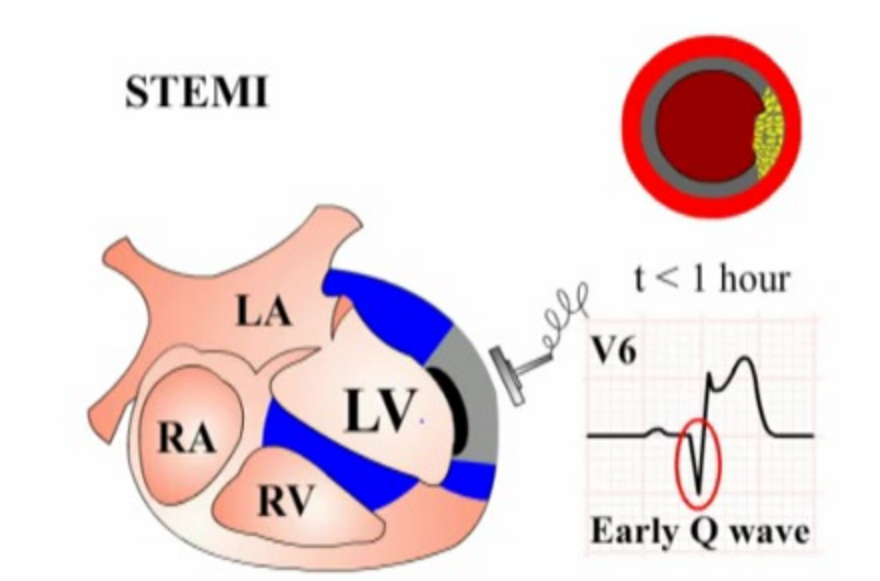


- Normal Q wave

STEMI



STEMI



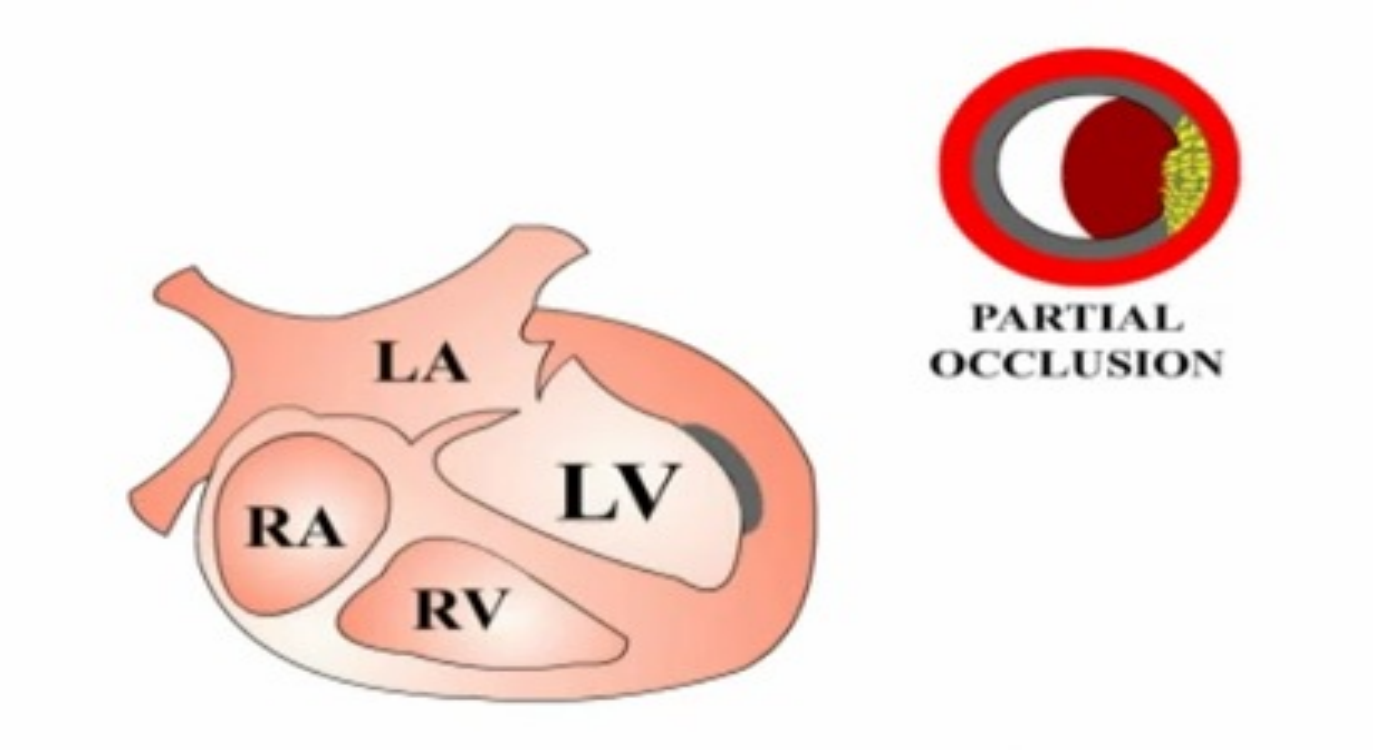
- Viable myocardium

STEMI

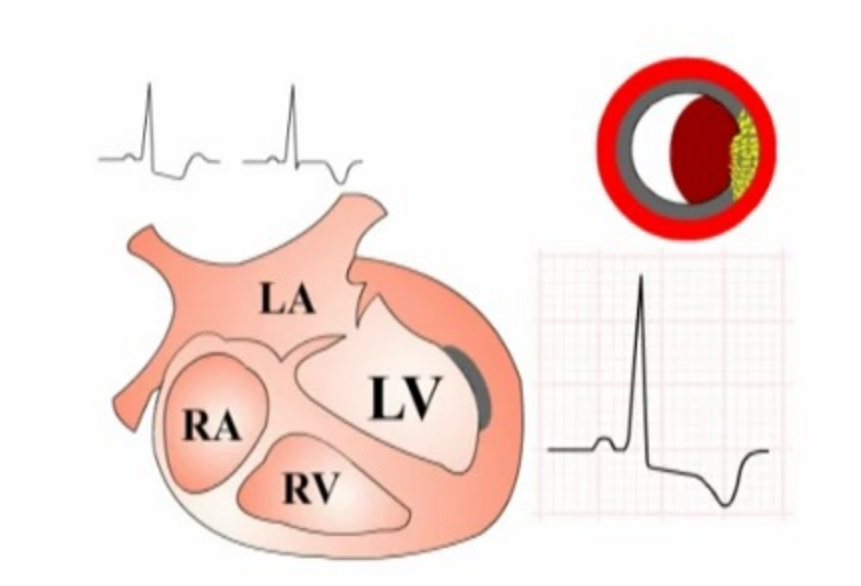
ECG	ONSET	RESOLUTION
HYPERACUTE T WAVE CHANGES	< 5 MINUTES	HOURS
ST ELEVATION	< 20 MINUTES	HOURS TO 3 DAYS
TERMINAL PORTION QRS CHANGES	HOURS	HOURS
Q WAVE FORMATION	9 HOURS TO 2 DAYS	PERMANENT
T WAVE INVERSION	VARIABLE	WEEKS

STEMI LOCALISATION

NSTEMI/UNSTABLE ANGINA

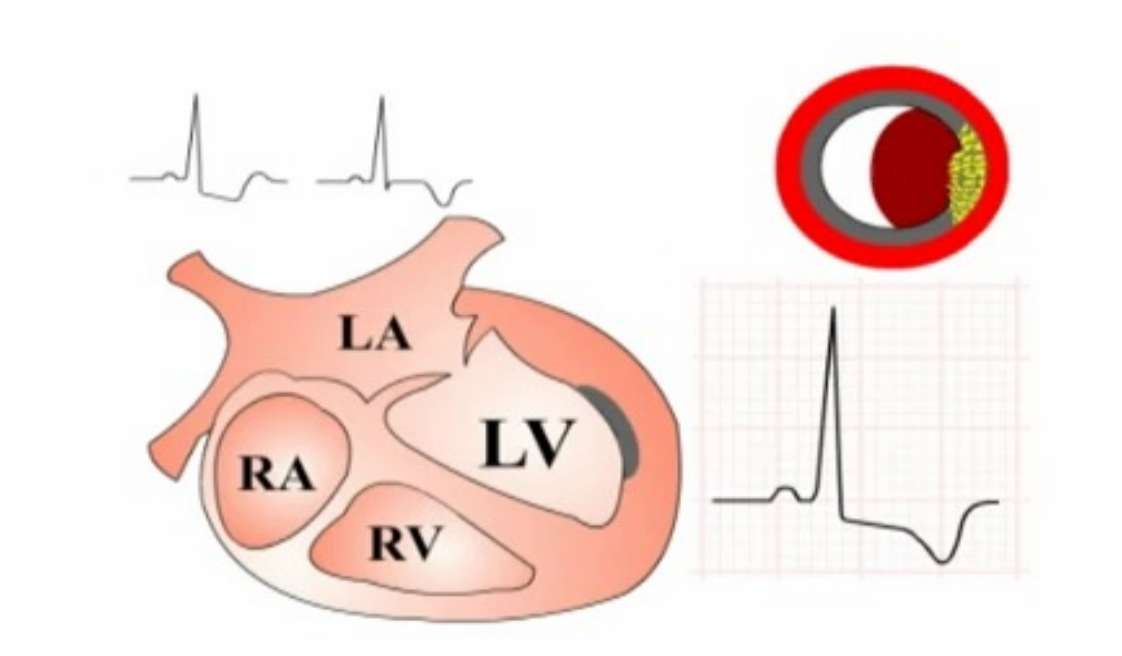


NSTEMI/UNSTABLE ANGINA



- T INVERSION

NSTEMI/UNSTABLE ANGINA



- ST SEGMENT DEPRESSION AND T INVERSION

NSTEMI/UNSTABLE ANGINA

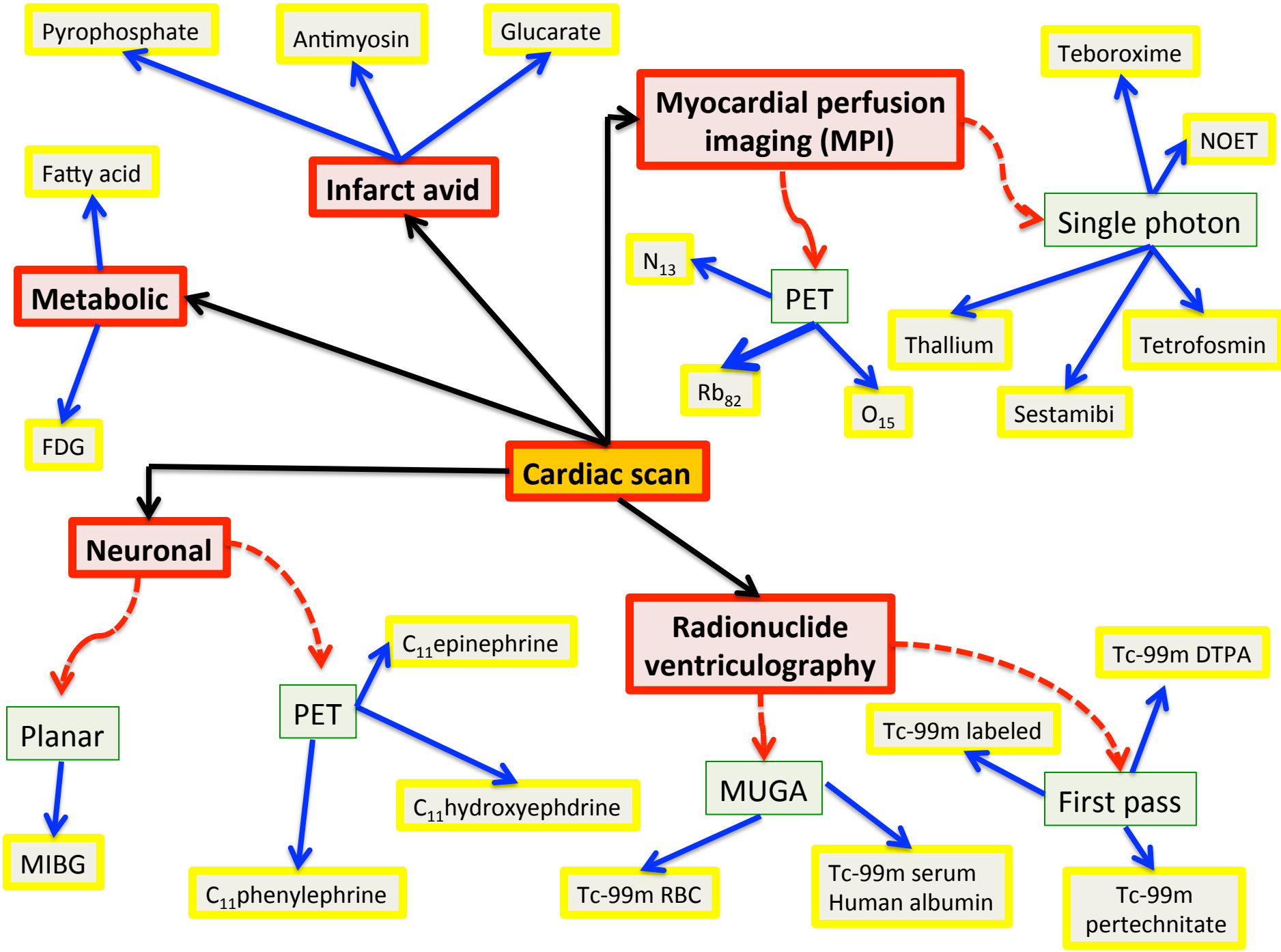
TROPONIN + : NSTEMI

ST Depression | **T wave Inversion** | **Both**

TROPONIN - : UA

SUMMARY

COMPLETE OCCLUSION (STEMI)	PARTIAL OCCLUSION (NSTEMI)
ST ELEVATION	ST DEPRESSION
Q WAVES	T INVERSION
	NO Q WAVES
FULL THICKNESS MI	NON Q WAVE MI
Q WAVE MI	PARTIAL THICKNESS MI
TRANSMURAL MI	SUBENDOCARDIAL MI


Pyrophosphate
Antimyosin
Glucarate
Infarct avid
Fatty acid
Metabolic
FDG
Myocardial perfusion imaging (MPI)
Teboroxime
NOET
Single photon
N13
PET
Rb82
O15
Thallium
Tetrofosmin
Sestamibi
Cardiac scan
Neuronal
Planar
MIBG
PET
C11epinephrine
C11hydroxyephdrine
C11phenylephrine
Radionuclide ventriculography
MUGA
Tc-99m RBC
Tc-99m serum Human albumin
Tc-99m DTPA
Tc-99m labeled
First pass
Tc-99m pertechnitate

Chemical, physical & pharmacokinetic	Thalium-201	Tc-99m Sestamibi (Cardiolite)	Tc-99m Tetrofosmin (Myoview)
Chemical	Element cation	Isonitrile cation	Diphosphine cation
Preparation	cyclotron	Generator/kit	Generator/kit
Mode of decay	Electron capture	Isomeric transition	Isomeric transition
Half life	73 H	6 H	6 H
Principle emissions	Mercury x rays 69-83KeV	Gamma rays 140KeV	Gamma rays 140KeV
Mechanism of uptake	Active transport	Passive diffusion	Passive diffusion
Myocyte localization	Cytosol	Mitochondria	Mitochondria
Redistribution	Yes	No	No
Extraction fraction	85%	60%	50%
Percent cardiac uptake	3%	1.5%	1.2%
Body clearance	Renal	Hepatic	Hepatic
Highest radiation absorbed dose	Kidney (rads/3mCi)	Colon (rads/30mCi)	Gallbladder (rads/30mCi)
Imaging time Stress Rest	 10 min 3-4 hrs	 15-30 min 30-90 min	 5-15 min 30 min

Which Perfusion tracer?

^{201}Thallium
potassium analogue

^{99m}Tc-MIBI & ^{99m}Tc-tetrofosmin,
uptake mediated by electro-potential gradient across intact myocardium cell membrane with mitochondria integrity

Physic Properties of Radioisotopes

Tl-201	Tc-99m
Cyclotron-produced Decay by electron capture $T_{½}$ = **73 hours** X-ray emission **69-83 keV** (88%) and the rest γ-ray emission of **167 keV** and **135 keV**. At the time of calibration, the preparation should contains <1% ^{200}Tl, <1% ^{202}Tl, < 0.25% ^{203}Pb and >98% ^{201}Tl. Available in the form of ^{201}Tl-**thallous chloride in isotonic saline solution**. Shelf life is **5-6 days** after calibration.	Generator elution Decay by isomeric transition $T_{½}$ = **6 hours** γ-ray emission of **140 keV** (88%) Shelf life is **12 hours** after elution.

Which Perfusion tracer?

Advantages of Thallium:	Disadvantages of Thallium
1. High intracellular concentration 2. Redistribution of tracer occur, so that: • Images obtained several hours after injection are similar to those that would have been obtained had thallium been injected at rest. A **single injection protocol** is possible. • Even the severely stenosed or occluded perfusion but non-infarcted myocardium region has shown uptake in redistribution with progession of time. This prevents overdiagnosis of infarction, underestimation of residual muscle mass and **allows assessment of myocardial viability**. 3. Excessive pulmonary uptake of Tl is associated with elevation of left sided filling pressure and is a **good marker of left ventricular impairment**.	**1.Long half-life** of 73 hour → dose administrated must be restricted **2.Low photon energy** (88% are of 60-80keV) → low resolution images and significant attenuation by overlying soft tissues 3.First-pass extraction fraction of nearly 90% but only 4% of the total dose given is taken up by myocardium → count density of myocardial images is low and background activity is high 4.Cyclotron produced → **restricted availability** and expensive **5.Stress imaging should begin within 5 minutes of injection** and should be completed within 30 min. to minimize the effect of redistribution

Which Perfusion tracer?

Advantages of Tc-99m Tetrofosmin / Tc-99m Sestamibi:	**Disadvantages of Tc-99m Tetrofosmin / Tc-99m Sestamibi:**
1.Higher energy photon (140keV) → higher spatial resolution images and less attenuation by overlying soft tissues **2.Short half-life of 6 hour** → larger dose can be administrated with higher count density obtained but with lower radiation burden 3.High count rate → **gated perfusion tomograms possible** with the allowed dose and enables wall motion and wall thickening to be assessed. **4.Generator produced** → cheap and readily availability **5.Lack of redistribution** → patient can be injected at sites distant from the camera location with later imaging → imaging can be repeated in the event of patient motion.	**1.High hepatobiliary uptake** which may interfere with the interpretation of cardiac activity in the inferior wall **2.Higher cost** in preparation 3.The reconstituted product has a **shelf-life** of only 6 hour

WHAT IS REDISTRIBUTION?

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REDISTRIBUTION

- Only occurs with Tl 201
- Is misnomer
- Tl 201 exits the myocardium more slowly from ischemic segments
- In delayed imaging, more rapid exit of Tl 201 from normal segments result in equilibrium among normal and ischemic segment

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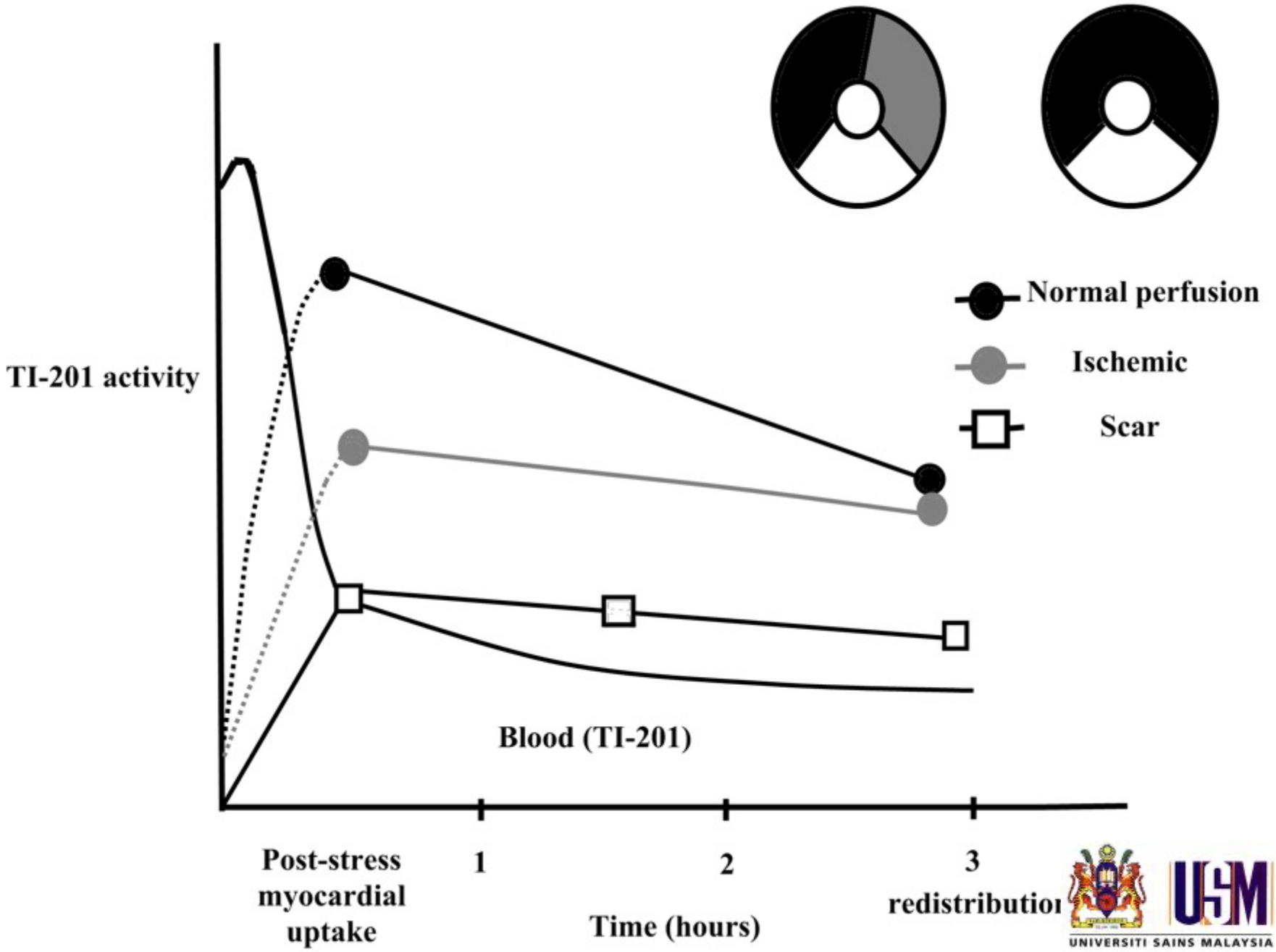

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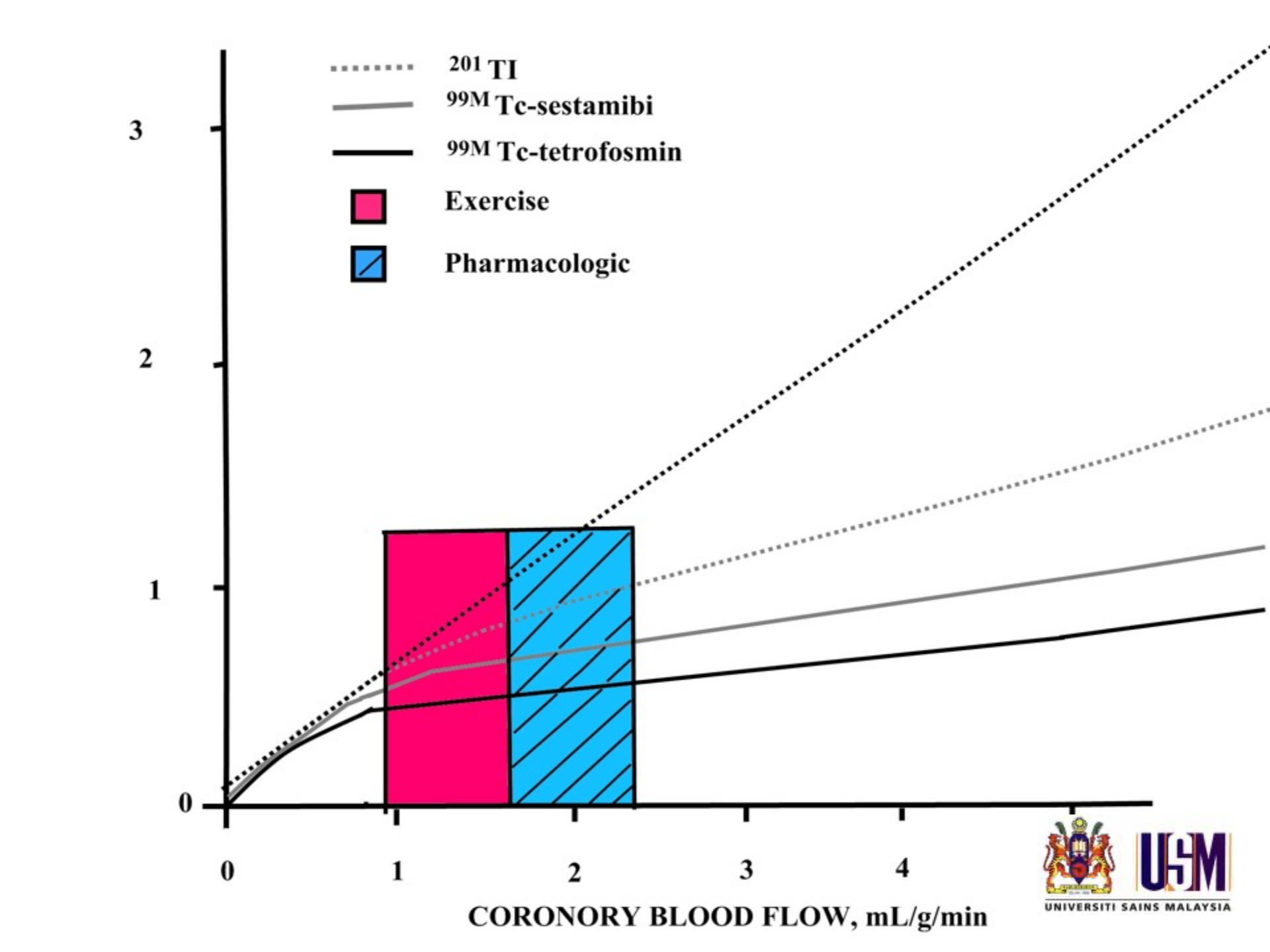
201 TI
99M Tc-sestamibi
99M Tc-tetrofosmin
Exercise
Pharmacologic
3
2
1
0
0
1
2
3
4
CORONORY BLOOD FLOW, mL/g/min
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WHAT IS STUNNED MYOCARDIUM?

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STUNNED MYOCARDIUM

- Myocardium with persistent contractile dysfunction despite restoration of perfusion after ischemia
- Improves with time
- Normal by perfusion imaging
- Absence of ventricular contraction on wall motion studies
- Increased uptake by FDG

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WHAT IS HIBERNATING MYOCARDIUM?

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HIBERNATING MYOCARDIUM

- Chronically ischemic myocardium that is still viable
- Appears cold on immediate Tl 201 imaging
- Absence of ventricular contraction on wall motion studies
- Increased uptake of FDG compared to perfusion imaging
- Improved perfusion on reinjection of Tl 201

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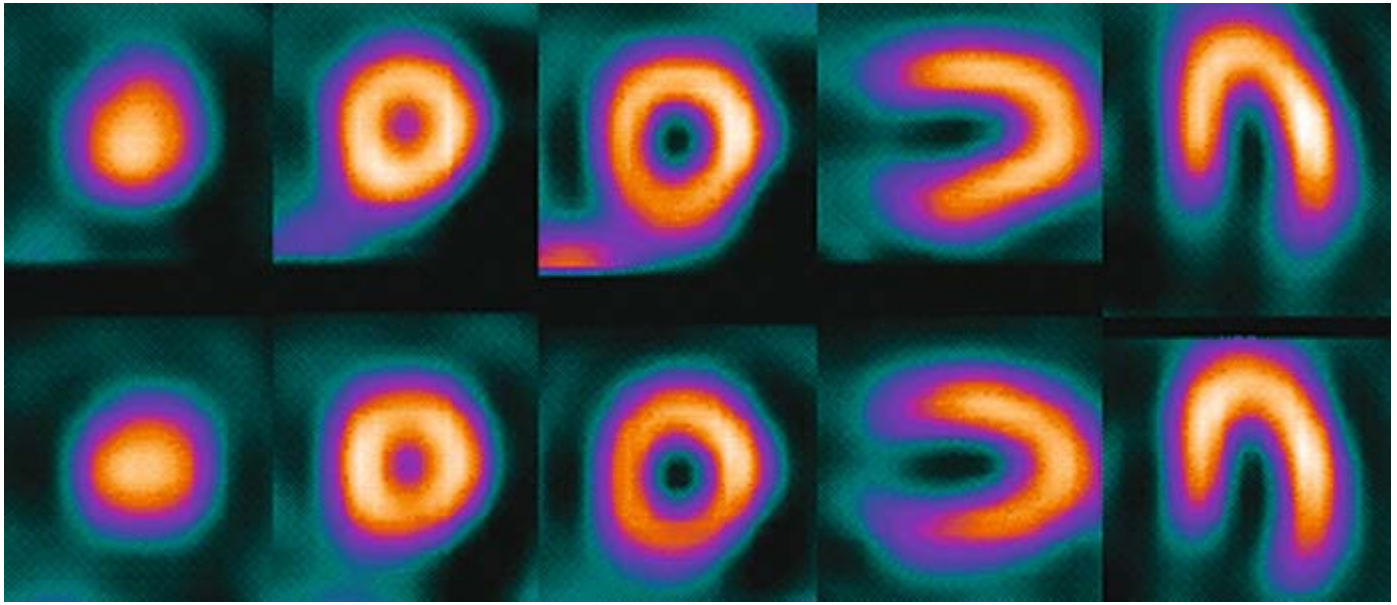
Normal scan



Stress (top) and rest (bottom) MPI images from normal male subject

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ISCHEMIC MYOCARDIUM IMAGES?

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ISCHEMIC MYOCARDIUM

- Reduced Tl 201 myocardial uptake on post stress images
- Improves uptake on the rest images

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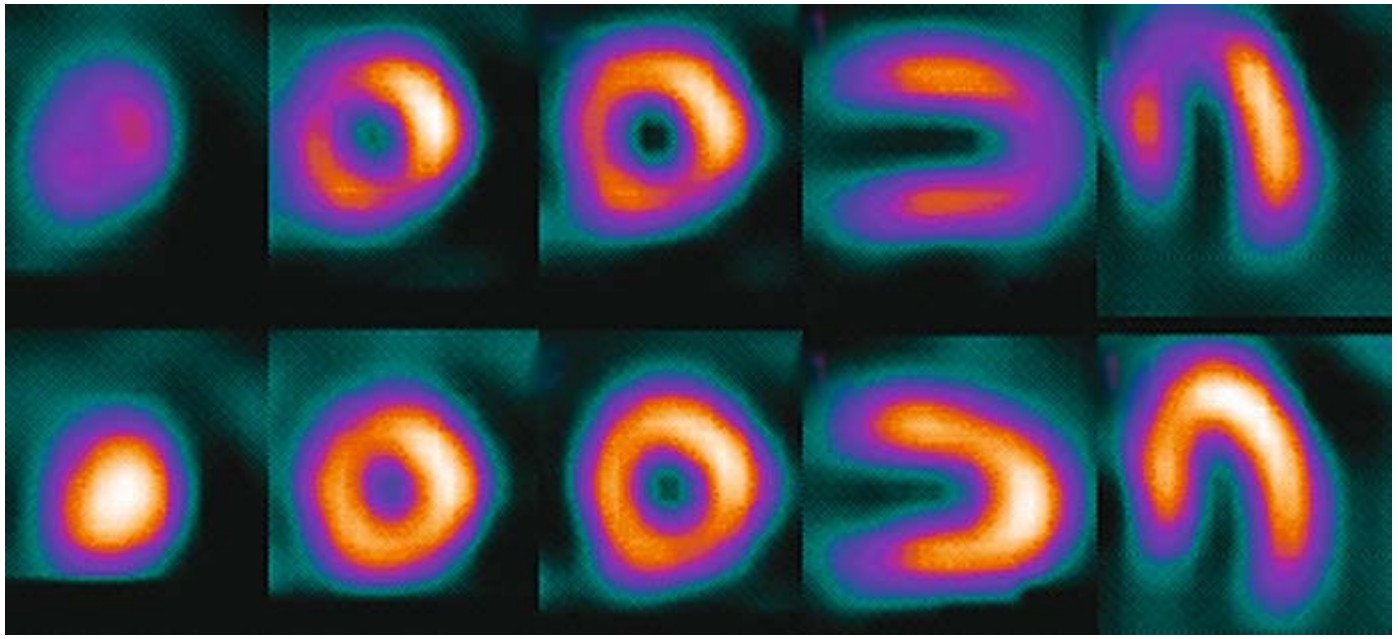
Apical ischemia



Stress (top) and rest (bottom) MPI images from a subject with apical ischemia.

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SCAR IMAGES ?

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SCAR

- Reduced Tl 201 myocardial uptake post stress images
- Reduced uptake on the rest images

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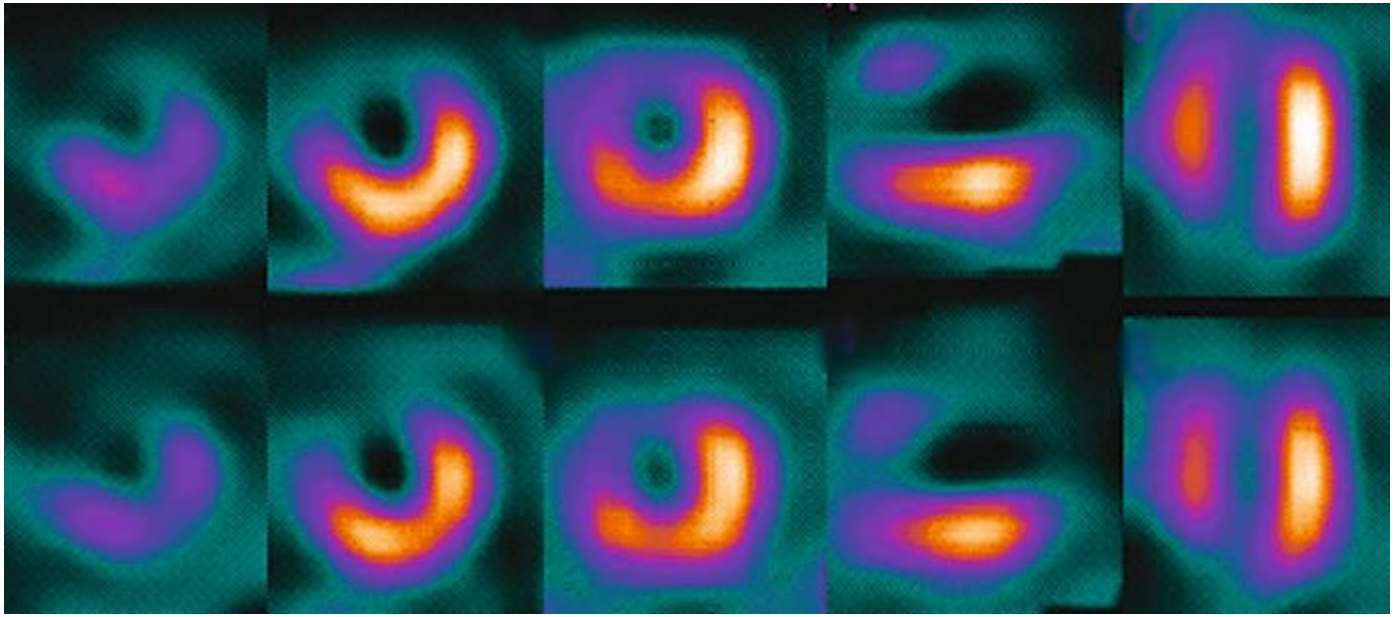
Antero-apical infarct



Stress (top) and rest (bottom) MPI images from a patient with prior extensive antero-apical MI and no residual ischemia.

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MYOCARDIAL IMAGING

RADIOPHARMACEUTICAL	DOSE (mCi)	IMAGING TECHNIQUE	TYPE OF STUDY
^{201}Tl Cl	2-3	Planar or SPECT	Perfusion
Tc 99m sestaMIBI	10-30	Planar or SPECT	Perfusion
Tc 99m teboroxime	15-30	Planar or SPECT	Perfusion
Tc 99m PYP	10-15	Planar	Infarct
^{111}In labeled antimyosin antibody	2-3	Planar	Infarct
^{82}RbCl	60	PET	Perfusion
$^{13}NH_3$	15-20	PET	Perfusion
^{18}F-FDG	5-10	PET	Metabolism

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	Sensitivity	***Specificity***
Myocardial Perfusion Scan	93%	88%
Stress Echocardiography	81%	82%
Exercise Stress Test	68%	77%

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INDICATIONS FOR MYOCARDIAL PERFUSION SCAN

- Detection of CAD
- Assessment of severity of myocardial ischemia or infarction
- Assessment of myocardial viability
- Evaluation for candidate of coronary bypass or angioplasty
- Clinical indication of MI, chest pain and SOB
- ↑ CPK,LDH, +ve troponin and myoglobin
- Detection of viable/hibernating myocardial tissue
- Evaluation of angioplasty/bypass surgery
- Evaluation of prognosis

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CONTRAINDICATIONS FOR MYOCARDIAL PERFUSION

- Chest pain
- Ventricular arrhythmia at rest
- Very high BP
- Allergy to pharmacological stress drugs
- Third degree heart block
- Severe valvular disease (aortic valve stenosis)

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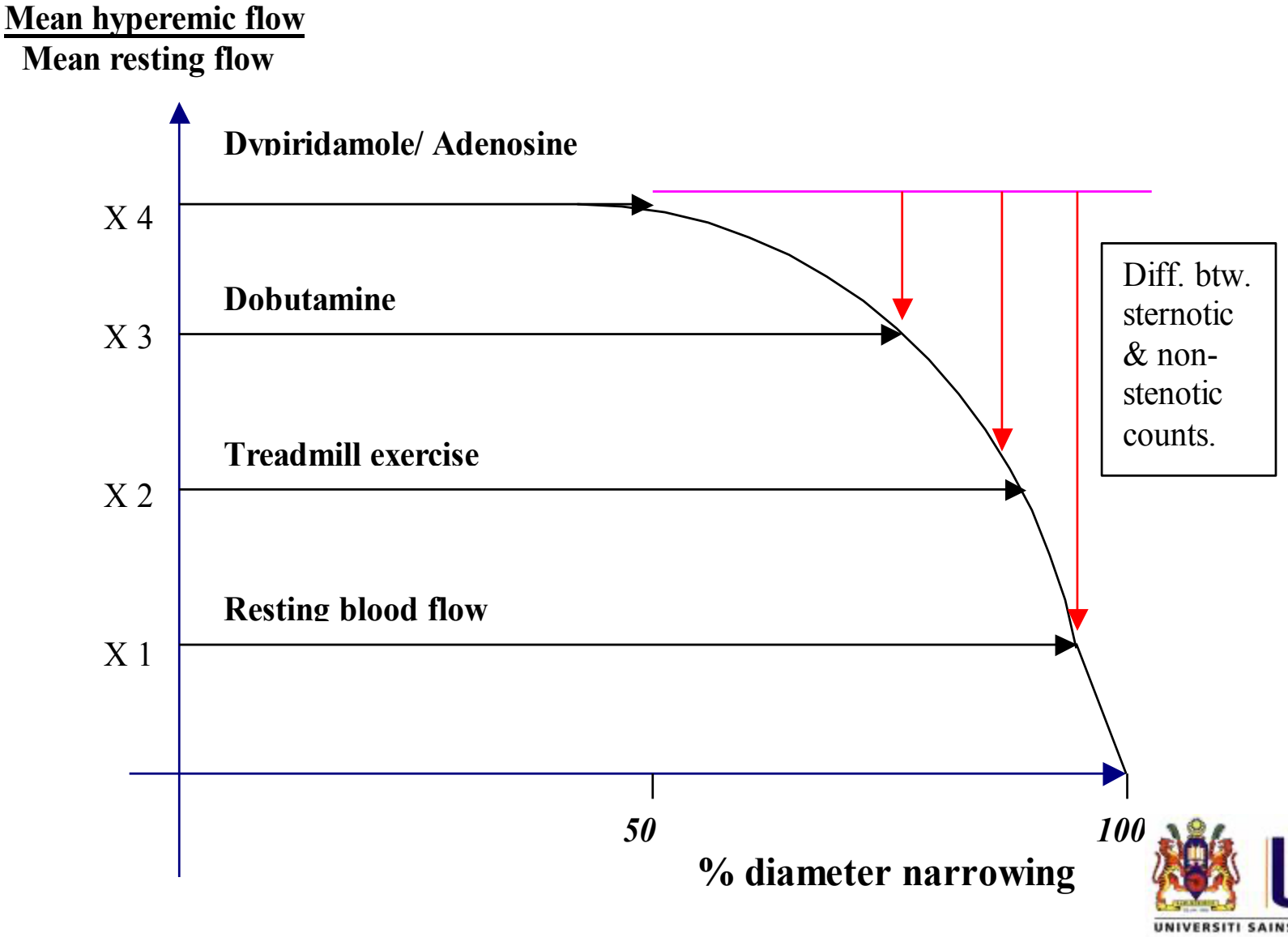
Selection of Stress Technique

Coronary flow disturbance vs diameter narrowing



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STRESS PROTOCOLS

1. PHYSICAL EXERCISE
2. PHARMACOLOGICAL STRESS

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STRESS TESTING INDICATIONS

- Diagnosis of CAD
- Evaluation of CAD, location and extent of ischemia
- Determine the cause for change in symptom pattern in patients with known CAD
- Evaluate the effectiveness of medical therapy
- Risk stratification post myocardial infarction
- Pre operative evaluation for major non cardiac surgery in patient with known CAD
- Assessment after angioplasty or bypass
- Guide to rehabilitation therapy

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STRESS TESTING CONTRAINDICATIONS

- Acute MI
- Unstable angina
- Severe tachyarrhythmias and bradyarrhythmias
- Uncontrolled symptomatic heart failure
- Critical aortic stenosis
- Acute aortic dissection
- Pulmonary embolism
- Poorly controlled HPT

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INDICATIONS FOR TERMINATING A STRESS TEST

- Patient's request
- Inability to continue due to fatigue, dyspnea, or faintness
- Moderate to severe chest pain
- Dizziness, near syncope
- Pallor
- Ventricular tachycardia
- Atrial fibrillation
- Third degree heart block
- ST segment depression > 3 mm
- Increased SBP > 240 mmHg or DBP > 120 mmHg

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Myoview counseling

Stop medications:

◆At the appointment date :

1. Aspirin
2. OHA/insulin

◆2 days prior :

1. Neulin (theophylline)
2. Beta blockers
3. Viagra

◆3 days prior :

1. Nitrates/trimetazidine

1. PATIENTS ON INSULIN

   Aim for early morning appointment

   Patient to take half their normal insulin, with no breakfast

   Patient to bring a snack, their glucose monitor, and their insulin

   After MIBI injection, and prior to imaging, patient is to be allowed to have snack, if required.

   If a patient becomes hypoglycaemic, then the correction of this takes precedence over the stress test booking.

2. PATIENTS NOT ON INSULIN

   Skip diabetic medication on the morning of the test

   Fast as per standard protocol

CARDIAC STRESS TEST : EXERCISE AND PHARMACOLOGY

- LEG EXERCISE
- Treadmill
- Bicycle ergometer

- PHARMACOLOGIC STRESS
- Dipyridamole
- Adenosine
- Dobutamine

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STRESS PROTOCOLS

1. PHYSICAL EXERCISE

2. PHARMACOLOGICAL STRESS

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PHYSICAL EXERCISE

- Treadmill or bicycle
- ECG 10-12 lead used
- Run baseline ECG
- Start exercise
- Monitor HR, BP, ECG changes till target HR is achieved > 85% of (220-AGE)
- Radiotracer is injected when target HR is reached
- Maintain exercise for 1 minute

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Selection of Stress Technique

Advantages of exercise treadmill stress test:	Limitations of exercise treadmill stress test:
1. Most **physiological form of stress**, mimics most closely the situation in which most patients experience angina 2. Estimated peak oxygen consumption in metabolic equivalent test unit (**METS**), pressure-rate (**double product**) at maximal stress level of physical activity and correlation with ECG testing can be obtained together	1. **Beta-blockers or calcium channel blockers should be tapered or withheld** for 48 hours before exercise test. 2. Long-acting **nitrates** should be discontinued 12 hours before the study, although sublingual nitroglycerin may be given up to 2 hours before the test.

Selection of Stress Technique

Patients might not be able to do adequate treadmill exercise due to:

- Old age
- Low stress level (e.g. on propranolol)
- Peripheral vascular disease
- Aortic disease (aortic stenosis – consider dipyridamole/adenosine)
- Arthritis
- Orthopedic problems
- Muscular diseases
- Severe obesity
- Fixed rate ventricular pacemakers
- Sick sinus syndrome and AV block
- Pre-operative risk stratification

STRESS PROTOCOLS

1. PHYSICAL EXERCISE

2.PHARMACOLOGICAL STRESS

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Discussion

ADENOSINE

- Endogenous vasodilator
- Produced from: ADP & AMP in myocardial and vascular smooth muscle
- Receptors : A_1 – slows A-V conduction and A_2 – coronary vasodilator
- Half life is short – seconds
- IV infusion (140 µg/kg/min for 6 minutes)

Discussion

ADENOSINE

- Side effects:
  1. Flushing (37%)
  2. Chest pain (35%)
  3. SOB (35%)
  4. GI symptoms (15%)
- Antidote : ~~aminophylline~~
- Contra Indication :
  1. Secondary heart block
  2. Low BP
  3. Asthma

Selection of Stress Technique

Advantages of adenosine:	**Limitations of dipyridamole:**
1. Short half-life	<u>Contraindications of adenosine</u> Absolute Contraindications: a) Second/Third Degree AV Block (unless pacemaker is present) b) History of severe Bronchospasm or Asthma c) Otherwise as for dipyridamole Relative Contraindications: a) Sick sinus syndrome b) Methylxanthine Use c) Dipyridamole

ADENOSINE

Indications. The indications for adenosine stress perfusion imaging are the same as for exercise myocardial perfusion imaging in the presence of the following conditions:

- Inability to perform adequate exercise due to any extracardiac factors (pulmonary, peripheral vascular, musculoskeletal conditions).
- Left bundle branch block (LBBB).
- Concomitant treatment with medications which blunt the heart rate response (beta blockers, calcium channel blockers).
- Evaluation of patients very early after acute myocardial infarction (<3 days) or very early after angioplasty/stenting (<2 weeks).

Hemodynamic effects. Adenosine results in a modest increase in heart rate and a modest decrease in both systolic and diastolic blood pressures.

Absolute contraindications

- Asthmatic patients with ongoing wheezing should not undergo adenosine stress testing. However, patients with adequately controlled asthma can undergo adenosine stress test.
- Greater than first degree heart block without a pacemaker or sick sinus syndrome.
- Systolic blood pressure less than 90 mm of Hg.
- Use of dipyridamole in last 24 hours or use of xanthines (aminophylline, caffeine) in the last 12 hours. Pentoxifylline (Trental) need not be stopped prior to adenosine stress perfusion imaging.

Relative contraindications

- Severe sinus bradycardia (heart rate <40/min).

Early termination of adenosine infusion. Adenosine infusion should be stopped early under any of the following circumstances:

- Severe hypotension (systolic blood pressure <80 mm of Hg).
- Development of symptomatic, persistent second degree or complete heart block.
- Wheezing.
- Severe chest pain associated with ≥2 mm ST depression.

UPDATED IMAGING GUIDELINES FOR NUCLEAR CARDIOLOGY PROCEDURES

Journal of Nuclear Cardiology
January/February 2001

Discussion

DIPYRIDAMOLE

- Indirect vasodilator
- Block it cellular reuptake → increases intravascular concentration of endogenous adenosine
- Longer half life
- Does not effect A-V conduction
- Antidote : aminophylline

Selection of Stress Technique

Advantages of dipyridamole:	**Limitations of dipyridamole:**
1. Useful for patients with **LBBB**	1. **Contraindication** in patient with: • known or suspected unstable angina • baseline hypotension • brochospasm in asthmatics • severe COPD 2. **Caffeine** should be avoided at least 12 hour prior to the study 3. **Methylxanthines** should be avoided for at least 24 hour prior to the study 4. Off **chocolate and nicotine** for 24 hour Dipyridamole stress could induced transient ischaemic attacks and stroke

Discussion

	Adenosine	Dipyridamole
Effect	Direct	Indirect
Half life	< 10 s	Minutes
Onset of action	Seconds	Minutes
A-V block	3-4%	-
Contra indication	Bronchospasm	Bronchospasm

Dobutamine

- ✔β adrenergic agonist
- ✔Synthetic catecholamine
- ✔β_1 affinity
- ✔Short plasma half life
- ✔Cause ionotrophic/chronotrophic effect due to high O_2 demand cause by artery stenosis
- ✔Infusion rate (40-50 υg/kg/min)

Dobutamine

✔Can be used in asthma patients

✔Side effect:

- ❑Supraventricular and ventricular arrhythmia
- ❑Palpitation
- ❑SOB
- ❑GI symptom
- ❑Chest pain

Dobutamine

✔Contraindications:

- ❖ST depression
- ❖Ventricular tachycardia
- ❖Systolic BP > 220 mmHg

Selection of Stress Technique

Advantages of dobutamine:	Limitations of dobutamine:
1. Safe in **asthmatics** 2. Short half-life of 2 min.	1. **Contraindicated** in unstable angina, uncontrolled hypertension, arrhythmia (ventricular premature beats, ventricular tachycardia, ventricular fibrillation, atrial fibrillation) 2. Atropine (0.2mg IV) may be needed after achieving a maximal dobutamine dose (>40 microgram/kg/min.) if the increase heart rate is submaximal (<80% of max. predicted)

DOLBUTAMINE

Indications

- Dobutamine is a secondary pharmacologic stressor that is used in patients who cannot undergo exercise stress and have contraindications to pharmacologic vasodilator stressors.
- Dobutamine perfusion imaging has not been studied as extensively as adenosine or dipyridamole in the evaluation and prognostication of patients with CAD.

Contraindications. Dobutamine stress testing should not be used under the following circumstances:

- Recent (<1 week) myocardial infarction.
- Unstable angina.
- Hemodynamically significant left ventricular (LV) outflow tract obstruction.
- Critical aortic stenosis.
- Atrial tachyarrhythmias with uncontrolled ventricular response.
- Prior history of ventricular tachycardia.
- Uncontrolled hypertension.
- Patients with aortic dissection or large aortic aneurysm.
- Patients who are on beta blockers may not show adequate heart rate response to dobutamine. It is preferable to use adenosine or dipyridamole in these patients.

UPDATED IMAGING GUIDELINES FOR NUCLEAR CARDIOLOGY PROCEDURES

Part 1

Journal of Nuclear Cardiology
January/February 2001

	Adenosine	**Dypiridamole**	**Dobutamine**
Mechanism of action	Direct	Indirect	Indirect
Half life	< 10 s	30 – 60 min	2 min
Onset of action	Seconds	2 min	1 – 2 min
Patients with side effect requiring medical intervention	0.6%	16%	NA

ADVERSE EFFECTS: ADENOSINE AND DIPYRIDAMOLE

ADVERSE EFFECT	ADENOSINE (%)	DIPYRIDAMOLE (%)
Flushing	37	3
Dyspnea	35	3
Chest pain	25	20
GI symptoms	15	6
Headache	14	12
Dizziness	9	12
A-V block	8	2
ST wave changes	6	8
Arrhythmia	3	5
Hypotension	2	5
Bronchospasm	0.1	0.15
MI	0.0001	0.05
Death	0	0.5

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ARTIFACTS FOR MPI

- Patient motion
- Diaphragm in men and breast in female cause attenuation artifacts
- Medallion, necklaces, pacemaker or metallic button
- Left arm of the patient, lying on the side may cause unwanted attenuation
- Gallbladder with sestaMIBI may cause problems

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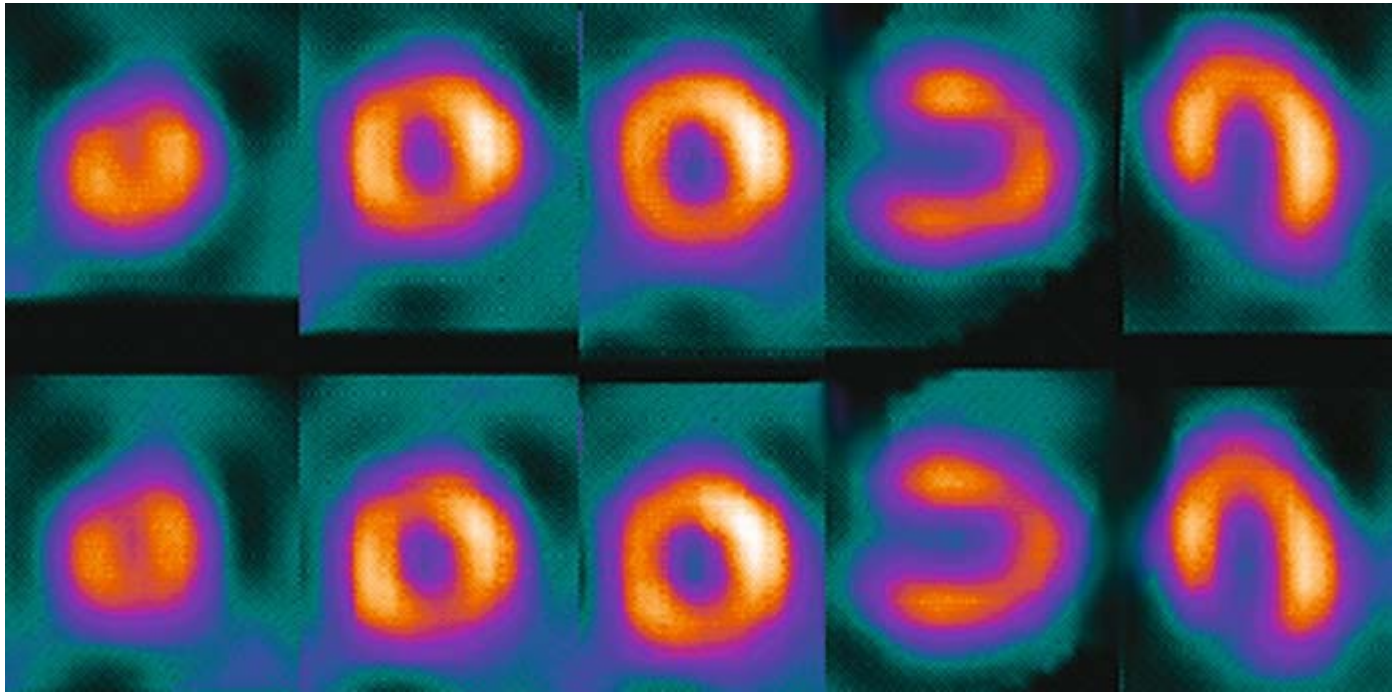
Breast attenuation effect



Stress (top) and rest (bottom) MPI images from a female subject showing a reduction in counts anteriorly in both stress and rest images.

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Imaging protocols for ^{99m}Technetium agents perfusion imaging

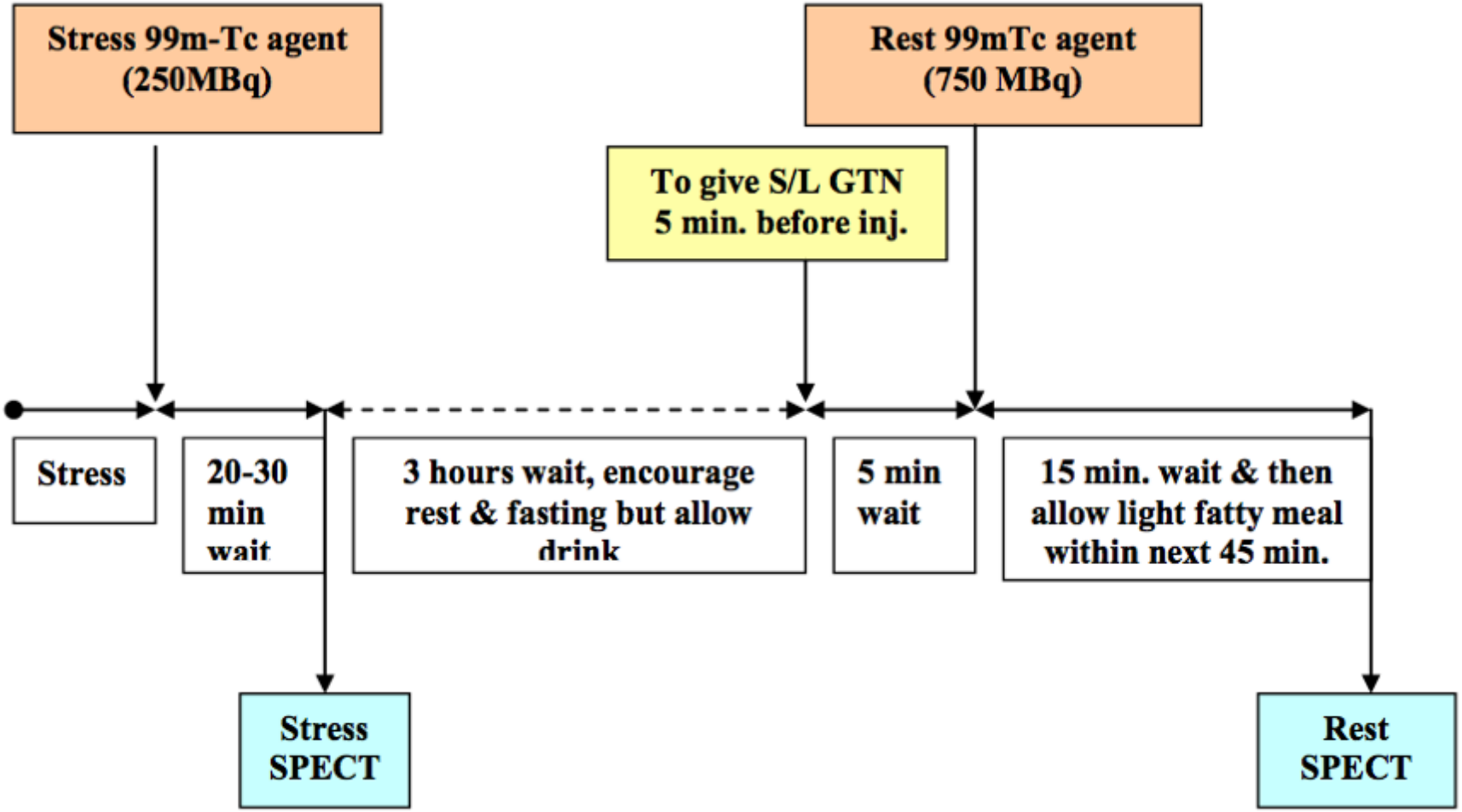
Stress-rest protocol:	Rest-stress protocol:
Procedure used for both 1 or 2-day protocol: 1.250-300 MBq of Tc-99m agent is given IV at peak exercise, which is then continued for another 3 minutes. SPECT imaging is performed 15 minutes later. 2.If these stress images is also normal, no further imaging is necessary. If the images are not normal, the patient may return after 4 or 24 hours later. 3.The reinjected Tc-99m agent dose is 300 MBq for 2-day protocol and 750-900 MBq for 1-day protocol. 4.SPECT imaging at rest is done 30 minutes after IV administration.	**Procedure used for both 1 or 2-day protocol:** 1.250-300 MBq of Tc-99m agent is given IV at rest. 2.SPECT imaging at rest is done 30 minutes after IV administration 3.Stress testing is performed. 4.The reinjected Tc-99m agent dose is the same 300 MBq for 2-day protocol and 750-900 MBq for 1-day protocol. 5.Tc-99m agent is given IV at peak exercise, which is then continued for another 90 seconds. 6.SPECT imaging is performed 15 minutes later.

Explanations / arguments:

- The **advantage of stress-rest protocol** is that if the initial stress images is normal, no further imaging is necessary and this reduce the radiation burden to the patient.
- The **disadvantage of 1-day stress-rest protocol** is that it tends to overestimate presence of myocardial scar compare to 1-day rest-stress protocol. A stress-rest sequence results in an increased number of ischemic segments incorrectly being identified as fixed defects (7% false-negatives). The rest portion of the exam may not be considered to be a "true" rest study as it follows a period of exercise and this may contribute to the overestimation of scar.

MPI protocol for HSAJB

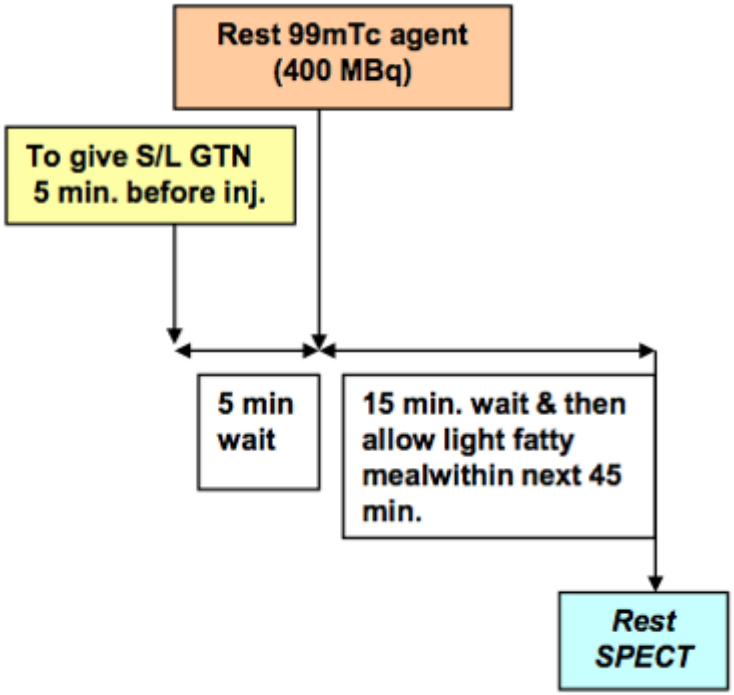
1-day Stress-Rest protocol with ^{99m}Tc-Tetrofosmin



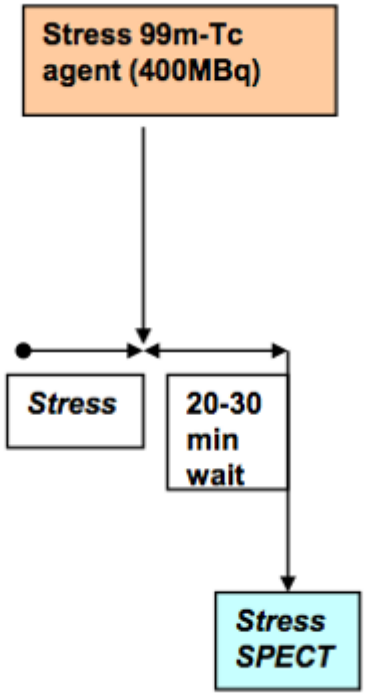
MPI protocol for HSAJB

2-day protocol with ^{99m}Tc-Tetrofosmin

For rest study:



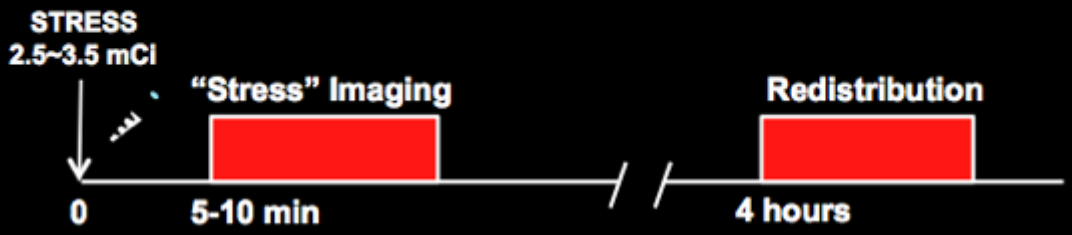
For stress study:



Imaging protocols for ^{201}Thallium perfusion imaging

Stress and Rest Reinjection potocol	Rest and Redistribution protocol
Procedure used to established myocardial ischaemia. Tl-201 (75MBq) is given IV at peak exercise at about 60 seconds before termination of adequate stress. SPECT is performed 10 to 15 minutes later to avoid 'upward creep' of the heart as the patient settles down. The rest SPECT imaging is obtained 4 hours later to determine which myocardial segment redistribute. If myocardial viability is an issue (when a fixed defect is seen both in stress and rest), another 25 MBq of Tl-201 may be injected and another series of resting SPECT reinjection images is obtained 10 minutes or 12 to 24 hours later, or alternatively, a second-day rest reinjection of thallium has also been proposed to give an accurately defined muscle mass.	Procedure of choice for determining presence of **myocardial mass and viability**. Tl-201 (74MBq) is injected IV. Resting SPECT images are obtained at 10 minutes. Another set of SPECT Tl-201 rest imaging are obtained 4 hours later. Delayed images can be obtained 12 to 24 hours later, preferably after IV injection of an additional 25 MBq of Tl-201 administered immediately after the last rest images.

Tl-201♪


STRESS
2.5~3.5 mCi
"Stress" Imaging
Redistribution
0
5-10 min
4 hours

Single or Dual isotope imaging protocol?

Dual Isotope imaging, rest Tl-201 / stress Tc-99m agent
75 MBq of Tl-201 is either injected the evening before or immediately before imaging. SPECT imaging is done. The patient is then placed on a treadmill or administered pharmacological stress with 500 MBq of Tc-99m agent injected. SPECT stress imaging are acquired 15 minutes later.
Explanations / arguments: The **advantage** of this 1-day protocol is no wait is required between the rest and stress study as the Technetium gamma energy is higher than the energy imaged for Thallium. Both the rest and the stress imaging can be done together in one sitting. A **drawback** of this technique is that because of the resolution differences between the two radionuclides, it is difficult to directly compare the images, particularly with subtle abnormalities. This 1-day protocol is **convenient** for patients with prior myocardial infarction, inpatients and patients who live a distance from the imaging center. It is **best for assessment of potential functional recovery** of hypokinetic, akinetic or dyskinetic segments. It is good for detection of inducible ischaemia and to determine the viability of a dysfunctional myocardial segment. A normal or equivocal dual isotope test indicates an excellent prognosis.

Lung uptake

- Presence of excessive thallium in the lungs post exercise is important >
- Normally = 30-50%
- Abnormal : > 50%, marker of transient LV dysfunction at exercise
- In the presence of CAD→ this is related to transient pulmonary oedema caused by the rise in LVED pressure secondary to stress induced myocardial ischaemia.
- Thallium leaks into the interstitial due to pulm oedema→ washes out in the delayed scan.
- 99mTc based ? documentation

SPECT : Image artifacts and Variants

CAUSE	RESULT	RECOGNITION/CORRECTION
ACQUISITION Soft tissue Attenuation Breast	Anterior/lateral wall defect	Bind/elevate breast View planar/rotating image View GSPECT 3D Cine (fixed defect) Use attenuation correction program
Elevated Left Hemidiaphragm	Inferior wall defect	Prone imaging View planar/rotating image View GSPECT 3D Cine (fixed defect) Use attenuation correction program
Abdominal Viscera	Relative increased Inf wall activity (overlap) Relative decreased in inf wall activity (reconstruction)	Repeat study
Postexercise resp motion (diaphraghmatic Creep)	Reversible Inf wall defect	Delay post exercise imaging
Patient motion	Myocardial defect (depends on movement)	View rotating film/sinogram Motion correction

Artifacts & Variants

CAUSE	RESULT	RECOGNITION/ CORRECTION
PROCESSING & DISPLAY Incorrect axis	Myocardial defect esp basal	Review axis esp long axis
NORMAL VARIANT Variable sepal & apical thinning	Myocardial defects	Typical location
Papillary muscle	Focal myocardial hot spot	Typical location (2 o'clock & 7 oclock) in short axis

NON coronary cause of abnormal MPI

CAUSE	RESULT	RECOGNITION/ CORRECTION
Vulvular lesion	Aortic regurgitation Aortic Stenosis/ Mitral valve prolapse	Apex
LBBB	Asynchronous septal relaxation out of phase with diastolic coronary filing → reduced septal perfusion at exercise	Septal/anteroseptal abnormality
Hypertensive Myocardial Hyperthrophy	Increased septal count → relative reduced lateral wall uptake	Fixed lateral wall defect
Dextrocardia	usually abnormal uptake at lateral wall (which actually the septum in dextrocardia)	SPECT acquisition range between -135 to +45 instead of 180 degrees

Reporting MPI

Inspection of raw projection data:

General:

- Appropriate acquisition arc
- Any truncation of organ of interest – heart
- Adequate cont rate
- Gating – major variation in count density of images, manifests itself as “flashing” of the cine display

Specific:

- Patient motion – vertical (craniocaudal), lateral (horizontal)
- Attenuation
- Extra cardiac uptake
- Lung uptake
- Hepatic / GI uptake

Inspection of raw projection data:

Patient motion:

3-point score for motion:

0 = no motion, 1 = slight motion, 2 = moderate to severe motion

- if moderate to severe motion is noted, the acquisition should be repeated.
- if slight motion is observed, images must first be restructured and acquisition repeated (prone position) if necessary.
- Motion correction algorithm usually does not work adequately with severe motion and frequently fails in lateral motion.

Display:

QC:

short-axis and long-axis images should be examined for overall adequacy of counts, appropriateness of the axis chosen for reconstruction and slice selection.

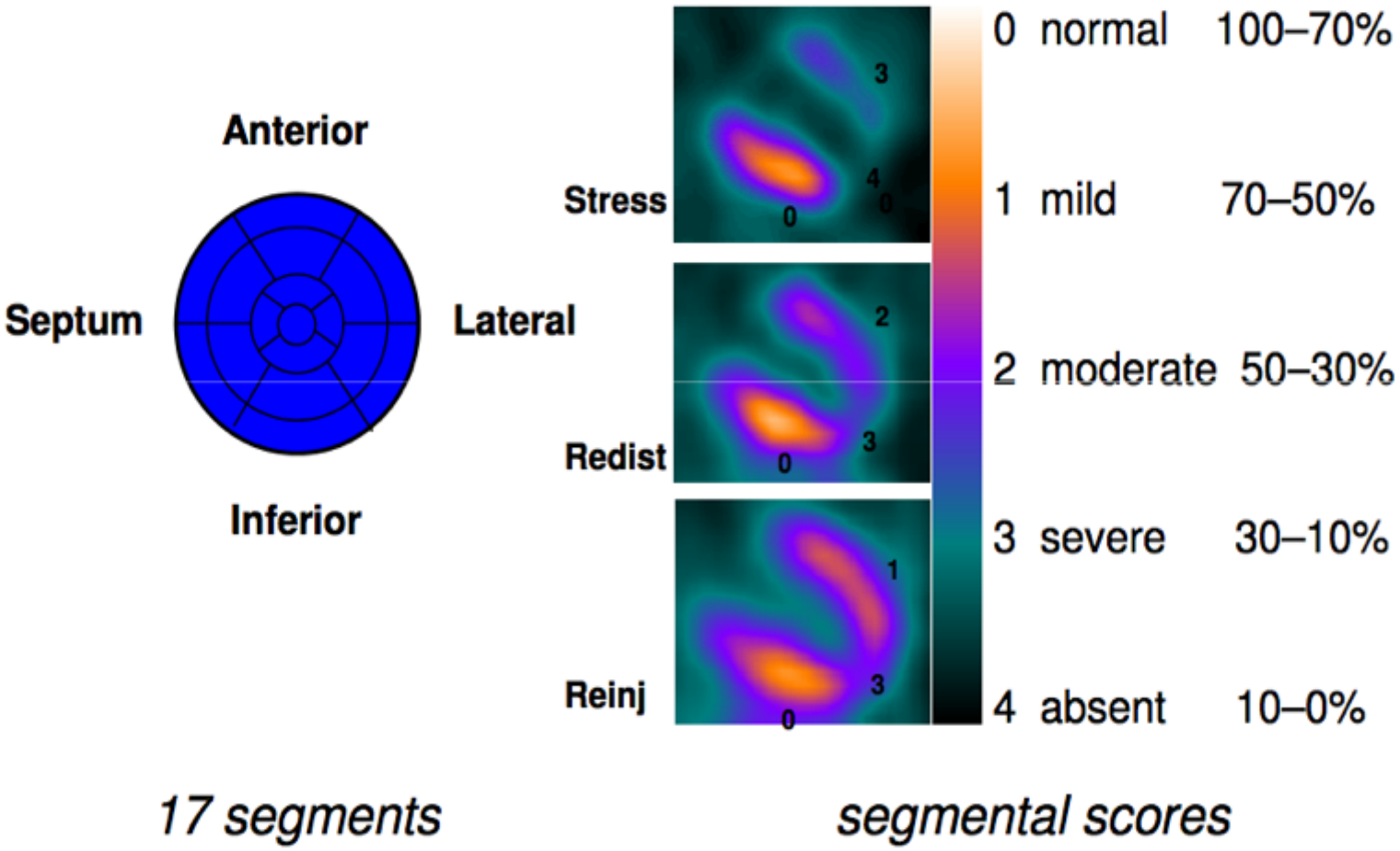
Overall quality of a study:

(e.g. 5= excellent; 4 = good; 3 = fair; 2 = poor; 1 = uninterpretable)

Segmental Scoring (5-point scoring system)

0	normal	used for normal
1	slight (equivocal) reduction of uptake	mild or equivocal reduction (could be abnormal but it could also represent a normal variant due to attenuation or artifactual cause)
2	moderate reduction of uptake	usually implies a significant abnormality. moderate defect, one in which the reader is quite confident that the defect is real
3	severe reduction of uptake	severe reduction
4	absence of radioactive uptake	visually absent

Visual scoring



17 segments, 5-point scoring system

- Summed scores
  - SDS : summed difference score
  - SSS : summed stress score
  - SRS : Summed rest score

Summed stress score	interpetation
4-8	Mildly abnormal
9-13	Moderately abnormal
> 13	Severely abnormal

Perfusion defect: Extent & Severity

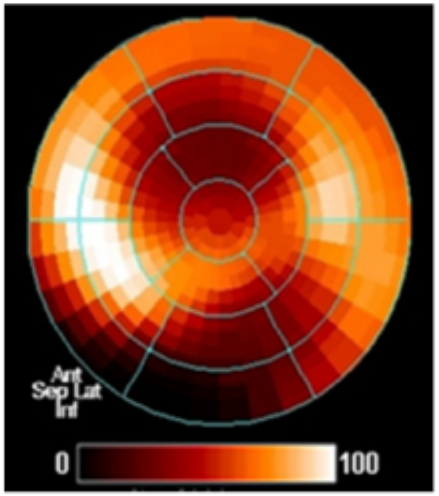
Based on the extent and severity of MPS perfusion defects:

< 5% → normal

5 -10% → mild / small

15-20% → moderate / medium

> 20% → severe / large



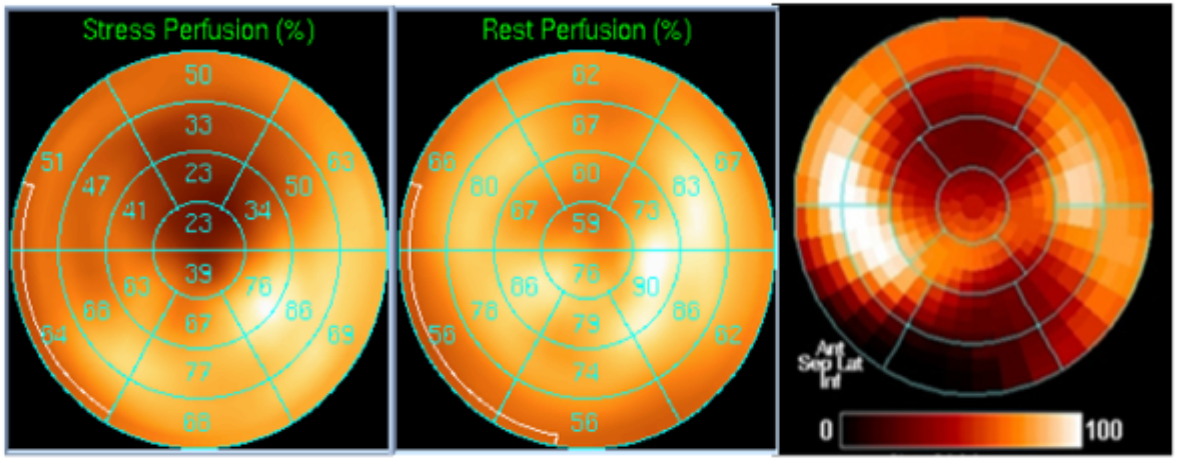
Perfusion defect: Extent & Severity

Calculating % myocardium (abnormal) with stress, rest, reversible defects: divide by max. score, multiply by 100

For 17-segments model: (a / 68 X 100)

For 20-segments model: (a / 100 X 100)

% Myocardium defect		% Reversibility		% Fixed	
Normal/ Equivocal	0-4%	Normal	0-2%	Normal/ Equivocal	0-4%
Mild	5-9%	Mild	3-5%	Mild	5-9%
Moderate	10-14%	Moderate	6-9%	Moderate	10-14%
Severe	>14%	Severe	>10%	Severe	>14%



Non-myocardial perfusion abnormalities:

- Size of LV
- Transient ischeamic dilatation (TID) of LV
- RV myocardial uptake pattern ± RV size
- Abnormal lung uptake
- Other abnormal extracardiac uptake

- **Suggested upper normal threshold for TID**

	Pharmaceutical Stress	Exercise stress
Tc-99m single-isotope study, same day low activity/high activity protocol	1.20	1.15
Tc-99m or Tl-201 single-isotope study, 2-day protocol	1.10	1.15
Dual isotope rest Tl-201/stress Tc-99m	1.36	1.22

Overall assessment of MPI:

A visual criteria for abnormality are:

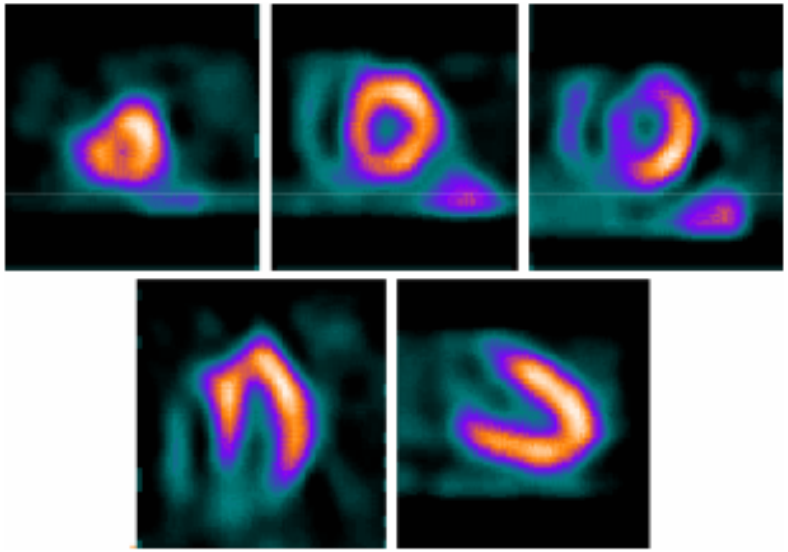
Normal	All segments = 0
Probable normal	Few segments = 1
Equivocal	Multiple reversible = 1 1 segment = 2
Probably abnormal	2 segments = 2
Definitely abnormal	$\geq$ 3 segments = 2 $\geq$ 1 segments $\geq$ 3

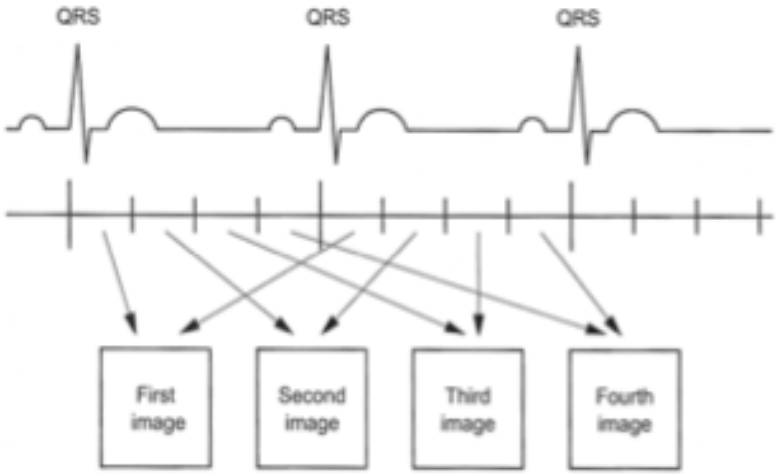
Weighting toward abnormal if:

- Defects are reversible
- Conform to a standard coronary territory
- Associated with TID (transient ischaemic dilatation)
- Presence of lung uptake

Gated Study

In Gated Mode, taking into account the repetitive pattern of the organ motion, the data from different phases of the motion cycles are accumulated into bins, which represent each phase over a period of time.



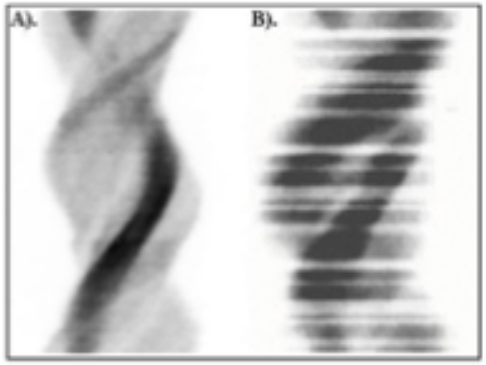


Assessment of gSPECT images:

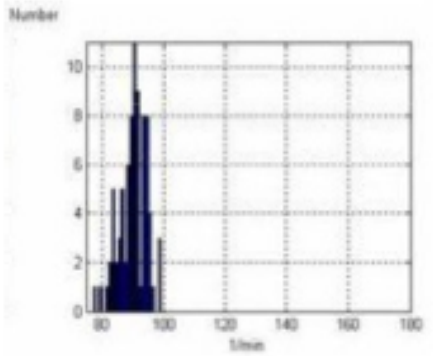
QC:

Cinematic display (rotating summed projection images)

Observation of "flashing" usually indicates that a gating error has occurred, resulting in the acquisition of a widely different number of cardiac cycle at different angles of projection along the acquisition arc.

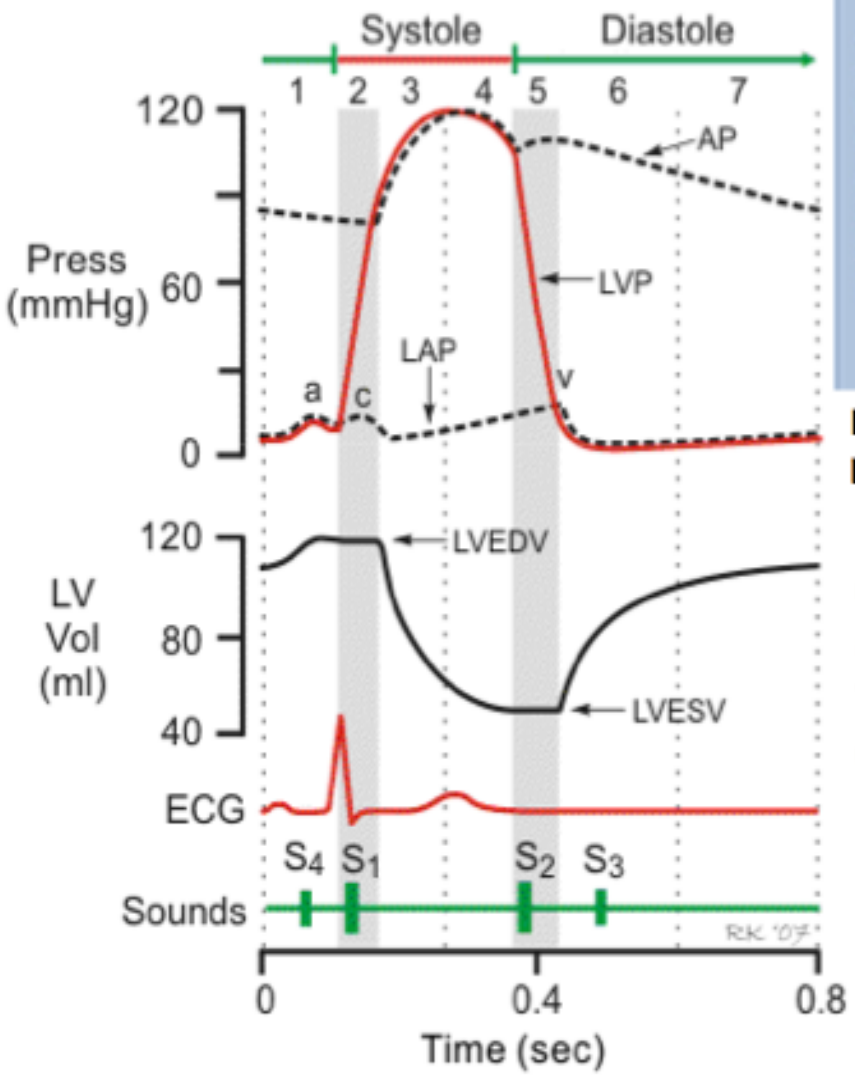


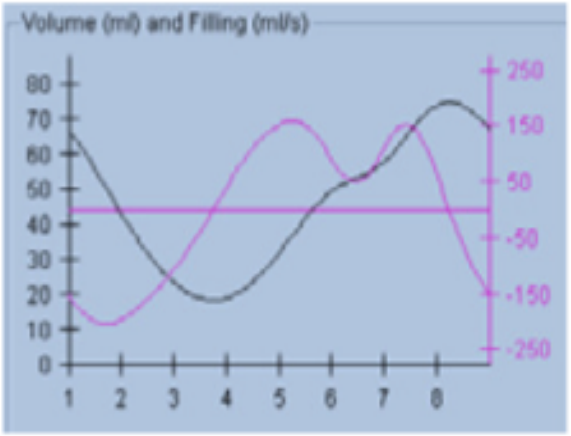
A normal myocardial perfusion SPECT sinogram (A) compared to the striped appearance characteristic of count losses resulting from inadequate gating of the SPECT data (B).



A heart-rate histogram provides objective documentation of the adequacy of gating.

Inspection of “time-volume curve”:

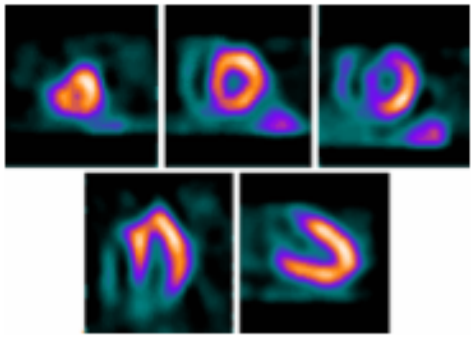




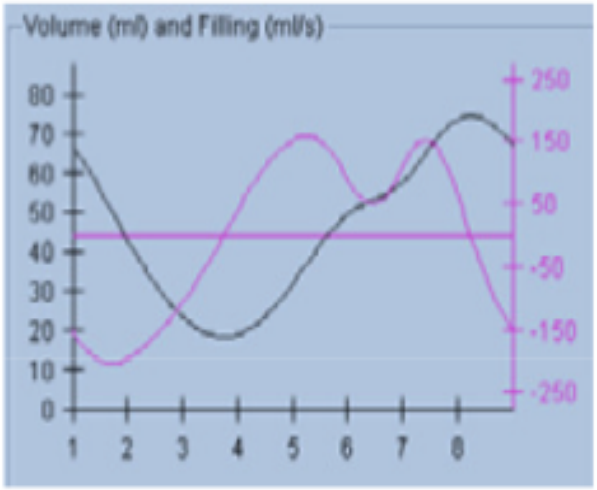
Black is time-volume curve

Pink is the filling curve.

Inspection of “time-volume curve” derived form quantitative gated SPECT algorithms provides an assessment of the LV site at various phase of the cardiac cycle.



Inspection of “time-volume curve”:



Black is time-volume curve
Pink is the filling curve.

The frame with the largest volume is the first frame, corresponding to end-diastole and that the overall curve has a characteristic U shape.

When the time-activity curve is clearly inappropriately timed, the gated SPECT data are generally considered nondiagnostic for the assessment of wall motion and wall thickening from the individual gated frames.

17-segment wall motion analysis (6-point motion score)

6-point motion score: (based on what is "normal" for a given region)

0 = normal
1 = mild (equivocal) hypokinesis
2 = moderate hypokinesis
3 = severe hypokinesis
4 = akinesis
5 = dyskinesis

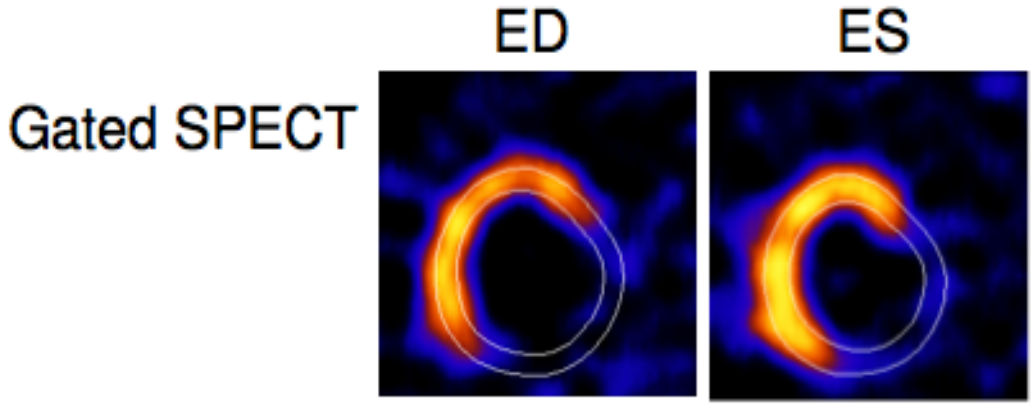
Wall thickening analysis:

- **increase in the apparent brightness of a wall** during cardiac cycle (partial volume effect).
  A 10-step scales may be used. With a 10-pont colour scale, there is at least a 2-color change from diastole to systole in normal zones. In the mid and apical short-axies slices, the mean normal thickening is approximately 40%.

- **actual increase in its thickness**.

  4-point system: (based on what is "normal" for a given region)

  0 = normal
  1 = mild (equivocal) reduction
  2 = moderate-severe (definite) reduction
  3 = absent / no detectable thickening



Wall motion & wall thickening:

In general, regional wall motion and wall thickening abnormalities accompany each other. It is commonly acceptable to incorporate the two findings into a single score while noting the presence of discordance in wall motion and wall thickening when it occurs.

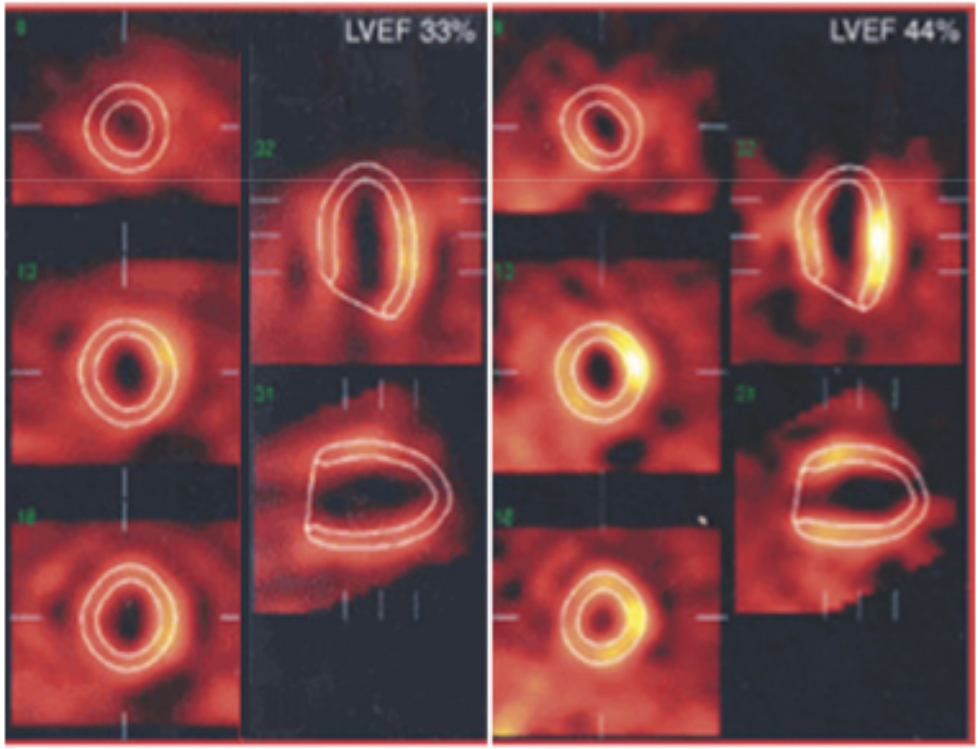
Combined rest/post-stess regional functional analysis

When available, the post-stress and rest gated images should be compared to identify the development of wall motion abnormality. Wall motion abnormalities that occur on post-stress images but are not seen on resting images imply the presence of ventricular stunning and are highly specific for the presence of CAD. This finding might be missed by perfusion defect assessment alone.

It is also important to routinely report the patient's state at the time of gated SPECT acquisition, e.g. rest, 30-minute post-stress, 1-hour post-stress etc. the earlier post-stress acquisition is performed after stress, the more likely that the post-stress motion abnormality will be observed.

LV volume & EF:

If a validated method for measuring LV volume is available on a particular camera-computer system, it should be reported as a standard component of gated SPECT analysis. Absolute LV volumes tend to be underestimated in patients with very small hearts. EF may then be overestimation in patients with small hearts.



Before revascularization After revascularization

Terminology:

Reversible defect: A perfusion defect seen in stress study which reverses or improves with rest.

Stress induced ischaemia / Inducible ischaemia: The ischaemic state demonstrated in the stress study that has been brought out using dynamic exercise stress or pharmacological stress agents. This reverses or improves with rest.

In short, a reversible defect suggests the presence of an inducible ischaemia.

- non-flow-limiting stenoses
- flow-limiting stenoses

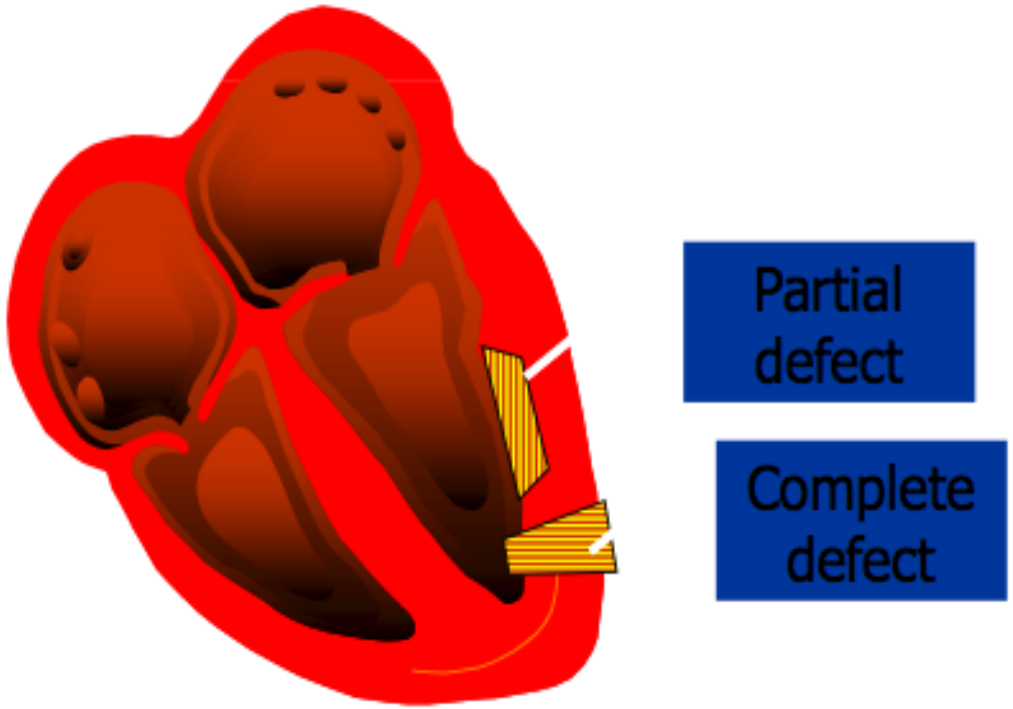
Complete reversibility: Areas that have no myocardial thinning in rest images and that have resting count densities similar to that of the reference areas.

Partial reversibility: Associated with segmental thinning, with count density corresponding to 50-80% of the density in normal referrence regions.

Terminology:

Complete infarction / Transmural infarction: Infarction involving the full thickness of myocardium.

Partial thickness infarct: Infarction or scar with viable partially perfused myocardium (segmental thinning with count density >50%); with or without inducible stress reversible ischaemia. This usually resulted from non-transmural or subendocardial infarct, commonly seen in cases of post-thrombolytic treatment.



Terminology:

Periinfact-inducible ischaemia: Myocardial infarct with a rim of either large or small ischaemic region around.

Paradoxical ischaemia / Reverse redistribution: Worsening of a stress defect or appearance of a new defect associated with severe coronary stenosis, stable CAD, thrombolytic therapy for AMI. It may be due to opening up of collateral during stress and closing during rest or microvascular reperfusion seen especially in diabetic.

Reporting:

Title:

Indication:

Clinical History:

Procedures/ Cardiac Stress Data:

Findings/ Imaging Result:

Stress:
Rest:

Impression/ Comment:

Reporting:

Title:

- Stress/Rest Tc-99m Tetrofosmin (Myoview) SPECT Myocardial Perfusion Imaging with Dipyridamole Dobutamine) Stress and Gated SPECT Imaging.
- Stress/Rest Tc-99m Tetrofosmin (Myoview) SPECT Myocardial Perfusion Imaging with Dobutamine Stress and Gated SPECT Imaging.

Indication:

- Diagnosis of coronary disease
- Evaluation of extent and severity of CAD
- Evaluation of myocardial viability
- Risk stratification – post-MI/preoperative/general
- Assessment of acute chest pain syndromes

Clinical History:

- ___ year old man/woman with (no) known CAD ……..
- Cardiac risk factors include:
- Previous cardiac procedures include:
- Current symptomatology includes:
- Medications:
- Height: Weight: Body mass index:

Reporting:

Procedures/ Cardiac Stress Data:

- Because of history of (?) bronchial asthma, stress was performed using dobutamine infused up to 40µg/kg/min with IV Atropine 0.2mg. Patient was monitored throughout the study. BP changed from 127/87mmHg to maximum recorded of 148/92mmHg and HR increased from 106 to 144/min. Achieved targeted HR (>80% of max predicted HR). No complaint of chest pain. When compared with resting ECG, no significant ST segment depression seen during stress.

- Patient was infused with I/V Dipyridamole 42mg over 4 minutes and was monitored thereafter. BP changed from 154/100mmHg to 135/94mmHg and HR increased from 58 to 86/min. Complaint of sense of heaviness over the chest. When compared with the resting ECG, no significant ECG changes noted during stress.

- Patient was infused with I/V Dipyridamole 42mg over 4 minutes, coupled with exercise bike at 25 watts and was monitored throughout the procedure. BP changed from 154/100mmHg to 135/94mmHg and HR increased from 58 to 86/min. Complaint of sense of heaviness over the chest. When compared with the resting ECG, no significant ECG changes noted during stress.

At peak pharmacologic effect, the patient was injected with ____mCi of ___. Myocardial perfusion imaging was performed ___ minutes following the injection of ___mCi of ____ and at rest. Gating post-stress tomographic imaging was performed ____ minutes after stress (and rest).

Reporting:

Findings/ Imaging Result:

- The overall quality of the study is (e.g. 5= excellent; 4 = good; 3 = fair; 2 = poor; 1 = uninterpretable)
- LV cavity size is noted to be normal/ enlarged on the rest (and/or stress) studies.
- There is evidence of abnormal lung activity. Additionally, the RV is normal/ abnormal (specify: ___).

- SPECT images demonstrate homogenous tracer distribution throughout the myocardium OR a small/ moderate. Large perfusion abnormality of mild/ moderate/ severe intensity is present in the _____ (location) region on the stress images. The rest images reveal ___. Gated SPECT imaging reveals normal myocardial thickening and wall motion. OR Gated SPECT imaging demonstrates hypokinesis/ akinesis/ dyskinesis of the ____ (location). The LV EF was calculated to be ____ % Or The LV EF was normal (>60%).

- Stress: There is poor tracer uptake seen over the anterior wall. No tracer uptake seen at the lateral and inferior walls.

  Rest: Following re-injection of tracer after rest, significant improved uptake is seen at the anterior wall and apical lateral segment. Slight marginal improved uptake is seen at the infero-septal segment. No changes in count uptake seen at the rest of lateral and inferior walls.

Reporting:

Impression/ Comment:

- Myocardial perfusion imaging is normal/ abnormal. There is a small/ moderate/ large area of ischaemia/ infarction in the _____ location. Overall LV systolic function was normal/ abnormal with/ without regional walll motion abnormalities (as noted above). Compared to prior study from ___ (date), the current study reveals _____.

- Transmural infarction at the lateral and inferior walls with minor extent of peri-infact ischaemia. Otherwise, these two areas supplied by LCx and RCA appear non-viable.

- Significant inducible ischaemia has been demonstrated over a greater part of anterior wall and relatively sparing the septal wall. Presence of a significant CAD needs to be ruled out at the LAD territory and very likely at its diagonal branches.

- I would be interested to learn a more detail findings of his most recent coronary angiography, if this is possible.

PET Cardiac

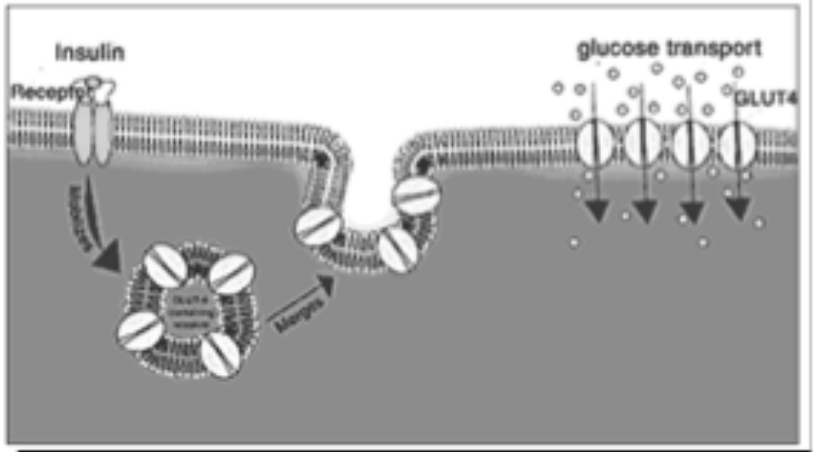
What do we expect from PET-CT?

- "flow-metabolism match"
  - Concordant reduction in myocardial blood flow and FDG uptake
  - Infarcted
- "flow metabolism mismatch"
  - Perfusion defect but preserved FDG uptake
  - Ischaemic and viable.

Cardiac Metabolism

- **Myocardial metabolism**
  - under aerobic conditions, the heart uses predominantly fatty acids,
    - but after carbohydrate loading, the is inhibitory effect of insulin on release of fatty acids from adipocytes
    - diminishes circulating fatty acids, and
    - up-regulates glucose use by the heart
    - similarly, with ischaemia, fatty acid metabolism is diminished and glucose uptake is enhanced

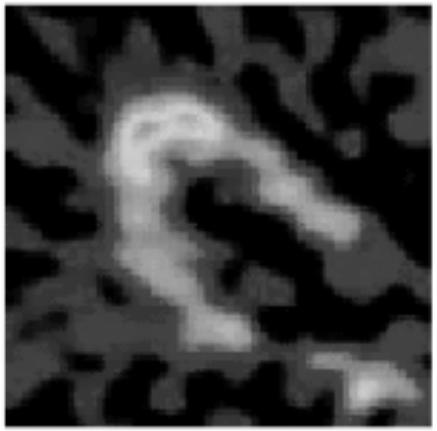
- Thus, diminished fatty acid use or normal (relative to flow) or enhanced glucose metabolism equates with ischaemia
- Stunned or hibernating myocardium also demonstrate preserved oxygen and glucose use relative to perfusion and function
- When a significant amount (approximately 20-25% of contiguous myocardium) of viable myocardium can be identified by PET, revascularisation is beneficial

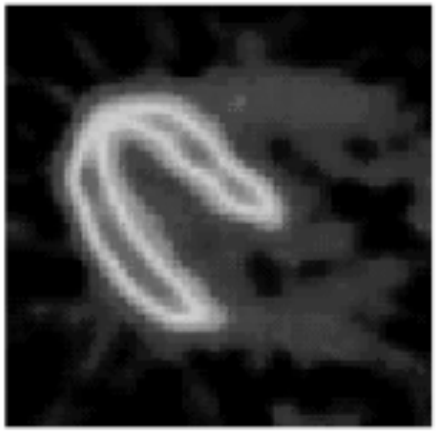


Fasting

Insulin

Glucose uptake





Free fatty acid uptake

Courtesy – Heart and Metabolism, 1999

18FDG PET-CT

Patient Preparation - ^{18}FDG

- Preparation for ^{18}FDG
  - Fast - minimum 6h, water intake as desired
    - except IDDM
      - normal diet and normal insulin
      - arrange study just prior to next meal
  - Insulin - Glucose Loading
    - 50% dextrose orally & sliding scale of insulin intravenously
  - Monitor BSL
  - Inject Tracer 10 minutes later

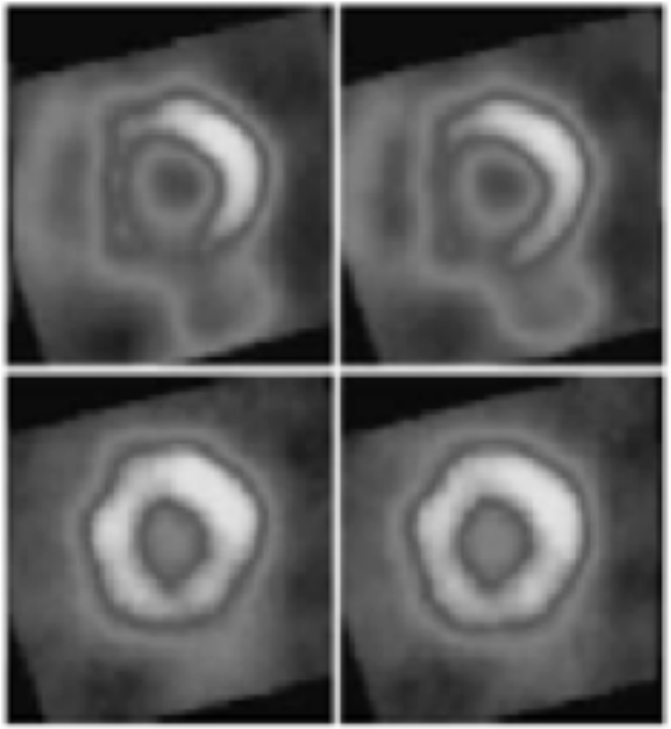
Scanning

3. FDG administration (250 MBq) 10 minutes after insulin administration

4. Scanning after 30 minutes uptake time.

5. Post Scan :
   - Check BGL, 25 mls of 50% dextrose orally/intravenously if hypoglycaemia.
   - Recheck BGL before going home.

Image Interpretation



FDG-SPECT imaging to assess viability

The 99mTc-Tetrofosmin SPECT study (upper panel) reveals reduced perfusion in the septum and inferior wall, whereas the FDG uptake (lower panel) is preserved in these regions (perfusion-metabolism mismatch)

PET Classification of Myocardial region based on their function, level of perfusion and metabolic activity

Tissue classification	Function	Perfusion	Metabolism Flow
Normal	Normal	Normal	Normal
Stunned	Diminished	Normal	Variable
Hibernating	Diminished	Diminished	Preserved or increased
Infarcted	Diminished	Diminished	Diminished

Concerning the blood supply of the normal heart

1. The right coronary artery supplies the AV node
2. The anterior intraventricular artery is a branch of RCA
3. Arise from the inferior aspect of the aortic arch
4. The circumflex artery is a branch of the LCA
5. The great cardiac vein drains the territory supplied by the RCA

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TFFTF

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FOLLOWING ARE INDICATIONS OF GATED BLOOD POOL STUDY

1. Measuring right ventricular ejection fraction
2. Quantifying shunts
3. Cardiotoxic drugs
4. Extent of infarct
5. Myocardial reserve

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IMAGING OF INFARCT

1. Tc pyrophosphate is the infarct avid imaging procedure of choice
2. Pyrophosphate uptake is taken more around the infarct than in the infarct
3. Myosin monoclonal antibody is useful only in imaged within 2-3 days after administration
4. Pyrophosphate is taken up by bone
5. Images are acquired after 48 hours in myosin antibody

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CONTRAINDICATION FOR MYOCARDIAL PERFUSION IMAGING (EXERSICE STRESS)

1. Sinus bradycardia
2. Third degree heart block
3. Ventricular arrhythmias
4. Aortic stenosis
5. Unstable angina

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MYOCARDIAL PERFUSION IMAGING

1. Bulls eye maps are used to predict the prognosis of infarct
2. Stress images are acquired 30-60 mins after injection
3. GTN is administered when acquiring rest images
4. Rest images are acquired far later than stress images
5. Injection is done at maximum stress

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TTTTT

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STRESS IN MYOCARDIAL PERFUSION IMAGING

1. Dipyridamole is the stress agent of choice
2. Systolic pressure less than 100mm is contraindication for adenosine
3. The aim of stress is to decrease the coronary arterial flow
4. Adrenaline is the antidote to adenosine complication
5. Asthma is a contraindication to adenosine

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CARDIAC SCINTIGRAPHY

1. LAO best for left ventricle
2. RAO 30 best for right ventricle
3. For assessing RV ejection fraction, inject the tight bolus
4. For shunt quantification, inject over 3 seconds
5. First pass takes 15 seconds

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CARDIAC SCINTIGRAPHY

1. MIBI is more prone for liver uptake
2. Tetrofosmin is easier to prepare than MIBI
3. Stannous pyrophosphate and pertechnate are mixed before administrating in vein
4. MUGA scan are better than LIST studies
5. Acquisition begins with R wave of each cycle

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THALLIUM 201

1. Decays by electron capture to Tl 203
2. Mainly produce gamma photon of 135 and 167 keV
3. After IV administration 15% is localized in the myocardium
4. All the thallium ions enter the myocytes by the sodium potassium ATPase pump
5. Extraction of thallium is reduced in acidosis

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FEATURES OF HIBERNATING MYOCARDIUM

1. Reversible
2. FDG PET is the standard for assessing myocardial viability
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4. Decreased uptake in FDG
5. Decreased perfusion in thallium scans

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1. 2 separate injection are required for thallium, unlike for MIBI and tetrofosmin
2. ST segment depression more than 3mm is indicator that dobutamine should be stopped
3. Rest images are performed first, followed by stress images
4. At least 2 days are required for satisfactory testing using MIBI
5. Infarcts will show decreased uptake during stress and improved in rest images

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1. Taken up by infarcts
2. Left ventricular function can be assessed using first pass studies
3. Can be used to assess a left to right shunt
4. Normal to have a photon deficient area at the apex
5. Left ventricular failure is associated with increased lung uptake

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THALLIUM SCINTIGRAPHY

1. Involves a lower radiation dose than Tc99m MIBI scanning
2. Reverse redistribution is commonly due to artifact
3. Injection is performed at peak exercise
4. There is increased uptake in areas of myocardial infarction
5. Is more sensitive than cardiac stress testing

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THALLIUM 201

1. Kidney is the critical organ
2. Distribution is proportional to perfusion
3. Physical half life is 24 hours, making it low dose
4. Images are of high resolution
5. High signal to noise ratio

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PET AGENTS USED IN HEART IMAGING

1. Nitrogen 13 ammonia
2. Rubidium 82
3. Potassium 38
4. Oxygen 15 labeled water
5. Inhaled 15 CO_2

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UPTAKE OF THALLIUM IS SEEN IN FOLLOWING STRUCTURES

1. Kidney
2. Lungs
3. Salivary glands
4. Skeletal muscle
5. Liver

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TTFTF

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STRESS TESTING

1. Adenosine combined with exercise improves detection of perfusion defects
2. Dobutamine avoided if patient has asthma
3. Adenosine should be avoided if patient has bifascicular block or LBBB
4. Bradyarrhythmia is reduced by exercise
5. Dipyridamole has the highest sensitivity and specificity among pharmacological agents

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MIBI CARDIAC IMAGING

1. Rescan is done at 4 hours as redistribution occurs
2. 5% of negative studies go on to get MI within one year
3. Increased uptake is seen in myocardial infarction
4. Gated studies useful to look at wall motion
5. Fatty meal should not be taken as it produces hepatic uptake

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INCREASED UPTAKE OF THALLIUM

1. Graves' disease
2. Thyroid ca
3. Bronchogenic ca in lung
4. Lymphoma of lung
5. Brain in encephalitis

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MYOCARDIAL PERFUSION SCINTIGRAPHY

1. The physical properties of thallium 201 are such that its use is preferable to that of Tc99m labeled compounds in myocardial perfusion imaging
2. The effective dose from Tl 201 myocardial perfusion scan is one of the highest in diagnostic imaging and roughly equates to 3 barium enemas
3. The uptake of Tl 201 relies solely on regional myocardial perfusion
4. Tl 201 is a Na analogue
5. Tl 201 remains irreversibly fixed to the myocardium within a few minutes of injection

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THE FOLLOWING MAY CAUSE REDUCTION IN Tl 201 UPTAKE TO THE MYOCARDIUM

1. Myocardial infarction
2. Hibernating myocardium
3. Cardiomyopathy
4. Cardiac sarcoidosis
5. Dobutamine

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PROGNOSIS IN CORONARY ARTERY DISEASE

1. Increased uptake of Tl 201 into the lungs is a poor prognostic indicator during myocardial perfusion imaging
2. Myocardial perfusion imaging may identify patients at increased risk of cardiac events following major vascular surgery
3. Myocardial perfusion imaging has greater prognostic power than exercise ECG
4. Myocardial perfusion imaging has less prognostic power than coronary arteriography
5. In a patient with a strongly positive ECG but a normal myocardial perfusion scan, the perfusion scan is the most appropriate for defining prognosis

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CONCERNING PHARMACOLOGICAL STRESSOR AGENTS

1. Dipyridamole reduces uptake of myocardial perfusion agents to myocardial
2. Adenosine may be use as a cardiac stressor
3. Caffeine intake should be restricted before an exercise myocardial perfusion
4. Aminophylline may reverse chest pain caused by dipyridamole
5. Dipyridamole is a potent coronary vasodilator

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Tc 99m LABELLED MYOCARDIAL PERFUSION AGENTS

1. Stress and redistribution images of Tc 99m SestaMIBI accurately identify ischemic myocardium
2. Tc99m SestaMIBI is more suited to SPECT scanning than Tl 201
3. A fatty meal is required following sestaMIBI injection
4. Tc 99m SestaMIBI stress and rest myocardial perfusion scans cannot be performed on the same day due to the long redistribution time of this agent in myocardium
5. Tc 99m SestaMIBI imaging should be performed as soon as possible following injection

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EQUILIBRIUM GATED BLOOD POOL IMAGING

1. Tc 99m DTPA is preferable to labeled red blood cells in gated ventriculography as radiopharmaceutical preparation is easier
2. Red cells may be labeled with Tc 99m in vivo
3. Concurrent ECG recording is only necessary if there is risk of arrhythmia
4. It is possible to assess regional wall motion abnormalities of the left ventricle
5. Background substraction is not usually required in measuring LV ejection fractions as activity within the adjacent lung is negligible

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EQUILIBRIUM GATED BLOOD POOL IMAGING

1. Patients with coronary artery disease typically show an increase in LV ejection fraction of only 5-10% on exercise
2. Regional wall motion abnormalities are more specific for coronary artery disease than changes in ejection fraction with exercise
3. Patients receiving chemotherapy should be suspected of having cardiotoxicity if the ejection fraction falls by more than 10% on sequential scans
4. It is possible to differentiate alcoholic from viral cardiomyopathy by gated blood pool imaging
5. It is possible to differentiate ischemic cardiomyopathy from dilated idiopathic cardiomyopathy with gated blood pool imaging

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RADIONUCLIDE VENTRICULOGRAPHY

1. Radionuclide ventriculography is a more accurate and reproducible method for measuring ejection fraction than echocardiography
2. Assumptions for the calculation of ejection fraction are greater for echocardiography than they are for radionuclide ventriculography
3. In severe left ventricular dysfunction the volume of injected radiopharmaceutical is reduced to avoid overload
4. Exercise ventriculography is not possible because there is too much motion of the patient
5. It is not possible to measure RV ejection fraction using gated equilibrium technique

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TTFFF

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FIRST PASS RADIONUCLIDE ANGIOGRAPHY

1. It is possible to detect R to L cardiac shunts with this technique
2. It is possible to detect L to R cardiac shunts with this technique
3. As large a dilution of radiopharmaceutical as possible should be used in this technique
4. It is an accurate technique to quantify cardiac shunting which coexist with coaortation of the aorta
5. It is often not possible to accurately quantitate cardiac L to R shunts in the presence of tricuspid regurgitation

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MYOCARDIAL INFARCT SCANNING

1. A myocardial infarction may be seen on an MDP bone scan
2. Tc 99m labeled pyrophosphate imaging may detect myocardial infarction before cardiac enzyme changes
3. Rib fracture may give false positive results with pyrophosphate scanning
4. Positive antimyosin monoclonal antibody scanning is specific for myocardial infarction
5. Rejection of heart transplants can be detected with antimyosin scanning

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How does the percent extraction of thallium-201 passing through the myocardial capillary bed compared with the extraction of c-99m sestamibi and Tc-99m teboroxime?

How does the percent extraction of thallium-201 passing through the myocardial capillary bed compared with the extraction of c-99m sestamibi and Tc-99m tetrofosmin?

- Tl-201 has a myocardial extraction fraction of 0.85 in normal subjects at a normal flow rates. The myocardial extraction of Tc-99m sestamibi and Tc-99m tetrofosmin is considerably lower 0.5 and 0.6 respectively.

What percentage of Tl-201, Tc-99m sestamibi and Tc-99m tetrofosmin localizes in the heart?

What percentage of Tl-201, Tc-99m sestamibi and Tc-99m tetrofosmin localizes in the heart?

- Tl-201 : 3-4%
- Tc-99m sestamibi : 1.5%
- Tc-99m tetrofosmin : 1.2%

What are the advantages and disadvantages of Tl-201 as perfusion agent?

What are the advantages and disadvantages of Tl-201 as perfusion agent?

Advantages

- Single injection because of redistribution
- Imaging within 10 – 15 minutes
- Can be used to assess viability

Disadvantages

- High radiation
- Poor imaging characteristics with a low photopeak of 69 – 80 keV
- High scatter fraction

What quality control to detect patient motion?

What quality control to detect patient motion?

- Review raw data in cinematic display and review of sonogram can confirm the extend of the problem.

In what ways can the image interpreter determine if fixed decreased activity is due to artifact or disease?

In what ways can the image interpreter determine if fixed decreased activity is due to artifact or disease?

- Review the raw data in the cinematic display to look for soft attenuation.
- Review the gated SPECT can help determine if there is wall motion and thickening that would indicate infarct or attenuation.
- Attenuation correction can be helpful.
- Prone can differentiate attenuation from infarction in inferior wall.

What is the significant of lung uptake on Tl-201 exercise study?

What is the significant of lung uptake on Tl-201 exercise study?

- Lung uptake on exercise stress images, but not the delayed images is consistent with exercise induced cardiac dysfunction.
- This finding is usually associated with three vessel disease.

What other scintigraphic finding suggest three vessel disease?

What other scintigraphic finding suggest three vessel disease?

- Exercise induced ischemic dilatation.
- The normal heart dilates during stress but gated SPECT is acquired poststress when normal hearts have returned to baseline size.

What is the mechanism of action of dipyridamole?

What is the mechanism of action of dipyridamole?

- Dipyridamole inhibits the action of adenosine deaminase.
- By augmenting the effects of endogenous adenosine, dipyridamole is a powerful vasodilator.

What effect can a cup of coffee have on dipyridamole or adenosine stress test?