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Inpatient General Cardiology Curriculum

Charoo Iyer

Rochester Regional Health, Charoo.Iyer@rochesterregional.org

Syed Faiz Abbas

Rochester Regional Health, SyedFaiz.Abbas@rochesterregional.org

Mallory A. Balmer-Swain

Rochester Regional Health, mallory.balmer-swain@rochesterregional.org

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INPATIENT GENERAL CARDIOLOGY CURRICULUM

Authors: Charoo Iyer, Syed Faiz Abbas, Mallory Balmer Swain

This curriculum serves as a concise primer for interns starting out on an inpatient general cardiology rotation. Following topics have been included:

- Pre and Post Cardiac Catheterization workflow, including obtaining consent and evaluation of suspected post cardiac catheterization bleeding
- Acute Coronary Syndromes
- Guideline Directed Medical Therapy (GDMT) for Heart Failure
- Introduction to Cardiac Stress Testing

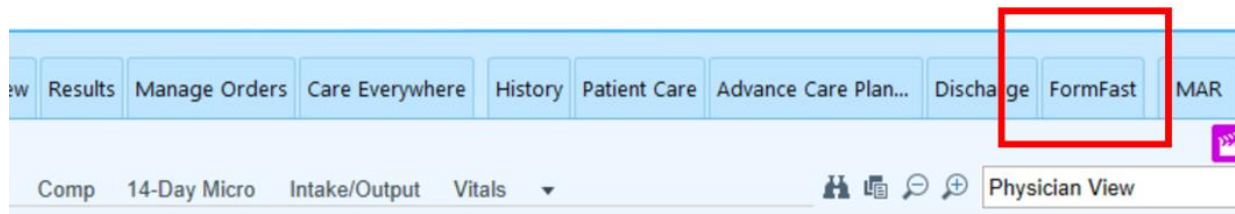
PRE AND POST CARDIAC CATHETERIZATION PLANNING:

Cardiology fellow will be the one taking the lead with this but it is always helpful to know what this involves.

PRE- CATH:






PRINTING THE CONSENT FORM:






1. Go to **FORMFAST** in the patient chart. (If you can't find it here, click on the drop down arrow and it might be hidden in the 'Rarely used' tab.)





2. Search for the forms "Procedure Authorization form: **Coronary Angiogram, Coronary angioplasty, Coronary Stent, Rotablator**" and "Procedure Authorization form: **Emergency Coronary Artery Bypass Graft Surgery**". The first is to consent for PCI and the second one is to consent for emergency CABG in case it is needed.
3. You can click on **Favorite** to ensure these get added to your favorites. This makes life easier as you won't have to search for the forms each time!
4. The consent form for blood transfusion is located at the back of these forms and also requires completion















Forms:

Favorites:     

Form Name:	Form / Packet ID:			
<input type="checkbox"/> Form: Procedure Authorization / Blood Transfusion Informed Consent - Spanish	N8ASpanish	1	1	
<input type="checkbox"/> Form: Procedure Authorization / Blood Transfusion Informed Consent - Spanish	N8ASpanish	1	1	
<input type="checkbox"/> Form: Procedure Authorization / Blood Transfusion Informed Consent	N8A	1	1	
<input type="checkbox"/> ProcedureAuthorizationForm: Emergency Coronary Artery Bypass Graft Surgery	N8AEMCABGS	1	1	
<input type="checkbox"/> ProcedureAuthorizationForm: Coronary Angiogram, Coronary Angioplasty, Coronary Stent, Rotablator	N8ACACCSR	1	1	

Forms  Search Forms...

Text: Search By: ☒ Form Name ☐ ID 

Form Name: (Count: 14)	Form / Packet ID:			
<input type="checkbox"/> Form: UH Cardiac Cath / PCI Consent For Coronary Angiography / Angioplasty / Stent	UHCLNCNECA	1	1	
<input type="checkbox"/> Form: UH Cardiac Cath / PCI Consent For Coronary Angiography / Angioplasty / Stent	UHCLNCNECA	1	1	
<input type="checkbox"/> ProcedureAuthorizationForm: Coronary Angiogram	N8ACORONAN	1	1	
<input checked="" type="checkbox"/> ProcedureAuthorizationForm: Coronary Angiogram, Coronary Angioplasty, Coronary Stent, Rotablator	N8ACACCSR	1	1	
<input type="checkbox"/> ProcedureAuthorizationForm: Coronary Angioplasty, Coronary Stent, Rotablator	N8ACORACSR	1	1	
<input type="checkbox"/> ProcedureAuthorizationForm: Coronary Artery Bypass Grafting	N8ACABG2	1	1	
<input type="checkbox"/> ProcedureAuthorizationForm: Coronary Artery Bypass Grafting	N8ACABG2	1	1	
<input checked="" type="checkbox"/> ProcedureAuthorizationForm: Emergency Coronary Artery Bypass Graft Surgery	N8AEMCABGS	1	1	
<input type="checkbox"/> Spanish ProcedureAuthorizationForm: Coronary Angiogram	N8ACORONANS	1	1	
<input type="checkbox"/> Spanish ProcedureAuthorizationForm: Coronary Angiogram, Coronary Angioplasty, Coronary Stent, Rotablator	N8ACACACSR	1	1	
<input type="checkbox"/> Spanish ProcedureAuthorizationForm: Coronary Angioplasty, Coronary Stent, Rotablator	N8ACORACSR	1	1	
<input type="checkbox"/> Spanish ProcedureAuthorizationForm: Coronary Artery Bypass Grafting	N8ACABG2S	1	1	
<input type="checkbox"/> Spanish ProcedureAuthorizationForm: Coronary Artery Bypass Grafting	N8ACABG2S	1	1	
<input type="checkbox"/> Spanish ProcedureAuthorizationForm: Emergency Coronary Artery Bypass Graft Surgery	N8AEMCABGSS	1	1	

TAKING CONSENT AND DOCUMENTING THIS ON CARE CONNECT:

1. While taking consent it is important to discuss the risks involved. Important ones are noted in the smart phrase below. These are also mentioned in the consent form itself.
2. If you have taken the consent, it is important to mention this in a separate progress note on Epic. For eg this is a smartphrase '.CATHCONSENT' that is copied from fellows:

*"Procedure discussed with patient. Risks include but not limited to **1% risk of bleeding or infection, 0.3% stroke, myocardial infarction, renal compromise from contrast dye, vascular injury, possible need for emergency open heart surgery, and death.** Patient agreed to sign consent."*

MAKING SURE THE CORRECT DIET ORDER IS IN:

1. All patients planned for coronary angiogram on should be on **Clear Liquid diet**.
2. For Nuclear stress tests patient needs to be NPO for minimum 4 hours and caffeine free for minimum 12 hours.

POST-CATH:

- An important post cath non-cardiac complication to be aware of is access site bleeding
- Always make sure to examine the access site(look for signs of bleeding, check pulses, sensation and movement in the distal limb)
- If you notice signs concerning for any complication, take action as outlined below but simultaneously, **always call fellow for help!**

FEMORAL ACCESS COMPLICATIONS INCLUDE:

Femoral access complications

- | | | |
|-----------------------------|---|--------------------------|
| 1. Lower extremity ischemia | → | Groin hematoma |
| 2. Bleeding | | |
| 3. Pseudoaneurysm | → | Retroperitoneal hematoma |
| 4. Arteriovenous fistula | | |
| 5. Infection | | |
| 6. Nerve injury | | |

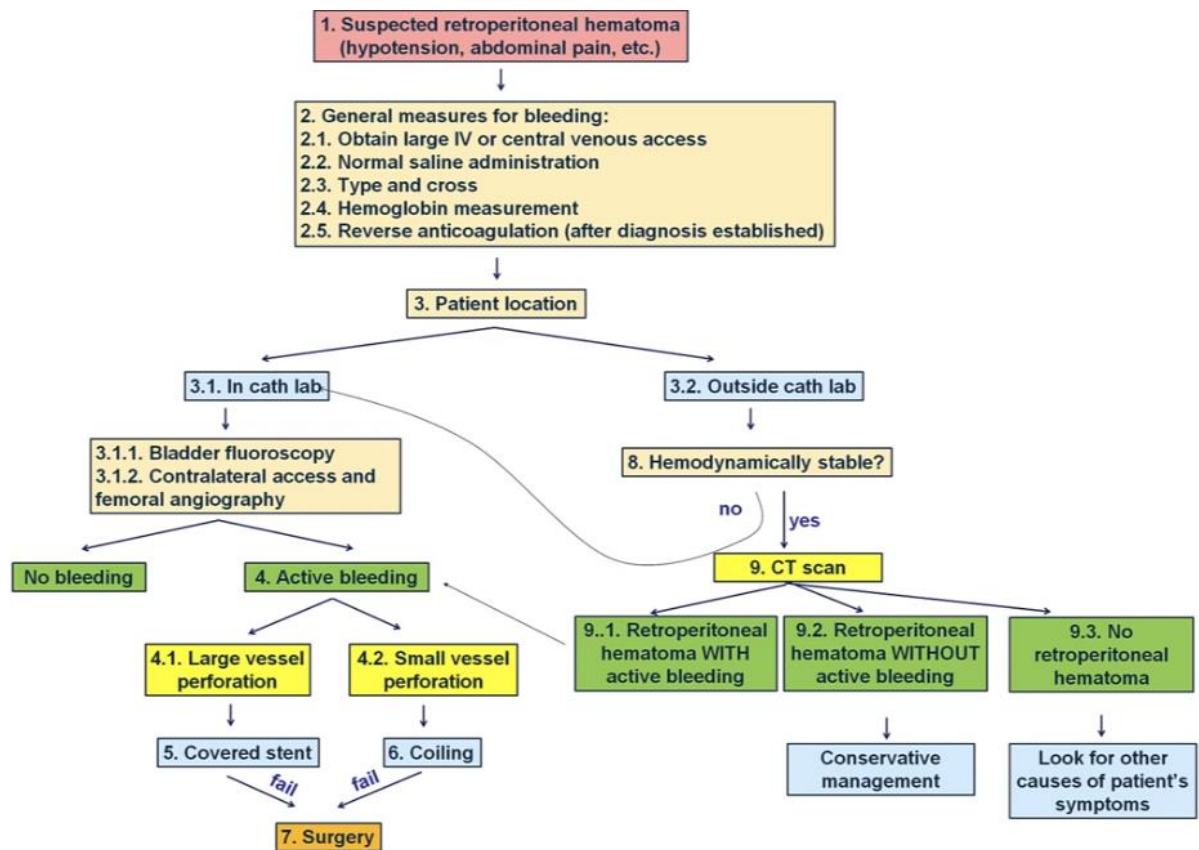
1. Groin hematoma

- Manual pressure **15 to 30 minutes**
- Rare cases: endovascular Rx - surgery

2. Retroperitoneal Hematoma:

- Suspect if there is a drop in hemoglobin, low blood pressure, flank or abdominal pain, bruising in the region of the flanks(Grey Turner's sign) or periumbilical area (Cullen's) in the post procedural period.
- If patient is hemodynamically unstable – prepare for blood transfusion and IV fluid resuscitation while simultaneously reaching out to the interventional cardiologist(for return to cath lab) for definitive diagnosis and management.

- If patient is hemodynamically stable, can first obtain diagnostic confirmation through CT Abdomen Pelvis before pursuing management.



3. Pseudoaneurysm:

Symptoms may include groin swelling, unusual pain, bruising, skin changes, neuropathy from femoral nerve compression, and, rarely, limb ischemia or claudication from embolization or arterial compression. Rupture can be associated with severe pain and hemodynamic instability.

Physical examination may reveal groin or limb swelling, mass, tenderness, bruising, skin necrosis, thrill, or bruit.

Diagnosis: Duplex ultrasound with B mode imaging, color flow imaging, and Doppler pulse wave analysis is the diagnostic test of choice

Management options include observation, ultrasound-guided compression, ultrasound-guided thrombin injection, or surgery. For small, stable pseudo aneurysms (<2 cm), observation with weekly duplex ultrasound until thrombosis occurs is appropriate. Anticoagulation should be held; patients should avoid lifting or bending.

RADIAL ACCESS SITE COMPLICATIONS INCLUDE:

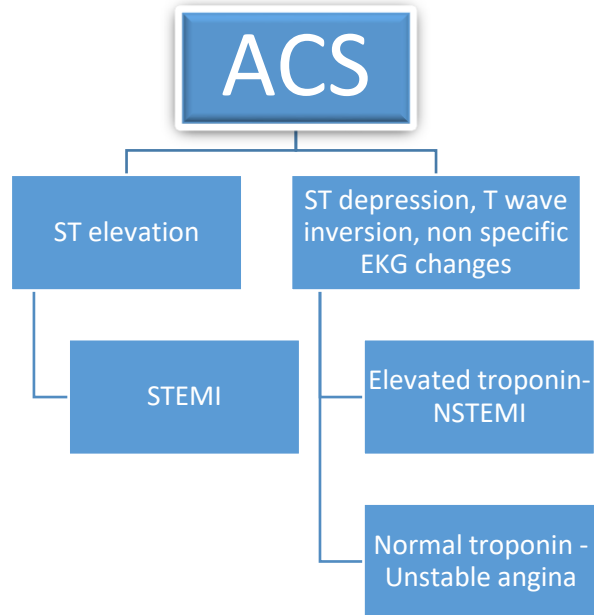
1. Access site bleeding/ hematoma

- Less common compared to femoral access site.
- Radial artery is smaller, more accessible and easily compressible. Therefore, if risk of bleeding is a major concern, then radial access may be preferred
- This site has a vascular band that is inflated with air (post PCI). The bedside nurse gradually deflates this. After this band is deflated, if bleeding is noted from access site then manual pressure can be applied to the site for at least 15 minutes. If bleeding continues, we may have to consider re-inflating the band. Always call the fellow in case of access site bleeding.

2. Pseudo aneurysm

- Less common compared to femoral site
- **Symptoms** would be similar to femoral site, including, pain, swelling, bruising, rarely - neuropathy
- **Physical exam** shows tenderness, bruising and may reveal pulsatile mass with thrill or bruit
- **Diagnosis and management** – same as femoral site (as noted above)

ACUTE CORONARY SYNDROMES



DEFINITION

STEMI:

ST-segment elevation at the J-point, ≥ 1 mm in ≥ 2 adjacent leads (other than leads V2 and V3)

In V2 V3, elevation of ≥ 2 mm in men (greater than 40 years old) or ≥ 1.5 mm in women

NON ST ELEVATION-ACS: NSTEMI

- Unlike STEMI, **EKG here can be normal**
- **Elevation in troponin** is what distinguishes this from unstable angina.
- It is important to note that this is not simply the presence of elevated troponin (which, when present alone denotes only myocardial injury) but needs to be accompanied by **at least one** of the following:
 - Symptoms of acute myocardial ischemia;
 - New ischemic ECG changes (not meeting criteria for STEMI)
 - Development of pathological Q waves;
 - Imaging evidence of new loss of viable myocardium or new regional wall motion abnormality in a pattern consistent with an ischemic etiology

NON ST ELEVATION-ACS: UNSTABLE ANGINA:

- New or worsening angina, severe enough to be concerning for ACS
- Unlike NSTEMI, troponin is **undetectable**
- **EKG changes may or may not be present**

MANAGEMENT: STEMI

- The focus here is to get the patient to the cath lab as soon as possible.
- STEMI alerts will be responded to by the fellow primarily

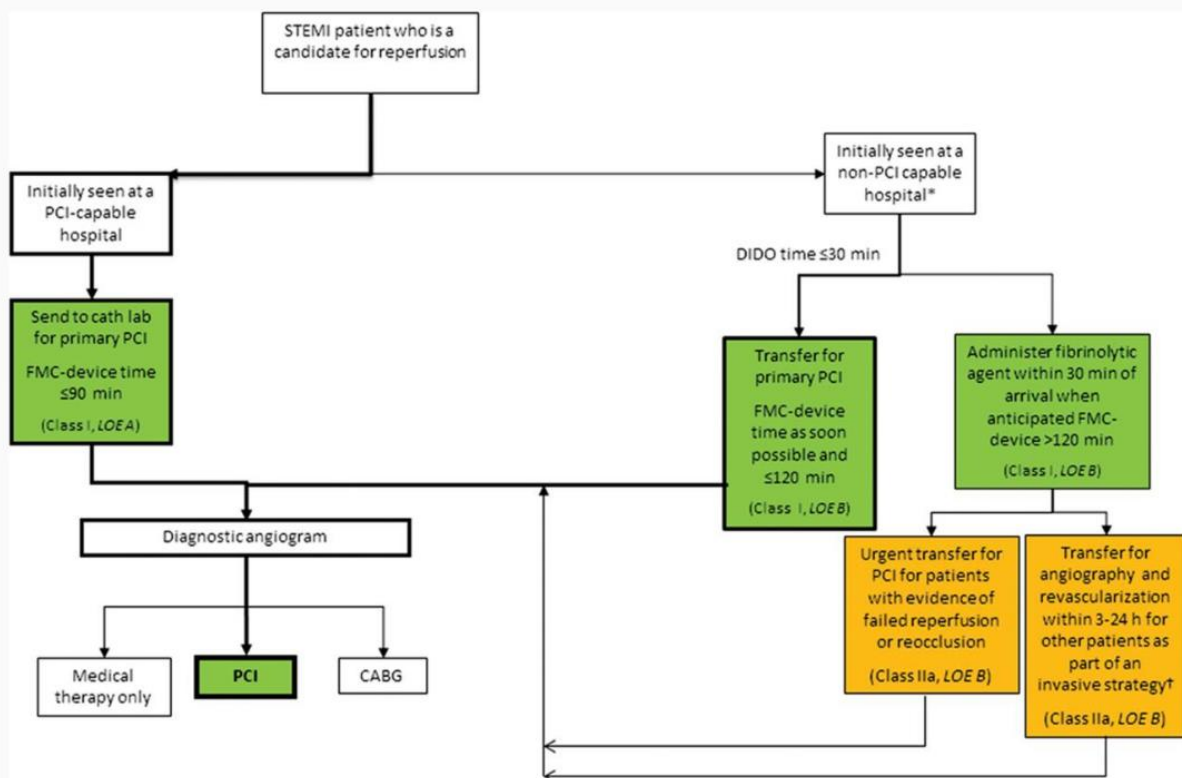


Figure 2. Reperfusion therapy for patients with STEMI. The bold arrows and boxes are the preferred strategies. Performance of PCI is dictated by an anatomically appropriate culprit stenosis. *Patients with cardiogenic shock or severe heart failure initially seen at a non-PCI-capable hospital should be transferred for cardiac catheterization and revascularization as soon as possible, irrespective of time delay from MI onset (Class I, LOE: B). †Angiography and revascularization should not be performed within the first 2 to 3 hours after administration of fibrinolytic therapy. CABG indicates coronary artery bypass graft; DIDO, door-in-door-out; FMC, first medical contact; LOE, Level of Evidence; MI, myocardial infarction; PCI, percutaneous coronary intervention; and STEMI, ST-elevation myocardial infarction.

NSTE-ACS MANAGEMENT

- History and physical examination
- Telemetry monitoring , serial EKG
- High sensitivity troponin
- Thrombolytics are not indicated in NSTE-ACS

Table 6. Summary of Recommendations for Early Hospital Care ([Table view](#))

Recommendations	COR	LOE
Oxygen		
Administer supplemental oxygen only with oxygen saturation <90%, respiratory distress, or other high-risk features for hypoxemia	I	C
Nitrates		
Administer sublingual NTG every 5 min × 3 for continuing ischemic pain and then assess need for IV NTG	I	C
Administer IV NTG for persistent ischemia, HF, or hypertension	I	B
Nitrates are contraindicated with recent use of a phosphodiesterase inhibitor	III: Harm	B
Analgesic therapy		
IV morphine sulfate may be reasonable for continued ischemic chest pain despite maximally tolerated anti-ischemic medications	IIb	B
NSAIDs (except aspirin) should not be initiated and should be discontinued during hospitalization for NSTE-ACS because of the increased risk of MACE associated with their use	III: Harm	B
Beta-adrenergic blockers		
Initiate oral beta blockers within the first 24 h in the absence of HF, low-output state, risk for cardiogenic shock, or other contraindications to beta blockade	I	A
Use of sustained-release metoprolol succinate, carvedilol, or bisoprolol is recommended for beta-blocker therapy with concomitant NSTE-ACS, <i>stabilized</i> HF, and reduced systolic function	I	C
Re-evaluate to determine subsequent eligibility in patients with initial contraindications to beta blockers	I	C
It is reasonable to continue beta-blocker therapy in patients with normal LV function with NSTE-ACS	IIa	C
IV beta blockers are potentially harmful when risk factors for shock are present	III: Harm	B
CCBs		
Administer initial therapy with nondihydropyridine CCBs with recurrent ischemia and contraindications to beta blockers in the absence of LV dysfunction, increased risk for cardiogenic shock, PR interval >0.24 s, or second- or third-degree atrioventricular block without a cardiac pacemaker	I	B
Administer oral nondihydropyridine calcium antagonists with recurrent ischemia after use of beta blocker and nitrates in the absence of contraindications	I	C
CCBs are recommended for ischemic symptoms when beta blockers are not successful, are contraindicated, or cause unacceptable side effects*	I	C
Long-acting CCBs and nitrates are recommended for patients with coronary artery spasm	I	C
Immediate-release nifedipine is contraindicated in the absence of a beta blocker	III: Harm	B
Cholesterol management		
Initiate or continue high-intensity statin therapy in patients with no contraindications	I	A
Obtain a fasting lipid profile, preferably within 24 h	IIa	C

*Short-acting dihydropyridine calcium channel antagonists should be avoided.

CCB indicates calcium channel blocker; COR, Class of Recommendation; HF, heart failure; IV, intravenous; LOE, Level of Evidence; LV, left ventricular; MACE, major adverse cardiac event; N/A, not available; NSAIDs, nonsteroidal anti-inflammatory drugs; NSTE-ACS, non-ST-elevation acute coronary syndromes; and NTG, nitroglycerin.

DECISION TO PURSUE CORONARY ANGIOGRAM IN NSTEMI-ACS: **INVASIVE VS ISCHEMIA GUIDED STRATEGY:**

HIGH OR INTERMEDIATE RISK: INVASIVE STRATEGY FAVORED OVER ISCHEMIA GUIDED

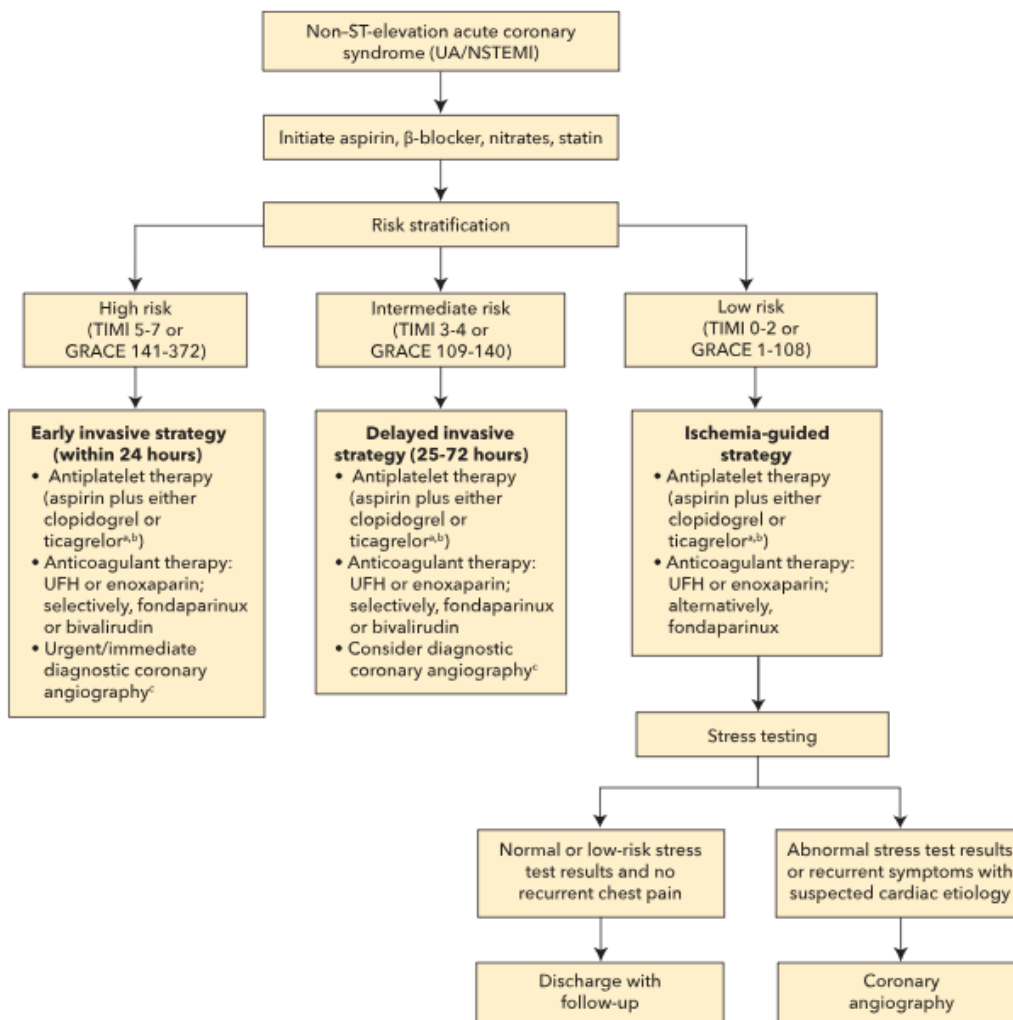
- **Urgent invasive strategy** within first 2 hours would be reserved for who are hemodynamically unstable, have refractory chest pain, ventricular arrhythmias or heart failure symptoms
- Early **invasive strategy** even in NSTEMI-ACS consists of pursuing angiogram within 24 hours
- **Delayed invasive strategy** , of performing angiogram within 72 hours is appropriate for intermediate risk patients

LOW RISK: ISCHEMIA GUIDED STRATEGY CAN BE CONSIDERED:

- Typically in low risk patients especially women
- Risk stratifications scores might be used to identify these patients (not routinely used on a daily basis at RGH)
- This includes TIMI (simpler) and GRACE score
- Ischemia guided strategy maybe considered if TIMI <2 or GRACE <109

TIMI Risk Score for Non-ST-Elevation Acute Coronary Syndromes	
Prognostic Variables (1 Point Each)	
Age ≥ 65 y	
≥ 3 Traditional CAD risk factors ^a	
Documented CAD with $\geq 50\%$ diameter stenosis	
ST-segment deviation	
≥ 2 Anginal episodes in the past 24 h	
Aspirin use in the past wk	
Elevated cardiac biomarkers (creatinine kinase MB or troponin)	
TIMI Risk Score (Sum of Prognostic Variables)	
0-2	Low risk
3-4	Intermediate risk
5-7	High risk

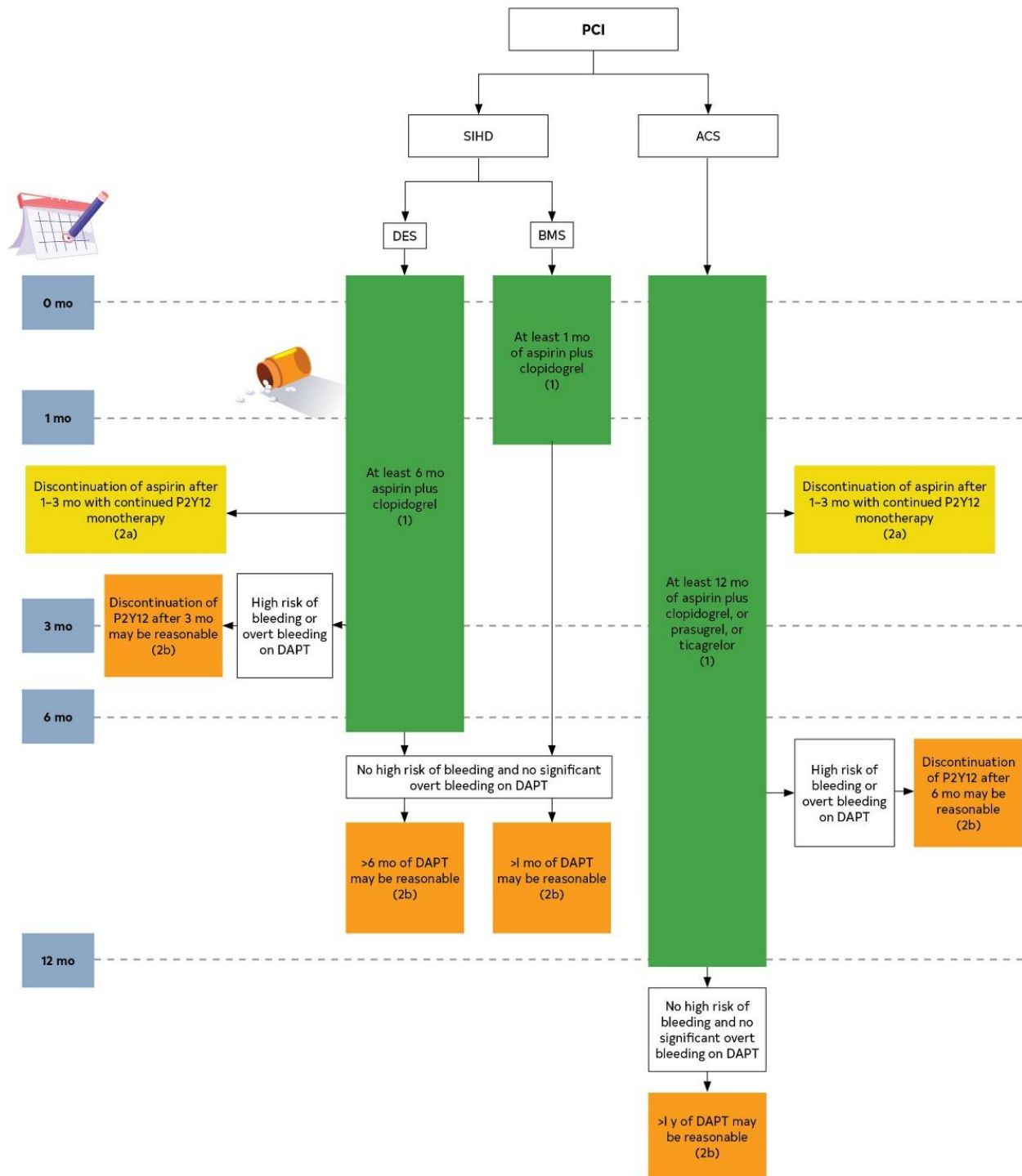
- For these patients stress testing is used to guide the decision on whether or not to pursue angiogram (see flow chart below)



MEDICAL THERAPY FOR ACS: COMMON FOR BOTH STEMI AND NSTEMI-ACS:

- **DAPT** for 12 months minimum followed by aspirin 81 mg indefinitely (If Brilinta or Effient, send prescription to pharmacy ahead of time, once cath lab confirms which one to use, Plavix is cheaper option in case you switch – need to reload with Plavix)
- **High intensity statin** with goal LDL <55. Add Zetia (ezetimibe) if you think statin alone will not achieve goal. Moderate intensity only if age >75 years or intolerant of high intensity
- **Beta blocker** therapy is indicated – use metoprolol, carvedilol or bisoprolol since they have benefit in HF as well
- **ACEi/ARB** are indicated when LV dysfunction /diabetes / hypertension/ kidney disease
- **Mineralocorticoid Receptor Antagonist (aldosterone or eplerenone)** – STEMI patient with LVEF<40% or diabetes
- **Sublingual nitrate** - as needed for antianginal rescue therapy

DAPT GUIDELINES:



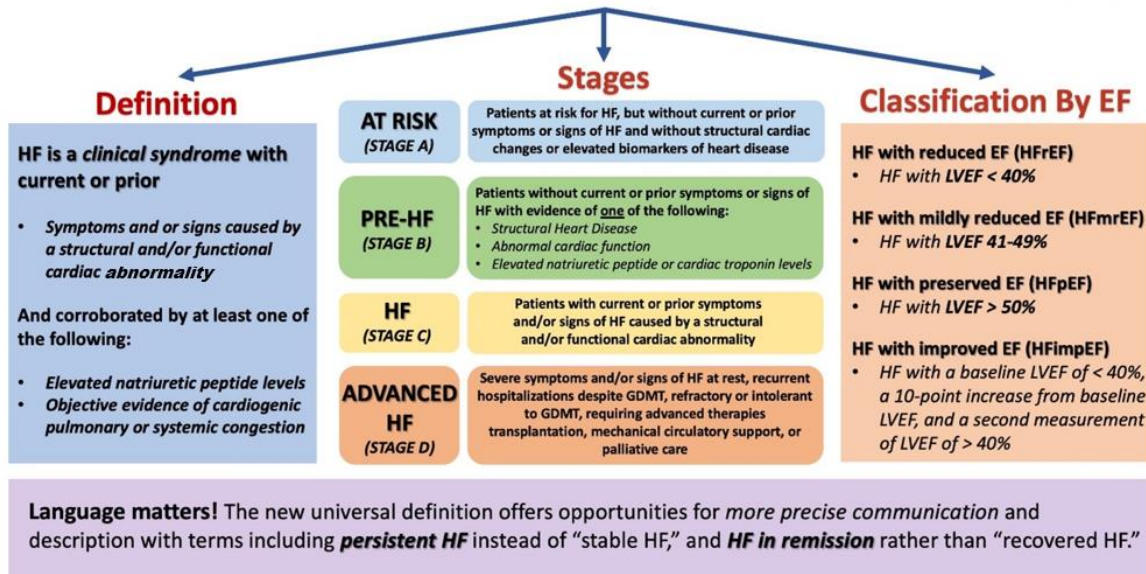
ANTIPLATELET MEDICATIONS:

DRUG	LOADING DOSE	MAINTENANCE DOSE	COMMENT
Aspirin	162 – 325 mg once (chew)	81 mg daily	-
Plavix (Clopidogrel)	600 mg once (300 mg if after lytic)	75 mg daily	CYP inhibition affects metabolism, some people have gene mutation – “Plavix non responders”
Brilinta (Ticagrelor)	180 mg once	90 mg twice daily	Associated with side effect of “dyspnea”
Effient (Prasugrel)	60 mg once	10 mg once daily, 5 mg once daily (if <60kg)	Contraindicated in TIA/stroke patients and in age >75 yrs

STATINS:

High-Intensity Statin Therapy	Moderate-Intensity Statin Therapy	Low-Intensity Statin Therapy
Daily dose lowers LDL on average by $\geq 50\%$	Daily dose lowers LDL on average by approximately 30-49%	Daily dose lowers LDL on average by <30%
Atorvastatin 40-80 mg Rosuvastatin 20-40 mg	Atorvastatin 10-20 mg Rosuvastatin 5-10 mg Simvastatin 20-40 mg Pravastatin 40-80 mg Lovastatin 40 mg Fluvastatin XL 80 mg Fluvastatin 40 mg BID Pitavastatin 2-4 mg	Simvastatin 10 mg Pravastatin 10-20 mg Lovastatin 20 mg Fluvastatin 20-40 mg

Universal Definition and Classification of Heart Failure (HF)



***GDMT: Guideline Directed Medical Therapy: First Line Pharmacotherapy for HFrEF that provides long term mortality benefits ***

HFREF OR HFIMPEF: PRIMARY GDMT

RENIN ANGIOTENSIN ALDOSTERONE SYSTEM INHIBITORS:

- Angiotensin Receptor Neprilysin Inhibitor (ARNI): Sacubitril-Valsartan (Entresto)**
 - Preferred over ACEI or ARB
 - Ensure Serum potassium < 5meq/L, eGFR > 30/ml/min/1.73m², SBP > 90mmHg, no history of angioedema.
 - Start at 24/26mg BID (in some cases 12/13mg BID ie half tablet), titrate up to maximum tolerated dose (97/103mg BID)
 - Expensive
- ACE Inhibitors– Lisinopril**
 - Can start as low as 2.5 to 5 mg once daily and titrate up to 20 to 40 mg once daily
 - Risk of causing hyperkalemia, AKI, cough, angioedema like ARNI.
 - But less expensive, once a day dosing favors compliance
 - If switching between ACEI & ARNI ensure 36 hour washout period
- Angiotensin Receptor Blocker (ARB) – Losartan**
 - Can start at 25 to 50 mg daily and titrate to maximum dose of 150mg daily
 - Risk of causing hyperkalemia, AKI. However risk of cough and angioedema is lower than ACEI/ARNI
 - 36 hour washout period is not needed if switching between ARB & ARNI

BETA BLOCKER: ONLY 3 HAVE SHOWN MORTALITY BENEFIT IN HFREF

1. Carvedilol

- Has alpha and beta blocking action – thus lowers blood pressure more compared to other beta blockers
- Start at 3.125 mg twice daily, can titrate to 25 mg twice daily (if weight > 85kg can go up to 50 mg BID)

2. Metoprolol succinate:

- Start at 12.5 to 25 mg once daily, can titrate up to 200 mg once daily. (For arrhythmias maximum dose is 400mg and can be dosed BID for better rate control)
- Tartrate is the immediate release form which has not shown mortality benefit

3. Bisoprolol:

- Started at low dose 1.25mg daily, can titrate up to 10mg daily
- In the US lowest dose tablets are 5mg, so starting at 1.25mg is not feasible

MRA-MINERALOCORTICOID RECEPTOR ANTAGONIST:

1. Spironolactone

- Ensure serum potassium < 5 mEq/L and eGFR > 30 mL/minute/1.73 m²
- Start at 12.5 to 25 mg once daily, can titrate up to 25 to 50 mg once daily or in two divided doses

2. Eplerenone

- Ensure serum potassium < 5 mEq/L and eGFR > 30 mL/minute/1.73 m²
- Start at 25 mg once daily, can titrate up to 50 mg once daily
- Risk of gynecomastia is much lower compared to aldactone

SGLT2 INHIBITORS:

1. Dapagliflozin (Farxiga):

- 10mg daily, fixed dose
- Available in-patient at our hospital
- Risk of recurrent genitourinary tract infections

2. Empagliflozin (Jardiance):

- 10mg daily, fixed dose
- Not available in-patient at RGH at present
- Risk of recurrent genitourinary tract infections

HFREF OR HFIMPEF: SECONDARY GDMT:

ISOSORBIDE DINITRATE AND HYDRALAZINE COMBINATION:

- Help with afterload reduction
- Alternative to ARNI/ACEI/ARBs if they are not tolerated
- Can also be added if persistent symptoms/ hypertension despite being on optimal medication
- 20 mg TID isosorbide dinitrate plus 25 mg hydralazine TID, can titrate up to 40 mg TID isosorbide dinitrate plus 100 mg hydralazine TID.

IVABRADINE:

- Additional therapy for persistent symptoms
- Most appropriate for patients in **sinus rhythm**, with **HR ≥70 bpm**, despite **maximal beta blocker** therapy
- Start at 2.5 to 5 mg BID, can titrate up to 7.5 mg twice daily

DIGOXIN:

- Additional therapy for persistent symptoms; rarely used
- Started at 0.0625 to 0.25 mg once daily – based on renal function, body weight
- Loading dose typically not used for heart failure
- Dose adjustments based on serum digoxin levels – seek guidance from pharmacy

HFPEF: GDMT:

If NYHA class II to III symptoms + elevated BNP; ie, BNP >100 pg/dL or NT-proBNP >300 pg/dL use both SGLT2I and MRA rather than no HFpEF-specific therapy, either treatment alone, or other agents.

SGLT2 INHIBITORS:

- In trials that included patients with HFpEF, SGLT2 inhibitors reduced the risk of HF hospitalization and improved quality of life but did not clearly reduce the risk of mortality. The benefit of SGLT2 inhibitors must be weighed against the risk of recurrent urinary tract infections and genital infections. (See meds above)

MRA-MINERALOCORTICOID RECEPTOR ANTAGONIST:

- In trials that included patients with HFpEF, MRAs reduced the risk of HF hospitalization but did not clearly reduce the risk of mortality. The benefit of MRA therapy must be weighed against the risk of hyperkalemia. (See meds above)

RENIN ANGIOTENSIN ALDOSTERONE SYSTEM INHIBITORS: SACUBITRIL-VALSARTAN/ ENTRESTO/ARNI:

- PARAGON-HF trial comparing entresto to valsartan showed that there were fewer hospitalizations for HF in the entresto group; however, this finding was of borderline statistical significance. There was no mortality benefit.
- Based on the above trial FDA *does recommend* using sacubitril-valsartan in HFpEF patients.
- It is, however, important to note that around 25% of the patients included in the trial had an LVEF<50% which does not meet the criteria for HFpEF. The incidence of hypotension and angioedema were also higher in entresto group and it is a more expensive medication.
- Thus, at RGH prescription of entresto to HFpEF patients is individualized. Typically, it is used in patients with persistent symptoms despite being on SGLTi and MRAs, who also have a BP >135/80mmHg. It is important to check potassium and renal function before initiating entresto (as noted above).

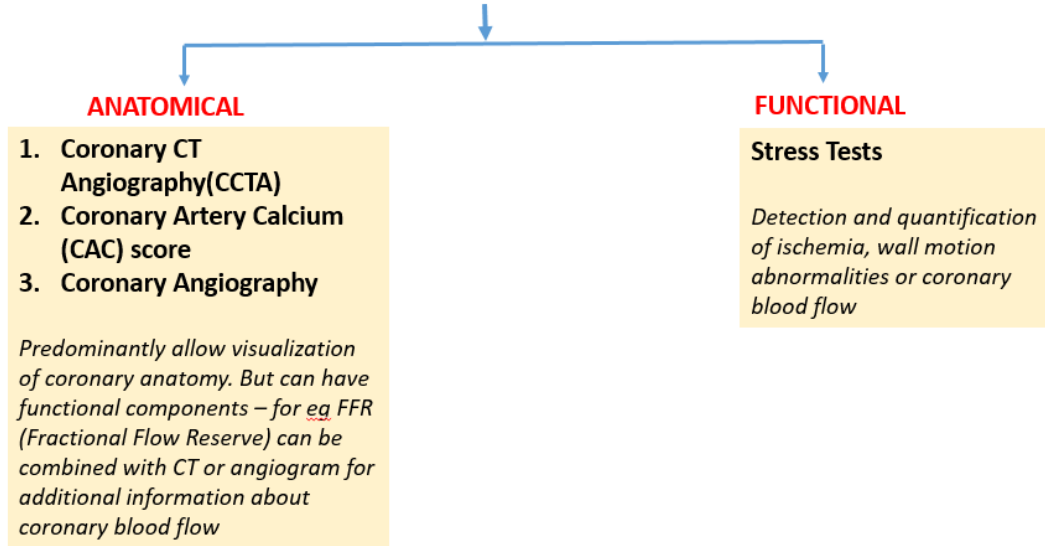
DIURETICS:

- Help with volume management and symptoms relief in all subtypes of HF
- Decrease hospitalizations but no mortality benefit
- Important to know the dose conversions between diuretics:

Loop diuretic	PO	IV
Furosemide (lasix)	40 mg	20 mg
Torsemide	20 mg	20 mg
Bumetanide	1 mg	1 mg

STRESS TESTING

DIAGNOSTIC TESTING FOR ATHEROSCLEROTIC CORONARY ARTERY DISEASE



WHEN TO CONSIDER STRESS TEST?

1. Most effective in patients with an **intermediate pretest probability of CAD** (10% to 90%), in whom a positive test result significantly increases disease likelihood and a negative test result significantly decreases likelihood.
2. There are some situations in which any kind of **stress test is contraindicated**, these include
 - Acute MI <2 days
 - High risk unstable angina or active ACS
 - Sustained ventricular arrhythmias or high grade AV Blocks
 - Decompensated heart failure
 - Severe symptomatic aortic stenosis
 - Hemodynamic instability
 - Uncontrolled hypertension (SBP >200 or DBP > 110 mmHg)
 - Acute medical illness (acute PE, myo/pericarditis, aortic dissection, respiratory failure)

TYPES – THE BASIC CONCEPT:

The type of test is determined by the **modality of stress** and the **modality of response detection** used:

MODALITIES OF STRESS	MODALITIES OF RESPONSE DETECTION
EXERCISE	EKG
PHARMACOLOGICAL	ECHOCARDIOGRAPHY
1. DOBUTAMINE	MPI-SPECT
2. VASODILATORS	MPI-PET/CT
Adenosine	CARDIAC MRI
Regadenoson	
Dipyridamole	

Thus, various combinations become possible, of which some are used more frequently than others are.

EXERCISE STRESS TEST

- Treadmill or bicycle used for exercise. The key is to determine if the patient has the ability to exercise.
- If a patient has mental or physical impairment leading to inability to exercise adequately, inability to achieve ≥ 5 METs or target HR (at least 85% of 220- age) then pharmacological stress test should be used.

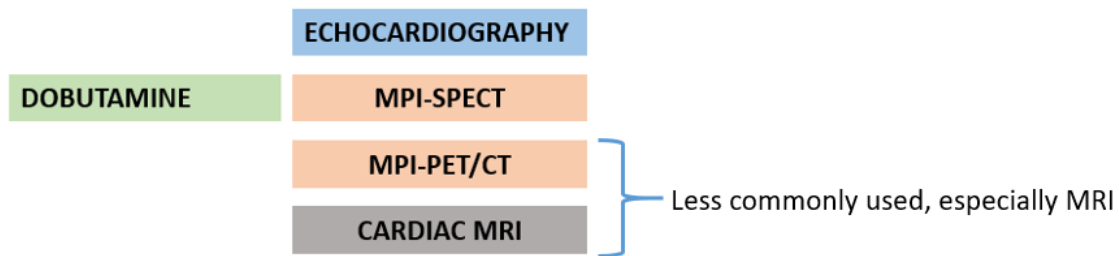
	EKG
EXERCISE	ECHOCARDIOGRAPHY
	MPI-SPECT

- **Exercise EKG** is not useful when baseline EKG is abnormal (eg LVH, LBBB, paced rhythm, pre-excitation, ST-segment depressions). Exercise Echo or SPECT then becomes a better alternative.
- **Echo: Advantages:** assessment of myocardium, wall motion, valve function and pulmonary pressure. Relatively portable & less costly compared to nuclear protocols, no radiation exposure, completed in ~1 hour
- **Echo: Disadvantage:** acoustic windows can be limited in some patients eg COPD. Microbubble contrast can help improve image quality. Not preferred in LBBB or pacemaker patients due to abnormal septal motion. *A patient unable to reach the desired target heart rate should be considered for pharmacological stress test.*
- **SPECT (Nuclear): Advantages:** Assesses blood flow to the heart, left ventricular function, and can assess high-risk findings such as transient ischemic dilation.
- **SPECT (Nuclear): Disadvantages:** Radiation exposure, more expensive, typically takes 2 to 4 hours, but can become a 2-day test if BMI is high (due to high radiation dose involved). *In patients with complete LBBB, permanent pacemakers, conduction delay in the septum may cause false-positive abnormalities; use of*

vasodilator stress can improve the accuracy & should be preferred over exercise SPECT.

PHARMACOLOGICAL: DOBUTAMINE:

1. The main advantage is that it can be used in patients who are unable to achieve target HR just with exercise.
2. The key in tests using dobutamine is to ensure that patients have no contraindication to this pharmacological agent such as:
 - Severe LVOT obstruction/HOCM
 - Severe tachyarrhythmias
 - Known hypersensitivity to dobutamine
 - Large aortic aneurysm
 - Patients on beta-blockers where the heart rate and inotropic responses to dobutamine will be attenuated
 - *Any contraindication to stress test in general(see above)*



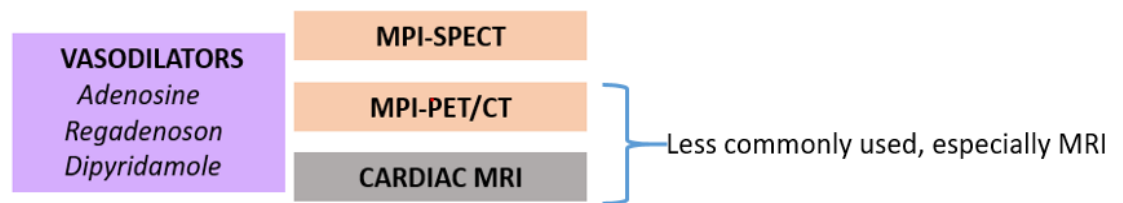
Dobutamine Echo: Advantages and disadvantages essentially same as exercise echo except points 1. & 2. above. Because the patient is supine, images are acquired continuously, allowing the test to be stopped as soon as ischemia is evident. Stepwise increases in dobutamine dose allow staged assessment of wall motion abnormalities.

Dobutamine SPECT: **Helpful if patient has contraindications to exercise or vasodilator use.** Other advantages & disadvantages as are similar to those of SPECT in general.

Dobutamine PET/CT, Dobutamine MRI – see below

PHARMACOLOGICAL: VASODILATOR

1. The main advantage is that it can be used in patients who are unable to achieve target HR just with exercise.
2. The key in tests using vasodilators is to ensure that patients have no contraindication to this pharmacological agent such as:
 - Known or suspected bronchoconstrictive or bronchospastic disease
 - Use of methylxanthines (caffeine, aminophylline, theophylline) within 12 hours
 - Recent use of dipyridamole or dipyridamole-containing medications (e.g., Aggrenox)
 - Known hypersensitivity to adenosine, regadenoson, or dipyridamole
 - Seizure disorder
 - High grade AV block, sick sinus syndrome (absolute); Mobitz Type 1 second-degree AV block (relative)
 - *Any contraindication to stress test in general (see above)*
3. Vasodilator agents can cause side effects like flushing, chest pain or dyspnea
4. Agents include adenosine (Adenoscan), regadenoson (**Lexiscan**), or dipyridamole (Persantine) studies



Vasodilator SPECT: compared to other types of SPECT, the use of vasodilator can help minimize septal abnormalities seen in patients with LBBB or pacemaker. Other advantages & disadvantages are similar to those of SPECT in general.

Dobutamine PET/CT, Dobutamine MRI – see below

PET/CT (NUCLEAR STUDY):

1. **Pharmacological agent:** can be dobutamine or vasodilator. There is **no exercise** protocol.
2. **Imaging agent:** Radioactive tracer (rubidium or N13) are common
3. **Advantages:**
 - Similar to SPECT -Assesses blood flow to the heart, left ventricular function, and can assess high-risk findings, such as transient ischemic dilation.
 - **With PET**, calculation of myocardial blood flow reserve adds diagnostic and prognostic information (eg. identifying microvascular dysfunction). Viability assessment is also possible.
 - Provides best perfusion images in patients with high BMI
 - Amount of radiation exposure & duration of study is also less
 - Can be combined with coronary artery calcium (CAC) score
4. **Disadvantages:** Very expensive and not widely available

SPECT (NUCLEAR STUDY):

1. **Pharmacological agent:** can be dobutamine or vasodilator. **There is exercise** protocol.
2. **Imaging agent:** Radioactive tracer (technetium)
3. **Advantages:**
 - SPECT Assesses blood flow to the heart, left ventricular function, and can assess high-risk findings, such as transient ischemic dilation.
 - Gating (image acquisition coordinated with the cardiac cycle); use of radioactive agents, such as technetium; provide improved sensitivity compared to stress echocardiography.
 - Viability assessment is also possible if thallium is the tracer used (not used here in RGH)
 - Vasodilator SPECT can be done in patients on beta blocker (unlike dobutamine stress)
4. **Disadvantages:**
 - Attenuation artifacts can be caused by breast tissue or diaphragm interference; attenuation correction and software programs can improve image interpretation
 - Radiation exposure
 - Expensive
 - typically takes 2 to 4 hours, but can become a 2-day test if BMI is high (due to high radiation dose involved).
 - In patients with complete LBBB, permanent pacemakers, conduction delay in the septum may cause false-positive abnormalities; use of vasodilator stress can improve the accuracy & should be preferred over exercise SPECT.

CARDIAC MRI:

1. **Pharmacological agent:** can be dobutamine or vasodilator.
2. **Imaging agent:** Gadolinium (usually)
3. **Advantages:**
 - Accurately assesses global and regional left and right ventricular function, myocardial ischemia and infarction,
 - Can assess myocardial viability
 - Detects myocardial edema and microvascular obstruction, which can help differentiate acute versus chronic MI, as well as other causes of acute chest pain, including myocarditis.
 - Identifies anomalous coronary artery origin
4. **Disadvantages:**
 - Some patients experience claustrophobia
 - May be contraindicated in patients with an older pacemaker, ICD, or other implanted device. These also produce artifact
 - Certain gadolinium-based contrast agents are contraindicated in patients with CKD (esp GFR <30)
 - Gadolinium allergy
 - Sinus rhythm and a slower heart rate are needed for improved image quality
 - Limited availability and expertise
 - Moderately expensive

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