The Patient with valvular heart disease having non cardiac surgery.

Basics for the FRCA

Richard Hayes 13th October 2021

Objectives

Spectrum of cardiac disease could take hours…

- Pre-operative evaluation
- Risk Stratification
- Peri-operative goals
- The pregnant patient

Why is this important?

- Major non-cardiac surgery has an incidence of preoperative cardiac death of 0.5-1.5%
- Risk of major cardiac complications - non-fatal cardiac arrest/non fatal myocardial infarction/heart failure/clinically relevant arrhythmia and stroke - is 2.0-3.5%
- Underlying cardiovascular disease significantly contributes to preoperative morbidity and mortality
- Prevelance of cardiac disease in patients undergoing non cardiac surgery ranges from <5% to 70% - the highest being over 70 year olds undergoing major vascular surgery.

Pre-operative assessment

Key to identification of these patients

- Identify active cardiac disease and arrange for assessment with cardiologist and treatment.

Heart Failure

Independent predictor of adverse outcome - greater perioperative risk than ischaemic heart disease.

- Check severity - Stress Echo, serum BNP, or NT-proBNP
- Likely to be on multiple drugs - ACEi, Angiotensin - II - receptor blockers, aldosterone antagonists and diuretics
- Risk of side effects - electrolyte disturbance, renal insufficiency, refractory interoperate hypotension.

Valvular Heart disease

All at increased risk of preoperative cardiac complications

- Clinical evaluation and Echo
- Severe Aortic stenosis (Aortic valve area <1cm^2) carries highest risk of morbidity and mortality
- Independent predictors of adverse outcome are female sex, peak aortic-jet velocity and BNP at baseline.
- Patient may benefit from pre-operative valve replacement or balloon aortic valve angioplasty

Surgical risk

Based on combined incidence of cardiac death and nonfatal MI within 30 days of surgery

- Low Risk <1%
  - Breast, Dental, Endocrine, Eye, Gynaecology, Reconstructive, Orthopaedic - minor (e.g. knee surgery), Urologic - Minor.
- Intermediate Risk 1-5%
  - Intraperitoneal/intrathoracic, Vascular (Peripheral artery angioplasty/carotid/EVAR), Head and Neck Surgery, Neurological/Orthopaedic - major (hip and spine surgery), Lung/Kidney/Liver transplantation, Urologic - Major
- High Risk >5%
  - Aortic - open, Peripheral vascular - major

Assessment of functional capacity

Pre-op functional status is most important predictive factor - assesses individuals ability to increase oxygen delivery when under stress.

- Duke Activity Status Index - questionnaire assessing functional status
- Metabolic Equivalent Task - Based on DASI - certain tasks given a metabolic equivalent
- Incremental Shuttle walk test - 10m course over set period total distance covered
- CPEX testing - Gold standard - symptom limited, gives VO2 max and Anaerobic threshold

Duke activity status index

Activity	Weight (MET units)
Take care of yourself, that is, eating, dressing, bathing and using the toilet?	2.75
Walk indoors such as around your house?	1.75
Walk a block on level ground?	2.75
Climb a flight of stairs or walk up a hill?	5.50
Run a short distance?	8.0
Do light housework like dusting or washing dishes?	2.7
Do moderate housework like vacuuming, sweeping floors, carrying in groceries?	3.5
Do heavy housework like scrubbing floors, or lifting or moving heavy furniture?	8.0
Do gardening including such things as raking leaves, weeding, or pushing a lawn mower?	4.5
Have sexual relations?	5.25
Participate in moderate recreational activities, like golf, bowling, dancing, or throwing a ball?	6.0
Participate in strenuous sports like swimming, football, basketball, or skiing?	7.5

Metabolic Equivalent tasks

MET	Activity
1	reading, watching television
	eating, getting dressed
2–3	walking on level ground at 3–4 km/h
	light housework
4	climbing a few stairs
	walking on level ground at ca. 6 km/h
	running (short distances)
	heavy household chores
	moderately strenuous sports (golf, dancing)
>10	highly strenous sports (tennis, soccer)

*modified from (e24)

Cardiac risk factors

Lee's revised cardiac risk index

Clinical Parameter	RCRI Point
Prior TIA or CVA	1
Diabetes mellitus requiring insulin therapy	1
Serum creatinine ≥2 mg/dL	1
History of coronary artery disease	1
High-risk surgery (chest, abdominal or suprainguinal vascular surgery)	1

Abbreviations: TIA = transient ischemic attack; CVA = cardiovascular accident.

Low risk = 0-1; moderate risk = 2; high risk ≥3. Event rates increase as RCRI score increases.

Incremental Shuttle walk test

ACSM METs[3]	Level	Speed (mph)	Shuttles
3.2	1	1.12	1 to 3
3.4	2	1.50	4 to 7
3.6	3	1.88	8 to 12
3.9	4	2.26	13 to 18
4.2	5	2.64	19 to 25
4.6	6	3.02	26 to 33
5.0	7	3.40	34 to 42
5.5	8	3.78	43 to 52
6.0	9	4.16	53 to 63
6.6	10	4.54	64 to 75
7.1	11	4.92	76 to 88
7.7	12	5.30	89 to 102

CPEX Testing

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Cardiopulmonary exercise testing—a beginner's guide to the nine-panel plot

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Learning objectives

By reading this article you should be able to:

- Describe the basic physiology underlying a cardiopulmonary exercise test.
- Demonstrate a structured approach to evaluating the nine-panel plot of a cardiopulmonary exercise test.
- Explain the pattern of physiological changes associated with cardiac and respiratory limitation within the nine-panel plot.
- Show how cardiopulmonary exercise testing can be used to assess patients undergoing major surgery.

Key points

- Cardiopulmonary exercise testing (CPET) is a dynamic, non-invasive assessment of the cardiopulmonary system at rest and during exercise.
- Deficiencies in the CPET-derived variables anaerobic threshold, peak oxygen consumption, and ventilatory efficiency for carbon dioxide are associated with poor postoperative outcomes.
- The normal physiological response to exercise is a characteristic increase in heart rate, stroke volume, tidal volume, and ventilatory frequency.
- Using a systematic approach, the nine-panel plot can be used to identify limitations in cardiac and respiratory capacity.
- CPET aids risk assessment, identification of comorbidities that may be optimised, and perioperative planning.

It has long been recognised that the physiological stress of major surgery increases an individual's baseline oxygen consumption ($\dot{V}O_2$), and that patients who are less physically fit are more likely to experience adverse perioperative outcomes. A hypothesis links these two observations: patients with insufficient cardiopulmonary capacity to increase O_2 delivery to match the increase in perioperative O_2 consumption are more likely to experience organ dysfunction.

Cardiopulmonary exercise testing (CPET) is a dynamic, non-invasive assessment of the cardiopulmonary system at rest and during exercise. The objective of CPET is to determine functional capacity in an individual. Deficiencies in CPET-derived variables—specifically ventilatory anaerobic threshold (AT), peak O_2 consumption ($\dot{V}O_{2peak}$), and ventilatory efficiency for carbon dioxide ($\dot{V}_E/\dot{V}CO_2$)—are associated with poor postoperative outcomes (mortality, morbidity, admission to intensive care, and length of hospital stay) after intra-abdominal surgery.[1–4] CPET is being used increasingly as part of a comprehensive perioperative assessment of high-risk patients. This helps to inform patients better of their individual perioperative risks, inform surgical decision-making, and plan both perioperative management and postoperative care.[4,5] CPET is used in 68% of departments performing elective surgery in the UK surgery to help assess elderly patients undergoing major procedures such as gastrointestinal, major vascular, major

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Pre-Op ECG and Echo

- Pre-op ECG
  - Recommended - for patients with cardiac risk factors undergoing intermediate or high risk surgery
  - Should be considered for patients with cardiac risk factors undergoing low risk surgery
  - May be considered for patients undergoing intermediate risk surgery
  - Not recommended for no cardiac risk factors undergoing low risk surgery
- Pre-op Resting Echo
  - Recommended - for patients with severe valvular heart disease
  - Should be considered for left ventricular assessment in patients undergoing high-risk surgery
  - Not recommended for left ventricular assessment in asymptomatic patients

Cardiac stress testing

Recommendations for cardiac stress testing

- Recommended for patients with greater than or equal to 3 cardiac risk factors undergoing high risk surgery.
- May be considered for patients with less than or equal to 2 cardiac risk factors undergoing high risk surgery or undergoing intermediate surgery
- Not recommended for low risk surgery.

Coronary angiography

Balance of risks of angio versus benefit of information it will provide

- Recommended for patients with Acute STEMI, NSTEMI and unstable angina and angina unresponsive to medical therapy.
- May be considered for cardiac style patients undergoing high risk surgery or intermediate risk surgery
- Not recommended for stable patients undergoing low risk surgery

Cardiac risk assessment algorithm

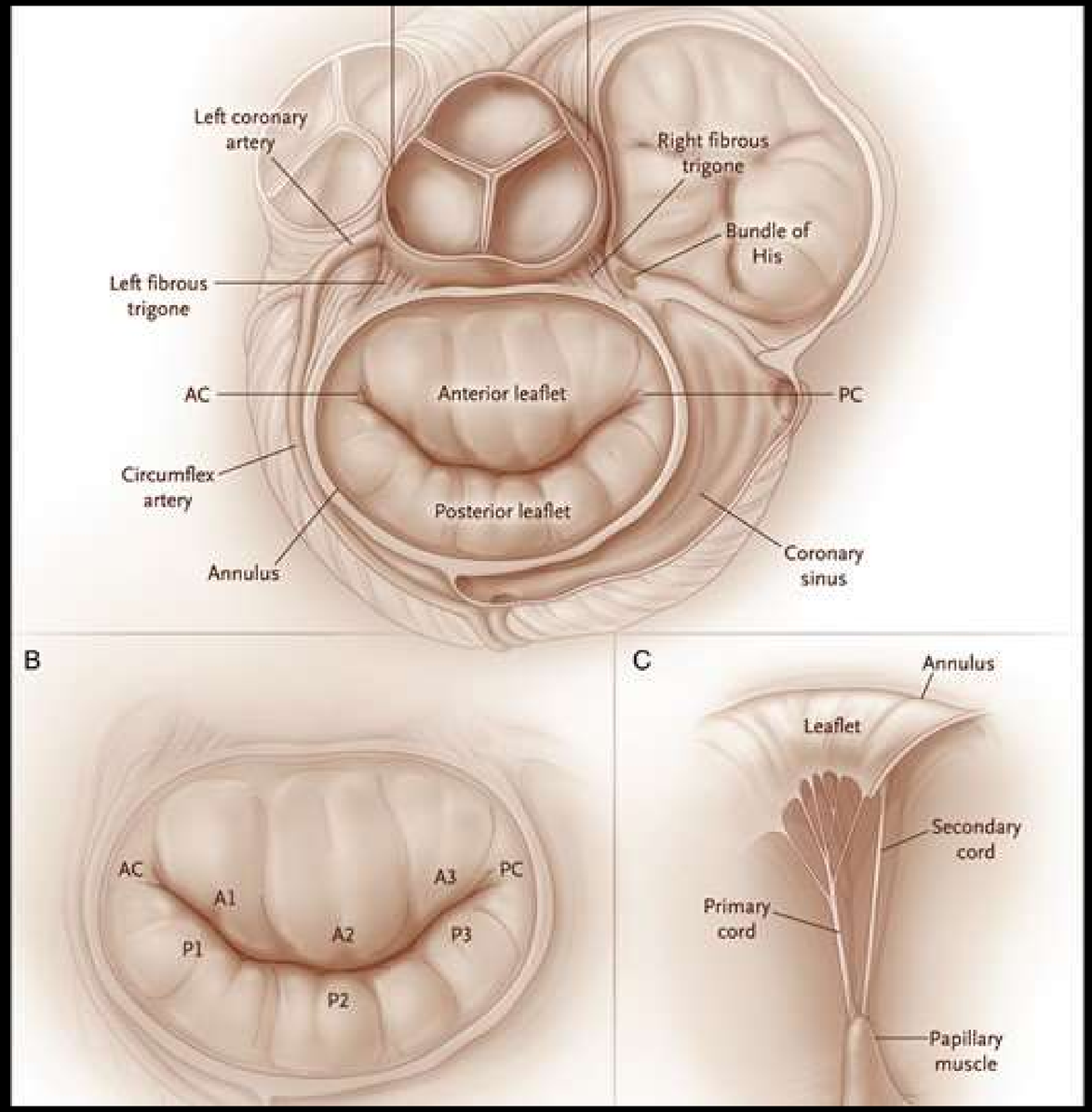
Stepwise approach

- Urgent surgery? - no additional assessment or treatment possible
- Assessment of presence of active cardiac conditions in elective surgery
- Assess surgical risk - low risk doesn’t need further cardiac testing, otherwise risk stratify
- Assess functional capacity - <4 METS needs evaluation and optimisation
- Assess risk factors - Lee’s Revised Cardiac Risk Index
- Consider non-invasive testing
- Interpret stress test results

Mitral Valve Disease

Anatomy

- Separates LA from LV
- Annulus D - shaped
- Close proximity to Aortic valve, surgery to one affects the other
- Circumflex artery follows the line of the annulus and can be damaged
- Anterior and posterior leaflets have 5mm overlap



Mitral Stenosis

- Normal valve area - >4cm^2
- Symptoms only present once stenosis moderate to severe
- Worldwide rheumatic fever is largest cause
- In developed countries - degenerative calcification or endocarditis more likely causes.
- Early disease well tolerated - as it progresses pulmonary hypertension develops leading to dyspnoea and pulmonary oedema
- Pregnancy and development of AF can lead to rapid progression of symptoms

Classification

Echocardiographic diagnosis of MS severity

	Mild	Moderate	Severe
Mitral Stenosis			
Mean Pressure Decrease	<5 mm Hg	6-10 mm Hg	>10 mm hg
Pressure Half Time	<139 ms	140-219 ms	>220 ms
Valve Area	1.6-2.0 cm^2	1.5-1.0 cm^2	<1.0 cm^2

Medical management of MS

- AF - in 40% cases - Rate control required with Beta Blockers of Calcium Channel Blockers
- Dyspnoea - treated with diuretics and long-acting nitrates
- Anticoagulation - if AF - can be warfarinised

Management of MS in non cardiac surgery

Pre-op assessment

- Symptoms of dyspnoa, fatigue and frequent LRTIs can be suggestive of right heart failure
- Low rumbling diastolic murmur
- Elevated PA pressures put strain on right ventricle which will eventually fail with raised JVP and peripheral oedema.
- LA can dilate leading to AF
- Investigate with Exercise tolerance testing to unmask poor functional ability, Echocardiography to give severity of lesion, assess LV and RV function and check PA pressures - If systolic PA pressure <50 mmHg non cardiac surgery is safe.
- ECG - may have AF and P-mitrale

Management of MS in non cardiac surgery

Perioperative management

- Fixed output state
- Maintain sinus rhythm and low normal heart rate to allow sufficient diastolic time for ventricular filling.
- Preload - aim for normovolaemia, keeping in mind fluid boluses can worsen pulmonary oedema.
- Afterload - as output fixed, reduction in SVR decreases coronary perfusion pressure. Maintenance of after load crucial, avoid hypoxia, hypercapnia and acidosis to optimise pulmonary vascular pressure and avoid right ventricle decompensation.
- Avoid nitrous as it increases pulmonary vascular resistance
- Inotropes may be needed to support right heart contractility

Management of MS in non cardiac surgery

Perioperative management

- Neuraxial anaesthesia - causes decrease in after load - potential for profound hypotension - spiral of poor myocardial perfusion and worsening cardiac function. Patient may also be anti coagulated.
- Post operative management
  - Best on HDU - aggressively treat hypotension and avoid fluid boluses

MS in Pregnancy

Needs specialist input

- Poorly tolerated due to increase in blood volume and heart rate
- Can present for the first time
- Anything worse then moderate disease (Valve area <1.5cm^2) frequently results in CCF which develops in second or third trimester and is progressive.
- Medical management - Control tachycardia and AF with Beta blockers, give diuretics if pulmonary congestion, could require percutaneous commisurotomy

MS in Pregnancy

Delivery

- Goals are to maintain afterloadm Heart rate and rhythm control with careful administration of fluids.
- Vaginal delivery is carefully managed
- Early epidural is used to prevent tachycardia due to sympathetic stimulation, Block is achieved slowly and Alpha agonists are used to manage hypotension.
- Second stage is assisted limiting labour duration and valsalva.
- C-section if Pulmonary hypertension or NYHA III/IV symptoms

MS in Pregnancy

Post Delivery

- Risk of flash pulmonary oedema as decompression of IVC can give increased pre-load - managed with head up position, 100% O2 but may need intubation if severe
- Oxytocin can be administered BUT carefully as it has vasodilation properties peripherally and can increase pulmonary vascular resistance
- Ergometrine is contraindicated due to increasing pulmonary vascular resistance

Mitral Regurgitation

- Acute (Can be vegetations or papillary muscle rupture) or chronic (most often degenerative disease), Primary (pathology cases valve not to close) or secondary (LV dysfunction causes valve not to close).
- LA dilates as blood forced back into it, AF is common
- Overload of pulmonary circulation causes dyspnoea
- Frank pulmonary oedema only in acute MR and Severe chronic MR
- LV is volume overloaded and annular dilatation worsens MR

Classification

Complex involving several techniques

- TOE gold standard
- TTE OK if good enough images
- Measurements include effective regurgitant orifice area, regurgitant volume and regurgitant fraction
- These are correlated with other measurements such as the narrowest part of the regurgitant jet (vena contracta) to support the diagnosis

	Mild	Moderate	Severe
Mitral Regurgitation			
Regurgitant fraction	<30%	30-49%	>50%
Regurgitant orifice area	<0.20cm^2	0.2-0.39cm^2	>0.4cm^2
Regurgitant volume	<30 ml $beat^{-1}$	30-59 ml $beat^{-1}$	>60 ml $beat^{-1}$

Management of MR

Medical

- Goals are - filling pressure reduction (nitrates and diuretics) and after load reduction (Vasodilators) which promotes forwards flow into aorta. Use of vasodilators is limited by hypotension and thus inotropic agents may need to be used.
- An Intra-aortic balloon pump can bridge to treatment and works by deflating during systole allowing forward flow of blood and inflating during diastole increasing aortic root pressure and thus coronary perfusion.
- In chronic MR with heart failure treatment is standard heart failure management including Beta blockers, ACEI, aldosterone antagonists and Diuretics.
- Early cardio version of AF is beneficial.
- In general if LV dysfunction develops, surgery is required

Management of MR

Surgical

- Depending on severity of heart failure patients may require surgical repair or replacement of valve
- Can be open, or minimally invasive or percutaneous

Management of MR in non cardiac surgery

Pre operative assessment

- Signs of pulmonary hypertension and right heart failure should be sought - dyspnoea, fatigue and frequent chest infections indicating pulmonary hypertension and peripheral oedema and raised JVP indicating right heart failure.
- May have pan systolic murmur but intensity is not related to severity of disease

Management of MR in non cardiac surgery

Pre operative assessment

- Echo can grade severity of lesion but LVEF can appear higher then normal and blood is ejected through both aortic and mitral valves during systole.
- ECG - seek signs of ischaemia - inferior MI is usually most likely cause of papillary muscle rupture.
- BNP can be useful - low plasma concentration has high NPV for developing further complications
- Exercise Testing - symptoms of MR can be masked by patients simply reducing their exertion./ CPEX testing can be used if picture is not clear and can give better picture of LV function
- If LV function is preserved and patient asymptomatic then non-cardiac surgery can generally proceed with no increased risk even in severe MR. Risk only increases once LV function is <30% or patient is symptomatic. In these cases medical management must be optimum.

Management of MR in non cardiac surgery

Perioperative management - “Full, Fast and Forward Flow”

- Rate/Rhythm - high normal HR 80-100bpm reduces LV filling time counteracting overload of the ventricle and encouraging forward flow. The rapid HR needs to be balanced with myocardial O2 demand in the presence of ischaemia.
- Preload - can be difficult to assess, well filled is preferred to encourage forward flow.
- Afterload - As SVR increases so does regurgitant fraction, low BP treated with fluids and increasing HR, use vasoconstrictors with care.
- Pulmonary vascular resistance to be kept low by avoiding hypoxia, hypercapnia and acidosis and avoiding using nitrous oxide.
- Contractility - Inotropes such as dobutamine, or indicators such as enoximone or levosimenden may be needed, especially in LVF - IABP should be considered.

Management of MR in non cardiac surgery

Spinal Anaesthesia

- Well tolerated as reduces after load encouraging forward flow.
- Use pressers carefully

Management of MR in non cardiac surgery

Postoperative management

- Recovery staff to be made aware of diagnosis
- Treatment goals remain the same.
- After valve replacement there is no ow pressure system for the LV to eject into and is is suddenly exposed to a higher workload.
- Poor function can be unmasked and inotropes and inodilators may be needed
- SVR should be minimised and IABP is usually left in place if put in pre-op until haemodynamic and metabolic stability is achieved

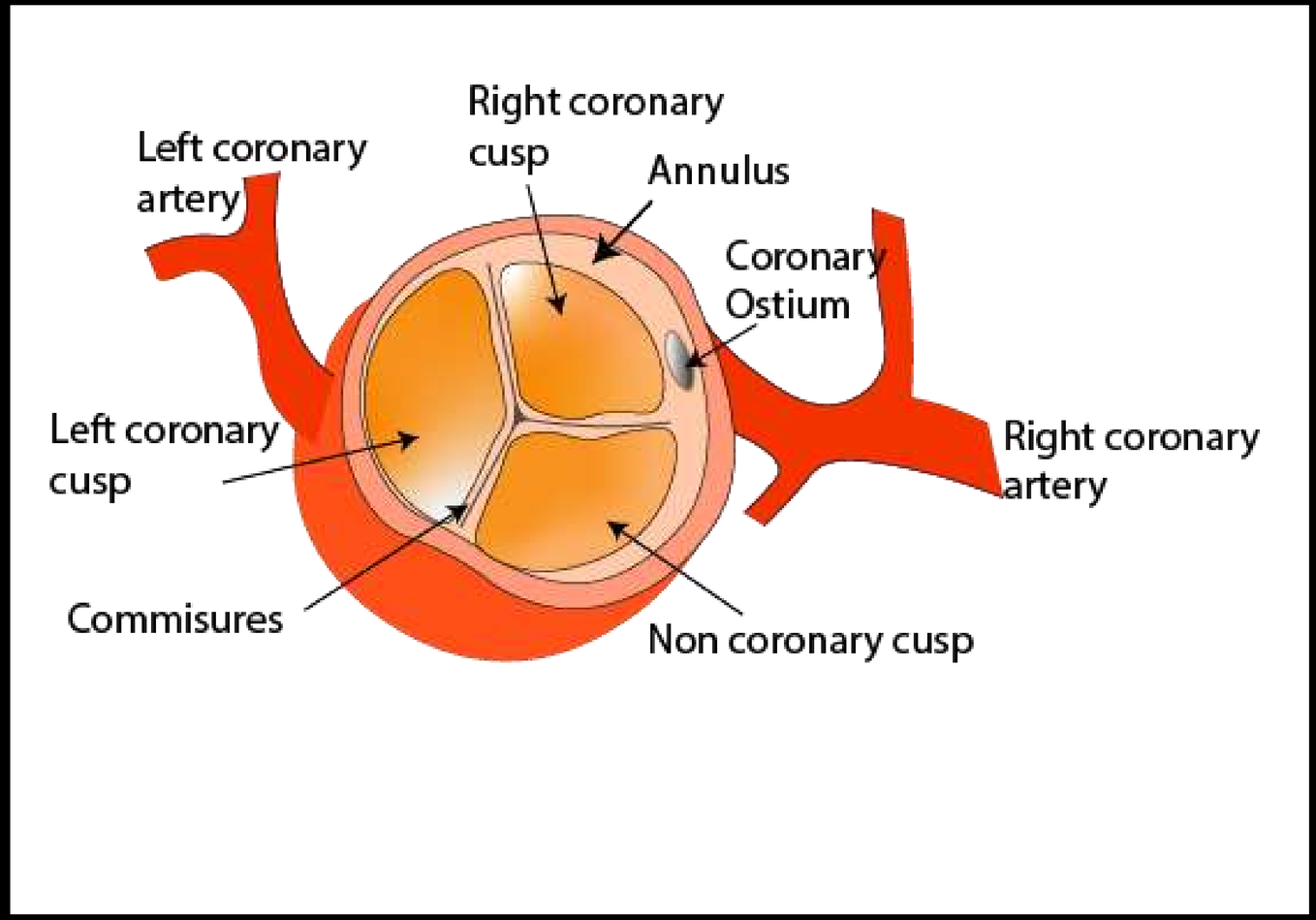
Management of MR in Pregnancy

- Pregnancy mimics the haemodynamic goals for regurgitant lesions with high HR and increased blood volume and decreased SVR encouraging forward flow and is usually well tolerated even in severe MR as long as LV function is preserved.
- If LV function is impaired, or MR is symptomatic then there is risk of heart failure. Diuretics are used to limit volume overload.
- Vaginal delivery is usually possible with epidural analgesia and assisted second stage to avoid spikes in SVR when pushing.

Aortic Valve disease

Anatomy

- Trileaflet valve
- Can be bicuspid
- Coronary arteries arise from the sinuses of Valsalva
- The three leaflets have a free margin and a margin attached to the aortic root
- Any disruption to the aortic root or the sinuses has severe clinical consequences



Aortic Valve Disease

Aortic Stenosis

- Commonest Major valve lesion - 3% of people aged >75 and 4% >85
- Causes -
- 50% age related progressive calcification of normal trileaflet valve
- Calcification of congenital bicuspid valve
- Rheumatic heart disease
- LV Outflow obstruction occurs due to narrowing of the aortic orifice leading to LV hypertrophy and reduction in compliance, results in a fixed low cardiac output state with an inability to compensate for systemic vasodilatation.

Aortic Stenosis

Clinical progression

- Once valve narrows to 1cm^2 symptoms develop as normal cardiac output becomes compromised.
- May develop angina as cardiac work increases
- LV dilates and there is a tendency towards AF
- Patient may suffer exertional syncope and pulmonary congestion

Degree AS	Mean Pressure gradient (mmHg)	Valve area (cm^2)
Mild	<25	<1.5
Moderate	25-40	1-1.5
Severe	>40	<1
Critical;	>70	<0.6

Aortic Stenosis

Investigations

- ECG - LVH/Strain Pattern
- ECHO
- Cardiac catheterisation

Aortic Stenosis

Pre-op Care

- If symptomatic and having elective non cardiac surgery - should have valve replacement first
- If asymptomatic but having elective major surgery associated with large fluid shifts and have a valve gradient >50% should also have valve replaced
- All patiens with aortic stenosis undergoing surgery will need IABP monitoring pre induction
- CVC, TOE and PAC may also be needed

Anaesthetic goals

Low Normal HR, SR, Normal preload, High afteload

- Main aim is to maintain afteload which maintains coronary perfusion and avoid tachycardia.
- Neuraxial anaesthesia is contraindicated and major regional techniques are relatively contraindicated.
- Anaesthetic agents should be administered carefully so as not to cause haemodynamic instability.
- Falls in SVR lead to severe hypotension, myocardial ischaemia, reduced contractility and further falls in BP and coronary perfusion

Aortic Stenosis

Post Op

- Monitor on HDU/ITU setting, Maintain BP ands sinus rhythm. Blood loss, tachycardia and and hypotension need to be recognised and treated aggressively.

Management of Aortic stenosis in pregnancy

- Avoid Sudden decreases in SVR
- Consider early and slowly titrated low dose epidural analgesia
- If GA required needs careful and slow induction

Aortic Regurgitation

Aetiology

- Commonest causes rheumatic fever, bacterial endocarditis and aortic dissection (trauma)
- Connective tissue disorders (ankylosing spondylitis, Marfan’s syndrome, tertiary syphilis) dilate aortic root causing secondary regurgitation.

Aortic Regurgitation

Pathophysiology

- Volume overload of LV causes dilation and eccentric hypertrophy.
- Afterload and HR determine regurgitant load
- Lower aortic pressure lowers LV after load and increases forward flow.
- HR usually elevated thus reducing diastole time and reducing regurgitation
- Acute AR - presents post endocarditis or dissection with acute LV failure/puilmonary oedema and needs emergency surgical correction.
- Chronic AR occurs over many years giving LV time to adapt to increased volume load, Symptoms of LV failure arise following rise in LVEDP and lead to progressive LV Dysfunction
- Onset of dyspnoea indicates mortality within 2-4 mars

Aortic Regurgitation

Clinical management

- All patients with ET <4 METS should be considered for valve surgery prior to elective surgery
- Pre op should elicit signs of ventricular failure
- Patients require awake IABP monitoring with possible CVC line and TOE monitoring

Aortic Regurgitation

Anaesthetic goals

- High normal HR ~ 90bpm
- Adequate preload
- Low/Normal SVR
- Maintain contractility
- Regional techniques may be well tolerated in AR
- Drugs with negative inotropic effects or positive chronotropic effects should be used with caution.

Management of AR in pregnancy

Similar to MR

- Usually well tolerated provided there is no significant LV dysfunction
- Depends on severity of condition
- Early low dose epidural analgesia and assisted stage 2 delivery are advocated
- Avoid large haemodynamic shifts

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