think ANAESTHESIA®

1 CPD

WEBINAR

Keep the Beat Going:
Anaesthesia of the Failing Heart

Speaker

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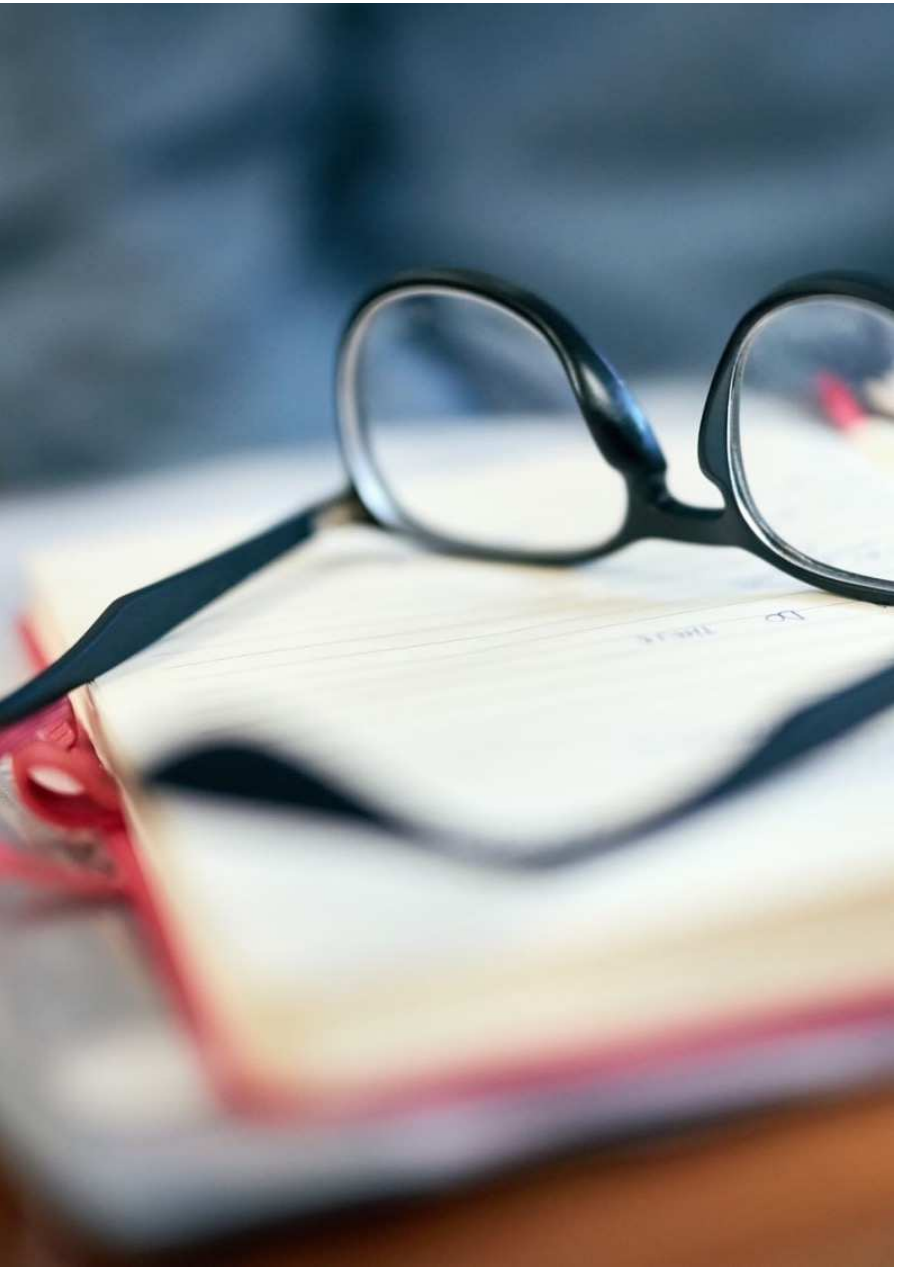


Overview

- Aims & considerations
- Pre-anaesthetic work up
- Anaesthetic management
- Case examples

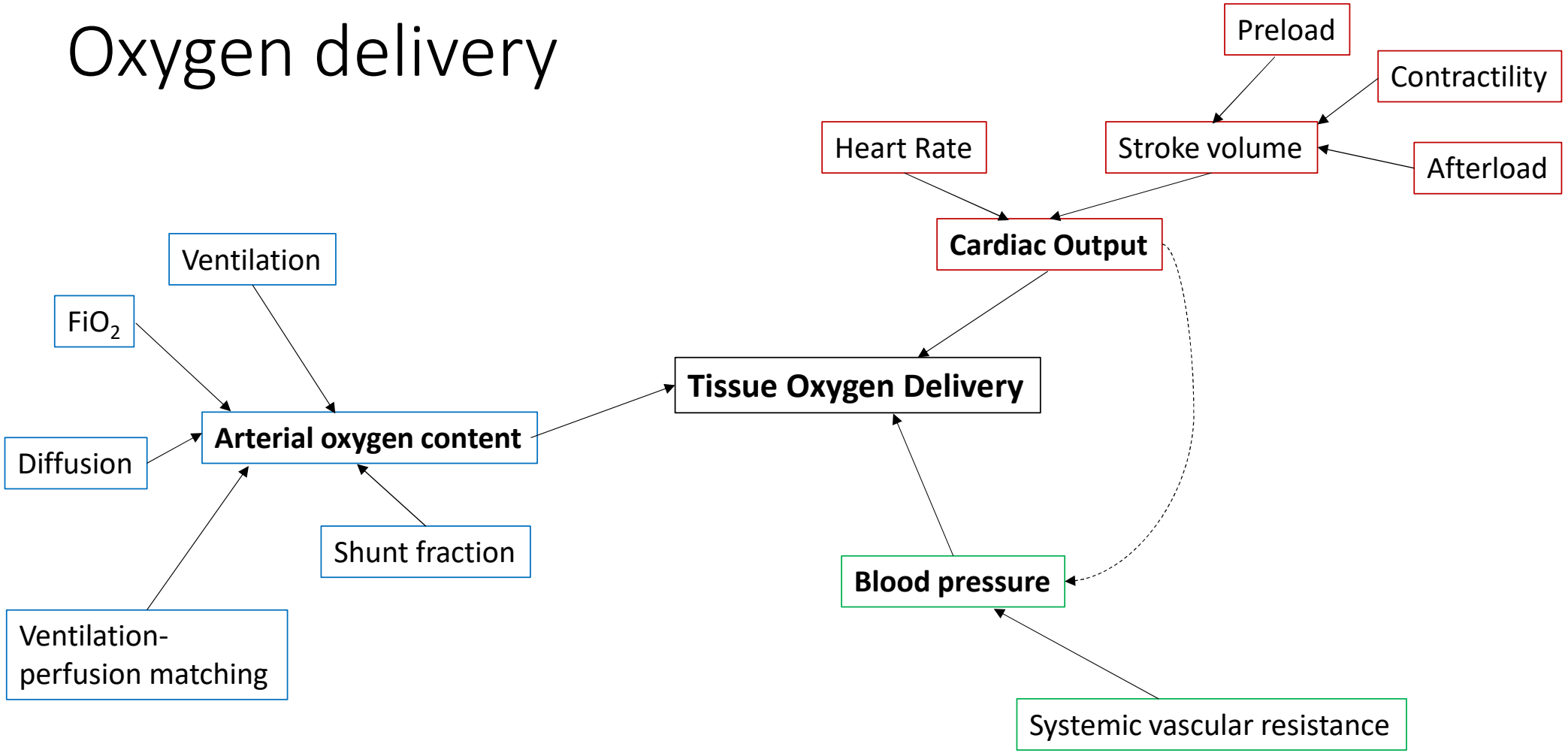
Aims & Considerations

Aims

"First, do no harm"

- Maintain oxygen delivery to vital tissues
- Do not worsen cardiac disease
  - Congestive cardiac failure
  - Arrythmias
- Ensure adequate depth of anaesthesia
- Ensure adequate provision of analgesia

Oxygen delivery



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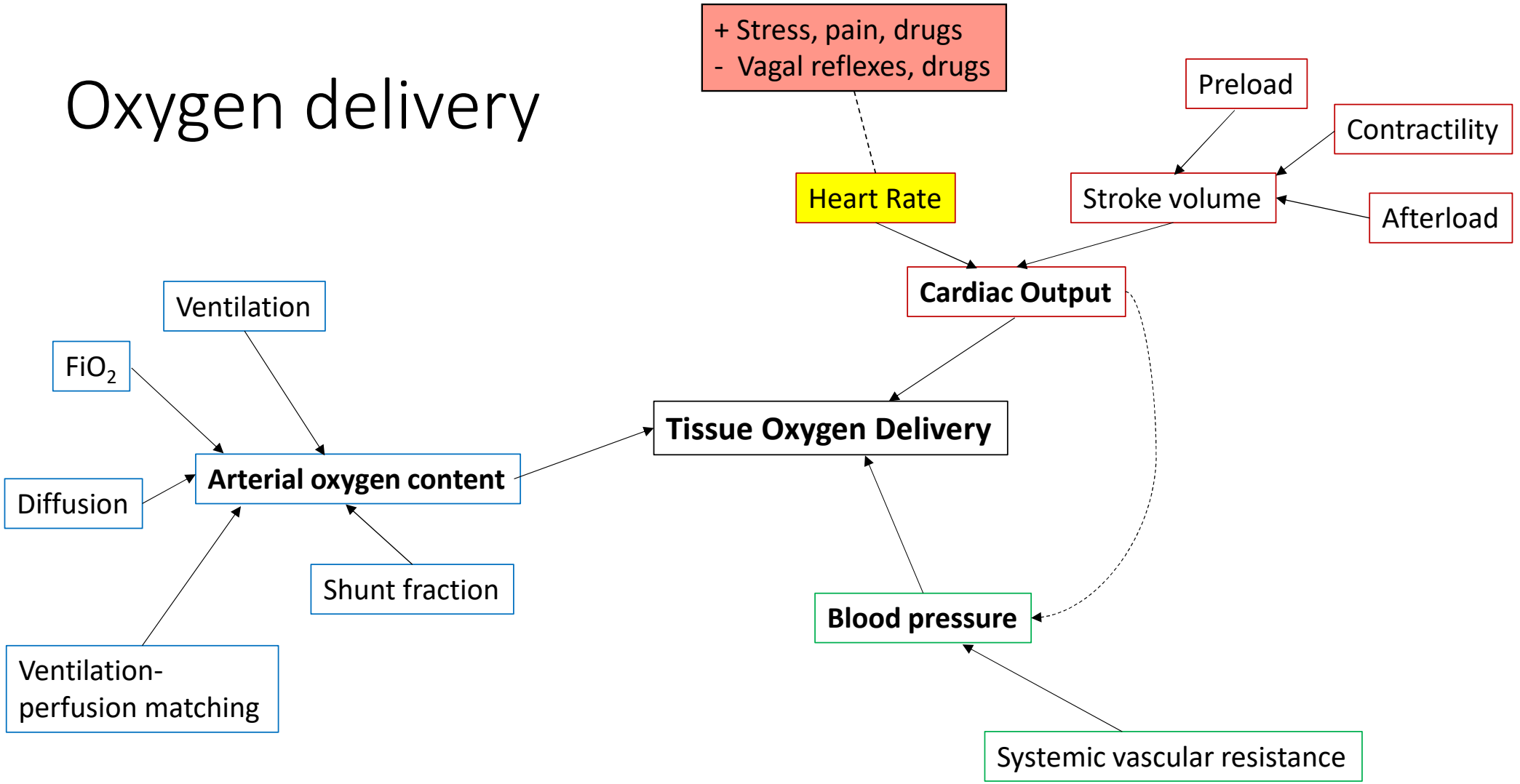

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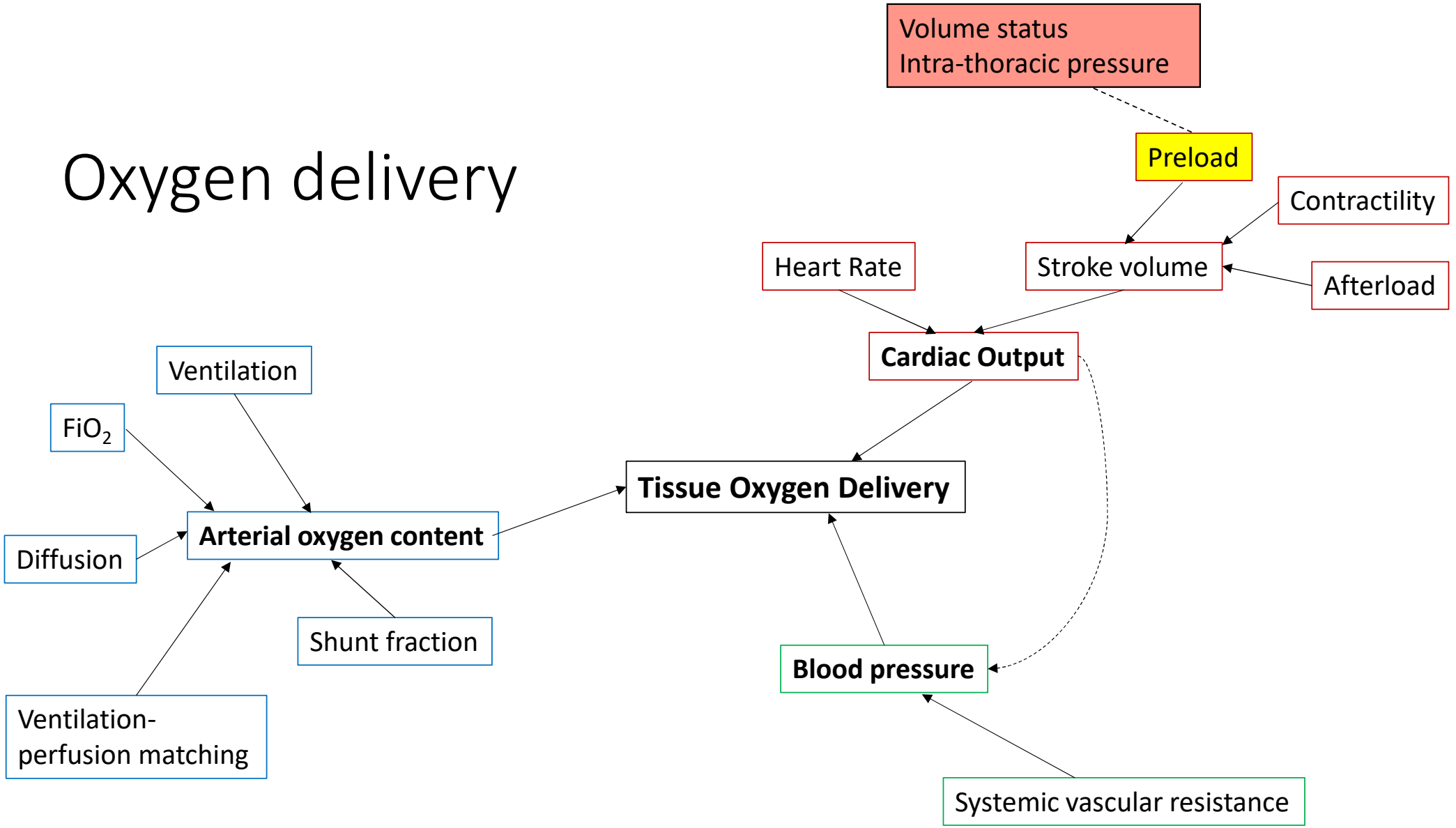

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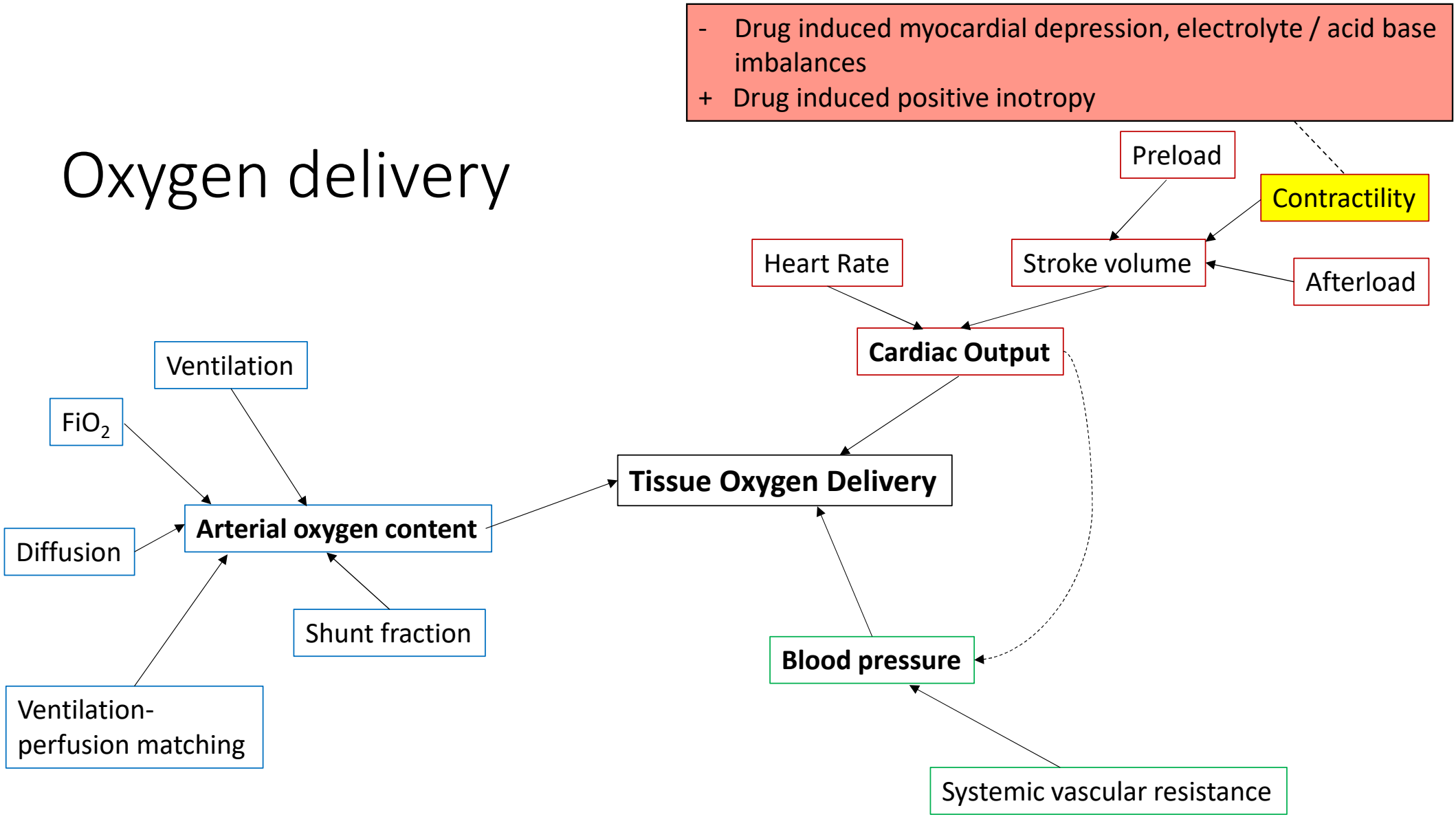

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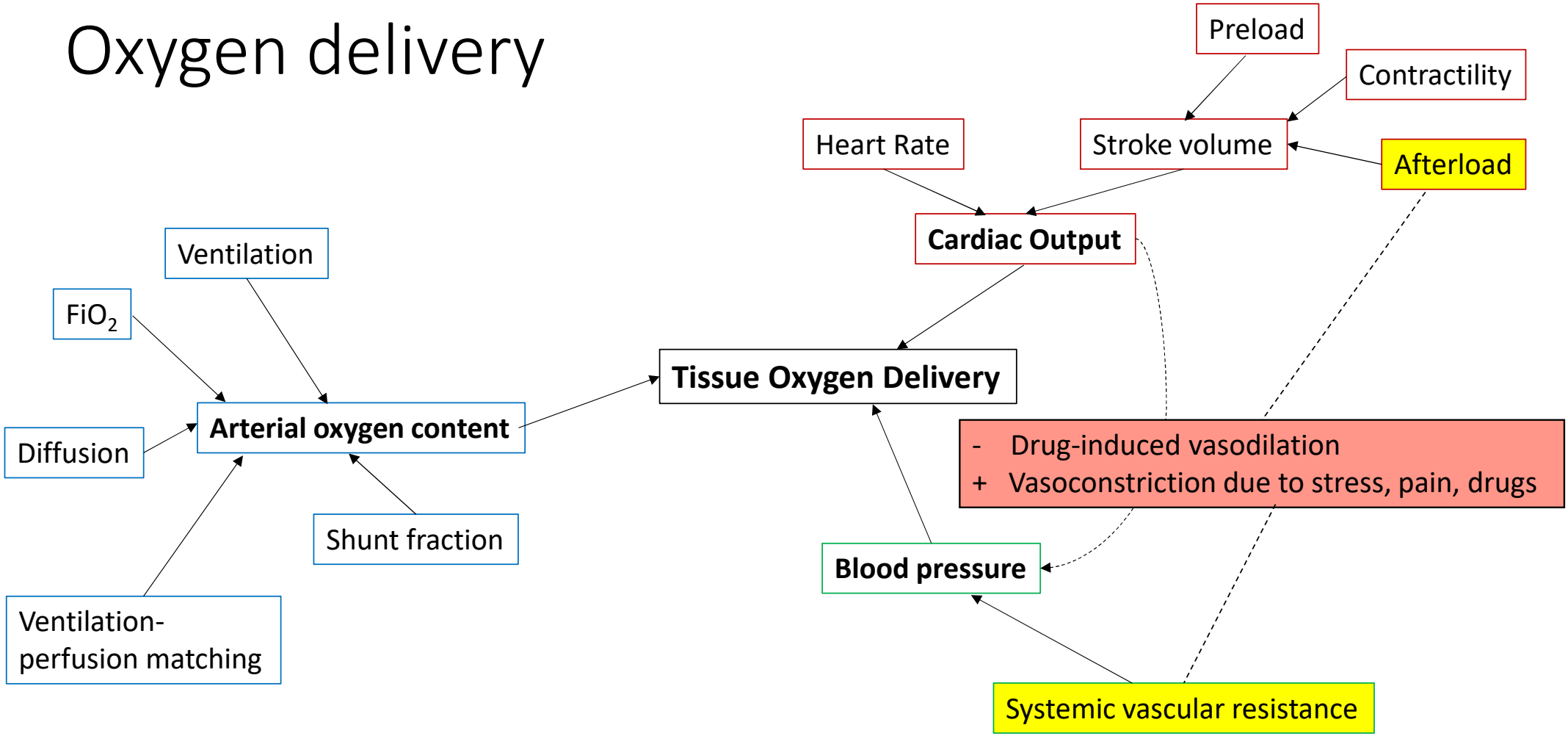

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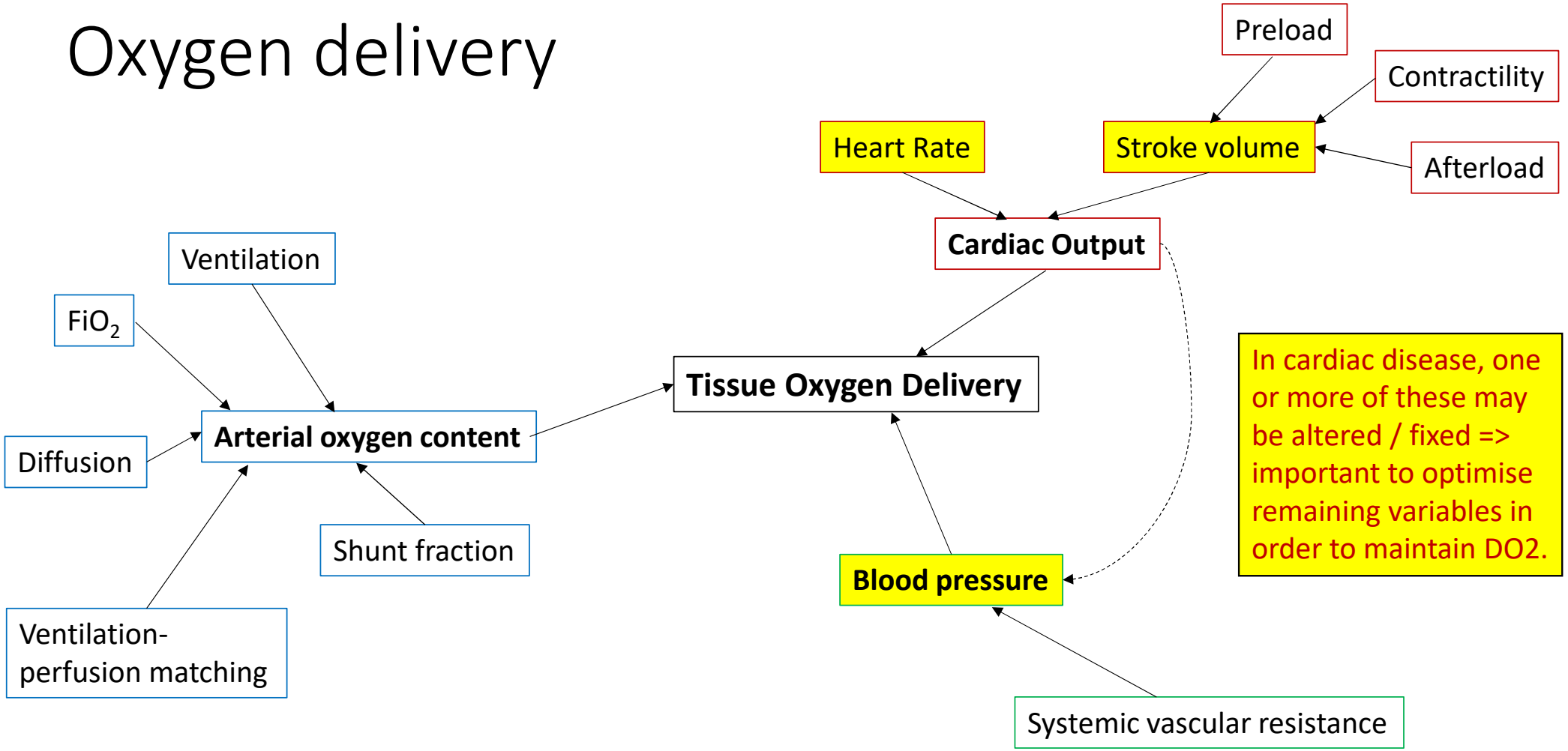

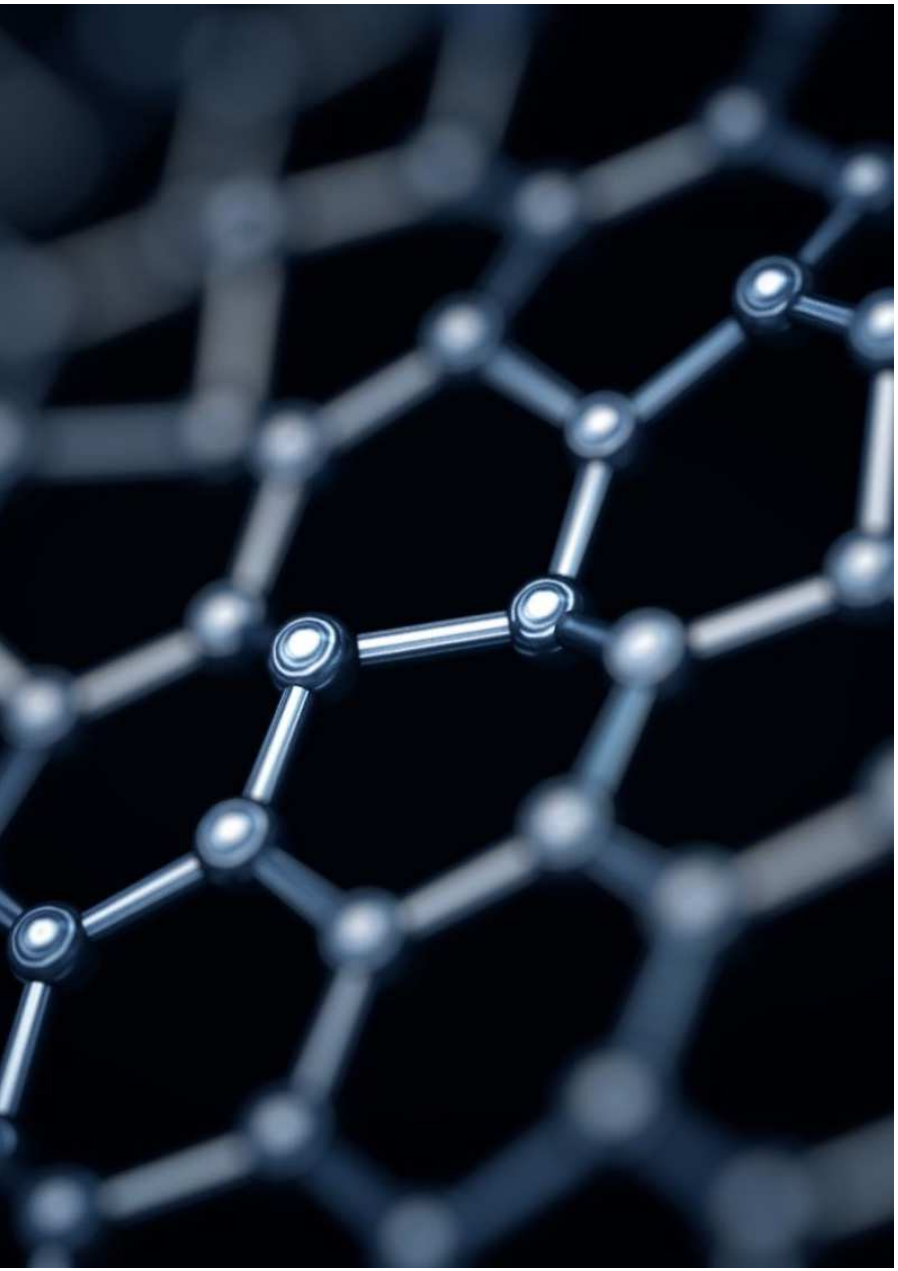

What reduces myocardial O_2 balance?

- Low heart rate
- Low blood pressure
- Hypoxaemia
- Severe hypocapnia (coronary vasospasm)
- Low haemoglobin

What increases pulmonary vascular resistance?

- Stress
- Pain / nociception
- Hypercapnia
- Acidosis

Type of dysfunction	Disease (s)	Heart Rate	Stroke Volume	Preload	Contractility	Systemic Vascular Resistance	Pulmonary Vascular Resistance
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Congenital shunts	Patent ductus arteriosus, ventricular septal defects, etc.	Cardiac output largely HR dependent → Maintain, treat arrhythmias	Reduced due to loss of shunt volume	May be excessive already (volume overload) → Maintain normovolaemia, but care to avoid overload	Maintain → Care with drugs that have negative inotropic effect (most anaesthetic/sedative agents!)	<u>Must maintain SVP > PVR or shunt may reverse</u>	Avoid further increases

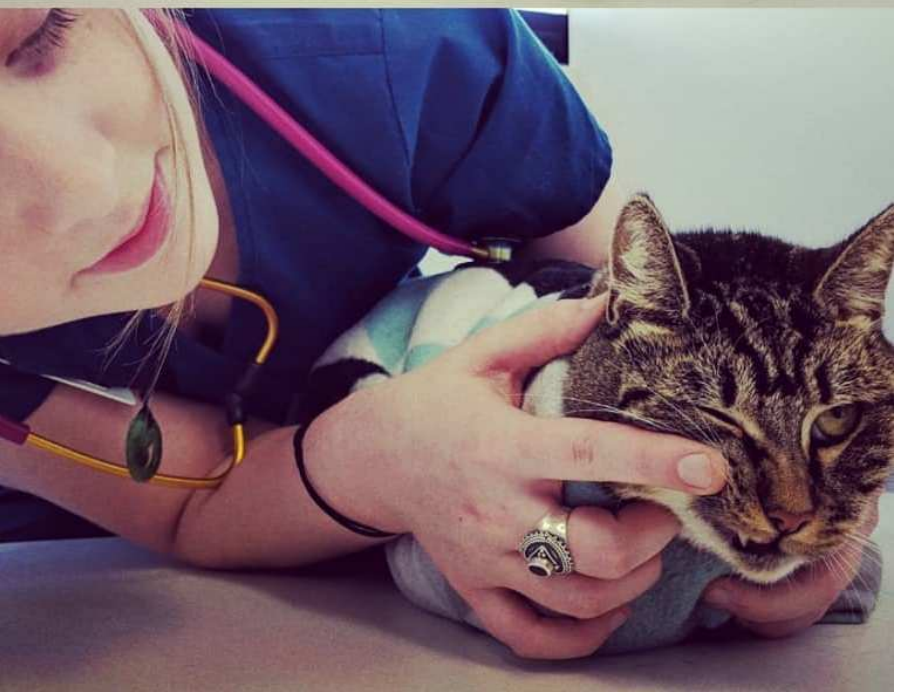
Pre-anaesthetic diagnostics

Questions I want to answer

- ✓ Is congestive cardiac disease present?
- ✓ What type of cardiac disease (volume overload, pressure overload, shunt, PE, etc.)
- ✓ Is systolic/diastolic function significantly affected
- ✓ Is arrhythmia present or likely, and if so what type?
- ✓ Has the disease, or medications for the disease, caused any electrolyte/fluid imbalances and/or renal dysfunction?

History

- ? Any previous history of heart disease
- ? Recent changes to exercise tolerance
- ? Respiratory rate during sleep
- ? Episodes of syncope, or similar
- ? Receiving any medication, and timing of last dose



Physical Examination

? Is heart rate and rhythm appropriate?

? Is a cardiac murmur present? Has it changed recently?

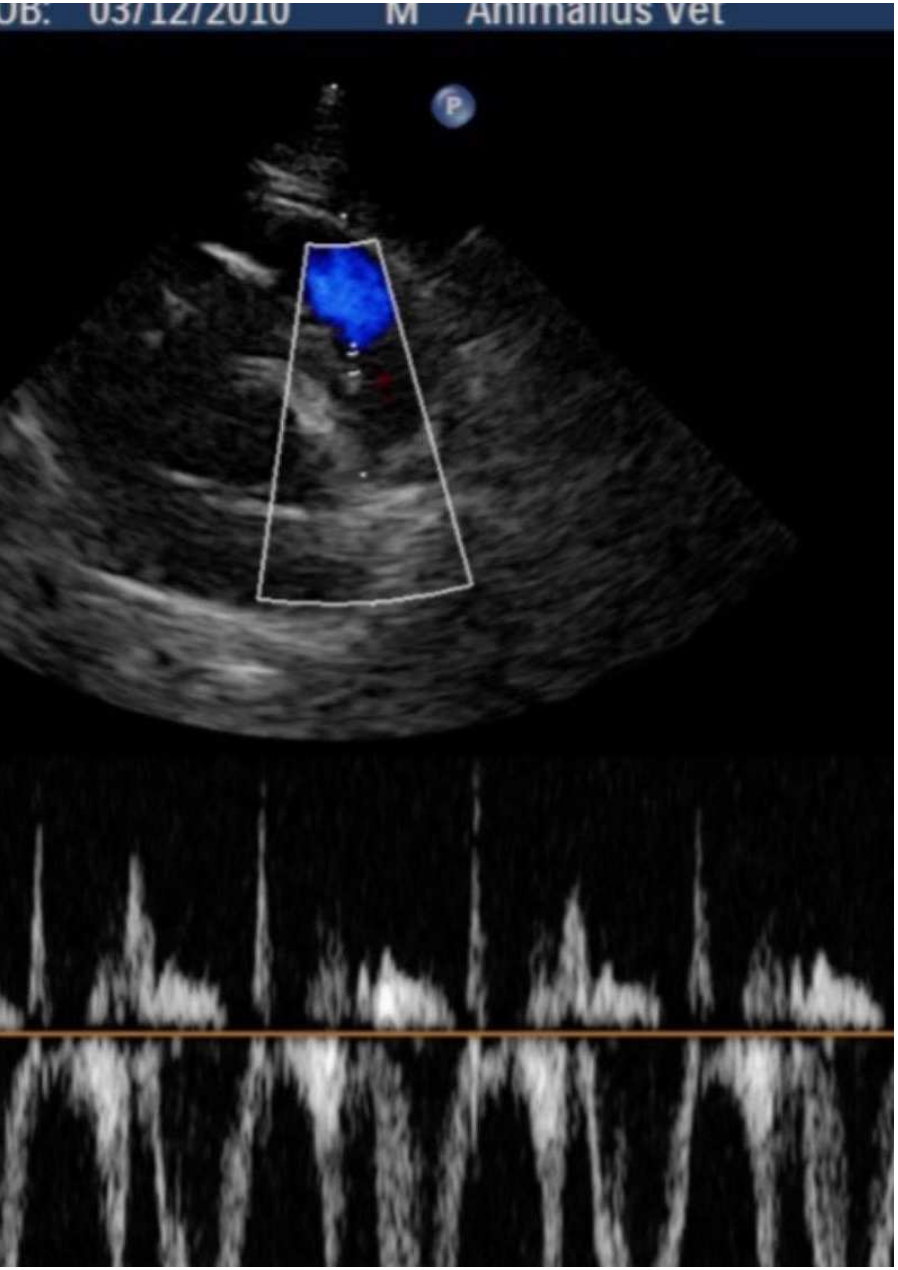
? Is respiratory rate and effort appropriate?

? Are lung sounds normal?

? Are there any pulse deficits?

? Does peripheral perfusion appear adequate?

? Any evidence of cachexia, abdominal effusion, etc.?



Advanced Diagnostics

Thoracic radiographs:

- Is there any evidence of congestive cardiac failure
  - Pulmonary oedema, pleural effusion
  - Cardiomegaly

Echocardiography

- Type of disease
- Systolic/diastolic function
- Pulmonary vascular resistance
- Consider provision of medication pre GA (e.g Pimobendan for high La:Lo)

Advanced Diagnostics

ECG

- Characterise arrhythmias
- Consider anti-arrhythmics pre GA?
- Consider further testing: electrolyte panel, atropine response test

Blood testing

- PCV, USG
- Electrolyte panel
- Renal parameters

Anaesthetic Management

Preparation

Stabilise disease as far as possible

Do not stop cardiac medications

Minimise stress and anxiety

Cardiac medications

Medication	Potential impact on anaesthesia
ACE inhibitors	Hypovolaemia, hypotension, tachycardia, hyperkalaemia
Diuretics	Hypovolaemia, hypotension, electrolyte imbalances
Pimobendan	Improved contractility
Digoxin	Arrythmias
Anti-arrythmics (e.g. propranolol, diltiazem, sotalol)	Arrythmias (i.e. bradycardia), hypotension

In most cases these medications are beneficial and should be continued right up to time of anaesthesia

Pharmacological Decisions…

Premedication & sedation

Drug	HR	Contractility	Systemic vascular resistance	Other notes
Acepromazine	⇣ or no effect	Minimal ⇣	Moderate ⇣	Cannot reverse
Medetomidine / Dexmedetomidine	⇣ (sustained) Bradyarrhythmias	Minimal ⇣	⇡ (initially)	
Diazepam / Midazolam	⇡ or no effect	No effect	⇣ or no effect	May cause significant respiratory depression in combination with other agents. Poor sedation / dysphoria
Opioids: full mu (morphine, methadone, fentanyl)	⇣ (dose dependent)	Minimal ⇣	⇣ No effect, except if histamine response occurs with morphine	
Pethidine	⇡	⇣	⇣ If histamine response	Short lived analgesia, cannot use IV
Buprenorphine / Butorphanol	⇣	Minimal ⇣	No effect	
Gabapentin	⇣ or no effect		⇣ or no effect	
Trazodone	⇣ effect reported in dogs Reports of arrythmias in people		⇣ (possibly due to alpha1 block)	Risk of drug interactions

Induction & maintenance

Drug	HR	Contractility	Systemic vascular resistance	Other notes
Alfaxalone	↑ (reflex) or no effect	↓	↓↓	
Propofol	↓ or no effect	↓	↓↓	
Ketamine	↑	Direct effect: ↓ Indirect effect: ↑	Direct effect: ↓ Indirect effect: ↑	Minimal cardiac effects at very low, sub-anaesthetic (analgesic) doses
Tiletamine/zolazepam	↑ (tachycardia in cats)	Direct effect: ↓ Indirect effect: ↑	Direct effect: ↓ Indirect effect: ↑	
Thiopentone	↑ (reflex) Ventricular arrythmias	↓	↓	Contradicted in most heart disease due to arrhythmogenic effects
Isoflurane		↓	↓↓	
Sevoflurane		↓	↓↓	No real benefit vs isoflurane
Nitrous oxide		↓	↑ (if adequate sympathetic reserve)	Increases pulmonary vascular resistance
Lignocaine (systemic)	Anti-arrthymic effect	↓	↓	

Fluid therapy

Must be provided:

- Important to maintain preload in face of reduced contractility.
- Animals with cardiac disease may have renal dysfunction.

Guidelines

Start at 5 mL/kg/hour for normovolaemic dogs and cats (base on lean weight if obese)

Use fluid “challenges” rather than large volume boluses

If using additional infusions (e.g. analgesic CRIs), reduce fluid rate accordingly to avoid increase in total fluid volume administration rate

Monitoring

Continuous HR and RR monitoring: non-negotiable!

- >1 method of HR monitor

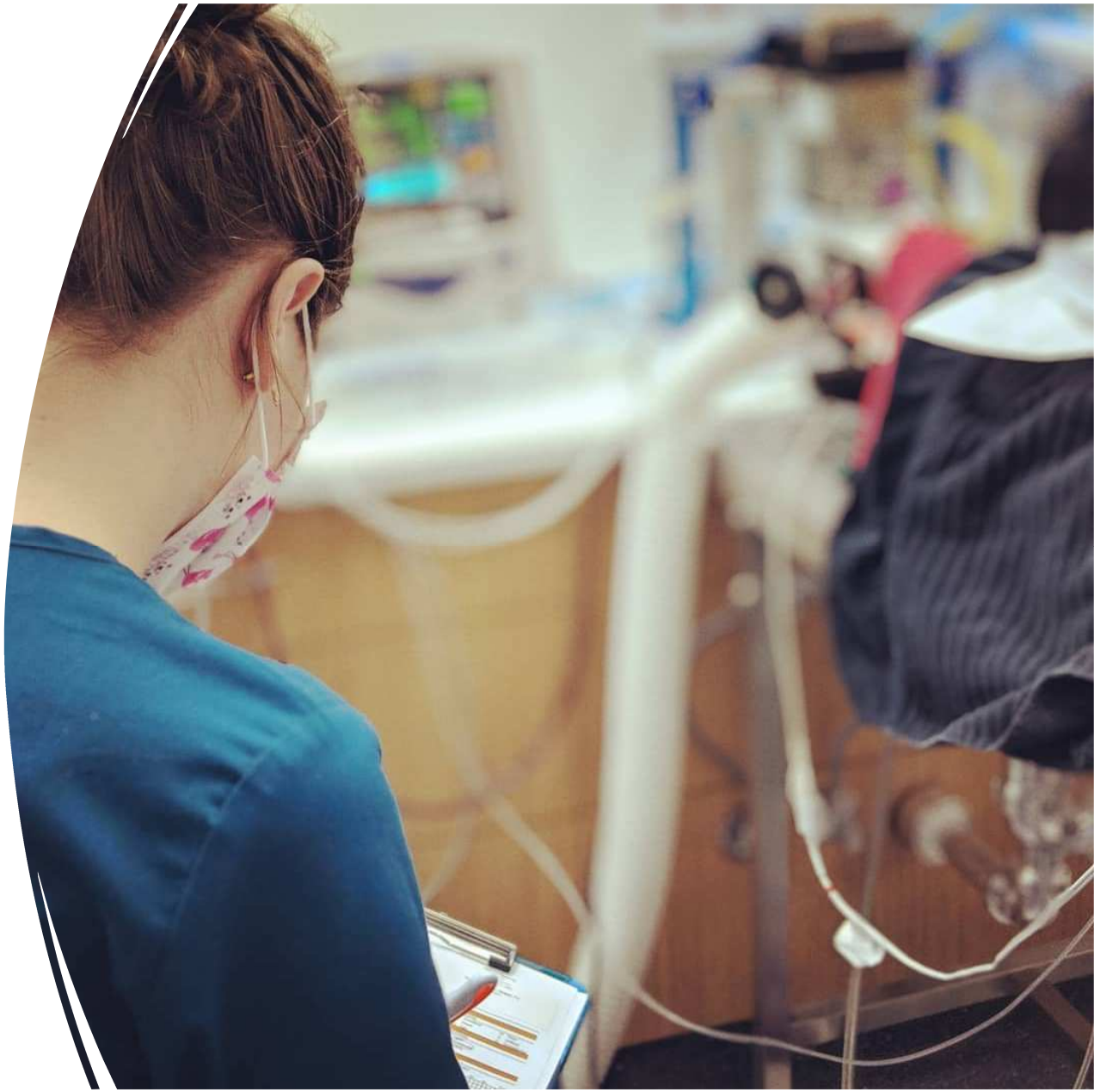
Capnography

Non-invasive blood pressure (NIBP)

Pulse oximetry

ECG

Electrolytes



10 Steps for Success

1. Careful physical examination +/- echo +/- thoracic radiographs prior to day of procedure
2. Re-schedule and stabilize cardiac disease if necessary
3. Understand how different types of cardiac disease impact anaesthetic aims
4. Low stress while awake (handling techniques, environment, premedication, recovery sedation, good analgesia)
5. Pre-oxygenate
6. Avoid sympathetic response to intubation
7. Always intubate and provide oxygen +/- positive pressure ventilation
8. Give preference to drugs with minimal effects on HR and SVR
9. Provide adequate, but careful, fluid therapy
10. Monitor HR (CONTINUOUSLY!), RR (CONTINUOUSLY!), $ETCO_2$, BP and Sp02. Plus ideally ECG.

Managing Heart Rate Abnormalities

Sinus bradycardia / AV block

Only treat if concurrent hypotension, or if cardiac arrest is imminent

Reduce anaesthetic depth if possible

Reduce doses of opioids, alpha-2 agonists

Stop anything that may be causing a vagal reflex (e.g. ocular traction)

Atropine 0.01 – 0.02 mg/kg IV, glycopyrrolate 0.005 – 0.01 mg/kg IV

Temporary pacing may be required for severe bradyarrhythmias that are not atropine responsive

Check electrolytes (e.g. K^+) if un-expected bradycardia

Managing Heart Rate Abnormalities

Sinus tachycardia

Increase anaesthetic depth if required
Provide analgesia (repeat dose, multi-modal approach, etc.)

Ventricular tachyarrhythmias

Remove underlying cause if possible
Lignocaine bolus (2mg/kg), then infusion (50 mcg/kg/min)
+/- magnesium infusion, β-blocker infusion (e.g. esmolol)

Supraventricular tachyarrhythmias

Use with care if structural heart disease

Remove underlying cause if possible
Esmolol infusion, diltiazem, sometimes lignocaine may work

For all types: rule out hypoxaemia, and check electrolytes and acid-base balance if possible.

When does a tachyarrhythmia require intervention?

Causing haemodynamic instability

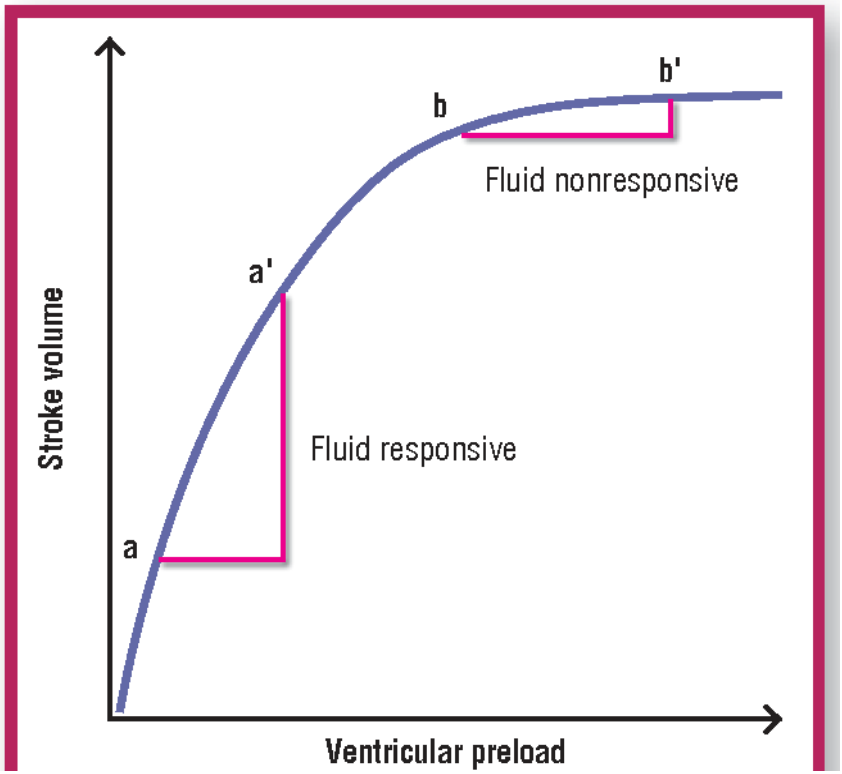
Runs (pairs, triplets, etc.) of VPCs

Risk of progression to ventricular fibrillation:
- Polymorphic VPCs
- Sustained rate > 180-200 bpm
- R on T phenomenon

Managing hypotension (MAP < 60mmHg)

1. Check depth and reduce dose of anaesthetic agents if possible
2. Fluid challenge +/- adjustment to fluid rate

Fluid Challenge



Sample "mini fluid challenge":

1. Administer 3mL/kg of balanced crystalloid solution over 3 minutes

2. Assess for haemodynamic response: >10% increase in BP and/or >10% reduction in HR.

3. Repeat until no further improvement in BP/HR, OR increase fluid rate to 10mL/kg/hour for next hour following a positive response

Only 50% of critically ill people have sufficient preload reserve to increase cardiac output in response to volume expansion
(Michard F, Teboul JL. Predicting fluid responsiveness in ICU patients: a critical analysis of the evidence. Chest 2002; 121: 2000–2008)

=> Important to "challenge" before bolus, in order to avoid overload.

Managing hypotension (MAP < 60mmHg)

1. Check depth and reduce dose of anaesthetic agents if possible
2. Fluid challenge +/- adjustment to fluid rate
3. Treat bradycardia with atropine / glycopyrrolate (unless high risk for tachyarrhythmias)
4. Consider MAC-sparing techniques (analgesic infusions, partial-intravenous anaesthesia, loco-regional anaesthesia)
5. Dopamine 5 – 20 mcg/kg/minute IV (*lower doses improve contractility, higher doses increase SVR)*
    1. Start low and increase dose every 5 minutes until required response
    2. Stop if significant arrythmias occur, or no improvement in BP even at high dose

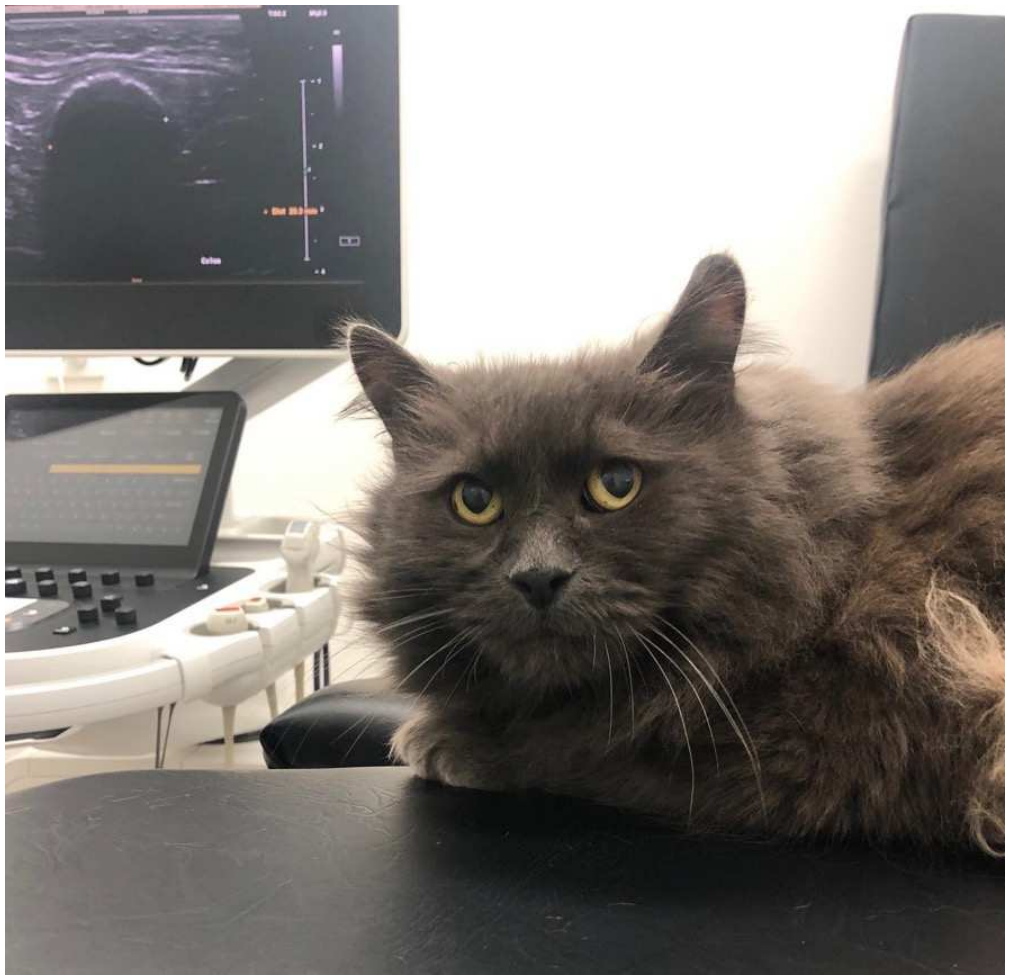
Case Examples

Case Example 1: George

7-year-old domestic long-haired MN cat, scheduled to undergo general anaesthesia for oral radiographs, periodontal treatment, and likely dental extractions.

History:

Reduced appetite, weight loss, lethargy (presumed to be due to dental disease)



Physical examination:

Body condition score 5/9 (weight = 5.5kg)

Quiet and alert, can become stressed and fractious during handling

HR 240

RR 36 (*at rest in cage*)

Thoracic auscultation: regular cardiac rhythm, marked gallop, grade 4/6 systolic murmur with PMI at left apex, normal lung sounds

Oral mms: pink, slightly tacky, crt 1-2s.

Normal femoral pulse rate and quality

Normal abdominal palpation

Rectal temp 37.9^{o}C

Heart murmur never previously detected!

What next?

A. Proceed with general anaesthesia immediately

B. Run bloodwork, proceed with general anaesthesia if normal

C. Call owner and recommend thoracic radiographs, ECG, and bloodwork, then to proceed if normal

D. Call owner and recommend thoracic radiographs, ECG, bloodwork, and specialist echocardiogram prior to the procedure

E. Cancel the procedure. Advise too risky to perform GA on this cat for a dental procedure, will have to manage medically instead.

Thoracic radiographs:

Cardiomegaly with left atrial prominence, normal lungs, no evidence of pleural effusion

ECG:

Sinus tachycardia

Bloods:

Mild haemoconcentration, bloodwork (inc. T4) otherwise nsf

Echo:

Concentric left ventricular hypertrophy and left atrial enlargement. Normal cardiac function/contractility. Systolic anterior mitral valve motion evident, suggesting dynamic aortic outflow obstruction.

Hypertrophic Cardiomyopathy with LVOT, no evidence of cardiac failure

Pre-GA stabilization:

Physical examination and bloodwork suggests mild dehydration.

⇒ Fluid therapy PRIOR TO anaesthesia may be beneficial and may avoid need for high fluid rates / boluses during.

- Schedule procedure for afternoon

- Hartmann's 2 x maintenance for ~ 4h prior

Type of dysfunction	Disease (s)	Heart Rate	Stroke Volume	Preload	Contractility	Systemic Vascular Resistance	Pulmonary Vascular Resistance
Volume overload	Dilated Cardiomyopathy	Ventricular arrhythmias common → Avoid increasing HR, treat arrhythmias Adequate HR important for CO in face of low SV → Avoid bradycardia	Fixed reduction due to poor contractility of dilated chambers	May be excessive already (volume overload) → Maintain normovolaemia, but care to avoid overload	Poor = > avoid further reductions → Care with drugs that have negative inotropic effect (most anaesthetic/sedative agents!)	Avoid significant changes: High SVR increases myocardial oxygen demand, Low SVR reduces CO and BP.	
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Avoid ↑ HR
Maintain normovolaemia
Avoid increasing cardiac contractility
Avoid significant vasodilation or vasoconstriction

What would you choose for premedication?

A. Opioid only IM

B. Opioid + acepromazine IM

C. Opioid + medetomidine (or dexmedetomidine) IM

D. Opioid + alfaxalone IM

E. No premedication for this case

My *preferred* choice for George:

Methadone 0.3 mg/kg + Alfaxalone 2mg/kg IM

Induction:

1. Place IVC once adequately sedated
2. Pre-oxygenate via mask or in oxygen cage for ~ 5 minutes
3. Alfaxalone or propofol slowly IV *"to effect"*
   - *Alfaxalone 0.5mg/kg every 15 seconds, until sufficient to intubate*
   - *Propofol 1mg/kg every 15 seconds, until sufficient to intubate*
   - Could add midazolam 0.2 mg/kg IV after first increment of alfaxalone/propofol to reduce dose requirements (but makes apnoea/hypoventilation more likely)
4. Topical local anaesthesia for larynx desensitization – then WAIT 30s while providing O_2 via mask and monitoring pulse/heart rate.
5. Intubate, and inflate cuff, as gently as possible.
6. Check pulse/heart rate again
7. Immediate provision of oxygen via anaesthetic breathing system, with manual ventilation if needed.
8. Attach all monitoring

Maintenance of anaesthesia:

- Isoflurane in oxygen
- Monitoring: capnography, pulse oximetry, NIBP, ECG, temperature
- Dental nerve blocks for all extractions using either:
  - Lignocaine, max. dose 4mg/kg
  - Bupivacaine, max. dose 1mg/kg
- Repeat methadone or fentanyl infusion if further analgesia required
- Hartmann's 5mL/kg/hr based on 5kg
- Active warming with forced air warmer once temp drops below 37.5^{o}C

Recovery:

- Continue IV fluids at maintenance
- Calm environment, away from dogs, etc.
- If stressed on recovery, consider medetomidine 1 – 2 mcg/kg IV (or dexmedetomidine 0.5 – 1 mcg/kg IV)
- Continue active warming if hypothermic
- Analgesia: continue methadone or switch to buprenorphine (depending on procedure and type of local anaesthetic used), commence NSAID, plan rescue if needed (e.g. tramadol, gabapentin)

Case Example 2: Echo

- 12-year-old toy poodle MN dog requires general anaesthesia for toe amputation due to a painful mass on one digit.
- Heart murmur was identified 12 months ago. Echo had a specialist echocardiograph performed at that time and was diagnosed with MVDD stage B2. His LA/Ao ratio was 2.1. Thoracic radiographs were normal. Echo commenced Pimobendan therapy at that time.
- Owners report he has been well with normal energy levels, just mild lameness due to mass affecting use of his hind foot.

Physical examination:

- Body condition score 6/9 (weight = 12kg)
- Bright, very anxious
- HR 140
- RR 24 (*at rest in cage*)
- Thoracic auscultation: regular cardiac rhythm, grade 4/6 systolic murmur with PMI at left apex, normal lung sounds
- Oral mms: pink, moist, crt <2s.
- Normal femoral pulse rate and quality
- Normal abdominal palpation
- Rectal temp 38.9^{o}C

What next?

A. Proceed with general anaesthesia immediately
B. Run basic bloodwork (e.g. PCV/TP, creatinine), proceed with general anaesthesia if normal
C. Run bloodwork. Recommend repeat specialist echo to reassess cardiac function prior to anaesthesia
D. Run bloodwork. Repeat thoracic radiographs, ECG, and specialist echo. proceed if normal
E. Cancel the procedure. Advise too risky to perform GA on this dog for an elective procedure.

Diagnostics:

Bloodwork = unremarkable

Repeat echo = La/Lo ratio now 1.7. Normal systolic function. Some evidence of pulmonary hypertension.

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Volume overload	Dilated Cardiomyopathy	Ventricular arrhythmias common → Avoid increasing HR, treat arrhythmias Adequate HR important for CO in face of low SV → Avoid bradycardia	Fixed reduction due to poor contractility of dilated chambers	May be excessive already (volume overload) → Maintain normovolaemia, but care to avoid overload	Poor = > avoid further reductions → Care with drugs that have negative inotropic effect (most anaesthetic/sedative agents!)	Avoid significant changes: High SVR increases myocardial oxygen demand, Low SVR reduces CO and BP.	
	Mitral Valve Degenerative Disease	Adequate HR important for CO in face of low SV → Avoid bradycardia	Fixed reduction due to regurgitant fraction	May be excessive already (volume overload) → Maintain normovolaemia, but care to avoid overload	Increase may be of benefit, if shown to be reduced	Reduced SVR may favour forward flow, BUT avoid excessive vasodilation which may cause hypotension	May be elevated → avoid further increases
Diastolic dysfunction	Hypertrophic Cardiomyopathy	Increased HR will worsen LV obstruction. Ventricular arrhythmias may be present → Avoid increasing HR, treat arrhythmias	Fixed reduction due to restricted LV outflow	Important to maintain → Maintain normovolaemia, but care to avoid overload	Increased contractility will worsen LV obstruction. → Avoid increasing (unless reduced contractility is present)	Avoid significant changes: High SVR increases myocardial oxygen demand, Low SVR reduces CO and BP.	
	Pericardial effusion	Cardiac output largely HR dependent → Maintain, treat arrhythmias	Reduced due to cardiac tamponade	Important to maintain → Avoid excessive ventilation pressures, maintain normovolaemia	Avoid further reductions → Care with drugs that have negative inotropic effect (most anaesthetic/sedative agents!)	Maintain in order to maintain blood pressure	
Pressure overload	Aortic stenosis, pulmonic stenosis	Cardiac output largely HR dependent → Maintain, treat arrhythmias	Fixed reduction due to reduced ventricular outflow	Important to maintain → Maintain normovolaemia, but care to avoid overload, avoid excessive ventilation pressures	May need to support (with positive inotrope drugs) in advanced cases	Maintain to avoid worsening pressure gradient. But afterload relatively fixed.	Avoid further increases (PS)
Congenital shunts	Patent ductus arteriosus, ventricular septal defects, etc.	Cardiac output largely HR dependent → Maintain, treat arrhythmias	Reduced due to loss of shunt volume	May be excessive already (volume overload) → Maintain normovolaemia, but care to avoid overload	Maintain → Care with drugs that have negative inotropic effect (most anaesthetic/sedative agents!)	Must maintain SVP > PVR or shunt may reverse	Avoid further increases

Type of dysfunction	Disease (s)	Heart Rate	Stroke Volume	Preload	Contractility	Systemic Vascular Resistance	Pulmonary Vascular Resistance
Volume overload	Dilated Cardiomyopathy	Ventricular arrhythmias common → Avoid increasing HR, treat arrhythmias Adequate HR important for CO in face of low SV → Avoid bradycardia	Fixed reduction due to poor contractility of dilated chambers	May be excessive already (volume overload) → Maintain normovolaemia, but care to avoid overload	Poor = > avoid further reductions → Care with drugs that have negative inotropic effect (most anaesthetic/sedative agents!)	Avoid significant changes: High SVR increases myocardial oxygen demand, Low SVR reduces CO and BP.	
	Mitral Valve Degenerative Disease	Adequate HR important for CO in face of low SV → Avoid bradycardia	Fixed reduction due to regurgitant fraction	May be excessive already (volume overload) → Maintain normovolaemia, but care to avoid overload	Increase may be of benefit, if shown to be reduced	Reduced SVR may favour forward flow, BUT avoid excessive vasodilation which may cause hypotension	May be elevated → avoid further increases
Diastolic dysfunction	Hypertrophic Cardiomyopathy	Increased HR will worsen LV obstruction. Ventricular arrhythmias may be present → Avoid increasi treat arrhythmias	Fixed reduction due to restricted LV outflow	Important to maintain → Maintain normovolaemia, but care to avoid overload	Increased contractility will worsen LV obstruction. → Avoid increasing (unless uced contractility is sent)	Avoid significant changes: High SVR increases myocardial oxygen demand, Low SVR reduces CO and BP.	
	Pericardial effusion	Cardiac output la dependent → Maintain, trea arrhythmias			oid further reductions Care with drugs that have gative inotropic effect (most aesthetic/sedative agents!)	Maintain in order to maintain blood pressure	
Pressure overload	Aortic stenosis, pulmonic stenosis	Cardiac output largely HR dependent → Maintain, treat arrhythmias	Fixed reduction due to reduced ventricular outflow	Important to maintain → Maintain normovolaemia, but care to avoid overload, avoid excessive ventilation pressures	May need to support (with positive inotrope drugs) in advanced cases	Maintain to avoid worsening pressure gradient. But afterload relatively fixed.	Avoid further increases (PS)
Congenital shunts	Patent ductus arteriosus, ventricular septal defects, etc.	Cardiac output largely HR dependent → Maintain, treat arrhythmias	Reduced due to loss of shunt volume	May be excessive already (volume overload) → Maintain normovolaemia, but care to avoid overload	Maintain → Care with drugs that have negative inotropic effect (most anaesthetic/sedative agents!)	Must maintain SVP > PVR or shunt may reverse	Avoid further increases

Avoid ⇣ HR
Maintain normovolaemia
Avoid vasoconstriction
Mild vasodilation may be of benefit
Avoid ⇡ PVR (stress, pain, hypoventilation)

What would you choose for premedication?

A. Opioid only IM

B. Opioid + acepromazine IM

C. Opioid + medetomidine (or dexmedetomidine) IM

D. Opioid + alfaxalone IM

E. No premedication for this case

My *preferred* choice for George:

Methadone 0.3 mg/kg + Acepromazine 0.02mg/kg IM

Induction

1. Place IVC once adequate sedated
2. Pre-oxygenate via mask for ~ 5 minutes
3. Alfaxalone slowly IV "*to effect*" + lignocaine 2mg/kg IV (attenuates cough and ANS response to intubation)
   - Give 0.5 mg/kg alfaxalone, then the lignocaine, then continue alfaxalone until adequate depth for intubation.
4. Intubate, and inflate cuff, as gently as possible.
5. Check pulse/heart rate again
6. Immediate provision of oxygen via anaesthetic breathing system, with manual ventilation if needed.
7. Attach all monitoring

Maintenance of anaesthesia:

- Isoflurane in oxygen
- Monitoring: capnography, pulse oximetry, NIBP, ECG, temperature
- Digit nerve block using either:
  - Lignocaine, max. dose 8mg/kg
  - Bupivacaine, max. dose 2mg/kg
- Repeat methadone, or fentanyl infusion if further analgesia required
- Hartmann's 5mL/kg/hr
- Active warming with forced air warmer once temp drops below 37.5^{o}C

Recovery:

- Continue IV fluids at maintenance
- Calm environment, away from loud dogs, etc.
- Continue active warming if hypothermic
- Analgesia: continue methadone or switch to buprenorphine, commence NSAID, plan rescue if needed (e.g. tramadol, gabapentin)

10 Steps for Success

1. Careful physical examination +/- echo +/- thoracic radiographs prior to day of procedure
2. Re-schedule and stabilize cardiac disease if necessary
3. Understand how different types of cardiac disease impact anaesthetic aims
4. Low stress while awake (handling techniques, environment, premedication, recovery sedation, good analgesia)
5. Pre-oxygenate
6. Avoid sympathetic response to intubation
7. Always intubate and provide oxygen +/- positive pressure ventilation
8. Give preference to drugs with minimal effects on HR and SVR
9. Provide adequate, but careful, fluid therapy
10. Monitor HR (CONTINUOUSLY!), RR (CONTINUOUSLY!), $ETCO_2$, BP and Sp02. Plus ideally ECG.