Hi! My name is Leah Contreras and I currently work as an anesthesia technician in Boston.

My hometown is Santa Monica, CA and I've been in the field since graduating high school. My first veterinary job was at SNP LA, and after a few years, I decided to make the jump to specialty medicine. I started at ASEC as a radiology assistant and shortly after joined the surgical team, where I stayed for 5 years.

Monitoring anesthesia and helping out in critical care is where I began to thrive, as well as unlocked my love of teaching. Excited to learn more, I expanded my horizons by joining the anesthesia department at Oregon State University, where I was responsible for teaching students during their small and large animal anesthesia rotations. Eventually, I made my way to Angell's anesthesia department, where my current job consists of helping to train new and current staff by elevating their knowledge, implementing training programs in anesthesia for different specialties, managing anesthetic cases, and creating anesthetic protocols.

My professional interests are critical case management of any species, local/regional blocks, cardiac and open chest anesthesia. I have two pets; a Siberian Forest Cat name Obi, and a squishy Rottweiler named Drago.

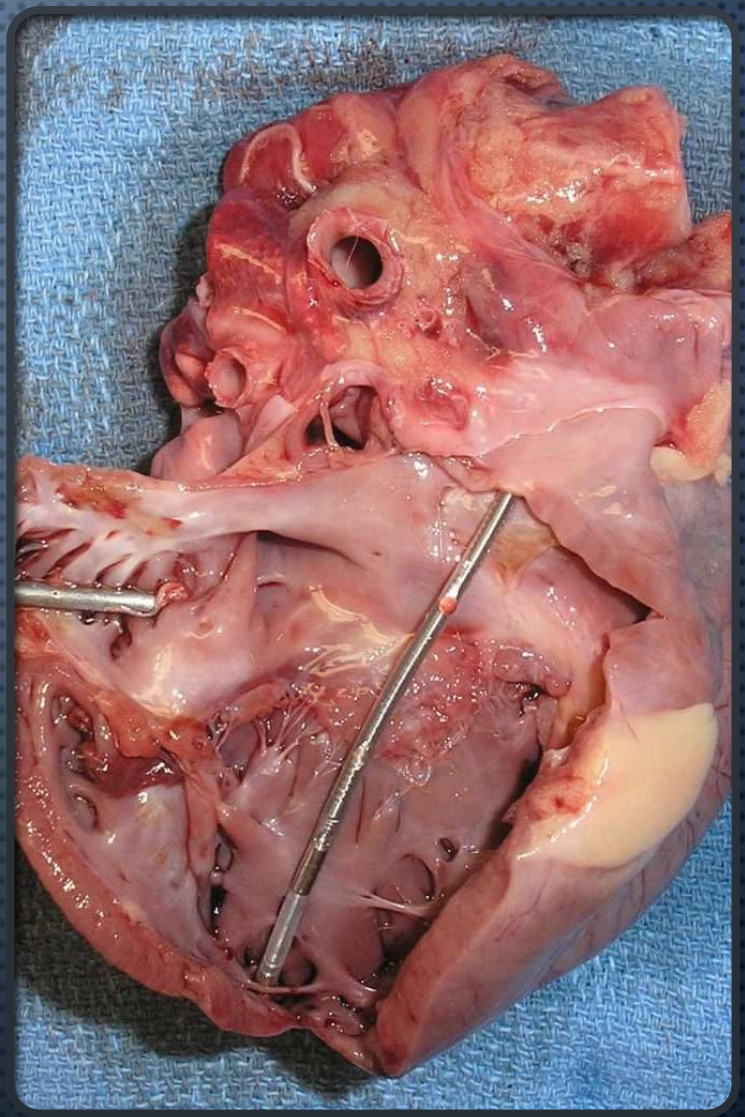
FOR THE FAINT OF HEART! CARDIAC COMORBIDITIES UNDER ANESTHESIA

LEAH CONTRERAS, CVT, RVT

MSPCA-ANGELL

ANESTHESIA TECHNICIAN

ASEC SYMPOSIUM 2024

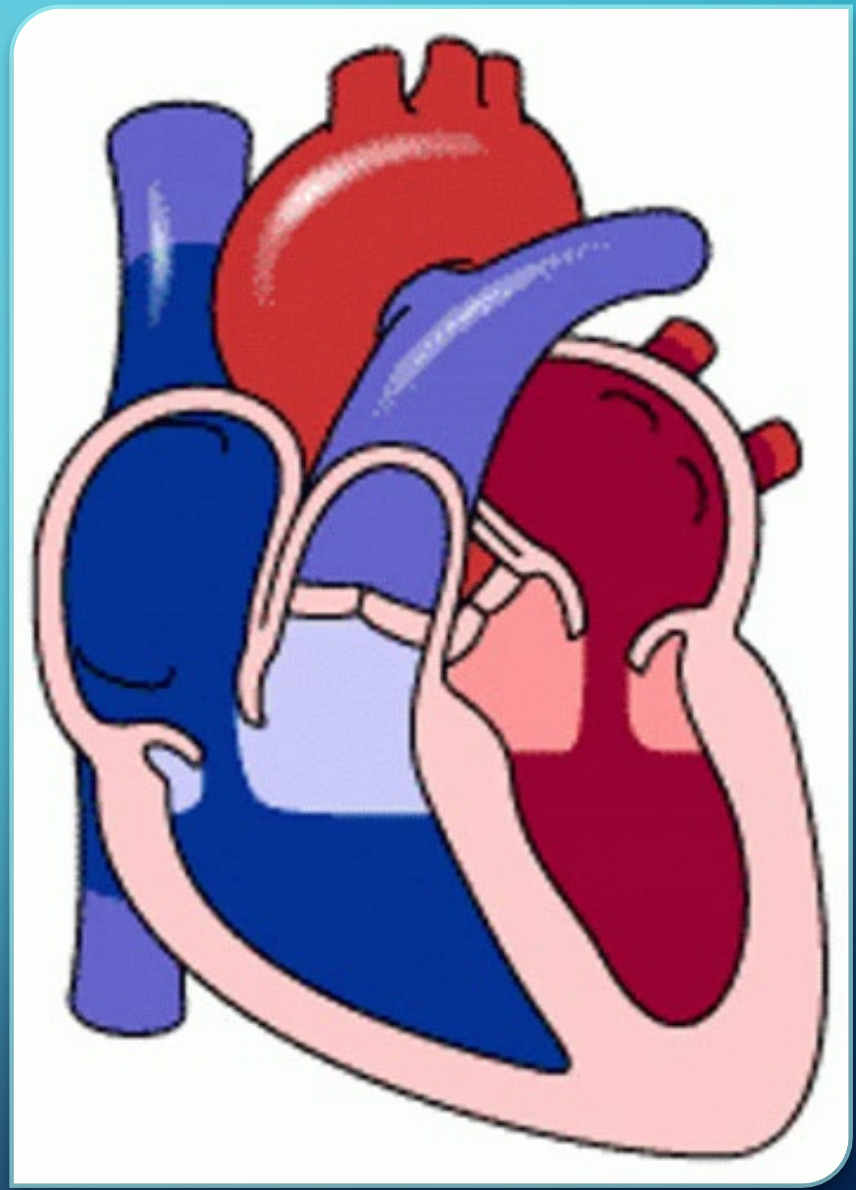


PRESENTATION OBJECTIVES

- Review of cardiac anatomy and physiology to understand pathophysiology (diseases of the heart)
- Mechanical vs Electrical systems
- Common ways to diagnose cardiac disease
- ***Anesthetic risk of cardiac patients***
- Relationship between inhalants, drug, & fluid therapy & cardiac disease

FUNCTION OF HEART

- Pump Blood
- Supply Oxygen
- Remove Metabolic Waste



NORMAL BLOOD FLOW

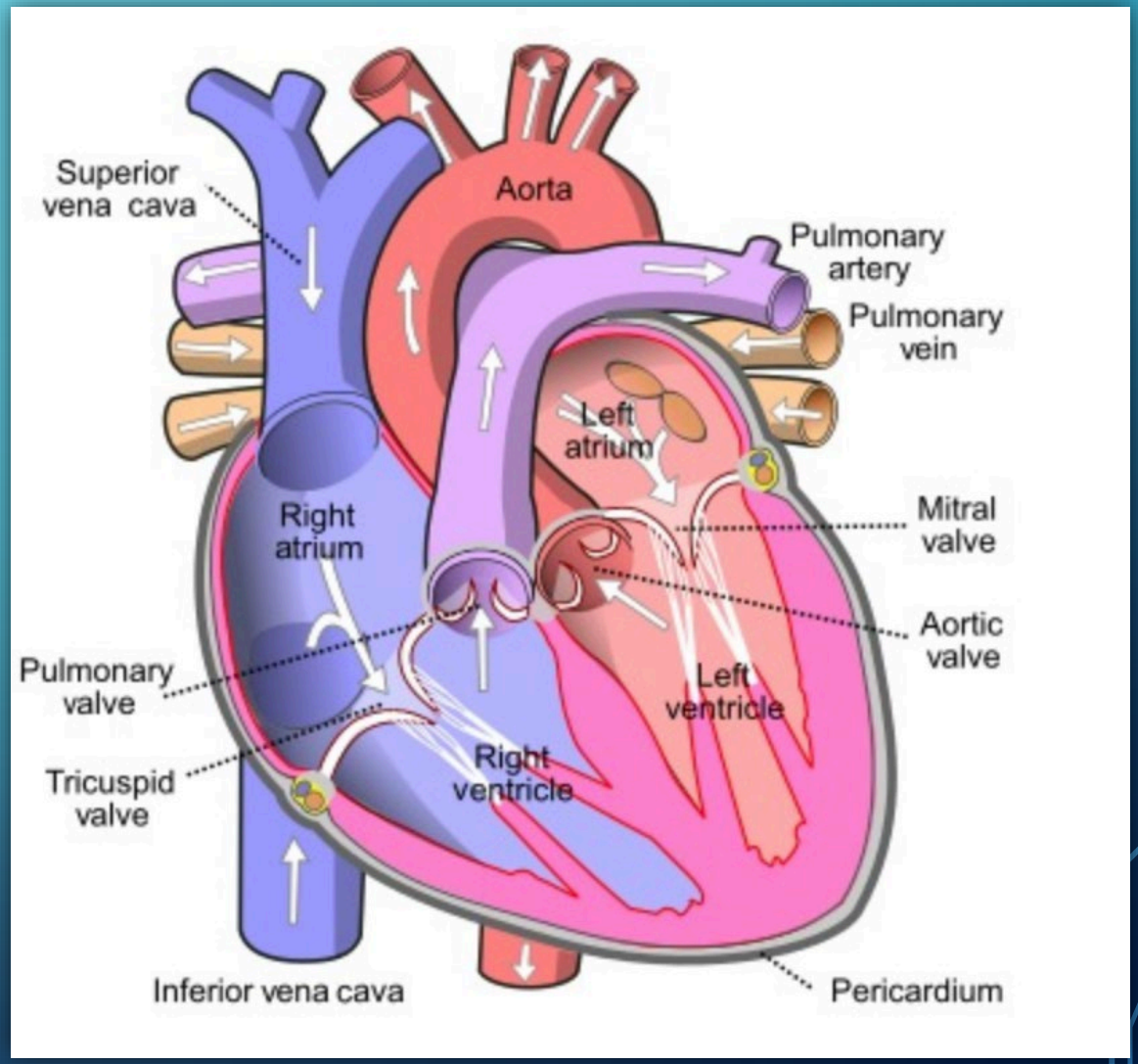
Chambers (Atrium & Ventricles)

One-way doors (Valves)

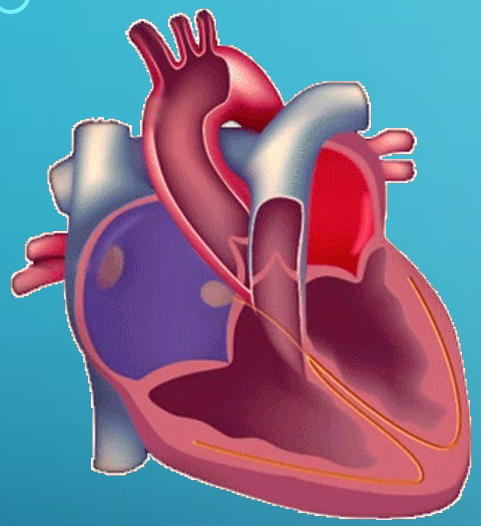
Greater Vessels (Vena Cava & Aorta)

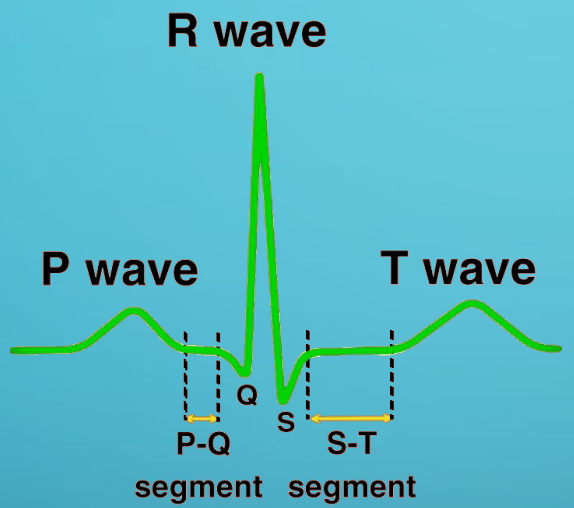
<u>Function dependent on:</u>

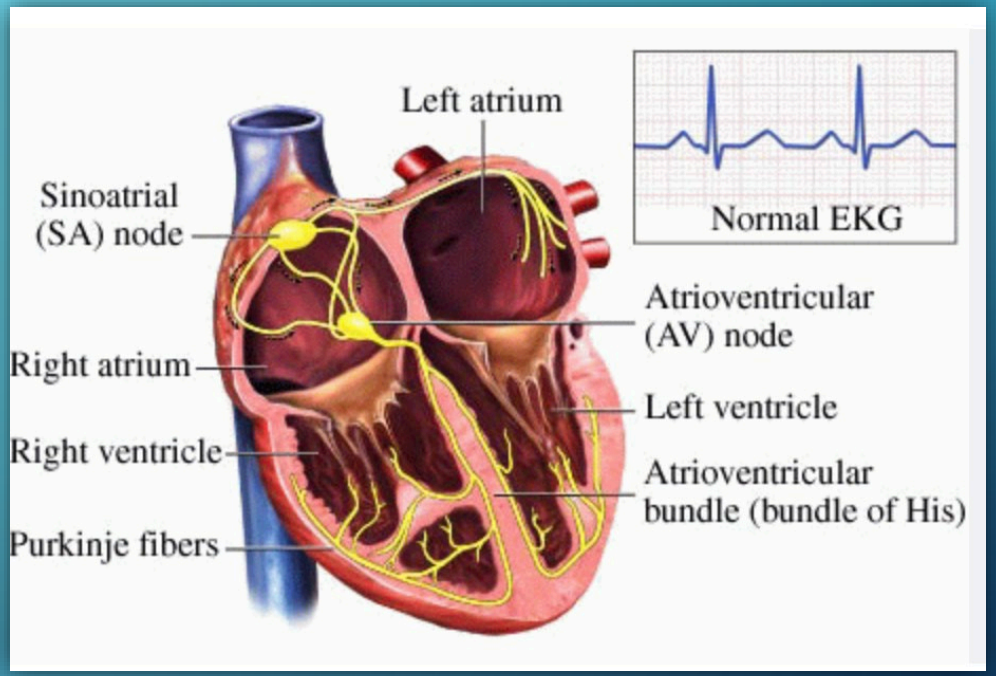
1. Volume
2. Pressure systems
3. Conduction systems
4. Electrolytes
5. Oxygen demand
6. Neurohormonal responses



CONDUCTION SYSTEM "ELECTRICAL"

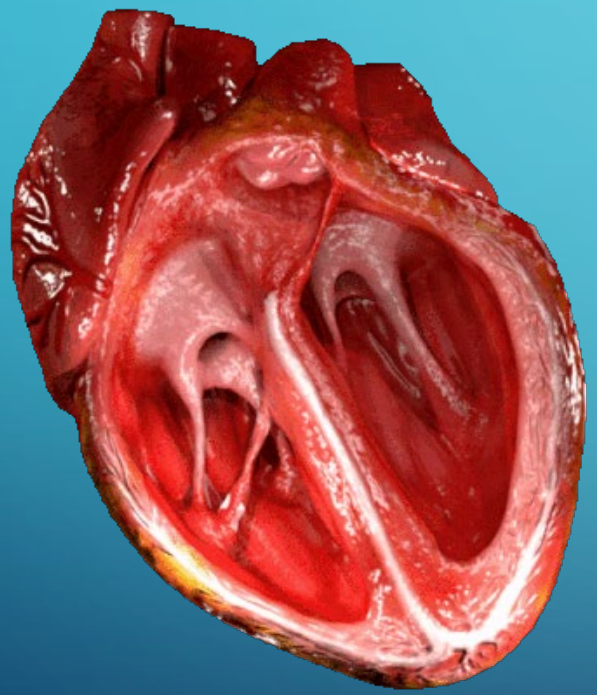


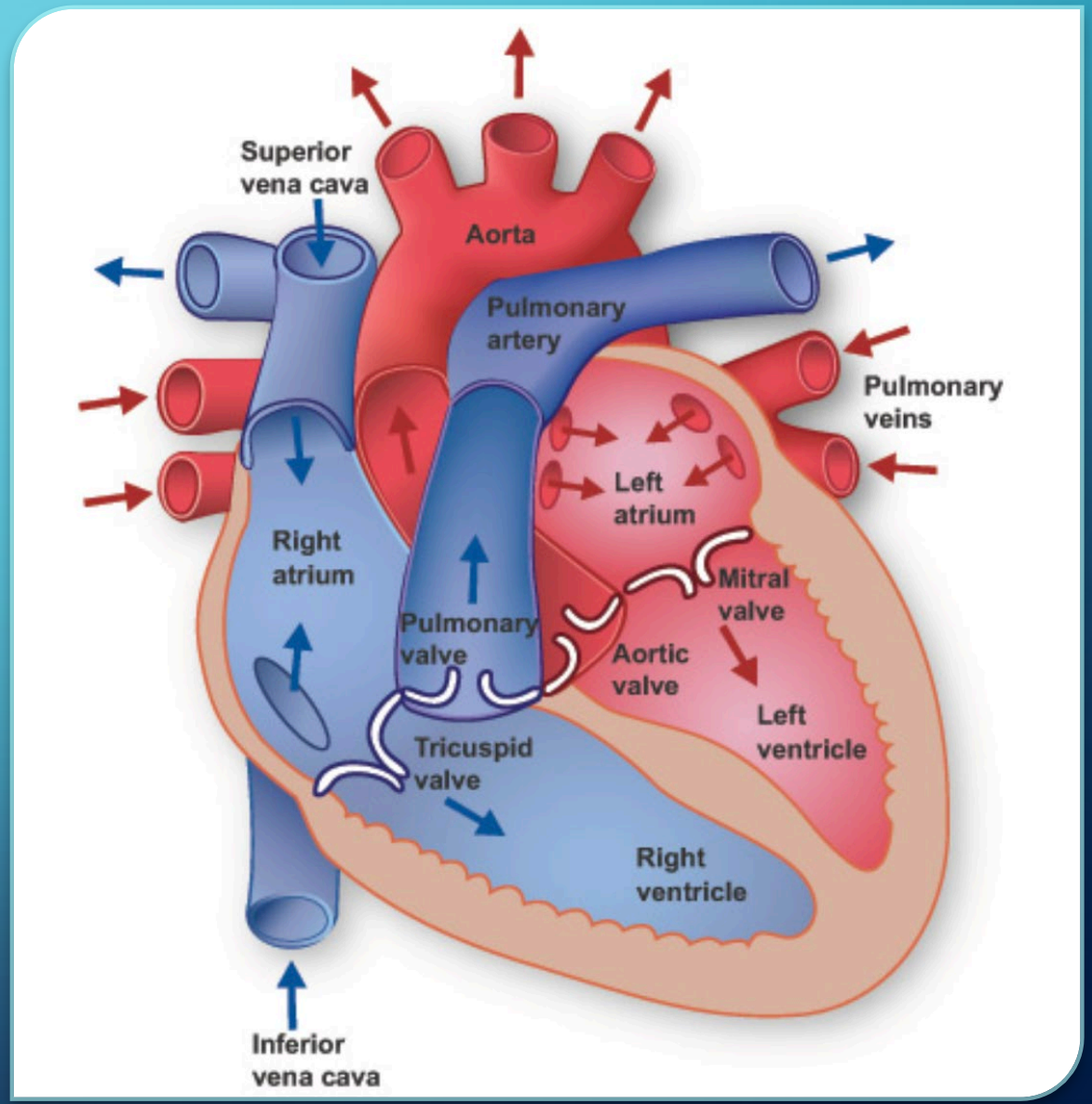




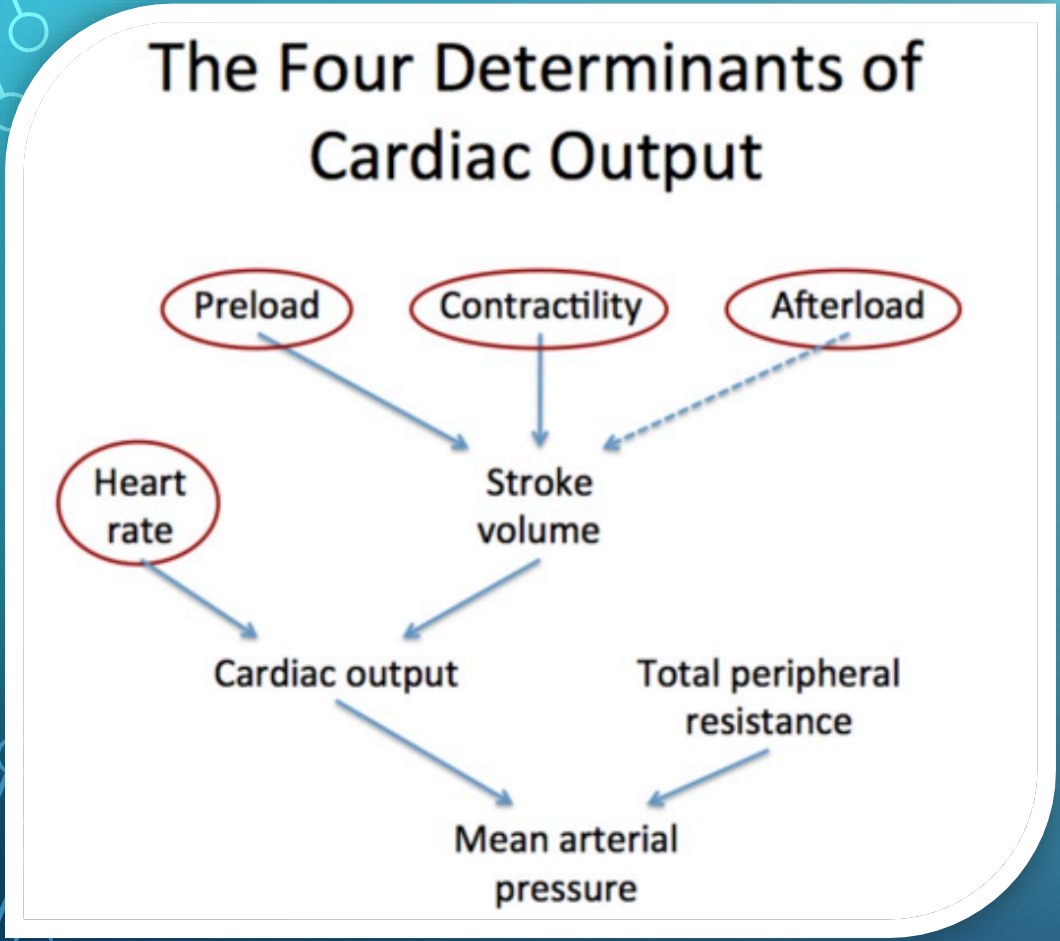
Reliant on coordinated conductions to make sure blood can enter and leave the heart effectively

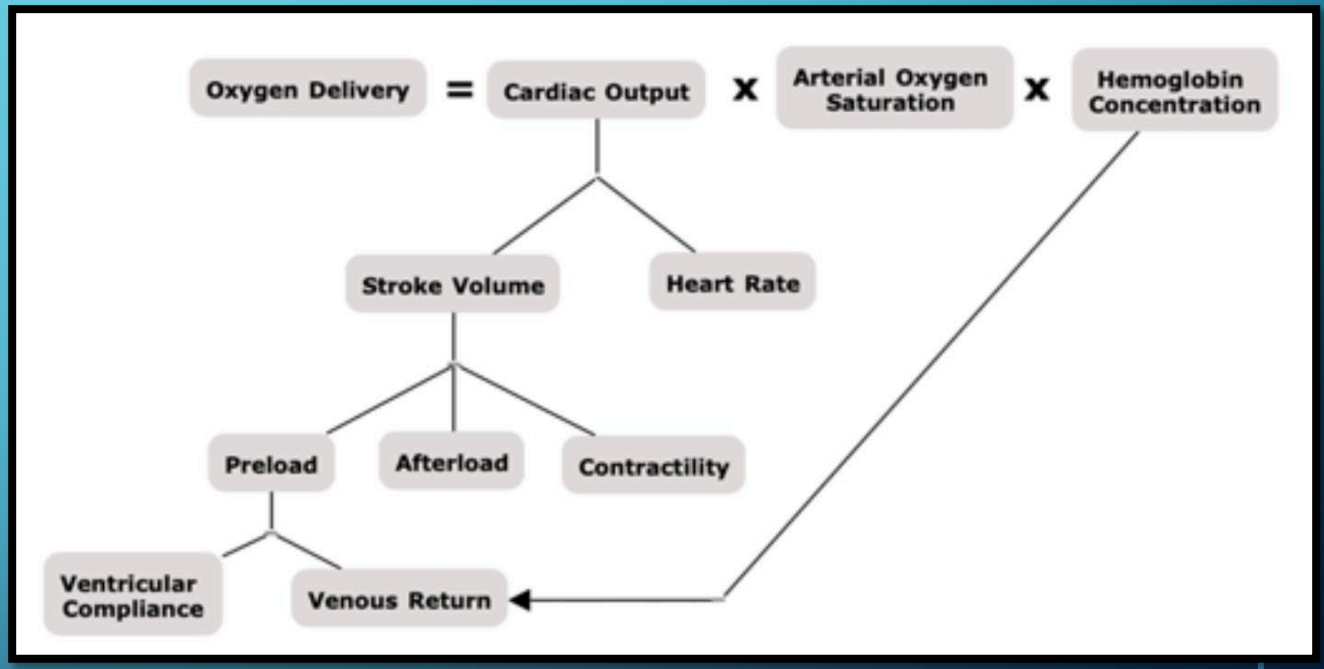
MECHANICAL PATHWAY "PLUMBING"





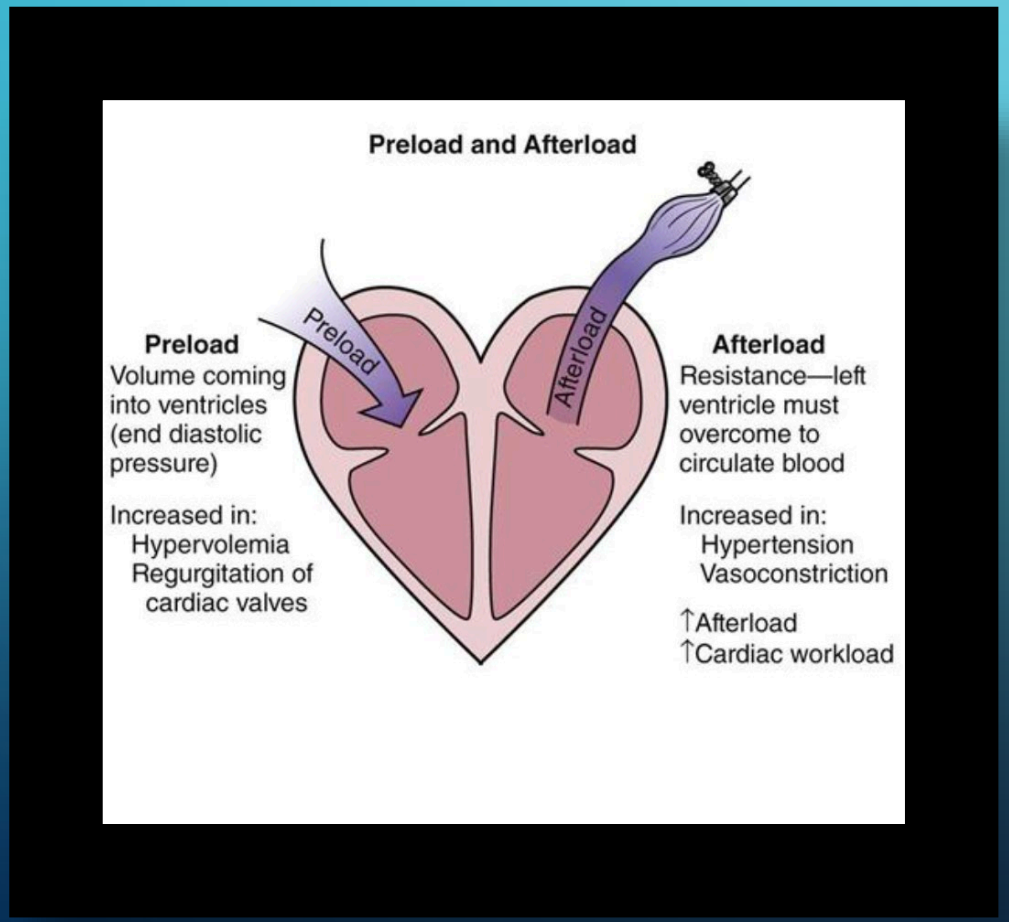
CIRCULATORY SYSTEM: DELIVERY OF O2

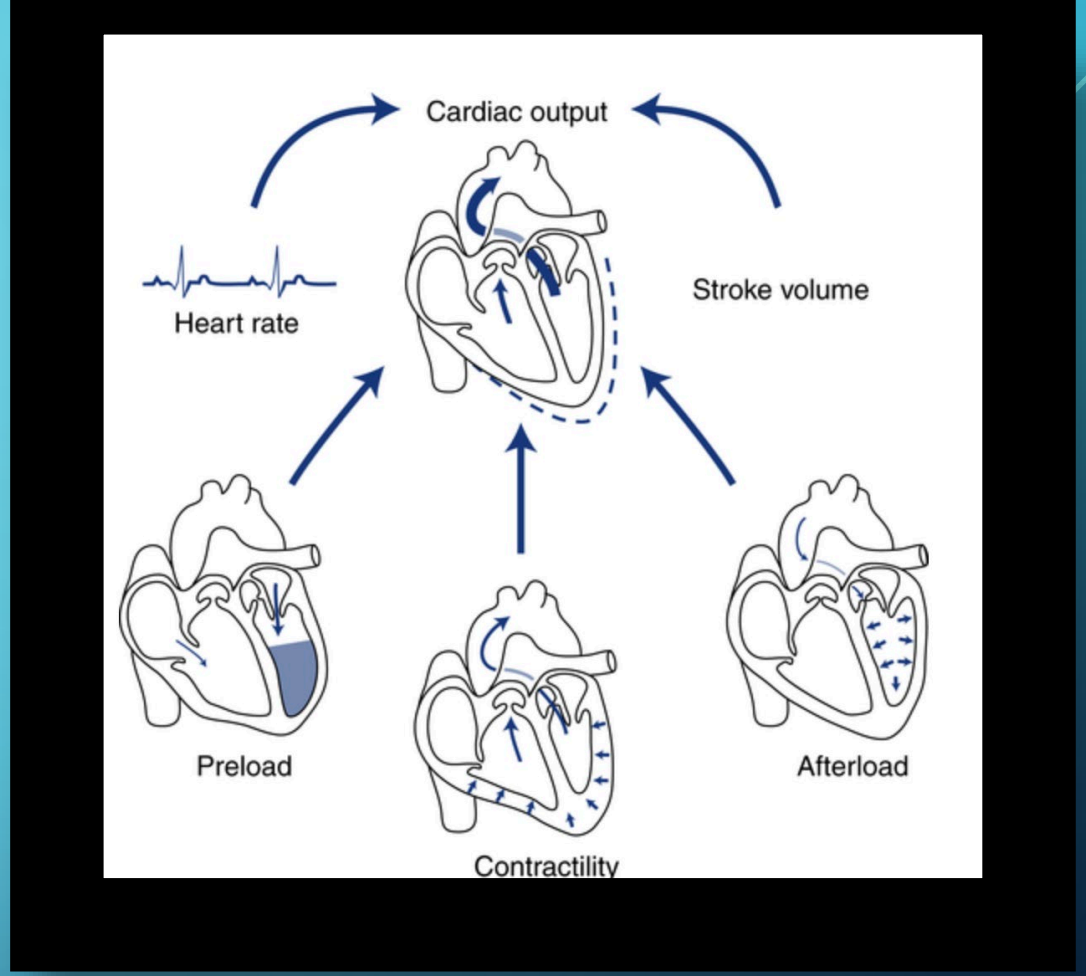




<u>CARDIAC OUTPUT:</u>

THE AMOUNT OF BLOOD THE HEART PUMPS THROUGH CIRCULATORY SYSTEM PER MINUTE





<u>Contractility:</u>

Ability of the heart to contract (pump blood)

DIAGNOSING CARDIAC DISEASE

PHYSICAL EXAM

Audible murmurs

Palpable thrill

Asynchronous pulses

History:

Exercise intolerance

Heart Rate

Respiratory Rate

Activity level

ELECTROCARDIOGRAPHY (ECG)

ECG is produced by recording the electrically synchronized depolarization and repolarization of the atria and ventricles.

Depolarization:

Na & Ca move through cell membrane from outside----inside of cell, which K moves from inside-----outside

- Essential for **contraction**

Repolarization:

Na, Ca & K all move back to OG locations; Na& Ca----back to outside, K----back to inside

- Essential for **relaxation**

THORACIC RADIOGRAPHY

Cardiac silhouette

Is anything abnormally sized; chambers?

Pulmonary Vasculature

- Evidence of congestion/overload/distention
- Pulmonary Edema
- Pulmonary Effusion

Greater Vessel Evaluation

-Aorta, Vena Cava, Pulmonary Artery

THORACIC RADIOGRAPHY W/ ECHOCARDIOGRAPHY

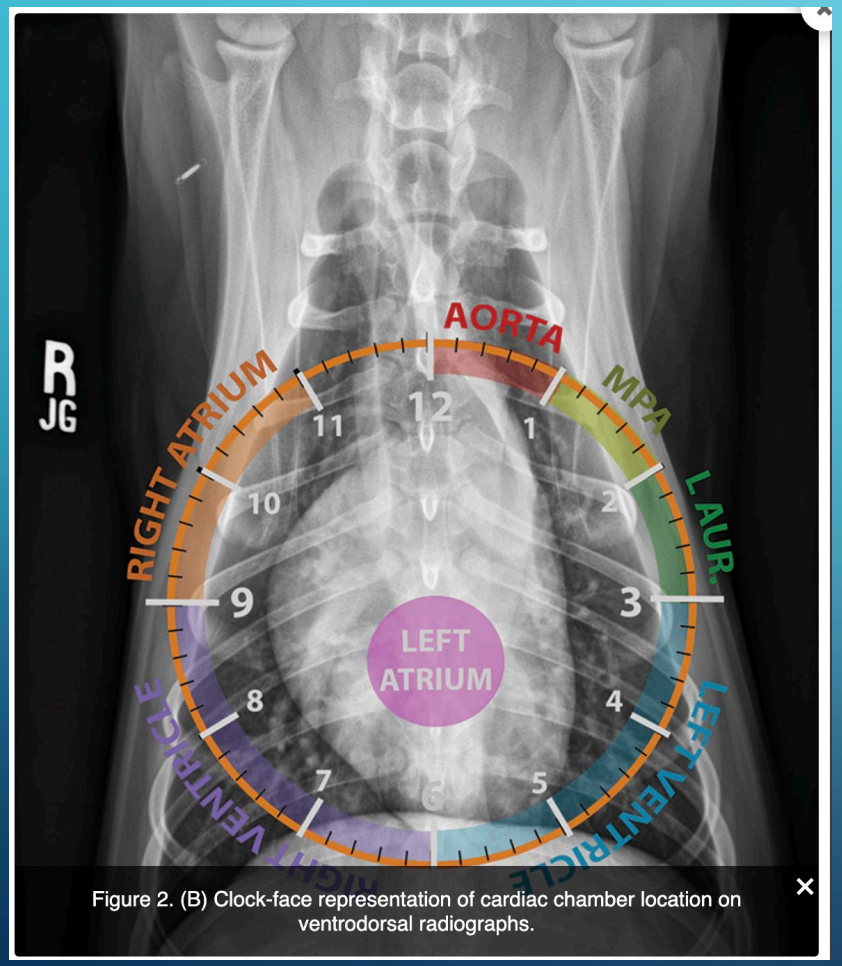
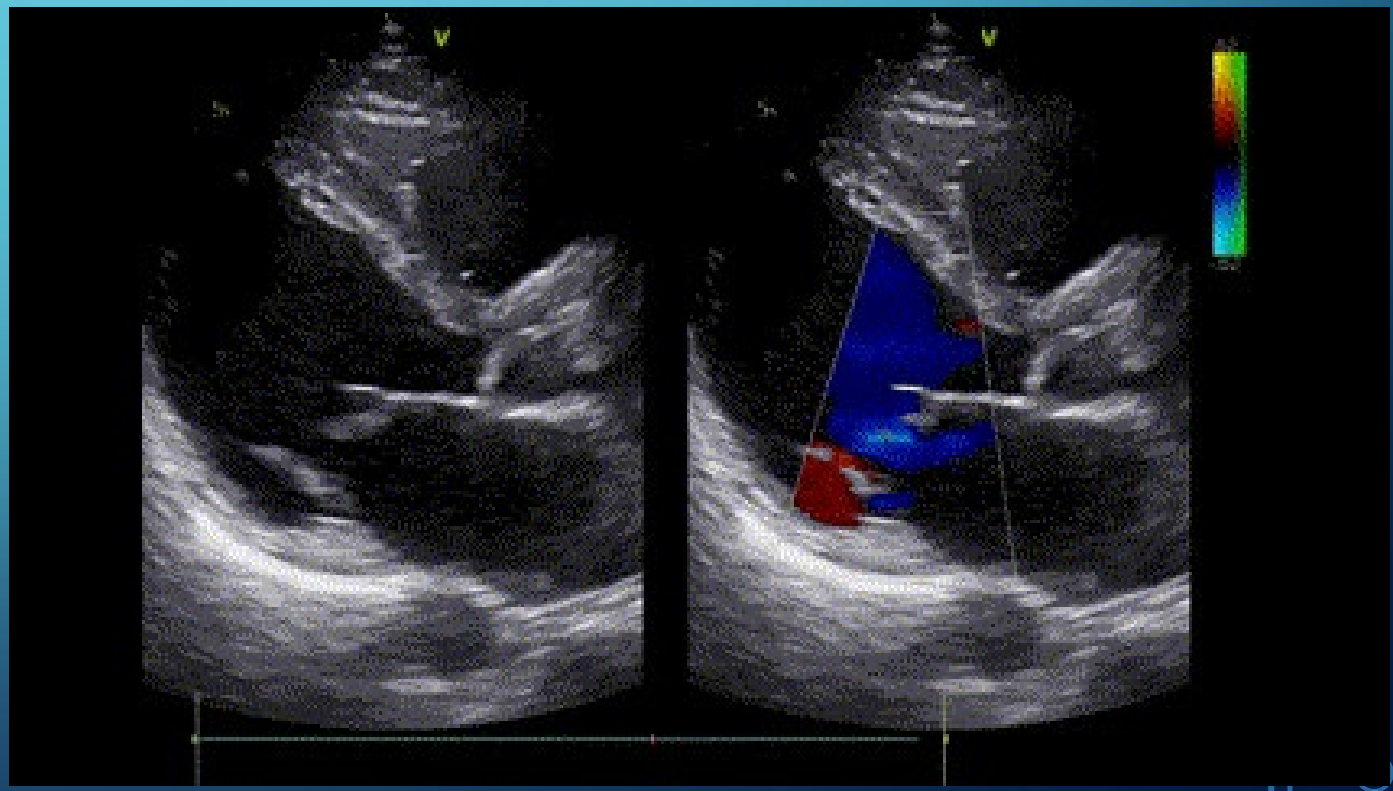


Figure 2. (B) Clock-face representation of cardiac chamber location on ventrodorsal radiographs.

NOT ALL HEART DISEASE IS EQUAL!



ANESTHETIC RISK & CARDIAC DISEASE

Inhalants & injectable anesthetics can:

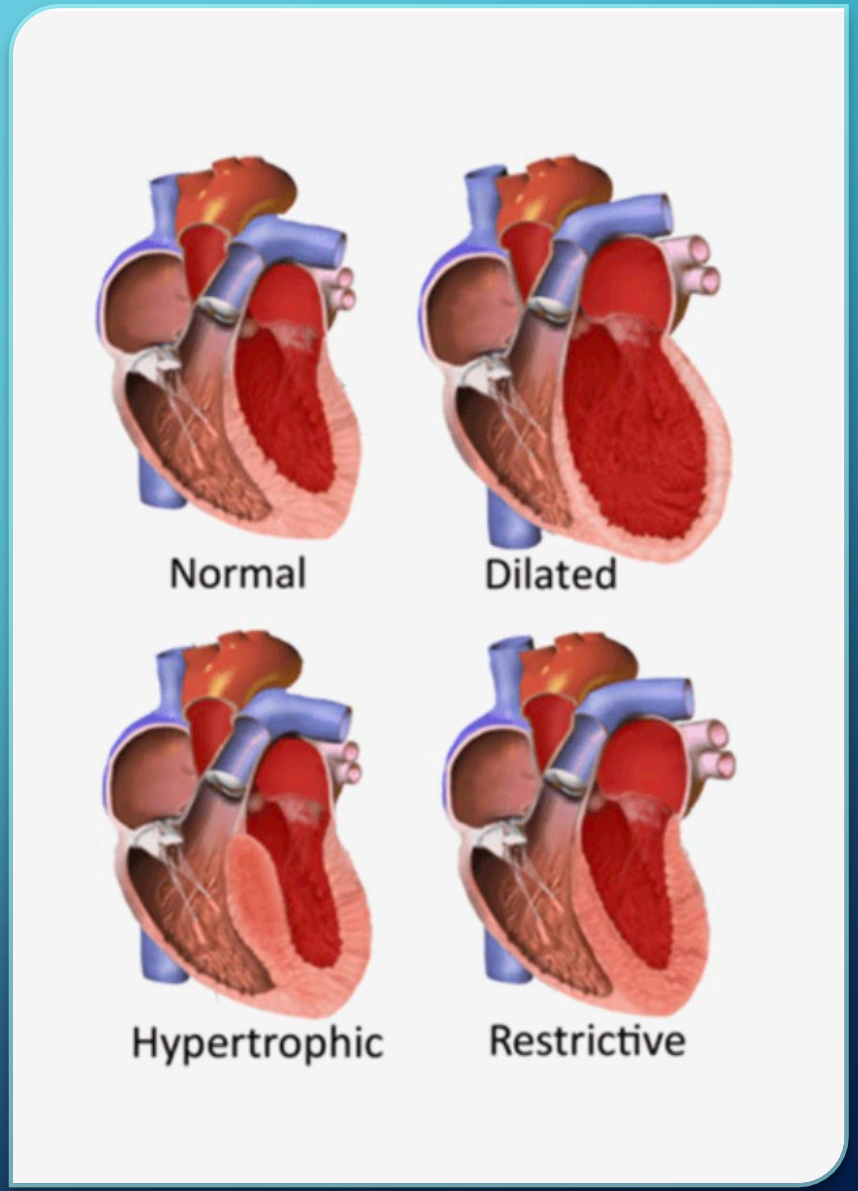
- Increase parasympathetic tone
  - Bradycardia
- Sensitize the myocardium to catecholamines
  - Arrhythmias
- Direct myocardial depression
  - Decrease cardiac output (CO)
- Potent vasodilator
  - Affect vessel tone (Systemic vascular resistance)
- Excessive doses depress central nervous system
  - Block normal compensatory responses at deep planes
- Depress ion channels necessary for contraction at different MAC concentrations
  - Block Ca, Na, Cl channels

These effects are all dose dependent and drug specific!

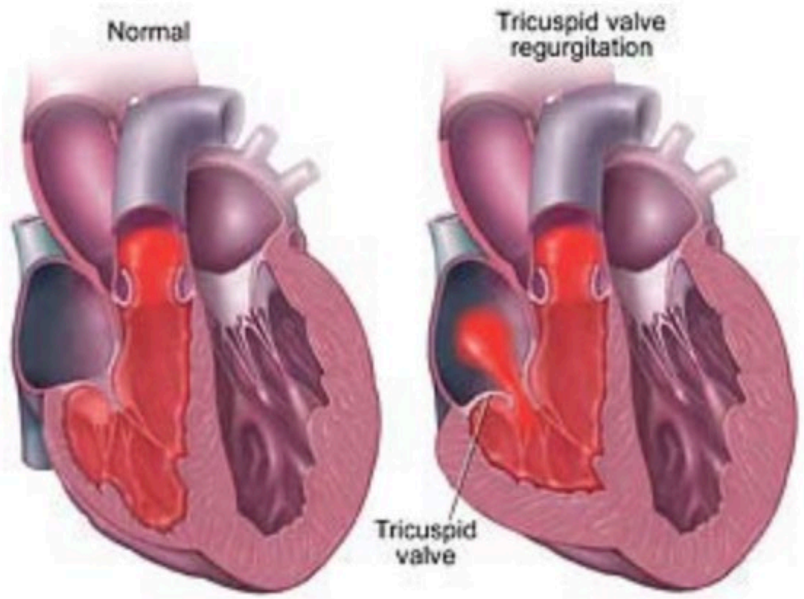
ANESTHETIC GOALS:

- Regardless of type of disease:
- **Preserve** compensatory mechanisms
  - Understand what the heart has done to itself to keep pumping
- **Maintain** their level of "normal"
- **No sudden changes** during anesthesia
  - Ex: If they usually run at a higher HR or higher BP, try to keep them at those values during anesthesia

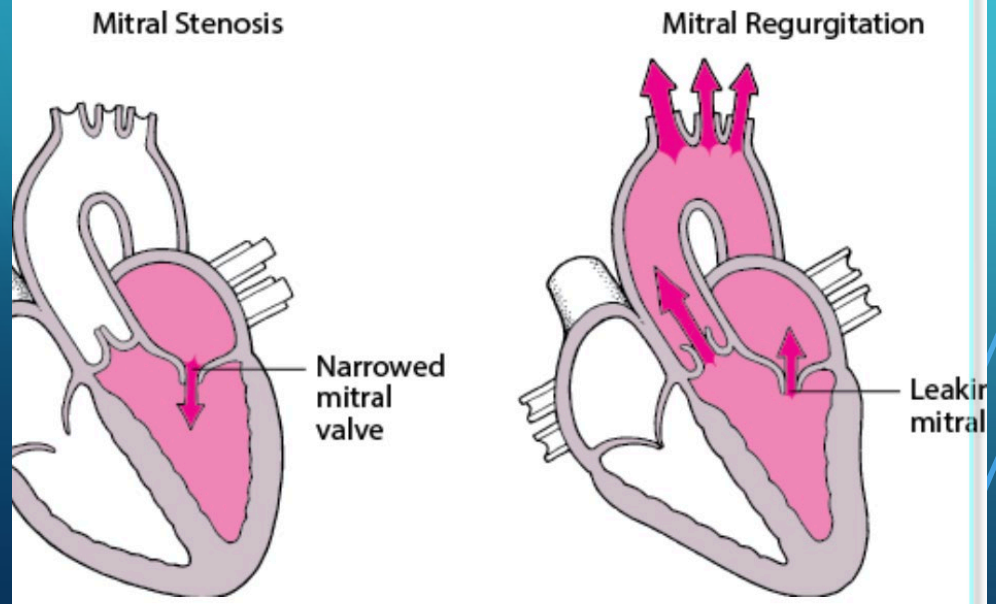
Preoxygenation is highly recommended for all cardiac patients, take the extra minute.



VALVULAR DISEASE



Tricuspid Regurgitation



Mitral (Left sided): Most common

Consequences:

- Volume overload of the left atrium---left ventricle
  - Eccentric hypertrophy + Annular dilation
- Backup to the lungs= Pulmonary edema
- Radiographs: **Heart size very indicative**

Tricuspid (Right sided): Less common/concurrent

Consequences:

- Volume overload of right atrium---right ventricle
- Back up to the body= Ascites

MITRAL DISEASE

Volume overload--→ pressure problem

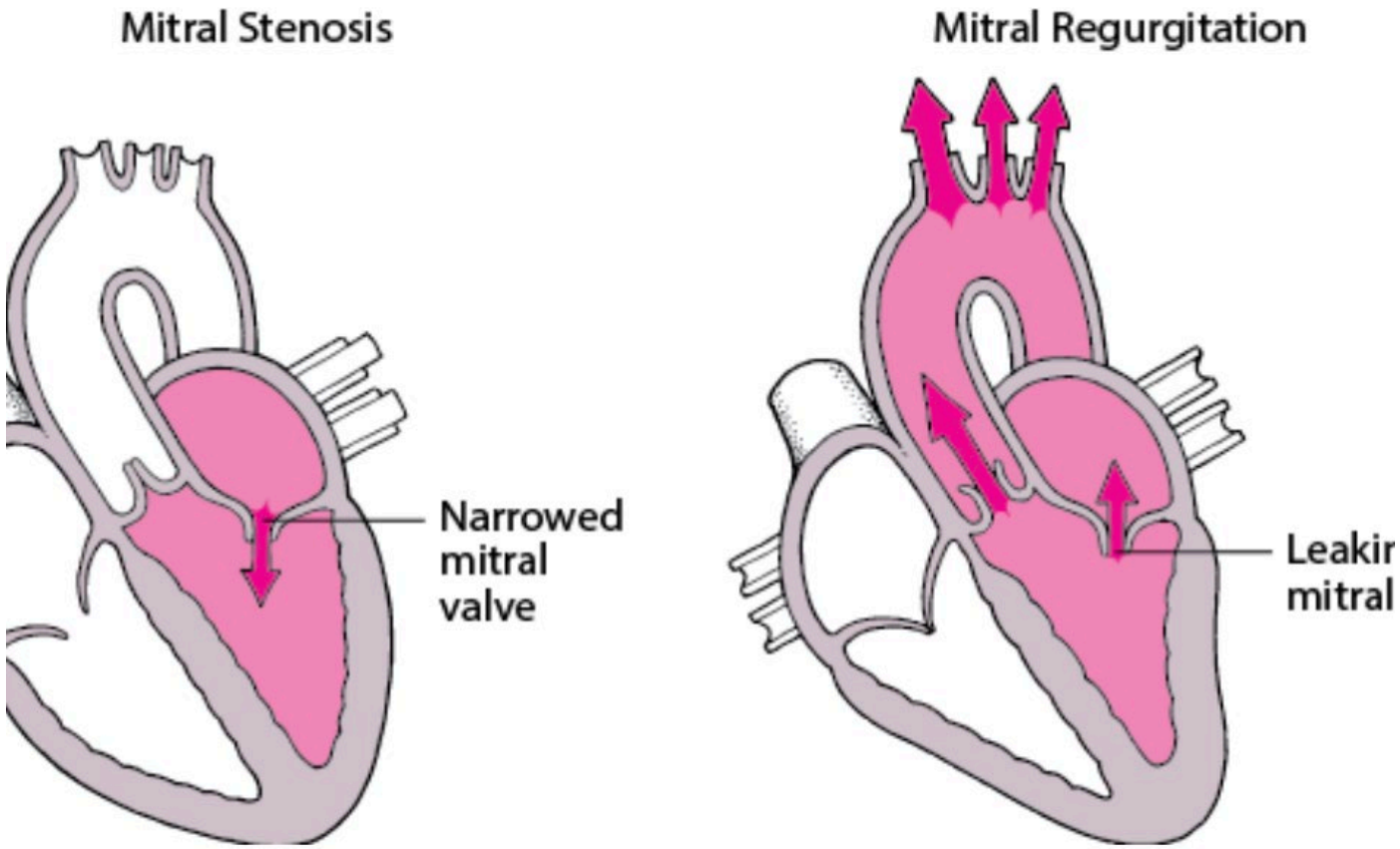
Regurgitant can be 50-70% of SV

Low pressure-high compliance system starts to turn into --→ high pressure, low compliance

Mismatch in <u>afterload</u>

Increasing myocardial work--oxygen demand

Compliance: Ability of a chamber or vessel to stretch, fill, distend



Afterload: Resistance ventricles must overcome to pump blood

ANESTHETIC CONSIDERATIONS- MITRAL

Goals:

Promote forward flow

- HR: normal to elevated
  - Small ventricular volume, minimize regurgitation

Decrease afterload

- Don't give the heart more work!
- Minimize stress

Maintain preload

- -If plumbing is failing, you don't turn up the faucet---flooding gets worse.
- Fluid therapy must be "targeted"

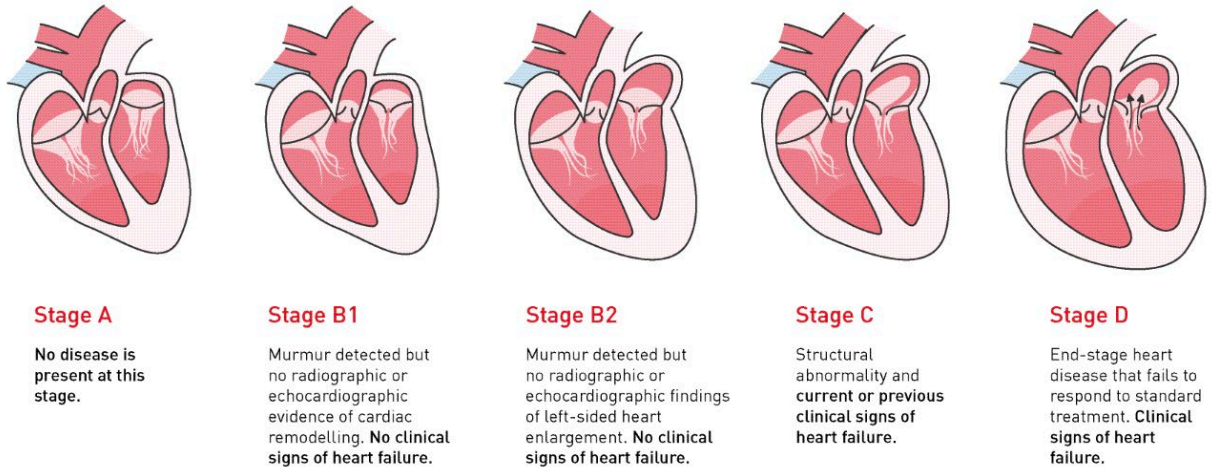


FIGURE (1) The progression stages of MMVD

MITRAL VALVE DISEASE-ANESTHETIC DRUGS

Premedication (IM/IV)

Opioids: lack myocardial depression

- Bradycardia → anticholinergics
  - Not only increase HR---CO
  - Use when bradycardia affecting BP

Poor sedative unless ill/depressed

DOSE DEPENDENT-higher for IM

Sedatives: Must minimize stress

Benzodiazepine: Poor sedative in animals not neonatal, geriatric or critical

- Paradoxical Excitement

Alfaxalone: Sedative effects >1 mg/kg in combination

- Minimal cardiovascular effects

DOSE DEPENDENT-higher for IM

SEDATIVES FOR MITRAL VALVE DISEASE

DEXMEDETOMIDINE: RED

Increases afterload (GOAL: decrease)

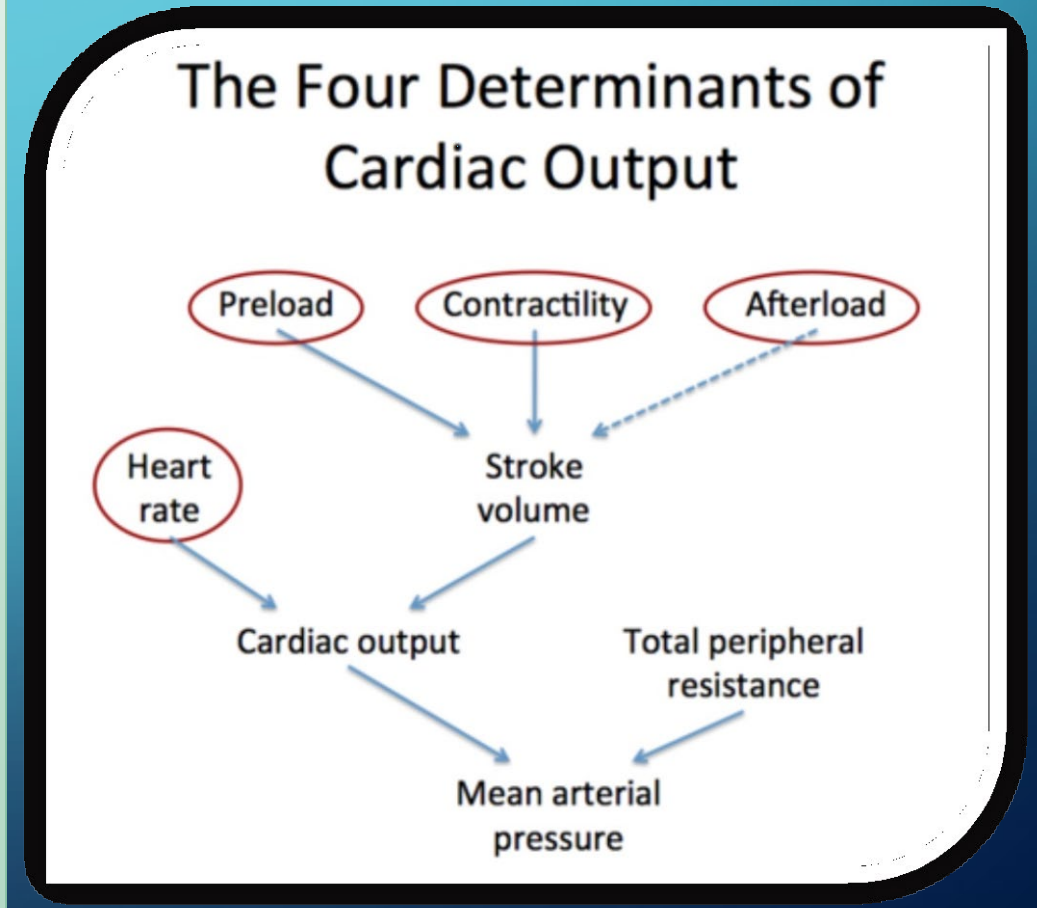
Reflex bradycardia from peripheral vasoconstriction (GOAL: elevated to normal HR)

- Heart slows down because of resistance
- Slower heart rate allows the ventricles more time to fill
  - Can increase regurgitant flow
  - (GOAL: decrease ventricular filling time)

REVERSIBLE, dose dependent effects

Dose: 1-5 ug/kg IV/IM

GOALS: BLUE



SEDATIVES FOR MITRAL VALVE DISEASE

ACEPROMAZINE: GREEN

Dose: 0.005 -0.03 ug/kg IV/IM/OTM

Decreases afterload ✓

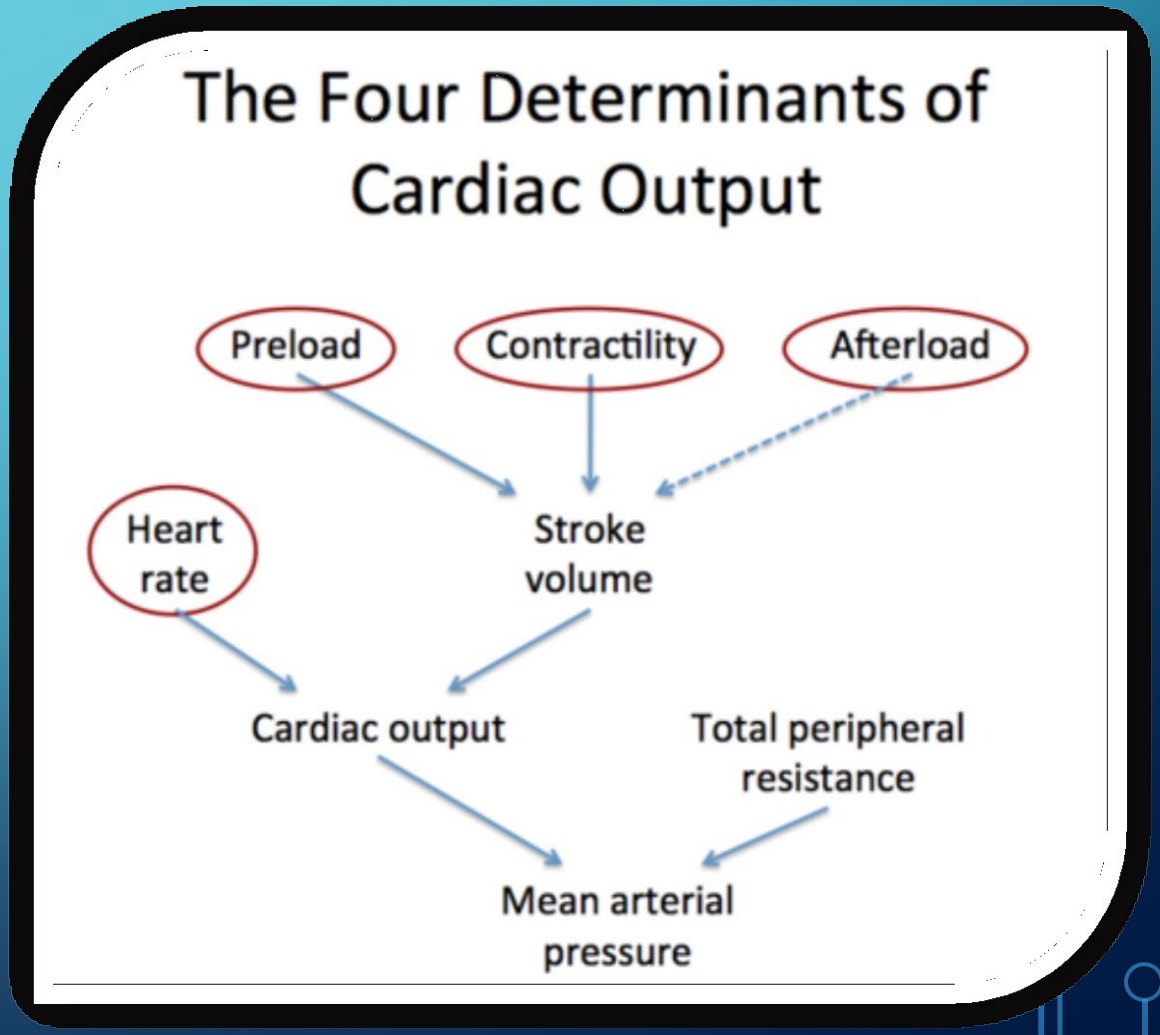
- Decreasing pressure from LV-Aorta promotes forward flow
- Decreases pressure gradient from LV-LA during contraction promotes forward flow
- Vasodilator from A1 antagonism
  - Careful with hypotension

Decreases arrhythmogenicity ✓

Heart rate unchanged ✓

NOT Reversible & long lasting

Dosing & procedure dependent



MITRAL VALVE DISEASE-ANESTHETIC DRUGS

Induction agents:

Goal: Maintain systolic function

Propofol: can cause dose dependent **vasodilation & bradycardia**

Alfaxalone: less vasodilation & IM use

Etomidate: no hemodynamic changes, non-arrhythmogenic, great for unstable cardiac

- **Must** use co-induction agents

Ketamine: **>5 mg/kg:** increase SVR, negative inotrope (decrease contractility)

Co induction agents:

Ketamine: 0.5-2 mg/kg dose

- Decrease amount of induction agent
- Maintain HR/Preserve BP
  - Positive inotropy

Lidocaine: class 1B anti-arrhythmic & analgesic

Midazolam/Diazepam: minimal CV affects, fully reversible, muscle relaxant

Severe systolic dysfunction/CHF: High dose fentanyl/midazolam induction, touch of etomidate

MITRAL VALVE-MAINTENANCE DRUGS

Inhalants

- Isoflurane: slightly more arrhythmogenic
- Sevoflurane:: change in depth faster, more soluble

MAC Sparing

- **TIVA:**
- Alfaxalone/Propofol
- **PIVA:** Inhalant + CRI
- Fentanyl, Lidocaine, Midazolam, Ketamine

- **Local Blocks!**

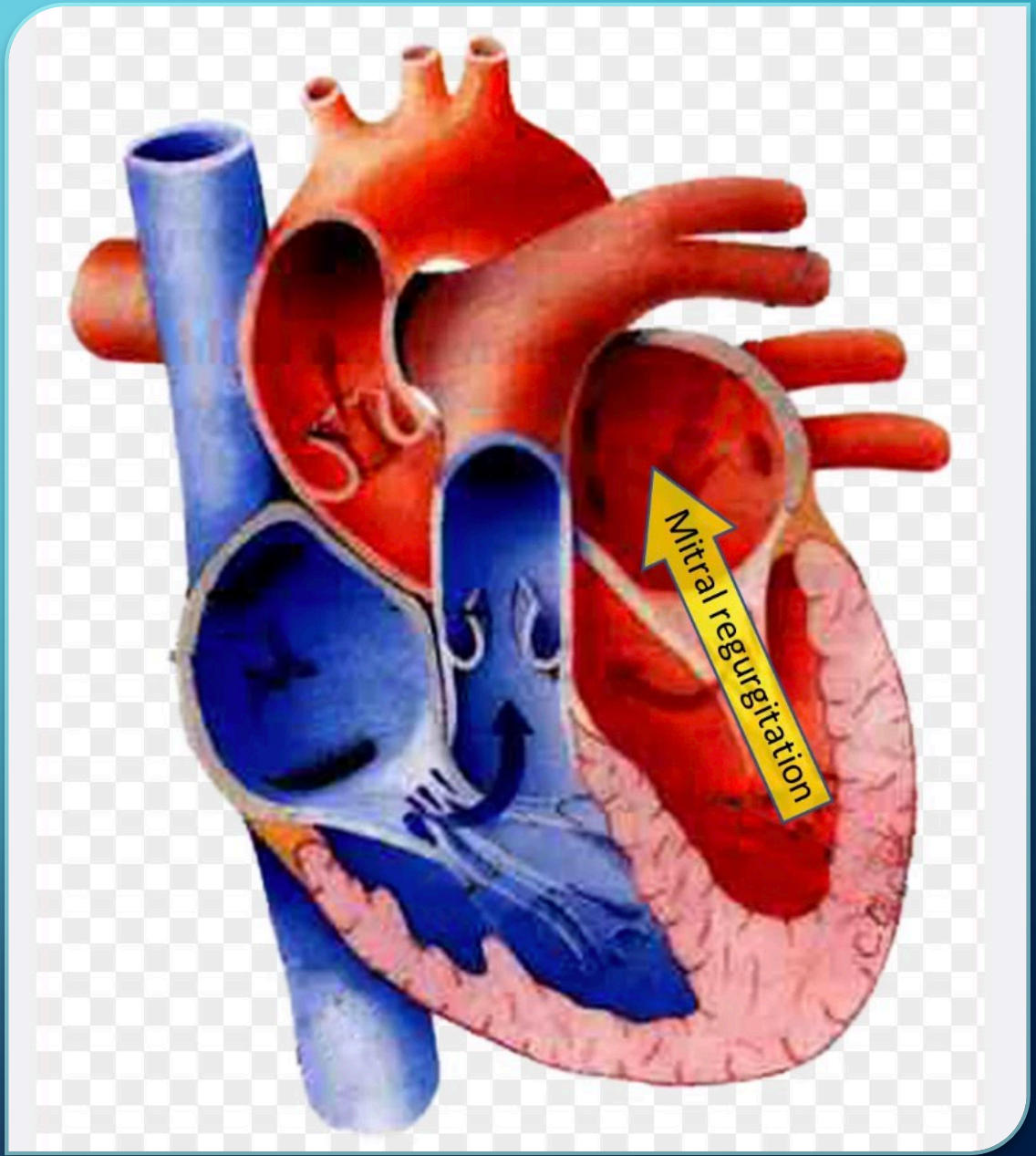
Addition of adjunct CRI's can preserve contractility from lighter use of inhalants to minimize myocardial depression

FIGURE 3. Examples of constant-rate infusion pumps used for total intravenous anesthesia delivered via Practivet (practivet.com).

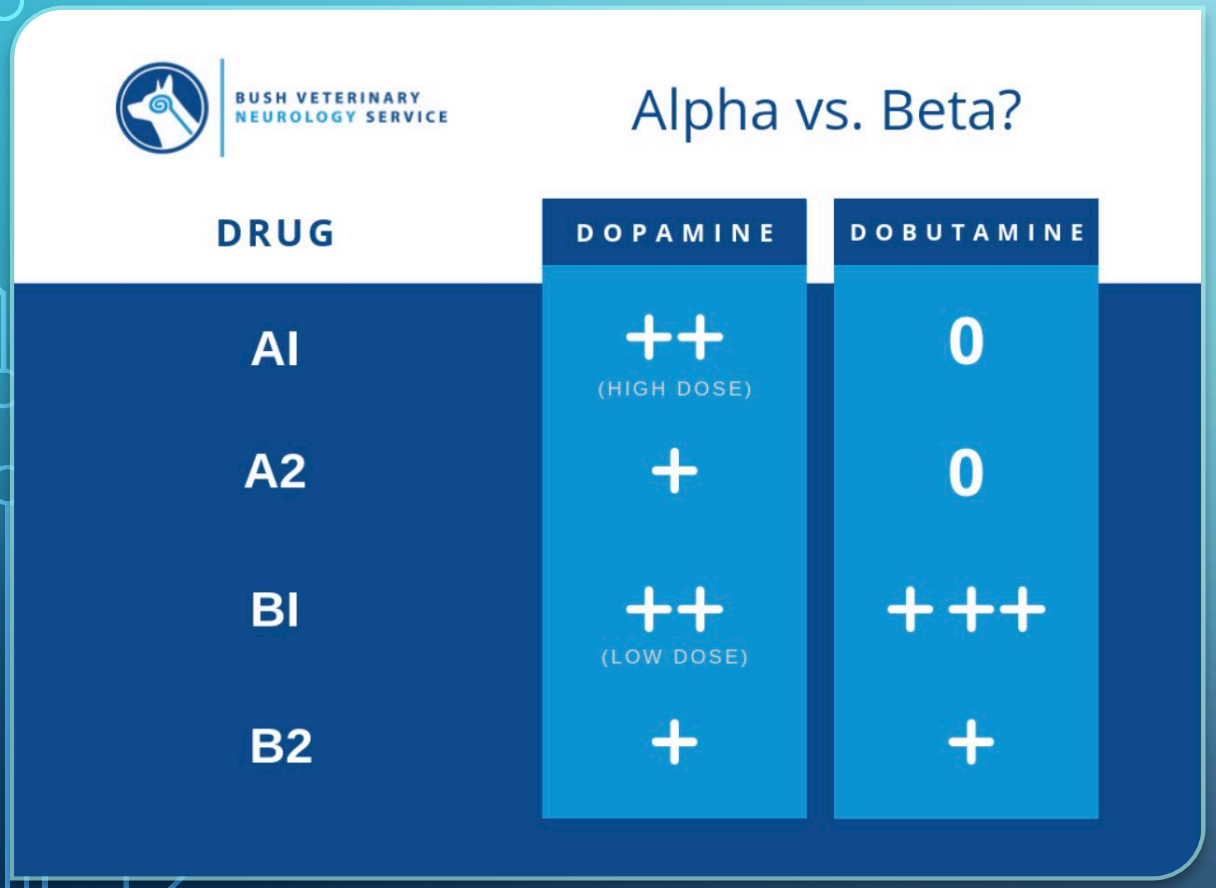
MITRAL VALVE DISEASE & FLUID THERAPY

Increase in preload (fluids) **unlikely** to help cardiac output (CO)

- Chambers are overfilled
  - Heart cannot take heavier load!
- CO benefit more from:
  - Positive inotropy
    - Increase strength of contractility



MITRAL DISEASE: INOTROPIC/VASOPRESSOR SUPPORT



BETA 1 agonism= increased contractility

Alpha 1 agonism= increased vasoconstriction

***Positive Inotropes:* Increase strength (contractility) of heart muscle**

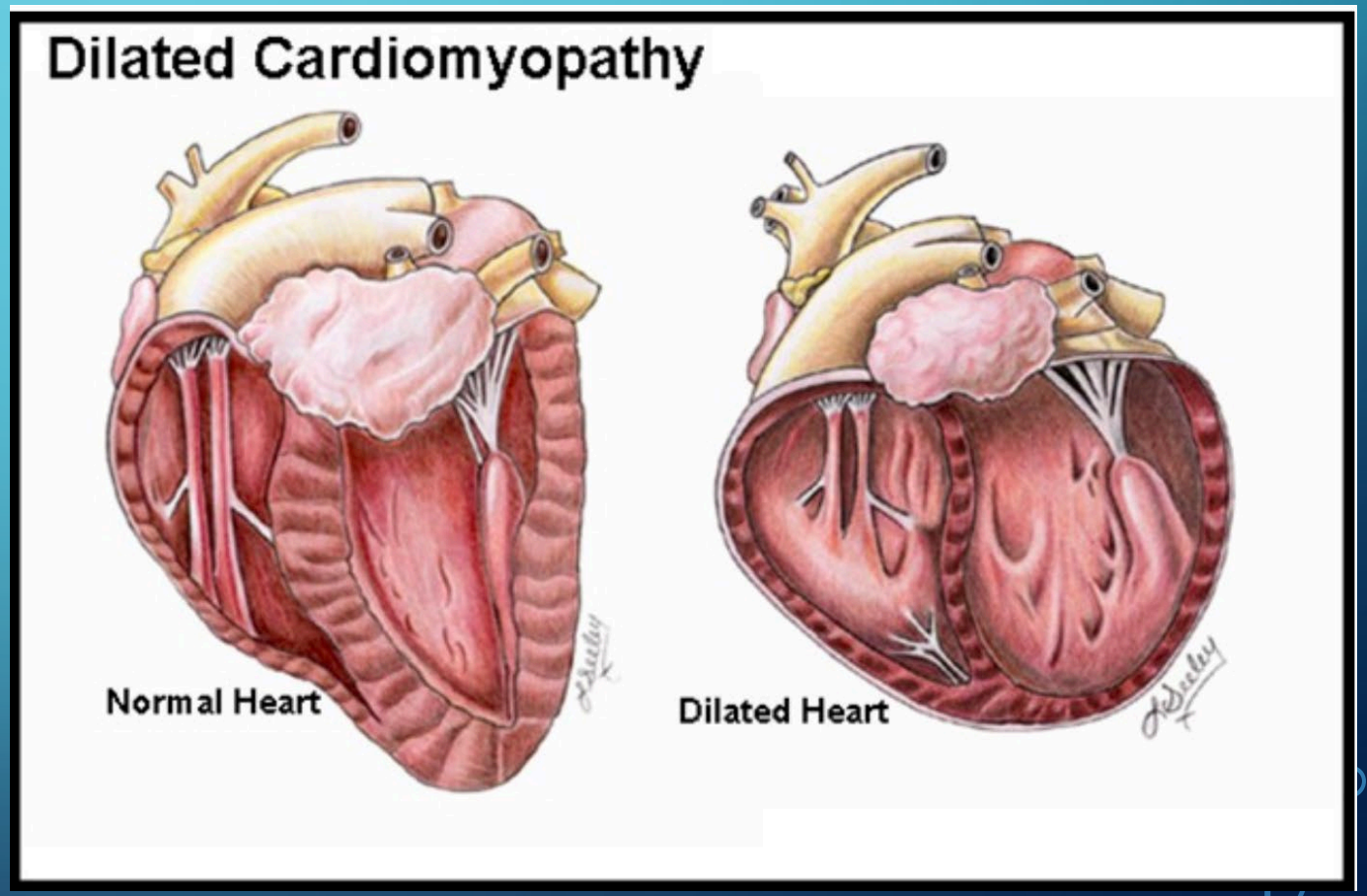
- Gentle helping hand
- May not drastically improve BP, but will increase CO

***Vasopressors:* Constrict vascular tone**

- Increase SVR
  - Not ideal for overworked heart
  - "Good BP"- at what cost?
    - Increased O2 demand by squeezing sick heart

DILATED CARDIOMYOPATHY (DCM)

- Systolic dysfunction (pumping problem)
  - Decreased contractility
    - THIN chamber with ⬆ volume
- Very large risk for CHF
- Arrhythmias due to irregular chamber sizes in ventricles and atria

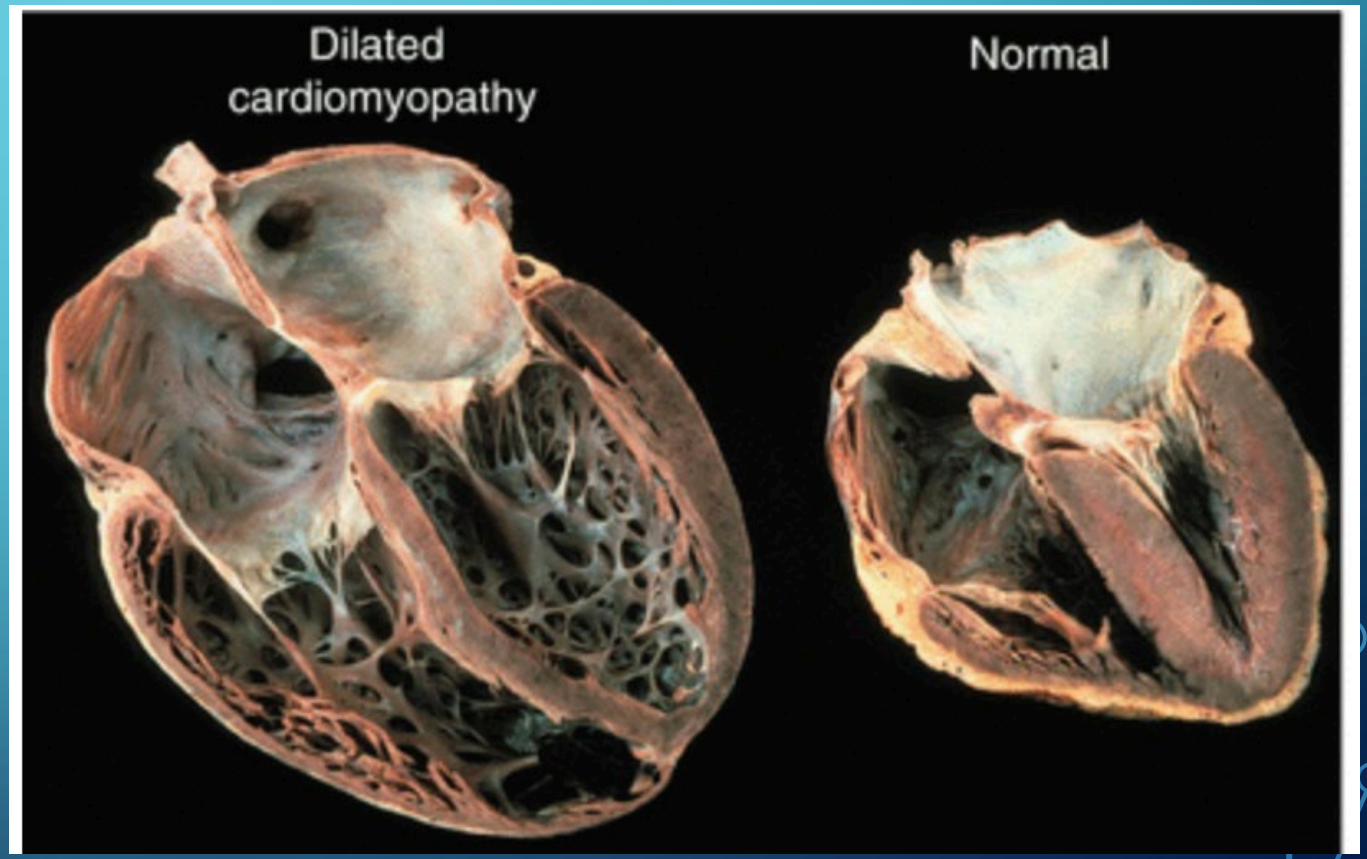


DCM- ANESTHETIC CONSIDERATIONS

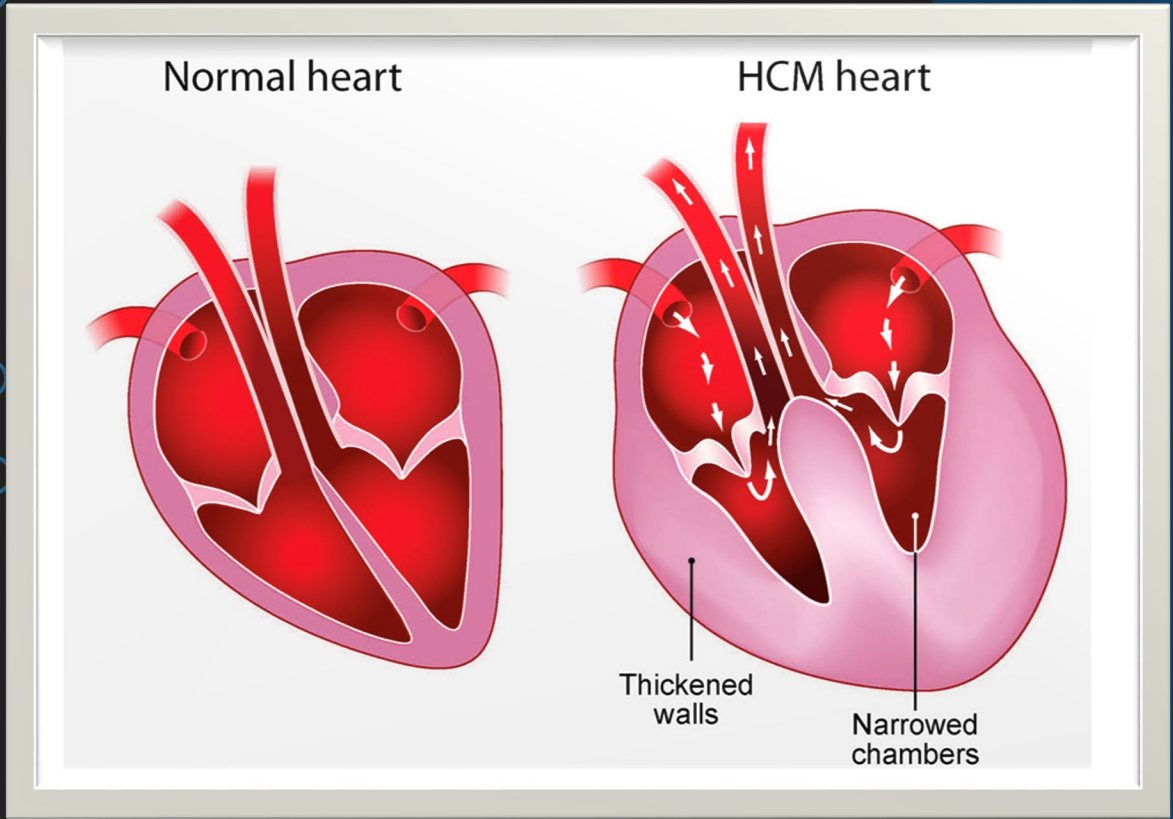
Goals:

- **Maintain preload**
  - Compensatory filling of ventricles, watch for overload.
  - **Fixed volume** : fluids unlikely to help
- **Decrease afterload**
  - Don't increase work!
- **Maintain or ↑ contractility**
  - Has no strength
- **Normal HR for that patient**
  - Body compensates by ↑ HR
- **Control arrhythmias**
  - Antiarrhythmics & rate control

    V-tach, A-fib, APC's,
- **Avoid tachycardia/hypotension**
  - Won't tolerate increase in O2 demand for long



HYPERTROPHIC CARDIOMYOPATHY (HCM)



Diastolic (relaxation) dysfunction

- Stiff, overgrown muscle that can't relax anymore.
  - Very little room in there
  - Intolerant of volume expansion
- Abnormally increased atrial pressures
  - Sluggish atrial flow of blood can lead to **clot formation**
    - Most common cause of sudden death
- Can be hidden disease
  - May or may not have a murmur
  - No outward clinical signs
  - Arrhythmias or "gallop" rhythm

Cause unknown

- Except in certain breeds:
  - Maine Coon/Ragdoll/Siberian/Norwegian/Sphynx
    - Genetic mutation

HCM-ANESTHETIC CONSIDERATIONS

Maintain preload w/out CHF

- Optimize volume to maintain filling non-compliant ventricle

Increase afterload

- Vasoconstrictors work in their favor

Reduction of contractility and HR

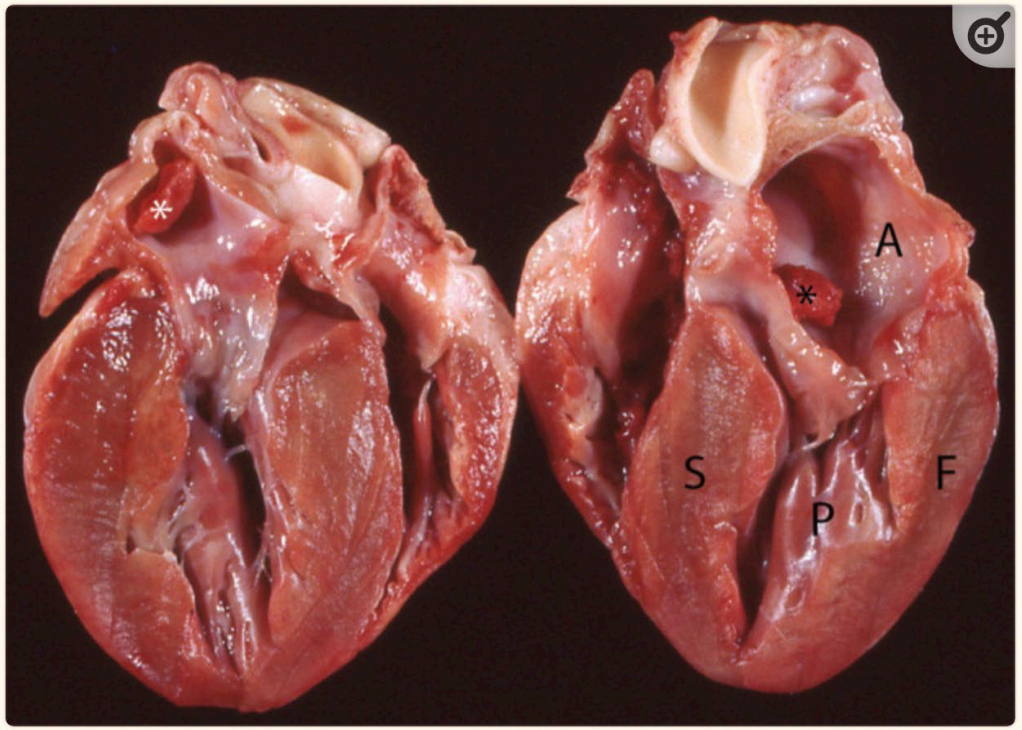
- Slower filling time

Maintain normal HR & rhythm

- Arrhythmias from chamber size reduction

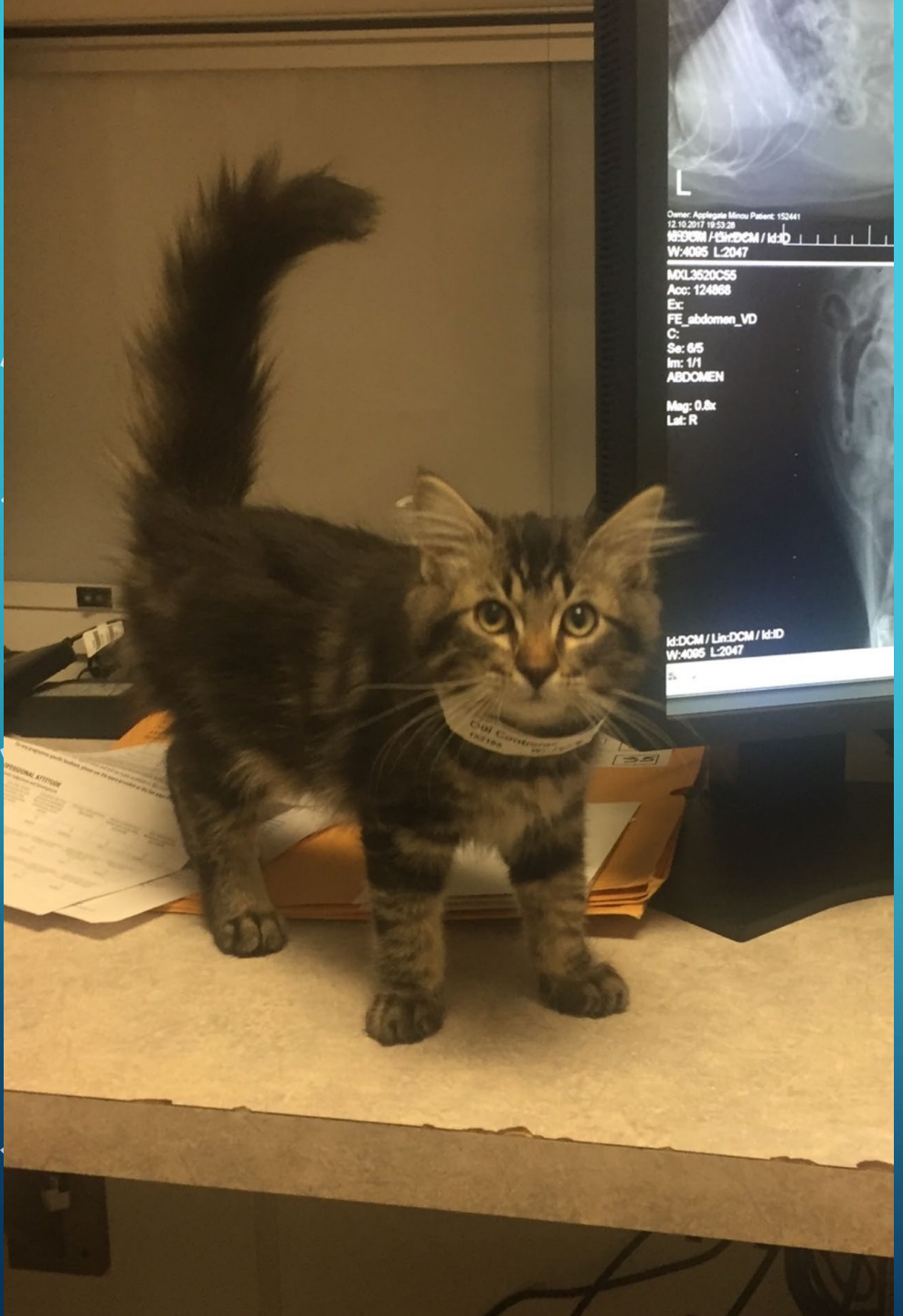
Avoid increase in myocardial O2 consumption

- Tachycardia, stress, excitement



1

athologic specimen of a heart showing markedly thickened left ventricular walls and papillary muscles and an
d left atrium. At the upper left there is a thrombus in the left auricle (white asterisk). Another thrombus is prese
y of the left atrium on the right (black asterisk). S = interventricular septum; F = left ventricular free wall; P =
apillary muscles; A = body of the left atrium



HCM-ANESTHETIC DRUGS

Premedication:

- Opioids: all choices are great, depending on procedure
  - Cats may need higher doses to sedate
    - Fentanyl CRI in cats need higher doses to be MAC sparing
- Used in combo with:
  - Midazolam/Alfaxalone/**low dose** ketamine/dexmed/ace?

SUBTYPES OF HCM- DYNAMIC OUTFLOW TRACT OBSTRUCTION (DVOTO)

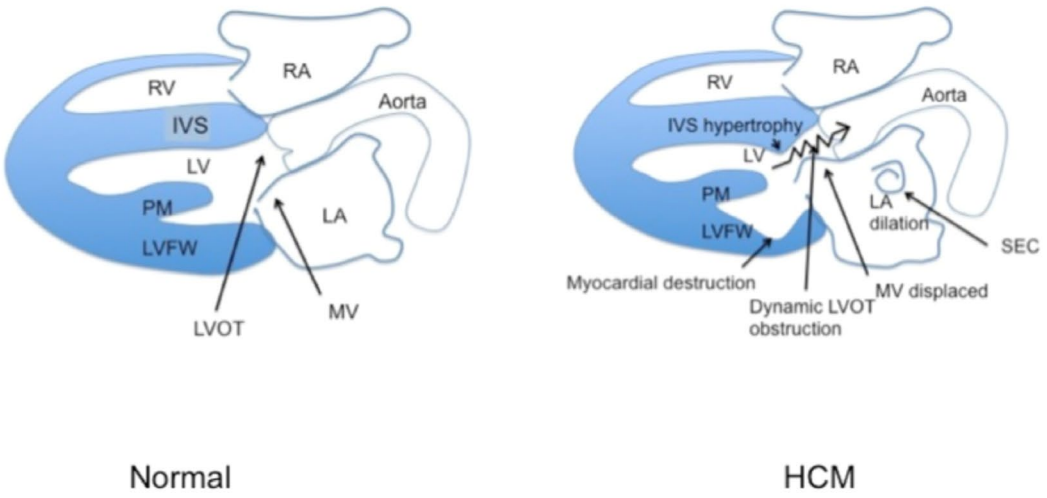


Figure 1: Features of hypertrophic cardiomyopathy (HCM) in cats. On the left, a normal heart is represented. RV: right ventricle; LV: left ventricle, RA: right atrium, LA: left atrium; MV: mitral valve, LVOT: left ventricular outflow tract; IVS: interventricular septum; PM: papillary muscle; LVFW: left ventricular free wall. On the right, the hypertrophy represented here affects the base of the septum but could affect any part of the left ventricular walls. The mitral valve is displaced against the septum, leading to dynamic obstruction of the LVOT (DOLVOT). (Artwork: Eric de Madron)

Mitral valve gets abnormally displaced and pushed up against intraventricular septum walls

- Obstructs blood flow
- Increases pressure and LA dilation

Increase in afterload may be helpful

- **Dexmedetomidine** could help cats with this **subtype**
  - **Alpha 2**
- **Phenylephrine** drug of choice
  - **Alpha 1**

HCM- ANESTHETIC DRUGS

Ketamine:

- **Positive & negative inotropy**
  - We don't want to increase contractility because the walls of ventricle barely move, they are stiff.
  - Forcing them to do more work will only increase O2 demand
- **Catecholamine release**
  - Avoid stress
  - Tachycardia---increased oxygen consumption
- **NOT reversible**

Low doses may be tolerated **if systolic function okay.**
(0.5-2mg/kg)

HCM-ANESTHETIC DRUGS

Induction agents:

- Alfaxalone & Propofol very common
  - Careful with dose dependent administration (bolus)
- Etomidate in moderate/severe cases
- Loss of consciousness decreases sympathetic nervous activity
  - Decreased SVR
  - May be extra-hypotensive in the post induction period

HCM-INTRAOPERATIVE MANAGEMENT

Maintenance: isoflurane/sevoflurane

- Dose dependent decrease SVR

<u>Adjunct CRI's</u>

- Fentanyl
- Midazolam
- Low dose ketamine
  - Total dose < 3 mg/kg
- Low dose dexmedetomidine (LVOT)
  - 1-2 ug/kg LD (loading dose)
  - 0.5-1 ug/kg/hr

Treating hypotension:

Bradycardia and hypotension –Consider low dose anticholinergic

Glycopyrrolate preferred: less tachycardia

Phenylephrine

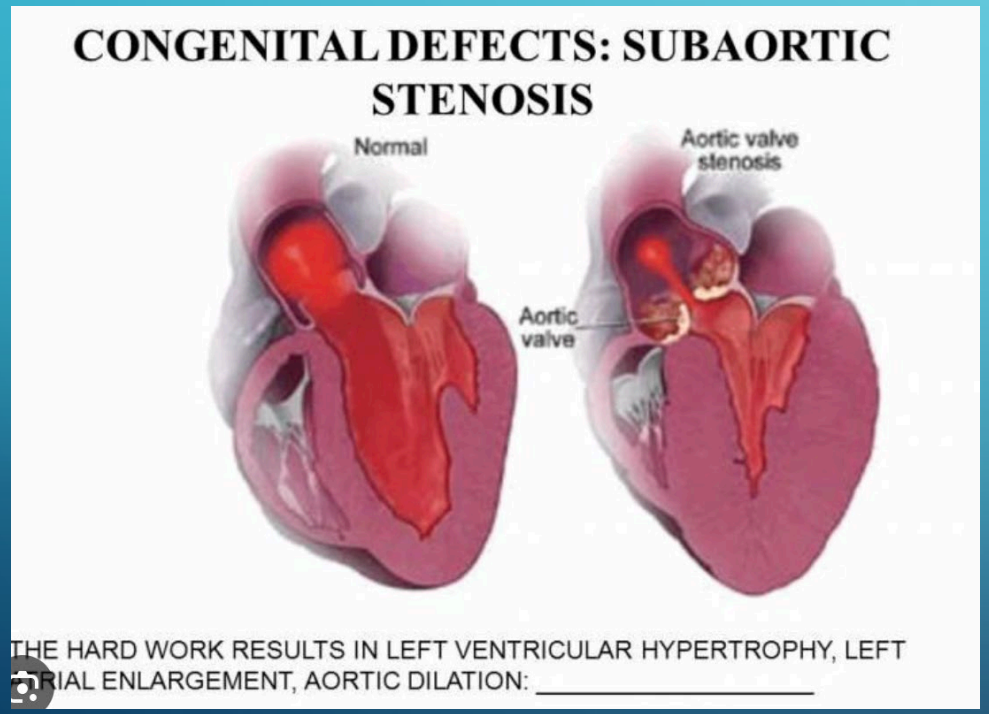
Increases SVR without direct effect on myocardium, purely alpha 1

Dopamine

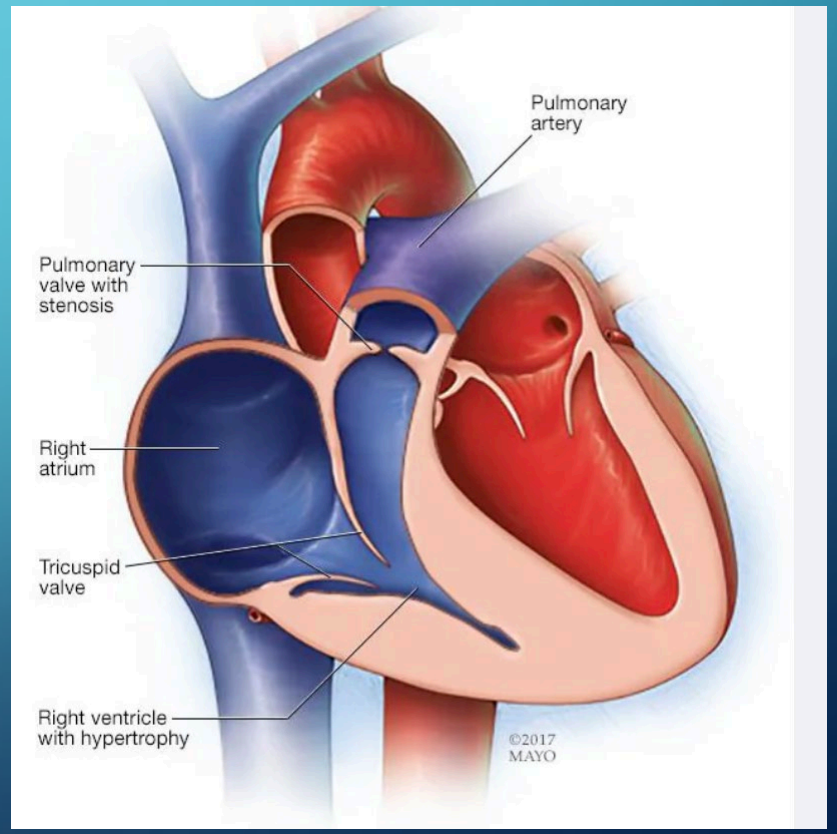
Can increase cardiac output if really needed

STENOSIS (VALVE NARROWING): PRESSURE OVERLOAD/DYSFUNCTION

SUBAORTIC STENOSIS



PULMONIC STENOSIS



PULMONIC STENOSIS

Anesthetic goals:

Increase preload

- Give fluids!

Avoid changes in HR

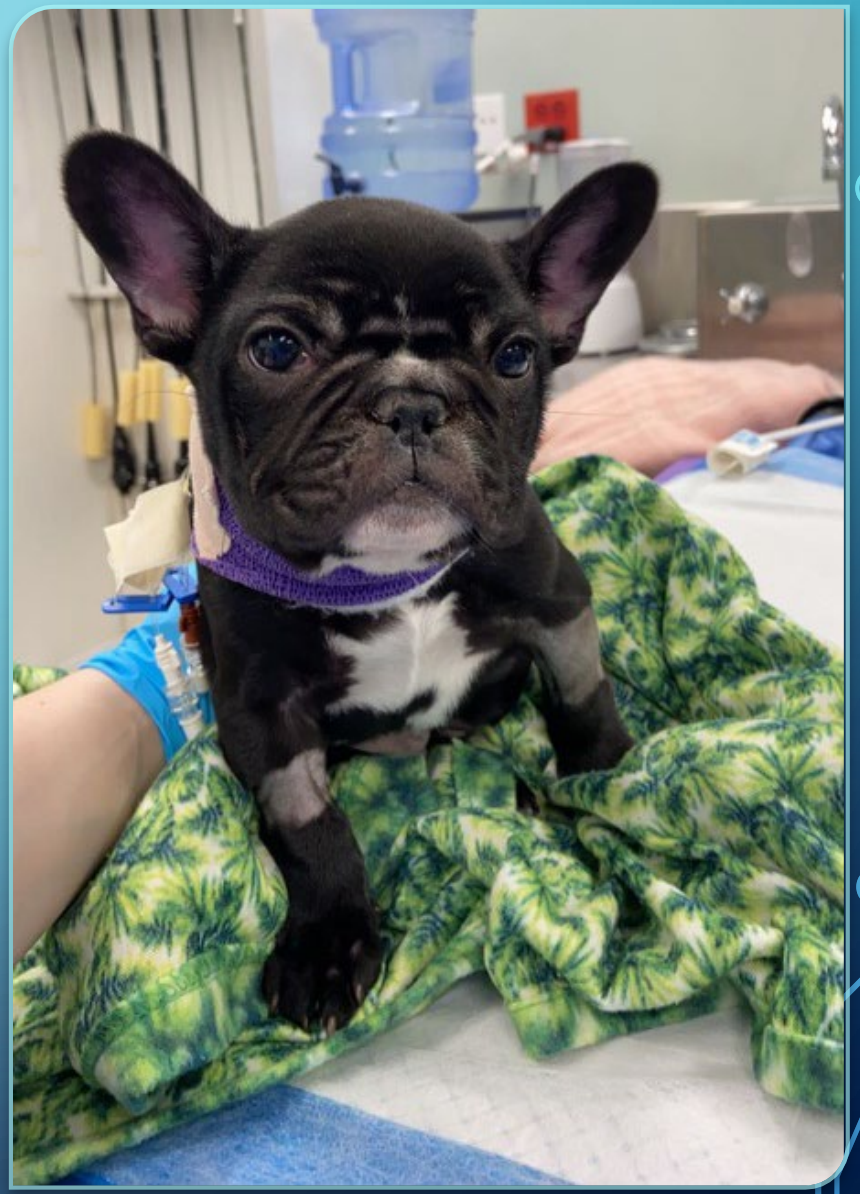
- Dependent on ”atrial kick”
  - No AV Blocks
- Tachycardia would worsen ventricular filling

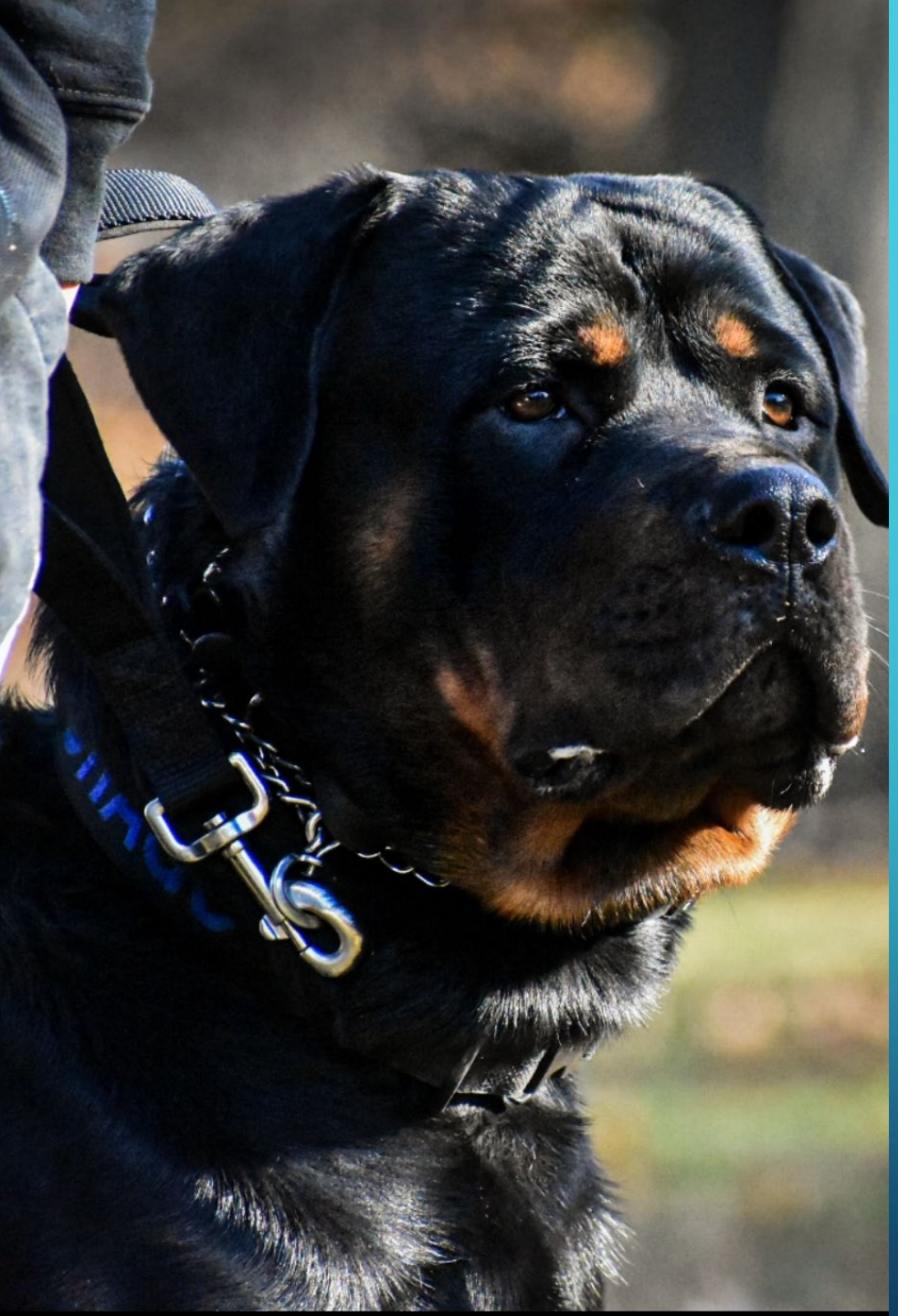
Aggressively treat hypotension

- Volume & vasopressor support

Avoid increases in pulmonary pressure (low pressure system)

- Avoid hypoventilation----hypercarbia---increase PVR





SUBAORTIC STENOSIS

Congenital defect: usually detected young by heart murmur

- **No procedural cure for this**
  - Beta blockers to control heart rate (atenolol)
  - Frequent Holter ECG Monitoring

Same anesthetic considerations for pulmonic stenosis

- Left sided heart failure more of a risk
  - Fluid overload consideration if advanced
- Can see in both puppies and adults

ARE MORE FLUIDS YOUR FRIEND OR NOT?

VOLUME OVERLOAD

- Mitral Valve Disease
  - Generally not recommended if higher disease type
- DCM (systolic dysfunction)
  - Fixed volume so adding more unlikely to help cardiac output
  - Needs contractility

HCM (diastolic dysfunction)

- Consider in absolute hypovolemia
- Needs increased afterload

INADEQUATE PRELOAD

Pulmonic Stenosis

- Yes, fluid therapy is first line for treatment of hypotension aggressively

Aortic Stenosis

- Yes, when no signs of CHF

Electrical disease

- Depends on the cause of arrhythmias
- Usually rate control is needed first

FLUID THERAPY- **PLETH VARIABILITY INDEX (PVI)**

- Determine likelihood of fluid responsiveness during hypovolemia

<u>Absolute: actual fluid losses</u>

- Hemorrhage, vomiting

<u>Relative: vasodilation</u>

- Inhalants, poor contractile function

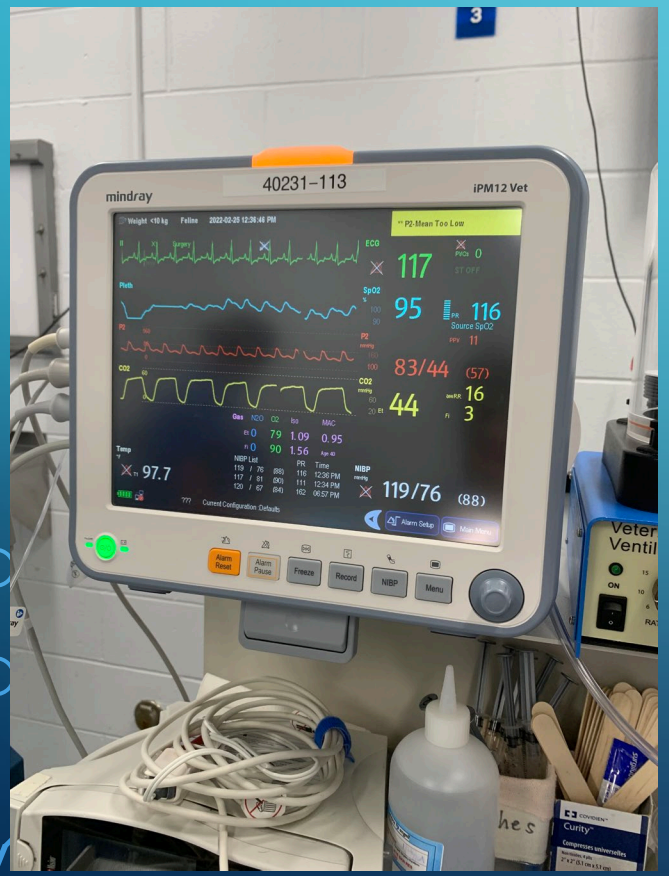
Values >15 indicate fluids

USE OF PVI IN CARDIAC (MITRAL) CASE: DMVD STAGE B2

HYPOTENSION UNRESPONSIVE TO DOPAMINE AT 7 UG/KG/MIN

PVI >20

POST 3 ML/KG LRS BOLUS



DENTAL PROPHYLAXIS W/ ON 12 YR MC MAINE COON

History:

- III/VI Heart Murmur auscultated on exam
- Moderate periodontitis
- **Known HCM w/ LVOT**
- Temperament: Nervous but tolerant

Current medications:

1. Clopidgrel (blood thinner; clots)
2. Enalapril (ACE inhibitor)-stopped 24 hours prior
3. Toresemide (loop diureutic for fluid overload)
4. Atenolol (Beta blocker for rate control)

PRE ANESTHESIA: DENTAL CAT W/ HCM

Pre-op plan:

Recheck imaging

- Thoracic radiographs
- When was last echo?

Can determine if medication has helped/disease gotten worse

Let's say: disease has remained stagnant but RV and LV walls thick

Anesthetic considerations:

- Maintain preload w/out CHF
- Increase afterload (LVOT)
- Reduction of contractility and HR
- Maintain normal HR & rhythm
- Avoid increase in myocardial O2 consumption

PRE MEDICATION DENTAL CAT W/ HCM

Pre-op plan:

- Performed echo without sedation
- Got stressed, now in O2 because of open mouth breathing
- NO IVC yet, what drugs do we choose?

Premed options:

1. Should we use a pure mu opioid or not?
   - Yes, because of extractions, painful dental disease

   Methadone/Hydromorphone + Benzodiazepine + Sedative
2. Which sedative should we add?

   Dexmedetomidine or Acepromazine

PRE MEDICATION & INDUCTION

Premedication:

Methadone: 0.3 mg/kg IM

- Higher dosing to sedate in cats

Midazolam: 0.25 mg/kg IM

- Can sedate debilitated patients

Dexmedetomidine: 5 ug/kg IM

- Low dose for increased afterload, sedation & analgesia

Result: Successful IVC placement

Induction:

1. Which agent?

- Propofol/Alfaxalone/Etomidate/Ketamine
  - Alfaxalone
- Might avoid ketamine at induction doses d/t stressed out prior

2. Should we add co-induction?

- Depends on how sedate patient is
  - He's pretty sleepy, getting preoxygenated and his ECGs are on already.

MAINTENANCE-HCM CAT DENTAL

Smooth induction & intubation: uneventful

Inhalant: **Sevoflurane** in O2 on a circle system

Adjunct CRI:

- 3 ug/kg **Fentanyl** bolus + CRI starting at 0.25 ug/kg/min= 15 ug/kg/min
- **Local Blocks w/ Bupivacaine:** extractions

Rational: Lower inhalant reduces vasodilation, relative hypovolemia and arrhythmia potential

INTRAOPERATIVE MANAGEMENT- HCM CAT DENTAL

<u>Blood pressure:</u>

- Highly recommend two ways of checking
- Non-invasive can be unreliable in small patients & with arrhythmias, cardiac disease
  - Doppler

<u>"Targeted fluid therapy" + vasopressor</u>

- **Phenylephrine**, norepinephrine, epinephrine CRI

INTRAOPERATIVE MANAGEMENT- HCM CAT DENTAL

Became **reactive** to the extractions

- Administered fentanyl bolus of 2 ug/kg IV

20 minutes later, became hypotensive but HR unchanged

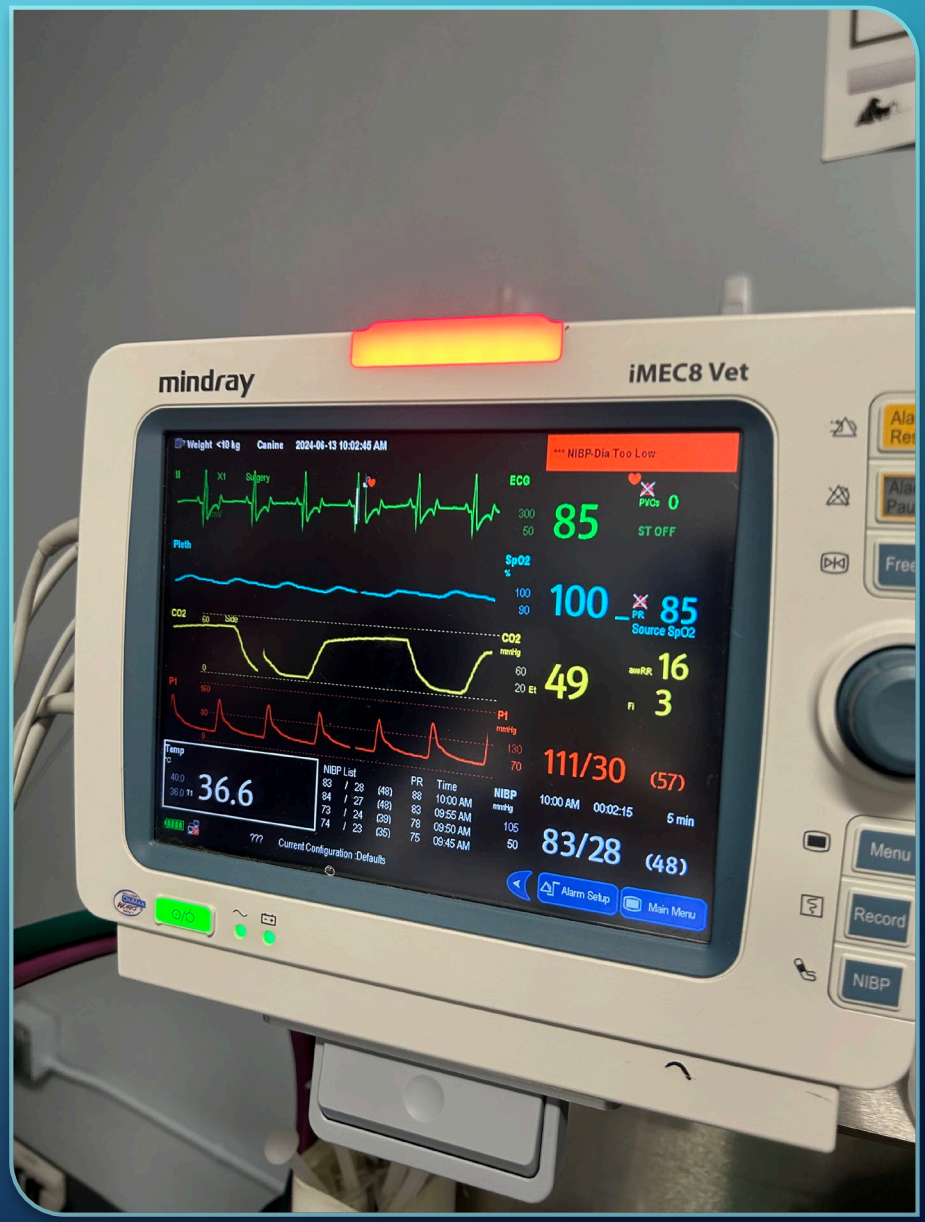
PVI <20: probably not going to be fluid responsive

<u>Vasopressor therapy:</u>

- Start phenylephrine CRI at 0.3 ug/kg/min

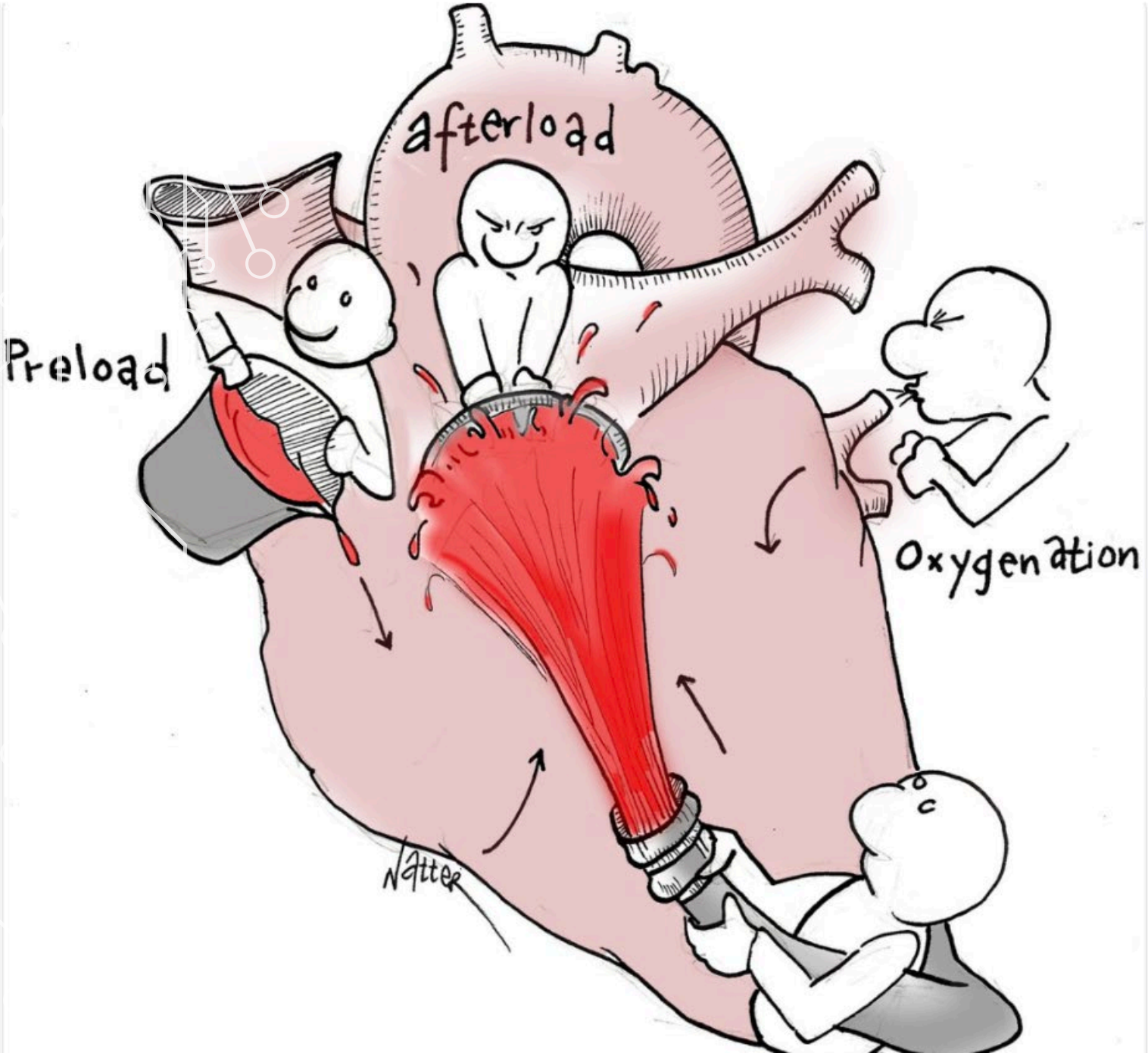
Maintained BP, HR, and ETCO2 within normal limits rest of procedure.

Smooth and uneventful recovery, no reversals needed.



PRESENTATION OVERVIEW

- Although patient with cardiac disease undergoing anesthesia have increased anesthetic risk, we can make informed, targeted decisions regarding our anesthetic technique.
- **Remember not all heart disease is classified the same!**
  - Avoid blanket statements and ultimatums
- **Review of pathophysiology** and careful **anesthetic considerations** can provide the anesthetist with proper tools for case management.



QUESTIONS?

WORKS CITED

"Heart Block | Atrioventricular Block | AV Block | Heart Conditions." *Heart of Dixie*, heartofdixiecardiologycenter.com/bradycardia/. Accessed 23 Oct. 2023. ! Webpage author × ! Date published ×

Hsu, Walter H. *Handbook of Veterinary Pharmacology*. Seoul, Republic Of Korea, Shinilbooks Books, 2013.

"Hypertrophic Cardiomyopathy (Cats)." *Gulf Coast Veterinary Cardiology*, gulfcoastvetcardiology.com/pet-owners/hypertrophic-cardiomyopathy-cats/. ! Webpage author × ! Date published ×

Linares, Mike. "Cellular Physiology: Sodium Potassium Pump." *Simple Nursing*, 15 Dec. 2018, simplenursing.com/cellular-physiology-sodium-potassium-pump/.

"OVERVIEW." *Advanced Cardiovascular Institute*, www.heartandveindoctor.com/heart-overview/. Accessed 23 Oct. 2023. ! Webpage author × ! Date published ×

Park, Sool Yi, et al. "Amlodipine Decreases Mitral Regurgitation Volume in Dogs over 7 Days: A Study of 24 Dogs with Myxomatous Mitral Valve Degeneration." *Veterinary Record Open*, vol. 9, no. 1, 5 Apr. 2022, https://doi.org/10.1002/vro2.33. Accessed 26 Apr. 2022.

Pulmonary Stenosis and Noonan Syndrome | Noonan Syndrome Awareness Association. noonansyndrome.com.au/pulmonary-stenosis-and-noonan-syndrome/. ! Webpage author × ! Date published × ! Website name ×

Texas Heart Institute . "Heart Information Center: Heart Anatomy | Texas Heart Institute." *Texas Heart Institute*, 2018, www.texasheart.org/heart-health/heart-information-center/topics/heart-anatomy/.

Works Cited

"ACE Inhibitors: Drug List, Side Effects, Mechanism of Action, Example Medications, Contraindications." *EZmed*, www.ezmedlearning.com/blog/ace-inhibitor-drug-list. ! Webpage author × ! Date published ×

"Adrenergic Antagonists: Beta Blockers: Video." *Osmosis*, www.osmosis.org/learn/Adrenergic_antagonists:_Beta_blockers. ! Webpage author × ! Date published ×

Barton, Anna K, et al. "Classification and Choice of Antiarrhythmic Therapies." *Prescriber*, vol. 31, no. 3, Mar. 2020, pp. 11–17, https://doi.org/10.1002/psb.1828.

"Basic Anatomy of the Human Heart." *Cardiology Associates of Michigan - Michigan's Best Heart Doctors*, 22 Oct. 2019, www.cardofmich.com/anatomy-human-heart-fun-facts/. ! Webpage author ×

"Beta-Blockers - Pharmacology - Medbullets Step 1." *Step1.Medbullets.com*, step1.medbullets.com/pharmacology/107020/beta-blockers. ! Webpage author × ! Date published ×

"Cardiac Output | BioNinja." *Ib.bioninja.com.au*, ib.bioninja.com.au/options/option-d-human-physiology/d4-the-heart/cardiac-output.html. ! Webpage author × ! Date published ×

"Class 4 Antiarrhythmic Drugs (Calcium Channel Blockers) | Concise Medical Knowledge." *Lecturio*, www.lecturio.com/concepts/class-iv-antiarrhythmic-drugs-calcium-channel-blockers/. ! Webpage author × ! Date published ×