

Shock, Hypertension and Hypotension

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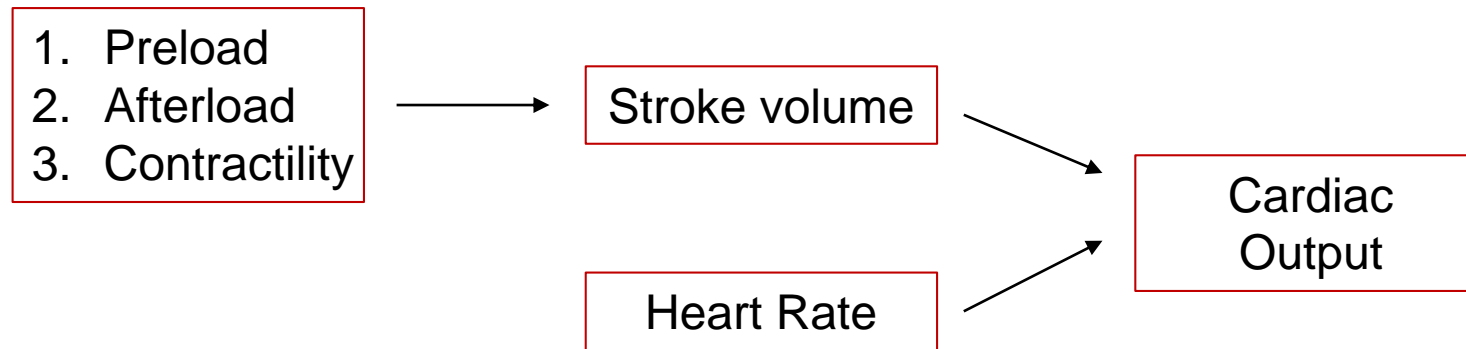


VETS30014 / VETS90124

Learning Objectives

1. **Revise** the terms cardiac output, stroke volume, contractility, afterload and preload
2. Define and utilise the terms **hypertension** and **hypotension** in relation to domestic animals
3. Understand the **causes** and **potential** consequences of systemic hypertension and explain why systemic hypertension tends to be a self-perpetuating phenomenon
4. Define the term '**shock**' and relate this to the '**tree of life**'
5. **Describe** the six main categories of shock and understand their **aetiopathogenesis** (hypovolaemic, cardiogenic, distributive, obstructive, metabolic and hypoxaemic)

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Hypertension refers to an increase in blood pressure

Hypotension refers to a drop in blood pressure below normal

Normal Arterial Blood Pressure Values in Adult Dogs & Cats⁴

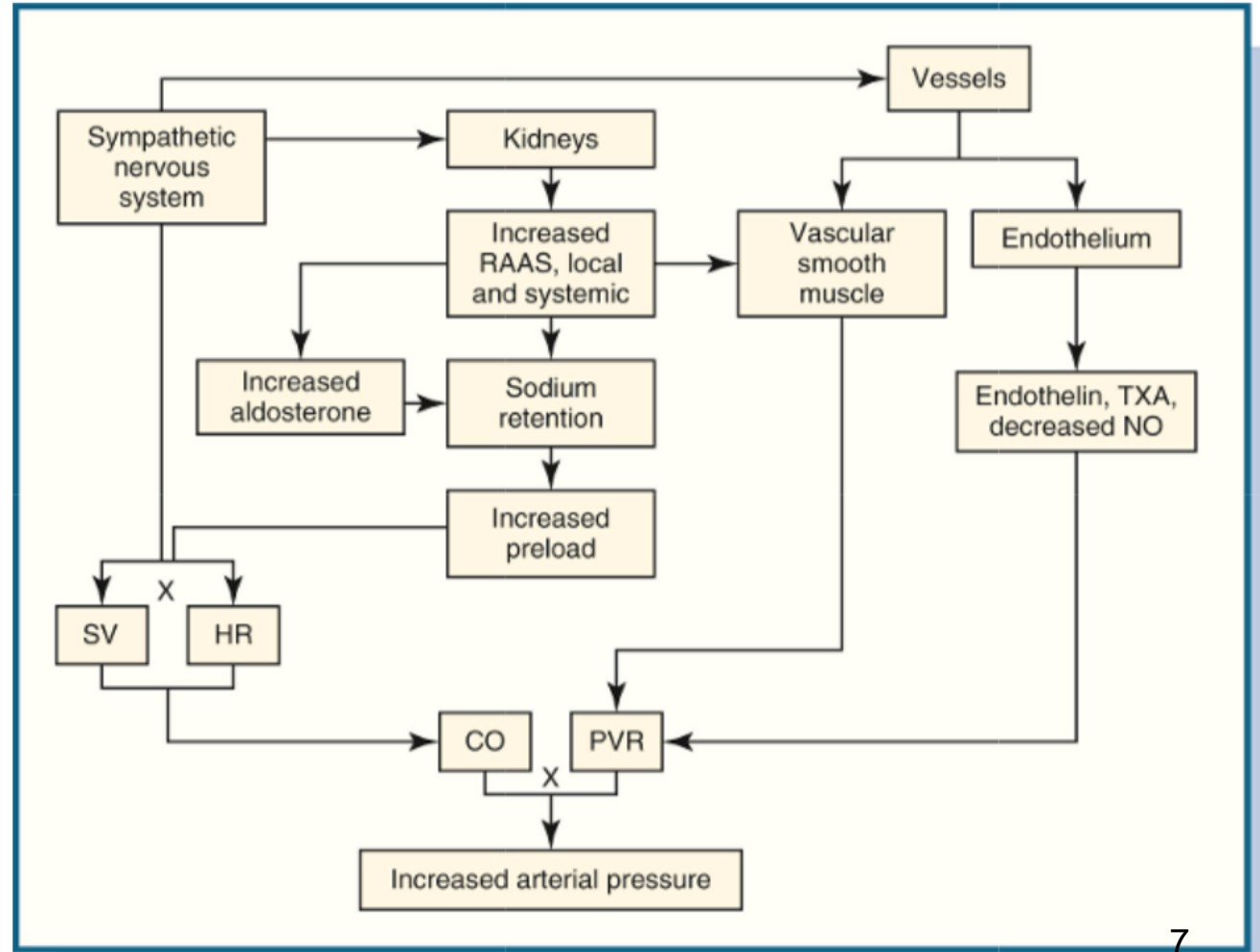
BLOOD PRESSURE VALUES	DOGS	CATS
Systolic arterial pressure	90 to 140 mm Hg	80 to 140 mm Hg
Diastolic arterial pressure	50 to 80 mm Hg	55 to 75 mm Hg
Mean arterial pressure	60 to 100 mm Hg	60 to 100 mm Hg

LO 3

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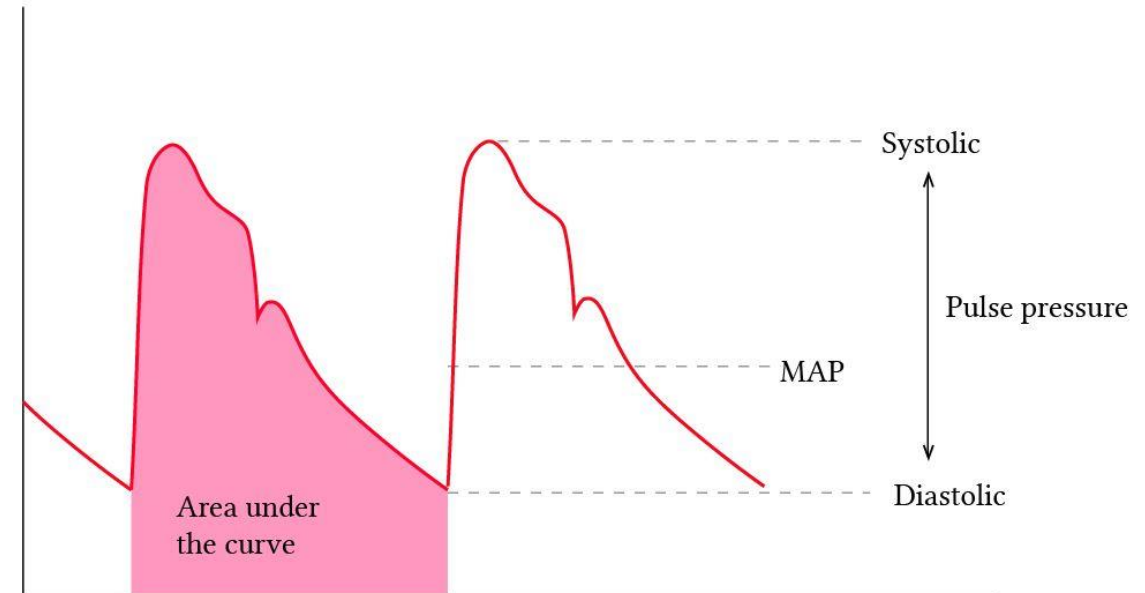
Systemic Hypertension

Sustained increase in arterial BP



Systemic Hypertension

- Arterial baroreflex is crucial in beat-to-beat control of the circulation: both heart rate and blood pressure
- Every time the heart beats, BP rises (artery stretch).
- There are arterial and cardiopulmonary baroreceptors, activation of which will cause inhibition of sympathetic output.
- The body is constantly measuring and readjusting heart rate
- Blood volume is also constantly being measured



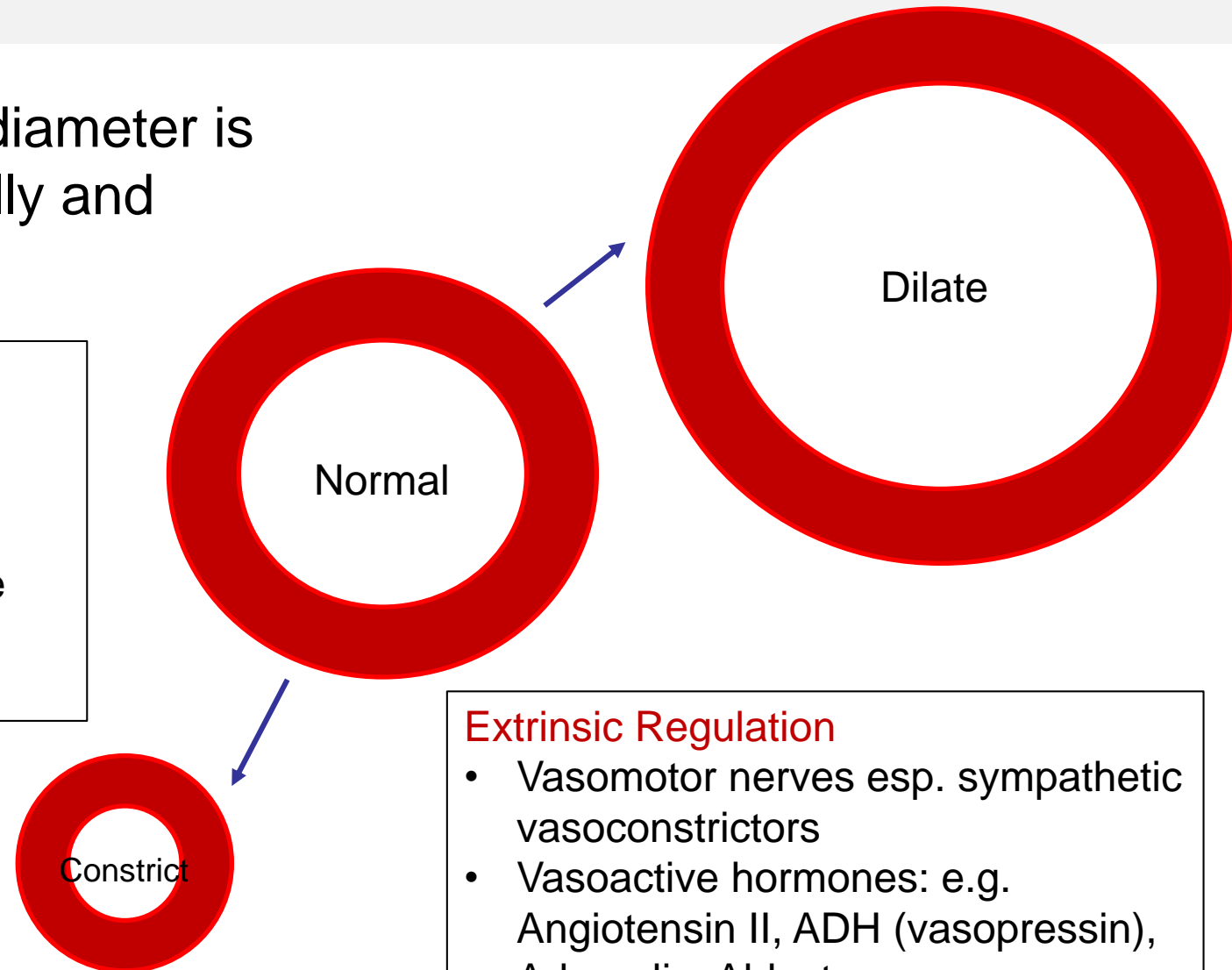
<https://derangedphysiology.com/main/cicm-primary-exam/required-reading/cardiovascular-system/Chapter%207.6.0/normal-arterial-line-waveforms>

Systemic Hypertension

- Regulation of arteriolar diameter is regulated both intrinsically and extrinsically

Intrinsic Regulation e.g.

- Pressure myogenic response
- Endothelially derived factors
 - E.g. Nitric Oxide
- Paracrine factors -e.g. histamine
- Local metabolites
- Temperature



Extrinsic Regulation

- Vasomotor nerves esp. sympathetic vasoconstrictors
- Vasoactive hormones: e.g. Angiotensin II, ADH (vasopressin), Adrenalin. Aldosterone

Doppler blood pressure measurement in a dog



- Non-invasive measurement of BP
- Doppler machine
- Blood pressure cuff measured to the size of the patient
- Sphygmomanometer
- Willow, our canine volunteer 😊

Systemic Hypertension in dogs and cats

- SH can be divided into two categories
 - Secondary hypertension → more common
 - Primary, or idiopathic, hypertension
- More common in older male dogs than females
- Doppler (better for cats) or oscillometric techniques for measurement.
- Be aware of the white coat effect
 - Take many readings
 - Quiet room

» Cats > 160mmHg

» Dogs > 150mmHg



<http://seattleclouds.com/myapplications/MattWalker/VetExam/CatBlood.html>

Secondary Hypertension

Conditions commonly associated with systemic hypertension:

- Kidney Disease
 - The most common
- Hyperadrenocorticism
- Adrenal Tumours
- Hyperthyroidism
- Diabetes Mellitus
- Cardiovascular Disease
- Obesity
- Drugs

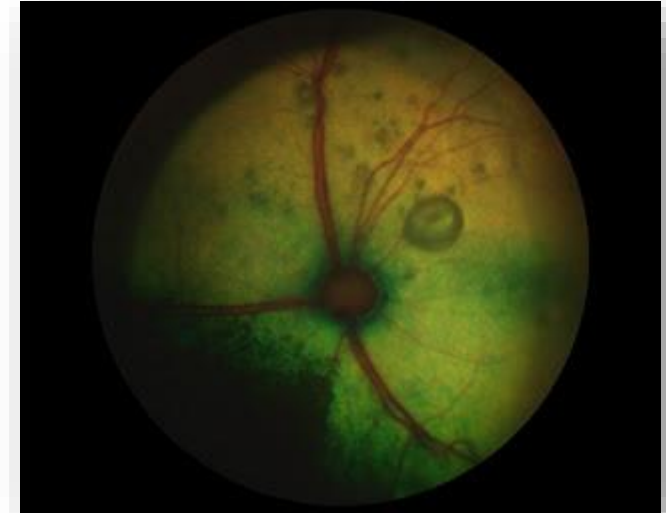
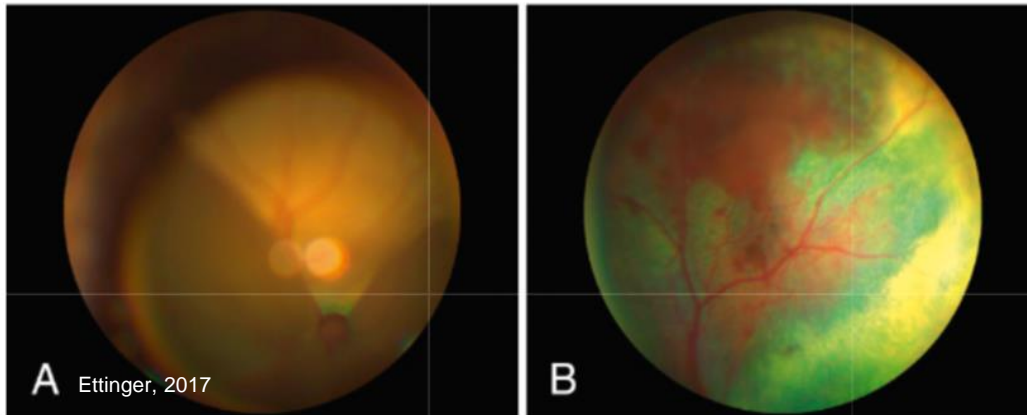


<http://doctoritapisicilor.blogspot.com/2015/02/importanta-unei-examinari-clinice.html>

- Target-organ Damage (TOD)

- 1. Ocular Manifestations

- Choroidopathy/Retinopathy → Altered vessel diameter --> partial or complete retinal detachment, haemorrhage, multifocal oedema
 - Common in geriatric feline patients



- Target-organ Damage (TOD)

2. Cardiac Manifestations

- Left ventricular hypertrophy most common
 - Normalise wall stress and preserve left ventricular chamber function



- Target-organ Damage (TOD)

3. Renal Manifestations

- Hypertensive nephrosclerosis
- Cause and effect?

4. Neurological Manifestations

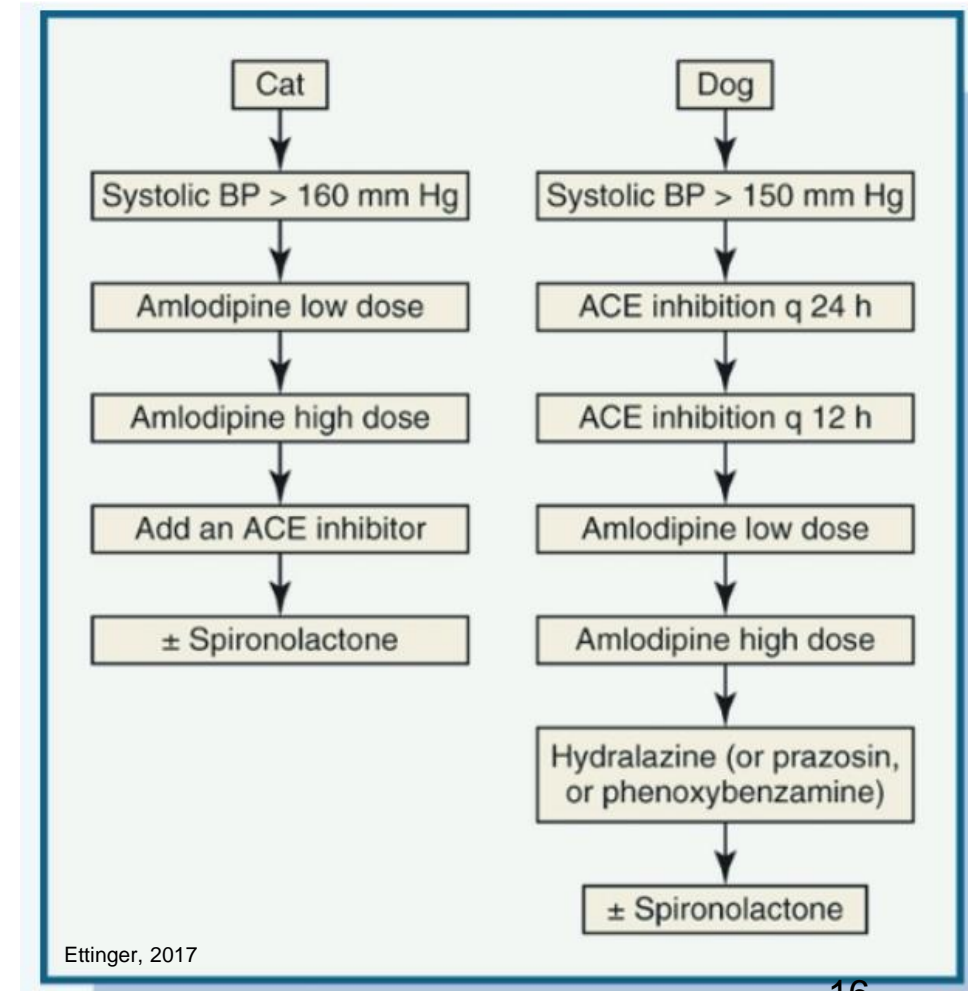
- Hypertensive encephalopathy

5. Epistaxis



Treatment

- Once identified it should be treated
- Treatment of primary disease
- Goal – amelioration of clinical signs if present



Systemic Hypotension



$$\text{SAP} = \text{cardiac output} \times \text{total peripheral vascular resistance}$$
$$= (\text{heart rate} \times \text{stroke volume}) \times \text{total peripheral vascular resistance}$$

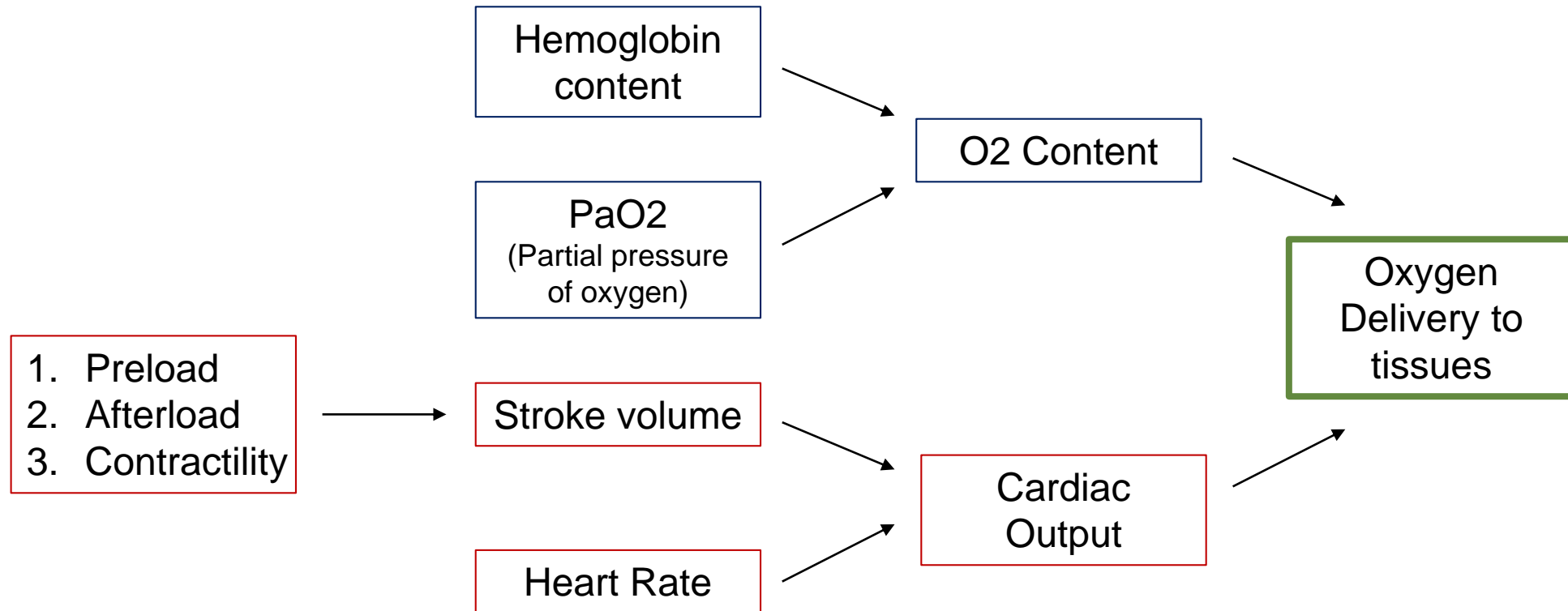
- Systemic hypotension can therefore result from any condition that promotes a persistent decrease in the CO and/or PVR
- Sustained hypotension can result in **shock**

» $\text{SAP} < 80 \text{ mmHg}$

» $\text{MAP} < 60 \text{ mmHg}$

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The Tree of Life



**What happens when
oxygen demand > delivery?**

Shock!

What is Shock?

Inadequate cellular energy production leading to a critical decrease in oxygen delivery (DO_2) in relation to oxygen consumption (VO_2)

Hypovolaemic
Cardiogenic
Distributive

Obstructive
Hypoxaemic
Metabolic

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Hypovolaemic Shock

- Decrease in blood volume (internal or external loss)
- Excessive loss of other bodily fluids (urine, vomit, diarrhoea, burns)
- Compensatory mechanisms are triggered to attempt to raise circulating blood volume “compensated shock”
- Decompensated shock follows

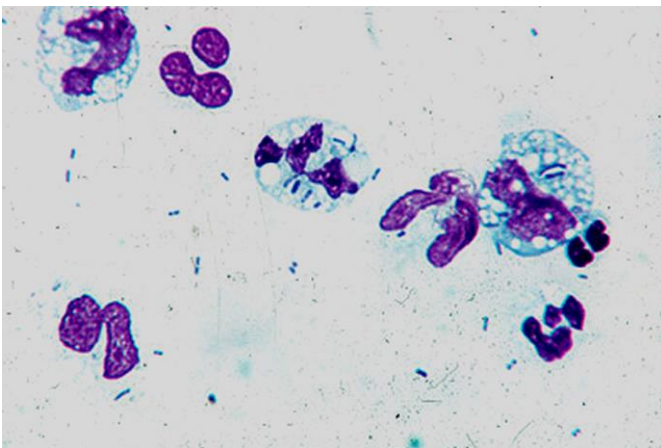


J. Charles 2020

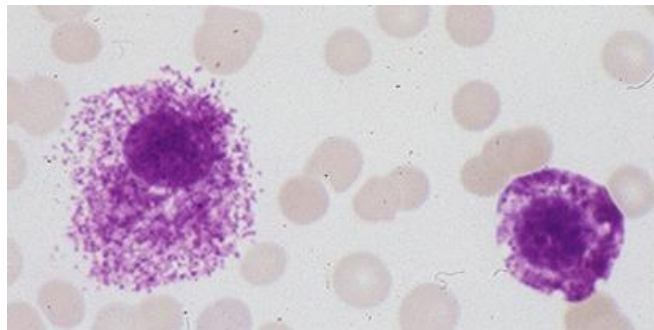


Distributive Shock

- A marked decrease in systemic vascular resistance (vasodilation) or maldistribution of blood
- Examples include
 - Sepsis (release of endotoxins, induction of pro-inflammatory cascades)
 - Systemic Inflammatory Response Syndrome (SIRS)
 - Disseminated Intravascular Coagulation (DIC, more next lecture)
 - Anaphylactic shock (degranulation of mast cells and basophils)
 - Catecholamine release (extreme fear, pheochromocytoma)



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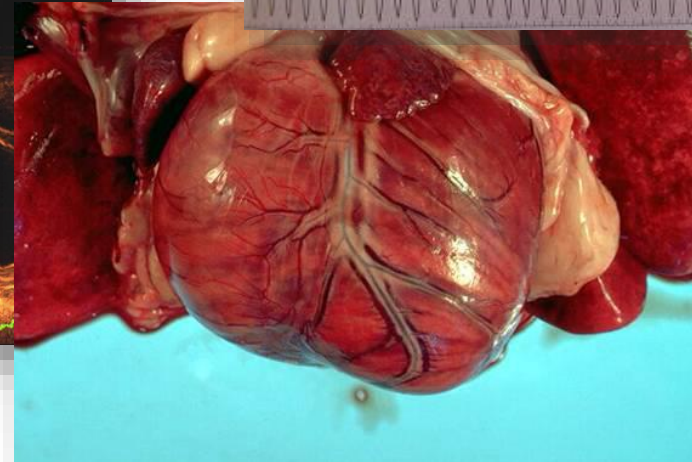
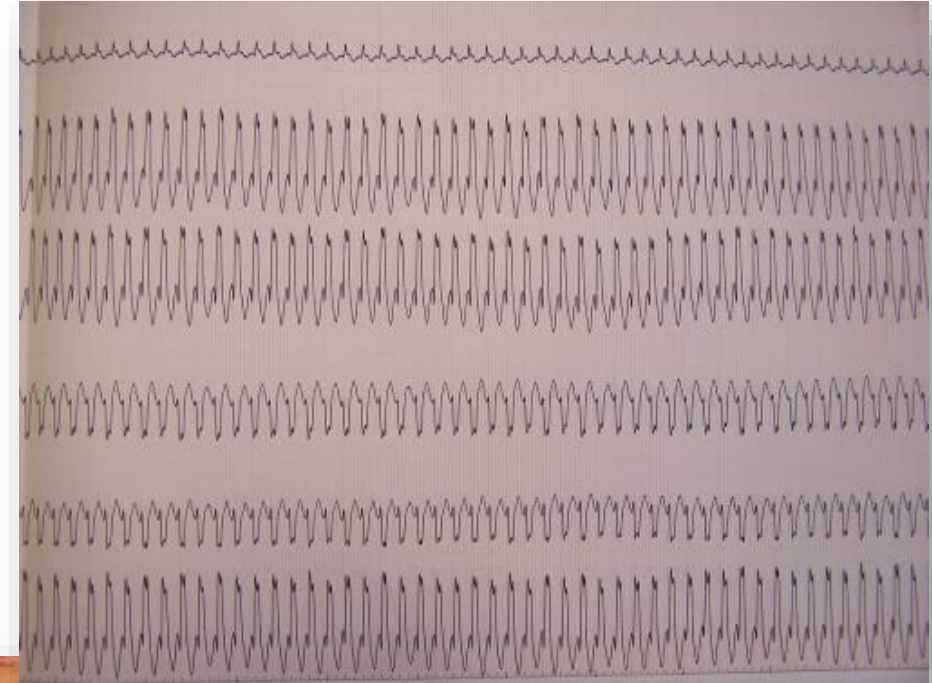
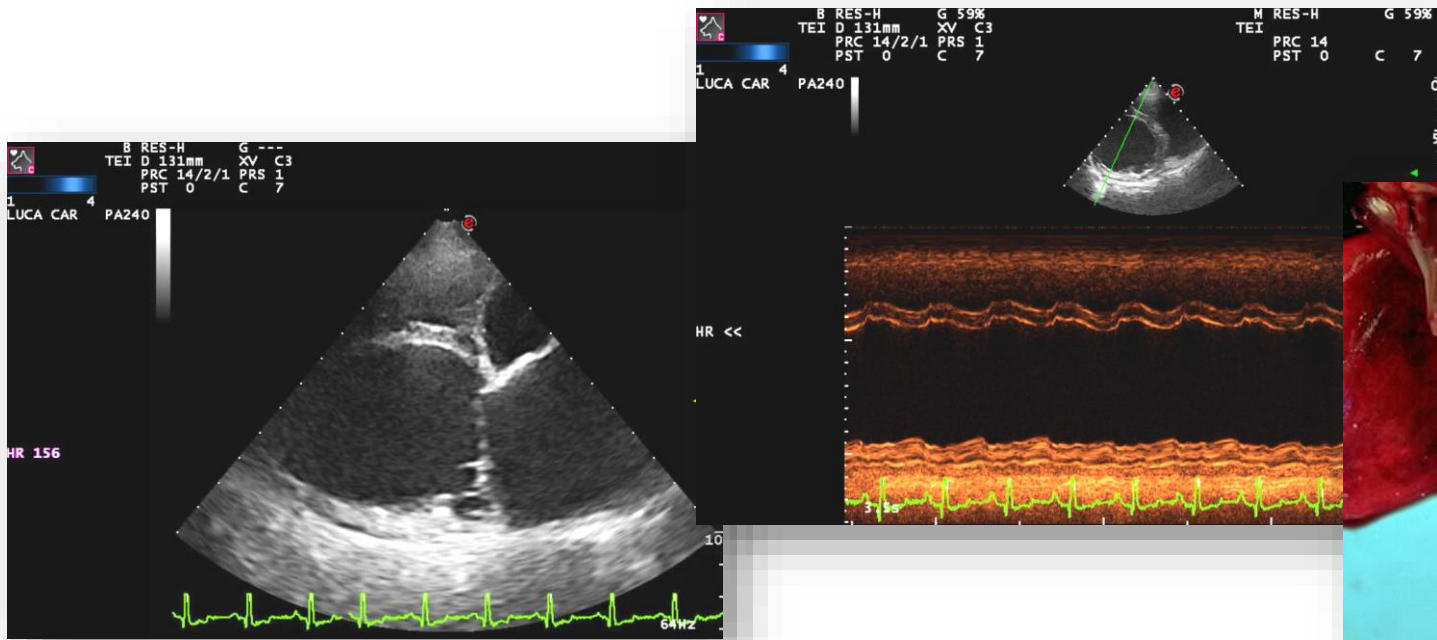


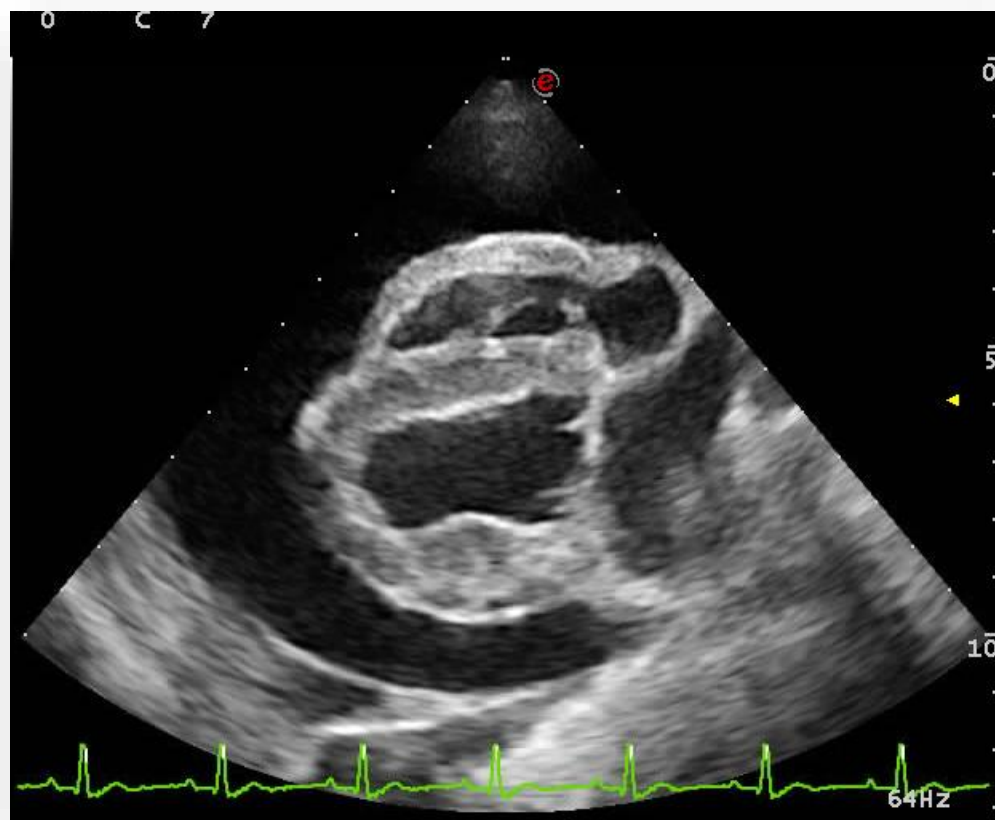
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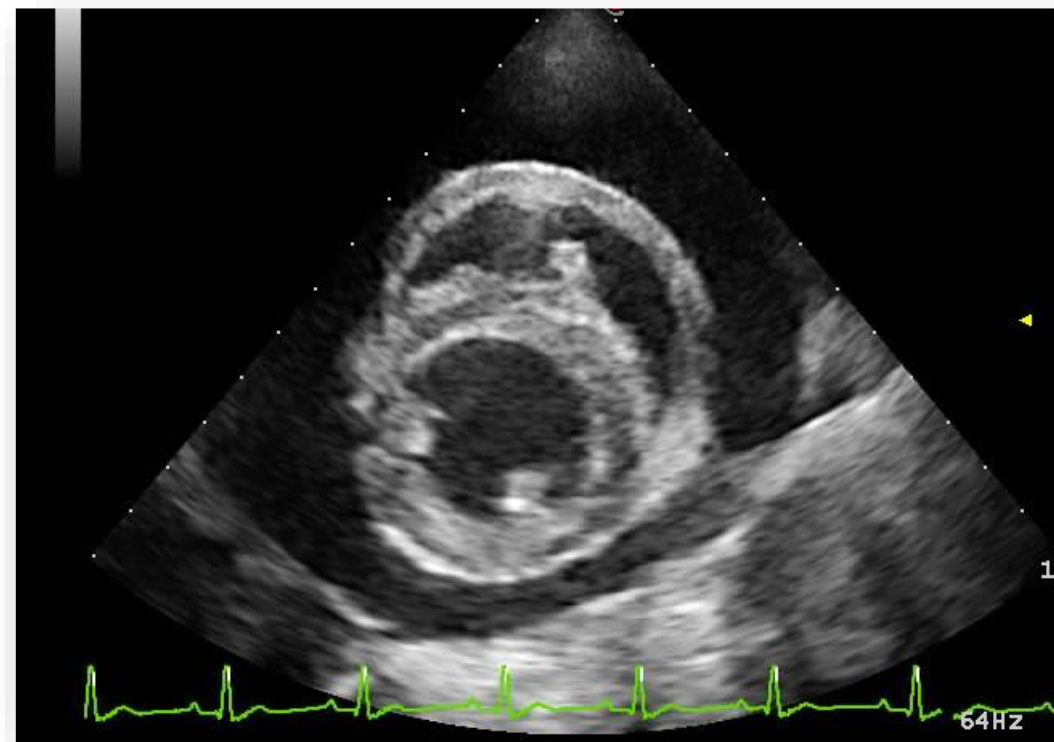
Cardiogenic Shock

- Failure of the heart to provide forward flow
- This may be due to a systolic or diastolic failure
 - Loss of myocardial contractility
 - Dysrhythmia
 - Structural or mechanical failure





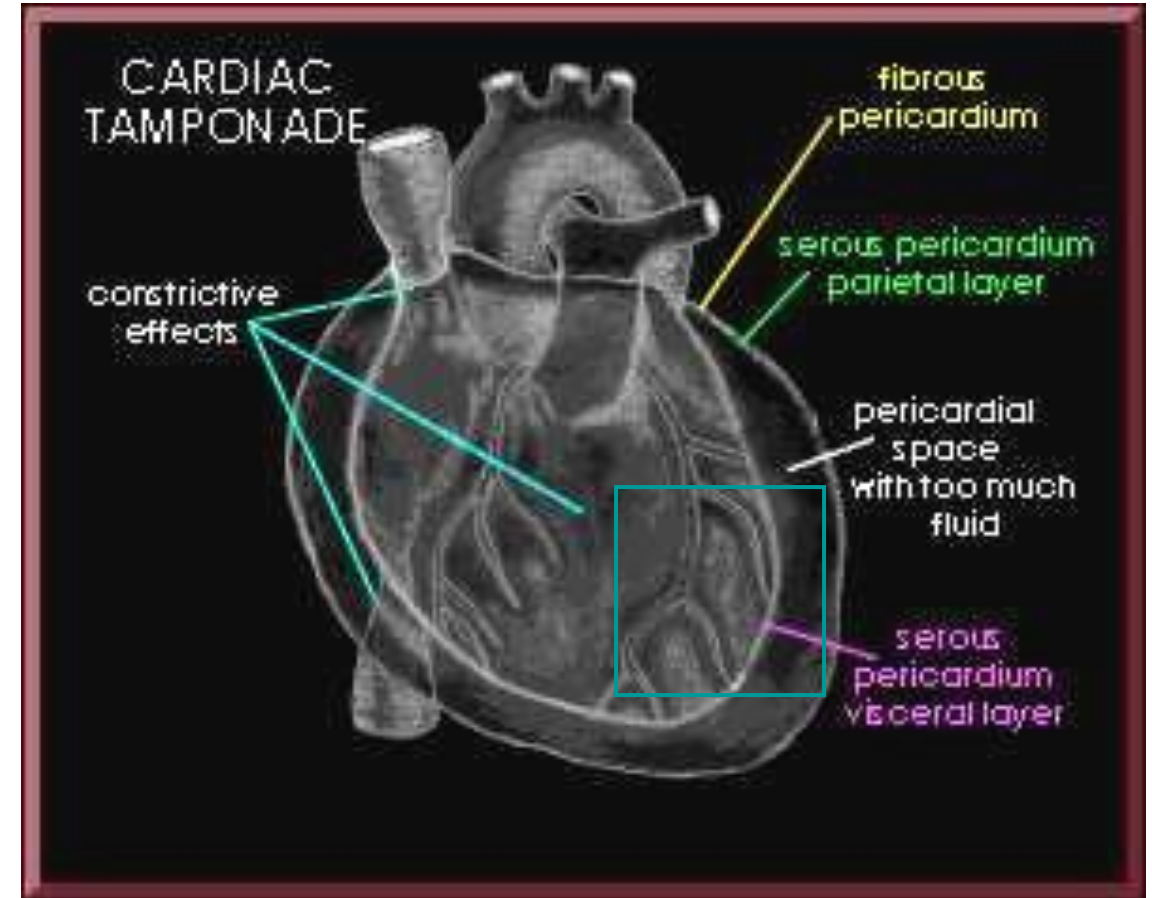
The University of Surrey, 2019



The University of Surrey, 2019

Obstructive Shock

- Pericardial effusion
- Cardiac tamponade occurs when intrapericardial pressure equals or exceeds RV pressure.
- CO is severely compromised and systemic venous pressure is substantially elevated.



- A slow rise in pericardial pressure leads to signs of right sided congestion alongside low CO
 - Idiopathic PE
 - Neoplastic PE
- A rapid rise in pericardial pressure can cause signs of poor CO alone without a large volume effusion
 - Left atrial rupture
 - Septic PE

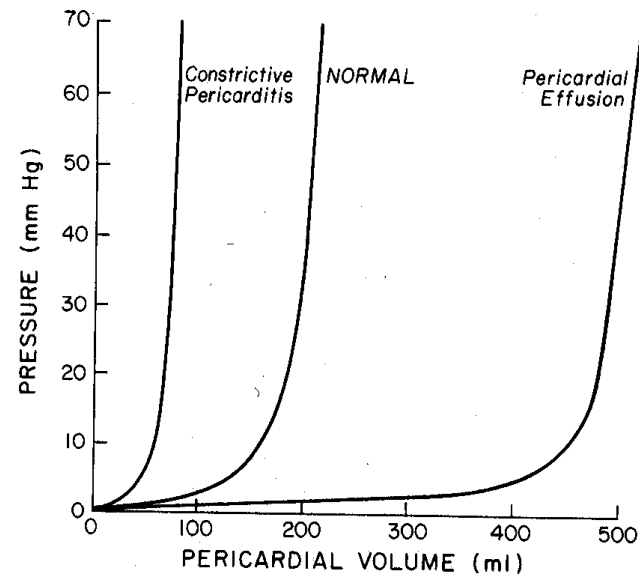


Vets Now Emergency Service, 2019





- Cardiac tamponade is alleviated by pericardiocentesis and removal of a **small quantity of fluid** can cause rapid reduction in IP and relieve clinical signs.
- It is **not necessary** to remove all of the pericardial fluid to achieve a beneficial haemodynamic effect



Metabolic and Hypoxemic Shock

Metabolic shock: Deranged cellular metabolic machinery

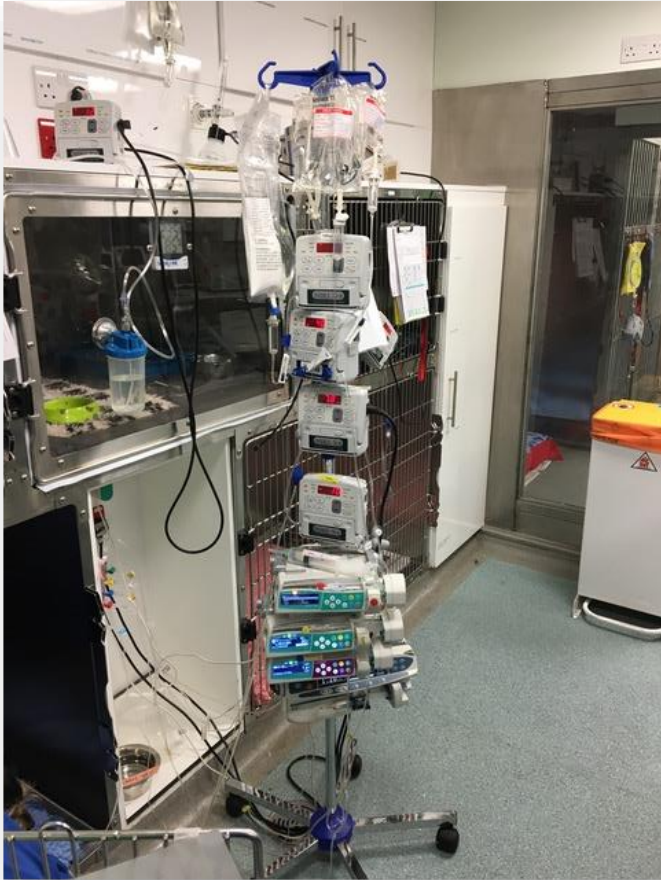
- Hypoglycemia
- Cyanide Toxicity
- Mitochondrial dysfunction

Hypoxemic Shock: A decrease in oxygen content in arterial blood

- Anemia
- Carbon monoxide toxicity
- Methemoglobinemia



Shock is an emergency



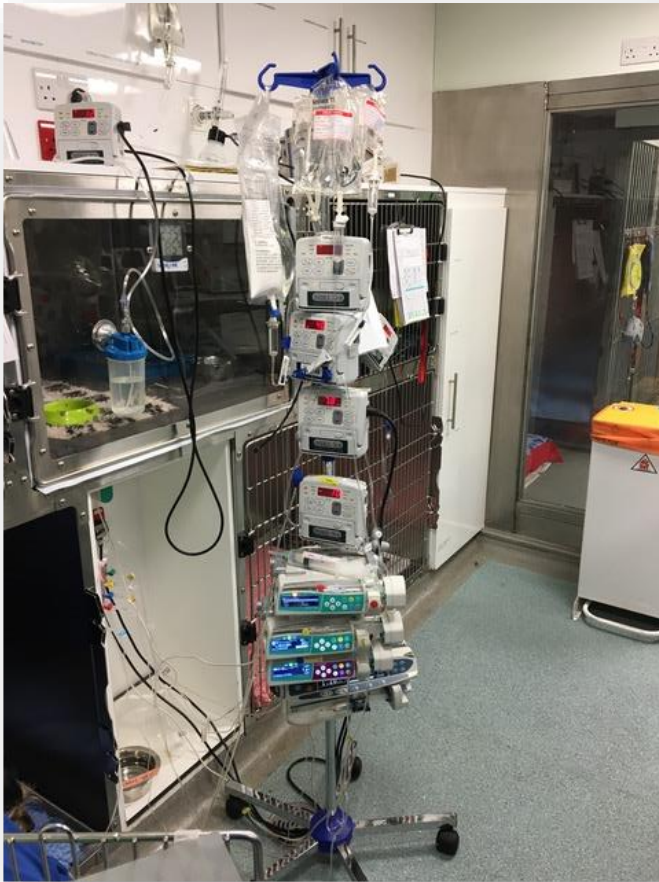
- In the compensatory stages the neurohormonal mechanisms are activated to maintain central venous pressure and O₂ supply to the heart, brain and lungs
- Neurohormonal mechanisms include
 - release of glucocorticoids
 - activation of the sympathetic nervous system
 - release of catecholamines
 - activation of the renin-angiotensin-aldosterone system
 - release of anti-diuretic hormone
 - release of aldosterone

Shock is an emergency

- Early recognition of shock is vital
- Aim to rapidly restore the cardiovascular system so that the delivery of O₂ to tissues is normalised as soon as possible

Table 2. Clinical parameters and resuscitation endpoints monitored during resuscitation from shock

Parameter	Normal	Compensatory Stage	Early Decompensatory Stage	Late Decompensatory Stage	Resuscitation End Point
Mentation	Alert	Excited and alert	Normal to decreased	Decreased to comatose	Alert
Heart Rate (bpm)	Dog: 60-120 Cat: 170-200	Dog: > 140 Cat: variable	Dog: > 140 Cat: variable	Dog: < 140 Cat: < 160	Dog: 80-140 Cat: 180-220
Mucous Membrane Color	Pink	Brick red	Pale	Grey/blue	pink
Capillary Refill Time (seconds)	1-2	<1	>2	>2	1-2
Mean Arterial Blood Pressure (mmHg)	80-100	> 80	Variable	< 80	80-100
Central Venous Pressure	0-2	Variable	< 5	variable	5-10



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