Managing Hypotension

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QVS

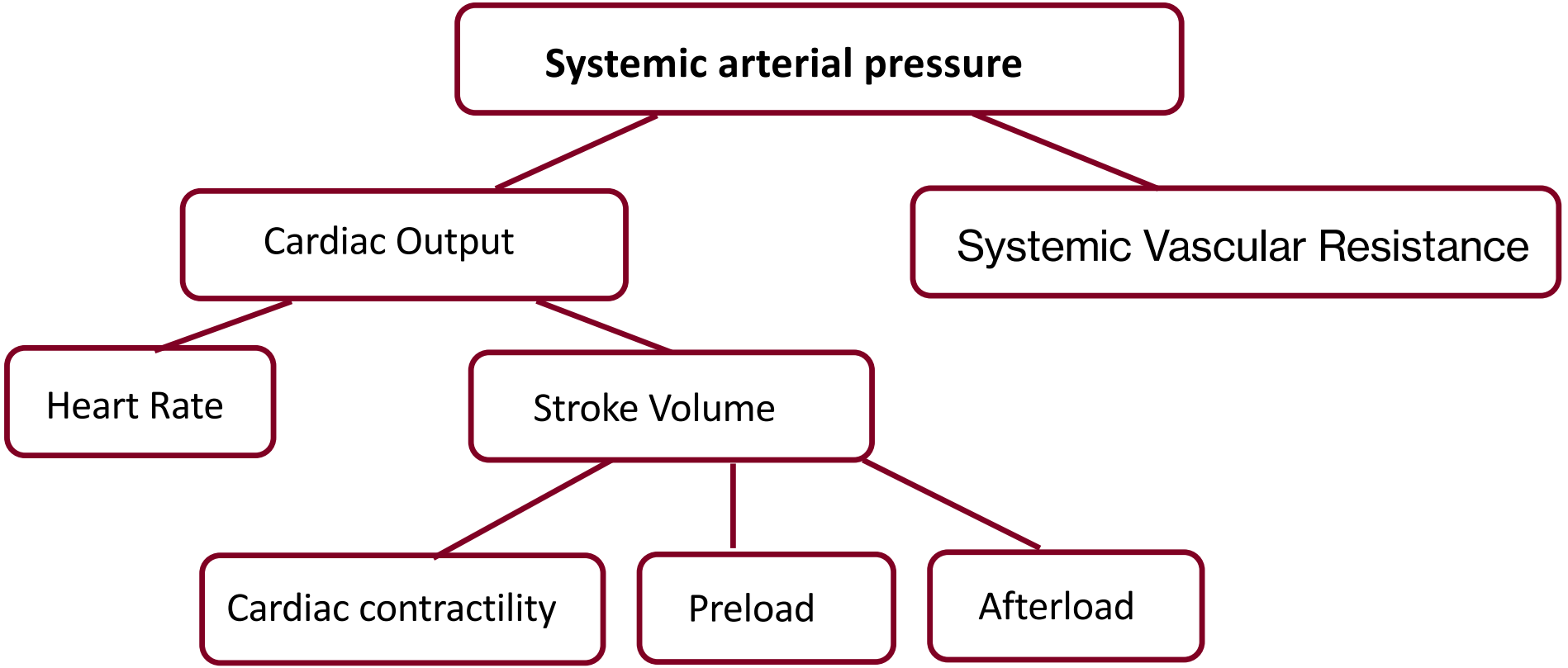
QUEENSLAND VETERINARY SPECIALISTS

Objectives

Understand:

- Physiological responses to hypotension
- Possible causes of hypotension
- Treatment options
- Clinical application

Definitions



Definitions

Hypotension = low systemic arterial blood pressure

Systolic blood pressure (SBP) <80mmHg

Mean arterial blood pressure (MAP) < 60-65mmg

Hypotension ≠ Shock

😮

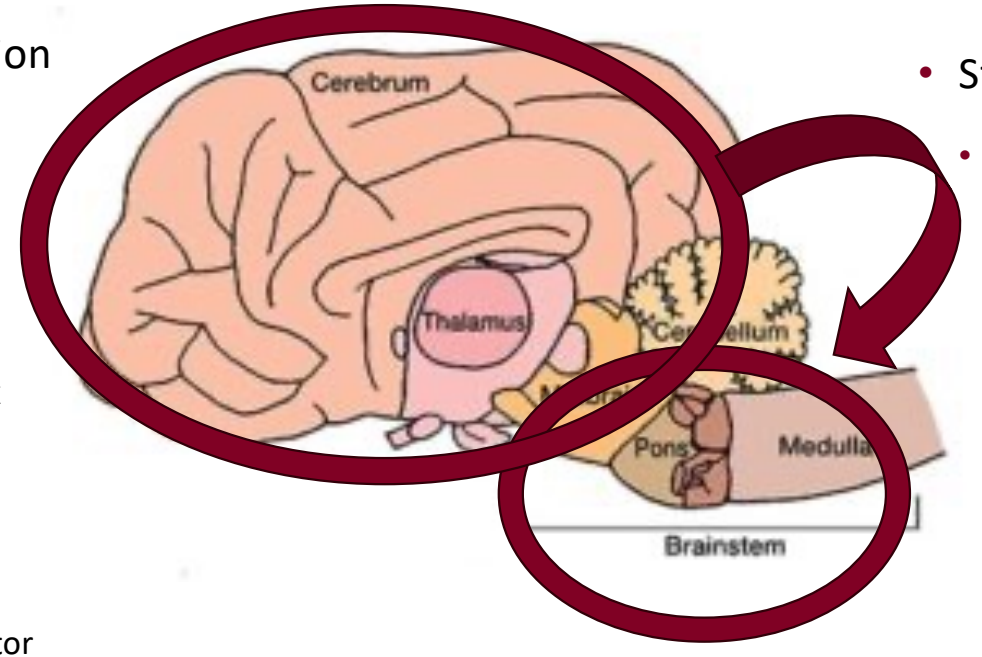
Blood Pressure Homeostasis

- Autoregulation maintains blood pressure within 70-175mmHg
- Compensation: neural, metabolic, humoral
- Combined vasoconstrictive and vasodilatory effects:
  1. Ensure adequate blood flow to tissues
  2. Prioritise flow to areas of high oxygen demand

Neural compensation

Vasomotor centre

- Direct sympathetic stimulation
  - Vasoconstriction
  - Cardiac ANS stimulation
- Controlled by
  - Hypothalamus/cerebral cortex
- Receive feedback from
  - Atria and carotid bodies
    - Chemoreceptor and baroreceptor



CNS Ischaemic Response

- Strong response
  - Only at SAP <50mmHg

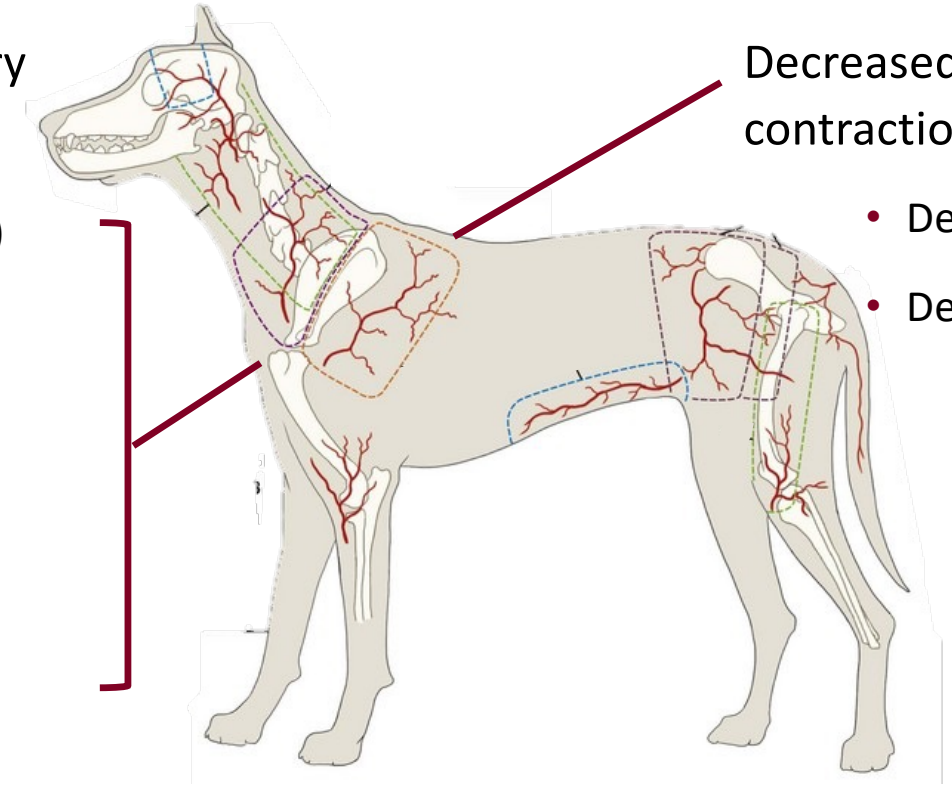
Image courtesy https://todaysveterinarypractice.com/

Metabolic compensation

Decreased tissue oxygen delivery (DO2) **increases** tissue blood flow

Accumulation of vasodilatory substances

- Adenosine (and compounds)
- Carbon dioxide (CO2)
- Histamine
- Potassium ions [K+]
- Hydrogen ions [H+]



Decreased energy for smooth muscle contraction

- Decreased DO2
- Decreased glucose delivery

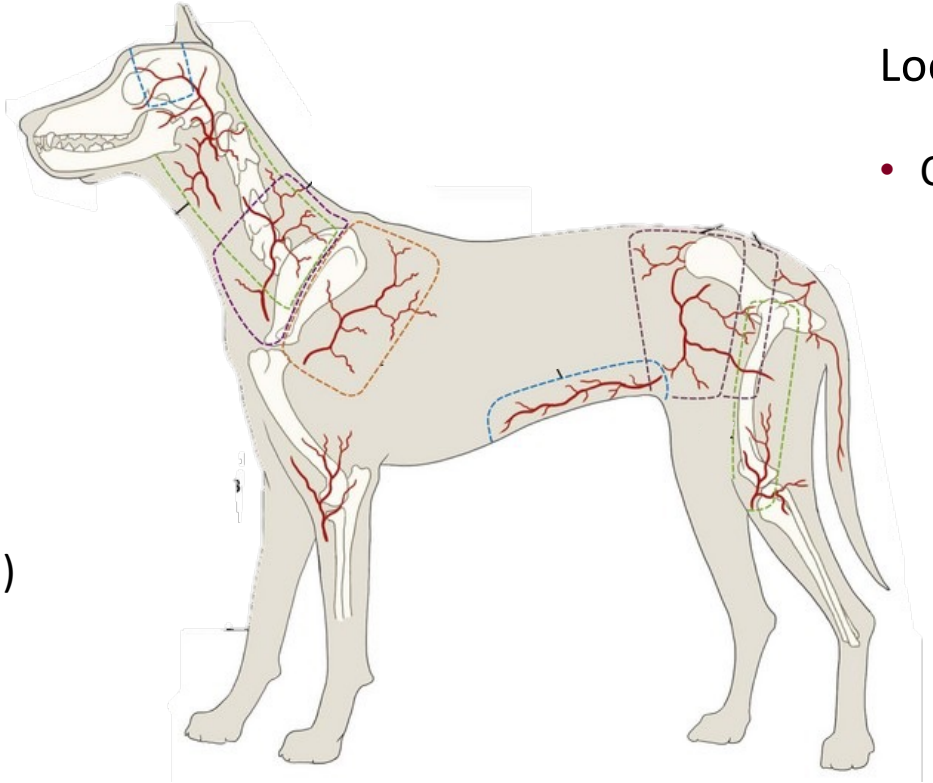
Image courtesy https://veteriankey.com/axial-pattern-and-myocutaneous-flaps/

Metabolic compensation

Ionic and Chemical Factors

Local vasodilation

- CO2
- [H+] (Acidaemia)
- [K+]
- Magnesium [Mg2+]
- Anions (acetate and citrate)



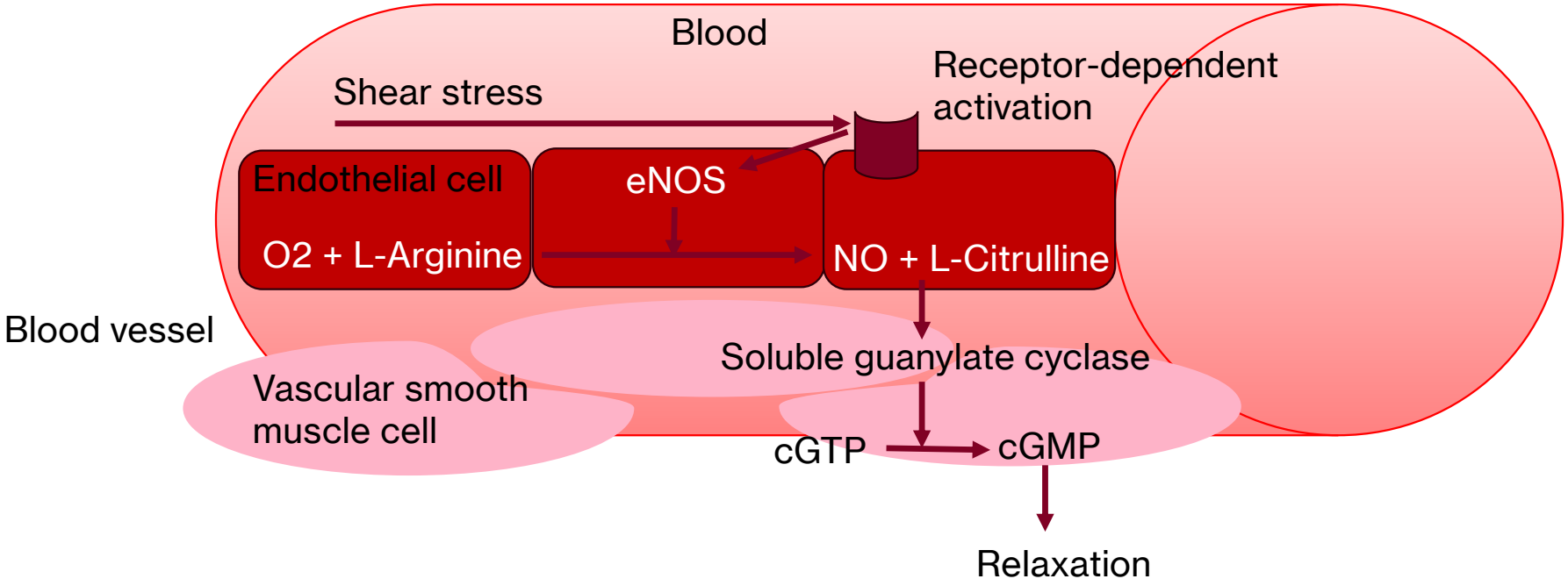
Local *vasoconstriction*

- Calcium [Ca2+]

Image courtesy https://veteriankey.com/axial-pattern-and-myocutaneous-flaps/

Metabolic compensation

Endothelial Derived Factors

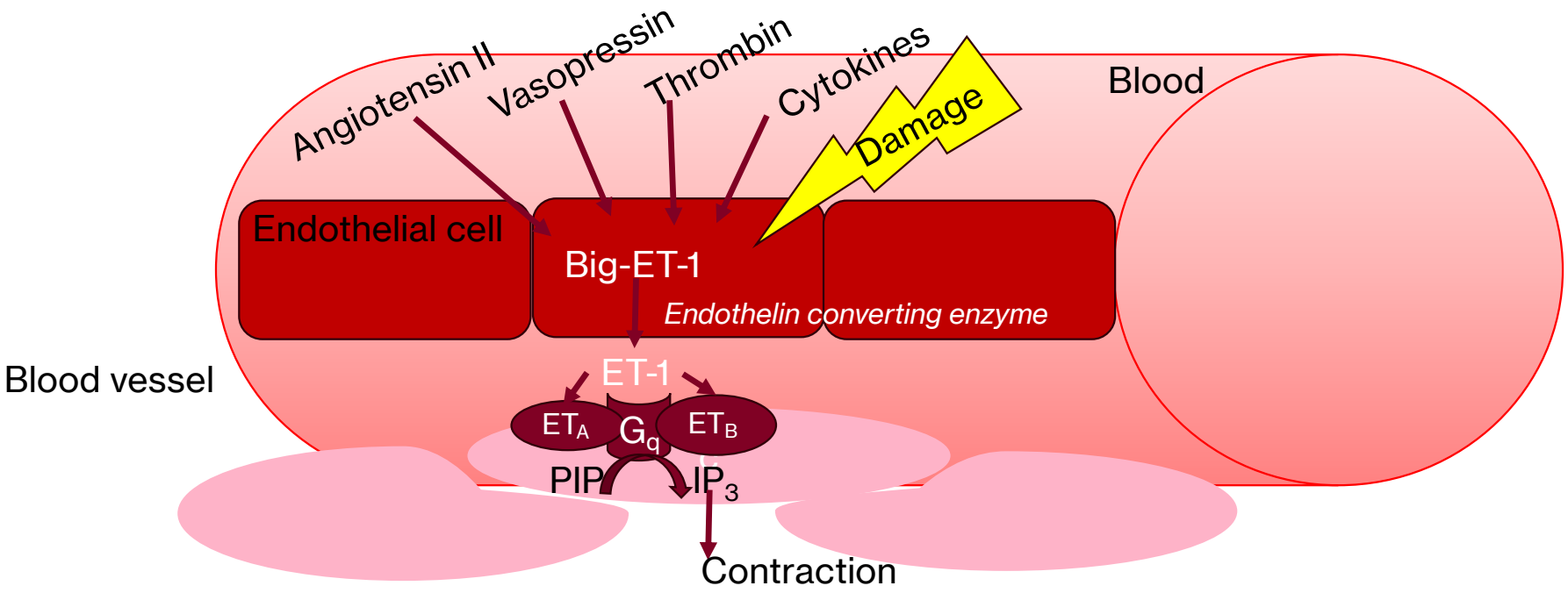


Nitric oxide causes vasodilation

Image adapted Guyton 2016

Metabolic compensation

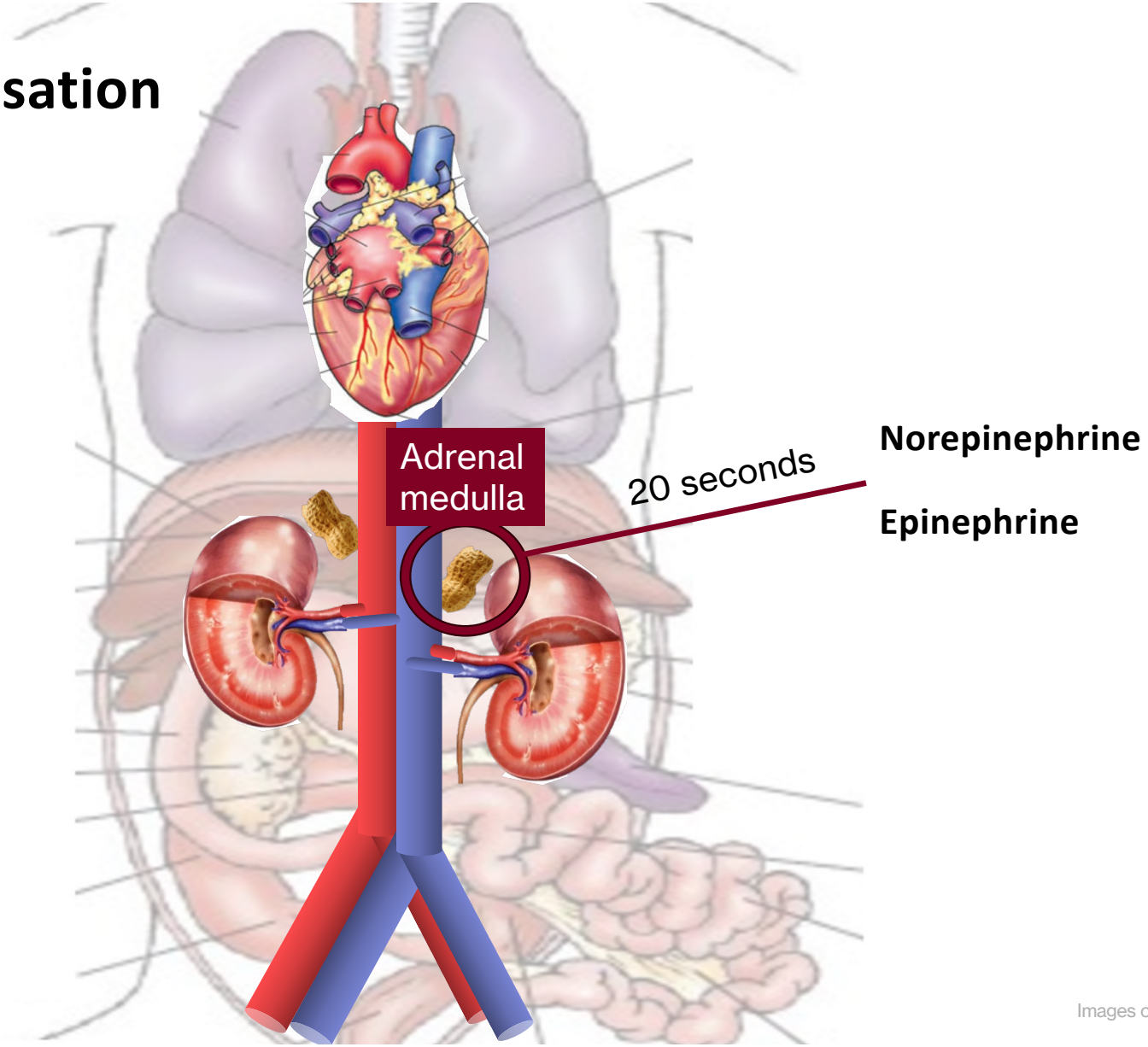
Endothelial Derived Factors



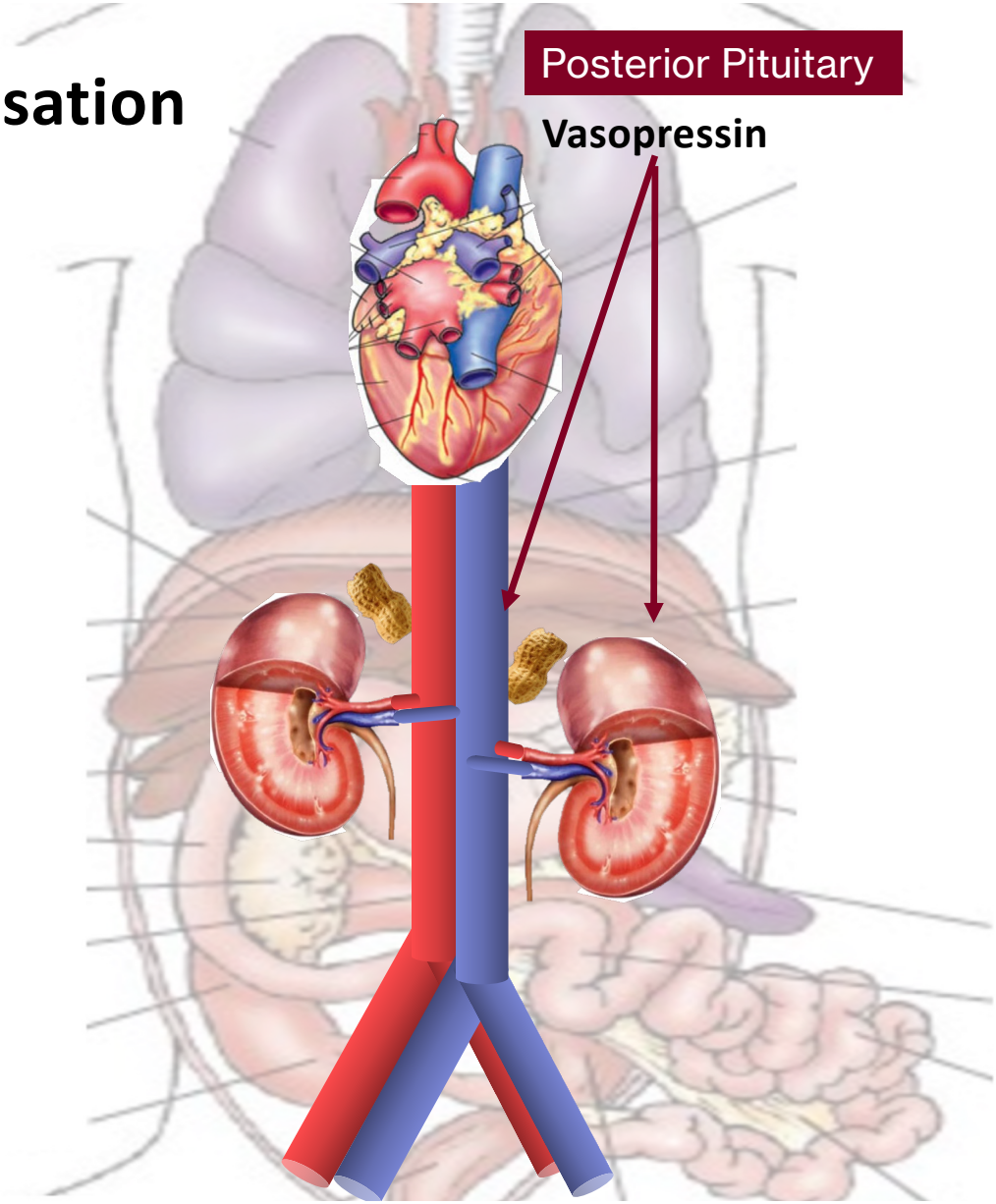
Endothelin (ET) causes vasoconstriction

Image adapted Guyton 2016

Humoral compensation

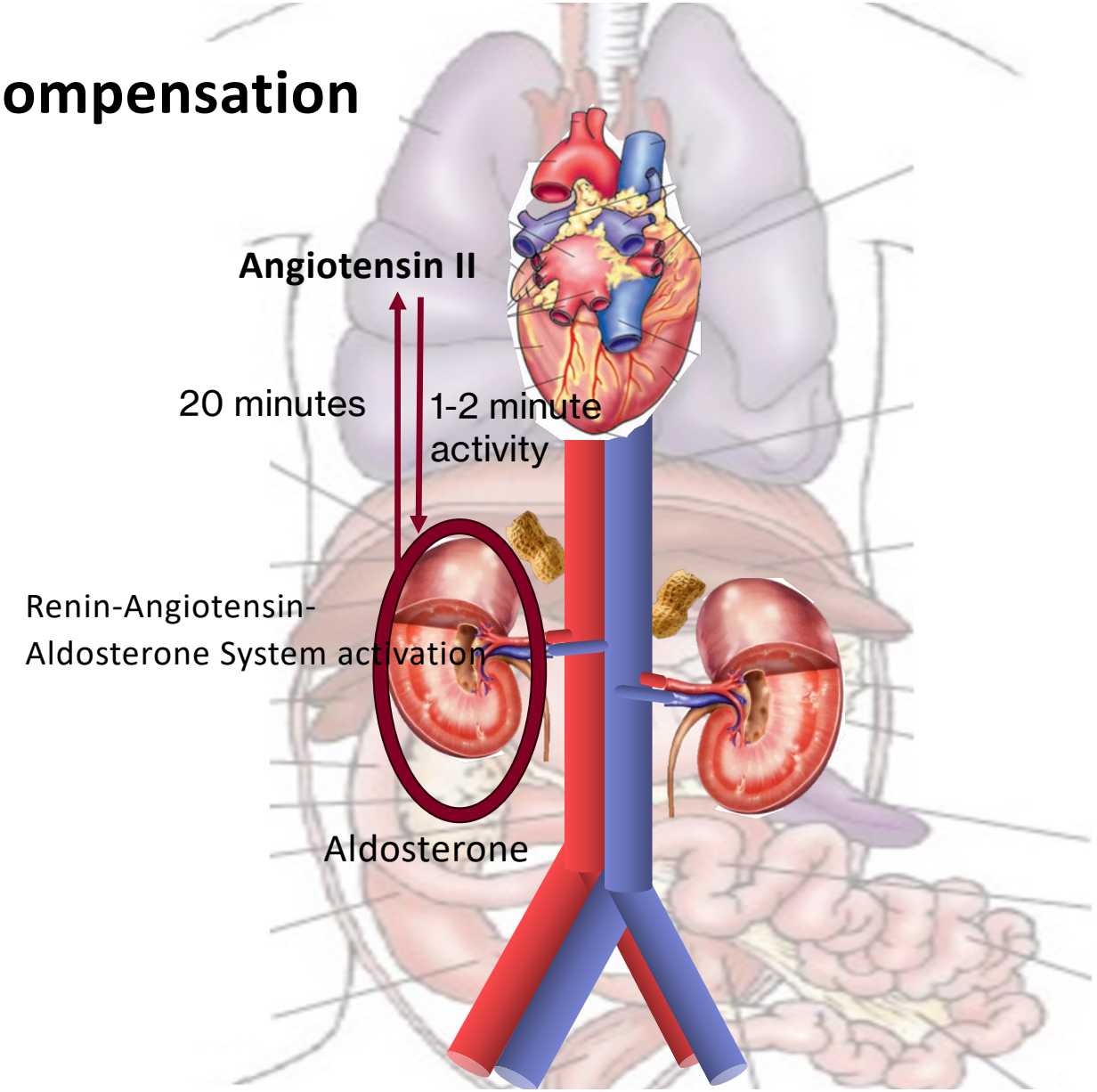


Humoral compensation



Images courtesy Jack CM 2008,
waggingright.com 2024

Humoral compensation



Pathophysiology

Hypotension occurs when:

- Compensatory mechanisms are insufficient
- Severity of pathology exceeds compensatory capacity

- Abnormal function in any determinant of blood pressure

↓ Preload

↓ Systemic vascular resistance

Cardiac dysfunction

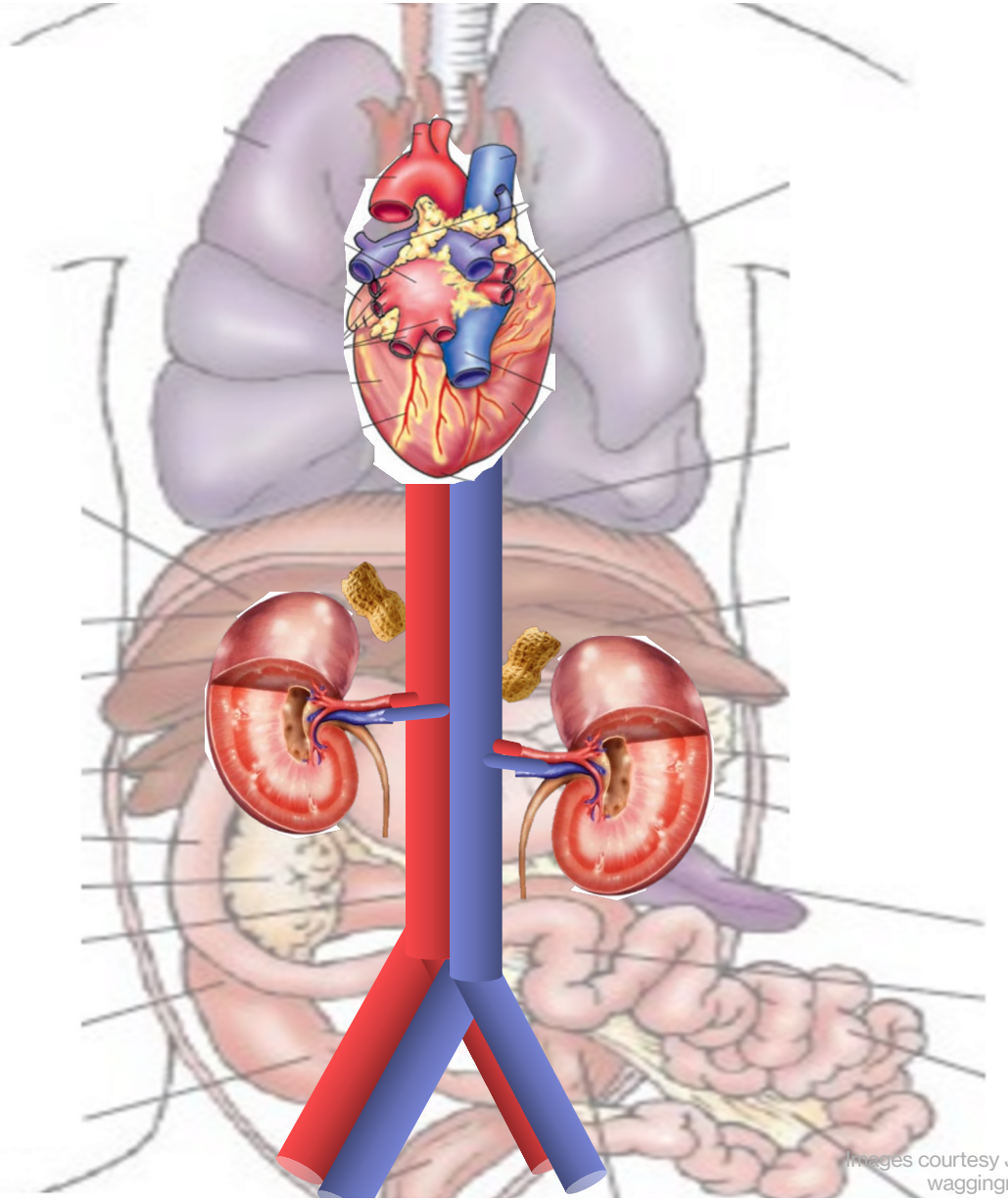
↓ Preload

Hypovolaemia

- Gastrointestinal losses (V+/D+)
- Haemorrhage
- Polyuria

Obstructed venous return

- Cardiac tamponade
- Pneumothorax
- Gastric Dilation Volvulus (GDV)

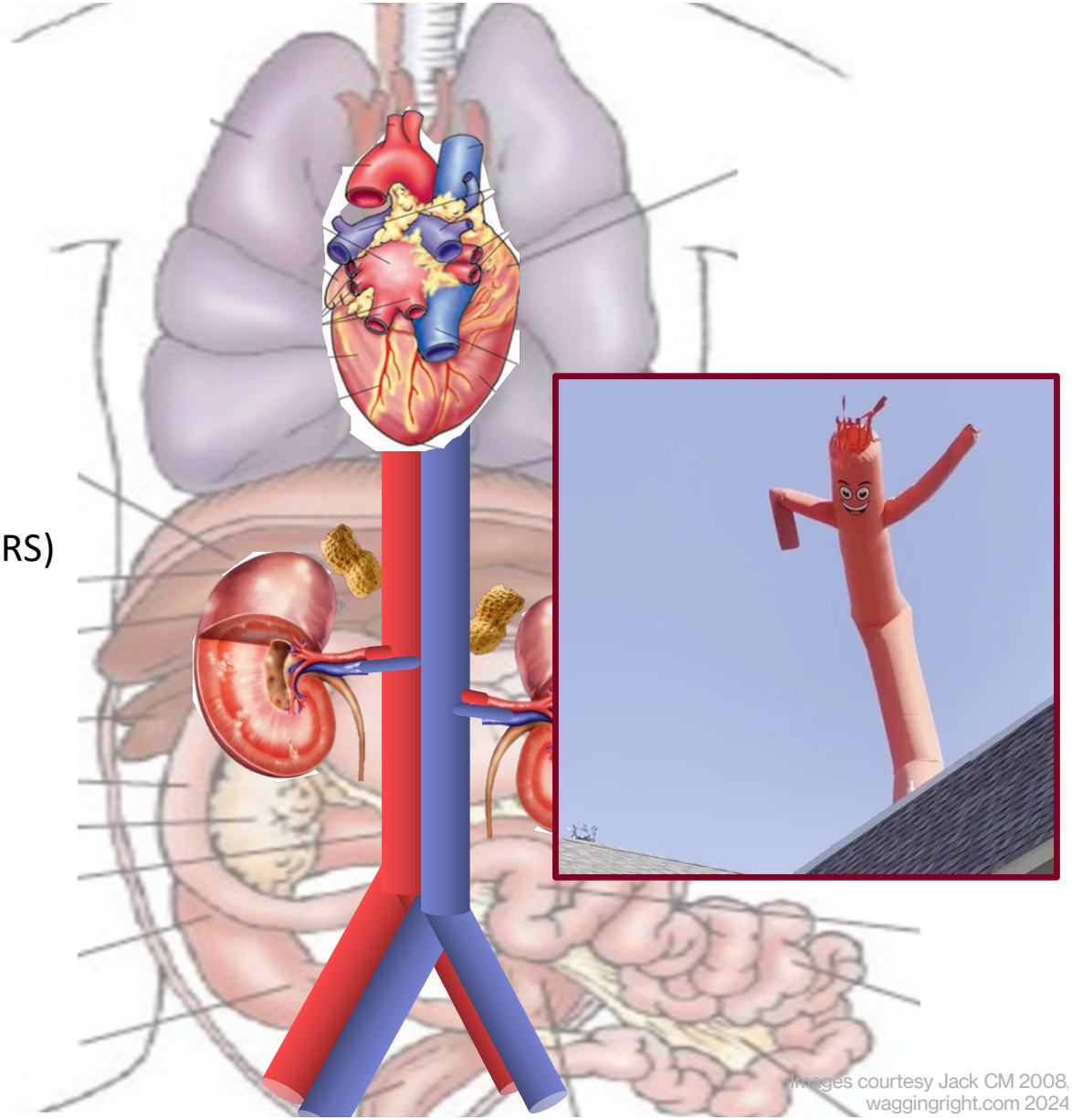


↓ Systemic vascular resistance

Primary disease process

- Sepsis
- Non-infectious systemic inflammation (SIRS)
  - Anaphylaxis
  - Thermal burn injury

Anaesthetic agents



Images courtesy Jack CM 2008, waggingright.com 2024

Cardiac dysfunction

Arrhythmias

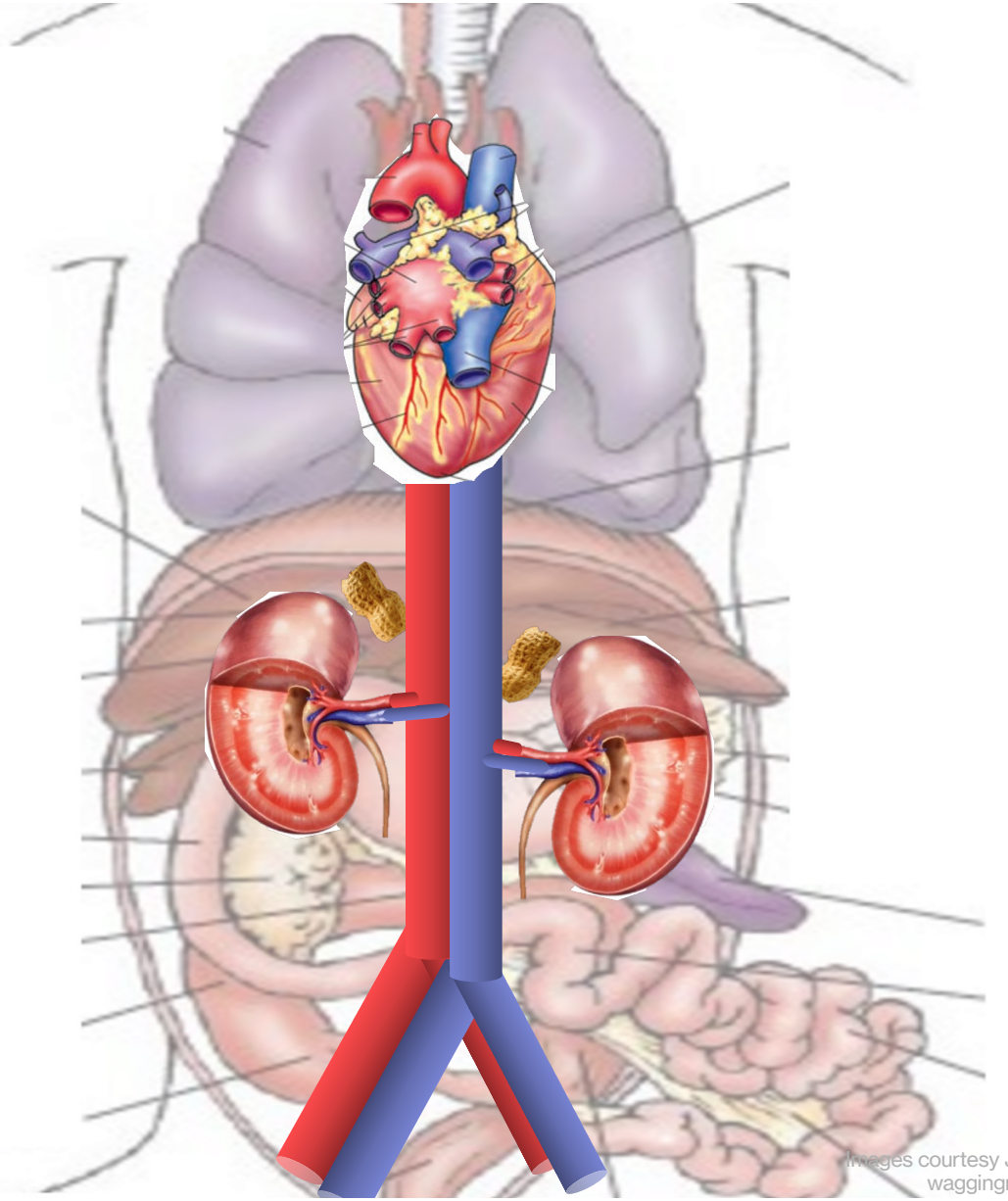
- Tachyarrhythmias (VT, SVT)
- Bradyarrhythmias (sinus, AV Block)

Systolic dysfunction

- Dilated cardiomyopathy
- Cardiomyopathy of sepsis

Diastolic dysfunction

- Hypertrophic cardiomyopathy



Diagnosing Hypotension

Blood Pressure Measurement

Direct

Gold Standard

- Pulse contours provide additional information
- Invasive
- Requires specialized equipment

Indirect

Doppler, Oscillometric

- Easily available
- Non-invasive
- Caution accuracy
  - Appropriate set up is important to minimize error

Diagnosing Hypotension

Hypotension ≠ Shock

😮

- Assess perfusion parameters:
  - Heart Rate
  - Mentation
  - Capillary refill time
  - Mucous membrane colour
  - Peripheral temperature
  - Peripheral pulse quality

Diagnosing Hypotension

- Diagnose cause of hypotension

1. Point of Care Ultrasound (POCUS)
2. Venous Blood Gas, Electrolyte and Metabolite Analysis
3. Electrocardiography

Treating Hypotension

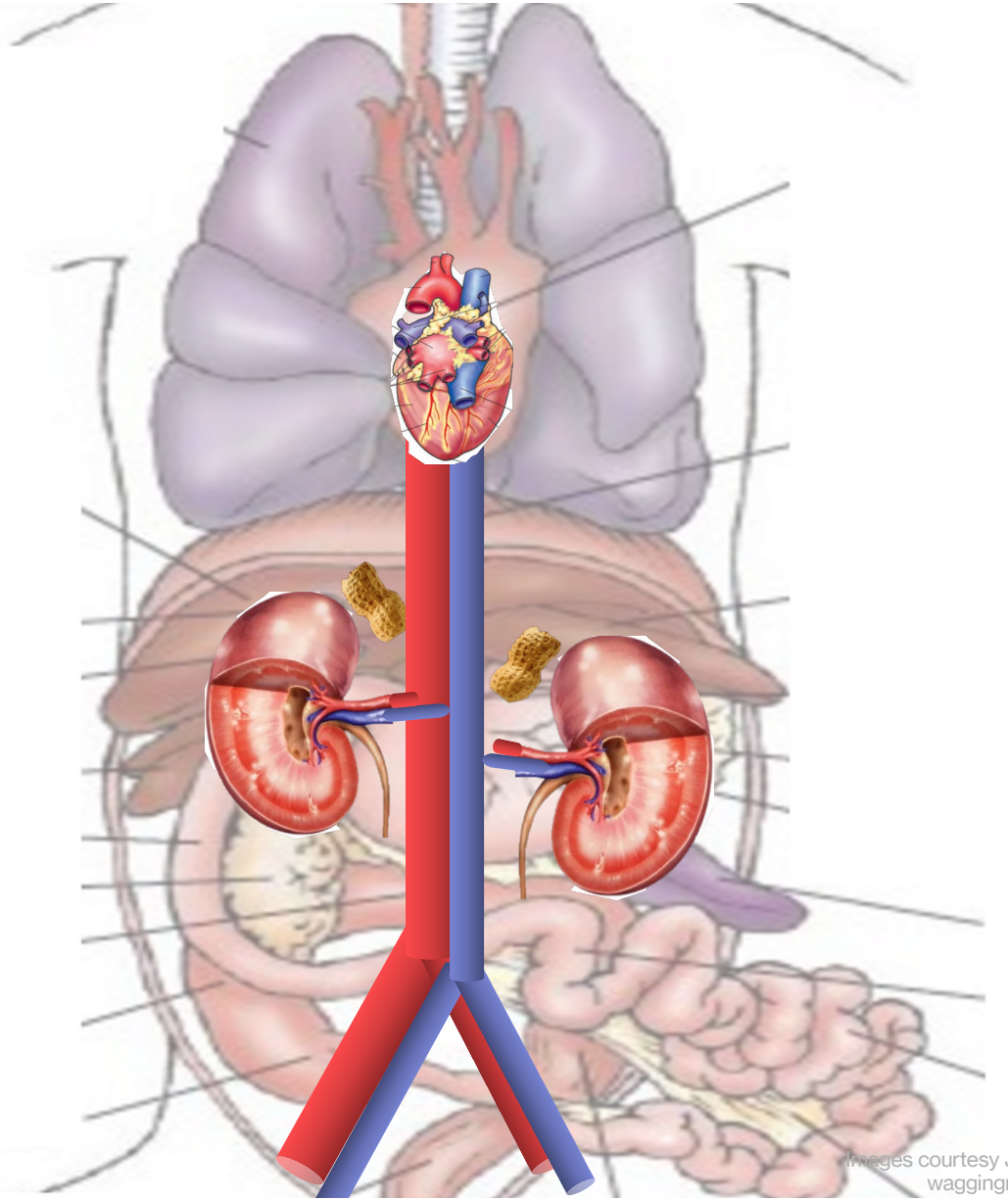
- Correct the cause of hypotension
  - May be multifactorial
  - May change

Multiple interventions may be required in an individual patient

↓ Preload

Requires <u>Volume</u>

- Balanced isotonic crystalloid
  - 10-15ml/kg over 10-15 min (dogs)
    - 5ml/kg cats
    - Easily accessible, rapid, inexpensive
    - Reassess normalization after bolus



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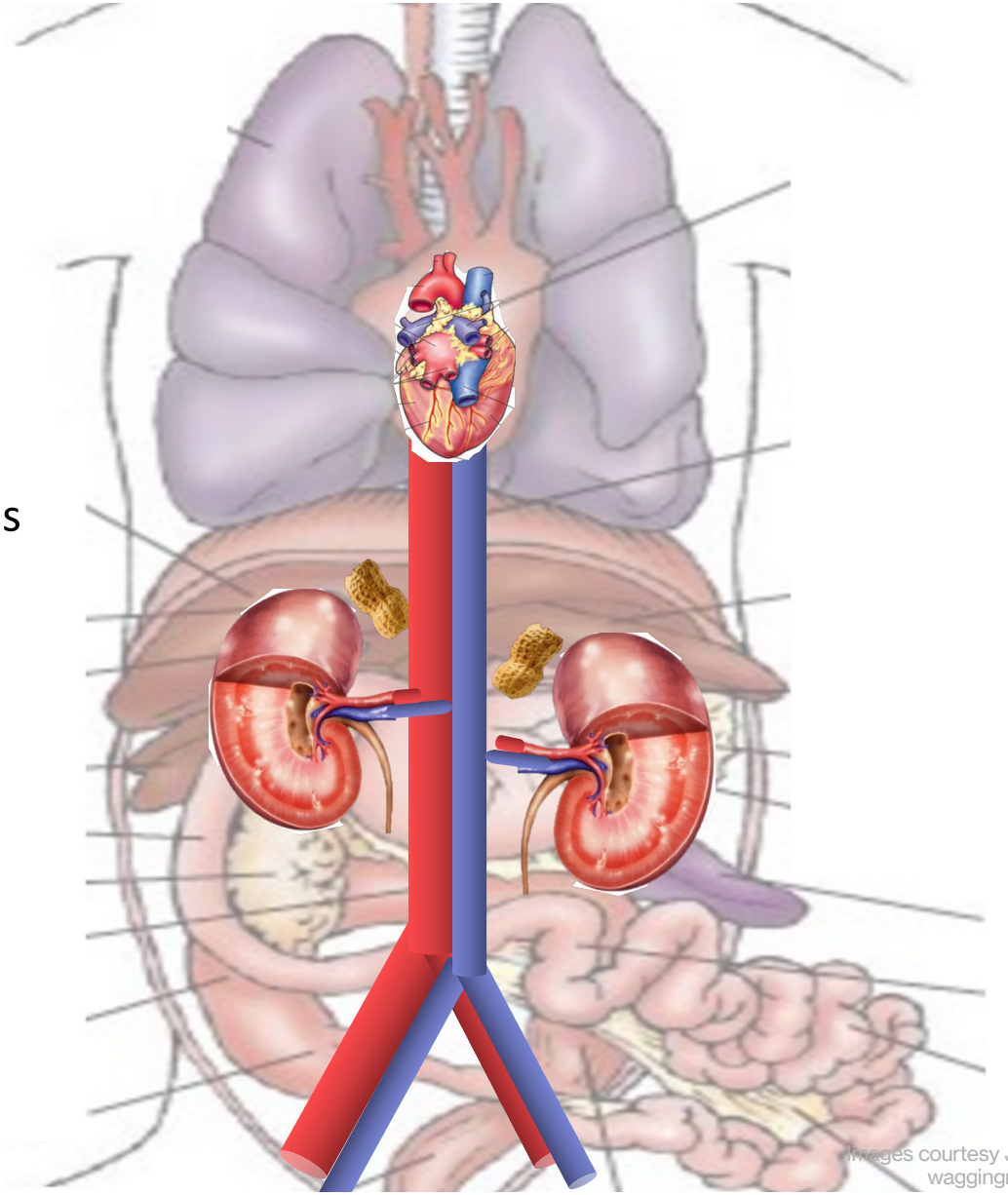
Requires **Volume**

- Persistent hypotension after 1-2 boluses
- Consider fluid type:



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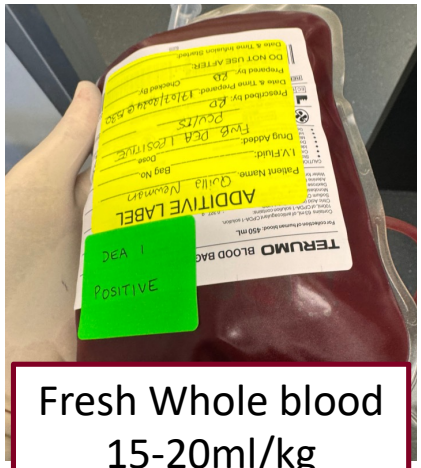
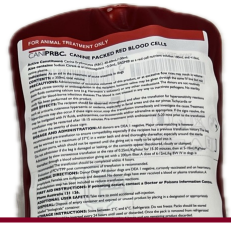
Caution: Citrate toxicity → ionized hypocalcaemia



Fresh Whole blood
15-20ml/kg

OR



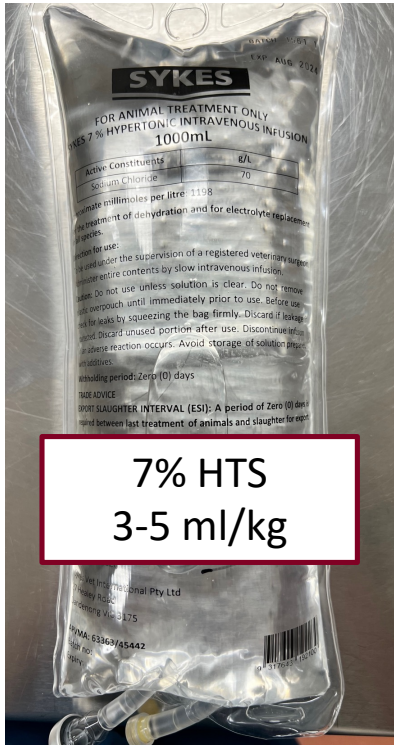
Packed red blood cells
10-15ml/kg

Fresh Frozen
Plasma
10-20ml/kg

OR

Fresh Frozen
Plasma
15-20ml/kg

OR

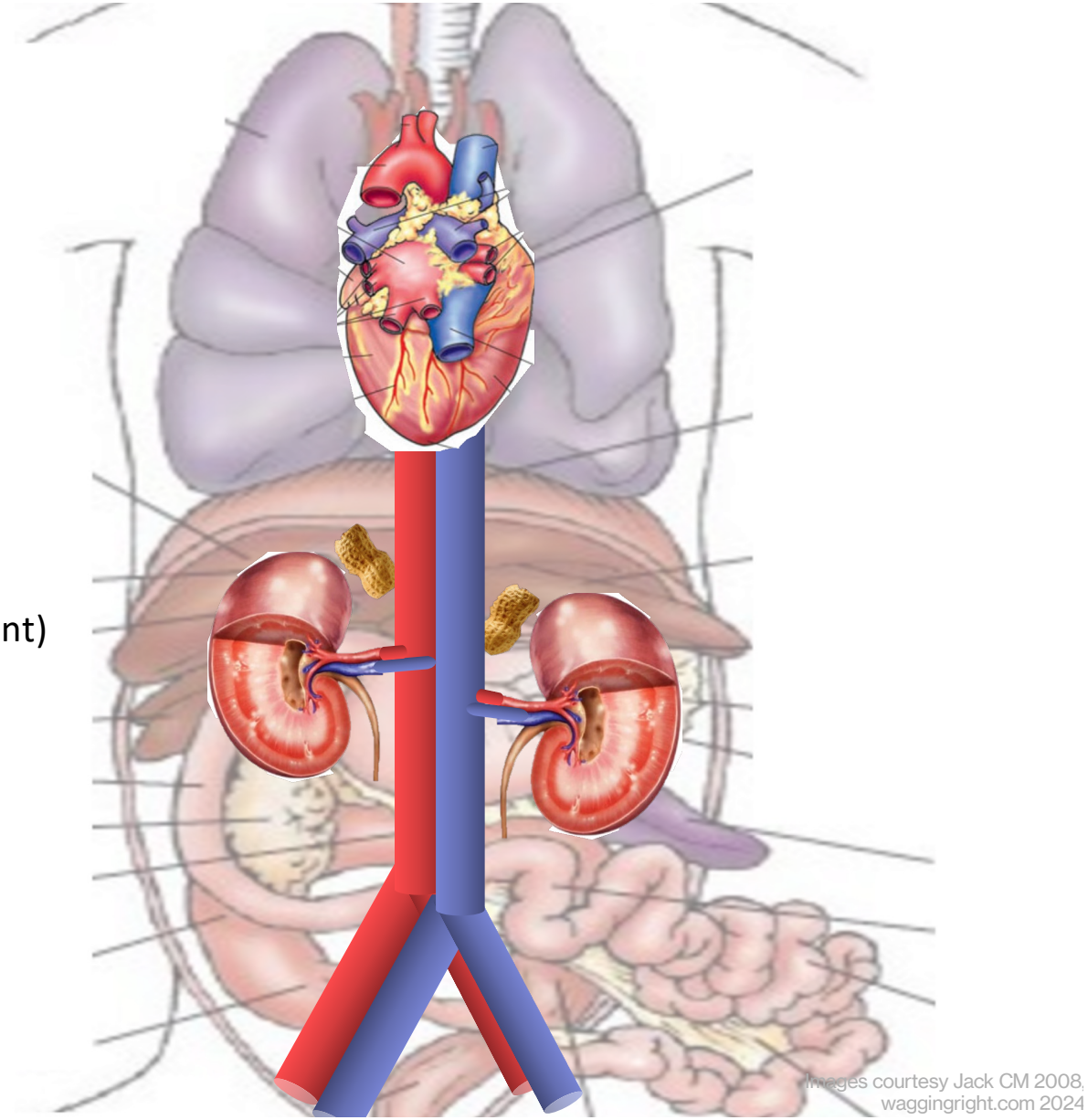


7% HTS
3-5 ml/kg

↓ Preload

+/- requires <u>Relief of obstruction</u>

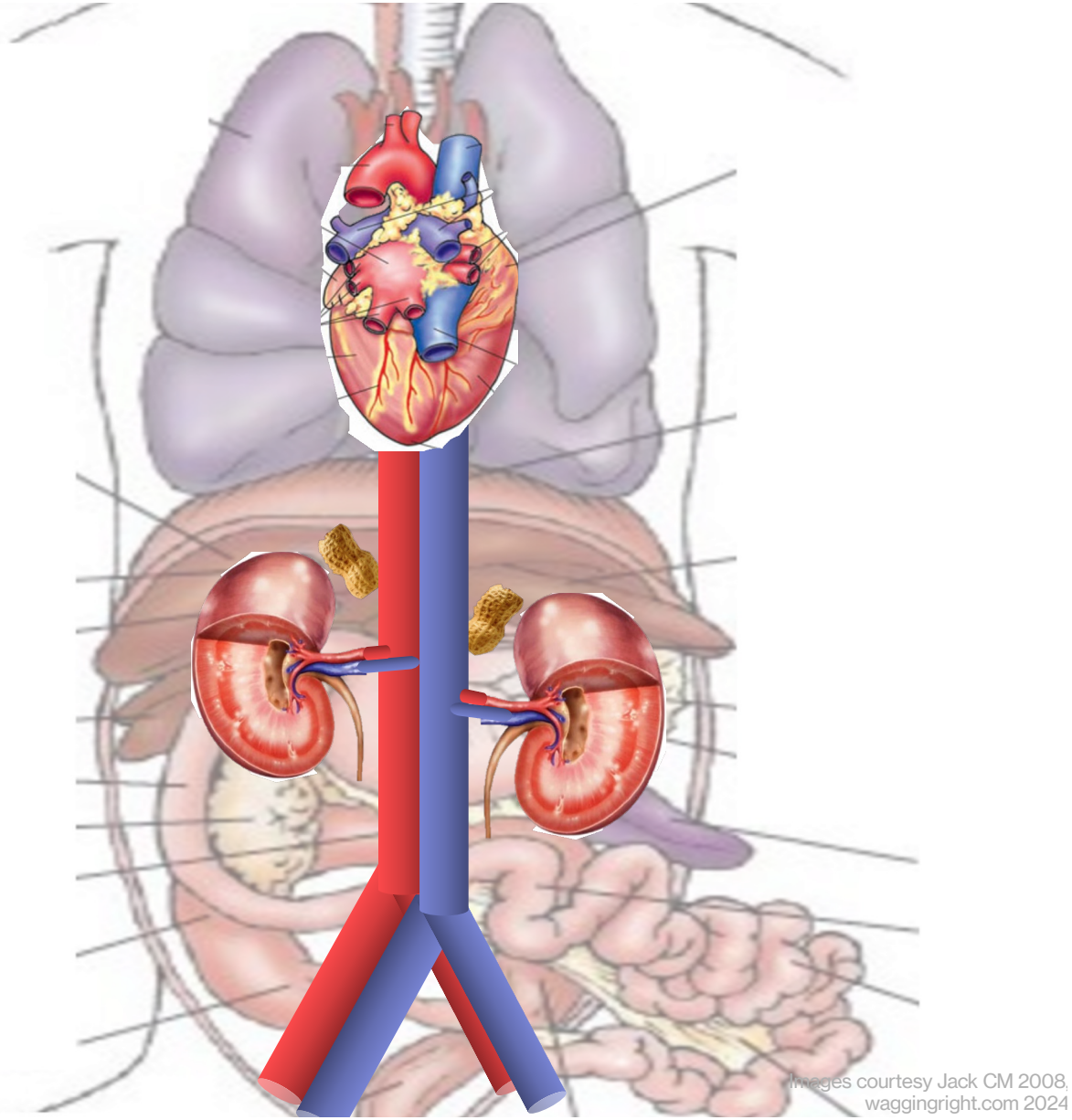
- Decompression
  - Pericardiocentesis, thoracocentesis, trocharisation (vs orogastric tube placement)



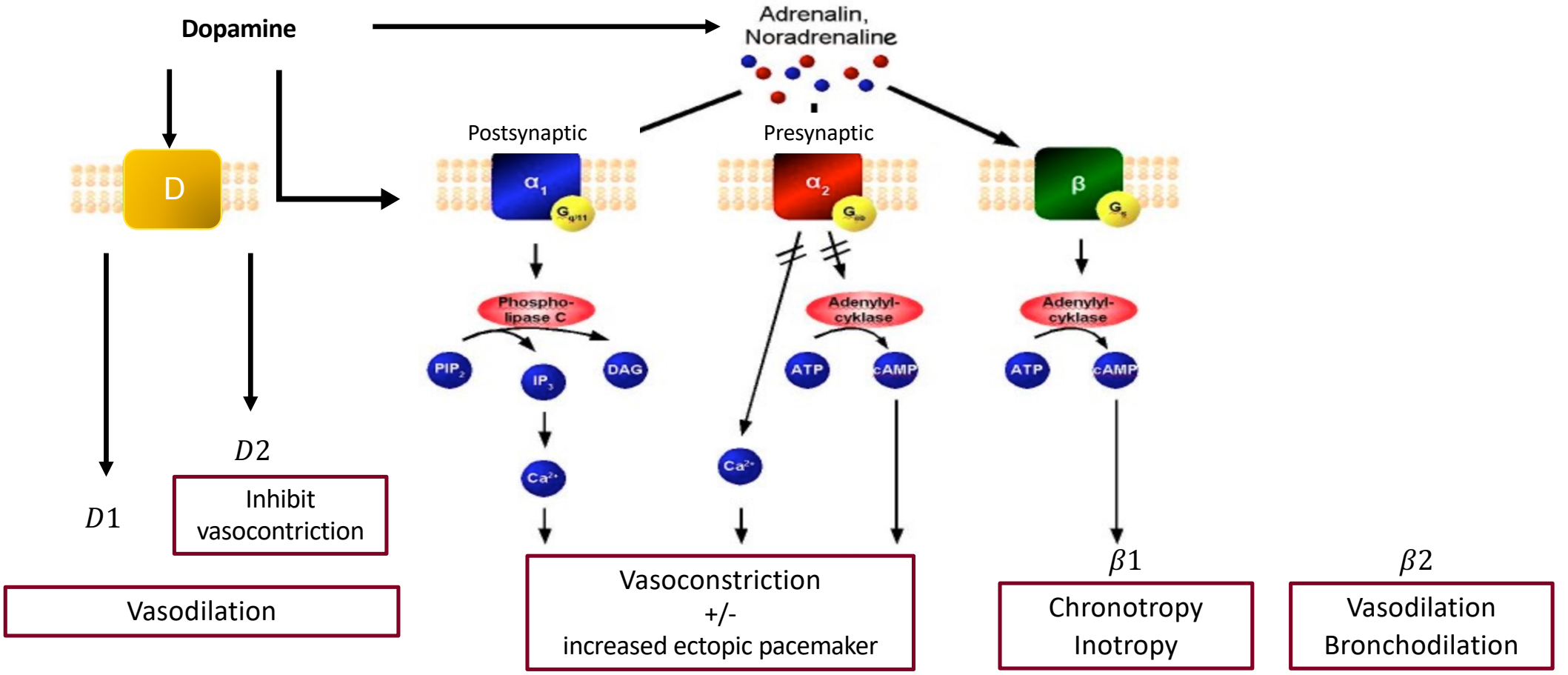
↓ Systemic vascular resistance

+/- requires vasoconstriction

- Vasopressor therapy



Catecholamines



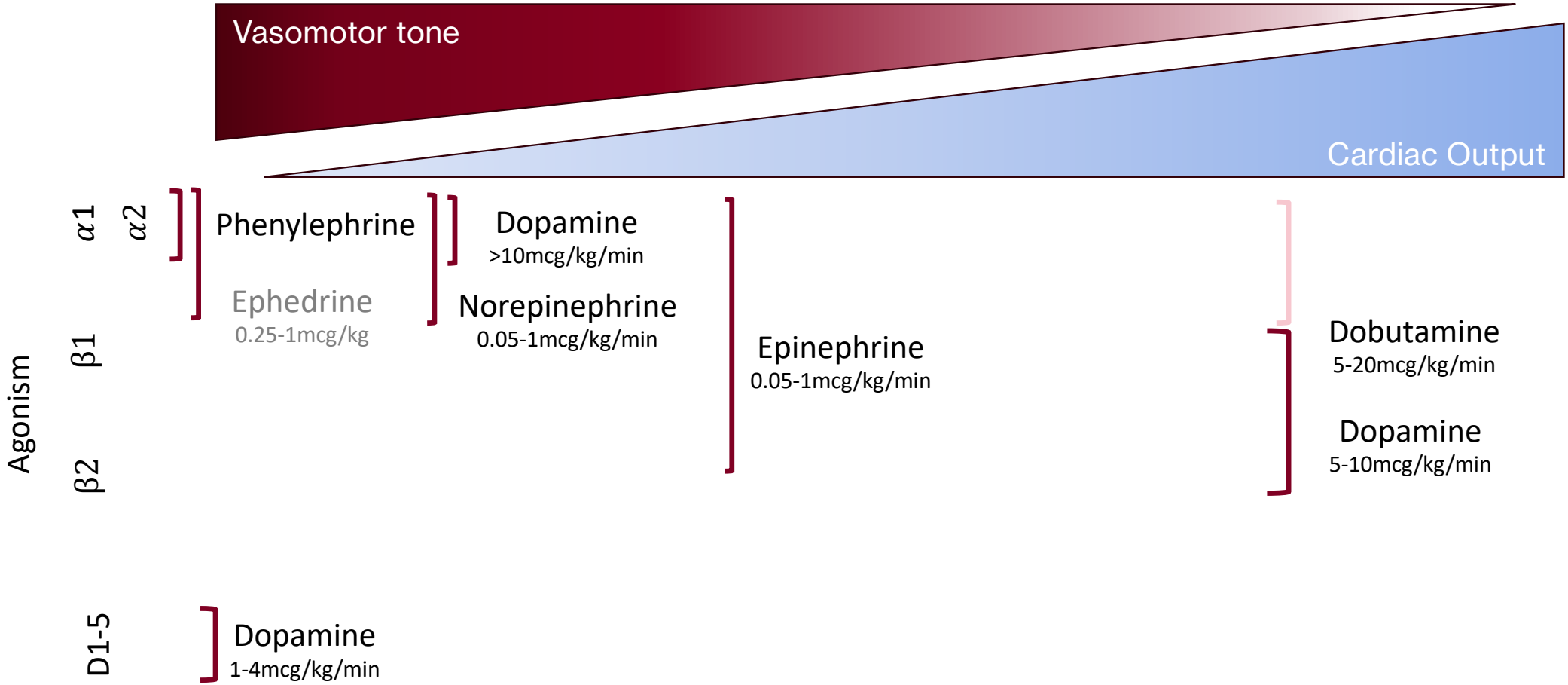
Graphic courtesy Wikimedia.org

Catecholamines

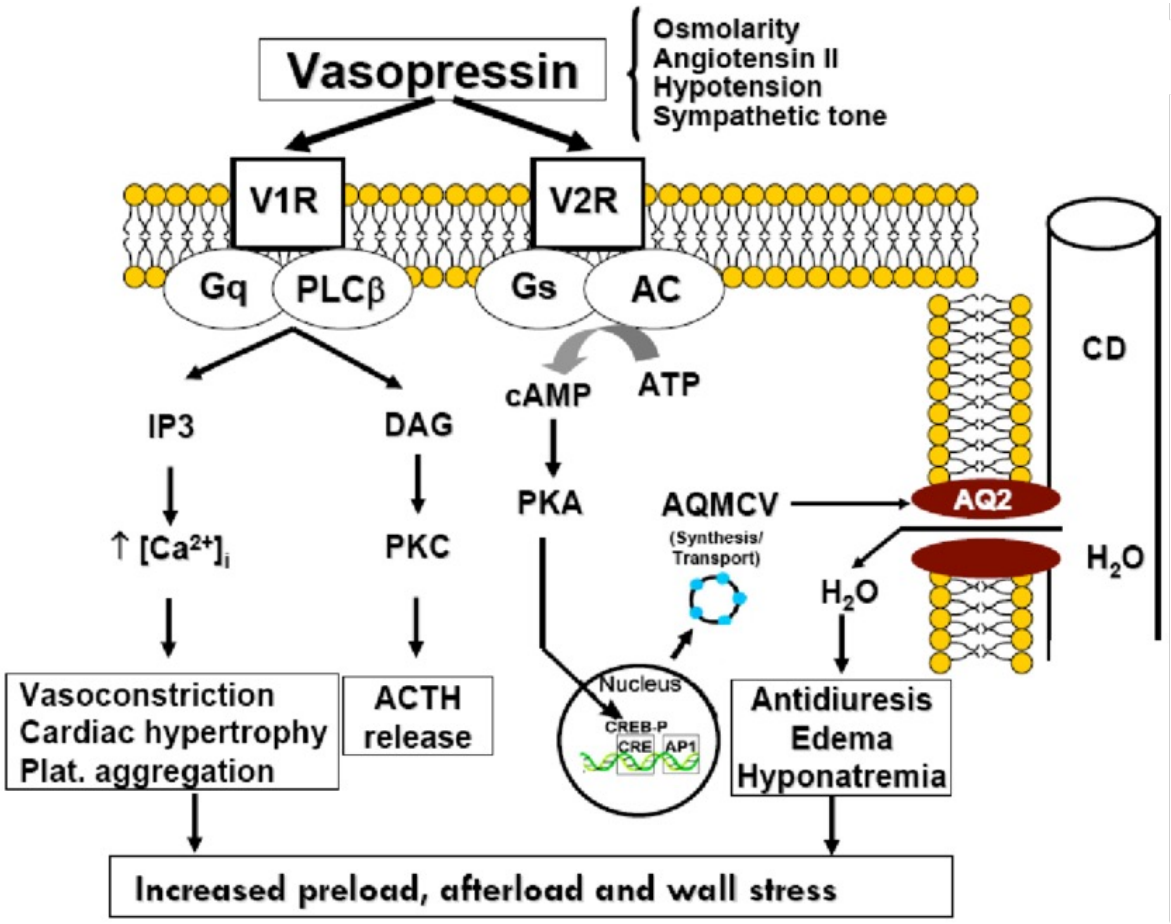
Other effects

- Increase glucose
  - Decrease insulin secretion, increase glyogenolysis;
  - Increase glucagon and adrenocorticotropic hormone secretion
- Increase lactate
- Increase myocardial oxygen consumption -> ventricular arrhythmias
- Increase shear-induced platelet reactivity
- Immunomodulation and mitochondrial dysfunction
- **Less effective in acidaemia**

Catecholamines

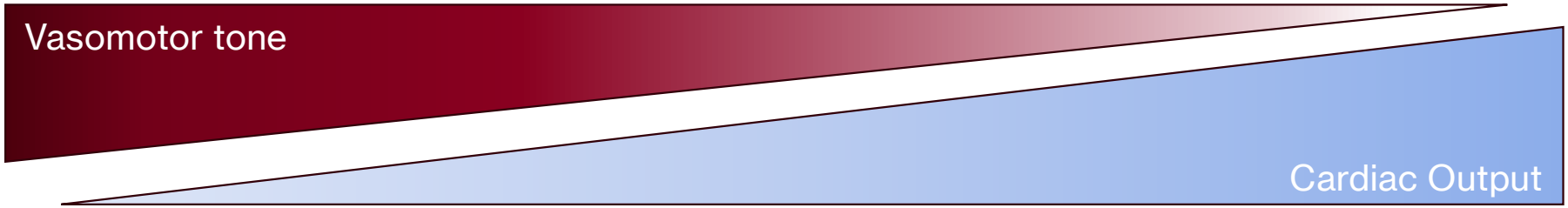


Vasopressin



Tamargo 2009 DOI:10.2174/092986710790192721

Vasopressin



Phenylephrine

Dopamine
5-10mcg/kg/min

Norepinephrine

Epinephrine

Dopamine
>10mcg/kg/min

Dobutamine

Agonism

V1

Vasopressin
0.5-5mU/kg/min

Dopamine
1-4mcg/kg/min

↓ Systemic vascular resistance

Vasopressor preferences

1. **Norepinephrine**
2. **Vasopressin**
3. **Epinephrine (replace norepinephrine)**

OR

3. **Add Dobutamine (start low)**

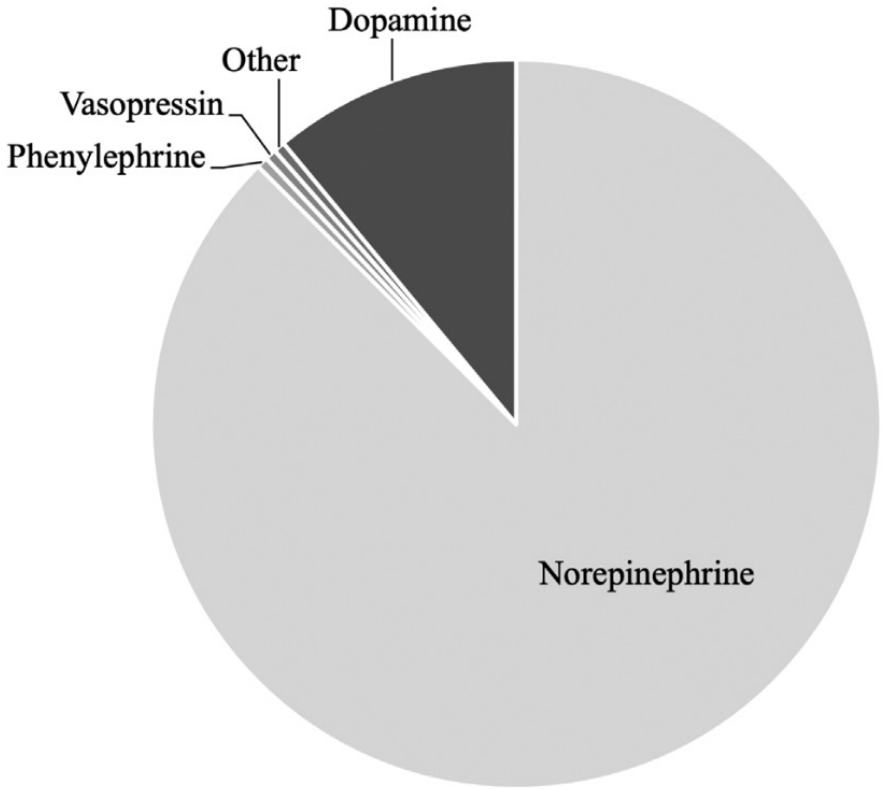
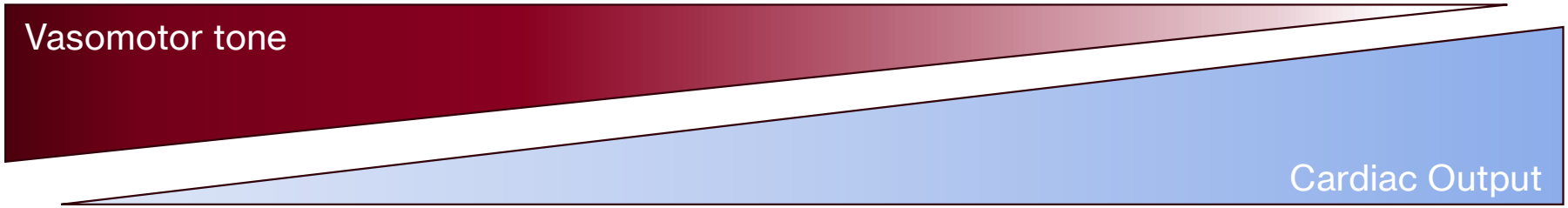


FIGURE 4 First-choice vasopressor for vasodilatory shock in dogs among Diplomates of the American College of Veterinary Emergency and Critical Care

Murphy 2022

Vasopressin



Phenylephrine

Vasopressin

Dopamine
5-10mcg/kg/min

Norepinephrine

Epinephrine

Dopamine
>10mcg/kg/min

Dobutamine

Dopamine
1-4mcg/kg/min

Decreased Systemic Vascular Resistance

Additional strategies to improve vascular tone

- Decrease anaesthetic agents

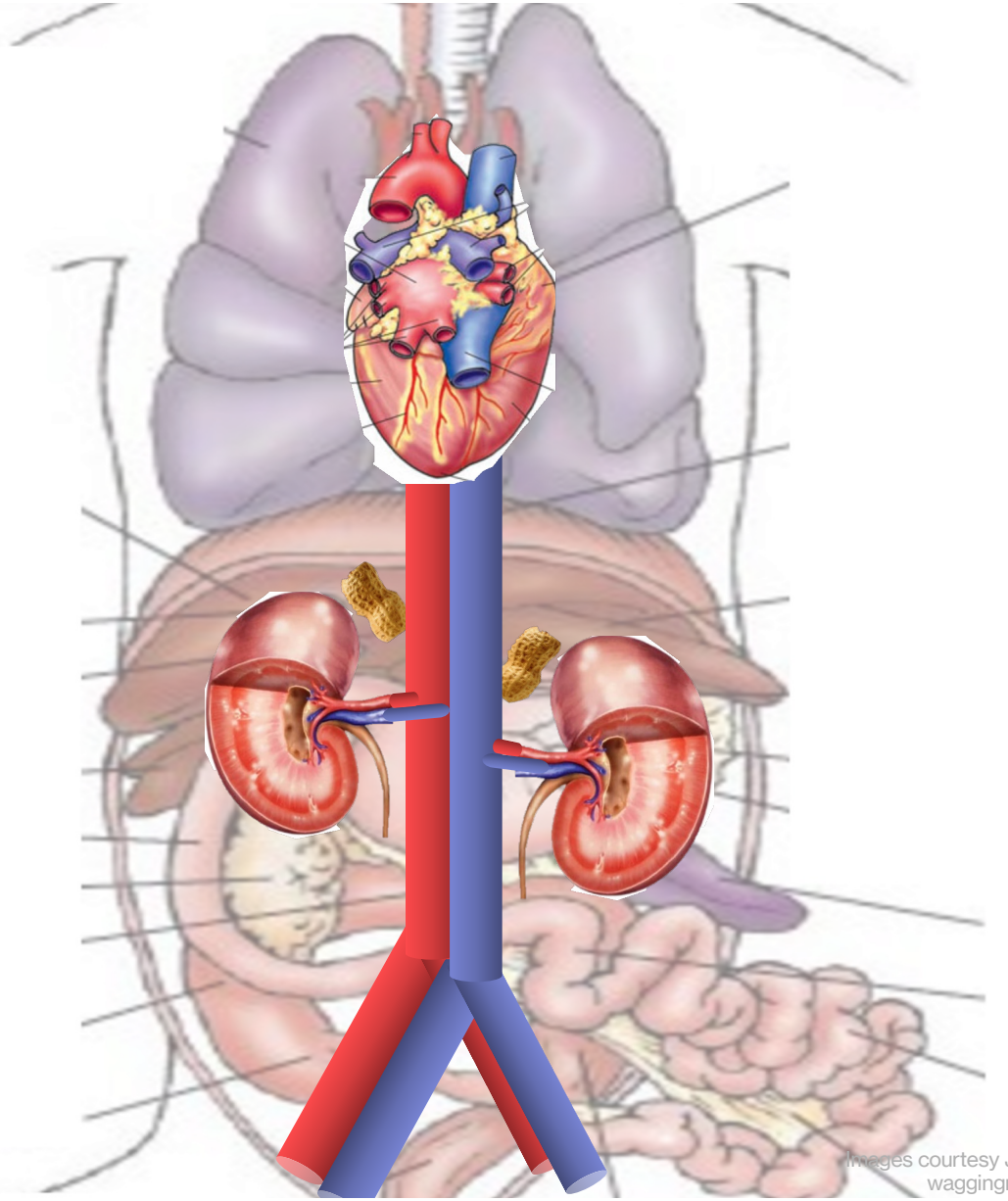
- Corticosteroid therapy
  - Hydrocortisone 2.5 -3mg/kg/day
  - Critical Illness-Related Corticosteroid Insufficiency (CIRCI)

- Angiotensin II
  - Not clinically available… yet

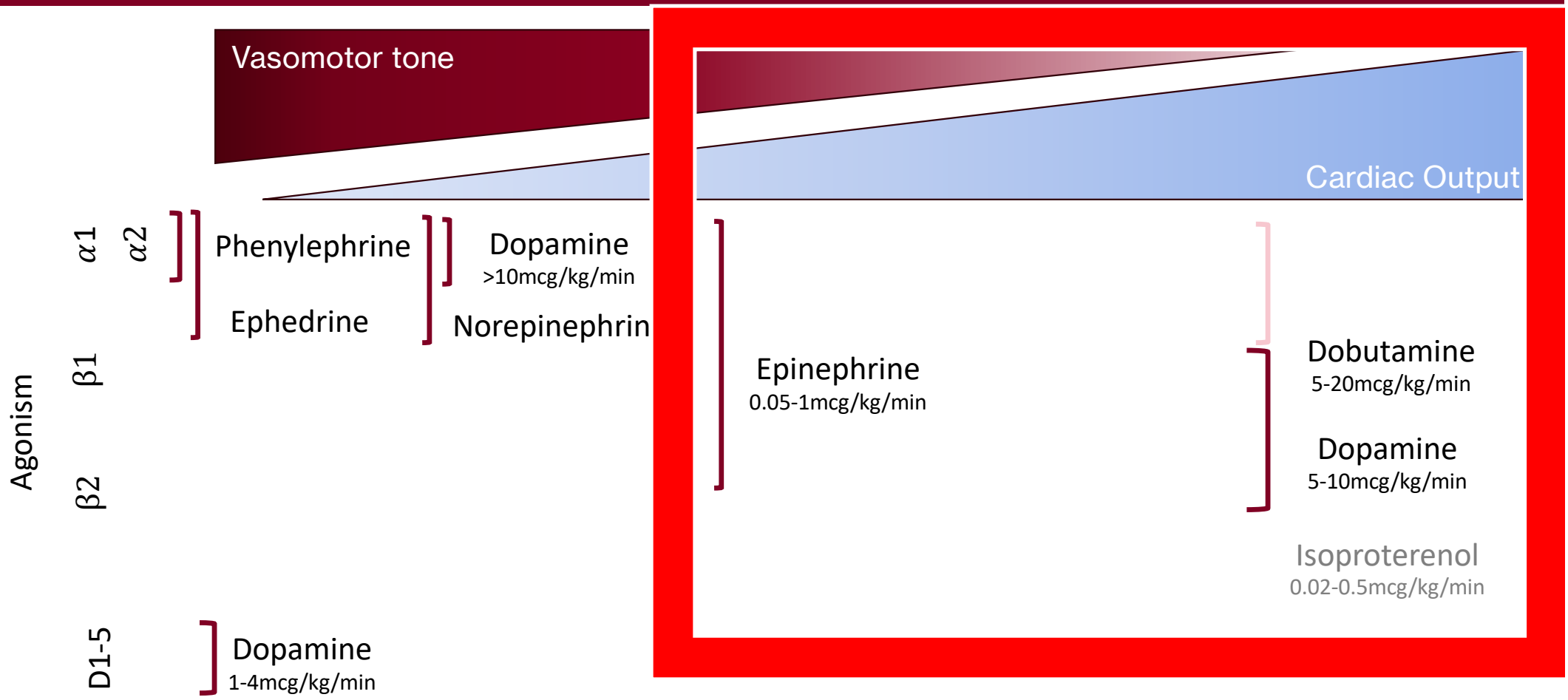
Cardiac dysfunction

Requires <u>fixing the pump!</u>

- Improve contractility
  - Inotropes
- Treat arrhythmias



Catecholamines



Impaired Cardiac Contractility

- Calcium sensitizing agents (PDE3-I)
  - Pimobendan
    - Effective inodilator for some structural cardiac diseases (MMVD, DCM)
    - Non-titratable
  - Levosimendan did not improve survival and increased risk of supraventricular tachycardia in adult humans with sepsis

Case Study

Archie

16 week ME Golden Retriever

Case Study

- 6 week history chronic diarrhoea
- Acute 24h onset vomiting, lethargy, anorexia
- Profuse liquid haemorrhagic diarrhoea
  - Parvovirus/coronavirus/giardia negative

- Dull, HR 200, RR 48, CRT 3 sec, MM pale
- Rectal temperature 37.4C
- Thready peripheral pulses

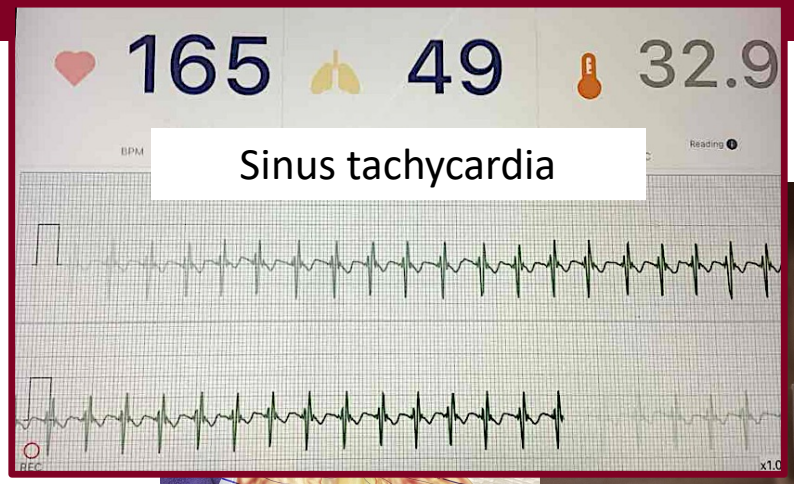
- NIBP (oscillometric): 94/52 (68)mmHg

Case Study

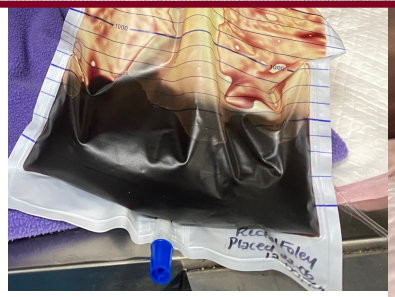
↓ Preload

10ml/kg over 10 minutes

Case Study



Sinus tachycardia



POCUS:
Severe hypovolaemia (LV underfilling)
Scant peritoneal effusion

ABL90 QLD Vet Specialists - Stafford I393-092R 11:59 AM
PATIENT REPORT Capillary - C 65uL Sample #

Identifications

Sex	Male
Accession No	
Patient last name	
Patient first name	
Sample type	Venous

PCV/TS: 44%/56g

Blood gas values

↓ pH	7.254		[7.380 -
pCO_2	40.2	mmHg	[40.0 -
pO_2	56.7	mmHg	[20.0 -

Oximetry values

? ctHb		g/dL	[-
? sO_2		%	[-
? FO_2Hb		%	[-
? FCOHb		%	[-
? FHHb		%	[-
? FMetHb		%	[-

Electrolyte values

↓ cK+	3.8	mmol/L	[4.0 -
cNa+	148	mmol/L	[141 -
↑ cCa^{2+}	1.47	mmol/L	[0.98 -
↓ cCl^-	110	mmol/L	[110 -

Metabolite values

cGlu	6.9	mmol/L	[-
↑ cLac	8.1	mmol/L	[0.0 -
? ctBil		µmol/L	[-
? cCrea		µmol/L	[-
? cUrea		mmol/L	[-

Acid-base status

$cBase(Ecf)_c$	-9.4	mmol/L

Case Study

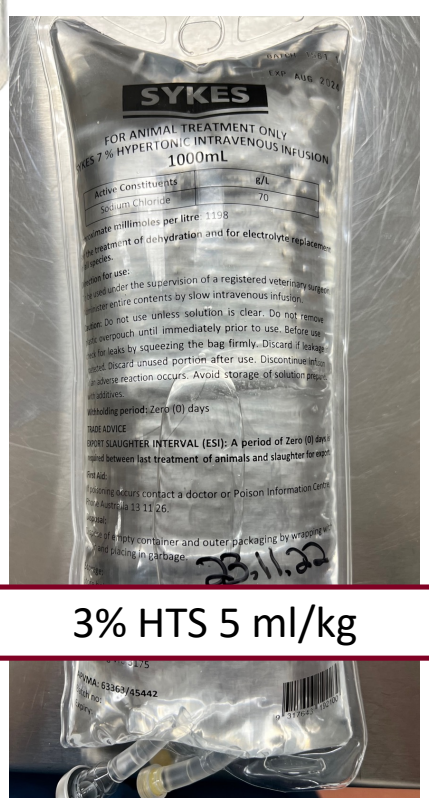
15ml/kg over 10 minutes

10ml/kg over 10 minutes

10ml/kg over 10 minutes

↓ Preload

Faecal output
19.4ml/kg/h



3% HTS 5 ml/kg

Case Study

↓ Systemic vascular resistance

Norepinephrine
0.1- 0.5mcg/kg/min

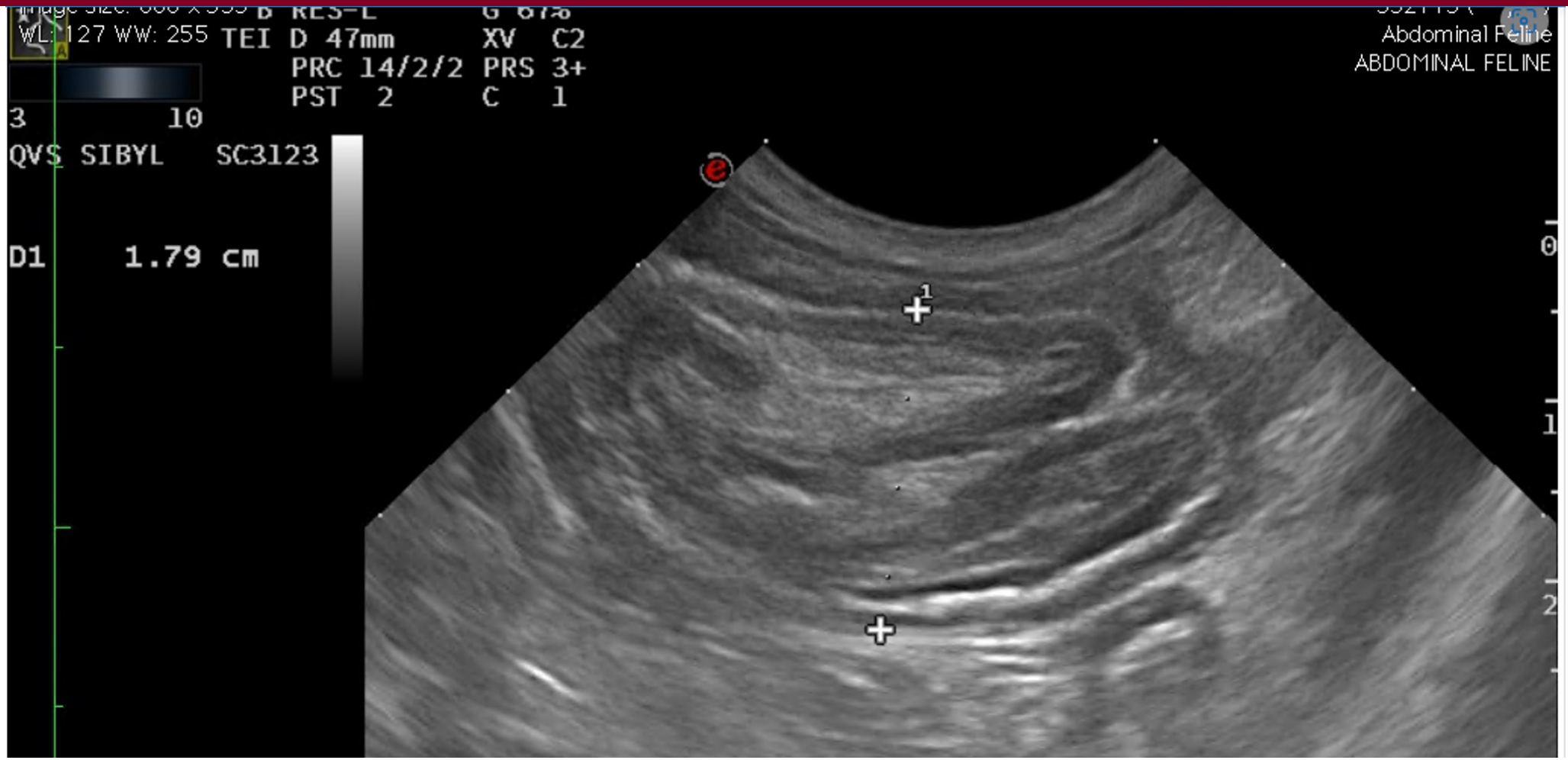
Case Study

↓ Preload

Faecal output
19.4ml/kg/h

Fresh Frozen Plasma
1 unit (200ml)

Case Study


WL: 127 WW: 255 TEI
D 47mm
PRC 14/2/2
PST 2
RES-L
XV C2
PRS 3+
C 1
3
10
QVS SIBYL SC3123
D1 1.79 cm
Abdominal Feline
ABDOMINAL FELINE
0
1
2

Case Study

TIVA
- Remifentanil CRI
- Propofol CRI
- No inhalant anaesthesia

Vasopressin 0.5-5mU/kg/min

Case Study

Case Study

- Ileal resection and anastomosis (ICCJ sparing)
- Faecal Microbial Transplant
- Cryptosporidiosis
- Discharged after 6 days hospitalization

Thank you!

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