



비엔동물전문의료센터
BIEN ANIMAL MEDICAL CENTER

비엔 마취 세미나 : Hypotension

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Previous seminar

1. Intubation

- Endotracheal tube
 - Types
 - Size determination
- Materials
- Intubation preparation
- Intubation
 - Positioning
 - Insertion
 - Laryngoscopy
 - After intubation

2. BOAS

- Morphological changes
- BOAS

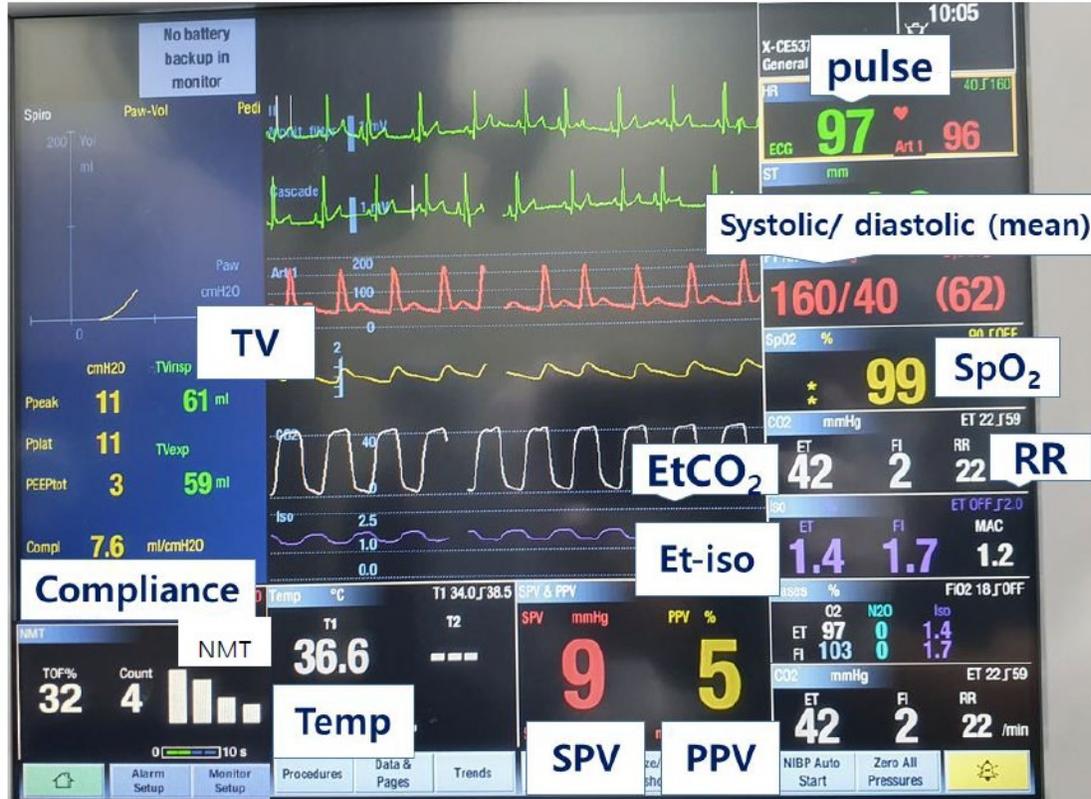
3. Noisy breathing

- Wheeze
- Rhonchi
- Stridor
- Stertor

Hypotension

- Hypotension
 - Definition
 - Criteria
- Causes of hypotension
- Detection of Hypotension
 - Physical examinations
 - Measurement of blood pressure
- Treatments of Hypotension
 - Fluid therapy
 - Vasoactive drugs
- Critical patients
 - Massive hemorrhage
 - Septic shock
 - Hypoalbuminemia
 - Hypersensitivity

What is monitoring? – 5 steps



Criteria

- ① Know the normal range
- ② Recognize abnormal status

Treatments

- ③ Differentiate the cause
- ④ Determine the priority of interventions
- ⑤ Re-evaluation

Hypotension = 저혈압

Hypotension = 저 혈 압

Blood pressure = 혈압; 혈관 벽에 가해지는 압력 = $CO \times SVR$

↓
혈관 수축력; 말초혈관 저항성

$HR \times SV$



↓
Pre/after-load \times Contractility

BP: blood pressure
CO: cardiac output
SVR: systemic vascular resistance
HR: heart rate
SV: stroke volume

Hypotension = 저혈압

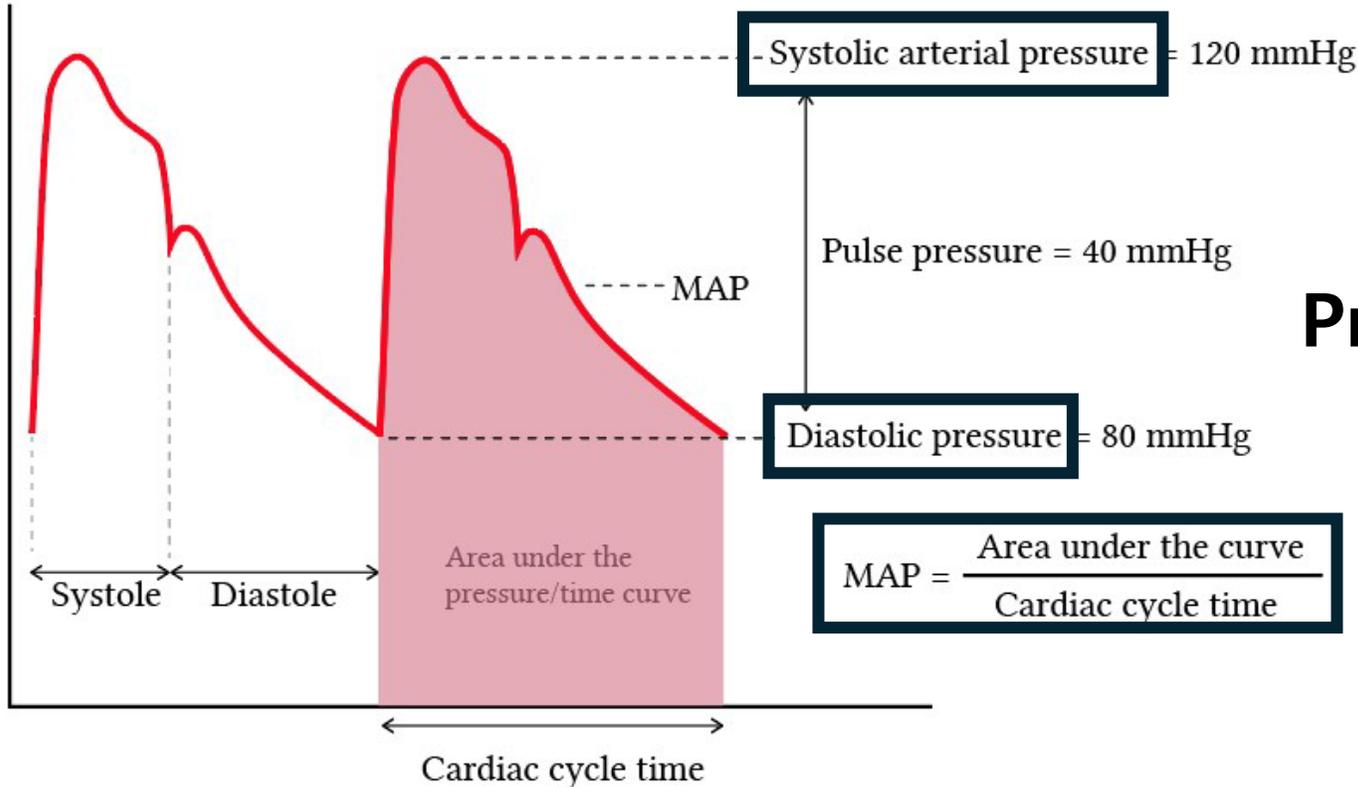
Blood pressure = 혈압; 혈관 벽에 가해지는 압력 = $CO \times SVR$

↓

$HR \times SV$

↓

Pre/after-load \times Contractility



<https://derangedphysiology.com/main/sites/default/files/sites/default/files/CICM%20Primary/G%20Cardiovascular%20system/crude%20representation%20of%20arterial%20pressures.jpg>

BP: blood pressure
 CO: cardiac output
 SVR: systemic vascular resistance
 HR: heart rate
 SV: stroke volume

Hypotension = 저혈압

	Dogs				Cats
Pulse	Puppy	Small	Medium	Large	
	70-220	90-180	80-160	70-140	140-220
BP	SAP	90-140 mmHg			80-140 mmHg
	MAP	60-100 mmHg			60-100 mmHg
	DAP	50-80 mmHg			55-75 mmHg
EtCO ₂	35-45 mmHg				27-41 mmHg
Temp.	37.5-39°C				38-39.5°C
SpO ₂	> 95%				

Hypotension

- SAP < 80 mmHg ← Doppler
- MAP < 60 mmHg ← Oscillometric (NIBP), IBP

Hypotension

- Mild: MAP < 60 mmHg
- Severe: MAP < 45 mmHg

Hypotension = 저혈압

Perfusion pressure

- Brain: MAP > 50 mmHg
 - MAP 40 mmHg → Cerebral ischemia
- Heart: DAP > 45 mmHg
- Kidney: MAP > 60 mmHg
 - MAP < 55 mmHg, > 15 min → Organ malfunction

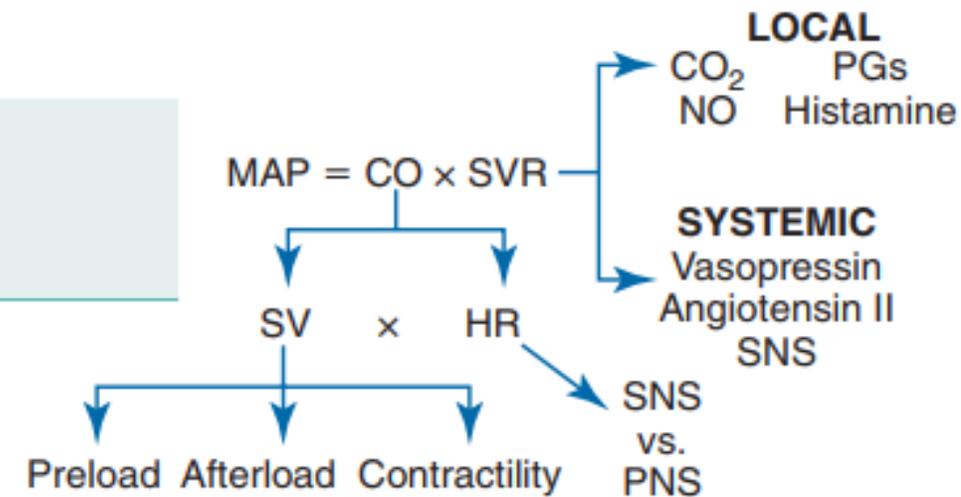
Hypotension

- Mild: MAP < 60 mmHg
- Severe: MAP < 45 mmHg

Causes of Hypotension

Table 8-1 Causes of Hypotension and Recommended Treatment

Cause	Sample Diseases	Treatments
Reduction in Preload		
Hypovolemia	Hemorrhage Severe dehydration Edema/cavitary effusions	Address underlying problem. Provide fluid resuscitation.
Obstructive	Gastric dilation-volvulus Mesenteric volvulus Caval/portal venous occlusion Pericardial effusion Severe pleural space disease Pulmonary thromboembolism	Relieve the obstruction if possible, with surgery, pericardiocentesis, or thoracentesis; administration of thrombolytics; or thrombectomy as needed. Provide fluid resuscitation.
Reduction in Cardiac Function		
Primary	Cardiomyopathy Valvular disease Tachyarrhythmia or bradyarrhythmia	Administer positive inotrope. Administer antiarrhythmics. Provide supportive measures for congestive heart failure
Secondary	Systemic inflammatory response syndrome/sepsis Electrolyte abnormalities Severe hypoxia Severe acidosis or alkalosis	Address the underlying cause. Administer positive inotrope.
Reduction in Systemic Vascular Resistance		
	SIRS/sepsis Electrolyte abnormalities Severe hypoxia Severe acidosis or alkalosis Drug or toxins	Address the underlying cause. Provide fluid resuscitation. Administer vasopressors.



Causes of Hypotension



Drugs

Injectable or inhalation anesthesia
Epidural anesthetics



Other patient problems & procedure

Azotemia, CNS depression, sepsis,
Hypoproteinemia, blood loss, compression of CVC



Equipment

Error of NIBP measurement



Allergic

Morphine, atracurium, contrast agents
Manipulation of mast cell tumor



Cardiac

Valvular dz, cardiomyopathy,
Pericardial effusion, PDA, PSS



Respiratory

Tension pneumothorax
Pleural effusion



Toxic

Endotoxin, pancreatitis

Causes of Hypotension

Injectable

- Alfaxalone
- Propofol

Inhalational

- Isoflurane

Sympathetic nervous systems ↓

Heart rate ↓

Vessel resistance ↓

Blood pressure ↓



Drugs

Injectable or inhalation anesthesia
Epidural anesthetics

Detection of Hypotension

Physical examinations

- Prolonged capillary refilling time (CRT)
- Pale mucus membrane color (MMC)
- Weak pulse on palpation
- Bradycardia or tachycardia



Normal



Pale



Icteric



Cyanotic

Detection of Hypotension



Physical examinations

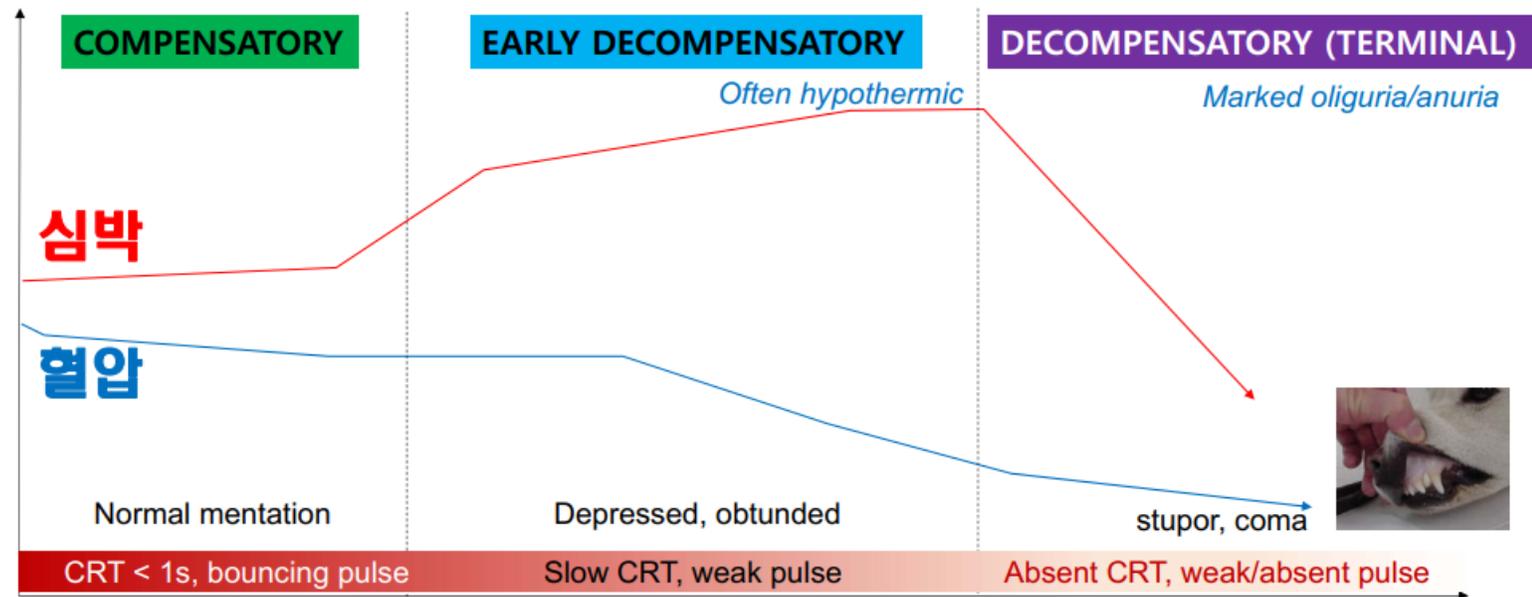
- Prolonged capillary refilling time (CRT)
 - Pale mucus membrane color (MMC)
 - Weak pulse on palpation
 - Bradycardia or tachycardia
- 
- Diastolic-systolic differences
 - Duration of the pulse
 - Size of vessel

Not suitable for detecting hypotension

Detection of Hypotension

Physical examinations

- Prolonged capillary refilling time (CRT)
- Pale mucus membrane color (MMC)
- Weak pulse on palpation
- Bradycardia or tachycardia



Detection of Hypotension

Measurement of blood pressure

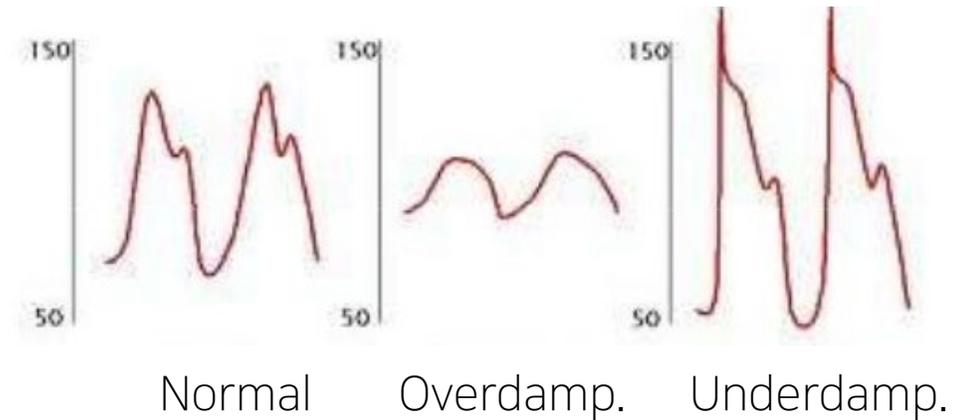
NIBP (Non-invasive blood pressure)

MAP

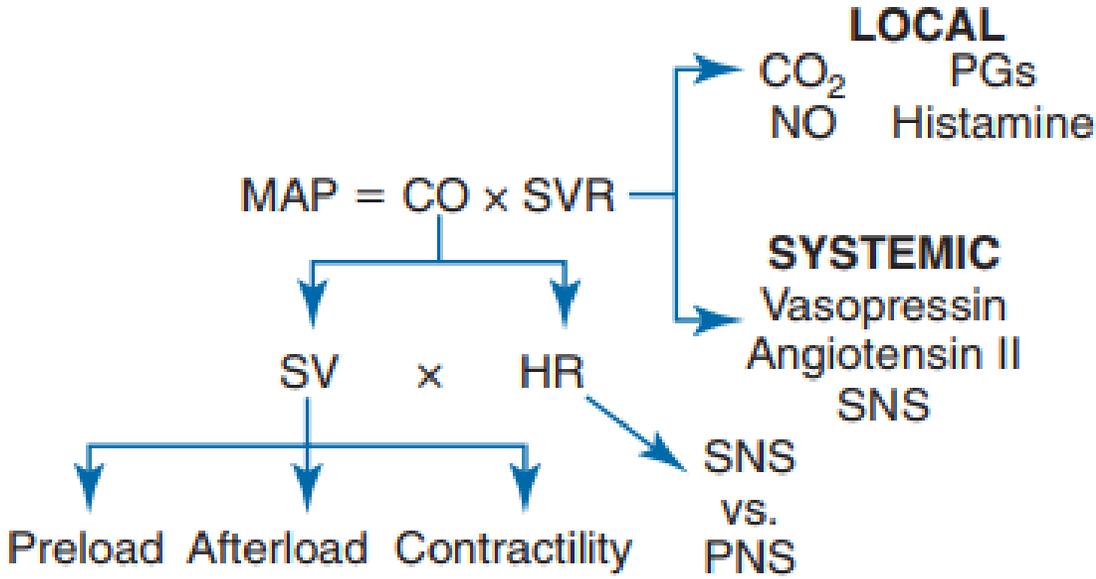
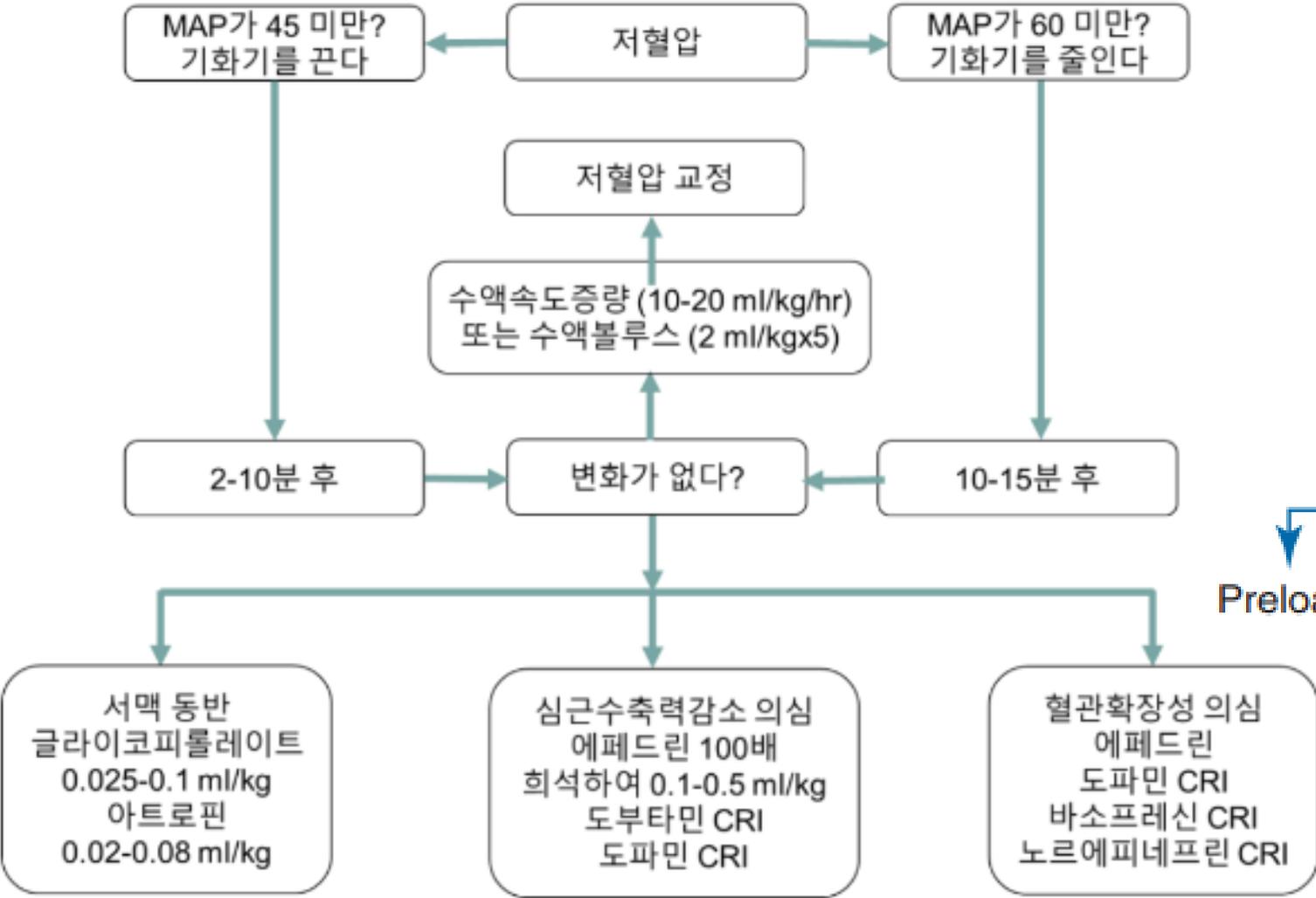
40%



- IBP (Invasive blood pressure)
- Dorsal pedal artery
 - Femoral artery
 - Ventral coccygeal artery
 - Lingual artery



Treatments of Hypotension



Cause?

Treatments of Hypotension

Fluid therapy

- Primary goal
 - Optimize cardiac preload
 - Increase cardiac output
 - Maintain adequate oxygen delivery to tissues
- Use isotonic crystalloid first!

Only 25% of the infused volume will remain in the intravascular space after approximately 30-60 minutes

The remainder will pass into the interstitium

	Sodium (mmol/ L)	Potassium (mmol/L)	Magnesium (mmol/L)	Calcium (mmol/ L)	Chloride (mmol/L)	Acetate (mmol/L)	Gluconate (mmol/L)	Lactate (mmol/ L)	Malate (mmol/ L)	eSID (mEq/ L)	Theoretical osmolarity (mOsmol/ kg)	Actual or measured ¹ osmolarity (mOsmol/ kg)	pH
Plasma	136-145	3.5-5.0	0.8-1.0	2.2-2.6	98-106	Nil	Nil	Nil	Nil	42	291	287	7.35-7.45
Sodium chloride (0.9%)	154	Nil	Nil	Nil	154	Nil	Nil	Nil	Nil	0	308	286	4.5-7
Ringer's lactate (lactate buffered)	130	4	Nil	3	109	Nil	Nil	28	Nil	27	278	256	5-7
Plasma-Lyte 148 [®]	140	5	1.5	Nil	98-106	27	23	Nil	Nil	50	295	271 ²	7.4 ³

Treatments of Hypotension

Fluid therapy

Recommendations for anesthetic fluid rates

- Maintenance rate at ≤ 10 mL/kg/hr

Rule of thumb for cats for initial rate: 3 mL/kg/hr

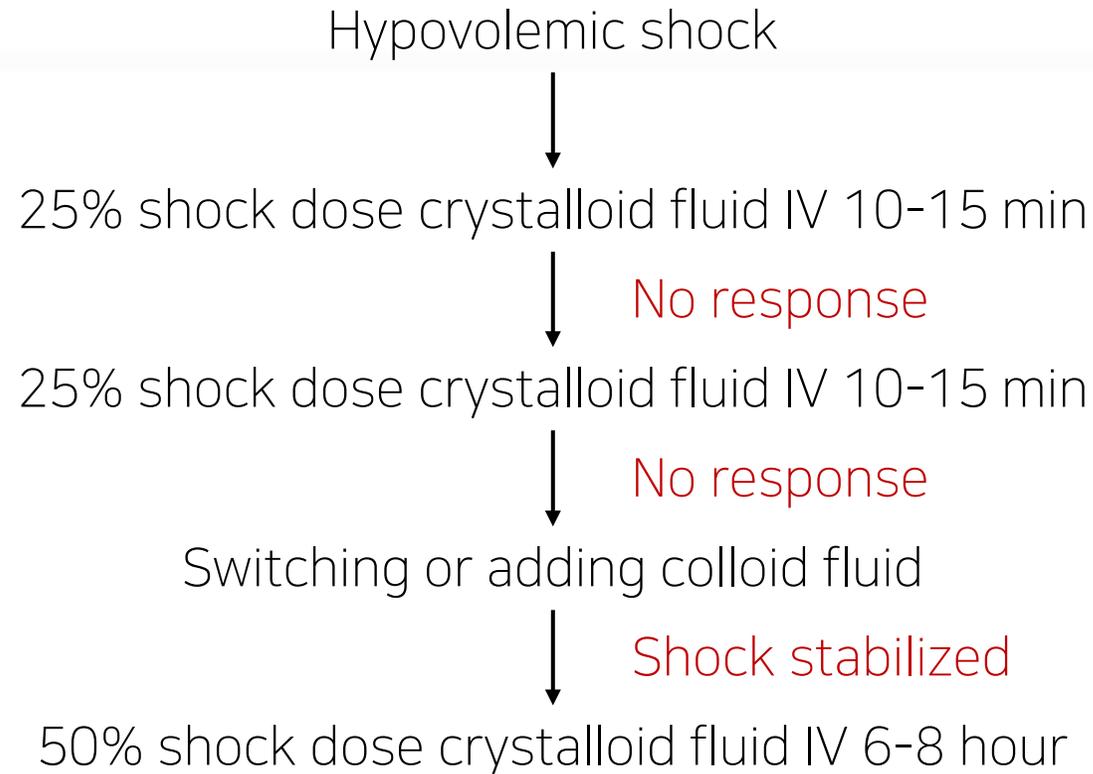
Rule of thumb for dogs for initial rate: 5 mL/kg/hr

- Lower in cats than in dogs
- Lower in patients with cardiovascular disease

Treatments of Hypotension

Fluid therapy

Shock doses: 80-90 mL/kg IV in dogs, 50-55 mL/kg IV in cats



- *** Colloid fluid
- Transfusion
 - Plasma
 - Hetastarch

Treatments of Hypotension

Fluid therapy

Fluid overload

- Increased body weight
- Pulmonary edema
- Reduced tissue oxygenation
- Decreased PCV
- Decreased total protein concentration
- Decreased body temperature
- Coagulation deficits

Central venous pressure (CVP)

Reference range of CVP

- Dog : 5-8 cm H₂O
- Cat : 2-3 cm H₂O

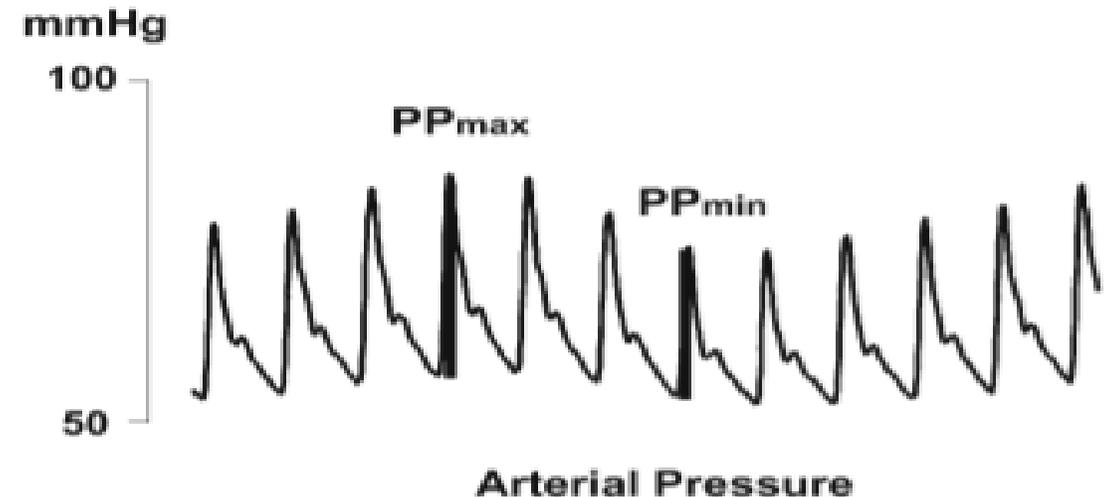
Invasive, not reliable

Pulse pressure variation (PPV)

Hypovolemia

- PPV \geq 13%

IBP, not sensitive



Treatments of Hypotension

Vasoactive drugs

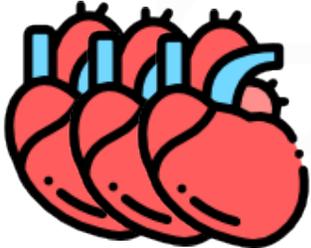
+ Atropine, glycopyrrolate

Drugs	Receptor Activity			Effect on*					Dosage
	β1	β1	α1 & α2	Contractility	Heart Rate	Cardiac Output	Vasomotor Tone	Blood Pressure	
Isoproterenol	+++	+++	0	↑↑↑	↑↑↑	↑↑↑	↓↓↓	↓↓↓	0.02-0.5 μg/kg/min
Dopexamine	0	++	0	0	↑	↑↑	↓↓	↓↓	1-10 mcg/kg/min
Dobutamine	++	+	+	↑↑	↑	↑↑	↓	Variable	5-20 mcg/kg/min
Dopamine	++	+	++	↑↑	↑↑	Variable	↑↑	↑↑	5-20 mcg/kg/min
Ephedrine	+	+	+	↑	↑	↑	Variable	↑	0.25-1 mg/kg
Epinephrine	+++	+++	+++	↑↑↑	↑↑↑	↑↑	↑↑↑	↑↑↑	0.05-1 mcg/kg/min
Norepinephrine	+	0	+++	↑	Variable	Variable	↑↑↑	↑↑↑	0.1-2 mcg/kg/min
Phenylephrine	0	0	+++	0	↓	↓	↑↑↑	↑↑↑	0.5-5 mcg/kg/min
Vasopressin	0	0	0	0	↓	↓	↑↑	↑↑	0.5-5mU/kg/min
Angiotensin	0	0	0	0	0	↓	↑↑	↑↑	0.01-0.1 mcg/kg/min

Treatments of Hypotension

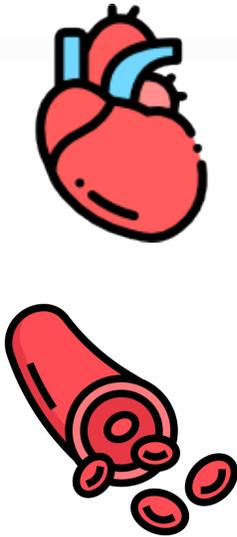
Vasoactive drugs

30-60 min
Anticholinergics



Heart rate ↑

30 min
Ephedrine



Contractility ↑
Vasoconstriction ↑

CRI
Dobutamine



Contractility ↑ ↑
Vasoconstriction ↑ / ↓

CRI
Norepinephrine



Contractility ↑
Vasoconstriction ↑ ↑ ↑

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Treatments of Hypotension

Vasoactive drugs

Inotropes & vasopressors

Ephedrine

- Beta 1 & 2 agonist
- Stimulate the release of endogenous noradrenaline
- Ideal drug for correction of mild hypotension
- Can be used as bolus dose
- Duration: 20-40 mins
- Useful for short procedures like CT scan

Treatments of Hypotension

Vasoactive drugs

Inotropes

Dobutamine

- Beta-1 agonist
- Little risk of cardiac arrhythmias
- SVR does not usually change or decrease
- Causes an increase in heart rate without increase in MAP
; sensitive to vasodilatory effects of dobutamine
- Require lower infusion rates & more fluid therapy & other drugs

Treatments of Hypotension

Vasoactive drugs

Inotropes & vasopressors

Norepinephrine

- Stimulate beta-1 adrenoceptor
- Effect of alpha-1 adrenoceptors is powerful and dose dependent
- Increase SVR
- Perfusion of liver, kidney, muscle and skin is reduced
- Use for as short time as possible
- Useful in patients with vasodilatory shock

수액 처치 필수 (중서체임)

Critical patients

Massive hemorrhage

Blood loss volume = A mL



3 x A mL crystalloid fluid IV
or

Transfusion IV (target PCV __%)

Blood loss evaluation using gauze visual analogue

		Percentage of Saturation			
		25%	50%	50%	100%
Gauze Size	10×10 cm	 3 mL	 6 mL	 6 mL	 12 mL
	30×30 cm	 25 mL	 50 mL	 75 mL	 100 mL
	45×45 cm	 40 mL	 80 mL	 120 mL	 160 mL

Blood in Suction (mL)

$$= \text{Volume in bottle (mL)} \times \frac{\text{Suction Hb conc. (g/dl)}}{\text{Pre-operative Hb conc. (g/dl)}}$$

Critical patients

Septic shock

Critical vasodilation

: Gallbladder/ Intestinal rupture, pyometra, peritonitis etc.

- CRP elevation
- Tachycardia + Hypotension

Treatment

- Norepinephrine 8-12 fold

→ Need strong vasoconstriction

With **hypoalbuminemia** and hypoglycemia?

- Plasma (**Glycocalyx**) / Albumin transfusion
- Glucose IV

→ Need stabilization of osmotic pressure

Critical patients

Hypoalbuminemia

- PLE, PLN, sepsis, liver failure, etc.
- Alb < 2.0

Treatment

- Plasma (Glycocalyx) / Albumin transfusion
- Need stabilization of osmotic pressure

Hypersensitivity

- Morphine, MCT, etc.

Treatment

- Anti-histamine drug (chlorpheniramine, famotidine)
- Vasopressor (epinephrine, norepinephrine)

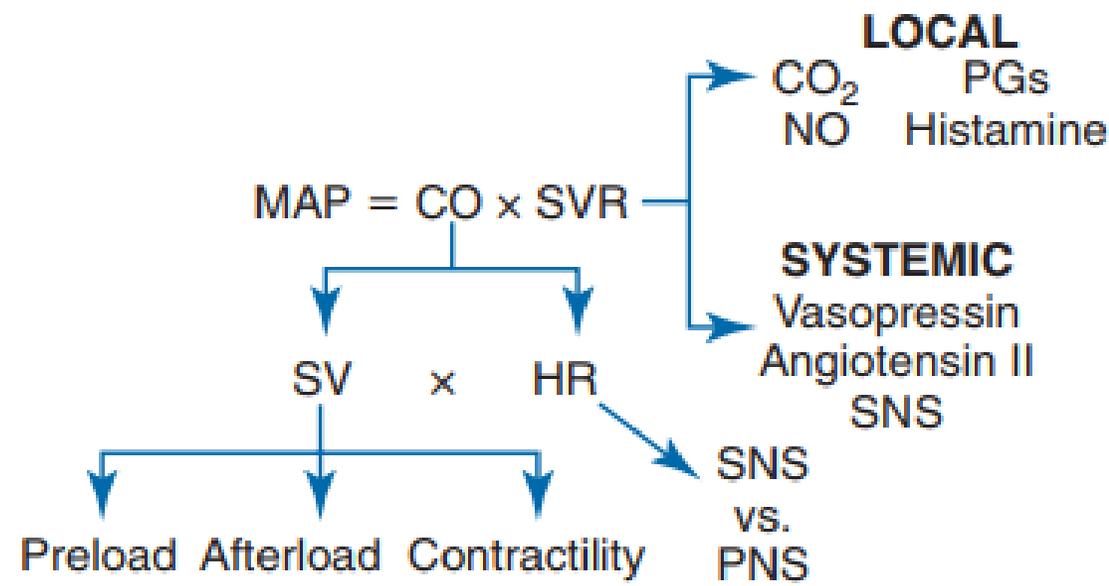
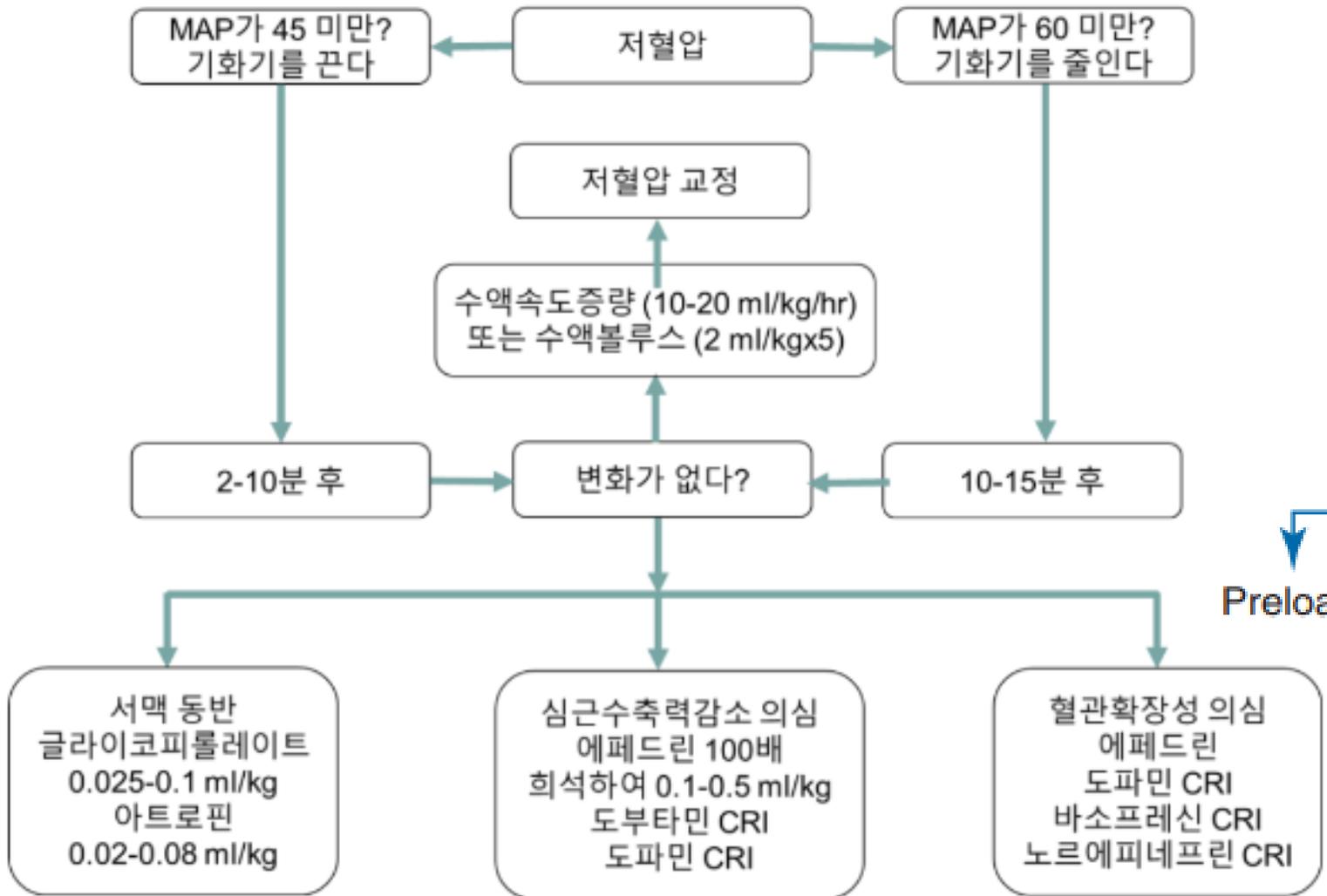


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ANIMAL MEDICAL CENTER

	Dogs				Cats
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Phenylephrine	0	0	+++	0	↓	↓	↑↑↑	↑↑↑	0.5-5 mcg/kg/min
Vasopressin	0	0	0	0	↓	↓	↑↑	↑↑	0.5-5mU/kg/min
Angiotensin	0	0	0	0	0	↓	↑↑	↑↑	0.01-0.1 mcg/kg/min