Author(s): Louis D’Alecy, 2009

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Regulation of Arterial Blood Pressure

M1 – Cardiovascular/Respiratory Sequence
Louis D’Alecy, Ph.D.
Monday 11/03/08, 11:00

The **Regulation** of Arterial Blood Pressure

Regulation requires both a **sensor** and a **set point** about which the variable is **controlled**.

Arterial Baroreceptor Reflex

24 slides, 50 min.
Arterial Baroreceptor Reflex

1. “Simplified” Flow Equation
2. Total Peripheral Resistance
3. Determinants of Mean Arterial Pressure
4. Baroreceptor Function
5. Basic Arterial Baroreceptor Reflex
6. Generalized vs. Localized Vasoconstriction
7. Medullary Cardiovascular Center
Flow = \frac{P_{\text{art}} - P_{\text{ven}}}{R}

When we assume:
- \(P_{\text{ven}}\), i.e. venous pressure is zero
- \(P_{\text{art}}\), i.e. arterial pressure in MAP
- Flow is cardiac output
- \(R\) systemic vascular resistance is TPR

Then the simplified flow equation says:
\[\text{CO} = \frac{\text{MAP}}{\text{TPR}}\]
Total Peripheral Resistance (TPR) or Systemic Vascular resistance (SVR)

- from root of aorta to right atrium
- excludes heart and lungs
- cardiac output flows through this resistance
- changes with **generalized** vasoconstriction
  - or **generalized** vasodilation
CO  =  \frac{MAP}{TPR}

Rearrange to focus on primary variable regulated in the cardiovascular system:
ARTERIAL BLOOD PRESSURE

MAP  =  CO  \times  TPR

Think of it as stating that MAP is directly determined by CO and TPR.
To Regulate Arterial Blood Pressure:

$$\text{MAP} = \text{CO} \times \text{TPR}$$

**Regulated Variable must be sensed:**

Arterial Blood Pressure ($\sim\text{MAP}$)

**Effectors must be controlled:**

$$\text{CO} \text{ thus } \text{HR} \times \text{SV}$$

and or

$$\text{TPR}$$
REFLEX ARC AS NEGATIVE FEEDBACK CONTROL SYSTEM

INTEGRATING CENTER

AFFERENT PATHWAY

RECEPTOR

EFFERENT PATHWAY

EFFECTOR

STIMULUS

RESPONSE

NEGATIVE FEEDBACK
Arterial Baroreceptors

Hering’s nerves via glossopharyngeal

Carotid Pressure Receptors via Vagus

Image of arterial baroreceptors removed

Aortic Arch Pressure Receptors

Please see: http://mor.phe.us/jtw/Gateway/Projects/Vertebrates/images/EvolutionOfTheHeart/ArterialBaroreceptors.gif
Mean arterial pressure (MAP)

Baroreceptor action potential frequency

Mean arterial pressure (mmHg)

Rate of Sensory Nerve Firing

Normal resting value
Steady State Response

Mean pressure mm Hg

Steady pressure

40

60

80
Baroreceptor afferents thus contain not only steady pressure information but heart rate and pulse pressure information.
Arterial Baroreceptors

Fig 9.1
Arterial Baroreceptor Reflex(s)

- minimize changes in arterial blood pressure
- tend to restore MAP to initial value
- move pressure pressure in opposite direction of disturbance (negative feedback)
- utilizes (controls) HR, SV, TPR, “other” changes
- can be over ridden by other reflexes and controls
Responses (Effectors) must be controlled:

\[ \text{CO} \quad \text{thus} \quad \text{HR} \times \text{SV} \]

and or

\[ \text{TPR} \]
To restore Arterial Pressure
Factors influencing heart rate

+ CHRONOTROPIC

↑ Plasma epinephrine

↑ Activity of sympathetic nerves to heart

↓ Activity of parasympathetic nerves to heart

SA node

↑ Heart rate
Controllers of stroke volume

- **End-diastolic ventricular volume**
  - Frank-Starling

- **Activity of sympathetic nerves to heart**

- **Plasma epinephrine**

- **Cardiac muscle**
  - **Stroke volume**

**How?**
Peripheral Venous Pressure

VR

Central Venous Pressure
Cardiac output

Begin

- **End-diastolic ventricular volume**
- **Activity of sympathetic nerves to heart**

- **Plasma epinephrine**
- **Activity of parasympathetic nerves to heart**

**Cardiac muscle**
- **Stroke volume**

**SA node**
- **Heart rate**

\[ \text{Cardiac output} = \text{Stroke volume} \times \text{Heart rate} \]
SYSTEMIC VASCULAR
(TOTAL PERIPHERAL RESISTANCE)

• Vasoconstriction (generalized) \(\Rightarrow \downarrow r \Rightarrow \uparrow TPR\)
  \(\Rightarrow \uparrow MAP \text{ or } \downarrow CO\)

• Vasodilation (generalized)
  \(\Rightarrow \uparrow r \Rightarrow \downarrow TPR \Rightarrow \downarrow MAP \text{ or } \uparrow CO\)

\[\uparrow\uparrow\uparrow MAP = CO \times \uparrow\uparrow\uparrow TPR\]
Fig 9.1
Other MCVC Inputs

**Higher Centers**
- Cortex-- cerebral, cerebellar
- Hypothalamus-- Na, H₂O, Pain, C°, Emotion, Activity

**Chemoreceptors**
- Carotid and aortic bodies
- Hypoxia--vasodilation BUT hypertension reflex

**Cardiopulmonary low pressure baroreflexes**
- Sense central venous volume
- Respond to alter fluid balance (renal effects)
- Long-term blood pressure response
TISSUE RESISTANCE

(**Assume Perfusion Pressure is Constant **)

LOCAL -- COMPETES WITH BAROREFLEX

• Vasoconstriction $\Rightarrow \downarrow r \Rightarrow \uparrow R_{tissue} \Rightarrow \downarrow F_{tissue}$

• Vasodilation
  $\Rightarrow \uparrow r \Rightarrow \downarrow R_{tissue} \Rightarrow \uparrow F_{tissue}$

$F_{tissue} = \frac{\text{Perfusion Pressure}}{R_{tissue}}$
Additional Source Information

for more information see: http://open.umich.edu/wiki/CitationPolicy

Slide 10: D'Alecy
Slide 11: Please see: http://mor.phe.us/jtw/Gateway/Projects/Vertebrates/images/EvolutionOfTheHeart/ArterialBaroreceptors.gif
Slide 12: McGraw-Hill
Slide 13: Source Undetermined
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