Renal Clearance & Blood Flow Mechanics

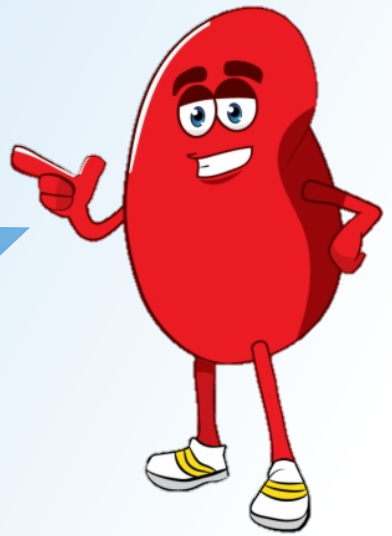
New concepts in renal physiology

Abbreviations

- C
- [U]
- [P]
- V
- GFR
- RPF
- RBF
- [TF]

Equations

- $C_X = {}^{[U]x * V}/_{[P]x}$
- $RPF = {}^{[U]PAH * V}/_{[RA]PAH - [RV]PAH}$
- $RBF = {}^{RPF}/_{1 - Hct}$
- $FF = {}^{GFR}/_{RPF}$



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Renal clearance

$$C_X = {}^{[U]x * V}/_{[P]x} = {}^{\text{urinary excretion}}/_{\text{plasma concentration}}$$

- *"The **volume** of plasma completely cleared of **a** substance by the kidneys **per unit time**"* – Costanzo
  - Appropriate units are volume per unit time, e.g mL/min, L/day

- INCREASED clearance → DECREASED plasma concentration

Clearance of specific substances

- Clearance takes into account
  1. Filtration
  2. Reabsorption
  3. Secretion

- Albumin
  - Not filtered at all → clearance of 0
- Glucose
  - Filtered but then completely reabsorbed → clearance of 0
- Inulin
  - Filtered but not absorbed/ secreted → clearance is equal to GFR
- *Para*-aminohippuric acid (PAH)
  - Filtered and also secreted → highest clearance possible

Clearance ratios

- Clearance ratio = $^{C\,x}$ / $_{C\,inulin}$
- Inulin is a **glomerular marker**
  - Filtered but not absorbed/ secreted → clearance is equal to GFR

- If $C_x / C_{inulin} = 1$
  - Substance is also a glomerular marker
- If $C_x / C_{inulin} < 1$
  - Substance is not filtered *OR*
  - Substance is filtered but then reabsorbed
- If $C_x / C_{inulin} > 1$
  - Substance is secreted

In other words:

- If C_x = GFR
  - There is no net tubular reabsorption or secretion of X
- If C_x < GFR
  - There is net tubular reabsorption of X
- If C_x > GFR
  - There is net tubular secretion of X

Renal blood flow (RBF)

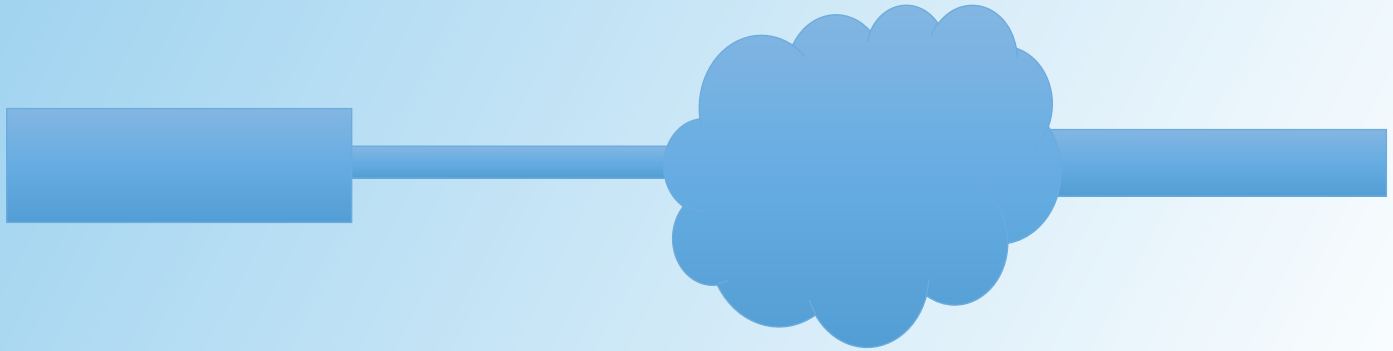
- 25% of cardiac output → 1.25 L/min, 1800 L/day
- Highly regulated:
  - Influenced by chemical mediators
  - Autoregulation

Vasoactive mediators

1. Sympathetic stimulation/ catecholamines
2. Angiotensin II
3. Atrial natriuretic peptide
4. Prostaglandins
5. Dopamine

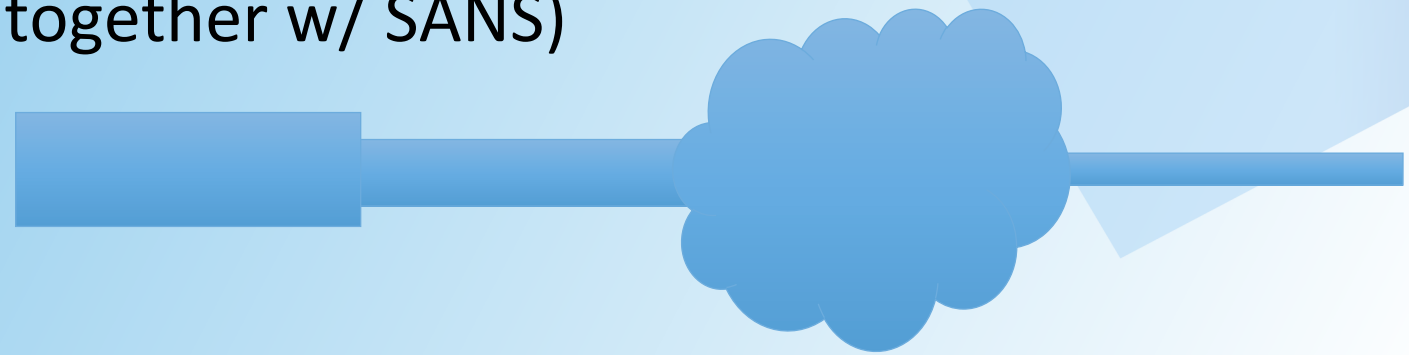
SANS/ Catecholamines

- Vasoconstriction via α1 receptors
  - Afferent >> efferent
- Decreases RBF → decreased GFR
- Important in shock (together with ATII)
  - Redirects blood flow to vital organs



Angiotensin II

- Vasoconstricts → decreases RBF
- Low levels:
  - Constrict efferent arterioles
- High levels:
  - Constrict afferent and efferent arterioles
  - Efferent >> afferent
- Important in shock (together w/ SANS)

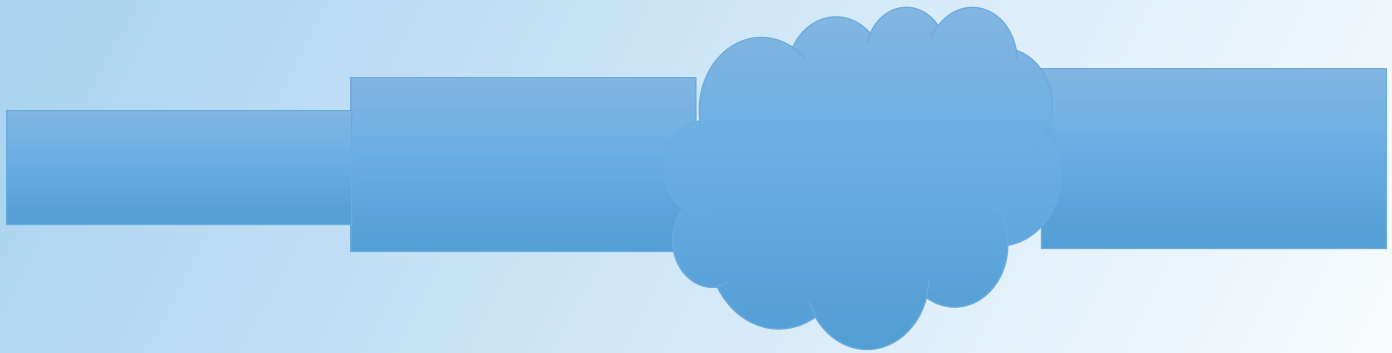


Atrial natriuretic peptide

- Dilates afferent, constricts efferent
- Increases RBF

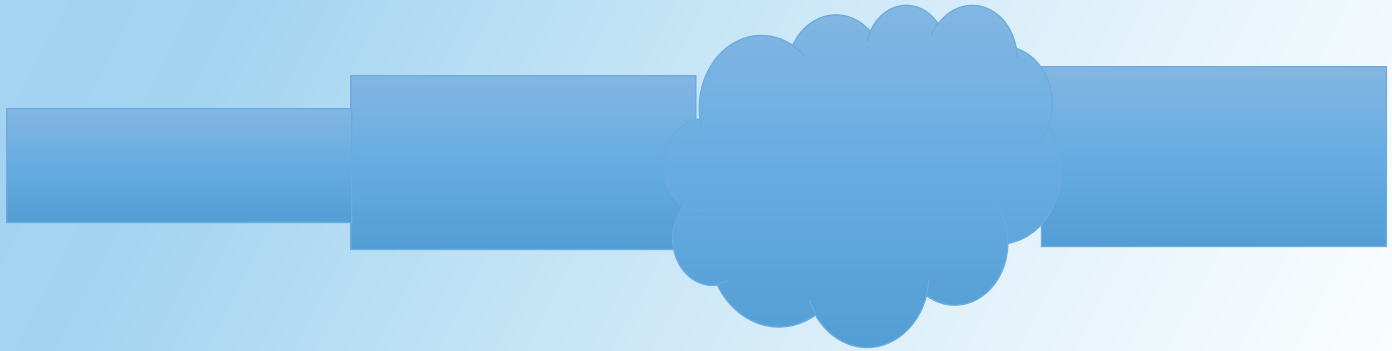
Prostaglandins

- Produced locally (PGE_2, PGI_2)
- Stimulated alongside SANS and ATII
  - Vasodilates
  - Increases RBF
  - Renoprotective in shock



Dopamine

- Vasodilates renal arterioles
- Important therapy during shock
  - Renoprotective while redirecting peripheral blood to vital organs



Summary: vasoactive mediators

Substance	Afferent constriction	Efferent constriction	RBF
SANS/ catecholamines	^^	^	v
Angiotensin II	^	^^	v
ANP	v	^	^^
Prostaglandins	v	v	^
Dopamine	v	v	^

Autoregulation

Maintains a constant RBF even though arterial pressure in the kidney can fluctuate from 80 to 200mmHg; controlled largely at the level of the afferent arteriole

Myogenic

- Increased arterial pressure stretches the arteriole →
  - Opens stretch-induced Ca^{++} channels →
    - ^[Ca] causes reflexive vasoconstriction →
      - Increased resistance to blood flow

Tubuloglomerular Feedback

- Increased arterial pressure increases RBF/ GFR →
  - More ultrafiltrate reaches macula densa, stimulating the JGA →
    - Juxtaglomerular apparatus releases a paracrine hormone that constricts the afferent arteriole →
      - Increased resistance to blood flow