Physiology Team 434

2.Regulation of Glomerular Filtration

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Physiology Team 434
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Glomerular Filtration Rate (GFR)

The volume of filtrate produced by both kidneys per min
Averages **125 ml/min** Totals about 180L/day (45 gallons)
So most filtered water **must be reabsorbed** or death would ensue from water lost through urination

✧ **GFR is directly proportional to the NFP**

An increase in NFP → ↑ GFR

A decrease in NFP → ↓ GFR

Changes in GFR normally result from changes in glomerular blood pressure.

Why is it important to have the GFR regulated?

↑GFR lead to

Fluid flows through tubules **too rapidly** to be absorbed

↓

Urine output **rises**

↓

dehydration and **electrolyte depletion**

↓GFR lead to

Fluid flows **sluggishly** through tubules

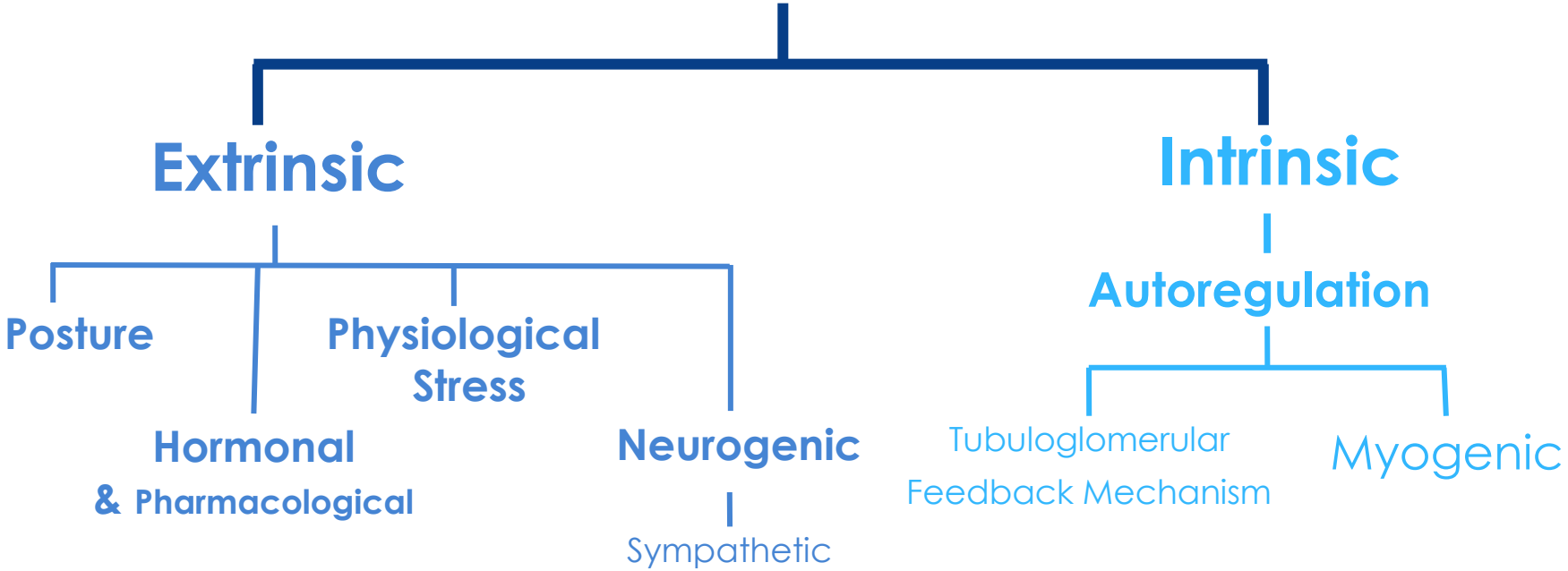
↓

Tubules reabsorb wastes that should be eliminated

↓

Azotemia develops (high levels of nitrogen-containing substances in the blood).

Regulation of GFR & RBF*



* : Renal Blood Flow

Mentioned in Males' Slides of Lecture 3

1) Autoregulation (intrinsic)

First of all you need to know the autoregulation mechanism happens when the range of blood pressure is between **75-160 mmHg** (systolic), which is not pathological changes, **Cannot** compensate for **extreme** BP changes

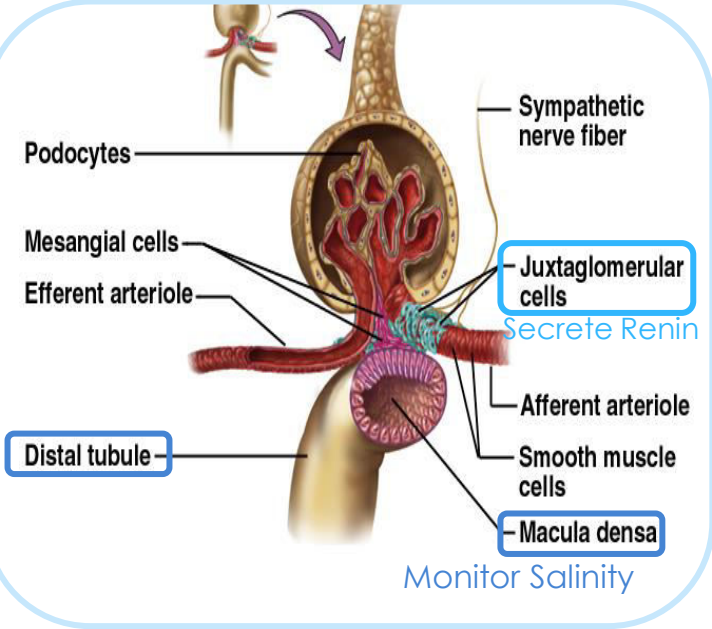
Autoregulation goal is **to make the GFR & RBF constant** (75-160mmHg) when the blood pressure changes in this normal range.

That means in normal kidneys, a decrease in arterial blood pressure as low as 75 mmHg, or an increase as high as 160 mmHg causes a change in GFR by **only a few percentage**.

However, autoregulation is not perfect but it prevents potentially great changes in GFR , with changes in blood pressure, therefore, kidney continue to excrete waste.

How autoregulation takes place?

Juxtaglomerular apparatus



Mentioned in Males' Slides of Lecture 3

1-Autoregulation of GFR :

A) Tubuloglomerular Feedback Mechanism

Decrease in blood pressure

↓

Decrease blood flow in renal tubules →decrease GFR

↓

Increase reabsorption by renal tubules

↓

Decrease delivery of **NaCl** to the **macula densa** cells, which are capable of sensing this change

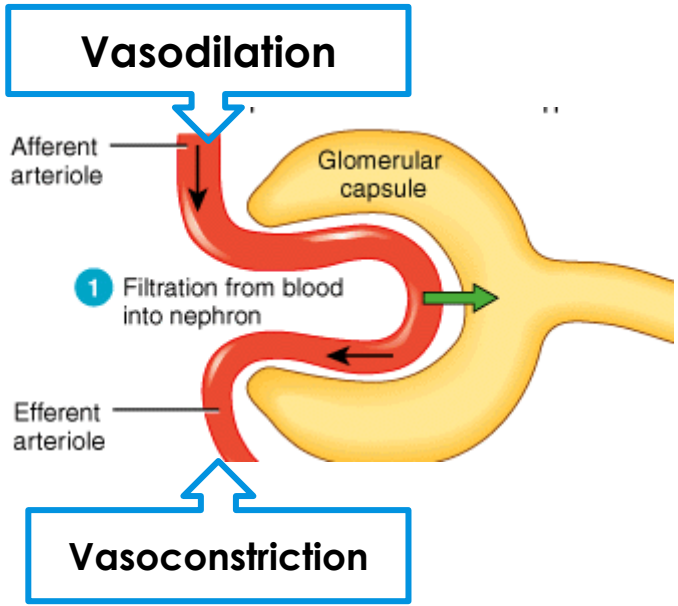
Note: macula densa cells are located at the beginning of distal tubules ,which is near to the afferent & efferent

↓

Macula densa releases substances which will cause **vasodilation of Afferent** & other substance released to the juxtaglomerular cells leads to release Renin

Note: Renin converts Angiotensinogen to Angiotensin I and ACE converts Angiotensin I to Angiotensin II which cause **vasoconstriction** of **EFFERNT**

The Net Result:
increase glomerular hydrostatic pressure & GFR to normal



Mentioned in Males' Slides of Lecture 3

Increase in blood pressure

↓

Increase blood flow in renal tubules →increase GFR

↓

decrease reabsorption by renal tubules
(caused by the rapid flow)

↓

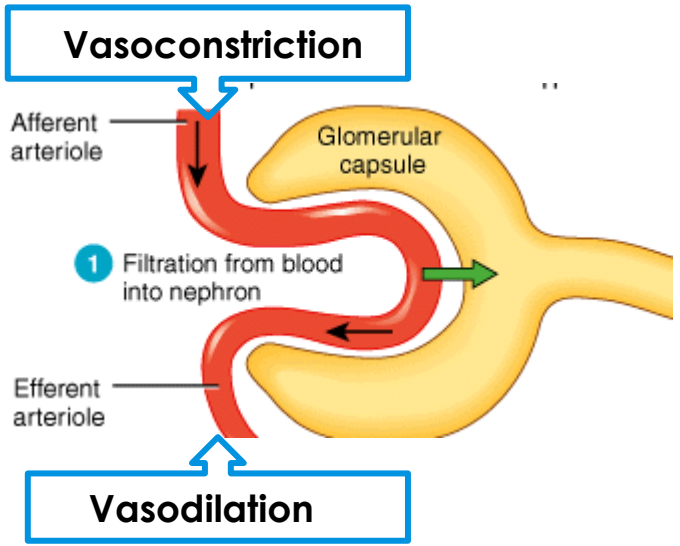
increase delivery of **NaCl** to the macula densa cells, which are capable of sensing this change

Note: NaCL is one of the substances that should be reabsorbed in normal situations

↓

Macula densa releases **paracrine** substances which will cause **vasoconstriction of Afferent** & other substance released to the juxtaglomerular cells leads **inhibit** the release of Renin to stop its action (vasoconstriction of EFFERNT) lead to **vasodilation of EFFERNT**

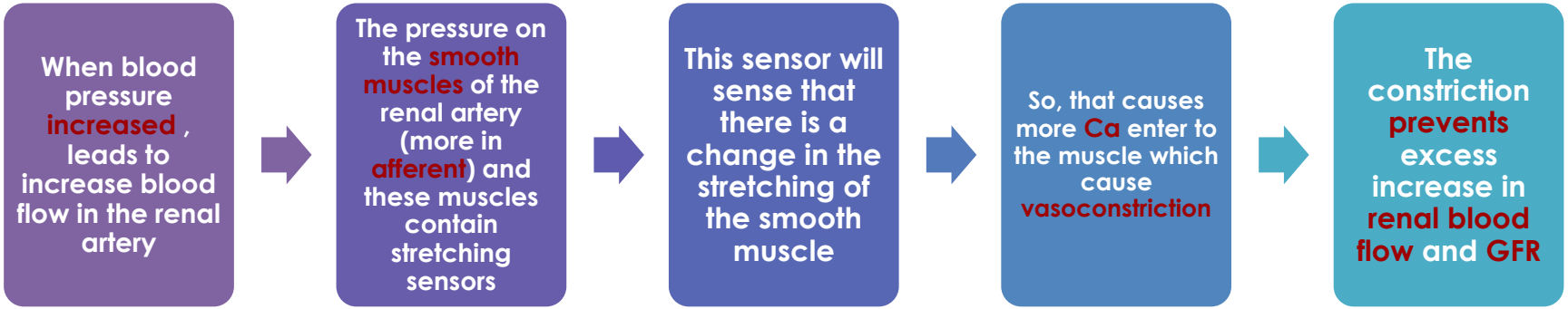
The Net Result:
decrease glomerular hydrostatic pressure & GFR to normal



Mentioned in Males' Slides of Lecture 3

B) Myogenic Mechanism

It is the intrinsic capability of blood vessels to constrict when blood pressure is increased.



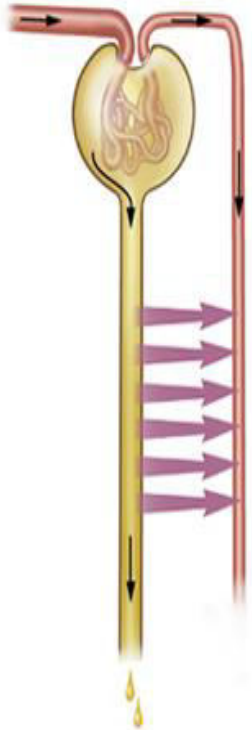
When blood pressure decreases the myogenic mechanism reduces vascular resistance and the vessel dilates.

Mentioned in Males' Slides of Lecture 3

2) Hormonal Control of GFR

Effects of Angiotensin II

Angiotensin II → Causes constriction of efferent arteriole



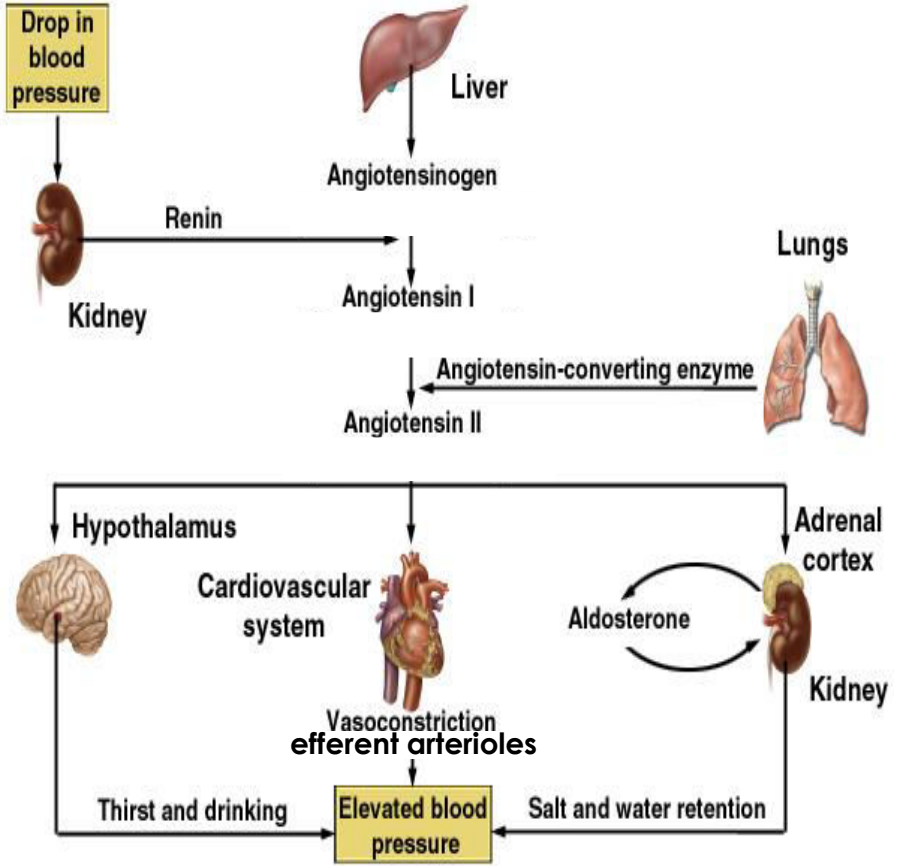
Increases glomerular blood pressure and filtration and Reduces blood pressure in peritubular capillary

Reduces resistance to tubular reabsorption

Tubular reabsorption increases

Urine volume is less but concentration is high

Effect more on efferent



Mentioned in Males' Slides of Lecture 3

3) Sympathetic Control of GFR (Extrinsic)

When the sympathetic nervous system is at rest:

1) Renal blood vessels are maximally dilated
2) Autoregulation mechanisms prevail

Under stress: during fight or flight & in severe change of the BP blood is shunted *away* from kidneys by the mechanism (more effect on afferent):

- **Norepinephrine** is released by the sympathetic nervous system
- **Epinephrine** is released by the adrenal medulla

→ **Afferent** arterioles constrict and filtration is <u>inhibited</u>

- Stimulates the **renin-angiotensin** mechanism

→ Induces vasoconstriction of **efferent** arteriole.

Mentioned in Males' Slides of Lecture 3

Extrinsic Regulation

	Physiological stress	Posture	Hormonal & Pharmacological	Neurogenic
Example	Cold, Deep anesthesia, Fright, Sever exercise Hypoxia &ischemia	In supine then sitting then standing.	**Example 1**	**Example 1**
			Epinephrine, Nor-Epinephrine, Angiotensin II, Prostaglandin (F), and Thromboxane	Sympathetic Nerve Fiber
			End Result 1	**End Result 1**
Explanation	Stimulate sympathetic NF	Changing the posture from lying to standing leads to a decrease of about 15% in RBF due to the stimulation of sympathetic NF.	Renal vasoconstriction and results in decrease in RBF and GFR.	The major NF to kidney. Stimulation of sympathetic NF causes renal vasoconstriction and results in decrease of RBF and
			Example 2	**Example 2**
			Acetylcholine, Bradykinin, Prostaglandin (D, E, and I), and bacterial pyogens	There are some parasympathetic
			End Result 2	**End Result 2**
End Result	Vasoconstriction and decrease in RBF.	Increase in RBF	Renal vasodilation and results in increase in RBF and GFR.	NF to efferent arterioles, mostly to juxtamedullary nephrons and sphincters of vasa recta. causes renal vasodilation and results in increase in RBF and GFR.

Only in Males' Slides of Lecture 3

Glomerular Filtration Rate (GFR)

The volume of filtrate produced by both kidneys per min

Averages **125 ml/min**

Totals about 180L/day (45 gallons)

So most filtered water must be **reabsorbed** or

Death would ensue from water lost through urination

If the GFR is too high:

Fluid flows through tubules **too rapidly** to be absorbed

Urine output **rises**

Creates threat of **dehydration** and **electrolyte depletion**

If the GFR is too low:

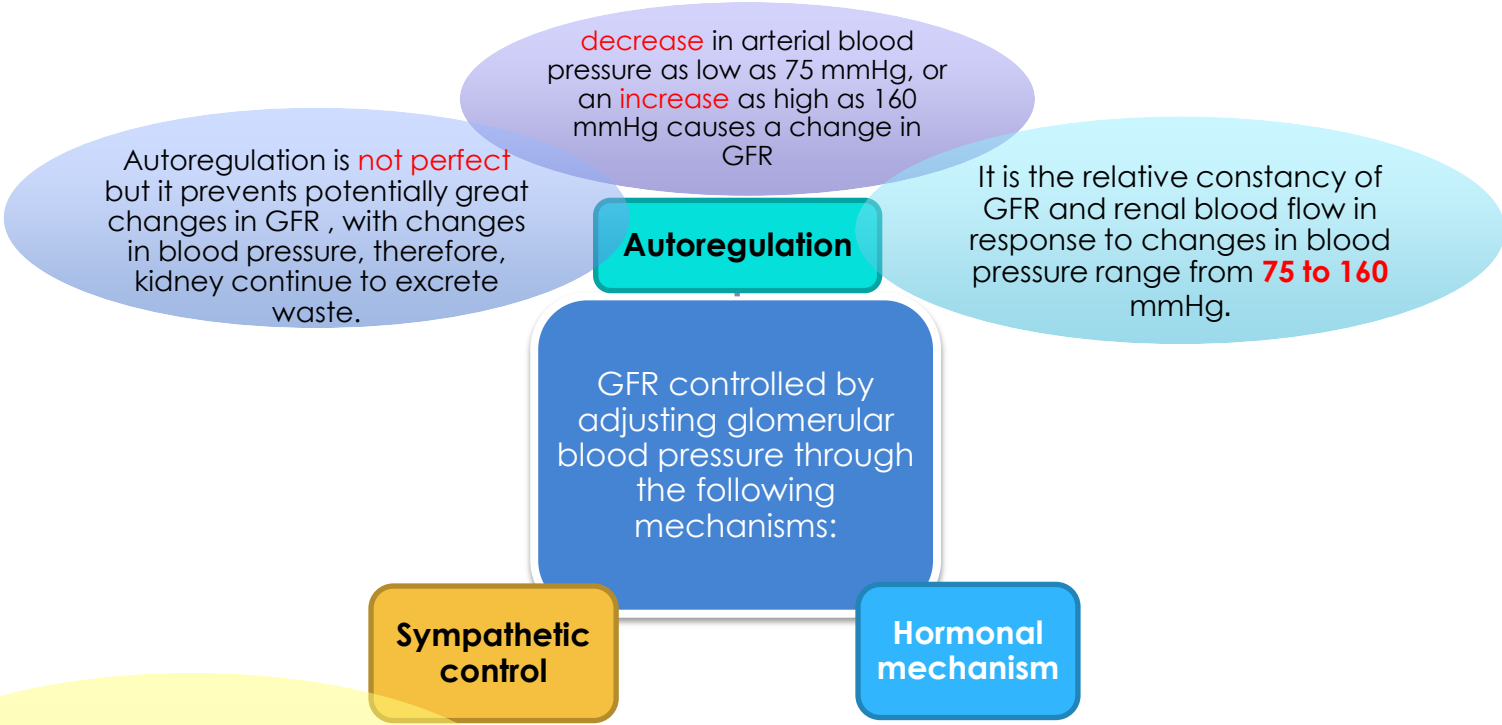
Fluid flows **sluggishly** through tubules

Tubules reabsorb wastes that should be eliminated

Azotemia develops

(high levels of nitrogen-containing substances in the blood).

Summary


decrease in arterial blood pressure as low as 75 mmHg, or an increase as high as 160 mmHg causes a change in GFR
Autoregulation is not perfect but it prevents potentially great changes in GFR , with changes in blood pressure, therefore, kidney continue to excrete waste.
Autoregulation
It is the relative constancy of GFR and renal blood flow in response to changes in blood pressure range from 75 to 160 mmHg.
GFR controlled by adjusting glomerular blood pressure through the following mechanisms:
Sympathetic control
Hormonal mechanism
The sympathetic nervous system also stimulates the renin-angiotensin mechanism. This induces vasoconstriction of efferent arteriole
When the sympathetic nervous system is at rest:
Renal blood vessels are maximally dilated
Autoregulation mechanisms prevail
Under stress:
Norepinephrine is released by the sympathetic NS
Afferent arterioles constrict and filtration is inhibited

Summary

1- The proximal convoluted tubules and distal convoluted tubules both secrete :
A. Aldosterone
B. Renin
C. ADH
D. Bicarbonate ions

2- Macula densa cells sense :
A. Renin
B. Sodium chloride
C. Urea
D. Glucose

3- Increased glomerular filtration results from :
A. Increased cardiac output
B. Rise in environmental temperature
C. Decreased fluid intake
D. Decreased blood pressure

4- When a patient is treated with an aldosterone antagonist, there is likely to be a fall in:
A. Urine volume
B. Plasma potassium concentration
C. Blood viscosity
D. Blood volume

5- The juxtaglomerular apparatus is a part of :
A. The efferent arteriole
B-. The distal convoluted tubule
C. The Afferent arteriole
D. Both C and B

6- When the sympathetic nervous system is stimulated:
A. Renin angiotensin mechanisms dilate Afferent arterioles
B. Renal blood flow is elevated
C. Norepinephrine is released from adrenal medulla
D. Afferent arterioles are constricted to decrease GFR

7- Increased glomerular filtration leads to:
A. Fluid flows through tubules too rapidly to be absorbed
B. Fluid flows through tubules slowly to be absorbed
C. None of the above
D. Both A and B

8- Autoregulation can only response when systemic pressure is:
A. Between 100 - 200 mmHg
B. Between 75 - 170 mmHg
C. Between 120-60 mmHg
D. None of the above

1.B
2.B
3.A
4.D
5.D
6.D
7.A
8.B

MCQs

1- Mention three of the main mechanisms that control the glomerular filtration rate?
*Autoregulation *Sympathetic control *Hormonal mechanism

2- Which one of the mechanisms regulating of GFR that work even if the kidney in denervated?
*Myogenic mechanism *Tubuloglomerular Feedback Mechanism

3- What is the effect of myogenic mechanism on Arterioles, RBF and GFR?
Constriction of arteriole, prevents excess increase in RBF and GFR

4- What type of sensor dose the myogenic mechanism mainly depends on?
Stretch sensor

5- Mention 2 of the effects of hypothalamus if GFR increases?
*Evoke the sensation of being thirsty *Trigger the antidiuretic hormone(ADH) to be secreted

6- What are the effects of Angiotensin II on the GFR?
Constriction of efferent arterioles preventing decreases in GFR

7- What is the effect of Nor-epinephrine on Arterioles?
Constriction of afferent arterioles

8- What will happen to the efferent arterioles when there's increase delivery of NaCl to the macula densa cells? Vasodilation

THANK YOU FOR CHECKING OUR WORK!

BEST OF LUCK

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