24.3C: Regulation of Glomerular Filtration Rate

Regulation of GFR requires both a mechanism of detecting an inappropriate GFR as well as an effector mechanism that corrects it.

Learning Objectives

• List the conditions that can affect the glomerular filtration rate (GFR) in kidneys and the manner of its regulation

Key Points

• Glomerular filtration occurs due to the pressure gradient in the glomerulus.
• Increased blood volume and increased blood pressure will increase GFR.
• Constriction in the afferent arterioles going into the glomerulus and dilation of the efferent arterioles coming out of the glomerulus will decrease GFR.
• Hydrostatic pressure in the Bowman’s capsule will work to decrease GFR.
• Normally, the osmotic pressure in the Bowman’s space is zero, but it will become present and decrease GFR if the glomerulus becomes leaky.
• Low GFR will activate the renin–angiotensin feedback system that will address the low GFR by increasing blood volume.

Key Terms

• **Bowman’s capsule**: A cup-like sac at the beginning of the tubular component of a nephron in the mammalian kidney.
• **osmotic pressure**: The pressure exerted by proteins that attracts water. Water tends to follow proteins based on an osmotic pressure gradient.

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**Glomerular Filtration Rate**

Glomerular filtration rate (GFR) is the measure that describes the total amount of filtrate formed by all the renal corpuscles in both kidneys per minute. The glomerular filtration rate is directly proportional to the pressure gradient in the glomerulus, so changes in pressure will change GFR.

GFR is also an indicator of urine production, increased GFR will increase urine production, and vice versa.

The Starling equation for GFR is:

\[ \text{GFR} = \text{Filtration Constant} \times (\text{Hydrostatic Glomerulus Pressure} - \text{Hydrostatic Bowman’s Capsule Pressure}) - (\text{Osmotic Glomerulus Pressure} + \text{Osmotic Bowman’s Capsule Pressure}) \]

The filtration constant is based on the surface area of the glomerular capillaries, and the hydrostatic pressure is a pushing force exerted from the flow of a fluid itself; osmotic pressure is the pulling force exerted by proteins. Changes in either the hydrostatic or osmotic pressure in the glomerulus or Bowman’s capsule will change GFR.

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**Hydrostatic Pressure Changes**

Many factors can change GFR through changes in hydrostatic pressure, in terms of the flow of blood to the glomerulus. GFR is most sensitive to hydrostatic pressure changes within the glomerulus. A notable body-wide example is blood volume.

Due to Starling’s law of the heart, increased blood volume will increase blood pressure throughout the body. The increased blood volume with its higher blood pressure will go into the afferent arteriole and into the glomerulus, resulting in increased GFR. Conversely, those with low blood volume due to dehydration will have a decreased GFR.

Pressure changes within the afferent and efferent arterioles that go into and out of the glomerulus itself will also impact GFR. Vasodilation in the afferent arteriole and vasoconstriction in the efferent arteriole will increase blood flow (and hydrostatic pressure) in the glomerulus and will increase GFR. Conversely, vasoconstriction in the afferent arteriole and vasodilation in the efferent arteriole will decrease GFR.

The Bowman’s capsule space exerts hydrostatic pressure of its own that pushes against the glomerulus. Increased Bowman’s capsule hydrostatic pressure will decrease GFR, while decreased Bowman’s capsule hydrostatic pressure will increase GFR.

An example of this is a ureter obstruction to the flow of urine that gradually causes a fluid buildup within the nephrons. An obstruction will increase the Bowman’s capsule hydrostatic pressure and will consequently decrease GFR.
Osmotic Pressure Changes

Osmotic pressure is the force exerted by proteins and works against filtration because the proteins draw water in. Increased osmotic pressure in the glomerulus is due to increased serum albumin in the bloodstream and decreases GFR, and vice versa.

Under normal conditions, albumins cannot be filtered into the Bowman’s capsule, so the osmotic pressure in the Bowman’s space is generally not present, and is removed from the GFR equation. In certain kidney diseases, the basement membrane may be damaged (becoming leaky to proteins), which results in decreased GFR due to the increased Bowman’s capsule osmotic pressure.

**Glomerular filtration**: The glomerulus (red) filters fluid into the Bowman’s capsule (blue) that sends fluid through the nephron (yellow). GFR is the rate at which this filtration occurs.

GFR Feedback

GFR is one of the many ways in which homeostasis of blood volume and blood pressure may occur. In particular, low GFR is one of the variables that will activate the renin–angiotensin feedback system, a complex process that will increase blood volume, blood pressure, and GFR. This system is also activated by low blood pressure itself, and sympathetic nervous stimulation, in addition to low GFR.