Renal Physiology

Table of Contents

1. Introduction

The urinary system is a combination of several organs that are associated with the production, filtration, reabsorption and secretion of urine from the human body. Organs like kidneys, ureters, bladder, urethra and renal pelvis are associated with each other in order to perform the renal system precisely. However, this study will demonstrate the functional units of kidneys along with nephrons with valid resources. Additionally, this paper will mention the significant roles of each region associated with filtration, secretion and reabsorption processes. It will address the way ADH acts on nephrons by mentioning its impacts on urine secretion and blood volume maintenance.

2. Overview of Renal System

2.1 Concept and functions of the renal system

The main purpose of the urinary system is to form urine from blood by regulating the chemicals and electrolytes in blood cells (Health Direct, 2023). Furthermore, the renal system is responsible for maintaining the water balance of the human body by regulating blood pressure levels. The renal system also maintains the consistency of red blood cells by maintaining the essential nutrients and salt within the body (Health Direct, 2023). The urinary system further intensifies the synthesis of Vitamin-D in order to keep the bones strong by excreting toxins from the blood. The urinary system mainly works as the filtration system within the human body which maintains the toxin levels of blood and excretes excess water in the form of urine (Health Direct, 2023). Henceforth, there are several functions of the renal system which require to be maintained duly for maintaining a standard state of living.

Figure 1: Diagram of the renal system

(Source: Health Direct, 2023)

2.2 Brief description of the key components of the urinary system

The renal system is composed of several organs such as kidneys, ureters, urethra and bladder which perform the formation of urine from blood. However, each of these organs has independent functions that help the human body to excrete liquid waste by keeping the balance of potassium and sodium. These organs perform their individual duties by filtrating, storing and excreting urine out of the body from the pelvic region.

Kidneys: There are two kidneys within the human body in the abdominal region just below the rib cage. Medical reports stated that an adult kidney is capable of filtrating 141.95 litres of blood in a day to produce almost 1.95 litres of urine (Cleveland Clinic, 2023).

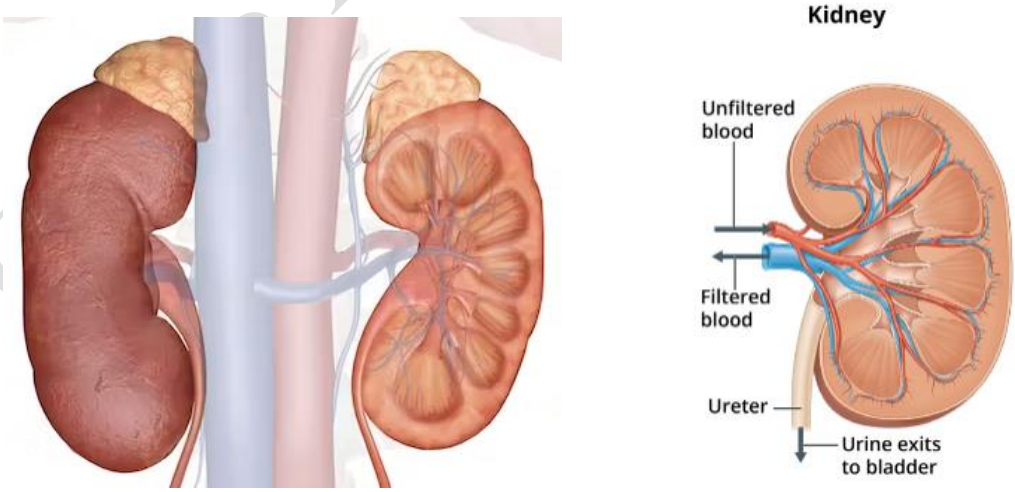

Figure 2: Anatomy of Kidney

(Source: NIDDK, 2023)

Bladder: The bladder is a hollow organ that is located in the lower region of the pelvis area in order to store urine. The balloon-shaped bladder is composed of the muscular wall which allows it to store a large quantity of urine produced by nephrons. The bladder is responsible for passing urine out of the body by shrinking itself to a certain limit. Several articles have shown that an adult bladder can hold over 2 cups of urine at a time which is almost 500 mm (Cleveland Clinic, 2023).

Urethra: The Urethra is a thin-walled tube that is composed of narrow fibromuscular ducts to transport urine and semen from the bladder to the outside of the body. This thin vessel is responsible for carrying urine from the human body with the help of two sphincter muscles that control frequent urination. These ring-like muscles are responsible for regulating the opening of the urethra vessel during excessive pressure.

Ureters: The ureters are two thin tubes or ducts that connect the kidney to the bladder in order to carry urine for successful excretion. The upper half of the 9-inch-long ureters is located in the abdomen and the lower half is located in the pelvic region (Cleveland Clinic, 2023). Medical studies have shown that this organ generally acts as a connecting bridge between the kidney and the bladder. The ureters are composed of smooth muscle which pushes urine from the kidneys to reach the bladder for storage.

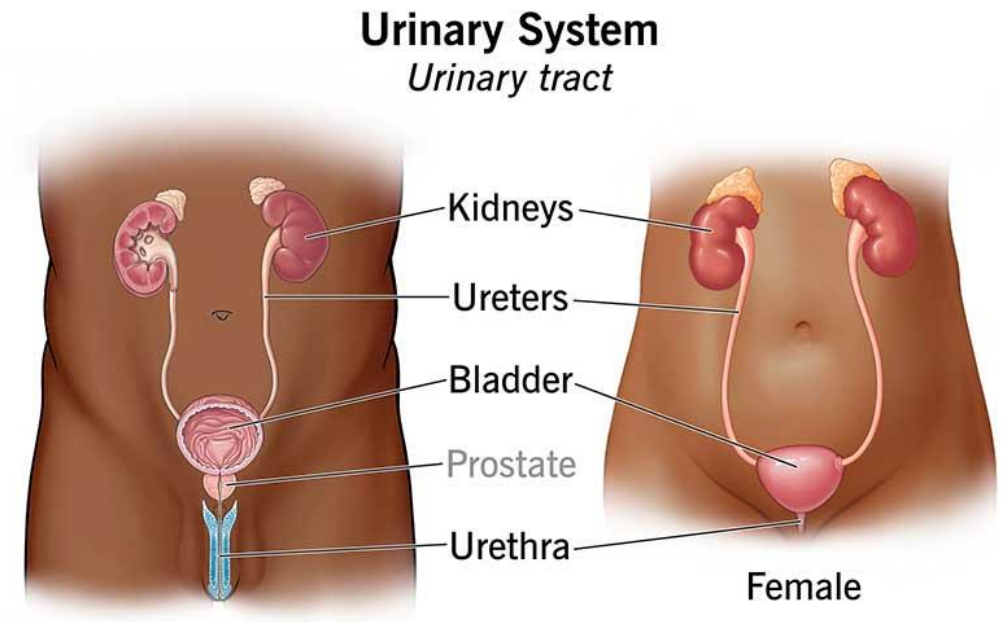

Figure 3: Diagram of the urinary system in male and female

(Source: Cleveland Clinic, 2023)

3. Structural and functional analysis of the nephron

The nephron is the functional and structural unit of the kidney which is mainly responsible for producing urine from liquid wastes of blood. There are almost 1,000,000 nephrons present within an adult human body which are composed of the renal tubule and renal corpuscle (Prof. Gallik, 2023).

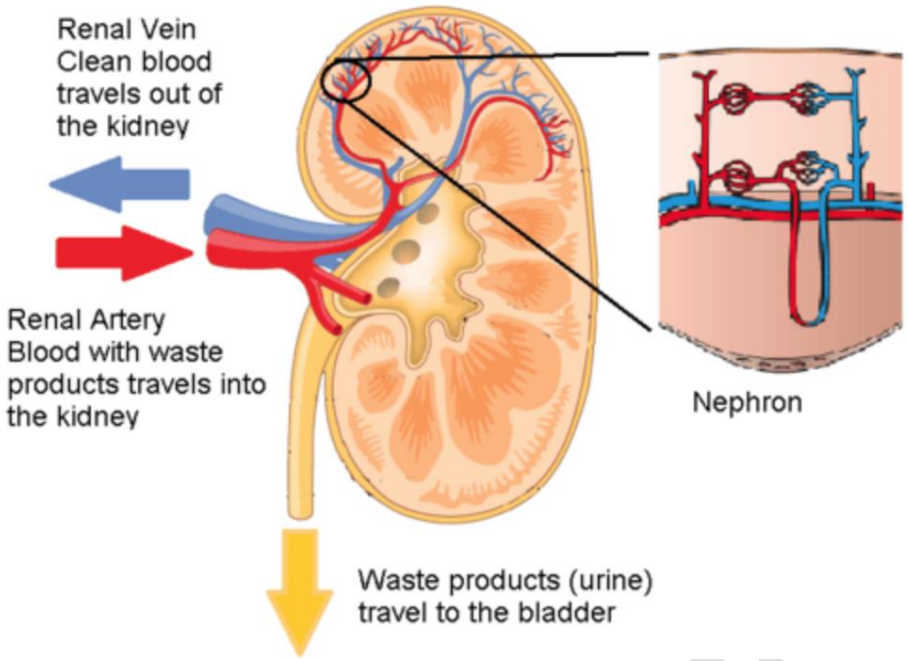

Figure 4: Basic structural analysis of the nephron

(Source: Prof. Gallik, 2023)

3.1 Skeletal Structure Analysis of Nephron

The nephron is composed of six significant elements Glomerulus, Bowman's capsule, Proximal Convoluted Tubule, Distal Convoluted Tubule and Loop of Henle.

Bowman's capsule: Bowman's capsule is the frontal-most part of nephrons that is a cup-like sack surrounding the glomerulus (Theodorou *et al.*, 2021). This double-walled is continued up to PCT or Proximal Convoluted Tubule by protecting blood vessels of the glomerulus. However, the two-layered Bowman's capsule is located in the renal cortex region of the kidney.

Glomerulus: Glomerulus is a network of blood capillaries or tuft located in the frontal region of the nephron. The glomerulus is generally known as the filtering unit of the kidney that is situated between twin resistance vessels in nephrons (Prof. Gallik, 2023). There are approximately 2 million glomeruli in two kidneys that can cause variations in blood filtration rate.

Proximal Convoluted Tubule: Medical reports have shown that the maximum rate of reabsorption process takes place in 14 mm lengthy PCT which is the frontal part of renal tubule. Studies have further shown that the PCT is 25% longer in Juxtamedullar nephrons than in superficial nephrons (Theodorou *et al.*, 2021). The PCT belongs from the renal pole of Bowman's capsule and is extended up to the beginning of the Loop of Henle

Loop of Henle: Henle's loop is composed of a descending and ascending limp that shows diverse permeability. The descending loop is permeable to water and the ascending limb of this region is permeable to electrolytes (Dr. Thomas, 2023).

Distal Convoluted Tubule: DCT is the last part of nephrons that are directly connected to collecting ducts in the medullary pyramids of the kidney.

Collecting duct: Collecting duct in medullary pyramids acts as a bridge to pass urine to ureters from kidneys (Theodorou *et al.*, 2021).

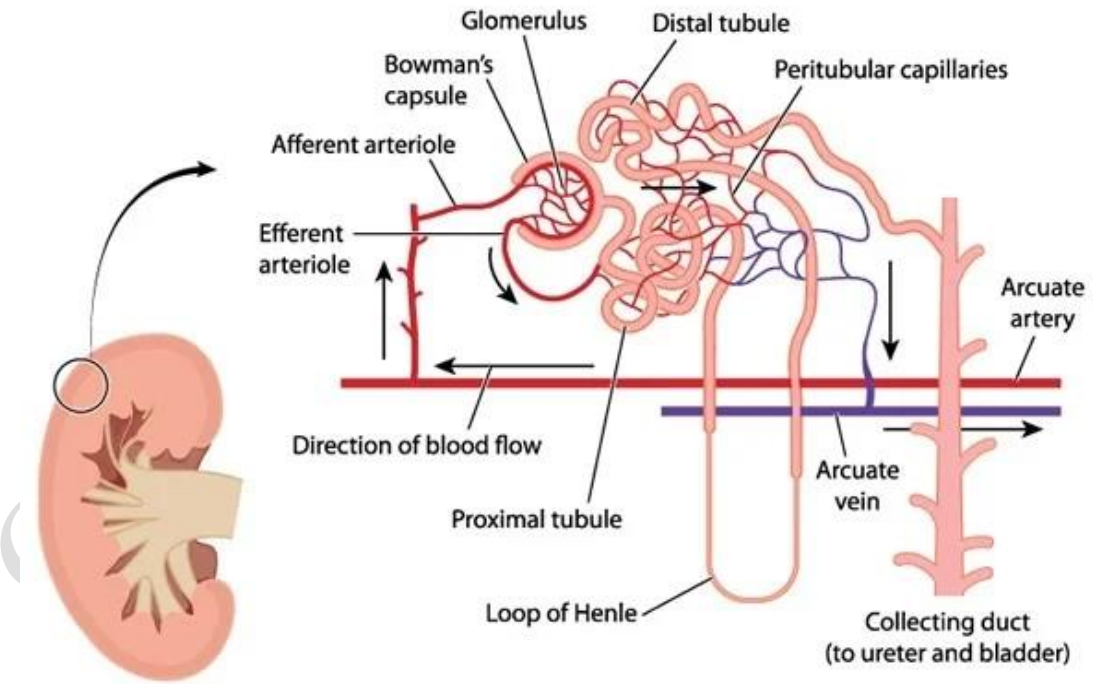

Figure 5: Components of nephrons

(Source: Dr. Thomas, 2023)

3.2 Functions of Nephron

Filtration: One of the major functions of the nephron is the filtration of blood to produce urine with several toxins. The major purpose of Bowman's capsule is to help the glomerulus filter the human blood to produce urine (Vallon and Thomson, 2020). Additionally, tiny blood capillaries of the glomerulus are associated with the filtration of blood in order to flow out filtered blood through renal veins. Blood enters the nephron through the afferent arteriole and flows into the glomerulus for excreting filterable components such as nitrogenous waste (Vallon and Thomson, 2020). However, the blood vessels of the glomerulus are protected by Bowman's capsule which assists in the Hemodynamic control of glomerular filtration.

Reabsorption: The majority of reabsorption takes place in renal tubules associated with PCT, Henle's Loop and DCT. The filtered blood from glomerulus capillaries is passed to PCT in order to get reabsorbed for excreting essential nutrients, glucose, amino acids and proteins (Sakolish *et al.*, 2020). The descending and ascending limbs of Henle's loop are responsible for the absorption of electrolytes along with water (Sakolish *et al.*, 2020). As the electrolytes are reabsorbed while passing through its ascending limb, the filtrate urine gets more diluted. DCT secretes various ions such as potassium and hydrogen while reabsorbing the filtrate before excretion.

Secretion: Studies have shown that the passing of waste ions and hydrogen ions from the blood capillaries of the glomerulus into the renal tubule is known as secretion (Vallon and Thomson, 2020). The secreted ions get combined with the remaining filtrate and water in order to produce urine. The filtered urine is then passed from renal tubules to the collecting duct in order to reach the bladder through ureters.

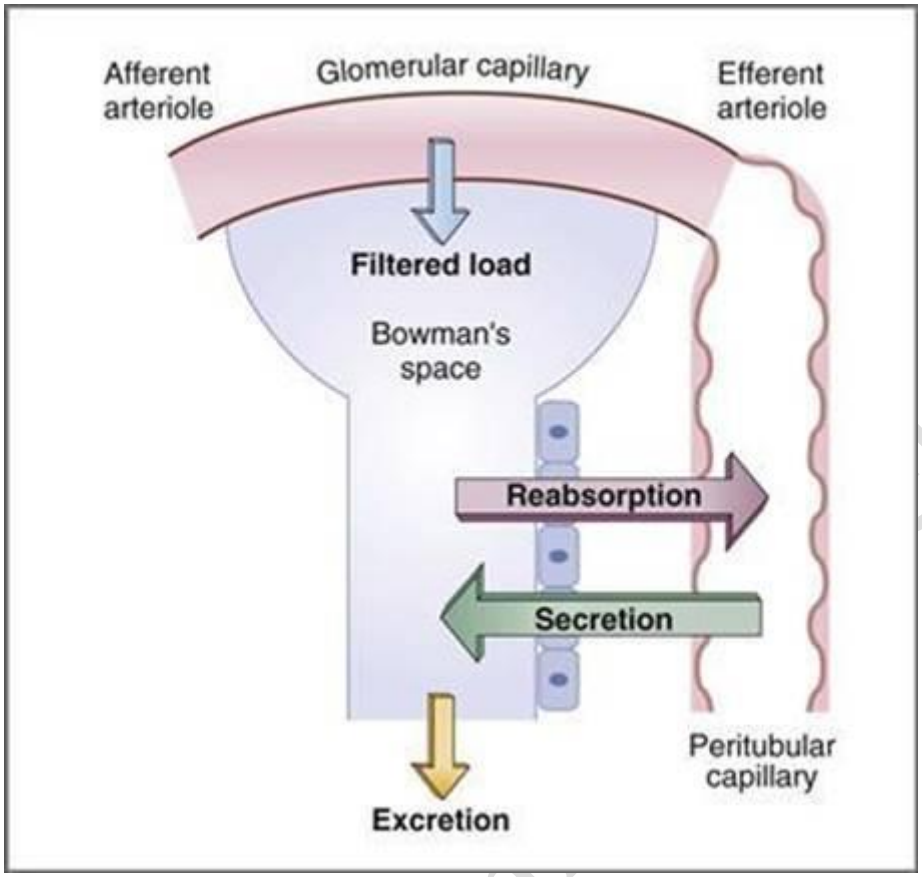

Figure 6: Functions of the nephron

(Source: Sakolish *et al.*, 2020)

4. Case study analysis for the impact of ADH

4.1 Explain how and where ADH acts upon the nephron

As per several medical researches, ADH or Anti-diuretic Hormone helps the water reabsorption process in order to produce more concentrated urine from the nephron. ADH is secreted from the pituitary gland in order to increase the reabsorption of water in the DCT and collecting duct (Widrow, 2022). In addition to this, dehydration in the human body triggers the secretion of ADH in order to conserve water. As per the case study, dehydration within Chalie's body during a bushwalk on a summer day caused the secretion of ADH in his DCT to conserve water.

4.2 Impact of ADH on urine output and blood volume

Urine output: Anti-diuretic Hormone or ADH is a chemical substance that decreases the amount of urine production in nephrons during dehydration. A high concentration of ADH secretion from Charlie's brain causes his body to limit the release of urine to protect the balance of water (Widrow, 2022). ADH is associated with increasing the osmolality of urine by decreasing its rate of flow without changing blood pressure.

Blood volume: The volume of urine can control the fluctuation of blood pressure levels due to the secretion of ADH. Studies have shown that the high concentration of urine volume causes dehydration and a fall in blood pressure (Widrow, 2022). Henceforth, dehydration causes low blood volume in Charlie's body which has been detected by baroreceptors in blood vessels. Therefore, the high concentration of salts in the bloodstream of Charlie also triggered the release of ADH to balance the water levels within his body.

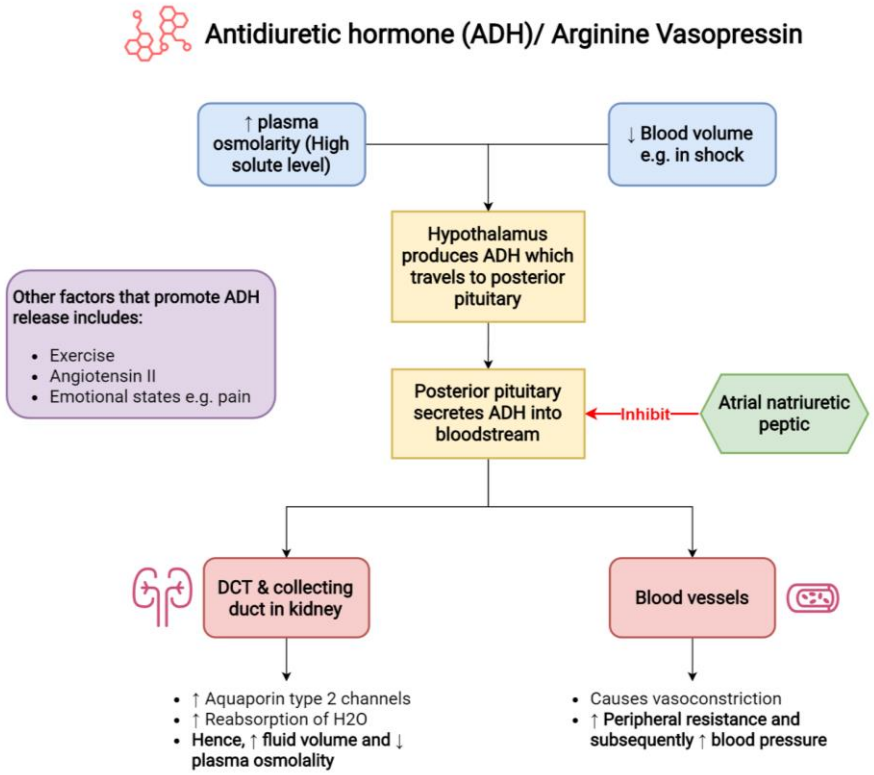

Figure 7: Functions of Anti-diuretic Hormone

(Source: Widrow, 2022)

5. Conclusion

This study has mentioned the key components of the urinary system by demonstrating the role of the renal system with valid resources. The concept of the urinary tract or renal system is also described within this paper in a summarised way. Besides this, the paper has mentioned the functions of different structural units of nephrons including filtration, reabsorption and secretion. In addition to this, the discussion has illustrated the overview of the case study by mentioning the way ADH reacts on the nephron during the dehydration phase. It has further mentioned the impact of ADH on blood volume regulation and urine secretion with supportive diagrams.

References

Cleveland Clinic, (2023). *Urinary System.* Available at: https://my.clevelandclinic.org/health/body/21197-urinary-system [Accessed: 5th October, 2023]

Dr. Thomas, L., (2023). *The Loop of Henle.* Available at:https://www.news-medical.net/health/The-Loop-of-Henle.aspx [Accessed: 6th October, 2023]

Health Direct, (2023). *Urinary system.* Available at: https://www.healthdirect.gov.au/urinary-system [Accessed: 3rd October, 2023]

NIDDK, (2023). *Your Kidneys & How They Work.* Available at: https://www.niddk.nih.gov/health-information/kidney-disease/kidneys-how-they-work#:~:text=The%20kidneys%20are%20two%20bean,extra%20water%20to%20make%20urine. [Accessed: 4th October, 2023]

Prof. Gallik, S., (2023). *How Many Nephrons Are in Each Kidney.* Available at: https://stevegallik.org/how-many-nephrons-are-in-each-kidney/ [Accessed: 4th October, 2023]

Sakolish, C., Chen, Z., Dalaijamts, C., Mitra, K., Liu, Y., Fulton, T., Wade, T.L., Kelly, E.J., Rusyn, I. and Chiu, W.A., (2020). Predicting tubular reabsorption with a human kidney proximal tubule tissue-on-a-chip and physiologically-based modeling. *Toxicology in Vitro*, *63*, p.104752.

Theodorou, C., Leatherby, R. and Dhanda, R., (2021). Function of the nephron and the formation of urine. *Anaesthesia & Intensive Care Medicine*, *22*(7), pp.434-438.

Vallon, V. and Thomson, S.C., (2020). The tubular hypothesis of nephron filtration and diabetic kidney disease. *Nature Reviews Nephrology*, *16*(6), pp.317-336.

Widrow, B., (2022). Blood Salinity Regulation, the ADH System. In *Cybernetics 2.0: A General Theory of Adaptivity and Homeostasis in the Brain and in the Body* (pp. 107-116). Cham: Springer International Publishing.

Widrow, B., (2022). The ADH System and the Aldosterone System Combined. In *Cybernetics 2.0: A General Theory of Adaptivity and Homeostasis in the Brain and in the Body* (pp. 127-133). Cham: Springer International Publishing.

Grade Assignment Help

Get professional help with either STEM or non-tech assignment

Fast delivery

Expert writers

Original papers

Order now

Free quote