V. anatomy and physiology

V. Anatomy and Physiology The Urinary Tract The Urinary System rids the body of nitrogenous wastes while regulating water, electrolyte, and acid-base balance of the blood. Kidneys Kidneys are small, dark red organs with a kidney-bean shape lie against the dorsal body wall in a retroperineal position (beneath the parietal peritoneum) in the superior lumbar region. The kidneys extend from T12 to the L3 vertebra; thus they receive some protection from the lower part of the rib cage. Because the liver crowds it, the right kidney is positioned slightly lower than the left. It is convex laterally and has a medial indentation called the renal bilum. Several structures, including the ureters, the renal blood vessels, and nerves, enter or exit the kidney at the hilum. A transparent fibrous capsule encloses each kidney and gives a fresh kidney a glistening appearance. A fatty mass, the perineal fat capsule surrounds each kidney and acts to cushion it against blows. The renal fascia, the outermost capsule, anchors the kidney and helps hold it in place against the muscles of the trunk wall. When a kidney is cut lengthwise, three distinct regions become apparent. The outer region, which is light in color, is the renal cortex. Deep the cortex is a darker reddish-brown area, the renal medulla. The medulla has many basically triangular regions with a striped appearance, the renal or medullary pyramids. The broader base of each pyramid faces toward the cortex, its tip, and the apex points toward the inner region of the kidney. The pyramids are separated by extensions of cortex-like tissue, the renal columns. Medial to the hilum is a flat, basin like cavity, and the renal pelvis. The pelvis is continuous with the ureter living the hilum. Extensions of the pelvis, calyces, form cup-shaped areas that enclose the tips of the pyramids. The calyces collect urine, which continuously drains from the tips of the pyramids into the renal pelvis. Urine then flows from the pelvis into the ureter, which transports it to the bladder for temporary storage. Blood Supply The kidneys continuously cleanse the blood and adjust its composition, so it is not surprising that they have a very rich blood supply. Approximately one-quarter of the total blood supply of the body passes through the kidneys each minute. The arterial supply of each kidney is the renal artery. As the renal artery approaches the hilum, it divides into segmental arteries, each of which gives off several branches called interlobar arteries, which travel through the renal columns to reach the cortex. At the cortex medulla junction, interlobar arteries give off the arcuate arteries, which curve over the medullary pyramids. Small cortical radiate arteries then branch off the arcuate arteries and run outward to supply the cortical tissue. Venous blood draining from the kidney flows through veins that trace the pathway of the arterial supply but in a reverse direction — cortical radiate veins to arcuate veins to interlobar veins to the renal vein, which emerges from the kidney hilum. (There are no segmental veins) Nephrons and Glomeruli Each kidney contains over a million tiny structures called nephrons. Nephrons are the structural units of the kidneys and, as such, responsible for forming urine. Each nephron consists of two main structures: a glomerulus, which is a knot of capillaries, and a renal tube. The closed end of the renal tube is enlarged and cup-shaped and completely surrounds the glomerulus. This portion of the renal tube is called the glomerular, or Bowman’s capsule. The inner (visceral) layer of the capsule is made up of highly modified octopus-like cells called podocytes. Podocytes have long branching processes called foot processes that intertwine with one another and cling to the glomerulus. Because opening, the so-called filtration slits, exist between their extensions, the podocytes form a porous, or “ holey, " membrane around the glomerulus. The rest of the tubule is about 3 cm (approximately 1. 25 inches) long. As it extends from the glomerular capsule, it coils and twists before forming a hairpin loop and then again becomes coiled and twisted before enetering a collecting tubule called the collecting duct. These different regions of the tubule have specific names; in order from the glomerular capsule they are the proximal convoluted tubule (PCT), the loop of Henle, and the distal convoluted tubule (DCT). The lumen surfaces of the tubule cells in the proximal convoluted tubules are covered with dense microvilli, which increases their surface area tremendously. Microvilli also occur on the tubule cell in other parts of the tubule but in much reduced numbers. Most nephrons are called cortical nephrons because they are located almost entirely within the cortex. In a few cases, the nephrons are called juxtamedullary nephrons, because they are situated close to the cortex-medulla junction, and their loops of Henle dip deep into the medulla. The collecting ducts, each of which receives urine from many nephrons, run downward through the medullary pyramids, giving the pyramids a striped appearance. They de; iver the final urine product into the calyces and renal pelvis. Each and every nephron is associated with two capillary beds — the glomerulus and the peritubular capillary bed. The glomerulus is both fed and drained by arterioles. The afferent arteriole, which arises from a cortical radiate artery, is the ‘ feeder vessel’ and the efferent arteriole receives blood that has passed through the glomerulus. The glomerulus, specialized for filtration, is unlike any other capillary bed in the entire body. Because it is both fed and drained by arterioles, which are high-resistance vessels, and because the afferent arteriole has a larger diameter than efferent, blood pressure in the glomerular capillaries is much higher than in other capillary beds. This extremely high pressure forces fluids and solutes (smaller than proteins) out of the blood into the glomerular capsule. Most of this filtrate (99 percent) is eventually reclaimed by the renal tubule cells and returned to the blood in the peritubular capillary beds. The second capillary bed, the peritubular capillaries, arises from the efferent arteriole that drains the glomerulus. Unlike the high-pressure glomerulus, these capillaries are low-pressure, porous vessels that are adapted for absorption instead of filtration. They cling closely to the whole length of the renal tubule, where they are in an ideal position to receive solutes and water from the tubule cells as these substances are reabsorbed from the filtrate percolating through the tubule. The peritubular capillaries drain into the interlobular veins leaving the cortex. Urine Formation Glomerular Filtration Each kidney has about a million nephrons, where urine formation takes place. At any given time, about 20 percent of the blood is going through the kidneys to be filtered so that the body can eliminate waste and maintain hydration, blood pH and proper levels of blood substances. The first part of the process of urine formation occurs in the glomeruli, which are small clumps of blood vessels. The glomeruli act as filters, allowing water, glucose, salt and waste materials to pass through to the Bowman's capsule, which surrounds each glomerulus, but preventing the red blood cells from passing. The fluid in the Bowman's capsule is referred to as the nephric filtrate and resembles blood plasma. It also includes urea, produced from the ammonia which accumulates when the liver processes amino acids and is filtered out by the glomeruli. Tubular Reabsorption About 43 gallons of fluid goes through the filtration process, but most is subsequently reabsorbed rather than being eliminated. Reabsorption occurs in the proximal tubules of the nephron, which is the portion beyond the capsule, in the loop of Henle, and in the distal and collecting tubules, which are further along the nephron beyond the loop of Henle. Water, glucose, amino acids, sodium and other nutrients are reabsorbed into the bloodstream in the capillaries surrounding the tubules. Water moves via the process of osmosis: movement of water from an area of higher concentration to one of lower concentration. Usually all the glucose is reabsorbed, but in diabetic individuals, excess glucose remains in the filtrate. Sodium and other ions are reabsorbed incompletely, with a greater proportion remaining in the filtrate when more is consumed in the diet, resulting in higher blood concentrations. Hormones regulate the process of active transport by which ions like sodium and phosphorus are reabsorbed. Tubular Secretion Secretion is the final step in the process of urine formation. Some substances move directly from the blood in capillaries around the distal and collecting tubules into those tubules. Secretion of hydrogen ions via this process is part of the body's mechanism for maintaining proper pH, or acid-base balance. More ions are secreted when the blood is acidic, less when it is alkaline. Potassium ions, calcium ions and ammonia also are secreted at this stage, as are some medications. The kidney is considered a homeostatic organ, one that helps maintain the chemical composition of the blood within strict limits. It does this partly by stepping up secretion of substances such as potassium and calcium when concentrations are high and by increasing reabsorption and reducing secretion when levels are low. The urine created by this process then passes to the central part of the kidney called the pelvis, where it flows into the ureters and then the bladder. The Gastrointestinal Tract The gastrointestinal tract (GIT) consists of a hollow muscular tube starting from the oral cavity, where food enters the mouth, continuing through the pharynx, oesophagus, stomach and intestines to the rectum and anus, where food is expelled. There are various accessory organs that assist the tract by secreting enzymes to help break down food into its component nutrients. Thus the salivary glands, liver, pancreas and gall bladder have important functions in the digestive system. Food is propelled along the length of the GIT by peristaltic movements of the muscular walls. The primary purpose of the gastrointestinal tract is to break food down into nutrients, which can be absorbed into the body to provide energy. First food must be ingested into the mouth to be mechanically processed and moistened. Secondly, digestion occurs mainly in the stomach and small intestine where proteins, fats and carbohydrates are chemically broken down into their basic building blocks. Smaller molecules are then absorbed across the epithelium of the small intestine and subsequently enter the circulation. The large intestine plays a key role in reabsorbing excess water. Finally, undigested material and secreted waste products are excreted from the body via defecation (passing of faeces). Small intestine The small intestine is composed of the duodenum, jejunum, and ileum. It averages approximately 6m in length, extending from the pyloric sphincter of the stomach to the ileo-caecal valve separating the ileum from the caecum. The small intestine is compressed into numerous folds and occupies a large proportion of the abdominal cavity. The duodenum is the proximal C-shaped section that curves around the head of the pancreas. The duodenum serves a mixing function as it combines digestive secretions from the pancreas and liver with the contents expelled from the stomach. The start of the jejunum is marked by a sharp bend, the duodenojejunal flexure. It is in the jejunum where the majority of digestion and absorption occurs. The final portion, the ileum, is the longest segment and empties into the caecum at the ileocaecal junction. The small intestine performs the majority of digestion and absorption of nutrients. Partly digested food from the stomach is further broken down by enzymes from the pancreas and bile salts from the liver and gallbladder. These secretions enter the duodenum at the Ampulla of Vater. After further digestion, food constituents such as proteins, fats, and carbohydrates are broken down to small building blocks and absorbed into the body's blood stream. The lining of the small intestine is made up of numerous permanent folds called plicae circulares. Each plica has numerous villi (folds of mucosa) and each villus is covered by epithelium with projecting microvilli (brush border). This increases the surface area for absorption by a factor of several hundred. The mucosa of the small intestine contains several specialised cells. Some are responsible for absorption, whilst others secrete digestive enzymes and mucous to protect the intestinal lining from digestive actions. Large intestine The large intestine is horse-shoe shaped and extends around the small intestine like a frame. It consists of the appendix, caecum, ascending, transverse, descending and sigmoid colon, and the rectum. It has a length of approximately 1. 5m and a width of 7. 5cm. The caecum is the expanded pouch that receives material from the ileum and starts to compress food products into faecal material. Food then travels along the colon. The wall of the colon is made up of several pouches (haustra) that are held under tension by three thick bands of muscle (taenia coli). The rectum is the final 15cm of the large intestine. It expands to hold faecal matter before it passes through the anorectal canal to the anus. Thick bands of muscle, known as sphincters, control the passage of faeces. The mucosa of the large intestine lacks villi seen in the small intestine. The mucosal surface is flat with several deep intestinal glands. Numerous goblet cells line the glands that secrete mucous to lubricate faecal matter as it solidifies. The functions of the large intestine can be summarised as: 1. The accumulation of unabsorbed material to form faeces. 2. Some digestion by bacteria. The bacteria are responsible for the formation of intestinal gas. 3. Reabsorption of water, salts, sugar and vitamins.