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**Urine Formation and Concentration**

Formation of urine

There are two kidneys which are bean-shaped and are approximately 10cm long, 5.5cm wide and 3cm thick. Each kidney weighs about 150g and has a marked indentation medially - the hilus - where the renal artery and renal nerves enter and the renal vein and ureter leave. Between them, the kidneys make approximately 30ml or more of urine every hour. Approximately 25 per cent of the cardiac output goes to the kidneys where organic waste products are removed in the million or so nephrons in each kidney. Normal urine production, therefore, depends on normal blood flow to the kidneys. The nephron is the functional unit of the kidney. Nephrons permit the passage of some substances out of the body but restrict the passage of others, for example, blood cells and large proteins.

Filtration

As blood flows through the glomerulus (a capillary network that forms part of the nephron), much of the fluid and waste products in the blood are forced out through the walls of the capillaries, filtered, and then flow into the Bowman’s capsule. The Bowman’s capsule is a double-walled endothelial cup that surrounds the glomerulus. This glomerular filtrate (about 125ml per minute) consists of water, glucose, waste salts such as sodium and potassium, and urea. [Urea is the most abundant waste product excreted by the kidneys](http://www.nursingtimes.net/clinical-archive/assessment-skills/why-do-we-test-for-urea-and-electrolytes-24-01-2014/) and is formed from ammonia, a highly toxic substance. Ammonia is formed in the liver from the breakdown of amino acids.

Absorption

Much of the glomerular filtrate, including most of the water, is reabsorbed into the capillaries surrounding the proximal and distal convoluted tubules, the loop of Henle and the collecting tubules. All of the glucose will be reabsorbed unless blood glucose levels are high - more than 8.9 millimoles per litre (mmol/l) or 160 milligrams per decilitre (mg/dl) - in which case some glucose will be excreted in the urine. Sodium is also reabsorbed but the amount varies, depending on how much the body requires to maintain a constant concentration of sodium ions in the blood.

Secretion

This is the final stage of urine formation, and occurs at the distal and collecting tubules. Substances either diffuse or are actively transported out of the capillaries and into the collecting tubules to be excreted in the urine. Hydrogen ions, potassium ions, ammonia and some drugs are all secreted at this stage and the kidneys play an important role in maintaining the acid-base balance within the body.

The ureters

Urine passes from the kidneys to the bladder through the ureters where it is stored until it is eliminated via the urethra. Urine is moved along the ureters to the bladder by peristaltic contraction and gravity. The ureters are muscular tubes about 30cm long. They are firmly attached to the posterior abdominal wall and are retroperitoneal; they do not enter the peritoneal cavity. The ureteral openings into the bladder are flattened (slit-shaped) rather than round. This is due to the oblique angle at which the ureters enter the bladder, which helps to prevent the back-flow of urine into the ureters when the bladder contracts.

Storage of urine

The bladder is a hollow, muscular sac which sits in the pelvis. In males, the base of the bladder lies between the rectum and pubic symphysis while in females the base is below the uterus and anterior to the vagina. The bladder stores urine and can contain approximately one litre when full. It is held in position by the peritoneum surrounding it (though only its top surface lies within the peritoneum) and by strong umbilical ligaments. The bladder is lined by mucosa. This is particularly thick in the area around the ureter openings and the junction with the urethra, where the mucosa acts as a funnel to channel urine into the urethra when the bladder contracts. During micturition, strong muscles in the bladder walls (the detrusor muscles) compress the bladder, pushing its contents into the urethra.

Control of bladder emptying

The opening, described as the neck of the bladder, between the bladder and the urethra, is closed by two rings of muscle - the internal and external sphincters. The internal sphincter contains smooth muscle fibres and the normal muscle tone of these fibres keeps it contracted; it is therefore not under voluntary control. The external sphincter is formed of a circular band of skeletal muscle which is supplied by the pudendal nerve and is under voluntary control. These fibres remain contracted, as a result of central nervous system stimulation, except during micturition when they relax.

The urethra

The urethra leaves the bladder at its most inferior point and extends from there to the outside of the body. In women, this exits near the anterior wall of the vagina and is 3-5cm long. Because the urethra is short and exits so close to the anus, women are particularly prone to urinary tract infections. In men, the urethra extends to the tip of the penis, a total distance of up to 20cm. It has four sections:

- The prostatic urethra, which passes through the centre of the prostate gland;

- The membranous urethra, the short middle portion, goes through the muscular pelvic floor;

- The bulbar urethra, which is surrounded by corpus spongiosum. Contraction of these muscle fibres assist with emptying the urethra at the end of micturition;

- The penile urethra, which reaches the tip of the penis.