

# The Urinary System

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The *urinary system* [Figure 10 - 1] provides the mechanism for extracting waste products and excess fluid from the blood, and excreting them.

### Kidneys

The *kidneys* are located on the posterior abdominal wall, one on each side of the spinal column, behind the peritoneum, and below the diaphragm.

The kidneys operate as filters, removing unwanted substances from the blood, and generate urine as a waste fluid output.

A kidney is surrounded by three layers of tissue:

**Renal fascia.** (outer layer) This is connective tissue, which surrounds the kidney, and attaches it to the posterior abdominal wall.

**Adipose capsule.** (middle layer) This is fatty tissue which protects the kidney against physical shock.

**Renal capsule.** (inner layer) This is tough fibrous tissue, and is continuous with the outer surface of the ureters.

The interior of a kidney is formed in three regions:

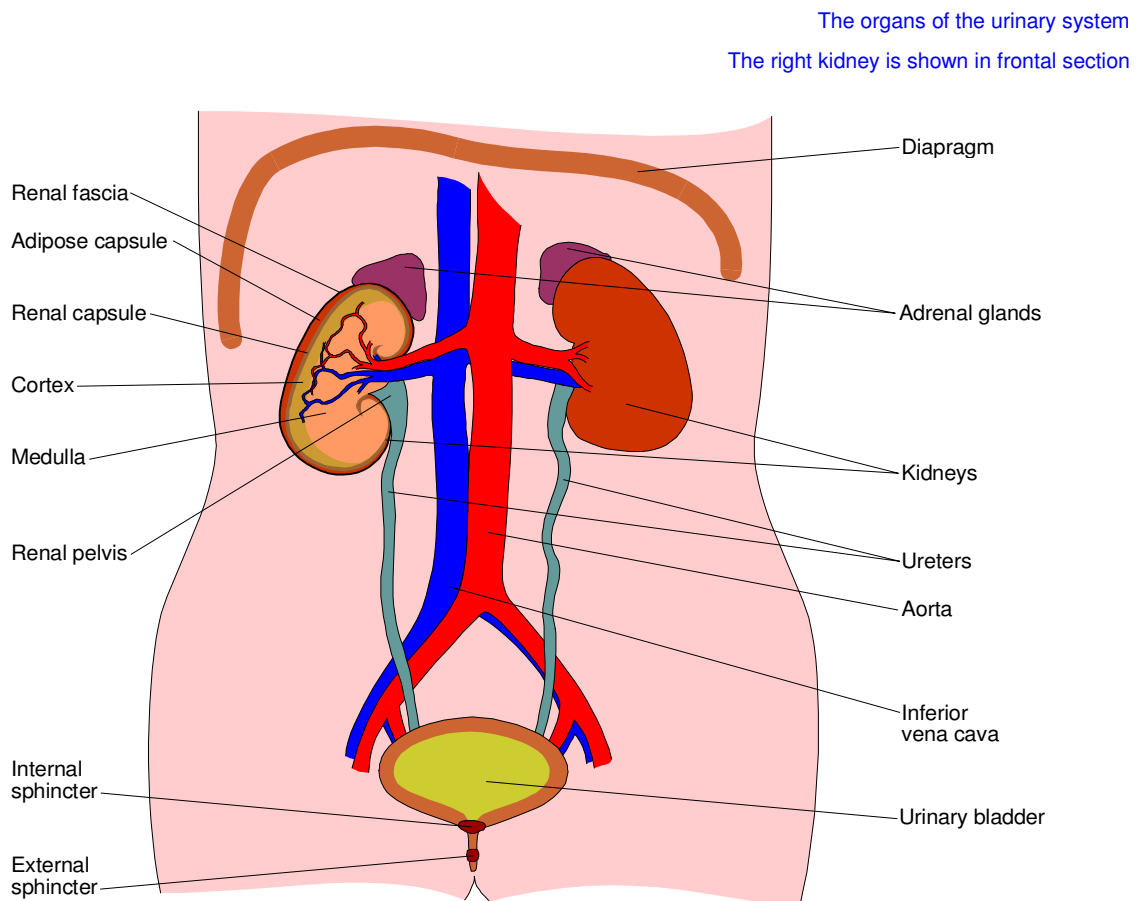
**Cortex.** This is an outer layer of tissue containing initial filtration mechanisms.

**Medulla.** This is the inner section, containing re-absorption mechanisms and urine collection vessels.

**Renal pelvis.** This is a collection area, formed from the expanded uppermost end of the ureter.

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**Figure 10 - 1** the urinary system



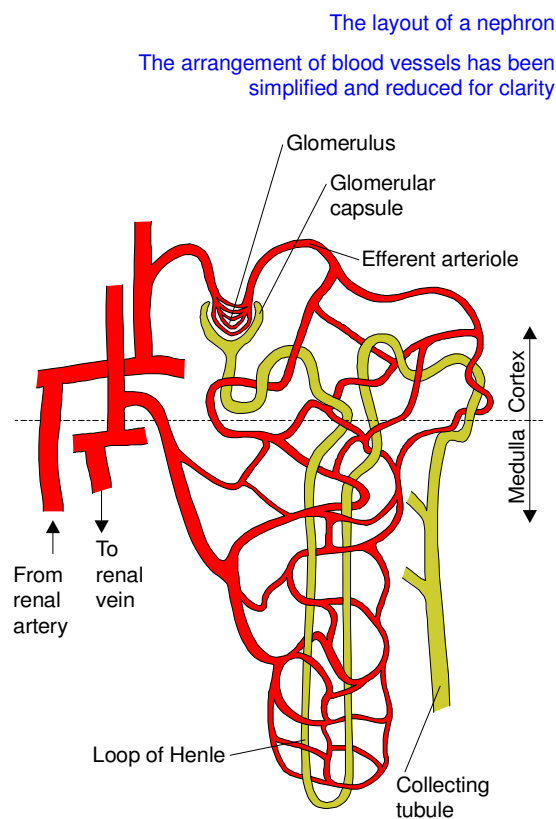
## Nephrons

Each kidney is made up from approximately 1 million functional units called *nephrons*, [Figure 10 - 2] grouped into 'pyramids'.

Blood is carried into the kidney along the *renal artery*. This then splits into arterioles, subdivisions of which carry the blood to nephrons.

At each nephron, the blood first reaches the *glomerulus*, a cup shaped collecting capsule containing a bundle of capillaries. The blood then passes on through the *efferent arteriole*. This leads to a network of capillaries which mesh with the tubule, and eventually re-combine to lead into the *renal vein*.

**Figure 10 - 2** a nephron



In the glomerulus, a considerable amount of water, dissolved matter, and cells pass out of the capillaries across semi-permeable membranes, and into the nephron.

The resulting liquid then passes through the tubule system of the nephron - the *loop of Henle*.

During this time, the majority (normally over 99%) of the water, and useful nutrients are re-absorbed into adjacent capillaries. However, some other waste products (some drug residues, for example) are passed into the tubules from the blood.

The resulting liquid, *urine*, in the tubule passes into a *collecting tubule*, and on into the ureter.

## Ureters

The *ureters* are tubes, about 3mm in diameter, which convey urine from the kidneys to the bladder.

The ureters are made up from three layers of tissue:

**Fibrous tissue.** This forms the outer layer and is continuous with the outer capsule of the kidney.

**Smooth muscle.** This forms the middle layer, as a spiral pattern of muscular layers.

**Stratified epithelium.** This forms a smooth inner layer.

The middle muscular layer provides peristaltic waves of contraction which force the urine into the bladder. This function which repeats at approximately ten second intervals, operates without nervous stimulation.

## Urinary Bladder

The *urinary bladder* lies in the pelvic cavity, and provides a reservoir for urine. Its size and exact position vary according to the amount of urine contained within.

The bladder is made up from three layers of tissue:

**Tunica serosa.** (outer layer) This is derived from the peritoneum, and covers the upper and lateral surfaces only. It reduces friction with adjacent abdominal organs.

**Tunica muscularis.** (middle layer) This is formed from smooth muscle and fibrous tissue.

**Tunica mucosa.** (inner layer) This is formed from stratified epithelium. This layer forms into folds, known as *rugae*, when the bladder is empty.

## Urethra

The *urethra* is the tube which conveys urine from the bladder to outside the body.

The urethra is made up from three layers of tissue, similar to the ureters, although the inner layer is composed of mucous membrane.

In the female, the urethra leads directly to its opening between the clitoris and vagina.

In the male, the urethra passes through the prostate gland, connecting to the reproductive system, and along the length of the penis.

Two sphincters control the emptying of the bladder: An *internal sphincter* at the start of the urethra at the bladder.

An *external sphincter*, which in males is just distal to the prostate gland, and in females is about midway along the length of the urethra.

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## ***Urination***

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When the bladder is stretched by holding approximately 200 - 300 ml of urine, autonomic nerves in the bladder wall are stimulated.

This initiates a reflex action to cause urination, however, in adults, this reflex action can normally be overruled, producing the sensation of the need to urinate. This inhibition of bladder emptying is possible until the bladder holds 600 - 800 ml of urine, at which point increasing pain is experienced.

During *urination*, the internal sphincter relaxes, the external sphincter is opened, and the bladder contracts rhythmically to force the urine out of the body via the urethra.

### *Bladder Calculi*

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*Bladder calculi (bladder stones)* are hard lumps of mineral matter which form in the bladder.

They are usually indicative of some other urinary problem - an infection or a condition which causes urinary retention. The urine is then abnormally concentrated and minerals crystallise out of solution to form the stones.

Bladder stones cause symptoms when they either irritate the tunica mucosa, or obstruct the flow of urine.

Difficulty in urinating, painful urination, pain and discomfort along the length of the urethra, and discoloured urine - maybe bloodstained - are the most likely symptoms.

### *Dialysis*

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*Dialysis* is an artificial method of filtering toxins and waste products from the blood when the kidneys are not functioning.

#### *Haemodialysis*

*Haemodialysis* is a technique in which the blood is diverted from the body, is passed through a dialysis machine, and is then returned to the body.

Inside the machine, the blood passes across a semi-permeable membrane. On the other side of this is a solution with similar electrolyte content to the blood. Water and waste matter pass by osmosis from the blood, through the membrane, and are removed.

The flow rate required for successful dialysis is higher than that possible using normal venous access routes. To withstand the flow, plus multiple puncturing, those who require long-term dialysis treatment have a strengthened vein surgically constructed. This is achieved by creating a join - a *fistula* - between an artery and a vein in an arm or leg. The walls of the vein then thicken up as they receive blood at arterial pressure, acquiring the strength needed for a dialysis connection.

Long-term dialysis treatment involves around three dialysis sessions per week. Each session last about 4 hours.

#### *Peritoneal dialysis*

*Peritoneal dialysis* is an alternative to haemodialysis which may be carried out in the home, although it requires sessions every day.

Dialysis is carried out by using the peritoneal membrane as the semi-permeable membrane.

The dialysis solution is injected into the peritoneal cavity. It is then drained out after allowing time for the dialysis to take place.

### *Glomerulonephritis*

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Glomerulonephritis is an inflammation of the glomeruli in the kidneys. It occurs when the immune system generates antibodies to an infection - often streptococcal bacteria - and these antibodies also attack the glomeruli. The glomerular membrane is often damaged.

The condition leads to blood and protein in the urine, together with fluid and urea retention in the body.

The acute form of glomerulonephritis usually passes with a full recovery of normal renal function.

There is a risk that the condition may become chronic. This will lead to progressive damage to the kidneys, and eventual renal failure.

### *Incontinence*

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The involuntary passing of urine - *urinary incontinence* - has a variety of causes and classifications.

**Nocturnal enuresis.** (*bed-wetting*) This is usually associated with behavioural or psychological problems in children. Infection may also be a cause.

**Overflow incontinence.** This is leakage from a full bladder - often related to urinary retention.

**Stress incontinence.** This is the forcing of small amounts of urine through the external sphincter by an action, such as coughing, which raises the intra-abdominal pressure.

**Urge incontinence.** This occurs when a desire to urinate occurs suddenly, perhaps precipitated by movement when the bladder is full, and the intention to restrain the flow is delayed.

Other causes of incontinence include injury to the bladder or urethra, infections, and damage to the nerve supply to the sphincters and bladder.

### *Pyelonephritis*

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*Pyelonephritis* is an inflammation of the kidneys caused by infection by E-coli or other bacteria. The infection may reach the kidneys via the circulation, but more usually spreads upwards through the bladder and ureters. It is often preceded by cystitis which encourages reflux of urine into the ureters as the bladder contracts during urination.

The infection initially settles in the nephrons, but then attacks the glomeruli and other renal tissue.

Fever, back pain, painful urination, and cloudy urine with a smell of ammonia are typical indications of the condition.

If pyelonephritis becomes chronic, fibrous tissue begins to replace diseased renal tissue. Renal failure may eventually result.

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### *Renal Calculi*

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If the concentration of certain substances in urine becomes excessive, these substances may crystallise out, forming *renal calculi*, or *kidney stones*.

Calcium Oxalate and Calcium Phosphate are the most common renal calculus materials, followed by Magnesium salts and uric acid salts.

Calculi form initially in the collecting tubules. Having moved to the renal pelvis, they continue to grow.

At this point, the calculi probably produce no symptoms, but if they move into the ureter they will most likely cause intense pain. This is likely to be worst with Calcium Oxalate calculi as these crystals have jagged edges. Problems with urination are also common.

Alternatively, the calculi may pass into the bladder and completely out of the system without any problems.

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### *Renal Failure*

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When *renal failure* occurs there will be a loss of ability to excrete waste products from the body.

This will result in a general fall in health, vomiting, and potential blood clotting problems as toxins build up. Fluid retention will cause generalised oedema, worse in the lower limbs.

This will be accompanied by a fall or cessation of urine output, although in some cases nocturnal urination may actually increase.

There are many causes of renal failure, including:

A decreased blood flow, through conditions such as hypovoleamic shock or toxic shock.

Poisoning by some metals, organic solvents, alcohol, and also some medications.

Clogging of the kidneys by very high levels of tissue debris, such as may be caused by extensive crush injuries.

Direct injury to the kidneys, or infection such as pyelonephritis.

Urinary tract obstruction by such as renal calculi or tumours.

Blood disorders or adverse reactions to transfusion.

Acute renal failure is not always permanent and with treatment a full recovery is possible.

Chronic renal failure, however, tends not to be reversible.

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### *Urinary Tract Infection*

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An infection to either the bladder or the urethra is usually termed a *urinary tract infection*. Most urinary tract infections are not severe.

#### *Cystitis*

*Cystitis* is an inflammation of the bladder, often caused by infection with E-coli or other bacteria found in the digestive system.

The inflammation of the bladder tissue causes minor bleeding into the bladder. The nerve endings in the bladder may become hypersensitive to the presence of urine - resulting in the sensation of the need to urinate when the bladder is only part full.

Pain and discomfort during urination are also typical symptoms.

#### *Urethritis*

This is usually a sexually transmitted disease, and is described as such.