

URINARY SYSTEM

ANATOMY and PHYSIOLOGY

The composition of blood is kept constant mainly through selective elimination of water and solutes by kidneys. This control involves balancing body's input of ions and water with amounts excreted. As Na^+ and Cl^- are most abundant somatically active solutes in plasma, control of plasma volume and tonicity can be largely achieved by controlling amounts of these ions and water excreted.

FUNCTIONS of the KIDNEY

1- Excretory: Excretion of water products and drugs in urine.

2- Regulatory: Kidney regulates volume, osmotic pressure of blood.

3-Endocrine: Kidney produces the following hormones.

a-Renin: It is produced by juxtaglomerular apparatus which is made of specialized cells on smooth muscle cells located on afferent glomerular arteriole as it enters glomerulus.

b-Erythropoietin: is a glycoprotein produced mainly by kidney and is one of the major stimuli of erythropoiesis.

c-Prostaglandin: The kidney produces prostaglandin E_2 , a powerful vasodilator agent.

4-Metabolic:

a-Vitamin D metabolism: Vitamin D requires hydroxylation in liver and again by kidney to produce 1,25 dihydroxy calciferol.

b-Protein and polypeptide hormones: The kidney is the major site for catabolism of insulin, parathyroid hormone and calcitonin.

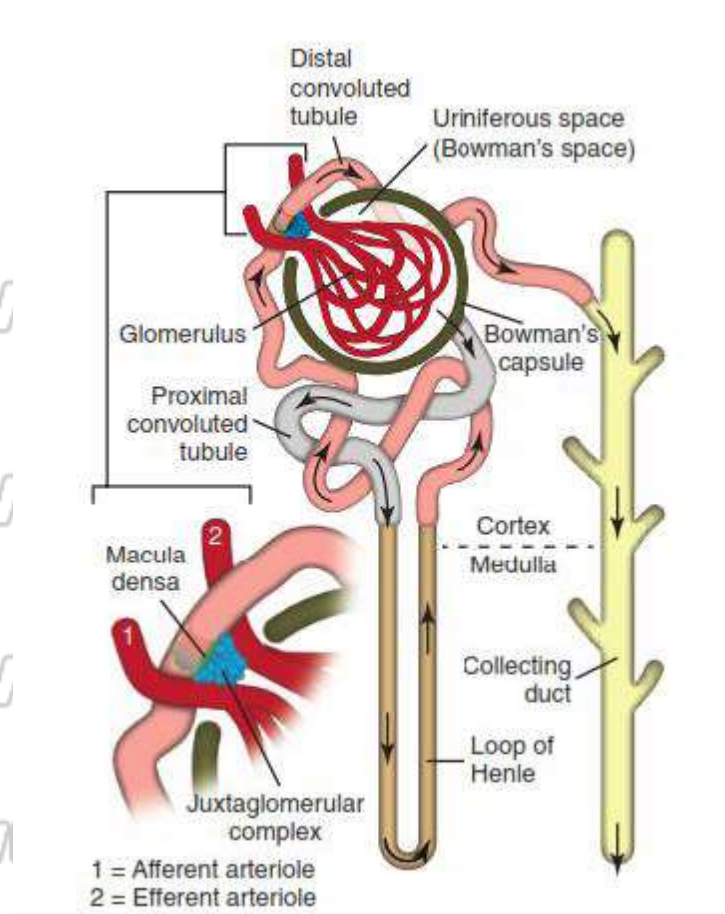
GROSS STRUCTURE of the KIDNEY

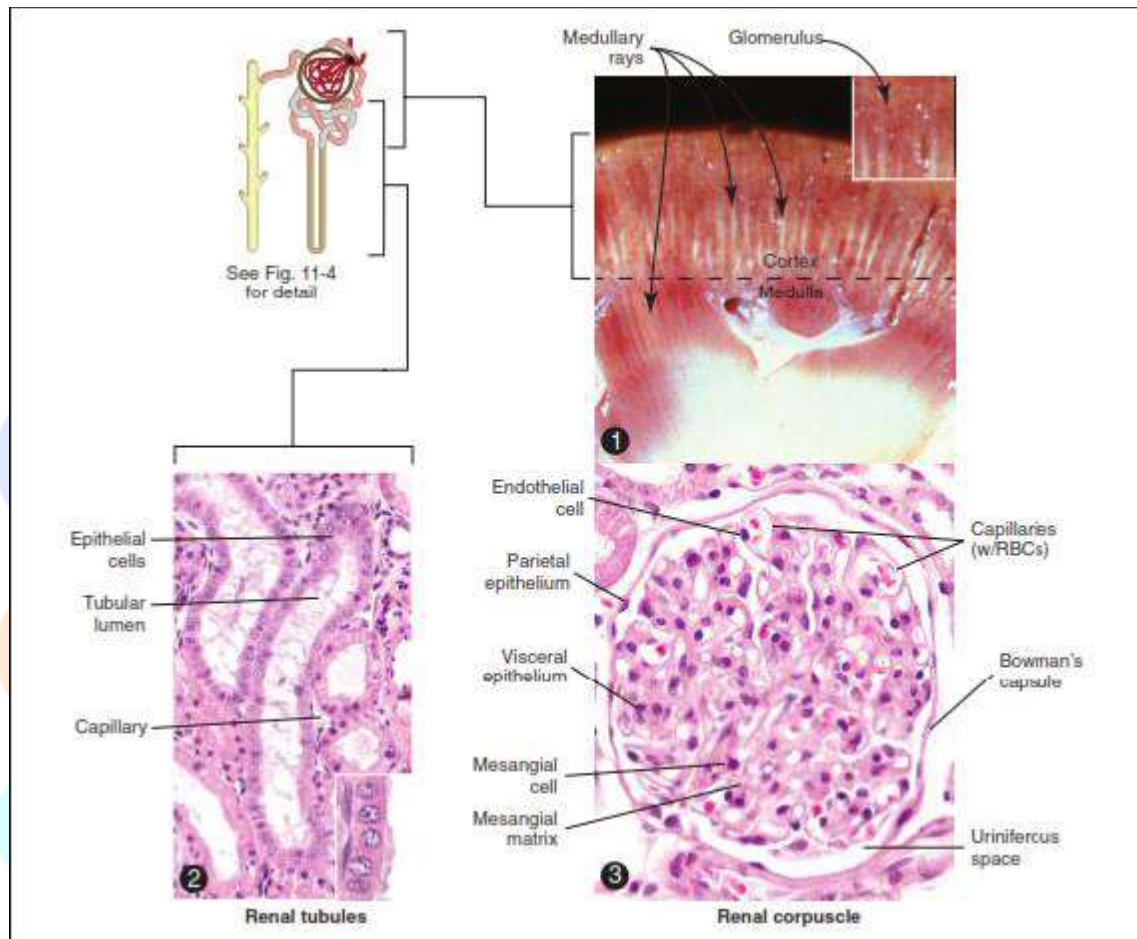
The basic unit of kidney function is the nephron of which there are about 1,000,000 nephrons in each kidney. Urine formed in tubular part of nephron collects in renal pelvis and then flows through ureter to bladder for subsequent elimination via the urethra.

The glomerulus is formed by invagination of a tuft of 50 anatomizing capillaries into dilated blind end of nephron (*Bowman's capsule*). Functionally the glomerular membrane permits the passage of substances up to 4 nm in diameter and does not allow the passage of those with diameter greater than 8 nm.

The proximal convoluted tubules (PCT) is made of a single layer of cells which show on their luminal edges brush border due to the presence of numerous microvilli. The structure of the loop of Henle differs according to its location in the kidney. The distal convoluted tubule (DCT) has a similar structure to loop of Henle. DCT from large number of different nephrons drain into a common collecting duct and then via a papillary duct into the renal pelvis. The largest collecting ducts empty through the

renal pelvis through the tips of the renal papillae, which protrude into the renal calyces.





Box 11-5 Renal Defense Mechanisms against Injury and Infectious Microbes

- Barrier system—glomerular basement membrane (GBM)
- Monocyte-macrophage system—glomerular mesangium
- Immune system
 - Innate responses
 - Humoral responses
 - Cellular responses

GENERAL TERMS *in* URINARY SYSTEM PATHOLOGY

1-Aplasia: Absence of one or both kidneys, absence of one kidney is observed in animals with compensatory hypertrophy of another kidney.

2-Hypoplasia: The size of kidneys remains small which don't grow properly due to *defect in autosomal gene*.

3-Hematuria: Presence of blood in urine giving bright red color. Occur due to damage in glomeruli, tubule or hemorrhage anywhere from glomeruli to urethra. The most important cause of hematuria is *bracken fern toxicity*.

4-Hemoglobinuria: When hemoglobin is present in urine without erythrocytes due to intravascular hemolysis. The urine becomes brownish red in color. Hemoglobinuria is caused by various infections such as *Leptospira* sp., *Babesia* sp. or *phosphorus deficiency* in animals.

5-Anuria: Absence of urine is known as anuria.

6-Polyuria: Increased amount of urine leading to frequent urination due to *diabetes insipidus*, *hormonal imbalance* and *polydipsia*.

7-Oliguria: Decreased in amount of urine that secreted, which occurs due to *glomerulonephritis*, *obstruction in urinary passage*, *dehydration* and *low blood pressure*.

8-Uremia: The presence of urine elements as uric acid, creatinine and urea in blood, occur due to *damage in kidneys* so urine remains in blood and causes uremia.

9-Glycosuria: The presence of glucose in secreted urine. This is also known as *diabetes mellitus* occur due to insulin deficiency. Occur in dogs due to hypoglycemia, in sheep due to enterotoxaemia caused by *Clostridium welchii* type D.

10-Pyuria: Presence of pus material in urine due to *suppurative inflammation* in urinary tract.

11-Ketonuria: Presence of ketone bodies in urine, which is common in *diabetes mellitus*, *acetonemia*, *pregnancy toxemia* and in *starvation*.

PIGMENTATION in RENAL TISSUES

Lipofuscinosis: Fine golden granules of brown iron-free pigment with the staining characteristics of lipofuscin (“wear and tear pigment”) can accumulate in renal epithelial cells of old cattle, resulting in lipofuscinosis. *Grossly*, the renal cortex can have streaks of brown discoloration, but renal function is not affected.

Microscopically, the accumulations are noted most prominently within proximal convoluted epithelial cells.

Hemosiderin and Ferritin: Pigment present in renal tubules. The origin of hemosiderin pigment is most likely from degradation of hemoglobin resorbed from glomerular filtrate by proximal tubular epithelium due to concurrent hemolysis of blood. In dogs, *microscopic* present in cytoplasm of proximal convoluted tubular epithelial cells.

Cloisonné kidneys: which occur in goats, due to proximal tubular basement membrane thickening as a result of deposits of ferritin and hemosiderin. *Grossly*, these kidneys have diffuse, intense, black or brown discoloration of cortex separated from medulla and renal function is normal.



Nephrosis

Nephrosis is degeneration and necrosis of tubular epithelium without producing inflammatory reaction. It mostly includes acute tubular necrosis as a result of ischemia or toxic injury to kidney. Nephrosis is characterized by necrosis and sloughing of tubular epithelial cells exhibited by uremia, oligouria, anuria.

Etiology

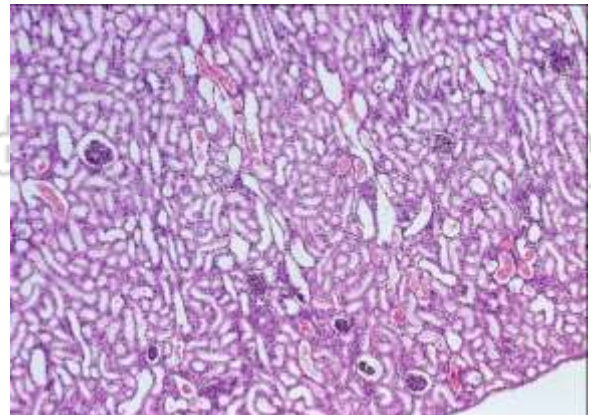
- 1- Hypotension.
- 2- Heavy metals.
- 3- Mycotoxins as Ochratoxin.
- 4- Antibiotics as Gentamicin.

Macroscopic features

- 1- Swelling of kidneys.
- 2- Capsular surface smooth, pale and translucent.

Microscopic features

- 1- Vacuolation in tubular epithelium.
- 2- Coagulative necrosis.
- 3- Sloughing of tubular epithelium.



Kidney of feedlot cattle showed nephrosis, the gross section showed pale color in cortex with hemorrhage at medulla are of kidney, while histopathological section showed degenerative and necrotic changes without infiltration of inflammatory cell

Glomerulonephritis

Glomerulonephritis is the inflammation of glomeruli primarily characterized by pale and enlarged kidneys with hemorrhage, edema of glomeruli, congestion and infiltration of inflammatory cells.

Etiology

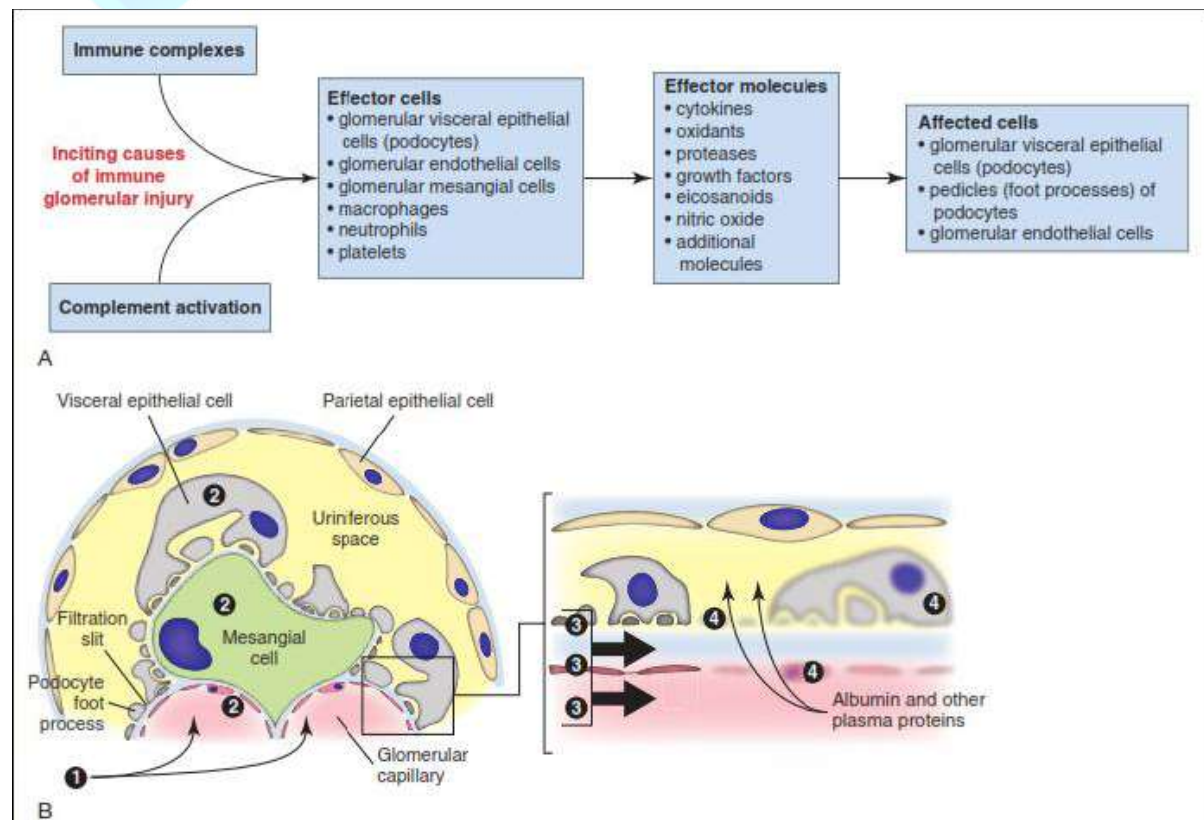
- 1- *Streptococci* infection.
- 2- Immune complexes.
- 3- Organochlorine pesticides.

Macroscopic features

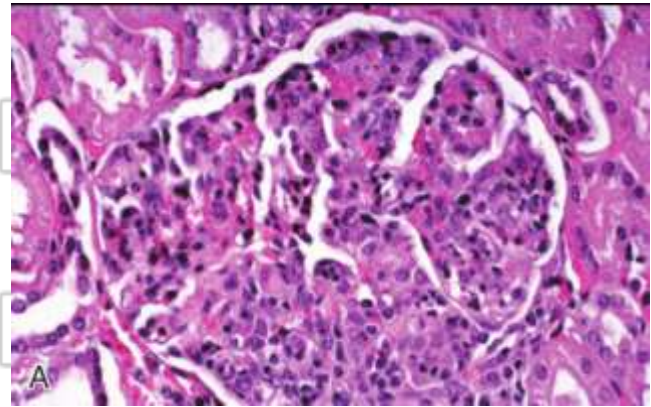
- 1- Enlarged, pale kidneys.
- 2- Petechial hemorrhage on kidneys.
- 3- Proteinuria, uremia and hypercholesterolemia.

Microscopic features

- 1- Edema of glomeruli leading to increase in size.
- 2- Infiltration of neutrophils, macrophages.
- 3- Thrombosis and necrosis of glomerular capillaries.



Mediators of Immune Glomerular Injury and Epithelial Cell Injury. A, Mediators of immune glomerular injury, including effector cells, molecules, and cells affected or injured. B, Visceral epithelial cell (podocyte) injury. The postulated sequence is a consequence of antibodies against epithelial cell antigens, arriving in the circulating blood (1) with subsequent activation of effector cells, including podocytes and mesangial cells (2). This leads to liberation of toxins, cytokines, or other effector molecules (3) that cause injury of podocytes, podocyte foot processes, and endothelial cells (4) with subsequent cell detachment, resulting in protein leakage through the defective glomerular basement membrane and filtration slits.



INTERSTITIAL NEPHRITIS

Inflammation of kidney characterized by degeneration and necrosis of tubular epithelium, edema and infiltration of inflammatory cells in interstitial tissue.

Etiology

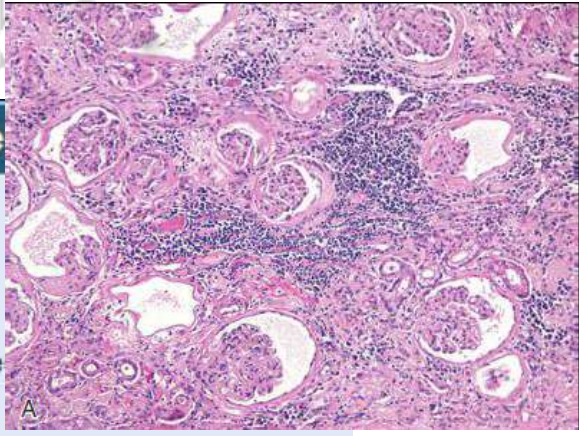
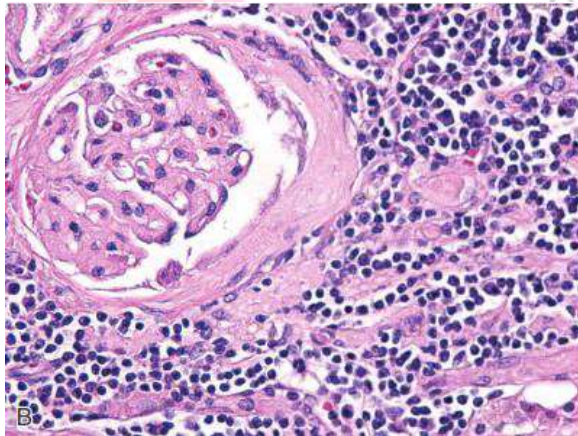
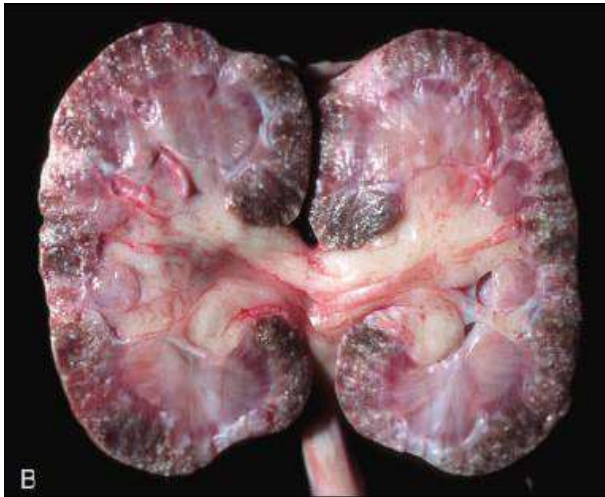
- 1- Fungal toxins as in ochratoxin.
- 2- *Leptospira* spp.
- 3- Toxins and pesticides.
- 4- Herpes virus infection.
- 5- Ketosis.
- 6- Antibody - Antigen - Complement complex.

Macroscopic features

- Enlargement of kidneys with petechial hemorrhage.

Microscopic features

- 1- Edema, congestion, hemorrhage with necrosis of tubular epithelium.
- 2- Infiltration of inflammatory cells neutrophils, macrophages and lymphocytes in interstitial.
- 3- Immune complexes are deposited in granular form causing degeneration of epithelial cells of tubules and mononuclear cell infiltration with fibrosis in chronic cases.



malignant catarrhal fever

SHEEP

Sheeppox

PIGS

Leptospira interrogans serovar pomona

Porcine reproductive and respiratory syndrome

DOGS

Leptospira interrogans serovars canicola, icterohaemorrhagiae, and others

Infectious canine hepatitis virus, recovery phase

Theileria parva

PYELONEPHRITIS

Inflammation of renal pelvis and parenchyma (tubules) characterized by congestion with suppurative inflammation and fibrosis.

Etiology

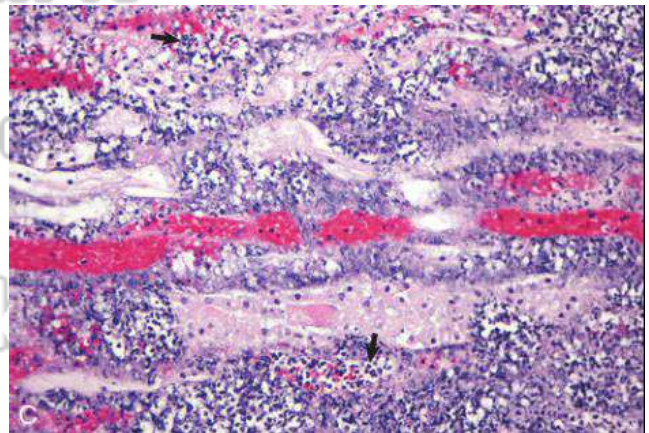
- 1- *Corynebacterium renale*.
- 2- *Staphylococcus aureus*.
- 3- *E. coli*.
- 4- *Actinomyces pyogenes*.
- 5- *Pseudomonas aeruginosa*.

Macroscopic features

- 1- Congestion, hemorrhage with abscess formation in renal cortex, renal pelvis and ureters.
- 2- Pyuria (pus mixed urine in bladder).
- 3- Enlargement of kidneys.

Microscopic features

- 1- Congestion, hemorrhage with Suppurative inflammation and purulent exudate in both pelvis and kidney parenchyma with Infiltration of neutrophils, lymphocytes and plasma cells in interstitial tissue of kidney.
- 2- Necrosis of collecting ducts with sloughing of cellular debris in lumen.



NEPHROSCLEROSIS

Chronic fibrosis of kidney characterized by loss of glomeruli and tubules with extensive fibrosis.

Etiology

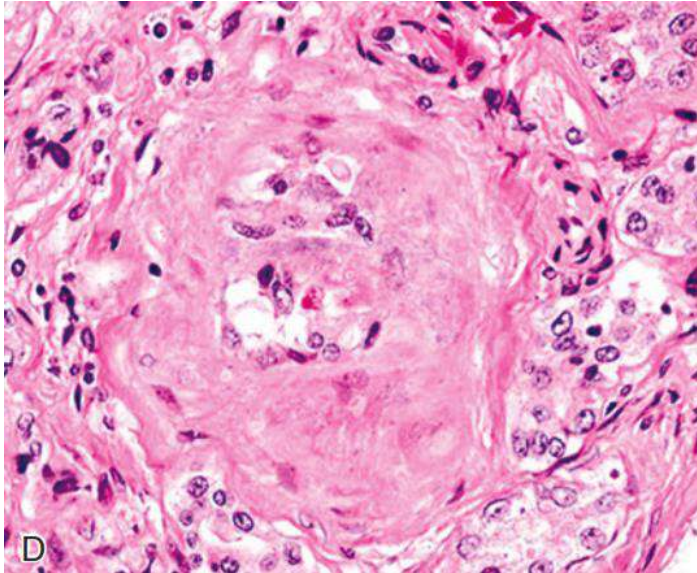
- 1- Chronic Glomerulonephritis.
- 2- Chronic Interstitial nephritis.
- 3- Arteriosclerosis.

Macroscopic Features

- 1- Hard, atrophied kidneys with fibrous nodules on surface.
- 2- Thickening of capsule.

Microscopic features

- 1- Ischemia, tubular atrophy.
- 2- Loss of glomeruli and tubules.
- 3- Extensive fibrosis.
- 4- Deposition of hyaline casts.
- 5- Infiltration of mononuclear cells.



UROLITHIASIS

Formation of stony precipitates anywhere in urinary passage including kidneys, ureter, urinary bladder or urethra.

Etiology

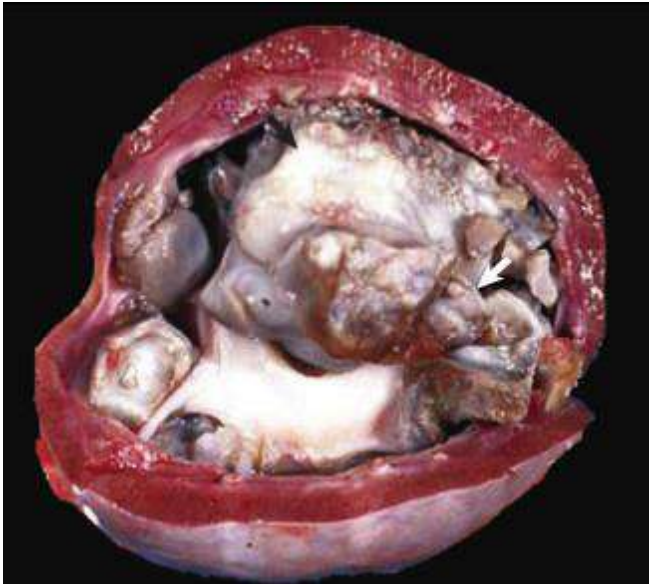
- 1- Bacterial infections.
- 2- Metabolic defects.
- 3- Vitamin A deficiency.
- 4- Hyperparathyroidism.
- 5- Mineral imbalance.

Macroscopic features

- 1- Nephrosis, Hydronephrosis.
- 2- Distension of ureters, urethra and urinary bladder.
- 3- Hard enlarged kidneys.
- 4- Presence of calculi (stone) in kidney, ureter, bladder or urethra which differ in size, shape and composition.

Microscopic features

- 1- Presence of crystals (stone) in lumen of tubules.
- 2- Degeneration and necrosis of tubular epithelium with hemorrhage.
- 3- Proliferation of fibrous tissue.



URETERITIS

Inflammation of ureter characterized by enlargement, thickening of ureter wall due to accumulation of urates, or calculi, pyonephrosis and pyelonephritis.

Etiology

- 1- Tuberculosis.
- 2- Calculi.
- 3- Hydronephrosis.
- 4- Pyelonephritis.
- 5- Pyonephrosis.

Macroscopic features

- 1- Deposits of whitish or yellowish urates in ureter.
- 2- Obstructions of ureter due to calculi leads to its enlargement and formation of diverticulum.

Microscopic features

- 1- Thickening ureter wall by congestion and infiltration of inflammatory cells.
- 2- Extensive fibrosis with infiltration of mononuclear cells in chronic cases.

CYSTITIS

Inflammation of urinary bladder characterized by congestion and fibrinous, purulent or hemorrhagic exudate.

Etiology

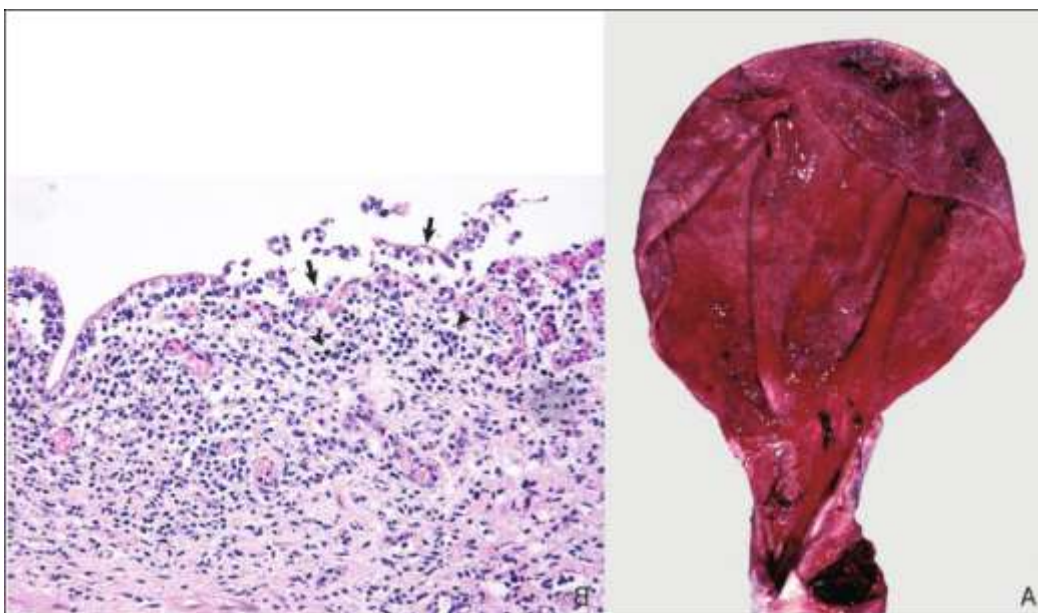
- 1- Urinary calculi.
- 2- Tuberculosis.
- 3- Blockage in urethra.
- 4- Bracken fern poisoning.

Macroscopic features

- 1- Congestion, hemorrhage with enlargement of urinary bladder.
- 2- Thickening of the wall and presence of small nodules on wall.

Microscopic features

- 1- Congestion, hemorrhage with fibrosis in chronic cases.
- 2- Thickening bladder wall due to infiltration of neutrophils and macrophages.
- 3- granulomatous masses in case of tuberculosis.



URETHRITIS

Inflammation of urethra which occurs as a result of catheter injury and calculi. It is characterized by congestion, obstruction and hydronephrosis.

Etiology

- 1- Calculi.
- 2- Catheter injury.
- 3- *Trichomonas foetus* infection.
- 4- Picorna virus infection.

Macroscopic features

- 1- Transient inflammation with congestion and hemorrhage.
- 2- Obstruction due to calculi, presence of calculi.

Microscopic features

- Thickening due to inflammatory exudate.

TYPES of STONES in URINARY SYSTEM

Oxalate calculi are hard, light yellow, covered with sharp spines found in urinary bladder and formed due to calcium oxalate. It causes damage in urinary bladder leading to hemorrhage.

Uric acid calculi are composed of ammonium and sodium urates and uric acids, yellow to brown in color, formed in acidic urine, spherical and irregular in shape and they are not radiopaque.

Phosphate calculi are white or grey in color, chalky in consistency, soft, friable and can be crushed with mild pressure. They are mostly multiple in the form of sand like granules. They are composed of magnesium ammonium phosphate and occur as a result of bacterial infection.

Xanthine calculi are brownish red, concentrically laminated, fragile and irregular in shape. They rarely occur in animals.

Cysteine calculi are small, soft with shiny and greasy in appearance, yellow in color which becomes darker on air exposure. Insoluble amino acid cystine precipitates in bladder to form calculi. Such calculi may cause obstruction of urethra with cystinuria.

TYPES of LESIONS in GLOMERULONEPHRITIS

1. Type-I MPGN

- §-Proliferation of mesangial cells.
- §-Deposition of immune complexes containing IgG, IgM, IgA and C3.
- §-Immune complexes penetrate vascular endothelium but not the basement membrane and are deposited in subendothelial region.
- §-Proliferation and swelling of endothelial cells.
- §-Immune complexes induce production of transforming growth factor (TGFB1) which increases production of fibrinogen, collagen and proteoglycans leading to thickness of basement membrane; this is also known as “*wire loop*” lesions.

2. Type-II MPGN (Membranous)

- §-Deposition of immune complexes in basement membrane (lamina densa).
- §-Due to uncontrolled activation of complement.
- §-Proliferation of endothelium and mesangial cells.
- §-Demonstration of C3 component, no immunoglobulin.

3. Type III MPGN (Acute Proliferative)

- §-Subepithelial deposits of immune complexes and disruption of basement membrane.
- §-Swelling of epithelium and its proliferation forming “*Epithelial crescent*”.
- §-Demonstration of IgG in subepithelial region.
- §-Congestion and edema of glomeruli.
- §-Infiltration of neutrophils, macrophages and lymphocytes.

4. Chronic glomerulonephritis

- §-Proliferation of epithelial and endothelial cells.
- §-Reduplication, thickening and disorganization of glomerular basement membrane.
- §-Lumen of capillaries occluded.
- §-Entire glomerulus is replaced by Hyaline connective tissue.

5. Focal embolic glomerulonephritis

- §-Focal zone of necrosis in glomeruli.
- §-Infiltration of neutrophils.
- §-Proliferation of epithelial cells and formation of crescent.

TUMORS of URINARY SYSTEM

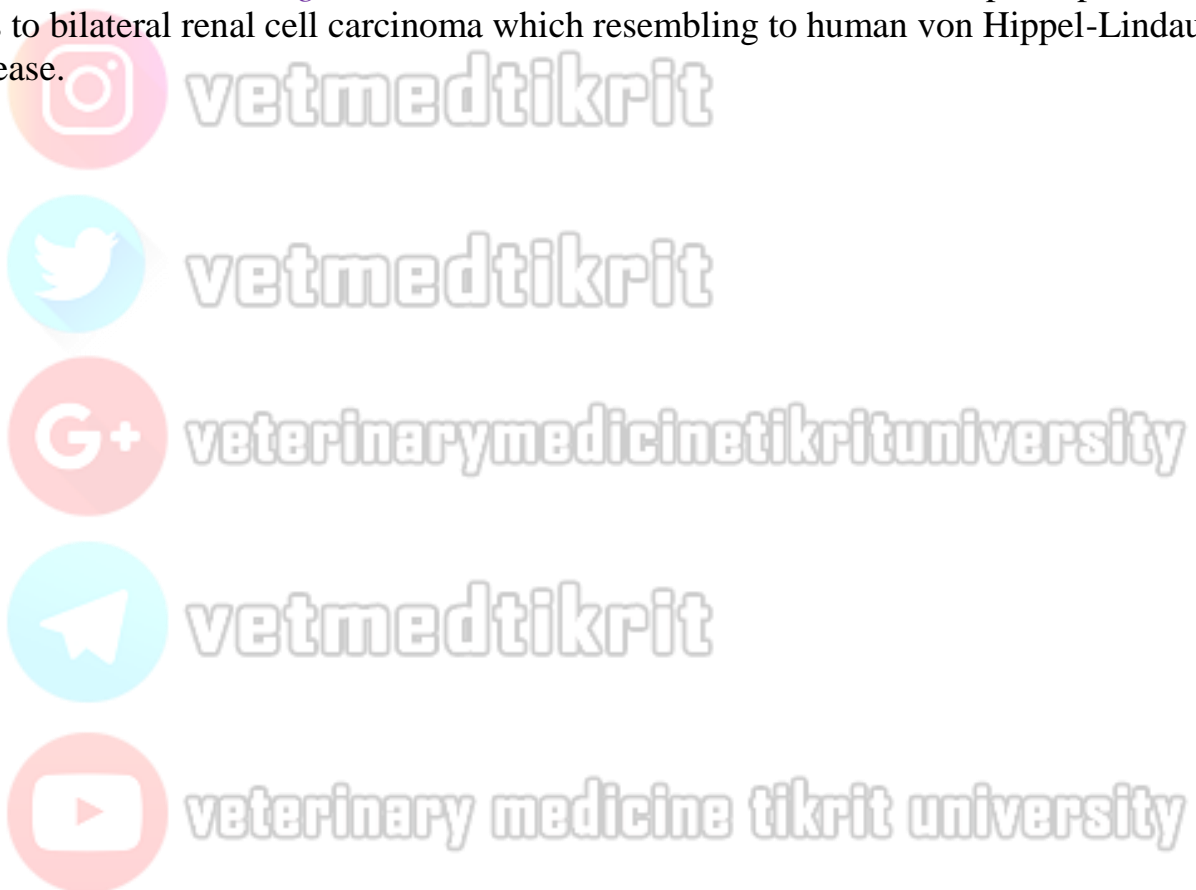
Oncocytomas. Oncocytomas are rare benign epithelial tumors that can occur in a variety of tissues. *Grossly*, renal oncocytomas are tan, homogeneous, well-encapsulated masses. *Histologically*, oncocytomas are composed of large eosinophilic, granular, round cells with condensed round nuclei.

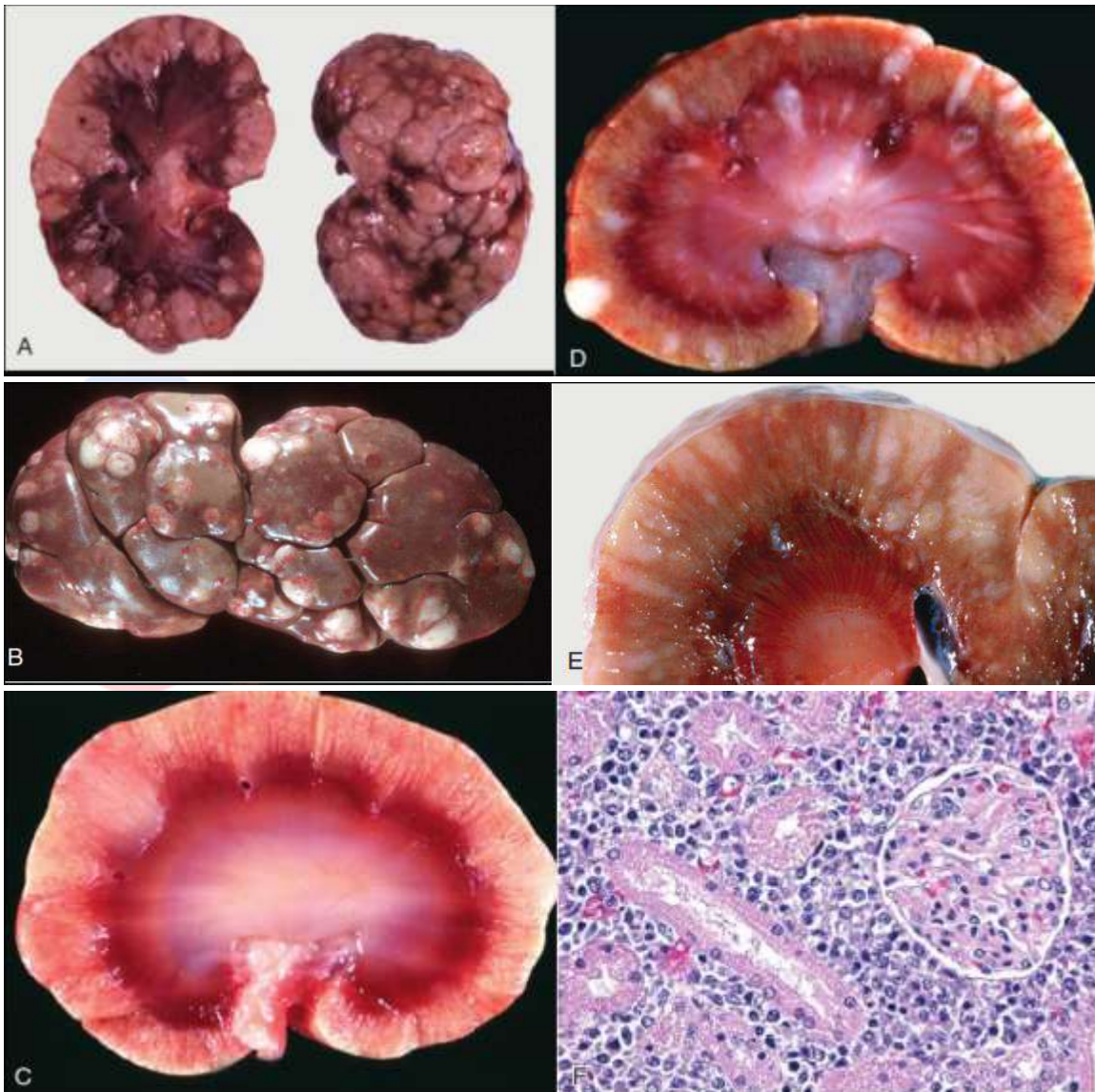
Renal Carcinomas. Renal carcinomas are the most common primary renal neoplasms and occur most frequently in older dogs. The etiology including the following:

1-Viruses: *Ranid herpesvirus 1 adenocarcinoma* (Lucke's tumor) in kidney of frogs, *avian erythroblastosis virus* (oncovirus) induce renal adenocarcinomas in chickens.

2-Chemical carcinogens: Several known carcinogens can be causative agents and exert their neoplastic influence by direct DNA damage or inhibition of DNA synthesis or repair.

3-Autosomal dominant gene mutations in Eker rats: These mutations predispose these rats to bilateral renal cell carcinoma which resembling to human von Hippel-Lindau disease.





MODEL QUESTIONS

Q. 1. *Fill in the blanks with suitable word(s).*

1. Increased amount of urine leading to urination is known as which is caused by , and to remove the at a faster rate.
2. Uremia is presence of like , and in blood.
3. Presence of ketones bodies in urine has been observed in , , and
4. are fungal toxins which may cause interstitial nephritis.

5. Environmental pollutants such as may induce the formation of in body leading to in animals characterized by proteinuria.
6. Pyelonephritis is caused by , , and ; of which is the main etiological agent causing disease in cattle.
7. Nephrosclerosis is of kidney characterized by , and and mostly occurs as a sequela to , and

Q.2. Write true or false against each statement and correct the false statement.

1. Glycosuria occurs in enterotoxaemia in sheep.
2. Arteriosclerosis may lead to pyelonephritis.
3. In cattle, *Corynebacterium ovis* causes pyelonephritis.
4. Oxalate calculi are hard and composed of diammonium and sodium oxalates.
5. Urolithiasis is presence of foreign body in kidneys.
6. In poultry, ureteritis is common feature of visceral gout.
7. Urinary calculi may cause urethritis in bullocks.
8. Low blood pressure may cause polyuria
9. Epithelial crescent is feature of interstitial nephritis.
10. Hypovitaminosis A may predispose the animal for calculi formation in urinary tract.

Q.3. Define the following

1. Hematuria 2. Pyuria 3. Cystitis 4. Anuria
5. Hemoglobinuria 6. Polyuria 7. Ketonuria 8. Oligouria
9. Epithelial crescents 10. Bracken fern toxicity

Q. 4. Write short notes on.

1. Uremia
2. Glomerulonephritis
3. Pyelonephritis
4. Nephrosclerosis
5. Urolithiasis
6. Cystic kidney

Q. 5. Select the most appropriate word(s) from the four options given against each statement.

1. C3 component of complement is found in which type of glomerulonephritis (MPGN).

- (a) Type-I (b) Type-II (c) Type III (d) Type-IV
2. In cattle, pyelonephritis is caused by
- (a) *E. coli* (b) *Proteus* spp. (c) *Corynebacterium renale* (d) *Actinomyces pyogenes*
3. Nephrosclerosis is disease of kidney
- (a) Acute (b) Chronic (c) Subacute (d) Peracute
4. Hypovitaminosis may cause urolithiasis
- (a) A (b) B (c) C (d) D
5. Ureteritis is the inflammation of
- (a) Uterus (b) Uterine glands (c) Ureter (d) Uterine tube
6. amino acid forms calculi in animal which causes obstruction in urethra.
- (a) Arginine (b) Lucine (c) Cystine (d) Gsolucine
7. Bracken fern causes
- (a) Hematuria (b) Pyuria (c) Hemoglobinuria (d) Anuria
8. Urethra may become infected by virus.
- (a) Picoma (b) Picobima (c) Bima (d) Adeno
9. Hyperplasia of collecting tubes with their dilation causes cysts in kidneys.
- (a) Type-I (b) Type-II (c) Type-III (d) Type-IV
10. Uremia is caused by the increased level of in blood.
- (a) Urea (b) Uric acid (c) Creatinine (d) All of the above

ANSWER

- Q. 1. (1) Frequent, polyuria, diabetes insipidus, hormonal imbalance, polydipsia, wasteproduct
- (2) Harmful wasteproducts, urea, uric acid, creatinine
- (3) Diabetes mellitus, acetonemia, pregnancy toxemia, starvation
- (4) Ochratoxins
- (5) Pesticides, immune complexes, glomerulonephritis
- (6) *Corynebacterium renale*, *Staphylococcus aureus*, *E. coli*, *Actinomyces pyogenes*, *Pseudomonas aeruginosa*, *corynebacterium. renale*.
- (7) Chronic fibrosis, loss of glomeruli, loss of tubules, extensive fibrosis, glomerulonephritis, interstitial nephritis, arteriolosclerosis.
- Q.2. (1) T, (2) F, (3) F, (4) F, (5) F, (6) T, (7) T, (8) F, (9) F, (10) T.
- Q.5. (1) b, (2) c, (3) b, (4) a, (5) c, (6) c, (7) a, (8) a, (9) a, (10) d.