Pathophysiology

Urinary system
Urinary system

Conditions Resulting in Altered Urinary Elimination.

1) **Incontinence:**
- Urinary incontinence is the loss of control over urination
- In children under 3 years urination is considered a reflex. While in older children and adults it is controlled continuously.

<table>
<thead>
<tr>
<th>Types of incontinence</th>
<th>Definition</th>
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<tbody>
<tr>
<td>1- Enuresis</td>
<td>It is the involuntary urination after 4-5 years. Usually it will occur at night – called Nocturnal enuresis – or bed wetting. It might be caused by anxiety or small bladder. It usually resolves with time.</td>
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<td>2- Transient incontinence</td>
<td>It is caused by temporary condition such as delirium, atrophic vaginitis, medications, Psychological factors, high urine output, restricted mobility, fecal impaction, alcohol, and caffeine.</td>
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<td>3- Stress incontinence</td>
<td>It is cause by putting pressure on the bladder where the sphincter muscle is weakened. Example of pressure as sneezing, laughing, pregnancy, or lifting a heavy object. Risk factors include prostate removal for men, childbirth for women where a cystocele Will form, obesity, and chronic cough.</td>
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<td>4- Urge incontinence</td>
<td>It is a sudden, intense urge to urinate, followed by an involuntary loss of urine. Warning is less than minutes. Causes include UTI, smoking and CNS problems. Overactive bladder is an urge incontinence with no known cause.</td>
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<td>5- Reflex incontinence</td>
<td>It is a urinary incontinence caused by trauma or damage to the nervous System. Causes include spinal cord injury above s2 to s4, DM, multiple sclerosis. Detrusor hyperreflexia is increased detrusor muscle contractility that occurs even Though there is no sensation to void.</td>
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<tr>
<td>Type</td>
<td>Description</td>
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<td>6- Overflow incontinence</td>
<td>Also called retention. It is the inability to empty the bladder. Causes include bladder damage, urethral blockage, nerve damage and prostate condition. Nurse’s bladder, also called chronic over distension. It happens since there is no time to get to the toilet. It causes detours muscle areflexia.</td>
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<td>7- Mixed incontinence</td>
<td>Symptoms of more than one incontinence is present.</td>
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<td>8- Functional incontinence</td>
<td>It occurs to older people, caused by physical or mental impairment that prevent toileting in time.</td>
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<tr>
<td>9- Gross total incontinence</td>
<td>It is a continuous leaking of urine with periodical large leaking. Causes include spinal cord injury, or fistula between the bladder and the vagina.</td>
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</table>

- **Risk factors of urinary incontinence**: Being female, being overweight, smoking, DM or renal Disease.
- **Complication include** skin rashes, UTIs, psychological problems.
- **Diagnostic procedures include**: a history, physical examination, bladder diary, urinalysis, urine Cultures, cystourethrogram, cystoscopy, pelvic ultrasound, postvoid residual measurement.

2) **Neurogenic Bladder**

- It is all bladder dysfunction caused by an interruption of normal bladder nerve innervation.
- **Factors include**: CNS problems, medications, SLE, herpes zoster.
- **Clinical manifestations include**: Symptoms of over or hypo-active bladder.
- **Diagnostic procedure**: is the same as incontinence’s, another procedure includes CT and MRI.

3) **Congenital Disorders**

- It always comes with a reproductive congenital disorder. It ranges from mild as both ureters draining one kidney to a life threatening as renal agenesis (failure to form in uterus).
- Urine start to be secreted at 9th to 12th week of gestation and it form the amniotic fluid which is critical for the fetus development.
4) Urinary Tract Infections

☑ UTIs are the second most frequently occurring infection.
☑ The lower urinary tract is the most frequent site for the infection.
☑ Renal system has protective mechanisms as one-way valve between ureters and bladder,
  Urination, the immune system, and prostate secretion in men.
☑ Invasion start from the urethra to the bladder then to the ureters and rarely to the kidneys.
☑ Usually the kidney gets the infection from the blood.
☑ The main pathogen is E. coli since it can avoid being washed out by urination by attach to the mucosa.
☑ Risk factors for women include: Women have shorter urethra, sitting position voiding
  Prevent full emptying of the bladder, perineal tissue irritation.
☑ Risk factor for men include that the pathogen hides deeply in the prostate, benign Prostatic hypertrophy.
☑ Common risk factors: Congenital urinary tract abnormalities, immobility, urinary or bowel incontinence, renal Calculi, decreased cognition, pregnancy, impaired immune response, impaired nerve Innervations, urinary catheterization, improper personal hygiene, using a diaphragm or Spermicide for birth control, using unlubricated condoms.

☑ Clinical manifestations:
  • Urgency.
  • Dysuria.    • Frequency.  • Hematuria
  • Bacteriuria  • Cloudy, foul-smelling urine • Fever, chills, and fatigue.

☑ Diagnostic procedures include: a history, physical examination, urinalysis, urine culture,
  Cystoscopy, cystourethrogram, X-ray, ultrasound, CT, and MRI of the kidneys, ureters, and Bladder.

5) Cystitis

☑ It is the inflammation of the bladder. It may be caused by infection or irritants.
☑ Clinical manifestations: are the same as UTI as well as abdominal pain and pelvic pressure.
☑ Diagnostic procedures: are the same as UTI.

6) Pyelonephritis

☑ It is the infection in one or both kidneys. It is common in people with recurrent UTI and who suffered from drug resistant bacteria.
☑ The kidney become edematous and filled with pus and that will put a pressure on blood Vessels leading to ischemia and necrosis.
☑ Clinical manifestations: are the same as UTI but more severe and has also, flank pain and Increased blood pressure.
☑ Diagnostic procedures: include a history, physical examination, urinalysis, urine and blood Cultures, CBC, cystoscopy, intravenous pyelogram, ultrasound, biopsy and Cystourethrogram

Pathophysiology/ Urinary function
7) **Urinary Tract Obstructions:**

- Blockages in any part of the plumbing system prevent the flow of the liquid causing the system to back up, blockages may be as simple as particulates collecting and forming stones to as complex as the growth of tumors.

- **Nephrolithiasis:**
  - It is the presence of renal calculi (kidney stones).
  - **Calculi:** are hard masses of crystals composed of minerals that the kidneys normally excrete.
  - **Their size:** vary from sand grain to a golf ball.
  - **They form in** the renal pelvis, ureters, and Bladder.
  - **The most common:** calcium stone with either oxalate or phosphate. Other types include Struvite, uric acid, cysteine or infection stones. Their color may be yellow or brown.
  - **Risk factors:** family history, obesity, hypertension, pH changes, excessive Concentration of insoluble salts in the urine, and urinary stasis.

- **Clinical manifestations:**
  - Dysuria.
  - Frequency.
  - Genital discharge
  - Nausea and vomiting.
  - Fever and chills.
  - Bloody, cloudy, or foul-smelling urine
  - Colicky pain in the flank area that radiates to the lower abdomen and groin

<table>
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<tr>
<th>TABLE 7-5</th>
<th>Types of Renal Calculi</th>
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<tbody>
<tr>
<td><strong>Type</strong></td>
<td><strong>Causes</strong></td>
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| Calcium | Causes of calcium calculi include the following:  
- Increased absorption of calcium from the small bowel  
- Hyperparathyroidism  
- Inability of renal tubules to reabsorb calcium  
- Dietary excess of calcium  
- Chronic bowel disease that results in steatorrhea; fat then combines with calcium and renders the calcium unable to bind to oxalate, causing stone formation | Treatment depends on the cause and includes the following:  
- Cellulose phosphate or thiazide diuretics to decrease dietary absorption of calcium  
- Surgical resection of the parathyroid gland to reduce hyperparathyroidism  
- Thiazide diuretic therapy to correct renal tubular defects, resulting in the inability to reabsorb calcium  
- Purine dietary restrictions to reduce uric acid production  
- Increased fluid intake and treatment of chronic diarrhea |
| Struvite (magnesium-ammonium-phosphate) | Caused by urase-producing bacteria  
Urinary pH around 7.2  
Usually large in size  
Texture is relatively soft  
Associated with frequent UTI  
More common in women | Prevention of UTI  
Percutaneous nephrolithotomy |
| Uric acid | Urine pH lower than 5.5 encourages insoluble urate salt formation  
Common causes include rapid and dramatic weight loss, and some malignancies | Large calculi can be dissolved by increasing the urine pH above 6.5 with potassium citrate (the solubility of urate salt is then increased) |
| Cystine | Abnormal excretion of cystine (amino acid), ornithine lysine, and arginine | Prevention: increase fluid intake and increase urine pH above 7.5 |
Diagnostic procedures for nephrolithiasis consist of: a history, physical examination, urine examination, kidney-ureter-bladder X-ray, CT, ultrasound, intravenous Pyelogram, calculi analysis and serum studies.

Hydronephrosis:
- It is an abnormal dilation of the renal pelvis and the calyces of one or both kidneys that occurs secondary to a disease.
- Risk factors include: congenital urologic defects e.g. reflux nephropathy, tumors, benign prostatic hyperplasia, strictures, and stenosis.
- Unilateral involvement indicates obstruction in one ureter, while bilateral indicates urethral obstruction.
- Severe Hydronephrosis applies direct pressure and compression of tissue and blood vessels leading to atrophy, necrosis, and glomerular filtration cessation.

Clinical manifestations include:
- Colicky flank pain or pressure.
- Frequency.
- Nausea and vomiting.
- Dysuria.
- Urgency.
- Abdominal distension.
- Decreased urine output.
- Bloody, cloudy, or foul-smelling urine.
- UTIs.

Diagnostic procedures: a history, physical examination, urinalysis, renal ultrasound, CT, intravenous pyelogram, and MRI.

8) Tumor
- Tumors can occur at any point along the urinary system.
- Tumors can obstruct urine flow and impair renal function in addition to leading to the consequences.

Wilms’ Tumor
- It also called nephroblastoma.
- It is a rare kidney cancer that primarily affects children.
- It is the most common cancer in children, occurring around age 3-4 years.
- It occurs in one kidney but can affect both in 4-5% of cases.
- A second tumor may appear later in the remaining kidney.
- This tumor usually grows as solitary mass that can become quite large.
- The exact cause of this tumor is unknown, but it is thought to arise in utero when the cells that normally form the kidneys fail to develop properly. And development may happen spontaneously or as a result of genetic changes. (genetic mutations on chromosome 11 and X chromosome).
It occurs in conjunction with several congenital defects, including aniridia (absence of the iris of the eye), hemihypertrophy (enlargement of one side of the body) and urinary tract abnormalities (such as cryptorchidism and hypospadias).

The risk of developing increase in females.

This tumor may sometimes go undetected early because the tumor can grow quite large without causing pain; nevertheless, most of these tumors are diagnosed before they have metastasized.

Clinical manifestations;
- asymptomatic abdominal mass
- high blood pressure
- hemihypertrophy
- hematuria
- UTIs
- abdominal pain
- nausea and vomiting
- anorexia
- fatigue
- weight loss
- bowel pattern changes

Diagnosis procedures; history, physical examination, renal ultrasound, BUN, creatinine, creatinine clearance, CBC, abdominal CT, urinalysis, biopsy.

Renal Cell Carcinoma
- Occurs more in adults (50-70 years)
- It is a primary tumor arising from the renal tubule.
- Exact causing unknown
- Risk factors include: being male, dialysis treatment, family history, hypertension, kidney diseases and smoking
- Metastasis to the liver, lungs, bone or nervous system is common at the time of diagnosis.
- It is typically asymptomatic in early stages and when it presents it include clinical manifestations:
  - Painless hematuria
  - Abnormal urine color (dark, rusty, brown)
  - Dull achy flank pain
  - Urinary retention
  - Palpable mass over the affected kidney
  - Unexplained
  - Anemia
  - Polycythemia
  - Hypertension
  - Paraneoplastic syndromes such as hypercalcemia
  - Fever

Diagnosis procedures;
- History, physical examination, renal ultrasound, CBC, CT, urinalysis, MRI, PET, chest X-rays, intravenous pyelogram, cystoscopy, renal arteriogram, biopsy, liver function panel, blood chemistry

Bladder Cancer
- It refers to any cancer that forms in the tissue of the bladder.
- Most bladder cancers are transitional cell carcinomas (cancer beginning in the cells that make up in the inner bladder lining).

Pathophysiology/Urinary function
Other types include squamous cell carcinoma (cancer beginning in thin, flat cells) and adenocarcinoma (cancer beginning in the cells that make and release mucus and other fluids), cell in this two types develop in the inner lining of the bladder because of chronic irritation and inflammation. 

Bladder cancer usually evolves as multiple invasive tumors that extend through the bladder wall and surrounding structures.

May metastasis to pelvic lymph nodes, liver, and bone. 

Most common in older adults and can occurs at any age

More common at men

Risk factors include; persons who with chemicals, smoke, have excessive used of analgesics, experience recurrent UTIs, have long term catheter placement, received chemotherapy or radiation.

Clinical manifestations: Painless hematuria, abnormal urine color (dark, rusty, brown), frequency, dysuria, urge incontinence, UTIs, back or abdominal pain.

Diagnosis procedures; history, physical examination, CBC, CT, urinalysis, MRI, PET, chest X-rays, intravenous pyelogram, cystoscopy, biopsy, liver function panel, blood chemistry

**9) Benign Prostatic Hyperplasia**

Also called benign prostatic hypertrophy, is a common, nonmalignant enlargement of the prostate gland that occurs as men age usually appearing by age 50.

Exact cause is unknown but declining testosterone and increasing estrogens levels are thought to cause prostatic stromal cell proliferation.

A second theory postulates that stem cells in the prostate do not mature and die as they are programmed to do apoptosis.

This make imbalance between dying cells and reproducing cells, which results in enlarges the prostate over time.

As the prostate expand, it presses against the urethra like clamp on a hose. Clamping the urethra obstructs urine flow, leading to urinary stasis and UTIs. The bladder will become thick and irritated as urine overfills this organ. The bladder begins to contract with even small amounts of urine and over time, it loses its ability to empty completely.

Clinical manifestations depend on the size of the prostate and it include:

- Frequency, urgency, urinary retention, difficulty initiating urination, weak urinary system, dribbling urine, nocturia, bladder distension, overflow incontinence, erectile dysfunction.

Diagnosis procedure;

- History, physical examination, urine flow measure, urinalysis, prostate – specific antigen PSA, rectal ultrasound, biopsy, cystoscopy, BUN, and creatinine.
Conditions Resulting in Impaired Renal Function.

1) Polycystic Kidney Disease
- PKD is an inherited disorder characterized by numerous, grape-like clusters of fluid-filled cysts in both kidneys.
- PKD affects men and women equally.
- These cysts enlarge the kidneys while compressing and eventually replacing the functional kidney tissue, and trigger for the formation of the cysts is unknown.
- Prognosis and progression of the disease vary widely, depending on the type of PKD.

- **Autosomal dominant PKD** is the most common type; it has been mapped to mutations on the short arm of chromosomes 4 and 16. This form of PKD occurs in both children and adults, but it is much more common in adults.
- **Autosomal recessive PKD** is far less common. This type appears in infancy or childhood, tends to be extremely serious, and progresses rapidly, resulting in renal failure and generally causing death in infancy or childhood.

- Clinical manifestations depend on the individual’s age and the type of PKD.

→ In neonates:
  - Potter facies: pronounced epicanthic folds (skin folds at the corner of the eyes on either side of the nose), pointed nose, small chin, and floppy, low-set ears
  - Large, bilateral, symmetrical masses on the flanks
  - Respiratory distress (caused by fluid accumulation from renal impairment)
  - Uremia (waste accumulation due to renal impairment)

→ In adults:
  - Hypertension (due to activation of the renin–angiotensin–aldosterone system)
  - Lumbar pain: السفل الظهر
  - Increased abdominal girth
  - Swollen, tender abdomen
  - Grossly enlarged, palpable kidneys

Pathophysiology/ Urinary function
Some other symptoms may affect both groups:
- Hematuria (due to impaired glomerular filtration)
- Nocturia (related to an inability to concentrate urine)
- Drowsiness (because of waste accumulation)

Conditions that may occur in conjunction with PKD include: (Brain aneurysms, cysts in other organs (especially the liver), and colon diverticula).
PKD can lead to critical complications such as pyelonephritis, cyst rupture, retroperitoneal bleeding, and chronic kidney disease.
Other, less serious complications include anemia, hypertension, and renal calculi (kidney stones).

2) Inflammatory Disorders

The inflammatory process can cause havoc in the urinary system, especially in the kidneys. The structures can become edematous and damaged due to the inflammatory mediators and their effects, and the kidney’s ability impair.

- **Glomerulonephritis:**
  - Glomerulonephritis is a bilateral inflammatory disorder of the glomeruli that typically follows a streptococcal infection.
  - Affecting men more than women.
  - Glomerulonephritis can be acute or chronic.
  - **Risk factors:**
    1. Streptococcal infection (typically).
    2. Immunodeficiency.
    3. The presence of chronic inflammatory conditions (e.g., systemic lupus erythematosus).

- **Forms of glomerulonephritis:** 1- Nephrotic Syndrome 2- Nephritic Syndrome

1-Nephrotic Syndrome

- Occurs when antibody–antigen complexes lodge in the glomerular membrane, triggering activation of the complement system.
- **Causes:**
  1. Systemic diseases that damage the kidneys (e.g., systemic lupus erythematosus, hepatitis B, and diabetes mellitus).
  2. Infections (e.g., streptococcal infections and mononucleosis).
  3. Reaction to medications (e.g., gold therapy and nonsteroidal anti-inflammatory drugs).
  4. Idiopathically (مجهول السبب)

Pathophysiology/ Urinary function
The inflammatory changes result in increased glomerular capillary permeability, leading to marked **proteinuria**, lipiduria, hypoalbuminemia, and massive generalized edema (**anasarca**).

The loss of protein in the urine (**proteinuria**) contributes to:
1- Low serum levels (**hypoalbuminemia**): this loss of immune cells, in turn, increases the individual’s risk for infection.
2- Gives the urine a dark and cloudy (smoky or coffee-colored) appearance.
3- Decreases colloidal pressure, leading to the massive edema.

To compensate (**تعويض**), the liver increases albumin, triglyceride, and cholesterol production, risk for atherosclerosis (**تصلب الشرايين**).

**2-Nephritic syndrome**

Refers to inflammatory injury to the glomeruli that can occur when antibodies interact with normally occurring antigens in the glomeruli.

Causes: the inflammatory response (e.g., infection).

Clinical manifestations:
(Gross hematuria, urinary casts and leukocytes, low GFR, azotemia (buildup of waste products), oliguria (decreased urine output), and high blood pressure).

The inflammatory injury among red blood cells being excreted in the urine changes circulatory pressures low GFR impair renal function.
3) Renal Failure

#Acute Renal Failure (ARF) or acute kidney injury:
- Refers to a sudden loss of renal function, generally reversible, most commonly occurs in critically ill, hospitalized patients.
- Categories of ARF depending on causes:

1. **Prerenal conditions**, which disrupt blood flow on its way to the kidneys:
   - Extremely low blood pressure or blood volume (e.g., hemorrhage, sepsis, dehydration, shock, and traumatic injury).
   - Heart dysfunction (e.g., myocardial infarction and heart failure).
2. **Intrarenal conditions**, which directly damage the structures of the kidneys:

- Reduced blood supply within the kidneys (e.g., atherosclerosis).
- Hemolytic uremic syndrome (associated with infection in children).
- Renal inflammation (e.g., glomerulonephritis and acute interstitial nephritis [usually associated with an allergic reaction to certain nephrotoxic medications]).
- Toxic injury (usually from alcohol, cocaine, heavy metals, solvents, fuels, chemotherapy drugs, and contrast dyes).

3. **Postrenal conditions**, which interfere with the urine excretion:

- Ureter obstruction (e.g., nephrolithiasis and tumors)
- Bladder obstruction and dysfunction (e.g., benign prostatic hyperplasia, tumors, and nerve innervation disruption)

☑️ **It has four phases:**

- **Initial phase**: It is asymptomatic. Since the other nephrons are still functioning.
- **Oliguric phase**: The damage lead to water and solutes reabsorptions. Urinary output will Decrease to 400 ml.
  > **S&S include**: decreased urine output, fluid volume excess, azotemia, metabolic Acidosis, electrolyte disturbances usually increase. It lasts few days to few weeks.

- **Diuretic phase**: Urine output will be around 5 L. it last days to weeks.
  > **S&S include**: increased urine output, electrolyte disturbances usually decreased, Dehydration, and hypotension.

- **Recovery phase**: It takes 3-12 months. Full renal function can be regained.

☑️ **Risk factors of ARF**: (advanced age, autoimmune disorders, and liver disease)

☑️ **Diagnostic procedures include**: a history, physical examination, BUN, creatinine, blood chemistry, arterial blood gases, urinalysis, biopsy, CBC, and renal ultrasound.

## Chronic Kidney Disease:

☑️ It is a gradual irreversible loss of the renal function
☑️ Healthy nephrons are replaced by scar tissue.

☑️ **Risk factor include**: Diabetes mellitus (type 1 and type 2), hypertension, Urine Obstructions, Renal diseases, Renal artery stenosis, ongoing exposure to toxins, Sickle Cell disease systemic lupus erythematosus, smoking, and aging.

☑️ It evolves within five stages I-V reaching less than 15ml of glomerular filtration rate (GFR).
Kidney can compensate to a loss up to 50% since its nephrons increase their work.

Clinical manifestations include:

- Cardiovascular (Hypertension, pericarditis, Congestive heart failure)
- Renal (polyuria with pale urine (early), Oliguria or anuria (late))
- Hematology (Anemia, Electrolyte imbalances, Azotemia)
- Neuromuscular (Muscle twitches and cramps, Peripheral neuropathy)
- Respiratory (Respiratory distress and abnormal breath sounds)
  - Sudden weight change.
  - Oliguria or anuria (late)
  - Malaise, Fatigue and weakness.
  - Sleep disturbances
  - Nausea and vomiting.
  - Edema of the feet and ankles
  - Increased mental alertness.
  - Flank pain
  - Jaundice & persistent pruritus.
  - Recurrent infections
  - Headaches that seem unrelated to any other cause

Diagnostic procedures include: history, physical examination, blood chemistry, CT, MRI, Renal biopsy, CBC, and arterial blood gases.