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Advances in Nephrology: Understanding Chronic Kidney Disease and Emerging Treatments

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Abstract: *Chronic Kidney Disease (CKD) is a progressive condition characterized by a gradual decline in kidney function over time, typically defined by a reduced glomerular filtration rate (GFR) or evidence of kidney damage lasting for at least three months. CKD can result from a variety of causes, including diabetes, hypertension, glomerulonephritis, and polycystic kidney disease, among others. Early stages of CKD are often asymptomatic, making early detection and management critical for slowing progression. As kidney function declines, complications such as electrolyte imbalances, anemia, bone mineral disorders, and cardiovascular disease commonly arise. The management of CKD focuses on controlling underlying conditions, slowing progression through lifestyle modifications, pharmacologic therapies (e.g., ACE inhibitors, angiotensin receptor blockers), and addressing complications. In end-stage renal disease (ESRD), dialysis or kidney transplantation becomes necessary. The increasing global prevalence of CKD presents a major public health challenge, with a significant impact on healthcare systems and quality of life. Early intervention and a multidisciplinary approach to care are essential to improving outcomes for individuals with CKD.*

Keywords: Chronic Kidney Disease

I. INTRODUCTION

Nephrology:

Nephrology is a branch of medical science. Nephrology refers to the study of the kidneys and related disorders that affect their functions. The treatment of chronic kidney disease, kidney stones, glomerulonephritis, and urinary tract infections all fall under nephrology.

Types of Kidney Diseases

1. Acute kidney injury
2. Kidney cancer
3. Urinary tract infection
4. Interstitial nephritis
5. Kidney failure
6. Lupus nephritis
7. Alport syndrome
8. Focal segmental glomerulosclerosis
9. IgA nephropathy
10. Kidney cysts
11. Kidney stones
12. Glomerulonephritis
13. Chronic kidney disease
14. Polycystic kidney disease

KIDNEY

The renal system consists of the kidney, ureters, and the urethra. The overall function of the system filters approximately 200 liters of fluid a day from renal blood flow which allows for toxins, metabolic waste products, and

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excess ion to be excreted while keeping essential substances in the blood. The kidney regulates plasma osmolarity by modulating the amount of water, solutes, and electrolytes in the blood. In ensure long term acid base balance and also produces erythropoietin which stimulates the production of red cell. It also produces renin for blood pressure regulation and carries out the conversion of vitamin D to its active form. The renal development, the process of urine production and excretion, and the clinical significance of the renal system will be the focus of this article.

The kidneys are bean shaped organs, with medical concavity and lateral convexity, weighing anywhere from 150 to 200 g in males and about 120 to 135g in females. The dimensions are usually a length of 10 to 12 cm, a width of 5 to 7 cm, and a thickness of 3 to 5 cm. Each kidney about the size of a closed fist. They are located retroperitoneally on the posterior abdominal wall and are found between the transverse processes of T12 and L3. Both of the upper poles are usually oriented slightly medially and posteriorly relative to the lower poles. If the upper renal poles are oriented laterally, this could suggest a horseshoe kidney or a superior pole renal mass. Further, the right kidney is usually slightly more inferior in position than the left kidney, likely because of the liver.

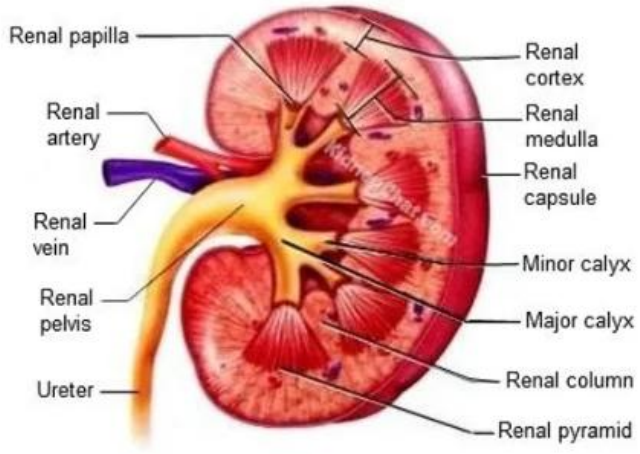
The following are the kidneys relatives to surrounding organs:

- Superiorly, on top of each kidney and separated by renal fascia, are the suprarenal glands (adrenal glands), the right pyramidal suprarenal gland oriented apically on the right kidney and the left crescentic suprarenal gland oriented apically on the right kidney and the left crescentic suprarenal gland oriented more medially on the left kidney.
- The right is posterior to the ascending colon, the second part of the duodenum medially, and the liver, separated by the hepatorenal recess.
- The left kidney is posterior to the descending colon, its renal hilum lateral to the tail of the pancreas, superomedial aspect adjacent tothe greater curvature of the stomach, and left upper pole adjacent to the spleen and connected by splenorenal ligaments.

Posteriorly, the diaphragm rests over the upper third of each kidney with the 12th rib passing posteriorly over the upper pole. The kidneys usually sit located over the medical aspect of thepsoas muscle and the lateral aspects of the quadratus lumborum. The proximal ureters will typically pass over the psoas muscle on their way to the bony pelvis.

At the medical margin of each kidney lies the renal hilum, where the renal artery enters, and the renal pelvis and vein leave the renal sinus. The renal vein is found anterior to the renal artery, which is anterior to the renal pelvis. The renal pelvis is the flattened, superior end of the ureter. It receives 2 or 3 major calyces, each of which receives 2 or 3 minor calves. The minor calyces are indented by the renal papillae, which are the apices of the renal pyramids. A pyramid and its cortical tissue comprise a lobe.

Each kidney is covered by a two-layered capsule and is surrounded by perinephric fat, groans fascia, Zuckerman fascia, and paranephric fat. The entire area immediately involving the kidneys is considered the retroperitoneum.



kidney

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Functions of Kidney:

The kidneys perform several vital functions to maintain overall health and homeostasis in the body:

1. Filtration of Blood: The kidneys filter waste products, toxins, and excess substances (such as water, salts, and urea) from the bloodstream to form urine. This helps maintain the body's internal chemical balance.
2. Regulation of Fluid and Electrolyte Balance: The kidneys regulate the volume and composition of body fluids by adjusting the levels of water, sodium, potassium, calcium, and other electrolytes, helping to maintain proper hydration and acid-base balance.
3. Excretion of Waste Products: The kidneys remove metabolic waste products such as urea, creatinine, and uric acid, which are produced during the breakdown of proteins and other substances in the body.
4. Acid-Base Balance: The kidneys help regulate the pH of the blood by excreting hydrogen ions (acid) and reabsorbing bicarbonate (base), maintaining the body's acid-base balance.
5. Blood Pressure Regulation: Through the renin-angiotensin-aldosterone system (RAAS), the kidneys help regulate blood pressure by controlling the volume of blood (through water retention) and the constriction of blood vessels.
6. Erythropoiesis Regulation: The kidneys produce erythropoietin, a hormone that stimulates the bone marrow to produce red blood cells in response to low oxygen levels in the blood.
7. Detoxification: The kidneys filter out and eliminate various toxins and drugs, preventing them from accumulating in the bloodstream.
8. Vitamin D Activation: The kidneys convert vitamin D into its active form, calcitriol, which is necessary for calcium absorption in the intestines and bone health.

Through these functions, the kidneys play a critical role in maintaining a stable internal environment, supporting the body's metabolism, and promoting overall health.

Parts of kidney:

- Nephrons
- Renal corpuscle
- Renal tubules
- Renal cortex
- Renal medulla
- Renal pyramids
- Collecting ducts
- Renal pelvis
- Calyces
- Hilum
- Ureter

Nephron

Functional unit of the kidney, the structure that produces urine in the process of removing waste and excess substances from the blood. There are about 1 million nephrons in each human kidney. Each has its own internal set of structures.

Renal corpuscle

After blood enters a nephron, it goes into the renal corpuscle, also called Malpighian body. They renal corpuscle contains two additional structures:

- **The glomerulus:** This is a cluster of capillaries that absorb protein from blood travelling through the renal corpuscle.
- **The bowman capsule:** The remaining fluid. Called capsular urine. Passes through the bowman capsule into the renal tubules.

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Renal tubules: The renal tubules are a series of tubes that begin after the bowman capsule and end at collecting ducts. Each tubule has several parts:

- **Proximal convoluted tubule:** This section absorbs water, sodium and glucose back into the blood.
- **Loop of Henle:** This section further absorbs potassium, chloride, and sodium into the blood.
- **Distal convoluted tubule:** This section absorbs more sodium into the blood and takes in potassium and acid.

Renal cortex: The renal cortex is the outer part of the kidney. It contains the glomerulus and convoluted tubules. The renal cortex is surrounded on its outer edges by the renal cortex and capsule house and protect the inner structures of the kidney.

Renal medulla: The renal medulla is the smooth, inner tissue of the kidney. It contains the loop of Henle as well as renal pyramids.

Renal pyramids: Renal pyramids are small structures that contain strings of nephrons and tubules. These tubules transport fluid into the kidney. This fluid then moves away from the nephrons towards the inner structures. That collect and transport urine out of the kidney.

Collecting ducts: There's a collecting duct at the end of each nephron in the renal medulla. This is where filtered fluids exit the nephrons.

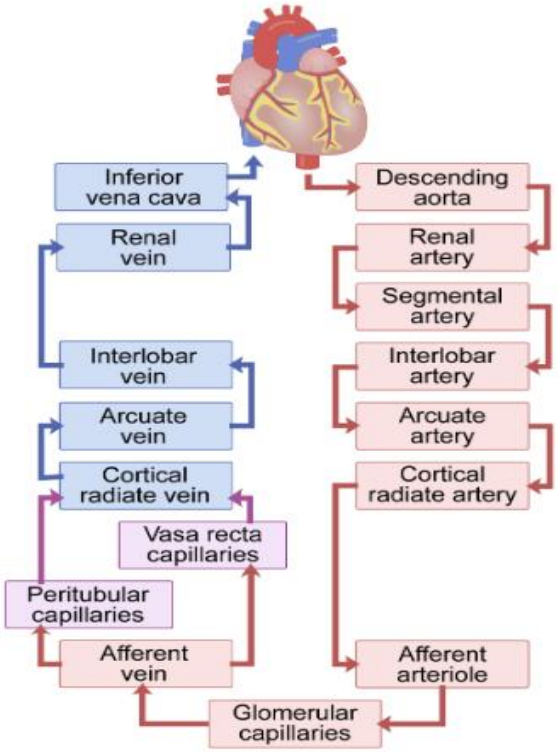
Renal pelvis: The renal pelvis is a funnel-shaped space in the innermost part of the kidney. It functions as a pathway for fluid on its way to the bladder.

Calyces: the first part of the renal pelvis contains the calyces. These are small cup-shaped spaces that collect fluid before it moves into the bladder. This is also where extra fluid and waste become urine.

Hilum: The hilum is a small opening located on the inner edge of the kidney, where it curves inward to create its distinct beanlike shape. The renal pelvis passes through it, as well as the:

- **Renal artery:** This brings oxygenated blood from the heart to the kidney for filtration
- **Renal vein:** This caried filtered blood from the kidney back to the heart.

Ureter: This is a tube of muscle that pushes urine into the bladder, where it collects and exits the body.



Blood supply of Kidney

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CHRONIC KIDNEY DISEASE

Chronic kidney disease (CKD) is characterised by the presence of kidney damage or an estimated glomerular filtration rate (eGFR) of less than 60 ml/min/1.73m^2, persisting for 3 months or more, irrespective of the cause. CKD is a state of progressive loss of kidney function, ultimately resulting in the need for renal replacement therapy, such as dialysis or transplantation. Kidney damage refers to pathologic abnormalities suggested by imaging studies or renal biopsy, abnormalities in urinary sediment, or increased urinary albumin excretion rates.

The 2012 kidney disease improving global outcomes (KDIGO) CKD classification recommends specifying the cause of CKD and classifies the condition into 6 categories, with based on GFR (G1 to G5, with G3 split into 3a and 3b). In addition, it also includes staging based on 3 levels of albuminuria (A1, A2, and A3), with each stage of CKD subcategorized according to the urinary albumin-creatinine ration (ACR; mg/g or mmol) in an early morning "spot" urine sample.

The 6 CKD categories, known as stages 1 through 5, are described below (stage 3 is separated into 3a and 3b):

- G1: GFR 90 mL/min/1.73 m^2
- G2: GFR 60 to 89 mL/min/1.73 m^2
- G3a: GFR 45 to 59mL/min/1.73 m^2
- G3b: GFR 30 to 44mL/min/1.73 m^2
- G4: GFR 15 to 29 mL/min/1.73 m^2
- G5: GFR less than 15mL/min/1.73 m^2 or treatment by dialysis

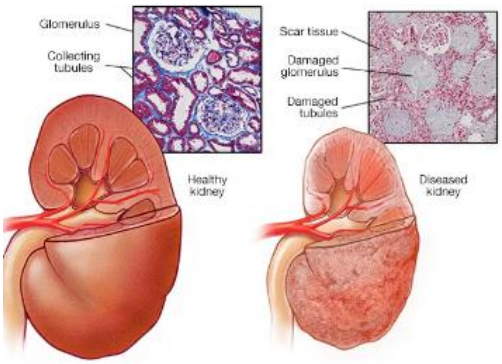
The 3 levels of albuminuria include an ACR:

- A1: ACR less than 30 mg/g (<3.4 mg/mmol)
- A2: ACR 30 to 299 mg/g (3.4-34mg/mmol)
- A3: ACR greater than 300 mg/g (>34 mg/mmol)

The improved classification of CKD has been beneficial in identifying prognostic indicators related to decreased kidney function and increased albuminuria. However, a downside of this classification system is the potential for overdiagnosis of CKD, particularly in order individuals.

Chronic kidney disease is a syndrome of persistent renal impairment involving loss of both glomerular and tubular function such that the kidneys' homoeostatic functions are compromised. It usually has a gradual onset and, in many cases, progresses inexorably to a critical state (established or end-stage renal failure) in which the patient's continued survival requires the initiation of renal replacement treatment, either by some form of dialysis or by renal transplantation. Although there are many causes of CKD, the clinical features of the condition tend to be similar regardless of the cause, being in effect due to a decrease in the number of functioning nephrons. Despite this, it is, as discussed below, important to attempt to determine the cause, although this is not always possible.

Although CKD may be discovered early, before it has given to any clinical disturbance (e.g. by the routine assessment of renal function in patients at risk of developing CKD), it frequently presents late, with a GFR already <20mL/min. Some patients will also have clinical features of 'uremic syndrome'. This term is used to describe the clinical features that can occur in patients with CKD, but is caused by the retention of many substances, of which urea itself is relatively unimportant, and by other (e.g. endocrine) abnormalities that arise as a result of renal dysfunction.



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Stages of chronic kidney disease: Chronic kidney disease has five stages. These start from a mildly damaged kidney and may end with kidney failure. Early diagnosis and treatment can help stop the disease from progressing.

Overview of stages

To assign a CKD stage, two tests are required to assess how well your kidneys work.

The first is a urine test to asses your albumin-creatinine ratio. This shows if protein leaks into the urine, which may be a sign of kidney damage. A higher level indicates more kidney damage.

ACR levels are staged as follows:

A1	lower than 3mg/mmol, a normal to mild increase
A2	3–30mg/mmol, a moderate increase
A3	higher than 30mg/mmol, a severe increase

The second is a blood test called the estimated glomerular filtration rate (eGFR). This shows how well your kidneys are filtering your blood. A GFR of 100 mL/min is normal. GFR shows how much blood your kidneys filter in 1 min.

To classify kidney damage into a stage, these tests must be repeated to monitor long-term kidney damage, which is damage of at least 3 months.

Stage	Description	GFR	Percent of kidney function
1	normal to highly functioning kidney	greater than 90 mL/min	>90%
2	mild decrease in kidney function	60–89 mL/min	60–89%
3A	mild-to-moderate decrease in kidney function	45–59 mL/min	45–59%
3B	mild-to-moderate decrease in kidney function	30–44 mL/min	30–44%
4	severe decrease in kidney function	15–29 mL/min	15–29%
5	kidney failure	less than 15 mL/min	<15%

Stage1 of kidney:

In stage 1, there's very mild damage to the kidneys. They're quite adaptable and can adjust for this, allowing them to keep performing at 90% or better.

At this stage, CKD is likely to be discovered by chance during routine blood and urine tests. You may also have these tests if you have diabetes or high blood pressure. These are the top causes of CKD in the United States.

Symptoms

Typically, there are no symptoms when kidneys function at 90% or better.

Stage 2 kidney disease

In stage 2 CKD, kidneys are functioning between 60-89%.

Symptoms

At this stage, you might still be symptom-free. Or symptoms are nonspecific, such as:

- Frequent urinary tract infections (UTIs)
- High blood pressure
- Swelling in hands and feet
- Blood in urine

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Stage 3 kidney disease

Stage 3A CKD is when kidney is functioning between 45-59%. Stage 3B means kidney function is between 30-44%. the kidneys aren't filtering waste, toxins, and fluids well, which are starting to build up.

This is a first stage when people are typically diagnosed with CKD because it's when an eGFR blood test alone can detect it.

Symptoms

Not everyone has symptoms at stage 3. However, you may experience:

- Back pain
- Fatigue
- Loss of appetite
- Persistent itching
- Sleep problems
- Swelling of the hands and feet
- Urinating more or less than usual
- Weakness

Stage 4 kidney disease

Stage 4 CKD means you have moderate-to-severe kidney damage. They're functioning between 15-29%, so you may build up more waste, toxins, and fluids in body.

At this stage, it's important to do everything you can to prevent progression to kidney failure.

According to the Centers for Disease Control and Prevention (CDC), 40% Trusted Source of people with severely reduced kidney function aren't even aware they have it.

Symptoms

Symptoms can include:

- back pain
- Chest pain
- Decreased mental sharpness
- Fatigue
- Loss of appetite
- muscle twitches or cramps
- nausea and vomiting
- persistent itching
- shortness of breath
- sleep problems
- swelling of the hands and feet
- urinating more or less than usual
- weakness
- weight loss

stage 5 kidney disease

stage 5 CKD means your kidneys are working at less than 15% capacity or have kidney failure.

When this happens, the buildup of waste and toxins becomes life threatening. This is end-stage renal disease.

Symptoms

Symptoms include:

- Back and chest pain

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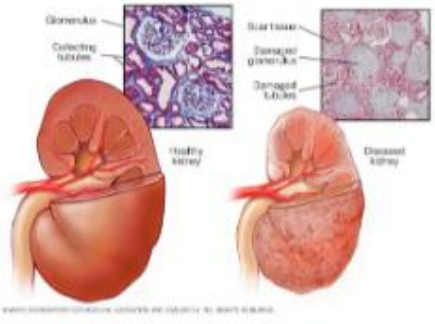
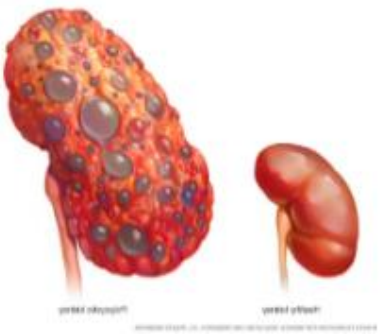
- Breathing problems
- Confusion and trouble focusing
- Weight loss
- Fatigue
- Little to no appetite
- Muscle twitches or cramps
- Nausea or vomiting
- Urinating more or less than usual

Etiology:



Healthy Kidney vs Diseased Kidney



Polyscistic kidney

The causes of CKD vary globally, with the most common primary diseases leading to CKD and ultimately, end stage renal disease(ESRD) being:

- Type 2 diabetes (30%-50%)
- Type 1 diabetes (3.9%)
- Hypertension (27.2%)
- Primary glomerulonephritis (8.2%)
- Chronic tubulointerstitial nephritis(3.6%)
- Hereditary or cystic diseases (3.1%)
- Secondary glomerulonephritis or vasculitis (2.1%)
- Plasma cell dyscrasias or neoplasm (3.1%)
- Sickle cell nephropathy, which accounts for less than 1% of ESRD patients in the United States.

CKD may result from disease processes in any of the 3 categories, including prerenal (decreased renal perfusion pressure), intrinsic renal (pathology of the vessels, glomeruli, or tubules-interstitial), or postrenal (obstructive).

Prerenal disease

Chronic prerenal disease occurs in patients with chronic heart failure or cirrhosis, where persistently decreased renal perfusion increases the risk of intrinsic kidney injury, such as acute tubular necrosis. Over time, this can lead to a progressive loss of renal function.

Intrinsic renal disease

Intrinsic renal vascular disease: the most common chronic renal vascular disease is nephrosclerosis, which causes ongoing damage to blood vessels, glomeruli, and the tubulointerstitial. Other renal vascular diseases include renal artery stenosis due to atherosclerosis of fibromuscular dysplasia, which, over months or years, can lead to ischemic nephropathy. This condition is characterised by glomerulosclerosis and tubulointerstitial.

Intrinsic glomerular disease (nephritic or nephrotic): A nephritic pattern is indicated by abnormal urine microscopy showing red blood cells (WBSs), along with a variable degree of proteinuria. The most common causes are post-infectious glomerulonephritis, infective endocarditis, IgA nephropathy, lupus nephritis, Goodpasture syndrome,and vasculitis.

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A nephrotic pattern is associated with proteinuria, usually in the nephrotic range(<3.5g/24h), and an inactive urine microscopic analysis with few cells or casts. Common causes include minimal change disease, focal segmental glomerulosclerosis, membranous glomerulonephritis, diabetic nephropathy, and amyloidosis.

Intrinsic tubular and interstitial disease: The most common chronic tubulointerstitial disease is polycystic kidney disease (PKD). Other etiologistincludes nephrocalcinosis (often due to hypercalcemia and hypercalciuria), sarcoidosis, Sjogren syndrome, and reflux nephropathy in children and young adults.

There is increasing recognition of a relatively high prevalence of CKD of unknown cause among agricultural workers from Central America and parts of Southeast Asia, known as Mesoamerican nephropathy or chronic interstitial nephritis in agricultural communities.

Postrenal (obstructive nephropathy): Chronic obstruction results from prostatic disease, nephrolithiasis, or an abdominal/pelvic tumour exerting a mass effect on the ureter(s). congenital abnormalities, or an abnormality causing obstruction at the ureteropelvic or ureterovesical junctions are also common. Rare causes of chronic ureteral obstruction include retroperitoneal fibrosis or neurogenic bladder.

Signs and Symptoms:

Signs and symptoms of chronic kidney disease develop over time if kidney damage progresses slowly. Loss of kidney function can cause a buildup of fluid or body waste or electrolyte problems. Depending on how severe it is, loss of kidney function can cause:

- Nausea
- Vomiting
- Loss of appetite
- Fatigue and weakness
- Sleep problems
- Urinating more or less
- Decreased mental sharpness
- Trouble concentrating
- Swelling of feet and ankles
- Dry, itchy skin
- High blood pressure (hypertension) that's difficult to control

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- Shortness of breath, if fluid builds up in the lungs
- Chest pain, if fluid builds up around the lining of the heart
- Muscle cramps
- Numbness
- Puffy eyes
- Foamy or bubbly pee
- A need to pee more often

Signs and symptoms of kidney disease are often nonspecific. This means they can also be caused by other illnesses. Because your kidneys are able to make up for lost function, you might not develop signs and symptoms until irreversible damage has occurred.

Risk Factors:

Several risk factors contribute to the development and progression of Chronic Kidney Disease (CKD). These factors can be broadly categorized into modifiable and non-modifiable risks:

Non-modifiable Risk Factors:

1. Age: The risk of CKD increases with age, particularly in individuals over 60 years old.

2. Genetic Factors: Family history of CKD, polycystic kidney disease, or other hereditary kidney conditions increase the likelihood of developing CKD.

3. Ethnicity: Certain ethnic groups, including African American, Hispanic, Native American, and Asian American populations, are at higher risk for CKD, potentially due to genetic and environmental factors.

4. Gender: Men are generally at a higher risk of developing CKD compared to women, although women tend to progress to end-stage renal disease (ESRD) more slowly.

Modifiable Risk Factors:

1. Diabetes: Both type 1 and type 2 diabetes are leading causes of CKD due to the damage high blood sugar can cause to the kidneys' filtering system over time.

2. Hypertension: Chronic high blood pressure can damage the blood vessels in the kidneys, impairing their ability to filter waste effectively.

3. Obesity: Excess body weight can increase the risk of developing diabetes and hypertension, both of which contribute to kidney damage.

4. Cardiovascular Disease: Heart disease and CKD share common risk factors, and the presence of one condition often worsens the other.

5. Smoking: Smoking can accelerate kidney damage, increase blood pressure, and reduce blood flow to the kidneys.

6. High Protein Diet: Excessive dietary protein, particularly from animal sources, can strain the kidneys, especially in individuals already at risk for kidney damage.

7. Chronic Use of Certain Medications: Prolonged use of nonsteroidal anti-inflammatory drugs (NSAIDs), certain antibiotics, and other nephrotoxic drugs can contribute to kidney damage.

8. High Cholesterol: Elevated cholesterol levels can contribute to the buildup of plaque in the blood vessels, reducing kidney function over time.

Other Risk Factors:

1. Low Birth Weight: Being born with a low birth weight has been associated with a higher risk of developing CKD later in life.

2. Chronic Infections or Inflammation: Conditions like glomerulonephritis, lupus, or urinary tract infections (UTIs) that affect the kidneys over time can lead to CKD.

3. Dehydration: Chronic dehydration or repeated episodes of acute kidney injury (AKI) can increase the risk of developing CKD.

By managing modifiable risk factors such as blood sugar levels, blood pressure, diet, and lifestyle choices, the progression of CKD can often be delayed or mitigated. Early detection and regular monitoring are key to reducing the long-term effects of CKD

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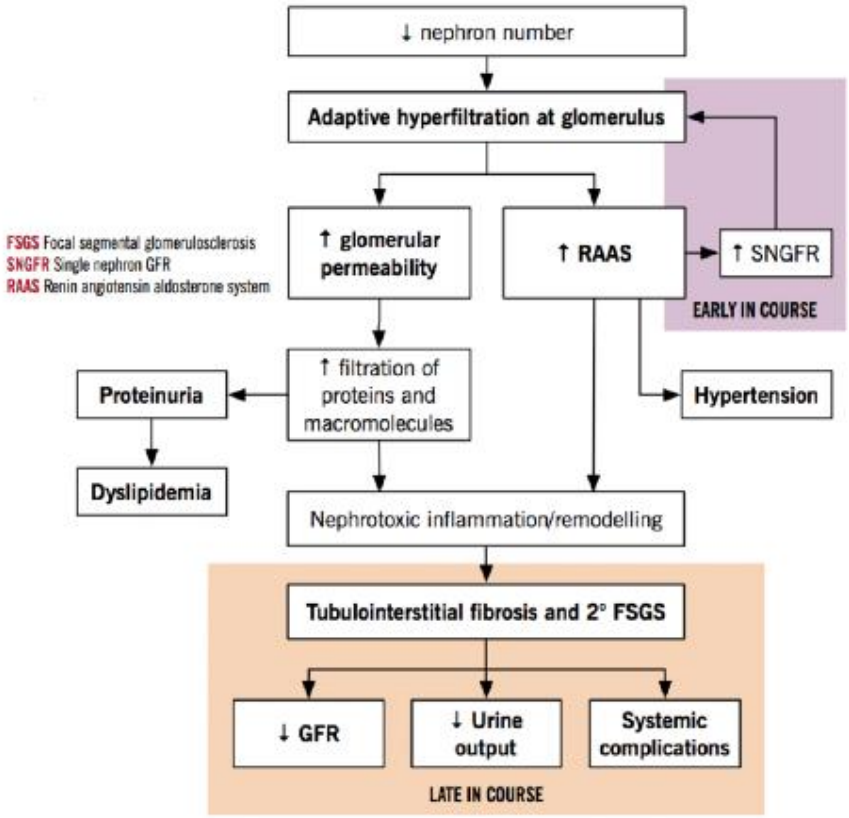
Pathophysiology:



Chronic kidney disease (CKD) is initially described as diminished renal reserve or renal insufficiency, which may progress to renal failure (end-stage kidney disease). Initially, as renal tissue loses function, there are few noticeable abnormalities because the remaining tissue increases its performance (renal functional adaptation).

Decreased renal function interferes with the kidney's ability to maintain fluid and electrolyte homeostasis. The ability to concentrate urine declines early and isfollowed by decreases in ability to excrete excess phosphate, acid and potassium. When renal failure is advanced (glomerular filtration rate [GFR]≤ 15 ml/min/1.73m^2), the ability to effectively dilute or concentrate urine is lost; thus, urine osmolality is usually fixed at about 300 to 320 mom/kg, close to that of plasma (275 to 295 mom/kg,) and urinary volume does not respond readily to variations in water intake.

Creatinine and urea

Plasma concentrations of creatinine and urea (which are highly dependent on glomerular filtration) begin a hyperbolic rise as GFR diminishes. These changes are minimal early on. When the GFR falls below 15 ml/min/1.73m (normal> 90 ml/min/1.73m^2), creatinine and urea levels are high and are usually associated with systemic manifestations (uraemia). Urea and creatinine are not major contributors to the uremic symptoms; they are markers for many other substances (some not yet well-defined) that cause the symptoms.

Despite a diminishing GFR, sodium and water balance are well- maintained by increased fractional excretion of sodium in urine and normal response to Thirst. Thus, the plasma sodium concentration is typically normal, and hypervolemia is infrequent unless dietary intake of sodium or water is very restricted or excessive. Heart failure can occur due to sodium and water overload, particularly in patients with decreased cardiac reserve.

Potassium

For substances whose secretion is controlled mainly through distal nephron secretion (e.g.potassium), renal adaptation usually maintains plasma levels at normal until renal failure is advanced or dietary potassium intake is excessive.potassium-sparing diuretic, angiotensin-converting enzyme inhibitors, beta-blockers, nonsteroidal anti - inflammatory drugs. (NSAIDs),cyclosporine, tacrolimus, sulphamethoxazole/trimethoprim (smx-

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tmp,clotrimazole),pentamidine,or angiotensin 2 receptor blockers may raise plasma potassium levels in patients with less advanced renal failure.

Calcium and phosphate

Abnormalities of calcium, phosphate, parathyroid hormone (PTH), and vitamin D metabolism can occur, as can renal osteodystrophy. Decreased renal production of calcitriol (1,25 $(OH)_2$ D, the vitamin D hormone) contributes to hypocalcemia. Decreased renal excretion of phosphate results in hyperphosphatemia. Secondary hyperparathyroidism is common and can develop in renal failure before abnormalities in calcium or phosphate concentrations occur. For this reason, monitoring PTH in patients with moderate CKD, even before hyperphosphatemia occurs, has been recommended.

Renal osteodystrophy (abnormal bone mineralization resulting from hyperparathyroidism, calcitriol deficiency, elevated serum phosphate, or low or normal serum calcium) usually takes the form of increased bone turnover due to hyperparathyroid bone disease (osteitis fibrosa) but can also involve decreased bone turnover due to adynamic bone disease (with increase parathyroid suppression) or osteomalacia. Calcitriol deficiency may cause osteopenia or osteomalacia.

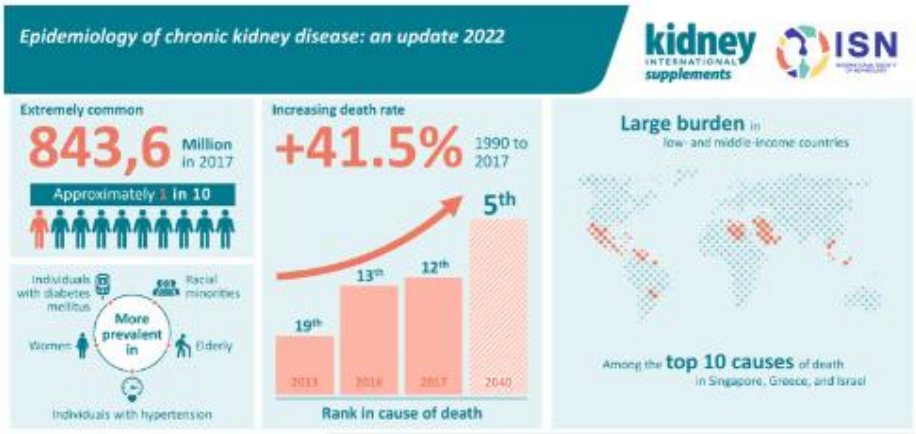
PH and bicarbonate

Moderate metabolic acidosis (plasma bicarbonate content15 to 20 mmol/L) is characteristic. Acidosis causes muscle wasting due to protein catabolism, bone loss due to bone buffering of acid, and accelerated progression of kidney disease.

Anemia

Anemia is characteristic of moderate to advanced CKD (≥stage3). The anemia of CKD is normochromic-normocytic, with a hematocrit of 20 to 30% (35 to 40 % in patients with polycystic kidney disease). It is usually caused by deficient erythropoietin production due to a reduction of functional renal mass. Other causes include deficiencies of iron, folate, and vitamin B12.

Epidemiology:



Chronic kidney disease (CKD) has emerged as one of the most prominent causes of death and suffering in the 21st century. Due in part to the rise in risk factors, such as obesity and diabetes mellitus, the number of patients affected by CKD has also been increasing, affecting an estimated 843.6 million individuals worldwide in 2017. Although mortality has declined in patients with end-stage kidney disease (ESKD), the Global Burden of Disease (GBD) studies have shown that CKD has emerged as a leading cause of worldwide mortality. It is, therefore, paramount that CKD is identified, monitored, and treated, and that preventative and therapeutic measures addressing CKD are systematically implemented worldwide. This narrative review summarizes information about global CKD prevalence, its trends over time, its various determinants, and its associated mortality. Other aspects of kidney disease epidemiology, such as CKD in paediatric patients, CKD incidence, progression to ESKD, or various clinical (e.g., cardiovascular disease) and patient-reported outcomes caused by CKD, are mentioned briefly or not discussed.

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Definitions of CKD and its pitfalls in epidemiologic studies

The diagnosis of CKD is made by laboratory testing, most often by estimating glomerular filtration rate (GFR) from a filtration marker, such as serum creatinine or cystatin C, using various formulas, or by testing urine for the presence of albumin or protein (or a combination of these). The classification schemes advocated by various professional organizations in the past 2 decades have laid the groundwork for the systematic detection and monitoring of CKD worldwide, resulting in an improved understanding of its prevalence and the resulting impact on outcomes, such as mortality. Most studies have used estimated GFR (eGFR) to determine the presence of CKD (and, therefore, report on the prevalence of CKD stages 3-5), whereas other studies have combined albuminuria (typically defined as an albumin-to-creatinine ratio of>30 mg/g) and decreased eGFR to report on CKD stages 1-5. Finally, to differentiate CKD (which is considered to be a chronic progressive disease) from conditions such as acute kidney injury or from transient fluctuations in kidney function unrelated to kidney damage, the standard definition of CKD includes a so-called "chronicity criterion" (i.e., that the low eGFR or elevated urine albumin should be detectable for at least 90 days, requiring the presence of repeated measurements over time). There is currently no consensus on the length of time used in the assessment of CKD when applying the chronicity criterion, with epidemiologic studies applying various algorithms, from single measurements (s) to 90 to 365 days, and from requiring consecutive repeated markers of CKD to accepting CKD markers interspersed with markers not conforming to CKD criteria. The potential impact of using 6 different definition algorithms (5 laboratory measurements based and one based on International Classification of disease (ICD) diagnostic codes) to a certain the prevalence of CKD was recently examined in a population-based cohort from Northern Denmark. The prevalence of CKD varied considerably between the various laboratory-based definitions, ranging from 8327 cases per 100,000 population when using a single eGFR value to 4637 cases per 100,000 population when using a time-limited repeated eGFR-based definition. Furthermore, when using an ICD diagnostic code-based definition, the prevalence of CKD was markedly lower, at 775 cases per 100,000 population. Studies assessing the prevalence of CKD have applied a variety of definitions of CKD, and thus their results (and especially the results of studies aggregating their findings, as described below) must be interpreted with caution.

Prevalence and global burden of CKD

The prevalence of CKD has been reported in an increasing number of studies worldwide (the individual discussion of which is beyond the scope of this review), which has made it possible to aggregate their findings and to derive information about global CKD prevalence overall, as well as in various patient subgroups and geographic regions. A study assessing the prevalence and burden of CKD in 2010 pooled the results of 33 population-based representative studies from around the world and reported an age-standardized global prevalence of CKD stages 1-5 in individuals aged≥20 years of 10.4% among men ad 11.8% among women. The study reported important differences by geographic region classified by income level, with a CKD age-standardized prevalence of 8.6% and 9.6% in men and women, respectively, in high-income countries, and 10.6 and 12.5% in men and women, respectively in high-income countries. The age-standardized global prevalence of CKD stages 3-5 in adults aged>20 years in the same study was 4.7% in men and 5.8% in women. A more recent study performed a compressive systematic review and meta-analysis of 100 studies comprising 6,908,440 patients, and reported a global prevalence of 13.4% for CKD stages 1-5 and 10.6% for CKD stages 3-5. The prevalence of the individual CKD stages was 3.5% (stage 1),3.9% (stage 2), 7.6% (stage 3), 0.4% (stage 4), and 0.1% (stage 5).On the basis of the results of studies examining the global prevalence of CKD, the current total number of individuals affected by CKD stages 1–5 worldwide was estimated to be 843.6 million.

Changes in CKD prevalence over time

There are significantly fewer studies examining changes in CKD prevalence over time, as this requires a reassessment of the same population using similar methods. In the United States, the Centres for Disease Control and Prevention CKD Surveillance System reported that the prevalence of CKD stages 1–4 was 11.8% in 1988 to 1994, and it increased to 14.2% in 2015 to 2016. This increase was not linear, as was reported by a study examining data from the National Health and Nutrition Examination Survey; this study showed that although the prevalence of CKD stage 3–4 increased from the 1990s to the 2000s, it has remained largely stable since. A similarly stable prevalence of CKD stages 1–5 was reported in Norway for the time period between 1995 and 2008.Interestingly, the prevalence of CKD stages 3–5 declined significantly over 7 years in the United Kingdom based on the nationally representative Health Survey for England. In this study, the adjusted odds ratio of an eGFR <60 ml/min per 1.73 m^2 comparing 2003 with 2009/2010

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was 0.73 (95% confidence interval, 0.57–0.93).The reasons for recently reported stabilized or improved CKD prevalence are unclear. These trends have occurred despite a concomitant increase in common risk factors of CKD, such as diabetes and obesity, although hypertension control has improved over this time period. It is worth mentioning that, due to population growth, a stable trend in CKD prevalence still represents an increase in the absolute number of patients with CKD. The reason(s) for the observed dynamic changes in CKD prevalence (and the discrepancies observed between the data from different countries) is difficult to determine. Disease prevalence could vary due to changes in disease incidence, but information about CKD incidence is much sparser in the literature, and the results of published studies cannot be interpreted in the context of prevalence estimates performed in different populations and different eras,due to the major impact of characteristics, such as age, sex, or race, on incidence values. Prevalence can also change because of changes in survival or longer lifetime duration of diagnosed CKD (e.g., from better screening); it is possible that the aggregate change in CKD prevalence may be the result of a combination of factors.

Effect of patient characteristics and comorbidities on CKD prevalenceThe prevalence of CKD is affected by both its definition and its pathophysiology. Because most CKD cases are identified using eGFR, its determinants will impact the estimates of CKD prevalence. Most important, higher age results in lower eGFR independent of the other components of the equation; hence, even with a stable serum creatinine concentration, an individual can develop CKD as a result of advancing age due to the assumption that age-related losses in muscle mass will obscure the decrease in age-associated losses in GFR. Indeed, the aforementioned meta-analysis by Hill *et al.* assessed the impact of age on CKD prevalence and reported a linearly higher prevalence for CKD stages 1–5 associated with advancing age, ranging from 13.7% in the 30- to 40-year-old group to 27.9% in patients aged >70 to 80 years.Similar trends were reported in the United States during 2015 to 2016, where the prevalence of CKD stages 1–4 was 5.6% among individuals aged 20 to 39 years and 44% among those aged >70 years.Notwithstanding the biological plausibility of age-associated loss of GFR, the pathologic significance of early-stage (i.e., stage 3a) CKD that is solely a result of advanced age (and characterized by normal urine albumin and serum creatinine values) continues to be debated.

The prevalence of CKD has been reported to be higher in females than in males. In the United States, the age-adjusted prevalence of CKD stages 1–4 in 2015 to 2016 was 14.9% in females and 12.3% in males,similar to the sex-based differences reported in the global studies mentioned above. The reasons for these differences are unclear and are likely to be complex. Although GFR estimating equations include a correction factor for sex, a single cutoff of <60 ml/min per 1.73 m^2 for CKD definition may result in overdiagnosing CKD in women. The higher CKD prevalence described in women also contrasts with experimental data showing the protective effects of estrogen and potential deleterious effects of testosterone on nondiabetic CKD,as well as data that indicate a higher incidence of kidney failure in men. A meta-analysis of 30 studies examining sex-stratified data concluded that CKD progression was faster in men compared with women,although other studies have cautioned that such differences may be due to nonbiological factors, such as lifestyle, cultural, and socioeconomic factors. Better characterization of the effects of sex on CKD incidence, prevalence, and progression requires further examination, including the study of potential development of sex-specific disease markers.

Racial differences in the incidence and prevalence of CKD and kidney failure are well described in the United States,but a global and systematic evaluation of such differences is difficult because variances between countries are complex and represent a combination of risk factors (including differences in race). Furthermore, within-country comparisons may not always be possible due to racial/ethnic homogeneities and/or local restrictions on reporting individuals' race and ethnicity. An additional challenge is the inaccuracy of GFR estimation formulas in individuals of different races, and an ongoing debate in the United States over the exclusion of the correction factor for self-reported African American race from the existing estimation formulas as a means to alleviate racial disparities. In the United States, the age-adjusted prevalence of CKD stages 1–4 among non-Hispanic Whites, non-Hispanic Blacks, and Mexican Americans in 2015 to 2016 was 13%, 16.5%, and 15.3%, respectively. The reasons for race-associated differences are complex, and include differences in the prevalence of CKD risk factors (such as diabetes mellitus, hypertension, and obesity), genetic causes, lifestyle and cultural differences, and socioeconomic disparities.

Diabetes mellitus has emerged as the most important risk factor for CKD in the developed world; this is reflected in studies examining CKD prevalence. In the United States, the prevalence of CKD stages 3–4 among diagnosed diabetics was 24.5% in 2011 to 2014, whereas in prediabetics it was 14.3% and in nondiabetics it was 4.9% The association

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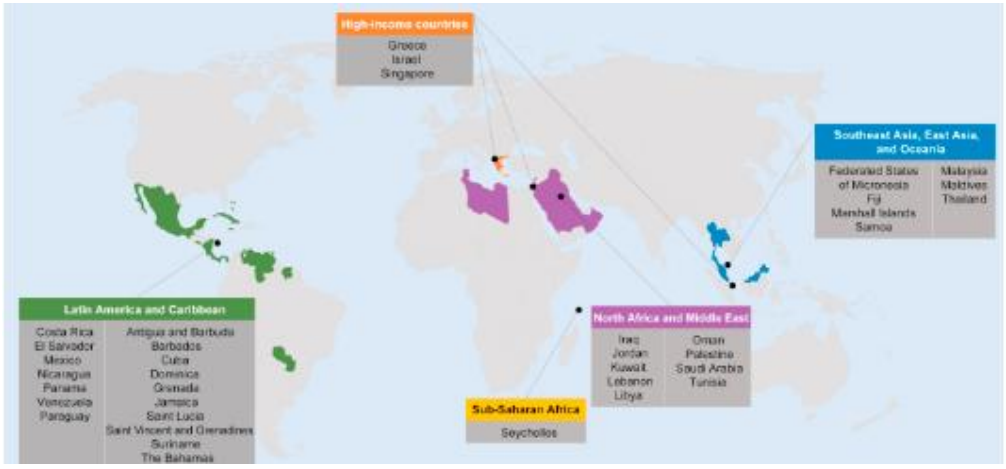
between diabetes mellitus and the prevalence of CKD was also reported in a meta-analysis that included 82 global studies.The effect of diabetes mellitus on kidney function and on the development and progression of CKD is well established. Nevertheless, epidemiologic studies examining CKD in diabetics have to contend with the fact that diabetic populations (especially type 2 diabetics) often experience multiple other comorbid conditions, such as hypertension or vascular disease, which are themselves independent risk factors for CKD. A study examining a national cohort of US veterans with newly diagnosed type 2 diabetes mellitus reported a crude prevalence of CKD stages 1–5 of 31.6%, half of whom had CKD stages 3–5. Although the timing of incident type 2 diabetes mellitus is difficult to ascertain, the high prevalence of CKD in this study suggests that at least some of the CKD cases diagnosed in diabetics may not be a direct result of diabetes-related mechanisms.

Hypertension is the strongest cardiovascular risk factor worldwide and is also closely associated with CKD. The prevalence of CKD among hypertensive US adults was 35.8% in 2011 to 2014, compared with a prevalence of 14.4% in prehypertensives and 10.2% among nonhypertensive individuals.A significant association between hypertension and the prevalence of CKD was also reported in a meta-analysis that included 75 global studies.

Mortality associated with CKD

CKD is now widely recognized as one of the leading causes of death worldwide. The GBD reports have been tracking causes of death across the globe for the past decade. The 2013 GBD report indicated that although relative death rates decreased for most communicable and noncommunicable diseases, CKD (defined as all stages, including patients on dialysis) was one of only a handful of conditions to show an increase since 1990. The global all-age mortality rate attributed to CKD increased by 41.5% between 1990 and 2017.Besides being one of the leading causes of death, CKD also became the 19th leading cause of years of life lost (which is calculated from the number of deaths attributable to CKD and the life expectancy of individuals in various age groups at the time of their death from CKD) in 2013, compared with being the 36th leading cause in 1990. Subsequent GBD reports indicate that the rise of CKD among the list of causes of death has continued, occupying the 13th place in 2016and 12th place in 2017, with predictions suggesting that it will become the fifth highest cause of years of life lost globally by 2040. The GBD reports also shed light on the disproportionate nature of the burden imparted by CKD-associated death in different world regions, with Latin America, the Caribbean region, Southeast Asia and East Asia, Oceania, North Africa, and the Middle East being especially affected. Among high-income nations, CKD was among the top 10 causes of death in Singapore, Greece, and Israel (These reports are especially noteworthy when considering that they did not include deaths that were caused indirectly by CKD, such as those related to acute kidney injury or to various cardiovascular causes, both of which can be caused or potentiated by CKD.

Figure



Regions and countries where chronic kidney disease is in the top 10 causes of years of life lost in 2013. On the basis of data from the Global Burden of Disease Study 2013

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Diagnosis:

As a first step toward diagnosis of kidney disease, doctor discuss your personal and family history with you. Among other things, your doctor might ask questions about whether you're been diagnosed with high blood pressure, if you've taken a medication that might affect kidney function, if you've noticed changes in your urinary habits and whether you have family members who have kidney disease.

Next, your doctor performs a physical exam, checking for signs of problems with your heart or blood vessels, and conducts a neurological exam.

For kidney disease diagnosis, you might also need certain tests and procedures to determine how severe your kidney disease is (stage). Tests might include:

Blood tests.

Kidney function tests look for the level of waste products, such as creatinine and urea, in blood.

Removing a sample of kidney tissue for testing.

Your doctor might recommend a kidney biopsy, which involves removing a sample of kidney tissue. Kidney biopsy is often done with local anesthesia using a long, thin needle that's inserted through your skin and into kidney. The biopsy sample is sent to a lab for testing to help determine what's causing your kidney problem.

Urine tests

One of the earliest sings of kidney disease is when proteins leak into your urine (proteinuria). Urine testing can check for this. There are two types of urine tests that can check your protein levels.

Dipstick urine test. A dipstick is a chemically treated paper placed in urine sample. It changes color if your levels are above normal. This test is often done as part of overall urine testing. It can also be done as a quick test to look for albumin (a protein produced by your liver) in your urine.

A dipstick urine test doesn't provide an exact measurement of albumin but does let your doctor know if your levels are normal. If you have abnormal albumin levels. Doctor may want to run further tests.

Urine albumin-to-creatinine ration (UACR).

This test measures the amount of albumin and compares it to the amount of creatinine (a normal waste product from your muscles) in urine. A UACR test lets the doctor know how much albumin passes into urine over a 24-hour period. A urine albumin test result of 30 or above may mean kidney disease.

It's important to know that:

- The test may be repeated once or twice to confirm the result.
- If you have kidney disease, your albumin level in your urine helps your doctor determine the best treatment option.
- If your urine level stays the same or goes down, it means your treatment is working.

Serum creatinine

Because your kidneys remove waste, toxins, and extra fluid from the blood, blood tests can check kidney function. They will show how well and how quickly kidneys are doing their job to remove waste.

A serum creatinine blood test measures the amount of creatinine in blood. If kidneys aren't working well, creatinine level goes up. Normal levels for you will depend on sex, age, and muscle mass.

Usually a creatinine level more than 1.2 for women and 1.4 for men may mean the kidneys aren't working well.

Glomerular filtration rate (GFR)

The GFR is a blood test that measures how well your kidneys remove waste, toxins, and extra fluid from blood. Your serum creatinine level, age, and sex are used to calculate GFR number. Like other kidney tests, a normal GFR number for you will depend on age and sex.

If your GFR is low, your kidneys are likely not working as they should. As kidney disease progresses, GFR goes down. The results of your test can mean the following:

If your GFR is 60 or more together with a normal urine albumin test, you are in the normal range. But you'll still want to talk to doctor about when you should be checked again.

If your GFR is less than 60, it may mean you have kidney disease. You'll want to talk to doctor about treatment options that are best for you.

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If your GFR is less than 15, it may mean your kidneys are failing. If results show kidney failure, you'll likely need dialysis or a kidney transplant. If your GFR level is less than 20 over 6 to 12 months, your doctor may consider a kidney transplant.

Blood urea nitrogen (BUN)

A BUN is a blood test that measures the amount of urea nitrogen in blood. Urea nitrogen is a waste product body makes from the breakdown of protein in the foods you eat. Healthy through your urine. This process helps keep BUN level within a normal range.

A normal BUN level depends on your age and other health conditions, but usually ranges from 7 to 20. If your BUN level is higher than normal, this may be a sign that your kidneys aren't working well. As kidney disease progresses, your BUN level goes up.

Imaging tests

- Imaging tests look for physical changes in your kidneys that may help find the cause of your kidney disease, such as:
- Abnormal size or shape of kidneys
- Blood flow to kidneys
- Signs of injury or damage to kidneys
- Kidney stones, cysts (fluid-filled sacs) or tumors
- Size of problems with your bladder (the organ that stores urine before it leaves your body)

After an imaging test, a radiologist will read your images and give the result to your doctor. You and your doctor will go over the results and decide your next steps.

Kidney ultrasound

A kidney ultrasound (also called a renal ultrasound) is a safe and painless imaging test that uses sound waves to make pictures of kidney:

1. You will lie down on an exam table.
2. The ultrasound tech (the person doing the ultrasound) will spread a warm gel on your belly over your kidney area.
3. The tech will rub a small probe against skin.
4. The tech may ask you to hold your breath or roll on your side while the computer is measuring the sound waves as they bounce back from your body to create images.

A kidney ultrasound takes about 20-30 minutes.

Computed tomography (CT or CAT) scan of the kidneys

A CT or CAT scan is a painless test that uses X-rays and computer technology to create detailed images of kidneys:

1. If you have a scan with contrast, you will get the contrast (a substance you will drink or get through a needle in a vein that helps certain tissues show up more clearly).
2. You will lie down on an exam table that slides into a large, circle opening of a scan machine.
3. The tech will move to another room to control the scan. You will be able to talk with the tech through a speaker-system.

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4. The scanner will rotate around you, and you will hear clicking sounds. You will need to lie very still, and the tech may ask you to hold your breath.
5. If you got contrast in a vein, the tech will remove it after the scan.

A CT scan takes about 30 to 60 minutes.

Magnetic resonance imaging (MRI) of the kidneys

An MRI uses magnets and radio waves to make 3D (3-dimensional) pictures of kidneys:

1. You will lie down on an exam table that slides into a large tunnel-like tube in the scanner.
2. The tech will move to another room to control the scan. You will be able to talk with the tech through a speaker system.
3. The scanner will take many sets of images. You will hear loud noises coming from the scanner.

An MRI takes about 30 to 60 minutes.

Kidney biopsy

A kidney biopsy can help doctor fig out what is causing your kidney problem, how severe your kidney problem is and the best treatment.

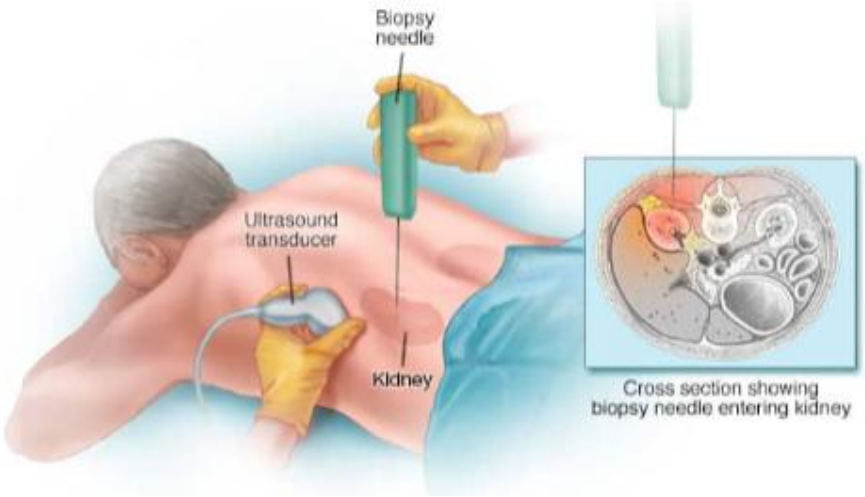
Your doctor may suggest a kidney biopsy if tests show:

- Blood in your urine(hematuria)
- Protein in your urine (proteinuria)
- Kidney disease with no clear cause
- Nephrotic syndrome (a group of symptoms that when happens together can show that your kidneys are not working as well as hey should)
- Concern for glomerular or inflammatory kidneys disease

Your doctor may also suggest a kidney biopsy to find out if:

- The treatment for your kidney problem is working
- There is damage to your kidneys that cannot be reversed
- A transplanted kidney is not working well
- You have a kidney tumor
- If your kidney problem is caused by a rare kidney disease.

If you have any questions about why you need a kidney biopsy and how it could help treat your kidney problem, talk to your doctor.



Genetic Testing

Genetic testing is a type of medical test that looks at your DNA, the genetic code that is unique to every individual.

This testinguses ablood or saliva (split) sample to look at changes in your genes, chromosomes or proteins. Genes are the information inside your cells that instruct it to do certain tasks, chromosomes are structures within your body's cells

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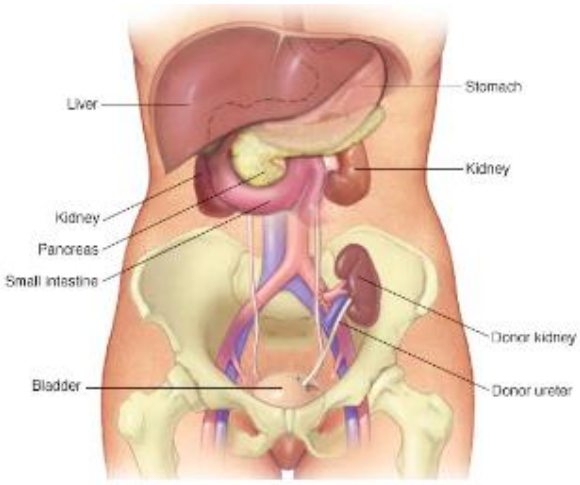
that contain your genes, and proteins are built from the cells using instructions found in your genes. Changes, or mutations, in your genes may cause certain types of kidney disease.

Results form a genetic test can help doctors confirm or rule out a genetic condition or can help a person better understand their chances of developing or passing on a genetic disorder.

Genetic testing may help your healthcare team to diagnose, monitor and manage certain types of kidney diseases. This type of testing can be helpful if you have a family history of kidney disease or if you don't know the cause of your kidney disease.

You may want to consider working with a genetic counsellor before or after genetic testing. They can tell you what test results mean and help support you and your family to make decisions based on your genetic testing results and offer helpful information to your healthcare team.

Treatment:



If a condition is "chronic," that means it's a long-term condition. If you have chronic kidney disease, you and your doctor will manage it together. The goal is to slow it down so that your kidneys can still do their job. Depending on the cause, some types of kidney disease can be treated. Often, though, chronic kidney disease has no cure.

Treatment usually consists of measures to help control signs and symptoms, reduce complications, and slow progression of the disease. If your kidneys become severely damaged. You might need treatment for end-stage kidney disease.

Treating the cause

Doctor will work to slow or control the cause of your kidney disease. Treatment options vary depending on the cause. But kidney damage can continue to worsen even when an underlying condition, such as diabetes mellitus or high blood pressure, has been controlled.

Medications

High blood pressure makes chronic kidney disease more likely and kidney disease can affect your blood pressure. So your doctor may prescribe one of these types of blood-pressure medicines:

ARBs, such as:

- Azilsartan (Edarbi)
- Eprosartan (Teveten)
- Irbesartan (Avapro)
- Losartan (Cozaar)
- Olmesartan (Benicar)
- Valsartan (Diovan)

Along with controlling blood pressure, these medications may lower the amount of protein in urine. That could help kidneys over time.

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The diabetes medicines dapagliflozin (Farxiga) and empagliflozin (Jardiance) have been shown to slow kidney disease even in people without diabetes.

You might also need to take a medicine to help body make erythropoietin, a chemical that tells your body to make red blood cells. so you might get a prescription for daprodustat (Jesduvroq), darbepoetin alfa (Aranesp), or epoetin alfa (Procrit, Epogen) to curb anemia.

Medications play a crucial role in managing Chronic Kidney Disease (CKD) by addressing the underlying causes, slowing disease progression, and managing complications. Treatment is typically tailored to the stage of CKD and any coexisting conditions (e.g., diabetes, hypertension). The main classes of medications used in CKD include:

1. Medications for Underlying Conditions

Angiotensin-Converting Enzyme Inhibitors (ACE inhibitors)

Examples: Enalapril, Lisinopril, Ramipril

Action: These medications help lower blood pressure and protect kidney function by reducing protein leakage (albuminuria) into the urine, a key marker of kidney damage. They also reduce the workload on the heart, which is beneficial for patients with both heart and kidney issues.

Angiotensin II Receptor Blockers (ARBs)

Examples: Losartan, Valsartan, Olmesartan

Action: Similar to ACE inhibitors, ARBs help lower blood pressure and protect the kidneys, particularly in patients who cannot tolerate ACE inhibitors due to side effects like a cough.

Diuretics

Examples: Furosemide, Hydrochlorothiazide

Action: Diuretics help control fluid retention and reduce swelling (edema), which is common in CKD. They also help lower blood pressure by removing excess salt and water from the body.

Insulin and Oral Hypoglycemics (for Diabetes)

Examples: Metformin (for type 2 diabetes), Insulin

Action: Managing blood sugar levels is critical in CKD, particularly for diabetic nephropathy (kidney damage due to diabetes). Metformin is often used in early stages of CKD unless GFR is severely reduced.

Statins (for High Cholesterol)

Examples: Atorvastatin, Rosuvastatin

Action: Statins help lower cholesterol and reduce the risk of cardiovascular events, which are common in CKD patients. They may also have benefits in reducing kidney damage in certain populations.

2. Medications to Manage CKD Complications

Phosphate Binders

Examples: Sevelamer, Calcium acetate

Action: In CKD, the kidneys' ability to excrete phosphate decreases, leading to high levels in the blood (hyperphosphatemia). Phosphate binders help reduce phosphate absorption from food to prevent bone and cardiovascular complications.

Erythropoiesis-Stimulating Agents (ESAs)

Examples: Epoetin alfa, Darbepoetin alfa

Action: These are used to treat anemia in CKD by stimulating the production of red blood cells, which is often impaired in kidney disease.

Vitamin D Analogues

Examples: Calcitriol, Paricalcitol

Action: CKD can impair the kidneys' ability to activate vitamin D, which is essential for calcium and bone health. Vitamin D analogues help prevent bone mineral disorders (e.g., osteodystrophy) associated with CKD.

Sodium Bicarbonate

Action: Sodium bicarbonate is used to correct metabolic acidosis, a common complication in CKD, where the kidneys can no longer effectively eliminate excess acid from the body.

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3. Medications for Blood Pressure Control

Calcium Channel Blockers

Examples: Amlodipine, Diltiazem

Action: These are used when ACE inhibitors or ARBs are insufficient or not tolerated. They help lower blood pressure and reduce proteinuria.

Beta-Blockers

Examples: Metoprolol, Atenolol

Action: Beta-blockers may be prescribed to control high blood pressure and to manage heart conditions like arrhythmias, which are common in CKD patients.

4. Medications to Control Hyperkalemia

Potassium Binders

Examples: Sodium polystyrene sulfonate, Patiromer

Action: As kidney function declines, potassium levels can rise, leading to potentially life-threatening hyperkalemia. Potassium binders help reduce potassium absorption from the digestive tract.

5. Other Medications

Antiplatelet Drugs (e.g., Aspirin)

Action: To reduce the risk of cardiovascular events, patients with CKD may be prescribed antiplatelet medications, especially if they have a history of heart disease or diabetes.

Antihistamines and Antifungal Drugs

Action: In some cases, CKD patients may be treated with antihistamines or antifungal medications for infections, as the immune system may be compromisedEmerging Therapies

SGLT2 Inhibitors

Examples: Empagliflozin, Canagliflozin

Action: SGLT2 inhibitors, originally developed for diabetes, have shown promise in slowing the progression of CKD by reducing the workload on the kidneys and controlling blood glucose levels. They are now commonly used in patients with diabetic nephropathy.

Mineralocorticoid Receptor Antagonists

Examples: Spironolactone

Action: These medications are used in specific cases of heart failure and CKD to block the effects of aldosterone, which can contribute to kidney damage and fluid retention.

Monitoring and Adjustments:

Patients with CKD require careful monitoring of kidney function (e.g., glomerular filtration rate, serum creatinine, and albuminuria) and regular adjustments to medications as kidney function declines. Certain drugs, such as those metabolized by the kidneys, may require dose adjustments or discontinuation in later stages of CKD.

In summary, the goal of pharmacologic treatment in CKD is to manage underlying diseases, slow progression, and alleviate complications. This requires a personalized approach involving a combination of medications tailored to the patient's specific needs and comorbidities.

Medicines to avoid

If your kidneys don’t work well, check with your doctor before you take medications, including over-the-counter drugs (medicines you can get without a prescription).

Doctor may tell you to avoid certain pain relievers such as aspirin, ibuprofen, naproxen (Aleve), and celecoxib (Celebrex). These drugs, which doctors call “NSAIDs” (nonsteroidal anti-inflammatory drugs), could play a role in kidney disease. If you take a type of heartburn drug called a “proton pump inhibitor (PPI)”, you may also want to know that some studies show a link between these medicines and chronic kidney disease. Doctor may want to check on whether you need these medicines, or if a different dosage or something else might work better for you.

Tell your doctor if you take any herbal products orother supplements. It’s best to have that talk before you start to take them.

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Diet

Your doctor may put you on a special diet that's lower in sodium, protein, potassium, and phosphate.

This diet helps because if your kidneys are damaged, it's harder for them to get those nutrients out of your blood. The special diet means that kidneys don't have to work as hard.

You may also have limits on how much water can be in the foods you eat and how much you drink. A kidney diet specialist, called a renal dietitian, can help. Your doctor can refer you to one. They may also advise you to take specific amounts of vitamins and minerals, such as calcium and vitamin D.

If you have diabetes or high blood pressure, you'll need to follow your doctor's diet advice if you have either or both of these conditions in addition to kidney disease. With diabetes, it's important to make the right food choices so that your blood sugar levels stay under control throughout the day. And if you have high blood pressure, you may need a low-salt diet to help manage it.

Dialysis

If your kidneys don't work well anymore, you'll need dialysis to do their job.

There are two main types of kidney dialysis:

1. Hemodialysis
2. Peritoneal

Hemodialysis dialysis:

Hemodialysis uses a machine with a mechanical filter to cleanse blood. You can get this done at a dialysis center or at home (after you or a caregiver learn how).

With the at-home version, you may have to do it up to 6 days a week, about 21/2 hours per day, instead of three times a week at a clinic. There is also the option of hemodialysis treatment at night.

Before you start hemodialysis, you'll need surgery to make a place of access for themachine. Your surgeon may connect an artery and vein in your arm through a "fistula". This is the most common type of access. It needs at least 6 weeks to heal before you can start hemodialysis.

If you need to start dialysis sooner than that, the surgeon might be able to make a synthetic graft instead of a fistula.

If neither of those options will work—for instance, if you need to start dialysis right away—you may get a dialysis catheter that goes into the jugular vein in neck.

When you get hemodialysis, another tube connects the machine to your access point so that your blood goes through the dialysis machine to be cleaned and pumped back into your body. This will take several hours.

Peritoneal dialysis:

Peritoneal dialysis is a different form of dialysis. It uses the lining of the abdomen, or peritoneal membrane, to help clean the blood.

First, a surgeon implants a tube into your abdominal cavity. Then, during each treatment, a dialysis fluid called dialysate goes through the tube and into your abdomen. The dialysis fluid picks up waste products and drains out after several hours.

You'll need several cycles of treatment—sending in the fluid (or "instilling" it), time for the fluid to work in abdomen, and drainage-- every day. Automated devices can now do this overnight, which may give you more independent and time during the day for usual activities. If you do it during the day, you may need to do the whole cycle several times.

Both types of dialysis have possible problems and risks, including infection. You'll want to talk with your doctor about the pros and cons of each option.

End stage treatment

End stage treatment typically begins when a person is at stage 5 and their kidney is functioning at 10-15% of its normal capacity. It occurs when the kidneys cannot keep up with the waste and fluid elimination process despite the person making lifestyle changes, making dietary changes, and taking medications.

For this reason, a person with the end stage renal disease will need dialysis or a kidney transplant for as long as possible because they can lead to potentially serious complications.

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Kidney transplant

If your kidney disease is advanced, a kidney transplant could be a treatment option.

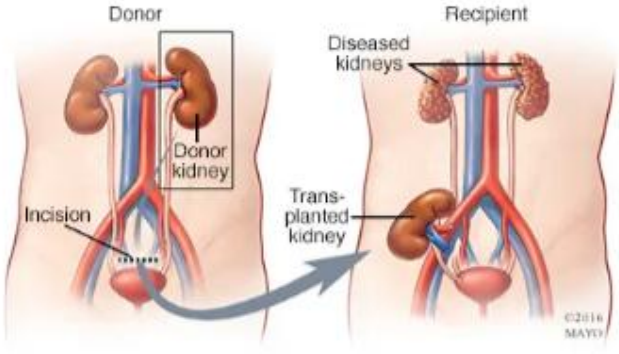
A "matching" kidney may come from a living family member, from someone who's alive and isn't a relative, or from an organ donor whohas recently died. It's major surgery, and you may go on a waitlist until a donated kidney becomes available.

A successful transplant would mean that you don't have to get dialysis. After your transplant, you will need to take medicines so that your body accepts the donated kidney.

A kidney transplant might not be right for you if you have other medical conditions. Your age might also be an issue. And you may need to go on a waitlist until a kidney is available. You'd get dialysis until your transplant can happen.

A kidney from a living donor will generally last 12 to 20 years. One that's donated from someone who recently died may last 8 to 12 years. If you have "end stage" renal (kidney) disease, doctors consider a transplant to be the best option if you're a good candidate.

The plan you and your doctor will decide on will depend on what's causing your kidney disease. In some cases, even when the cause of your condition is controlled, your kidney disease will worsen.



KIDNEY TRANSPLANT

Prevention:

Chronic kidney disease (CKD) cannot always be prevented, but you can take steps to reduce the chances of getting the condition.

Manage underlying conditions

If you have a long-term condition that could lead to CKD, such as diabetes or high blood pressure. It's important this is managed carefully.

Follow the advice of your GP, take any medicine you're prescribed and keep all appointments relating to your condition.

Stop smoking or using tobacco

Smoking increases your risk of cardiovascular disease, including heart attacks or strokes. Which is associated with a higher risk of CKD.

Smoking increases will improve your general health and reduce your risk of these serious conditions.

Sing tobacco (smoking or chewing) can make your blood pressure go up, which in time can lead to kidney disease. If you already have kidney disease, using tobacco can make kidney disease worse in time. using tobacco can also cause other serious health problems such as cancer, heart disease and stroke. Quitting can help lower your chance of getting kidney disease or help prevent your kidney disease from getting worse.

Healthy diet

A healthy, balanced diet can reduce your risk of kidney disease by keeping your blood pressure and cholesterol at a healthy level.

A balanced diet should include:

- Plenty of fruit and vegetables-aim for at least 5 portions a day
- Meals that include starchy foods, such as potatoes, wholegrain bread, rice or pasta

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- Some dairy or dairy alternatives
- Some beans or pulses, fish, eggs, or meat as a source of protein
- Low levels of saturated fat, salt and sugar

You may also be given advice about dietary changes that can specifically help with kidney disease, such as limiting the amount of potassium or phosphate in your diet.

Eating foods that are low in sodium (salt) and fat can help keep your kidneys healthy.

Here are some tips to eat less sodium(salt):

- Cook with fresh herbs, lemon juice or spices to add flavor instead of adding salt to your food.
- Choose fresh or frozen vegetables instead of canned. If you do use canned vegetables, rinse them with water before eating or cooking to remove extra salt.
- Shop for items that say "reduced sodium "or "low sodium". If you have kidney disease, check that these foods do not contain potassium instead of salt.
- Avoid processed foods, such as frozen dinners or packaged lunch meats.
- Limit fast food and salty snacks, such as chips, pretzels and salted nuts.
- Limit foods that are pickled or preserved, such as pickles and olives.

Manage alcohol intake

Drinking excessive amounts of alcohol can cause your blood pressure and cholesterol levels to rise to unhealthy levels.

Sticking to the recommended alcohol limit is the best way to reduce your risk:

- Men and women are advised not to regularly drink more than 14 units a week
- Spread your drinking over 3 days or more if you drink as much as 14 units a week

14 units is equivalent to 6 pints of average-strength beer or 10 small glasses of low strength wine.

Exercise regularly

Regular exercise should help lower your blood pressure and reduce your risk of developing kidney disease.

At least 150 minutes (2 hours and 30 minutes) of moderate-intensity aerobic activity, such as cycling or fast walking, every week is recommended, as well as strength exercises on 2 or more days a week that work all the major muscles (legs, hips, back, abdomen, chest, shoulders and arms)

Be careful with painkillers

Kidney disease ca be caused by taking too many non-steroidal anti-inflammatories (NSAIDs), such as aspirin and ibuprofen, or taking them for longer than recommended.

If you need to take painkillers, make sure you follow the instructions that come with the medicine.

INNOVATIVE TECHNOLOGIES TRANSFORMING KIDNEY CARE: A Lookatthe Latest Developments

The current standard for end-stage renal disease (ESRD) patients is a kidney transplant or dialysis when a kidney donor is unavailable. The global dialysis population is exponentially growing, with 3 million patients worldwide currently on haemodialysis. The need for kidney organ donors in the U.S. is predicted to grow 8% each year (from 2018).

Thus, there is an increased need for innovative technologies, specifically in the field of kidney replacement technology, to address organ shortages and reduces risk associated with dialysis and renal failure.

Advances in Dialysis

End-stage renal disease (ESRD) is characterized as a disease with a high hospitalization and mortality rate. Haemodialysis remains the most broadly used treatment for ESRD, with kidney transplants being the only alternative to kidney replacement therapy (KRT).

Technical, economic, and regulatory challenges faced in renal dialysis technology innovation have resulted a standstill over the last 50 years. To promote increased cooperation and encourage innovation, the kidney Health Initiative developed an international roadmap for new approaches to renal replacement therapy.

Recent innovations in haemodialysis have focused on portability and total replacement, not just replacing the kidney's filtration function (clearance). Several enterprises and organizations, including The Advancing American Kidney Health Initiative, The Kidney Health Initiative, and Kidney X: The Kidney Accelerator, are collaborating to develop innovative technologies that may transform the treatment of ESRD.

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Advances in haemodialysis include:

Hemodiafiltration

Hemodiafiltration is a form of KRT that makes use of convection in tandem with diffusive clearance. In the process of hemodiafiltration, the small to middle-sized solutes are carried through the membrane pores by convection. Convection allows a higher clearance rate of larger solutes compared to haemodialysis. Despite the advantages of hemodiafiltration, it has yet to gain acceptability in the U.S. due to regulatory and cost issues.

Portable haemodialysis machines

Recently portable and compact machines have been developed to reduce the size of dialysis machines. These devices make it easier for kidney disease patients to perform dialysis at home, resulting in increased flexibility and freedom.

Wearable artificial kidney (WAK)

Wearable and portable dialysis systems (artificial kidneys) perform the same functions as dialysis. However, these systems are housed in smaller and less intrusive packages. For hemodialysis patients, WAK devices integrate a dual-channel battery-operated pump for driving dialysate and blood together with dialysate regenerative technology.

For peritoneal dialysis, a model of WAK is commercialized as an automated wearable kidney device. This device recycles peritoneal dialysate through a system made up of urease enzymes. These enzymes convert urea to ammonia, with sorbents such as zirconium which absorbs the ammonia.

Sorbent devices in dialysis therapy

Sorbent devices work by direct retention or absorption of specific molecules. In recent years, there has been progress in developing biocompatible sorbents. Current sorbents particles can remove toxins and impurities from the dialysate during dialysis. Sorbents aid in the reuse and regeneration of dialysate fluids.

Prospective studies have examined adding sorbent cartridges to conventional hemodialysis to improve the quality of life and survival rate.

Bioartificial Kidney

Bio-engineering artificial kidneys has been a research and innovation topic for the last 30 years. The basics of the technology used to develop bioartificial kidneys are based on cell-based therapeutics, specifically the principle that damaged or dysfunctional cells in multiple disease states can be replaced.

Like a human kidney, the bioartificial kidney produces ultrafiltrate that undergoes processing, resulting in the reabsorption of water and electrolytes back into the bloodstream. Examples of bioartificial kidneys include:

- The implantable kidney (The kidney Project).
- The renal assist device (RAD).
- The human nephron filter.
- The bioartificial renal epithelial cell system (BRECS).

New Technology for Kidney Transplants

Historically, kidney failure may be best treated by a kidney transplant from an organ donor. Unfortunately, donor kidneys are limited; thus, ESRD patients end up on dialysis, which affects their overall quality of life and mortality. Dialysis is limited and often linked with poor patient outcomes as it does not make up for the loss of a healthy kidney's endocrine, metabolic, and reclamation functions.

Thus, over the last 20 years, innovations in renal replacement therapy have been working to create a product that will replace full renal functionality. Two early models of renal replacement technology are the automated WAK and the WAK. These two devices are still limited as they only focus on ultrafiltration not full renal functionality.

The latest technologies transforming renal replacement are the implantable bioartificial kidney (BAK) and kidney regeneration technology, which addresses the limitation of the WAK and AWAK devices.

The implantable BAK is a free-standing, compact, surgically implanted device used to perform the majority of the biological kidney function in ESRD or kidney failure patients. The implantable BAK builds upon a Renal Assist Device (RAD), which is located outside the body. RAD is a bioartificial kidney that integrates a bioreceptor of human renal tubule cells and a membrane hemofilter to imitate a healthy kidney's immunological, metabolic, and endocrine functions.

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Kidney regeneration technology is the second innovation transforming the challenges faced in kidney care. Recent advancements in stem cell and developmental biology have resulted in the aim of creating a transplantable kidney craft constructed from a patient's own cells.

The current method in kidney generation is scaffolding. Scaffolding is used for 3D structural support for specific cells and vasculature of the organ. Further research is needed to provide a roadmap for building kidney scaffolds necessary to facilitate organ functionality.

New Diagnostic Methods

New diagnostic methods would allow healthcare professionals to diagnose CKD earlier, as most patients are only diagnosed in stage 3. Novel diagnostic methods may be used to identify CKD in earlier stages.

Imaging. Imaging techniques are non-invasive and can safely be repeated to evaluate changes in disease status. Advancements in imaging relate to overall kidney function, estimation of nephron numbers, fibrosis, and new functional MRIS and ultrasound techniques such as diffusion-weighted MRI.

Biological fluid biomarkers. In nephrology, metabolomics and proteomics have been tested, in some cases being used as biomarkers or as tools used to identify individual biomarkers that are then further assessed. Furthermore, both DNA and RNA in biological fluids may also act as biomarkers. Biological fluid biomarkers should correspond with kidney disease, progression, early disease, and outcomes, allowing for non-invasive, rapid, and specific measurements.

Additional Advances in Kidney Disease Treatment

The main objective of these kidney disease treatment is to avoid dialysis care centers, prevent CKD progression, or treat CKD complications in advanced stages. Current advances in kidney disease treatment that have not already been discussed include the following:

Xenotransplantation

Xenotransplantation is an old concept of transplanting organs from animals such as pigs into humans. Due to the increased waiting list for kidney transplants, this concept has regained clinical and research attention. The fields of biotechnology and CRISPR/Cas9 has allowed xenotransplantation across non-human species to have lower complications and higher success rates.

Medications

New drugs that have promising results in clinical trials and have recently been approved for the treatment of CKD complications, kidney protection, and specific causes of CKD include:

- **Nonsteroidal MRA.** This medication is used for kidney protection and has been shown to decrease hospitalization rates for strokes, Myocardial infarction, and heart failure. It may reduce CKD progression by reducing proteinuria.
- **Endothelin receptor antagonists.** This medicine may be used to decrease proteinuria and kidney disease progression in CKD patients with scleroderma.
- **HIF stabilizers.** These are oral agents used to treat CKD-associated anemia. Some HIF stabilizers are currently in clinical use in Japan and China, with the EMA recently approving Roxadustat.
- **Voclosporin.** This drug is showing promising results in phase 3 clinical trials for patients with active lupus nephritis. So far, voclosporin has provided better kidney outcomes, including urine protein to creatine ratio and eGRF.

Panoramic Health

Panoramic Health is a value-based kidney care platform led by physicians. Our priority is ensuring that our patients receive the care that they deserve, ultimately improving outcomes and quality of life.

Our Clinical Research Division is at the forefront of kidney care innovation, filling the gaps in clinical research so that our patients may have improved outcomes, enhanced quality of life, and slowed disease progression. We collaborate directly with the scientific community and partner with CROs and sponsors to bring long-term advancements to CKD treatment.

Recent advances in wearable biosensors for non-invasive monitoring of specific metabolites and electrolytes associated with chronic kidney disease: Performance evaluation and future challenges

Graphical abstract

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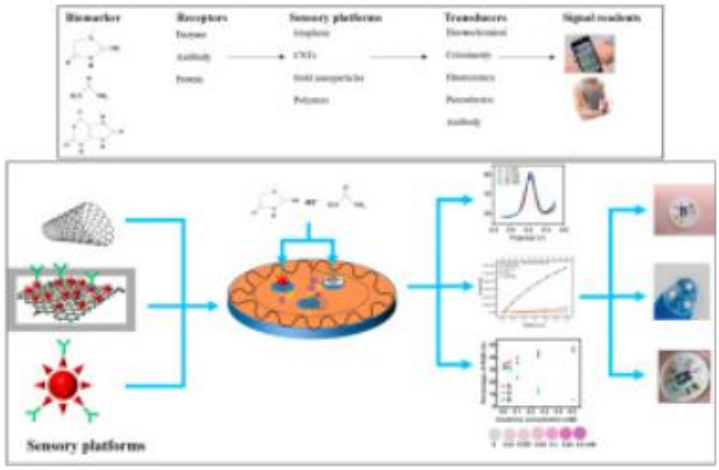

Introduction

The high, ever-increasing mortality rate of non-communicable diseases (NCDs) has become a global health concern during the past 20 years or so. According to a report published by the World Health Organisation (WHO) IN 2018, the four major groups of NCDs (cancer, cardiovascular diseases, chronic respiratory diseases, and diabetes) cause~ 41 million humans deaths every year, accounting for 71% of all human deaths globally. In economically weak countries, NCD-related deaths are termed premature because of ~80% of them are in people aged 30-69 years. A combination of causes (e.g., excessive use of tobacco and alcohol, prolonged physical inactivity, unhealthy dietary habits, and unhealthy lifestyle) can increase the risk of developing and dying from an NCD.

Most NCDs culminate in impaired renal function, causing chronic kidney disease (CKD). According to the Global Burden of Diseases study in 2016, CKD is the 8th leading cause of mortality in India. The risk CKD poses to life expectancy has stimulated the development of biosensing technologies for CKD biomarkers (e.g., creatinine (CR), potassium, urea, and uric acid (UA)).CKD development is characterised by a steady increase in serum and saliva CR levels. CR is the second- most analyzed biomolecule, next to glucose. The normal serum, saliva, sweat, interstitial fluid(ISF), and tear levels of CR lie in ranges of 0.6-1.2, 0.05-0.2, 0.009-0.02, 0.6-1.2, and 0.5-1.0 mg dL, respectively. In addition to CR, biomarkers such as glucose, sodium, potassium, urea, and UA are prominent indicators of homeostatic conditions in human bodies. The concentration levels of those biomarkers in serum, saliva, sweat, ISF, and tears are provided. Health care practitioners regularly use fluctuations in the levels of those CKD biomarkers, adjusted for sex, age, and muscle mass, to monitor the conditions of CKD patients. Increased levels of CKD biomarkers are associated with poor glomerular filtration rates (GFR) in CKD and end stage renal disease (ESRD; patients with GFR values < 15 mL min^{-1}).

The WHO guidelines recommend that point-of-care (POC) measurements of clinically significant metabolites or biomolecules follow the ASSURED rule, that is be affordable, sensitive, selective, user-friendly, rapid, devoid of equipment, and deliverable to the end user. However, routine clinical analysis of CKD biomarkers requires the extraction of serum samples. For instance, clinical detection of serum CR is routinely performed using the Jaffé method, a rapid and economical colorimetric reaction that uses the formation of a chromogen ($\lambda_{absorption\ (ab)}$ = 470–550 nm and $\lambda_{ab\ maxima}$ = 520 nm) when CR chemically reacts with picric acid. However, it is highly sensitive to variations in pH, temperature, and the presence of interfering compounds (e.g., proteins and the red color of blood) in biological samples. In developing clinical POC biosensing technologies, the presence and concentrations of CKD biomarkers should be assessed in various biological fluids.

During the late 20th century, glucose biosensing technologies first enabled the use of disposable blood glucose strips. During the early 21st century, there is a growing need for selective, sensitive, and rapid assays that patients can administer themselves. Demand for such assays has led to technological advances in the detection of CKD biomarkers. Recently, the integrated efforts of scientists, engineers, and medical practitioners have paved the way for the development of wearable technologies that can detect analytes in peripheral body fluids (saliva, sweat, ISF, and tears).

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Table 2 lists some recently commercialized minimally invasive continuous glucose monitoring (CGM) technologies. The rapid expansion of wearable technologies for commercial use is intended to enhance patient compliance and facilitate the monitoring of target analytes. However, so far, those technologies are available only for glucose analysis. Continuous monitoring of peripheral body fluids using wearable biosensors could yield clinically relevant information about continuous variations in the levels of CKD biomarkers. The ability of wearable biosensors to eliminate painful blood sampling procedures could improve the lives of CKD and ESRD patients.

During the past decade, wearable sensing technology has moved from science fiction to the translation stage of technology development in health care and consumer electronics. The rapid expansion of wearable physical sensing devices can be ascribed to advances in nanoelectronics, internet of things (IoT)-based connected technology, the mass availability of smartphones at the global level, and growing awareness of personal health technology. However, most technologies commercialized to date have been limited to monitoring individual performance in terms of physical activity parameters such as number of steps, number of calories burned, heart rate, and oxygen saturation. Many recently published reviews have highlighted the potential of wearable biosensors for monitoring and managing personal health. Despite the high potential and hype, the application of commercially available wearable biosensors has so far been restricted to the development of glucose biosensors. The practical, mass implementation of wearable biosensors for the management of NCDs other than diabetes, such as CKD, remains elusive. In fact, most reported wearable biosensors for monitoring CKD biomarkers remain in the proof-of-concept stage of development. The successful translation of those laboratory studies to clinically validated commercialized technologies should be prioritized.

Before a commercially viable, wearable biosensor can be developed for continuously monitoring CKD biomarkers, researchers need a critical understanding of the structural and physiological characteristics of human skin. In consideration of the current state-of-the- art in wearable technologies and existing research gaps, this review describes the key technical issues in the evolution of wearable biosensor technologies for the detection of CKD biomarkers in peripheral body fluids. Thus, we discuss the future prospects of wearable biosensing devices that can monitor CKD patients and the vital advances already achieved in this field during the past 5 years. For wearable biosensors that can detect CKD biomarkers to be successfully commercialized, they must overcome various limitations: (a) continuous variability in the levels of the target analytes in bodily fluids, (b) surface biofouling at the body–sensor interface, (c) poor transport of the target analyte across the sensor, (d) low stability of many bioreceptors, and (e) repeated calibration of on-body biosensors [19]. The continuous and rapid expansion of wearable biosensors for CKD biomarkers could provide much-needed alternatives to invasive bioanalytical devices and gold-standard serum bioassays.

CKD: physiology and biomarkers

The manifestation of CKD is associated with the inability of kidneys to maintain the homeostatic environment within the body (e.g., for >3 months). According to the global burden of disease study conducted in 2017, nearly one thirds of CKD cases are reported from China and India. The major causes for CKD are usually identified as type-1 and type-2 diabetes, hypertension, cardio-vascular disorders, and glomerulonephritis. The rapid development in science and technology has

Basic architecture of a microfluidic wearable biosensing device

Microfluidics has been instrumental to the success of many scientific achievements, including the human genome project. The steady progress in developing microfluidic technology for wearable sensing applications is a result of its low volume requirements, rapid reactions, portability, simplicity in operation, multiplex capability, and real-time analysis capability. Consequently, most wearable biosensing technologies developed during the past few years rely on microfluidic

Anatomical resistance

Wearable biosensor technologies must interact with the sensory components of human bodies, primarily the epidermal layer of the skin. ISF and sweat, which circulate in or are excreted from the skin, are the primary targets for wearable sensing devices. The sensory component must have access to the bioanalytes present in those body fluids to exhibit a detectable sensory response. However, the skin primarily acts as a barrier to restrict interactions between bioanalytes and the outside world. In

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Biosensing modalities for minimally-invasive monitoring of specific metabolites and electrolytes associated with CKD

The great utility of peripheral body fluids (sweat, ISF, saliva, and tears) is recognized in that they can serve as the major avenues for minimally-invasive monitoring of CKD associated metabolites and electrolytes (e.g., CR, urea, UA, sodium, potassium, and chloride). Note that the serum concentration levels of the aforementioned CKD biomarkers have already been used as a golden standard for routine health monitoring purpose. Therefore, it is necessary to find any correlations in the

Performance comparison of various wearable biosensing devices

Conventional sensor performance is usually assessed in terms of quality assurance (QA) parameters (e.g., LOD, sensitivity, and dynamic range). In this review, we have discussed some recent studies conducted to explore the potential of wearable devices to quantitate CKD biomarkers in sweat, ISF, saliva, or tears using electrochemistry or colorimetry. Some of those studies validated the suitability of their wearable biosensors for the real-time detection of CKD biomarkers. Nevertheless, the major

Challenges for ISF- and sweat-based analyses

As discussed in Section 5.1.2, RI and MNs-based sampling are the two major techniques employed for ISF sampling. In this context, one of the earliest commercialized glucose Biosensor called as Glucowatch biographer (Cygnus Inc.) was developed based on amperometry assisted RI for extraction of ISF from blood capillaries. However, the upscaling of this device was not realized owing to: (a) RI induced skin irritation, (b) prolonged warm up duration (2–3 h), (c) ISF dilution, (d) sweat

Conclusion and future outlook

In this research, we focused on the potential offered by various peripheral body fluids to non-invasively monitor CKD biomarkers. We have highlighted recent advances in wearable biosensing technologies for monitoring CKD biomarkers by using studies published mainly in past three years. Wearable sensing devices can reliably detect biomarkers such as lactate, glucose, urea, uric acid, CR, sodium, and potassium in peripheral body fluids such as sweat, ISF, saliva, and tears. The biosensors

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

II. CONCLUSION

In conclusion, nephrology stands at the forefront of addressing the complexities associated with kidney health and chronic kidney disease (CKD). As we delve deeper into the anatomy and functions of the renal system, it becomes evident how crucial kidneys are in maintaining overall homeostasis. The various stages of CKD highlight the progressive nature of this disease, making early diagnosis and intervention paramount. As the prevalence of chronic kidney disease continues to rise globally, driven by factors such as diabetes and hypertension, it is imperative for healthcare systems to prioritize early detection and management strategies. As novel technologies and innovative treatment methods emerge, they offer promising avenues for improving patient outcomes and enhancing the quality of life for those affected by kidney disorders. Ultimately, a comprehensive understanding of nephrology not only advances medical knowledge but also emphasizes the importance of preventive measures and lifestyle choices in safeguarding kidney health. By prioritizing kidney health awareness, we can pave the way for better management of CKD and cultivate a proactive approach to kidney care, benefiting communities worldwide.

REFERENCES

[1]. Vaidya, S. R., & Aeddula, N. R. (2024, July 31). *Chronic kidney disease*. StatPearls - NCBI Bookshelf. https://www.ncbi.nlm.nih.gov/books/NBK535404/

[2]. Chronic kidney disease - Symptoms and causes. (n.d.). Mayo Clinic. https://www.mayoclinic.org/diseases-conditions/chronic-kidney-disease/symptoms-causes/syc-20354521

[3]. Chronic Kidney Disease. (2024, May 1). Cleveland Clinic. https://my.clevelandclinic.org/health/diseases/15096-chronic-kidney-disease

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[4]. Uetani N, Bouchard M. Plumbing in the embryo: developmental defects of the urinary tracts. Clin Genet. 2009 Apr;75(4):307-17.

[5]. Costantini F, Kopan R. Patterning a complex organ: branching morphogenesis and nephron segmentation in kidney development. Dev Cell. 2010 May 18;18(5):698-712.

[6]. Johnson JR, Ireton RC, Lipsky BA. Emphysematous pyelonephritis caused by Candida albicans. J Urol. 1986 Jul;136(1):80-2.

[7]. Huang JJ, Tseng CC. Emphysematous pyelonephritis: clinicoradiological classification, management, prognosis, and pathogenesis. Arch Intern Med. 2000 Mar 27;160(6):797-805.

[8]. Chronic kidney disease - Diagnosis and treatment - Mayo Clinic. (n.d.). https://www.mayoclinic.org/diseases-conditions/chronic-kidney-disease/diagnosis-treatment/drc-20354527

[9]. American Kidney Fund. (2024, August 28). *Tests for kidney disease*. https://www.kidneyfund.org/all-about-kidneys/tests-kidney-disease

[10]. Facts About Chronic Kidney Disease. (n.d.). National Kidney Foundation. https://www.kidney.org/kidney-topics/chronic-kidney-disease-ckd

[11]. Website, N. (2024, January 11). Prevention. nhs.uk. https://www.nhs.uk/conditions/kidney-disease/prevention/

[12]. American Kidney Fund. (2024a, August 28). Stages of kidney disease (CKD*)*. https://www.kidneyfund.org/all-about-kidneys/stages-kidney-disease

[13]. Acko, T. (2024, January 18). What Is a Nephrology & Functions of Kidneys. ACKO. https://www.acko.com/health-insurance/nephrology/#4-kidney-transplant

[14]. Cameron, K. (2023, October 24). Kidney Disease: Causes, Symptoms, and Treatment. WebMD. https://www.webmd.com/a-to-z-guides/understanding-kidney-disease-basic-information

[15]. Newman, T. (2024, July 22). What to know about chronic kidney disease.https://www.medicalnewstoday.com/articles/172179

[16]. Deepak Kukkar, Daohong Zhang, B.H. Jeon, Ki-Hyun Kim,Recent advances in wearable biosensors for non-invasive monitoring of specific metabolites and electrolytes associated with chronic kidney disease: Performance evaluation and future challenges,TrAC Trends in Analytical Chemistry,Volume 150,2022,116570,ISSN0165-9936,https://doi.org/10.1016/j.trac.2022.116570.

[17]. Panoramic Health. (2023, July 13). Innovative Kidney Care and Technologies - Panoramic Health. https://panoramichealth.com/blog/innovative-technologies-transforming-kidney-care-a-look-at-the-latest-developments/#:~:text=The%20latest%20technologies%20transforming%20renal,the%20WAK%20and%20AWAK%20devices.

[18]. Ogobuiro, I., & Tuma, F. (2023, July 24). *Physiology, Renal*. StatPearls - NCBI Bookshelf. https://www.ncbi.nlm.nih.gov/books/NBK538339/

[19]. Jewell, T. (2018, May 22). Kidney Overview. Healthline. https://www.healthline.com/human-body-maps/kidney#nephrons

[20]. Risk Factors for Chronic Kidney Disease. (2024, May 15). Chronic Kidney Disease. https://www.cdc.gov/kidney-disease/risk-factors/index.html

[21]. Kovesdy, C. P. (2022). Epidemiology of chronic kidney disease: an update 2022. Kidney International Supplements, *12*(1), 7–11. https://doi.org/10.1016/j.kisu.2021.11.003