

KIDNEY FAILURE: THE BASICS

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Plan

- Basic terms
- Its significance
- Basic information
- Differential diagnosis of acute kidney injury-
chronic kidney disease
- Acute kidney injury
- Chronic kidney disease
- Renal replacement therapies

What is kidney failure?

- Impairment of glomerular filtration function
- It can be acute or chronic
- Waste products such as urea and creatinine accumulate due to decrease of glomerular filtration and many system/organ functions are affected
- Nowadays we use terms acute kidney injury (acute kidney failure) and chronic kidney disease (chronic kidney failure)

How it is diagnosed?

- By measuring glomerular filtration rate

4 concepts

- Acute kidney injury (AKI)
- Chronic kidney disease (CKD)
- Acute kidney disease (AKD)
- AKI on CKD

4 concepts: Practical definitions

- Acute kidney injury: Rapid deterioration
- Chronic kidney disease: Longer than 3 months
- Acute kidney disease: Shorter than 3 months
- Acute kidney injury on Chronic kidney disease: Rapid deterioration in a chronic patient

Acute kidney injury

- Increase in SCr by ≥ 0.3 mg/dl within 48 hours; or
- Increase in SCr to ≥ 1.5 times baseline, which is known or presumed to have occurred within the prior 7 days; or
- Urine volume < 0.5 ml/kg/h for 6 hours.

Practical information

- Acute kidney injury has a wide clinical spectrum
- It consists both of a patient with serum creatinine increased from 0.8 to 1.2 mg/dl and a patient requiring dialysis

Baseline SCr

- **If unknown**, using MDRD formula, 75 ml/min/1.73 m² can be assumed

Estimated baseline SCr

(75 ml/min/1.73 m² and other than Black)

Age	Male	Female
20-24	1.3	1.0
25-29	1.2	1.0
30-39	1.2	0.9
40-54	1.1	0.9
55-65	1.1	0.8
> 65	1.0	0.8

Chronic kidney disease

- CKD is defined as abnormalities of kidney structure or function, present for > 3 months, with implications for health.

Practical information

- All kidney failure are kidney disease
- But kidney failure does not develop in all kidney diseases
- Chronic kidney disease can occur without kidney failure

Acute kidney disease

- Acute kidney injury develops within days/weeks, diagnosis of chronic kidney disease requires 3 months
- It is used for circumstances not appropriate for chronic kidney disease and acute kidney injury
- Acute kidney injury is also an acute kidney disease

Acute kidney disease

- Acute kidney injury OR
- GFR <60 ml/min per 1.73m^2 for <3 months OR
- Decrease in GFR by $\geq 35\%$ OR
- Increase in SCr by 50% for <3 months

Acute kidney injury on chronic kidney disease

- Acute kidney injury may develop in a patient with chronic kidney disease, in this condition we use the term: acute kidney injury on chronic kidney disease

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Its significance

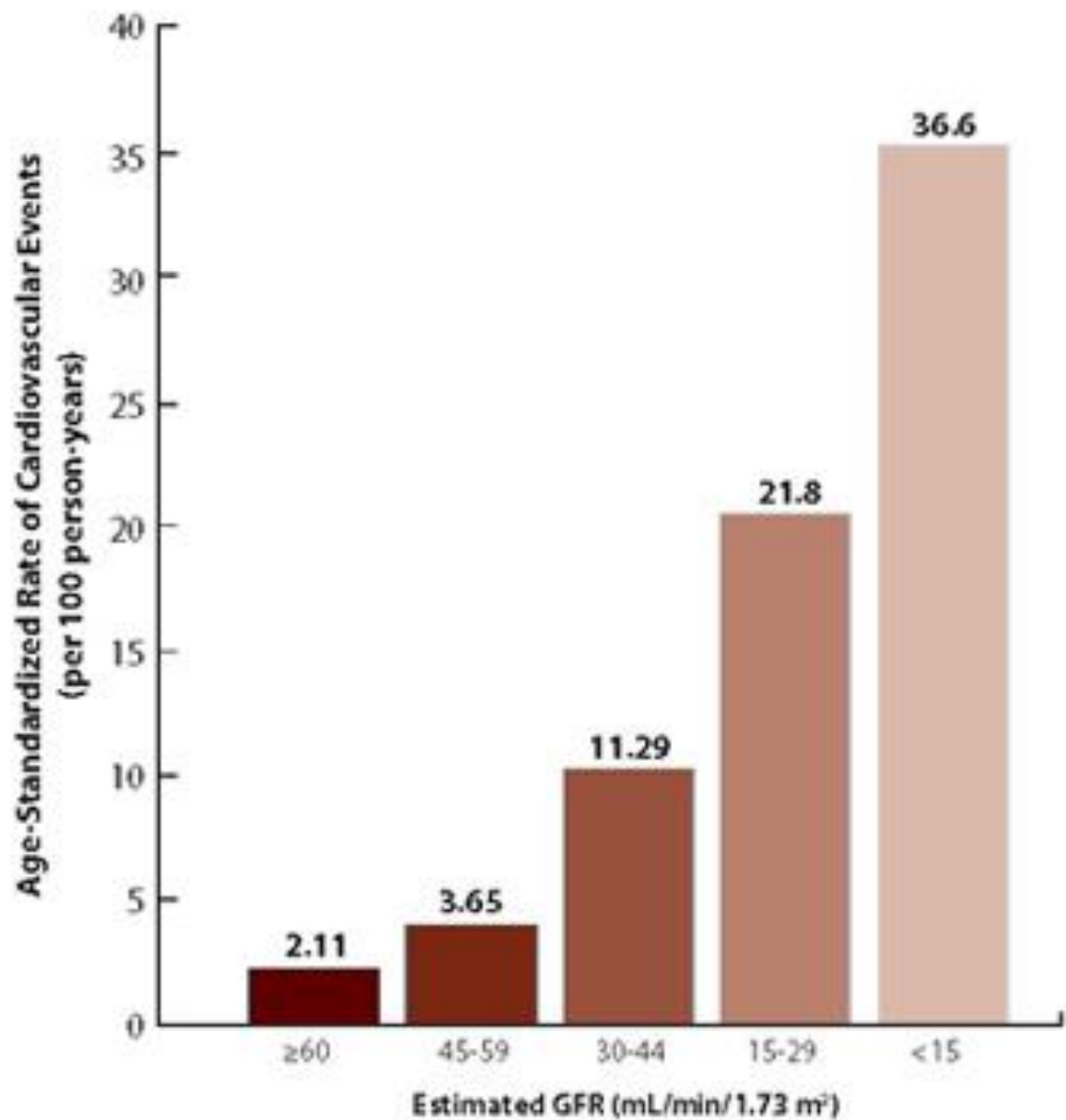
- Acute kidney injury is a life threatening disease, but preventable in most of the times
- It increases current problems, leads to vicious cycles and increases treatment cost
- Chronic kidney disease is a disease with affecting more people and causing social, economical and psychological problems

Why kidney disease is important?

- Cardiovascular risk factor
- Cost

WORLD KIDNEY DAY

- Second Thursday of March, every year
- First time in 2006



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What are the functions of kidneys

- Kidneys provide and maintain internal body balance by producing urine. To function properly, there must be:
 1. Blood supply
 2. Glomerular filtration
 3. Tubular reabsorption
 4. Tubular secretion

Glomerular filtration rate

- Serum creatinine level and glomerular filtration rate are very important, both in acute kidney injury and chronic kidney disease
- Glomerular filtration rate is probably the most important kidney function test

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Differential diagnosis of acute-chronic kidney failure

- Kidney failure is diagnosed by serum creatinine level and glomerular filtration rate (only method)
- Once kidney failure was diagnosed we need differential diagnosis

Differential diagnosis of acute-chronic kidney failure

- 1. History
- 2. Objective findings
- 3. Less sensitive laboratory tests

1. History

- Edema, nocturia, hematuria, itching, neuropathy suggests chronic disease
- Diabetes mellitus and hypertension supports chronic disease, but acute kidney injury must not be forgotten in these patients

2. Objective findings

- Small kidneys are the most objective finding.
- We can detect by ultrasonography easily.
- Findings such as uremic bone disease, band keratopathy, conjunctival calcification can only be seen in late chronic disease, but in practice, we do not use and we do not need them in the differential diagnosis today.

3. Less sensitive laboratory tests

- Anemia, hypocalcemia and hyperphosphatemia are signs of chronic disease, but we can also see them in acute disease
- Duration of acute kidney injury and cause of acute kidney disease are important

Chronic kidney disease causes without small kidneys

- Diabetes mellitus
- Amyloidosis
- Hydronephrosis
- Polycystic kidney disease
- Infiltrative diseases

Oliguria/anuria: differential diagnosis

- All diseases causing acute kidney injury may lead to oliguria
- In a patient with acute kidney injury and anuria, bilateral cortical necrosis, acute proliferative glomerulonephritis, vascular obstruction or complete urinary obstruction should be considered

Oliguria/anuria: differential diagnosis

- If urine both decreases and increases, partial urinary obstruction must be thought
- In chronic kidney disease, we can see oliguria and anuria when glomerular filtration rate decreases to about 1 liter/day

Practical information

- In general, oliguria/anuria is a sign of acute kidney injury
- Kidney failure can occur without any decrease in urine
- Acute kidney injury can be categorized into two groups: oliguric and nonoliguric
- Acute kidney injury may develop in a patient with chronic kidney disease

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AKI: Differential diagnosis

- After diagnosis, we must determine the cause of AKI in a short time
- For example diagnosis and treatment of urinary obstruction is very important
- There may be more than one disease/mechanism leading to AKI in some patients

AKI: Causes

- **Prerenal causes:** Dehydration, Conditions affecting blood flow
- **Renal causes:** Diseases affecting glomerular filtration
- **Postrenal causes:** Conditions blocking urine flow in other words obstruction

AKI: Causes

- Sepsis
- Critical disease
- Hypotension
- Burns
- Trauma
- Cardiac surgery (especially bypass)
- Noncardiac major surgery
- Nephrotoxic medicines
- Contrast agents
- Poisonous plant and animals

AKI: Predisposing factors

- Dehydration or hypovolemia
- Advanced age
- Female gender
- Black race
- Chronic kidney disease
- Chronic diseases (heart, lung, liver)
- Diabetes mellitus
- Cancer
- Anemia

Clinical findings

- AKI is one of the most complicated states that can a physician can see, but with pay attention to basic principles, course can be handled properly and recovery of kidneys is expected
- Initiation of AKI can be oliguric or nonoliguric
- Poliuria and recovery periods follow cases having oliguria

Clinical findings

- Oliguric period can end within a few hours, but also months; average 10-14 days
- During poliuric period, urine increases, it can increase to 5-10 liters/daily
- Serum creatinine ve BUN levels may continue to increase at the beginning of poliuric period

Clinical findings

- In general, we do not see polyuria in nonoliguric patients
- Both in oliguric and nonoliguric types, recovery of GFR happens mostly in early phases, but recovery can continue to 1 year

Clinical findings

- First symptom of AKI may be oliguria, hypervolemia, acidosis or uremic symptoms
- But nowadays, due to intensive follow up of cases and availability of biochemical tests, in general, first finding is oliguria or elevation of serum creatinine and at this period, there is not any sign related to uremia

Clinical findings

- Depending on underlying cause, period of disease and administered treatments, hyponatremia, hyperpotasemia, hyperphosphatemia, hypocalcemia, hypermagnesemia, hypercalcemia, hyperuricemia and anemia may develop
- Uremic symptoms related to neurophyschiatric and gastrointestinal systems may arise

Practical information

- AKI mostly improves
- It is important to keep patient alive and handle problems until kidney recovers
- Most of the deaths occur during recovery period

Akut tubular necrosis

- It is one the causes of acute kidney injury

Akut tubular necrosis

- To occur ATN, renal perfusion must be impaired due to prerenal causes
- After impairment of renal perfusion, injury develops, extends, continues and gets repaired
- There may not be correlation between GFR and histological changes, in other words we can see severe GFR reduction **without** severe histological changes

Practical information

- Acute tubular necrosis is mostly diagnosed by exclusion of other causes

ATN diagnosis

Is obstruction present?

Is prerenal factors present?

Is vascular disease present? Large vessel, small vessel

Is glomerular disease present?

Is interstitial disease present?

Is intrarenal crystal deposition present?

If all answers are NO, DIAGNOSIS IS ATN

Treatment

1. Treatment of underlying disease
2. Treatment of existing problems/diseases
3. Conservative treatment
4. Renal replacement therapies

Prognosis

- Mortality is still high, therefore, prevention is very important
- Mortality are high in AKI following operation or severe trauma, elderly, in the presence of systemic diseases
- Infection, cardiovascular causes, gastrointestinal bleeding and fluid-electrolyte disturbances are the most important causes of mortality

Prognosis

- Most of the deaths occur in the recovery period
- Important factors affecting survival in AKI are age, cause, severity and existence of complications

Staging of AKI

Stage 1

- Serum creatinine: 1.5–1.9 times baseline OR \geq 0.3 mg/dl increase
- Urine output: 0.5 ml/kg/h for 6–12 hours

Stage 2

- Serum creatinine: 2–2.9 times baseline
- Urine output: <0.5 ml/kg/h for \geq 12 hours

Staging of AKI

Stage 3

- Serum creatinine: 3 times baseline OR Increase to ≥ 4.0 mg/dl
- OR Initiation of renal replacement therapy
- OR In patients <18 years, decrease in eGFR to <35 ml/min per 1.73 m²
- Urine output: <0.3 ml/kg/h for ≥ 24 hours OR Anuria for ≥ 12 hours

Practical information

- Most of the times, AKI is the result of a nonrenal disease
- The faster improvement of nonrenal disease, the faster improvement of AKI

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CKD: Definition

- CKD is defined as abnormalities of kidney structure or function, present for > 3 months, with implications for health.
- CKD is classified based on Cause, GFR category (G1-G5), and Albuminuria category (A1-A3), abbreviated as CGA.

Markers of kidney damage (one or more)

- Albuminuria (AER \geq 30 mg/24 hours; ACR \geq 30 mg/g [\geq 3 mg/mmol])
- Urine sediment abnormalities
- Electrolyte and other abnormalities due to tubular disorders
- Abnormalities detected by histology
- Structural abnormalities detected by imaging
- History of kidney transplantation

GFR categories in CKD

GFR category	Term	GFR ml/min/1.73 m ²
1	Normal or high	≥ 90
2	Mildly decreased	60-89
3a	Mildly to moderately decreased	45-59
3b	Moderately to severely decreased	30-44
4	Severely decreased	15-29
5	Kidney failure	< 15

Decreased GFR

- GFR < 60 ml/min/1.73 m² (GFR categories G3a-G5)

Albuminuria categories explanation

- AER: Albumin excretion rate
- ACR: Albumin to creatinine ratio
- Pay attention to units
- Albuminuria (AER ≥ 30 mg/24 hours; ACR ≥ 30 mg/g [≥ 3 mg/mmol])

Albuminuria categories in CKD

Category	Term	AER	ACR
1	Normal or mildly increased	<30 mg/day	<30 mg/g (<3 mg/mmol)
2	Moderately increased	30-300 mg/day	30-300 mg/g (3-30 mg/mmol)
3	Severely increased	>300 mg/day	>300 mg/g (>30 mg/mmol)

- AER: Albumin excretion rate
- ACR: Albumin to creatinine ratio

KDIGO 2021: Kidney Int. 2021;99(3S):S1-S87.

CURRENT CHRONIC KIDNEY DISEASE (CKD) NOMENCLATURE USED BY KDIGO

CKD is defined as abnormalities of kidney structure or function, present for > 3 months, with implications for health. CKD is classified based on Cause, GFR category (G1–G5), and Albuminuria category (A1–A3), abbreviated as CGA.

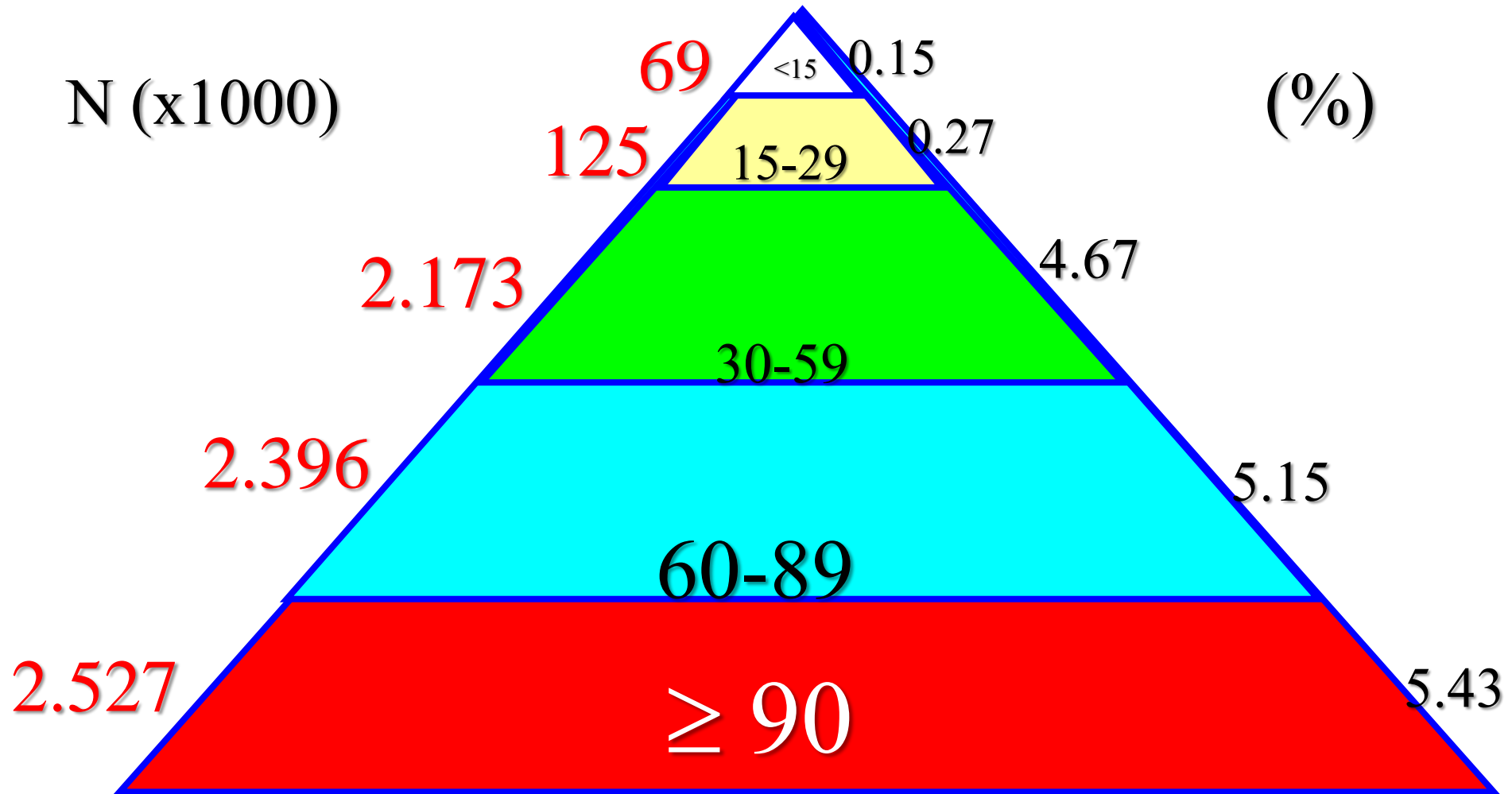
				Persistent albuminuria categories		
				Description and range		
Prognosis of CKD by GFR and albuminuria categories: KDIGO 2012				A1	A2	A3
				Normal to mildly increased	Moderately increased	Severely increased
				< 30 mg/g < 3 mg/mmol	30–300 mg/g 3–30 mg/mmol	> 300 mg/g > 30 mg/mmol
GFR categories (ml/min/1.73 m ²) Description and range	G1	Normal or high	≥ 90			
	G2	Mildly decreased	60–89			
	G3a	Mildly to moderately decreased	45–59			
	G3b	Moderately to severely decreased	30–44			
	G4	Severely decreased	15–29			
	G5	Kidney failure	< 15			

Green, low risk (if no other markers of kidney disease, no CKD); yellow, moderately increased risk; orange, high risk; red, very high risk. GFR, glomerular filtration rate.

CKD: Staging (old, 2002)

Stage	Term	GFR ml/min/1.73 m ²
-	Increased risk	≥60 (risk factors +)
1	Kidney damage but GFR normal increased	≥ 90
2	Kidney damage, GFR mildly decreased	60-89
3	GFR moderately decreased	30-59
4	GFR severely decreased	15-29
5	Kidney failure	< 15

CKD & Epidemiology: TR



Practical information

- Diabetes mellitus and hypertension are the two most common causes of chronic kidney disease

CKD: Causes

Diabetes mellitus: Common, patients live longer

Hypertensive nephropathy: Common, patients live longer

Chronic glomerulonephritis

Urological diseases

Cystic kidney diseases

Chronic interstitial nephritis

Other causes

Unclear

Signs

- Depends on the cause
- Patients may be asymptomatic unless $GFR < 35-50$ ml/min
- In general, nocturia and fatigue due to anemia are first symptoms
- CKD may have an insidious course
- When GFR falls below 20-25 ml/min uremic symptoms arises

Signs

- Nausea, vomiting, itching, pallor, weight loss, uremic mouth smell, loss of muscles are other common sign and symptoms
- Nearly all organs or symptoms can be affected either at the beginning or during the course of CKD
- When GFR falls to below of 15 ml/min, it is end stage renal disease and patients can require renal replacement therapies

Purposes of treatment

1. Treatment of underlying disease
2. Control of factors increasing progression of kidney disease, slowing of kidney failure
3. Prevention and treatment of problems related to decrease of kidney functions
4. Renal replacement therapy in end stage renal disease patients

Slowing and prevention of progression

- Hypertension
- Heart failure
- Proteinuria
- Uncontrolled blood sugar
- Infection
- Dehydration
- Smoking
- Nephrotoxic medicines
- Management of urological problems

Risk factors

- Diabetes mellitus
- Hypertension
- Autoimmun diseases
- Systemic infections
- Nephrotoxic medicines
- Procedures leading to decrease of kidney functions
- Improved acute kidney injury
- Older than 60 years of age
- Family history of kidney disease
- Reduced kidney mass (renal transplanted patients and kidney donors)

Treatment

- Diet
- Fluid
- Control of hypertension
- Decrease of cardiovascular risk
- Treatment of anemia
- Prevention and treatment of uremic bone disease

Treatment

- Vaccination
- Prevention and treatment of malnutrition, vitamins
- Existing problems
- Avoidance of nephrotoxic medicines and dose adjustment of medicines
- Exercise

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Renal replacement therapies

1. Dialysis

2. Renal transplantation

**ÜREM KREATİNİNİM YÜKSEK DİYALİZİ NASIL
ÖNLERİM?**

[tekinakpolat.com/wp-content/uploads/2016/11/ure-
kreatinin-kitap.pdf](http://tekinakpolat.com/wp-content/uploads/2016/11/ure-kreatinin-kitap.pdf)

Dialysis treatment

- There are two types: Hemodialysis and peritoneal dialysis
- Dialysis is a process whereby the solute composition of a solution, A (patient's blood), is altered by exposing solution A to a second solution, B (dialysate), through a semipermeable membrane.
- In general, movement of solute and water transfer is from the patient to the dialysate.
- With removal of dialysate, the patient gets closer to the equilibrium

CKD: dialysis indication (absolute)

- Uremic pericarditis
- Uremic encephalopathy or neuropathy (convulsion, disorientation, confusion, myoclonus)
- Pulmonary edema and/or hypervolemia resistant to medical treatment
- Uncontrolled hypertension
- Uremic bleeding
- Frequent nausea, vomiting and fatigue
- Acute psychosis
- Malnutrition
- Creatinine >12 mg/dl or BUN >100 mg/dl (changes to the patient, THERE IS NO DISEASE, THERE IS PATIENT).

CKD: dialysis indication (relative)

- Memory and cognitive function problems
- Early peripheral neuropathy
- Peripheral edema resistant to diuretics
- Intractable itching
- Bad control of serum calcium and phosphorus
- Anemia resistant to erythropoietin treatment

Acute dialysis indications

1. Acute kidney injury
2. Chronic kidney disease
3. Hyperpotasemia
4. Metabolic acidosis
5. Hypercalcemia
6. Hypervolemia
7. Hiperuricemia
8. Hyperphosphatemia
9. Metabolic alkalosis
10. Hyponatremia
11. High dose medicine intake and poisoning

Transplantation

- Best treatment for end stage renal disease
- There are two types of donor: Living and cadaveric
- It increases both survival and life quality
- Unlike dialysis, transplantation improves all kidney functions

SOURCE

<http://tekinakpolat.com/dersler-icin-kaynak/>

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