

A decorative graphic consisting of two thick, curved bands. The left band is blue and the right band is green. They are positioned around a central white area, creating a frame for the text. The bands have a slight gradient and a soft shadow effect.

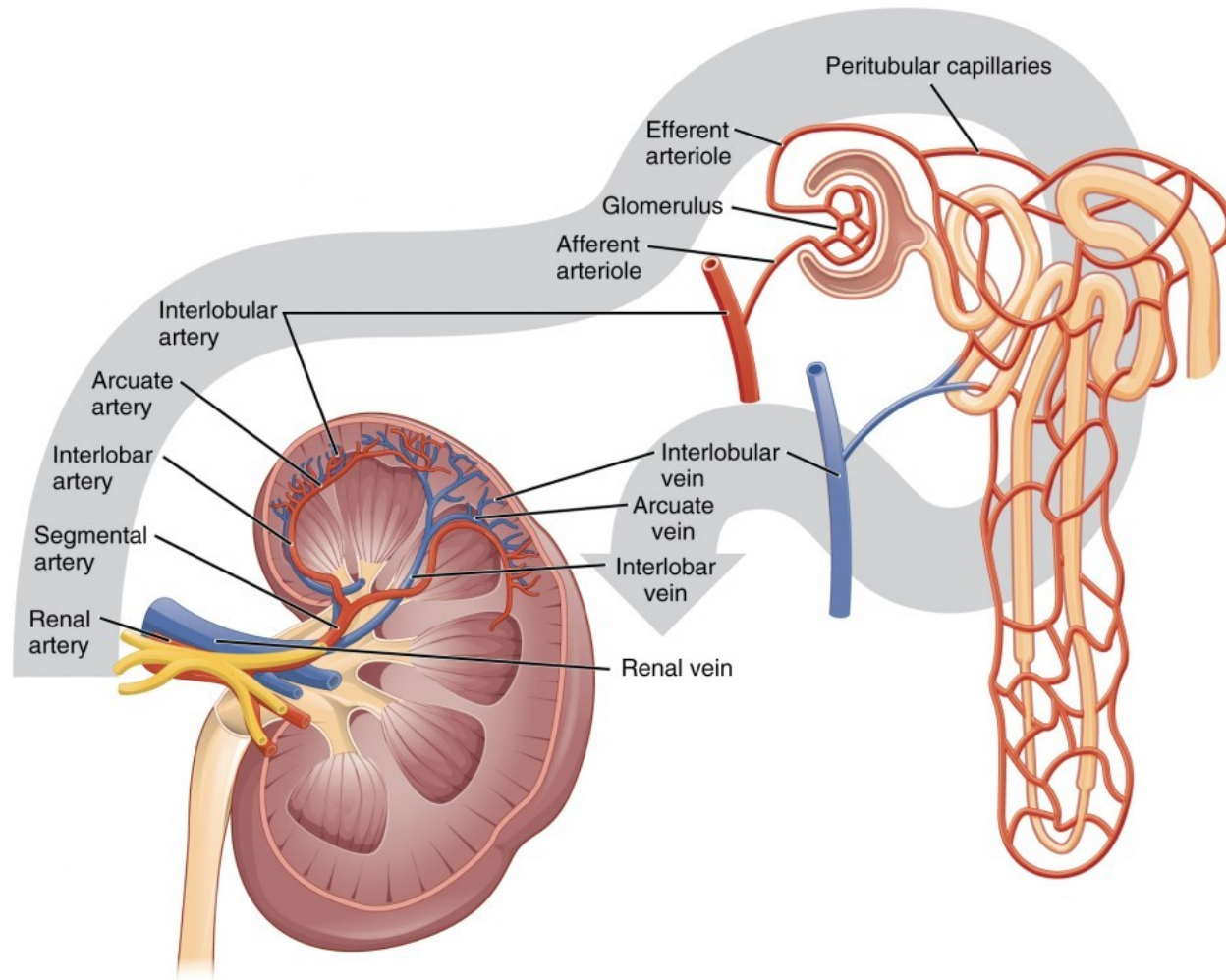
Kidney Physiology in a Nutshell

Jan Novák

Kidney Functions

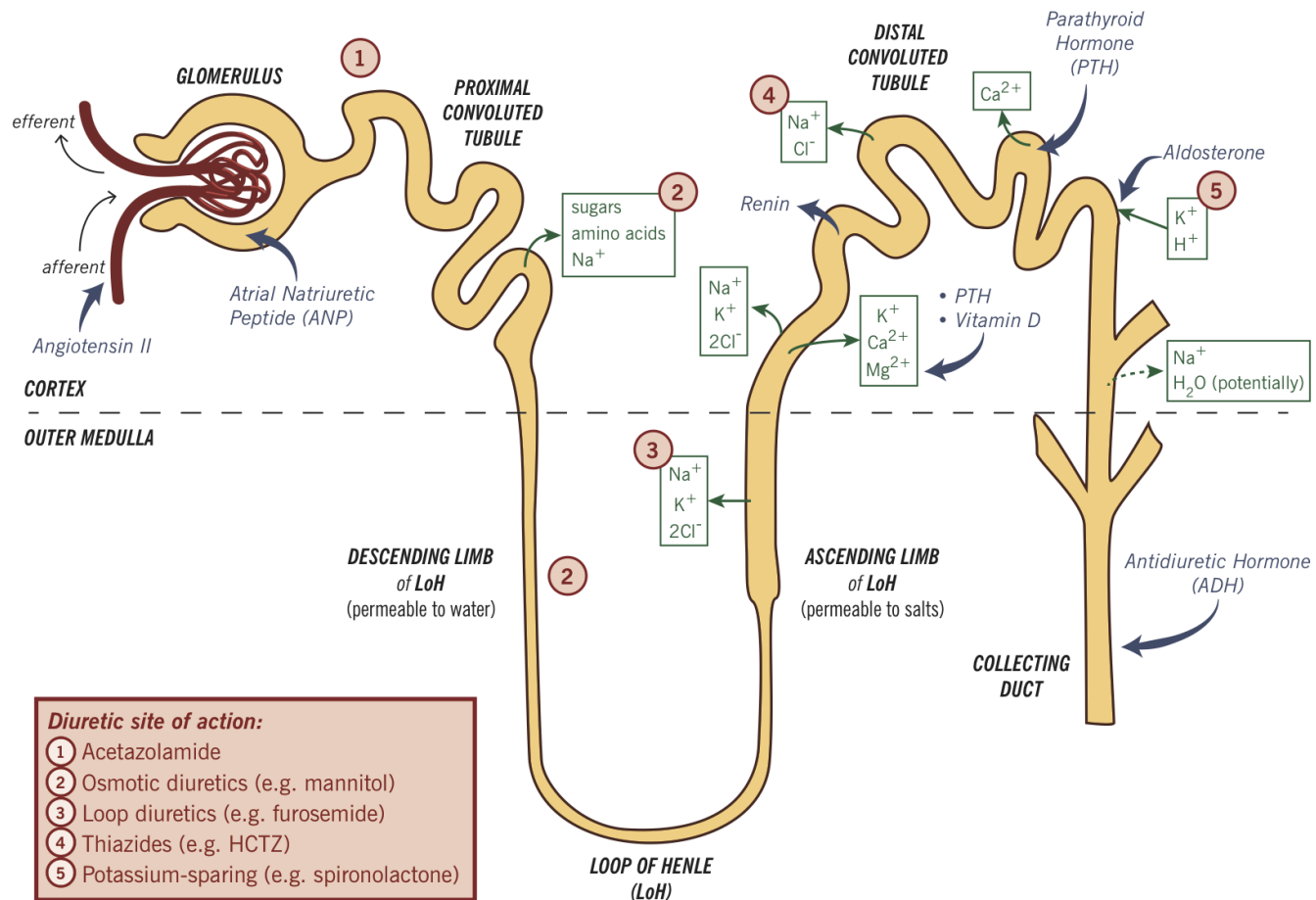
- Excretory function (= removal of unnecessary or harmful substances from the body)
- Urine and N-substances in it (urea, creatinine)
- Xenobiotics (drugs, toxic substances)
- Maintenance of stable ionic composition (Na^+ , K^+ , Cl^- , Ca^{2+} , PO_3^{2-})
- Maintenance of acid-base balance (HCO_3^- , H^+)
- Endocrine function
 - renin production (part of RAAS)
 - vitamin D metabolism
- Control of body volume and blood pressure

Blood flow through the kidney

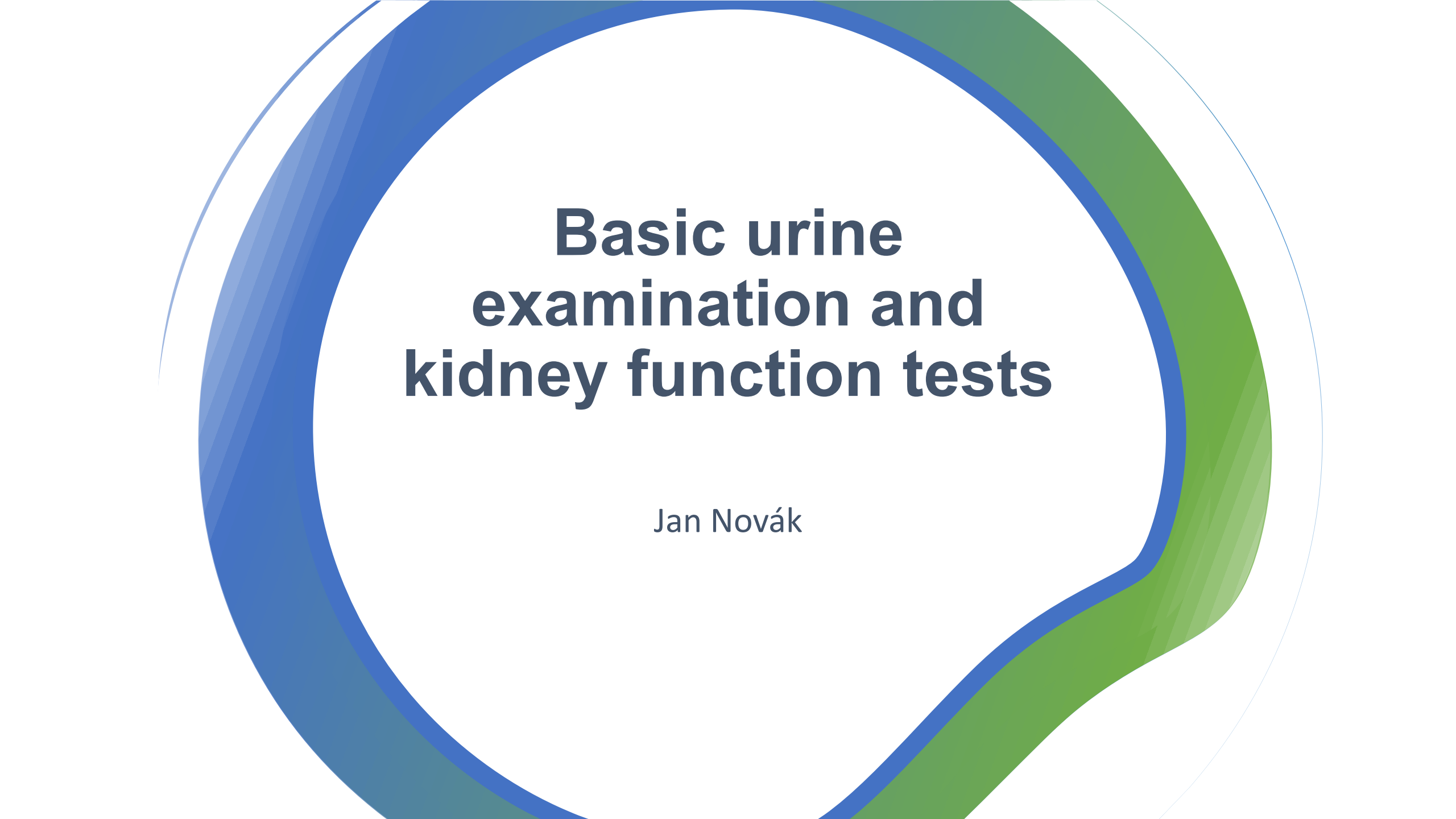


- 20% of cardiac output (1 liter per minute)
- "Plasma skimming"
- vas afferens - glomerulus - vas efferens
- the difference between cortical and juxtamedullary nephrons

Nephron – the functional morphology



- Glomerulus and Bowman's body = GF
- Proximal tubule = volume resorption
- Loop of Henle = countercurrent system and osmotic stratification of the medulla
- Distal tubule = controlled resorption
- Collection channel = water resorption due to ADH

The background features a large, stylized graphic composed of two thick, curved bands. The left band is blue, and the right band is green. They are separated by a white space and together form a shape reminiscent of a kidney or a stylized letter 'C'.

Basic urine examination and kidney function tests

Jan Novák

Urine collection

- **Disposable (one-time)**

- First / second morning urine
- Random sample
- Catheterized

- Genital cleansing
- Medium urine flow (after 2-3s)

- **Urine collection**

- 24 hours
- 4 hours

- **The right technique** (the patient urinates and collects 24 hours from that moment)

Physical evaluation (by sight, smell)

- **Colour**

- Shades of yellow = state of hydration
Light = polyuria
"Normal" = normal
Dark = dehydration
Amber = severe dehydration
- Shades of red / brown = hematuria
- Green, "cafe au lait", bluish - mostly infections

- **Turbidity**

Typically for infections
but also sperm, erythrocytes,
precipitated substances (when
storing urine in the refrigerator)

- **Odor**

Fruit sweet = ketonuria
Mouse = phenylketonuria
Disgusting putrefactive = infection

Urine „chemically + sediment“

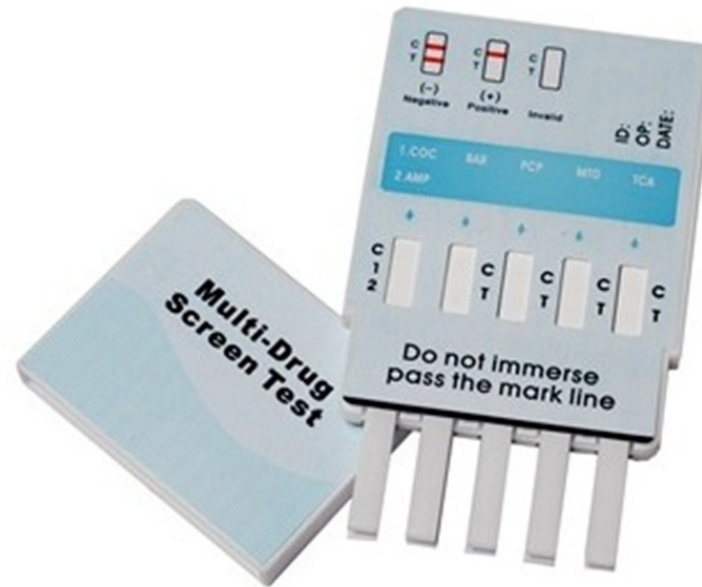
- **Specific density**(dimensionless number; ratio of sample density to distilled water; reflects tubular function)
- **pH** (normal 4.5 - 8; e.g. Klebsiella lowers urine pH; important in calcium oxalate stones = formation in acidic environment)
- **Leukocytes** (leukocyte esterase)
- **Nitrites** (bacteria reduce nitrates to nitrites)
- **Protein** (above 150mg / l, the first sign of glomerular or tubular proteinuria)
- **Blood** (heme detection, microscopic x macroscopic, prerenal x renal x subrenal)
- **Glucose**
- **Ketone bodies** (beta-hydroxybutyrate and acetetoacetate)
- **Bilirubin** (conjugated is released into the urine)

Urine „**chemically** + sediment“

- **Erythrocytes**
 - if the blood has been proven "chemically" and if there are no erythrocytes in the "sediment", this indicates a prerenal source (hemoglobin, myoglobin in the urine)
 - if there are erythrocytes in the sediment, we distinguish between glomerular ("wrinkled" = dysmorphic erythrocytes) and subrenal (normal shape)
- **Leukocytes**
- **Epithelium**
- **Bacteria and yeasts**
- **Parasites**
- **Sperm**
- **Mucus, cylinders, crystals...**

Other detectable analytes from a disposable urine

- **Pregnancy test (HCG)**
- **The indicative drug tests**
 - amphetamine (AMP)
 - barbiturates (BAR)
 - benzodiazepins (BZD)
 - cocaine (COC)
 - metamphetamine (MET)
 - morphine (MOR)
 - metadone (MTD)
 - phencyclidine (PCP)
 - propoxyphen (PPX)
 - tricyclides (TCA)
 - marihuana (THC)
 - ecstasy (XTC)



24 (4) hours urine collection

- **Calculation of glomerular filtration** => Creatinine clearance
 - The volume of blood purified from a given substance per unit time
 - $GF = \text{urine volume in 24 h} * C \text{ creatinine in urine} / C \text{ creatinine in serum}$
- **Examination of tubular functions** => Fractional excretion
The amount of filtered substance that we can find in the definitive urine
e.g. 180 l of primary urine is produced per day, we urinate 1.8 liters = FE 1%
- **Calculation of excreted substances per day** (typically proteinuria)

What are the N-substances?

- **Urea** **1,7 – 8,3 mmol/l**
 - the most quantitatively significant degradation product of amino acids and proteins
 - blood urea concentration depends on dietary protein content, renal excretion and hepatic metabolic function

- **Creatinine** **44 – 104 $\mu\text{mol/l}$ in women**
 44–110 $\mu\text{mol/l}$ in men
 - formed in the muscles from creatine and creatine phosphate
 - serum levels also reflect the proportion of muscle mass
 - used to calculate or estimate the glomerular filtration

Estimation of glomerular filtration

Creatinine Clearance (Cockcroft-Gault Equation) ☆

Calculates CrCl according to the Cockcroft-Gault equation.

When to Use ▾ Pearls/Pitfalls ▾ Why Use ▾

Sex Female Male

Age years

Weight kg ↕

Creatinine Norm: 62 - 115 μmol/L ↕

The Cockcroft-Gault Equation may be inaccurate depending on a patient's body weight and BMI; by providing additional height, we can calculate [BMI](#) and provide a modified estimate and range.

Height Norm: 152 - 213 cm ↕

Result:

Please fill out required fields.

CKD-EPI Equations for Glomerular Filtration Rate (GFR) ☆

Estimates GFR based on serum creatinine, serum cystatin C, or both.

When to Use ▾ Pearls/Pitfalls ▾ Why Use ▾

Equation CKD-EPI Creatinine CKD-EPI Cystatin C CKD-EPI Creatinine-Cystatin C

Gender Female Male

Age years

Race Black Non-black

Serum creatinine Norm: 62 - 115 μmol/L ↕

Result:

Please fill out required fields.

MDRD GFR Equation ☆

Estimates glomerular filtration rate based on creatinine and patient characteristics.

INSTRUCTIONS

Only for chronic kidney disease (CKD); not accurate for acute renal failure. Also, note that a [later study](#) indicates the MDRD may underestimate the actual GFR in healthy patients by up to 29%. This calculator uses the 4-variable equation from [Levey 2006](#), as it has been recalibrated for differences in the lab testing of creatinine.

Pearls/Pitfalls ▾

Sex Female Male

Black race No Yes

Age years

Creatinine Norm: 62 - 115 μmol/L ↕

Result:

Please fill out required fields.

Cystatin C: a low molecular weight protein, expressed in a constant amount, freely by the glomerular membrane and is fully resorbed and degraded in the tubule. If serum levels rise, it reflects a decrease in GFR.

Estimation of glomerular filtration

Creatinine Clearance (Cockcroft-Gault Equation) ☆

Calculates CrCl according to the Cockcroft-Gault equation.

When to Use ▾	Pearls/Pitfalls ▾	Why Use ▾
Sex	Female	Male
Age	31	years
Weight	119.8	kg ⇄
Creatinine	87	μmol/L ⇄

184 mL/min

Creatinine clearance, original Cockcroft-Gault

150 mL/min

Creatinine clearance modified for overweight patient, using adjusted body weight of 98 kg (215 lbs).

127.9–150.4

mL/min

Note: This range uses IBW and adjusted body weight. Controversy exists over which form of weight to use.

Copy Results 📄

Next Steps >>>

CKD-EPI Equations for Glomerular Filtration Rate (GFR) ☆

Estimates GFR based on serum creatinine, serum cystatin C, or both.

When to Use ▲	Pearls/Pitfalls ▾	Why Use ▾
<ul style="list-style-type: none">• Patients with chronic kidney disease (not acute), to measure renal function.• CKD-EPI Cystatin C is preferred in cirrhotics and other patients with low muscle mass.• CKD-EPI Creatinine can be used in settings where cystatin C is not available.		
Equation	CKD-EPI Creatinine CKD-EPI Cystatin C CKD-EPI Creatinine–Cystatin C	
Gender	Female	Male
Age	31	years
Race	Black	Non-black
Serum creatinine	87	μmol/L ⇄

102 mL/min/1.73 m²

Estimated GFR by CKD-EPI Creatinine

Stage I

CKD stage by CKD-EPI Creatinine

Copy Results 📄

Next Steps >>>

MDRD GFR Equation ☆

Estimates glomerular filtration rate based on creatinine and patient characteristics.

INSTRUCTIONS

Only for chronic kidney disease (CKD); not accurate for acute renal failure. Also, note that a [later study](#) indicates the MDRD may underestimate the actual GFR in healthy patients by up to 29%. This calculator uses the 4-variable equation from [Levey 2006](#), as it has been recalibrated for differences in the lab testing of creatinine.

Pearls/Pitfalls ▾		
Sex	Female	Male
Black race	No	Yes
Age	31	years
Creatinine	87	μmol/L ⇄

94.4 mL/min/1.73 m²

Glomerular Filtration Rate by the MDRD Equation.

Copy Results 📄

Next Steps >>>

Estimation of glomerular filtration – why?

- We use estimation because accurate calculations over 24 hours of urine collection are often lengthy and burdensome for the patient.
- According to GFR, the dosage of various drugs is adjusted (most of the antibiotics, DOACs, LMWH), when GFR is reduced below a certain limit, other drugs are completely contraindicated (eg metformin) or are ineffective (some "weaker" diuretics)

Case report # – *title*

- Case description

Description of what happened and why the patient is coming.

- Medical history

Basic and relevant patient data

- FH = family history
- PH = personal history
- MH = medication
- AA = allergies
- Abusus

Case report # – *title*

Urine - chemically	
pH	
Proteins	
Glucosis	
Urobilinogen	
Bilirubin	
Ketones	
Nitrites	
Leukocytes	
Blood	

Urine - Sediment	
Leucocytes	
Erythrocytes	
Bacteries	
Mucus	
Epithelium flat	
Epithellium round	

Basic biochemistry				
Na	132-142 mmol/l			
K	3,5-5,2 mmol/l			
Cl	97-108 mmol/l			
Urea	1,7 – 8,3 mmol/l			
Crea	44–110 µmol/l			
GFR	> 1 ml/s/1,73m ²			
Gly	3,9 - 5,5 mmol/l			
CRP	1 – 10 mg/l			

Case report 1 – Unconscious patient

Ambulance brings a 88-year-old lady to an internal clinic.

Ambulance was called by the lady's family for the gradual deterioration of the mental and body condition during the day, until the unconsciousness, she does not react to the family.

Upon arrival:

BP 100/60 mmHg, P 70/min, afebrile

Vitals: **unconsciousness**, without jaundice, without dyspnea, **miotic pupils**, **breathing is clean, quiet, slow**, heart rate regular, no abdominal pain, legs without swelling, **3 patches of Fentanyl on the back**

Medical history

- **PH:** hypertension, light cognitive deficiency, vertebrogenic algic syndrome of lumbar spine
- **Allergies:** no
- **Mediaction:**
 - Prestarium Neo 5mg tbl 1-0-0
 - Fentanyl 100ug/h – one patch change every 72 hours
- **Abusus:** non smoker, no alcohol, no drugs (by family)

Case report 1 – Unconscious patient

What next ???

Urine - chemically	
pH	5,0
Proteins	0
Glucosis	0
Urobilinogen	0
Bilirubin	0
Ketones	0
Nitrites	0
Leukocytes	0
Blood	0

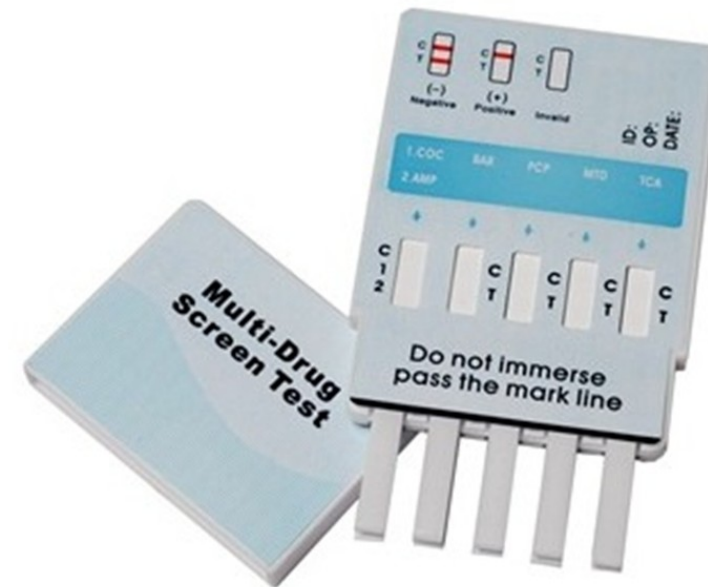
Urine - Sediment	
Leucocytes	0
Erythrocytes	0
Bacteries	0
Mucus	0
Epithelium flat	0
Epithellium round	0

BB				
Na	132-142 mmol/l	140		
K	3,5-5,2 mmol/l	4,8		
Cl	97-108 mmol/l	100		
Urea	1,7 – 8,3 mmol/l	2,0		
Crea	44–110 µmol/l	39		
GFR	> 1 ml/s/1,73m ²	1,25		
Gly	3,9 - 5,5 mmol/l	5,2		
CRP	1 – 10 mg/l	8		

Case report 1 – Unconscious patient

- **The indicative drug tests**

- amphetamine (AMP)
- barbiturates (BAR)
- **Benzodiazepins (BZD) +++**
- cocaine (COC)
- metamphetamine (MET)
- **Opiates +++**
- metadone (MTD)
- phencyclidine (PCP)
- propoxyphen (PPX)
- tricyclides (TCA)
- marihuana (THC)
- ecstasy (XTC)



Case report 1 – Unconscious patient

- Conclusion:
 - Intoxication of benzodiazepines
 - Intoxication of opiates
- Checkpoints:
 - Miotic pupils and respiratory depression = signs of opiate overdose
- Explanation:
 - The patient could not sleep for the last 3 days due to back pain, so she borrowed Lexaurin (BZD) from a neighbor to make her sleep better
 - Because Lexaurin was not enough, she applied one extra patch in the morning, and because she forgot about it at noon, she applied a third...thus overdosing herself

Case report 2 – *Domestic violence*

The patient, 29 years old, calls the Police that she was attacked by a friend who beat her, kicked her, maybe even raped her and injected her with some drugs, she is now lying on the ground and unable to get up.

Police arrives at the place, calls ambulance. The patient was found in the apartment in the living room, a laceration on her head, bruises all over her body.

Brought to the surgical outpatient clinic – there was a fracture of the humerus without dislocation and fracture of L2 vertebra according to X-ray, both without dislocation. Ultrasound of the abdomen shown no internal bleeding. Wound on the head was sewed, orthosis and spine corset were applied. Due to possible intoxication with an unknown substance, she was referred to internal department.

Upon arrival:

BP: 120/70 mmHg, pulse 105/min, afebrile

Vitals: conscious, oriented, anxious, wound on the head sewed, right arm in the orthosis, respiration clean, heart rate regular, no abdominal pain, peristaltics +, hematomas over the body, legs without swelling

Medical history:

PH: sine

Medication: sine

Alergies: sine

Abusus: smoker (10 cigarettes a day), a week ago she had marijuana, alcohol occasionally, she hadn't drank at all for the last month

Drugs test: THC ++, others neg.

Case report 2 – *Domestic violence*

Urine - chemically	
pH	5,0
Proteins	0
Glucosis	0
Urobilinogen	0
Bilirubin	0
Ketones	0
Nitrites	0
Leukocytes	0
Blood	3

Urine - Sediment	
Leucocytes	0
Erythrocytes	0
Bacteries	0
Mucus	3
Epithelium flat	3
Epithellium round	1

BB				
Na	132-142 mmol/l	139		
K	3,5-5,2 mmol/l	3,8		
Cl	97-108 mmol/l	103		
Urea	1,7 – 8,3 mmol/l	3,5		
Crea	44–110 µmol/l	82		
GFR	> 1,5 ml/s/1,73m ²	1,23		
Gly	3,9 - 5,5 mmol/l	3,9		
CRP	1 – 10 mg/l	4,4		
Myo	30 - 80 µg/l	1424		
CK	0,45-2,45 ukat/l	77,9		
CKMB	0,2–1,8 ukat/l	2,13		

Case report 2 – *Domestic violence*

- Conclusion:
 - Muscle trauma after domestic violence = elevation of CK (indirectly CKMB), myoglobin
 - In the chemical examination of urine we can see a positive test for blood („heme“) but a negative sediment for erythrocytes = evidence of prerenal "overload" of the kidneys with heme
 - The cylinders and epithelium indicate myoglobin overload of the tubules

Case report 2 – *Domestic violence*

Urine - chemically	
pH	5,0
Proteins	0
Glucosis	0
Urobilinogen	0
Bilirubin	0
Ketones	0
Nitrites	0
Leukocytes	0
Blood	3

Urine - Sediment	
Leucocytes	0
Erythrocytes	0
Bacteries	0
Mucus	3
Epithelium flat	3
Epithellium round	1

BB				
Na	132-142 mmol/l	139	137	138
K	3,5-5,2 mmol/l	3,8	3,7	3,7
Cl	97-108 mmol/l	103	105	104
Urea	1,7 – 8,3 mmol/l	3,5	2,9	2,6
Crea	44–110 µmol/l	82	60	59
GFR	> 1,5 ml/s/1,73m ²	1,23	1,97	1,99
Gly	3,9 - 5,5 mmol/l	3,9	4,4	5,0
CRP	1 – 10 mg/l	4,4	14,3	4,1
Myo	30 - 80 µg/l	1424	332	160
CK	0,45-2,45 ukat/l	77,9	90,8	50,4
CKMB	0,2–1,8 ukat/l	2,13	--	--

Case report 3 – *Apartment opened by the Police*

The ambulance arrives to the internal department with an 84-year old patient from an apartment opened by Police.

Ambulance was called by neighbors - the man has not left the apartment for 2 days. The ambulance crew found the patient lying on the ground in the kitchen. Hypothermic, dehydrated, wet, stiff.

The patient states that he has not been well for the last few days, he urinated a lot, while urinating he felt burning. He tried to drink enough, but he had no appetite, then he probably had a fever and when he got up from his chair, he got dizzy and fell and was unable to get up nor to call for help.

Upon arrival:

- BP 80/40 mmHg, pulse 86 bpm , TT 36.1 C
- V: conscious, slowed psychomotoric pace, decreased skin turgor, no jaundice, no dyspnea, breathing clean, heart rate regular, no abdominal pain, legs without swelling. After the introduction of urine catheter, it drains amber turbid urine.

Medical history:

PH: hypertension, dyslipidemia, CHOPN, DM2T

Medication:

- Prestance 5/5mg tbl 1-0-0
- Atorvastatin 20mg tbl 0-0-1
- Ultribro breezhaler 1 vdech 1-0-1
- Metformin 1g tbl 1-1-1

• **Alergies:** sine

• **Abusus:** The smoker about 20 a day from the age of 18, no use of drugs and alcohol

Case report 3 – *Apartment opened by the Police*

Urine - Chemically	
pH	6,0
Proteins	2
Glucosis	0
Urobilinogen	0
Bilirubin	0
Ketones	1
Nitrites	3
Leukocytes	4
Blood	1

Urine - Sediment	
Leucocytes	4
Erythrocytes	1
Bacteries	2
Mucus	
Epithelium flat	3
Epithellium round	1
Appearance	Turbidity
Colour	Amber

BB				
Na	132-142 mmol/l	129		
K	3,5-5,2 mmol/l	4,0		
Cl	97-108 mmol/l	96		
Urea	1,7 – 8,3 mmol/l	10,1		
Crea	44–110 µmol/l	133		
GFR	> 1 ml/s/1,73m ²	0,76		
Gly	3,9 - 5,5 mmol/l	6,2		
CRP	1 – 10 mg/l	107,5		

Case report 3 – *Apartment opened by the Police*

- Conclusion:
 - The patient had a urinary tract infection for the last few days, gradually weakening and eventually falling
 - Initially, he had no temperature because he was hypothermic from lying on the ground
 - From the urinary sediment we can clearly say that the patient has a urinary tract infection (bacteria, nitrites present), is dehydrated with deterioration of kidney function (reduced GFR), BB then confirms inflammation in the body (CRP)
 - Ketone bodies in urinary sediment reflect starvation
 - Patient hydrated and treated with ATB

Case report 3 – *Apartment opened by the Police*

Urine - Chemically		Urine - Sediment		BB				
pH	6,0	Leucocytes	0	Na	132-142 mmol/l	129	142	
Proteins	0	Erythrocytes	0	K	3,5-5,2 mmol/l	4,0	3,7	
Glucosis	0	Bacteries	0	Cl	97-108 mmol/l	96	105	
Urobilinogen	0	Mucus		Urea	1,7 – 8,3 mmol/l	10,1	7,0	
Bilirubin	0	Epithelium flat	0	Crea	44–110 µmol/l	133	94	
Ketones	0	Epithellium round	0	GFR	> 1 ml/s/1,73m ²	0,76	1,16	
Nitrites	0			Gly	3,9 - 5,5 mmol/l	6,2	5,1	
Leukocytes	0	Appearance	clear	CRP	1 – 10 mg/l	107,5	37,4	
Blood	0	Colour	yellow					

Case report 4 – *Unconsciousness and dyspnea*

The ambulance arrives to emergency with a young patient, 22 years old, found by a roommate around noon on the dormitory lying on the ground, unresponsive, hyperventilating.

According to a roommate, the patient has been complaining for the last 2 weeks that he has to drink a lot, he urinates a lot, that he has a headache, his vision was blurred. That's why he didn't even go to lectures in the morning and after the lectures he found him.

Upon arrival of ambulance the patient is unconscious, hyperventilating, acetone odour from breath. Blood glucose immeasurably high. Transfer to the emergency room.

Vitals at ER: normostenic, unconsciousness, blood pressure 80/60 mmHg, pulse 125 bpm, hyperventilation, respiration otherwise clean, abdomen without pain, peristaltics +, legs without swelling

Medical history:

PH: till now sine

Medication: sine

Alergies: neg.

Abusus: non-smoker, no drugs and alcohol

Drugs test: negat.

Case report 4 – *Unconsciousness and dyspnea*

Urine - chemically		Urine - sediment		BB			
pH	5,0	Leucocytes	0	Na	132-142 mmol/l	132	
Proteins	1	Erythrocytes	0	K	3,5-5,2 mmol/l	5,4	
Glucosis	4	Bacteries	0	Cl	97-108 mmol/l	82	
Urobilinogen	0	Mucus	1	Urea	1,7 – 8,3 mmol/l	16,1	
Bilirubin	0	Epithelium flat	1	Crea	44–110 µmol/l	217	
Ketones	2	Epithellium round	0	GFR	> 1 ml/s/1,73m ²	0,47	
Nitrites	0	Appearance	clear	Gly	3,9 - 5,5 mmol/l	61,8	
Leukocytes	0	Colour	yellow	CRP	1 – 10 mg/l	6,7	
Blood	1			pH	7,36-7,44	6,98	

Case report 4 – *Unconsciousness and dyspnea*

- Conclusion:
 - The patient shows signs of higher glycemia (polyuria, polydipsia, blurred vision, headache) for the last two weeks
 - Brought in a hyperosmolar hyperglycemia and ketoacidotic coma with Kussmaul (acidotic) breathing, severely dehydrated
 - Diagnosis of DM recens (=newly diagnosed DM; later DM1T type LADA was confirmed)

A decorative graphic consisting of two thick, curved bands. The left band is blue and the right band is green. They are positioned around the central text, creating a frame-like effect. The bands have a slight gradient and are set against a white background.

Acute kidney injury, chronic kidney disease

Jan Novák

Acute kidney injury (AKI)

- AKI term: acute kidney injury (often AKI on CKD) – previously also acute renal failure (ARF)
- rapid loss of renal function, increasing N-substances, decrease in GFR and urine production, disturbance of ionic balance (life-threatening is especially hyperkalaemia)
- potentially reversible
- ETIOLOGY:
 - Prerenal: heart failure, hypovolemia, hypotension, sepsis
 - Renal: glomerulonephritis, interstitial tubulonephritis, drug-induced
 - Postrenal: urinary tract obstruction
- classification : RIFLE, AKIN (according to KDIGO)

Acute kidney injury - classification

Table 1. RIFLE Classification System

Stage	Glomerular Filtration Rate (GFR)	Urinary Output
1: Risk	SCr increased to 1.5-2 times baseline, <i>or</i> GFR decreased to <25%	<0.5 mL/kg/h in <6 h
2: Injury	SCr increased to 2-3 times baseline, <i>or</i> GFR decreased to <50%	<0.5 mL/kg/h in >12 h
3: Failure ^a	SCr increased by >3 times baseline, <i>or</i> GFR decreased by 75%, <i>or</i> SCr ≥4 mg/dL; acute rise ≥0.5 mg/dL	<0.3 mL/kg/h over 24 h, <i>or</i> anuria lasting >12 h

^a Requires renal replacement therapy.

RIFLE: Risk, Injury, Failure, Loss, and End-stage kidney disease; SCr: serum creatinine.

Source: References 10,11.

KDIGO definition of acute kidney injury

Stage	Creatinine Criteria	Urine Output Criteria
1	Cr 1.5-1.9 times baseline, OR Cr increase >0.3 mg/dL	< 0.5 ml/kg/hr x 6-12 hours
2	Cr 2-2.9x baseline	<0.5 ml/kg/hr for >12 hours
3	Cr > 3x baseline, OR Cr > 4 mg/dL, OR Initiation of dialysis	<0.3 ml/kg/hr for >24 hours, OR Anuria > 12 hours

Patients are staged based on the single most concerning feature.

Chronic kidney disease (CKD)

- Slow progressive process, with renal function declining over the years
- Etiologically: diabetic nephropathy, hypertensive nephrosclerosis, polycystic kidneys, chronic glomerulonephritis
- Classification:
 - according to the GFR
 - according to albuminuria

**Prognosis of CKD by GFR
and albuminuria categories:
KDIGO 2012**

Persistent albuminuria categories Description and range		
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 per 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			

> 1,5
1 – 1,49
0,75 – 0,99
0,5 – 0,74
0,25-0,49
< 0,25

Low risk (if no other markers of kidney disease, no CKD)	Moderately increased risk	High risk	Very high risk
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Case report 1 – *Sportsman*

A young man, 19 years old, comes to your clinic for chest pain. Its were formed about 3 hours ago when he was in the gym and doing bench-press. Its haven't stopped since. It is a dull pain, it is related to movement. His uncle had a heart attack recently, so he's afraid he has it too.

Medical report:

PH: sine

Medication: sine

Alergies: neg.

Abusus: smoker about 5 a day from the age of 15, negates drugs and alcohol

Case report 1 – *Sportsman*

Urine - chemically		Urine - sediment		BB				
pH	6,0	Leucocytes	0	Na	132-142 mmol/l	138		
Proteins	0	Erythrocytes	0	K	3,5-5,2 mmol/l	4,2		
Glucosis	0	Bacteries	0	Cl	97-108 mmol/l	101		
Urobilinogen	0	Mucus		Urea	1,7 – 8,3 mmol/l	6,0		
Bilirubin	0	Epithelium flat	0	Krea	44–110 µmol/l	127		
Ketones	0	Epithellium round	0	GFR	> 1,5 ml/s/1,73m ²	1,16		
Nitrites	0			Gly	3,9 - 5,5 mmol/l	4,6		
Leukocytes	0	Appearance	clear	CRP	1 – 10 mg/l	2		
Blood	0	Colour	yellow	TnT	1-14 ng/l	8		

Case report 1 – *Sportsman*

Concusion:

- The patient is an athlete, he goes to the gym often and he takes **creatine supplements** – he de not have AKI, only the preanalytic phase was affected by non-standard conditions with increased creatinin production and intake
- Yyou ask the patient not to take these products for a week and come back for a check-up after 48 hours of non exercising

Case report 1 – *Sportsman*

Urine - chemically		Urine - sediment		BB			
pH	6,0	Leucocytes	0	Na	132-142 mmol/l	138	138
Proteins	0	Erythrocytes	0	K	3,5-5,2 mmol/l	4,2	4,2
Glucosis	0	Bacteries	0	Cl	97-108 mmol/l	101	101
Urobilinogen	0	Mucus		Urea	1,7 – 8,3 mmol/l	6,0	6,0
Bilirubin	0	Epithelium flat	0	Krea	44–110 µmol/l	127	87
Ketones	0	Epithellium round	0	GFR	> 1,5 ml/s/1,73m ²	1,16	1,85
Nitrites	0	Appearance	clear	Gly	3,9 - 5,5 mmol/l	4,6	4,6
Leukocytes	0	Colour	yellow	CRP	1 – 10 mg/l	2	2
Blood	0			TnT	1-14 ng/l	8	8

Case report 2 – *Too honest family*

- The family brings a completely devastated patient, 89 years old woman, to your internal medicine clinic. The daughter reports mother had diarrhea, vomiting, anorexia for the last 3 days, the mother practically does not eat, she drinks a maximum of 0.5 liters of water a day or Coca-Cola in spoons.
- The condition gradually worsens, she vomits more and more, the anorexia worsens, she is getting weaker, she can't even walk anymore, she collapsed in the morning, so the family no longer knows what to do.
- However, the daughter says, that the mother takes her chronical medication honestly every morning...

Case report 2 – *Too honest family*

Medical history:

PH: CAD, st.p. STEMI of anterior wall 1998, chronical heart failure due to CAD, atrial fibrilation – med. Warfarine, hypertension, st.p. breast cancer (in remission, disp. oncology)

Medication: Prestance 5/5mg tbl 1-0-0

Furon 40mg tbl 1-1-0

Concor cor 5mg tbl 1-0-0

Verospiron 25mg tbl 0-1-0

Digoxin 0,125mg tbl 1-0-0

Warfarin 5mg tbl dle INR

Allergies: neg.

Abusus: non-smoker, no drugs or alcohol

Case report 2 – *Too honest family*

Vitals:

BP 80/40 mmHg, pulse 40 bpm irreg (atrial fibrillation)

conscious, oriented, slowed psychomotor pace, decreased skin turgor
heart rate irreg, breathing alveolar clean

Abdomen soft, no pain, peristaltics +
legs without swelling

Case report 2 – *Too honest family*

BB		
Na	132-142 mmol/l	141
K	3,5-5,2 mmol/l	7,5
Cl	97-108 mmol/l	106
Urea	1,7 – 8,3 mmol/l	64,2
Krea	44–110 µmol/l	984
GFR	> 1 ml/s/1,73m ²	0,06
Gly	3,9 - 5,5 mmol/l	6,2
CRP	1 – 10 mg/l	3

Hyperkalemia (+ betablocker + digoxin) causes bradycardia

Hyperkalemia is caused by renal failure + medication which elevates potassium levels (aldosteron blocker + ACEi)

Hyperuraemia leads to uremic syndrome with nausea and vomiting

Nausea, vomiting and diarrhea lead to dehydration. State is even worse, that patient is still using her chronical medication with diuretics ... it leads to prerenal kidney injury.

Case report 2 – *Too honest family*

Conclusion:

- The patient has acute renal failure most likely of prerenal etiology with severe dehydration and hypotension
- Due to bradycardia (and a history of collapse) and potassium 7.5, she is indicated for acute HD, but due to age and condition (fragile elderly lady), it is possible to conservatively hydrate the patient on the monitored bed.

Case report 3 – *Swelling of the lower limbs does not have to be caused the heart*

- The patient, man, 56 years old, comes to his general practitioner in the middle of December 2018, saying that his limbs are swollen for the last month – right limb more, he feels more tired overall.
- Due to asymmetric swelling, the patient was sent for vascular examination, deep vein thrombosis was detected in the right limb, DOAC (Rivaroxaban) was used; but due to the swelling of both limbs the patient was issued a request for a complete internal examination
- The next day, the patient wakes up with leaky eyelids, he breathes heavily after standing, swelling of the limbs is still progressive, he comes to the internal medicine...

Case report 3 – *Swelling of the lower limbs does not have to be caused the heart*

Medical history:

PH: hypertension, astma bronchiale allergy, sekundary artrosis of talocrural joint, recently treated DVT of right leg

FA: Agen (Ca blocker) 5mg 1-0-0

Controloc (PPI) 40mg 1-0-0

Alvesco 1 inbreathe in the evening

Xarelto 20mg tbl 1-0-0

Alergies: dust, pollen

Abusus: non-smoker, no drugs or alcohol abuse

Case report 3 – *Swelling of the lower limbs does not have to be caused the heart*

Vitals and other examination:

BP 170/80 mmHg, pulse 66 bpm

conscious, well oriented, resting eupnoea, without jaundice, swollen eyelids,

HB reg, breathing generally quiet, weakened basally with crackles

Abdomen in niveau, soft, painless, subcutaneous penetration

lower limbs with swelling to the groin

EKG: low voltage

RTG of chest: pleural effusion bilat., heart shadow dilated in both directions

Echokardiography: pericardial effusion, otherwise normal EF

Case report 3 – *Swelling of the lower limbs does not have to be caused the heart*

Urine - chemically	
pH	6,0
Proteins	4
Glucosis	0
Urobilinogen	0
Bilirubin	0
Ketones	0
Nitrites	0
Leukocytes	0
Blood	0

Urine - sediment	
Leucocytes	0
Erythrocytes	0
Bacteries	0
Mucus	0
Epithelium flat	0
Epithellium round	0
Appearance	Turbid
Colour	yellow

BB		
Na	132-142 mmol/l	131
K	3,5-5,2 mmol/l	4,4
Cl	97-108 mmol/l	102
Urea	1,7 – 8,3 mmol/l	23,0
Krea	44–110 µmol/l	284
GFR	> 1,5 ml/s/1,73m ²	0,33
Gly	3,9 - 5,5 mmol/l	4,9
CRP	1 – 10 mg/l	1
Alb	36-63g/l	22,8

Urine collection:
Albumin 776 mg/l
Proteins 3,7 g/24h

Lipids:
Cholesterol 8,4
TAG 6

Case report 3 – *Swelling of the lower limbs does not have to be caused the heart*

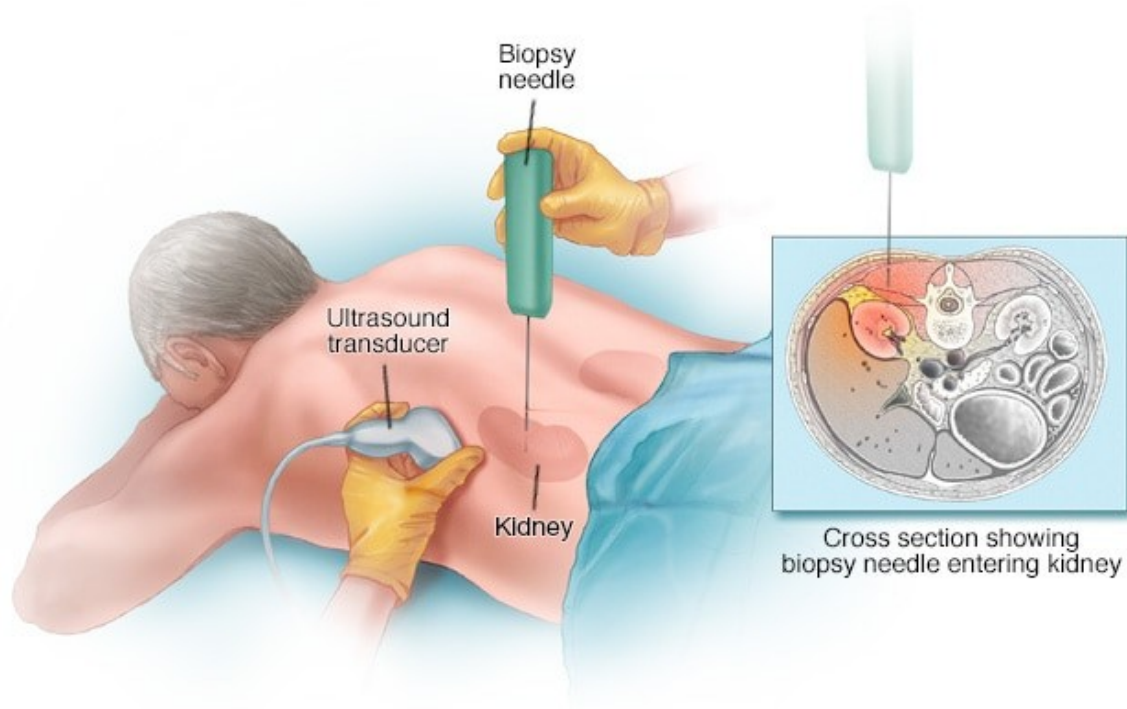
Conclusion 1:

- The performed examinations show that the patient suffers from nephrotic syndrome:
 - proteinuria > 3.5 g/24 hours
 - hypalbuminemia (below 30g/l)
 - peripheral edema
 - hypercholesterolemia > 8 mmol/l
- The cause of nephrotic syndrome is usually glomerulonephritis = biopsy verification required

Case report 3 – *Swelling of the lower limbs does not have to be caused the heart*

Renal biopsy

- Invasive procedure, we obtain a sample of kidney tissue under ultrasound control
- The patient is monitored after the procedure, including urine ch + s

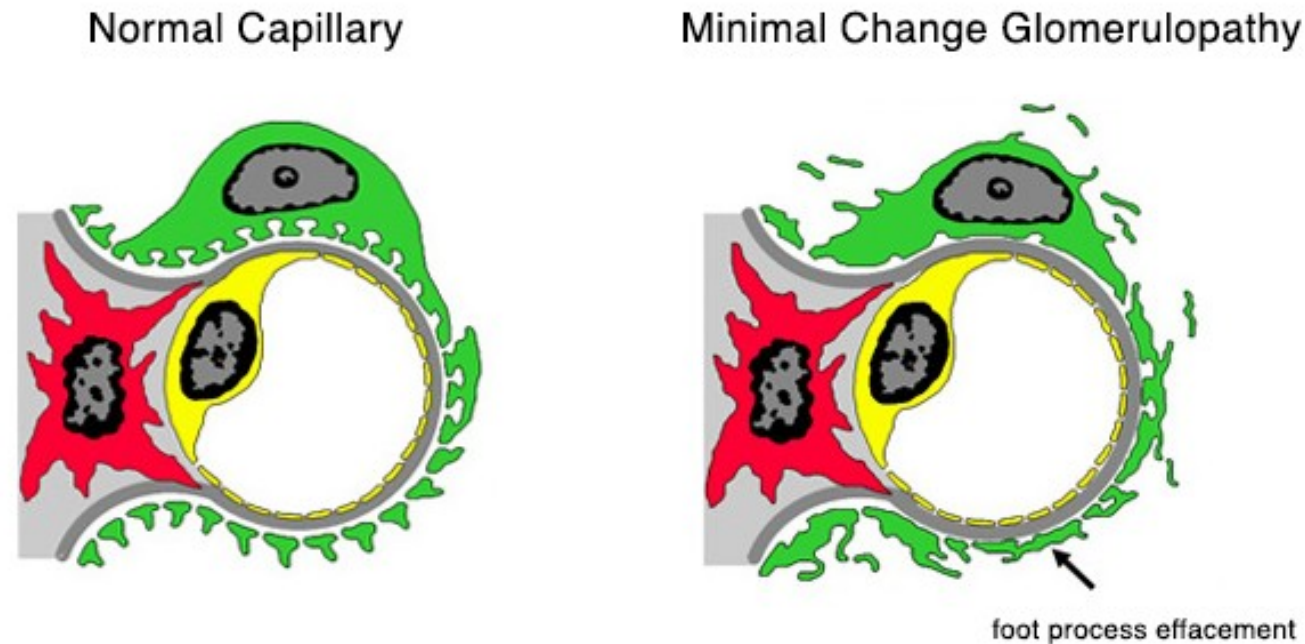


Urine - sediment		0	+4	+8	+12	+24
Leukocytes	0	0	0	0	0	0
Erythrocytes	0	1	4	3	1	0
Bacteria	0	0	0	0	0	0
Mucus	0	0	0	1	0	0
Epitelia	0	0	0	0	0	0

Case report 3 – *Swelling of the lower limbs does not have to be caused the heart*

Conclusion 2:

- The biopsy revealed a minimal change disease



- Corticosteroid therapy initiated with a very good effect

Case report 3 – *Swelling of the lower limbs does not have to be caused the heart*

BB		GP 01/2017	2 years without controll		18.12. 2018	26.12. 2018	29.12. 2018	18.1. 2019		
Na	132-142 mmol/l				131	137	136	142		
K	3,5-5,2 mmol/l				4,4	4,3	3,9	4,7		
Cl	97-108 mmol/l				102	104	104	102		
Urea	1,7 – 8,3 mmol/l	6,9			23,0	18,9	10,2	5,7		
Krea	44–110 µmol/l	80			284	162	99	93		
GFR	> 1 ml/s/1,73m ²				0,33	0,65	1,18	1,27		
Gly	3,9 - 5,5 mmol/l				4,9					
CRP	1 – 10 mg/l				1					
Alb	36-63g/l				22,8	28	35	42,5		

Case report 4 – „*Unnecessary*“ *permanent urinary catheter*

- The patient, 88 years old, was transferred to your internal department from a psychiatric hospital, where he was hospitalized for a dementia syndrome with delirious conditions to set up psychiatric medication.
- Before admission to a psychiatric hospital in terms of internal – the patient was stable, kidney stage CHRI CKD3a
- In a psychiatric hospital, the development of swelling of the lower limbs, Furosemide increased in medication, the swelling does not flare up too much due to this medication
- Therefore, blood samples were taken and, with reference to them, a translation of the patient to the internal clinic / see below /

Case report 4 – „*Unnecessary*“ PUC

Medical history:

PH: Dementia Syndrome, probably vascular etiology, behavioral disorders
Chronic heart failure due to CAD, st.p. decompensation 2016
Prostate Ca (2006) pT1c (T3) N0 M0G 3 (combined Gleason score 3 + 5), low-differentiated acinar prostate adenocarcinoma, stp. neoadj. hormone therapy, stp. RT on the prostate and small pelvis
Macrocytic anemia from B12 and folic acid deficiency
Mixed hyperlipidemia
Hypothyroidism, for substitution
St.p. herpes zoster reg. glutei lat. hall. v.s. 2016
St.p. stroke 2007 according to doc.

Med.: Nalpaza 40 mg tbl 1-0-0 Carsaxa 100 mg tbl 0-1-0 Ketilept 25 mg tbl 0-0-1
Letrox 50 mg tbl 1/2- 0-0 Mirtazapin 15 mg tbl 0-0-1 Memigmin 10 mg tbl 2-0-0
Furon 40 mg tbl 1-0-0

Allergies: neg. **Abusus:** neg.

Case report 4 – „*Unnecessary*“ PUC

Vitals:

Conscious, manifestations of dementia - confused, unfocused

HR reg, breathing alveolar, clean

abdomen soft, **palpable resistance in the lower abdomen, painful under pressure**, peristaltics present

lower limbs swollen to half shin

Case report 4 – „*unnecessary*“ PUC

- **Conclusion:**

- The patient has acute renal failure which has developed within a month
 - the renal cause unlikely in his age (glomerulonephritis not suspected)
 - prerenal cause of dementia (decreased fluid intake) and furosemide drainage may be affected
 - tactile resistance in the lower abdomen is the bladder, after the introduction of PUC drains 2.5 liters of urine
- The patient is after radiotherapy due to carcinoma of prostate, he has a stricture of the ureter and should have PUC permanently - after admission to Psychiatry dep. it is pulled out and not placed back again by mistake
- After the instillation of PUC, the renal parameters are rapidly corrected, intercurrent infection is cured by ATB

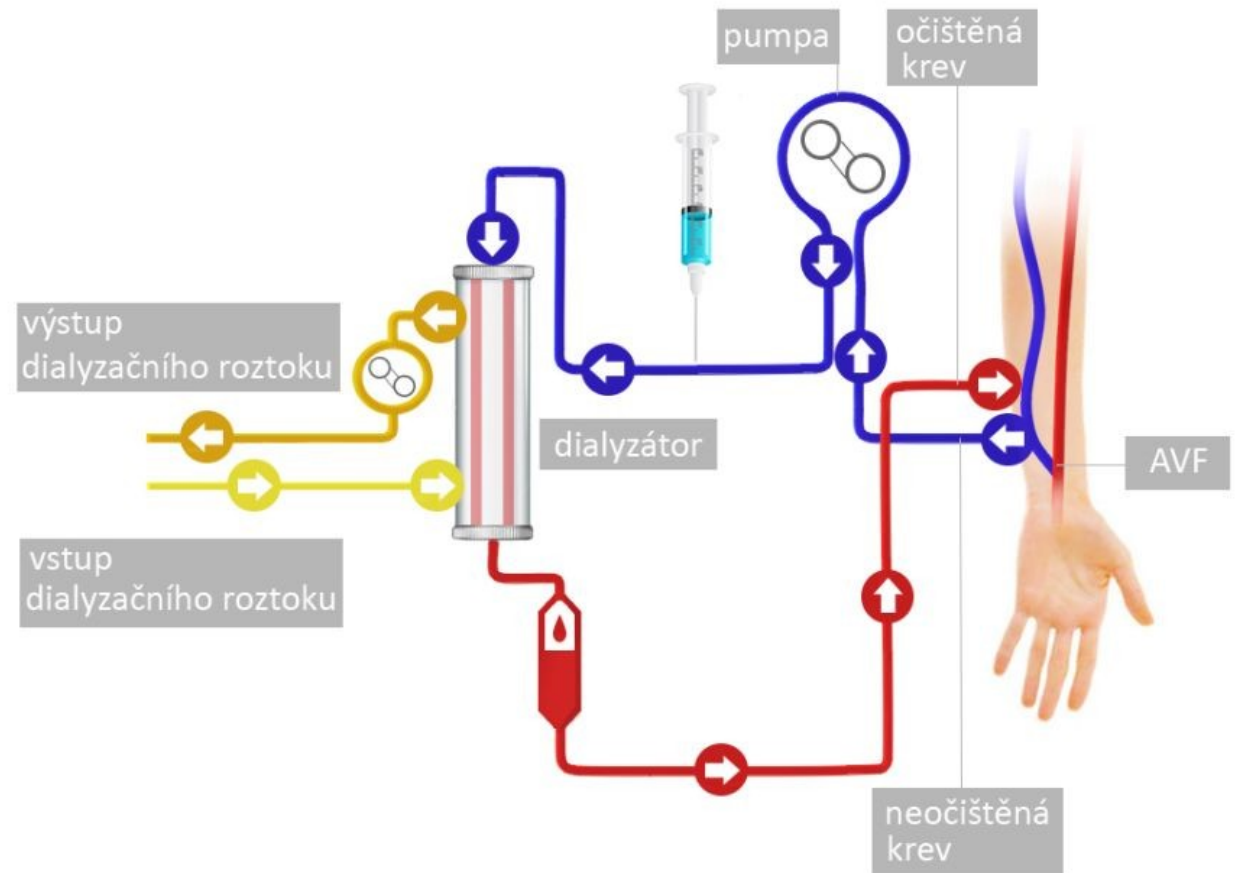
A decorative graphic consisting of two thick, curved bands. The left band is blue and the right band is green. They are positioned around a central white area, creating a partial circular frame. The bands have a slight gradient and a soft shadow effect.

Elimination techniques

Jan Novák

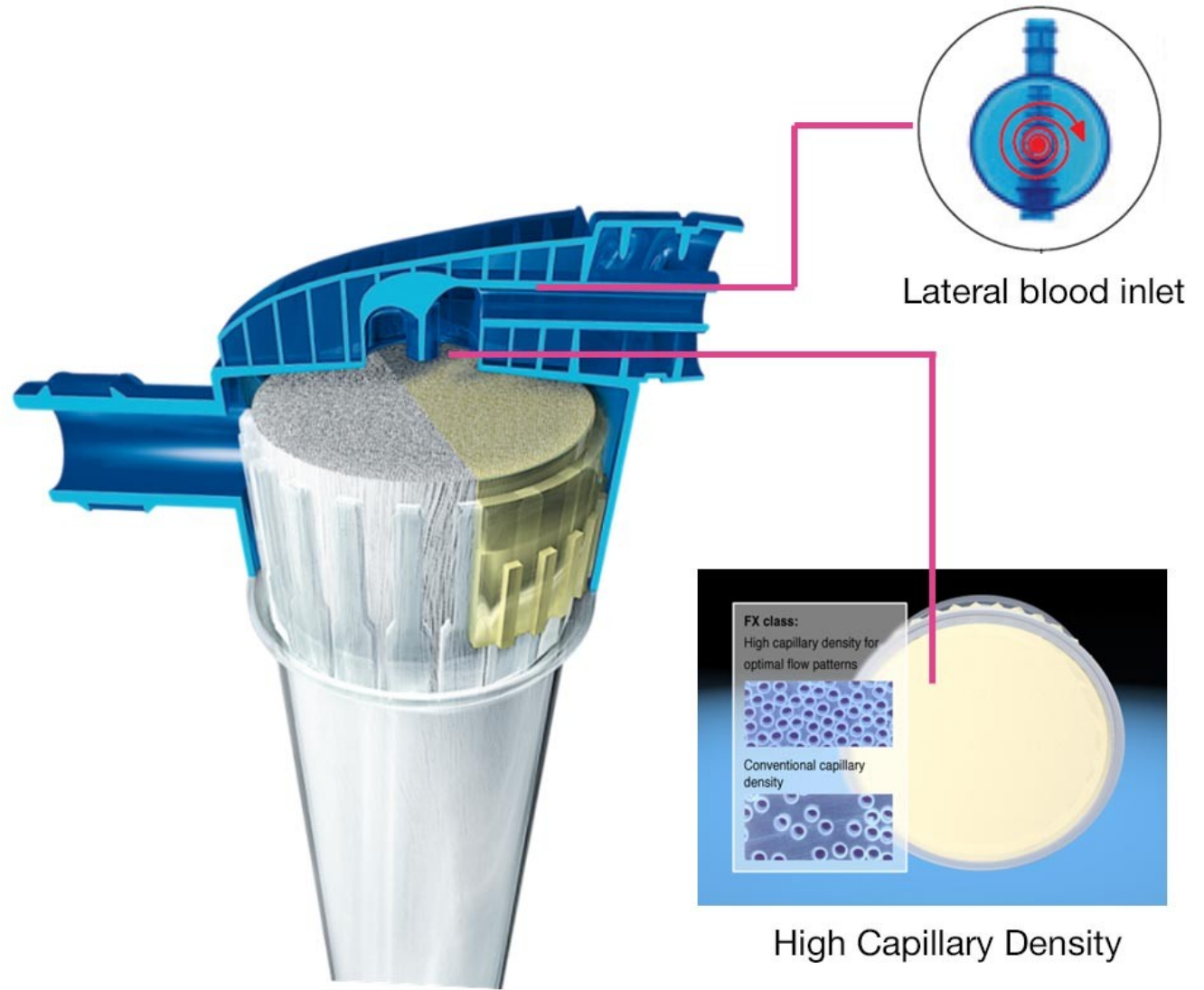
Hemodialysis

- Blood from the patient's body is pumped into the capillary of the device
- Here, N / toxic substances pass into dialysis solution after a concentration gradient - dialysis solution, thereby purifying the patient's blood



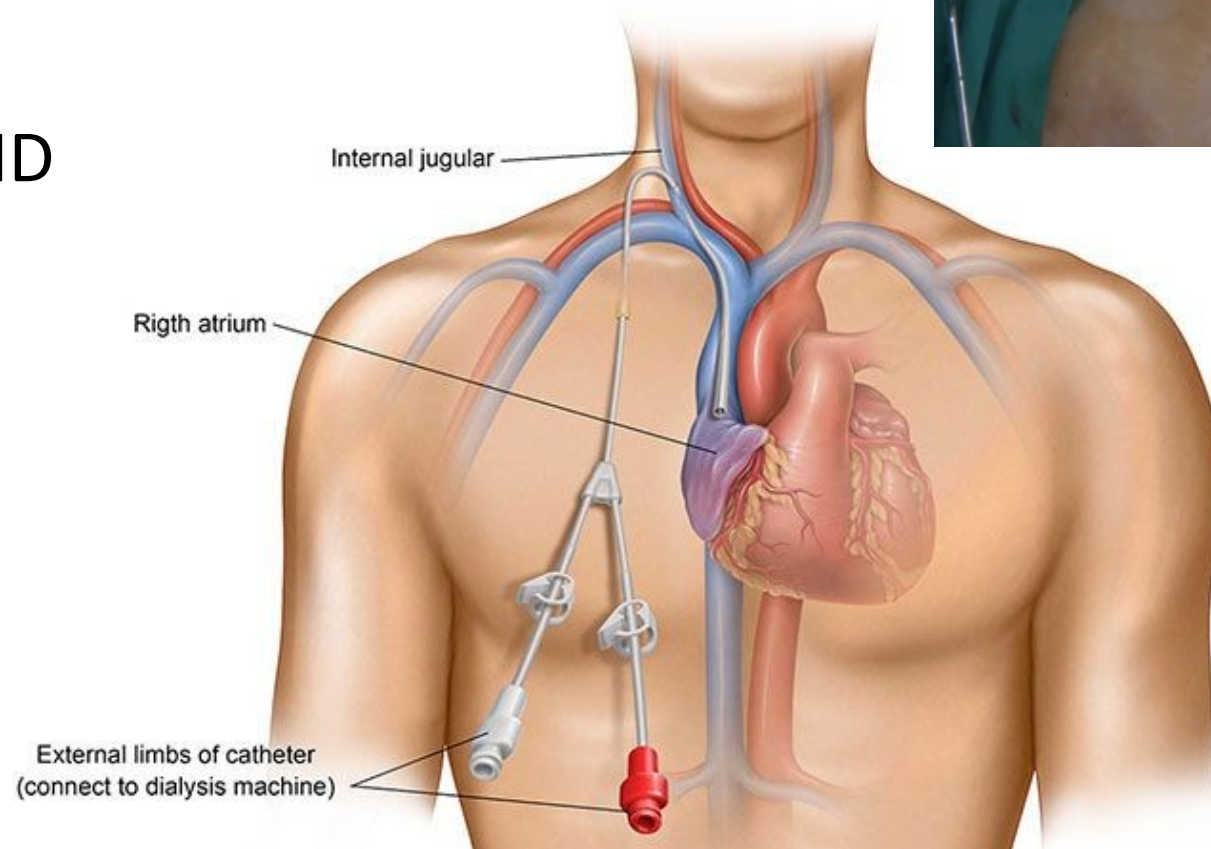
Hemodialysis

- Dialysis capillary is a system of very small tubes formed by a highly permeable membrane, inside which blood flows and which are washed with a dialysis solution
- Countercurrent system



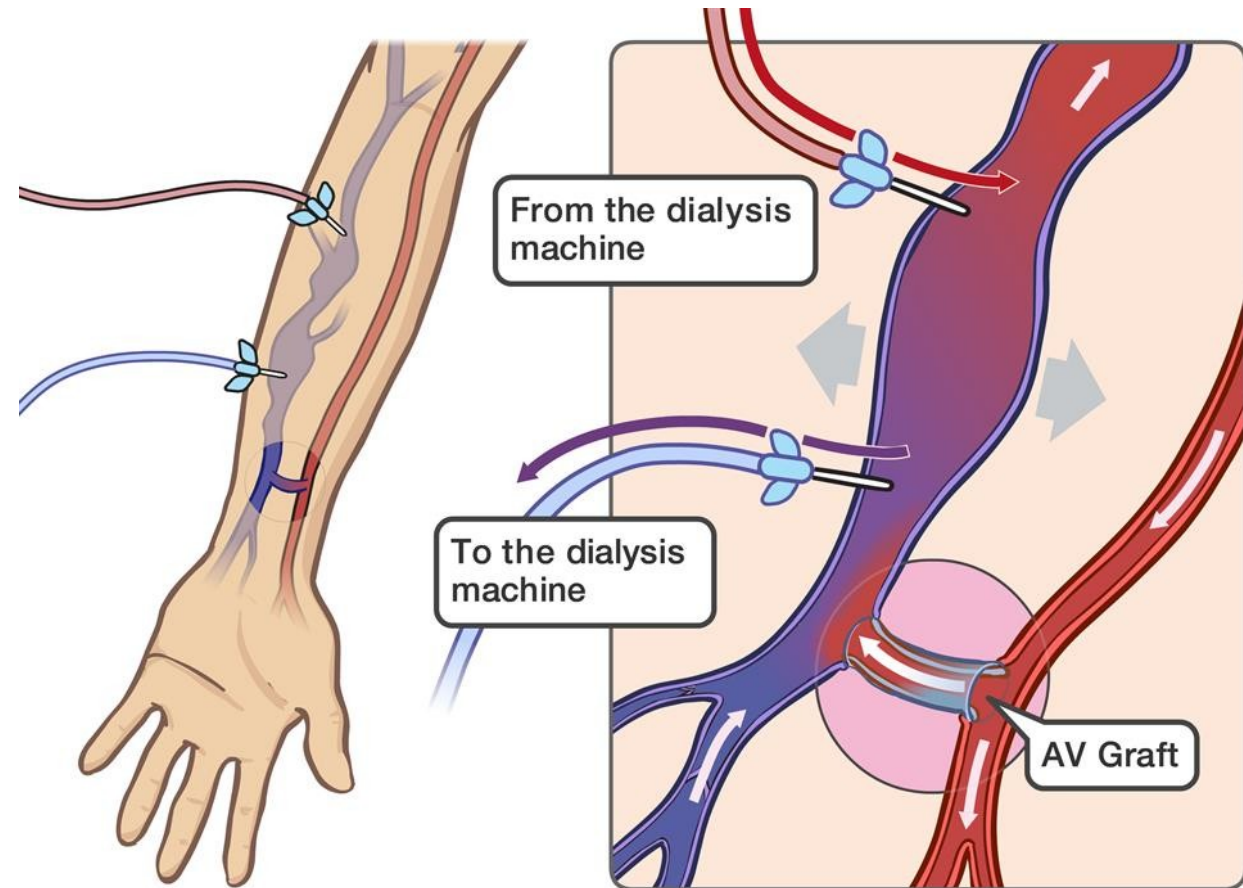
Hemodialysis - access

- Acute HD = temporary intravenous HD catheter
 - V. Jug. Int.
 - V. Subclavia
 - V. femoralis



Hemodialysis - access

- Chronic HD
 - PermCath
 - V. Jug. Int.
 - V. Subclavia
 - V. femoralis
 - Translumbar
 - AV shunt



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Hemodialysis

Indications to acute HD

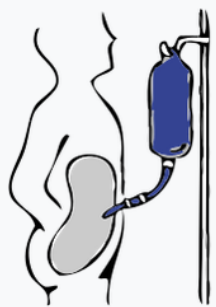
- Hyperkalemia > 6 mmol / l
- Hypercalcaemia > 3.5 mmol / l
- Hyperuricemia > 1000 μ mol / l
- uncorrectable metabolic acidosis, pH <7.1
- hyperhydration with heart failure
- oligouria lasting longer than 3 days
- intoxication with low molecular weight water-soluble substances

Hemodialysis

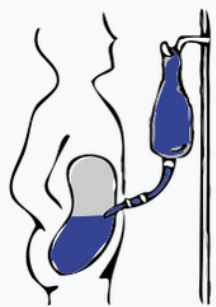
Indications to chronic HD program:

- urea > 30 mmol/l,
- creatinine 600–800 $\mu\text{mol/l}$,
- clearance of creatinine < 0,25 ml/s

Peritoneal dialysis



Připojení



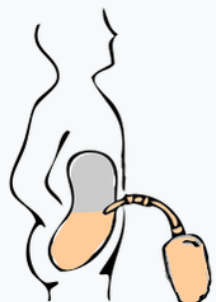
Infuze



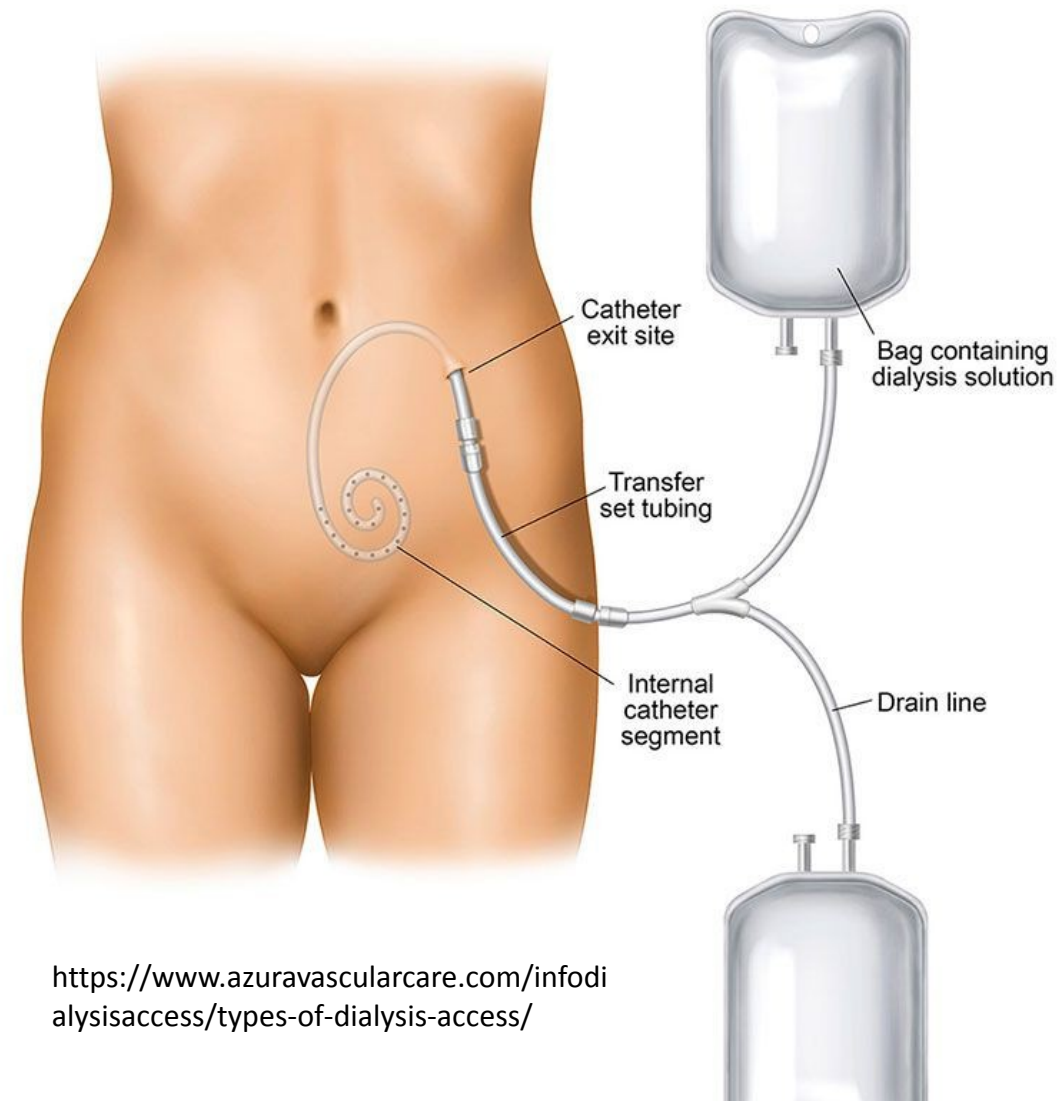
Difuze (čerstvý roztok)



Difuze (odpadní roztok)



Odvod kapaliny



<https://www.azuravascularcare.com/infodialisaccess/types-of-dialysis-access/>

Case report 1 – *From predialysis to dialysis*

- A 45-year-old patient with CKD based on diabetic nephropathy and hypertensive nephrosclerosis has been monitored in your nephrology clinic for many years.
- Despite proper treatment of blood pressure and diabetes over the years, you can see a gradual decline in renal function, progression of CKD, the patient stops urinating, his lab results worsen (levels of Ca, P,...), so you agree to start HD.

BB		2015	2016	2017	2018					
Urea	1,7 – 8,3 mmol/l	17,2	20,0	20,7	40,0					
Krea	44–110 µmol/l	276	357	353	642					
GFR	> 1 ml/s/1,73m ²	0,46	0,33	0,34	0,16					

Case report 1 – *From predialysis to dialysis*


- The patient goes to a vascular examination - he has good quality vessels on both upper limbs, so an AV shunt is created on a non-dominant upper limb
- After the operation, you wait about 4 weeks for AV shunt to dilate and gain its function, after that you can start regular dialysis treatment twice a week.

BB		2015	2016	2017	2018	after HD	before HD	after HD	before HD	after HD
Urea	1,7 – 8,3 mmol/l	17,2	20,0	20,7	40,0	18,5	34,1	16,7	17,4	5,0
Krea	44–110 µmol/l	276	357	353	642	262	502	357	588	287
GFR	> 1 ml/s/1,73m ²	0,46	0,33	0,34	0,16	0,49	0,14	0,21	0,11	0,46


Case report 1 – *From dialysis to kidney transplant*

- The patient gradually gets from the HD program twice a week to the three times a week program and at the same time is included in the waiting list for patients for kidney transplantation.
- A suitable cadaveric donor appears for the patient after about 2 years.

BB		21.7.	22.7.	23.7.	24.7.	25.7	28.7.	1.8.	14.8.	1.9.	10.9.
Urea	1,7 – 8,3 mmol/l	25,1	31,5	33,5	34,1	30,7	31,5	25,0	19,3	7,2	6,0
Krea	44–110 µmol/l	766	759	728	502	357	297	236	178	99	91
GFR	> 1 ml/s/1,73m ²	0,08	0,08	0,09	0,14	0,21	0,26	0,34	0,48	0,98	1,09



Transplantation of kidney



dimision

Case report 2 – *Peritoneal dialysis*

Patient, 54 years old, with CKD based on chronic IgA nephropathy + FSGS (biopsy verified 2006). He also has nephrogenic anemia, hypertension and hyperparathyroidism, treated with DM2T, is after radical prostatectomy for prostate Ca.

Gradually, over the last year, the renal function worsened, so the patients need renal replacement therapy (RRT).

ZBV		11/2019	5/2020	6/2020	7/2020				
Urea	1,7 – 8,3 mmol/l	29,0	35,9	36,8	35,1				
Krea	44–110 µmol/l	401	521	588	580				
GFR	> 1 ml/s/1,73m ²	0,23	0,17	0,14	0,15				



Start of RRT

Case report 2 – *Peritoneal dialysis*

The patient is an active businessman, he does not want to come to the hospital for hemodialysis twice or three times a week.

He prefers a peritoneal dialysis, therefore the Tenckhoff catheter was operated and the peritoneal dialysis program started.

Regime:

1. **Filling** (within 15 minutes, 2300 ml of solution), 1st filling in the evening
2. **Delay** (time when the solution is in the peritoneal cavity: 1h 28 minutes), then draining
3. This cycle **runs 4 times during the night** by an automatic device
4. After the last change, fill with 500 ml and drain in the evening before the next cycle

Case report 2 – *Peritoneal dialysis*

Patients in a chronic peritoneal dialysis program tend to have higher urea and creatinine levels than they would on a hemodialysis program.

They will get used to them in the long run.

In the event that the diuresis disappears, solutions with a higher osmolarity are used, which osmotically withdraw water from the body (then the patient fills about 2300 ml and discharges 2500 or more ml)

BB		11/2019	5/2020	6/2020	7/2020	8/2020	9/2020	10/2020	
Urea	1,7 – 8,3 mmol/l	29,0	35,9	36,8	35,1	21,6	24,5	25,0	
Krea	44–110 μ mol/l	401	521	588	580	543	540	590	
GFR	> 1 ml/s/1,73m ²	0,23	0,17	0,14	0,15	0,16	0,16	0,14	



Start of PDP



**Thank you for your
attention!**