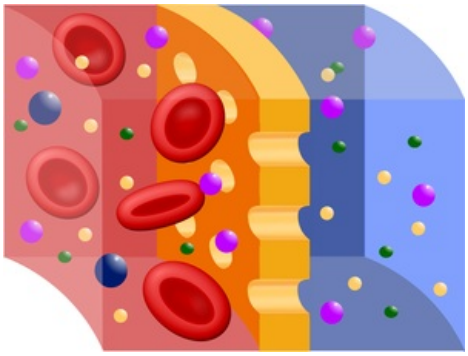
Hemodialysis

If the kidneys are not able to perform their basic functions (ie dialysis, resorption and filtration) even under resting conditions, we speak of kidney failure. Dialysis is a process in which metabolic waste products (eg potassium, urea, excess water) are trapped in the body during kidney failure.

Principle of dialysis

Hemodialysis

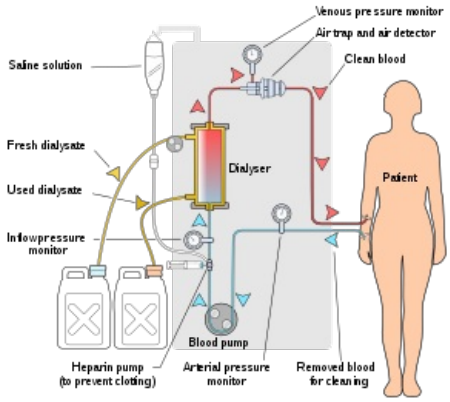
The device that allows this process is known as **an artificial kidney.** This modern device is very technically demanding and high demands are placed on it in terms of efficiency, reliability, safety and ease of use. Hemodialysis is usually performed in a hospital or special dialysis centres with the help of trained nurses, home dialysis is not very common in the Czech Republic, but it can be performed with the assistance of a trained family member. The patient usually undergoes hemodialysis about three times a week for four to six hours. The artificial kidney consists of three basic parts: the **extracorporeal** (extracorporeal) **circulation of the patient's blood**, **the dialyzer** and **the circuit ensuring the flow of dialysis solution**.



The semipermeable membrane, which separates blood and dialysis fluid in the dialyzer, which is not in direct contact, passes through the membrane only with substances of small molecular size.

Extracorporeal blood circulation

This part of the process is performed by a circuit that pumps the patient's venous blood using rotary pumps through a dialyzer under more or less the same hemodynamic conditions as in the patient's body. Because the blood here comes into contact with a surface other than the vascular endothelium, there is a risk of thrombi. Therefore, most patients are **heparinized** (only patients with bleeding conditions are contraindicated). The circulation also includes sensors that control the formation of air bubbles in the blood, which could be a source of embolization.



Hemodialysis scheme, arrows indicate the direction of blood flow that flows from bottom to top in the dialyzer, while dialysis fluid flows from top to bottom (vice versa) to maintain the gradient required for the passage of substances through the semipermeable membrane.

Dialyser

The dialyzer, or **capillary**, is the main functional unit of the artificial kidney. The dialysis itself (physically it is a process in which substances of different sizes and solubilities are separated from each other) and the ultrafiltration of substances and water from the blood into the dialysis solution takes place through **a semipermeable membrane** (see picture). Membranes of animal origin (eg fish bladders, intestines) were used as filters in the first experiments, but now mainly **artificial membranes** are used, eg cellophane, glucose esters or some modern plastic (Cuprophan), which unfortunately may have the ability to stimulate immune patient system (of course less than the original materials) - therefore the number of dialyses may increase the risk of transplant rejection in the future. The membrane can be arranged in the dialyzer either in the form of leaves or a large number of thin tubes - the aim, of course, is to keep the effective area as large as possible. The membrane thus divides the dialyzer into the blood and a dialysate part. On one side of the membrane, the blood flows through a laminar flow, during which the erythrocytes accumulate in the flow axis and the membrane is thus more washed by the plasma. The volume flow here is approx. 200-300 ml / min. On the opposite side of the membrane, the dialysis solution flows in the opposite direction by turbulent flow, the volume flow here is about 500 ml / min. In this way, the required concentration gradient and thus rapid diffusion of toxic low-molecular substances from the patient's blood into the dialysate is achieved. Dialyzers are usually disposable, but they can be used more than once in the same patient, the efficiency does not decrease in this way (but disposable capillaries are currently used).

Dialysate circuit

This circuit involves both the preparation of the solution and its flow through the dialyzer. The dialysate is prepared by mixing a concentrated sodium bicarbonate solution prepared in a company or a pharmacy with treated water. It is very important that the dialysis solution contains electrolytes at approximately the same concentration as in the plasma and has the correct pH so that the acid-base balance of the patient is not disturbed. At the same time, by adding some ions, especially K + and Ca 2+, (again using preformed solutions supplied by the company) it is possible to correct ionic imbalances. Glucose can be added to the dialysate, paradoxically in patients who are type 1 diabetics, because they are at risk of hypoglycemia during dialysis (due to the dialysis itself, but also insulin dosing, which is normal for the patient, but glucose intake is lower). It is important to control and maintain a constant temperature during the process. Consumption of dialysates in 4-6 hour hemodialysis is about 150 litres.

Types of dialysis

Acute hemodialysis

Acute dialysis is used **in emergencies** where the patient's body is unable to clear itself of endogenous or exogenous toxic substances, fluid volume, or ions. Indications for acute dialysis include the following conditions:

- **acute renal failure** - such as rapidly progressing glomerulonephritis (RPGN),
- **hyperkalaemia** > 6 mmol / l, which cannot be managed with conservative therapy,
- **hypercalcaemia** > 3.5 mmol / l,
- **hyperuricaemia** > 1000 µmol / l,
- uncorrectable **metabolic acidosis**, pH <7.1,
- **hyperhydration** with heart failure,
- **oliguria** lasting longer than 3 days,
- **intoxication** with low-molecular water-soluble substances which remain in free form in the bloodstream after intoxication - eg ethylene glycol (fridex - antifreeze mixture), lithium. Other poisons can be eliminated by hemoperfusion, ie adsorption on activated carbon, which is performed by supplementing the hemodialysis device with a hemoperfusion cartridge (eg green toadstool poison, paracetamol, some antidepressants).

Among the generally accepted principles of acute dialysis is to consider whether it is not possible to manage some of these conditions with conservative therapy (ion breakdowns, disorders of the internal environment) because dialysis is a method that **burdens the body** (cardiovascular system, immune system). In acute dialysis, **a central venous catheter** (CVC) is used as input. Dialysis frequency as needed.

Chronic hemodialysis

Chronic hemodialysis is used in patients who have usually developed renal failure despite chronic renal insufficiency (stage 5 according to K / DOQI), a condition in which even under basal conditions their body is unable to get rid of excess metabolites, fluid volume and correct internal environment (pH, ions). Patients usually go on dialysis 3 times a week, dialysis for 4-6 hours. Of the vascular approaches, **an arteriovenous shunt** between the radial artery and the cephalic vein is preferred: If contraindicated (heart failure), a central venous jugular catheter is used. This treatment is for life or kidney transplantation.

Indications for dialysis (in diabetics previously):

- **urea > 30 mmol/l**,
- **creatine 600–800 µmol/l**,
- **clearence creatinine < 0,25 ml/s**.

300px|thumb| **Patient on dialysis** (https://upload.wikimedia.org/wikipedia/commons/2/2f/Patient_receiving_dialysis.jpg) Diseases that lead to hemodialysis are:

- **diabetic nephropathy,**
- **hypertensive nephropathy,**
- **chronic glomerulonephritis**,
- **rapidly progressing glomerulonephritis** (RPGN) - when it reaches irreversible fibrotic changes,
- **autosomal dominant polycystic kidney disease.**

In patients for whom dialysis is expected, we should first contact the Transplant Coordination Center or the IKEM Transplant Surgery Clinic to ensure the possibility of kidney transplantation as soon as possible. We should also treat anaemia (erythropoietin), which most patients with renal failure suffer from, and carry out preventive vaccination against hepatitis B (the development of which is a reason for delaying transplants and shortening survival). Acute complications of hemodialysis include **hypotension** (from a sudden loss of circulating fluid volume), **convulsions** (decrease in Na +, K +, Ca2 +), **arrhythmias** (sudden hypokalaemia) and **bleeding** at the vascular access site (related to heparinization). Chronic complications of hemodialysis include **cardiovascular complications** (CHD, myocardial infarction, CMP, hypertension, which are more common in dialysis patients than in the general population), **infections** (hepatitis B and hepatitis C), **amyloidosis** (beta2-microglobulin).

Complications in chronic dialysis

- heart failure
- infection
- anaemia

Links

Related artical

- Vascular approaches for dialysis
- Peritoneal dialysis
- Kidney transplantation

References

- ČEŠKA, Richard, et al. *Interna.* 1. edition. Praha : Triton, 2010. 855 pp. pp. 558. ISBN 978-80-7387-423-0.

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