

Replacement of kidney function

There are several methods of replacing kidney function, some of which can be described as relatively permanent solutions and others as temporary. A group of patients can be singled out for whom temporary replacement of kidney function must be provided for some acute condition, or where kidney damage is reversible. The second group consists of patients whose kidneys are irreversibly damaged and need to replace kidney function for life.

Kidney replacement methods include:

1. **kidney transplant**,
2. **hemodialysis**,
3. **peritoneal dialysis** (lavage).

Specific indications are given for each method separately (below). In general, preparing a patient for kidney replacement should begin before kidney failure occurs (no later than stage 4 chronic kidney failure), but often the sooner the better. The choice of which method should be adapted to the patient - his age (IgA nephropathy often affects young people), prognosis. **Kidney transplantation appears to be the most advantageous method of replacing kidney function**, which can be not only the most effective (return of lost function, patient independence, prolongation of survival...) but also the most economical.

Kidney transplantation

Kidney transplantation is indicated in any patient with chronic renal failure. Currently, it is a routine method of kidney function replacement, which should be preferred over others (hemodialysis, peritoneal dialysis), both from a prognostic and economic point of view.

Indication

Transplantation should be indicated for a patient who reaches stage 4 of chronic renal insufficiency according to K/DOQI in the progression of renal failure, generally the earlier the better. It would be ideal if the patient did not have to undergo another method of replacing kidney function (hemodialysis) before the transplant.

Diseases that lead to kidney failure:

1. glomerulopathy (most often IgA);
2. chronic tubular diseases;
3. diabetic nephropathy;
4. polycystic kidney disease.

In the case of a diagnosis of diabetes mellitus type I in combination with severe (terminal) diabetic nephropathy, the kidneys are transplanted at the same time as the pancreas as a combined pancreas and kidney transplantation, where the benefits of subsequent joint immunosuppressive treatment are used. A previous kidney transplantation (with subsequent immunosuppressive treatment) is also a supporting factor for the decision to perform a pancreas transplantation in a diabetic.

Contraindication

- Acute or chronic infection;
- Heart Failure;
- coagulopathy;
- AIDS;
- malignant disease;
- advanced liver or lung diseases.

Donors

Living donors

Most often they are relatives, partners, but it is not a condition. They can also be strangers. The main factor is the voluntariness of the donation and the health of the donor. In order not to endanger the donor by removing one kidney, it is necessary to assess the function of the kidney in the future, if there is no risk of, for example, glomerulonephritis?).

Deceased (cadaveric) donors

In the Czech Republic, the so-called assumed consent for donation after death applies. If a person does not express during his life that he does not want to donate organs, he is automatically considered a donor. One of the requirements is brain death proven by panangiography (2x within 30 min), then also no damage to kidney function (preserved peripheral circulation required) and cold ischemia for up to 24 hours.

Immunology

Compatibility in **blood groups** (AB0 system) is one of the most important. Transplantation is, however, also possible in case of mismatched blood groups (in the Czech Republic since January 2011). Antibodies in the event of a mismatch must be removed from the recipient's blood, for example by adsorption or plasmapheresis. If there is a match in as many **HLA features** as possible and there is a low titer of lymphocytotoxic antibodies, the cross-test will be negative. The cross-examination means that we combine the recipient's serum, the donor's lymphocytes and the complement. If the cross-test is positive, the antibodies need to be removed.

Surgical technique

1. Kidney removal;
2. placement of the graft heterotopically in the right iliac fossa (vessels are connected to the iliac artery and vein, the ureter is sutured to the bladder);
3. the original kidneys are usually left in place, where they gradually shrink and atrophy (the exception is polycystic kidneys, which are removed);
4. in most cases, only one kidney is transplanted, rarely two (the other to the left iliac fossa), when one would not be enough to restore renal function.

Postoperative development

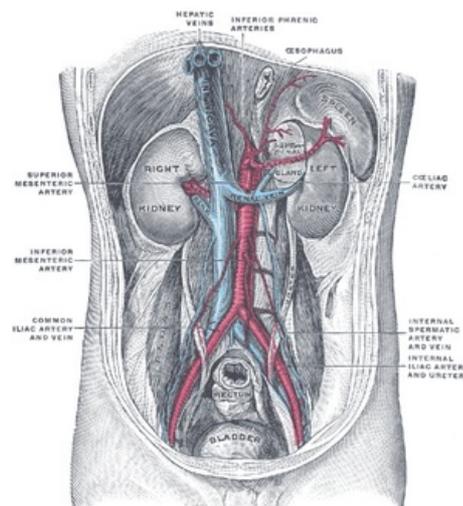
In 65 % of cases, the **kidney functions** immediately after transplantation. The patient is hydrated to begin urine formation.

In 25 %, there is a **delayed development of graft function** and the kidney does not function for a short time (days to weeks). After a certain time, the function develops, until then hemodialysis is necessary.

In 10 %, the **kidney does not function** at all due to thrombosis or unknown causes, for example due to primary afunction.

Statistical data

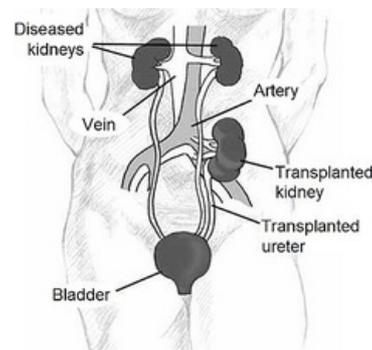
The average **waiting time for a kidney is 12 months**, which is much less than, for example, in the USA (3-4 years). This is due to the fact that many patients in our country are not indicated for transplantation, even if they could be. Up to 15 % of kidney transplants are repeat transplants. Due to a temporary rejection of the graft, which is not a contraindication to further procedure. One-year survival of patients after transplantation exceeds 95 %. Ten-year graft survival after transplantation is 50 %.



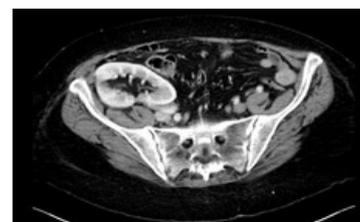
Kidney anatomy, vascular supply, syntopy in the retroperitoneum

Immunosuppression

1. **Inductive**
 - ATG - antithymocyte globulin - polyclonal antibodies against T lymphocytes
 - **basiliximab** - monoclonal antibody against the IL-2 receptor on T lymphocytes (anti CD25)
 - alemtuzumab (anti-CD52)
2. **Maintenance** - triple combination:
 - corticosteroids (prednisone);
 - basic immunosuppressants (cyclosporin A or **tacrolimus**);
 - adjuvant immunosuppressants (azathioprine, **mycophenolate mofetil**).
3. **Anti-rejection** - therapy of acute graft rejection:
 - pulse corticosteroid doses of 250-500 mg of prednisone for 3-5 days, if even doses of 2-3 g of prednisone do not take, we consider corticosteroid resistant;
 - in corticoreistance to polyclonal antilymphocyte antibodies - ATG or monoclonal basiliximab (anti IL-2R), alemtuzumab (anti CD52).



Kidney localization after transplantation



CT of the transplanted kidney in the right iliac fossa

Cyclosporin A and tacrolimus bind to cycloneurin and inhibit IL-2 expression.

Possible side effects

Adverse effects include mainly nephrotoxicity and neurotoxicity. Tacrolimus can cause receptor-type DM, so ciclosporin is used instead of tacrolimus in diabetics. Azathioprine is hepatotoxic and myelotoxic. It is therefore recommended to use mycophenolate mofetil instead. Last but not least, it is necessary to mention that other side effects include the threat of developing DM, Cushing's syndrome, osteoporosis, hyperlipidemia due to corticoids.

Complications after transplantation

1. Early:
 - graft rejection (hyperacute, acute) - treatment see above;
 - urinary fistula;

This circuit includes both the preparation of the solution and its flow through the dialyzer. The dialysate is prepared by mixing a concentrated sodium bicarbonate solution prepared by the company or in a pharmacy with treated water. It is very important that the dialysis solution contains electrolytes in approximately the same concentration as found in plasma and has the correct pH so that the patient's acid-base balance is not disturbed. At the same time, by adding some ions, especially K⁺ and Ca²⁺, (again using preformed solutions supplied by the company) ion imbalances can be corrected. 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 the insulin dosage, which is normal for the patient, but the glucose intake is lower). It is important to control and maintain a constant temperature during the process. Dialysate consumption during 4-6 hour hemodialysis is about 150 liters.

Types of dialysis

Acute hemodialysis

Acute dialysis is used in sudden conditions where the patient's body is not able to cleanse itself of endogenous or exogenous toxic substances, fluid volume or ions. Indications for acute dialysis include the following conditions:

- **acute kidney failure** - for example, rapidly progressive glomerulonephritis (RPGN),
- **hyperkalemia** > 6 mmol/l, which cannot be managed with conservative therapy,
- **hypercalcemia** > 3.5 mmol/l,
- **hyperuricemia** > 1000 μmol/l,
- uncorrectable metabolic acidosis, pH < 7.1,
- **hyperhydration** with heart failure,
- **oliguria** lasting more than 3 days,
- **intoxication** with low-molecular substances soluble in water, which after intoxication remain in free form in the bloodstream - e.g. ethylene glycol (fridex - antifreeze), lithium. Other poisons can be eliminated by hemoperfusion, i.e. adsorption on activated carbon, which is carried out by supplementing the hemodialysis machine with a hemoperfusion cartridge (e.g. green toadstool poison, paracetamol, some antidepressants).

Among the generally valid principles of acute dialysis is primarily consideration of whether it is possible to manage some of these conditions with conservative therapy (ion disruptions, disturbances of the internal environment), because dialysis is a method that puts a **strain on the organism** (cardiovascular, immune system). In acute dialysis, a **central venous catheter** (CVI) is used as an input. Frequency of dialysis as needed.

Chronic hemodialysis

Chronic hemodialysis is used in patients who, usually due to chronic kidney insufficiency, have reached renal failure (stage 5 according to K/DOQI), i.e. a condition where, even when maintaining basal conditions, their body is unable to get rid of excess metabolites, fluid volume and correct internal environment (pH, ions). Patients usually come to dialysis 3 times a week, they undergo dialysis for 4-6 hours. Of the vascular accesses, an **arteriovenous shunt** between *a. radialis* and *v. cephalica* is preferred: If it is contraindicated (heart failure), a central venous catheter is used in the *jugular vein*. This treatment is for life or until a kidney transplant.

Indications for dialysis (earlier in diabetics):

- **urea** > 30 mmol/l,
- **creatinine** 600-800 μmol/l,
- **creatinine clearance** < 0.25 ml/s.

Diseases that lead to hemodialysis are:

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

For patients in whom we expect to start dialysis, we should first of all contact the Transplantation Coordination Center or the IKEM transplant surgery clinic in order to ensure the possibility of a kidney transplant in the shortest possible time. Furthermore, we should treat anemia (with erythropoietin), which most patients with renal failure suffer from, and carry out preventive vaccination against hepatitis B (the development of which is the reason for postponing transplantation and shortening survival time). Acute complications of hemodialysis include **hypotension** (from sudden loss of circulating fluid volume), **convulsions** (decrease in Na⁺, K⁺, Ca²⁺), **arrhythmia** (sudden hypokalemia), and **bleeding** at the vascular access site (related to heparinization). Chronic complications of hemodialysis include **cardiovascular complications** (ICH, 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



Dialysis patient

- anemia

Peritoneal dialysis

Peritoneal dialysis (PD) is a dialysis method to **replace kidney function**. PD uses the **peritoneum as a membrane** through which fluids and solutes (electrolytes, urea, glucose, albumin, osmotically active particles and other small molecules) are exchanged from the blood. Dialysis fluid is fed into the abdominal cavity through a permanently inserted **catheter**.

Dialysis takes place either **every night** while you sleep (automatic peritoneal dialysis) or during regular changes **during the day** (continuous ambulatory peritoneal dialysis). PD is used as an alternative to **hemodialysis**, although significantly less frequently in many countries (e.g. USA). It is comparably safe, but significantly less expensive in most countries of the world. The main advantage of PD is the possibility to undergo treatment without visiting a medical facility. The most common complication in PD is **infection** through a permanently inserted catheter in the abdominal cavity.

Performance and types of peritoneal dialysis

The fluid enters the abdominal cavity through a **peritoneal catheter**, which is inserted permanently through the abdominal wall below the level of the navel. The patient can fill and drain the dialysis solution into the abdominal cavity by himself several times a day, up to 4 times during **continuous ambulatory peritoneal dialysis (CAPD)**, when the fluid is usually left in the peritoneal cavity for 6 hours. The used and contaminated **dialysis solution** is drained out and a new and clean dialysate is infused instead (if the patient dialyzes several times a day).

Automated peritoneal dialysis (APD) using the device limits the number of exchanges to one a day and replaces frequent exchanges at night, the patient connects to the machine before going to sleep, ensuring the exchanges automatically, and his sleep is not affected.

Principle of peritoneal dialysis

Best practices

According to the best recommended practice, before starting peritoneal dialysis treatment, it



1. Connection; 2. Infusion; 3. Diffusion (fresh solution); 4. Diffusion (waste solution); 5. Liquid drainage

is necessary to evaluate how well the patient understands the PD process itself, to educate them about proper care of the catheter and to complete any missing information. The patient should be **continuously monitored** to ensure that the dialysis is taking place in the right way and should be **regularly examined** for possible complications. The patient should also be properly **educated about the importance of infection prevention** and an **appropriate treatment plan** should be drawn up with him.

1. In preparation for the procedure, the abdominal cavity is **cleaned** and a **catheter is surgically inserted** with one end in the abdominal cavity and the other emerging from the skin.
2. Before each infusion, the catheter must be cleaned and flow checked in both directions.
3. Within about ten to fifteen minutes, **2-3 liters** of dialysis fluid (the so-called dialysate) are introduced into the abdominal cavity. Its total volume can reach up to 3 liters and it is possible to add medicines to the liquid just before administration.
4. The fluid is left in the abdominal cavity for a certain period of time (the so-called **delay**), when waste products pass into it from the vascular system through the peritoneum. After this delay (usually 4-6 hours, depending on the treatment), the fluid is pumped out and replaced with fresh. This can happen automatically while you sleep (**automated peritoneal dialysis, APD**), or during the day, with two liters of dialysate constantly left in the abdominal cavity and exchanged four to six times a day (continuous ambulatory peritoneal dialysis, CAPD).

The fluid usually contains sodium, chloride, lactate or bicarbonate and a high percentage of glucose to provide hyperosmolarity.

The intensity of dialysis depends on the amount of dialysate, the regularity of its exchange and the concentration of the solution. APD has 3-10 exchanges per night, while CAPD has four per day, with dialysate volumes ranging between 2-3 liters and dwell times of 4-8 hours.

The visceral part occupies roughly four-fifths of the total area of the peritoneum, but the **parietal peritoneum** is more important for PD. The principle of membrane dialysis is explained by two complementary models - **the three-pore model** (where molecules - proteins, electrolytes or water - pass through the membrane and it "sieves" them depending on the size of the pores) and the **distributed model** (which emphasizes the role of capillaries and the ability of the solution to increase number of active capillaries participating in PD).

A high concentration of **glucose** stimulates the osmotic filtration of fluid from the peritoneal capillaries into the abdominal cavity. Glucose passes relatively quickly from the dialysate into the blood (capillaries). After a **4-6 h** delay, the osmotic glucose gradient usually drops to too low a level for osmotic filtration to continue. The dialysate is therefore reabsorbed from the abdominal cavity into the capillaries based on the *colloid-osmotic pressure of the plasma*, which exceeds the colloid-osmotic pressure in the peritoneum by approximately **18-20 mmHg** (cf. the

Starling mechanism). **Lymphatic absorption** also contributes to some degree to the *reabsorption of fluid* from the abdominal cavity into the plasma. In patients with **high water permeability** (UF coefficient) of the peritoneal membrane, increased reabsorption of fluid from the peritoneum may occur towards the end of the delay.

The ability to exchange small particles and fluids between the peritoneum and the plasma can be classified as **high** (fast), **low** (slow), or **moderate**. **Rapid exchange** patients have good diffusion (easy exchange of small molecules between blood and dialysate, some improvement in results can be achieved with more frequent, shorter delays as in APD), while **slow exchange** patients show a higher UF filtration coefficient (due to slower reabsorption of glucose from abdominal cavity, where longer delays with higher fluid volumes show better results), although in practice both types of patients can generally be treated with appropriately adjusted APD or CAPD.

Although there are several different shapes and sizes of catheters that can be used, different catheter insertion sites, number of cuffs, and anchorages, there are no known differences in terms of **morbidity, mortality**, or rates of **infection**, but the information is not of sufficient quality to draw definitive conclusions.

Complications

The **volume of pumped dialysate** and the **patient's weight** are monitored. If **more than 500 ml** of fluid remains or if **1 liter** of fluid is lost during **three** consecutive treatments, the patient's attending physician is usually notified. **Excessive fluid loss** can lead to **hypovolemic shock** or **hypotension**. **Excessive fluid retention** can lead to **hypertension** and **edema**.

The **color** of the discharged fluid is also monitored: under normal circumstances it is **pinkish** in the first **four** cycles and then clear or pale yellow. The presence of pink or bloody discoloration indicates **bleeding into the abdominal cavity**, feces indicate intestinal perforation, and turbidity may indicate infection.

The patient may also experience **pain** or **discomfort** if the dialysate has an overly acidic reaction, is too cold, or is infused too quickly. Diffuse pain and cloudy discharge may indicate **infection**. Sharp pain in the anus or perineum may be the result of an incorrectly inserted catheter. Dialysate can also increase pressure on the diaphragm, making breathing difficult, and constipation can limit fluid flow through the catheter.

A potentially fatal complication, estimated to occur in about **2.5% of patients**, is *encapsulating peritoneal sclerosis*, in which bowel obstruction occurs due to a thick layer of fibrin in the peritoneum.

Glucose is the primary osmotic agent in the dialysate, but this can lead to peritonitis, failure of the kidneys and peritoneum as a membrane, and other health complications. Acidity, high concentration and presence of lactate and especially glucose breakdown products in the solution can contribute to such problems. Solutions that have a **neutral reaction**, use **bicarbonate** instead of lactate and contain fewer glucose breakdown products, are safer, but there are no studies to confirm this unequivocally yet.

Risks and benefits

PD is **less effective in removing waste products** from the body than hemodialysis, and the presence of a catheter poses a risk of **peritonitis** by possible introduction of bacteria into the abdominal cavity. There is insufficient evidence on the best treatment for peritonitis associated with PD, although direct intra-abdominal infusions of antibiotics show marginally better results than intravenous administration. There is no clear advantage of other frequently used methods of treatment, e.g. regular peritoneal lavages or the use of urokinase.

Infection of the catheter insertion site may also occur. Prophylaxis using **nasal mupirocin** can reduce the number of such infections, but it does not affect peritonitis. Infections occur on average once every **15 months** (0.8 episodes per patient per year), but in many sites significantly less often – once every 40 or more months compared to hemodialysis allows the PD patient **better mobility**, occurs to **fewer fluctuations in the occurrence of symptoms** and **phosphates are better removed**, but a large amount of **albumin** is also removed from the body, which requires constant monitoring of the **nutritional status**.

In most countries of the world, the cost of PD is generally **lower** than that of HD, the price difference being most pronounced in **developed countries**.

There has not yet been a large enough study to compare the risks and benefits of CAPD and APD. The independent peer review organization Cochrane compared the results of three smaller clinical trials and found **no difference** in clinically relevant parameters (ie, morbidity and mortality) in patients with end-stage renal disease, nor an advantage of either method in terms of preserving renal function. The results suggest that APD may have **psychosocial benefits** in younger patients and those who are employed or studying.

Other complications include **hypotension** (due to increased fluid exchange and sodium loss), shoulder pain, and hernias or fluid leaks due to increased intra-abdominal pressure. PD can also be used in patients with **cardiovascular instability** because it does not cause rapid and significant changes in body fluids and in patients with type 1 diabetes because of the impossibility of influencing blood sugar levels through a catheter. **Hypertriglyceridemia** and **obesity** are also possible risks due to the large amount of glucose in the dialysis fluid, which can supply the body with **2000-5000 kJ per day**.

Of the **three connection types** and fluid exchange systems (standard, dual-bag, and Y-coupler, the latter two operating with two bags and only one catheter connection, with the Y-coupler set having a single Y-connection between the drain bags, lavage and infusion) **dual-bag Y-connector** systems show better results in preventing peritonitis than conventional systems.

Extension of the method

According to a 2004 worldwide survey, approximately **11 % of end-stage renal disease patients** were treated with **PD** versus the much more common hemodialysis. In Hong Kong and Mexico, PD is more common than the global average – in Mexico it is used in the majority of patients (**75 %**) – while in Japan and Germany PD use is below the global average.

Improvised dialysis

Peritoneal dialysis can be performed **impromptu**, e.g. in combat conditions or during disasters, using surgical catheters and dialysate made from commonly available infusion solutions, providing temporary replacement of kidney function in patients who have **no other option**.

Indication

This method is advantageous for **young patients**, who do not have to regularly go to the hospital for hemodialysis, so they can continue their normal activities (work, study). We also use peritoneal dialysis in **children** and **in circulatorially unstable patients**, where we cannot provide permanent and suitable conditions for hemodialysis.

Contraindication

Peritoneal dialysis is not indicated in patients with extensive peritoneal adhesions, hernia, colostomy, active bowel disease (Crohn's disease), ascites, or in uncooperative patients.

Complication

The most common complication is the development of an **infection** - usually staphylococcal peritonitis clogged by the catheter (both general and local ATB therapy). Over time, peritoneal dialysis can cause **thickening of the peritoneum**. This impairs its diffusion function and the patient should be transferred to hemodialysis.

Links

Related articles

- Chronic kidney disease
- Acute renal failure
- Vascular approaches for dialysis
- Catheter for peritoneal dialysis
- Dialysis amyloidosis

External links

- Česká transplantační společnost pacientům - transplantace ledvin (https://transplantace.eu/site/?page_id=119)
- Koordinační středisko transplantací - transplantace ledvin (<http://www.kst.cz>)

Source

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Categories: Nephrology, Pathology, Internal Medicine, Patophysiology