# Dialysis

| Dialysis | |
|---|---|
| *Intervention* | |
|  Patient receiving dialysis | |
| **ICD-9-CM** | 39.95 [1] |
| **MeSH** | D006435 [2] |

In medicine, **dialysis** (from Greek "dialusis", meaning dissolution, "dia", meaning through, and "lysis", meaning loosening) is a process for removing waste and excess water from the blood, and is primarily used to provide an artificial replacement for lost kidney function in people with renal failure. Dialysis may be used for those with an acute disturbance in kidney function (acute kidney injury, previously acute renal failure) or for those with progressive but chronically worsening kidney function–a state known as chronic kidney disease stage 5 (previously chronic renal failure or end-stage kidney disease). The latter form may develop over months or years, but in contrast to acute kidney injury is not usually reversible, and dialysis is regarded as a "holding measure" until a renal transplant can be performed, or sometimes as the only supportive measure in those for whom a transplant would be inappropriate.[3]

The kidneys have important roles in maintaining health. When healthy, the kidneys maintain the body's internal equilibrium of water and minerals (sodium, potassium, chloride, calcium, phosphorus, magnesium, sulfate). Those acidic metabolism end products that the body cannot get rid of via respiration are also excreted through the kidneys. The kidneys also function as a part of the endocrine system producing erythropoietin and calcitriol. Erythropoietin is involved in the production of red blood cells and calcitriol plays a role in bone formation.[4] Dialysis is an imperfect treatment to replace kidney function because it does not correct the endocrine functions of the kidney. Dialysis treatments replace some of these functions through diffusion (waste removal) and ultrafiltration (fluid removal).[5]

## History

Dr. Willem Kolff, a Dutch physician, constructed the first working dialyzer in 1943 during the Nazi occupation of the Netherlands.[6] Due to the scarcity of available resources, Kolff had to improvise and build the initial machine using sausage casings, beverage cans, a washing machine and various other items which were available at the time. Over the following two years, Kolff used his machine to treat 16 patients who suffered from acute kidney failure, but the results were unsuccessful. Then, in 1945, a 67-year-old woman in uremic coma regained consciousness following 11 hours of hemodialysis with the dialyzer, and lived for another seven years before dying of an unrelated condition. She was the first-ever patient successfully treated with dialysis.[6]

## Principle


A hemodialysis machine

Dialysis works on the principles of the diffusion of solutes and ultrafiltration of fluid across a semi-permeable membrane. Diffusion describes a property of substances in water. Substances in water tend to move from an area of high concentration to an area of low concentration.[7] Blood flows by one side of a semi-permeable membrane, and a dialysate, or special dialysis fluid, flows by the opposite side. A semipermeable membrane is a thin layer of material that contains various sized holes, or pores. Smaller solutes and fluid pass through the membrane, but the membrane blocks the passage of larger substances (for example, red blood cells, large proteins). This replicates the filtering process which takes place in the kidneys, when the blood enters the kidneys and the larger substances are separated from the smaller ones in the glomerulus.[7]

The two main types of dialysis, hemodialysis and Peritoneal dialysis, remove wastes and excess water from the blood in different ways.[3] Hemodialysis removes wastes and water by circulating blood outside the body through an external filter, called a dialyzer, that contains a semipermeable membrane. The blood flows in one direction and the dialysate flows in the opposite. The counter-current flow of the blood and dialysate maximizes the concentration gradient of solutes between the blood and dialysate, which helps to remove more urea and creatinine from the blood. The concentrations of solutes (for example potassium, phosphorus, and urea) are undesirably high in the blood, but low or absent in the dialysis solution and constant replacement of the dialysate ensures that the concentration of undesired solutes is kept low on this side of the membrane. The dialysis solution has levels of minerals like potassium and calcium that are similar to their natural concentration in healthy blood. For another solute, bicarbonate, dialysis solution level is set at a slightly higher level than in normal blood, to encourage diffusion of bicarbonate into the blood, to act as a pH buffer to neutralize the metabolic acidosis that is often present in these patients. The levels of the components of dialysate are typically prescribed by a nephrologist according to the needs of the individual patient.

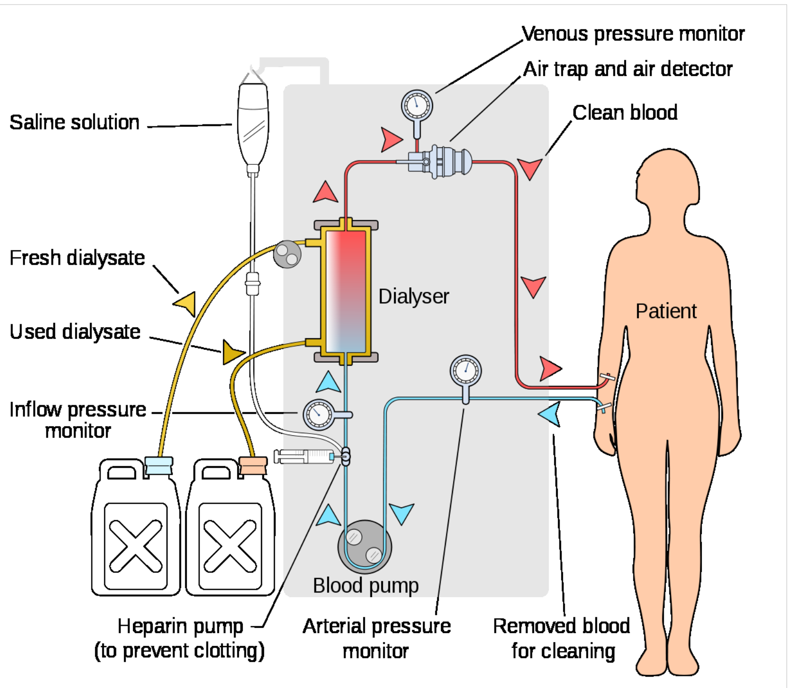
In peritoneal dialysis, wastes and water are removed from the blood inside the body using the *peritoneal membrane* of the peritoneum as a natural semipermeable membrane. Wastes and excess water move from the blood, across the peritoneal membrane, and into a special dialysis solution, called dialysate, in the abdominal cavity which has a composition similar to the fluid portion of blood.

## Types

There are three primary and two secondary types of dialysis: hemodialysis (primary), peritoneal dialysis (primary), hemofiltration (primary), hemodiafiltration (secondary), and intestinal dialysis (secondary).

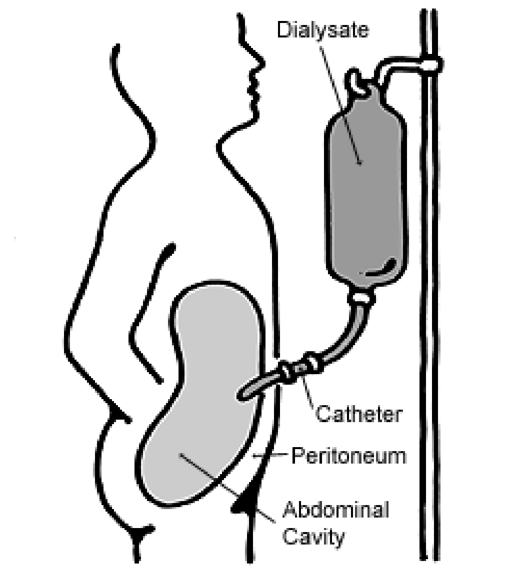
### Hemodialysis

In hemodialysis, the patient's blood is pumped through the blood compartment of a dialyzer, exposing it to a partially permeable membrane. The dialyzer is composed of thousands of tiny synthetic hollow fibers. The fiber wall acts as the semipermeable membrane. Blood flows through the fibers, dialysis solution flows around the outside of the fibers, and water and wastes move between these two solutions.[8] The cleansed blood is then returned via the circuit back to the body. Ultrafiltration occurs by increasing the hydrostatic pressure across the dialyzer membrane. This usually is done by applying a negative pressure to the dialysate compartment of the dialyzer. This pressure gradient causes water and dissolved solutes to move from blood to dialysate, and allows the removal of several litres of excess fluid during a typical 3 to 5 hour treatment. In the US, hemodialysis treatments are typically given in a dialysis center three times per week (due in the US to Medicare reimbursement rules); however, as of 2007 over 2,500 people in the US are dialyzing at home more frequently for various treatment lengths.[9] Studies have demonstrated the clinical benefits of dialyzing 5 to 7 times a week, for 6 to 8 hours. This type of hemodialysis is usually called "nocturnal daily hemodialysis", which a study has shown a significant improvement in both small and large molecular weight clearance and decrease the requirement of taking phosphate binders.[10] These frequent long treatments are often done at home while sleeping, but home dialysis is a flexible modality and schedules can be changed day to day, week to week. In general, studies have shown that both increased treatment length and frequency are clinically beneficial.[11]




Hemodialysis schematic

## Peritoneal dialysis



Schematic diagram of peritoneal dialysis

In peritoneal dialysis, a sterile solution containing glucose is run through a tube into the peritoneal cavity, the abdominal body cavity around the intestine, where the peritoneal membrane acts as a semipermeable membrane.The peritoneal membrane or peritoneum is a layer of tissue containing blood vessels that lines and surrounds the peritoneal, or abdominal, cavity and the internal abdominal organs (stomach, spleen, liver, and intestines).[12] The dialysate is left there for a period of time to absorb waste products, and then it is drained out through the tube and discarded. This cycle or "exchange" is normally repeated 4-5 times during the day, (sometimes more often overnight with an automated system). Each time the dialysate fills and empties from the abdomen is called one exchange. A dwell time means that the time of dialysate stay in patient's abdominal cavity—wastes, chemicals and extra fluid move from patient's blood to the dialysate across the peritoneum. A drain process is the process after the dwell time, the dialysate full with waste products and extra fluid is drained out of patient's blood.[13] Ultrafiltration occurs via osmosis; the dialysis solution used contains a high concentration of glucose, and the resulting osmotic pressure causes fluid to move from the blood into the dialysate. As a result, more fluid is drained than was instilled. Peritoneal dialysis is less efficient than hemodialysis, but because it is carried out for a longer period of time the net effect in terms of removal of waste products and of salt and water are similar to hemodialysis. Peritoneal dialysis is carried out at home by the patient. Although support is helpful, it is not essential. It does free patients from the routine of having to go to a dialysis clinic on a fixed schedule multiple times per week, and it can be done while travelling with a minimum of specialized equipment.

## Hemofiltration

Hemofiltration is a similar treatment to hemodialysis, but it makes use of a different principle. The blood is pumped through a dialyzer or "hemofilter" as in dialysis, but no dialysate is used. A pressure gradient is applied; as a result, water moves across the very permeable membrane rapidly, "dragging" along with it many dissolved substances, importantly ones with large molecular weights, which are cleared less well by hemodialysis. Salts and water lost from the blood during this process are replaced with a "substitution fluid" that is infused into the extracorporeal circuit during the treatment. Hemodiafiltration is a term used to describe several methods of combining hemodialysis and hemofiltration in one process.

## Hemodiafiltration

Hemodialfiltration is a combination of hemodialysis and hemofiltration. In theory, this technique offers the advantages of both hemodialysis and hemofiltration.

## Intestinal dialysis

In intestinal dialysis, the diet is supplemented with soluble fibres such as acacia fibre, which is digested by bacteria in the colon. This bacterial growth increases the amount of nitrogen that is eliminated in fecal waste.[14] [15] [16] An alternative approach utilizes the ingestion of 1 to 1.5 liters of non-absorbable solutions of polyethylene glycol or mannitol every fourth hour.[17]

## Starting indications

The decision to initiate dialysis or hemofiltration in patients with renal failure depends on several factors. These can be divided into acute or chronic indications.

- Indications for dialysis in the patient with acute kidney injury are:[18]
  1. Metabolic acidosis in situations where correction with sodium bicarbonate is impractical or may result in fluid overload.
  2. Electrolyte abnormality, such as severe hyperkalemia, especially when combined with AKI.
  3. Fluid overload not expected to respond to treatment with diuretics.
  4. Complications of uremia, such as pericarditis, encephalopathy, or gastrointestinal bleeding.
  5. Intoxication, that is, acute poisoning with a dialyzable substance. These substances can be represented by the mnemonic SLIME: salicylic acid, lithium, isopropanol, Magnesium-containing laxatives, and ethylene glycol.
- Chronic indications for dialysis:
  1. Symptomatic renal failure
  2. Low glomerular filtration rate (GFR) (RRT often recommended to commence at a GFR of less than 10-15 mls/min/1.73m$^2$). In diabetics dialysis is started earlier.
  3. Difficulty in medically controlling fluid overload, serum potassium, and/or serum phosphorus when the GFR is very low

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## External links

- Machine Cleans Blood While You Wait (http://books.google.com/books?id=ZyEDAAAAMBAJ&pg=PA103#v=onepage&f=true)—1950 article on early use of Dialysis machine at Bellevue Hospital New York City—i.e. example of how complex and large early dialysis machines were
- Dialysis search engine (http://www.Renalsite.com/)—Dialysis Clinic locations around the World
- Global Dialysis (http://www.globaldialysis.com)—Resource and community for dialysis patients and professionals
- Virtual Dialysis Museum (http://www.homedialysis.org/learn/museum/)—History and pictures of dialysis machines through time
- Virtual CKD patient/care giver community (http://ihatedialysis.com/forum/index.php)—by far the largest CKD discussion forum on the web.
- HDCN Online journal (http://hdcn.com/inslidef.htm)—Free medical lectures pertaining to various aspects of dialysis and nephrology; intended for physicians and nurses, not for patients.
- Information on Nephrology & Kidney Disease for Professionals and Patients (http://ukidney.com)
- Nephrology Now Meta-Journal and Online Journal Club (http://www.nephrologynow.com)—Nephrology literature update service, as well as a place to discuss important articles with colleagues around the world.
- The Noor Foundation UK (http://www.noorfoundation.org)—A UK based charity that sets up and runs free kidney dialysis centres in 3rd world countries
- American Kidney Fund (http://www.kidneyfund.org)—A United States nonprofit organization that provides treatment-related financial assistance to dialysis patients
- National Kidney Foundation (http://www.kidney.org)—A major voluntary nonprofit health organization, is dedicated to preventing kidney and urinary tract diseases, improving the health and well-being of individuals and families affected by kidney disease and increasing the availability of all organs for transplantation
- American Association of Kidney Patients (http://www.aakp.org)—A national non-profit organization founded by kidney patients for kidney patients
- HDCN Online journal (http://hdcn.com/inslidef.htm)—Free medical lectures pertaining to various aspects of dialysis and nephrology; intended for physicians and nurses, not for patients
- The Kidney Foundation of Canada (http://www.kidney.ca)
- Dialysis Clinics (http://www.yourdialysis.net/)—List of dialysis centers in United States.

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