Peritoneal dialysis

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

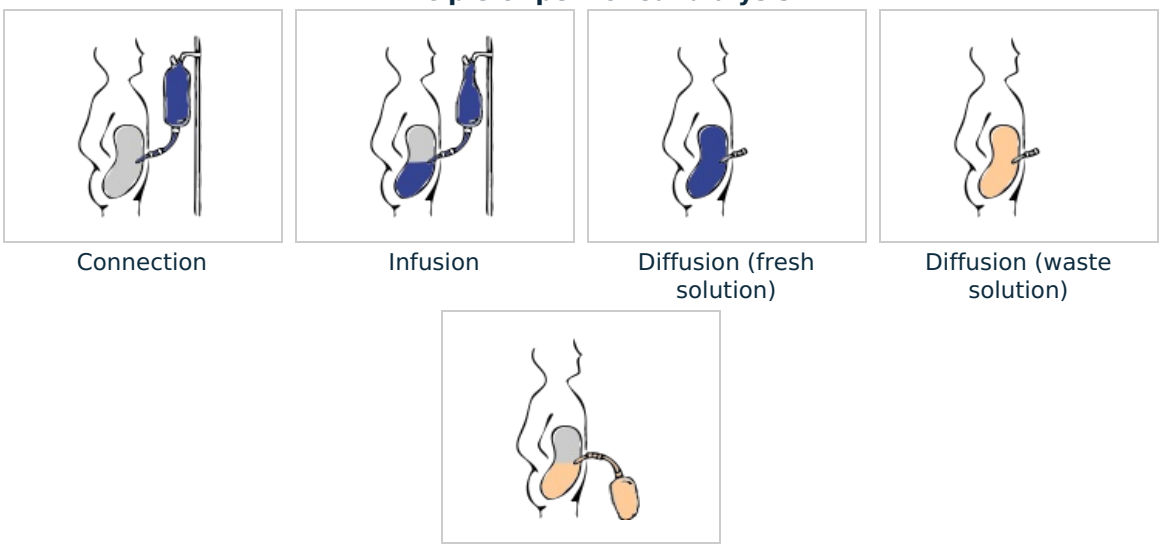
Dialysis takes place either **every night** during sleep (automated peritoneal dialysis) or during regular changes **during the day** (continuous ambulatory peritoneal dialysis). PD is used as an alternative to **hemodialysis**, although significantly less often in many countries (e.g., the USA). It is relatively safe and inexpensive in most countries of the world. The main advantage of PD is the ability to undergo treatment without visiting a medical facility. The most common complication of PD is an **infection** related to the permanently inserted catheter in the abdominal cavity.

Design and types of peritoneal dialysis

The liquid enters the abdominal cavity via a **peritoneal catheter** inserted permanently through the abdominal wall below the level of the navel. The patient may inject and withdraw the dialysis solution into the abdominal cavity alone several times a day, up to 4 times during **continuous ambulatory peritoneal dialysis** (CAPD), when fluid in the peritoneal cavity is usually left for 6 hours. Used and contaminated dialysis solution is withdrawn from the abdominal cavity and a new and pure dialysis is injected in its place (if the patient undergoes dialysis multiple times a day).

Automated peritoneal dialysis (APD) by the means of a machine (automated cycler) limits the number of dialysate replacements to once during the day and allows for more frequent replacements at night[1]. The patient connects to an automatic replacement machine at bedtime and his sleep is not affected.

Principle of peritoneal dialysis



Connection | Infusion | Diffusion (fresh solution) | Diffusion (waste solution) | Drainage

Best practices

Before starting treatment with peritoneal dialysis, it is necessary to evaluate how well the patient understands the PD process itself, educate them about proper catheter care, and fill in any missing information. The patient should be **permanently monitored** to ensure that dialysis is carried out in the correct manner and should be **examined regularly** for possible complications. The patient should also be properly advised on the importance of preventing infections and should be given an **appropriate treatment plan**.[2]

1. In preparation for the procedure, the abdominal cavity is cleared and a catheter is surgically inserted with one end in the abdominal cavity and the other exiting the skin.[3]
2. Before each infusion, the catheter should be cleaned and flow should be checked both ways.
3. In about ten to fifteen minutes, **2-3 liters** of dialysis fluid are introduced into the abdominal cavity. Its total volume can reach up to 3 liters and drugs can be added to the fluid just before administration.
4. The liquid is left in the abdominal cavity for a period of time (so-called delay) when waste products pass into it from the vascular system through the peritoneum. At the end of this delay (usually 4-6 hours depending on treatment[4]), the liquid is drained and replaced with a fresh one. This can happen automatically in your sleep **(automated peritoneal dialysis, APD)**, or during the day, with two liters of dialysis constantly left in the abdominal cavity and exchanged four to six times per day (continuous outpatient peritoneal dialysis, CAPD).[5][6]

The liquid usually contains sodium, chloride, lactate, or bicarbonate and a high percentage of glucose to ensure hyperosmolality.

The dialysis intensity depends on the amount of dialysis, the frequency of dialysate replacement, and the concentration of the solution. For APD, there are 3-10 exchanges per night, while for CAPD there are four per day, with a dialysis volume of between 2-3 liters and a delay time of 4-8 hours.

The visceral portion of the peritoneum is roughly four-fifths of the total area of the peritoneum; however, the **parietal peritoneum** is more important for PD. The principle of dialysis across the membrane is explained by two complementary models - a **model of three pores** (where molecules - proteins, electrolytes, or water - pass through the membrane and blood is "sifted" depending on the size of the pores) and a **distributed model** (which emphasizes the role of capillaries and the ability of the solution to increase the number of active capillaries involved in the PD).

High **glucose** concentrations stimulate osmotic filtration of fluid from the peritoneal capillaries into the abdominal cavity. Also, glucose passes relatively quickly from the dialysate to the blood (in the capillaries). After a **4-6 h** delay, the osmotic glucose gradient usually becomes too low for osmotic filtration to continue. Dialysate is therefore absorbed back from the abdominal cavity into the capillaries based on *colloidal-osmotic plasma pressure* which exceeds the colloidal-osmotic pressure in the peritoneum by approximately **18-20 mmHg** (Starling mechanism). [7] **Lymphatic drainage** also contributes to some extent to the *reabsorption of fluid* from the abdominal cavity into plasma. In patients with **high water permeability** (UF coefficient) of the peritoneal membrane, increased reabsorption of peritoneal fluid may occur towards the end of the delay.

The ability to exchange tiny particles and fluids between peritoneum and plasma can be classified as **high** (rapid), **low** (slow), or **medium**. Good diffusion occurs in patients with **rapid exchange** (easy exchange of small molecules between blood and dialysis occurs, improvement in results can be achieved by more frequent and shorter delays as in APD), while patients with **slow exchange** show a higher UF filtration rate (due to slower absorption of glucose from the abdominal cavity, better results can be achieved with longer delays with higher volume of fluids).[8]

Although there are several different shapes and sizes of catheters, different catheter insertion sites, and a number of cuffs and attachments that can be used, there are no known differences in terms of **morbidity, mortality** or number of cases of **infection** (the current data is not sufficient to draw definitive conclusions about their differences).[9]

Complications

It is important to monitor the volume of the fluid drained and the patient's weight. If **more than 500 mL** of liquid remains or **1 liter** of fluid is lost during **three** consecutive treatments, the patient's treating physician should be advised. **Excessive** fluid loss may lead to **hypovolemic shock** or **hypotension**. **Excessive** fluid retention can lead to **hypertension** and **edema**.

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

The patient may also experience **pain** or **discomfort** if the dialysate is too acidic, too cold, or is infused too quickly. Diffuse pain and murky discharged fluid may indicate infection. Severe pain in the rectum or perineum may be the result of a catheter inserted incorrectly. Dialysis may also increase the pressure on the diaphragm, making breathing more difficult, and constipation may restrict fluid flow through the catheter.[4]

A potentially fatal complication estimated to occur in around **2.5% of patients** is encapsulating peritoneal sclerosis, in which the intestines become obstructed due to the thick layer of fibrin in the peritoneum.[10]

The primary osmotic agent in dialysis tends to be **glucose**, but this can lead to peritoneal inflammation, kidney and peritoneal failure as membranes, and other medical complications. Acidity, high concentration and presence of lactate and especially glucose breakdown products in solution may contribute to such problems. Solutions that are **neutral** use **bicarbonate** instead of lactate, contain fewer glucose breakdown products, and are considered safer, but there are no studies to confirm this definitively yet.[11]

Risks and benefits

PD is **less effective** in **removing waste** from the body than hemodialysis, and the presence of a catheter poses a risk for **peritonitis** through the possible introduction of bacteria into the abdominal cavity.[5] There is insufficient evidence on the best way to treat PD-related peritonitis; however, direct infusions of antibiotics into the abdominal cavity show slightly better results than intravenous administration. There is no clear benefit from other commonly used treatments such as regular peritoneal lavage or urokinase use.[12]

There may also be an infection of the catheter insertion site. The number of such infections can be reduced by prophylaxis with **nasal mupirocin**, but this does not help treat or prevent the risk for peritonitis.[13] Infections occur on average once every **15 months** (0.8 episodes per patient per year), but in a number of workplaces significantly less frequently - once every 40 months or more. Compared to hemodialysis, PD allows for better patient mobility and fewer fluctuations in the incidence of symptoms due to its continuous nature. Also, PD is better at removing phosphates. However, a large amount of **albumin** is also removed from the body, requiring constant monitoring.

In most countries of the world, the cost of PD is generally **lower** than that of HD, with the price difference being most pronounced in **developed countries**.[14]

There hasn't been enough research to compare the risks and benefits of CAPD and APD. The independent expert organization Cochrane compared the results of three small clinical trials and found **no difference** in clinically relevant parameters (i.e., morbidity and mortality) in patients with end-stage renal disease, nor any advantage of either method in terms of maintaining kidney function. Results suggest that APD may have **psychosocial benefits** in younger patients and those who are employed or studying.[15]

Other complications include **hypotension** (due to increased fluid exchange and sodium loss), pain in the hips and hernias, or fluid leakage 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 it can be also used in patients with **type 1 diabetes**. Possible risks are also **hypertriglyceridemia** and **obesity** due to the large amount of glucose in the dialysis fluid, which can supply the body with **2000-5000 kJ per day**.[16]

Of the **three types of connections** and fluid exchange systems (standard, with two bags, and with a Y-coupling, the latter two working with two bags and only one catheter connection, with the Y-coupling kit being the only Y-shaped connection between the discharge bags), systems with **two bags and a Y-joint** show better results in preventing peritonitis than conventional systems.[17]

Extension of the method

According to a 2004 global survey, approximately **11% of end-stage renal disease patients** were treated with **PD** compared to the significantly more common hemodialysis. In Hong Kong and Mexico, PD is more common than the global average - in Mexico it is applied to most patients (**75%**) - while in Japan and Germany, PD use is below the world average.[18]

Unplanned dialysis

Peritoneal dialysis can be **unplanned**. For example, PD can be performed in combat conditions or in catastrophes for emergency purposes, using surgical catheters and dialysate made from commonly available infusion solutions to provide temporary replacement of renal function in patients for whom there is **no other option**.

Indications

This method is advantageous for **young patients** who do not have to go to the hospital regularly for hemodialysis, so they can continue their normal activities (work, study). Peritoneal dialysis is also used **in children** and **circulatory unstable patients** since stable and suitable conditions for **hemodialysis** cannot be provided.

Contraindications

Peritoneal dialysis is not indicated in patients with extensive peritoneal adhesions, hernias, colostomies, active bowel disease (Crohn's disease), ascites, or in non-cooperating patients.

Complications

The most common complication is **infection** - usually catheter-related staphylococcal **peritonitis** (general and local ATB therapy is necessary). Over time, peritoneal dialysis can **thicken the peritoneum**. This disrupts the peritoneum's diffusion membrane function and the patient should be indicated for hemodialysis instead if necessary.

References

Related articles

- Catheter for peritoneal dialysis
- Hemodialysis

Citations

1. ČEŠKA, Richard, et al. *Interna.* 2. vydání. Praha : Triton, 2015. 909 s. ISBN 978-80-7387-895-5.
2. Wood, M; et al. (2008-08-01). "Nephrology Nursing Standards and Practice Recommendations" (PDF). Canadian Association of Nephrology Nurses and Technologists. Retrieved 2010-09-08.
3. Haralampos V. Harissis et al. A new simplified one port laparoscopic technique of peritoneal dialysis catheter placement with intra-abdominal fixation. The American Journal of Surgery 192 (2006) 125–129 https://www.youtube.com/watch?v=0MuJURb7vpg
4. *Best practices: evidence-based nursing procedures*. 2007. ISBN 1-58255-532-X.
5. Crowley, LV (2009). *An Introduction to Human Disease: Pathology and Pathophysiology Correlations*. Jones & Bartlett Publishers. pp. 507–509. ISBN 0-7637-6591-0.
6. McPhee, SJ; Tierney LM; Papadakis MA (2007). *Current medical diagnosis and treatment*. McGraw-Hill. pp. 934–935. ISBN 0-07-147247-9.

7. Rippe, B, Venturoli, D, Simonsen, O, de Arteaga, J (2004). "Fluid and electrolyte transport across the peritoneal membrane during CAPD according to the three-pore model.". *Perit Dial Int* 24: 10–27. PMID 15104333.
8. Daugirdas, JT; Blake PG; Ing TS (2006). "Physiology of Peritoneal Dialysis". *Handbook of dialysis*. Lippincott Williams & Wilkins. p. 323.
9. Strippoli, GFM; Tong A; Johnson DW; Schena FP; Craig JC (2004). Strippoli, Giovanni FM, ed. "Catheter type, placement and insertion techniques for preventing peritonitis in peritoneal dialysis patients". *Cochrane Database of Systematic Reviews* **4**: CD004680.doi:10.1002/14651858.CD004680.pub2. PMID 15495125.
10. Kawanishi, H.; Moriishi, M. (2007). "Encapsulating peritoneal sclerosis: prevention and treatment". *Peritoneal dialysis international : journal of the International Society for Peritoneal Dialysis*. 27 Suppl 2: S289–S292. PMID 17556321.
11. Perl, J.; Nessim, S. J.; Bargman, J. M. (2011). "The biocompatibility of neutral pH, low-GDP peritoneal dialysis solutions: Benefit at bench, bedside, or both?". *Kidney International* **79** (8): 814–824. doi:10.1038/ki.2010.515. PMID 21248712.
12. Ballinger, AE; Palmer, SC; Wiggins, KJ; Craig, JC; Johnson, DW; Cross, NB; Strippoli, GFM (26 April 2014). "What is the best treatment to manage peritonitis in people on peritoneal dialysis?". *Cochrane Database of Systematic Reviews* **4**: CD005284.doi:10.1002/14651858.CD005284.pub3. PMID 18254075.
13. Strippoli, GFM; Tong A; Johnson DW; Schena FP; Craig JC (2004). Strippoli, Giovanni FM, ed. "Antimicrobial agents for preventing peritonitis in peritoneal dialysis patients". *Cochrane Database of Systematic Reviews* 4 (4):
14. Karopadi, AN; Mason G; Rettore E; Ronco C (2013). Zoccali, Carmine, ed. "Cost of peritoneal dialysis and haemodialysis across the world". *Nephrol Dial Transplant* **28**: 2553–69. doi:10.1093/ndt/gft214. PMID 23737482.
15. Rabindranath, KS; et al. (2007). Rabindranath, Kannaiyan S, ed. "Continuous ambulatory peritoneal dialysis versus automated peritoneal dialysis for end-stage renal disease". *Cochrane Database of Systematic Reviews* **2** (2): CD006515. doi:10.1002/14651858.CD006515.PMID 17443624.
16. Ehrman, JK; Gordon P; Visich PS; Keteyian SJ (2008). *Clinical Exercise Physiology*. Human Kinetics. pp. 268–269. ISBN 0-7360-6565-2.
17. Daly, C; Khan, I; Rabindranath, KS; Vale, L; Wallace, SA (13 August 2014). "Y-set and double bag systems offer the most protection against peritonitis during continuous ambulatory peritoneal dialysis (CAPD)". *Cochrane Database of Systematic Reviews* (8): CD003078.doi:10.1002/14651858.CD003078.pub2. PMID 11406068.
18. Grassmann, A; Gioberge S; Moeller S; Brown G (2005). "ESRD patients in 2004: global overview of patient numbers, treatment modalities and associated trends". *Nephrology Dialysis Transplantation* **20** (12): 2587–2593. doi:10.1093/ndt/gfi159. PMID 16204281.

Literature

- KLENER, Pavel. *Vnitřní lékařství.* 3. edition. Prague : Galén, 2006. 1158 pp. ISBN 80-7262-430-X.
- KYMPLOVÁ, Jaroslava. *Katalog metod v biofyzice* [online]. [cit. 2012-09-20]. <https://portal.lf1.cuni.cz/clanek-793-katalog-metod-v-biofyzice>.
- ČEŠKA, Richard. *Interna.* 1. edition. Prague : Triton, 2010. 855 pp. pp. 558−560. ISBN 978-80-7387-423-0.