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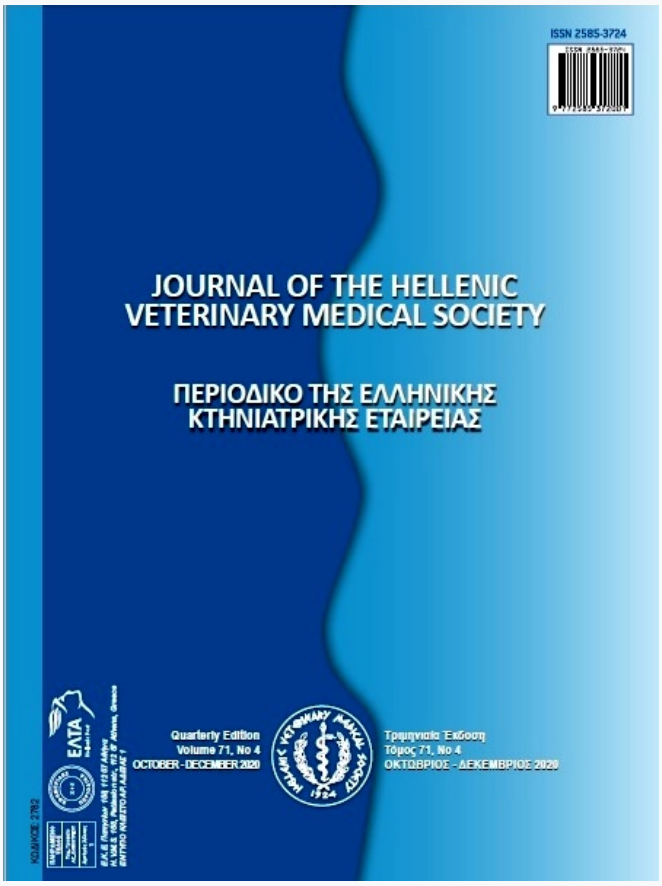

Peritoneal dialysis in dogs and cats

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Review article
Ανασκόπηση

Peritoneal dialysis in dogs and cats

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ABSTRACT: Dialysis represents the separation process of a colloidal dispersion substance from molecular dispersion particles, based on the property of certain membranes to retain only colloidal particles. In veterinary medicine, the most common use for peritoneal dialysis is the therapy of acute kidney injury, although it can be employed for removing dialyzable toxins and treating pancreatitis, electrolyte disorders and acid-base imbalances, refractory congestive heart failure and metabolic congenital disorders. Peritoneal dialysis is contraindicated in patients with peritoneal adhesions, fibrosis or abdominal malignant tumours. The ideal catheter for dialysis allows for an adequate administration and evacuation of the dialysate, it determines minimum subcutaneous losses, it minimizes infection both in the peritoneal cavity and in the subcutaneous tissue. The placement method for peritoneal dialysis catheters depends on the catheter itself, on the patient and on the approximate duration of the dialysis. In cases of extreme emergency, when the peritoneal dialysis should not be used more than 72 hours, the placement of a short-term catheter is justified. The peritoneal dialysis system is placed immediately after the peritoneal dialysis catheter is inserted and attached to a closed collection system, being carefully prepped in place with dry sterile dressings. The ideal peritoneal dialysis solution should achieve the low absorption clearance of osmotic agents, provide missing or insufficient electrolytes and nutrients, correct acid-base imbalances, inhibit growth of microorganisms, and be inert with regard to the peritoneum. When initiating peritoneal dialysis in acute kidney injury, the main goal is not to immediately normalize uraemia. The initial objectives should be to normalize the hemodynamic status of the patient and the acid-base and electrolyte imbalances, as well as to reduce uraemia to a BUN of 60-100 mg/dl and to reach a creatinine of 4.0-6.0 mg/dl in 24-48 hours. Complications of peritoneal dialysis are common, but they can be easily managed if discovered or addressed in due time. The most common complications are: peritoneal catheter obstruction, electrolyte imbalances, hypoalbuminemia and bacterial peritonitis.

***Keywords*:** peritoneum, AKI, CKD, peritoneal dialysis

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Invited Review Article

INTRODUCTION

Dialysis represents the separation process of a colloidal dispersion substance from molecular dispersion particles, based on the property of certain membranes to retain only colloidal particles.

In veterinary medicine, the most common use for peritoneal dialysis is the therapy of acute kidney injury, although it can be employed for removing dialyzable toxins and treating pancreatitis, electrolyte disorders and acid-base imbalances, refractory congestive heart failure and metabolic congenital disorders.

The principle of peritoneal dialysis is represented by the transfer of solutions through a semipermeable membrane based on the principle of diffusion. These membranes are the visceral and parietal peritoneum.

Peritoneal dialysis is an excellent substitute for hemodialysis in cases of patients who, out of various reasons, cannot withstand hemodialysis. (Acierno, M.J., Labato, Mary, 2011)

INDICATIONS

The most important indication for peritoneal dialysis in dogs and cats is anuria generated by an acute kidney injury (AKI) that is unresponsive to fluid therapy. (Barges, J., Polzin, D. J., 2011)

Dialysis is also indicated in patients showing acute non-anuric uraemia, when blood urea nitrogen (BUN) reaches levels over 100 mg/dl or when creatinine is higher than 10 mg/dl.

Peritoneal dialysis can also be employed to stabilize patients with uroabdomen or other urinary tract obstructions before surgery. (Mazzaferro, Elisa, 2012)

Peritoneal dialysis is indicated in various cases of intoxication and metabolic abnormalities. It can also be employed to remove dialyzable toxins, such as ethylene glycol, ethanol, barbiturates, propoxyphene and hydantoin, as well as in cases of electrolyte imbalances, such as hyperkalemia. (Holowaychuk, Marie, Marks, S. L., 2011)

Peritoneal dialysis is indicated when hemodialysis or charcoal hemoperfusion is not available, when vascular access is difficult to gain or when patient suffers from refractory hypotension, thus making hemodialysis too risky a procedure. (Viţălaru, B. Al., Micşa, C., 2015)

Peritoneal dialysis is also used on a wide scale in new born humans showing urea cycle disorders. It is used as an emergency tool when correcting hyperammonemia along with supplementary drug management in order to stabilize the condition until a liver transplant. (Viţălaru, B. Al., Ştefănescu Alina, 2015)

Congestive heart failure refractory to medical management is another indication for peritoneal dialysis in human medicine. (Langston, Cathy, 2011)

CONTRAINDICATIONS

Peritoneal dialysis is contraindicated in patients with peritoneal adhesions, fibrosis or abdominal malignant tumours. (Munteanu, Raluca et. all, 2017)

Peritoneal dialysis is also contraindicated in patients with pleuroperitoneal accumulations, because of their predisposition to develop pleural accumulations during dialysis. (Michell, A. R., 2010)

Relative contraindications are required in patients that have recently undergone abdominal surgery or in those that have inguinal or abdominal hernia, because of the increased risk of high intraperitoneal pressure. (Ross, Linda, 2011)

Patients in a severe hypercatabolic state, such as burn victims or patients in extreme malnutrition states, have a relative contraindication because of their tendency to lose proteins across the peritoneum. (Donohoe, Charlotte, 2012)

Patients who have recently undergone surgery, especially gastrointestinal surgery, present a risk for dehiscence and infection during peritoneal dialysis because of the higher intraperitoneal pressure and because of the extravasation potential of the dialysis fluid across the incision. (Ross, Linda, 2011)

Peritoneal dialysis presents as well as a high risk of complications in patients presenting polycystic kidney disease, extreme obesity, peripheral vascular disease and hyperlipidemia. (Elliott, D. A., 2011)

TYPES OF PERITONEAL CATHETERS

The ideal catheter for dialysis allows for an adequate administration and evacuation of the dialysate, it determines minimum subcutaneous losses, it minimizes infection both in the peritoneal cavity and in the subcutaneous tissue. (Thornhill, J. A., 1981)

Catheters for acute dialysis are placed percutaneously, under local anaesthesia, with the help of a stiletto and they require immediate heparinization.

These catheters are usually straight with orifices at the distal end. Acute catheters generally do not have Dacron cuffs in order to protect the patient against bacterial infection and catheter migration, that may lead to a high peritonitis rate in case of extensive use. There is also a high risk of bowel perforation during catheter placement. (Viţălaru, B. Al., 2014)

Catheters for chronic peritoneal dialysis have specific models, both intraperitoneal and extraperitoneal, in order to reduce secondary effects and to minimize blockage. These catheters are made of silicon, rubber or polyurethane. (Viţălaru, B. Al., Petrescu, V. F., 2016)

Catheters designed for chronic peritoneal dialysis have Dacron cuffs meant to protect the patient against bacterial infection and catheter migration that may lead to a high peritonitis rate in case of extensive use. (Thornhill, J. A., 1981)

The intraperitoneal segment of catheters has numerous lateral orifices at the distal end that allow the free flow of dialysate. The distal end of the peritoneal dialysis catheter may be straight or coiled. The coiled end may help with avoiding blockage. The segment of the catheter that comes out of the abdomen usually presents one or two Dacron cuffs. Usually, the middle segment is incorporated in the right abdominal muscle. The Dacron cuffs generate a local inflammatory response that triggers the emergence of granulation or fibrous tissue. This tissue fixes in place the catheter and it prevents the migration of bacteria from skin to the peritoneal cavity. In peritoneal dialysis, studies show that, in catheters with a single Dacron cuff, peritonitis shows up in a much shorter amount of time and that the infection rate for the placement area is higher, although other studies revealed no difference between catheters with different numbers of Dacron cuffs. (Viţălaru, B. Al., 2014)

The extraperitoneal segment of the catheter may be straight or with a curve between the two cuffs. The swan-neck catheters are meant to have a subcutaneous tunnel oriented straight down, in order to reduce the risk of infection at catheter level. There are no studies performed in veterinary medicine meant to assess the practicality of a certain type of catheter for peritoneal dialysis. (Viţălaru, B. Al., et. all, 2014)

In human medicine, the Tenckhoff catheter is the one most widely used in chronic peritoneal dialysis. This silicon catheter boasts a straight extraperitoneal segment and either a straight intraperitoneal segment, or a curved one with various orifices on the distal end. The Tenckhoff catheter may have one or two Dacron cuffs.

Among other catheter types used in veterinary medicine, there are Blake 15 Fr surgical drain, straight or curved Swan Neck, Missouri catheter, 10 cm PD catheter, Quinton pediatric catheter for peritoneal dialysis, and Dawson-Mueller drain. All these catheters require surgical placement. (Holowaychuk, Marie, Marks, S. L., 2011)

Simple tubular catheters with trocar can be placed on conscious animals, using local anaesthetics in case of major emergencies. The catheter for percutaneous cystostomy can also be used successfully in veterinary medicine instead of a peritoneal catheter in renal patients. (Viţălaru, B. Al., 2015)

PERITONEAL CATHETER INSERTIONS

The placement method for peritoneal dialysis catheters depends on the catheter itself, on the patient and on the approximate duration of the dialysis. In cases of extreme emergency, when the peritoneal dialysis should not be used more than 72 hours, the placement of a short-term catheter is justified. (Viţălaru, B. Al., 2015)

In order to place a percutaneous peritoneal dialysis catheter for short-term use, the animal is placed in dorsal decubitus and the abdomen is trimmed and prepared in sterile conditions using proper asepsis and antisepsis techniques. It is very important that each aspect is taken into account in order to preserve the asepsis and the antisepsis and in order to prevent catheter-related infections. A 1-2 mm incision, 3-5 cm from the umbilicus, in the direction of the pelvis, will be made. The trocar is tunnelled subcutaneously a few centimetres before inserting it into the abdomen. The catheter is then passed over the trocar until it fully penetrates the abdomen.

After catheter insertion, a tobacco pouch suture will be performed to secure the catheter. The suturing material is extremely important in the prevention of catheter related infections. Non-absorbable monofilament sutures (Nylon - polyamide, polypropylene) are to be preferred. Therefore, it is indicated to perform long-term peritoneal dialysis via peritoneal catheters with Dacron cuffs. (Viţălaru, B. Al., Ştefănescu Alina, 2018)

When placing a peritoneal dialysis catheter, which is meant to be used for more than three days, it is recommended to use a permanent catheter. The long-term peritoneal dialysis catheter should be surgically placed. The surgical placement of the catheter allows the visualization of the abdominal cavity and it is useful in omentectomy. Surgical omentectomy is also recommended due to the high risk of catheter blockage by the omentum.

Omentectomy is a surgical procedure which should be performed under maximum safety with regard to asepsis and antisepsis conditions and under general anaesthesia. (Costea, Ruxandra, Vitalaru, B. Al., 2015)

Peritoneal dialysis catheters can be trimmed (cut), resizing them at the desired level for entering the peritoneal cavity, in order to reach the bottom of the Douglas pouch. The catheters are pre-measured and, after being cut, they are inserted into the cavity. The abdominal muscles are sutured using an absorbable monofilament thread and the last suture, or a separate suture point, is anchored in the distal Dacron cuff of the peritoneal catheter. Subsequently, the anterior end of the catheter is passed through a subcutaneous lateral tunnel and it is exteriorized through the skin at 3-5 cm from the main incision line, so that the second Dacron cuff is located at subcutaneous level. (Viţălaru, B. Al., el. all, 2019)

After the placement, the catheter should be sutured at the skin level using Chinese finger trap or Roman sandals suture. (Viţălaru, B. Al., el. all, 2020)

In the first 24-48 hours after catheter placement, it is not recommended to use large volumes of dialysate in order to reduce intraperitoneal pressure, since this may cause leakage at the catheter placement site. (Viţălaru, B. Al., 2020)

PERITONEAL DIALYSIS SYSTEM

The peritoneal dialysis system is placed immediately after the peritoneal dialysis catheter is inserted and attached to a closed collection system, being carefully prepped in place with dry sterile dressings.

The peritoneal dialysis catheter is connected to the dialysis bag through a plastic tubing called a transfer set.

The Y transfer set consists of a Y-shaped tubular piece connected to both a dialysis bag and a drainage bag.

During the exchange, the dialysate is allowed to flow into the effluent bag. Prior to introducing fresh dialysis fluid into the peritoneum, a low volume of fresh dialysate solution is drained from the dialysis bag directly into the effluent bag, bypassing the patient. This step is supposed to eliminate the bacteria that were introduced into the system at the time of connection. Upon completion of the lavage, the dialysate may be instilled into the peritoneum.

It is absolutely necessary to use strictly sterile techniques at any time when manipulating the peritoneal dialysis catheter and the drainage system. (Viţălaru, B. Al., 2020)

PERITONEAL DIALYSIS SOLUTIONS

The specific composition of the dialysate is an important factor to consider when performing peritoneal dialysis.

The ideal peritoneal dialysis solution should achieve the low absorption clearance of osmotic agents, provide missing or insufficient electrolytes and nutrients, correct acid-base imbalances, inhibit growth of microorganisms, and be inert with regard to the peritoneum. (Thornhill, J. A., 1981)

The standard dialysis solution contains glucose as an osmotic agent. The glucose-based dialysate is present in three different concentrations: 1.5%, 2.5% and 4.25%. The dialysis performed in order to remove uremic toxins is generally done using a 1.5% solution.

The use of a hypertonic glucose solution (4.25%) is reserved for overhydrated patients, in which case the strong osmotic dialysate is used for the removal of water from the body through osmosis.

Peritoneal dialysis can be performed using commercial dextrose dialysate solutions or a mixture formulated by adding dextrose to Ringer's lactate solution. (Holowaychuk, Marie, Marks, S. L., 2011)

Recipes for "Homemade" peritoneal dialysis fluids can also be used. "Homemade" solutions contain 0.45% or 0.9% sodium chloride or lactated Ringer solution, depending on the patient's needs and the dextrose added.

Dextrose at a concentration of 1.5% is suitable for a dialysate solution and it can be obtained by adding 30 ml of 50% dextrose to one litter of lactated Ringer solution or 50 ml in order to obtain a 2.5% solution. (Viţălaru, B. Al., 2020)

PERITONEAL DIALYSIS PROTOCOL

When initiating peritoneal dialysis in acute kidney injury, the main goal is not to immediately normalize uraemia. The initial objectives should be to normalize the hemodynamic status of the patient and the acid-base and electrolyte imbalances, as well as to reduce uraemia to a BUN of 60-100 mg/dl and to reach a creatinine of 4.0-6.0 mg/dl in 24-48 hours. (Viţălaru, B. Al., Ştefănescu Alina, 2018)

The volume of the introduced dialysate varies depending on the concentration, composition and individual needs of the patient with an average of 40-60 ml/kg/exchange in a complete peritoneal dialysis cycle. In practice, a much more convenient formula can be used, essentially the amount of dialysate introduced being of 1 l/1sqm/exchange.

The dialysate should be heated to 38°C or even 39°C to improve peritoneal permeability and patient comfort prior to instillation into the peritoneal cavity.

Most patients with acute kidney injury will experience hyperkalemia, and most dialysis solutions do not have added potassium. In the initial cycles of peritoneal dialysis this is an ideal situation. However, hypokalemia may occur over time and, in order to prevent it, 2-4 mEq/l of potassium may be added to the dialysate after several cycles. (Viţălaru, B. Al., 2015)

To initiate a peritoneal dialysis session, the new dialysis bag is placed above the patient while the effluent bag is placed under the patient. A small amount of dialysate is washed from the dialysis bag directly into the effluent bag. At the first instillation, 10 ml/kg of dialysate solution is instilled by gravity into the peritoneum for 10 minutes and the solution is allowed to remain inside for 30-40 minutes.

The peritoneal cavity is allowed to drain by gravity into the sterile effluent bag for 10 to 20 minutes. The system is closed and the line washing procedure is repeated.

After the initial shifts in the first 24 to 48 hours, the patient can be transferred onto a chronic peritoneal dialysis protocol. Cycles of 3 to 6 hours will be performed and then these may be transformed into 3 to 4 daily shifts as renal function is restored.

It is recommended to gradually reduce the number of shifts and to prolong the duration of dialysis until reaching intermittent peritoneal dialysis which is performed at 3 to 4 days, with frequent patient re-evaluation before deciding on discontinuation of dialysis. (Viţălaru, B. Al., 2020)

PERITONEAL DIALYSIS COMPLICATIONS

Complications of peritoneal dialysis are common, but they can be easily managed if discovered or addressed in due time. The most common complications are: peritoneal catheter obstruction, electrolyte imbalances, hypoalbuminemia and bacterial peritonitis. (Holowaychuk, Marie, Marks, S. L., 2011)

Dialysis solution retention is defined as the recovery of less than 90% of the dialysate solution, which represents approximately 45% (on average) in animals undergoing peritoneal dialysis. (Acierno, M.J., Labato, Mary, 2011)

The most common causes of dialysate solution retention are the occlusion created by entrapping the omentum in the catheter pores and the accumulation of fibrin on the catheter. Performing partial omentectomy prior to placing the peritoneal catheter considerably decreases the frequency of this complication. (Viţălaru, B. Al., Ştefănescu Alina, 2018)

Accumulation of the dialysate solution at the subcutaneous level is another common problem in about 35% (on average) of patients. Regardless of the peritoneal, percutaneous or surgical catheter placing method, in veterinary medicine, extravasation of the dialysate solution at subcutaneous level is a frequent complication because, most of the time, the catheter is used immediately after placing it. (Viţălaru, B. Al., 2020)

The presence of hypoalbuminemia in animals undergoing peritoneal dialysis has been reported to be in the range of 41-90%. (Viţălaru, B. Al., 2015)

Peritonitis is diagnosed when two of the three following criteria are identified: turbid dialysate fluid when extracted, extracted dialysate fluid with more than 100 inflammatory cells/μL, or a positive bacterial culture test in the extracted dialysate solution, and clinical symptomatology characteristic of peritonitis. Peritonitis is the most common complication in peritoneal dialysis.

Pleural effusion and dyspnea are rare complications in patients undergoing peritoneal dialysis. Pleural effusions may be caused by hyperhydration or peluro-peritoneal leaks. Careful monitoring of the patient's hydration status, central venous pressure, urinary output and body weight may reduce the inci-

dence of hyperhydration.

Respiratory insufficiency due to intra-abdominal pressure and the respiratory rate in accordance with the introduced dialysis fluid flow should be carefully monitored. The volume of the dialysate solution should be decreased if intra-abdominal pressure causes ventilatory dysfunctions. (Viţălaru, B. Al., 2020)

Dialysis disequilibrium syndrome is a very rare complication of peritoneal dialysis and it is characterized by convulsive seizures, coma and/or exitus. This is secondary to the sudden drop in blood osmolarity. (Polzin, D., 2006)

Peritoneal membrane exchanges and ultrafiltration loss associated with peritonitis are the most serious complications of peritoneal dialysis. (Viţălaru, B. Al., 2020).

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