Peritoneal dialysis in animals- A review

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Abstract

Peritoneal dialysis has become a commonly practiced technique for the treatment of both acute and chronic kidney failure and for removal of dialyzable exogenous and endogenous poisons in animals. With the increased availability of veterinary services today and with the further advancement expected in the future, peritoneal dialysis likely will find ever widening use, particularly for old and geriatric patients.

INTRODUCTION

Uremia, renal failure and acute intoxication are few medical problems often encountered in animals. In such cases, there is a rise in the waste toxic product in the plasma/blood of the animals. This is frequently reported disease in ruminants seen mainly as a consequence to urolithiasis and ruptures of urinary bladder and following repair of bladder (Reddy et al., 1995). Treatment of early diagnosed cases is often proved beneficial where level of toxicants viz. creatinine and blood urea nitrogen is not too high. Medical management is not suffice in chronic cases with uremia, peritonitis and renal failure.

Dialysis has been introduced along with the medical management to cope up with chronic nature of this disease. Dialysis is the diffusion of solutes from one solution (plasma/ blood/interstitial fluid) to another (dialysate in peritoneum cavity) across a semipermeable membrane (Grauer and Brown, 1997). Dialysis particularly removes the waste or toxic substances rapidly by the process of diffusion, ultrafiltration and solute drainage (Parker, 1980; Thornhill, 1981; Carter et al., 1989) and as a result of that physiology improves drastically over the period of few days/or weeks.

PRINCIPLE OF DIALYSIS

Dialysis is transfer of solutes across a semi-permeable membrane by the process of diffusion and the membranes are parietal and visceral peritoneum. Solutes that are in high concentration region pass through the pores in the membrane and the process finally helps in the movement of intoxicants from the blood out of the system.

MODE OF DIALYSIS

Peritoneal and haemodialysis are the two ways washing away the toxicants from the system that are in practice for animals, however, hemodialysis in animals appears expensive (Abe et al., 1913) and studies have further indicated that this methods is relatively difficult to perform for animals with higher body weight (>13.6 kgs) (Di Bartola et al., 1985). Haemodialysis often not fruitful method as it does not eliminate the system from toxicants that has higher molecular weight (i.e. ranging 500-5000) which are the main elements of uremia (Chew and Crisp, 1992) manifestation. Pleural dialysis has also been reported by some earlier worker (Reddy et al., 1994; Shahar and Holmberg, 1985), but this is not into routine practice for animals. Pleural dialysis is performed in the same manner as that of peritoneal dialysis, however, here pleural membrane works as a barrier while diffusion instead of peritoneum.

NEED FOR PERITONEAL DIALYSIS

Animals with acute intrinsic renal failure (AIRF), acutely decompensated CRF, and post renal azotemia that can not undergo immediate surgical correction are candidates for peritoneal dialysis. Brief indications and contraindications of peritoneal dialysis are:

A. ACUTE RENAL FAILURE (AIRF)

Failure of fluid, diuretic and vasodilator therapy to induce a diuresis in oliguric/ anuric patients.

Failure of fluid, diuretic and vasodilator therapy to control the biochemical and clinical manifestations of uremia.

Life threatening fluid overload/ pulmonary edema.

Life threatening electrolyte and / or acid-base disturbance.

B. CHRONIC RENAL FAILURE

Uremia that is unresponsive to conventional dietary /medical management.

Long term peritoneal dialysis for irreversible, end stage renal disease rarely practical in animals.

C. MISCELLANEOUS CONDITIONS

Severe pulmonary edema that is refractory to conventional medical therapy.

Acute intoxication/drug overdose when the toxicant is dialyzable (eg. Ethylene glycol, barbiturate).

Contraindications

Diaphragmatic hernia

Severe intra-abdominal adhesions

Recent abdominal surgery (a relative contraindication)

Volume and flow of dialysate solution may contribute to breakdown of suture lines in stomach, intestine, or urinary bladder.

Distention of the abdomen with dialysate solution may result in leakage through a ventral midline incision and increase the possibility of peritonitis.

Selection and preparation of dialysate for peritoneal dialysis

Dialysate is generally chosen to approximate normal plasma composition (with the exception of protein) (Rudnick et al., 1987). Dialysate should be tailored, however, to the individual patient for sodium, chloride, potassium and alkalis needs. The concentration gradient between blood and dialysate largely determines what substances are removed from or added to the animal's blood (Hall, 1983). A large concentration gradient from blood to dialysate favors solute removal from the body, whereas a large concentration gradient from dialysate to blood favors uptake of solute to the body. The concentration gradient between blood and dialysate should be non-existent for substances not desired to be removed from or added to the body.

COMMERCIAL DIALYSATE SOLUTION

The composition of commercially available solutions and a home made dialysis solution which approximates 1.5% dextrose containing dialysate that is made by adding 30 ml 50 % dextrose to one liter bag of lactated ringer's solution is listed below. The dextrose should be added immediately prior to use and all injection ports should be scrubbed with a betadine solution. The transfer should be made as sterile as possible to minimize the chances of contaminating the dialysis solution.

As most patients with renal failure have metabolic acidosis, the lactate in dialysis solution helps to correct the acid/base imbalance. Glucose solution assists to draw water which contains waste products into the abdominal cavity. 1.5% glucose containing solution is slightly hyper-osmolar compared to plasma, and will cause water to be removed from the patient. 4.25% glucose containing dialysate has an osmolality of 486 milli osmol/liter and can quickly volume deplete the patient if care is not exercised in its use in most cases. 1.5% dextrose containing solutions are appropriate. 500 to 1000 units of heparin can be added to each liter of dialysate to reduce clotting in the catheter.

HOME MADE DIALYSATE SOLUTIONS AS FIRST AID IN PERITONEAL DIALYSIS

Home made dialysate should have lacted Ringer's, 0.45% sodium chloride or 0.9% sodium chloride as base solution can be individually tailored to the patient as an alternative to commercial fluids. Rapid infusion og dialysate at 200 to 300ml /min by gravity is well maintained in animals (Parker et al., 1972; Thornhill, 1981) as and when home made dialysate are used as first aid for peritoneal dialysis. Commercial dialysate fluids are generally preferred, since alternations of the dialysate (additive) increases the risk for bacterial contamination during preparation. All home made-prepared solutions require the addition of glucose. Thirty milliliters of 50% dextrose is added to each liter to achieve a 1.5% dextrose solution, or 50 ml of 50% dextrose to achieve a 2.5% dextrose solution (Chew and Crisp, 1992). In the home made dialysate solutions, magnesium (72 mg/liter of fluid to achieve 1.5 meq/l), sodium bicarbonate (30 -45 meq/liter as a source of alkali), heparin (just prior to infusion, 1000 units/l), antibiotics (if peritonitis is suspected) and potassium (in hypokalemia, 4 meq/l) should be added. In case of hypercalcemia or hyperphosphatemia it may be advisable initially to choose a home made preparation that is lacking in calcium (0.9 % sodium chloride with glucose added). In general, it is advised that rapid drainage of dialysate should not be performed with compressed as it could be painful in dogs (Parker, 1981).

TYPE OF PERITONEAL DIALYSIS

A. Continuous peritoneal dialysis (CPD); B. Intermittent

peritoneal dialysis (IPD);

A. Continuous peritoneal dialysis: In this method, an uninterrupted flow of solution is done through the abdominal cavity with the aid of two canulas. There are two kind of CPD namely; 1. Continuous ambulatory peritoneal dialysis (CAPD); 2. Continuous cycling peritoneal dialysis (CCPD).

Continuous ambulatory peritoneal dialysis (CAPD): This was described by Popvich and Moncrief (1976). CAPD is continuous because it works a lot like kidney did; it is a very natural process. It constantly cleans the blood as long as there is dialysis fluid in the peritoneal cavity. This is the most commonly used form of peritoneal dialysis and works by using gravity. It is carried out manually through out the day. A bag of fluid is warned to body temperature and placed at a high enough level to allow the filtered the blood of waste products, chemicals and water, an empty bag is placed at a low enough level to allow the fluid to drain out the abdomen through the tube. The exchange takes about 45 minutes. CAPD performed four exchanges per day, seven days per week.

Continuous cycling peritoneal dialysis (CCPD): It is a modification of CAPD and IPD and is performed by a machine that automatically exchange the waste filled dialysate with fresh dialysate while the patient sleep at night. This cycle is repeated according to a pre-set programme. This cycler does exchanges automatically over 8 to 10 hours.

B. Intermittent /fractional peritoneal dialysis (IPD): In this, determined volume of solution is periodically introduced into the cavity and eventually removed from it after a certain period of exposure. In this case one and the same canula is used for introducing and withdrawing the solution. One complete cycle is called exchange and IPD exchange takes about 1 hour to complete. CAPD technique is more suitable than intermittent peritoneal dialysis for long term treatment of chronic renal failure.

TECHNIQUE OF PERITONEAL DIALYSIS

Aseptic technique is imperative with any type of peritoneal dialysis (Thornhill, 1981; Copley, 1987). This includes the use of surgical scrub and sterile surgical technique during catheter placement, as well as the use of sterile gloves, disinfectants, and the careful handling of dialysate fluids, catheters, and catheter line during dialysis.

A. PERITONEAL DIALYSIS CATHETER

An indwelling catheter is recommended because of the repeated dialysate exchanges.

B. IDEAL CATHETERS HAVE THE FOLLOWING CHARACTERISTICS-

Efficient fluid inflow and outflow

Biocompatibility

Resistance to infection of the subcutaneous tunnel and peritoneal cavity

Little fluid leakage at the peritoneal interface

C. TYPE OF CATHETER

1. Simple type of catheters (figure 1 and 2)

Figure 1

Figure 1

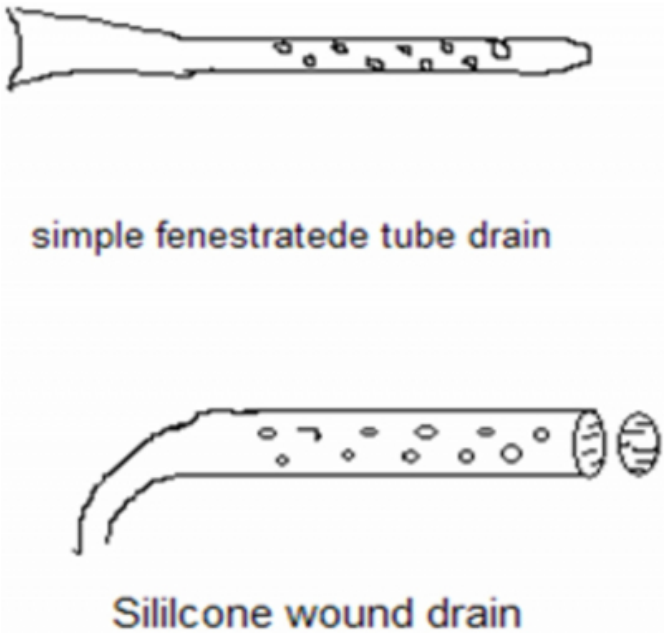
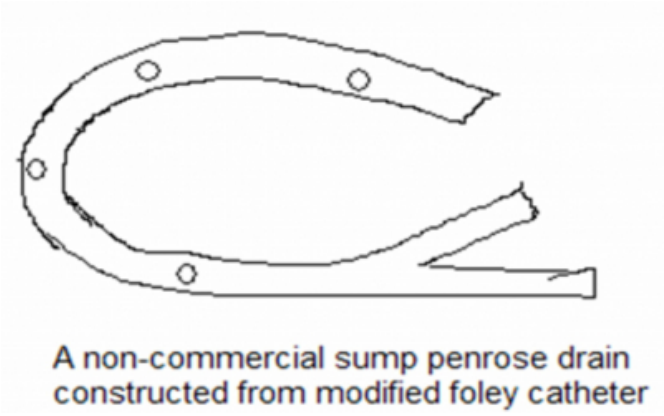


Figure 2

Figure 2



2. Straight tube catheters (Parker peritoneal dialysis canulas and Tencnoff catheters)

(a) Advantages-

Relatively inexpensive

Can usually be inserted with local anesthesia

(b) Disadvantages-

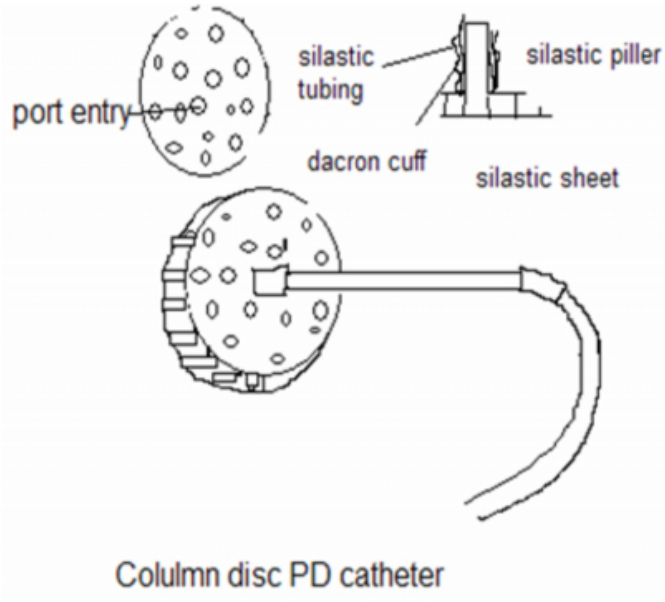
Catheter holes easily plugged with fibrin and omentum, causing fluid outflow obstruction

Greater potential for dialysate leakage at catheter placement site

2. Column disk catheters (Lifecath, Quinton Instrument Co., Seattle, WA (Fig. 3)

Figure 3

Figure 3



(a) Advantages-

Less prone to outflow obstruction

Less prone to leakage at catheter site

(b) Disadvantages-

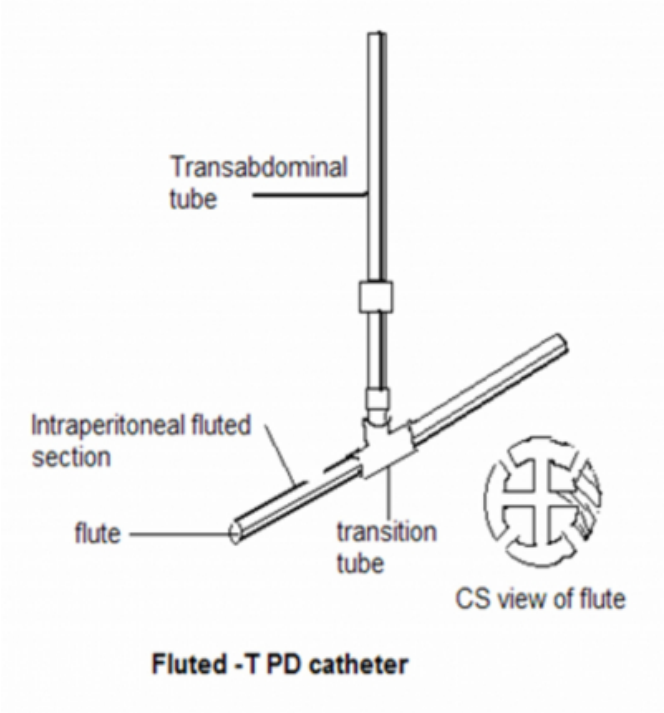
Expensive but can be re-sterilized and reused

Usually requires general anesthesia and surgery to insert

Fluted- T peritoneal dialysis catheter (figure 4) (Ash and Janle, 1993)

Figure 4

Figure 4



METHOD TO ACCESS INTO PERITONEAL CAVITY

1. Acute process – percutaneous peritoneal dialysis:Acute(short-term, temporary) dialysis can be most simply accomplished using a multiple intermittent puncture technique with large gauge hypodermic needle for infusion and drainage of dialysate. An 18 or 20 gauge needle puncture along the ventral midline 2 cm caudal to the umbilicus can be used to infuse dialysis fluids. Drainage of dialysate may require a 16 or 14 or 12 gauge needle or plastic canula. A sterile intravenous extension set and collection bag (empty parenteral fluid bag) is attached to the drainage needle during outflow. Trauma from multiple puncture and difficulty in consistent out-flow of dialysate limit the long-term usefulness of this technique. Obstruction of dialysate out flow is common with this technique and frequent postural adjustments or repeated puncture are necessary to encourage continued drainage.

Peritoneal lavage (continuous peritoneal dialysis) is an alternative technique to treat the uremia in bovines (Singh and Sahu, 1995; Cowgill, 1995) and in canines (Rukmani and Tiwari, 2004). A 14 French tube is percutaneously placed in the flank for infusion of dialysate. One or more outflow drains is placed inside a fenestrated penrose drain and then inserted along with ventral abdomen. Infection with this technique can be a problem because this is an open

drainage system (Parker, 1972).

2. Chronic access- Surgically placed catheter

Two catheters designed for long term peritoneal dialysis in dogs are commercially available that are parkers and column disk peritoneal dialysis. Parker peritoneal dialysis canula consist of a trocar, guide tube, a stainless steel needle, and a silicone rubber dialysis canula- This catheter can be placed with local anesthetic if the animal is severely depressed and is transfixed across the flank in a bowed manner ventral to the bladder . Leakage of dialysate is minimal because of the dorsal flank exit site for the catheter. A Dacron cuff is present at the level of the body wall to decrease in dogs has been shown to be highly successful in the reduction of uremic solutes and in its ability to freely drain dialysate (Parker et al., 1972). Unfortunately this catheter has not achieved widespread use due to limited commercial availability initially.

The column disk peritoneal dialysis catheter represents the device used most commonly for long term placement and rapid drainage of dialysate in dogs. The catheter is made of silicone and consists of a single tube opening two parallel disks separated by numerous pillars. Advantage from this catheter includes excellent effluent drainage and minimal leakage of dialysate. The pillars help prevent catheter out follow occlusion by omentum, fibrin, and abdominal organs. The disks are secured into a non-movable position along the body wall. Two Dacron cuffs are placed on the catheter to allow fibrous tissue growth and prevent ascending bacterial migration.

FACTORS INFLUENCING THE PERITONEAL DIALYSIS

1. Peritoneal blood flow: Though the peritoneal surface area is large, but solute and water exchange is occur across the peritoneal capillaries and possibly terminal arterioles (Nolph, 1986). Less than 0.2% of the peritoneal surface area has been estimated to have functional area (pores) for exchange. Therefore, peritoneal blood flow is important for maximal clearance (Nolph, 1986; Rudnick et al., 1987). Peritoneal blood flow becomes limiting during peritoneal dialysis when severe hypotensive shock exists (Nolph, 1986; Rudnidk et al., 1987; Kliger, 1981). Warming the dialysate solution 2-3° F above the animal's body temperature increases peritoneal blood flow (Grauer and Brown, 1997). Peritonitis alters peritoneal blood flow, effective peritoneal surface area, or peritoneal permeability. Peritonitis may also result the loss of mesothelial microvilli and increased diameter of intercellular gaps. Chronic peritoneal dialysis during peritonitis in human increases clearances of urea and creatinine, increases glucose absorption from dialysate, increases protein loss into dialysate, and decreases effluent drainage (Rubin et al., 1981). It appears that peritonitis does not reduce clearance of uremic solute during peritoneal dialysis. The nature of the peritoneal membrane and efficiency of peritoneal dialysis in dog may change with age. Puppies' less than 1 month old exhibit greater peritoneal membrane permeability and increased functional peritoneal membrane surface area relative to body weight as compared with adult dog (Elzuki et al., 1981).

2. Composition of dialysate: Solute and water transport across the peritoneum is dependent on the type of dialysate solution to which the peritoneum is exposed (Zelman et al., 1977). Hypertonic dialysate is much more efficient than isotonic solutions in the removal of uremic solute (Henderson, 1969; Henderson and Nolph, 1969; Brown et al., 1978). Sodium and attendant anions along with dextrose account for most of the osmolality within dialysate. Osmolality during standard dialysis is altered by varying the amount of dextrose in dialysate from a minimum of 1.5% to a maximum of 4.5%. Hypertonic dialysate increase solute clearance by a combination of solute drag following ultrafiltration, capillary vasodilation, increased pore diameter, and dehydration of the peritoneal interstitium that alters interstitial aqueous channels. Amino acids added to dialysate can increases osmolality as well as provide nutrition for human patients undergoing CAPD (Hain and Kessel, 1987). A 2% amino acid solution can result in as much ultrafiltration as absorbed from using a 4.25% dextrose solution (Kirk, 2004) but is very expensive ((Hain and Kessel, 1987). Alkali precursors (lactate or acetate) are added to commercial dialysate. Acetate and lactate promote vasodilation of peritoneal vessels in addition to their systemic alkalinizing effects (Miller et al., 1981). Shock or hypotension can reduce the metabolic conversion of acetate or lactate to bicarbonate. It appears that in general vasodilators (isoproternol) only modestly increase clearance of small and middle molecules while substantially increasing clearance of high molecular weight substances (proteins) (Felt et al., 1979). Hypertonic dextrose dialysate (4.55) has a much greater effect on increasing small solute clearance than doe's administration of vasodilators.

The surface active agents' trisaminomethane and dioctyl sodium sulfosuccinate increase urea clearance in dog through poorly understood mechanisms (Brown et al., 1978),

but their use has been limited because of toxicity.

3. Volume of dialysate solution infused into the animal: Large volume provide greater amount of surface area for diffusion but also require longer equilibration times. The may also decrease cardiac output and causes increased peripheral resistance associated with increased intra abdominal pressure and decreased venous return. Sometimes this may bring abdominal discomfort and dyspnea/respiratory distress by decreasing movement of the diaphragm. Similarly small volumes have certain advantages as it reduces the equilibration time and cardiovascular complications are minimized. However, in this more fluid exchanges must be performed which increases technical time enhances the chances of infection.

PROBLEMS AND COMPLICATIONS

(a) Catheter insertion problems (most commonly associated with straight tube catheters)

1. Penetration of bowel or urinary bladder

2. Laceration of a major vessel

(b) Paracatheter fluid leakage

(c) Catheter failure

1. The most common problem

2. Characterized by an inability to retrieve all the infused fluid

3. Corrective measures

Flush the catheter rapidly with 20 ml heparinized saline in an attempt to dislodge blood and /or fibrin clots and omentum.

Reposition the animal

Try to reposition the catheter within the abdomen by external manipulation

Placement of a new catheter may be necessary.

(d) Peritonitis: Septic and aseptic peritonitis are common complications but are not necessarily indications to stop dialysis.

1. Diagnosis

Systemic signs (e.g. fever, abdominal pain, vomiting) may or may not be present.

Retrieved dialysate has a cloudy appearance.

Analysis of retrieved dialysate shows large numbers of neutrophils; bacteria may also be observed.

Bacterial culture and sensitivity are performed on the retrieved dialysate.

2. Prevention

Flush abdomen with 1 liter o fnorma saline once daily.

Instill a saline –iodine solution (0.2 ml of 2% iodine USP in 1 L of saline) for 4 minutes and then drain (Thornhill, 1983).

3. Treatment

Dialysis can usually be continued.

Systemic and intraperitoneal antibiotic treatment is based on bacterial culture and sensitivity of the retrieved dialystae.

Cephalothin is given as a loading dose of 1 g/L of dialysate, followed by a maintenance dose of 250 mg/L of dialysate.

Aminoglycoside is given as a loading dose of 4 mg/kg IM, followed by a maintenance dose of 6 mg/L of dialysate (Thornhill, 1983).

Heparin (500 U/L) is added to the dialysate to prevent fibrin occlusion of the catheter.

Treatment should be continued for 10 – 14 days.

If after 96 hours of aggressive treatment no clinical improvement occurs, the peritoneal access catheter should be removed.

(e) Hypoalbuminemia

This occurs as a result of the relative permeability of albumin to peritoneal membrane.

The rate of albumin loss is accelerated with peritonitis.

(f) Pleural effusion

May develop associated with the combination of overhydration and hypoalbuminemia.

May necessitate occasional thoracocentesis.

(g) Fluid overload

This is when there is too much fluid in the body and it may be due to (I) increase fluid input and (II) decreased fluid out

put from either dialysis fluid or urine. The signs are weight gain, high blood pressure, puffy hands or eyes and breathing difficulties.

(i) Dehydration

This is when there is too little fluid in the body and it may be due to diarrhea, vomiting, increased output from dialysate fluid or urine, decreased fluid intake or sweating. The signs are weight loss, low blood pressure, sunken eyes, dry mouth or coated tongue or inelastic skin.

Crisp et al. (1989) performed peritoneal dialysis in 27 dogs and cats. They found hypoalbuminemia and catheter retention as a frequent complications of peritoneal dialysis. The other complications are shown in the following table.

FUTURE PROSPECTS OF DIALYSIS IN ANIMALS

In the animals, cost of treatment and post operative management is a common huddle for popularization of any new technique. This is a one of the reason that haemodialysis is not used in animals clinically. Therefore, it has less future in animals until and unless a artificial kidney is designed for animals with less cost. However, peritoneal dialysis is can be utilized effectively in animals owing to its easiness and simple process. Although in veterinary, uremic cases in spite of high BUN and creatinine oftenly recovered by surgical intervention and intravenous fluid administration, however its use helps in early and faster recovery from the uremia. However, further investigation is needed to develop a type of dialysate that remove the solute effectively and quickly with its reutilization.

CONCLUSIONS

Dialysis is an alternative modality to treat the cases of acute renal failure or uremia especially when dietary and a medical remedy is failed. The use of peritoneal dialysis is common in veterinary practice owing to its easy application, whereas haemodialysis, frequently used in medical science, is limited only to some referral Veterinary clinic. A judicious use of peritoneal dialysis, as a sole or in adjunction to medicinal therapy, can restore the patient life towards normalcy.

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