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Peritoneal Dialysis in Dogs: 20 cases (2006-2008)

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Abstract : Peritoneal dialysis (PD) is a clinical technique that therapeutically removes toxic solutes from body fluids and normalizes endogenous solutes whose aberrant concentrations disrupt normal physiology. This study retrospectively evaluated clinical outcomes and complications of PD in 20 dogs with renal failure. Blood works (total count of red blood cells (RBC), packed cell volume (PCV), the serum biochemical, and electrolyte values related to renal insufficiency) and complications associated with peritoneal dialysis, and clinical outcomes were recorded before and after PD. Additionally, creatinine reduction ratio (CRR) and urea nitrogen reduction ratio (URR) were calculated for evaluating the efficacy of PD. PD resulted in a significant ($p < 0.05$) reduction in blood urea nitrogen (BUN) concentration in 19 dogs, while a significant ($p < 0.05$) reduction in creatinine concentration in 17 dogs. The complications of PD were hypoalbuminemia (12/20, 60%), anemia (10/20, 50%), subcutaneous dialysate leakage (9/20, 45%), bacterial peritonitis (6/20, 30%), dialysate retention (5/20, 25%) and limb edema (4/20, 20%). This study demonstrated that PD was effective in reducing the magnitude of azotemia in dogs with renal failure especially in acute phase, although the complication rate was high but manageable.

Key words : peritoneal dialysis, renal failure, dialysate, azotemia, dog.

Introduction

Peritoneal dialysis (PD) is a clinical technique that therapeutically removes toxic solutes from body fluids and normalizes endogenous solutes whose aberrant concentrations disrupt normal physiology. Since the first application of PD for treating acute renal failure (ARF) in humans at 1923, PD is used in dogs to manage ARF and chronic renal failure (CRF), to remove dialyzable toxins (e.g. ethylene glycol, gentamycin), to reduce severe metabolic disturbances, to be a part of treatment of peritonitis, pancreatitis and uroabdomen, and to remove fluid overload (e.g. acute pulmonary edema), although the major indication of PD is ARF in veterinary medicine. Although the technique for PD has been well described in veterinary literature (3,4,6,7,8,12,13), two major complications (i.e. catheter failure and hypoalbuminemia) of PD is hindering the application of PD in small animal practice (1,5,10).

Hemodialysis (HD) is another type of clinical procedure for treating acute uremia in dogs and uses the extracorporeal circulation for filtering out uremic toxins. Although the HD is superior to PD for treating ARF and CRF and thus is principally used for the management of refractory ARF and CRF in Korea and some other countries, clinical application of HD is still limited in Korean veterinary practice, because of substantial expense related to HD (e.g. cost of dialyzer, circuits and dialyzing solution), need for general anesthesia and sophisticated training of delivery system, inappropriate pumping pressure for toy dog breeds, and risk of bleeding. Therefore PD may be more appropriate method of dialysis in local clinics of Korea, because it only requires inexpensive equipments related to PD and easier application after minimal training.

The purpose of this retrospective study was to evaluate the clinical outcomes and complications of PD in dogs with renal failure.

Materials and Methods

Dogs

Twenty dogs (11 males and 9 females) with renal failure were enrolled in this study. The patient information enrolled in this study and etiologies of each case were summarized in Table 1.

Peritoneal dialysis

The simple tube catheter method described in elsewhere were used in this study. However, the type of peritoneal catheter (Dawson-Mueller drainage catheter, COOK®, USA) has never been applied in other studies (Fig 1A). For PD, using aseptic technique, the catheter (over the trocar) was inserted through a stab incision 3 to 5 cm lateral to the umbilicus oriented toward the pelvis (Fig 1B). The trocar was tunneled

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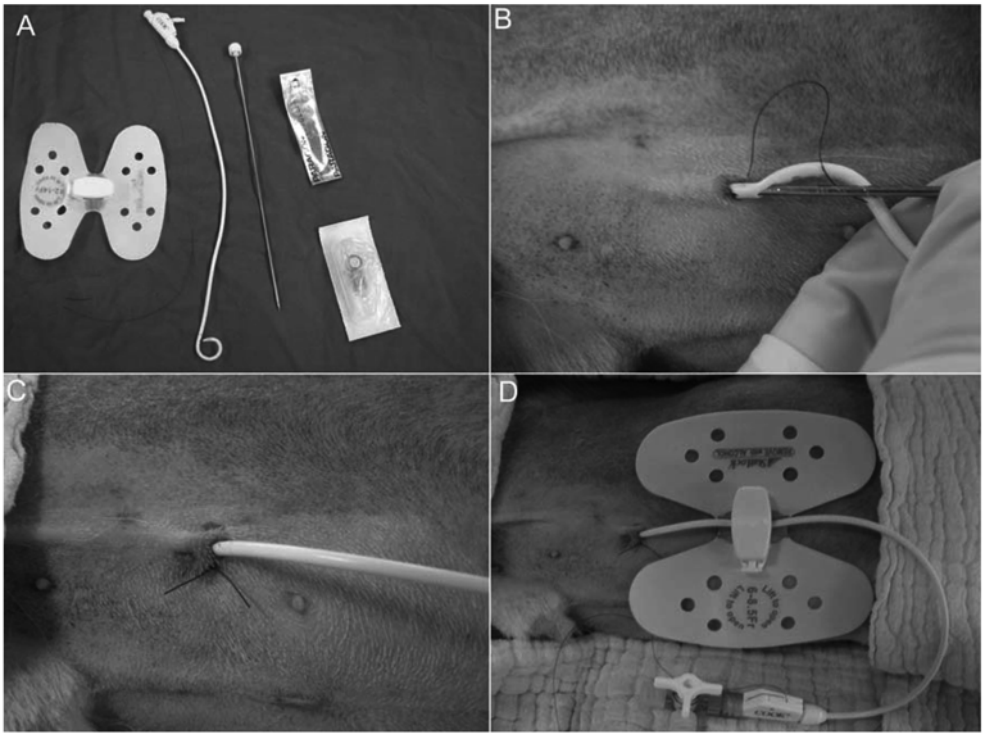

Fig 1. Procedure of peritoneal dialysis. A: Catheter (brand, COOK®, USA) and equipments. B: The catheter (over the trocar) was inserted through a stab incision 3 to 5 cm lateral to the umbilicus oriented toward the pelvis. C: A purse-string suture was placed to secure the catheter. D: A tape butterfly was added to secure the catheter to the skin in the lateral abdomen.

subcutaneously for several centimeters before being inserted through the abdominal muscles into the abdomen. The catheter was then threaded over the trocar until fully in the abdomen (Fig 1C). A purse-string suture was placed to secure the catheter and a tape butterfly was added to secure the catheter to the skin in the lateral abdomen (Fig 1D).

Dialysate solution was made with 970 mL of lactated Ringer solution, 30 mL of 50% dextrose solution and 0.1 mL of heparin (500 U/mL, Pine injection, Huons, Korea) to reach the final concentration of 1.5% dextrose in the dialysate solution. Dextrose concentration was increased to 3%, if the dog absorbed dialysate solution. The exchange technique for PD was as follows: (1) the dialysate was infused at a dose of 30 to 40 mL/kg over a 10-minute period; (2) the dialysate remained in the abdomen for 30 to 40 minutes (dwell time) and was then drained into a collection bag by gravity over a 20- to 30-minute period; (3) dialysis cycles were repeated every 1 to 2 hours until the concentration of blood urea nitrogen (BUN) and creatinine had been either reached to BUN of 60 to 100 mg/dL and a creatinine of 4.0 to 6.0 mg/dL or diseased.

Concurrent medical treatment with PD was also performed, based on the underlying causes of renal failure in each dog.

Assessment of efficacy and adverse effects of PD

Blood cell count, blood chemistry and plasma electrolyte analysis were performed prior to initiation of PD, with blood cell analyzer (FORCYTE™, Oxford Science Inc., USA), serum biochemistry analyzer (SPOTCHE™, EZ SP-4430, Arkray factory Inc., Japan) and I-Stat® (Heska, USA), respectively. The serum biochemical and electrolyte values related to renal insufficiency, total count of red blood cells (RBC) and packed cell volume (PCV) at presentation of each case were recorded (Table 2). Creatinine reduction ratio (CRR) and urea nitrogen reduction ratio (URR) were calculated by the following equation: 1- [pre-value – post-value]/[pre-value]. The dialysis cycle per either CRR or URR was calculated by the following equation: CRR (or URR)/total number of dialysis cycles (Table 3). The duration of peritoneal dialysis, complications associated with peritoneal dialysis and clinical outcomes were also recorded (Table 1 and 4).

Statistical analysis

The mean and SD were calculated for each of these values. Pre- and post-dialysis BUN and creatinine concentrations for each patient were analyzed, using the Wilcoxon signed rank test. Paired student *t*-test was performed on pre- and post-dialysis BUN and creatinine concentrations.

Results

Mean ages of affected dogs were 5.5 ± 4.17 years (ranging from 1 to 14 years). Etiologies of each case were defined by antemortem diagnostic studies and/or postmortem exami-

Table 1. Patient information, etiology and clinical outcome form peritoneal dialysis in dogs enrolled in this study

ID	Gender	Age	Breed	Etiology	Clinical outcome
CASE 1	M	5	Sharpei	CRF by renal amylodosis	Death
CASE 2	F	4	Cocker spaniel	ARF by pylonephritis (pyometra)	Survived
CASE 3	M	1	Maltese	ARF by gentamycin	Survived
CASE 4	F	14	Yorkshire terrier	ARF by cardiogenic	Survived
CASE 5	M	14	Maltese	ARF by cardiogenic	Survived
CASE 6	M	7	Maltese	CRF by unknown	Death
CASE 7	M	11	Mixed	ARF by pulmonary cancer	Survived
CASE 8	M	7	Pomeranian	CRF by unknown	Survived
CASE 9	F	12	Yorkshire terrier	ARF by poisoning	Death
CASE 10	F	3	Cocker spaniel	CRF by Glomerulonephritis by HWD	Death
CASE 11	M	4	Jindo	CRF by Glomerulonephritis by HWD	Survived
CASE 12	F	6	Jindo	ARF by Pyelonephritis by pyometra	Death
CASE 13	M	3	Tosa	CRF by glomerulonephritis by HWD	Death
CASE 14	M	3	Schunauzer	CRF by unknown	Death
CASE 15	F	2	Shih tzu	ARF by poisoning	Survived
CASE 16	M	2	Shih tzu	ARF by poisoning	Death
CASE 17	F	3	Shih tzu	ARF by cardiogenic	Survived
CASE 18	M	1	Poodle	CRF by unknown	Survived
CASE 19	F	2	Shih tzu	ARF by gentamycin	Death
CASE 20	F	7	Pekinese	ARF by multiple cancer	Survived

Abbreviation: M (Male); F (Female); CRF (Chronic renal failure); ARF (Acute renal failure); HWD (Heartworm disease)

nation. Acute renal failure was more common reason for performing PD (12/20; 60%). Of those animals with acute renal failure, poisoning (3/12, 25%), complications from cardiac medications (3/12, 25%), gentamycin toxicosis (2/12, 16.7%), pyelonephritis sequel to pyometra (2/12, 16.7%) and cancer complications (2/12, 16.7%) were the reason for PD, while of dogs with chronic renal failure, unknown etiology (4/8, 50%), glomerulonephritis sequel to heartworm infection (3/8, 37.5%) and Shar pei fever were the reason (Table 1).

Of those animals with acute renal failure, hemoconcentration (2/12, 16.7%), anemia (4/12, 33.3%), hypoproteinemia (1/12, 8.3%), hypoalbuminemia (6/12, 50%,) hypocalcemia (2/12, 16.7%), hyperphosphatemia (9/12, 75%), hyonatremia (7/12, 58.3%), hyperkalemia (3/12, 25%), hypokalemia (5/12, 41.7%) and hypochloremia (4/12, 33.3%) were the common laboratory findings (Table 2). In contrast, of those animals with chronic renal failure, hemoconcentration (3/8, 37.5%), anemia (4/8, 50%), hypoproteinemia (2/8, 25%), hypoalbuminemia (5/8, 62.5%), hypocalcemia (1/12, 8.3%), hyperphosphatemia (7/8, 87.5%), hyonatremia (3/8, 37.5%), hyperkalemia (3/8, 37.5%), hypokalemia (3/8, 37.5%) and hypochloremia (4/8, 50%) were the common laboratory findings (Table 2).

Analysis of the pre- and post-dialysis BUN and creatinine concentrations for each patient was performed. Mean concentrations of pre-dialysis creatinine and BUN were 8.32 ± 4.41 and 208.7 ± 75.4, respectively. The mean number of peritoneal dialysis cycles applied was 8.6 ± 4.3 cycles. Peritoneal dialysis (PD) resulted in a significant ($p < 0.05$) decrease in BUN concentration in 19 dogs, while a significant ($p < 0.05$) decrease in creatinine concentration in 17 dogs (Table 3). The mean of URR was much higher than that of CRR (0.51 ± 0.20 *vs* 0.37 ± 0.29; $p < 0.01$). The mean CRR and URR per dialysis cycles were 0.054 ± 0.031 and 0.067 ± 0.03, respectively.

The most common complication of peritoneal dialysis was hypoalbuminemia (12/20, 60%), anemia (10/20, 50%) and subcutaneous dialysate leakage (9/20, 45%) (Table 4). Six dogs treated with peritoneal dialysis had bacterial peritonitis (*E.coli* was the major contaminant bacteria). Other complications associated with PD observed in this study were dialysate retention (5/20, 25%) and limb edema (4/20, 20%).

Eleven of the dogs were rescued by PD, while 9 dogs were either died during the treatment regimen or were euthanatized because of the severity of underlying renal disease. Of 12 dogs with acute renal failure, 8 dogs were rescued by PD, while only 3 of 8 dogs with chronic renal failure were rescued (Table 1).

Discussion

In PD, an electrolyte solution (dialysate) is infused into the abdominal cavity, where it equilibrates with plasma by osmosis across the peritoneal membrane and then the dialysate is drained from the abdomen, thereby removing excess solutes and water (7). Although over 20,000 human patients a year

Table 2. Laboratory test results of dogs enrolled in this study

ID	PCV	RBC	BUN	CRET	T.P	ALB	Ca	P	Na	K	Cl
CASE 1	57.1	8.98	162	12.3	6.3	2	11	25	111	5.9	91
CASE 2	24	3.16	301	14.8	5.9	2.5	8.8	15	125	9	103
CASE 3	20.2	2.23	210	5.3	5.6	2.2	10.3	10.7	144	4.8	112
CASE 4	35.2	5.5	203	4.6	6	2.3	10.5	11	123	3.2	115
CASE 5	40.8	6.9	210	2.9	6	2.7	10.5	17	122	3.1	100
CASE 6	50.8	12.3	320	16.9	5.8	1.7	5.6	24	149	2.4	96
CASE 7	36.8	6.22	217	3.6	4.5	1.8	9.4	6.7	124	7	89
CASE 8	65.4	4.7	332	5.1	6.7	2.5	13.1	3.2	120	6.2	87
CASE 9	35	4.86	137	4.8	6.7	2.8	5.9	10.9	119	3.4	89
CASE 10	47.2	2.23	321	7.9	5.2	1.3	11.4	7.1	149	7	112
CASE 11	21.5	3.66	135	9.1	5.1	1.9	8.9	6.9	144	4.2	106
CASE 12	36.8	7.11	176	4.3	9.1	4.2	10.9	4.3	165	4.7	102
CASE 13	39.9	6.4	124	4	7.4	3.5	8.7	4.7	150	3.8	111
CASE 14	36.3	5.26	83	5.1	6.4	3.2	10.3	5.1	133	6.1	95
CASE 15	30.3	4.98	254	10.1	6.4	2.1	13.6	0.5	140	6.3	104
CASE 16	15.8	2.69	158	12.5	7	2.6	11.5	15	134	3.9	100
CASE 17	59.2	7.83	189	14.5	7.2	3.1	12	5	140	4	95
CASE 18	82.1	11.36	169	7.1	10	4.3	13.2	20	148	4.3	107
CASE 19	61.4	8.26	152	7.3	6.2	3	11.4	15	154	5.1	115
CASE 20	55	7.45	321	14.1	8.2	4.1	3.5	20	122	2.8	76
Mean	42.54	6.104	208.7	8.315	6.585	2.69	10.025	11.355	135.8	4.86	100.25
± SD	17.0971	2.787603	75.40634	4.410308	1.324774	0.848466	2.601391	7.202227	14.52982	1.69656	10.52753

Abbreviation and Unit: PCV (Packed cell volume, %); RBC (Red blood cells, $X10^6$/uL); CRET (Creatinine, mg/dL); BUN (Blood urea nitrogen, mg/dL), T.P (Total protein, g/dL), ALB (Albumin, g/dL), Ca (Calcium, mg/dL), P (Phosphorus, mg/dL), Na (Sodium, mEq/L), K (Potassium, mEq/L)

in America with chronic renal failure are being maintained by PD (9), the clinical outcome of PD was disappointing in veterinary medicine in the past (10). The major reasons of this disappointed outcome were i) innate physiological differences between humans and animals, ii) tendency for veterinarians to consider PD as last therapeutic method (so thus the animals receiving PD had more grave prognosis), iii) technical difficulties (e.g. poor training, catheter obstruction) (7). In our retrospective study, most dogs receiving PD were referred from local clinic with unstable health status. Furthermore, most dogs have had medical treatment for renal failure longer than weeks to months for dogs with chronic renal failure. Those dogs were very poor health condition with unbalanced acid-base and electrolyte condition. Furthermore, many dogs were treated with wrong choice of fluid therapy, for instance, lactated Ringer solution in hyperkalemic dogs. Overall survival rate was 55% (11/20) in this study, but survival rate in dogs with chronic renal failure was on 37.5% (3/8). Probably this lower survival rate in dogs with chronic renal failure was due to the severity of underlying diseases, because the URR and CRR were not much different in dogs with acute and chronic renal failure. Since the efficacy of PD was clearly demonstrated in this study, the earlier intervention with PD might be increased survival rate after PD in dogs with renal failure. Also most etiologies related to acute renal failure were drug related in this study (e.g. gentamycin, cardiac medication and poisoning), while those to chronic renal failure were secondary to underlying diseases (e.g. pyometra and heartworm disease). Therefore, practitioners should be aware of the danger of nephrotoxic drugs in dogs having higher risk of renal failure before the prescription, and should carefully monitor the secondary renal infection from pyometra and renal complication associated with heartworm treatment. These efforts will remarkably reduce the incidence of renal failure in veterinary practice.

Known complications with PD are hypoalbuminemia, dialysate retention (due to catheter failure), peritonitis, exit site leaks (subcutaneous leakage), third space fluid accumulation (e.g. limb edema, pleural effusion and pulmonary edema), dyspnea caused by increased abdominal pressure, changes in hydration and electrolyte status (7). As reported previously, we have also seen most complications in this study, although no dogs showed dyspnea due to increased abdominal pressure and pleural effusion (10). Hypoalbuminemia is the most common complication seen in humans and dogs (1,2,10). Loss can be variable but be dependent on dialysate volume, flow rate, concentration of dextrose, and

Table 3. Creatinine and urea nitrogen reduction ratio in dogs enrolled in this study after peritoneal dialysis.

ID	Pre-Creat	Post-Creat	CRR	CRR/F	Pre-BNU	Post-BUN	URR	URR/F	Frequency
CASE 1	12.3	8.5	0.31	0.062	162	110	0.32	0.064	5
CASE 2	14.8	7.8	0.47	0.047	301	163	0.46	0.046	10
CASE 3	5.3	2.5	0.53	0.048	210	61	0.71	0.065	11
CASE 4	4.6	1.3	0.72	0.072	203	80	0.61	0.061	10
CASE 5	2.9	2.2	0.24	0.019	210	126	0.40	0.031	13
CASE 6	16.9	9.3	0.45	0.112	320	191	0.40	0.101	4
CASE 7	3.6	1.1	0.69	0.139	217	39	0.82	0.164	5
CASE 8	5.1	3.8	0.25	0.015	332	140	0.58	0.034	17
CASE 9	4.8	4.2	0.13	0.063	137	131	0.04	0.022	2
CASE 10	7.9	6.8	0.14	0.028	321	180	0.44	0.088	5
CASE 11	9.1	5.5	0.40	0.066	135	81	0.40	0.067	6
CASE 12	4.3	2.5	0.42	0.052	176	114	0.35	0.044	8
CASE 13	4	2	0.50	0.050	124	34	0.73	0.073	10
CASE 14	5.1	2.3	0.55	0.078	83	41	0.51	0.072	7
CASE 15	10.1	8.7	0.14	0.035	254	167	0.34	0.086	4
CASE 16	12.5	7.9	0.37	0.041	158	13	0.92	0.102	9
CASE 17	14.5	9.6	0.34	0.028	189	63	0.67	0.056	12
CASE 18	7.1	5.1	0.28	0.020	169	56	0.67	0.048	14
CASE 19	7.3	3.4	0.53	0.033	152	74	0.51	0.032	16
CASE 20	14.1	10.5	0.26	0.064	321	200	0.38	0.094	4
Mean	8.32	5.25	0.37	0.054	208.7	103.2	0.51	0.067	8.6
± SD	4.41	3.12	0.29	0.031	75.4	57.1	0.20	0.033	4.3

Abbreviation: Pre-Creat (Creatinine before peritoneal dialysis); Post-Creat (Creatinine after peritoneal dialysis); CRR (Creatinine reduction ratio); CRR/F (Creatinine reduction ratio per 1 cycle of peritoneal dialysis); Pre-BUN (Blood urea nitrogen before peritoneal dialysis); Post-Creat (Blood urea nitrogen after peritoneal dialysis); URR (Blood urea nitrogen reduction ratio); URR/F (Blood urea nitrogen reduction ratio per 1 cycle of peritoneal dialysis); Frequency (Total number of dialysis cycles)

Table 4. Complications associated with peritoneal dialysis in dogs enrolled in this study.

Complication	No. of animal	Percent
Hypoalbuminemia*	12	60%
Dialysate retension	5	25%
Peritonitis	6	30%
Subcutaneous leakage	9	45%
Limb edema	4	20%
Anemia*	10	50%

*More than 20% of decrease value from pre-peritoneal dialysis value

peritonitis (8). This protein loss found to be higher during the first few cycles of PD and then tended to stabilize (8). One human study found albumin loss was more severe and was approximately 10 g/day, depending on the condition of PD (8). Hypoalbuminemia was observed 60% of dogs in this study, which comparably higher than other complications and previous study (44%) (10). Nutritional support including feeding tubes, partial parenteral nutrition, total parenteral nutrition, and a new technique of PD using 1.1% amino acid solutions (Nutrineal®) and plasma transfusion (also canine recombinant albumin) will be beneficial for lessening hypoalbuminemia during PD (7).

Dialysate retention might be a major technical complication associated with PD and resulted from catheter blockage by blood clot or omentum (2,7). Probably this technical complication is the main cause for giving up PD in practice. There are many peritoneal catheters commercially available for PD, for instance, Stamey percutaneosus suprapubic catheter (Cook®, USA), spiral fenestrated silicone peritoneal dialysis catheter (Cook®, USA), T-style fluted peritoneal dialysis catheter (Ash Advantage peritoneal catheter®, Medigroup, USA), coaxical design peritoneal dialysis catheter (Cook®, USA) (7). The advantage and disadvantage of those catheters have been well described in literature (7). In this retrospective study, dialysate retention was relatively rarer complication, since we used spiral fenestrated silicone catheters. We found the omentum and body fat were major causes for catheter failure. Although surgical removal of omentum and body fat were indicated in this case, we believed this indication might not be appropriate in dogs, because it required anesthesia. Furthermore newly developed catheterizing techniques and equipments probably provide sufficient solution for cases with catheter failure.

Peritonitis is the main concern for any dogs receiving PD, since it often causes life-threatening situation (2,7). Rela-

tively higher prevalence of peritonitis associated with PD compared to human studies has been reported in veterinary literature (22%) (5). The most common source of peritonitis is contamination of the bag or tubing by the handler, infection from exit sites, blood and intestine (rarely) (7). Our study found 30% of dogs showed peritonitis. Since most these dogs had more than 3 times catheter placement due to either catheter occlusion or exit site leaks, most contamination might be occurred during catheter placement. Therefore meticulous sterile process should be maintained from the beginning to the end of catheter placement. Furthermore, regular-based cytological examination on dialysate will help to recognize peritoneal infection earlier.

In conclusion, this study clearly demonstrated that PD was effective in reducing the magnitude of azotemia in dogs with acute and chronic renal failure, although the complication rate was high but manageable. Therefore PD is more realistic treatment option for dogs with unresponsive renal failure in Korean veterinary practice.

Acknowledgement

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개에서 복막투석 적용: 20 증례 (2006-2008)

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요 약 : 복막투석은 정상적인 생리적 상태의 장애를 야기하는 체내의 독성물질을 치료적으로 제거하는 임상적 방법이다. 본 연구에서는 신부전으로 내원한 환자에게 복막투석을 적용한 20증례의 임상적 결과와 합병증을 후향적으로 평가하였다. 복막투석을 실시하는 동안 적혈구수, 혈구용적, 신기능과 관련된 혈액 화학적 수치 및 전해질 등의 혈액학적 분석과 합병증, 임상적 결과 등을 기록하였다. 복막투석의 결과로 19마리의 개에서 혈중 요소 질산 농도가 유의하게 감소하였고 ($p<0.05$), 17마리의 개에서 혈중 크레아티닌의 농도가 유의하게 감소하였다 ($p<0.05$). 복막투석의 부작용으로는 저알부민혈증(12/20, 60%), 빈혈(10/20, 50%), 투석액의 피하 누출(9/20, 45%), 세균성 복막염 (6/20, 30%), 투석액의 저류 (5/20, 25%)와 사지의 부종(4/20, 20%)이 나타났다. 본 증례고찰을 통하여 복막투석은 신부전(특히 급성기)에 이환된 개에서 질소혈증을 개선하는데 효과적임을 알 수 있었다.

주요어 : 복막투석, 신부전, 투석액, 질소혈증, 개.