RESEARCH ARTICLE

Therapeutic Efficacy of Intermittent Haemodialysis in Dogs with Progressive Renal Impairment

Gurwinder Singh*, Sikh Tejinder Singh, Ashwani Kumar Sharma

Abstract

Renal failure is a common and clinically significant condition in dogs, necessitating thorough diagnostic evaluation and timely therapeutic intervention. This study evaluated 50 dogs exhibiting clinical signs of renal dysfunction and serum creatinine concentrations exceeding 1.4 mg/dL. All dogs underwent comprehensive clinical examination, haematological and serum biochemical analysis, and routine urinalysis to determine the severity and nature of renal impairment. Anaemia, azotemia characterized by elevated BUN and creatinine concentrations, hyperphosphatemia, and related abnormalities were among the most common significant findings. Based on clinical status and treatment requirements, 7 of the 50 dogs received intermittent haemodialysis (IHD) in addition to standard medical therapy. Dogs receiving IHD showed marked clinical improvement, especially with respect to uremia-associated signs compared to conventional therapy, and resulted in significant reductions in BUN, creatinine, and inorganic phosphorus concentrations, as reflected by meaningful urea and creatinine reduction ratios after each dialysis session. Electrolyte concentrations and liver-associated biochemical parameters remained largely stable, suggesting that IHD, when appropriately prescribed and monitored, is a safe therapeutic intervention without inducing major biochemical derangements. Despite the evident biochemical and clinical benefits, survival outcomes remained guarded in dogs with stage IV chronic renal failure. However, dogs in earlier stages of renal disease, demonstrated prolonged survival, underscoring the importance of early diagnosis and timely initiation of advanced renal replacement therapies. The study provides an in-depth diagnostic characterization of canine renal insufficiency and offers comparative insight into the therapeutic outcomes of conventional management versus adjunctive haemodialysis.

Key words: Dog, Intermittent haemodialysis, Renal Failures.

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Introduction

The kidney is a multifunctional organ that, in addition to filtering nitrogenous waste and producing urine through regulation of extracellular fluid volume, plays essential roles in maintaining acid-base equilibrium, electrolyte balance, and endocrine and metabolic homeostasis in mammals. In situations involving acute or chronic renal injury, a range of renal replacement therapies (RRT) have been developed in human medicine and subsequently adapted for use in veterinary patients over the past four decades (Cowgill and Francey, 2012; Singh, 2021).

Intermittent haemodialysis (IHD) is a renal replacement therapy characterized by short, high-efficiency dialysis sessions designed to remove endogenous and exogenous toxins from the bloodstream. It is indicated for a range of clinical conditions, including drug or toxin ingestion, acute or acute-on-chronic kidney injury, and chronic kidney disease (CKD). Depending on the underlying condition, IHD may be administered as a single session, commonly in cases of toxin exposure, or as repeated treatments performed daily or on alternate days for several consecutive days, as often required in acute kidney injury (AKI). In patients with CKD, IHD can be incorporated into a long-term management plan, with treatments scheduled two to three times weekly for the duration of the patient's life (Bloom and Labato, 2011). Haemodialysis is primarily employed for the management of acute and chronic renal failure that does not respond adequately to conventional medical therapy. Growing recognition of haemodialysis as an effective renal replacement therapy, along with increasing demand from pet owners, continues to support its expansion and establishes its role as a valuable therapeutic option in veterinary medicine (Elliott, 2000). The dialysis prescription is tailored for each treatment session to optimize the removal of waste solutes and to restore fluid, electrolyte, and acid-base balance as effectively as possible. For any given patient, the prescription may vary from one session to the next, depending on factors such as

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residual renal function, urine output, biochemical parameters, and concurrent medical conditions (Fischer *et al.,* 2004).

Before initiating haemodialysis, key aspects of medical management should be optimized. The patient must be adequately hydrated, and if urine output is reduced or unknown, rehydration should be completed over 4 to 6 h unless cardiovascular compromise prevents rapid fluid administration. Hypotension should be corrected to ensure adequate renal perfusion, with a target systolic blood pressure of >80 mm Hg. If these measures fail to restore urine production, diuretics may be administered. Furosemide is the most commonly used potent diuretic; if an initial intravenous dose of 2.2 mg/kg does not increase urine output within 20 to 30 min, the dose may be doubled or tripled, up to a maximum of 8.8 mg/kg IV. When anuria or oliguria persists despite appropriate medical intervention, haemodialysis becomes inevitable (Langstone, 2002). This study was therefore aimed to evaluate the therapeutic efficacy of intermittent haemodialysis in dogs with progressive renal impairment.

Materials and Methods

Patient Preparation

Pre-dialysis evaluation of patient included assessment of body weight, vital parameters, and clinical signs or patient-reported symptoms, along with documentation of co-morbidities such as diabetes mellitus, hypertension, and cardiovascular disease. Comprehensive haemato-biochemical investigations and routine urinalysis (physical, chemical, and microscopic) were performed, including evaluation of proteinuria and determination of the urine protein-to-creatinine ratio.

Physical Examination and Clinical Monitoring

Rectal temperature, respiratory rate, and heart rate were recorded, and cardiac and pulmonary auscultation was performed. The oral cavity was examined for dental tartar and ulceration, while the skin coat was evaluated for ectoparasites, lesions, and hydration status. Abdominal palpation and regional lymph node examination were conducted to assess pain and abnormal growths. Based on these findings, a preliminary diagnosis was formulated and animals were subjected to further diagnostic evaluation.

Haemato-Biochemical and Urine Analysis

Approximately 2 mL and 5 mL of blood were collected for complete blood count and serum biochemical analysis, respectively. Haematological parameters were analysed using a fully automated laser-based haematology analyser (ADVIA® 2120, Siemens Healthcare Diagnostics Inc., USA). Differential leukocyte count was performed manually on Leishman's-stained blood smears. Biochemical parameters were estimated using the Vitros DT 350 Chemistry System (Ortho Clinical Diagnostics, Johnson & Johnson) including BUN, creatinine, AST, ALP, total protein, albumin, sodium, potassium, chloride, calcium, inorganic phosphorus, random blood glucose, cholesterol, and triglycerides.

Urine samples were collected by cystocentesis and subjected to routine urinalysis such as colour, turbidity, odour, pH, and specific gravity. Chemical analysis was performed using Multistix® 10 SG reagent strips for qualitative detection of protein, glucose, bile pigments, ketone bodies, and blood cells. Microscopic examination of urine sediment was carried out under low and high magnification to identify and quantify cells, casts, and crystals. Urine protein and creatinine concentrations were estimated using the Vitros DT 350 Chemistry System, and the urine protein-to-creatinine ratio was calculated.

BP, ECG Measurement and Ultrasonography

Blood pressure was measured using Vmed Vet-Dop2 Veterinary Doppler (Cagatay, 2025), placing cuff just below the elbow joint and the mean of three systolic readings was recorded. Electrocardiography was performed at a paper speed of 50 mm/s in conscious dogs positioned in right lateral recumbency. Abdominal ultrasonography was carried out in real-time B-mode using convex (1-5 MHz) or linear (7-12 MHz)

(a) (b) (c)

Fig. 1: Ultrasound of kidney (a) normal kidney with presence of cortico-medullary differentiation, (b) loss of cortico-medullary differentiation with hyperechoic renal cortex, (c) moderate loss of cortico-medullary differentiation with hyperechoic renal cortex; irregular contour of kidney with acoustic shadowing of renal cortex suggestive of nephrolith

transducers. Ultrasonographic findings of abdominal and pelvic organs were systematically recorded (Fig. 1).

Haemodialysis

The haemodialysis procedure, including dialysis prescription, vascular access, preparation of the dialysis machine, intradialytic management, blood circuit configuration, and selection of dialyzers, was performed in accordance with the protocol described by Langstone (2002) (Fig. 2). The post-dialysis assessment included vital signs like blood pressure (BP ≤ 170 mmHg), heart rate (HR 70-120 beats/min), respiratory rate (RR 16-34 breaths/min, and rectal temperature (T 101-103 °F). The blood tests included haemoglobin, haematocrit, platelet count, BUN, serum creatinine, potassium, sodium, phosphate and calcium as described earlier.

Conventional Treatment

The conventional treatments, used in dogs not requiring dialysis (43) and those underwent dialysis (7), included fluid therapy, antibiotics, phosphate binding agents, diuretics, antiemetics, ace inhibitor and calcium channel blocker, vitamin B complex and renoprotective drugs as per need of the patient.

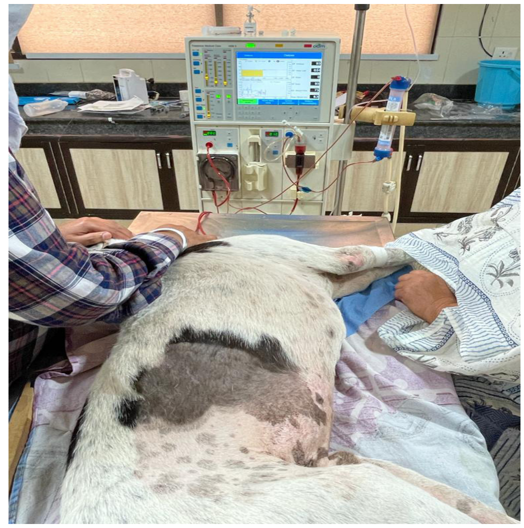

Fig. 2: Haemodialysis in a dog with renal failure

Table 1: Effect of conventional treatment + IHD on clinical signs in dogs with renal insufficiency

Clinical signs	Stage 3 (Serum Cr 1.4-2.8 mg/dL) (n=1)			Stage 4 (Serum Cr 2.9-5 mg/dL) (n=6)					Overall (N=7)				
	0 day	7-10 days	Recovery %	0 day		7-10 days		Recovery %	0 day		7-10 days		Recovery %
	n	n		n	%	n	%		n	%	n	%	
Vomiting	1	0	100	6	100	3	50	50	7	100	3	42.9	57.1
Anorexia	1	1	0	6	100	5	83.3	16.7	7	100	6	85.7	14.3
Melena	1	0	100	6	100	4	66.7	33.3	7	100	5	71.4	28.5
Halitosis	0	0	-	6	100	5	83.3	16.7	6	85.7	6	85.7	0
Oral ulcer	0	0	-	3	50	2	33.3	33. 3	3	42.9	2	28.5	14.3
Polydipsia	0	0	-	1	16.7	0	0	100	2	28.5	1	14.3	50
Polyuria	0	0	-	1	16.7	1	16.7	0	1	14.29	1	14.3	0
Oliguria	0	0	-	0	0	0	0	-	0	0	0	0	-
Fever	0	0	-	0	0	0	0	-	0	0	0	0	-
Hematuria	0	0	-	1	16.7	0	0	100	1	14.3	0	0	100
Ascites	0	0	-	0	0	0	0	-	0	0	0	0	-

Table 2: Effect of conventional treatment + IHD on vital parameters in dogs with different stages of renal insufficiency (Mean ±SE)

Parameters	Stage 3 (Serum Cr 2.9-5 mg/dL) (n=1)		Stage 4 (Serum Cr >5 mg/dL) (n=6)		Overall (N=7)	
	0 day	7-10 days	0 day	7-10 days	0 day	7-10 days
Rectal temperature (°F)	100.5	100.0	$101.5^a \pm 0.5$	$100.9^a \pm 0.4$	$101.3^a \pm 0.4$	$100.7^a \pm 0.3$
Heart rate (Beats/min.)	114.0	116.0	$102.7^a \pm 6.9$	$102.3^a \pm 5.0$	$104.3^a \pm 6.1$	$104.3^a \pm 4.7$
Respiration rate (Breaths/min.)	30.0	32.0	$31.3^a \pm 2.2$	$28.5^a \pm 1.4$	$31.1^a \pm 1.8$	$29.0^a \pm 1.3$

Figures with different superscripts differ significantly (p≤0.05).

Statistical Analysis

The data analysis for each response variable was performed using statistical methods such as ANOVA, t-test, and correlation. The SAS software was utilized for this purpose.

Results and Discussion

Six dogs with stage IV and one dog with stage III renal disease received intermittent haemodialysis in conjunction with conventional medical therapy. The treatment regimen included fluid therapy, proton pump inhibitors, antiemetics, vasodilators, phosphate binders, antibiotics (as required), and vitamin B complex supplementation. The effects of therapy on clinical outcome and haemato-biochemical parameters were evaluated.

Vomiting and anorexia were the most prevalent clinical signs across all stages of renal insufficiency (Table 1), likely attributable to uremic gastropathy and accumulation of uremic toxins (Queau, 2012). Improvement in these signs was more pronounced following intermittent haemodialysis (IHD), reflecting enhanced uremic toxin clearance. Melena was observed predominantly in stage IV cases and was associated with gastrointestinal ulceration and uremia-induced thrombocytopathy (Queau, 2012). A recovery rate of 28.5% was recorded in dogs with melena following IHD.

Effects on Vital Parameters

The effects of treatment on vital parameters are summarized in Table 2. Rectal temperature, heart rate, and respiratory rate did not differ significantly between day 0 and days 7-10, indicating preservation of physiological homeostasis despite renal disease. Similar findings, with no significant variation in these parameters during disease progression or treatment, have been reported in dogs with renal failure (Dunaevich *et al.*, 2020).

Effects on Haemato-Biochemical Profile

Conventional therapy combined with IHD did not significantly affect haemoglobin, PCV, TEC, or TLC in dogs with stage IV renal failure. Among differential leukocyte parameters, absolute eosinophil counts and neutrophil-to-lymphocyte ratios showed improvement, while platelet counts decreased following therapy compared to day 0 values (Table 3). Consistent with these findings, King *et al.* (1992) reported non-regenerative, normocytic, normochromic anaemia in 70.6% of dogs with end-stage chronic renal failure, with anaemia severity correlating with serum creatinine concentrations.

The effects of treatment on biochemical parameters are presented in Table 4. Significant reductions in blood urea nitrogen, creatinine, and phosphorus concentrations were observed following therapy. Similar findings were reported by Geraldes *et al.* (2020), who demonstrated the efficacy of intermittent haemodialysis (IHD) in enhancing clearance of urea, creatinine, and phosphorus in dogs with stage IV renal failure. No significant changes were observed in serum potassium, sodium, chloride, or calcium concentrations, consistent with previous reports (Francey, 2012). The observed reduction in phosphorus may be attributed to effective clearance by IHD in conjunction with oral phosphate binders. Additionally, serum ALT, ALKP, total protein, albumin, globulin, and glucose concentrations remained unchanged post-treatment, in agreement with the findings of King *et al.* (1992).

Effects on Mortality

Survival time was categorized at fortnightly intervals from the day of presentation up to three months. Among dogs with stage IV chronic renal failure (CRF), two and three animals (out of six) died within 16-30 and 31-45 days of dialysis therapy, respectively, indicating a mortality rate of 71.5% within 45 days. Only two dogs (28.6%) survived beyond 120 days, including one dog with stage III CRF. Comparable trends have been reported previously, with markedly shorter survival in advanced stages of renal disease. Pedrinelli *et al.* (2020) reported a maximum survival of 13 days in stage IV cases, whereas dogs in stages II and III survived up to 475 and 187 days, respectively. Similarly, Parker and Freeman (2011) demonstrated higher survival rates in dogs diagnosed at earlier stages compared to stages III and IV.

Effects of Intermittent Haemodialysis

During the first intermittent haemodialysis (IHD) session in seven dogs, mean serum creatinine concentrations decreased significantly ($p < 0.05$) from 9.51 ± 1.0 to 6.31 ± 0.7 mg/dL, corresponding to a mean creatinine reduction ratio (CRR) of 33.41 ± 4.8%. The CRR) serves as a measure of dialysis adequacy, the higher CRR values indicate more effective creatinine removal and improved treatment quality (Kinoshita *et al.*, 2022).

Mean BUN levels also declined significantly from 109.28 ± 21.3 to 73.00 ± 11.8 mg/dL, yielding a urea reduction ratio (URR) of 30.91 ± 5.36%. The URR is a simple and reliable index for assessing solute clearance during IHD (Liang *et al.*, 2019). Higher-than-expected URR values indicate effective dialysis, whereas lower values may reflect technical limitations such as dialyzer clotting, membrane obstruction, or catheter recirculation, resulting in reduced clearance efficiency (Langston *et al.*, 2010).

Three of these dogs underwent a second IHD session, during which mean serum creatinine decreased significantly from 10.0 ± 2.1 to 6.0 ± 1.0 mg/dL, with a mean CRR of 38.76 ± 4.8%. Mean BUN concentrations declined from 91.66 ± 6.4 to 60.33 ± 5.9 mg/dL, resulting in a URR of 34.36 ± 3.2%. In dogs with chronic kidney disease (CKD), successive haemodialysis sessions have been associated with progressive increases in URR and CRR, demonstrating efficient removal of urea and creatinine (Patil, 2011; Singh, 2021). Nevertheless, IHD

Table 3: Effect of conventional treatment + IHD on haematological profile in dogs with different stages of renal insufficiency (Mean±SE)

Parameters	Stage 3 (Serum Cr 2.9-5 mg/dL) (n=1)		Stage 4 (Serum Cr >5 mg/dL) (n=6)		Overall (N=7)	
	0 day	7-10 days	0 day	7-10 days	0 day	7-10 days
Hb (g/dL)	10.9	8.0	$8.5^{a} \pm 0.5$	$8.4^{a} \pm 0.6$	$8.9^{a} \pm 0.5$	$8.0^{a} \pm 0.4$
PCV (%)	31.0	24.5	$25.3^{a} \pm 1.9$	$24.5^{a} \pm 2.2$	$26.1^{a} \pm 1.8$	$24.5^{a} \pm 1.9$
TEC ($\times 10^6$/cmm)	5.3	4.1	$4.0^{a} \pm 0.3$	$3.7^{a} \pm 0.3$	$4.1^{a} \pm 0.3$	$3.8^{a} \pm 0.3$
TLC (/cmm)	7300.0	4400.0	$16470.0^{a} \pm 5066.3$	$18785.0^{a} \pm 4177.4$	$15160^{a} \pm 4477.7$	$16730^{a} \pm 4085.1$
Absolute Neutrophil count (/cmm)	5256	3256	$14330.33^{a} \pm 5256.36$	$17439.66^{a} \pm 3765.79$	$13034.0^{a} \pm 4627.7$	$15413.4^{a} \pm 3773.0$
Absolute Lymphocyte count (/cmm)	1606	968	$2096.83^{a} \pm 686.73$	$1218.83^{a} \pm 380.39$	$2026.7^{a} \pm 584.6$	$1183.0^{a} \pm 323.5$
Absolute Eosinophil count (/cmm)	438	176	$42.66^{a} \pm 42.66$	$26.33^{b} \pm 126.33$	$89.1^{a} \pm 67.0$	$133.4^{b} \pm 107$
N: L	3.3	3.4	$10.3^{a} \pm 3.5$	$21.2^{b} \pm 6.0$	$9.33^{a} \pm 3.1$	$18.6^{b} \pm 5.6$
Platelets (/cmm)	418000	302000	$237670.0^{a} \pm 66267.0$	$198500.0^{a} \pm 34847.0$	$263428.5^{a} \pm 61646.8$	$213285.7^{b} \pm 32954.3$

Figures with different superscripts differ significantly ($p \leq 0.05$).

Table 4: Effect of conventional + IHD treatment on biochemical profile in dogs with different stages of renal insufficiency (Mean ±SE)

Parameters	Stage 3 (Serum Cr 2.9-5 mg/dL), (n=1)		Stage 4 (Serum Cr >5 mg/dL), (n=6)		Overall (N=7)	
	0 day	7- 10 days	0 day	7- 10 days	0 day	7- 10 days
BUN (mg/dL)	53.0	77.0	$118.3^{a} \pm 21.3$	$85.7^{b} \pm 10.0$	$109.0^{a} \pm 20.2$	$77.3^{b} \pm 10.9$
Creatinine (mg/dL)	5.0	2.5	$10.7^{a} \pm 0.7$	$7.2^{b} \pm 0.3$	$9.8^{a} \pm 1.0$	$6.5^{b} \pm 0.7$
BUN/Creatinine	10.6	30.8	$11.5^{a} \pm 2.4$	$12.2^{a} \pm 1.8$	$11.3^{a} \pm 2.0$	$12.4^{a} \pm 1.6$
K^+ (mEq/L)	5.1	4.7	$4.9^{a} \pm 0.3$	$5.2^{a} \pm 0.2$	$4.9^{a} \pm 0.2$	$5.1^{a} \pm 0.1$
Na^+ (mEq/L)	128.0	131.0	$140.5^{a} \pm 2.7$	$140.8^{a} \pm 3.4$	$138.7^{a} \pm 2.9$	$139.4^{a} \pm 3.2$
Cl^- (mEq/L)	92.0	98.0	$109.7^{a} \pm 4.4$	$108.3^{a} \pm 4.7$	$107.1^{a} \pm 4.5$	$106.9^{a} \pm 4.3$
Pi (mg/dL)	7.1	8.6	$16.6^{a} \pm 1.9$	$11.9^{b} \pm 1.6$	$15.2^{a} \pm 2.1$	$11.5^{b} \pm 1.5$
Ca^{++} (mg/dL)	9.8	10.1	$11.1^{a} \pm 0.4$	$10.8^{a} \pm 0.4$	$10.9^{a} \pm 0.4$	$10.7^{a} \pm 0.4$
ALT (U/L)	17.0	17.0	$100.3^{a} \pm 42.6$	$80.5^{a} \pm 26.4$	$88.4^{a} \pm 37.9$	$71.4^{a} \pm 24.1$
ALKP (U/L)	59.0	62.0	$316.5^{a} \pm 120.3$	$251.0^{a} \pm 81.8$	$279.7^{a} \pm 108.1$	$224.0^{a} \pm 74.2$
Total Protein (g/dL)	5.0	5.2	$7.3^{a} \pm 0.5$	$7.1^{a} \pm 0.4$	$6.9^{a} \pm 0.5$	$6.9^{a} \pm 0.4$
Albumin (g/dL)	1.9	2.3	$3.1^{a} \pm 0.3$	$3.1^{a} \pm 0.2$	$2.9^{a} \pm 0.3$	$2.9^{a} \pm 0.2$
Globulin (g/dL)	3.1	2.9	$4.2^{a} \pm 0.3$	$4.1^{a} \pm 0.3$	$4.0^{a} \pm 0.3$	$3.9^{a} \pm 0.3$
Glucose (mg/dL)	132.0	115.0	$98.7^{a} \pm 7.5$	$112.0^{a} \pm 4.5$	$103.4^{a} \pm 7.9$	$112.4^{a} \pm 3.9$

Figures with different superscripts differ significantly ($p \leq 0.05$).

is considered effective in managing end-stage CKD by reducing azotemia and correcting associated electrolyte, mineral, acid–base, and hypertensive disturbances (Lippi and Guidi, 2013).

Conclusions

The present study demonstrates that intermittent haemodialysis (IHD), when used as an adjunct to conventional medical therapy, is an effective renal replacement modality for dogs with progressive renal impairment, particularly those in advanced stages with severe azotemia and inadequate response to standard treatment alone. Despite the evident biochemical and clinical benefits, survival outcomes remained guarded in dogs with stage IV chronic renal failure. Overall, IDH serves as a valuable therapeutic option for managing severe renal failure in dogs, improving short-term clinical status and biochemical parameters. While its long-term benefits in end-stage renal disease may be limited. IHD can play a critical role as a life-sustaining and stabilizing intervention, either as a bridge to recovery in acute or acute-on-chronic renal injury or as a supportive measure to enhance quality of life in selected chronic kidney disease cases. Further studies with larger cohorts are warranted to refine patient selection criteria and optimize long-term outcomes.

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