Journal of Veterinary Internal Medicine
Open Access

Standard Article

J Vet Intern Med 2017;31:402–409

Blood Transfusions in Dogs and Cats Receiving Hemodialysis: 230 Cases (June 1997–September 2012)

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Background: Multiple factors exist that contribute to anemia in dogs and cats receiving hemodialysis, can necessitate transfusion.

Objectives: To describe blood product usage in dogs and cats with acute and chronic kidney disease that were treated with intermittent hemodialysis to determine risk factors associated with the requirement for blood product transfusion.

Animals: 83 cats and 147 dogs undergoing renal replacement therapy at the Animal Medical Center for acute or chronic kidney disease.

Methods: Retrospective medical record review of all dogs and cats receiving renal replacement therapy for kidney disease, from June 1997 through September 2012.

Results: Blood products (whole blood, packed RBCs, or stromal-free hemoglobin) were administered to 87% of cats and 32% of dogs. The number of dialysis treatments was associated with the requirement for transfusion in cats (adjusted OR 2.21, 95% CI 1.13, 4.32), but not in dogs (adjusted OR 0.98, 95% CI 0.95, 1.03). Administration of a blood product was associated with a higher likelihood of death in dogs (OR 3.198, 95% CI 1.352, 7.565; $P = .0098$), but not in cats (OR 1.527, 95% CI 0.5404, 4.317, $P = .2$).

Conclusions and Clinical Importance: Veterinary hospitals with a hemodialysis unit should have reliable and rapid access to safe blood products in order to meet the needs of dogs and cats receiving dialysis.

Key words: Anemia; Darbepoetin; Erythropoiesis-stimulating agent; Kidney failure; Renal replacement therapy.

Hemodialysis is an increasingly used modality for both acute and chronic kidney disease, although availability remains limited to a small number of veterinary hospitals.[1,2] Comorbidities can complicate treatment in these often-critically ill cats and dogs. Anemia, in particular, occurs commonly and can require administration of blood products.

Multiple factors contribute to anemia in cats and dogs receiving hemodialysis. Both clotting and incomplete return of blood in the extracorporeal circuit during dialysis and hemorrhage secondary to anticoagulant administration can be important sources of blood loss, especially in smaller cats and dogs.[1] Other factors contributing to blood loss include hemorrhage due to uremic thrombocytopathy or gastrointestinal ulceration, and repeated blood sampling.[3,4] Insufficient erythropoietin production, anemia of inflammatory disease, absolute or functional iron deficiency, decreased red blood cell survival, and hemolysis can also play a role. Administration of exogenous erythropoiesis-stimulating agents (ESAs) such as epoetin alfa and darbepoetin alfa in patients with erythropoietin deficiency can reduce transfusion dependency in people with chronic kidney disease (CKD), and play a role in treating anemia in patients undergoing dialysis for acute kidney injury (AKI).[5–7]

Abbreviations:

AKI	acute kidney injury
CKD	chronic kidney disease
DA	darbepoetin alfa
ESA	erythropoiesis-stimulating agent
HBOC	stromal-free hemoglobin
rhEPO	recombinant human erythropoietin

Although a wealth of information regarding transfusion medicine in dogs and cats is available, to the authors' knowledge, no published reports exist describing the use of transfusions or the impact of ESA use in cats and dogs receiving hemodialysis. Cats and dogs require transfusion of a substantial volume of blood products for a variety of reasons, both related and unrelated to hemodialysis. The primary objective of this study was to describe blood product usage in dogs and cats with acute and chronic kidney disease that were treated with intermittent hemodialysis. A secondary objective of this study was to determine risk factors associated with the requirement for administration of blood products.

Materials and Methods

Medical records of all cats and dogs undergoing renal replacement therapy at the Animal Medical Center for acute or chronic

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The work for this study was performed at The Animal Medical Center, New York, NY.

This study was not supported by any grants nor was it presented at any meetings.

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Submitted June 13, 2016; Revised October 6, 2016; Accepted December 20, 2016.

DOI: 10.1111/jvim.14658

kidney disease during the study period (June 22, 1997–September 31, 2012) were reviewed. Data recorded for each cat or dog included species, age, breed, body weight before the first hemodialysis treatment, PCV before the first hemodialysis treatment, and number of hemodialysis treatments administered. The reason for initiation of renal replacement therapy was classified, according to the chronicity of renal injury, into the following categories: AKI, acute on chronic kidney disease, and CKD. Cats and dogs with acute kidney injury were assigned to this category if there was no previous evidence that they met the criteria for classification in any of the 4 International Renal Interest Society stages for CKD. Cats and dogs were considered to have acute on chronic kidney disease if stable CKD (defined by the International Renal Interest Society staging scheme) was present before an abrupt rise in serum or plasma creatinine concentration. Cats and dogs were considered to have CKD if they were classified in stage IV of the International Renal Interest Society staging scheme either before initiation of renal replacement therapy or during the course of renal replacement therapy. In addition, whether an ESA was administered and, if so, the specific agent used (either rhEPO or DA) was recorded. Both cats and dogs were divided into 2 groups: those that were administered a transfusion of either packed red blood cells (pRBC), whole blood (WB), or a hemoglobin-based oxygen carrier (HBOC)[a], and those not administered a blood product with oxygen carrying capacity. Cats and dogs administered frozen plasma or fresh frozen plasma and no other blood product were included in the second group. For the transfusion group, the reason for transfusion, the type of blood product used, and the total amount transfused (in mL) were also recorded. Transfusions that were administered before the patient's admission to the Animal Medical Center or after the dialysis catheter was removed were not included. Patients were excluded if the medical record was incomplete, if they did not survive the first hemodialysis treatment, or if they only received 1 hemodialysis treatment for intoxication without renal impairment.

When the volume of blood product administered was not specifically documented in the medical record, the volume was estimated based on a per unit basis. A unit of canine pRBC was estimated at 150 mL, and ½ unit of canine pRBC was estimated at 75 mL. One unit of canine WB was estimated at 400 mL, and ½ unit of canine WB was estimated at 250 mL. Similarly, 1 unit of feline pRBC was estimated at 30 mL and ½ unit of feline pRBC was estimated at 15 mL. One unit of feline WB was estimated at 60 mL, while ½ unit of feline WB was estimated at 30 mL. To calculate the total amount of blood product used, we considered each ml of WB or HBOC to be equal to 0.5 mL pRBC.[8,9]

Survival was defined as renal recovery sufficient to live independent of dialysis for at least 30 days. Animals that died or were euthanized during hospitalization or within 30 days of the final dialysis treatment were placed in the nonsurvival category. Only cats and dogs with AKI and acute on chronic kidney disease were included in survival analysis because it was assumed that those with CKD were indefinitely dependent on renal replacement therapy for survival.

Data were analyzed by a statistical software package (Stata 12.0 for Windows, Stata Corporation, College Station, TX). All continuous variables were graphically inspected for a normal distribution. Because most continuous variables had a non-normal distribution, median, IQR, and range were used to describe and the Mann-Whitney *U*-tests was used to compare the distributions of predialysis variables and the number of dialysis treatments between transfused and nontransfused cats and dogs. Categorical variables were expressed as frequencies and percentages, and chi-square or Fisher's exact tests were used to compare these variables between transfused or nontransfused cats and dogs. Univariate and multivariate logistic regression analysis was used to determine if age, weight, predialysis PCV, reason for renal replacement therapy, or the number of dialysis treatments predicted the requirement for transfusion. All statistical significance was set at $\alpha = 0.05$.

Results

During the study period, 92 cats and 171 dogs were treated with a variety of forms of renal replacement therapy (RRT). Three cats and 2 dogs were excluded because they did not survive the first hemodialysis treatment. Five cats and 10 dogs were excluded due to incomplete medical records. One cat and 12 dogs were treated with renal replacement therapy once for acute intoxication without renal impairment and thus excluded from analysis. The remaining 230 animals (83 cats and 147 dogs) were included in the study.

Cats

Of the 83 cats included in analysis, 5 cats (6%) were treated with RRT on 2 separate occasions each (9 months to 13 years apart). For statistical purposes, the second episode for each of these cats was excluded from analysis. Four of these 5 cats were administered blood products during the first episode of renal replacement therapy, and all 5 of these cats were administered blood products during the second episode.

Blood products were administered to 72 of the 83 cats (87%) during the course of renal replacement therapy. Variables for all cats before dialysis included in the analysis are presented in Table 1. The only variable before dialysis for which a statistically significant difference was demonstrated between transfused and nontransfused cats was PCV. The reason for initiation of renal replacement therapy is described in Table 2. The median number of dialysis treatments administered to transfused cats was significantly different from the median number of dialysis treatments administered to nontransfused cats (4 vs. 2, *P* value = .0022; Fig 1).

The volume of blood products administered is reported in Table 3. Twenty-six cats received more than 1 blood product, 20 cats received only WB, 24 received only pRBC, and 2 received only HBOC. By converting each ml of WB or HBOC to 0.5 mL and thus approximately normalizing oxygen carrying capacity of the various blood products, we were able to estimate the total volume of blood product used (Table 3). The volume of the blood units was available in the medical record of 25 cats and estimated for 19 cats. Thirteen cats received blood products at the initiation of extracorporeal circulation in 27 treatments.

Of the 83 cats in the study, ESA was administered to 28 (34%) cats. rhEPO[b,c] was administered in 10 cats (until mid-2007), while DA[d] was administered in 18 cats (after mid-2007). All cats receiving an ESA were in the transfusion group.

While both the PCV before dialysis and the number of dialysis treatments were associated with the requirement for transfusion in univariate analysis, only the number of dialysis treatments was independently associated with the requirement for transfusion (Table 4). For chronicity of

Table 1. Comparison of age, weight, predialysis PCV, and sex of transfused and nontransfused cats.

	All Cats		Transfused Cats		Nontransfused Cats		*P* Value
Age (years)	8.2		8.4		7.5		.29
IQR	5.3, 11.1		5.4, 11.7		3.6, 9.7		
Range	0.6, 15.9		1.0, 15.9		0.6, 13.0		
Weight (kg)	4.9		4.8		5.0		.41
IQR	3.9, 6.0		3.9, 6.0		4.1, 6.1		
Range	2.3, 12.1		2.3, 8.8		3.3, 12.1		
PCV (%)	23		22.5		29		.02*
IQR	20, 30		19, 29.5		25, 30		
Range	12, 38		12, 38		20, 34		
Sex (# cats)	F	M	F	M	F	M	*P* value
	33	50	27	45	6	5	.33

Data presented as mean ± standard deviation for age, weight, and PCV.

*Statistically significant.

Table 2. Reason for initiation of renal replacement therapy in cats.

	All Cats	Transfused Cats	Nontransfused Cats
Acute kidney injury (# cats)	30	26	4
Acute on chronic kidney disease (# cats)	42	35	7
Chronic kidney disease (# cats)	11	11	0
Total (# cats)	83	71	11

kidney disease, the presence of CKD was omitted from the model because all 11 cats with CKD were administered at least 1 blood transfusion (Table 4).

Of the 61 cats with AKI or acute on chronic kidney disease that were administered transfusion, 28 (46%) were classified as survivors (11 cats with AKI and 17 cats with acute on chronic kidney disease). Two of these 28 cats subsequently received a renal transplant (and survived for greater than 30 days). Thirty-three cats (54%) of the transfused cats with AKI (15 cats) or acute on chronic kidney disease (18 cats) were classified as nonsurvivors. One of these cats received a renal transplant, but died within 30 days of the final dialysis treatment. Of the 11 cats with AKI or acute on chronic kidney disease that did not receive a transfusion, 7 (64%) were classified as survivors. An association between transfusion and survival was not demonstrated ($P = .2$).

Dogs

Of the 147 dogs included in the analysis, 2 dogs were treated with hemodialysis on 2 occasions (1–4.5 years apart). For statistical purposes, the second episode for each of these dogs was excluded from analysis. Neither of these dogs were administered blood products during the first episode of renal replacement therapy, but both dogs were administered blood products during the second episode.

Blood products were administered to 47 of the 147 dogs (32%) dogs during the course of renal replacement therapy. Predialysis variables for all dogs included in the analysis are presented in Table 5. The only variable for which a statistically significant difference was demonstrated between transfused and nontransfused dogs was PCV. The reason for initiation of renal replacement therapy is described in Table 6. A difference in the number of dialysis treatments administered

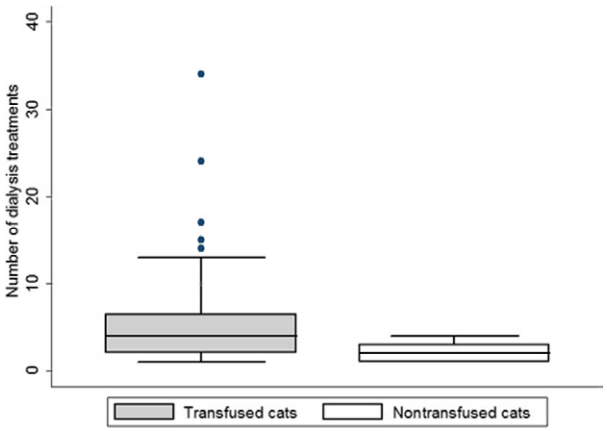

Fig 1. Comparison of number of dialysis treatments based on transfusion status.

Table 3. Volume of blood products administered to cats and dogs receiving hemodialysis.

	pRBC	WB	HBOC	Total Blood Product
Cats				
N	42	44	14	72
Total volume (ml)	70.5	61.5	60	62
IQR	30, 106	43, 100	22, 95	35, 105.5
Range	15, 413	21, 432	10, 115	10.5, 413
Volume/kg body wt	13.2	13.6	12.7	15
IQR	7.3, 31.1	836, 23	5.6, 16.6	7, 24.6
Range	3, 79	5.1, 52.7	1.5, 41.3	2.8, 79.3
Dogs				
N	44 (94%)	7	5	47
Total volume (ml)	260	350	250	250
IQR	117.5, 475	140, 450	155, 375	135, 530
Range	30, 1810	120, 450	125, 500	30, 1810
Volume/kg body wt	16.9	17.7	8.1	17.2
IQR	10.9, 27	10, 20	6, 18.1	9.4, 27.7
Range	0.6, 63.6	9.7, 22	4.9, 19.1	0.6, 63.6

Table 4. Univariate and multivariate logistic regression analyses for risk factors associated with the requirement for blood transfusion in cats.

	Univariate Analysis			Multivariate Analysis		
Variable	Odds Ratio	95% CI	*P* Value	Odds Ratio	95% CI	*P* Value
Age (years)	1.09	0.93, 1.30	.26	1.09	0.85, 1.42	.47
Weight (kg)	0.78	0.55, 1.12	.17	0.80	0.49, 1.32	.39
PCV (%)	0.89	0.80, 1.00	.042*	0.876	0.75, 1.02	.086
# Of dialysis treatments	2.02	1.11, 3.66	.021*	2.21	1.13, 4.32	.021*
Etiology						
AKI	Referent			Referent		
AoCKD	0.55	0.15, 2.01	.36	0.488	0.09, 2.66	.41

*Statistically significant.

Table 5. Comparison of age, weight, predialysis PCV, and sex of transfused and nontransfused dogs.

	All dogs		Transfused dogs		Nontransfused dogs		*P* value
Age (years)	7.7		7.0		7.9		.14
IQR	5.3, 10.3		4.0, 9.6		5.5, 10.8		
Range	0.2, 17.3		0.3, 17.3		0.2, 15.7		
Weight (kg)	21.8		19.7		23.6		.16
IQR	10.0, 33.8		10.9, 29.1		9.7, 37.0		
Range	3, 58.2		3, 49		3.2, 58.2		
PCV (%)	30		25		30		.0021*
IQR	25, 33		23, 32		27, 33		
Range	18, 67		18, 67		20, 48		
Sex (# dogs)	F	M	F	M	F	M	*P* value
	67	80	24	23	43	57	.36

Data presented as median (IQR, range) for age, weight, and PCV.

*Statistically significant.

to transfused dogs vs. dogs not administered a transfusion was not demonstrated (median 4; IQR 2, 7; range 1, 52 vs. median 4; IQR 2,10; range 1, 95; $P = .6289$).

The volume of blood products administered is reported in Table 3. Some dogs might have received more than 1 product type. By means of the same conversion factor described previously, we were able to estimate the total volume of blood product used per dog (Table 3). The volume of the blood units was available in the medical record of 33 dogs and estimated for 13 dogs. Only the predialysis PCV was associated with the requirement for transfusion in both the univariable and multivariable analyses (Table 7).

An ESA was administered in 37 dogs (25%). Of these 37 dogs, rhEPO was administered in 15 (41%) dogs (before and during 2004), while DA was administered in 22 (59%) dogs (from 2004 and later). Twelve dogs receiving an ESA (32%) were in the transfusion group. Conversely, 25 dogs receiving an ESA (68% of dogs receiving an ESA) were in the nontransfusion group. An association between administration of an ESA and administration of a blood product could not be demonstrated ($P = 1$). Of all the dogs included in the study, 72 (49%) received a blood replacement product, an ESA, or both.

Of the 40 dogs with AKI or acute on chronic kidney disease that were administered transfusion, 9 (23%) were classified as survivors (7 dogs with AKI and 2 dogs with acute on chronic kidney disease). Thirty-one (78%) of the transfused dogs with AKI (28 dogs) or acute on chronic kidney disease (3 dogs) were classified as nonsurvivors. Of the 82 dogs with AKI (72 dogs) or acute on chronic kidney disease (10 dogs) that were not administered a transfusion, 39 (48%) dogs survived (38 dogs with AKI and 1 dog with acute on chronic kidney disease). One of the nontransfused dogs was lost to follow-up. The median PCV before the first dialysis treatment was 30% in survivors and nonsurvivors. Administration of a blood product was associated with a higher likelihood of mortality (OR 3.198, 95% CI 1.352, 7.565; $P = .0098$).

Discussion

Many veterinary hospitals rely on both commercial acquisition of blood products and maintenance of a blood donor program to sustain an adequate supply of feline and canine blood products. Therefore, the introduction of any new treatment modality, such as hemodialysis, that may increase the use of blood products, should be performed with consideration and proper planning for adequate availability of red blood cell products. The information obtained from this study will be useful for any veterinary hospital planning to initiate a hemodialysis program, as this study demonstrates that, in our hospital, a large proportion of cats (87%) and a moderate proportion of dogs (32%) treated with intermittent hemodialysis are administered blood products.

There are several possible explanations for the frequent requirement for blood product transfusions in veterinary hemodialysis patients. It is suspected, although not proven, that blood loss is a large contributor to anemia and the need for transfusion. At the conclusion of each dialysis treatment, the blood in the

Table 6. Reason for initiation of renal replacement therapy in dogs.

	All Dogs	Transfused Dogs	Nontransfused Dogs
Acute kidney injury (# dogs)	107	35	72
Acute on chronic kidney disease (# dogs)	15	5	10
Chronic kidney disease (# dogs)	25	7	18
Total (# dogs)	147	47	100

extracorporeal circuit is returned to the patient; however, blood that has clotted or remains in gravity-dependent portions of the extracorporeal circuit cannot be returned. There is wide variation in the amount of blood that remains in the dialyzer, with 1 report of an average of 2.05 ± 3.21 mL of packed RBC per dialyzer (range, 0.01–24 mL) used in people.[10] That study found polyacrylonitrile (AN69) dialyzers demonstrating more blood loss than cellulose acetate. In cats, the extracorporeal circuit volume, which includes the tubing and the dialyzer, averages 23% of the blood volume of the patient, ranging from 7 to 50% in our unit. In dogs, the extracorporeal circuit volume averages 9% of the blood volume, ranging from 2 to 35%. Thus, even if the volume of blood left in the circuit is a small fraction of the circuit size, the cumulative loss in cats can become clinically relevant. Interestingly, the subjective scoring of the amount of clotting in dialyzers used in cats is typically less than the score for dogs.[11,12]

Catastrophic intradialytic events such as circuit clotting or inadvertent catheter removal can occur, preventing either partial or complete extracorporeal circuit blood return and further contributing to blood loss. Complete loss of the blood in the circuit occurs in less than 1% of all treatments in our unit.

There are many additional potential sources of blood loss in the cat or dog with AKI. Uremic thrombocytopathy likely contributed to clinically apparent bleeding in some patients. Coagulation disorders associated with leptospirosis, the etiologic agent of AKI in a significant part of our canine dialysis population, were also a contributor to bleeding disorder. Sources of bleeding identified during therapy were causes commonly encountered in veterinary medicine, including intraoperative bleeding and gastrointestinal bleeding.[13–17] The 3 cats with retroperitoneal or perirenal hemorrhage all had ureteral obstruction. Systemic heparin anticoagulation was used in the vast majority of dialysis treatments reported here to prevent clotting in the extracorporeal circuit, with a target of prolonging the activated clotting time to 1.5–2 times normal. Although the anticoagulation should be of limited duration based on heparin's relatively short half-life (1–2 hours in people), it can induce or exacerbate bleeding.

Hemolysis can occur in conjunction with hemodialysis, precipitated by contaminants in the water supply, hypotonic or overheated dialysate, or extracorporeal circuit tubing problems (kinked or manufacturing defects).[18–20] Excessive negative access pressure (less than −350 mmHg) has been reported to cause minor hemolysis.[20,21] Careful attention to access pressure makes this unlikely in our unit. Subjectively, hemolyzed postdialysis samples were uncommon in the absence of transfusion.

In some treatments, blood transfusions were administered during initiation of a hemodialysis treatment to compensate for large volumes of blood being removed from the patient to fill the extracorporeal circuit. The transfusion was initiated by priming the extracorporeal circuit with a blood product, rather than with saline or a synthetic colloid. Using blood to prime the extracorporeal circuit is a common practice in pediatric CRRT.[22] An alternate method is a rapid transfusion directly to the patient as the extracorporeal circulation is started. Despite concerns about rapid transfusion (typically in less than 15 minutes), we have only observed 1 cat with clinical signs that may have been associated with a minor transfusion reaction. That cat had transient (15 minutes) facial pruritus at the start of

Table 7. Univariate and multivariate logistic regression analyses for risk factors associated with the requirement for blood transfusion in dogs.

	Univariate Analysis			Multivariate Analysis		
Variable	Odds Ratio	95% CI	*P* Value	Odds Ratio	95% CI	*P* Value
Age (years)	0.93	0.85, 1.03	.15	0.92	0.83, 1.02	.098
Weight (kg)	0.98	0.95. 1.01	.13	0.98	0.96, 1.01	.22
PCV (%)	0.94	0.88, 0.99	.025*	0.94	0.88, 0.99	.030*
# of dialysis treatments	0.98	0.94, 1.02	.31	0.98	0.95, 1.03	.50
Etiology						
AKI	Referent			Referent		
AoCKD	1.19	0.38, 3.77	.77	1.29	0.37, 4.49	.69
CKD	0.844	0.32, 2.20	.73	0.92	0.32, 2.72	.89

*Statistically significant.

dialysis, which resolved without intervention. Blood priming increases the cost of providing dialysis, due to the cost of blood products and cross-matching, but subjectively, hemodynamic stability seems better during treatments initiated with a blood prime in cats.

In the majority of situations, it was impossible to determine a precise reason a transfusion was administered. In the earlier years of the study period, limitations in available blood supply may have impacted decisions to transfuse, particularly in cats, whereas canine blood products were generally readily available. Despite a normal PCV before the first dialysis treatment in some animals, development of anemia over the course of hospitalization was common. In some animals, a defining event triggering transfusion such as severe blood loss was present, although not all animals with identifiable major blood loss received a transfusion. The decision to administer a transfusion was based on clinical assessment.[9,23] Disturbances of sufficient oxygen delivery to the tissues from hypotension, respiratory dysfunction related to volume overload or pulmonary hemorrhage, or anemia are common with during hemodialysis. Transfusion to correct anemia might be administered when other factors are not readily or rapidly correctable.

The decision of which product to use (pRBC or WB) in cats was usually made based on availability. In some cases, we specifically wanted only pRBC due to volume overload. In dogs, pRBC was the predominant product available during the entire study period and was the predominant product used.

Stromal-free hemoglobin was used when blood supply was limited or a compatible donor could not be found. Use of these products and complications associated with them have been described in both dogs and cats.[24–26] Despite potential complications associated with use, HBOCs increase oxygen delivery to tissues when perfusion is maintained.[25] HBOC is no longer available in the USA.

Two thirds of the transfused cats and ¼ of transfused dogs had some chronic component to their disease, but only 11 cats and 7 dogs in the transfused groups had end-stage renal disease. The majority of cats with an acute exacerbation of CKD had ureteral obstruction. Most had no clinical evidence of uremic signs before an acute obstruction and would not likely have been anemic if baseline values had been available. Chronic erythropoietin deficiency seems unlikely to have played a role in the pathogenesis of anemia in this population. However, AKI can abruptly decrease erythropoietin production, and critical illness with AKI is associated with resistance to the effects of endogenous erythropoietin, making it difficult to replenish lost or damaged red blood cells.[14,27]

The use of ESA is common in people receiving hemodialysis for CKD. The introduction of ESA has dramatically decreased, but not eliminated, the administration of blood transfusions in this population.[5] In more recent years, ESAs have been investigated in treatment of AKI. Although critical illness blunts the responsiveness to endogenous erythropoietin, these patients remain responsive to exogenous ESA.[27–29] Additionally, ESAs has anti-apoptotic effects and have shown renoprotective effects in some, but not all studies.[28,30,31] Darbepoetin was used almost exclusively from mid-2004, and the use of ESA has increased. We were unable to demonstrate that cats and dogs receiving ESA were less likely to be transfused. Our criteria for administering an ESA were not standardized. It is probable that multiple prior transfusions influenced the decision to start ESA use in cats. Starting ESA earlier in the course of dialysis might decrease transfusion requirements.

There was no difference in survival in transfused cats (46%) compared to nontransfused cats (64%) in the cats with AKI or acute on chronic disease, but few cats in the study did not receive a transfusion. Retrospective studies in transfused cats with various disease processes have reported 59-64% survival.[16,17,32,33] Transfused dogs were 3 times more likely to die. The survival rate of 23% in this transfused group is much lower than reported survival to discharge from the hospital of 47–61% in transfused dogs with a variety of disease processes.[34,35] Liberal transfusion may increase mortality compared to restrictive transfusion strategies.[36] Although numerous studies have found higher mortality rates in people receiving more transfusions, a recent review found that while restrictive transfusion strategies reduce in-hospital deaths, they do not reduce 30-day death in people.[37] An alternative explanation is that this association is not a causal relationship and that dogs that need a transfusion have more severe disease or are less responsive to ESA administration. While transfusion appears to be an integral part of dialytic therapy in cats, the need for transfusion in a dog indicates a worse prognosis.

There was an independent association of the number of dialysis treatments with the likelihood of transfusion in cats, in that each dialysis treatment doubled the chance a cat would receive a transfusion. This association was not present in dogs. The greater the number of treatments administered, more cumulative blood loss in the extracorporeal circuit is expected, leading to an increase in transfusion requirements in cats. Larger dogs would be more likely to tolerate multiple episodes of blood loss associated with multiple treatments without requiring a transfusion.

A major limitation is the retrospective nature of the study. Oftentimes, the contribution of blood loss via gastrointestinal hemorrhage or other sources of bleeding was speculative. A necropsy was not performed on all cases. Furthermore, the volume of blood product transfused on a mL/kg basis can be altered by the volume status of the patient. Hemodialysis patients often present with clinically significant volume overload, and although dialysis can remove excess fluid by the process of ultrafiltration, hemodynamic instability in the patients may necessitate a slow removal process as several dialysis treatments performed over several days. The risk of exacerbating volume overload is always balanced against the need for oxygen carrying capacity, and might have limited the amount of blood products

used in an individual cat or dog in the early stages of dialysis therapy. Another limitation is that the transfusion practices of our unit might not represent transfusion practices in other practices.

Conclusion

Dogs and cats undergoing hemodialysis often require administration of a blood product. In this population, over 50% required a blood production of some type. The need for transfusion might be directly related to hemodialysis or the underlying disease process but is most often multifactorial. Veterinary hospitals with a hemodialysis unit should have reliable and rapid access to safe blood products in order to meet the needs of the dialysis patients. Further study is warranted to determine whether administration of erythropoiesis-stimulating agents make a substantial impact on blood product administration in this population.

Footnotes

[a] Oxyglobin, OPK Biotech, Cambridge, MA
[b] Epogen, Amgen, Thousand Oaks, CA
[c] Procrit, Centocor Ortho Biotech Products, Horsham, PA
[d] Aranesp, Amgen, Thousand Oaks, CA

Acknowledgments

Conflict of Interest Declaration: Authors declare no conflict of interest.

Off-label Antimicrobial Declaration: Authors declare no off-label use of antimicrobials.

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