Evaluation of use of human albumin in critically ill dogs: 73 cases (2003–2006)

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Objectives—To evaluate the use of human albumin in critically ill dogs.

Design—Retrospective case series.

Animals—73 client-owned hospitalized dogs.

Procedures—Medical records of dogs that received human albumin were reviewed to assess effects of the use of human albumin on serum albumin concentration, colloid osmotic pressure, and total protein concentration; determine the relationships between these variables and outcome; and assess its safety. Data for signalment, diagnoses, physiologic variables, dosage, amount of crystalloid fluid administered prior to human albumin administration, complications, and outcome were reviewed. Additionally, pre- and postadministration values for serum albumin, colloid osmotic pressure, and total protein were recorded.

Results—Administration of human albumin resulted in significant changes in serum albumin, colloid osmotic pressure, and total protein. The serum albumin, total protein, degree of improvement in serum albumin, colloid osmotic pressure, and dosage of human albumin were significantly greater in survivors. Seventeen of 73 (23%) dogs had at least 1 complication that could be potentially associated with the administration of human albumin that occurred during or immediately following administration of human albumin. Three of 73 (4%) dogs had severe delayed complications.

Conclusions and Clinical Relevance—Administration of human albumin significantly increased serum albumin, and total protein concentrations and colloid osmotic pressure, especially in survivors. Because of the high mortality rate of the study population and other confounding factors, it was uncertain whether complications were associated with the underlying disease or with human albumin administration. Acute and delayed complications may have been under-recognized. (*J Am Vet Med Assoc* 2008;233:607–612)

Hypoalbuminemia and decreased colloid osmotic pressure are common in critically ill dogs.[1–5.a] Hypoalbuminemia is associated with morbidity and death in humans and dogs.[1,6–17] Albumin is responsible for 50% of total plasma protein concentration and 80% of plasma oncotic pressure.[2] In critically ill humans and dogs, the relationship between serum albumin concentration and colloid osmotic pressure is less predictable,[18-20] as is the relationship between hypoalbuminemia and edema formation.[2,4,5,10,21] Edema formation in critically ill patients results from a host of complex pathophysiologic processes, which include changes in capillary permeability,[2,10,22] lymphatic function,[2,10,22] extracellular matrix structure,[23,24] albumin kinetics, and blood colloid osmotic pressure.[2,10,22]

Although formulas used to estimate colloid osmotic pressure on the basis of total protein, albumin, and globulin concentrations have been devised, their usefulness has not been demonstrated when applied to healthy or sick humans or other animals, and direct measurement of colloid osmotic pressure is more accurate.[5,18–20,25] It is not known whether measured colloid osmotic pressure values or changes in those values in dogs are related to outcome or whether colloid osmotic pressure values have a predictable relationship with serum albumin concentration or total protein concentration in critically ill dogs. Treatment strategies to increase or restore plasma colloid osmotic pressure include the use of natural and synthetic colloids, including human albumin. Presently, the extent to which administration of human albumin can increase plasma colloid osmotic pressure values in critically ill dogs is not known.

Despite increasing interest and use of human albumin in critically ill veterinary patients, few data exist about the efficacy and safety of this treatment modality. A previously published retrospective study[26] evaluating the use of human albumin in dogs reported the effects of human albumin administration on serum albumin, total solids, and blood pressure. The authors found that serum albumin, total solids, and systolic blood pressure increased significantly with albumin administration and that human albumin was deemed to be safe to ad-

Abbreviation

SPI2 Survival prediction index 2

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minister to dogs. In contrast, 3 recent studies[27–29] evaluating human albumin use in healthy dogs reported serious acute and delayed reactions, including acute renal failure, peripheral edema, urticaria, lethargy, lameness, joint effusion, vomiting, and death. Although human albumin administration has been recommended as a means to improve colloid osmotic pressure in veterinary patients, the effect of human albumin administration on colloid osmotic pressure has not been described.

The primary goals of the study reported here were to describe the therapeutic use of human albumin in a population of critically ill dogs; assess its safety, including short- and long-term complications; assess its effects on serum albumin concentration, colloid osmotic pressure, and total protein concentration; and determine the relationships between these variables and outcome.

Materials and Methods

Case selection—The medical records of dogs that received human albumin between January 2003 and June 2006 were reviewed. Dogs were identified from the hospital's human albumin administration log, colloid osmotic pressure patient database, and pharmacy records.

Medical records review—The medical records were reviewed by use of a standardized data sheet for signalment, diagnoses, physiologic variables required for the calculation of the SPI2,[3] dosage of human albumin administered, amount of crystalloid fluid administered prior to human albumin administration, time in hospital before administration of human albumin, complications, and outcome. The SPI2 score was used to assess the severity of illness of each dog and was calculated by use of the following formula: logit $P = 0.3273 + (0.0108 \times \text{mean arterial pressure}) - (0.0102 \times \text{respiratory rate}) - (0.2183 \times \text{creatinine}) + (0.0164 \times \text{PCV}) + (0.3553 \times \text{albumin}) - (0.1184 \times \text{age}) - (0.8069 \times \text{medical vs surgical status}$ [medical vs surgical status is a dichotomous variable, where medical status = 1 and surgical status = 0]). Additionally, pre- and posthuman albumin administration (typically 2 hours after administration) values for serum albumin, blood colloid osmotic pressure, and total protein were evaluated.

Statistical analysis—Distribution of data was examined graphically. Descriptive data are presented as mean ± SD for normally distributed data and median (range) for skewed data. Data not normally distributed were logarithmically transformed. A χ^2 analysis and the Fisher exact test were used to evaluate relationships among categoric data, and the independent *t* test was used to assess continuous variables. When data could not be transformed, the Wilcoxon signed rank test was used to evaluate paired continuous variables and the Mann-Whitney *U* test was performed for unpaired continuous variables. The Pearson correlation test was used to determine any associations between 2 continuous variables. All statistical tests were performed with commercial software.[b] Differences were considered significant at a value of $P < 0.05$.

Results

During the study period, 73 dogs were administered human albumin. A commercially available 25% solution of human albumin[30,c] was typically diluted to a 10% solution with saline (0.9% NaCl) solution and administered through a transfusion filter.[d] The dosage of human albumin was chosen on the basis of primary clinician preference; dosages were based on either a calculated albumin deficit[1] or an extrapolated empirical dosage of 2 to 5 mL of 25% human albumin/kg (0.91 to 2.23 mL/lb).[2]

Median age of the population was 7.6 years (range, 0.3 to 14.3 years). There were 41 male dogs (31 neutered) and 32 female dogs (25 neutered). There were 38 breeds represented, including Golden Retriever (n = 8); mixed breed (8); Labrador Retriever (6); Greyhound (4); German Shepherd Dog (3); American Bulldog (3); Akita (2); Bearded Collie (2); Border Collie (2); Cocker Spaniel (2); Daschshund (2); Doberman Pinscher (2); English Setter (2); Samoyed (2); and one of each of the following: Basset Hound, Bernese Mountain Dog, Boxer, Chihuahua, Chow Chow, English Bull Terrier, English Springer Spaniel, Great Dane, Great Swiss Mountain Dog, Irish Wolfhound, Irish Setter, Jack Russell Terrier, Keeshound, Maltese, Mastiff, Polish Lowland Sheepdog, Pomeranian, Pitbull Terrier, Miniature Schnauzer, Norfolk Terrier, Portuguese Waterdog, Standard Poodle, Tibetan Terrier, Toy Poodle, and Weimaraner.

Septic peritonitis was the most common diagnosis identified (n = 20), most frequently caused by a perforating foreign body (16). Other diagnoses included neoplasia (n = 14), of which lymphoma (5) and hemangiosarcoma (4) were most common; severe trauma (8); hepatic disease (6); pancreatitis (2); gastric ulceration (2); and one of each of the following: thromboembolic disease, coagulopathy, disseminated intravascular coagulation, immune-mediated hemolytic anemia, leptospirosis, pneumonia, pericardial effusion, diaphragmatic hernia, chronic valvular disease with subsequent mitral valve replacement, acute respiratory distress syndrome, biliary cyst, portal thrombus, uroabdomen secondary to outflow obstruction, gastric dilatation volvulus, lung lobe torsion, liver lobe torsion, vertebral instability, diabetes mellitus, pyometra, β-hemolytic streptococcal fasciitis, and myasthenia gravis. Four patients received mechanical ventilation.

Fifty-six of 73 (77%) dogs were treated surgically. All dogs with intestinal foreign bodies or septic peritonitis underwent surgery. Five of the trauma patients underwent surgery for fractures or wounds. One of the dogs with pancreatitis underwent surgery for biliary obstruction, whereas the other underwent surgery for treatment of gastric ulcer perforation. In surgical patients, human albumin was predominantly administered after surgery; however, some were treated during surgery.

Median time from admission to administration of human albumin was 1 day (range, 0 to 12 days). Median rate of crystalloids administered prior to human albumin administration was 6 mL/kg/h (2.7 mL/lb/h; range, 0 to 120 mL/kg/h [0 to 54.5 mL/lb/h]). Forty-seven of 73 (64%) dogs also received blood products during hospitalization, including packed RBCs, whole blood, fresh frozen plasma, or frozen plasma; however, none of the blood products were administered concurrently with human albumin. Median dosage of human albumin administered was 1.4 g/kg (0.6 g/lb; range, 0.1 to 6 g/kg [0.05 to 2.7 g/lb]). Median prehuman albumin administration serum albumin concentration was 1.5 g/dL (range, 0.4 to 2.3 g/dL; n =

62). Median serum albumin concentration after administration of human albumin (n = 59) was 2.7 g/dL (range, 0.9 to 4.4 g/dL). Following human albumin administration, there was a significant increase in serum albumin ($P < 0.001$). Median prehuman albumin administration colloid osmotic pressure (n = 65) was 10.5 mm Hg (range, 4.7 to 18.0 mm Hg), which increased to 14 mm Hg (range, 8.7 to 26.9 mm Hg) after human albumin administration (54), and was also significant ($P < 0.001$). Median total protein concentration before human albumin administration was 2.8 g/dL (range, 0.5 to 5.8 g/dL), and this significantly ($P < 0.001$) increased to 4.0 g/dL (range, 2.0 to 6.2 g/dL) following human albumin administration. Median magnitude of colloid osmotic pressure increase (n = 52) was 3.7 mm Hg (range, –1.5 to 17.5 mm Hg), median magnitude of albumin concentration increase (54) was 1.1 g/dL (range, –0.2 to 2.9 g/dL), and median total protein increase (66) was 1.0 g/dL (range, –0.7 to 4 g/dL).

Median SPI2 score for the entire population was 0.58 (range, 0.1 to 0.9). Data for calculation of SPI2 were available for 55 of 73 (75%) dogs. Median duration of hospitalization was 5 days (1 to 30 days). Thirty-six of 73 (49.3%) dogs did not survive to hospital discharge; of those, 18 dogs were euthanatized and 18 dogs died during hospitalization. Median duration of hospitalization was 6 days (2 to 30 days), 4 days (1 to 13 days), and 3.5 days (1 to 9 days) for survivors, dogs euthanatized, and dogs that died, respectively. Among survivors (n = 37), 32 (87%) underwent surgery, whereas among nonsurvivors (36), 24 (67%) were treated surgically. The difference in survival rates between dogs treated medically and those treated surgically approached significance ($P = 0.056$).

Compared with nonsurvivors, serum albumin concentration and total protein concentration in survivors were significantly higher after administration of human albumin ($P = 0.004$ and 0.021, respectively; **Table 1**).

Table 1—Comparison of variables (median [range] values) between critically ill dogs that survived or did not survive after receiving human albumin.

Variable	Nonsurvivors	Survivors	*P* value
Age (y)	8.0 (0.4 to 13.2)	7.5 (0.3 to 12.7)	0.782
SPI2 score	0.59 (0.27 to 0.91)	0.59 (0.32 to 0.87)	0.358
Dosage of human albumin (g/kg)	1.2 (0.1 to 4.8)	1.7 (0.5 to 6.0)	0.006
Volume of fluid (mL/kg/h) infused before human albumin administration	3.7 (1.5 to 37.3)	6.7 (0 to 120)	0.119
Serum albumin concentration (g/dL) before human albumin administration	1.3 (1.0 to 1.8)	1.5 (0.4 to 2.1)	0.337
Total protein concentration (g/dL) before human albumin administration	2.8 (0.9 to 5.8)	2.7 (0.5 to 4.3)	0.089
Colloid osmotic pressure (mm Hg) before human albumin administration	11.0 (6.8 to 18.0)	10.3 (4.9 to 14.9)	0.423
Serum albumin concentration (g/dL) after human albumin administration	2.4 (0.9 to 2.9)	2.9 (1.5 to 4.4)	0.004
Total protein concentration (g/dL) after human albumin administration	3.8 (2.2 to 4.4)	4.0 (2.6 to 6.2)	0.021
Colloid osmotic pressure (mm Hg) after human albumin administration	13.4 (10.7 to 17.5)	14.2 (8.7 to 26.9)	0.538
Change in serum albumin concentration (g/dL)	1.0 (–0.2 to 1.8)	1.3 (0.4 to 2.9)	0.028
Change in total protein concentration (g/dL)	1.0 (0.4 to 2.3)	1.5 (–0.2 to 4.0)	0.001
Change in colloid osmotic pressure (mm Hg)	3.2 (0.7 to 7.5)	4.0 (–1.5 to 17.5)	0.033

The magnitude of improvement after administration of human albumin for serum albumin, colloid osmotic pressure, and total protein was also significantly (P = 0.028, 0.033, and 0.001, respectively) higher in survivors. The median dosage of albumin administered was significantly (P = 0.006) higher in survivors (Table 1). There was no difference between survivors and nonsurvivors with respect to age, illness severity as measured by use of the SPI2 score, prehuman albumin administration values for serum albumin, colloid osmotic pressure, PCV, total protein, amount of crystalloid infused before human albumin administration, and time to administration of human albumin.

The dosage of human albumin administered correlated positively with the magnitude of improvement in serum albumin concentration ($P < 0.001$; r = 0.55). The dosage of human albumin administered also correlated with the magnitude increase in colloid osmotic pressure ($P < 0.001$; r = 0.57). There was a strong correlation between the change in serum albumin after human albumin administration and changes in colloid osmotic pressure ($P < 0.001$; r = 0.79). Changes in serum albumin also correlated well with changes in total protein, but degree of correlation was lower ($P < 0.001$; r = 0.58). Changes in colloid osmotic pressure correlated with changes in total protein, ($P < 0.001$; r = 0.54). Effect of human albumin administration on improvement of peripheral edema could not be assessed because of limited information in medical records. Apparent worsening of edema following treatment was only reported in a single dog.

Several variables were associated with survival in dogs that received human albumin. The dosage (P = 0.006), posthuman albumin administration serum albumin concentration (P = 0.004), magnitude of serum albumin increase (P = 0.028), posthuman albumin administration total protein concentration (P = 0.021), magnitude of increase in total protein (P = 0.001), and magnitude of increase in colloid osmotic pressure (P = 0.033) were all positively associated with survival.

Twenty of 73 (27%) dogs had at least 1 complication that could be potentially related to the administration of human albumin. Three complications appeared to be delayed complications that could be attributed to human albumin administration, whereas the remaining dogs had potential acute complications during or soon after administration of human albumin. Complications were defined as mild or serious. Mild complications included increased respiratory rate (n = 3), increased heart rate (2), increased temperature (3), peripheral edema (1), and premature ventricular contractions and ventricular arrhythmias (3). Serious complications included development of new coagulopathies (n = 1) and cardiac arrest (4) that occurred during human albumin infusion or within 24 hours of administration. Fulminant anaphylaxis was not recorded. Development of a complication during or following infusion did not appear to be associated with outcome (P = 0.302) or length of hospitalization (P = 0.569). The only factors significantly related to development of complications were PCV before administration of human albumin and total crystalloid administered before administration of human albumin (P = 0.02 and 0.007, respectively); dogs that developed complications had lower PCV (median, 24% [range, 16% to 46%] vs 30% [range, 15% to 65%]) and received a lower amount of crystalloids (median, 4.2 mL/kg/h [range, 0 to 17 mL/kg/h] vs 6.4 mL/kg/h [range, 0 to 120 mL/kg/h]). The clinical importance of these findings was unclear.

Evidence of delayed reactions 5 to 14 days after administration, such as unexplained lethargy, edema, urticaria, lameness, pyrexia, cutaneous lesions indicative of vasculitis, vomiting, generalized pain, and inappetance, was detected in 3 dogs that were reevaluated 6 to 18 days after being discharged from the hospital. Exhaustive investigations did not yield other possible explanations for the clinical signs; therefore, a delayed reaction to human albumin administration was suspected. On the basis of the nature of clinical signs and clinician preference, a variety of treatments was used in each dog, including cephalexin, corticosteroids, diphenhydramine, doxycycline, famotidine, pentoxyphylline, and S-adenosyl-methionine. In 2 dogs, signs completely resolved in 2 to 5 days. The other dog was improving at a 10-day reexamination but was lost to follow-up 6 weeks later, by which time all clinical signs had resolved.

Discussion

The population evaluated in this study comprised dogs with a wide range of critical illnesses. Despite the heterogeneity of the population, the magnitude of improvement in colloid osmotic pressure and serum albumin and total protein concentrations after human albumin administration was positively associated with survival. Survivors also appeared to have received higher dosages of human albumin, which may explain the observation that they had the greatest increase in serum albumin and total protein after treatment. The changes in albumin correlated well with changes in colloid osmotic pressure, which suggested that point-of-care colloid osmotic pressure measurements may be used to assess the degree of change in albumin concentration after administration, as assays for serum albumin are not usually available as point-of-care measurements.

The dosage of human albumin had a weak, positive correlation with percentage increase in albumin concentration and colloid osmotic pressure. The median albumin increase was 1.1 g/dL, and the median dosage was 1.35 g/kg (0.61 g/lb). Because of the variation in underlying diseases and ongoing losses of albumin, a predictable relationship between dosage of albumin and change in albumin concentration could not be determined. Because the study was retrospective and observational, the method by which the dosage of albumin was calculated was not standardized among dogs. However, because the median colloid osmotic pressure and serum albumin and total protein concentrations after human albumin administration were still within or less than the reference range, use of either method did not appear to result in overadministration of albumin. A hypothesis put forth by authors of a recent report[27] of acute and delayed immunologic reactions in healthy dogs administered human albumin suggested that supraphysiologic concentrations of albumin may be partly responsible for adverse reactions.

The SPI2 scores were used in the present study to help stratify dogs on the basis of severity of illness. This allowed comparisons between subpopulations and with other studies that used SPI2 scores. The range of the SPI2 score is from 0 to 1, with 0 indicating the most severe disease with the highest expected mortality rate. Median SPI2 score in dogs in the present study was 0.58, which was comparable to the mean scores recently reported in dogs with septic peritonitis treated during 2 periods (0.685 and 0.594, repectively).[31] However, SPI2 scores could not be calculated in 18 of 73 (25%) dogs because of missing datum points. There were no differences in SPI2 scores between survivors and nonsurvivors, nor were there differences between those dogs that developed complications possibly related to human albumin administration and dogs that did not have complications.

Recent findings have highlighted the potential risks to dogs receiving human albumin. In particular, anaphylactic-type reactions resulting in shock and even death have been reported in healthy dogs administered human albumin.[27–29] In 1 study,[28] 9 dogs were administered 50 g (200 mL) of 25% human albumin with a median dosage of 2.5 g/kg (1.1 g/lb). Initial infusion rate was approximately 10 mL/h (2.5 g/h), increasing by 10 mL/h to as much as 40 mL/h in 15-minute increments if no adverse reactions were observed.[28] Severe anaphylactoid reactions were observed in 1 of 9 dogs during the first infusion and anaphylactic reactions in 2 of 2 dogs administered a second infusion. These reactions were characterized by shock and collapse, which resolved with IV administration of crystalloids and diphenhydramine. Two dogs developed severe edema and urticaria 6 or 7 days after an initial infusion. These signs also resolved with administration of diphenhydramine.

In another study,[27] 6 dogs were administered 2 mL/kg (0.91 mL/lb) of 25% human albumin during a 1-hour period. An immediate hypersensitivity reaction was seen in 1 dog and was characterized by vomiting and facial edema. Delayed adverse reactions were seen in all 6 dogs and included lethargy, lameness, peripheral edema, ecchymoses, vomiting, and anorexia, among other signs. Delayed complications in 2 of these dogs resulted in death and were suspected to have occurred because of serum sickness secondary to type III hypersensitivity reactions.[32] The dogs died from renal failure and coagulopathy, and 1 dog had shock and sepsis associated with multidrug-resistant *Escherichia coli* infection. The delayed complications were seen 5 to 13 days after administration of human albumin.

In the present study, serious complications that could be attributed to administration of human albumin included development of cardiopulmonary arrest in 4 dogs and coagulopathy in 1 dog. It is difficult to determine whether the arrests resulted from worsening of the underlying condition or human albumin administration. Prolongation of clotting times after administration of human albumin could have resulted from worsening of the underlying condition or from dilutional coagulopathy. Dogs that had cardiopulmonary arrest during or soon after being administered human albumin were being treated for various diseases, including sepsis and respiratory failure requiring mechanical ventilation, fulminant hepatic failure, concurrent hepatic and renal failure, and severe trauma (ie, pulmonary contusions, pneumothorax, hemoabdomen, and coagulopathy).

Although most of the complications associated with human albumin administration in the present study were considered minor, concerns regarding the safety of human albumin administration to dogs remain. Dogs in the present study that survived had a median length of hospitalization of 6 days (2 to 30 days). Evidence of delayed complications, such as those described in healthy dogs, was recorded in 3 dogs that eventually recovered with supportive care. No deaths or other serious sequelae were identified in this patient population. Given the high rate of deaths in this population, the severity of illness of many dogs, and the fact that the median length of hospitalization for all patients was < 7 days, it is possible that signs of adverse reactions, both acute and delayed, may have been under-recognized.

On the basis of our experience with the use of human albumin in critically ill dogs, we propose that administration of 10% human albumin may be useful in dogs with reversible disease and clinically affected by marked hypoalbuminemia (serum albumin, < 1.5 g/dL) and low colloid osmotic pressure (colloid osmotic pressure, < 14 mm Hg). Dilution of concentrated human albumin to 10% may be preferable to undiluted 25% human albumin, which has been associated with acute, even fatal, adverse reactions when administered to healthy dogs; however, this warrants further investigation. More specific recommendations for the use of human albumin in veterinary patients, including indications, protocols for preparation, administration, and monitoring, may be obtained elsewhere.[2,26,33] Reasonable goals for human albumin administration in dogs may be to increase serum albumin to 2.0 to 2.5 g/dL and colloid osmotic pressure to 14 to 20 mm Hg. Dogs with surgical diseases and septic peritonitis should be especially considered because of the role of albumin in wound healing. The protocol most often used for calculating the dosage of human albumin to administer in the present study was as follows: albumin deficit (g) = 10 × (serum albumin desired – serum albumin of patient) × body weight (kg) × 0.3. Alternatively, some dogs received 0.5 to 1.25 g/kg (0.2 to 0.6 g/lb), as described.[2] In the authors' institution, the calculated dosage of human albumin was aseptically diluted to a 10% solution with saline (0.9% NaCl) solution and administered over a 12-hour period with a transfusion filter. The use of a transfusion filter was in accordance with instructions in the package insert[30] of human albumin and is intended to filter macroaggregates that may form in the solution. It is uncertain whether the protocol used at the authors' institution may be responsible for the lower prevalence and lesser severity of reactions, compared with reports in which human albumin was administered undiluted and over a shorter amount of time to healthy dogs. Because of the antigenicity of human albumin in dogs, no dog was eligible for receiving additional human albumin after 7 days following initial human albumin administration.

Although there are some recommendations in the literature of administering plasma to increase serum albumin concentrations, there are several reasons

why such an approach may be impractical. To increase serum albumin by 0.5 g/dL, a plasma dosage of 22.5 mL/kg may be required.[2] This translates into a liter of plasma necessary to provide the equivalent amount of albumin that can be supplied by a 100-mL vial of 25% human albumin. At the authors' institution, a liter of plasma costs approximately $1,200, which is > 12 times the cost of a 100-mL vial of 25% human albumin. To the authors' knowledge, the effects of plasma administration on serum albumin and colloid osmotic pressure in critically ill dogs have not been reported.

Given the risks for complications and uncertain positive influence on outcome associated with human albumin administration in dogs, thoughtful consideration and extreme care must be taken when deciding whether to administer human albumin transfusions to critically ill dogs, and these concerns should be discussed with clients. Frequent monitoring should always be used, including temperature, respiratory rate, and heart rate; dogs should also be monitored for delayed reactions, which can occur weeks after administration. Although the present study revealed that human albumin administration can effectively increase serum albumin and total protein concentrations and colloid osmotic pressure and that survivors had more pronounced increases in these variables, future randomized trials are warranted to evaluate the efficacy and safety of human albumin therapy in critically ill dogs.

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