

Studies on components of Blood and its functions

Chapter 2

An introduction to blood groups and blood transfusion in domestic animals

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1. Blood groups

Blood groups are decided by genetically influenced, polymorphic, antigenic components of the erythrocyte membrane. Blood group systems in general are independent of each other, and their inheritance conforms to Mendelian dominance. For polymorphic blood groups, an animal usually inherits 1 allele from each parent and thus expresses not more than 2 blood group antigens of a system. An exception being cattle, where multiple alleles or phenogroups are inherited. Normally, an individual does not have antibodies against any of the antigens present on its own red blood cells (RBC) or against other blood groups antigens of that species' systems unless they have been induced by transfusion, pregnancy or immunization. The so called naturally occurring isoantibodies in some species (sheep, cattle, horses, pigs, dogs and cats), not induced by transfusion or pregnancy, may be present in variable but detectable titres. For example, cats with Group B essentially have anti-A antibody. With random blood transfusions in dogs, there is a 30-40% chance of sensitization of the recipient, primarily to blood group antigen DEA 1 (DEA stands for Dog Erythrocyte Antigen). ~50% of dogs have a naturally occurring cold hemagglutinin, DEA 7. In horses, transplacental immunization of the mare by an incompatible fetal antigen inherited from the sire may occur. As reported by Susan M. Cotter [1], immunization also may result when some homologous blood products are used as vaccines (e.g., anaplasmosis in cattle).

The number of major recognized blood group systems is species dependent with cattle being the most complex and cats the simplest. Animal blood groups are typed to aid in the matching of donors and recipients and to identify breeding pairs potentially at risk of causing hemolytic disease in their offspring. Because expression of blood group antigens is genetically controlled and the modes of inheritance are apprehended, these systems also have been used to corroborate pedigrees in cattle and horses; however in most cases, DNA fingerprinting has replaced blood typing for paternity testing.

Table: Major blood groups of clinical interest [2]

Species	Blood Group
Canine	DEA 1.1 and 7
Feline	A, B, mic
Equine	A, C, Q
Bovine	B, J
Ovine	B, R

2. Blood typing

Blood typing is a general term describing the procedures used to identify the antigen or antigens in a given blood sample. Antisera used to identify blood groups usually are produced as isoimmune sera. Their in vitro serologic signatures differ with the species. Many reagents are hemagglutinins; others are hemolytic and require complement to complete the serologic reaction, such as in cattle (because RBC don't readily agglutinate) and horses (because RBC rouleaux are a problem). Other typing reagents, neither hemagglutinating nor hemolytic, combine with RBC antigens in an incomplete reaction because they lack additional combining sites to agglutinate other RBC; addition of species-specific antiglobulin is required for agglutination.

The blood group diversity in animals and the deficiency of commercially available blood-typing reagents make complete typing and matching cumbersome but should not preclude the clinical use of transfusions. In dogs and horses, the blood group antigens most frequently implicated in transfusion incompatibilities are known; by selecting donor animals that lack these groups, or that match the recipient, the likelihood of sensitization of the recipient to the most crucial antigens can be minimized. Blood types are inherited in all species, and they are often used to establish and monitor pedigrees.

3. Cross matching

The ability to identify blood group antigens in a potential transfusion recipient is limited by the availability of reagents for each antigen for each species. The direct crossmatch procedure with suitable controls is effective for all species. The major crossmatch detects

antibodies already present in recipient plasma that could cause a hemolytic reaction when donor RBC are transfused; it won't detect the potential for sensitization to develop. Some newer crossmatching systems using a gel technique are becoming available. This is especially important in equine because their RBC tend to form rouleaux. The minor crossmatch is the reverse of the major crossmatch, i.e., recipient cells are combined with the donor plasma. The minor crossmatch is important only in species such as cats with clinically important naturally occurring isoantibodies or if the donor has been previously transfused or in previously pregnant horses.

4. Blood transfusions

Frequently, the need for blood transfusions is acute, as in case of acute hemolysis or hemorrhage. Transfusions are also appropriate in treatment of acute or chronic anemias. Animals with hemostatic disorders usually require repeated transfusions of blood, red cells, plasma, or platelets. Blood transfusions must be given with care because they have the potential for further compromising the recipient.

Whole blood frequently is seldom the ideal product to be transfused. Plasma is particularly useful as a substitute for blood in transfusions because the proteins in it give it the same osmotic pressure as blood. If the need is to replace the oxygen-carrying capacity of the blood, then packed RBC are more appropriate. If replacement of circulatory volume is required, crystalloid or colloid solutions may be used to restore volume, with packed RBC added as needed. Platelet number rises rapidly after hemorrhage, so substitution therapy is rarely needed. Plasma is not needed except in massive hemorrhage. Animals that require coagulation factors benefit most from administration of fresh-frozen plasma or cryoprecipitate if the need is specifically for factor VIII, von Willebrand's factor or fibrinogen. Platelet-rich plasma or platelet concentrates may be of value in thrombocytopenia, although immune-mediated thrombocytopenia is refractory to administration of platelets because they are removed rapidly by the spleen.

The decision to transfuse RBC is determined by clinical signs in the patient, and not by any pre-selected packed cell volume (PCV). Animals with acute anemia exhibit the signs of weakness, tachycardia and tachypnea at a higher PCV than animals with chronic anemia. The amount of RBC required to relieve clinical signs will generally increase the PCV above 20%. Not more than 25% of a donor animal's blood is collected at a time.

5. Collection of blood for transfusion

Aseptic conditions should prevail while collecting, storing and transfusing blood. The anticoagulant of choice is citrate phosphate dextrose adenine (CPDA-1). Blood bags containing the appropriate amount of anticoagulant for a unit (500 mL) are available (MSD Manual, Veterinary Manual). Heparin has a longer half-life in the recipient and causes platelet

activation; and heparinized blood can't be stored, so heparin should be avoided for use as anticoagulant in case of blood transfusion. One must be careful not to use too much citrate because it can combine with sufficient calcium ions to produce hypocalcemia, which may impair functions of nerves, skeletal and cardiac muscles and leads to tetany, hypotension and cardiac arrest. Potassium salts are seldom used in transfusions because of the possibility of producing hyperkalemia, which may alter cardiac electrical activity (tall peaked T waves, bradycardia, atrial standstill, heart block or cardiac arrest).

Blood collected in CPDA-1 with Adsol nutrient solution added may be safely stored at 4°C for 4 weeks. If the blood is not used immediately, the plasma can be removed and stored frozen for later use as a source of coagulation factors or albumin for acute reversible hypoalbuminemia. Plasma must be frozen at -20° to -30°C within 6 hours of collection to assure that factor VIII levels are adequate and remain so for 1 year. Colloid solutions like hetastarch are more effective for the treatment of disorders like hypoalbuminemia. Human albumin has been tried in dogs, but the risk of sensitization and allergic reaction is significant.

6. Risks associated with transfusions

Blood transfusions can be lifesaving but at the same time they are not without a small degree of risk. The most serious risk of transfusion is acute hemolysis. This is rare in domestic animals. Dogs seldom have clinically important preformed antibodies, so only those that have received repeated transfusions are at risk. The most common hemolytic reaction in dogs that have received transfusions more than once is delayed hemolysis, seen clinically as shortened survival of transfused RBC and a positive Coombs' test. Even crossmatch-compatible RBC given to horses or cattle survive for about 2-4 days. Repeated transfusions can cause acute hemolysis. Non-immune causes of hemolysis include improper collection or separation of blood, freezing or overwarming of RBC, and infusing under pressure through a small needle.

Other risks associated include sepsis from contaminated blood, hypocalcemia from too much citrate and hypervolemia (in preexisting heart diseased animals). Urticarial, fever or vomiting are seen occasionally. Diseases from donor to recipient can be transmitted through transfusions, such as RBC parasites (eg, *Babesia* in dogs or *Mycoplasma* in cats) and viruses (eg, retroviruses in cats, cattle or horses). Other diseases such as those caused by rickettsia or other bacteria can also be spread if the donor is bacteremic.

7. Substitutes for blood

Because of problems associated with finding consistent donors and disease transmission by transfusion, the search for a red cell substitute has been ongoing for more than 50 years now. A best possible substitute would transport and deliver oxygen like red cells, be easy to produce in large quantities, be non-antigenic and persist in the circulation at least long enough

for resuscitation.

At present, one hemoglobin-based oxygen carrier of bovine origin is licensed for use in dogs (Oxyglobin®). Oxyglobin (HB-200) improves packed red blood cell transfusion (pRBCT) in dogs with anemia from babesiosis vis-à-vis blood gas, acid-base and blood pressure [3]. The hemoglobin is collected aseptically, filtered to remove all red cell stromal components, and polymerized to allow the product to remain in the circulation for a half-life of 36 hours. This product has been shown to carry and deliver oxygen efficiently, can be used immediately without need for typing and has a 3 year shelf life at room temperature. Bovine hemoglobin is minimally antigenic because the structure of the hemoglobin molecule is similar between species.

In hypotension, hypovolemia or local tissue ischemia, oxygen delivery to tissues may be impaired. If hemoglobin is given, the oxygen content of the plasma improves and the oxygen delivery improves. One concern with hemoglobin solutions is that nitric oxide is scavenged and removed by the product. This might paradoxically cause vasoconstriction and decrease oxygen delivery to ischemic tissues.

8. Conclusions

Blood transfusion is an intricate process requiring unique skills as well as devoted owners and animals. The benefit of blood transfusion is immeasurably large and a very common treatment in case of small animals like cats and dogs. In certain circumstances, transfusions can be fatal which can be avoided by blood typing animals before they receive blood and cross matching them if appropriate.

9. References

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